NASA
National Aeronautics and
Space Administration

# Budget Estimates

## FISCAL YEAR **1986**

## Volume I

**Agency Summary**

**Research and Development**

**Space Flight, Control and Data Communications**

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1986 ESTIMATES

VOLUME I

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AGENCY
SUMMARY

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

**FISCAL YEAR 1986 ESTIMATES**

**GENERAL STATEMENT**

The National Aeronautics and Space Administration conducts space and aeronautical activities for peaceful purposes and the benefit of all people. NASA's activities are designed to enhance United States leadership in aeronautics and in space research, exploration and utilization. More specifically, the objectives of NASA's activities are to:

-- Make the Space Transportation System fully operational and cost effective;

-- Move forward toward the establishment of a permanently manned Space Station;

-- Conduct an effective and productive program of aeronautical research and technology which will contribute materially to the enduring preeminence of the United States in aviation;

-- Conduct an effective and productive Space and Earth Sciences program which expands human knowledge of the Earth, its environment, the solar system and the universe;

-- Conduct effective and productive space applications and technology programs which contribute materially to our nation's current and future leadership in space; and

-- Enhance opportunities for U.S. private sector involvement in civil space and space-related activities

The NASA FY 1986 budget recommendation of $7,886 million provides for a deliberately paced program of flight projects and ground-based activities to make progress toward these objectives.

Space program elements in FY 1986 involve:

o Definition and technology effort in preparation for development of a permanently manned Space Station, the next major step in exploration and utilization of space and a key element in continued U.S. leadership in space. The ability to function routinely in space onboard the space station will provide countless opportunities for experimenting in the known sciences as well as in those still to be discovered. Commercial companies, other United States government agencies, and foreign governments have been invited to join us in this endeavor broadening the horizons for all those who participate. Definition and preliminary design contracts will be initiated in FY 1985 so that the best ideas and technology of industry are considered before the final design and development are begun.

o Expanded use of the Space Shuttle and other elements of the Space Transportation System capitalizing on its demonstrated capabilities to place satellites in orbit, to retrieve and repair satellites, and to conduct experiments and make observations using the Shuttle and the Spacelab. The FY 1986 program will provide for the procurement of the hardware, mission integration and training, ground processing and flight operations of the Space Shuttle. Flights during 1986 include payloads for NASA, Department of Defense and domestic commercial and international users of space. The present fleet of three orbiters will be expanded with the delivery of the fourth orbiter in mid-1985, and final operational modifications to OV-102 will be completed during 1985. Additional Spacelab flights will capitalize on the success of the initial mission as this unique capability is exploited for space research and applications missions. The Centaur upper stages for Department of Defense and NASA missions will proceed toward the critical first uses of the planetary version in 1986 for the Galileo and Ulysses Missions. The initial launch from the Vandenberg launch site scheduled for early 1986 will use the first set of lighter weight filament wound cases for the Solid Rocket Booster. Work will continue on the the Space Shuttle main engine to improve the operating margins, reliability and maintainability of the present configuration. Development efforts will be initiated on a reuseable orbital maneuvering vehicle to extend operational on-orbit capabilities beyond the range of the orbiter.

o A banner year for the Space Science and Applications program including the planned launch of the Galileo and Ulysses (formerly the International Solar Polar Mission) missions and the Hubble Space Telescope, the observations of Halley's Comet from Astro telescopes aboard the Space Shuttle, and the Voyager encounter with Uranus. The Galileo mission will retain an option to fly by the asteroid Amphitrite on its way to Jupiter where it will send a probe into Jupiter's atmosphere and conduct a series of encounters with satellites of the giant planet. Ulysses will fly past Jupiter and use the powerful gravitational force of the planet to accelerate the spacecraft into a trajectory which will permit observation of the Sun at high latitudes previously beyond our capability to observe. The Hubble Space Telescope will provide a quantum jump over the best ground-based telescopes in our ability to observe and better understand the Universe. Work will continue on important missions for the future: the Gamma Ray Observatory will study extremely high energy phenomena; the Venus Radar Mapping mission will penetrate the dense cloud cover and provide global imagery of the surface of Venus; the Upper Atmosphere Research Satellite will provide important information on the chemical composition and vulnerability of the upper atmosphere; the Mars Orbiter will provide geoscience and climatology mapping of Mars; the Advanced Communications Technology Satellite will demonstrate new capabilities in frequency reuse and on-board switching; and, the Scatterometer will fly on a Navy satellite to acquire global ocean data. Progress will continue in other areas including Materials Processing in Space, the Search and Rescue locator system and analysis of data acquired from the Earth Radiation Budget Satellite launched in late 1984.

o Space research and technology activities to advance the technology base which provides new concepts, materials, components, devices, software and subsystems for use in United States civil and military space activities. This research emphasizes the longer range aspects of generic research and technology development in transportation, spacecraft and platform systems which are crucial to future United States leadership in space.

The Aeronautical research and technology program contributes materially to the enduring preeminence of U.S. civil and military aviation by: (1) conducting disciplinary and systems research at the leading edge of technology in those areas critical to the continued superiority of U.S. aircraft; (2) maintaining the research centers in positions of excellence in facilities and technical staff; (3) assuring timely transfer of research results to the U.S. aeronautical industry; (4) assuring appropriate involvement of universities and industry; and (5) providing aeronautical development support to other government agencies and U.S. industry. Conducted well in advance of and independent of specific applications, the Aeronautical research and technology program includes both fundamental research in the aeronautical disciplines and systems research applicable to general classes of advanced military and civil aircraft. The program involves participation by aeronautical manufacturers to ensure that the technology is compatible with practical design considerations and can be successfully transferred into application in new and better aircraft, systems and components.

Resources Summary

The budget authority recommended for FY 1986 totals $7,886.0 million with estimated outlays of $7,772.0 million and civil service staffing level of 21,800 full-time equivalent workyears.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(Thousands of Dollars)

| | Budget Plan 1984 | 1985 | 1986 |
|---|---|---|---|
| RESEARCH AND DEVELOPMENT | 2,064,200 | 2,422,600 | 2,881,800 |
| Space Station | (21,900) a/ | 150,000 | 230,000 |
| Space Transportation Capability Development | 431,700 | 351,400 | 459,300 |
| Space Science and Applications | 1,157,000 | 1,404,500 | 1,613,200 |
| Technology Utilization | 9,000 | 9,500 | 11,100 |
| Commercial Use of Space | --- | (8,500) b/ | 30,000 |
| Aeronautical Research and Technology | 315,300 | 342,400 | 354,000 |
| Space Research and Technology | 137,000 | 150,000 | 168,000 |
| Tracking and Data Advanced Systems | 14,200 | 14,800 | 16,200 |
| SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS | 3,772,300 | 3,601,800 | 3,509,900 |
| Shuttle Production and Operational Capability | 1,646,300 | 1,492,100 | 976,500 |
| Space Transportation Operations | 1,452,000 | 1,314,000 | 1,725,100 |
| Space & Ground Network, Comm. and Data Systems | 674,000 | 795,700 | 808,300 |
| CONSTRUCTION OF FACILITIES | 155,500 | 150,000 | 149,300 |
| RESEARCH AND PROGRAM MANAGEMENT | 1,255,908 | 1,336,300 | 1,345,000 |
| TOTAL | 7,247,908 | 7,510,700 | 7,886,000 |
| OUTLAYS | 7,047,600 | 7,317,000 | 7,772,000 |

a/ In FY 1984, funded as part of the Office of Space Flight ($13.0 million), Office of Aeronautics and Space Technology ($6.0 million), Office of Space Science and Applications ($2.0 million), and Office of Space Tracking and Data Systems ($0.9 million).

b/ In FY 1985, funded as part of the Office of Space Station ($0.2 million), Office of Space Flight ($4.5 million), Office of Space Science and Applications ($2.0 million), Office of Aeronautics and Space Technology ($0.7 million), and Office of Space Tracking and Data Systems ($1.1 million).

## SPACE STATION

- o Establish a permanently manned space station:
  - The next logical step in U.S. leadership in space
  - Built upon the operational capabilities of the Space Shuttle
  - Conducive to user community
  - Orbital activities begin in the next decade
- o Perform a thoroughly detailed front-end definition including:
  - Engineering design by industrial contractors
  - Subsystem advanced development and tests in dedicated test beds
  - Early flight experiments on the Space Shuttle to prove system feasibility
  - Continued trade studies for system optimization
- o Develop a multi-purpose facility involving both manned and unmanned elements to perform:
  - Essential scientific and technical research
  - Unique commercial activities
  - Operational tasks in space more efficiently such as:
    - Satellite servicing
    - Assembly and servicing of platforms
    - Placement of spacecraft into higher orbits
  - Extensive national and international user community participation through:
    - Simplified user interfaces
    - Capability for on-orbit crew maintenance
    - Operational autonomy to achieve effective long-term performance
  - Staging base for potential future national programs such as:
    - Manned missions to the Moon or planets
    - Unmanned scientific probes and sample returns

MAJOR FLIGHT ACTIVITY

| | Fiscal Years 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|
| Flight Experiments on Space Shuttle......... | .......... | △———— | ———— | ———— | ———— | ———— |

| BUDGET PLAN (millions of dollars) | FY 1984 | FY 1985 | FY 1986 |
|---|---|---|---|
| Utilization | (4.1) | 9.0 | 15.0 |
| Advanced Development | (6.9) | 52.3 | 82.0 |
| Systems Definition | (5.5) | 52.0 | 74.0 |
| Operation Readiness | (---) | 3.0 | 7.0 |
| Program Management Integration | (5.4) | 33.7 | 52.0 |
| Systems Development | (---) | --- | --- |
| Total | (21.9)* | 150.0 | 230.0 |

*Funded as part of the Office of Space Fight ($13.0), Office of Aeronautics and Space Technology ($6.0), Office of Space Science and Applications ($2.0), and Office of Tracking and Data Systems ($0.9) FY 1984 budgets.

## SPACE TRANSPORTATION CAPABILITY DEVELOPMENT

- Proceed with development of the capabilities to enhance the space transporation system throuyh pursuit of:
  - Manned orbital experiments using Shuttle and Spacelab
  - Complete development of Centaur upper stage to place payloads into deep space and in geosynchronous orbits
  - Identification of future space proyrams and new technology to reduce program risks
  - Orbital placement, servicing and retrieval of automated satellites
  - Orbital maneuvering vehicle to extend operational on-orbit capabilities range
- Development of United States-Italian Tethered Satellite System
- Maintain engineering, scientific and technical support capability
- Development of operational equipment to support payload pre- and post-launch processing and on-orbit operations

MAJOR FLIGHT ACTIVITY

Fiscal Years: 1984 1985 1986 1987 1988 1989 1990

Spacelab (Development flights) ........ △ (1985)
(Operational flights) ........ (1985–1990)
Upper Stages ........ △ (1984–1990)
Tethered Satellite System ........ △ (1989)

| BUDGET PLAN (millions of dollars) | FY 1984 | FY 1985 | FY 1986 |
|---|---|---|---|
| Space Transportation Capability Development | 431.7 | 351.4 | 459.3 |

**NATIONAL AERONAUTICS *AND* SPACE ADMINISTRATION**
**PROGRAM HIGHLIGHTS**
**RESEARCH AND DEVELOPMENT**

## SPACE SCIENCE AND APPLICATIONS

- o Increase our understanding of the Earth and its environment, the solar system, and the universe through a balanced program of space exploration missions and ground-based investigations;
- o Utilize the space environment for research in the biomedical, biological, and bioinstrumentation fields;
- o Exploit the knowledge gained from current and completed program efforts by thorough analysis and interpretation of the scientific data obtained; and
- o Develop and demonstrate practical uses of space and space-derived technology

MAJOR FLIGHT ACTIVITY

| | Fiscal Years 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|
| Hubble Space telescope | | | △ | | | | |
| Gamma ray observatory | | | | | △ | | |
| Explorer launches | △ | A | A | △ △ | △ | A | |
| Shuttle/Spacelab science and applications missions | △ ——— | ——— | ——— | ——— | ——— | ——— | ——— |
| Dedicated life sciences Spacelab missions | | | △ ——— | ——— | ——— | ——— | ——— |
| Voyager | | | Ⓤ | | | Ⓝ | |
| Galileo | | | △ | | | Ⓙ | |
| Ullyses (International solar polar mission-ESA Spacecraft) | | | △ | | | | △ Polar Passage |
| Venus radar mapper mission | | | | | △ Ⓥ | | |
| Mars Observations | | | | | | | △ |
| Landsat-D' | △ | | | | | | |
| Search and rescue locator system on weather satellites | △ ——— | ——— | ——— | ——— | ——— | ——— | ——— |
| Earth radiation budget experiment | △ ——— | ——— | ——— | ——— | ——— | ——— | ——— |
| Advanced communications technology satellite | | | | | | △ | |
| Upper atmospheric research satellite | | | | | | | △ |
| Scatterometer (to be launched on Navy's NROSS mission) | | | | | | △ | |

| BUDGET PLAN (millions of dollars) | FY 1984 | FY 1985 | FY 1986 |
|---|---|---|---|
| Physics and Astronomy | 567.6 | 677.2 | 630.4 |
| Life Sciences | 58.0 | 62.3 | 72.0 |
| Planetary Exploration | 217.4 | 290.9 | 359.0 |
| Solid Earth Observations | 76.4 | 57.6 | 74.9 |
| Environmental Observations | 162.0 | 212.7 | 317.5 |
| Materials Processing in Space | 25.6 | 27.0 | 34.0 |
| Communications | 41.1 | 60.6 | 106.2 |
| Information Systems | 8.9 | 16.2 | 19.2 |
| Total Space Science and Applications | 1157.0 | 1404.5 | 1613.2 |

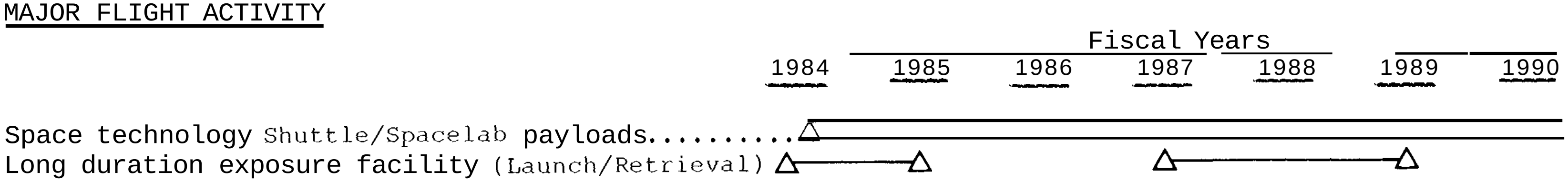
NATIONAL AERONAUTICS *AND* SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
RESEARCH AND DEVELOPMENT

## SPACE RESEARCH AND TECHNOLOGY

- o Provide a technology base essential to future United States leadership in space by:
  - Improving performance and effectiveness
  - Reducing cost and risk
  - Increasing reliability
  - Developing technological options

- o Achieve these objectives, by means of ground and space-based research and technology activities, through advances in the technology areas of:
  - Aerothermodynamics
  - Materials and structures
  - Space energy conversion
  - Propulsion
  - Space data and communications
  - Information sciences
  - Controls and guidance
  - Human factors
  - Space flight systems
  - Systems analysis

MAJOR FLIGHT ACTIVITY




| BUDGET PLAN (millions of dollars) | FY 1984 | FY 1985 | FY 1986 |
|---|---|---|---|
| Space Research and Technology | 137.0 | 150.0 | 168.0 |

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**
**PROGRAM HIGHLIGHTS**
**RESEARCH AND DEVELOPMENT**

## AERONAUTICAL RESEARCH AND TECHNOLOGY

- Conduct the fundamental research and technology in the aeronautical disciplines and systems research applicable to general classes of advanced civil and military aircraft to:
  - Improve performance
  - Reduce costs
  - Increase safety
  - Reduce energy requirements
  - Decrease environmental effects

- Develop and sustain a strong Research and Technology Base in:
  - Fluid and thermal physics
  - Applied aerodynamics
  - Materials and structures
  - Controls and guidance
  - Human factors
  - Information sciences
  - Propulsion and power
  - Flight systems
  - Systems analysis

- Conduct focused systems technology to evaluate the technical feasibility of advances or concepts:
  - Numerical aerodynamic simulation for complex aerospace computational problems
  - Technology for next generation rotorcraft including X-Wing and advanced tilt-rotor technology
  - Turbine engine hot section technology for higher performance and longer lasting engines
  - High-performance flight research
  - Advanced rotorcraft technology and flight research
  - General aviation/commuter engine technology for better performance and efficiencies
  - Advanced turboprop systems for faster, more fuel-efficient transport and commuter aircraft
  - Ceramics for turbine engines for high operating temperatures
  - Oblique wing technology for aerodynamic efficiency over transonic speeds

- Maintain expertise and operate significant national facilities to support research and technology:
  - Research and test facilities
  - Simulation facilities
  - Wind tunnels

| BUDGET PLAN (millions of dollars) | FY 1984 | FY 1985 | FY 1986 |
|---|---|---|---|
| Aeronautical Research and Technology | 315.3 | 342.4 | 354.0 |

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

## SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY/SPACE TRANSPORTATION OPERATIONS

- Continue with the operational establishment of a versatile and cost-effective space transportation system to provide for:
  - Completing and operating a national fleet of four Space Shuttle orbiters
  - Ground support equipment, launch site equipment and manpower to support launch and landing operations
  - External tanks and solid rocket boosters and the manufacturing tooling/equipment supporting their production
  - Establishing logistics support capability to provision spares, repair and overhaul flight hardware
  - Provision of capability for training astronauts, launch and flight operation personnel
- Thirteen to fourteen operational flight missions in FY 1986 building to a flight rate of 24 per year by FY 1989
- Continued improvement of Shuttle performance capability
- Support to first Vanderburg Air Force Base flight
- Implementation of improvements to make space transportation more economical and cost effective to all users

MAJOR FLIGHT ACTIVITY

| | Fiscal Years | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
| Space Shuttle: Operational flights | 4 | 10-11 | 13-14 | 17 | 19 | 24 | 24 |

| BUDGET PLAN (millions of dollars) | FY 1984 | FY 1985 | FY 1986 |
|---|---|---|---|
| Shuttle Production and Operational Capability | 1,646.3 | 1,492.1 | 976.5 |
| Space Transportation Operations | 1,452.0 | 1,314.0 | 1,725.1 |
| | 3,098.3 | 2,806.1 | 2,701.6 |

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**
**PROGRAM HIGHLIGHTS**
**SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS**

## SPACE AND GROUND NETWORKS, COMMUNICATION AND DATA SYSTEMS

o Tracking and Data Acquisition using Space and Ground Network interconnected with highly reliable communications to provide support to:

- Shuttle operational flights
- Automated Earth orbiting missions - supports applications and scientific spacecraft including the Nimbus, Landsat, International Ultraviolet Explorer, International Sun-Earth Explorer, Applications Technology Satellites, Solar Maximum Mission, Dynamics Explorer, Solar Mesosphere Explorer, Earth Radiation Budget Satellite, and Active Magnetospheric Particle Tracer Explorer.
- Planetary missions - support will continue for Pioneers-10 and -11, Pioneer Venus, and Voyagers-1 and -2, as well as limited support for Helios and earlier Pioneer missions
- Upcoming missions which will include Space Telescope, Galileo and Ulysses
- Sounding rockets
- Aeronautical flight research program

o The Tracking and Data Relay Satellite System (TDRSS) will replace most ground stations in providing tracking, command and telemetry services to all low-Earth orbital missions. The first spacecraft was launched in April 1983, the second is scheduled to be launched in February 1985 and the third launch is planned for the last half of 1985.

MAJOR FLIGHT ACTIVITY

| | Fiscal Years | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
| Tracking and Data Relay Satellite..................... (Backup satellites available) | | △ △ | | | | | |

| BUDGET PLAN (millions of dollars) | FY 1984 | FY 1985 | FY 1986 |
|---|---|---|---|
| Space & Ground Network, Comm., and Data Systems | 674.0 | 795.7 | 808.3 |

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1986 ESTIMATES

SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS
(Thousands of Dollars)

| | Total | Research and Development | Space Flight, Control and Data Comm. | Construction of Facilities | Research and Program |
|---|---|---|---|---|---|
| **Fiscal Year 1984** | | | | | |
| Appropriation, PL 98-45............ | 7,177,500 | 2,011,900 | 3,791,600 | 135,500 | 1,238,500 |
| Reappropriation, PL 98-396......... | 20,000 | 20,000 | --- | --- | --- |
| Transfer between accounts .......... | --- | 19,300 | -19,300 | --- | --- |
| Unobligated balance transferred.... | 13,000 | 13,000 | --- | --- | --- |
| Supplemental Appropriation, PL 98-181....................... | 20,000 | --- | --- | 20,000 | --- |
| Supplemental Appropriation, PL 98-396....................... | 17,582 | --- | --- | --- | 17,582 |
| Total Budget Plan............... | 7,248,082 | 2,064,200 | 3,772,300 | 155,500 | 1,256,082 |
| **Fiscal Year 1985** | | | | | |
| Appropriation, PL 98-371........... | 7,491,400 | 2,422,600 | 3,601,800 | 150,000 | 1,317,000 |
| Proposed Supplemental Appropriation. ..................... | 23,300 | --- | --- | --- | 23,300 |
| Proposed Recission................. | -4,000 | --- | --- | --- | |
| Total Budget Plan............... | 7,510,700 | 2,422,600 | 3,601,800 | 150,000 | 1,336,300 |
| **Fiscal Year 1986** | | | | | |
| Appropriation request/budget plan.. | 7,886,000 | 2,881,800 | 3,509,900 | 149,300 | 1,345,000 |

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

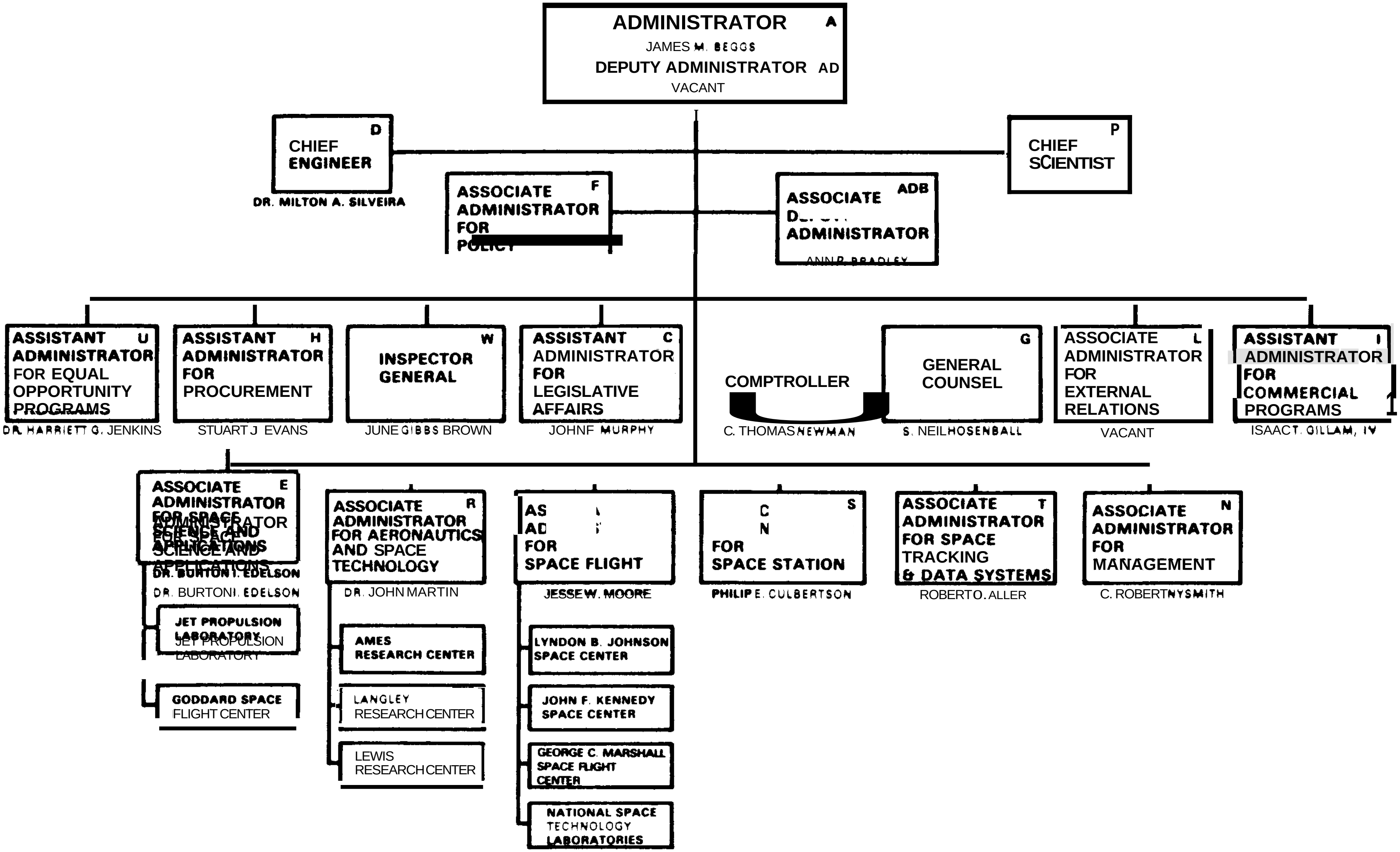
FISCAL YEAR 1986 ESTIMATES

SUMMARY OF BUDGET PLANS BY INSTALLATION BY APPROPRIATION
(Millions of Dollars)

| | Total | | | Space Flight Control and Data Communications | | | Research and Development | | | Construction of Facilities | | | Research dnd Program Management | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1984 | 1985 | 1986 | 1984 | 1985 | 1986 | 1984 | 1985 | 1986 | 1984 | 1985 | 1986 | 1984 | 1985 | 1986 |
| Johnson Space Center........ | 1,612,496 | 1,572,781 | 1,417,605 | 1,303,210 | 1,124,450 | 910,100 | 175,849 | 233,153 | 292,692 | 2,300 | 3,200 | 1,100 | 201,137 | 211,978 | 213,713 |
| Kennedy Space Center........ | 724,090 | 631.499 | 659,691 | 439,900 | 372,900 | 375.500 | 53.008 | 47,019 | 73.860 | 58,550 | 29,600 | 21,000 | 172,632 | 181,980 | 189,331 |
| Marshall Space Plight Center | 1,921,564 | 1,915,382 | 1,982,795 | 1,272,900 | 1,224,400 | 1,273,800 | 447,112 | 491,806 | 506.690 | 11,700 | 1,600 | 6,500 | 189,852 | 197,576 | 195,805 |
| National Space Technology Laboratories............. | 20.549 | 31,691 | 32,253 | 800 | 6,300 | 7,200 | 9,555 | 11,451 | 11.422 | — | 3,000 | 2,500 | 10,194 | 10,940 | 11,131 |
| Goddard Space Flight Center. | 950,607 | 1,028,099 | 1,088,496 | 405,916 | 428,030 | 366,100 | 357,918 | 398,387 | 510,877 | — | 2,200 | 11,800 | 186,773 | 199,402 | 199,719 |
| Jet Propulsion Laboratory... | 349,824 | 469,616 | 602.356 | 97,189 | 109,500 | 124,800 | 248,335 | 347,916 | 468,656 | 4.300 | 12,200 | 8,900 | — | — | — |
| Ames Research Center........ | 318,057 | 400,472 | 386,284 | 9,800 | 11,200 | 14,100 | 189,670 | 254,145 | 240,076 | 4,700 | 13,600 | 8,200 | 113,887 | 121,527 | 123,908 |
| Langley Besearch Center..... | 289,760 | 336,605 | 324,325 | 200 | 100 | 100 | 140,107 | 173.974 | 170,266 | 9,500 | 13,800 | 4,900 | 139,953 | 148,731 | 149,059 |
| Lewis Research Center....... | 423,233 | 405,362 | 520,806 | 2,000 | 20 | — | 281,929 | 266,084 | 380,910 | 10,600 | — | — | 128,706 | 139,258 | 139.896 |
| Inspector General........... | 4,734 | 5.878 | 5,603 | — | — | — | — | — | — | — | — | — | 4,734 | 5,878 | 5.603 |
| Headquarters................ | 553,118 | 687,515 | 836.386 | 240,385 | 324,900 | 438,200 | 160,717 | 198,665 | 226,351 | 43,800 | 45,000 | 55,000 | 108.216 | 118,950 | 116,835 |
| Undistributed Construction of Pacilities: | | | | | | | | | | | | | | | |
| Various Locations.. ....... | 1,450 | 13,800 | 17,400 | — | — | — | — | — | — | 1,450 | 13,800 | 17.400 | — | — | — |
| Facility Planning and Design............. | 8.600 | 12.000 | 12,000 | — | — | — | — | — | — | 8.600 | 12.000 | 12.000 | — | — | — |
| Total Budget Plan........ | 7,248,082 | 7,510,700 | 7,886,000 | 3,772,300 | 3,601,800 | 3,509,900 | 2,064,200 | 2,422,600 | 2,881,800 | 155,500 | 150,000 | 149,300 | 1,256,082 | 1,336,300 | 1,345,000 |

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**
**SUMMARY OF PERMANENT CIVIL SERVICE WORKYEARS BY INSTALLATION**
**FISCAL YEAR 1986 ESTIMATES**

| | FY 1984 | FY 1985 | FY 1986 |
|---|---|---|---|
| Johnson Space Center | 3.196 | 3.222 | 3.201 |
| Kennedy Space Center | 2.074 | 2.075 | 2.054 |
| Marshall Space Flight Center | 3.270 | 3.251 | 3.229 |
| National Space Technology Laboratories | 107 | 109 | 106 |
| Goddard Space Flight Center | 3.608 | 3.599 | 3.569 |
| Ames Research Center | 2.023 | 2.021 | 2.001 |
| Langley Research Center | 2.869 | 2.860 | 2.808 |
| Lewis Research Center | 2.634 | 2.604 | 2.582 |
| Headquarters | 1.327 | 1.326 | 1.292 |
| Inspector General | 90 | 97 | 97 |
| Subtotal. Full-Time Permanent Civil Service | 21.198 | 21.164 | 20.939 |
| Other than full-time permanent workyears | 882 | 836 | 861 |
| Total. Ceiling Controlled Civil Service | 22.080 | 22.000 | 21.800 |


ADMINISTRATOR A
JAMES M. BEGGS
DEPUTY ADMINISTRATOR AD
VACANT
CHIEF ENGINEER D
DR. MILTON A. SILVEIRA
CHIEF SCIENTIST P
ASSOCIATE ADMINISTRATOR FOR [redacted] F
ASSOCIATE ADMINISTRATOR ADB
ANN P. BRADLEY
ASSISTANT ADMINISTRATOR FOR EQUAL OPPORTUNITY PROGRAMS U
DR. HARRIETT G. JENKINS
ASSISTANT ADMINISTRATOR FOR PROCUREMENT H
STUART J. EVANS
INSPECTOR GENERAL W
JUNE GIBBS BROWN
ASSISTANT ADMINISTRATOR FOR LEGISLATIVE AFFAIRS C
JOHN F. MURPHY
COMPTROLLER
C. THOMAS NEWMAN
GENERAL COUNSEL G
S. NEIL HOSENBALL
ASSOCIATE ADMINISTRATOR FOR EXTERNAL RELATIONS L
VACANT
ASSISTANT ADMINISTRATOR FOR COMMERCIAL PROGRAMS I
ISAAC T. GILLAM, IV
ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS E
DR. BURTON I. EDELSON
JET PROPULSION LABORATORY
GODDARD SPACE FLIGHT CENTER
ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY R
DR. JOHN MARTIN
AMES RESEARCH CENTER
LANGLEY RESEARCH CENTER
LEWIS RESEARCH CENTER
FOR SPACE FLIGHT
JESSE W. MOORE
LYNDON B. JOHNSON SPACE CENTER
JOHN F. KENNEDY SPACE CENTER
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL SPACE TECHNOLOGY LABORATORIES
FOR SPACE STATION S
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*RESEARCH AND*
DEVELOPMENT

# SUMMARY INFORMATION

NATIONAL AERONATUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1986 ESTIMATES

## GENERAL ATEMENT

The objectives of the National Aeronautics and Space Administration program of research and development are to extend our knowledge of the Earth, its space environment, and the universe; to expand the technology for practical applications of space technology; to develop and improve manned and unmanned space vehicles; and to assure continued development of the long-term aeronautics and space research and technology necessary to accomplish national goals. These objectives are achieved through the following elements:

**SPACE STATION:** A program to define the systems and develop a United States space station to continue the Nation's leadership in Space and to provide for enhancement of science and applications programs and for development of capabilities for further exploitation of space.

**SPACE TRANSPORTATION CAPABILITY DEVELOPMENT:** A program to provide for the development and use of capabilities related to the Space Shuttle. The principal areas of activity in Space Transportation Capability Development are efforts related to the development and flight certifiction of the jointly developed U.S./Italy Tethered Satellite System, development of the Orbital Maneuvering Vehicle, Spacelab, the upper stages that place satellites in high altitude orbits, the engineering and technical base support at NASA centers, payload operations and support equipment, and advanced programs study and evaluation efforts.

**SPACE SCIENCE *AND* ICATIONS** A program using space systems, supported by ground-based and airborne observations, (1) to conduct a broad spectrum of scientific investigations to advance our knowledge of the Earth and its space environment, the Sun, the planets, interplanetary and interstellar space, the stars of our galaxy and the universe; and (2) to identify and develop the technology for the useful applications of space techniques in the areas of advanced communications satellite systems technology; materials processing research and experimentation; and remote sensing to acquire information which will assist in the solution of Earth resources and environmental problems.

**TECHNOLOGY UTILIZATION:** The program includes activities to accelerate the dissemination to both the public and the private sectors of advances achieved in NASA's research, technology, and development programs.

**COMMERCIAL USE OF SPACE:** A program to increase private sector awareness of space opportunities and encourage increased industry investment and participation in high technology, space-based research and development.

**AERONAUTICS *AND* SPACE TECHNOLOGY:** A program to conduct the fundamental long-term research and to develop the discipline and systems technology required to maintain United States leadership in aeronautics and space.

**TRACKING AND DATA ADVANCED SYSTEM:** This program includes activities to perform studies and provide for the development of systems and techniques leading to improved tracking and data program capabilities.

NATIONAL AERO[illegible] ICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT
FY 1986 BUDGET ESTIMATES

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| **SPACE STATION** | (21,900) a/ | 150,000 | 150,000 | 230,000 |
| **[illegible] TRANSPORTATION [illegible]** | 431,700 | 361,400 | 351,40[illegible] | 459[illegible] |
| **SPACE SCIENCE AND APPLICATIONS** | 1,157,000 | 1,371,500 | 1,404,500 | 1,613,200 |
| Physics and astronomy.................. | 567,600 | 677,200 | 677,200 | 630,400 |
| Life sciences.......................... | 58,000 | 63,300 | 62,300 | 72,000 |
| Planetary exploration.................. | 217,400 | 286,900 | 290,900 | 359,000 |
| Solid earth observations............... | 76,400 | 63,600 | 57,600 | 74,900 |
| Environmental observations............. | 162,000 | 220,700 | 212,700 | 317,500 |
| Materials processing... ................. | 25,600 | 23,000 | 27,000 | 34,000 |
| Communications.......................... | 41,100 | 20,600 | 60,600 | 106,200 |
| Information systems.................... | 8,900 | 16,200 | 16,200 | 19,200 |
| **COMMERCIAL PROGRAM** | 9,000 | 9,500 | 9,500 | 41,100 |
| [illegible] tion | 9,000 | 9,500 | 9,500 | 11,100 |
| [illegible] Use of Space | --- | --- | (8,500) b/ | 30,000 |
| **AERONAUTICS AND SPACE TECHNOLOGY** | 452,300 | 492,400 | 492,400 | 522,000 |
| Aeronautical research and technology.... | 315,300 | 342,400 | 342,400 | 354,000 |
| Space research and technology........... | 137,000 | 150,000 | 150,000 | 168,000 |
| **[illegible]RACKING AND DATA ADVANCED SYSTEMS** | 14,200 | 15,300 | 14,800 | 16,200 |
| **TOTAL** | 2,064,200 | 2,400,100 | 2,422,600 | 2,881,800 |

a/ In FY 1984, funded as part of the Office of Space Flight ($13.0 million), Office of Aeronautics and Space Technology ($6.0 million), Office of Space Science and Applications ($2.0 million), and Office of Space Tracking and Data System ($0.9 million).

b/ In FY 1985, funded as part of the Office of Space Station ($0.2 million), Office of Space Flight ($4.5 million), Office of Space Science and Applications ($2.0 million), Office of Aeronautics and Space Technology ($0.7 million), and Office of Space Tracking and Data Systems ($1.1 million)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND DEVELOPMENT

For necessary expenses, not otherwise provided for. including research, development, operations. services, minor construction. maintenance, repair. rehabilitation and modification of real and personal property; purchase, hire, maintenance. and operation of other than administrative aircraft, necessary for the conduct and support of aeronautical and space research and development activities of the National Aeronautics and Space Administration; [including not to exceed (1) $155.500,000 for a space station; (2) $195,000,000 for space telescope development; (3) $120,200,000 for the gemma ray observatory: (4) $92,400,000 for upper stapes: (5) $92,500,000 for the Venus radar mapper mission; and (6) $56,100,000 for Galileo; without the approval of the Committees on Appropriations; $2,422,600,000] *$2,881,800,000,* to remain available until September 30, [1986; including $155,500,000 for a space station. of which $5,500,000 shall be made available from prior year appropriations: *Provided,* That of this amount. $63,800,000 is available for space station systems definition and integration studies, including $6,300,000 for systems engineering and integration support activities: *Provided further,* That within this amount. NASA shall conduct a study of an option which "phases-in" the permanently manned features of the station. as one of the reference configurations to be examined in the definition studies: *Provided further.* That the result of this study shall be reported to the House and Senate Committees on Appropriations prior to the selection by the Administrator of a configuration for the permanently manned space station: *Provided further.* That of this amount. $57,500,000 shall be withheld from obligations or expenditure until April 1, 1985: *Provided further.* That the recommendations contained in the report required under the "Research and Program Management" be incorporated in any contract entered into as part of the systems definition and integration studies] *1987: Provided. That notwithstanding the provisions of the Small Business Innovation Development Act. Public Law 97-219, amounts available in fiscal year 1986 for corning out the Small Business Innovation Research Program rhall not exceed the rate authorized for fiscal year 1985 for carrying out this program. (Department of Housing and Urban Development-Independent Agencies Appropriation Act, 1985.)*

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

**RESEARCH AND DEVELOPMENT**

**PROGRAM AND FINANCING**
**(in thousands of dollars)**

| Identification code **80-0108-0-1-999** | | 1984 actual | 1985 estimate | 1986 estimate |
|---|---|---|---|---|
| | Program by activities: | | | |
| | Direct program: | | | |
| | Space transportation systems: | | | |
| 00.0101 | Capability development | 484,795 | 456,725 | 453,935 |
| 00.0201 | Operations | 41,669 | 139 | --- |
| 00.0301 | Space station | --- | 142,500 | 226,000 |
| | Scientific investigations in space | | | |
| 00.1001 | Physics and astronomy | 564,885 | 700,381 | 632,780 |
| 00.1101 | Planetary exploration | 205,956 | 302,907 | 355,550 |
| 00.1301 | Life sciences | 56,088 | 64,228 | 71,500 |
| | Space and terrestrial applications: | | | |
| 00.2001 | Space applications | 283,058 | 432,072 | 542,910 |
| 00.2101 | Commercial programs | 10,467 | 12,283 | 39,545 |
| 00.3001 | Space research and technology | 134,617 | 157,320 | 167,100 |
| 00.4001 | Aeronautical research and technology | 323,545 | 352,118 | 353,400 |
| 00.4101 | Supporting activity: Tracking and data acquisition. | 69,687 | 16,488 | 16,090 |
| 00.9101 | Subtotal, direct program | 2,174,767 | 2,637,161 | 2,858,810 |
| 01.0101 | Reimbursable program | 642,223 | 745,983 | 597,780 |
| 10.0001 | Total obligations | 2,816,990 | 3,383,144 | 3,456,590 |

| Identification code 80–0103–0–1–999 | 1984 actual | 1985 estimate | 1986 estimate |
|---|---|---|---|
| Financing: | | | |
| Offsetting collections from: | | | |
| 11.0001 Federal funds | –411,284 | –514,503 | –456,414 |
| 14.0001 Non-Federal sources | –123,982 | –155,097 | –137,586 |
| 21.4001 Unobligated balance available, start of year | –676,230 | –445,524 | –154,580 |
| 22.4001 Unobligated balance transferred, net | 13,000 | --- | --- |
| 24.4001 Unobligated balance available, end of year | 445,524 | 154,580 | 173,790 |
| 25.0001 Unobligated balance lapsing | 182 | --- | --- |
| 39.0001 Budget authority | 2,064,200 | 2,422,600 | 2,881,800 |
| Budget authority: | | | |
| 40.0001 Appropriation | 2,024,900 | 2,422,600 | 2,881,800 |
| 41.0001 Transferred to other accounts | --- | --- | --- |
| 42.0001 Transferred from other accounts | 19,300 | --- | --- |
| 43.0001 Appropriation (adjusted) | 2,044,200 | 2,422,600 | 2,881,800 |
| 50.0001 Reappropriation | 20,000 | --- | --- |
| Relation of obligations to outlays: | | | |
| 71.0001 Obligations incurred, net | 2,281,724 | 2,713,544 | 2,862,590 |
| 72.4001 Obligated balance, start of year | 1,149,420 | 634,454 | 950,531 |
| 74.4001 Obligated balance, end of year | –634,454 | –950,531 | –1,119,221 |
| 77.0001 Adjustments in expired accounts | –4,878 | --- | --- |
| 90.0001 Outlays | 2,791,812 | 2,397,467 | 2,693,900 |

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

**Research and Development**

**Reimbursable Summary**
**(In thousands of Dollars)**

| Research and Development | Budget Plan FY 84 | FY 85 | FY 86 |
|---|---|---|---|
| Space Transportation Capability | 136,245 | 227,600 | 201,499 |
| Space Science and Applications | 249,041 | 296,600 | 262,901 |
| Technology Utilization | 3,792 | 3,400 | 1,900 |
| Space Research and Technology | 10,750 | 9,900 | 17,800 |
| Aeronautical Research and Technology | 56,550 | 45,200 | 40,000 |
| Energy Technology | 103,622 | 86,900 | 69,900 |
| Total | 560,000 | 669,600 | 594,000 |

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

**RESEARCH AND DEVELOPMENT**

FISCAL YEAR 1986 ESTIMATES

SUMMARY OF BUDGET PLAN BY SUBFUNCTION
(In thousands of dollars)

| Code | | FY 1984 | FY 1985 | FY 1986 |
|---|---|---|---|---|
| 253 | Space Flight.................................. | 431,700 | 501,400 | 709,300 |
| 254 | Space Science, Applications and Technology........... | 1,303,000 | 1,564,000 | 1,802,300 |
| 255 | Supporting Space Activities......................... | 14,200 | 14,800 | 16,200 |
| (250) | Subtotal, General Science, Space and Technology.... | 1,748,900 | 2,080,200 | 2,527,000 |
| 402 | Air Transportation................................. | 315,300 | 342,400 | 354,000 |
| | Total........................................ | 2,064,200 | 2,422,600 | 2,881,800 |

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Fiscal Year 1986 Estimates
Distribution of Research and Development Budget Plan by Installation and Fiscal Year
(Thousands of Dollars)

| Program and Project | | Total | Johnson Space Center | Kennedy Space Center | Marshall Space Flight Center | National Space Technology Laboratories | Goddard Space Flight Center | Jet Propulsion Laboratory | Ames Research Center | Langley Research Center | Lewis Research Center | NASA Headquarters |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Station | 1984 | (21,900) | (9,200) | (400) | (2,800) | (---) | (300) | (1,800) | (1,000) | (1,200) | (1,200) | (4,000) |
| | 1985 | 150,000 | 62,300 | 2,800 | 34,900 | 300 | 16,200 | 4,800 | 3,700 | 4,200 | 16,800 | 4,000 |
| | 1986 | 230,000 | 111,900 | 5,300 | 45,400 | 400 | 17,800 | 7,600 | 4,500 | 4,100 | 26,800 | 6,200 |
| Space Transportation Capability Development | 1984 | 431,700 | 118,000 | 47,600 | 121,700 | 7,200 | 2,200 | 1,100 | 400 | 1,500 | 127,200 | 4,800 |
| | 1985 | 351,400 | 113,200 | 34,700 | 89,200 | 8,200 | 300 | 300 | --- | 300 | 73,000 | 32,200 |
| | 1986 | 459,300 | 115,100 | 56,900 | 128,400 | 7,100 | --- | 1,000 | --- | 200 | 115,300 | 35,300 |
| Space Science and Applications | 1984 | 1,157,000 | 43,695 | 4,668 | 311,066 | 2,205 | 341,782 | 212,093 | 58,110 | 11,456 | 35,779 | 136,146 |
| | 1985 | 1,404,500 | 44,736 | 8,854 | 352,426 | 2,766 | 369,530 | 309,796 | 103,175 | 15,337 | 55,519 | 142,361 |
| | 1986 | 1,613,200 | 51,242 | 9,350 | 305,100 | 3,422 | 479,227 | 424,146 | 71,166 | 15,536 | 100,900 | 153,111 |
| Physics and Astronomy | 1984 | 567,600 | 7,253 | 3,295 | 297,417 | --- | 187,695 | 17,826 | 14,655 | 877 | 150 | 38,432 |
| | 1985 | 677,200 | 8,563 | 6,754 | 334,348 | --- | 191,078 | 26,679 | 57,842 | 2,914 | --- | 49,022 |
| | 1986 | 630,400 | 9,500 | 7,250 | 283,298 | --- | 216,996 | 34,525 | 27,500 | 3,233 | --- | 48,098 |
| Life Sciences | 1984 | 58,000 | 20,752 | 1,373 | --- | 23 | 110 | 2,618 | 22,099 | 365 | --- | 10,660 |
| | 1985 | 62,300 | 22,035 | 2,100 | --- | 50 | 300 | 500 | 24,300 | 500 | 15 | 12,500 |
| | 1986 | 72,000 | 26,550 | 2,100 | --- | 100 | 200 | 1,500 | 28,850 | 600 | --- | 12,100 |
| Planetary Exploration | 1984 | 217,400 | 10,420 | --- | 95 | --- | 3,703 | 135,791 | 16,687 | 5 | --- | 50,699 |
| | 1985 | 290,900 | 10,260 | --- | 100 | --- | 5,079 | 215,795 | 16,774 | --- | --- | 42,892 |
| | 1986 | 359,000 | 11,105 | --- | 100 | --- | 3,620 | 284,755 | 10,159 | --- | --- | 49,261 |
| Solid Earth Observations | 1984 | 76,400 | 3,300 | --- | 245 | 2,093 | 47,361 | 16,144 | 1,016 | --- | --- | 6,241 |
| | 1985 | 57,600 | 1,000 | --- | 262 | 2,281 | 33,657 | 15,426 | 500 | --- | --- | 4,474 |
| | 1986 | 74,900 | 250 | --- | 277 | 2,875 | 37,175 | 28,184 | 645 | --- | --- | 5,494 |
| Environmental Observations | 1984 | 162,000 | 159 | --- | 5,630 | 34 | 95,615 | 23,541 | 3,190 | 9,769 | --- | 24,062 |
| | 1985 | 212,700 | 466 | --- | 8,485 | 235 | 126,220 | 36,661 | 3,429 | 10,568 | --- | 26,636 |
| | 1986 | 317,500 | 477 | --- | 10,315 | 237 | 206,466 | 56,057 | 3,662 | 10,503 | --- | 29,783 |
| Materials Processing in Space | 1984 | 25,600 | 1,786 | --- | 7,603 | --- | --- | 6,362 | --- | 390 | 5,207 | 4,252 |
| | 1985 | 27,000 | 2,212 | --- | 9,106 | --- | --- | 5,485 | --- | 1,355 | 5,754 | 3,088 |
| | 1986 | 34,000 | 3,150 | --- | 10,980 | --- | --- | 8,075 | --- | 1,200 | 6,700 | 3,895 |
| Communications | 1984 | 41,100 | --- | --- | --- | 20 | 4,775 | 4,342 | 258 | 50 | 30,422 | 1,233 |
| | 1985 | 60,600 | --- | --- | --- | --- | 3,787 | 4,400 | --- | --- | 49,750 | 2,663 |
| | 1986 | 106,200 | --- | --- | --- | --- | 2,720 | 6,000 | --- | --- | 94,200 | 3,280 |
| Information Systems | 1984 | 8,900 | 25 | --- | 76 | 35 | 2,523 | 5,469 | 205 | --- | --- | 567 |
| | 1985 | 16,200 | 200 | --- | 125 | 200 | 9,409 | 4,850 | 330 | --- | --- | 1,086 |
| | 1986 | 19,200 | 210 | --- | 130 | 210 | 12,050 | 5,050 | 350 | --- | --- | 1,200 |
| Commercial Programs | 1984 | 9,000 | 154 | 240 | 346 | 150 | 951 | 357 | 48 | 651 | 450 | 5,653 |
| | 1985 | 9,500 | 217 | 265 | 280 | 185 | 1,057 | 120 | 70 | 537 | 365 | 6,404 |
| | 1986 | 41,100 | 1,850 | 1,710 | 6,590 | 500 | 1,850 | 1,210 | 2,910 | 4,130 | 2,310 | 18,040 |
| Technology Utilization | 1984 | 9,000 | 154 | 240 | 346 | 150 | 951 | 357 | 48 | 651 | 450 | 5,653 |
| | 1985 | 9,500 | 217 | 265 | 280 | 185 | 1,057 | 120 | 70 | 537 | 365 | 6,404 |
| | 1986 | 11,100 | 250 | 210 | 390 | 100 | 1,050 | 510 | 2,010 | 530 | 310 | 5,740 |
| Commercial Use of Space | 1984 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | 1985 | (8,500) | (1,000) | (300) | (1,900) | (200) | (200) | (300) | (300) | (1,000) | (700) | (2,600) |
| | 1986 | 30,000 | 1,600 | 1,500 | 6,200 | 400 | 800 | 700 | 900 | 3,600 | 2,000 | 12,300 |
| Aeronautics and Space Technology | 1984 | 452,300 | 14,000 | 500 | 14,000 | --- | 8,400 | 25,300 | 131,100 | 126,500 | 118,500 | 14,000 |
| | 1985 | 492,400 | 12,700 | 400 | 15,000 | --- | 6,500 | 22,900 | 147,200 | 153,600 | 120,400 | 13,700 |
| | 1986 | 522,000 | 12,600 | 600 | 21,200 | --- | 6,900 | 23,600 | 161,500 | 146,300 | 135,600 | 13,700 |
| Aeronautical Research and Technology | 1984 | 315,300 | 900 | --- | 400 | --- | 400 | 600 | 118,700 | 97,000 | 90,100 | 7,200 |
| | 1985 | 342,400 | 1,000 | --- | 1,000 | --- | 300 | 200 | 132,400 | 115,300 | 86,000 | 6,200 |
| | 1986 | 354,000 | 1,000 | --- | 1,000 | --- | 300 | 200 | 146,200 | 101,300 | 97,800 | 6,200 |
| Space Research and Technology | 1984 | 137,000 | 13,100 | 500 | 13,600 | --- | 8,000 | 24,700 | 12,400 | 29,500 | 28,400 | 6,800 |
| | 1985 | 150,000 | 11,700 | 400 | 14,000 | --- | 6,200 | 22,700 | 14,800 | 38,300 | 34,400 | 7,500 |
| | 1986 | 168,000 | 11,600 | 600 | 20,200 | --- | 6,600 | 23,400 | 15,300 | 45,000 | 37,800 | 7,500 |
| Space Tracking and Data Acquisition | 1984 | 14,200 | --- | --- | --- | --- | 4,585 | 9,485 | 12 | --- | --- | 118 |
| | 1985 | 14,800 | --- | --- | --- | --- | 4,800 | 10,000 | --- | --- | --- | --- |
| | 1986 | 16,200 | --- | --- | --- | --- | 5,100 | 11,100 | --- | --- | --- | --- |
| Total Budget Plan | 1984 | 2,064,200 | 175,849 | 53,008 | 447,112 | 9,555 | 357,918 | 248,335 | 189,670 | 140,107 | 281,929 | 160,717 |
| | 1985 | 2,422,600 | 233,153 | 47,019 | 491,806 | 11,451 | 398,387 | 347,916 | 254,145 | 173,974 | 266,084 | 198,665 |
| | 1986 | 2,881,800 | 292,692 | 73,860 | 506,690 | 11,422 | 510,877 | 468,656 | 240,076 | 170,266 | 380,910 | 226,351 |

SPACE
TRANSPORTATION
SYSTEMS

SPACE
STATION

**RESEARCH AND DEVELOPMENT**

**FISCAL YEAR 1986 ESTIMATES**

**OFFICE OF SPACE STATION**

**BUDGET SUMMARY**

**OFFICE OF SPACE STATION** | **SPACE STATION PRC**

SUMMARY OF RESOURCES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | | (Thousands of Dollars) | | | |
| Utilization.............................. | (4,100) | 12,500 | 9,000 | 15,000 | RD 1-5 |
| Advanced Development....................... | (6,900) | 65,400 | 52,300 | 82,000 | RD 1-5 |
| Program Management/Integration............ | (5,400) | 16,300 | 33,700 | 52,000 | RD 1-6 |
| Operational Readiness..................... | (---) | 3,800 | 3,000 | 7,000 | RD 1-6 |
| Systems Definition....................... | (5,500) | 52,000 | 52,000 | 74,000 | RD 1-5 |
| Total.............................. | (21,900)* | 150,000 | 150,000 | 230,000 | |

* Funded as part of the Office of Space Flight ($13.0 million), Office of Aeronautics and Space Technology ($6.0 million), Office of Space Science and Applications ($2.0 million), and Office of Space Tracking and Data Systems ($0.9 million).

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| **Distribution of Program Amount by Installation:** | | | | |
| Johnson Space Center.................... | (9,200) | --- | 62,300 | 111,900 |
| Kennedy Space Center.................... | (400) | --- | 2,800 | 5,300 |
| Marshall Space Flight Center............ | (2,800) | --- | 34,900 | 45,400 |
| National Space Technology Laboratories... | (---) | --- | 300 | 400 |
| Goddard Space Flight Center............. | (300) | --- | 16,200 | 17,800 |
| Jet Propulsion Laboratory................ | (1,800) | --- | 4,800 | 7,600 |
| Ames Research Center.................... | (1,000) | --- | 3,700 | 4,500 |
| Langley Research Center................. | (1,200) | --- | 4,200 | 4,100 |
| Lewis Research Center................... | (1,200) | --- | 16,800 | 26,800 |
| Headquarters............................ | (4,000) | 150,000 | 4,000 | 6,200 |
| Total.. ......................... | (21,900)* | 150,000** | 150,000 | 230,000 |

* Funded as part of the Office of Space Flight ($13.0 million), Office of Aeronautics and Space Technology ($6.0 million), Office of Space Science and Applications ($2.0 million), and Office of Space Tracking and Data Systems ($0.9 million) FY 1984 budgets.

** In the FY 1985 budget justification document, the funding was shown at Headquarters pending implementation decisions on the individual elements and related field center assignments.

## OBJECTIVES AND STATUS

A United States Space Station will provide permanently manned space-based facilities to allow for enhancement of the Nation's science and applications programs and for development of capabilities for further commercial utilization of space, while stimulating advanced technologies. A vigorous but deliberately-paced Space Station program will permit us to maintain the preeminence in space our Nation has attained through various manned and unmanned programs.

The Space Station will be a multi-purpose facility providing a permanent human presence in space to conduct essential scientific and technical research, to perform unique commercial activities, and to perform more efficiently operational tasks in space such as satellite servicing. The development and the use of the Space Station will involve extensive national and international participation. The program definition phase will feature continuing emphasis on and iteration of user requirements. The Space Station will incorporate a modular design philosophy which will permit the system to evolve through time, as warranted, to provide greater user utility and operational capabilities. Its manned and unmanned elements will be designed to facilitate maximum on-orbit maintainability/restorability, operational autonomy, and simplified user interfaces. Implicit in these objectives is the recognized need to optimize the synergistic effects of the man/machine combination in space via automation, robotics, and artificial intelligence technology. The Space Station will provide essential system elements and operational considerations for an integrated national space capability. The Space Station facility (core and associated platforms) will be placed and maintained in low-Earth orbit by the Space Transportation System, thereby building upon the previous national investment in space.

A basic premise of the Space Station program is to provide a thoroughly detailed front-end definition. Such detailed definition consists of engineering design by industrial contractors, subsystem advanced development and tests in dedicated test beds, early flight experiments on the Space Shuttle to prove system feasibility, and continued trade 'studies for system optimization. It will also include a thorough analysis of a "man-tended" Space Station option. Detailed definition, thoroughly digested and incorporated into hardware specifications, provides the greatest single assurande of program success and the achievement of cost and schedule targets. Following an extensive definition program, consisting of both in-house and contracted activities, development is planned to begin in FY 1987 with an initial Space Station operating capability in about a decade. Throughout the definition period, an effort to better understand growth potential and evolutionary configuration will be undertaken to insure that the Station is not restricted in growth capability.

In the past fiscal year, a Source Evaluation Board (SEB) was established to review U.S. industry proposals for a definition and preliminary design study of the Space Station. Contracts for the definition analysis are scheduled to be awarded during April 1985. One or more contractors will be selected for each of the four basic work packages. The established system requirements were the result of extensive system engineering studies conducted in-house by NASA. These engineering studies evaluated mission requirements, user requirements, and various system architectural options to meet these system requirements.

The program office has been organized at NASA Headquarters. The lead center, the Johnson Space Center (JSC), will manage the program and perform in-house system engineering and integration. Major development responsibilities have been assigned to the Marshall Space Flight Center (MSFC), the Lewis Research Center (LeRC), and the Goddard Space Flight Center (GSFC). Also, an Advanced Development program has been defined to support the Space Station definition program. Major technical options have been identified that will be carried forth in the various technical disciplines. A major study is underway to provide the Congress, prior to initiation of definition in April 1985, with an assessment on how Space Station can incorporate various automation/robotics technology into its design.

The program has two contracts underway which are defining a potential end-to-end data management system architecture for the Space Station program. This study will define the basic data management system to be used both in flight and on the ground. The results of this study will be folded into the system definition contracts.

Utilization efforts will identify potential users and define the payload requirements for science, commercial, and technology development missions which will drive the design of the overall Space Station systems capabilities to provide services which are user friendly and cost effective.

The Systems Engineering and Integration (SE&I) organization at JSC is currently being staffed to handle the difficult and complex work of integrating the Space Station elements into an effective and efficient system. An important tool in carrying out this SE&I work will be the Technical and Management Information System (TMIS). In the past year, a significant amount of SE&I work has been accomplished including preliminary definition of the overall Space Station system initial program planning and system trade studies.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

The total funding for **FY** 1985 did not change from the **FY** 1985 budget request; however, some changes were made within the program. There has been a reallocation of funding in Advanced Development, Utilization, and Operational Readiness to Program Management/Integration in recognition of the near-term need of increasing the support for Systems Engineering and Integration and the TMIS. The reductions in Advanced Development have been in the areas of systems/operations, environmental control and life support, human productivity, and data management. **FY** 1985 Utilization estimates were reduced when the projected start of the definition contract was delayed from January to April 1985, permitting a delay in starting the refinement of the mission data base which will be the basis for establishing the performance envelope update to be given to the definition contractors.

## BASIS OF FY 1986 ESTIMATE

Utilization - This activity develops functional and user requirements based on both national and international missions. These requirements specify user needs in terms of power, volume, services, heat, communications, etc. The objective of gathering this data now is to insure that the Space Station and supporting ground systems are "user friendly." The Missions Requirements Working Group and Customer Advocacy Panels deal directly with the user in three specific areas: (1) science and applications; (2) technology; and, (3) commercial. Aspects of this include: on-board accommodations; servicing free-flying spacecraft already launched; constructing and servicing platforms; placement of spacecraft into various required orbits; and commercial endeavors in the fields of life sciences, astrophysics, environmental sciences, materials processing, and advanced technology development.

Advanced Development - This activity provides for the development of advanced technology options that are reliable and cost effective both for the initial and evolutionary Space Station. The proposed Space Station hardware development start date in FY 1987 allows time in which to mature new technologies for application in the initial system and, subsequently, in its evolutionary growth configurations. The approach being taken by NASA to develop and demonstrate technology for the Space Station builds upon the Agency's strong generic research and technology base program. In this context, advanced development implies a process whereby applicable generic technologies are focused on the Space Station and matured to a brassboard/prototype level in order to demonstrate their feasibility, establish their performance, and quantify the risk (cost and schedule) associated with their inclusion in the Space Station development phase.

Examples of key technologies which are identified for the Advanced Development program are: solar concentrator arrays and regenerative fuel cells in the power area; two-phase thermal bus for heat acquisition transport and deployable heat pipes in the thermal area; carbon dioxide concentration/removal and water reclamation in the environmental control and life support area; gaseous hydrogen/oxygen propulsion systems for orbit maintenance; and docking/berthing systems in the structures and mechanisms area. Candidate Space Shuttle flight experiments include environmental interaction plasma effects, contamination, cryogenic fluid management, thermal systems and environmental control and life support hardware. Studies will also be performed to define the Space Station requirements of elements in assembling the Space Station as well as servicing satellites and the necessary operations associated with these tasks.

System Definition - System definition contracts will be awarded to industry for the performance of detailed definition and preliminary design efforts beginning in April 1985 applying the FY 1985 funding in addition to $5.5 million brought forward from FY 1984. Proposals for these design efforts were requested under a single request for proposal for separate contracts to define the common module/laboratory outfitting, the assembly hardware and habitability provisions, the platforms/servicing function, and the power system. These contracts will include hardware and software analysis and design tasks as well as systems engineering and integration support tasks. Funding for the definition contract effort will continue in FY 1986.

Operational Readiness - This activity develops requirements and commences the implementation of the launch, orbit, and logistics operational support systems. The launch support systems include equipment and facilities definition necessary for launch readiness of the Space Station elements, logistics support, and user payload processing. The orbital requirements and facilities requirements identification activities include: definition of the concepts of station and user operations; payload and station support center facilities requirements identification; Space Station operational requirements, e.g., maintenance, display and controls; and, the planning activities to insure user accommodations. The logistics activities include the definition of the systems and processes to support resupply of the Space Station system on a regular basis. The objective of these activities is to insure the operational readiness of the Space Station, including the platforms.

Program Management/Integration - This activity provides for the necessary program management and integration functions for the total program. The major effort within this activity is the SE&I which provides the capability to perform in-house systems engineering and integration including the definition of design requirements, environmental requirements, architecture configurations commonality, and system interfaces. SE&I also provides for the creation and maintenance of an engineering master data base and the performance and management of special studies. The integration activity will encompass both the element definition work done by the contractors as well as the individual advanced development tasks.

Also included in the Program Management/Integration effort is the Technical and Management Information System (TMIS) which will provide an advanced, program-wide network of compatible hardware and integrated software linking all elements involved in the program. This system will be the principle mechanism for electronic processing and exchange of data with primary utilization in the broad areas of engineering and technical support, as well as program management and information, and communications.

CAPABILITY
DEVELOPMENT

**RESEARCH AND DEVELOPMENT**

**FISCAL YEAR 1986 ESTIMATES**

**BUDGET SUMMARY**

**OFFICE OF SPACE FLIGHT** — **SPACE TRANSPORTATION CAPABILITY DEVELOPMENT PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | | (Thousands of Dollars) | | | |
| Spacelab | 111,000 | 69,300 | 58,300 | 96,700 | RD 2-6 |
| Upper stages | 143,200 | 92,400 | 92,400 | 122,000 | RD 2-9 |
| Engineering and technical base | 93,100 | 105,700 | 105,700 | 109,700 | RD 2-12 |
| Payload operations and support equipment | 59,600 | 61,300 | 56,300 | 63,900 | RD 2-15 |
| Advanced programs | 21,500 | 14,500 | 20,500 | 21,000 | RD 2-17 |
| Tethered satellite system | 3,300 | 18,200 | 18,200 | 21,000 | RD 2-19 |
| Orbital maneuvering vehicle | --- | --- | --- | 25,000 | RD 2-20 |
| Total | 431,700 | 361,400 | 351,400 | 459,300 | |

Distribution of Program Amounts By Installation

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| Johnson Space Center | 118,000 | 115,300 | 113,200 | 115,100 |
| Kennedy Space Center | 47,600 | 43,100 | 34,700 | 56,900 |
| Marshall Space Flight Center | 121,700 | 81,000 | 89,200 | 128,400 |
| National Space Technology Laboratories | 7,200 | 6,600 | 8,200 | 7,100 |
| Goddard Space Flight Center | 2,200 | --- | 300 | --- |
| Jet Propulsion Laboratory | 1,100 | 300 | 300 | 1,000 |
| Langley Research center | 1,500 | 100 | 300 | 200 |
| Lewis Research Center | 127,200 | 85,000 | 73,000 | 115,300 |
| Ames Research Center | 400 | --- | --- | --- |
| Headquarters | 4,800 | 30,000 | 32,200 | 35,300 |
| Total | 431,700 | 361,400 | 351,400 | |

**OFFICE OF SPACE FLIGHT** **SPACE TRANSPORTATION PROGRAM**

## PROGRAM OBJECTIVES AND JUSTIFICATION

The principle areas of activity in Space Transportation Capability Development are efforts related to the Spacelab, the Upper Stages that place satellites in high altitude orbits, the Engineering and Technical Base support at NASA centers, Payload Operations and Support Equipment, Advanced Programs study and evaluation efforts, the development and first flight of the United States/Italy Tethered Satellite System, and the development of the Orbital Maneuvering Vehicle.

Spacelab is a major element of the Space Transportation System (STS) that provides a versatile, reusable laboratory which is flown to and from Earth orbit in the orbiter cargo bay. The development program which has been carried out jointly by NASA and the European Space Agency (ESA) continues with the second verification mission, Spacelab 2, currently scheduled for the last quarter of FY 1985. NASA's support of the Spacelab development effort includes ancillary flight and ground hardware and system integration efforts which assure Spacelab compatibility with experiments and the orbiter. The first operational mission, Spacelab 3, is currently planned to fly in the middle of FY 1985 and will be of the same general configuration as the first Spacelab mission.

Upper Stages are requied to deploy payloads to orbits and trajectories not attainable by the Shuttle alone. The program provides for procurement of stages for NASA missions, for technical monitoring and management activities for government and commercial Upper Stages, a Solid Rocket Motor integrity program to establish an engineering data base for Upper Stage components and for the NASA share of the joint Air Force development effort on the Centaur upper stages for use in the Shuttle.

The Engineering and Technical Base provides the core capability for the engineering, scientific and technical support required at the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), the White Sands Test Facility (WSTF), and the National Space Technology Laboratories (NSTL) for research and development activities. In FY 1985 and subsequent years, computational capability is included to provide for complex flow dynamics modeling and other analyses in support of MSFC programs.

Payload Operations and Support Equipment provides for developing and placing into operational status the ground and flight systems necessary to support the Space Transportation System payloads during pre-launch processing, on-orbit mission operations and, when appropriate, post-landing processing. Included within this program area are the development and the initial operation of the Payload

Operations Control Center, satellite servicing tools and techniques development, STS support services for NASA payloads flight demonstrations and multi-mission payload support equipment.

The Advanced Programs effort identifies potential future space programs and provides technical as well as programmatic data for their definition and evaluation. In support of this effort, advanced development activites are conducted to provide a basis for obtaining significant performance and reliability improvements and reducing future program risks and development costs through the effective use of new technology.

The Tethered Satellite System (TSS), initiated in FY 1984, will provide a new capability for conducting space experiments in regions remote from the Space Shuttle orbiter. The objectives of the initial TSS mission planned for 1988, are twofold: (1) to verify the controlled deployment, operation, and retrieval of the TSS, and (2) to quantify the interaction between the satellite/tether and space plasma in the presence of a current drawn through the tether.

The development of the Orbital Maneuvering Vehicle will provide a capability for payload delivery, retrieval, and servicing beyond that currently available in the Space Transportation System.

## OBJECTIVES AND STATUS

The integration of experiments for Spacelab-3 and Spacelab-2 missions are continuing with both flights scheduled in FY 1985. The last major piece of the Spacelab's European-developed flight hardware, the instrument pointing system (IPS) has been delivered by ESA and will be flown and verified on the Spacelab-2 mission. The second IPS procured under the NASA-funded follow-on procurement contract with ESA is to be delivered in May 1985. Development is underway on the igloo pallet as a part of the Spacelab Pallet System to provide extensive support for users on mixed cargo flights. The development of the Hitchhiker carrier system is also underway. It will provide low cost, faster access to space for users with fewer support requirements.

Some Spacelab elements which will be flown on the D-1 mission, the first major reimbursable Spacelab mission, are being staged into the proper configuration in West Germany and are being prepared for delivery to KSC for integration into the complete Spacelab system in mid-FY 1985. Demonstrating their versatility, Spacelab pallets were successfully used to carry two satellites back to Earth on the first Space Shuttle retrieval mission.

In Upper Stages, a joint development program with the DOD was initiated in FY 1983 for the use of the Centaur as an STS upper stage. The common vehicle, designated Centaur-G, accommodates a 40-foot long, approximately 10,000-pound payload in the orbiter vehicle bay, and is capable of placing it into geosynchronous orbit. A longer version of the Centaur-G, known as G Prime, is being developed for launch of the Galileo and Ulysses spacecrafts in mid-1986. The G Prime is approximately 10 feet longer than the G Vehicle and is capable of placing a 14,560-pound payload into geosynchronous orbit from the orbiter. Two Centaur-G Prime vehicles are currently under procurement for the Galileo and Ulysses missions. Procurement has been initiated for one Centaur-G vehicle to support the Venus Radar Mapper mission in 1988.

The commercially developed Payload Assist Modules (PAM) provide low cost transportation, principally for commercial spacecraft, from the Shuttle's low Earth orbit. The Delta class PAM-D is capable of injecting up to 2,750-pound payloads into geosynchronous transfer orbit. The PAM-DII will be capable of placing a 4,100-pound payload into geosynchronous transfer orbit and will be available for launch by mid 1985. The Atlas-Centaur class PAM-A is capable of inserting 4,400-pound payloads into the same orbit and was system-qualified in late 1984. Twenty-six PAM-D's have been successfully launched on the Delta, Atlas, and Space Shuttle. Since the Westar VI and Palapa B-2 PAM-D failures on STS-11, there have been eight successful PAM-D missions as of December 10, 1984.

The Inertial Upper Stage (IUS) has completed modification for operational use after experiencing a failure during its first STS launch (TDRS-1) on April 4, 1983. TDRS-2, which is the next NASA use of an IUS, is scheduled for launch in February 1985.

The Transfer Orbital Stage (TOS) is a three-axis stabilized perigee stage that is being commercially developed by the Orbital Sciences Corporation for use in the Shuttle. It will have the capability of placing 6,000 to 13,000 pounds into geosynchronous transfer orbit and thus bridges the gap between PAM-DII and Centaur. The scheduled launch availability is early 1987.

In Payload Operations and Support Equipment, payload integration support and payload-related hardware are developed and furnished for NASA payloads. Multi-mission payload equipment being developed includes a payload bay bridge structure to carry small payloads, apparatus for providing cooling of the heat generated in the orbiter bay by the radioisotope thermal generators (RTG's) used for planetary missions, and a standard mixed cargo wire harness.

The Advanced Programs effort is focused on five major areas--satellite services, spacecraft system, advanced transportation systems, crew systems, and generic space system capabilities. Satellite servicing systems will continue definition and advanced development work in remote and proximity operations. Continued efforts will be made in the areas of platform systems and servicing and advanced tether applications. Advanced transportation concepts will be studied, including orbital transfer vehicles (OTV's), propellant management, advanced launch vehicles, and advanced STS analytical tools. Systems supporting human presence in space as well as generic work in space structures, orbital debris management and retrieval, and artifical intelligence applications will be investigated.

The Tethered Satellite System (TSS) hardware development was initiated in FY 1984 following the completion of an advanced development phase initiated in FY 1983. The Italians started hardware development in FY 1984 and a cooperative first flight is presently scheduled for 1988. After completion of systems definition studies in FY 1985, effort will be initiated in FY 1986 for comprehensive design and requirements validation and procurement of long lead time flight hardware elements and tooling.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

SPACELAB

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Development | 91,600 | 31,200 | 19,200 | 16,000 |
| Operations | 19,400 | 38,100 | 39,100 | 80,700 |
| Total | 111,000 | 69,300 | 58,300 | 96,700 |

**OBJECTIVES AND STATUS**

The Spacelab is a versatile, reusable facility carried in the cargo bay of the Space Shuttle orbiter which affords scientists the opportunity to conduct scientific experiments in the unique environment of space. Ten European nations, including nine members of the European Space Agency (ESA), are participating in this joint development program with NASA. ESA designed, developed, produced, and delivered the first Spacelab consisting of a pressurized module and unpressurized pallet segments, command and data management, environmental control, power distribution systems, an instrument pointing system and much of the ground support equipment and software for both flight and ground operations.

NASA is responsible for the remaining hardware including such major elements as the crew transfer tunnel, verification flight instrumentation, certain ground support equipment, and a training simulator. Support software and procedures development, testing, and training activities not provided by ESA which are required to demonstrate the operational capability of Spacelab are also included in NASA's funding. NASA is completing the procurement of additional Spacelab hardware from ESA under terms of the ESA/NASA Memorandum of Understanding and the Intergovernment Agreement. In addition, NASA is developing a Spacelab Pallet System (SPS) for mixed cargo opportunities, two small payload carriers called the Spacelab Hitchhikers, which will use existing hardware and accommodate payload requirements between the current Spacelab and the NASA getaway special (GAS) capabilities, and a second Spacelab Payload Operations Control Center.

Spacelab operations includes mission planning and flight and ground operations for all missions other than the development flights (SL-1 and SL-2). This includes integration of the flight hardware and software, payload operations data management, and logistical support.

The first Spacelab operational flight (SL-3) is currently scheduled for mid-FY 1985. The second verification flight (SL-2) is scheduled for the second half of FY 1985. Current activities prior to flight include physical integration, checkout of the Spacelab elements, and support of training including the operations of the Spacelab simulator. After the flight, SL-2 will require deintegration of the Spacelab system components and post-flight data analysis. Also in FY 1985, processing of the second flight of the Materials Science Laboratory (MSL) and preparation for the first Hitchhiker flights will take place. The integration of the first life sciences mission (SLS-1) and astronomical observations mission (ASTRO-1) will also be in process and analytical integration, configuration management, and software development for future flights will be conducted.

Procurement of spares for both NASA developed hardware and for hardware developed by U.S. companies under contract with ESA will continue in FY 1985. Expansion of the Software Development Facility to accommodate instrument pointing system software requirements necessary to support the planned flight rate will be completed in FY 1985. Production of the second Spacelab flight unit, which is under contract with ESA, will continue with all components scheduled to be delivered by the end of FY 1985. The initial lay-in and replenishment of spares for the ESA-delivered hardware, and for the establishment and operation of depot maintenance for U.S.-provided and European-supplied hardware will continue in FY 1985.

**CHANGES FROM 1985 BUDGET ESTIMATE**

The FY 1985 current estimate reflects a decrease of $11.0 million, primarily due to savings in the procurement of spares and maintenance. The follow-on-procurement contract with ESA for the production for the second Spacelab unit has also experienced savings. These savings are due to fewer hardware modifications than expected, and a favorable exchange rate because of the strengthened value of the U.S. dollar versus European currencies. Two new development programs were added since the FY 1985 Budget Estimate: the second Payload Operations Control Center to be located at MSFC, and provision for the Spacelab Hitchhiker carriers for small payloads.

**BASIS OF FY 1986 ESTIMATE**

Funding in FY 1986 is required for Spacelab operational flights including SLS-1, ASTRO-1, Sunlab-1 and the combined EOM-1/EOM-2, all to be flown in that fiscal year. The reimbursable West German Spacelab mission, Spacelab D-1, will also be flown in FY 1986. Also, FY 1986 funding is required to support flights to be flown in subsequent years including the Material Science Laboratory missions (MSL 3,4,5 and 6), ASTRO-2 and 3, EOM-2, OAST-2, SHEAL-1 and Sunlab-2. This support includes analytical integration, configuration management, hardware integration and software development and integration. The Hitchhiker system will be ready in FY 1986 to support up to four missions per year.

Development funding is required in FY 1986 for: continued procurement of initial lay-in and replenishment spares from both United States and European sources; establishment and operation of depot maintenance for U.S. and European supplied hardware; and, sustaining engineering to support the hardware and software. Additional payload operational control capability is being implemented for Spacelab missions by modifying an existing MSFC facility. This additional capability will be completed and operational in FY 1986 to support the ASTRO-1 mission and will provide the required support to the Spacelab manifest. The Igloo Pallet version of the SPS mixed cargo capability will also be completed and ready for the ASTRO-1 mission.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

UPPER STAGES

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Development.......................... | 80,900 | 8,700 | 9,700 | 5,700 |
| Procurement and operations........... | 62,300 | 83,700 | 82,700 | 116,300 |
| Total............................. | 143,200 | 92,400 | 92,400 | 122,000 |

**OBJECTIVES AND STATUS**

The STS upper stages are required to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone. The Inertial Upper Stages (IUS), the Centaur/STS, the Payload Assist Modules (PAM-A, PAM-D and PAM-DII -- formerly the Spinning Solid Upper Stages (SSUS)), and the Transfer Orbit Stage (TOS) represent the four classes of upper stages that are or will be available for use with the STS.

The IUS was developed under a DOD contract to provide the capability to place payloads of up to 5,000 pounds into geosynchronous orbit. The first IUS was successfully launched in October 1982 on a Titan 34-D booster. The first IUS/STS launch in April 1983 carried the TDRS-1 spacecraft. The IUS failed to operate nominally during the second stage boost. The IUS anomalies were resolved by joint USAF/NASA action, and the DOD/NASA/Industry Anomaly Investigating Team has determined that the IUS is ready for flight. Four IUS vehicles have been procured for launch of the initial four Tracking and Data Relay Satellite System spacecraft; the first three were funded through the TDRSS contract while the fourth is funded under this budget element.

NASA and DOD have entered into a joint development program for a wide-body derivative of the Centaur stage as used in the Atlas-Centaur program. The common vehicle, designated Centaur-G, will accommodate a 40-foot long, approximately 10,000-pound payload in the orbiter payload bay, and be capable of placing it into geosynchronous orbit. It will be available in 1987. A longer and more powerful version of the Centaur-G, known as G Prime, is being developed for launch of the Galileo and Ulysses spacecraft in mid-1986. Two Centaur-G Prime vehicles are currently being procured for the Galileo and Ulysses missions. Procurement was initiated in FY 1985 for one G vehicle to support the Venus Radar Mapper mission. The Air Force and NASA equally share common design and development costs for the Centaur-G. The Air Force and NASA separately budget for hardware production and operations costs associated with each agency's missions. Both NASA and DOD plan additional procurement of vehicles at a later date to meet future requirements. The planned activities for Centaur in 1986 include the work required on the RL-10 engine to provide added capability for NASA and DOD missions.

The objective of the PAM program is to provide low cost transportation, principally of commercial spacecraft from the Shuttle's low Earth orbit to geosynchronous transfer orbit. The Delta class PAM-D is capable of injecting up to 2,750-pound payloads into geosynchronous transfer orbit. The Atlas-Centaur class (PAM-A) is capable of inserting 4,400-pound payloads into the same orbit. PAM's are being developed commercially, but NASA monitors the development and production to assure that the PAM is technically adequate and will be available when needed. Twenty-six PAM-D's have been successfully launched on the Delta, Atlas, and Space Shuttle. Eight of these have occurred since the two PAM-D's failed on STS-11. The PAM-DII is being developed commercially and will be capable of injecting 4,100-pound payloads into geosynchronous transfer orbit for missions beginning in mid-1985.

TOS is a three-axis stabilized perigee stage that is being commercially developed by the Orbital Sciences Corporation for use in the Shuttle. It will have the capability to place 6,000 to 13,000 pounds into geosynchronous transfer orbit, and thus bridge the gap between PAM-DII and Centaur. The scheduled launch availability is early 1987.

The Solid Rocket Motor Integrity program was initiated during FY 1984 to establish an urgently needed engineering data base for use of composite materials in upper stage motor nozzles, to minimize risk to planned missions and to restore user confidence in U.S. launch systems. Physical and mechanical properties of selected components are currently being examined and means of instrumenting manufacturing processes and their impact on material properties are being developed. Motor testing will be conducted to verify analysis and create an engineering data base.

## CHANGES FROM FY 1985 BUDGET E

The development total has increased by $1.0 million to cover a study of possible advanced electronics/avionics for the Centaur/STS. The current system is 20 years old and production difficulties are occurring. Within the procurement and operations total, funds have been reallocated to continue a solid rocket motor integrity program to gather a general engineering data base on the composite materials used in solid rocket motors.

## BASIS OF FY 1986 ESTIMATE

The FY 1986 development funds are required to continue the RL-10 engine improvement program in order to provide increased capability for NASA and DOD missions. Also, technical monitoring of the TOS upper stage will be continued.

Production and Operations funds in FY 1986 are required to complete production, acceptance, and flight of two Centaur-G Prime vehicles to support the Gailieo and Ulysses launches in May 1986 and continue production of one Centaur-G vehicle to support the Venus Radar Mapper mission scheduled for launch in 1988. Operational funds are also required for KSC to process and qualify support hardware and systems in preparation for the Galileo and Ulysses flight vehicle processing. Funds are required to complete the procurement of NASA's one remaining IUS vehicle and to support IUS checkout and the stand-by launch capability for the ground spare spacecraft, TDRS-4. Monitoring of the PAM-D and PAM-DII programs will continue. Funds are also required to support continuation of the solid rocket motor integrity program.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

ENGINEERING AND TECHNICAL BASE

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Research and test support............ | 38,200 | 44,600 | 46,100 | 50,300 |
| Data systems and flight support....... | 13,200 | 17,000 | 16,500 | 17,000 |
| Operations support................. .. | 39,100 | 41,100 | 40,100 | 39,300 |
| Launch systems support............... | 2,600 | 3,000 | 3,000 | 3,100 |
| Total............................. | 93,100 | 105,700 | 105,700 | 109,700 |

**OBJECTIVES AND STATUS**

The Engineering and Technical Base (ETB) provides the core capability required to sustain an engineering and development base for various NASA programs at the manned space flight centers. Additional center program support requirements above the core level are funded by the benefitting programs, such as Shuttle Operations and Shuttle Production and Capability Development. The centers involved are the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the National Space Technology Laboratories (NSTL).

The core level of support varies from center to center due to programmatic and institutional differences. At JSC, the core level requirement is that one shift of operations be maintained in the engineering and development laboratories, the White Sands Test Facility, and reliability and quality assurance areas. The core level for the Central Computer Complex is established as a two-shift operation. The funding for center operations base support is split between the ETB and Shuttle Operations budget elements in accordance with the principle that ETB will provide the core level and the benefitting program is responsible for funding additional support requirements. At KSC, due to its operational character, the core level provides for future studies and ground systems research and development. ETB funds at MSFC provide for multi-program support activities, including computational and communications services, and at NSTL for facilities operations, including security.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

The total funding for ETB has not changed in FY 1985. There have been reallocations within the total estimate to support the increased computational capabilities at MSFC. Reductions have been possible by some deferrals of activity including ADP equipment acquisitions in data systems and flight support and operations support.

## BASIS OF FY 1986 ESTIMATE

The requested funding for the ETB in FY 1986 provides for a continuation of the FY 1985 level of support for institutional research and development facilities and services at the centers. The increase in FY 1986 budget authority requirements over FY 1985 reflects the funding for the augmented computational capabilities at MSFC.

In research and test support, effort will be continued on the provision for increased computational capabilities at MSFC for engineering and science project enabled by acquisition of a class VI system. This capability is required for the solution of more complex SSME three-dimensional dynamics modeling problems and for complex structural analyses. At JSC, the requested funding will provide for a five-day, one-shift operation for the safety, reliability and quality assurance activities and for the engineering and development laboratories, such as the Shuttle Avionics Integration Laboratory (SAIL), the Electronic Systems Test Laboratory, and the Water Immersion Facility. Present supporting activities at MSFC will be continued during FY 1986.

Data systems and flight support provide a minimal core level of support based on a five-day, two-shift operation of the Central Computer Complex at JSC.

Operations support funding provides for the maintenance of technical facilities and equipment, chemical cleaning, engineering design, technical documentation and analysis, telecommunications, component fabrication, photographic support, and logistics support. Examples of specific services to be provided in FY 1986 include: (1) operation and maintenance of specialized electrical and cryogenic systems, and maintenance of test area cranes; (2) operation of shops to do metal refurbishing, anodizing, plating, stripping, and etching of selected items of in-house hardware; (3) engineering, installation, operation, and maintenance of closed circuit fixed and mobile television required for the support and surveillance of tests; (4) photographic services, including still and motion picture processing, and audio-visual mission support; (5) fabrication of models, breadboards, and selected items of flight hardware; (6) technical documentation services, telecommunications, and graphics; (7) technical services in support of center operations including receipt, storage, and issue of research and development supplies and equipment and transportation services; and (8) management services in support of center operations, including data management, microfilming, and preparation of technical documentation. In addition, FY 1986 funds will provide the basic level of institutional support at NSTL for continuing SSME testing activities.

In launch systems support, funds are required to continue work related to the research and development technologies available to enhance launch site hardware, ground processing, and support systems.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### PAYLOAD OPERATIONS AND SUPPORT EQUIPMENT

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Payload operations.................... | 40,800 | 45,200 | 38,300 | 53,400 |
| Payload support equipment........... .. | 18,800 | 16,100 | 18,000 | 10,500 |
| Total.............................. | 59,600 | 61,300 | 56,300 | 63,900 |

## OBJECTIVES AND STATUS

The Payload Operations and Support Equipment objectives are to centralize the provisioning of payload services, both unique and common, which are required beyond the basic standard services for NASA missions, and to provide multimission support equipment in support of payload operations. Payload operations provides unique hardware, analyses, and launch site support services to support STS missions. Payload support equipment funds the development and acquisition of multi-mission reusable ground support equipment required for a wide range of payloads. This includes test equipment required to checkout payload-to-orbiter interfaces at KSC, test equipment for checkout of NASA payloads at VAFB, canisters for transportation of payloads to the orbiter, mixed cargo hardware such as standard cable harnesses and displays and controls related to payload bay operations. In addition, this program provides for the activation and operations through completion of Spacelab development flights in 1985 of the Payload Operations Control Center (POCC) located at JSC. This facility enables command and control of Shuttle/Spacelab attached payloads and its funding requirements will be supported by Spacelab Operations after completion of the development flights.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

As part of the general reduction identified in the FY 1985 R&D appropriation, payload operations and support equipment has been reduced a net of $5.0 million. Payload operations funding requirements have decreased by $6.9 million due to a reevaluation of payload support requirements and changes in the launch dates of several NASA missions. Revisions include funding for an operational orbital refueling system and other flight capability demonstrations, as well as funding €or unique camera systems to document inflight operations of the orbiter, crew and payloads.

Payload support equipment estimates have increased by $1.9 million reflecting the net effect of deferrals of cargo integration test equipment spares from 1984 and the addition of fiber optic cabling and associated equipment to improve data transfer capability and communications within the cargo integration network.

## BASIS OF ET 1986 ESTIMATE

Payload operations funding is required to furnish continued payload services for currently scheduled NASA launches. Major payloads receiving support during this year include Galileo, Venus Radar Mapper, Ulysses, Tracking and Data Relay Satellite, Hubble Space Telescope, Spartan Halley, Astro-1, and Spacelabs-2 and -3. Further, efforts will continue to provide the means to maintain and repair satellites on-orbit by developing a series of tools, aids, and techniques, and to demonstrate capabilities and methods of improving the efficiency of on-orbit operations. The demonstrations will provide the experience necessary for realization of the Shuttle's potential for satellite servicing missions and on-orbit assembly functions.

FY 1986 funding for payload support equipment will be used for the development, test, and installation of mixed cargo hardware and test equipment, long lead procurement of equipment for NASA payloads at VAFB, procurement and installation of fiber optics, and continued procurement of cargo integration hardware required to meet the mission manifest.

## ADVANCED PROGRAMS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Advanced programs.................... | 21,500 | 14,500 | 20,500 | 21,000 |

**OBJECTIVES AND STATTJS**

Advanced Program's principal objectives are to conduct mission requirements analyses, conceptual system definition, detailed system definition, and advanced and supporting developments to acquire the technical and programmatic data for the evaluation of new space flight initiatives. Future space program and systems requirements, configurations, costs, and capabilities are identified to provide the basis for development decisions on new space flight systems. Past program efforts have provided such information for new major agency programs and systems including Apollo, Skylab, and the Space Transportation System. Subsystem studies and advanced and supporting development efforts are conducted to demonstrate the required performance and reliability. Improvements which reduce system program costs and performance schedule risks will also be investigated.

In FY 1985, the Advanced Programs effort is focused in five major areas--satellite services, spacecraft systems, advanced transportation systems, crew systems, and generic space system capabilities. Defintion studies as well as advanced development efforts are being continued in the areas of satellite servicing systems; manned extravehicular activity; spacecraft and platform resupply, maintenance and repair; rendezvous and proximity operations; satellite maintenance and repair in low and geostationary Earth orbit; and autonomous capabilities. In spacecraft systems, definition activities continue for free flying and tethered space platforms in low and geostationary orbits operating from the Shuttle. Advanced transportation studies are focused on study of potential future reusable orbital transfer vehicles (OTV), space-based operations of OTV's, Shuttle-derived launch vehicle concepts, propellant scavenging, and aft cargo carrier concepts. Crew systems efforts will focus on definition and advanced development related to future space flight systems. Generic space system capabilities will include studies related to space debris. Preliminary definition and ground simulation evaluations of assembly and construction operations for large space systems and orbital structures will be pursued.

A major thrust in FY 1985 is completion of the detailed definition of alternative concept systems of an Orbital Maneuvering Vehicle (OMV) and the preliminary systems concept studies for a reusable OTV. The reusable OMV will extend the capability for conducting orbital operations with spacecraft and payloads 800 to 1400 nautical miles beyond the practical operational accessability limits of the baseline STS. The OTV studies will lead into a joint OSF/OAST sponsored Aeroassist demonstration for competitive aerobrake techniques. OSF is responsible for the test vehicle and test specimens; OAST will support instrumentation and data reduction. Aeroassist has the potential to double the payload capability from a reusable OTV; no other development offers improvement of this magnitude.

**CHANGES IN FY 1985 BUDGET ESTIMATE**

In accordance with Congressional direction, advanced programs have been increased by $6.0 million for advanced work on Shuttle-derived launch vehicle systems. Discussions are underway with the DOD concerning joint studies.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, major emphasis will be placed on system concept definition and key advanced developments in crew systems, geostationary unmanned platforms, reusable OTV's, new capability mission kits for orbital maneuvering vehicles, future tethered systems applications, satellite servicing systems near and remote from the orbiter, and generic space systems capabilities. The overall goal continues to be the definition of the space elements needed for space operations over the next twenty years.

Intensive study of unmanned launch vehicles will be continued in coordination with USAF. Depending on present discussions, a major portion of the FY 1985 funds may go to a joint project office. Alternatively, NASA may issue study contracts with senior level NASA/DOD coordination.

OTV studies in the advanced transportation area will seek further insight into issues not resolved at the conclusion of the present definition studies. The OTV studies will head into a joint OSF/OAST sponsored demonstration of competitive Aeroassist braking techniques to enhance the payload potential of an OTV. Spacecraft systems will focus on geostationary platforms capability definition and delineation of critical mechanisms and designs which require advanced development efforts. Under spacecraft systems efforts, detailed engineering systems analysis will be continued to determine the efficiency of future tethered systems applications. In the crew systems and satellite servicing systems areas, activity will continue an detailed definition, prototype development, and ground-based developmental testing of high leverage manned servicing tools, equipment, interface hardware, and operational techniques for in-the-bay and near-the-orbiter servicing of spacecraft and platforms. Satellite servicing will explore remotely manned servicing to extend manned STS operational capability for remote low and geosynchronous support of spacecraft and platforms. Generic space systems capability efforts will continue to conduct definitions and simulations of construction and assembly of large space systems and structural elements, establishing techniques and systems engineering understanding. Analysis and potential in situ verification of space debris and its control will be pursued. The application of artificial intelligence to space systems applications will also be studied.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

TETHERED SATELLITE SYSTEM

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Tethered satellite system............ | 3,300 | 18,200 | 18,200 | 21,000 |

**OBJECTIVES AND STATUS**

The development of a Tethered Satellite System (TSS) will provide a new facility for conducting space experiments at distances up to 100 kilometers from the Space Shuttle orbiter while being held in a fixed position relative to the orbiter. A number of significant scientific and engineering objectives can be uniquely undertaken with a TSS facility such as the observation of important atmospheric processes occurring within the lower thermosphere, new observations of crustal geomagnetic phenomena, and entirely new electrodynamic experiments interacting with the space plasma. This is being undertaken as a cooperative development program with the Italian government. Formal signing by representatives of both governments of a memorandum of understanding took place in March 1984.

The United States TSS hardware development of the deployment mechanism began in FY 1984 following the completion of an advanced development phase initiated in FY 1983. The United States is also responsible for overall program management and orbiter integration. The Italians completed the definition phase in FY 1983 and initiated the satellite hardware development in 1984. They are responsible for the satellite development and instrument and experiment integration. Some program delays are being encountered on the development of the Italian satellite and the presently planned 1988 launch schedules are being reevaluated.

**BASIS OF FY 1986 ESTIMATE**

FY 1986 funding of $21.0 million will continue the hardware design and development leading to an engineering verification flight. The planning estimate for the total development cost for the United States activities remains at $50-60 million.

## BASIS OF FY 1986 FUNDING REQUIREMENT

ORBITAL MANEUVERING VEHICLE

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Orbital maneuvering vehicle.......... | --- | --- | --- | 25,000 |

## OBJECTIVES AND STATUS

The Orbital Maneuvering Vehicle (OMV) will provide a new STS reusable extension capability for conducting orbital operations with spacecraft and payloads beyond the practical operational accessibility limits of the baseline STS. By means of direct man-in-the-loop control, the reusable OMV, operating as far as 800-1400 nautical miles from the orbiter, will provide delivery, maneuvering, and retrieval of satellite payloads to and from altitudes or inclinations beyond the existing STS capability; reboost of satellite to original operational altitudes or higher; delivery of multiple payloads to different orbital altitudes and inclinations in a single flight; and safe deorbit of satellites which have completed their useful life. It will be designed to accommodate the add-on of future "mission kits" as needed to support more advanced missions such as the servicing of satellites and platforms and the retrieval of space debris which could represent an orbital hazard to all future space missions.

## BASIS FOR FY 1986 ESTIMATES

The funding in FY 1986 will provide for the timely initiation of OMV flight hardware development following completion in 1985 of systems definition efforts initiated with FY 1984 Advanced Programs funding. Initiation of hardware development in FY 1986 will lead to an initial operating capability in 1990 at a total estimated cost of about $400 million. In FY 1986, funding will enable a comprehensive design and requirements confirmation/validation effort to be pursued and procurements for long lead time flight hardware elements and tooling will be initiated.

SPACE SCIENCE
AND
APPLICATIONS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1986 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PI FOR SPACE E AND APPLICATIONS PROGRAMS

| Programs | 1984 Actual | Budget Plan 1985 Budget Estimate | Budget Plan 1985 Current Estimate | Budget Plan 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Physics and astronomy.................. | 567,600 | 677,200 | 677,200 | 630,400 |
| Life sciences.......................... | 58,000 | 63,300 | 62,300 | 72,000 |
| Planetary exploration.............. .... | 217,400 | 286,900 | 290,900 | 359,000 |
| Solid earth observations................ | 76,400 | 63,600 | 57,600 | 74,900 |
| Environmental observations............. | 162,000 | 220,700 | 212,700 | 317,500 |
| Materials processing in space........... | 25,600 | 23,000 | 27,000 | 34,000 |
| Communications......................... | 41,100 | 20,600 | 60,600 | 106,200 |
| Information systems.................... | 8,900 | 16,200 | 16,200 | 19,200 |
| Total............................ | 1,157,000 | 1,371,500 | 1,404,500 | 1,613,200 |

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

## SPACE SCIENCE AND APPLICATIONS
## MAJOR FLIGHT ACTIVITY

| | FISCAL YEARS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
| Hubble Space Telescope | | | △ | | | | | | |
| Gamma Ray Observatory | | | | | △ | | | | |
| Explorer Launches | △ | △ | △ | △ △ | △ | △ | | | |
| Shuttle/Spacelab Payloads | △ ═══ | ═══ | ═══ | ═══ | ═══ | ═══ | ═══ | ═══ | ═══ |
| Dedicated Life Sciences Spacelabs | | | ═══ | ═══ | ═══ | ═══ | ═══ | ═══ | ═══ |
| Voyager-Uranus (U) and Neptune (N) Encounter | | | (U) | | | (N) | | | |
| Galileo | | | △ | | | (J) | | | |
| Ulysses (International Solar Polar-ESA Spacecraft) | | | ⊏ | | | | △ Polar Passage | | |
| Venus Radar Mapper Mission | | | | | △ (V) | | | | |
| Mars Observer (MGCO) | | | | | | | △ | (M) | |
| Search and Rescue Locator System On Weather Satellites (Subject to NOAA Call-up) | ═══ | ═══ | ═══ | ═══ | ═══ | ═══ | ═══ | ═══ | ═══ |
| Earth Radiation Budget Experiment | ═══ | ═══ | ═══ | ═══ | ═══ | ═══ | ═══ | ═══ | ═══ |
| Upper Atmospheric Research Satellite | | | | | | △ | | | |
| Advanced Communications Technology Satellite (ACTS) | | | | | | △ | | | |
| Scatterometer (Navy Remote Ocean Sensing System - N-ROSS) | | | | | | △ | | | |

PHYSICS AND
ASTRONOMY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1986 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — PHYSICS AND ASTRONOMY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | | (Thousands of Dollars) | | | |
| Hubble space telescope development..... | 195,600 | 195,000 | 195,000 | 127,800 | RD 3-4 |
| Gamma ray observatory development...... | 85,950 | 120,200 | 117,200 | 87,300 | RD 3-6 |
| Shuttle/Spacelab payload development and mission management.............. | 80,900 | 105,400 | 105,400 | 135,500 | RD 3-8 |
| Explorer development.................. | 48,700 | 51,900 | 51,900 | 55,200 | RD 3-10 |
| Mission operations and data analysis... | 68,100 | 109,100 | 109,100 | 119,900 | RD 3-13 |
| Research and analysis................. | 35,873 | 36,900 | 39,900 | 42,300 | RD 3-15 |
| Suborbital program.................... | 52,477 | 58,700 | 58,700 | 62,400 | RD 3-18 |
| Total.............................. | 567,600 | 677,200 | 677,200 | 630,400 | |

Distribution of Program Amount by Installation

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| Johnson Space Center.................. | 7,253 | 4,500 | 8,563 | 9,500 |
| Kennedy Space Center.................. | 3,295 | 11,000 | 6,754 | 7,250 |
| Marshall Space Flight Center........... | 297,417 | 336,888 | 334,348 | 283,298 |
| Goddard Space Flight Center............ | 187,695 | 232,521 | 191,078 | 216,996 |
| Jet Propulsion Laboratory.............. | 17,826 | 26,308 | 26,679 | 34,525 |
| Ames Research Center.................. | 14,655 | 21,446 | 57,842 | 27,500 |
| Langley Research Center......,........ | 877 | 2,183 | 2,914 | 3,233 |
| Lewis Research Center................. | 150 | --- | --- | --- |
| Headquarters.......................... | 38,432 | 42,354 | 49,022 | 48,098 |
| Total.............................. | 567,600 | 677,200 | 677,200 | 630,400 |

## PROGRAM OBJECTIVES AND JUSTIFICATION

The major objective of the Physics and Astronomy program is to increase our knowledge of the origin, evolution, structure, and composition of the universe, including the Sun, the stars, and other celestial bodies. Space-based research is being conducted to investigate the structure and dynamics of the Sun and its long-and short-term variations; cosmic ray, x-ray, ultraviolet, optical, infrared, and radio emissions from stars, interstellar gas and dust, pulsars, neutron stars, quasars, blackholes, and other celestial sources; and the laws governing the interactions and processes occurring in the universe. Many of the phenomena being investigated are not detectable from ground-based observatories because of the obscuring or distorting effects of the Earth's atmosphere.

To achieve the objectives of the Physics and Astronomy program, NASA employs theoretic and laboratory research; aircraft, balloon and sounding rocket flights; Shuttle/Spacelab flights; and free-flying spacecraft. Research teams involved in this program are located at universities, industrial laboratories, NASA field centers, and other government laboratories.

The scientific information obtained and the technology developed in this program are made available to the scientific communities for application to and the advancement of scientific knowledge, education and technology.

The Physics and Astronomy missions undertaken to date have been extraordinarily successful, and a number of missions continue to produce a rich harvest of scientific data; the International Ultraviolet Explorer (IUE) and the Solar Maximum Mission (SMM) are still operating, and new scientific results are continually emerging from the analysis of the High Energy Astrophysics Observatories (HEAO) and Infrared Astronomical Satellite (IRAS) data sets.

Explorer satellites are relatively low cost but extremely effective missions which have been developed and launched since the beginning of our country's space program. Our most recent Explorer mission, the Active Magnetospheric Particle Tracer Explorer (AMPTE) was launched in 1984. AMPTE, a cooperative project with the Federal Republic of Germany and the United Kingdom, consists of two spacecraft provided by the U. S. and Germany; the latter has a subsatellite attached which was provided by the United Kingdom. This mission is studying the solar wind at the subsolar point and identifying particle entry windows, energization processes and transport processes into the magnetosphere. The Infrared Astronomical Satellite (IRAS), developed in collaboration with the

Netherlands and the United Kingdom, and launched in January 1983, made exciting discoveries and significant contributions to astronomical research as it observed the cool and obscured objects of the universe. While the spacecraft has completed operations, the analysis of the IRAS data will continue for several years.

In FY 1985, the integration and testing activities of the Hubble Space Telescope will be continued in preparation for launch in 1986. The major activity during FY 1985 will be the assembly and verification of the total Space Telescope system. The Hubble Space Telescope program will provide an international spaceborne astronomical observatory capable of measuring objects appreciably fainter and more distant than those accessible from the ground. This increased capability will allow us to address such basic questions as the origin, evolution, and disposition of stars, galaxies, and clusters, thus allowing us to significantly increase our understanding of the universe.

Two major Explorer missions are now under development: the Cosmic Background Explorer (COBE) and the Extreme Ultraviolet Explorer (EWE). In addition, a U.S. X-ray high resolution imager is being developed for launch in 1985 on the Roentgen Satellite (ROSAT), which is being developed by the Federal Republic of Germany. A Cosmic Ray Isotope Experiment is also being developed for flight in 1986 on a Department of Defense satellite.

The Shuttle/Spacelab program will continue, with flight of both Spacelabs-2 and -3 scheduled to occur in 1985. The Spacelab-3 mission will emphasize Life Sciences and Materials Processing experimentation, while Spacelab-2 , the second of two verification flights of the European-built Spacelab system, emphasizes solar physics, plasma physics, and astrophysics. Activity will also be conducted on several future missions, including Astro-1 and -2, the Environmental Observation Missions (EOM), the Materials Science Lab, and the first dedicated Life Sciences mission (Life Sciences-1). In addition, sounding-rocket-type instrumentation will be developed to be flown on the Space Transportation System to allow longer flight time of these relatively low-cost instruments.

Suborbital observations will continue to be conducted in FY 1986 from balloons, sounding rockets, and high-flying aircraft that carry instruments above most of the atmosphere.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

HUBBLE SPACE TELESCOPE DEVELOPMENT

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Spacecraft............................ | 167,000 | 174,800 | 174,100 | 113,900 |
| Experiments.......................... .. | 28,600 | 20,200 | 20,900 | 13,900 |
| Total............................ | 195,600 | 195,000 | 195,000 | 127,800 |
| Mission operations and data analysis.. | (41,500) | (74,700) | (74,700) | (88,000) |
| Space transportation system operations | (16,500) | (29,700) | (30,100) | (41,500) |

**VES AND STATUS**

The Hubble Space Telescope will make a major contribution to understanding the stars and galaxies, the nature and behavior of the gas and dust between them, and the broad question of the origin and scale of the universe. Operating in space above the atmospheric veil surrounding the Earth, the Hubble Space Telescope will increase, by more than a hundredfold, the volume of space accessible for observations. With its significant improvements in resolution and precision in light sensitivity and in wavelength coverage, the Hubble Space Telescope will permit scientists to conduct investigations that could never be carried out with ground-based observatories limited by the obscuring and distorting effects of the Earth's atmosphere.

The Hubble Space Telescope will enhance the ability of astronomers to study radiation in the visible and ultraviolet regions of the spectrum. It will be more sensitive than ground-based telescopes and will allow the objects under study to be recorded in greater detail. It will make observations possible of objects so remote that the light will have taken many billions of years to reach the Earth. As a result, we will be able to look far into the distant past of our universe. The Hubble Space Telescope will also contribute significantly to the study of the early state of stars and the formation of solar systems, as well as the observation of such highly-evolved objects as supernova remnants and white dwarf stars. With the Hubble Space Telescope we may be able to determine the nature of quasars and the processes by which they emit such enormous amounts of energy; it may also be possible to determine whether some nearby stars have planetary systems.

The Hubble Space Telescope will be an automated observatory, delivered into orbit by the Space Shuttle. Data from its scientific instruments will be transmitted to Earth via the Tracking and Data Relay Satellite System. The Hubble Space Telescope design will permit in-orbit maintenance and repair, and/or retrieval by the Space Shuttle for return to Earth for required refurbishment and then relaunch by the Space Shuttle.

During FY 1984, significant progress was made on the Hubble Space Telescope with the completion of the scientific instrument verification and acceptance program at the Goddard Space Flight Center, delivery of the Optical Telescope Assembly, the Science Instrument Control and Data Handling Unit, the Wide Field/Planetary Camera, the Faint Object Spectrograph and the High Speed Photometer to the Lockheed Missiles and Space Company for assembly and verification into the spacecraft, and the continued structural and electronic development activities at Lockheed.

In FY 1985, the program focus will be placed on the assembly and verification activities at Lockheed. In addition, completion and delivery of the three flight Fine Guidance Sensors, the High Resolution Spectrograph, and the Faint Object Camera is scheduled.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

In total, the FY 1985 current estimate remains the same as the budget estimate. However, within the project, there has been minor shifting of funds between the spacecraft and experiments to accommodate later than planned delivery of the instruments due to some required rework.

**BASIS OF FY 1986 ESTIMATES**

The FY 1986 funding is required to complete the integration and testing of the total Hubble Space Telescope system prior to the shipment of the integrated system to the Kennedy Space Center in preparation for the launch in the second half of 1986.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### GAMMA RAY OBSERVATORY DEVELOPMENT

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Spacecraft.. ............................ | 85,950 | 101,700 | 98,700 | 59,700 |
| Experiments and ground operations...... | --- | 18,500 | 18,500 | 27,600 |
| Total........................... | 85,950 | 120,200 | 117,200 | 87,300 |
| Space transportation system operations | (300) | (300) | (100) | (12,000) |

## OBJECTIVES AND STATUS

The objective of the Gamma Ray Observatory mission is to measure gamma radiation from the universe, and to explore the fundamental physical processes powering it. Certain celestial phenomena are accessible only at gamma ray energies. The observational objectives of the Gamma Ray Observatory are to search for direct evidence of the synthesis of the chemical elements; to observe high energy astrophysical processes occurring in supernovae, neutron stars and black holes; to locate gamma ray burst sources; to measure the diffuse gamma ray radiation for cosmological evidence of its origin; and to search for unique gamma ray emitting objects.

Cosmic gamma rays represent one of the last frontiers of the electromagnetic spectrum to be explored. The low flux levels of gamma rays, and the high background they produce through their interaction with the Earth's atmosphere, coupled with the demand for better spectral, spatial, and temporal resolution of source features, combine to require that very large gamma ray instruments be flown in space for a prolonged period of time. Gamma rays provide unique information on the most intriguing astronomical objects yet discovered, including quasars, neutron stars, and black holes.

The Gamma Ray Observatory is scheduled for launch by the Space Shuttle in 1988. The spacecraft is being designed to accommodate four scientific instruments, and will be designed to allow for refueling and for .retrieval by the Space Shuttle. Because of the necessity for long exposures, the spacecraft will be pointed in a fixed direction in space for periods of a few hours up to two weeks at a time.

In FY 1984, critical design reviews were held for the instruments, as was the preliminary design review for the spacecraft. In addition, fabrication of instrument hardware was initiated. In FY 1985, the spacecraft critical design review will be held. All subsystem fabrication will be underway in FY 1985 and the fabrication of the spacecraft flight structure will be initiated.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

The reduction of $3.0 million in the current estimate reflects the application of a portion of the general reduction in the R&D appropriation; the decrease has been accommodated by the rephasing of program activities.

## BASIS OF FY 1986 ESTIMATE

The FY 1986 funding is required for calibration of the science instruments; for continuation of the spacecraft fabrication and delivery of the Command and Data Handling system; and for continuation of the ground operations preparations.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

SPACELAB PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Payload development & mission management...................... | 80,900 | 105,400 | 105,400 | 135,500 |
| (Solar Optical Telescope Development) | (6,000) | (8,800) | (9,800) | (30,000) |

**OBJECTIVES AND STATUS**

The objectives of Spacelab payload development and mission management are to develop instruments in order to conduct experiments and acquire new knowledge in the disciplines of physics and astronomy, to develop experiment interface hardware for materials processing, to develop sounding rocket class payloads for flight on the Space Shuttle, and to manage the mission planning and execution of all NASA Spacelab payloads. This project supports the development of all physics and astronomy experiments; system management and engineering development of flight equipment and software; payload specialist training and support; physical integration of the payloads with the Spacelab system; operation of the payloads in flight; dissemination of data to experimenters; and analysis of physics and astronomy flight data. In addition, this project funds the mission management efforts for all NASA Spacelab payloads.

Instruments are currently under development for several Shuttle/Spacelab missions with primary emphasis on physics and astronomy. These instruments are divided in two classes: multi-user instruments and principal investigator instruments. The multi-user instruments are those instruments that have a broad capability, can accommodate a number of principal investigator-furnished instruments, and have a larger user community. The principal investigator instruments are those proposed for a specific scientific investigation by a single investigator who may not have co-investigators. The Spacelab-2 mission, which is the second verification flight of the European-built Spacelab, is scheduled for launch in mid-1985. The objectives of Spacelab-2 are to verify the Spacelab pallet and igloo systems, and to obtain scientific data with emphasis on astrophysics and solar physics. The Instrument Pointing System, developed by the European Space Agency, will be flown for the first time on Spacelab-2.

Three ultraviolet telescopes are also currently in development leading to a launch in 1986 (Astro-1). This mission is designed to conduct investigations in ultraviolet imaging, spectrophotometry, and polarimetry at very high resolution. The Astro-1 mission will also carry two wide-field cameras, to conduct unique scientific observations of Halley's Comet in the near-earth environment. Astro-1, as well as reflights of this instrumentation, are designed to allow scientific investigations of a broad range of objects, from nearby comets and planets to the most distant quasars.

The Solar Optical Telescope (SOT), which is a multi-user instrument facility, currently in the definition and preliminary design phase. The development phase is planned to begin in FY 1985, leading to a launch in the early 1990's. The SOT will provide extremely high resolution images of the Sun's surface and atmosphere, permitting for the first time, measurement matched to the spatial scale of fundamental solar phenomena.

Mission management activities are continuing on several space science and applications missions, for example, the Environmental Observations Missions (EOM), several materials processing payloads, and the first dedicated Life Sciences mission.

Spacelab-3, primarily a materials processing and life sciences mission, is scheduled for launch later this year. One of the major experiments which will be flown on Spacelab-3 is the Fluid Experiment System/Vapor Crystal Growth.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

In total, the FY 1985 current estimate remains the same as the budget estimate. However, the Solar Optical Telescope funding has been increased by $1 million to allow for a slight enhancement in the contractor efforts as SOT moves into the development phase in FY 1985.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, mission management of the ongoing Spacelab missions will be continued. Mission management for the non-physics and astronomy missions includes all Spacelab efforts except instrument development and data analysis. Development of the Solar Optical Telescope will be continued in FY 1986, and development of the Space Plasma Lab will be continued. Effort will also be continued on the Shuttle High Energy Astrophysics Lab. FY 1986 funding is required for the development of low-cost sounding rocket class payloads which will be flown on the Space Shuttle to provide more flight opportunities to the science community.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### EXPLORER DEVELOPMENT

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Active magnetospheric particle tracer explorer.............................. | 7,800 | --- | --- | --- |
| Cosmic background explorer.... .......... | 28,300 | 32,600 | 30,600 | 25,400 |
| Roentgen satellite experiments.......... | 2,300 | 1,100 | 1,200 | 2,200 |
| Extreme ultraviolet explorer...... ...... | 4,600 | 15,000 | 15,600 | 24,100 |
| Other explorers.............. .......... | 5,700 | 3,200 | 4,500 | 3,500 |
| Total............................ | 48,700 | 51,900 | 51,900 | 55,200 |
| Mission operations and data analysis | (12,800) | (20,400) | (20,400) | (19,700) |
| Transportation system operations | (400) | (6,000) | (4,500) | (17,700) |

## OBJECTIVES AND STATUS

The Explorer program provides the principal means of conducting investigations of stellar physics and of the near-Earth interplanetary environment that have limited specific objectives and that do not require major observatories. Included in the present program are studies of atmospheric and magnetospheric physics; the several magnetospheric boundaries; interplanetary phenomena; cosmic ray investigations; and x-ray, ultraviolet and infrared astronomy. Studies are conducted to define future high priority science explorer missions. NASA engages in cooperative missions with other federal agencies and other nations whenever such cooperation will assist in achieving the mission objectives.

Solar terrestrial and atmospheric explorers provide the means for conducting studies of the Earth's near-space environment. The program requires a wide variety of satellites in orbits extending from the very lowest reaches of the upper atmosphere to the interplanetary medium beyond the Earth's magnetosphere. Efforts in FY 1984 included launch of the Active Magnetospheric Particle Tracer Explorer (AMPTE). The AMPTE, a cooperative project with the Federal Republic of Germany and the United Kingdom, consists of two spacecraft and one sub-satellite. The mission is studying the solar wind at the subsolar point and will identify particle entry windows, energization processes and transport processes into the magnetosphere. The San Marco-D mission, a cooperative project with Italy which is scheduled to be launched in FY 1985, will include a group of U. S. experiments to study the relationship between solar activity and the Earth's meterological phenomena.

Astrophysics explorers have been instrumental in conducting the first astronomical sky surveys in the gamma ray, x-ray, ultraviolet, infrared, and low frequency radio regions of the electromagnetic spectrum. A prime example is the Infrared Astronomical Satellite (IRAS) which has just completed a highly successful survey mission.

In FY 1985, development will continue on the Cosmic Background Explorer (COBE), the Extreme Ultraviolet Explorer (EWE), and on the x-ray imaging instrument to be flown on the German Roentgen Satellite (ROSAT). COBE will carry out a definitive, all-sky exploration of the infrared background radiation of the universe between the wavelengths of 1 micrometer and 9.6 millimeters. The detailed information which the COBE will provide on the spectral and spatial distribution of low energy background radiation is expected to yield significant insight into the basic cosmological questions of the origin and evolution of the universe. Funding in FY 1985 will support cold testing of the two COBE cryogenic instruments. Mission design work will continue in FY 1985 on EWE, which will carry out the first detailed all-sky survey of extreme ultraviolet radiation between 100 and 900 angstroms--a hitherto unexplored portion of the electromagnetic spectrum. ROSAT, a cooperative project between the Federal Republic of Germany and the United States, will perform high resolution imaging studies of the x-ray sky. The United States will provide a high resolution imaging instrument and launch services, and Germany will provide the spacecraft and other instrumentation.

In response to an innovative suggestion from industry, NASA is considering a new approach to providing a spacecraft platform for EWE and other future explorers. Under this approach, NASA would obtain spacecraft services through a privately owned and developed platform, which could be shared with commercial users. A Request for Proposal was released by NASA to industry in January 1985.

Work is also continuing in FY 1985 on the Cosmic Ray Isotope Experiment (CRIE). The CRIE sensor, which will be launched in 1986 on a Department of Defense spacecraft, will study galactic cosmic rays and accelerated nuclei from solar flares. In addition, instrumentation development is being continued for reflight of the Long Duration Exposure Facility to gather data on the relative energies and abundances of the rare heavy cosmic ray nuclei. This spacecraft is scheduled to be launched in 1986 by the Space Shuttle, with subsequent retrieval about two and a half years later.

FY 1985 funding will also support definition studies of potential future explorer missions, including the X-ray Timing Explorer and the Far Ultraviolet Spectroscopy Explorer.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

In total, the FY 1985 current estimate remains the same as the budget estimate. However, within the Explorer Development line, there have been minor adjustments which principally reflects the rephasing of individual explorer funding to reflect the scheduled development activities.

## BASIS OF FY 1986 ESTIMATE

FY 1986 funding is required for the continuation of COBE development activities leading to a launch in 1988. During FY 1986, the COBE science instrument fabrication will be completed. The COBE cryogenic device and all other major system elements will be delivered beginning in late 1986. FY 1986 funding is also required for continuation of EUVE design and development activities and €or continuation of development activities on experiments which will be flown on the German ROSAT mission in 1987 and on a Department of Defense satellite in 1986.

## BASIS OF FY 1986 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| High energy astronomy observatory extended mission.................. | 5,400 | 5,000 | 5,000 | 4,500 |
| Solar maximum mission extended mission........................... | 1,800 | 1,500 | 1,500 | 4,300 |
| Solar maximum mission retrieval/repair mission........................... | 6,600 | 7,500 | 7,500 | 3,400 |
| Hubble Space Telescope operations..... | 34,000 | 49,000 | 54,100 | 57,300 |
| Hubble Space Telescope maintenance and refurbishment...................... | 7,500 | 25,700 | 20,600 | 30,700 |
| Explorers............................ | 12,800 | 20,400 | 20,400 | 19,700 |
| Total........................... | 68,100 | 109,100 | 109,100 | 119,900 |

## OBJECTIVES AND STATUS

The purpose of the mission operations and data analysis effort is to conduct operations and analyze data received from the physics and astronomy spacecraft after launch. The program also supports the continued operation of a number of spacecraft after their originally planned objectives have been achieved, for purposes of conducting specific investigations that have continuing, high scientific significance. The funding supports the data analysis activities of the many investigators at universities and other research organizations associated with astrophysics and solar terrestrial operational satellite projects. Actual satellite operations, including operation control centers and related data reduction and engineering support activities, are typically carried out under a variety of mission support or center support contracts.

In addition to the normal support required for mission operations, the Hubble Space Telescope program encompasses several unique aspects which must be provided for in advance of the launch. The Hubble Space Telescope is designed for operation for more than a decade, using the Space Shuttle/Orbital Maneuvering Vehicle combination and/or Space Station for on-orbit maintenance of the spacecraft and in-orbit changeout or repair of the scientific instruments.

The Hubble Space Telescope will be used primarily by observers selected on the basis of proposals submitted in response to periodic solicitations. Science operations will be carried out through an independent Hubble Space Telescope Science Institute. The Institute will operate under a long-term contract with NASA. While NASA will retain operational responsibility for the observatory, the Institute will implement NASA policies in the area of planning, management, and scheduling of the scientific operations of the Hubble Space Telescope.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

In total, the FY 1985 current estimate remains the same as the budget estimate. However, an adjustment has been made between the Hubble Space Telescope Operations and the Hubble Space Telescope Maintenance and Refurbishment lines to ensure operational readiness of the software and ground system in support of the second half 1986 launch.

## BASIS OF FY 1986 ESTIMATE

FY 1986 funds will provide support for the continued mission operations and data analysis activities for the International Ultraviolet Explorer, continued analysis of the extensive data obtained by the Infrared Astronomical Satellite and the High Energy Astronomy Observatories. FY 1986 funding will provide for the continued operation of and analysis of data collected from the repaired Solar Maximum Mission and €or continued preparation for operation of the Hubble Space Telescope in late 1986. In FY 1986, the development of mission operations procedures as well as development of the science operations ground system will be continued for the Hubble Space Telescope operations. The Hubble Space Telescope Science Institute activities such as development of the Guide Star Selection System and Science Data Analysis Software will be continued, leading to initial operational capability. In 1986, maintenance and refurbishment preparation activities such as the purchase of orbital replacement units and space support equipment will be continued to allow for the capability to service the Hubble Space Telescope after launch.

## BASIS OF FY 1986 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Supporting research and technology...... | 22,550 | 23,400 | 25,900 | 27,900 |
| Advanced technology development......... | 8,162 | 8,000 | 8,500 | 8,500 |
| Data analysis.......................... | 5,161 | 5,500 | 5,500 | 5,900 |
| Total............................ | 35,873 | 36,900 | 39,900 | 42,300 |

## OBJECTIVES AND STATUS

This program provides for the research and technology base necessary to define, plan and support flight projects. Preliminary studies to define missions and/or payload requirements are carried out, as are theoretical and ground-based supporting research and advanced technology development (ATD). Activities included are supporting research and technology (SR&T), ATD, and data analysis.

o Supporting Research and Technology (SR&T): The objectives of supporting research and technology are to: (1) optimize the return expected from future missions by problem definition, development of advanced instrumentation and concepts, and sound definition of proposed new missions; (2) enhance the value of current space missions by carrying out complementary and supplementary ground-based observations and laboratory experiments; (3) develop theories to explain observed phenomena and predict new ones; and (4) strengthen the technological base for sensor and instrumentation development and conduct the basic research necessary to support our understanding of astrophysics and solar-terrestrial relationships.

  Research is supported in the disciplines of astronomy, astrophysics, gravitational physics, and solar and heliospheric physics. Research in astronomy and astrophysics involves the study of stars, galaxies, interstellar and intergalactic matter, and cosmic rays. The work in solar and heliospheric physics involves the study of the solar atmosphere and the influence of the Sun on interplanetary phenomena. The theory activities are related to all the Physics and Astronomy disciplines and is critical to the correlation of available information. The SR&T funding will provide for continuation of definition work on the future Gravity Probe-B mission. The development of new instruments, laboratory and theoretical studies of basic physical processes, and observations by ground-based and balloon-borne instruments will also be continued. Results achieved in the SR&T program will have a direct bearing on future flight programs. For example, the development of advanced X-ray, ultraviolet, and infrared astronomy imaging devices under this program will most likely enable spacecraft to carry instruments for astronomical observations which have increases of orders of magnitude in sensitivity and improved resolution over currently available detectors.

The SR&T program carries out its objectives through universities, non-profit and industrial research institutions, NASA centers and other government agencies. Current emphasis is being placed on studies of advanced instrumentation with increased sensitivity and resolution.

- Advanced Technological Development (ATD): The advanced technological development activities support detailed planning and definition of new potential physics and astronomy missions. ATD activities assure that future missions address the scientific questions most important to the evolution of knowledge in the field, and that those missions use the appropriate technology and techniques. Funding is applied to the definition and preliminary design for specific missions or subsystems/elements critical to eventual mission development in order that technical readiness and resources may be adequately defined before the missions are proposed for implementation.

  Candidate missions for the 1980's and early 1990's that require ATD activities include the Advanced X-Ray Astrophysics Facility (AXAF) and the Space Infrared Telesope Facility (SIRTF). The AXAF mission, which is the first priority new mission recommendation in astronomy by the National Academy of Sciences, will study stellar structure and evolution, active galaxies, clusters of galaxies and cosmology. The AXAF's imaging X-ray telescope is planned to have a sensitivity approximately 100 times that of HEAO-2 and a resolution increase of nearly a factor of twenty. The SIRTF will observe faint, cool infrared sources in the universe and significantly build on the IRAS science foundation. Major Spacelab payloads being considered for future missions and requiring advanced technological development support include the Pinhole/Occulter Facility, a detector for imaging hard X-rays. During FY 1985, major emphasis will continue on the AXAF definition as well as continued technological preparation for SIRTF.

- Data Analysis: The acquisition, analysis and evaluation of data represents the primary purpose of the laboratory, balloon, rocket and spacecraft activities. While a considerable amount of analysis is done during the prime project phase, experience has shown that considerably more time is required to reap the full benefit from these programs. This will come about only when the data is correlated with other projects, when detailed cause-and-effect studies are made with data sets from other sources, when very long-term (e.g., one solar cycle) effects can be studied by using complementary sets of data, and when new ideas that originate from the results of the initial analysis can be tested. For example, astronomical image processing facilities have been developed to take advantage of high technology developed under the Landsat and planetary programs. This technology allows astronomers to extract a maximum amount of information from the data they obtained from standard photographic emulsions and more advanced imaging techniques such as the charge-coupled devices now being ground tested for use on the Hubble Space Telescope.

## CHANGES FROM FY 1985 BUDGE" ESTIMATE

The increase of $3.0 million in the current estimate reflects Congressional action on the NASA FY 1985 budget request. These funds will be used primarily to enhance research efforts in astrophyics theoretical studies and to enhance university instrumentation.

## BASIS OF FY 1986 ESTIMATE

During FY 1986, the supporting research and technology program will support those tasks which contribute to maintaining a firm base for a viable physics and astronomy program. Emphasis will continue on infrared detector development and on expansion of technology activities related to large x-ray mirrors, advanced x-ray detectors, gamma ray spectrometers and instrumentation. Emphasis will also be placed on the development of a large array micro-channel plate, and on intensified charge-coupled imagery devices. In the area of solar physics, activities will support the Solar Maximum Mission, especially through theoretical studies of high energy phenomena. Development of advanced generation instrument concepts will continue especially for the extreme ultraviolet and x-ray wavelengths, and for analyzing the structure and dynamics of the solar interior. FY 1986 funding will also support continued feasibility and definition studies on future potential candidate missions such as the Advanced X-ray Astrophysics Facility, Gravity Probe-B mission, and the Space Infrared Telescope Facility. In the data analysis activities to be carried out at university and government research centers in FY 1986, emphasis will be placed on correlative studies involving data acquired from several sources (spacecraft, balloons, sounding rockets, research aircraft and ground observatories).

## BASIS OF FY 1986 FUNDING REQUIREMENT

### SUBORBITAL PROGRAMS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Airborne science and applications....... | 18,900 | 22,000 | 22,000 | 23,400 |
| Balloon program......................... | 5,755 | 7,200 | 7,200 | 7,600 |
| Sounding rockets....................... | 27,822 | 29,500 | 29,500 | 31,400 |
| Total............................... | 52,477 | 58,700 | 58,700 | 62,400 |

## OBJECTIVES AND STATUS

The suborbital program uses balloons, aircraft, and sounding rockets to conduct versatile, relatively low cost research of the Earth's ionosphere and magentosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astronphysics. Activities are conducted on both a domestic and an international cooperative basis.

o Sounding Rockets:

A major objective of the sounding rocket program is to support a coordinated research effort. Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters. Special areas of study supported by the sounding rocket program include the nature, characteristics, and composition of the magnetosphere and near space; the effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurorae and the coupling of energy into the atmosphere; and the nature, characteristics, and spectra of radiation of the Sun, stars and other celestial objects.

Additionally, the sounding rocket program provides the physics and astronomy program with the means for flight testing instruments and experiments being developed for later flight on the Shuttle/Spacelab and space probes, and for calibrating and obtaining vertical profiles in concert with current orbiting spacecraft.

In FY 1984, 40 rockets were launched from five launch ranges located in the United States, Norway, Canada, and Peru. These rockets supported the research activities of about 18 groups from over 13 universities, NASA field centers, other government agencies and foreign research groups.

An important element of the sounding rocket program is the Spartans. The Spartans are low-cost Shuttle payloads flown as autonomous subsatellites deployed and retrieved by the Space Shuttle. Three Spartan missions are currently under development and each with a different scientific instrument. Spartans allow the accomplishment of single, specific scientific objectives with efficiency and simplicity. The first Spartan mission is planned for 1985.

One highlight in 1984 in the plasma physics discipline was that rocket launches confirmed the existence of large electric fields which have not been explained by theory. Correlative instrumentation and flights showed cloud-like heavy particles at 60 kilometers with scattered light from the Sun, with molecular weights of tens of thousands of atomic molecular units being measured, resulting in the prognosis that the fields are real. In the astrophysics disciplines, a new high resolution spectograph detector system was developed and flown successfully. The detector system is expected to be utilized on the Hubble Space Telescope.

The FY 1985 program again will be a well balanced discipline effort. A significant event will be a series of launches in Greenland to measure ionospheric and magnetospheric auroral zone turbulence, cleft irregularities, and acceleration mechanisms.

o Airborne Science and Applications:

Research with instrumented jet aircraft has been an integral part of the overall NASA program in physics and astronomy since 1965. For astronomy research, the airborne science and applications program utilizes a C-141 instrumented with a 91-centimeter infrared telescope. The C-141 "Kuiper Airborne Observatory", which began operational flights in 1974, is a full-scale, manned facility. This aircraft provides a large payload capacity and facilities for extending observations over any region of the Earth, and can operate at high altitudes (nearly 13 kilometers), in order to provide a cloud-free site for astronomical observations and auroral geophysics experiments. The possibility of conducting observations at this altitude, above most of the infrared-absorbing water vapor of the Earth's atmosphere, has been essential in expanding astronomical observations in the infrared region of the electromagnetic spectrum from one micrometer to hundreds of micrometers.

In FY 1984, 64 flights were flown to make far-infrared observations, including an expedition to Australia to observe the center of our own galaxy. In FY 1985, approximately 68 flights of the C-141 will be made to continue exploration in the star-forming regions. Data gathered by the Infrared Astonomical Satellite will be used extensively to determine targets of observation.

This program also provides flight support to other major segments of the Space Science and Applications program, with an aircraft fleet currently consisting of two U-2C's, one ER-2, one C-130, one CV-990, and a Learjet. These aircraft serve as test beds from newly developed instrumentation and permit the demonstration of new sensor concepts prior to their flight on satellites and the Spacelab. The data acquired during these flights are used to refine algorithms and develop ground data handling techniques. An example of such activities is flights in the ER-2/U-2C's to acquire simulated thematic mapper data. Another principal use of ER-2/U-2C's is to acquire stratospheric air samples and conduct in situ measurements at altitude ranges above the capability of more conventional aircraft and below those of orbiting satellites. This capability is important in the study of stratospheric transport mechanisms.

o Balloon Program:

For the development of scientific experiments for space flight and for independent scientific missions, it is desirable to test the instrumentation in the space radiation environment and to make observations at altitudes which are above most of the obscuring effects of the atmosphere, particularly for observations in infrared, gamma ray, and cosmic ray astronomy. In many instances it is necessary, because of size and weight, as well as low cost, to fly these experiments on balloons.

The balloon program funding is required for purchase of balloons, helium, launch services, tracking and recovery, and maintenance and operations of the National Science Balloon Facility (NBSF) at Palestine, Texas. This facility supports the launch of over 75 to 80 percent of NASA's balloon payloads, and it is the nation's primary means €or carrying out large scientific balloon operations. NASA assumed total funding responsibility for the NSBF, including administrative costs, from the National Science Foundation at the beginning of FY 1984. Funding for the experiments which are flown on balloons is provided from supporting research and technology programs.

In FY 1984, 44 balloons were flown from launch sites in the United States and Canada. In FY 1985, 67 balloon flights are planned to continue scientific research in the areas of atmospheric chemistry, high energy astrophysics, galactic astronomy and solar studies.

## BASIS OF FY 1986 ESTIMATE

FY 1986 funds will provide for continuation of the sounding rocket program with continued development of the Spartan missions.

The FY 1986 funding will provide for the continuation of the balloon program as well as management and operation of the NSBF. This funding is also required to continue definition activities on potential future long-duration balloon flights.

In FY 1985, the airborne science and applications funding will be used to continue operation of the Kuiper Airborne Observatory, to fly the U-2C's, ER-2, Learjet, and CV-990 to continue infrared astronomy exploration, acquire stratospheric air samples, test newly developed instrumentation, permit the demonstration of new sensor concepts, etc.

LIFE
SCIENCES

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1986 ESTIMATES

BUDGET *SUMMARY*

**OFFICE OF SPACE SCIENCE AND APPLICATIONS** — **LIFE SCIENCES PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | | (Thousands of Dollars) | | | |
| Life sciences flight experiments....... | 23,000 | 27,100 | 27,100 | 33,400 | RD 4-4 |
| Research and analysis.. ................. | 35,000 | 36,200 | 35,200 | 38,600 | RD 4-6 |
| Total | 58,000 | 63,300 | 62,300 | 72,000 | |

Distribution of Program Amount By Installation

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| Johnson Space Center..................... | 20,752 | 23,736 | 22,035 | 26,550 |
| Kennedy Space Center..................... | 1,373 | 1,600 | 2,100 | 2,100 |
| Goddard Space Flight Center............. | 110 | 85 | 300 | 200 |
| Jet Propulsion Laboratory............ .... | 2,618 | 1,700 | 500 | 1,500 |
| Ames Research Center..................... | 22,099 | 24,364 | 24,300 | 28,850 |
| National Space Technology Laboratories... | 23 | --- | 50 | 100 |
| Langley Research Center.................. | 365 | 400 | 500 | 600 |
| Lewis Research Center.................... | --- | --- | 15 | --- |
| Headquarters............................ | 10,660 | 11,415 | 12,500 | 12,100 |
| Total.............................. | 58,000 | 63,300 | 62,300 | 72,000 |

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1986 ESTIMATES

BUDGET SUMMARY

OFFICE AND SPACE SCIENCE AND APPLICATIONS | LIFE SCIENCES PROGRAM

## PROGRAM OBJECTIVE AND JUSTIFICATION

The goals of the Life Sciences program are to provide a sound scientific, medical, and technical basis €or safe and effective manned space flight, and to advance the understanding of the basic mechanisms of biological processes by using the unique capabilities of the space program. Results from the research program are applied to: the immediate needs in the maintenance and health of the astronauts; understanding the response of biological systems to weightlessness; the design of the advanced life support systems for use on future missions; and understanding the biosphere of the planet Earth, its origin, evolution, and present state.

The Life Sciences program is the key to developing a capability to sustain a permanent manned presence in space and to utilize the space environment to study living systems. These activities include both ground-based and space research efforts which are mutually supportive and integrated, and use a composite of disciplines and techniques in both biology and medicine to address space-related medical problems and fundamental biological processes.

The Life Sciences research and analysis program includes five major elements: 1) space medicine, which is focused on the health and well-being of space crews by understanding and preventing any adverse physiological changes which occur in space flight; 2) advanced life support systems, which is a program of research and technology development for life support systems necessary to maintain life in space autonomously for long periods of time; 3) gravitational biology, which consists of flight and ground-based experiments that focus on using microgravity as a biological research tool to understand its effect on plants and animals; 4) exobiology research, which is directed toward understanding the origin and distribution of life and life-related molecules on Earth and throughout the universe; and 5) biospheric research, which is directed toward understanding the interaction between life on Earth and its physical and chemical environment.

The goals of the Space Medicine program are to assure astronaut and payload specialist health and ability to function effectively in the space environment. In the future, experience gained from medical operations in space flight will allow a broader segment of the population to participate in all aspects of space missions. Particular emphasis is being placed on testing countermeasures designed to prevent physiological problems associated with exposure to the space environment. It is essential that long-term monitoring of space flight crews be performed in a standardized and organized fashion in order to develop risk factors and establish the long-term clinical significance associated with repeated exposure to the space environment. In addition, biomedical research is designed to understand the physiological basis for problems encountered in manned space flight. Areas of emphasis include: vestibular dysfunction, cardiovascular deconditioning, immunology, bone and muscle loss, and radiation damage. This research concentrates on trying to define potential flight protocols and countermeasures, first as space flight experiments and ultimately on an operational basis.

The Advanced Life Support System program seeks ways to develop technologies for more efficient life support systems for the space program and it also undertakes the scientific work in chemistry and biology necessary to understand how life can be maintained in closed systems which receive only energy from the external environment. All are aimed at potential future needs of long duration manned space flight and lunar colonization.

The objective of the Gravitational Biology program is to further our understanding of basic physiological mechanisms through the use of microgravity in the space environment. Plant and animal experiments have been flown on Soviet Cosmos satellites and on STS missions. Experiments are also under development for a number of Shuttle flights including the first dedicated Life Sciences mission (Space Life Sciences-1) to explore the physiological effects of space flight on inner ear €unction, blood factors, bone formation, and plant growth and structure. This information should contribute to a better understanding of and possible solution to biological and medical problems on Earth as well as contribute to man's effective functioning in space. The unique properties of space (e.g., microgravity) provide an opportunity to explore significant scientific questions in biology under controlled conditions that cannot be duplicated in laboratories on Earth.

The Exobiology efforts are concentrated on studies of life's origin, with particular emphasis on developing sound hypotheses which could lead to discovering the relationships which may link the formation of the solar system and the origin of life. Ground-based research on model systems and analysis of extraterrestrial materials, coupled with the results of planetary flight experiments, are clarifying the mechanisms and environments responsbile for the chemical evolution leading to life's origin. Studies of life's origin and evolution will be extended to enhance our understanding of the interaction of the biota with the Earth's present environment, and thereby provide a more comprehensive picture of life--its past, present, and future.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

LIFE SCIENCES FLIGHT EXPERIMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Life sciences flight experiments......... | 23,000 | 27,100 | 27,100 | 33,400 |

**OBJECTIVES AND STATUS**

The objective of the Life Sciences Flight Experiments program is to assimilate information and scientific questions from the various life sciences disciplines and translate them into payloads designed to expand our understanding of the basic physiological mechanisms involved in adaptation to weightlessness. The program includes selection, definition, inflight execution, data analysis, and reporting on medical and biological investigations. Past experience indicates that humans clearly undergo physiological changes in weightlessness. Thus far these changes appear to be reversible upon return to Earth; however, many of the observed changes are physiologically significant and are not well understood. With weightless exposure beyond several months, these changes may prove irreversible. Shuttle/Spacelab missions are suitable for gaining a greater understanding of the early response to weightlessness, which will improve the management of several existing problems (e.g., space adaptation syndrome) and will enhance the confidence of estimating the physiological consequences of more sustained weightless exposure.

Current activities include the development of life sciences flight experiments to be flown on Spacelabs-2 and -3 and the first dedicated Life Sciences Spacelab mission (Space Life Sciences-1). Most of the experiments onboard the early Shuttle flights have served as pathfinding activities for Spacelab Life Sciences-1. Activities on Spacelab-3 will involve evaluation of functional performance and compatibility of hardware that is essential to human and animal investigations which will be conducted on SLS-1 and follow-on missions. In addition, hardware development and mission planning activiites are proceeding on schedule for the United States vestibular experiment which will be flown on the German-Dl mission; these are follow-up investigations to those conducted on Spacelab-1 in 1983.

Eighteen investigations have been tentatively selected for flight on Spacelab Life Sciences-1, with six more investigations to be conducted on later flights. The definition phase activities have been completed and the design and development of the flight hardware is well underway. These investigations have been combined into a comprehensive, integrated exploration of the known problems of manned space flight through the use of both human and animal subjects, and include key scientific investigations in gravitational biology. Teams of principal investigators will examine cardiovascular adaptation, space adaptation syndrome, muscle atrophy, demineralization of bone, the early anemia of weightlessness, and the effects of weightlessness on plant and animal development. The SLS-1 mission will be unique in several respects: it will be the first Shuttle/Spacelab mission dedicated entirely to life sciences, and will involve highly skilled scientists as payload specialists, permitting the use of numerous experimental techniques and procedures never before utilized in space; and the experiments will employ complementary human and animal investigations in order to validate models for human physiology.

**BASIS OF FY 1986 ESTIMATE**

FY 1986 funding is required €or the continued definition and development of hardware which will be flown on future Spacelab missions, i.e., Spacelab-3, German-D1, SLS-1 and the second dedicated life sciences mission, yet to be designated. Flight hardware integration and experiment development associated with Spacelab-2, 3, and D-1 will be completed in preparation for launches in 1985. The Life Sciences-1 mission is scheduled for launch in early 1986. In addition, the selection process for experiments for the follow-on dedicated Spacelab life sciences missions has been initiated through the recent release of a new flight Announcement of Opportunity (AO) and experiment proposals are now being evaluated.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### RESEARCH AND ANALYSIS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Life sciences research and analysis...... | 35,000 | 36,200 | 35,200 | 38,600 |

## OBJECTIVES AND STATUS

The research and analysis activity of the Life Sciences program is concerned with ground-based and pre-flight research in basic biology and in those medical problem areas that affect manned spaceflight. The program is comprised of five elements: (1) space medicine (2) advanced life support systems research; (3) gravitational biology; (4) exobiology; and (5) biospheric research.

The Life Sciences Space Medicine program is responsible for bringing the technology and practice of medicine to bear on solving the problems of sustaining, supporting, and protecting individuals working in the space environment. The program provides the means for assuring the physical welfare, performance, and adequate treatment of in-flight illnesses or injuries to spaceflight crews. Such conditions as spatial disorientation and fluid and endocrine shifts which can decrease performance, cardiovascular tolerance, and possibly aggravate latent diseases, will be carefully monitored to determine preventive measures. To this end, careful medical selection, periodic evaluation of health status, and in-flight monitoring of the time required for adaptation to the space environment will be continually undertaken. The supporting applied science element of the space medicine program is accomplished through a biomedical research program and seeks to develop the basic medical knowledge needed to enable men and women to operate more effectively in space. The program is organized into discrete elements, each designed to rectify a particular physiological problem known or expected to affect the human organism in space. Such problems as motion sickness, bone loss, and electrolyte imbalances are under intense scrutiny not only to provide a better understanding of their underlying causes, but also to develop more effective preventive measures. The program makes extensive use of ground-based simulation techniques which evoke, in both humans and animals, physiological changes similar to those seen in space.

The Advanced Life Support Systems research program concentrates on enhancing our ability to support a long-duration manned presence in space and optimizing the productivity of the STS crews. Improvements are sought in spacecraft habitability and man-machine system engineering methods as well as a means to provide air, water, and food to support life directly. The program has developed technology for building apparatus to regenerate spacecraft air and water supplies in flight and is investigating the scientific basis for new systems such as food recycling for long-term missions. Research is in progress on space suits for quick reaction situations and on innovative approaches to designing space tools and work stations.

The Gravitational Biology program explores the role of gravity in life processes and uses gravity as an environmental tool to investigate fundamental biological questions. Specific objectives are to: (1) investigate and identify the role of gravity in plant and animal behavior, morphology and physiology; (2) identify the mechanisms of gravity sensing and transmission of gravity perception information within both plants and animals; (3) identify the interactive effects of gravity and other stimuli (e.g., light) and stresses (e.g., vibration and disorientation) on the development and metabolism of organisms; (4) use gravity to study the normal nature and properties of living organisms; and (5) extend the limits of knowledge about plant and animal growth as well as long-term survival and reproduction of life in space.

The Exobiology program is directed toward furthering our understanding of the origin and evolution of life and life-related molecules on Earth and elsewhere in the universe. Research, in general, builds on data acquired by missions in planetary exploration and astrophysics to uncover the relationship between the origin and evolution of the solar system and life itself. Theoretical and laboratory investigations are also included in this program to develop a better understanding of the conditions on the primitive Earth as related to early chemical and biological evolution.

The Biospheric Research program explores the interaction between the biota and the contemporary environment to develop an understanding of global bio-geochemical cycles. Laboratory and field investigations are correlated with remote sensing data to characterize the influence of biological processes in global dynamics. Biospheric modelling efforts are focused on integrating biology with atmospheric, climate, oceanic, terrestrial, and bio-geochemical cycling data to reflect the state of the biosphere as a function of both natural and anthropogenic perturbations.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The decrease of $1.0M million reflects the accommodation of a portion of the general reduction in the appropriation; this reduction is being accommodated by the deferral of some previously planned research and analysis activities.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, the Space Medicine program will collect information on occupational exposures in zero-gravity on each Shuttle flight; conduct inflight clinical testing of countermeasures, especially in the areas of cardiovascular deconditioning and vestibular problems, and develop health care procedures compatible with the space environment. Medical data will be evaluated in order to better define responses of different population groups to space flight. The biomedical research element will focus primarily on problems related to vestibular dysfunction because of the high incidence of space adaptation syndrome in Shuttle operations. Psychology, human factors, and the enhancement of performance and efficiency among flight crews are all receiving increased emphasis. Studies of bone loss and of electrolyte imbalance will also be pursued so that potential countermeasures can be devised. Increased exposure to, and awareness and understanding of the potential radiation hazard from space flight has resulted in more emphasis being placed on the precise measurement of radiation doses, the specific biological effects of cosmic rays, and the identification of possible radiation shielding.

In **FY** 1986, the Advanced Life Support Systems program will continue to investigate basic biological processes and physical methods to control the interior environments of manned spacecraft; and will continue development of data acquistion systems and computer technologies to analyze and simulate human physical activities. Laboratory plant growth methods developed in recent years will be scaled up to obtain a capability to produce plant material at efficiency and productivity levels high enough for space life support applications.

In FY 1986, the Gravitational Biology program will focus on continuation of research directed at understanding animal and plant equilibrium, gravity perception, and biotransduction mechanisms, as well as gravity's effect on plant and animal development, structure, and behavior. Increased emphasis will be placed on research that will lead to the development of hypotheses, and provide baseline data for future Shuttle/Spacelab flight experiments.

In **FY** 1986, the Exobiology program emphasis will be placed on the continuation of such efforts as expanding our knowledge of non-biological mechanisms for synthesis of biologically significant molecules both in space and on the Earth. This research is crucial for gaining further insight into the origin of life, assessing the possibility of these processes occurring elsewhere in the universe, and preparing for future flight experiments.

In **FY** 1986, the Biospheric Research program will place emphasis on improving our estimating techniques for determining the size and distribution of the terrestrial biomass by combining ground-based measurements with remote sensing data. Additional emphasis will be placed on characterizing biogenic gas fluxes of key atmospheric constituents. This information is required for the development of a better understanding of global bio-geochemical cycles.

In **FY** 1986, emphasis will also be placed on the formulation of improved approaches to the operational management of space adaptation syndrome. In-flight evaluation of these approaches will be conducted to provide the basis for the development of more effective countermeasures. An interdisciplinary approach to determining how to enhance the capabilities, performance and efficiency of spaceflight crews will be undertaken. The object of this effort will be to allow humans, to the fullest extent possible, the opportunity to explore and work in space by improving the working environment and by facilitation of the human interaction with the automated devices that can be placed at their disposal.

PLANETARY
EXPLORATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1986 ESTIMATES

BUDGET SUMMARY

**OFFICE OF SPACE SCIENCE AND APPLICATIONS** — **PLANETARY EXPLORATION PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | (Thousands of Dollars) | | | | |
| Galileo development | 79,500 | 56,100 | 56,100 | 39,700 | RD 5-5 |
| Venus radar mapper mission | 29,000 | 92,500 | 92,500 | 112,000 | RD 5-7 |
| Ulysses (ISPM) | 6,000 | 9,000 | 9,000 | 5,600 | RD 5-9 |
| Mars Observer (MGCO) | --- | 16,000 | 13,000 | 43,800 | RD 5-11 |
| Mission operations and data analysis | 43,400 | 58,800 | 58,800 | 95,000 | RD 5-13 |
| Research and analysis | 59,500 | 54,500 | 61,500 | 62,900 | RD 5-15 |
| Total | 217,400 | 286,900 | 290,900 | 359,000 | |

Distribution of Program Amount by Installation

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| Johnson Space Center | 10,420 | 8,150 | 10,260 | 11,105 |
| Marshall Space Flight Center | 95 | --- | 100 | 100 |
| Goddard Space Flight Center | 3,703 | 3,357 | 5,079 | 3,620 |
| Jet Propulsion Laboratory | 135,791 | 234,283 | 215,795 | 284,755 |
| Ames Research Center | 16,687 | 12,074 | 16,774 | 10,159 |
| Langley Research Center | 5 | --- | --- | --- |
| Headquarters | 50,699 | 29,036 | 42,892 | 49,261 |
| Total | 217,400 | 286,900 | 290,900 | 359,000 |

**PROGRAM I AND JUSTIFICATION**

The Planetary Exploration program encompasses the scientific exploration of the solar system including the planets and their satellites, comets and asteroids, and the interplanetary medium. The program objectives are: (1) to determine the nature of planets, comets, and asteroids as a means for understanding the origin and evolution of the solar system; (2) to understand the Earth better through comparative studies with the other planets; (3) to understand how the appearance of life in the solar system is related to the chemical history of the solar system; and, (4) to provide a scientific basis for the future use of resources available in near-Earth space. Projects undertaken in the past have been highly successful. The strategy that has been adopted calls for a balanced emphasis on the Earth-like inner planets, the giant gaseous outer planets, and the small bodies (comets and asteroids). Missions to these bodies start at the level of reconnaissance to achieve a fundamental characterization of the bodies, and then proceed to levels of more detailed study.

The reconnaissance phase of inner planet exploration, which began in the 1960's, is now virtually completed, although we still know little about the nature of the planet Venus' surface. Mars has provided program focus because of its potential as a site of biological activity. The Viking landings in 1976 carried the exploration of Mars forward to a high level of scientific and technological achievement, thereby setting the stage for the next step of detailed study. Analyses of meteorites and the lunar rock samples returned by Apollo continue to be highly productive, producing new insights into the early history of the inner solar system and thus leading to revision of our theoretical concepts. The Pioneer Venus mission is continuing to carry the study of the Earth's nearest planetary neighbor and closest planetary analog beyond the reconnaissance stage to the point where we have now obtained a basic characterization of Venus' thick, massive atmosphere, as well as fundamental data about the formation of the planet.

The exploration of the giant outer planets began relatively recently. The Pioneer-IO missions to Jupiter in 1973 and 1974 were followed by the Voyager-I and 2 spacecraft encounters in 1979. Voyager-I then encountered Saturn in November 1980, and Voyager-2 in August 1981. The Voyager data on these planets, their satellites, and their rings have revolutionized our concepts about the formation and evolution of the solar system. Voyager-2 is now headed for an encounter with Uranus in 1986 that will provide our first look at this giant outer planet. Its trajectory will then carry it to the planet Neptune in 1989. The Pioneer-IO and 11 and Voyager-I spacecraft are on trajectories heading out of the solar system, as they continue to return scientific data about the outer reaches of the solar system.

The Galileo orbiter/probe mission to Jupiter will be launched in 1986 by the Space Shuttle/Centaur Upper Stage. The comprehensive science payload will extend our knowledge of Jupiter and its system of satellites well beyond the profound discoveries of the Voyager and Pioneer missions. During twenty months of operation in the Jovian system, Galileo will inject an instrumented probe into Jupiter's atmosphere to make direct analyses, while the orbiter will have the capability to make as many as eleven close encounters with the Galilean satellites.

Ulysses, formerly the International Solar Polar Mission (ISPM), is a joint NASA and European Space Agency activity. The mission will carry a package of experiments to investigate the Sun at high solar latitudes that cannot be studied from the Earth's orbit. Ulysses will be launched in 1986 on the Shuttle/Centaur Upper Stage.

The Venus Radar Mapper (VRM) mission, initiated in FY 1984, will provide global maps of the cloud-shrouded surface of Venus, including its land forms and geological features. Using a synthetic aperture radar to penetrate the planet's opaque atmosphere, VRM will achieve a resolution sufficient to identify small-scale features and to address fundamental questions about the origin and evolution of the planet. VRM will also obtain altimetry and gravity data to determine accurately the planet's gravity field as well as internal stresses and density variations. With these data, the evolutionary history of Venus can be compared with that of the Earth. VRM is scheduled for launch in 1988 on the Shuttle/Centaur Upper Stage.

A major new flight program element is the Mars Observer (MGCO), a FY 1985 new initiative in response to the Solar System Exploration Committee's recommendations. The Mars Observer Mission will follow up on the earlier discoveries of Mariner 9 and Viking and will emphasize the geologic and climatic evolution of this complex planet. The MGCO will be a relatively low-cost mission due to the use of a modified Earth-orbiting spacecraft, thereby benefitting from aerospace industry's earlier investment in development.

We are now about to enter an exciting new phase of exploration by making our first close-up studies of the solar system's mysterious small bodies -- comets and asteroids. These objects may represent unaltered original solar system material, preserved from the geological and chemical changes that have taken place in even small planetary bodies. By sampling and studying comets and asteroids, we can begin to make vigorous inquiries into the origin of the solar system itself. These efforts will begin with the encounter of Comet Giacobini-Zinner by the International Comet Explorer (ICE) spacecraft in September 1985 and will continue through our involvement with the 1986 encounters of Comet Halley by foreign spacecraft. In addition, we are studying a Comet Rendezvous/Asteroid Flyby (CRAF) mission in which a Mariner Mark II spacecraft would make long-term observations of an active comet, together with a close flyby of an asteroid.

The Planetary Exploration program is also founded on a coordinated research and analysis effort. Research and analysis activities will continue to maximize the scientific return from both ongoing and future missions and from such Earth-based activities as lunar sample and meteorite analysis, telescope observations, theoretical and laboratory studies, and instrument definition. This program strives for interdisciplinary coordination among various research groups and for the wide dissemination of scientific results. A close coupling is also maintained between the research programs and planning activities that are undertaken to define the scientific rationale and technology needed for future missions.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### GALILEO DEVELOPMENT

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Spacecraft | 50,578 | 26,300 | 22,400 | 13,800 |
| Experiments | 9,375 | 8,100 | 9,500 | 7,900 |
| Ground Operations | 19,547 | 21,700 | 24,200 | 18,000 |
| Total | 79,500 | 56,100 | 56,100 | 39,700 |
| Space transportation system operations | (37,200) | (35,900) | (36,300) | (44,200) |

## T AND STATUS

The objective of the Galileo program is to conduct a comprehensive exploration of Jupiter, its atmosphere, magnetosphere, and satellites through the use of both remote sensing by an orbiter and in situ measurements by an atmospheric probe. The scientific objectives of the mission are based on recommendations by the National Academy of Sciences to provide continuity, balance, and orderly progression of the exploration of the solar system.

The Orbiter and Probe will be launched together in 1986 as a single combined payload using the Shuttle/Centaur Upper Stage. Arrival at Jupiter will be in late 1988 when the Orbiter will provide remote sensing of the probe entry site and provide the link for relaying the probe data back to Earth. Twenty months of orbital operations will follow in which both Jupiter's surface and the dynamic magnetosphere will be comprehensively mapped. Eleven close flybys of Jupiter's major satellites are targeted; however, the number of tour orbits at Jupiter will be decreased by one orbit if the decision is made after launch to incorporate a flyby of the asteroid Amphritrite. If the asteroid flyby is incorporated, the plan is to extend the length of the Jupiter tour from twenty months to twenty-two months to permit the achievement of all major objectives previously encompassed by the eleven orbit tour.

The Galileo flight system will be powered by two general purpose heat-source Radioisotope Themoelectric Generators (RTG's) being developed by the Department of Energy. The Orbiter will carry approximately 100 kg of scientific instruments and the Probe will carry approximately 25 kg of scientific instruments.

During FY 1985, major activities of the Galileo program will involve completion of the environmental test cycle, retrofit of selected subsystems with more radiation resistant electronic components, and completion of development of the flight software.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

In total, the FY 1985 current estimate remains unchanged from the budget estimate. However, reallocation of funds within the project was made to meet the scheduled milestones in the most efficient manner.

**BASIS OF FY 1986 ESTIMATE**

The FY 1986 funding will provide for completion of the integration and testing, the pre-launch check-out at the Jet Propulsion Laboratory and for the pre-launch and launch activities at the Kennedy Space Center in support of the May 1986 launch. Funding in FY 1986 will also be used for the final development of the ground systems and the associated software to support mission operations. In addition, funds will be required to reimburse the Department of Energy for completing development of the Radioisotope Thermoelectric Power Generators required for the Orbiter.

## BASIS OF FY 1986 FUNDING REQUIREMENTS

VENUS RADAR MAPPER MISSION

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Spacecraft............................ | 15,955 | 65,800 | 64,100 | 75,800 |
| Experiments....................... | 12,483 | 24,500 | 26,200 | 29,800 |
| Ground Operations..................... | 562 | 2,200 | 2,200 | 6,400 |
| Total............................ | 29,000 | 92,500 | 92,500 | 112,000 |
| Space Transportation system operations | (---) | (12,300) | (10,000) | (27,500) |

## OBJECTIVES AND STATUS

The objective of the Venus Radar Mapper (VRM) mission is to address fundamental questions regarding the origin and evolution of Venus through global radar imagery of the planet. VRM will also obtain altimetry and gravity data to determine accurately the planet's gravity field as well as internal stresses and density variations. The detailed surface morphology of Venus will be analyzed to compare the evolutionary history of Venus with that of the Earth.

The VRM spacecraft will carry a single major scientific instrument, a synthetic aperture radar, which will be used to obtain high resolution (120 to 200 meter) images of the planetary surface as well as altimetric data. Gravity data will be obtained by processing radio signals from the spacecraft. Spacecraft development is making extensive use of existing designs, technology, and residual hardware; for example, the spacecraft will use a bus structure, large antenna, and propulsion components from the Voyager program. Spare flight computers and other equipment will be obtained from the Galileo program after the Galileo launch in 1986.

In April 1988, the VRM spacecraft will be launched by the Shuttle/Centaur Upper Stage on a direct trajectory to Venus. Arriving at Venus in July 1988, the spacecraft will perform a retro-propulsive maneuver and enter a near-polar elliptical orbit. After an initial check-out period, the spacecraft will map the planet over a 243 day period (one Venus year).

During FY 1985, major activities will include completion of final spacecraft and instrument systems design, testing breadboard development models of the radar circuits, building the development model of the radar, and preparing the detailed designs of the spacecraft subsystems.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

In total, the FY 1985 current estimate remains unchanged from the budget estimate; however, reallocation of the funds within the project has been made based on the contractor's development schedule requirements.

## BASIS OF FY 1986 ESTIMATE

FY 1986 funds will provide for completion of all design effort for the spacecraft, radar instrument, and mission operations lead Voyager program. Spare flight computers and other equipment will be obtained from the Galileo program after the Galileo launch in 1986.

In April 1988, the VRM spacecraft will be launched by the Shuttle/Centaur Upper Stage on a direct trajectory to Venus. Arriving at Venus in July 1988, the spacecraft will perform a retro-propulsive maneuver and enter a near-polar elliptical orbit. After an initial check-out period, the spacecraft will map the planet over a 243 day period (one Venus year).

## BASIS OF FY 1986 FUNDING REQUIREMENT

ULYSSES (FORMERLY INTERNATIONAL SOLAR POLAR MISSION)

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Spacecraft | 2,200 | 4,000 | 4,000 | 700 |
| Experiments | 1,500 | 2,100 | 2,100 | 2,200 |
| Ground Operations | 2,300 | 2,900 | 2,900 | 2,700 |
| Total | 6,000 | 9,000 | 9,000 | 5,600 |
| Space transportation system operations | (37,100) | (37,400) | (36,200) | (44,300) |

## OBJECTIVES AND STATUS

Ulysses is a joint mission of NASA and the European Space Agency (ESA). ESA is providing the spacecraft and some scientific instrumentation. The U.S. is providing the remaining scientific instrumentation, the launch, tracking support, and the Radioisotope Thermoelectric Power Generators (RTG). The mission is designed to obtain the first view of the Sun above and below the plane in which the planets orbit the Sun. The mission will study the relationship between the Sun and its magnetic field and particle emissions (solar wind and cosmic rays) as a function of solar latitude, to provide a better understanding of solar activity on the Earth's weather and climate. Ulysses will be launched in 1986 on the Shuttle/Centaur Upper Stage.

Ulysses was restructured in FY 1981, from a two-spacecraft mission--one provided by the United States and one provided by ESA--to a single ESA spacecraft mission; however, the United States participation in the program remains substantial. NASA is developing five of the nine principal investigator instruments, and three of the four European investigations have U.S. co-investigators. During FY 1983, the U.S. flight instruments were delivered to the ESA spacecraft developer for integration and system testing. All spacecraft testing has been completed and the spacecraft is being partially disassembled for storage until launch.

BASIS OF FY 1986 ESTIMATE

The FY 1986 funding is required to support U.S. principal investigators in their mission planning; and for retrofitting of the U.S. instruments with the spacecraft prior to shipment to the Kennedy Space Center. In addition, FY 1986 funds are required to complete the ground system development activities and to reimburse DOE for the continued development of the Radioisotope Thermoelectric Power Generators.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

MARS OBSERVER MISSION (FORMERLY MARS GEOSCIENCE/CLIMATOLOGY ORBITER)

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Spacecraft development.................. | --- | 6,000 | 6,000 | 28,600 |
| Experiments............................ | --- | 5,000 | 5,000 | 4,300 |
| Ground Operations...................... | --- | 5,000 | 2,000 | 10,900 |
| Total.............................. | --- | 16,000 | 13,000 | 43,800 |

**OBJECTIVES AND STATUS**

The Mars Observer mission is the first planetary mission utilizing a new approach to low-cost inner solar system mission exploration. This approach, which was recommended by the Solar System Exploration Committee, starts with a well defined and focused science objective and makes use of high-inheritance, modified production line Earth-orbital spacecraft. The objective of the Mars Observer mission is to extend and complement the data acquired by the Mariner and Viking missions by mapping the global surface composition, atmospheric structure and circulation, topography, figure, gravity and magnetic fields of Mars to determine the location of volatile reservoirs and characterize their interaction with the Martian environment.

The Mars Observer mission will be launched in 1990 using the Space Shuttle, and will be inserted into Martian orbit in 1991, where it will carry out geochemical, geophysical, and climatological mapping of the planet over a period of two years.

**CHANGES FROM ET 1985 ESTIMATE**

The decrease of $3.0 million in the current estimate reflects the application of a portion of the general reduction in the appropriations; the decrease has been accommodated by the rephasing of activities within the project.

## BASIS OF FY 1986 ESTIMATE

The FY 1986 funds are required to fund the continued design and development activities leading to the preliminary design review in late FY 1986. This spacecraft design is a modified Earth-orbital spacecraft design. FY 1986 funding is also required for initiation of design and development activities for experiments selected in response to the Announcement of Opportunity. In addition, development activities will be continued in FY 1986 on the X-band transponder to be flown on the Mars Observer mission.

**BASIS OF FY 1986 NG REQUIREMENT**

MISSION OPERATIONS AND DATA ANALYSIS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Galilee operations....... .............. | --- | --- | --- | 20,000 |
| Ulysses operations.................... | --- | --- | --- | 2,000 |
| Voyager extended mission............. | 19,100 | 29,400 | 29,400 | 26,400 |
| Pioneer programs..................... | 6,400 | 7,000 | 7,000 | 7,600 |
| Voyager/Neptune Encounter............ | --- | --- | --- | 9,000 |
| Planetary flight support............. | 17,900 | 22,400 | 22,400 | 30,000 |
| Total........................... | 43,400 | 58,800 | 58,800 | 95,000 |

**OBJECTIVES AND STATUS**

The objectives of the mission operations and data analysis activities are in-flight operation of planetary spacecraft and the analysis of data from these missions. Currently, two major classes of planetary spacecraft are operating--the Pioneer and the Voyager spacecraft. The planetary flight support activities are those associated with the design and development of planetary flight operation systems, and other activities that support the mission control, tracking, telemetry, and command functions for all planetary spacecraft.

The two Voyager spacecraft are now traveling through the outer solar system on trajectories that will take them into interstellar space. Voyager 1 continues to provide data on the interplanetary medium in that distant part of the solar system. In January 1986, Voyager 2 will make a close flyby of the planet Uranus, the first time this planet has ever been visited by a spacecraft. The observatory phase of this encounter, beginning in November 1985, will include detailed observations of the planet, its rings, and moons. After the Uranus encounter is completed, the spacecraft will continue on to the planet Neptune, where, in 1989, it will provide us with our first close look at this distant planet.

Pioneers 10 and 11 will continue to explore the outermost solar system. Pioneer 10 will soon enter the unexplored region beyond Pluto where the Sun's influence is secondary to those of true interstellar space. These spacecraft will continue the search for gravitationai evidence of a tenth planet. Pioneers 6-9 are still collecting information on the interplanetary magnetic field and solar wind as they orbit the Sun. In 1986, these spacecraft will be used to observe Comet Halley as it passes in their vicinity.

The Pioneer Venus orbiter continues to obtain data from Venus' atmosphere and magnetosphere. In early 1986, the spacecraft's spin axis will be adjusted to allow ultraviolet observations of Comet Halley. The Pioneer Venus will be the only spacecraft able to observe the Comet at its closest approach to the Sun and will provide critical additions to data from foreign spacecraft making observations at other points in the Comet's orbit.

The planetary flight support activities include the procurement, operation and maintenance of mission operations and general purpose scientific and engineering computing capabilities at the Jet Propulsion Laboratory (JPL). In addition, the activity supports the development of the Space Flight Operations Center at JPL. This facility will be a versatile, cost-effective means for carrying out multi-mission data acquisition, telemetry and image processing, and commanding of planetary and orbital missions.

## BASIS OF FY 1986 ESTIMATE

FY 1986 funding is required for the continued operation and data analysis activities in support of the Voyager and Pioneer operations. In addition, the Voyager Neptune encounter activities will be initiated in April 1986. Planetary flight support funding is required in FY 1986 €or preparation of the 1986 launches of Galileo and Ulysses as well as for the Voyager Uranus encounter. In addition, the FY 1986 funding is required for the operation of the Galileo and Ulysses mission, both of which will be launched in May 1986. Development activities will also be continued in FY 1986 on the Space Flight Operations Center at the Jet Propulsion Laboratory.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

RESEARCH AND ANALYSIS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Supporting research and technology..... | 43,500 | 37,900 | 45,100 | 46,000 |
| Advanced programs..................... | 9,800 | 9,000 | 10,000 | 10,100 |
| Mars data analysis.. .................... | 2,900 | 4,300 | 2,600 | 2,800 |
| Halley's comet co-investigations and watch....................... | 3,300 | 3,300 | 3,800 | 4,000 |
| Total............................ | 59,500 | 54,500 | 61,500 | 62,900 |

**OBJECTIVES AND STATUS**

The research and analysis program consists of four elements required to (1) assure that data and samples returned from flight missions are fully exploited; (2) undertake complementary laboratory and theoretical efforts; (3) define science rationale and develop required technology to undertake future planetary missions; and (4) coordinate an International Halley's Comet Watch and provide co-investigator support to the European Space Agency's Giotto mission to Halley's Comet.

The supporting research and technology activity includes planetary astronomy, planetary atmospheres, planetary geology/geophysics, planetary materials/geochemistry, and instrument definition.

The planetary astronomy activity includes all observations made by ground-based telescopes of solar system bodies excluding the Sun. Emphasis is on the outermost planets, comets and asteroids. Observations are made at a wide range of wavelengths from ultraviolet to radio. The rate of new discoveries continues to be high, and the data acquired is used both for basic research in support of planetary program objectives and €or direct support of specific flight missions. The planetary astronomy funding also provides for the continued operation of the Infrared Telescope Facility in Hawaii.

The planetary atmospheres activity includes data analysis, laboratory, and theoretical efforts. The properties of other planetary atmospheres are amenable to measurement with planetary spacecraft and can aid us in better understanding our own weather and climate. Observations of the atmospheres of

Venus, Jupiter and Saturn, acquired by Pioneer Venus and Voyager, have laid the basic observational groundwork for major advances in this field.

The planetary geology/geophysics activity is a broadly scoped program that includes the study of surface processes, structure, and history of solid components (including rings) of the solar system and investigation of the interior properties and processes of all solar system bodies, both solid and gaseous. This program emphasizes comparative studies to gain a fundamental understanding of the physical processes and laws which control the development and evolution of all planetary bodies, including the Earth. In this respect, data from the Venus Radar Mapper mission will be of crucial importance.

The planetary materials/geochemistry activity supports an active scientific effort to determine the chemistry, mineral composition, age, physical properties and other characteristics of solid material in the solar system through the study of returned lunar samples and meteorites and through laboratory and theoretical studies of appropriate geochemical problems. Extraterrestrial dust grains, collected for analysis, continue to yield new and otherwise unobtainable information about the solar system, and its early history. This program is coordinated with the lunar sample and meteorite research which is supported by other agencies such as the National Science Foundation. The operation of the Lunar Curatorial Facility is also supported by the planetary materials/geochemical funding.

The instrument definition activity is directed toward ensuring maximum scientific return from future missions by the definition and development of state-of-the-art scientific instrumentation which is optimized for such missions.

The objective of the advanced program activity is to provide planning and preparation for the systematic exploration of the solar system on a scientifically and technically sound basis. Prospective planetary missions are identified and defined through long-range studies; their technological and fiscal feasibility is evaluated, and their scientific merit is determined through interaction with the scientific community. The strategy for future solar system exploration has been developed by the Solar System Exploration Committee (SSEC), an advisory group, which has recommended a series of "low-cost" but scientifically important potential future missions.

The Mars Data Analysis activity continues to ensure that we capitalize on the wealth of data provided by Viking and earlier missions and that we are scientifically prepared for the next phase of Mars exploration, more specifically, the Mars Observer mission. While continuing to support a variety of scientific investigations, the major emphasis of this program will address the origin and evolution of Martian volatiles.

The International Halley's Comet Co-Investigations and Watch will capitalize on the opportunity to observe Comet Halley during its next apparition in 1985-1986 by supporting co-investigators on the

European Space Agency's (ESA) Giotto mission, and by conducting complementary remote sensing investigations using both Earth-orbiting and ground-based facilities. The ESA Giotto mission will fly by Halley's Comet in 1986. Concurrently, an observation program called the International Halley Watch, coordinated by the United States, will conduct world-wide scientific observations of the Comet Halley. The objectives of the Watch are: (1) to coordinate scientific observations of Comet Halley through its 1985-1986 apparition; (2) to promote the use of standardized instrumentation and observing techniques; (3) to help insure that data is properly documented and archived; and (4) to receive and distribute data to participating scientists.

## CHANGES FROM FY 1985 ESTIMATE

The increase in the FY 1985 current estimate reflects an augmentation of $7.0 million in Research and Analysis consistent with the authorization and appropriation actions; this augmentation is being used primarily to enhance the supporting research and technology activities and the university laboratory equipment.

## BASIS OF FY 1986 ESTIMATE

During FY 1986, research efforts will continue in the areas of planetary astronomy, planetary atmospheres, planetary geology/geophysics, planetary materials/geochemistry, instrument definition, Mars data analysis, and in the development of required technology to undertake future missions. Ground telescope observations will provide data complementary to that obtained from the flight missions, with emphasis on the outermost planets, comets and asteroids. A variety of efforts will be pursued to improve our understanding of planetary atmospheres, including laboratory studies of reactions in deep planetary and tenuous cometary atmospheres. Geology/geophysics research will be directed, in FY 1986, at specific problems in understanding the various processes that have shaped planetary surfaces, as well as geological analyses and a cartography effort based on the Galilean and Saturnian satellite imaging data acquired by Voyager. Analysis of lunar samples, meteorites, and extraterrestrial dust particles will be continued in FY 1986 to determine their chemical and physical properties and thereby derive their origin and evolutionary history. Instrument definition for potential future missions will be also be continued in FY 1986.

The FY 1986 Halley's Comet Co-Investigations and Watch funding is required to support U.S. co-investigators involved in the European Space Agency's Giotto mission, and to provide support for a Jet Propulsion Laboratory managment team and several scientists at other institutions, who are establishing a worldwide network for the astronomical study of Halley's Comet.

The FY 1986 funding is also required to continue operations of both the Infrared Telescope Facility and the Lunar Curatorial Facility.

# SOLID EARTH OBSERVATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1986 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — SOLID EARTH OBSERVATIONS PROGRAM

SUMMARY OF RESOURCE REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| Landsat-4 | 16,800 | --- | --- | --- | |
| Shuttle/Spacelab payloads | 17,000 | 18,100 | 12,100 | 23,100 | RD 6-4 |
| Geodynamics | 28,000 | 29,900 | 29,900 | 31,700 | RD 6-6 |
| Research and analysis | 14,600 | 15,600 | 15,600 | 20,100 | RD 6-8 |
| Total | 76,400 | 63,600 | 57,600 | 74,900 | |

Distribution of Program Amount by Installation

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| Johnson Space Center | 3,300 | 3,300 | 1,000 | 250 |
| Marshall Space Flight Center | 245 | 400 | 262 | 277 |
| Goddard Space Flight Center | 47,361 | 40,600 | 33,657 | 37,175 |
| Jet Propulsion Laboratory | 16,144 | 15,300 | 15,426 | 28,184 |
| Ames Research Center | 1,016 | 600 | 500 | 645 |
| National Space Technology Laboratories | 2,093 | 1,400 | 2,281 | 2,875 |
| Headquarters | 6,241 | 2,000 | 4,474 | 5,494 |
| Total | 76,400 | 63,600 | 57,600 | 74,900 |

## PROGRAM OBJECTIVES AND JUSTIFICATION

The objectives of the Solid Earth Observations program are to develop space observations and experimentation techniques to further the understanding of the global, physical, chemical, and biological processes involving the land/solid areas of the Earth and interactions of these land areas with the earth's oceans and atmosphere; to improve our ability to evaluate systematically the composition and geometry of the Earth's mineral and energy resources; and to increase our understanding of the Earth, its interior structure and composition, its rotational dynamics, the processes related to the movement and deformation of its crust, and mechanisms associated with the occurrence of earthquakes.

Principal elements of the program include the development of spaceborne and supporting ground systems; improved data processing and analysis techniques; sensor and technique development; as well as basic and applied research for identifying, monitoring, analyzing and modeling the vegetated, geological, and geophysical features of the Earth.

An important aspect of the program is the research associated with understanding the physical relationship of electromagnetically sensed phenomena to the radiation emitted or reflected by various types of surface features of the Earth; the development of models to increase our understanding of global processes; and the evaluation of the use of space-derived data along with other data sources in meeting the research needs of the scientific community.

Studies of the movement and deformation of the Earth's crust, the rotational dynamics of the Earth, and the Earth's gravity and magnetic fields provide information which is needed to: understand the processes leading to the release of crustal strain in the form of earthquakes; improve our understanding of the formation of mineral deposits; contribute to long-term weather and climate forecasting; and better understand the Earth as a planet. Space techniques such as laser ranging to satellites and the Moon, and very long baseline interferometry using radio stars or satellites, are the only methods which can provide the precise measurements needed for these studies.

Landsat-4, launched on July 16, 1982, has continued to provide Multispectral Scanner and Thematic Mapper images for many applications in civil remote sensing. NOAA assumed operational responsibility for the Landsat-4 spacecraft and the Multispectral Scanner in January 1983, and for Thematic Mapper operations and data processing in August 1984. The Landsat-5 spacecraft was modified before its launch in March 1984 to correct for anomalies developed in-orbit on Landsat-4.

The objective of the Shuttle/Spacelab payload development project is to develop, test and evaluate Earth-viewing remote sensing instruments and systems to obtain data for solid earth observations research. The Shuttle Imaging Radar, which was most recently flown on the Shuttle in October, 1984, has demonstrated the utility of spaceborne imaging radar for geologic exploration. The Large Format Camera (LFC), required for high resolution mapping applications, was flown successfully on the Shuttle in 1984 and an additional reflight of the LFC is planned for 1986. The next generation Shuttle Imaging Radar, involving use of SIR-B components and a multi-polarized, dual frequency instrument is under consideration.

Advanced spectrometer technology development activities include fundamental research in remote sensing. This involves an imaging spectrometer development plus some continuing multispectral linear array technology development activities. The imaging spectrometer and MLA solid-state sensor research focuses on the development of such features as electronic scan, inherent geometric and spectral registration and programmable high spatial and spectral resolution. The critical technology development and supporting research on the linear array focal plane and the Shuttle Imaging Spectrometer will continue in FY 1986.

Along with the Environmental Observations program, the Solid Earth Observations activities compose an integral part of NASA's total Earth sciences and applications effort with emphasis on understanding the Earth as a planet, studying its dynamics, processes, habitability, and solar-terrestrial environment.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Imaging Radar Program.................. | 5,600 | 5,900 | 5,900 | 13,400 |
| Large format camera.................... | 600 | 200 | 200 | --- |
| Multispectral linear array/advanced spectrometer............,........... | 10,800 | 12,000 | 6,000 | 9,700 |
| Total............................ | 17,000 | 18,100 | 12,100 | 23,100 |

**OBJECTIVES AND STATUS**

The objective of this program is to develop, test, and evaluate Earth-viewing remote sensing instruments and systems to obtain data for land remote sensing research.

In FY 1985, preparations are continuing for a reflight of the Large Format Camera (LFC) and the Shuttle Imaging Radar-B (SIR-B). The SIR-B will obtain a quantitative assessment of the effect of various radar viewing geometries on the mapping of surface texture and topographic features. The SIR-B instrumentation is based on an upgraded SIR-A instrument including the addition of a variable look angle antenna, digital data handling, and increased bandwidth and resolution. Data will be recorded on-board and transmitted via the Tracking and Data Relay Satellite System (TDRSS). Following the reflight of SIR-B, use of the SIR-B components for use in building the next generation Shuttle Imaging Radar instrument will be reviewed. The SIR-C instrument will utilize multi-polarized, dual frequency sensor technology.

Advanced Spectrometer technology development activities include fundamental research in remote sensing involving a Multispectral Linear Array (MLA) and Imaging Spectrometer. The Imaging Spectrometer and MLA solid-state sensor research focuses on the development of such features as electronic scan, inherent geometric and spectral registration, and programmable high spatial and spectral resolution. The critical technology development and supporting research on the linear array focal plane and the Shuttle Imaging Spectrometer will continue.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

The decrease in the FY 1985 current estimate from the budget estimate reflects a partial offset of the increases in Space Communications to allow for initiation of the Advanced Communications Technology Satellite flight program design and development, and the increase in Materials Processing. The reduction was accommodated by the phaseout of NASA activities in the Multispectral Linear Array (MLA) technology development, as this technology is being overtaken by the capabilities of other remote sensing instruments, such as the solid state planar array technology of the Imaging Spectrometer which NASA has also been pursuing.

## BASIS OF FY 1986 ESTIMATE

FY 1986 funding is required for reflight of the Large Format Camera and the Shuttle Imaging Radar-B (SIR-B) plus data analysis. FY 1986 funding is also required for continued development of SIR-C technology, and for advanced spectrometer activities including the development of a Shuttle Imaging Spectrometer Experiment.

**BASIS OF FY 1986 FUNDING**

GEODYNAMICS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Crustal dynamics project................ | 17,500 | 18,700 | 18,000 | 18,500 |
| Laser network operations...... .......... | 7,500 | 8,000 | 8,000 | 8,500 |
| Research and technique development...... | 3,000 | 3,200 | 3,900 | 4,700 |
| Total........................... | 28,000 | 29,900 | 29,900 | 31,700 |

**OBJECTIVES AND STATUS**

The objective of the Geodynamics program is to understand the origin, evolution, and current state of the solid Earth by measuring the movement and deformation of the tectonic plates and by measuring its rotational dynamics and potential fields. Laser ranging, microwave interferometry and the global positioning satellites are used to determine precise position locations. The global gravity and magnetic fields are determined from satellite observations.

Measurements over the past five years have provided experimental verification of the velocities of several of the major tectonic plates. Measurements of regional deformation across the San Andreas Fault continue to indicate a relative movement of the Pacific and North American Plate of about 6 cm per year. In addition, new measurements indicate that about 4 cm of this movement is occurring in Southern California. Measurements of polar motion and changes in the length of day have been correlated, to a high degree, with variations in the angular momentum and the inertial balance of the Earth's atmosphere due to high altitude winds. In 1982 the Earth's rotation was found to have slowed by five milliseconds due to the El Nino effect. The Earth's rotational dynamics are also influenced by motions of the Earth's core and the oceans. Models of the Earth's gravity field, derived from Laser Geodynamics Satellite (LAGEOS-1) data have provided the first evidence of gravity field variations. These variations are believed to be caused by continued relaxation of the crust following the last ice age and have confirmed estimates of the viscosity of the Earth's mantle layer. Analysis of the magnetic field, using data from Magsat has confirmed (within a few percent) the diameter of the Earth's outer core (determined by seismological measurements) and has provided new data on secular variations of the magnetic field.

**CHANGES FROM FY 1985 BUDGET ESTIMATES**

In total, the FY 1985 current estimate remains the same as the budget estimate; however, an adjustment has beem made between the crustal dynamics project and research and technique development activities to augment the Caribbean studies.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, measurements of plate motion between North America and Europe will be continued in cooperation with NOAA and several European countries. Measurements of the motions of the Pacific Plate will also be continued in cooperation with DoD and Japan and will be extended to include China. In addition, regional crustal deformation measurements in the western North America will continue in FY 1986 in cooperation with NOAA, Canada and Mexico. Similar measurements will be initiated in Europe in cooperation with a consortium of 10 European, North African, and Mid-East countries. The Caribbean studies will be continued in FY 1986 and are expected to involve some 14 countries by 1988.

LAGEOS-1 and other satellites will continue to be used in FY 1986 for studies of plate motion. NASA systems in the U.S., Pacific, South America, and Australia will be operated in cooperation with laser systems in 12 other countries. Activities on LAGEOS-2, initiated in FY 1985, will be continued in FY 1986. The mission is being developed by Italy and will be launched by the U. S. in 1987.

Theoretical studies of crustal motion, internal Earth structure and composition, and the modeling and interpretation of geopotential fields will be continued in FY 1986. In addition, system studies of a second magnetic field satellite for long-term measurements of the Earth's field, studies of geopotential research and laboratory development of room-temperature and cryogenic gravity gradiometer instrumentation will be continued in FY 1986.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

RESEARCH AND ANALYSIS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Biogeochemical processes........... | 4,600 | 3,600 | 4,000 | 4,700 |
| Geological processes.............. | 5,100 | 5,500 | 5,100 | 6,300 |
| Hydrologic processes............... | 2,900 | 5,500 | 2,900 | 5,100 |
| Remote sensing science............ | 2,000 | 1,000 | 3,600 | 4,000 |
| Total........................ | 14,600 | 15,600 | 15,600 | 20,100 |

**OBJECTIVES AND STATUS**

The major objectives of the Solid Earth Observations research and analysis program are to develop remote sensing technology and to apply such technology to the study of the Earth's land surface.

Sensor system technology currently under development is needed to obtain measurements of Earth radiation in various portions of the electromagnetic spectrum. Typical questions encountered in this type of research concern the precision that can be achieved with specific techniques and tradeoffs involved when using specific sensor systems. Research is also conducted to develop procedures for extracting information about the Earth's surface from remotely sensed data. This type of research is concerned with such topics as pattern recognition; image segmentation and classification; modeling of scene components; atmospheric effects in remotely sensed imagery; and data base manipulation and merging. This wide range of technique development activities is designed to provide a new set of unique tools for Earth-related research of both a basic and applied nature.

The Research and Analysis program also involves the application of remote sensing methods to the study of the Earth. Research is typically conducted within specific disciplinary fields to determine the various types of ecological, geological, and hydrological information that can potentially be inferred from remotely sensed data. Global Earth phenomena currently under study includes the influence of vegetation upon the global carbon dioxide budget and other biogeochemical cycles, and rock weathering in arid regions. A wide range of topical problems have tentatively been identified as likely candidates for future research studies of an interdisciplinary nature.

In ecology and hydrology, the focus is on understanding how land processes, most of which are mediated by vegetation, interact with global processes relating to climate, the hydrological cycle, and the various biogeochemical cycles. The principal satellite sensors employed are the Thematic Mapper, the Landsat Multispectral Scanner, and the Advanced Very High Resolution Radiometer. Significant inputs are also being provided by other sensors such as the Shuttle Imaging Radar. In geology, research is underway to evaluate the utility of different remote sensing techniques for geological mapping, and to apply techniques of proven utility to the study of the Earth's crust. These basic crustal studies are expected to lead to an improved understanding of the physical processes responsible for the concentration of geological resources within the Earth's crust.

In addition, feasibility and conceptual design studies of future sensors and missions are being conducted to ensure future capabilities in remote sensing of Earth resources.

Select remote sensing projects are jointly conducted with outside cooperating organizations to apply remote sensing technology in a problem oriented setting. Joint research projects will continue to be carried out with public and private sector organizations involving predictive permafrost modeling in the Alaskan Arctic biomass; wetlands stratification for biogeochemical cycle modeling; assessment of vegetative stress from acid rain; crop condition assessment and monitoring; cropland conversion; timber resource inventory; facility site selection and waste disposal impact assessment; and land capability analysis. In addition, nine multi-disciplinary, university-based remote sensing centers will be maintained for the purpose of research, test, and evaluation of emerging remote sensing techniques.

## CHANGES FROM FY 1985 ESTIMATE

In total, the FY 1985 current estimate remains the same as the budget estimate: however, an adjustment has been made between the various Research and Analysis elements to more appropriately respond to future Earth Observations objectives.

## BASIS OF FY 1986 ESTIMATE

During FY 1986, the research and analysis disciplines will continue to make use of Landsat Thematic Mapper data. Radar data from the SIR-B will also be used to conduct further research. The FY 1986 Research and Analysis program will focus on the analysis of this new data to improve our understandings of long-term land processes, and develop some techniques for merging multisensor/multispectral data sets. Fundamental remote sensing science research on scene radiation and atmospheric effects will be continued, as will pattern recognition and image analysis. Advanced mission studies will be continued with emphasis on Shuttle-borne sensor feasibility studies and space platform payloads.

Investigations are being continued in FY 1986 to extend our basic understanding of sensor-target relationships in the optical, thermal, and microwave portions of the spectrum. Results to date indicate microwave measurements can be used to model vegetation canopies according to leaf, branch, and trunk components. This research also supports generic technique development to extract the full potential of information found in the image data. Results to date include a technique which can be used to identify spatially-related spectral patterns in image data which improves discrimination, for instance, between forested and agricultural fields, as well as between different densities of forest canopy.

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VATIONS

**RESEARCH AND DEVELOPMENT**

**FISCAL YEAR 1986 ESTIMATES**

**BUDGET SUMMARY**

**OFFICE OF SPACE SCIENCE *AND* APPLICATIONS** | **ENVIRONMENTAL OBSERVATIONS PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | | (Thousands of Dollars) | | | |
| Upper atmosphere research and analysis.. | 28,435 | 31,000 | 31,000 | 33,000 | RD 7-6 |
| Atmospheric dynamics and radiation research and analysis................. | 27,465 | 28,500 | 28,500 | 30,300 | RD 7-8 |
| Oceanic processes research and analysis.. .......................... | 18,200 | 19,400 | 19,400 | 20,600 | RD 7-10 |
| Space physics/research and analysis..... | 16,800 | 16,700 | 16,700 | 17,800 | RD 7-12 |
| Shuttle/Spacelab payload development.... | 7,600 | 7,800 | 7,800 | 5,600 | RD 7-14 |
| Operational satellite improvement program............................. | 600 | --- | --- | --- | --- |
| Earth radiation budget experiment....... | 15,500 | 8,100 | 8,100 | 2,000 | RD 7-16 |
| Extended mission operations..... ........ | 27,400 | 29,500 | 29,500 | 37,000 | RD 7-18 |
| Interdisciplinary research and analysis........ ..................... | --- | 1,000 | 1,000 | 1,000 | RD 7-21 |
| Tethered satellite payloads...... ....... | --- | 3,000 | 3,000 | 4,500 | RD 7-22 |
| Scatterometer.......................... | --- | 15,000 | 12,000 | 31,700 | RD 7-23 |
| Upper atmosphere research satellite mission.............................. | 20,000 | 60,700 | 55,700 | 134,000 | RD 7-25 |
| Total............................ | 162,000 | 220,700 | 212,700 | 317,500 | |

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Distribution of Program Amount by Installation | | | | |
| Johnson Space Center.................... | 159 | 800 | 466 | 477 |
| Marshall Space Flight Center............ | 5,630 | 9,046 | 8,485 | 10,315 |
| Goddard Space Flight Center............. | 95,615 | 133,136 | 126,220 | 206,466 |
| Jet Propulsion Laboratory............... | 23,541 | 38,973 | 36,661 | 56,057 |
| Ames Research Center.................... | 3,190 | 4,650 | 3,429 | 3,662 |
| Langley Research Center................. | 9,769 | 7,856 | 10,568 | 10,503 |
| National Space Techonology Laboratories. | 34 | --- | 235 | 237 |
| Headquarters. .......................... | 24,062 | 26,239 | 26,636 | 29,783 |
| Total............................ | 162,000 | 220,700 | 212,700 | 317,500 |

## OBJECTIVES AND JUSTIFICATION

The objectives of the Environmental Observations program are to improve our understanding of the processes in the magnetosphere, atmosphere, and the oceans; to provide space observations of parameters involved in these processes; and to extend the national capabilities to predict environmental phenomena, both short and long term, and their interaction with human activities. Because many of these phenomena are global or regional, they can be most effectively, and sometimes solely, observed from space. NASA's programs include scientific research efforts plus the development of new technology for global and synoptic measurements. NASA's research satellites provide a unique view of the radiative, chemical, plasma acceleration, and dynamic processes occurring in the magnetosphere, atmosphere, and oceans.

To achieve these goals, a number of significant objectives have been established for the next decade. These include advancing the understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere and their sources in the lower atmosphere; optimizing the use of space-derived measurements in understanding large scale weather patterns; advancing our knowledge of severe storms and forecasting capabilities, ocean productivity, circulation, and air-sea interactions; improving the knowledge of seasonal climate variability leading to a long-term strategy for climate observation and prediction; and enabling a comprehensive understanding of solar terrestrial processes and a detailed determination of the physics and coupling between the solar wind, magnetosphere, and ionosphere, and atmosphere.

Effective utilization of remote sensing requires a balanced set of activities including: analytical modeling and simulation; laboratory research of fundamental processes; development of instrumentation, flight of the instruments on the Space Shuttle and dedicated spacecraft; collection of *in situ* ancillary or validation data; and scientific analysis of data. The approach is to develop a technological capability with a strong scientific base and then to collect appropriate data, through remote and *in situ* means, which will address specific program objectives.

Studies of the upper atmosphere have led to a new assessment of the impact of chlorofluorocarbons on stratospheric ozone. New insight has been gained on the dependence of ozone depletion on the amount of chlorofluorocarbon release to the atmosphere. The importance of monitoring trace gases such as methane and nitrous oxide, which are both natural and man-made in origin, has been emphasized.

Three-dimensional models of the stratosphere are being developed to quantify our understanding of the interrelation of chemistry with dynamics and radiation. The record of satellite ozone measurements now extends for over a decade and is being used in studies to determine if there have been long-term trends in the average amount of global ozone which shields the Earth's surface from harmful ultraviolet radiation.

The Upper Atmospheric Research Satellite (UARS) will place a set of instruments in Earth orbit which will make a comprehensive measurement of the state of the stratosphere, providing data about the Earth's upper atmosphere in spatial and temporal dimensions which are presently unattainable. Detailed definition studies of the instruments have been completed, and the design and development activities have begun. Development of the UARS observatory will be well underway in FY 1986.

The Earth Radiation Budget Satellite (ERBS) was successfully launched in 1984, and data continues to be collected from the satellite. The ERBE instruments which will be flown on NOAA-G have been completed. NOAA-F was launched December 12, 1984, with a set of ERBE instrumentation; the NOAA-G launch is scheduled for August 1985. NASA is also continuing to support the National Oceanic and Atmospheric Administration (NOAA) by managing the implementation of the NOAA and Geostationary Operational Environmental Satellites (GOES) series on a reimbursable basis.

Design and development activities were initiated in FY 1985 on the Scatterometer, which will be flown on the Navy Remote Ocean Sensing System (N-ROSS) in mid-1989, to acquire global ocean data for operational and research usage by both the military and civil sectors.

The ability to perform temperature and moisture soundings of the atmosphere from geostationary orbit has been demonstrated by the flight of the NASA-developed visible/infrared spin-scan radiometer and atmospheric sounder instrument flown on the GOES spacecraft. The opportunity afforded by geostationary orbits to observe a localized region continuously will permit intensive study of the evolving temperature and moisture environment of severe local storms. Low Earth orbit sounding capabilities are now enabling the extension of forecast reliability from three to five days. In certain situations, reliable forecasts of eight to ten days duration have been achieved.

The Nimbus spacecraft continues to collect unique data which is being used in the study of long term trends of the Earth's atmosphere, oceans and polar ice, and provides near real time data. Collection and analysis of the Solar Mesophere Explorer (SME) data continues. The Dynamics Explorer continues to collect valuable data on magnetosphere-ionosphere coupling processes. In addition, the ISEE-3 spacecraft, renamed International Cometary Explorer, has completed an exploration of the Earth's geomagnetic tail and is being redirected toward a planned encounter in 1985 with the comet Giacobini-Zinner.

Along with the Solid Earth Observations program, the Environmental Observations activities compose an integral part of NASA's total Earth sciences and applications efforts, with emphasis on understanding the Earth as a planet, studying its dynamics, processes, habitability, and solar-terrestrial environment.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

UPPER ATMOSPHERE RESEARCH AND ANALYSIS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Upper atmosphere research............. | 17,000 | 18,700 | 18,700 | 19,900 |
| Stratospheric air quality research..... | 6,085 | 6,400 | 6,400 | 6,800 |
| Tropospheric air quality.............. | 5,350 | 5,900 | 5,900 | 6,300 |
| Total | 28,435 | 31,000 | 31,000 | 33,000 |

**OBJECTIVES AND STATUS**

The upper atmosphere research program is a comprehensive research and technology effort designed to investigate and monitor the phenomena of the upper atmosphere and related phenomena in the lower atmosphere. It is aimed at improving our basic scientific understanding of the global atmosphere and the methods needed to assess its susceptibility to significant chemical and physical change. The program's three major thrusts are in the areas of upper atmospheric research, stratospheric air quality research, and tropospheric air quality research.

In particular, the goal of the upper atmosphere research program is to understand the physics, chemistry and transport processes in the atmosphere on a global scale, and to assess as accurately as possible the perturbations to the atmosphere caused by man's activities. In order to accomplish this, efforts are underway to: (1) improve upper atmosphere and global troposphere models, validate them, and assess their uncertainties; (2) measure important trace chemical constituents, temperature, and radiation fields throughout the atmosphere; (3) develop sensors capable of making chemical and physical measurements of the upper atmosphere and the global troposphere both directly and remotely from space; (4) assemble and maintain the existing long-term data base of stratospheric and tropospheric ozone measurements to aid in the detection of long-timescale natural variations and man-made ozone changes; (5) determine the effects of global tropospheric chemistry on the atmosphere; (6) conduct theoretical and field studies of tropospheric/stratospheric exchange; and (7) carry out laboratory kinetics and spectroscopy investigations to support these activities.

A variety of *in situ* and remote sensing techniques are needed to meet the objectives of determining and understanding the distribution of ozone and other trace species in the atmosphere. Data sets from satellites are now generally available to the scientific community, including a record of the global distribution of ozone extending back over a decade, and simultaneous observations of a number of trace constituents for the winter of 1978-79. This data is being exploited to determine if trends in the ozone amount has been detected and to understand those processes which are directly involved with these trends.

## BASIS OF FY 1986 ESTIMATE

Recent developments in our understanding of the ozone layer have revealed a possible non-linear dependence of ozone depletion on the amount of fluorocarbon released to the atmosphere. These findings place increase urgency on the need to verify the completeness and accuracy of the theoretical stratospheric models. In FY 1986, tests of the models will be conducted by means of field measurements, model calculations, and interpretation of satellite data. The development of more realistic two- and three-dimensional models will be continued. The global data sets from past and present satellites will be further analyzed in FY 1986 to aid in the understanding of large-scale atmospheric processes.

The intercomparison of balloon, aircraft, and ground-based measurements will be continued in FY 1986 to ensure the validity of the different techniques that have been developed and to observe chemical species in the stratosphere and troposphere to determine the exchange of gases between the lower and upper atmosphere. These balloon and aircraft measurement programs are the only way to measure many of the localized phenomena of the atmosphere; they also help to validate satellite observations. Studies of potential new instruments for use on future satellites and suborbital measurement platforms will also be conducted in FY 1986 to ensure that new technologies are put to use in improving the capability and cost efficiency of tropospheric composition and upper atmosphere measurements.

## BASIS OF FY 1986 FUNDING REQUIREMENT

ATMOSPHERIC DYNAMICS AND RADIATION RESEARCH AND ANALYSIS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Global-Scale Atmospheric Processes Research and Analysis | 12,900 | 13,400 | 13,400 | 14,200 |
| Mesoscale Atmospheric Processes Research and Analysis | 7,300 | 7,550 | 7,550 | 8,000 |
| Climate Research and Analysis | 7,265 | 7,550 | 7,550 | 8,100 |
| Total | 27,465 | 28,500 | 28,500 | 30,300 |

## OBJECTIVES AND STATUS

The research and analysis activities within the Atmospheric Dynamics and Radiation program comprise a core effort which is fundamental to using space technology to solve problems in atmospheric science. The program's three main thrusts are in the areas of global-scale processes research, mesoscale processes research and climate research.

The objectives of the global scale research program are to improve our understanding of large-scale atmospheric behavior and to develop improved capability to observe the atmosphere from space; the program involves the development of advanced remote sensing instrumentation to observe the atmosphere, the development of advanced analysis techniques to utilize better existing meteorological satellite data, and development of advanced numerical models which use satellite observations to describe the state of the atmosphere both diagnostically and predictively. Recent accomplishments include the development of techniques which utilized passive multispectral data from the NOAA operational satellites to provide global maps of a number of key atmospheric and surface parameters. In addition, special attention has been devoted to developing active lidar techniques to provide detailed profiles of atmospheric temperature, pressure, and moisture data from future spaceborne platforms. Simulations of these advanced techniques indicate a great potential in meteorological prediction capability.

The objectives of the mesoscale processes research program are to improve our understanding of the behavior of the atmosphere on short (minutes to hours) time scales and over local to regional size scales (severe weather, such as tornadoes and hurricanes). Since the characteristic parameters of these mesoscale processes cannot be measured directly, new techniques are under study to derive the information from other observations which can be directly measured. Such an activity requires advanced data handling and analysis techniques which rely upon man-computer interactive display and manipulation. A joint NASA-NOAA project of this type was completed and is known as the Centralized Storm Information System. In the area of remote sensor development, successful flights of instrumentation on the ER-2 aircraft to observe cloud top dynamics have been completed, and a feasibility study of a potential lightning mapper has been completed.

The Climate Research Program seeks to develop a space capability for global observations of climate parameters which will contribute to our understanding of the processes that influence climate and its predictability. Research is focused in accordance with the National Climate Program wherein NASA has the role of lead agency for solar and Earth radiation research. Future study thrusts will be aligned with programs of solar irradiance monitoring, Earth radiation budget monitoring and analysis, the distribution and effect of cloud systems and stratospheric aerosols on the radiation budget, and selected process studies which relate to monitoring of climate change. The past year's activities have included extensive flight surveys to monitor the effect of the El Chichon volcano and observations by NASA research satellites and aircraft. The first results of the data phase of the International Satellite Cloud Climatology Project (ISCCP) have been sucessfully archived and detailed planning for the First ISCCP Regional Experiment (FIRE) has been initiated through a national project office located within NASA. Data from ISCCP and FIRE will be analyzed in conjunction with the Earth Radiation Budget Experiment (ERBE) data to improve our knowledge of cloud-radiation interactions which affect our climate. In addition, measurements of the solar irradiance will continue through the repaired Solar Maximum Mission (SMM) spacecraft, Nimbus 7 and reflights of the Active Cavity Radiometer flown on Spacelab-I.

**BASIS OF FY 1986 ESTIMATE**

FY 1986 funding is required to conduct aircraft flights to study the detail of flows around thunderstorms and fronts, continue comparison of models, study atmospheric scale interactions, and develop techniques to display model outputs in 3-dimensions. In FY 1986 three major interagency field experiments will significantly improve our understanding of the atmosphere for air/ocean interaction which generate crippling New England snowstorms (GALE), the physics of small strong downdrafts called microbursts which are on the scale of tornados (MIST), and the mechanism of regional precipitation quantification (SPACE) through space, aircraft, radar balloon, and surface-based observations. Other activities will involve continued retrieval and archiving of global International Satellite Cloud Climatology Project data sets, analysis of data from the Earth Radiation Budget Experiment and the Stratospheric Aerosol and Gas Experiment, and continued ground-based and rocket flight support €or solar irradiance monitoring. Technology development of active temperature, pressure, and moisture sounders as well as basic lidar technology development will also be continued in FY 1986.

**IS OF FY 6 FUNDING REQUIREMENT**

OCEANIC PROCESSES RESEARCH AND ANALYSIS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Research and analysis... ............ | 18,200 | 19,400 | 19,400 | 20,600 |

**OBJECTIVES**

The Oceanic Processes Research and Analysis (R&A) program emphasizes the development and application of spaceborne observing techniques to advance our understanding of the fundamental behavior of the oceans, as well as to assist users with the implementation of operational systems. As such, the program operates in concert with a variety of federal agencies (e.g., Navy, NOAA, NSF) and foreign countries (e.g., Canada, Europe, Japan).

The Oceanic Processes R&A program is organized into three discipline areas: (1) physical, (2) biological, and (3) polar oceanography. The spaceborne observational technique of prime importance, and its corresponding scientific use for each area are as follows. In physical oceanography, satellite scatterometers and altimeters are used to observe surface roughness and topography, from which surface winds and ocean current response can be estimated. In biological oceanography, color scanners are used to observe chlorophyll concentration, from which primary productivity can be estimated. In polar oceanography, microwave radiometers and synthetic apeture radars are used to estimate the characteristics of sea-ice cover and the details of its motion.

The Oceanic Process R&A program is actively pursuing scientific research with other federal agencies and foreign countries for the World Climate Research Program (WCRP). Component WCRP efforts include the Tropical Ocean/Global Atmosphere (TOGA) and World Ocean Circulation Experiments (WOCE), a Global Flux Experiment (GFE), and an Arctic Basin research effort (POLESTAR).

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, the physical oceanography research activities will include concentration on the experimental design for WOCE and TOGA, as well on the development of numerical models and associated data assimilation techniques for use in determining the general circulation of the oceans. In biological oceanography, the analysis of data from Nimbus-7 will be continued in order to help with the conceptual design of the Global Flux Experiment. In addition, preliminary design of the Ocean

Color Imager, including accommodation studies for the NOAA-K and SPOT-3 spacecraft, will be performed. In polar oceanography, emphasis will be placed on experimental design for the Artic Basic research effort (POLESTAR), as well as working with the World Data Center for Snow and Ice on processing and archival of microwave radiometer data. Activities will also be pursued on determining how to optimally process synthetic aperture radar data from the ERS-1 satellite. In addition, the transition of the Pilot Ocean Data System from a technical demonstration to a scientific support facility will be completed in FY 1986. Interagency coordination with the Office of Naval Research, NSF, and NOAA will be finalized for the utilization of spaceborne observing techniques in oceanographic research, including the definition of interfaces between the Pilot Ocean Data System and the computing facilities and/or data archives of other agencies.

Advanced technology development activities will also be continued on prospective future missions, e.g., TOPEX, etc.

## BASIS OF FY 1986 FUNDING REQUIREMENT

SPACE PHYSICS RESEARCH AND ANALYSIS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Plasma physics SR&T and data analysis.... | 10,900 | 11,500 | 10,500 | 12,300 |
| Advanced technology development.......... | 2,800 | 1,900 | 2,900 | 2,000 |
| Solar terrestrial theory.... ............. | 3,100 | 3,300 | 3,300 | 3,500 |
| Total............................ | 16,800 | 16,700 | 16,700 | 17,800 |

## OBJECTIVES AND STATUS

Space physics research and analysis is a broadly structured effort to enhance our understanding of the characteristics and behavior of plasmas in the solar corona, the interplanetary medium and in the vicinity of the Earth and other planets. These studies include: the complex coupling of the atmosphere with the ionosphere and the magnetosphere; the solar wind and how it interacts with planetary magnetospheres and ionospheres; and how variations in the solar wind are coupled into the near planetary environment and neutral atmosphere. This discipline also includes the conduct of active experiments to extract information under controlled conditions, and the use of space as a laboratory for the study of plasmas in parameter regimes that are unattainable on the Earth. The understanding of the plasmas in the solar system, the only naturally occurring plasmas to which we have direct access, will also enable us to refine theories regarding astrophysical plasma processes.

The major thrust of the space physics program is directed at studies of the near Earth environment, from the flow of the solar wind past the magnetosphere, to manifestations of variations of the plasma environment detectable near the surface of the Earth. Not only are these studies of great interest to the Earth sciences community, but also there are other practical components concerned with these aspects, such as ionospheric influences on communication, global circulation of the atmosphere driven by magnetospheric input, the charging of spacecraft immersed in plasma, and the behavior of antennas and their signals in the magnetosphere.

This field of research is one of relative maturity, with emphasis on multipoint, *in situ* measurements and on active perturbation experiments rather than isolated exploratory observations. For example, there are presently four spacecraft systems--the Interplanetary Monitoring Platform, the

International Sun-Earth Explorer (ISEE), Dynamics Explorer, and the Active Particle Tracer Explorers (AMPTE) taking such measurements. AMPTE has begun a program of coordinated chemical releases and plasma diagnostics to investigate solar wind plasma entry into the magnetosphere and energization as the plasma flows towards the atmosphere. There is an active program of sounding rocket and balloon investigations aimed principally at spatially or temporally isolated atmospheric, ionospheric or magnetospheric phenomena. Active theoretical, modeling and supporting laboratory activities are also being conducted.

The solar terrestrial theory activity continues to provide a strong basis for all of the programs in both solar physics and space plasma physics. Theoretical groups are engaged in research on virtually every aspect of the solar terrestrial problem by using both fundamental process calculations and numerical models of the large scale phenomena.

**CHANGES FROM FY 1985 ESTIMATE**

In total, the **FY** 1985 current estimate remains the same as the budget estimate. However, within the project, $1.0 million has been transferred from SRT to ATD activities to enhance the definition activities on the International Solar Terrestrial Physics Mission (ISTP).

**BASIS OF FY 1986 ESTIMATE**

During **FY** 1986, the space physics research and analysis activities will be continued with particular emphasis on the analysis of data from ISEE-3, which has spent most of 1983 in the Earth's magnetotail, and the International Cometary Explorer's (ICE) encounter of comet Giacobini-Zinner in 1985. Definition studies will be continued during **FY** 1986 on such missions as the potential cooperative Japanese and European International Solar-Tethered Satellite System and on the chemical release investigations in support to the Combined Chemical Release and Radiation Effects Satellite (CRRES) which is being developed by the Department of Defense.

The solar terrestrial theory program will be continued during **FY** 1986. In addition, a comprehensive and quantitative aggregate model of the solar-terrestrial interaction will continue to be developed.

**BASIS OF FY 1986 FUNIDNG REQUIREMENT**

SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT (ENVIRONMENTAL OBSERVATIONS)

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Measurement of air pollution from satellites (MAPS).................. | 700 | 650 | 500 | 500 |
| Atmosphere trace molecules observed by spectroscopy (ATMOS)............ | 2,600 | 2,000 | 1,600 | 1,800 |
| Active cavity radiometer (ACR, ACRIM)............................... | 2,200 | 2,000 | 2,000 | 900 |
| Light detection and ranging (LIDAR)... | 1,200 | 2,000 | 3,000 | 1,600 |
| Principal investigator instrument development and reflight program.... | 900 | 1,150 | 700 | 800 |
| Total........................... | 7,600 | 7,800 | 7,800 | 5,600 |

**OBJECTIVES AND STATUS**

The Space Transportation System offers the unique opportunity for frequent short-duration flights of instruments. The Environmental Observations program has incorporated this capability into the Shuttle/Spacelab payload development activities in these important aspects: early test, checkout and design of remote sensing instruments for long duration free-flying missions; and short-term atmospheric and environmental data gathering for basic research and analysis where long-term observations are impractical.

The Measurement of Air Pollution from Satellites (MAPS) experiment is a gas-filter correlation radiometer designed to measure the levels of tropospheric carbon monoxide and the extent of interhemispheric mass transport in the lower atmosphere. The instrument was flown successfully on two Shuttle flights. It is approved for four flights, one for each season of the year to provide the first observations of the global seasonal variation of carbon monoxide in the Earth's atmosphere. Reflight of MAPS is planned on both OSTA-5 and -7 missions.

The objective of the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS) experiment is to make detailed measurements of gaseous constituents (e.g., hydrogen chloride, water, ammonia, methane) in the Earth's atmosphere by using the technique of infrared absorption spectroscopy. The data will help determine the compositional structure of the upper atmosphere, including the ozone layer and its spatial variability on a global scale. The instrument is scheduled for launch in 1985 on Spacelab-3; it will be reflown on the Earth Observation Mission (EOM) series in 1985/86.

In response to an Announcement of Opportunity, a number of principal investigator class instruments were selected for development. Payloads currently under development include the Active Cavity Radiometer-I (ACR-1) which is designed to aid in the study of the Earth's climate and the physical behavior of the Sun. Reflights of ACR-1 on future EOM missions are planned. Other experiments have also been selected for reflight, including some instruments which were flown on the Shuttle orbital flight tests and on Spacelab 1.

**CHANGES TO FY 1985 BUDGET ESTIMATE**

In total, the FY 1985 current estimate remains the same as the budget estimate; however, there has been some transfer of funds with the Shuttle/Spacelab Payload Development elements to allow for an increase in the range of LIDAR development activities.

**BASIS OF FY 1986 ESTIMATE**

FY 1986 funds will be used to support the Measurement of Air Pollution from Satellites (MAPS) science team activities including data reduction, refurbishment for reflight and upgrading of the ground service equipment and new data recorder.

The initial flight of the Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) instrument is scheduled for 1985. The FY 1986 funding is required to support the continued science team activities, data processing and analysis of the data, and refurbishment reflight in 1986.

FY 1986 funding is also required to continue the Active Cavity Radiometer (ACR) data processing, science team activities, and refurbishment for reflight on a future Shuttle mission. Definition studies of a potential free-flyer version of ACR will also be undertaken. The principal investigator instrument development and reflight program will be continued with research efforts concentrated on atmospheric chemistry, solar intensity and variability, and upper atmospheric winds.

Development activities will continue on the Light Detection and Ranging (LIDAR) instrumentation following completion of preliminary definition, breadboard laboratory activites, and conceptual design reviews.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### EARTH RADIATION BUDGET EXPERIMENT

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Spacecraft.............................. | 4,900 | --- | --- | --- |
| Sensors.............................. | 3,700 | --- | --- | --- |
| Mission operations and data analysis... | 6,900 | 8,100 | 8,100 | 2,000 |
| Total........................... | 15,500 | 8,100 | 8,100 | 2,000 |

## OBJECTIVES AND STATUS

The objective of the Earth Radiation Budget Experiment (ERBE) is to measure the temporal and spatial variations in the Earth's radiation budget to gain basic insight into the causes for climatic fluctuations.

Experimental Earth radiation budget instruments have been flown on the Nimbus satellites. Sampling studies based on those experiments have shown that adequate global coverage requires a multiple satellite system. These studies also indicate the need for improved calibration of the sensors and measurements covering at least one full cycle of seasons. In order to provide adequate and meaningful coverage, identical Earth radiation budget instruments are being installed on the NOAA-F and NOAA-G satellites and on one dedicated NASA observatory (ERBS). The scientific objectives and measurement requirements were developed by a combined NOAA/NASA/university/industry team of scientists.

In addition to the ERBE instruments, the NASA observatory carries the Stratospheric Aerosol and Gas Experiment (SAGE II) which provides aerosol measurement data.

The ERBS spacecraft was completed in 1983 with instrument integration completed in early 1984. The ERBS was launched by the Space Shuttle to an altitude of 300 km and then propelled to the operational altitude of 610 km by an auxiliary on-board propulsion system in October, 1984. The other ERBE instruments are being flown on NOAA-F and NOAA-G; NOAA-F was launched in December 1984, and NOAA-G is planned for launch in early 1986.

**BASIS OF FY 1986 ESTIMATE**

The FY 1986 funding is required to support the operation of ERBS and analysis of the data collected by experiments on ERBS, NOAA-F and NOAA-G. This flight data will be used to update the existing climate models.

EXTENDED MISSION OPERATIONS (ENVIRONMENTAL OBSERVATIONS)

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Operations for the extended mission of: | | | | |
| Nimbus 7 | 7,300 | 7,700 | 7,200 | 6,600 |
| Stratospheric aerosol and gas experiment (SAGE) | 300 | --- | --- | --- |
| Solar mesosphere explorer (SME) | 2,600 | 2,300 | 2,400 | 2,300 |
| Solar backscatter ultraviolet instrument/corrective measurement | 2,200 | 1,650 | 2,300 | 1,400 |
| Earth radiation budget experiment extended operations | 200 | 900 | 1,300 | 7,100 |
| Active magnetospheric particle tracer explorer extended operations | --- | 800 | 600 | 3,800 |
| International Sun-Earth explorers | 5,200 | 6,600 | 6,400 | 6,600 |
| Interdisciplinary monitoring platform | 600 | 650 | 600 | 600 |
| Dynamics explorer extended operations | 9,000 | 8,900 | 8,700 | 8,500 |
| San Marco extended operations | --- | --- | --- | 100 |
| Total | 27,400 | 29,500 | 29,500 | 37,000 |

**OBJECTIVES AND STATUS**

The objectives of the extended mission operations is to provide for the operations, data processing, validation and data analysis of missions which have completed basic operations.

Launched in 1978, the Nimbus-7 spacecraft continues to provide significant quantities of global data on sea ice coverage, atmospheric dynamics and chemistry, the Earth's radiation budget, ocean temperature and ocean color. Preliminary evaluation of data has demonstrated the utility of these measurements, and the instrument techniques are being used on operational satellites. Reduction and validation of this data is continuing, as is the operation of the satellites themselves. There is a strong demand for both historical and current data on radiation budget, atmospheric dynamics, and trace constitutent concentrations and distribution; all of this data is used for global weather trend studies, severe storm analysis and prediction, improved numerical forecast models, ozone concentration trend analysis, and Earth climate studies.

The Solar Mesosphere Explorer (SME), launched in October 1981, is providing major input to our overall atmospheric parameter data base. SME is producing simultaneous measurements needed to understand the complex chemical processes taking place in the mesosphere, including data measurements of ozone, atomic oxygen, nitric oxide and temperature. All instruments are functioning well. Early data results indicate greater short-term variations and magnitude than was expected of many of the mesospheric properties. A ground truth program to aid in the validation of the SME data is also being undertaken. SME is providing excellent data on the effect of volcanoes on the Earth's atmosphere and long-term effects on the climate through the El Chichon measurements.

Solar terrestrial research activities rely on data received from the International Sun-Earth Explorers, the Interplanetary Monitoring Platform (IMP), and the Dynamics Explorers which are still operational. Recent analysis of DE-1 data have shown coupling of plasma and mesospheric chemistry. IMP continues to provide the only available source of solar wind input measurements to the Earth. The combined measurements of ISEE-1 and -2 in the same eccentric orbit continue to provide important data to study the structure and motions of the essential magnetospheric boundaries, bow shock, magnetopause, plasma pause and sheet. ISEE-3 made important first time measurements of solar wind-magnetosphere interraction in the Earth's distant geotail. The ISEE-3 spacecraft, renamed the International Cometary Explorer (ICE), is presently traveling towards an encounter with the Giacobini-Zinner Comet in 1985. ICE will also provide complementary solar wind measurements upstream of Comet Halley in late 1985 and early 1986.

**CHANGES FROM 1985 BUDGET ESTIMATE**

In total, the FY 1985 current estimate remains the same as the budget estimate; however, there has been some adjustments within the extended operations program to better align the funding with the actual operating spacecraft requirements.

**BASIS OF FY 1986 ESTIMATE**

FY 1986 funding is required to support continuing mission operations and data analysis activities for the International Sun-Earth Explorers, the Interplanetary Monitoring Platform and the Dynamics Explorers. Extended operations support of the Active Magnetospheric Particle Tracer Explorer, which was launched in 1984, will be continued in FY 1986. Operation of the Nimbus and SME satellites and processing of the collected data will be continued as will activities to provide ground truth for a NASA-developed ozone instrument to be flown on a NOAA weather satellite. The SME and Nimbus satellites continue to produce extremely valuable data on ozone concentrations which will be used to estimate the occurrence of natural variations, sea surface temperatures, aerosol measurements, and ocean productivity. Correlative ground truth activities will also be continued in FY 1986; these in situ observations are needed to verify the quality of remote observations and improve our ability to interpret them. In addition, FY 1986 funding is required for operation and data analysis activities associated with the Earth Radiation Budget Satellite, which was launched in 1984.

## INTERDISCIPLINARY RESEARCH

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Interdisciplinary Research and Analysis.... | --- | 1,000 | 1,000 | 1,000 |

**OBJECTIVES AND STATUS**

Interdisciplinary research activities need to be conducted to characterize quantitatively the Earth's chemical, physical, and biological processes on the land, along with the interactions between the land, the oceans, and atmosphere, which are of particular importance in assessing the impact of these phenomena on global, physical, and biogeochemical processes. Such research is essential to investigating and assessing long-term physical, chemical, and biological trends and changes in the Earth's environment.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, interdisciplinary studies will be continued with emphasis on integrating discipline-specific research activities of Oceanic Processes, Atmospheric Dynamics and Radiation, Upper Atmosphere/Tropospheric Chemistry, and Land Processes into a unified program which will help increase our understanding of critical global processes. Emphasis will be placed on initiating specific pilot studies of land-atmosphere and ocean-atmosphere interactions in energy, water, and key nutrient cycles.

## TETHERED SATELLITE PAYLOADS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Tethered Satellite Payloads........... | --- | 3,000 | 3,000 | 4,500 |

**OBJECTIVES AND STATUS**

The Tethered Satellite System (TSS) will provide a new facility for conducting experiments weighing 500 kg or less from distances of 100 km above or below the Space Shuttle. The TSS will allow unique science to be undertaken such as observations of atmospheric processes occurring within the lower thermosphere (below 180 km altitude), new observations of crustal geomagnetic phenomena, and direct observation of magnetospheric-ionospheric-atmospheric coupling processes in the 125-180 kilometer region. In addition, the satellite, coupled to the conducting tether, can generate large amplitude hydromagnetic waves and electrodynamic waves in the local space plasma, thus enabling active space plasma and magnetospheric physics experiments to be performed. The objective of the initial TSS mission is to verify the controlled deployment, retrieval and on-station stabilization of the satellite tethered from the orbiter, and to carry out scientific research using a conducting tether extended 20 km above the orbiter. NASA is providing the scientific payloads €or the initial flight of the TSS.

The TSS is an international cooperative project with the Italian government. The United States is developing the tether deployment and retrieval system, is responsible for overall project management and system integration, for development and integration of the instruments, and flight on the Shuttle. Italy is developing the satellite and is responsible for development and integration of European investigations. An Announcement of Opportunity for investigations was issued in April 1984. Selection of investigators is expected in early 1985 after which instrument design will be initiated. Some program delays are currently being encountered by the Italians in the development of the satellite, and the launch schedule is being reevaluated.

**BASIS OF FY 1986 ESTIMATE**

The FY 1986 funding is required to continue design and development activities on the scientific instruments for flight on the Tethered Satellite System.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### SCATTEROMETER

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Scatterometer.......................... | --- | 15,000 | 12,000 | 31,700 |

## OBJECTIVES AND STATUS

The purpose of the Navy Remote Ocean Sensing System (N-ROSS) is to acquire global ocean data for operational and research usage by both the military and civil sectors. A Scatterometer sensor is required to meet the objectives of this mission. NASA will provide the Scatterometer sensor and the Department of Defense will provide the N-ROSS spacecraft and launch services for a launch in mid-1989.

The Scatterometer will provide accurate, global measurements of ocean surface winds which will be useful for both oceanography and meteorology. In addition to satisfying Navy operational requirements for providing wind field data, Scatterometer data will permit the first global study of the influence of winds on ocean circulation, provide data on the effects of the oceans on the atmosphere, and provide improved marine forecasting (winds and waves). Flight of the N-ROSS in mid-1989 will provide an overlap of data gathering with the World Ocean Circulation Experiment planned by the international oceanographic community. The feasibility of using the Scatterometer technique from space to accurately measure winds was demonstrated by Seasat in 1978.

Definition studies conducted by NASA during FY 1983 and early FY 1984 have resulted in the determination that the performance requirements as stated jointly by the research community and the Navy can be satisfied by utilizing system design concepts similar to those used on the Seasat Scatterometer. The major improvements include the addition of two antennas for improved wind direction determination and the addition of digital filtering to compensate for earth rotational effects. In FY 1985, the design and development activities were initiated, not only on the Scatterometer instrument, but also on the ground data processor which will utilize research quality algorithms to process the scatterometer raw data into geophysical products for utilization by the oceanographic and meteorological research communities. An Announcement of Opportunity (AO) for specific research investigations using Scatterometer data will be released in FY 1985.

**CHANGES FROM 1985 BUDGET ESTIMATE**

The $3.0 million decrease is the result of a slip in the launch of the Navy Remote Ocean Sensing System (N-ROSS) from 1988 to 1989.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, design and development of the Scatterometer will be continued leading to the scheduled launch in mid-1989. In particular, design and development activities on the transmitters, antennas, and Radio Frequency Subsystem (RFS) will be intensely pursued.

BASIS OF FY 1986 FUNDING REQUIREMENT

UPPER ATMOSPHERE RESEARCH SATELLITE PROGRAM

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Spacecraft............................ | --- | 25,700 | 20,700 | 80,200 |
| Experiments.... ........................ | 20,000 | 35,000 | 35,000 | 53,800 |
| Total............................ | 20,000 | 60,700 | 55,700 | 134,000 |

**OBJECTIVES AND STATUS**

The Upper Atmosphere Research Satellite (UARS) program is the next logical step in conducting a comprehensive program of research, technology development and monitoring of the upper atmosphere aimed at improving basic scientific understanding. This mission is essential for understanding the key radiative, chemical and dynamical processes which couple together to control the composition and structure of the stratosphere. The UARS mission will provide the first integrated global measurements of: ozone concentration; chemical species that affect ozone; energy inputs; temperature; and winds in the stratosphere and mesosphere. These measurements will complement the measurements of ozone and of atmospheric parameters affecting ozone that were made on Nimbus and SAGE. The UARS program is a critical element in overall stratospheric research and monitoring efforts; it will provide the first full data set on stratospheric composition and dynamics which will be required when very difficult decisions must be made in the future regarding production of chlorofluorocarbons. The UARS mission will also contribute to the assessment of the impact of stratospheric changes on our climate and will provide the data needed €or a full understanding of the stratosphere. These understandings are essential for subsequent design and implementation of a long-term stratospheric monitoring activity.

A final selection of eleven experiments has been made, including infrared and microwave limb sounders which require advances in cryogenics, solid-state devices and microwave antennas beyond earlier capabilities. The instrument design and development activities are underway. In addition, development of the central ground data handling facility, which will permit near-realtime interactive utilization of data by the twenty-one design and theoretical investigator teams, is underway.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

The $5.0 million decrease reflects a partial offset of the increase in Space Communications to allow for initiation of the Advanced Communications Technology Satellite flight program design and development, and in Materials Processing made in general consonance with authorization action. The decrease, in consonance with authorization action, has been accommodated by the rephasing of activities within the project.

## BASIS OF FY 1986 ESTIMATE

The **FY** 1986 funds are required for continuation of the design and development activities on the UARS instruments leading to the critical design review €or approximately one-half of the full instrument complement. In addition, the spacecraft design and development activities will be continued in **FY** 1986, leading to the observatory preliminary design review in 1986 and the critical design review in early 1987.

The ground data handling facility will enable a higher level of interaction among experimenters and theoreticians than has existed with past programs. Implementation of this concept requires that it be designed early in the UARS design and development activities so that individual experiment data processing subsystems, including algorithms, and the interactive data base in the design and development phase provide maximum interaction and effectiveness. Therefore, **FY** 1986 funding is also required for the continued design of the ground data handling facility and algorithm development, and to support the science team.

MATERIALS
PROCESSING
IN SPACE

**RESEARCH AND DEVELOPMENT**

**FISCAL YEAR 1986 ESTIMATES**

**BUDGET SUMMARY**

**OFFICE OF SPACE SCIENCE AND APPLICATIONS** — **MATERIALS PROCESSING IN SPACE PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | | (Thousands of Dollars) | | | |
| Research and analysis............. | 11,000 | 11,700 | 11,700 | 12,400 | RD 8-3 |
| Materials experiment operations.... | 14,600 | 11,300 | 15,300 | 21,600 | RD 8-4 |
| Total........................ | 25,600 | 23,000 | 27,000 | 34,000 | |
| **Distribution of Program Amount by Installation** | | | | | |
| Johnson Space Center.............. | 1,786 | 2,000 | 2,212 | 3,150 | |
| Marshall Space Flight Center....... | 7,603 | 7,300 | 9,106 | 10,980 | |
| Lewis Research Center............. | 5,207 | 4,550 | 5,754 | 6,700 | |
| Langley Research Center........... | 390 | 750 | 1,355 | 1,200 | |
| Jet Propulsion Laboratory.......... | 6,362 | 5,900 | 5,485 | 8,075 | |
| Headquarters..... .................. | 4,252 | 2,500 | 3,088 | 3,895 | |
| Total........................ | 25,600 | 23,000 | 27,000 | 34,000 | |

**OFFICE OF SPACE SCIENCE AND APPLICATIONS** **MATERIALS PROCESSING IN SPACE PROGRAM**

**PROGRAM OBJECTIVES AND JUSTIFICATION**

The Materials Processing in Space program emphasizes the science and technology of processing materials to understand constraints imposed by gravitational forces and the unique capabilities made possible by controlling these processes in the space environment. Ground-based research, technology development, and payload definition activities in FY 1985 are being concentrated on six major processing areas: metals and alloys, electronic materials, glass and ceramics, biotechnology, combustion, and fluid dynamics and transport phenomena. These activities will provide the scientific basis for future space applications of materials processing technology as well as provide a better understanding of how these processes occur on the ground. Definition studies will be performed for Shuttle experiment candidates in areas such as containerless experiments, combustion science, solidification and crystal growth, and blood storage. Also included are maintenance of capabilities for experimentation in drop tubes, towers, and aircraft. An outreach program, consisting of technical publications, workshops, experiment accommodation studies and support for Joint Endeavor and Technical Exchange Agreements, are included in this program.

Materials Experiment Operations is a consolidation of ongoing activities which provide a range of experimental capabilities for all scientific and commercial participants in the materials processing program. These include Shuttle mid-deck experiments, the Materials Experiment Assembly and the Materials Science Laboratory, which is carried in the orbiter bay. These capabilities will enable users to develop different experiments in a cost-effective manner and allow a better understanding of the technical risks associated with experiment concepts before attempting to develop more complex hardware. In addition, reflight of investigations on Shuttle/Spacelab missions and the mid-deck is provided for in Materials Experiment Operations.

**BASIS OF FY 98 FUNDING REQUIREMENT**

RESEARCH AND ANALYSIS (MATERIALS PROCESSING)

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Ground-based investigations, analysis and studies............ | 11,000 | 11,700 | 11,700 | 12,400 |

**0 AND STATUS**

The research and analysis activity provides the scientific foundation for all current and future projects in the microgravity science and applications program. Emphasis is placed on ground-based research which is expected to evolve into space investigations with potential for future applications. This activity also supports technology development for future ground and space capabilities, and commercialization activities leading toward privately-funded space enterprises. Most research projects are initiated as a result of proposals from the scientific community which are extensively peer reviewed prior to selection. The FY 1985 funding is being used to support ongoing research in infrared detector materials, spherical shell technology, floating zone crystal growth, separation and synthesis of biological materials, fluid flow effects in materials processing, combustion science, and containerless processing techniques. Coordinated activities with the NASA Commercialization Office will continue with studies of institutional arrangements associated with joint NASA/industry ventures, information activities directed toward industry involvement in microgravity science and applications projects, and early negotiations and continuing technical support with companies interested in undertaking joint space endeavors with NASA.

**BASIS OF FY 1986 ESTIMATE**

Ground-based research and analysis will be continued in FY 1986 in the areas of metals and alloys, electronic materials, glass and ceramics, biotechnology, combustion, and fluid dynamics and transport phenomena. Research will be conducted to define the role of gravity-driven influences in generic processing methods. Effort will continue at the centers for bioprocessing research located at the University of Arizona and the University City Science Center in Philadelphia, PA as well as the Microgravity Materials Science Lab at the Lewis Research Center.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### MATERIALS EXPERIMENT OPERATIONS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Materials experiment operations........ | 14,600 | 11,300 | 15,300 | 21,600 |

## OBJECTIVES AND STATUS

The materials experiment operations program provides a wide range of opportunities for scientific and commercial experiments in microgravity science and applications. Development of Shuttle mid-deck and cargo bay experiments are supported under this activity. Preliminary data analysis on Shuttle experiments already flown has shown promising results.

## CHANGE FROM FY 1985 BUDGET ESTIMATE

The increase of $4.0M reflects a reallocation of funds from other areas of the Space Applications program in consonance with Congressional action. The funding increase will be used to augment the materials processing flight experiment activities, and to initiate the development of two new Physics and Chemistry Experiments: the Lambda Point of Helium and Solid Surface Combustion.

## BASIS OF FY 1986 ESTIMATE

**FY 1986** funding is required to continue basic and applied research activities using mid-deck and cargo bay experiments leading to several flights over the next few years. Investigations will be conducted in electronic materials biotechnology and combustion. Development will begin on a number of Physics and Chemistry Experiments (PACE).

COMMUNICATIONS

**RESEARCH AND DEVELOPMENT**

**FISCAL YEAR 1986 ESTIMATES**

**BUDGET SUMMARY**

**OFFICE OF SPACE SCIENCE AND APPLICATIONS** | **COMMUNICATIONS PROGRAM**

SUMMARY OF ES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | (Thousands of Dollars) | | | | |
| Advanced Communications Technology Satellite (ACTS) | 25,000 | 5,000 | 45,000 | 90,000 | RD 9-4 |
| Research and analysis | 8,500 | 9,100 | 9,100 | 10,600 | RD 9-6 |
| Search and rescue | 3,800 | 2,400 | 2,400 | 1,300 | RD 9-8 |
| Technical consultation and support studies | 2,700 | 2,900 | 2,900 | 3,100 | RD 9-10 |
| Experiment coordination and operations support | 1,100 | 1,200 | 1,200 | 1,200 | RD 9-11 |
| Total | 41,100 | 20,600 | 60,600 | 106,200 | |

Distribution of Program Amount by Installation

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| Goddard Space Flight Center | 4,775 | 4,300 | 3,787 | 2,720 |
| Jet Propulsion Laboratory | 4,342 | 3,350 | 4,400 | 6,000 |
| Ames Research Center | 258 | 680 | --- | --- |
| National Space Technology Laboratories | 20 | --- | --- | --- |
| Langley Research Center | 50 | --- | --- | --- |
| Lewis Research Center | 30,422 | 11,050 | 49,750 | 94,200 |
| Headquarters | 1,233 | 1,220 | 2,663 | 3,280 |
| Total | 41,100 | 20,600 | 60,600 | 106,200 |

## OBJECTIVES AND STATUS

The objective of the Advanced Communications Technology Satellite (ACTS) program is to prvve the feasibility of certain advanced communications satellite technologies through a flight test program. These technologies, including a multibeam antenna, baseband processor, RF matrix switch, traveling wave tube amplifier, and low noise receiver, will be applicable to a wide range of communications systems in the 1990's. A contract was awarded to RCA in August 1984 for development of the ACTS system.

The Communications Research and Analysis program continues to provide development of component and device technology required by NASA, other government agencies, and U.S. industry for advanced communications satellite systems. Big payoff items leading to greater spectrum and bandwidth efficiency are being pursued. In addition, in FY 1985, the Mobile Satellite activities will continue to address the development of critical enabling technologies needed to insure growth of a commercial mobile satellite service. This effort, in cooperation with U.S. industry, Canada, and other government agencies, will help implement a first generation system with a launch in the late 1980's.

The Search and Rescue program is an international cooperative program that demonstrates the use of satellite technology to detect and locate aircraft or vessels in distress. The United States, Canada, France, and the Soviet Union developed the system, in which Norway, the United Kingdom, and Sweden also participate. Three COSPAS satellites are currently in operation, and NOAA-F was successfully launched on December 12, 1984. Over 350 lives have been saved in numerous incidents worldwide, and the list continues to grow on a weekly basis. During FY 1984, the demonstration and evaluation phase of the program was officially completed, and a new agreement was signed to continue operation of the system.

The technical consultation and support program will continue to provide for studies of radio interference, propagation and special systems required for the growth of existing satellite services and the extension of new satellite applications. Support to the Department of State, the Federal Communications Commission, the National Telecommunications and Information Administration, and the Federal Emergency Management Agency in the development of frequency and orbit sharing techniques and strategies for upcoming World Administrative Radio Conferences (WARC's) are continuing.

The experiment coordination and operations support program assists other federal agencies and public sector organizations in the development of experimental satellite communications for emergency, disaster and public service applications. Operations of the Applications Technology Satellites (ATS) 1 and 3 are continuing through contracts with universities. ATS-5 was turned of€ in March 1984.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Advanced communications technology satellite.......................... | 25,000 | 5,000 | 45,000 | 90,000 |
| Space transportation system operations | (---) | (---) | (---) | (2,300) |

**OBJECTIVES AND STATUS**

The objective of the Advanced Communications Technology Satellite (ACTS) program is to prove the feasibility of certain advanced communications satellite technologies through a flight test program. The specific technologies to be validated include: (a) the use of multiple fixed and scanning spot antenna beams; (b) frequency reuse; (c) beam interconnectivity at both intermediate frequencies and at baseband; (d) advanced system network concepts; and (e) dynamic rain-compensation techniques. These technologies will be applicable to a wide range of communications systems in the 1990's. A contract was signed in August 1984 with RCA to develop the flight and ground hardware leading to a 1989 launch. TRW, Comsat, Motorola, Electomagnetic Sciences, Hughes, and other manufacturers are major subcontractors.

The ACTS spacecraft will be launched from the Shuttle into geostationary orbit. The spacecraft will consist of a commercial communications bus and a multibeam communications package, including a multibeam antenna, baseband processor, RF matrix switch, traveling wave tube amplifier, and low noise receiver. The ground segment will consist of a NASA ground station and a master control station. Following launch and checkout, a two-year program of user-funded experiments will be initiated, during which time ACTS system technologies will be tested, evaluated, and validated. Over 40 organizations, including DOD, have requested consideration for experiment opportunities on ACTS to date.

**CHANGES FROM 1985 ESTIMATE**

The increase in the FY 1985 current budget reflects the result of appropriation and authorization action to provide for initiation of the Advanced Communications Technology Satellite flight program design and development activities leading to a 1989 launch.

**BASIS OF FY 1986 ESTIMATE**

FY 1986 funding is required for the continued design and development of the spacecraft bus, the communications electronics package, the baseband processor, and the multibeam antenna leading to the system preliminary design review in 7986. The development of the NASA ground station and the software needed for the master control station will be initiated in FY 1986.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

RESEARCH AND ANALYSIS (COMMUNICATIONS)

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Interconnectivity and RF Technologies........................ | 5,700 | 6,700 | 6,700 | 6,600 |
| Mobile Communications Technologies.... | 2,800 | 2,400 | 2,400 | 4,000 |
| Total........................... | 8,500 | 9,100 | 9,100 | 10,600 |

**OBJECTIVES AND STATUS**

The Communications Research and Analysis program emphasizes the development of high-risk technology required to maintain U.S. preeminence in the international satellite communications market, and to meet the communications needs of NASA and other government agencies. The technological thrust of this activity is aimed at the "interconnectivity technologies" of on-board switching, intersatellite links, and antennas, as well as the conventional RF technologies. Advanced studies are performed to determine the future satellite communications needs of the country, and to define the technology required to meet those needs. The technology is developed and tested through an advanced proof-of-concept (POC) program. The POC devices and components are then integrated into a multiple terminal, satellite communications network in a laboratory where they undergo comprehensive evaluation.

In FY 1985, phase two of the baseband processor large scale integrated circuit development which is needed to reduce power and weight of a flight baseband processor is continuing. Advanced signal design activities that will investigate modulation techniques to increase power and spectrum efficiency have been initiated. The development of monolithic switch and receiver technology is underway. Testing and evaluation of ACTS proof-of-concept hardware is continuing under simulated space flight conditions. Efforts are also continuing on the design and development of laser intersatellite link communications systems.

The mobile communications technologies activity is aimed at accelerating the introduction of a commercial mobile satellite service in the U.S., and developing power, bandwidth and orbital-slot efficient ground segment technology and networking techniques needed to insure its growth. The Mobile

Satellite, which has been formally coordinated with Canada is expected to be implemented through a Joint Endeavor Agreement (JEA) as follows: a U.S. system operator, who would procure, own and operate the satellite, would supply a small percentage of the satellite channel capacity to NASA for use in terminal hardware validation and in carrying out other government experiments, and the operator would utilize the additional channel capacity to develop commercial markets. In exchange, NASA would provide standard launch services.

In FY 1985, development efforts on ground segment technology will continue. Definition of low cost, high gain rooftop vehicle antennas that can at least double the number of orbital slots available has been completed. Functional design is continuing on terminal and networking techniques that will result in power/bandwidth efficient voice transmissions (approximately six times greater than the new cellular terrestrial technology) and information (voice plus data) throughput increases. NASA will continue to work with other government agencies on experiment requirements and definition. Toward this goal and to foster cooperation during the experimental phase, six Mememorandum of Understanding (MOU's) have been signed to date.

**BASIS OF FY 1986 ESTIMATE**

During FY 1986, advanced studies to determine the functional and technical requirements necessary to support the assembly, checkout, launch, and servicing of a large geostationary platform, and the system interfaces with Space Station, will be initiated. The design and development of engineering model laser power summing systems, lightweight optical antennas, and a high data rate laser communications terminal for a laser intersatellite communications system will be continued. Market and traffic studies, which focus on future high risk communications technology needs, will also be continued in FY 1986, as will efforts to develop high efficiency traveling wave tube (TWT) transmitters and high power solid state transmitters.

In FY 1986, all functional design and specficiation work necessary to define power, frequency, and orbital-slot efficient mobile terminal designs and networking algorithms will be completed. Development work on advanced speech compression techniques will be continued in FY 1986. Breadboard development of the high gain rooftop antenna will be completed and test and evaluation will be initiated. Additional mobile-terminal related breadboard development and design/development of the small ground station needed to control the experimental network will be initiated in FY 1986. NASA will also continue to supply technical assistance to other government agencies on experiment definition.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### SEARCH AND RESCUE

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Search and rescue................... | 3,800 | 2,400 | 2,400 | 1,300 |

## OBJECTIVES AND STATUS

The Search and Rescue program is demonstrating the feasibility of using satellites to significantly improve the capability of search and rescue forces to detect and locate general aviation aircraft and marine vessels during emergencies. This satellite system provides comprehensive coverage which enables rescue forces to arrive at accident scenes quickly.

The first satellite, within the framework of the joint COSPAS/SARSAT project, was launched by the Soviet Union on June 30, 1982. In March 1983, the second COSPAS satellite and the first SARSAT-equipped satellite, NOAA-E, were successfully launched. A third COSPAS satellite was launched in June 1984. The Soviet satellites are operating quite well, as is NOAA-F, which was launched in December 1984 (NOAA-E failed in June 1984). Ten ground stations and five control centers are in regular operation in the U.S., Canada, France, the USSR, Norway, and the United Kingdom. The performance of the combined satellite/ground system has equaled or exceeded expectations in terms of sensitivity, accuracy, and ground coverage.

In October 1984, NOAA (on behalf of the U.S.) and foreign participants signed an agreement extending the program from a successful demonstration and evaluation phase to an operational phase, ensuring satellite coverage throughout the 1980's. This agreement provides for the continuous operation of orbit under "normal operations". Search and Rescue instruments are scheduled to be flown on NOAA G-J. In FY 1985, the U.S. operational agencies--NOAA, USCG, USAF, and NASA--will sign a new Memorandum of Understanding to continue the program. NOAA will assume the lead role for operation of the system, and the Coast Guard and Air Force will operate the ground segment. NASA's role will be to perform R&D for operational system improvements and provide continued technical support. During FY 1985, NASA will also study the feasibility of a low cost satellite, which would carry search and rescue instruments, to fill gaps that might develop in the operational constellation.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, NASA will continue to improve system software to enable more efficient handling of data, and will make corresponding modifications to the local user terminals and mission control centers. The development of high power, low cost emergency locator transmitters, which will send coded messages at 406 MHz, will be continued. NASA will **also** keep a special purpose ground station operating to provide system engineering support to the operational agencies.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### TECHNICAL CONSULTATION AND SUPPORT STUDIES

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Technical consultation and support studies..................... | 2,700 | 2,900 | 2,900 | 3,100 |

## OBJECTIVES AND STATUS

Technical consultation and support studies provide the technical basis for regulatory and policy development needed to assure the orderly growth of existing and new satellite services. Unique analytical tools are developed and used to solve problems of inter- and intra-satellite/terrestrial system interference. Emphasis is placed on on-orbit and spectrum utilization studies, which include the development of frequency and orbit sharing techniques and strategies, design standards, and the determination of the effect of propagation phenomena and man-made noise on performance, design, and efficient use of the geostationary orbit and radio spectrum.

In early 1985, the Federal Communications Commission (FCC) is expected to issue a Notice of Proposed Rulemaking to establish a commercial land mobile satellite service. This proceeding is the culmination of almost ten years of technology development, economic analyses, user experiments, propagation studies, and regulatory proceedings. NASA will respond, comment, and support the rulemaking, which is a six to ten month process. The end product is expected to be a new multibillion dollar industry with both domestic and foreign markets and a commercial service owned and operated by the private sector by the late 1980's. In FY 1985, NASA will also participate in the 1985/88 World Administrative Radio Conference (WARC) on geostationary orbit planning.

## BASIS OF FY 1986 ESTIMATE

During FY 1986, policy and technical papers and propagation experiments will be completed for the 1987 WARC to be held in Geneva on mobile communications services. NASA will also intensify its efforts in preparation for the 1988 WARC on geostationary orbit planning. Studies will continue on techniques needed to alleviate the adverse affects of propagation phenomena and to create an acceptable international propagation model for satellite systems over 12 GHz. The concepts of multifrequency, multifunctional satellites, platforms and space station will be explored to determine how different functions and frequencies can be accommodated on the same system.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### EXPERIMENT COORDINATION AND OPERATIONS SUPPORT

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Experiment coordination and operations support.. ............................ | 1,100 | 1,200 | 1,200 | 1,200 |

## OBJECTIVES AND STATUS

The objective of this program is to appropriately document and archive a wide range of user experiments and demonstrations in the application of satellite communications. Past experiments on experimental satellites such as the Applications Technology Satellite (ATS) series and the Communications Technology Satellite (CTS), have generated great interest nationally and internationally in satellite telecommunications. Nearly 400 communications experiments using the ATS series and CTS have been successfully conducted during the extended lifetime of these satellites, thus providing users with the experience necessary for making informed decisions regarding their communications functions. NASA's stimulus in encouraging use of these unique facilities has led to wider application of commercial satellites, which can better meet the need for flexibility and continuity of services.

More than twenty organizations are currently using the ATS-1 and ATS-3 satellites for communication experiments. ATS-3 is supporting emergency medical experiments conducted in conjunction with the Southern Regional Medical Consortium (SRMC). The SRMC experiments determine the value and cost effectiveness of mobile communications via satellite for emergency notification, vehicle dispatch, and two-way voice and biomedical telemetry between paramedics and hospital physicians. Efforts toward rural, wilderness, and offshore oil rig applications are emphasized. Similarly, in the Pacific basin, ATS-1 connects 22 islands and provides disaster relief, medical, educational, and emergency service. This satellite service has been a valuable asset to Pacific users who, prior to ATS-1, received their news 24 hours after the fact.

## BASIS OF FY 1986 ESTIMATE

Operational support for ATS-1 has been assumed by the University of Hawaii and for ATS-3 by the University of Miami. NASA will continue to maintain approval and policy control of the ATS program. NASA FY 1986 activities will include continued planning for educational and public service communications; the development of low cost ground terminals for the mobile satellite program; continuing support for the management and operation of the Denver Satellite Access Facility; and continuing support for ATS experimenters.

INFORMATION
SYSTEMS

**RESEARCH AND DEVELOPMENT**

**FISCAL YEAR 1986 ESTIMATES**

**BUDGET SUMMARY**

**OFFICE OF SPACE SCIENCE AND APPLICATIONS** | **INFORMATION SYSTEMS PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | | (Thousands of Dollars) | | | |
| Data systems.......................... | 7,900 | 8,400 | 8,400 | 9,000 | RD 10-2 |
| Information systems................... | 1,000 | 7,800 | 7,800 | 10,200 | RD 10-2 |
| Total............................ | 8,900 | 16,200 | 16,200 | 19,200 | |

Distribution of Program Amount by Installation

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| Johnson Space Center...................... | 25 | --- | 200 | 210 |
| Marshall Space Flight Center............. | 76 | 11 | 125 | 130 |
| Goddard Space Flight Center.............. | 2,523 | 11,058 | 9,409 | 12,050 |
| Jet Propulsion Laboratory............. .... | 5,469 | 4,584 | 4,850 | 5,050 |
| Ames Research Center..................... | 205 | --- | 330 | 350 |
| National Space Technology Laboratories.... | 35 | --- | 200 | 210 |
| Headquarters............................. | 567 | 547 | 1,086 | 1,200 |
| Total............................... | 8,900 | 16,200 | 16,200 | 19,200 |

## PROGRAM OBJECTIVES AND JUSTIFICATION

The objectives of the Information Systems program are to: develop and demonstrate advanced capabilities of managing, distributing, and processing data and information; implement information system standards and provide common software in order to lower data system costs; and develop the basis for data services to provide improved access to, and rapid delivery of, space data and advanced data systems in support of the Nation's satellite programs and the space science and applications projects.

This program provides for timely development of data system capabilities to meet the needs of flight missions and major space science and applications programs. The early demonstration of capabilities has a high potential for reducing ground data system development risks and the chance of late data delivery.

## BASIS OF FY 1986 ESTIMATE

The FY 1986 Information Systems funding is required to provide support for space science and applications programs. Specifically, funds are required to continue development of the oceans, climate, planetary, and land pilot projects which are engineered to support those disciplines at the Jet Propulsion Laboratory, Goddard Space Flight Center, and universities; to complete implementation of on-line catalogs and common software for climate, oceans, and land data which supports ongoing research; and to continue development of data management and data archiving with flight projects, discipline program offices, and other NASA program offices. Evaluation of the capability to process image data using the Massively Parallel Processor will also be conducted in FY 1986. In addition, the FY 1986 funding is required to support operation of the Science and Applications Computer Center and the National Space Science Data Center at the Goddard Space Flight Center.

COMMERCIAL
PROGRAMS

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

**FISCAL YEAR 1986 ESTIMATES**

**RESEARCH AND DEVELOPMENT BUDGET PLAN FOR COMMERCIAL PROGRAMS**

| Commercial Programs | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimates |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Technology utilization................................ | 9,000 | 9,500 | 9,500 | 11,100 |
| Commercial use of space............................. | --- | --- | (8,500) | 30,000 |
| Total............................................ | 9,000 | 9,500 | 9,500 | 41,100 |

TECHNOLOGY
UTILIZATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1986 BUDGET ESTIMATES

BUDGET SUMMARY

OFFICE OF COMMERCIAL PROGRAMS

TECHNOLOGY UTILIZATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | (Thousands of Dollars) | | | | |
| Technology dissemination................ | 5,500 | 5,800 | 5,800 | 6,300 | RD 11-3 |
| Technology applications........... ...... | 3,500 | 3,700 | 3,700 | 4,800 | RD 11-4 |
| Total............................ | 9,000 | 9,500 | 9,500 | 11,100 | |

Distribution of Program Amount by Installation

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| Johnson Space Center................... | 154 | 325 | 217 | 250 |
| Kennedy Space Center.................... | 240 | 260 | 265 | 210 |
| Marshall Space Flight Center............ | 346 | 480 | 280 | 390 |
| National Space Technology Laboratories.. | 150 | 250 | 185 | 100 |
| Goddard Space Flight Center............. | 951 | 840 | 1,057 | 1,050 |
| Jet Propulsion Laboratory............... | 357 | 435 | 120 | 510 |
| Ames Research Center................... | 48 | 160 | 70 | 2,010 |
| Langley Research Center................. | 651 | 910 | 537 | 530 |
| Lewis Research Center.................. | 450 | 360 | 365 | 310 |
| Headquarters........................... | 5,653 | 5,480 | 6,404 | 5,740 |
| Total............................ | 9,000 | 9,500 | 9,500 | 11,100 |

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1986 BUDGET ESTIMATES

OFFICE OF COMMERCIAL PROGRAMS — TECHNOLOGY UTILIZATION PROGRAM

## PROGRAM OBJECTIVES AND JUSTIFICATION

The objective of the NASA Technology Utilization Program is to enhance the national economy and industrial productivity through a series of interactive processes and mechanisms designed to transfer aerospace technology evolving from NASA's R&D programs to non-aerospace sectors of the U. S. economy. Almost every part of the U. S. industry is touched by the transfer process, especially such areas as automation, electronics, materials, and productivity. In the public sector, medicine, rehabilitation, transportation, and safety are but a few of the areas receiving benefits. The specific objectives of the program are:

- to accelerate and facilitate the application of new technology, thus shortening the time between the generation of advanced aeronautics and space technologies and their infusion into the economy;

- to encourage the multiple secondary uses of NASA technology in industry, education, and government, where a wide spectrum of technological problems and needs exist;

- to understand more fully the technology transfer process and its impact on the economy; and

- to develop applications of NASA's aerospace expertise, with its technology, technologists and unique facilities to priority non-aerospace needs of the Nation.

## OBJECTIVES AND STATUS

NASA Tech Briefs is the Agency's principal technology announcement publication designed to promote and encourage the effective secondary use of new aerospace advancements. Conversion of the NASA Tech Briefs to a commercially viable, private sector publication is on schedule with the first commercial issue to be released in February 1985. This commercialization effort will (a) allow the continued free distribution of this quarterly journal to current subscribers (75,000 scientists, engineers and business representatives in U. S. industry), and (b) provide for circulation growth to meet the demand throughout industry which is estimated at two to three times the present readership.

Thousands of U. S. industrial firms are being provided computerized access to NASA information through the NASA-sponsored dissemination center network. Technology transfer services growing out of this information access have focused a wide array of technologies on technological problems specified by network industrial clients. These firms, especially those in the industrial manufacturing and research sectors, have found dissemination center information and technology transfer services to be beneficial in the development of new or improved products or processes. COSMIC, the NASA-supported center for computerized software dissemination, realized significant growth in the sale/lease of NASA-developed computer programs for industrial use. Overall, the entire university-based dissemination network received approximately $6 million from industry last year for information products and technology transfer services, underscoring the continued interest and importance which this activity has throughout industry.

Emphasis during the past year was placed on automation, electronics, materials, and bioengineering and rehabilitation. Most of the projects had joint participation from user agencies or industry. In electronics and automation two new engineering feasibility studies resulted in a project with the Department of Transportation (Automobile Radar Collision Surveillance System) and a project with Texas Instruments to develop a new robotic vision system for industrial automation. The National Space Technology Laboratories aquaculture treatment techiques to purify drinking water are being transferred to the State of Louisiana. The hydrocephalus shunt technology project has been transferred to the Cordis Corporation, and the Firefighters' Training Simulator technology has been transferred to the Essex Corporation.

**BASIS FOR FY 1986 ESTIMATE**

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Technology Dissemination.............. | 5,500 | 5,800 | 5,800 | 6,300 |

In FY 1986, NASA will continue development of NASA technology dissemination systems and capabilities to provide technical information and technology transfer services to expanded user markets in U. S. industry. Technology dissemination outreach efforts will be coordinated and integrated, where possible, with state-supported economic and industrial development programs. Such activities will serve broader industrial markets nation-wide, with particular emphasis on small and medium size manufacturing and high technology business firms. Enhancements in the NASA dissemination systems will include expanded use of remote interactive and high speed data base searching methods. Moreover, selected computer interface improvements, such as artificial intelligence applications, will be explored. Increased use of the telecommunications will also be pursued to provide rapid and effective delivery of technologies to meet the critical needs of U. S. industrial firms engaged in a wide range of scientific, engineering, manufacturing, and commercial pursuits. In addition, industrial profile analyses will be conducted and market planning strategies will be pursued for emerging aerospace technologies, thus enhancing NASA's ability to accelerate the flow of research and development results to, and their effective use in the U. S. industrial marketplace.

| | | | | | |
|---|---|---|---|---|---|
| Technology Applications............. | . | 3,500 | 3,700 | 3,700 | 4,800 |

The Technology Applications Program is designed to respond to a national "pull" for technology that is needed by U. S. industry, state or federal government in order to meet the specific objectives of the user. Goals are defined in terms of enhancing the quality of life, increasing the marketability of U. S. industry and utilization of a national resource. Emphasis will be to transfer new technology and information resulting from NASA R&D efforts to the non-aerospace segment of the economy. The main thrusts of the technology transfer effort will be in automation, electronics, materials, bioengineering and rehabilitation.

COMMERCIAL
USE OF SPACE

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1986 ESTIMATES

BUDGET SUMMARY

OFFICE OF COMMERCIAL PROGRAMS

COMMERCIAL USE OF SPACE PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | (Thousands of Dollars) | | | | |
| Commercial Use of Space................. | -- | -- | (8,500) | 30,000 | RD 12-2 |
| Total.............................. | -- | -- | (8,500) | 30,000 | |

Distribution of Program Amount by Installation

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| Johnson Space Center.................... | -- | -- | (1,000) | 1,600 |
| Kennedy Space Center.................... | -- | -- | (300) | 1,500 |
| Marshall Space Flight Center............ | -- | -- | (1,900) | 6,200 |
| National Space Technology Laboratories... | -- | -- | (200) | 400 |
| Goddard Space Flight Center............. | -- | -- | (200) | 800 |
| Jet Propulsion Laboratory.... ............ | -- | -- | (300) | 700 |
| Ames Research Center.................... | -- | -- | (300) | 900 |
| Langley Research Center................. | -- | -- | (1,000) | 3,600 |
| Lewis Research Center................... | -- | -- | (700) | 2,000 |
| Headquarters....... ..................... | | | (2,600) | 12,300 |
| Total.............................. | -- | -- | (8,500) | 30,000 |

## PROGRAM OBJECTIVES AND JUSTIFICATION

The objective of the Commercial Use of Space program is to increase private sector awareness of space opportunities and encourage increased industry investment and participation in high technology, space-based research and development. Expansion of the level of private sector investment in commercial space activities will help the U. S. to retain its leadership in science and technology and accrue associated benefits to our Nation. This program will be built on Shuttle and related space-based operational capabilities. The program is responsive to the President's National Space Strategy and National Policy on the Commercial Use of Space, both of which direct NASA to expand private sector investment and involvement in space activities. The FY 1985 House and Senate Authorization Conference Report directed that NASA propose a new line item for this activity in the FY 1986 Budget Request.

## CHANGES FROM THE FY 1985 BUDGET ESTIMATE

Through realignments within the National Aeronautics and Space Administration's appropriated levels, the program is initiating several high priority efforts in FY 1985. These include the establishment of Centers for the Commercial Development of Space, increasing the availability of NASA facilities and equipment, and stimulating NASA and private sector research with commercial applications. Within the Research and Development program, $.2 million was drawn from the Space Station program, $2.0 million from the Physics and Astronomy program, and $.7 million from the Space Research and Technology program. Within the Space Flight Control and Data Communications program, $4.5 million was drawn from the Space Transportation Operations programs, and $1.1 million from the Space and Ground Network, Communications and Data Systems program.

## BASIS FOR FY 1986 ESTIMATE

FY 1985 activities include the preliminary implementation of the National Policy on the Commercial Use of Space, establishment of an organizational focal point for commercial programs at NASA, and the initiation of efforts specifically intended to foster commercial use of and access to space. These specific efforts include the initiation of additional Centers for the Commercial Development of Space, increased accessibility to NASA facilities and equipment particularly in space, small focused research efforts on processes having commercial potential, and the incorporation of other functions designed to facilitate private sector utilization of space for commercial ventures. FY 1986 activities will provide a continuation and some enhancement of the FY 1985 program initiatives. These efforts are designed to encourage significant private investment in commercial enterprises that take advantage of the unique characteristics of space, such as vacuum, microgravity and radiation.

# AERONAUTICS AND SPACE TECHNOLOGY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1986 ESTIMATES

## RESEARCH AND DEVELOPMENT PLAN FOR AERONAUTICS AND SPACE TECHNOLOGY

| | Budget Plan | | | |
|---|---|---|---|---|
| | | 1985 | | 1986 |
| | 1984 Actual | Budget Estimate | Current Estimate | Budget Estimate |
| | (Thousands of Dollars) | | | |
| Aeronautical research and technology.. | 315,300 | 342,400 | 342,400 | 354,000 |
| Space research and technology......... | 137,000 | 150,000 | 150,000 | 168,000 |
| Total.............................. | 452,300 | 492,400 | 492,400 | 522,000 |

AERONAUTICAL
RESEARCH AND
TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1986 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES RGQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | | (Thousands of Dollars) | | | |
| Research and technology base.......... | 228,450 | 233,300 | 223,300 | 239,300 | RD 13-5 |
| Systems technology programs.......... | 86,850 | 109,100 | 119,100 | 114,700 | RD 13-37 |
| Total.............................. | 315,300 | 342,400 | 342,400 | 354,000 | |

Distribution of Program Amount by Installation

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| Johnson Space Center.................. | 900 | 1,200 | 1,000 | 1,000 |
| Marshall Space Flight Center.......... | 400 | 500 | 1,000 | 1,000 |
| Jet Propulsion Laboratory............. | 600 | 500 | 200 | 200 |
| Goddard Space Flight Center........... | 400 | 400 | 300 | 300 |
| Ames Research Center.................. | 118,700 | 134,700 | 132,400 | 146,200 |
| Langley Research Center............... | 97,000 | 116,100 | 115,300 | 101,300 |
| Lewis Research Center................. | 90,100 | 81,500 | 86,000 | 97,800 |
| Headquarters.......................... | 7,200 | 7,500 | 6,200 | 6,200 |
| Total.............................. | 315,300 | 342,400 | 342,400 | 354,000 |

## PROGRAM OBJECTIVES AND JUSTIFICATION

The objective of the aeronautical research and technology program is to conduct an effective and productive program that contributes materially to the enduring preeminence of U.S. civil and military aviation by: (1) conducting appropriate levels of disciplinary and systems research at the leading edge of technology in those areas critical to the continued superiority of U.S. aircraft; (2) maintaining the research centers in positions of excellence in facilities and technical staff; (3) assuring timely transfer of research results to the U.S. aeronautical industry; (4) assuring appropriate involvement of universities and industry; and (5) providing on a reembursable basis aeronautical development support to other government agencies and U.S. industry. Conducted well in advance of and independent of specific applications, the aeronautical research and technology program includes both fundamental research in the aeronautical disciplines and systems research directed at interaction among disciplines, components, and subsystems applicable to general classes of advanced aircraft. The program involves participation by aeronautical manufacturers from the industrial base essential to both military and civil aviation to ensure that the technology is compatible with practical design considerations and can be successfully transferred into application.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

The FY 1985 program has been adjusted to accommodate Congressional actions with respect to realignment of the aeronautics program. In an effort to initiate a full-scale flight test of the advanced turboprop propulsion concept in 1987, the research and technology base has been decreased by $10.0 million, and this amount has been applied to the advanced turboprop systems program in advanced propulsion systems technology. In accordance with other Congressional recommendations, within the research and technology base, $1.2 million has been redirected to support high speed advanced/short takeoff and vertical landing (A/STOVL) research, and $1.0 million has been redirected to continue development of technology to accommodate alternate fuels in general aviation aircraft. The systems technology programs have been realigned to provide $2.5 million from the turbine engine hot section technology program to support research in ceramics for turbine engines.

**BASIS OF FY 1986 ESTIMATE**

The FY 1986 estimate reflects the need to continue efforts both in the basic aeronautical disciplines and in areas of systems research; maintain specialized facilities essential to aeronautical research; and undertake systems technology efforts of high potential payoff to the nation.

The research and technology base program includes disciplinary research which is both broadly applicable to all classes of aircraft (such as general aviation, transports, rotorcraft and hypersonic and other high-performance aircraft), as well as the disciplinary research which is unique to any of these classes of aircraft. The systems technology programs on the other hand are more focused in applications and/or have the characteristics of specific projects (such as advanced turboprop systems and oblique wing technology). Funding for the technical operation of wind tunnels, propulsion facilities, computational facilities, simulators, and flight research operations is covered in the most appropriate discipinary elements of the research and technology base. The increased research and technology base funding will support, in addition to inflation, the operation of the national transonic facility (NTF), which will be in the first year of operational status, as well as the operating costs for the numerical aerodynamic simulator (NAS). A summary of some of the major thrusts for both the research and technology base and systems technology programs follows.

Fluid and thermal physics research will increase emphasis on computational fluid mechanics for internal turbomachinery flows and will initially focus on scaling and modeling three-dimensional end-wall boundary layers. In applied aerodynamics, research on drag reduction techniques, such as laminar flow control, large eddy break-up devices and riblets which hold the potential for significantly reducing drag, will be carried through larger scale wind tunnel tests and flight evaluation.

Areas of emphasis in materials and structures will include advanced powder metallurgy aluminum alloys and damage-tolerant polymeric composites. Increased emphasis will be directed to computational structural mechanics to enable improved analysis of complex aircraft structures. Systems technology efforts in ceramics and turbine engine hot section technology will continue toward achievement of higher engine operating temperatures for significant increases in durability and efficiency.

In the controls and guidance and human factors areas, research emphasis will continue on flying qualities for highly controls-augmented aircraft, working closely with the Federal Aviation Administration (FAA) in integration of airborne capabilities that will support the national airspace modernization, validation methodology for fault-tolerant systems, and human factors of advanced crew station automation.

Information sciences research and technology will emphasize research and evaluation of parallel architecture machines for computational fluid dynamics and computational structural mechanics applications through cooperative efforts with the evaluation of an experimental high-speed network to provide remote user access.

Rotorcraft systems technology efforts will include the detailed design and fabrication of an x-wing rotor system in preparation for flight testing on the rotor systems research aircraft.

Areas of continued emphasis in high-performance aircraft research will include high angle-of-attack flight, vertical thrust and short takeoff/vertical landing, supersonic cruise/maneuverable aircraft, integrated propulsion/flight control, mission adaptive wing and forward swept wing. The oblique wing research aircraft program with the Navy will continue with the redesign and modification of NASA's F-8 aircraft. Flight test is planned to begin in FY 1988. Continuing research efforts will address hypersonic propulsion, structures and configuration aerodynamics and integration. Additional emphasis in this area will address the technology for an air turboramjet propulsion system for future hypersonic aircraft.

In the advanced turboprop program, the large-scale single-rotation propellers will be integrated into a flight-weight propulsion system for static propeller tests and low-speed wind tunnel integration tests in FY 1986 leading to a full-scale flight test in FY 1987 in order to make this technology available for next-generation commercial transport/cargo aircraft. The large-scale proof-of-concept testing of the unducted fan will also be completed. The general aviation/commuter engine technology program will concentrate on multifueled rotary engines. The propulsion power research and technology program has been restructured to focus on technologies for integrated systems and specific vehicle applications.

In the numerical aerodynamic simulation program, the processing system network development will lead to completion of the initial operating configuration in FY 1986. The acquisition of the second high-speed processor for the extended operating configuration will be initiated for delivery in FY 1987.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### RESEARCH AND TECHNOLOGY EASE

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| Fluid and thermal physics research and technology | 43,404 | 49,000 | 44,000 | 48,500 | RD 13-6 |
| Applied aerodynamics research and technology | 42,300 | 42,500 | 42,000 | 43,700 | RD 13-10 |
| Materials and structures research and technology | 23,903 | 25,800 | 27,800 | 28,000 | RD 13-15 |
| Propulsion and power research and technology | 23,500 | 30,500 | 28,700 | 31,000 | RD 13-19 |
| Information sciences research and technology | 34,943 | 23,800 | 21,100 | 22,500 | RD 13-23 |
| Controls and guidance research and technology | 19,602 | 21,500 | 20,500 | 22,100 | RD 13-26 |
| Human factors research and technology | 19,394 | 21,300 | 20,300 | 22,000 | RD 13-30 |
| Flight systems research and technology | 17,504 | 16,300 | 16,300 | 18,300 | RD 13-32 |
| Systems analysis | 3,900 | 2,600 | 2,600 | 3,200 | RD 13-35 |
| Total | 228,450 | 233,300 | 223,300 | 239,300 | |

|  | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
|  | (Thousands of Dollars) |  |  |  |
| Fluid and thermal physics research and technology........ .................. | 43,404 | 49,000 | 44,000 | 48,500 |

**OBJECTIVES AND STATUS**

The fluid and thermal physics research and technology program is a combined analytical and experimental research effort directed at external and internal aerodynamics. One of its principal objectives is the development of computational methods for the prediction and/or simulation of complex fluid flows over aircraft and within inlets, flow passages, and exhaust ducts of turbomachinery. A second objective is the maintenance of a coordinated experimental test program to provide insight into the fundamentals of flow physics and to provide required detailed flow measurements for verification and validation of prediction and simulation methods. The experimental program also includes the development of advanced test methods and instrumentation to provide for increased accuracy and productivity of NASA wind tunnels and developmental facilities. Rapid progress is being made in the development of computational techniques for complex flow configurations that will lead to reduced development time and costs for future aircraft and will provide the basis for achieving new and higher levels of aircraft and missile performance.

A key goal of the computational fluid dynamics (CFD) research is to provide a means for calculation of aerodynamic forces and moments acting on a complete aircraft under all conditions of attitude, speed, and altitude. The second part of this goal is the development of algorithms and predictive codes for gas flows over compressor and turbine blades and within the duct passages of gas turbine engines. This program provides a better understanding of fluid physics phenomena in addition to solving the fundamental fluids equations for various flows. Progress has been made in computing turbulent flow parameters which cannot be measured with state-of-the-art instrumentation. These calculated quantities are used in the development of turbulence models which are incorporated into engineering analytical design tools. In FY 1985, many new analytical techniques and corresponding computer codes are being developed for the key CFD goal of providing the means for calculation of aerodynamic forces acting on complex aircraft configurations. These activities are leading toward early utilization of the advanced computational capabilities to be provided in FY 1986 by the initial operations of the numerical aerodynamic simulation (NAS) program.

Recent discoveries in the area of turbulent flow research have led to the development of friction-reducing devices capable of significant reductions in drag. Independent experimentation has confirmed the Langley Research Center's results of ten percent net drag reduction, using surface etchings (riblets).

Another surface geometry modifier, which is showing favorable drag reduction in wind tunnel tests, is the large eddy break-up device. This concept acts on a different portion of the drag-producing turbulence and potentially could be used in concert with riblets to provide very high overall drag reduction. Passive concepts such as these are very attractive in that no power is required for operation, and their simplicity makes them essentially maintenance free.

The National Transonic Facility (NTF) at the Langley Research Center is a cryogenically cooled wind tunnel which has the unique capability of providing full-scale flight conditions for aircraft models. Additionally, the facility can perform independent testing of compressibility, viscous, and aeroelastic effects. Calibration Phase I and tunnel cleanup are completed, and the first research model, Pathfinder I, is being installed. The tunnel will be fully operational in 1985 and will be utilized by NASA, the Department of Defense (DOD), industry, and universities. Test programs will include aircraft component and configuration studies, preliminary design assessment, and final aerodynamic design evaluation.

Internal computational fluid mechanics (ICFM) is emerging as a highly important tool for improved understanding of flow physics in aeropropulsion systems. It provides the capability to simulate conditions which are difficult, if not impossible, to physically measure and provides results which can be readily visualized and manipulated to support detailed analyses and design trades. The Lewis Research Center program has been restructured to emphasize development of computational techniques. The reorganization will provide for coupling of internal fluid flow simulations and benchmark experiments to create an integrated computational-experimental methodology which will improve fundamental understanding of propulsion system aerothermodynamics. Recent efforts have focused on direct numerical simulation (DNS) techniques. These techniques provide numerical "data" in areas where experimental data is difficult to obtain, i.e., coupled turbulence-chemical reactions using DNS techniques and an advanced Cray computer as the high-speed vector processor. Preliminary results indicate excellent comparison between experimental visualization and numerical representation of the flowfield.

The objective of the multidisciplinary research program is to conduct novel, long-term, innovative research of a multidisciplinary nature related to aeronautics. This research is conducted principally at universities through the following three programs: (1) graduate program in aeronautics, (2) joint university institutes, and (3) the large-scale scientific computing training program. The graduate program in aeronautics sponsors graduate training and research relevant and acceptable to both NASA and universities in the field of aeronautics; encourages a greater number of newly graduated U.S. citizen engineers to pursue graduate training; and provides excellent interaction among students, faculty, and NASA researchers in the conduct of research. The joint university institutes program provides a core level of funding for the promotion of an active NASA/university interchange in certain key areas in order to maintain cooperative, innovative, venturesome research at the leading edge of the latest technology. Current elements include the Joint Institute for Advancement of Flight

Sciences (JIAFS), Joint Institutes for Aeronautical Propulsion and Power (JIAPP), and the Joint Institute for Aeronautics and Acoustics (JIAA) located at Langley Research Center, Lewis Research Center, and Ames Research Center, respectively. The large-scale scientific computing training program, which provides for the development of interdepartmental university curricula and sponsors graduate training, is a multidisciplinary follow-on to the successful computational fluid dynamics training program. This program trains students in the use of supercomputers to solve a broad range of aeronautics problems in response to the rapidly escalating need for specialists by NASA, the DOD, and the aerospace industry.

Fundamental aeroacoustics research is being conducted both to enhance the competitivenes of commercial U.S. aircraft and to increase the mission effectiveness of U.S. military aircraft. This research is focused on identifying noise generation mechanisms; understanding the interaction of acoustic waves with laminar and turbulent boundary layers; and predicting/reducing far-field propagation of aircraft noise through the real atmosphere. Recent accomplishments include the development and experimental verification of a computer code to predict jet plume noise and aeroacoustic loads. This capability is particularly important to advanced aircraft (vertical and short takeoff and landing (V/STOL) and hypersonic) requiring highly integrated engine/airframe systems.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

This program has been decreased by a total of $5.0 million, primarily in the areas of combustion, fuels, and heat transfer as a portion of a general reduction to support the acceleration of the advanced turboprop program. This action was part of the restructuring of the aeronautics program at the Lewis Research Center.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, the CFD program will strive toward improved three-dimensional (3-D) configuration analysis and design capability and a better understanding and prediction of wing flow separation and wake flow phenomena. Advanced algorithm and adaptive grid research will be emphasized for improved efficiency and accuracy of numerical methods. Sophisticated 3-D upwind Navier-Stokes solutions will be sought for improved configuration analysis capability in the supersonic/hypersonic range. The use of spectral methods and 3-D graphics/image processing will be exploited to enhance CFD efficiency. Special efforts will be made to meet the need for CFD codes to analyze fighter aircraft configurations.

The ICFM program will emphasize advanced algorithm development, computer architecture, and geometry and grid generation techniques in FY 1986. In particular, improved solution accuracy and the influence of computational grids which can introduce error through "false diffusion" will receive

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Propulsion and power research and technology........................ | 23,500 | 30,500 | 28,700 | 31,000 |

## AND STATUS

The objective of the propulsion and power research and technology program is to conduct a wide range of analytical and experimental research at the disciplinary, component and system levels. In FY 1985, the program was restructured to focus primarily on the technologies for integrated systems and specific vehicle applications. These technology advances will support and stimulate future improvements in propulsion system efficiency, performance capability, fuel flexibility, reliability, and durability. The potential benefits of advanced propulsion system concepts will also be evaluated within these programs. Research is being performed on a wide variety of propulsion systems for flight vehicles ranging from the general aviation class through the high-performance supersonic/hypersonic flight regimes. Supporting research on new and improved power transfer mechanisms, intermittent combustion engine technology, instrumentation, and aerothermodynamic concepts is being performed. These efforts will lead to major propulsion system improvements for all types of aircraft including advanced rotorcraft.

In high-speed (supersonic/hypersonic) technology, the design of a Mach 5 inlet model was completed and fabrication initiated. Two approaches for combustion enhancement of storable hydrocarbons (instead of the more conventional but less combat-acceptable hydrogen scramjet fuel) were identified and will be tested for effectiveness and practical acceptability. The design, construction, and testing of a parametric model of a turboramjet exhaust nozzle were completed at Mach 5 internal conditions, equaling or exceeding performance predictions. The temperature and species measurements in a coaxial subsonic hydrogen flame were determined via the non-intrusive Coherent Antistokes Raman Spectroscopy (CARS) approach showing good agreement with theory. Ignition and flameholding studies using arc plasma and pyrophoric silane as ignitor were completed indicating practical ignition enhancement potential. Shock tube studies of methane-silane ignition kinetics revealed enhanced ignition rates. The thermal analysis of a methane fuel turboramjet propulsion cooling system was completed by the contractor verifying the cooling adequacy of methane fuel up to Mach 5. The variable diameter inlet and the hypersonic inlet mechanical designs were completed, and their models are under construction in preparation for tests in the LeRC 10-foot wind tunnel in 1986.

In powered-lift propulsion, the General Dynamics E-7 ejector test program for the 0.3-scale model has been completed in both the Lewis 9x15-foot tunnel and the Langley V/STOL tunnel. Procurement of

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Applied aerodynamics research and technology........................... | 42,300 | 42,500 | 42,000 | 43,700 |

**OBJECTIVES AND STATUS**

The objectives of the applied aerodynamics research and technology program are to provide the necessary research and technology advances for an improved and validated base of new aerodynamics technology for application to future generations of both flight vehicles. The program is organized into various major categories which include advanced aircraft aerodynamics for both fixed-wing and rotary-wing aircraft, powered-lift aircraft technology, flight dynamics and controls for aerospace vehicles, aircraft configuration/propulsion/airframe integration, and development of laminar flow concepts for viscous drag reduction.

The objective of the high-performance aircraft research and technology program is to generate technology advancements needed to establish and maintain technological superiority in high-speed aircraft and missiles, including powered-lift aircraft and V/STOL capabilities, supersonic cruise and maneuver aircraft with conventional or short takeoff and landing characteristics, and hypersonic cruise aircraft.

In powered-lift research and technology, emphasis continues to be concentrated on analytical techniques and acquiring a data base essential for development of efficient and effective military V/STOL aircraft. Aerodynamics performance characteristics are being obtained on two V/STOL models in the supersonic speed range. The full span 0.3-scale of an ejector lift concept fighter model was tested in the V/STOL tunnel for ground effect. A free-flight model of the ejector configured aircraft is also being constructed and will be tested in FY 1985 in the 30x60-foot wind tunnel. A Harrier YAV-8B aircraft was acquired in FY 1984 and will be modified for flight control and performance evaluation in FY 1985.

In flight dynamics, an extensive analytical/experimental program continues in the high angle-of-attack, stability, control, handling qualities, and stall/spin behavior of advanced aircraft concepts to improve the low-speed combat maneuverability and safety of high-speed aircraft. Investigations were initiated in novel and unconventional aerodynamic devices, such as thrust vectoring for enhanced pitch and yaw control and vortex flaps. In aerodynamics and propulsion integration, wind tunnel test data of two advanced supersonic tactical aircraft models are being analyze?. Nonlinear wave drag methods for supersonic airfoil design are being examined. Nonlinear full potential flow analytical methods are being developed and verified for fighter performance predictions and wing design at supersonic maneuvering conditions. Currently, an aerodynamic technology data base for efficient weapons integration, carriage, and separation at supersonic speeds is being established, and a computational effort in this area is being initiated. Cooperative efforts continue to be pursued with industry and DOD on high-performance military aircraft design, especially in the areas of wing design and weapons carriage. Aerodynamically efficient hypersonic configurations are being reexamined with a focus on viscous effects.

Work in the supersonic aircraft integration technology program is directed at the application of emerging technologies in aerodynamics, propulsion, controls, and structures and materials to military concepts. Several concepts that synergistically integrate advanced technologies for large potential performance gains are being studied. Supersonic propulsion integration research emphasis focuses on the design and fabrication of a variable-diameter centerbody inlet and on the design and analysis of inlet concepts that will allow high angle-of-attack operation. Mach 5 turboramjet aircraft system studies have identified a promising inlet concept, of which model design and fabrication are underway. Tests of a Mach 5 liquid natural gas-fueled airplane model have been completed at supersonic speeds. Dual-mode subsonic/supersonic combustion was achieved with high levels of net thrust and without inlet-combustor interaction. Hypersonic air-breather missile concepts are under study for potential future Navy and Air Force mission requirements. A focused hypersonic research program plan that culminates in an "X-airplane" was recently submitted to the House Committee on Science and Technology.

The objectives of the rotorcraft research and technology program are to provide a sound analytical capability; a high-quality experimental data base; and support for unique, national test facilities for rotorcraft testing. Areas of emphasis are: (1) validation of theoretical aerodynamic analyses; (2) acoustic theory for external noise; (3) a data base for complex interactional aerodynamics; (4) an understanding of man-machine problems unique to helicopters; (5) analysis and test of selected structural components; (6) reduction of dynamic loads; and (7) development of handling qualities criteria for new or difficult operating conditions. In addition, this program provides the wind tunnel, flight test, and simulation support for joint NASA/Army endeavors.

In FY 1985 a laminar flow control research, flight program was initiated. Acceptance testing for two distinct test articles has been completed, and research experimentation is now underway with the testing of the anti-insect liquid systems. In the variable sweep transition flight experiment portion of the laminar flow program, design of the wing gloves for F-14 aircraft has been completed.

The objective of the subsonic configuration/propulsion/airframe integration program is to reduce integration losses associated with integrating propulsion systems with the airframe. Emphasis has continued to focus on enhanced aerodynamic performance of new configuration concepts for general aviation, commuter, and large transport aircraft to minimize aerodynamic drag penalties. An advanced aviation, commuter, and large transport aircraft to minimize aerodynamic drag penalties. An advanced technology base is being developed for subsonic aircraft to improve safety and productivity, reduce cost, and reduce performance losses associated with propulsion/airframe integration. Analytical and experimental investigations are being conducted which include computer analysis, simulation studies, and wind tunnel and flight tests of model and full-scale aircraft. Significant design criteria for natural laminar flow (NLF) and practical limits of NLF for subsonic aircraft are being determined, which include the investigation of NLF engine nacelle and fuselage shapes. The effect of the propeller slipstream on NLF is being examined, and various insect and icing protection systems for NLF have been evaluated.

The objective of the flight dynamics program for general aviation is to develop a better understanding of basic phenomena, improved analytical and experimental techniques, new control concepts, and valid experimental data relating to flight dynamics and handling qualities of small- and medium-sized subsonic aircraft. Emphasis is being directed toward cooperative activities with general aviation aircraft manufacturers to incorporate aircraft spin-resistance concepts and advanced aerodynamics into future aircraft designs. An outboard wing leading-edge modification that provides increased aircraft spin resistance has been demonstrated.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The applied aerodynamics program was decreased by $0.5 million as a portion of a general reduction to support the acceleration of the advanced turboprop program.

**BASIS OF FY 1986 ESTIMATE**

In powered lift, the critical technology areas that will be investigated are in ejector performance and vectored thrust, both in and out of ground effect. The specific program is directed at achieving an understanding of the factors that influence ejector system performance.

Flight dynamic activities will emphasize three areas of concern to future tactical military aircraft: (1) analyses of nonlinear high-altitude, high angle-of-attack flight characteristics; (2) stall departure/spin behavior; and (3) improved high angle-of-attack combat maneuverability. Coordination of the high-alpha thrust utilization activity through an intercenter plan is underway with the focus on the F-18 as a high-alpha research vehicle; the disciplines to be emphasized are aerodynamics, agility, and flight dynamic theory. Piloted simulation studies to define control system effectiveness and requirements for advanced configurations, utilizing thrust vectoring for pitch and yaw control and for integration of vortex flaps into the control system, will be conducted. Also, piloted simulation of thrust vectoring throughout the flight envelope will be applied to short takeoff and landing (STOL) and short takeoff and vertical landing (STOVL) concepts.

Aerodynamic and propulsion integration research will emphasize STOL and STOVL, sustained supersonic operation, and long-range missile concepts. The vectored-thrust, two-dimensional nozzle program will include analytical efforts addressing internal aerodynamics, heat transfer and materials, and improved hot section testing capability. This activity will include tests on full-scale nozzles.

In the area of supersonic cruise, research will concentrate on configuration development and technology integration tradeoff studies for competitive vehicle concepts. Specific areas of interest include arrow and curved leading-edge wing configurations, transonic interference effects and high angle-of-attack performance. Testing will continue on the variable-diameter centerbody inlet wind tunne1 model.

Hypersonic vehicle activities are focusing on two applications with concurrent technology development. For the Mach 5 cruise vehicle with the dual engine propulsion system, research activities include variable-geometry inlets, various geometry nozzles, and hot structures for nacelle construction. Buildup of the hypersonic dual-mode scramjet test module will also be completed. The space research and technology program includes an evaluation of a high lift/drag (L/D) entry research vehicle which may provide additional aeronautical performance data in this flight regime.

FY 1986 activities in rotorcraft aerodynamics will include flight tests of the Boeing Model 360 and UH-60 instrumented rotors. The rotor systems research aircraft (RSRA) will complete a high-speed rotor loads survey. Theoretical rotorcraft aerodynamics will emphasize completing the various transonic codes and holding workshops with industry to encourage their use. Correlation with wind tunnel tests will continue to validate these codes. Unsteady evaluation of several quiet rotor types will begin in FY 1986.

In the transport aircraft laminar flow control (LFC) research area, LFC technology will be demonstrated on the NASA JetStar aircraft which contains both the Douglas and Lockheed LFC concepts. A simulated airline-type operation phase of flight testing will be performed where the aircraft will operate out of "home base" areas throughout the U.S. to provide operational experience. The LFC systems will be operated in a "hands-off" mode to establish a maintenance and reliability data base.

In flight dynamics for subsonic vehicles, an extensive analytical/experimental program continues in high angle-of-attack stability, control, handling qualities, and stall/spin behavior of advanced aircraft concepts to improve the low-speed combat maneuverability and safety of high-speed aircraft. Investigations will continue in novel and unconventional aerodynamic devices, such as thrust vectoring for enhanced pitch and yaw control and vortex flaps. In aerodynamics and propulsion integration, wind tunnel tests of two advanced supersonic tactical aircraft models will be analyzed. Separated leading-edge vortex flows will continue to be studied. Nonlinear wave drag methods for supersonic airfoil design will continue. Nonlinear full potential flow analytical methods will be developed and verified for fighter performance predictions and wing design at supersonic maneuvering conditions.

Currently, an aerodynamic technology data base for efficient weapons integration, carriage, and separation at supersonic speeds is being established, and a computational effort to be initiated in FY 1985 in this area will be extended into FY 1986. Cooperative efforts continue to be pursued with industry and DOD on high-performance military aircraft design, especially in the areas of wing design and weapons carriage. Hypersonic aerodynamic configurations are being reexamined with a focus on viscous effects and the results of this effort will guide the FY 1986 activities in this area.

In FY 1986, the general aviation flight dynamics program will continue NASA/FAA/industry cooperative efforts in stall/spin resistance technology transfer for incorporation into new aircraft design. Both single- and multi-engine aircraft configurations will be considered, with emphasis on the prevention of twin-engine aircraft stall and the departure from controlled flight. Investigations will continue to determine appropriate wing leading-edge modifications on existing and advanced NLF airfoils for improved stall/departure resistance.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Materials and structures research and technology............. | 23,903 | 25,800 | 27,800 | 28,000 |

## OBJECTIVES AND STATUS

The objectives of the materials and structures research and technology program are to: (1) investigate and characterize advanced metallic, ceramic, polymer, and composite materials; (2) develop structural concepts and design methods to exploit the use of advanced materials in aircraft; (3) advance analytical and experimental methods for determining the behavior of aircraft structures in flight environments; and (4) generate research data to promote improvements in performance, safety, durability, and economy in aircraft. Areas of emphasis include high-temperature engine and airframe materials and structural concepts; composite materials application, life prediction, and thermal and dynamic response, including aeroelasticity; and more accurate and efficient integrated design methods for airframes and engines.

Significant improvements in the performance of turbine engines can be obtained by increasing engine operating temperatures. A process has been developed to greatly increase the strength of some metals for use at these elevated temperatures. During this process, powdered metals are produced by rapidly solidifying the liquid material at cooling rates near one million degrees per second. Nickel-aluminum alloys produced from such powder metals have demonstrated a substantial increase in ductility over metals produced by conventional metallurgical methods.

An advanced structural tailoring system for turbine engine blades was completed. The system accounts €or a full range of realistic constraints including stress, resonance, fatigue and flutter. Analytical studies have demonstrated fan blade designs which are 30 percent lighter than baseline designs. Also, a nonlinear composite structural analysis program was developed for metal matrix turbine blades. Using this system, a turbine blade behavioral response can be structurally analyzed from fabrication through an entire mission cycle.

In the aeroelasticity program, a new device has been demonstrated which passively suppresses fighter aircraft wing-store flutter. Flutter is an instability that occurs in flight when structural and aerodynamic parameters adversely couple. The new device, called a "decoupler pylon," replaces a standard wing pylon and is designed to decouple the pitch motion of the store from the wing aerodynamic response. During wind tunnel and flight tests, the decoupler pylon was shown to be effective to speeds at least 35 percent greater than the flutter speed of the wing with a standard pylon.

Structurally efficient fuselage panels are designed to allow buckling to occur at applied loads below the ultimate load-carrying capability of the structure. Analytical studies and experimental tests have been completed that have examined the post-buckling behavior of graphite-epoxy structural components. Results of these studies have shown that these components can exhibit substantial post-buckling strength under combined compression and shear loading. Large rotation and transverse deformation analysis methods developed accurately predicted post-buckling behavior of those components subject to severe local bending gradients. This activity is part of the ongoing research to understand and characterize the failure behavior of primary composite aircraft structures.

Research to understand the crashworthiness behavior of transport-type aircraft was a major emphasis during the year. Analytical modeling of a transport aircraft and associated experiments were conducted to understand the dynamic behavior and failure mechanisms for transport aircraft structures subjected to impact loads. Full-scale instrumented fuselage sections were drop-tested at an equivalent sink rate of 20 feet per second to measure and understand the behavior of aircraft structures subjected to high dynamic impacts. This information was also required to support the Boeing 720 controlled impact demonstration (CID) program. A major element in the CID program was to obtain structural loads and response characteristics of a full-scale impact of a transport aircraft under controlled flight conditions. A total of 350 data channels of airframe and wing structural measurements were obtained from this experiment. Correlation of experimental results with analytical predictions will result in understanding current capabilities to predict structural behavior of aircraft structures under impact conditions, define load transmission and failure mechanisms in aircraft structures, and provide insight to improve aircraft crashworthiness design concepts.

An important objective of the materials and structures research program is to develop ceramics for hot section components in gas turbine engines. Ceramics provide higher temperature capability than metals but are not as durable as current high temperature metals. During FY 1985, research was focused on sintered silicon carbide and silicon nitride monolithic ceramics and on silicon carbide reinforced silicon nitride composites. In support of this basic materials research, work continued to develop three-dimensional modeling methodology and design techniques that can be used to reduce internal stresses and contact stresses. Also, work continued to develop nondestructive evaluation methodology to monitor the formation and growth of small cracks in ceramics and to evaluate the use of conventional fracture mechanics techniques to predict life and toughness of ceramics.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The materials and structures research and technology program was increased by $2.0 million. This is the result of the transfer of the integrated program for aerospace vehicle design from the information sciences research and technology program to materials and structures and the realignment of the effort for the initiation of research in computational structural mechanics.

**BASIS OF FY 1986 ESTIMATE**

Research on high-temperature engine materials will emphasize improved durability and reliability of ceramics, thermal barrier coatings for metal turbine blades, and high-temperature lubricants. These research efforts will focus on the development of a detailed understanding of the sintering, hot isostatic pressing, and powder processes in order to limit the number of strength-reducing flaws in high-temperature ceramic materials. New thermal barrier coatings with improved resistance to erosion and foreign object damage will be identified. Improved fluorocarbon lubricants will be developed which improve the oxidation stability and wear resistance at elevated temperatures.

Studies to understand the fundamental fatigue and fracture behavior of experimental and engineering materials will continue in order to develop reliable life prediction methods. Research in composites will focus on the development of micromechanical models and new testing techniques in order to characterize the behavior of new 3-D reinforced materials. For metallic materials, the work will concentrate on the determination of the fatigue behavior of powder-aluminum alloys and the development of fracture theories for these ductile metals. Special attention will be given to developing nonlinear analyses that predict the growth rates of very short cracks.

Research on composite materials will continue to place high emphasis on the toughness and durability of highly loaded structures. New materials, including semicrystallines and hybrids, will be developed to be more resistant to impact and fracture through a better understanding of the relationships between material structural mechanics and the molecular structures. Research on advanced structural concepts and configurations that exploit the advantages of composite materials will continue. The primary effort will focus on the prediction and correlation of structural behavior of post-buckled stiffened composite panels and development of failure theories for composite structures.

The dynamics and aeroelasticity program will continue to emphasize the development of improved analytical tools for predicting unsteady aerodynamic pressures, particularly in the transonic speed range, and the aeroelastic response of wings and engine turbine blades. Analysis methods will be verified through systematic tests of both idealized and true-scale airfoils and will concentrate on nonlinear 3-D flow effects. This effort will provide the basis for a significant advance in the development of active control technology.

In the area of integrated analysis and optimization, efforts will concentrate on the development of methods in computational structural mechanics for the analysis of complex aerospace vehicles. Emphasis will be placed on methods for predicting nonlinear transient dynamics and on the development of new solution techniques that take advantage of advanced computer hardware/software concepts e.g., parallel processing, and hybrid analysis techniques. In addition, work will continue in the development of methodology for multidisciplinary design of aircraft vehicles. The number of parameters taken into account in the optimization procedure will be expanded to include vehicle aerodynamic shape and active controls, as well as structural design constraints.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Propulsion and power research and technology... | 23,500 | 30,500 | 28,700 | 31,000 |

**OBJECTIVES AND STATUS**

The objective of the propulsion and power research and technology program is to develop focused propulsion technology via a wide range of analytical and experimental research conducted at the disciplinary, component and system levels. In FY 1985, the program was restructured to focus primarily on the technologies for integrated systems and specific vehicle applications. These technology advances will support and stimulate future improvements in propulsion system efficiency, performance capability, fuel flexibility, reliability, and durability. The potential benefits of advanced propulsion system concepts will also be evaluated within these programs. Research is being performed on a wide variety of propulsion systems for flight vehicles ranging from the general aviation class through the high-performance supersonic/hypersonic flight regimes. Supporting research on new and improved power transfer mechanisms, intermittent combustion engine technology, instrumentation, and aerothermodynamic concepts is being performed. These efforts will lead to major propulsion system improvements for all types of military and civil aircraft including advanced rotorcraft.

In high-speed (supersonic/hypersonic) technology, the design of a Mach 5 inlet model was completed and fabrication initiated. Two approaches for combustion enhancement of storable hydrocarbons (instead of the more conventional but less combat-acceptable hydrogen scramjet fuel) were identified and will be tested for effectiveness and practical acceptability. The design, construction, and testing of a parametric model of a turboramjet exhaust nozzle were completed at Mach 5 internal conditions, equaling or exceeding performance predictions. The temperature and species measurements in a coaxial subsonic hydrogen flame were determined via the non-intrusive Coherent Antistokes Raman Spectroscopy (CARS) approach showing good agreement with theory. Ignition and flameholding studies using arc plasma and pyrophoric silane as ignitor were completed indicating practical ignition enhancement potential. Shock tube studies of methane-silane ignition kinetics revealed enhanced ignition rates. The thermal analysis of a methane fuel turboramjet propulsion cooling system was completed by the contractor verifying the cooling adequacy of methane fuel up to Mach 5. The variable diameter inlet and the hypersonic inlet mechanical designs were completed, and their models are under construction in preparation for tests in the LeRC 10-foot wind tunnel in 1986.

long-lead materials for a lightweight, high-temperature carbon/carbon nozzle has been initiated. Formulation of the terms and conditions required for finalizing the joint U.S./Canadian propulsion/ejector program is underway. Efforts to develop the diffuser separately from the overall ejector configuration are proceeding with design and fabrication of a more packageable, 12-inch inlet, short diffuser to follow the successful long diffuser tests.

Research is underway leading to a new, quieter, longer life, more reliable and efficient transmission gearing for transmitting increased power (over current state-of-the-art transmissions) and tolerating the rapid torque transients required for the new high-performance, more versatile rotorcraft.

For rotorcraft, preliminary design of the 3600-horsepower split-torque transmission promising a 20-percent weight savings was completed. A new 500-horsepower transmission delivering a 42-percent improvement in power-to-weight ratio was demonstrated, as was the validity of the life analysis code for the turboprop transmission. An optimum way to lubricate and cool gear teeth for longer life was determined, and material screening tests for serviceable, tapered roller bearings, capable of a period of safe operation when oil is suddenly lost, were completed.

In intermittent combustion engine research, the two-dimensional rotary engine airflow modeling code was completed. The ceramic apex seal specimens were obtained for wear tests in an engine rig. The use of advanced materials (such as ceramics, and coatings), for rotary engine seals and structural components has been initiated. The single-cylinder, two-stroke diesel testing was continued.

Instrumentation research continued to address advanced sensors, optical measurement systems, high-temperature electronics, engine sensors, and fiber optic control system integration. The first electronic device (a diode) using a silicon carbide crystal was made for high-temperature applications. Development of a color rainbow Schlieren system for quantitative evaluation of flows was completed.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

The propulsion and power research and technology program was reduced by $1.8 million. The program at the Lewis Research Center has been restructured to reduce disciplinary component research and to emphasize technologies for integrated systems and specific vehicle applications. The net effect is a $3 million reduction to support the acceleration of the advanced turboprop program, offset by an increase of $1.2 million for advanced short takeoff and vertical landing (A/STOVL) activities. Within this budget line item, $1.0 million has been redirected, in accordance with a Congressional recommendation, to continue work on technology for general aviation propulsion systems which will allow utilization of alternate fuels.

**BASIS OF FY 1986 ESTIMATE**

In support of the hypersonic propulsion program, second-generation supersonic combustion concepts will be evaluated over the Mach number range of 4 to 7. Mixed-mode (subsonic-supersonic) combustor modeling techniques will be demonstrated. Plasma torch evaluation, as a practical flame holding tool, will be completed along with a shock tunnel study of mixing and combustion in very high Mach number scramjets. Characterization of the supersonic combustion flame via Coherent Antistokes Raman Spectroscopy (CARS) data acquisition will be accomplished and comparisons made with computed predictions. Dimethyl silane will be evaluated to determine its practicability as a piloting fuel. In support of the proposed advanced STOVL program, tasks related to the U.S./Canadian propulsion/ejector program will be carried out including completion of the design, fabrication, and testing of the improved short diffuser portion of the ejector and completion of the joint Lewis and Ames Research Center analytical evaluation of the contemplated A/STOVL configurations. In-house and contracted studies will be performed to evaluate the supersonic military performance of the reduced procurement cost turbine bypass engine and on a novel supersonic through-flow fan engine configuration that promises improved performance with a dramatic reduction in engine weight.

In the area of intermittent combustion engines for light aircraft, baseline performance characterization and evaluation of an improved fuel injection and ignition system on the stratified-charge rotary test rig will be completed. The rotary engine materials and mechanical components program will be continued. The finite-element analysis of the advanced, rotary engine rotor and housing and the initial test on a high- performance version of the rotary engine having multifuel capability will be performed. The potential for early application to light aircraft will be assessed. Quantification of the potential and establishment of the technology for minimum heat rejection operation and advanced turbo-charged/turbo-compounded intermittent combustion engines will be accomplished.

Testing of the 500-horsepower advanced technology helicopter transmission including the advanced technology, bearingless planetary gear will be completed and the results compared with the state-of-the-art OH-58 transmission performance. Advanced models for prediction of transmission efficiency, sealing effects, life and performance will be completed. Vibration and efficiency results will be obtained for the 3000-horsepower Blackhawk helicopter transmission, and a life analysis of helicopter transmission systems will be completed.

In the area of advanced instrumentation research, emphasis will be placed on new flow visualization systems based on holography and interferometry and the conceptual design of fiber optic integrated controls. Improved capabilities will be demonstrated for measurement of heat flux via miniature sensors and for measuring temperatures and velocities via nonintrusive instrumentation methods.

Several activities will be carried out to explore the methods and grow high-temperature electronic silicon carbide crystals. Development and testing of a prototype high-accuracy fuel mass flow meter will be continued.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Information sciences research and technology............. | 34,943 | 23,800 | 21,100 | 22,500 |

**OBJECTIVES AND ~~STATUS~~**

The objectives of the information sciences program are to explore the Eundamental principles underlying aerospace computing, to understand the relationship and tradeoffs between algorithms and computing architectures, and to develop advanced computational concepts and system architectures. The program supports research in concurrent processing, reliable computing, software engineering, and information management, and provides large-scale scientific computational facilities €or aeronautics research.

Concurrent processing research addresses system architectures and algorithms for computationally intensive problems in aeronautics, such as computational fluid dynamics, computational chemistry, and structural dynamics. In 1984, the massively parallel processor, which was developed by Goodyear Aerospace for image processing applications at Goddard Space Flight Center, was analyzed by researchers in the Research Institute for Advanced Computer Science (RIACS) to assess the suitability of the processor architecture for solving problems in CFD. Beam-warming and Lax-Wendroff algorithms were analyzed. The processor was analytically shown to be capable of supporting sustained speeds of 250 million floating point operations per second (MFLOPS) with expanded main memory. A special purpose computer architecture developed at the Massachusetts Institute of Technology was also evaluated to assess its ability to deliver very large amounts of computation to problems in fluid dynamics, chemistry, and artificial intelligence. This architecture was shown to be both feasible and effective. RIACS is halfway through its three-year startup phase and has already established itself in the nation's computing research community. During its first 18 months of operation, RIACS' scientists have produced 28 reports for outside publication and 7 additional internal reports. In related work at Langley Research Center, scientists at the Institute for Computer Applications in Science and Engineering (ICASE) have developed and implemented an Ada-based model for the distributed storage and processing of large arrays. ICASE researchers have also developed a model for determining the execution time of parallel algorithms on arrays of processors.

Research in reliable computing is focusing on the analysis of software reliability models. Empirical studies of software time-to-failure characteristics are being conducted, with early results suggesting that conventional reliability models for software have serious deficiencies. System-theoretic techniques are being applied to the analysis of fault-tolerant software, including the investigation of voting algorithms for multidimensional variables.

In software engineering, the integrated verification and testing system was completed and installed at Langley Research Center. A translator writing system was developed under a grant to the College of William and Mary and distributed to 35 user sites. A detailed analysis of Ada for distributed system applications was completed, and an Ada/VAX execution testbed for failure tests was developed.

Information management research is focusing on graphics tools and language extensions for aeronautics applications. A subroutine library for raster display of 3-D shaded images has been completed by Brigham Young University. Software for color graphic displays of airfoil pressure data has been developed using North Carolina State University interpolation routines, and researchers at George Washington University have completed the design and initiated the development of a graphics programming language employing graphics data types and operators.

A major objective of the computer science and applications program is to provide state-of-the-art high-performance computational facilities for aeronautics research. Ames Research Center operates a Cyber 205/Cray XMP-2200 central computer facility, and Lewis Research Center operates a Cray XMP system. These systems provide vital computational support to researchers in fluid dynamics, chemistry, and thermal and structural analysis.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The information sciences research and technology program was decreased by a total of $2.7 million, which included the transfer of the integrated program for aerospace vehicle design to materials and structures research and technology and a portion of a general reduction to support the acceleration of the advanced turboprop program.

**BASIS OF FY 1986 ESTIMATE**

In concurrent processing, analytic performance analysis of the dataflow processor architecture for aeronautics applications will be completed, and a prototype custom processor architecture design tailored to these applications will be selected, including cost, schedule, and benefit determination. Studies of existing CFD, structural dynamics, and computational chemistry algorithms, as applied to parallel computing, will be completed and coordinated research into next-generation algorithms and architectures will be conducted. RIACS will be expanding its program to include a visiting scientists program, focusing its energies on technology to greatly improve the productivity of aeronautics research scientists through computational systems employing artificial intelligence and very high-performance computing architectures.

Reliable computing research will provide validated software reliability data derived from controlled experiments conducted in the avionics integration research laboratory (AIRLAB) facility. This data will be used in the long term to provide credible models of software reliability. Studies of fault-tolerant software for the software implemented fault-tolerant computer will be completed.

In software engineering, a source code managment system, designed in 1984, will be developed and installed at Langley Research Center, and related fundamental research supporting the development of a software life cycle development environment for aeronautics will be continued.

In information management, graphics research leading to the development of a general purpose, interactive image processing system capable of supporting multidisciplinary research will continue. The long-term objective is to make realistic 3-D raster graphics images a routine display capability through the development of high-level software tools for the nonspecialist.

Support for the supercomputer facilities at Ames Research Center and Lewis Research Center will be continued. Ames will be adding a central data storage capability. Marshall Space Flight Center will be developing a program support communications network to link the agency supercomputer facilities. The internal telecommunications systems at Lewis Research Center are being upgraded.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Controls and guidance research and technology..... ........ | 19,602 | 21,500 | 20,500 | 22,100 |

**OBJECTIVES *AND* STATUS**

The objectives of the controls and guidance research and technology program are to: (1) develop handling qualities criteria and integrated control analysis methods for extending the performance envelope and reliability of highly augmented future aircraft; (2) develop architectures for flight crucial systems for future aircraft and to devise analytical methods and techniques for assessing the reliability and performance of complex integrated fault-tolerant systems; (3) investigate emerging control and guidance technologies which offer future alternative approaches for continued aviation safety, effectiveness, and efficiency; (4) develop methods for more efficient and safe transport aircraft operations in the national airspace system; and (5) explore new concepts for achieving integration of multidisciplinary technologies. Major program elements are: control theory, guidance concepts, flight crucial controls, rotorcraft guidance and control, advanced transport operating systems, and multidisciplinary integration technology.

Control theory research is a major element in the controls and guidance program, and excellent progress has been made in developing methods for analyzing and simulating reconfigurable/restructurable control systems. This activity is being performed in close coordination with the Air Force project to develop and demonstrate self-repairing flight control systems technology. Four failure detection and identification techniques for a restructurable control system were initially evaluated, and flight research was completed on an assessment of the accuracy of parameter identification techniques for augmented flight control systems. Progress has also been made on the development of a new time domain handling qualities criteria method for superaugmented aircraft.

Guidance concepts research provides optimum trajectory algorithms to improve the performance of aircraft operating in the air traffic control system and advanced display technology to improve presentation of information in the cockpit. A fuel-efficient climb/cruise/descent algorithm, developed at Ames Research Center, was implemented in a number of commercial flight management systems. An advanced air traffic control flow-management concept was developed for the FAA, and simulator studies were conducted to investigate its effectiveness. Research in the display area, which is a joint activity with the DOD, developed new phosphors which will enable, for the first time, color thin-film electroluminescent displays. In addition, a full-color light-emitting diode display module was developed for use as a programmable legend switch in a multifunction keyboard.

Flight crucial controls research has concentrated on fault-tolerant system architectures for application to future aircraft. The AIRLAB facility at Langley Research Center, which became operational in April 1983, has been the focus for a significant part of this research and, during the past year, there have been six universities involved in AIRLAB research. A computer-aided reliability estimation program, developed as an important analytical tool for assessing the reliability of fault-tolerant systems, has been validated and released €or public dissemination. Lightning effects on digital electronics continue to be a concern. A lightning channel/aircraft interaction model has been integrated with a nonlinear corona model, and a statistical analysis technique has been developed and applied to direct strike data obtained in flight with the NASA F-106 aircraft.

Rotorcraft guidance and control research involves unique concepts to improve the overall effectiveness and utilization of rotorcraft for military and civil missions. Progress has been made on the development of a highly portable, low-cost beacon landing guidance system using airborne radar technology which has accuracy and coverage comparable to a conventional instrument landing system. Studies continued on techniques to utilize the DOD NAVSTAR satellites to provide helicopter onboard navigation and precision approach capability to any remote site. The external data link concept has been identified as the preferred differential satellite navigation configuration €or providing this capability.

Advanced transport operating systems research has concentrated on the integration of airborne systems capabilities with the evolving national airspace system, the reduction of aircraft costs through technology to improve operations, and improved man-machine interfaces. Significant progress has been made in upgrading the capabilities of the transport systems research vehicle with improved onboard computers and cockpit displays. Extensive analyses and simulations have continued to indicate the potential of the total energy control system concept and the possibilities of practical accurate four-dimensional guidance.

Multidisciplinary integration technology is an evolving, newer element in the controls and guidance program. Progress has been made in defining the most promising potential applications of this technology and establishing the critical subelement areas. Advanced military tactical aircraft designed with full reliance on thrust vectoring for trim and maneuvering control have continued to be the most attractive focus for the development of this new technology.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The program was decreased by $1.0 million in the integrated propulsion/controls research area, and the funding has been redirected within the aeronautics program primarily to support A/STOVL and the advanced turboprop program.

**BASIS OF FY 1986 ESTIMATE**

In the control theory area, research will continue in developing handling qualities criteria for superaugmented aircraft and in developing tools and design guidelines for full-authority flight control systems. Also, research on reconfigurable/restructurable control systems will be expanded to encompass systems involving both aerodynamic and thrust vectoring control. This research will provide the initial conceptual approaches needed in the development of usable methods for the analysis of highly integrated airframe/propulsion control systems.

Guidance concepts research will concentrate on new optimal approaches for long-range cruise flight and for operations in the terminal area. Research will continue on advanced cockpit display hardware, such as color thin-film electroluminescent and fixed optics displays, and on advanced concepts aimed at achieving a true 3-D display.

In the flight crucial controls area, research will continue on advanced fault-tolerant architectures applicable to future aircraft. These architectures have been derived from the assessment of engineering models of fault-tolerant computers and from system studies such as the integerated flight and propulsion control system architectural study for advanced high-performance aircraft. They will be assessed and validated in AIRLAB, which also will be used to validate other advanced control systems architectures. Research in the design of digital control system concepts protected from computer upset caused by lightning strikes will continue, and efforts to define the lightning strike environment will extend flight testing to lower altitudes.

Rotorcraft guidance and control research will concentrate on the further development of the beacon landing guidance and differential satellite navigation concepts. Ground testing of parabolic antennas for the beacon landing system has been conducted, and flight testing of a final antenna configuration will take place to verify expected guidance accuracies. Analyses will be performed to establish the full benefits derivable from satellite-based navigation systems for improved position fixing and flight guidance.

In the advanced transport operating systems area, research will continue to develop and demonstrate the capability to achieve near optimum performance of the crew/aircraft system over the full flight profile. The four-dimensional guidance concepts currently under consideration or analysis will be tested in ground-based simulators and in the transport systems research vehicle (TSRV). The upgraded display system will receive its initial checkout in the TSRV prior to use in display and crew interface integration research to reduce workload and improve flight path conformance. Support to the FAA program to improve current operations and evolve an advanced airspace system will continue.

Multidisciplinary integration research will concentrate on the development of the methodology for analyzing and validating highly integrated airframe/propulsion control systems and for the introduction of evolving concepts such as artificial intelligence to achieve significant improvements in system operation, permitting performance gains in the airframe configuration. The initial focus will be an advanced tactical military aircraft with a sustained supersonic cruise requirement. Different system architectures will be formulated and assessed in the AIRLAB.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Human factors research and technology | 19,394 | 21,300 | 20,300 | 22,000 |

**OBJECTIVES AND STATUS**

The objective of the human factors research and technology program is to provide a technology base for the solution of human problems which impede the growth, efficiency and safety of aviation. This is accomplished by developing a fundamental understanding of the capabilities, limitations and tendencies of aircrew members in interacting with each other, with cockpit systems, and with the air traffic control system. There are three areas of emphasis in the human factors research program: flight management, human reliability, and human engineering methods.

The flight management research program has continued to develop a basic understanding of information transfer, decision making, and resource management in the cockpit in order to provide a data base for improved cockpit systems and operational procedures. In this area, research on cockpit display of traffic information (CDTI) continued in cooperation with the FAA. A full-mission simulation evaluation of CDTI on airline crews during terminal-area operations showed crews to be capable of performing in-trail self-spacing with an acceptable increase in workload. Other flight management research is focused on developing cockpit allocation strategies which make maximum use of automation technology in view of human capabilities and limitations. In this area, a prototype expert system for aircraft engine fault diagnosis was developed as a first step toward studying the interactions of crews and expert systems. A third area of flight management research is the development of technology for improved use of electronic cockpit displays. A computational model of the human eye was developed which will be the basis for formulating criteria for electronic displays which are optimally matched to the human visual system. Also, in this area, development of an expert system was begun which will aid in the selection of symbology and in the formatting of electronic displays.

Human reliability research is aimed at understanding the limitations of the crew in the flight environment and at developing techniques to work around these limitations. A new memorandum of agreement was signed with the FAA for NASA to continue managing the aviation safety reporting system (ASRS) for the next five years. Research also continued in fatigue and jet lag effects on the aircrew. The short-haul portion of the fatigue research program was completed and NASA is coordinating with the Air Force on a study of the effects of fatigue on military airlift command (MAC) aircrews. Army and Air Force research personnel are participating in the generic studies of fatigue and jet lag which are underway at the Ames Research Center.

The goal of human engineering methods research is to develop tools and techniques for the design and evaluation of cockpit equipment and operations. A subjective rating scale for assessing operator workload was developed, and a new method of characterizing flight crew communication and decision making was completed. A new laboratory for research on physiological aspects of workload was developed to complement research on subjective and performance measures of workload.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

This program was decreased by $1.0 million, primarily in the simulation science area, and the major portion of the funding was redirected to support the acceleration of the advanced turboprop program.

**BASIS OF FY 1986 ESTIMATE**

The flight management research program will phase down the CDTI work and increase emphasis on human interaction with increased cockpit automation. An evaluation of human factors aspects of threat alert and collision avoidance system (TCAS) will also be undertaken, building on the CDTI research base. The visual model will be expanded to include 3-D motion and binocular effect. Cockpit automation research will include the completion of the expert system for display formatting and the initiation of research on crew interaction with expert systems in the cockpit. Human interaction with highly automated cockpit systems will be modeled.

In the human reliability area, the study of long-haul crew fatigue and jet lag will continue and include a major international study of sleep quality and flight duty characteristics. This latter element includes the participation of Japan Air Lines, Pan American Airlines, Lufthansa, and Stanford University.

The development of a general methodology for the recording and analysis of interactive flight crew behavior capable of use in full-mission simulation and in flight will be initiated. The management of the ASRS for the FAA will continue.

In the human engineering methods area, a battery of performance assessment techniques will be developed for characterizing and predicting flight crew performance during both real and simulated full-mission flights. A predictive workload model will also be developed to account for both physical and mental workload over a range of operator performance conditions. Simulator studies of flight crew performance under simulated full-mission conditions will be continued in the man-vehicle systems research facility.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Flight systems research and technology.......................... | 17,504 | 16,300 | 16,300 | 18,300 |

**OBJECTIVES AND STATUS**

The objectives of the flight systems research and technology program are to provide the necessary research and technology development for an improved and validated base of advanced technology for application by industry to future generations of the entire spectrum of aircraft. In many cases, joint funding is provided by NASA, DOD, and FAA. The program is organized into the following main categories: (1) meteorology hazards to aviation, (2) convertible engine rotorcraft propulsion, and (3) flight support. The activities within this program encompass advanced engineering techniques and the demonstration of the feasibility of concepts to ensure rapid application of promising new technology essential to meeting one or more of the following goals: (1) defining the hazards of the atmospheric environment in which future aircraft and their systems will operate; (2) understanding the interaction of aircraft and the characterized environment; (3) improving operations safety and efficiency by developing advanced technology to design out hazard effects; (4) improving aircrew awareness and performance through enhanced simulation of meteorology hazards; and (5) developing convertible engine propulsion concepts that will enable military aircraft to retain the low-speed advantages of helicopters while allowing highly maneuverable high-speed flight.

The objectives of the activities in meteorology hazards to aviation are to provide a better understanding of aeronautical safety hazards and their consequences and to provide criteria for design of aircraft systems and operating techniques. They involve aviation meteorology hazards and related operations safety technology and support human factors research and technology. In FY 1985, the interagency national aircraft icing plan was completed. Also, modern icing instrumentation devices were successfully flown on a NASA Twin Otter research aircraft in a wide variety of icing conditions to establish new calibrations as the basis for national standards. NASA and the Army completed in-flight helicopter evaluations of an operational pneumatic deicing boot. The instrumented F-106 severe storms research aircraft continued characterization of direct lightning strikes to the aircraft in convective weather. The resulting first-of-a-kind data is being used by DOD, FAA, and industry as threat models €or materials and avionics protection. The interagency-sponsored doppler radar characterization of hazardous wind shear was completed, and the data was applied to NASA and industry research, development, and training simulators to reduce the possibility of flight into known hazardous weather. The NASA/FAA remotely piloted full-scale transport controlled impact demonstration of antimisting kerosene safety fuel and characterization of fuselage and seat response at and following impact was successfully completed. The results are being used by FAA in decisions for rule making and by NASA for correlation with structural impact dynamic prediction models. The NASA/FAA fireworthy cabin interior materials program was completed, and the FAA initiated implementation of advanced seats, windows, and panels. Flight research to characterize the hazards of clear air turbulence based on remotely measured temperature profiles was completed. The B-57B continued flight research in low-altitude turbulent conditions to determine the variation in turbulence from wingtip to wingtip.

The objectives of the convertible engine rotorcraft propulsion technology program are to demonstrate technology readiness in experimental propulsion systems for rotorcraft and V/STOL aircraft incorporating advanced convertible engine concepts for both shaft and thrust power requirements. In FY 1985, the basic concept of the convertible engine was demonstrated successfully on an engine test stand at the Lewis Research Center. The convertible engine concept will provide designers of rotorcraft and V/STOL aircraft a new dimension by providing a powerplant to provide tubroshaft power and turbofan thrust power simultaneously or individually. Steady-state turbofan performance and power shaft output performance testing for the original plan concept has been completed. The initial operation of the digital electronic control system has been completed, and planning has been initiated for future flight/propulsion controls integration research.

The objectives of the flight support program are to provide a variety of support services to flight research projects using standard aircraft for chase, airspeed calibration, remotely piloted research vehicle air drops, and flight crew readiness training. This is an ongoing level of effort.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The funding of this activity has not changed; however, $0.5 million was transferred to this program for convertible engine research from rotorcraft systems technology, and $0.5 million was transferred to the high-performance aircraft systems technology line to meet priority program requirements.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, the aviation safety program will expand ongoing fixed- and rotary-wing aircraft icing research to implement the national aircraft icing plan developed by NASA, DOD, FAA, National Science Foundation, and National Weather Service. A major element will be the NASA/Army flight testing of advanced rotorcraft icing protection concepts developed by NASA and proven in the NASA icing research tunnel. Flight research will continue with completion of the characterization of weather hazards associated with severe storms, including lightning, turbulence, winds, wind shear, and heavy rain. The resulting data will be used for development of advanced lightning protection concepts and practices, aerodynamic performance degradation determinations, aircrew training, and design of advanced remote detection devices for hazard avoidance and cockpit displays.

In the convertible engine technology program, NASA will support the DOD by cooperating in joint programs with the Defense Advanced Research Projects Agency (DARPA) and the Navy. The NASA/DARPA program focuses on propulsion controls integration for the DARPA advanced convertible engine. Using convertible engine hardware, the NASA/Navy program focuses on developing cross-shafted, shared-power technology required for twin-engine V/STOL aircraft during emergency one-engine inoperative situations. NASA convertible engine research will be expanded to include the development of a torque converter to be used as a lightweight engine fan decoupler. The torque converter concept will make such advanced configurations as the folding tilt rotor aircraft become a nearer term possibility.

Flight test support of flight research projects will continue using a variety of both fixed- and rotary-wing aircraft. In the main, these standard aircraft will be flown as chase aircraft in support of research helicopters and aircraft described under high-performance aircraft systems technology (AFTI, X-29A, F-15, F-18, X-29A, YAV-8B). The test support activity also provides for flight crew training, maintenance of flight data facilities, aircraft instrumentation, and flight data processing.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Systems analysis..................... | 3,900 | 2,600 | 2,600 | 3,200 |

**OBJECTIVES AND STATUS**

Activities in systems analysis provide long-term guidance and direction to the extensive array of aeronautical research and technology programs performed by NASA and the aircraft and gas turbine engine industries. Modern aircraft are highly integrated systems; they operate over a wide speed and altitude range and are required to satisfy many external constraints (noise, pollution, safety, weapons launch, etc.). Systems analysis identifies both potential gains and problem areas so that concepts appear to be acceptable and economically reasonable for various aircraft applications.

NASA uses systems analysis to screen advanced concepts €or payoff potential, to determine technical deficiencies amenable to research within the skill mix and facilities available. Systems analysis activities currently underway address a variety of evolving vehicle and engine concepts and will form the basis for research programs that will be accomplished over the next several decades.

Advanced turboprop research has been underway for several years. Although propulsion historically has been the long lead-time technology, other technologies such as structural noise control, laminar flow, composite structures, and advanced controls are also extremely powerful in both performance and economics when integrated into an aircraft. Systems analysis efforts are addressing new and different configuration concepts to determine benefits and penalties associated with integration of these technologies. A major activity addresses the problem of engine installation, location, and benefits/penalties of single- and counter-rotating turboprop engines.

The area of A/STOVL has been and continues to be studied extensively through several different activities. One is directed at understanding installation benefits/penalties/problems for a variety of propulsion concepts in advanced military aircraft. This work is used to direct programs in propulsion, propulsion/airframe integration, advanced controls, and lightweight high-temperature materials. Another part is directed at evaluating a trend toward high thrust-to-weight ratio engines over the next decade which may allow, for the first time, the marriage of supersonic cruise and STOVL. Aircraft configurations and concepts to capitalize on these divergent operational requirements may look very different and include twin-boom configurations and tail sitters which appear to offer significant improvements in the mission/performance area, but may include disadvantages in design experience, technology voids, and operational and handling quality deficiencies. NASA studies of the turbine bypass engine concept continue to show strong benefits and simplicity of installation, provided that the thermal/structural/materials technology is developed for design of the engine core.

**BASIS OF FY 1986 ESTIMATE**

Trends in the long-range planning and studies activities, directed by the Office of Science and Technology Policy and Congress, suggest an increased interest in the review of technologies that would need to be applied to future advanced concepts such as the transpacific range transport, hypersonic cruise research aircraft, and transatmospheric vehicles.

As ongoing activities are completed, NASA will begin to direct its systems analysis activities toward the integration of advanced propulsion systems concepts, high-strength, lightweight, long-life, high-temperature structural materials, and advanced configurations for each systems concept. Most technologies in this area have been supported at very low levels primarily because of research emphsis and other high priority areas. In addition, the full impact of advanced electronic controls and computational capabilities in fluid mechanics, structural dynamics, and propulsion/airframe integration have not been incorporated in analysis of future vehicles.

Since propulsion is the pivotal and pacing technology in the majority of the vehicle concepts, the area of propulsion systems will receive special emphasis. Because propulsion systems tend to be the enabling technology, advanced propulsion concepts will be analyzed for application to these vehicles. Propulsion concepts include variable-cycle engines and turbine bypass engine concepts for transports, air turboramjets, and other composite engine concepts for hypersonic cruise, and the application of supersonic combustion ramjet (SCRAMJET) technology for some of the transatmospheric vehicle concepts.

**BASIS OF FY 1986 FUNDING REQUIREMENTS**

SYSTEMS TECHNOLOGY **PROGRAMS**

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | (Thousands of Dollars) | | | | |
| Rotorcraft systems technology......... | 27,950 | 26,500 | 26,000 | 20,500 | RD 13-18 |
| High-performance aircraft systems technology......................... | 19,900 | 21,000 | 21,500 | 21,800 | RD 13-41 |
| Subsonic aircraft systems technology.. | 5,000 | 19,000 | 19,000 | --- | RD 13-44 |
| Advanced propulsion systems technology | 17,000 | 16,100 | 26,100 | 44,200 | RD 13-46 |
| Numerical aerodynamic simulation...... | 17,000 | 26,500 | 26,500 | 28,200 | RD 13-49 |
| Total.............................. | 86,850 | 109,100 | 119,100 | 114,700 | |

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Rotorcraft systems technology | | | | |
| Guidance and navigation.. ........... | 1,600 | --- | --- | --- |
| Rotor systems research aircraft (RSRA) flight research/rotors..... | 3,300 | --- | --- | --- |
| Advanced rotorcraft technology...... | 14,700 | IO,200 | 9,700 | 2,700 |
| Technology for next generation rotorcraft....................... | 8,350 | 16,300 | 16,300 | 17,800 |
| Total............................. | 27,950 | 26,500 | 26,000 | 20,500 |

**OBJECTIVES AND STATUS**

The rotorcraft systems technology program conducts research on two fronts. The first thrust consists of efforts in broad systems technology areas that advance the state of the art in flight dynamics and controls. The second thrust involves advanced concepts which are investigated in conjunction with DOD and FAA. These currently include the X-wing rotor demonstration test on the rotor systems research aircraft (RSRA) and XV-15 tilt rotor flight testing. In both of these thrusts, integrated system testing is required and involves large-scale wind tunnel testing, flight testing and moving-base simulation.

In the noise program conducted in collaboration with the American Helicopter Society (AHS), an initial, comprehensive noise prediction code was released to industry. Portions of the code were used to reduce tail rotor noise on the Navy MH-53E helicopter in a new design. Also, the first indication that blade-vortex interaction impulsive noise could be reduced by airfoil leading-edge shaping was discovered using new analytical tools. A full-scale hovering test of a Hughes 500 helicopter, with various noise sources muffled, was initiated to determine varying noise levels due to turbulence and wind.

For improved analysis and assessment of vibration, the dynamic analysis of model vibration program conducted structural dynamics correlation with both metal and composite fuselage construction. The UH-60 and AH-64 underwent ground vibration tests to correlate against finite-element model predictions. The Bell advance composites aircraft program and Boeing 360 aircraft fuselages were modeled to predict fuselage dynamic response to rotor vibration.

In full-scale testing, preparations continue for the start-up of the 40x80-foot wind tunnel in early 1986. A tail rotor was thoroughly documented for loads and acoustics on the outdoor aerodynamics research facility for an FY 1986 main rotor/tail rotor interference test in the 40x80-foot wind tunnel. The main rotor rig for that test was shake tested and load cells were calibrated.

In rotorcraft controls, the ultrareliable, fault-tolerant control system underwent full pilot simulation in preparation for flight testing. Superaugmented controls were studied in conjunction with the Army single-pilot lightweight helicopter mission and various taxing civil tasks such as all-weather search and rescue missions.

In flight dynamics, the first air-to-air combat simulation was conducted on the vertical motion simulator (VMS). Also, the first full-fidelity autorotation was accomplished with excellent pilot comments on motion representation. Energy management techniques for autorotation were investigated. In a cooperative program between the Ames and Lewis Research Centers, a real-time pilot simulation of digital flight/propulsion control integration was conducted.

Under the joint DARPA/NASA RSRA/x-wing program, the prime objective is to perform an x-wing rotor conversion from rotary to stopped-rotor flight and return to rotary wing flight. It will also investigate through flight research the dynamic stability, performance, and rotor control characteristics of the x-wing rotor system. In 1985, the final modification to the RSRA will be completed. The fabrication of the x-wing rotor system will also be completed and installed on the aircraft. Preceding installation, the propulsion system will be extensively tested on the propulsion system testbed, an "iron bird" ground-based facility, and the reliability of the flight control system will be extensively tested in the vehicle management systems laboratory which was specifically built to test the unique x-wing flight control system. Supporting research includes upgraded simulations conducted in the Ames Research Center's vertical motion simulator, concentrating on the conversion flight mode in which the aircraft "converts" from rotary to stopped-rotor to rotary flight at speeds greater than 200 knots, typically the maximum speed of conventional helicopters.

Supporting the Navy joint services advanced vertical lift (JVX) program, XV-15 tilt rotor flight testing continued. A side arm controller was evaluated. New steel hubs were installed, enabling high gross weights and more demanding maneuvers to be evaluated. The advanced technology blades (ATB) were installed on the aircraft, and a limited evaluation begun. In ground-based testing, reports on the very successful hover tests of the XV-15, JVX, and ATB rotors were issued. Preparation began for a 40x80-foot wind tunnel test. On the VMS, a full JVX simulation was conducted, the third in a series. A study of the civil market and research, development, test, and evaluation recoupment issues was conducted in conjunction with the JVX program office.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

unding amounting t $ milli was ransferred from advanced rotorcraft to the resea and technology base for flight systems :h and technology to supp prior on tible gine research requirements

**BASIS OF FY 86 ESTIMATE**

The NASA/AHS program will continue with the release of an updated, comprehensive noise prediction code (called ROTONET) that incorporates the best available subroutines for rotor loads and rotor wakes. Blade vortex interaction noise will be emphasized to determine the benefits of airfoil nose shape using more powerful, three-dimensional predictions.

The XV-15 flight testing will continue in support of the JVX program. Using joint support by the Navy, NASA, and the Army, it will be possible to complete flight evaluation of the ATB rotor and perform military suitability tests. Wind tunnel and simulation tests will also be supported for JVX.

The X-wing rotor program will be generating ground-based, piloted simulation, propulsion system testbed data and vehicle management systems data in support of the flight investigation of the X-wing rotor on the RSRA. This fast-paced, advanced technology program will require extensive, coordinated testing in 1986 which is crucial to the success of the flight investigation, and will require special NASA capabilities to support the contractor's efforts. In particular, the flight testing will culminate in the historic demonstration of conversion from rotary to stopped-rotor to rotary flight.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| High-performance aircraft systems technology | | | | |
| High-performance flight research.... | 8,700 | 9,200 | 9,700 | 9,800 |
| Turbine engine hot section technology... .................... | 11,200 | 11,800 | 9,300 | 5,200 |
| Ceramics for turbine engines........ | --- | --- | 2,500 | 2,100 |
| Oblique wing technology... .......... | --- | --- | --- | 4,700 |
| Total............................. | 19,900 | 21,000 | 21,500 | 21,800 |

**OBJECTIVES AND STATUS**

The objective of the high-performance aircraft systems technology program is to generate validated engineering methods and design data applicable to the development of advanced high-performance, high-speed aircraft applications. The program objectives are accomplished by analysis, ground-based simulations, wind tunnel experimental research, and flight research tests of aircraft.

In the joint NASA/Air Force advanced fighter technology integration (AFTI) program, the AFTI/F-16 automated maneuvering attack system flight phase has been initiated. In the AFTI/F-111 mission adaptive wing project, the aircraft is in final preparation for the start of the flight test program in the second quarter of FY 1985. In the F-15 highly integrated digital electronic control (HIDEC) program, which builds on the capability developed during the digital electronic engine control program, flight research testing has begun to validate performance improvements by use of an adaptive engine control system. In the NASA/DARPA X-29A forward-swept wing flight demonstration program, the aircraft has begun the baseline flight program. The F-4C aircraft modifications with spanwise nozzles for over-the-wing blowing have continued, and the flight validation of low-speed flying qualities improvements predicted by analytical and wind tunnel tests will be completed during FY 1985. The preliminary design of an oblique wing research aircraft is being initiated, in a joint program with the Navy, to develop an experimental aircraft for an FY 1989 flight program which will extend oblique wing technology to transonic and supersonic speeds. The F-16 decoupler pylon, which provides isolation between the wing and stores structural modes, has completed flight test. An F-18 test aircraft has been acquired and is being modified for a flight research program which is closely integrated with analytical, wind tunnel, and ground simulation activities to enhance the U.S. capability to predict and exploit the high angle-of-attack flight regime. Analytical tests and capability to predict and exploit the high angle-of-attack flight regime. Analytical tests and studies have continued on the use of vortex flap technology to improve aircraft lift characteristics. In the powered-lift program, a YAV-8B Harrier is being modified for an FY 1985 flight program for simulator and low-speed aerodynamic performance validation.

During FY 1985, the turbine engine hot section technology (HOST) program continues to address the issues involved in engine durability. The objectives are to establish predictive methods for the structural response and life of hot section components by developing analysis methods, instrumentation and verification test methodology. During this year, a cyclic thermal-structural test apparatus was developed for verification of combustion linear structural analysis methods. Data were obtained on internal and external heat transfer rates in air-cooled turbine blades. These data are necessary to verify aerothermal analysis codes and also to provide essential input to the nonlinear, high-temperature, 3-D structural analysis methods being developed. This research permits prediction of the structural behavior of turbine engine hot section components over an entire thermal cycle. A method was also developed to accurately predict the life of isotropic single crystals for hot section components. As part of the activity for increased turbine blade life, materials research continued to focus on sintered silicon carbide and silicon nitride ceramics. This work includes development of analysis techniques that apply advanced fracture mechanics methods to understanding and predicting the response of ceramic materials subjected to aerothermal loads.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

Precursor oblique wing activities within the high-performance flight research program were augmented by a transfer of $0.5 million from the flight systems research and technology base program. In addition, in response to Congressional recommendations, $2.5 million was internally realigned to augment ceramics for turbine engines. This was accommodated through a reduction in the turbine engine hot section technology program.

**BASIS OF FY 1986 ESTIMATE**

The flight research activity in FY 1986 will involve a variety of high-performance aircraft to investigate advanced concepts. Several projects will continue their flight test phases during this period. Under the joint NASA/Air Force AFTI projects, the F-16 aircraft will complete its flight program, and the F-111 mission adaptive wing will continue the research program with evaluation of the automatic mode for in-flight adjustment of wing camber. The F-15 HIDEC will continue flight research to evaluate the potential of improving performance and mission effectiveness due to engine-airframe control integration. The joint NASA/DARPA X-29A forward-swept wing aircraft will complete the baseline flight program and begin the flight research phase to fully exploit the technologies designed into the aircraft.

The F-18 high angle-of-attack aircraft will start the flight research program with focus on aerodynamics and control system design for aircraft operations at high angles of attack. Vortex flap technology will be evaluated to determine if a flight research program using a NASA F-106 aircraft should be initiated in FY 1986. The YAV-8B flight research program will continue, and modifications for advanced electronics, displays, flight, and propulsion and control systems will be initiated.

The FY 1986 funding level reflects the start of the final design and construction phase of the oblique wing research aircraft. A single contractor will be selected from those participating in the preliminary design contracts during FY 1985. The NASA F-8 digital fly-by-wire test aircraft will be converted to the research testbed for the flight program. This aircraft provides for easy installation of the oblique wing, a well defined readily modifiable, highly flexible, digital flight control system.

During FY 1986, the HOST program will continue to concentrate on developing improvements in high-temperature instrumentation, predictive methods for structural analysis, aerothermomechanical environment and life. Research will be conducted using the newly developed high-temperature structures laboratory at Lewis Research Center to study the behavior of turbine blade material and actual burner liner hardware under realistic, complex aerothermomechanical loading conditions. Paralleling the experimental work will be continued development of specialized structural analysis codes designed to predict the detailed turbine engine component stress-strain response over an entire mission. Life prediction methodology will be extended to anisotropic superalloys. Ceramics research will focus on identifying critical processing variables affecting reliability, development of methodology for measuring crack growth, and nondestructive evaluation techniques for monitoring small flaws.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Subsonic aircraft systems technology | | | | |
| Advanced composite structures technology | 5,000 | 19,000 | 19,000 | --- |
| Total.............................. | 5,000 | 19,000 | 19,000 | --- |

**OBJECTIVES AND STATUS**

The objective of the subsonic aircraft systems technology program is to provide a substantiated base of key technologies, design data, and validated design procedures. Individual concepts are examined in the systems context with other interacting components and technologies to define techniques and procedures for obtaining maximum benefit from these applications.

The objective of the advanced composite structures technology program is to develop a composite primary airframe structures technology base that achieves the full potential of weight, fuel, and cost savings possible for the design of transport aircraft in the 1990's. The program's purpose is to establish a composite engineering data base which will permit government and industry management decisions to commit composites to advanced, large aircraft with acceptable cost and risk. Full airframe use of lighter weight composites in primary airframe structure can reduce overall aircraft weight and acquisition costs by up to 15 percent, significantly lowering operational costs and extending service usage.

The program is focused on the key technologies for wing and fuselage structures of composite material including the development of a solid data base for the design and analysis of heavily loaded thick laminate wing structures. Large multistringer composite wing-type structures have been designed, fabricated and tested. It has been demonstrated that highly loaded composite panels can satisfactorily meet damage tolerant criteria and continue to support design loads after impact damage. Lightning strike tests have further demonstrated that stiffened panels with mechanical fasteners can be designed so that no electrical spark arcing will occur endangering the aircraft by fuel tank explosion. Additionally, special laminate treatments to prevent fuel leakage have also been shown to be effective. Concepts for highly loaded critical wing-fuselage joint assemblies have demonstrated in test their ability to carry loads and meet fatigue criteria.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, the advanced composite structures technology program will be terminated in order to meet other higher priority program requirements. Composite structures technology is further advanced than other higher priority projects which were continued. On this basis, there is a greater possibility that industry will continue its development.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Advanced propulsion systems technology | | | | |
| Advanced turboprop systems.......... | 15,000 | 14,000 | 24,000 | 42,000 |
| General aviation/commuter engine technology........................ | 2,000 | 2,100 | 2,100 | 2,200 |
| Total............................. | 17,000 | 16,100 | 26,100 | 44,200 |

**OBJECTIVES AND STATUS**

The objective of the advanced propulsion systems technology program is to explore and exploit advanced technology concepts €or future aircraft propulsion systems in high-payoff areas through the focusing of fundamental research and technology efforts and integration of advanced propulsion components.

Activities in the advanced turboprop systems program are focused on development of a broad research and technology data base and systems integration activities in preparation for flight verification which is necessary to establish large-scale advanced turboprop feasibility. The design of the large-scale advanced propeller (LAP) was completed by Hamilton Standard, and the fabrication of the 9-foot-diameter unit is underway, along with the fabrication of a 2-foot-diameter aeroelastic model to evaluate the aeroelastic scalability of the 9-foot LAP. Lockheed-Georgia has been selected as the prime contractor for the propeller test assessment (PTA) and is now progressing toward the key flight evaluation of the LAP in FY 1987. A contract has also been awarded to General Electric Company for a ground test of a gearless counter-rotation propfan concept. Model tests in the 2-foot-diameter size are verifying the counter-rotation propeller performance and acoustics predictions, and fabrication for the ground test vehicle is well underway with test initiation planned for June 1985. Evaluation of 2-foot-diameter geared counter-rotation models is also underway with good results at Hamilton Standard, and contracts were signed with Pratt & Whitney and Allison Gas Turbine to evaluate and verify technology for large-scale gearboxes. Wind tunnel aerodynamic, acoustic, and stability and control investigations were conducted for aft-mounted single- and counter-rotation turboprops. It was determined that the source noise directivity patterns are different for single- and counter-rotation propellers and that normal forces generated by the propellers at takeoff conditions are greater for counter-rotation than single-rotation configurations.

In the general aviation/commuter engine technology program, aimed at raising the performance level of small turbine engines to more nearly match that of large engines, the detailed laser anemometry measurements in low-aspect-ratio fans have been completed. The multistage compressor facility was modified to include support equipment for stage-matching investigations. Combustor experiments aimed at determining flowfields and temperature distribution in dilution twin sections of reverse flow combustors were completed. A cruise missile combustor was designed and fabricated and installed for testing. The aerodynamic and mechanical design of a small engine compatible, high-work radial turbine was completed. Fabrication of the turbine blading for the fundamental loss measurement rig was completed. Fabrication of the winglet rotor was completed. Check-out tests on the 10-pounds-per-second, 8:1 pressure ratio centrifugal compressor were completed, as part of a three-part test to experimentally describe the causes of incremental small-engine losses over and above those suffered by large turbine engines.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

This program was increased by realignment of $10.0 million to the advanced turboprop program from the research and technology base program for efforts leading to an initial flight test in 1987, as directed by Congress.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, advanced turboprop systems program activities will consist of continued development of the broad-based supporting technology and preparation for the flight evaluation of the large-scale advanced propeller. Analysis and testing of the low- and high-speed propeller/inlet/diffuser testing will be completed. Three LAP rotors will be delivered to the propeller test assessment program and evaluated at static conditions with a modified gearbox and engine, as well as tested at low-speed conditions for performance, structural integrity, and cabin acoustics in the Ames Research Center's 40x80-foot wind tunnel. Wind tunnel tests of a one-ninth scale model of the PTA aircraft will also be accomplished to determine the flying qualities of the airframe/turboprop combination. Evaluation of the gearless counter-rotation concept will be concluded. High-speed wind tunnel investigations will be continued for wing- and aft-mounted single- and counter-rotation configurations for stability and control evaluation, as well as code verification. Acoustics efforts will include counter-rotation source noise prediction modeling, cabin acoustics investigations, and experimental evaluation of counter-rotation propeller configurations. Contracted studies to evaluate the suitability of advanced turboprop technology for application to multipurpose subsonic naval aircraft, general aviation aircraft, and military tactical transports will be completed. Test and analysis of acoustics and performance results will be completed on the unique, high-radius-ratio, counter-rotating, gearless model propulsion system. The full size, first build of this system will be completed, and ground testing will be initiated.

The general aviation/commuter engine technology effort will continue to focus on the development of a fundamental understanding and analytical data base €or flow phenomena and heat transfer in small gas turbine engine components. The following activities will be completed: testing of the axial stage group to be used as part of the axial/centrifugal configuration; design of the high hub-to-tip ratio centrifugal stage suitable €or the axial/centrifugal comparison; heat transfer studies of a porous wall, felt-back ceramic liner with conventional fuels; and development of the viscous flow scroll computer code.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Numerical aerodynamic simulation...... | 17,000 | 26,500 | 26,500 | 28,200 |

**OBJECTIVES AND STATUS**

The numerical aerodynamic simulation (NAS) program objective is to significantly augment the nation's capabilities in computational fluid dynamics and other areas of computational physics by developing a preeminent capability for numerical simulation of aerodynamic flows. This program will provide the computational capabilities required to obtain solutions to problems which are currently intractable. Ongoing research and technology base efforts in computational aerodynamics will benefit significantly from the advanced computational capabilities to be provided by the NAS program. The combination of these programs will provide pathfinding aeronautical research for the future, allowing solutions of the full Navier-Stokes equations, providing first-principle prediction of viscous flow about simple aeronautical shapes, and enabling the prediction of performance of complete aircraft. The NAS program will develop an extensive, user friendly system to assist engineers and scientists in all aspects of problem solution, from problem formulation through graphical presentation of results. The heart of this system is the high-speed processors, which will be the most advanced commercially available supercomputers. These machines will provide the large-capacity/high-speed computational capability required in advanced fluid dynamic research and applications.

The NAS program study and planning phase was initiated in the research and technology base in FY 1983, with system development having begun in FY 1984. The system design review was held in FY 1984 and formalized the design of the NAS system. The system software development contractor began development of the network language and protocols during FY 1984. Major hardware procurements were initiated in FY 1984, leading toward assembly of the initial operating configuration during FY 1985. Full-scale development of the NAS network hardware begins with the delivery of the integrated support processor complex (front-end computers and supporting equipment) in early FY 1985. The first high-speed processor, a Cray 2 supercomputer, will be delivered late in FY 1985 and integrated into the NAS network, initiating extensive hardware and software test and integration activities. During FY 1985, construction will be initiated for the NAS facility.

**BASIS OF FY 1986 ESTIMATE**

The first part of FY 1986 will be an intense test and integration period leading to operational status of the NAS initial operating configuration (IOC) during the third quarter of FY 1986. System software development will continue for all components of the NAS network leading toward an operational readiness review for the NAS IOC in the third quarter FY 1986. During FY 1986, procurement of hardware and software for the NAS extended operating configuration (EOC) will begin. The key components in the EOC are the high-speed processor number two, the expanded graphics subsystem and the expanded long-haul communications subsystem.

The successful operation of the initial NAS configuration in FY 1986 will not only provide the world's premier computational capability for NASA and the nation, but will also provide the critical networking capabilities required to support the expanded NAS EOC which will reach operational status in early FY 1989.

SPACE RESEARCH
AND
TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1986 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

## SUMMARY OF RESOURCES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | (Thousands of Dollars) | | | | |
| Research and technology base.......... | 124,885 | 136,000 | 136,350 | 140,000 | RD 14-5 |
| Systems technology programs........... | 7,515 | 9,100 | 8,750 | 20,000 | RD 14-32 |
| Standards and practices............ ... | 4,600 | 4,900 | 4,900 | 8,000 | RD 14-41 |
| Total.............................. | 137,000 | 150,000 | 150,000 | 168,000 | |

Distribution of Program Amount by Installation

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| Johnson Space Center................. | 13,100 | 14,100 | 11,700 | 11,600 |
| Kennedy Space Center................. | 500 | 600 | 400 | 600 |
| Marshall Space Flight Center.......... | 13,600 | 16,500 | 14,000 | 20,200 |
| Goddard Space Flight Center........... | 8,000 | 8,700 | 6,200 | 6,600 |
| Jet Propulsion Laboratory.... .......... | 24,700 | 22,700 | 22,700 | 23,400 |
| Ames Research Center.................. | 12,400 | 13,500 | 14,800 | 15,300 |
| Langley Research Center.............. | 29,500 | 32,900 | 38,300 | 45,000 |
| Lewis Research Center................ | 28,400 | 32,800 | 34,400 | 37,800 |
| Headquarters.... ..................... | 6,800 | 8,200 | 7,500 | 7,500 |
| Total.............................. | 137,000 | 150,000 | 150,000 | 168,000 |

**OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY** **SPACE RESEARCH AND TECHNOLOGY PROGRAM**

## PROGRAM OBJECTIVES AND JUSTIFICATION

The overall goal of the space research and technology program is to advance the technology base in support of NASA's role as an effective, productive, and long-term contributor to the continued preeminence of the United States in space. The specific objectives of this program are to: (1) support a broad-based advanced technology program designed to provide new concepts, materials, components, devices, software, and subsystems for use in United States civil and military space activities; (2) assure preeminent national capability through extensive and interrelated participation in the program by the NASA centers, other government agencies, universities, and industrial research and technology organizations; and (3) support a strong institutional base to maintain NASA centers in positions of recognized excellence in critical space technologies. The space research and technology program is comprised of two major elements: (1) the research and technology base to support advanced disciplinary technologies that provide the necessary data base and understanding to create new opportunities for future national, civil, military, and commercial space mission objectives; and (2) systems technology programs which extend research and technology base efforts by providing system-level and in-space experiment capabilities which permit the generation of data not possible in ground facilities and the *in situ* validation of advanced technology in support of its transfer into space projects.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

The space research and technology program total remains unchanged from the FY 1985 budget estimate; however, within this program a number of realignments have been made to cover high priority requirements. Automation activities have been increased by $4.0 million in accordance with Congressional direction, and other realignments have been made as described in the individual program statements.

## BASIS OF FY 1986 ESTIMATE

The FY 1986 program in space research and technology will continue to be directed toward providing the broad base of innovative technology essential to the conduct of future space missions. As such, it supports agency goals in space transportation, space station, science and applications, as well as synergistic support to military and commercial space user needs.

In aerothermodynamics, continued program emphasis will be directed toward analytical and predictive techniques for the transition between continuum and rarefied flow regimes; additional emphasis will be placed on investigating aerodynamic and aerothermodynamic performance of a recoverable orbital transfer vehicle (OTV) and an aeronautics/space transatmospheric vehicle. Materials and structures activities will continue with research in large area space structures, emphasizing erectables and deployables; generic mechanism technology; analysis of dynamic response; and controls interaction. The work on improved thermal protection systems for OTV aerobraking and other advanced transportation vehicle concepts will continue. The effects of the space environment on lightweight materials for spacecraft and platforms will continue as a major thrust. The space energy conversion program will continue its emphasis on high-capacity power and thermal systems for evolutionary space station needs and on technology for high-specific power, low weight systems for low earth and geosynchronous orbits and planetary missions. Propulsion technology will be directed toward understanding of performance and life parameters for advanced cryogenic engines stressing component and integrated diagnostic instrumentation techniques; orbital transfer engine technology to enable development of space-based, throttleable, reusable systems; and technology for gaseous oxygen-hydrogen propellant systems for evolutionary growth station or OTV auxiliary propulsion needs. The electric propulsion effort will address auxiliary propulsion applications with continuing attention on power processors and thrusters. In space data and communications, emphasis will be placed on advanced information processing, high-capacity, high-data-rate storage systems to increase the capabilities of onboard and ground data systems, and advanced microwave and optical communications technology. The information sciences program will emphasize software technology, space station data management, radiation tolerant electronics, and automation research addressing teleoperations and robotics for potential space station applications. Emphasis in the controls and guidance area will be placed on precise control of large, flexible space structures, the precision pointing of large spacecraft, and adaptive guidance concepts for future transportation systems. Human factors efforts are aimed at the enhancement of astronaut productivity through improved information management techniques, extravehicular work stations, and a telepresence capability. Efforts in space flight systems are directed toward orbiter experiments which will continue to exploit the operational flights of shuttle to investigate leeside flowfield heating phenomena, upper atmosphere constituents and density, pressure measurements during entry for validation of experimental and predictive techniques for future space transportation systems, and a cryogenic fluid management experiment which will provide the understanding for storage, acquisition, and transfer of cryogenic fluids. The systems analysis area will be focused on the identification of requirements and high-leverage technologies for the development of future space missions, such as a space-based OTV and the evolutionary space station. The analysis efforts provide scope and direction to the base research programs and identify system-level technology programs required to assure transition of identified technologies into flight programs.

In systems technology, the advanced space shuttle main engine (SSME) technology program will focus on providing system-level data for modeling performance and life and evaluating advanced technology components designed to improve life and reduce maintenance costs. The components will be installed on a testbed engine and instrumented to provide the overall understanding and data base on performance in the realistic hot-fired engine environment. This is a joint program in which the Office of Space Flight will provide a non-flight SSME as the testbed engine. The space flight experiments program will encompass the design, development and flight test of experiments and the development of special purpose, reusable, flight research facilities for use in space. Current experiment efforts include: (1) a superfluid helium on-orbit transfer experiment; (2) design of two of the thermal energy management processes experiments; and (3) a solid-state laser light direction and ranging (LIDAR) technology demonstration.

Two systems technology program enhancements are being proposed. The first, control of flexible structures, addresses structural, dynamics, and controls issues which must be understood prior to the deployment of large space structures having precision control requirements. The second, OTV technologies, is directed at critical capabilities for a reusable, space-based orbital transfer vehicle. It includes the systems definition study for an aeroassist flight experiment and the fabrication and test of advanced technology components which may be required for a full-scale OTV research engine.

**BASIS OF FY 1986 FUNDING REQUIREMENTS**

RESEARCH AND TECHNOLOGY BASE

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| Aerothermodynamics research and technology... | 8,480 | 8,900 | 10,100 | 10,600 | RD 14-6 |
| Materials and structures research and technology | 16,694 | 18,100 | 18,800 | 19,300 | RD 14-9 |
| Space energy conversion research and technology | 22,006 | 22,700 | 22,500 | 22,900 | RD 14-12 |
| Propulsion research and technology.... | 19,497 | 20,500 | 20,500 | 20,900 | RD 14-15 |
| Space data and communications research and technology | 17,802 | 17,800 | 16,500 | 16,900 | RD 14-18 |
| Information sciences research and technology... | 16,001 | 16,200 | 17,600 | 18,000 | RD 14-20 |
| Controls and guidance research and technology | 7,402 | 8,500 | 8,600 | 8,900 | RD 14-23 |
| Human factors research and technology | 3,003 | 3,500 | 3,700 | 4,000 | RD 14-25 |
| Space flight systems research and technology.. | 6,800 | 11,700 | 11,450 | 11,900 | RD 14-27 |
| Systems analysis.... | 7,200 | 8,100 | 6,600 | 6,600 | RD 14-29 |
| Total | 124,885 | 136,000 | 136,350 | 140,000 | |

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Aerothermodynamics research and technology...... .................... | 8,480 | 8,900 | 10,100 | 10,600 |

**OBJECTIVES AND STATUS**

The aerothermodynamics program has the following objectives: (1) to develop validated experimental and computational techniques for predicting flowfields for a broad range of generic aerospace vehicle configurations; (2) to improve techniques for predicting aerodynamic and aerothermodynamic characteristics of vehicle concepts in the continuum to rarefied flow regimes; and (3) to provide the experimental technology required for aerodynamic and aerothermodynamic testing. Improved techniques for predicting the capability and response of future aerospace vehicles in the various flow regimes, including ascent to orbit, low earth orbit, and earth and other planet entry, will provide the increased confidence needed €or maximum use of the performance and payload potential of those systems.

Progress in the ability to predict flowfields about vehicles entering the Earth's or other planetary atmospheres has been accelerated by new computational techniques capable of analyzing shuttle-like vehicles at high angles-of-incidence that produce locally subsonic flows over the entire lower surfaces. These predictive codes have been validated by the data returned from shuttle flights one through five. Flow over the upper surfaces of such vehicles remains difficult to calculate because of the formation of separated zones that roll up into large vortex systems. At present, empirically derived methods provide limited capability for these upper surface predictions. Study of the very high Mach number flows over entry bodies has provided new information on chemical reaction rates and radiative properties of gases which will be useful in the future development of aeroassisted orbital transfer vehicles and heat shields for spacecraft entering the atmospheres of Saturn, Jupiter, Titan, and Mars. Exploratory studies of space-based aeroassisted orbital transfer systems have identified nonequilibrium, radiative shock-layer flows as an unknown factor that will control important decisions on heat shield geometry/material and vehicle aerodynamic design.

The theory of rarefied gases has been advanced by the use of a dedicated computer specially programmed for the multibody collision processes involved. The methods developed are being used in the study of contamination of spacecraft by control jets and, also, for estimation of forces and torques acting on reentry vehicles in the initial high-altitude portion of the trajectories.

The orbiter experiments program has made use of the shuttle orbiter as a research aircraft permitting the evaluation of aerodynamic prediction methods. The flight data have generally corroborated predictions over much of the flight regime; however, several situations were found in which sizable differences occurred. Of particular interest for future aeroassist maneuvers is the uncertainty in atmospheric density that was identified during the STS flight 5 as varying by as much as 25 percent from the best estimates. Variations of this size could pose serious problems for the guidance and control of space-based aeroassisted orbital transfer vehicles. Nonintrusive photodiagnostic instrumentation will be developed to define the free-stream density variations and to survey the orbiter flowfield.

Aerothermal loads research focuses on the interaction of high-temperature, high-Mach number flows with specific surface structure. The goal is to establish an integrated flow thermal/structural prediction and design capability that will eventually provide more accurate structural analysis and more optimum structural concepts. During the past year, analytical studies were performed to predict the heating of bowed quilt-like surfaces simulating advanced thermal protection systems, and a parallel test program was conducted in the 8-foot high-temperature structures tunnel at the Langley Research Center. The experimental results verified the analytical predictions, showing significant pockets or hot spots generated by the distorted surface. During the past year, the program supported the operation of high- temperature, high-Mach number facilities at the Ames and Langley Research Centers. These facilities provide a unique group of test jets and tunnels that were used extensively in the shuttle development. Also, they will be needed for all future development of advanced vehicles and for validation of the developing computational methods of vehicle design. In the aerothermal loads disciplines, these methods are finite element analogs with aerothermal interface between fluid and structure to account for the coupled response.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The aerothermodynamics research and technology program estimate was increased by $1.2 million in support of the following high-priority requirements: advanced orbital transfer vehicle effort, photodiagnostic instrumentation, orbiter experiments data analysis, and advanced space transportation system aerothermodynamic studies.

**BASIS OF FY 1986 ESTIMATE**

Computational methods will continue to be advanced to treat the problems of vortex generation over upper surfaces of reentry vehicles of advanced design. The capability for computing rarefied gas flows will continue to be developed and applied to estimating the forces and torques on very large space structures, and flight test data from the shuttle will continue to be evaluated to obtain comparisons with the theory. Ground-based tests in this flow regime, heretofore thought not yet possible, will be considered.

Aerothermodynamic characteristics of a series of vehicle designs will be determined in a cooperative program with the Air Force, as expressed in a memorandum of understanding (MOU) between Langley Research Center (LaRC) and the Air Force Wright Aeronautical Laboratories. Orbit-on-demand (OOD) vehicles, boost glide vehicles, and maneuvering research reentry vehicles will be considered. These vehicle shapes and flight corridors will be sufficiently different from the shuttle orbiter to require their own aerothermodynamic data base, as well as to present unique challenges such as leading-edge heating, shear layer/vortex impingement, and aerothermal loads problems. Aerothermodynamic discipline personnel will support the systems analysis effort which seeks to define the advanced space transportation technology needs for a priority personnel vehicle to complement potential heavy-lift cargo vehicles in the space station area.

Blunt configured vehicles will be studied for use as aeroassisted orbital transfer vehicles (AOTV) which require addressing new environmental conditions. The AOTV will have to be designed by computational techniques because nonequilibrium radiation, which dominates the aerobrake (AOTV forebody) flowfield, cannot be simulated in existing ground experimental facilities. The latest and most promising algorithm for computing the AOTV flowfield is the conservative supra-characteristic method. The development effort on this algorithm will be enhanced in the coming year, and an implicit nonequilibrium chemistry scheme will be incorporated. Accurate finite-rate chemistry models will be essential for input into the AOTV computational effort, and, in this regard, the computational nonequilibrium chemistry modeling work at the Ames Research Center (ARC) will be intensified. In general, the determination of the aerodynamic and aerothermodynamic consequences of vehicle flowfields characterized by finite-rate reactions and nonequilibrium radiation will continue to be a major effort in FY 1986.

The aerothermodynamic facilities at both the Ames and Langley Research Centers will be used to provide data on forces, stability and control, and heating for the cooperative Air Force program to establish a data base for use in design of orbital transfer vehicles ranging from bent conical bodies to blunt and bulbous shapes simulating inflatable and deformable heat shields.

The aerothermal loads program will continue the development of finite-element methods for solving the Navier-Stokes equations applied to high-temperature and Mach number flows over advanced thermal protection materials. The finite-element fluids methods will be matched to finite-element structural codes to provide a complete method for determining the coupled response of the dynamic fluid and loaded flexing structure with aerodynamic and conductive heat transfer.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Materials and structures research and technology............ | 16,694 | 18,100 | 18,800 | 19,300 |

**OBJECTIVES AND STATUS**

The objectives of the materials and structures research and technology program are to provide the performance, efficiency, durability, and economy required for large-area space structures, antennas and space platforms, advanced space transportation systems, orbiting spacecraft, planetary probes, and shuttle payloads. Major technical areas of emphasis in materials include: basic understanding of advanced materials; development of computational chemistry methodology; characterization of long-duration space environmental effects on materials; and the development of ceramic, metallic, and advanced carbon-carbon thermal protection systems. Structures technology is directed toward development of advanced truss structural concepts; reliable methods for deployment/erection of space structures; new structural and tankage concepts for advanced space transportation systems and orbital transfer vehicles; and efficient analytical methods for design and evaluation of advanced space structures, including integrated structures/thermal controls analysis and optimization techniques.

A key element for structural dynamics research during FY 1985 was the establishment of a focused program for the dynamic response and passive/active control of flexible space structures. This activity encompasses a variety of large space structures that includes joint-dominated deployable beams, flexible platform structures, and antenna structures. The major program goal is to develop validated structures/controls analysis methods which will then allow detailed design studies that can assess technology merits between utilizing structural stiffness, passive damping techniques, and active control methods to obtain specified system performance and accuracy requirements. As part of the ongoing space construction research activities, an in-space shuttle bay, structural assembly experiment will be conducted in mid-1985. This experiment involves the construction of a joint-dominated beam from the cargo bay of the space shuttle by two astronauts. The data gained from this experiment will be used to evaluate on-orbit assembly techniques and understand factors that affect human productivity. During this past year, fabrication and ground testing was completed on a 15-meter deployable hoop-column antenna; similar tests were conducted on segments of a large deployable 50-meter antenna; and thermal-vacuum tests were conducted on various composite panel mirror segments. The purpose of these tests was to develop a data base to guide future development of large space structural concepts and to support the ongoing development of methods for the structural analysis of space structures. As part of this analytical effort, a program was initiated to develop advanced methods to accurately predict the nonlinear dynamic response of large multibodied space structures.

Materials research focused on the effects of the space environment including atomic oxygen and ultraviolet radiation. Special emphasis was placed on developing space-durable polymeric composite materials and protective coatings, and the study of methods for nondestructive testing and evaluation. Supporting research was conducted to understand the mechanisms controlling surface properties of materials in a space environment. Part of this program includes methods in computational chemistry to predict the behavior of materials under these conditions. Extensive research for advanced thermal protection systems (TPS) will continue in FY 1985. The effort was focused on advanced carbon-carbon panel concepts and ceramics in the form of tailorable advanced blanket insulation (TABI). Three-dimensional weaving procedures were developed for ceramic TABI, resulting in blankets of significantly greater durability.

Increased emphasis was placed on the requirements for an aeroassisted orbital transfer vehicle and an aeronautics/space transatmospheric vehicle. Part of the assessment process for advanced TPS concepts included exposure to an arc jet to simulate accelerated space environment testing. Research also continued for developing fully space-qualified composites for long-term space use.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The materials and structures research and technology program was increased by $700 thousand. This increase supports a greater effort in thermal structures, with a focus placed on the requirements of an advanced orbital transfer vehicle.

**BASIS OF FY 1986 ESTIMATE**

The effect of the space environment on structural materials for spacecraft, space station, and orbital transfer vehicle applications will be a major thrust. Included in this activity will be research on the durability of polymeric materials, thermal control coatings, films, adhesives, and seals. The radiation damage mechanism in epoxy matrix composites in a simulated environment at geosynchronous earth orbit will be identified, and test data €or accelerated aging of these materials in the combined radiation of electrons, protons, and ultraviolet will be obtained. Thermal control coatings research to allow full benefit of composite structures for large-area space application and the study of the dimensional stability of composite structures in the space-cyclic thermal environment will continue. Basic research in the fundamentals of tribology of bearings for spaceborne mechanisms will be carried out with particular emphasis on solid lubrication for traction-drive actuators. Advanced carbon-carbon composite concepts will remain a major focus in the TPS program. Activities in the ceramic thermal protection system area will continue to be directed toward the further development of flexible ceramic blanket-type insulation for application to advanced orbital transfer vehicles and for further upgrade of material currently used on the shuttle. Both rigid and flexible TPS will be evaluated for use on a rapid-response transatmospheric vehicle. Research in advanced space structures will establish structural concepts, deployment schemes, and packaging techniques that will permit structures on the order of 100 to 200 meters in size to be carried into orbit in one shuttle flight and automatically deployed. Erectable concepts and assembly methods for structures between 100 and 1000 meters in size will be developed. Research will be performed to establish the technology base for the control of flexible structures dynamic response with the goal to conduct in-space structural dynamics flight experiments in order to validate technology. This activity will require both analytical and experimental research to develop procedures to characterize structural configurations during ground tests, as well as during space tests. Active and passive damping techniques to reduce structural vibration will be developed in parallel with the development of methods for predicting and reducing the dynamic response of structural configurations for large-area space platforms and antenna structures. Advanced analytical methods that include deployment dynamics and mechanism simulation will be initiated for analysis of large, flexible space structures and platforms.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Space energy conversion research and technology..................... .... | 22,006 | 22,700 | 22,500 | 22,900 |

**OBJECTIVES AND STATUS**

The objectives of this program are to: (1) increase the performance, capacity, and cost effectiveness of space electric power generation and energy storage subsystems; (2) provide the technology for efficient, reliable, and low-cost management and distribution of electrical and thermal energy for space systems; and (3) advance the technology of life support systems for large manned space platforms. In FY 1984, significant progress was made in developing efficient radiation-resistant solar cells, high-power arrays for low earth orbit application, and ultra-lightweight arrays for geosynchronous and planetary spacecraft. A corrugated, radiation-tolerant gallium arsenide cell design was demonstrated, and its response to irradiation by high-energy protons investigated. A high-quality aluminum gallium arsenide cell was fabricated for application to high-efficiency multi-bandgap cells. In the area of high-power arrays, an advanced substrate structure was demonstrated for the miniature Cassegranian concentrator configuration, and discussions were initiated with the Department of Defense to conduct a joint program on concentrator configurations capable of operating in high-radiation environments. An ultra-lightweight photovoltaic structure with stiffness nearly ten times as great as that previously available was fabricated with approximately no change in structural weight. A milestone in photovoltaic technology was reached with the successful deployment and retraction of the 105x13-foot lightweight solar array experiment aboard the space shuttle Discovery in September 1984. This experiment increased confidence in the use of large photovoltaic arrays in space systems. In space nuclear power (SP-100) research, thermoelectric, thermionic, and dynamic energy conversion concepts are being studied. A critical technology issues program was implemented and aimed at improvement of thermoelectric materials efficiency, insulator development for thermionic diodes, and linear alternator development for the thermodynamic cycle engine. In the electrochemistry area, a six-cell regenerative hydrogen/oxygen fuel cell substack successfully passed 15,000 hours of endurance testing. A flexible, high-energy-density cathode for a rechargeable lithium battery was fabricated and was successfully cycled over 600 times. This represents a potential solution to the key problem of cycling of high-energy-density batteries for geosynchronous orbit applications.

Under the power management program, advances were made in materials, devices, and systems technology. High-conductivity, high-stability bromine intercalated graphite fibers were successfully demonstrated, and a thin flexible coating that successfully protects Kapton and other materials against degradation by atomic oxygen in low earth orbit was developed. Switches capable of operating at very high currents and voltages and at very high speeds were demonstrated, and progress was made in development of solar-array and energy-storage simulators for use in power subsystem automation investigations. To provide guidance in the design of low earth orbit (LEO) and geosynchronous earth orbit (GEO) systems, work on the Volt-A flight project was initiated; the "Spacecraft Charging Design Guidelines" document was completed; and scaling laws were developed for the electromagnetic interference (EMI) generated by arcing from dielectric materials. In the laser area, closed-cycle solar-pumped lasing was demonstrated, and it was determined that solar pumping of dye lasers is possible. In the thermal management area, advances were made for the liquid droplet radiator (LDR) concept through studies of the fluid dynamics and droplet formation processes and by development of a fabrication capability for the liquid droplet generator. Coordination with the Air Force on the LDR concept continued. In addition, a capillary pump energy-transport capability, 100 times as great as that available in the existing state of the art, was demonstrated. In the advanced life support technology area, efforts continued on the verification of technology for controlled closure of the water-air-waste cycle and on advancing the technologies of portable life support and on-orbit servicing subsystems that would enable space-based extravehicular activity (EVA) systems.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

This program has been reduced by $200 thousand to accommodate the realignment of funding and management responsibility of the extravehicular activity (EVA) suit work to the human factors program.

## BASIS OF FY 1986 ESTIMATE

The FY 1986 technology program will be directed at substantial improvements in performance, capacity, and cost of space energy conversion systems. In the photovoltaic area, development and evaluation will be made of: (1) very thin gallium arsenide, other advanced-composition, concentrating, and cascade cells for high-efficiency conversion; (2) Cassegranian and low-aperture concentrator arrays to enable reduced area, reduced cost, and increased lifetime in low earth and high radiation orbits; and (3) lightweight arrays, deployment mechanisms, and their response to radiation to enhance or enable future NASA geosynchronous and planetary missions. In the thermal-to-electric program, research and technology will be performed in both solar dynamic and nuclear systems. In the solar system area, efforts will address energy concentrators, receivers, and storage technology. In the space nuclear (SP-100) area, the critical issues program in the thermoelectric, thermionic, and thermodynamic cycle engine conversion technologies will be continued and aimed at providing a basis for selection of a single approach. Efforts under the tri-agency activity will be conducted with the objectives of analyzing civil missions that benefit from use of nuclear power and of defining candidate reactor systems for these missions. In the area of chemical energy conversion and storage, emphasis will be placed on high-energy-density, long-life primary (nitrogen-hydrogen) and secondary (lithium) batteries. Demonstration of a 200-watt hour/kilogram, 1000-cycle battery is planned.

In the power management and distribution program, technology will continue to be aimed at developing and assessing materials, components, and subsystems for high-voltage, high-power space systems. Techniques for bulk intercalation of spools of graphite fibers will be identified and evaluated, and superlattice electronic materials and insulated gate materials will be characterized. Efforts will proceed in control circuit and component definition, system automation technology, and modeling and guideline development for system environmental interactions. In the laser area, technology will be continued in both direct and black body solar pumping of lasers and in identification of new applications of laser power transmission. In the thermal management technology program, high-capacity, high-performance thermal transport systems for the interior of the spacecraft, and low-weight high-performance radiators for heat dissipation to space will be evaluated. Capillary and forced convection two-phase fluid systems will be investigated. The crew and life support technology activities will be continued in the areas of water recovery, air revitalization, and waste disposal, and in portable and on-board servicing subsystems needed to support a space-based EVA system.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Propulsion research and technology.... | 19,497 | 20,500 | 20,500 | 20,900 |

**OBJECTIVES AND STATUS**

The objective of the propulsion program is to provide the technology base for improving the life, performance, reliability, and maintainability of chemical and electrical propulsion systems for future space transportation, manned and unmanned platforms, and spacecraft systems. The program includes efforts directed at providing longer life, reusable propulsion systems for lower cost operations; high-performance, variable-trust propulsion for increased mission flexibility and capability; efficient, long-life, on-board auxiliary propulsion for precise attitude control and station-keeping functions; and electric-thruster system technologies for potential future missions.

Technology for high-thrust (SSME class), high-pressure, reusable cryogenic propulsion systems is focused primarily on technology to extend the life of engine components which are subjected to the severe internal dynamic, mechanical, and thermal environments that are typical of high-pressure rocket engines of this class. Both hydrogen- and hydrocarbon-fueled engines will benefit from these technologies. Turbine blade life is being extended significantly by the development of damping mechanisms which control flexural fatigue and by improved heat-resistant coatings. A cryogenic mass flow meter has been demonstrated that is simple and yet promises to provide accurate measurements in severe cryogenic environments. A fluorocarbon elastomeric material has been developed for use in 4000 pounds per-square-inch (psi) liquid and gaseous oxygen, promising lower cost and more efficient gaskets and seals. A dependable three-dimensional hot gas flow model has been developed, and when applied to the SSME, it indicates that one of three transfer ducts from the high-pressure fuel pumps to the main injector carries little flow and could be eliminated with significant, beneficial reduction in engine environments. Technologies specifically directed toward hydrocarbon-fueled engines are being used to establish combustion performance, heat transfer rates, and fuel cooling characteristics at very high pressures (3000 pounds psi) using subscale combustor hardware.

Work on the orbital transfer vehicle propulsion system continues to emphasize very high-performance, variable-thrust, long-life components and concepts, and "state-of-health" monitoring systems. A number of studies are in progress to define the characteristics of the OTV stage. Four vehicle system contractors are defining overall characteristics of candidate systems, and three propulsion contractors are evaluating engine design alternatives and defining areas for significant technology improvement. These technology areas will permit increasing performance from today's 446 seconds to 485 seconds (equivalent to a twenty percent savings in propellent required for delivery of GEO spacecraft); maintaining high efficiency while throttling; improving the heat transfer in the combustion chamber; developing high-expansion ratio nozzles; and designing for in-orbit servicing and maintenance.

In the auxiliary propulsion area, trade studies identifying critical technologies for candidate oxygen-hydrogen drag makeup and attitude control systems have been completed, and technology efforts have been initiated. Small gaseous oxygen-gaseous hydrogen thruster testing has demonstrated the feasibility of attaining desired performance without sacrificing thruster life. System definition studies have been initiated to establish optimum component operating conditions. Efforts are in support of potential use of hydrogen/oxygen systems on space stations, space platforms, and vehicle stages.

The electric propulsion program develops technology for future thermal and electrostatic thrusters and the associated power processing systems. The thermal resistojets, or arc-jet systems, heat a wide range of gases and develop small forces suitable for attitude control, station-keeping, or drag makeup. Electrostatic, or ion, propulsion generates very high specific impulses at millipound force levels and is particularly attractive for long-duration planetary missions. The thermal thruster program is actively investigating hardware concepts and preparing to test small units in a large vacuum tank facility recently renovated at Lewis Research Center (LeRC). Ion propulsion efforts have simplified power supply designs, modeled performance with various propellants, improved the efficiency of the ion thruster, and increased its thrust density capability.

## BASIS OF FY 1986 ESTIMATE

The technology effort for advanced, high-pressure, reusable propulsion systems will be directed toward continued development of analytical models designed to define hot gas flow distributions and resulting dynamic loads; the characterization of the structural response and material behavior of parts subjected to these dynamic loads; and the development of accurate life prediction techniques. In addition, advanced instrumentation will continue to be developed for use in the testbed engine to more accurately measure the true dynamic environment, permitting a better understanding of actual engine operating conditions, and to permit the validation of computer codes analytically simulating the engine environment.

The focus of research effort in hydrocarbon-fueled, high-performance, reusable propulsion systems will continue to be on fundamental work in combustion, stability, heat transfer, and cooling. Experimental testing with subscale hardware will be conducted for the purpose of validating computer codes that analytically model combustion processes, carbon deposition, and heat transfer coefficients. Cold flow testing with subscale hardware will be used when feasible to supplement hot firing test data.

The technology effort for variable-thrust orbital transfer engines will emphasize component research directed toward generating analyses and design criteria for the engine components critical to the achievement of the life, performance, and maintainability goals for a space-based, man-rated vehicle. Critical components include high-performance, long-life, high-heat transfer combustors; highly efficient variable flow rate turbopumps; and integrated diagnostic instrumentation. Test rigs will be used to validate analytical models and advanced component designs as they evolve.

Auxiliary propulsion technology efforts will focus on gaseous oxygen-gaseous hydrogen component development guided by the system definition and evolution studies that have now been completed. Primary emphasis will be on designs to increase thruster performance and life, propellant conditioning components, and diagnostic instrumentation.

In the electric propulsion program, the effort will continue to address the technologies required to provide improved thrust density, power efficiency, and long-life cathodes.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Space data and communications research and technology...................... | 17,802 | 17,800 | 16,500 | 16,900 |

**OBJECTIVES AND STATUS**

The space data and communications program consists of research and technology efforts to advance the capability for processing, storing, managing, and communicating space-derived data.

The objectives of the data systems program are to provide the technology to enable more cost-effective utilization of space-derived information, to increase substantially the capability of on-board and ground processing for future missions, to provide the computational systems necessary for the management of data anticipated on the evolutionary space station, and to provide the computational systems necessary for modeling of global phenomena. In 1984, the massively parallel processor became fully operational at Goddard Space Flight Center and available to researchers from NASA, National Science Foundation (NSF), and National Security Agency (NSA). The unit contains 16,384 processors, capable of executing six billion operations per second, an3 provides a major technological advance in computational capability for multidimensional modeling and image analysis. In addition, a ten terabit optical-disk juke-box data storage system was installed and made available to the space physics community at Marshall Space Flight Center. During 1984, three major joint efforts were initiated: (1) NASA initiated the first non-DOD very high-speed integrated circuit insertion contract for a high-performance processor applicable to space station; (2) a high-bandwidth terabit ($10^{12}$) optical-disk buffer system development was started with five other government agencies; and (3) NASA joined with the Air Force in the development of a 500 million bit-per-second fiber optics common module for space applications.

The objective of the communications technology program is to provide the high-payoff research and technology required to ensure U.S. preeminence in satellite communications. In 1984, the technology necessary for the x-band downconverters for the Galileo and Venus radar mapper missions and the technology and prototype for the traveling wave tube amplifier for the advanced communications technology satellite were transferred to the Office of Space Science and Applications. The crucial role of oxygen in the failure mechanisms and lifetime degradation of cathodes in microwave tubes was understood, leading to the invention of a novel long-life cathode. A technique, which produces low secondary emission in cathodes, was invented to further extend the lifetimes of MDCs. The electromagnetic analysis and modeling of large reflector antennas with quasi-periodic rough surface perturbations, unlike those anticipated for large mesh deployable antenna systems such as a mobile satellite mission, together with the antenna/feed design, was accomplished. In optical communications, amplitude and phase modulation in optoelectronic modulator arrays and phase coherent semiconductor laser array emitters was successfully designed and demonstrated.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The scope of this program has been decreased by a total of $1.3 million ($800 thousand in space data efforts and $500 thousand in communications research) to provide funding for other higher priority program requirements within the research and technology base.

**BASIS OF FY 1986 ESTIMATE**

Based on FY 1985 studies, the development of a very high-speed integrated circuit (VHSIC) based on-board an array processor for data processing and decision making, a symbolic processor for multispectral images, synthetic aperture radar, and other advanced high-data-rate instruments will be initiated. This will provide the capability for complex sets of space instruments to transmit partially processed data to the ground through constrained communications resources and to increase the science return through improved data selection.

In FY 1986, efforts will continue on advanced microwave traveling wave tube design with the dynamic velocity taper concept expected to be transferred to the military communications satellite, Milstar. The Ka-band and the very high-efficiency x-band traveling wave tubes will be transferred to the Office of Space Tracking and Data Systems for the deep space network, while the 29-GHz tunneladder traveling wave tube circuit technology should be ready for application to the Office of Space Science and Applications' advanced communications technology satellite. In order to test the modeling of large antennas for a mobile satellite mission, electromagnetic measurements on a 15-meter model antenna, together with a 16-element feed network array, will be initiated. Technology for a space optical transceiver package for satellite-to-satellite and deep space applications will be continued.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Information sciences research and technology............ | 16,001 | 16,200 | 17,600 | 18,000 |

**OBJECTIVES AND STATUS**

The objective of the information sciences program is to provide advanced concepts, techniques, system architectures, hardware components, algorithms, and software for space information systems. The program contains disciplinary activities in electronics, sensor systems, automation, and computer science. Research in electronics is directed at investigating and advancing new and existing scientific concepts necessary for the development of solid-state devices to meet NASA's unique requirements for sensors, data and signal processors, and controllers. Sensor research is focused on extending the capabilities of active and passive sensing systems in terms of NASA's unique requirements for spectral range, sensitivity, and resolution. Automation research is developing the theoretical and technological base in artificial intelligence and robotics to increase the productivity and effectiveness of future operations in space. The computer science program is improving the state of knowledge of fundamental aerospace computing principles and advancing the state of computing technology in space applications such as spacecraft operations and information extraction from images.

In electronics, the first strained layer indium arsenide/gallium arsenide (InAs/GaAs) superlattice device was made which should open up revolutionary possibilities in tailoring detector material to the very special space requirements of narrow spectral sensitivity and tunability. The special custom test chip, built for NASA to monitor radiation damage aboard the NASA/DOD/Air Force chemical release and radiation effects satellite (CRRES), has been developed with a special radiation-hardened version in the planning stage. A major breakthrough has been achieved in understanding the nature of radiation damage mechanisms at the silicon/silicon dioxide interface in certain semiconductor devices that are critical components in electronic circuits.

In sensor technology, a charge-coupled detector imaging device achieved high sensitivity across a very broad spectral band from the X-ray to the near infrared portion of the electromagnetic spectrum. In addition, a unique charge-injection imaging integrated array device was successfully tested in a spectroscopic application on a ground-based telescope facility. A unique magnetic switch employing metallic glass technology has been invented which will enable much greater lifetimes and efficiencies necessary for spaceborne laser remote sensing. The prototype components that are prerequisites for a possible geodynamic instrument for future earth observation systems have been successfully tested. Finally, an experimental detector based on a superlattice concept, called modulation doped epitaxial layers, has been successfully tested to a wavelength of 200 microns, bridging the gap between conventional germanium and indium phosphide detectors.

In automation, the performance of the automated mission planning program, DEVISER, was improved nearly a hundredfold, demonstrating its capability to plan operational command sequences for the Voyager encounter with Uranus. Planning software, complete with graphics aids, is being turned over to the Voyager project. A diagnostic program was demonstrated for monitoring the Voyager telemetry stream to detect and diagnose Voyager ground system and spacecraft errors and malfunctions. Work has begun to integrate automated planning with monitoring and fault diagnosis software to demonstrate rudimentary levels of system autonomy. Another expert system scheduler was demonstrated for the Kuiper Airborne Observatory astrophysics program. This system is the forerunner of a lineage of schedulers to support astrophysics missions such as the shuttle infrared telescope facility (SIRTF) and the large deployable reflector (LDR). In robotics research, a powerful pipelined vision processor was conceived, designed, and is currently being built. This programmable image feature extractor (PIFEX) is designed primarily for low-level image processing but has an extremely flexible and programmable architecture that allows it to be adapted to solve some high-level image understanding and image analysis problems. PIFEX will permit real-time processing of images at speeds up to ten billion operations per second, a speed not achievable by conventional Von Neumann computers.

In computer science, the conceptual design of an expert system to provide integrated data management and data analysis capabilities for imaging spectrometer data was completed, and interactive exploratory analysis software for imaging spectrometry was developed. Data base research resulted in the development of a solution to the common user interface problem based on the recently developed data base logic. This work, which is being implemented as the distributed access and view integrated data base (DAVID) system, provides the foundation that will eventually enable NASA space data users access to multiple data bases independent of their physical distribution or specific organization. Software engineering research resulted in the design of an integrated software management environment consisting of tools, measures, and interfaces. A major emphasis in this work involves coordination and cooperation with the DOD software technology for adaptable reliable systems (STARS) program. The University of Illinois developed a portable simulator for the massively parallel processor (MPP) to allow off-site development and testing of programs. This simulator will greatly enhance the utility and productivity of the MPP and the people using it.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The $1.4 million increase to this program is the net effect of several actions. Automation efforts have been increased by $4.0 million in accordance with Congressional direction by reducing funding for fundamental electronics work within this budget line by $3.0 million, and adding $1.0 million redirected from other research and technology base programs. The sensors work has been increased by $400 thousand.

## BASIS OF FY 1986 ESTIMATE

The electronics research area will continue to focus on NASA unique solid-state device requirements such as superlattices with material properties that are tunable over a wide portion of the electromagnetic spectrum. The CRRES chip for assessing radiation damage effects in orbit will be completed and transferred to the project manager. Sensors research and technology will focus on the development of advanced space-qualified lasers employing semiconductor laser-array pumping schemes for use in the active remote sensing programs. Detector arrays for sensing electromagnetic phenomena from the far infrared to the X-ray portion of the spectrum will continue.

In automation, a joint enterprise including Ames Research Center, industry, and academia has been formed to develop a spaceborne very high-speed integrated circuit symbolic processor. This machine will be the forerunner of computers which will be required for spaceborne applications of artificial intelligence software. Work will continue to develop generic software tools for the development of knowledge-based systems for space applications. This includes domain-independent inference systems, languages, knowledge representation schemes, and information extraction algorithms. A focus of activity in FY 1986 will be on developing expert systems techniques which exploit concurrency in execution in order to substantially speed up execution. This is required to perform real-time control of very large systems such as the space station with knowledge-based systems. Automated control of a regenerative environmental control and life support system (ECLSS) for an evolutionary space station will be demonstrated, culminating a three-and-one-half year technology program at Honeywell addressing automated subsystem operation. The PIFEX hardware development will be completed in 1986, and application testing to several real-time image processing scenarios such as correlation tracking, three-dimensional mapping, and object tracking will begin. Research and technology development focused on space station automation applications, particularly on robotics applications in space, will be a principal programmatic thrust of the FY 1986 program.

In computer science, knowledge-based techniques applied to hyperspectral scene analysis for geologic remote sensing data will be demonstrated, and prototype versions of DAVID will be installed for evaluation in space science applications. An experimental software management environment will be implemented, and a dynamic, simulation-based cost model for the software life cycle will be developed and validated. Studies of parallel algorithms and principles of concurrency employing the California Institute of Technology's hypercube machine will continue, with emphasis on time-dependent problems, optimization, mathematical programming techniques, and nonlinear systems. The Center for Aeronautics and Space Information Sciences at Stanford University will continue as a center of excellence in aerospace computing, conducting research and educating students in concurrent processing, information management, and large-scale system architecture.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Controls and guidance research and technology............. | 7,402 | 8,500 | 8,600 | 8,900 |

**OBJECTIVES AND STATUS**

The space controls and guidance research and technology program goal is to develop the design methods and techniques required to enable precise pointing and stabilization of future spacecraft and guidance of space transportation system vehicles. Emphasis has been placed on advancing modern control theory and analysis techniques and validating advanced controls and guidance concepts. Recent accomplishments include the generation of new control algorithms and software programs to identify and simulate vibrational frequencies, damping characteristics of large space systems having multiple vibration modes, and the successful demonstration of a new real-time adaptive control technique. Dynamic behavior modeling for the initial and the evolutionary space station has identified many areas where advanced control techniques will greatly enhance the capability to design and stabilize complex space station configurations consisting of a combination of rigid core habitation modules, flexible solar arrays, deployable masts and radiators, rigid payload modules, and flexible payloads, all having rigid/nonrigid coupled devices between them. The controls program is also developing models that will be used to test and evaluate control technologies for large space systems such as large antennas used for communications, astrophysics and earth observations, and segmented reflector telescopes.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The increase of $100 thousand in this program reflects a minor realignment of funding within the research and technology base to support a general increase in controls and guidance research and technology.

**BASIS OF FY 1986 ESTIMATE**

Specific FY 1986 controls technology activities will include further research into analytical techniques for space system plant parameter identification and on-board model error estimation important to interactive structure/control design methodologies. The fault-tolerance management of sensors, actuators, and related control strategies for large space systems will be tested in laboratory experiments. The analytical techniques and strategies which show the most promise will be validated on the control of flexible structures (COFS) flight experiment in a timely manner to support evolutionary space station configurations, large antennas, and other advanced spacecraft and platforms. An experimental version of an advanced three-dimensional shape and motion sensing system, which can be used to determine configuration and vibration motion of large space structures with dimensions on the order of 100 meters, will be tested to characterize and determine multitarget tracking performance. A new hierarchical structure of "levels of control" that provides greater system autonomy will be examined for the evolutionary space station concept. In space transportation vehicle guidance, navigation and control technology, research will be conducted to expand the shuttle controls envelope and to enable vibration-free payload pointing and stabilization when using the shuttle reaction control system thrusters. Adaptive guidance techniques will be researched for a new class of vehicle, designated the advanced orbital transfer vehicle (AOTV), that utilizes the earth's atmosphere for braking and maneuvering and for atmospheric planetary entry vehicles.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Human factors research and technology | **3,003** | 3,500 | 3,700 | 4,000 |

**OBJECTIVES AND STATUS**

The goal of the human factors program is to develop techniques, data bases, and standards for the design and evaluation of man-machine interfaces for use in orbit and in ground control. This program has three thrusts: crew station design, teleoperation, and space suit technology.

From crew station designs developed in the aeronautics human factors program, a technology for implementing three-dimensional perspective formats on electronic displays was adapted for potential use in space station. A program plan was developed for determining selection and implementation criteria for space station/crew station display and data input hardware, and the first task in this plan, cursor control evaluation, was completed. A method for rapidly gathering anthropometric data on astronauts was developed which permits simultaneous three-dimensional mapping multiple-body views. Such data is needed to better understand human capabilities in the design of man/machine interfaces. Preliminary crew station display techniques for the shuttle to enable docking with the space station were developed. The effects of habitats analogous to space station on the confinement of small groups for long periods of time were analyzed, and the implications for space station were developed. A mockup of a space station habitable module was constructed incorporating innovative ideas for enhancing crew productivity and habitability.

In the teleoperation human factors area, a human arm zero-gravity simulator was built and used to test the effects of zero gravity on astronauts' ability to precisely control a force-reflecting time-delayed remote manipulator. A method for damping control was developed to improve the stability of human control of a remote manipulator in the presence of force disturbances and trajectory discontinuities. A graphic display method was developed that further aided stabilization. A beam-assembly teleoperator (BAT) was built and tested and will be used as a testbed for improved teleoperation technology in neutral buoyancy tanks. A workshop which attracted leading teleoperation scientists was held to prioritize research elements. Highest priority elements include the development of: visually coupled head-up display (HUD) and voice-recognition technologies to reduce manual workload; hand-controller techniques for remotely manipulating multiple-dexterous intelligent end-effectors; and techniques for imbedding systems models in teleoperator controls to reduce the performance decrement due to feedback time delays.

In space suit technology, the focus is on improved suit mobility and tool development to improve the suited astronaut's productivity. A state-of-the-art helmet-mounted head-up display was developed to a brassboard state by a joint NASA/Air Force research team. This approach greatly increases an astronaut's access to information while performing extravehicular activity. Also, for new work station technology concepts, generic technology and a powered-glove end-effector were researched.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The human factors program has been increased by $200 thousand for EVA suit research.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, crew station design research will focus on three-dimensional perspective display techniques for potential use in space station and shuttle. Further work will be carried out to determine selection and implementation criteria €or other space station/crew station hardware. Initial work will be undertaken to add strength and movement capabilities to the anthropometric data collection and synthesis system. The human visual system model, developed under the aeronautics human factors program, will be applied to the development of guidelines for space station displays with minimum bandwidth and power requirements.

In the teleoperation human factors program, optimal hand-controller designs will be researched, and work will be undertaken on techniques for hybrid manual/computer control and stereo viewing with television. Research will also begin on the use of multiple arms with dexterous intelligent end-effectors.

In the space suit technology program, the helmet-mounted head-up display will be evaluated, and the generic EVA work station and the power glove end-effector will be fabricated and evaluated. Advanced technology will be developed for 8-pound psi hard suits.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Space flight systems research and technology.............................. | 6,800 | 11,700 | 11,450 | 11,900 |

**OBJECTIVES AND STATUS**

The objective of this program is to provide research-quality flight data supportive of ground-based research and technology efforts for the development of future space transportation systems. Data obtained from this effort support the development and verification of analytical theories and the verification of ground facility performance, test methods, and techniques. This objective is accomplished through the utilization of the space shuttle as a research testbed.

Instrumentation for the determination of aerodynamic coefficients continued to be flown successfully on all shuttle flights in FY 1984. Data from these instruments have been used to improve analytical models for the prediction of aerodynamic performance and have permitted the first lift/drag calculations in the transitional flow regime.

Key aerodynamic/aerothermodynamic experiments have completed integration into orbiter OV-102 (Columbia) during its modification period at Palmdale, California. These include low- and high-altitude research-quality air data systems for the measurement of air density from the upper atmosphere (transitional flow) to touchdown (continuum flow), and an infrared scanner in the vertical stabilizer to measure entry heating on the shuttle upper wing and fuselage surfaces. Additionally, two flight control experiments have been integrated into the orbiter. The first experiment will quantify orbiter handling qualities, and the second will provide flight data on an advanced, adaptive autopilot. These data will permit the supporting technology programs to be responsive to actual flight conditions. The first flight for these experiments is expected to be in the late FY 1985 or early FY 1986 timeframe.

Several advanced thermal protection system test panels are in development for flight opportunities in FY 1986. These panels will provide actual flight data on durable, high-performance concepts which could become candidates for future aerospace vehicles.

Additional orbiter experiments are in the initial phases of design development. These include the plume survey experiment to measure the flowfield properties in the exhaust plume of a shuttle reaction control engine and the orbital acceleration research experiment to provide measurements of aerodynamically induced deceleration at orbital altitudes. In FY 1985, development of long lead-time cryogenic fluid management facility (CFMF) hardware will be initiated. This experiment will provide the understanding for storage, acquisition, and transfer of cryogenic fluids.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

This program was decreased by $250 thousand, which is the net effect of a reduction of $600 thousand in orbiter experiments research activities, offset by a $350 thousand realignment from space flight systems technology to cover high-priority program requirements.

## BASIS OF FY 1986 ESTIMATE

A major effort in FY 1986 will be to support the aerodynamic instrumentation and thermal protection system experiments installed on Columbia and to reduce and analyze the resulting data. This instrumentation will provide a wealth of benchmark flight data which is expected to enable significant advances in the design of future space transportation systems.

Hardware development for the plume survey experiment and the orbital acceleration research experiment will continue through FY 1986, leading to expected flights in 1987/1988. Also, long lead-time hardware procurements and component fabrication for the CFMF experiments will be underway.

The dynamics, acoustics and thermal environment experiment program will continue to instrument selected payloads to address observed differences between predicted and measured low-frequency (10 to 50 hertz) loads environment. The goal will be to provide the payload designer simple, reliable tools for the design of shuttle payloads and to serve as a data base €or development of prediction models for future transportation vehicles.

Additional flight data requirements will be initiated, as required, and scheduled to support corollary ground-based research.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Systems analysis.................... | 7,200 | 8,100 | 6,600 | 6,600 |

**OBJECTIVES AND STATUS**

The objectives of the systems analysis program are to: (1) conduct system trade analyses to identify technology requirements for spacecraft systems, space transportation systems, and large space systems that are anticipated by a national space program; (2) integrate these requirements into a comprehensive plan of supporting technology base programs; and (3) justify the development of these technologies in a timely manner. Close coordination with NASA flight program offices and other users is maintained to ensure proper prioritization of the enabling and high-leverage technologies.

The spacecraft systems analysis area is subdivided into planetary, communications, earth sciences, and astrophysics. In FY 1985, the planetary systems analysis has focused on enabling technologies for sample return missions, particularly the Mars surface sample return and the comet nucleus sample return missions. Some of the critical technical issues that have been identified are the technologies relating to the Mars rover and the autonomous rendezvous/docking technologies in Mars orbit. In communications, the emphasis has been on quantifying the benefits from reducing the mass of spacecraft power and propulsion systems thereby permitting the weight of communication hardware to be increased. These studies show that a concerted technology program could potentially double the payload fraction on future spacecraft, thereby greatly enhancing both science and profitability. In the earth sciences area, analysis has identified instrument pointing as a crucial technology. In many cases, current instrument sensitivities are not achievable in practice because of pointing and jitter on the spacecraft. In the astrophysics area, we have pursued a jointly funded prephase-A study with the Office of Space Science and Applications to define the technologies for a large deployable reflector infrared telescope. In all of the above applications, where large space structures issues are involved, the Office of Aeronautics and Space Technology capability in integrated computer-aided design is being exploited to support the missions and technology trade-off studies.

The space transportation systems analyses are focused on four topics: technology issues for aeroassist orbital transfer vehicle (OTV), orbit-on-demand vehicle (OOD), heavy-lift cargo vehicle (HLCV), and advanced space transportation systems and analysis methods. AOTV technology studies are being used to prioritize the enabling and high-leverage technologies required to design a space-based, reusable OTV. The application of aeroassist braking on return of the OTV from GEO to LEO will result in a 50-percent reduction in propellant requirements and cost or a corresponding increase in payload delivery capability. Because the AOTV will fly a significantly different trajectory than any previous entry vehicle, advancements in technology are required in order to reliably predict the environment and design thermal protection systems that will survive the high temperatures encountered. OOD systems studies are being used to identify the enabling technologies required for the design of a quick response earth-to-orbit vehicle. This technology will be required primarily by DOD systems, such as the transatmospheric vehicle (TAV) and the advanced military spaceflight capability (AMSC) vehicles. HLCV studies are required to identify the technologies that enable the low-cost delivery of payloads in excess of 100,000 pounds to low earth orbit required by NASA and DOD missions. And finally, systems analysis methods are needed to conduct the required trade studies in a cost-effective manner. This involves the development of both technology and cost data bases, as well as computer-aided engineering software.

In the area of large space systems, both manned and unmanned, the analysis program is undergoing a transition in focus from the technological needs of the early space station to a broader category of large space systems including unmanned platforms, antennas, and evolutionary space stations. Additionally, the new focus will begin to identify appropriate technology development activities utilizing the operational space station as a facility in space.

In FY 1985, there are several activity areas in the large space systems analysis program. The objective of the systems analysis methods activity is to develop analytic simulation/emulation capabilities applied to specific subsystems to determine operational characteristics, predict nominal and worst-case failure modes, and to identify critical interface requirements. A simulation/emulation of an environmental control and life support system will be completed in the current year. The objective of the early space station system analysis activity has been to conduct subsystem trade studies addressing the technologies which have been identified as having potential for high payoff. Activities in this area are in their last year of funding and will culminate with the completion of the data management architectural studies jointly funded by the Office of Space Station, Office of Space Tracking and Data Systems, and Office of Aeronautics and Space Technology. The systems analysis effort for evolutionary space stations will begin in FY 1985. The primary objective is to analyze future missions and system requirements and identify technology needs and trends which will be used to provide scope and direction for the Office of Aeronautics and Space Technology's multidisciplinary research and technology programs. Specifically, the FY 1985 and 1986 effort will be devoted to developing generic models to permit the conduct of subsystem sensitivity trades for various combinations of subsystem technology options and designs.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The $1.5 million decrease in this program represents a reduction in scope of the systems analysis activities to support other higher priority requirements within the research and technology base.

**BASIS OF FY 1986 ESTIMATE**

In spacecraft systems, the analysis effort to identify the high leverage technologies for future NASA, military, and commercial users will focus on providing the next level tradeoff studies for the large deployable reflector. A joint analysis of the technology requirements for the earth observing system will be initiated in conjunction with the Office of Space Science and Applications' Earth Science Division. Planetary systems analysis will address the technology issues associated with comet sample return missions. Development of spacecraft computer analysis capability will also be continued.

In transportation systems, the analysis effort in FY 1986 will continue the definition of key areas for technology growth in orbital transfer vehicles and advanced systems for delivery of payloads to low earth orbit. Particular emphasis will be given to establishing the focused technology program required to support the development of the advanced aeroassist orbital transfer vehicle. Analysis will be conducted to determine the key OTV technologies and system trades performed to identify technology development payoff and cost benefit. In support of the technology development program, vehicle configurations and flight experiment requirements will be evaluated for the aeroassist flight experiment (AFE). The AFE, a joint OAST/OSF program, is required to obtain data on flight environments and vehicle performance not obtainable through ground tests or mathematical analysis. The FY 1986 transportation analysis program will continue to address the vehicles and technologies required for a wide range of space applications and missions. The development of design and analysis tools and the technology data base for vehicles such as a heavy lift cargo, orbit on demand, lunar transportation, and advanced shuttle type systems will enable the development of economical space systems in the future.

In large space systems, with the planning and definition activities associated with the early space station nearing a point in time when applicable technology will be baselined, the systems analysis program will be refocused to address the needs and opportunities of a broader menu of space systems including large antennas, unmanned platforms, and evolutionary space stations. The primary intent of the extended perspective is to insure that the R&T base program is structured to support the needs of these missions as they are being projected for the turn of the century. Additionally, the FY 1986 program will expand the efforts started in FY 1985 to include system analysis to support planning for using the space station as a facility in space for technology development.

## BASIS OF FY 1986 FUNDING REQUIREMENTS

SYSTEMS TECHNOLOGY PROGRAMS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | | (Thousands of Dollars) | | | |
| Chemical propulsion systems technology.......................... | --- | 2,100 | 2,100 | 5,800 | RD 14-33 |
| Space flight systems technology....... | 7,515 | 7,000 | 6,650 | 6,200 | RD 14-35 |
| Control of flexible structures........ | --- | --- | --- | 5,000 | RD 14-37 |
| Orbital transfer vehicle technologies | --- | --- | --- | 3,000 | RD 14-39 |
| Total............................. | 7,515 | 9,100 | 8,750 | 20,000 | |

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Chemical propulsion systems technology | | | | |
| Advanced SSME technology........... .. | --- | 2,100 | 2,100 | 5,800 |

**OBJECTIVES AND STATUS**

The objective of the advanced SSME systems technology program is to develop technology for advanced cryogenic engines by utilizing a testbed engine assembled from existing SSME hardware for the purpose of providing data to assist in developing models and validating analytical methods and advanced component concepts emanating from the propulsion research and technology base program. Initially, extensive instrumentation will be installed on the engine in order to experimentally establish a data base which characterizes the internal dynamic environment of the engine; much of this instrumentation will be a direct result of the OAST technology program. This data base will then be used to validate computer codes which were developed to analytically simulate these dynamic environments. Those advanced components designed €or extended life and/or performance will be evaluated at the engine system level in the true engine environment. This will be accomplished through the assembly of engine components, such as turbopumps or combustors, which include advanced technology subcomponents (e.g., bearings, seals, turbine blade dampers/coatings, advanced materials, etc.) which will then be installed in the testbed engine. The subcomponent technology advances will have been screened and evaluated initially in test rigs.

The testbed engine will provide the lowest risk path €or transferring improvements from the research and technology base program into a mainstream development program such as the SSME. Many promising products are emerging from the research and technology base program; they could be ready for testbed engine testing in the FY 1987/1988 timeframe. In addition, the testbed engine program will provide the experimental tool needed to evaluate longer term, higher risk technology items that will lay the foundation for advanced SSME derivatives or for the more improved high-pressure, reusable engines essential for future launch vehicles. The Office of Aeronautics and Space Technology (OAST) portion of this program funds the analyses, design, and fabrication of advanced component features from the technology program. Office of Space Flight (OSF) funds are used to procure component hardware, install advanced subcomponent technology items in the component hardware, assemble the testbed, and conduct test operations. Fabrication of advanced technology hardware will begin in FY 1986.

**BASIS OF THE FY 1986 ESTIMATE**

Subcomponent level advanced technology items will be procured for installation in advanced turbopump configurations by the Office of Space Flight. These advances include longer life bearings, low-leak seals, and improved turbine blade coatings. In addition, advanced instrumentation will be fabricated and delivered to the testbed engine for environmental mapping of engine dynamics in FY 1987. The initial focus of the advanced instrumentation effort is on high-response pressure and temperature sensors.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Space flight systems technology | | | | |
| Space flight experiments.. .......... | 6,290 | 5,900 | 5,350 | 6,200 |
| Long-duration exposure facility..... | 700 | 800 | 700 | --- |
| Ion auxiliary propulsion system..... | 525 | 300 | 600 | --- |
| Total............................ | 7,515 | 7,000 | 6,650 | 6,200 |

**OBJECTIVES AND STATUS**

The objective of the space flight systems technology program is to conduct research in space, capitalizing on the use of the space shuttle, spacelab, and free-flying vehicles where it is impossible or too costly to simulate the space environment in ground laboratories. The space environment uniquely provides long-term, zero gravity and the combination of space-vacuum and space-radiation environments necessary to the development and characterization of many technologies important to future space systems. This program element encompasses the design, development, and flight test of experiments and the development of special purpose, reusable, flight research facilities for use in space.

Current experiment efforts include: (1) a superfluid helium on-orbit transfer experiment; (2) design of two of the thermal energy management processes experiments; and (3) design efforts for an in-space solid-state laser light detection and ranging (LIDAR) technology experiment.

Development of a space technology experiments platform (STEP) will be initiated in FY 1985 to provide a dedicated support system for easy integration with the orbiter, which will be used to conduct flight experiments on the control of flexible structures in space.

In addition, in FY 1985 launch of the following experiments will occur: drop dynamics facility, feature identification and location experiment, and the superfluid helium characterization experiment. The long-duration exposure facility, having orbited for approximately 12 months, will be retrieved by the shuttle and the experimental data analyzed. Also, in FY 1985, a joint NASA/industry program will be initiated which will culminate in an in-space test of leading deployable truss structural concepts and advanced flexible body control techniques. Data from the solar array flight experiment, flown in September 1984, is presently being analyzed.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

This program was reduced by a total of $350 thousand. Space flight experiments and the long duration exposure facility activities were reduced by $550 thousand and $100 thousand, respectively. $300 thousand of this reduction was applied to the ion auxiliary propulsion system effort, and $350 thousand was transferred to the research and technology base to cover high-priority program needs.

## BASIS OF FY 1986 ESTIMATE

In 1986, the ion auxiliary propulsion system will have completed integrated systems tests and will be awaiting flight on a DOD spacecraft.

LIDAR design will be completed and hardware development initiated. The superfluid helium on-orbit transfer experiment hardware will be fabricated and component and subassembly testing performed. Additional flight experiments and concept definition activities will be initiated based on evolving requirements identified in the research and technology base program, technology urgency, and funding availability.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Control of flexible structures | | | | |
| Control of flexible structures flight experiment. .......................... | --- | --- | --- | 5,000 |

**OBJECTIVES AND STATUS**

The objective of the control of flexible structures (COFS) program is to develop and validate analytical methods for predicting coupled structural dynamics and controls response for multibody space structures with flexible components, interfaces and dissipative mechanisms. As the agency initiates planning and implementation for large space systems (space station/platforms/antennas), there are basic unknowns in the areas of structural dynamics, controls, structural interaction, structural performance, and deployment dynamics which must be resolved in order to develop this new class of spacecraft with the assurance of meeting safety, performance, and cost goals. The size and flexibility of the systems in question require a ground research program and a space-based experiment activity addressing the key unknowns through graduated testing of flexible elements of large space structures. In order to meet these requirements in a timely manner, consistent with NASA's overall space objectives, a program has been established, beginning in 1985, to focus on COFS. The COFS program includes both a ground research program and the space flight experiments.

The existence of an operational shuttle provides the opportunity to test and validate in space the dynamics, controls, structural concepts, theories, and system components required by future large structure missions. A test program will be conducted with a series of three or more flights, building progressively from modeling and modal characterization of large space structures to more complex flexible-body interactive controls issues. The approach provides for modal and functional complexity in a baseline configuration, through the design of a phenomena model flight test article that addresses many large space systems (LSS) discipline issues. Therefore, the phenomena model capabilities can be tailored to validate discipline research objectives addressing the major concerns of LSS spacecraft, independent of any specific configurations ultimately chosen for new missions.

The first flight article is a large (60 meters), deployable/stowable "next generation'' truss-beam structure (termed MAST) which will be flown in space cantilevered from the orbiter. Actuators and instrumentation, necessary for excitation, measurement, and control of the low-frequency modes of the MAST, are an integral part of the MAST flight experiment. The MAST test article will be transported to space and mounted on the space technology experiments carrier which will be integrated with the orbiter.

Specific objectives of the flight experiment are to determine the degree to which theory and ground testing can predict flight performance of next-generation, low-frequency structures; evaluate mathematical modeling of large, lightweight, complex systems on which ground test results are questionable; evaluate control/structure interactions; evaluate sensor/measurement techniques applicable to low-frequency systems with low-motion/deflection tolerances; evaluate deployment kinematics in zero-g vs. one-g; evaluate damping effects in zero-g; and evaluate LSS control laws and control mechanizations.

**BASIS OF FY 1986 ESTIMATE**

COFS will consider a variety of structures including joint-dominated, deployable beams of a generic nature; multibodied flexible arrays; and supported mesh antenna structures. Initially, COFS will concentrate on a joint-dominated, slender, flexible beam. Analytical methods development and ground-based experiments initiated during FY 1985 will be continued during FY 1986 to accurately characterize/synthesize the dynamic behavior of the structure and to develop control laws and methods to control its configuration and motion. Additional analysis and ground-based experiments will focus on expanding the newly developed technology for application to more complex multibody and three-dimensional structures.

The preliminary design review and the critical design review of the MAST flight test article will be completed in FY 1986. Flight test article delivery will occur at the end of FY 1986. The characteristics of the MAST truss-beam flight test article will be defined through initiation of a mathematical model to be later validated in the ground-based and space test programs.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Orbital transfer vehicle technologies | | | | |
| Aeroassist technology.............. | --- | --- | --- | 1,500 |
| Propulsion technology.............. | --- | --- | --- | 1,500 |
| Total............................. | --- | --- | --- | 3,000 |

**OBJECTIVES AND STATUS**

The objectives of the orbital transfer vehicle (OTV) technologies program are to ensure that the enabling and high-leverage technologies are in place to support the design and development of a cost-effective, space-based OTV. The two basic technologies required are aeroassist technology and propulsion technology.

When the OTV returns from geosynchronous orbit to low earth orbit, it must decelerate from approximately 33,800 feet per second to 25,000 feet per second. The advancement of aeroassist technology will permit the use of an aerodynamic braking device instead of having to rely solely on the propulsion system to decelerate. This would result in a propellant savings of up to 37 percent per flight, or approximately $35 million. Conversely, for a given amount of propellant, use of aeroassist braking will permit a 50-percent increase in payload weight. The primary emphasis in the aeroassist technology program is the OAST and OSF joint sponsorship of an aeroassist flight experiment in order to acquire data unobtainable in ground test facilities. These data are required to develop and validate theoretical/empirical aerodynamic and aerothermodynamic prediction techniques and to verify thermal protection system materials. Due to the high-velocity, high-altitude regime through which the OTV will fly, it will encounter levels of nonequilibrium radiation not previously experienced by any spacecraft/aircraft. Current estimates of the level range by a factor of three to four. The aeroassist flight experiment will result in a significant improvement in prediction accuracy, thus permitting a significant reduction in the vehicle weight and risks.

The propulsion technology program is directed toward the development of an advanced research engine (ARE) that would support the requirements of a fuel-efficient, space-based OTV propulsion system. The ARE will provide space maintainability, reusability, automated fault detection, and higher performance, higher specific impulse ($I_{sp}$), which will result in a propellant savings of up to 26 percent, or approximately $20 million per flight.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, the aeroassist technology program will concentrate on concept trade studies for the aeroassist flight experiment to determine the optimum configuration that will provide the maximum amount of data applicable to the OTV design. Also, system studies will be conducted to provide data for a reliable cost estimate for the AFE.

In FY 1986, the propulsion technology program will focus on component design and analysis efforts for advanced engines designed to meet the requirements of a space-based, man-ratable, aeroassist OTV. Under the research and technology base program, three contractors -- Aerojet, Pratt & Whitney, and Rocketdyne -- have developed unique advanced engine design concepts and have identified technology advances critical to achieving each of their engine's performance and life goals. Subcomponent laboratory scale experiments in the areas of heat transfer, combustion, high-speed bearings and seals, nozzle aerodynamics, fluid and gas dynamics, and materials and structures are developing design criteria and analytical methods to design and fabricate advanced components and subsystems. Emphasis in FY 1986 will be on the design of enhanced heat transfer combustor, high-efficiency turbomachinery designed to operate over a wide flow range for throttling, and diagnostic instrumentation and controls. This will allow an orderly progression into component fabrication in FY 1987 for later assembly into research engine configurations at each of the contractors for integrated component evaluation and verification of advanced technologies in actual engine system operational environments. These FY 1986 studies will provide the basis for meeting the aeroassist flight experiment and the advanced research engine requirements.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

STANDARDS AND PRACTICES

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of dollars) | | | |
| Standards and Practices........... | 4,600 | 4,900 | 4,900 | 8,000 |

**OBJECTIVES AND STATUS**

The objective of the Standards and Practices program is to support the Agency's goals through activities in productivity; reliability and quality assurance; safety; software assurance; systems engineering; and program practices which reduce program risk, improve product confidence, and encourage good program procedures in the technical execution of NASA programs.

During FY 1984, the Office of the Chief Engineer continued its efforts to improve the Agency's software management, assurance, and productivity. Emphasis was directed toward developing validated procedures to ensure the integrity of the systems to be put into service. Non-destructive evaluation (NDE) testing techniques were extended to new materials such as composites. An evaluation of materials and equipment returned from the Solar Maximum Mission Satellite was begun with particular emphasis on failure analysis, materials and electronic parts degradation, and radiation effects. Work continues on efforts with the NASA Centers and industry in the areas of Computer-Aided Design/Computer-Aided Manufacturing; materials, treatments and processes; test methods; quality technology; integrated circuit product assurance; microcircuit radiation effects evaluations; aerospace and systems safety related matters; and other activities which support agency-wide responsibilities for safety, reliability and quality assurance. In support of the Congressional Committees on Appropriations, the National Academies of Science/Engineering completed a review of the Numerical Aerodynamic Simulation program and also provided an "Assessment of Candidate Expendable Launch Vehicles to Perform Alternative Missions." A number of workshops were sponsored to improve agency-wide productivity and cooperation, as well as to reduce overlap and take advantage of the collective technical expertise of our staff to arrive at solutions for specific technical problems.

**BASIS OF FY 1986 ESTIMATE**

In support of the goals of the Agency, the FY 1986 Standards and Practices program will continue to conduct activities related to productivity; systems engineering; reliability and quality assurance; software assurance; and program practices. The increase in funding from the FY 1985 level reflects a broadened and accelerated NDE program, and an expansion of the Agency's Microelectronics Radiation Effects Ground Test Program. Management responsibility for the agency's radiation effects efforts have been consolidated within the Office of the Chief Engineer.

The NDE Measurement Assurance Program will establish a long-range activity to augment the evolution and transformation of promising new NDE science to practical measurement methodology by developing inspection and quality control tools and techniques for both qualitative and quantitative assessments. This program will focus on bridging the gap between laboratory science and program NDE requirements with particular emphasis on measurement assurance needs for metals; composites; ceramics; the STS Solid Rocket Motor Filament Wound Casing; and large space structures.

The efforts in the radiation effects area are critical to improving our ability to confidently predict the reliability and performance of future microelectronic systems in space. NASA and military spacecraft have experienced integrated circuit performance degradation and system failures caused by cosmic rays and total radiation dose. In concert with the Air Force's Chemical Release and Radiation Effects Satellite (CRRES) program, NASA is conducting a ground test program to develop a better understanding of the causes of the degradation and failures. The Air Force will provide NASA with data from the environmental measurement instruments and integrated circuit devices on the CRRES spacecraft to serve as the basis for conducting ground tests on duplicate devices from the same production lot. The NASA program will use ground-based radiation sources to accurately duplicate the device degradations and failures measured on the CRRES spacecraft. The results will be applied to testing new devices for radiation hardness for use in future NASA, DOD, and commercial programs.

The FY 1986 funds will also continue to provide for special Congressional or NASA directed efforts focused on finding solutions to specific technical problems arising from programmatic activities. In addition, overall support is required to continue to ensure that advances in technology, such as microelectronics, robotics, computer automation, and composite fibers can be confidently qualified for use in NASA programs within a time frame that is consistent with project needs.

TRACKING AND
DATA ADVANCED
SYSTEMS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1986 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRACKING AND DATA SYSTEMS

TRACKING AND DATA ADVANCED SYSTEMS

SUMMARY OF RESOURCES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | [Thousands of Dollars) | | | | |
| Advanced systems................. | 14,200 | 15,300 | 14,800 | 16,300 | RD 15-2 |
| Total | 14,200 | 15,300 | 14,800 | 16,200 | |
| Distribution of Program Amounts by Installation | | | | | |
| Goddard Space Flight Center............... | 4,585 | 4,800 | 4,800 | 5,100 | |
| Jet Propulsion Laboratory................. | 9,485 | 10,500 | 10,000 | 11,100 | |
| Ames Research Center..................... | 12 | --- | --- | --- | |
| Headquarters............................. | IIS | --- | --- | --- | |
| Tc~til.............................. | 14,200 | 15,300 | 14,800 | 16,200 | |

## BASIS OF FY 1986 FUNDING REQUIREMENTS

ADVANCED SYSTEMS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Advanced systems..................... | 14,200 | 15,300 | 14,800 | 16,200 |

## OBJECTIVES AND STATUS

The overall objective of the Advanced Systems Program is to perform studies and provide for the development of tracking and data systems and techniques required to: (1) obtain new and improved tracking and data handling capabilities that will meet the needs of approved new missions and near term new starts; and (2) improve the cost effectiveness and reliability needed for overall support of the total mix of spaceflight missions.

This program is a relatively small but vital portion of the Space Tracking and Data Systems Program. Activity continues under this program to assess and make use of the dramatic changes taking place in the state of the art in telecommunications, electronic micro-circuitry and computer technology. Such effort is critical for proper planning and for the application of new technology to future support capabilities that are cost effective and reliable. Efforts include the investigation of upcoming missions and studies of ground systems and telecommunications links to determine design approaches and overall tradeoffs for the lowest life cycle costs to support future space missions.

## CHANGES PROM FY 1985 BUDGET ESTIMATE

The decrease of $.5 million in this program represents the application of a portion of the general reduction in the FY 1985 appropriation.

## BASIS OF FY 1986 ESTIMATE

The following are examples of activities planned for FY 1986. Technology aimed at obtaining ranging accuracies to the one meter level for Earth-orbiting spacecraft will be investigated. Such precision will make possible a new class of high precision Earth observatory missions on the Shuttle, Space Station and on free flying spacecraft. The techniques to be studied include using the military's Global Positioning System and Very Long Baseline Interferrometry. Work will also continue on extremely precise radiometric techniques for determining angular direction of future planetary missions to an accuracy of five nano-radians. Such activity typically leads to improved spacecraft navigation and the carrying out of science experiments not previously possible.

New methods of increasing NASA's capability to communicate with spacecraft will continue in such areas as signal coding techniques, large diameter antennas using millimeter wave frequencies, and the development of efficient transmitters, high reliability para-magnetically coded telemetry receivers and antenna feed systems capable of multiple frequency operation, i.e., K, X. and S-bands. Improving space-to-ground link performance can benefit many future missions by reducing mission costs through reduced spacecraft weight and power requirements or increasing the amount or quality of the data returned. Optical telecommunications technology to meet telecommunications needs beyond the 1980's will also be investigated for its cost-performance advantages over microwave options.

As the TDRSS era progresses, the data handled from Earth-orbital missions is expected to increase from a peak of 15 megabits per second to the TDRSS design limit of 300 megabits per second in the future. These future requirements result from high resolution sensors such as multispectral scanners and synthetic aperture radars. New techniques and systems will be developed for the transfer and processing of such high data rates. These developments include computer assisted operations, digital processing of high volumes of data, improved man-machine interfaces, and wide band satellite communications to distribute data to processing centers and users. High density tape and optical disk storage with automated quality control of data will be investigated to meet future image data processing requirements.

Techniques will continue to be investigated to reduce future manpower needed to operate the mission control facilities and to provide the necessary real time interaction between the spacecraft experimenters and their experiments. Studies include the use of automated mission control techniques, distributed command terminals and on-board spacecraft orbit and attitude computations.

Many of the activities being undertaken in this program also have the potential for reducing risk and costs in the area of space commercialization, e.g., developments aimed at faster and more cost-effective data processing systems; more commonality in spacecraft and ground hardware; greater spacecraft autonomy; and, less vulnerability of micro-circuitry to radiation.

SPACE FLIGHT
CONTROL AND DATA
COMMUNICATIONS

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

**SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS**

**FISCAL YEAR 1986 ESTIMATES**

## GENERAL STATEMENT

The objective of the National Aeronautics and Space Administration program of space flight, control and data communications is to provide for the operational activities of the Space Transportation System. This objective is achieved through the following elements:

**SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY:** A program to provide a cost effective shuttle system with a minimum flight rate capability of 24 per year by providing the national fleet of Space Shuttle orbiters, main engines, launch site and mission operations control requirements, initial spares, production tooling, and related supporting activities.

**SPACE TRANSPORTATION OPERATIONS:** A program to provide the standard operational support services for the Space Shuttle and the expendable launch vehicles. Within Shuttle operations, external tank and solid rocket booster flight hardware is produced; operational spare hardware is provisioned, overhauled and repaired; and manpower, propellants, and other materials are furnished to conduct both flight and ground (launch and landing) operations.

**SPACE AND GROUND " WORK, COMMUNICATIONS AND DATA SYSTEMS:** A program to provide vital tracking, telemetry, command, and data acquisition support to meet the requirements of all NASA flight projects. This support is currently provided by a worldwide network of NASA electronic ground stations interconnected by a communications system using ground, undersea, and satellite circuits. In late 1985, the Tracking and Data Relay Satellite Systems (TDRSS) will become the primary system for supporting upcoming Earth orbiting missions.

NATIONAL AERONAUTICS AND SPACE ADMININSTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS
FY 1986 BUDGET ESTIMATES

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY | 1,646,300 | 1,465,600 | 1,492,100 | 976,500 |
| SPACE TRANSPORTATION OPERATIONS | 1,452,000 | 1,339,000 | 1,314,000 | 1,725,100 |
| SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS | 674,000 | 795,700 | 795,700 | 808,300 |
| TOTAL | 3,772,300 | 3,600,300 | 3,601,800 | 3,509,900 |

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

### SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

For necessary expenses, not otherwise provided for; in support of space flight, spacecraft control and communications activities of the National Aeronautics and Space Administration, including operations, production, services, minor construction, maintenance, repair, rehabilitation. and modification of real and personal property; tracking and data relay satellite services as authorized by law; purchase. hire, maintenance and operation of other than administrative aircraft; [and including not to exceed (1) $1,510,600,000 for space shuttle production and operational capability; and (2) $1,339,000,000 for space transportation operations; without the approval of the Committees on Appropriations; $3,601,800,000] *$3,509,900,000* to remain available until September 30, [1986] *1987*. *(Department of Housing and Urban Development-Independent Agencies Appropriation* Act, *1985.)*

**NATIONAL AERONAVTICS AND SPACE ADMINISTRATION**

**SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS**

**PROGRAM AND FINANCING**
**(in thousands of dollars)**

| Identification code 80-0105-0-1-250 | 1984 actual | 1985 estimate | 1986 estimate |
|---|---|---|---|
| Program by activities: | | | |
| Direct program: | | | |
| Space transportation systems: | | | |
| 00.0101 Shuttle production and capability development.. ... | 1,569,303 | 1,494,492 | 1,002,280 |
| 00.0201 Operations ........................................ | 1,397,638 | 1,302,662 | 1,704,545 |
| 00.1001 Supporting activity: Tracking and data acquisition. | 590,631 | 839,284 | 807,670 |
| 00.9 101 Total direct program........................... | 3,557,572 | 3,636,438 | 3,514,495 |
| 01.0101 Reimbursable program.............................. | 537,800 | 902,490 | 825,204 |
| 10.0001 Total obligations.... .............................. | 4,095,372 | 4,538,928 | 4,339,699 |
| Financing: | | | |
| Offsetting collections from: | | | |
| 11.0001 Federal funds.................................... | -514,379 | -588,587 | -510,620 |
| 14.0001 Non-Federal sources.............................. | -235,621 | -269,613 | -233,900 |
| 21.4001 Unobligated balance available, start of year........ | --- | -426,928 | -348,000 |
| 24.4001 Unobligated balance available, end of year......... | 426,928 | 348,000 | 262,721 |
| 39.000 1 Budget authority........... ...................... | 3,772,300 | 3,601,800 | 3,509,900 |

| Identification code 80-0103-0-1-999 | 1984 actual | 1985 estimate | 1986 estimate |
|---|---|---|---|
| Budget authority: | | | |
| 40.0001 Appropriation.. | 3,791,600 | 3,601,800 | 3,509,900 |
| 41.0001 Transferred to other accounts | -19,300 | --- | --- |
| 43.000 1 Appropriation (adjusted) | 3,772,300 | 3,601,800 | 3,509,900 |
| Relation of obligations to outlays: | | | |
| 71.0001 Obligations incurred, net | 3,345,372 | 2,680,728 | 3,595,179 |
| 72.4001 Obligated balance, start of year | --- | 430,758 | 690,286 |
| 74.4001 Obligated balance, end of year | -430,758 | -690,286 | -714,965 |
| 90.0001 Outlays | 2,914,614 | 3,421,200 | 3,570,900 |

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

**Space Flight, Control and Data Communications**

**Reimbursable Summary**
**(In thousands of Dollars)**

| Space Flight, Control and Data Communications | Budget Plan FY 84 | FY 85 | FY 86 |
|---|---|---|---|
| Shuttle Production and Capability Development | 283,974 | 201,800 | 212,000 |
| Space Transportation Operations | 202,000 | 517,500 | 418,820 |
| Expendable Launch Vehicles | 231,225 | 103,300 | 90,700 |
| Tracking and Data Acquisition | 32,801 | 35,600 | 23,000 |
| Total | 750,000 | 858,200 | 744,520 |

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1986 ESTIMATES

SUMMARY OF BUDGET PLAN BY SUBFUNCTION
(In thousands of dollars)

| Code | | FY 1984 | FY 1985 | FY 1986 |
|---|---|---|---|---|
| 253 | Space Flight....................................... | 3,098,300 | 2,806,100 | 2,701,600 |
| 255 | Supporting Space Activites........................... | 674,000 | 795,700 | 808,300 |
| | Total, General Science, Space and Technology.... | 3,772,000 | 3,601,800 | 3,509,900 |

NATIONAL AERUNAUTICS AND SPACE ADMINIS'PKATIUN
FISCAL YEAH 1986 ESTIMATES
DISTRIBUTION OF SPACE FLIGHT CONTROL AND DATA CUMUNICATIONS BUDGET PLAN BY INSTALLATION AND FISCIAL YEAH
(Thousands of Dollars)

| Program | | Total | Johnson Space Center | Kennedy Space Center | Marshall Space Flight Center | National Technology Laboratories | Goddard Space Flight Center | Jet Propulsion Laboratory | Ames Research Center | Lanyley Hesearch Center | Lewis Hesearch Center | NASA Headquarters |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Office of space Transportation Systems | 1984 | 3,098,300 | 1,302,600 | 439,900 | 1,259,700 | 800 | 48,500 | 1,300 | 3,200 | 200 | 2,000 | 40,100 |
| | 1985 | 2,806,100 | 1,124,300 | 371,900 | 1,107,000 | 6,300 | 900 | 2,300 | 2,600 | 100 | --- | 89,700 |
| | 1986 | 2,701,600 | 910,100 | 375,500 | 1,245,900 | 7,200 | 1,100 | --- | 3,100 | 100 | --- | 158,600 |
| Shuttle Production and Operational Capability | 1984 | 1,646,300 | 871,900 | 111,200 | 633,400 | 800 | 400 | 1,300 | --- | 100 | 2,000 | 25,200 |
| | 1985 | 1,492,100 | 741,400 | 103,200 | 572,600 | 6,300 | --- | 2,300 | --- | --- | --- | 66,300 |
| | 1986 | 976,500 | 371,400 | 56,700 | 449,800 | 7,200 | --- | --- | --- | --- | --- | 91,400 |
| Space Transportation operations | 1984 | 1,452,000 | 430,700 | 328,700 | 626,300 | --- | 48,100 | --- | 3,200 | 100 | --- | 14,900 |
| | 1985 | 1,314,000 | 382,900 | 269,700 | 634,400 | --- | 900 | --- | 2,600 | 100 | --- | 23,400 |
| | 1986 | 1,725,100 | 538,700 | 318,800 | 796,100 | --- | 1,100 | --- | 3,100 | 100 | --- | 67,200 |
| Space and Ground Network Comm and Data System | 1984 | 674,000 | 610 | --- | 13,200 | --- | 357,416 | 95,889 | 6,600 | --- | --- | 200,285 |
| | 1985 | 795,700 | 150 | --- | 17,400 | --- | 427.130 | 107,200 | 8.600 | --- | 20 | 235,200 |
| | 1986 | 808,300 | --- | --- | 27,900 | --- | 365,000 | 124,800 | 11,000 | --- | --- | 279,600 |
| Total Budget Plan | 1984 | 3,772,300 | 1,303,210 | 439,900 | 1,272,900 | 800 | 405,916 | 97,189 | 9.800 | 200 | 2,000 | 240,385 |
| | 1985 | 3,601,800 | 1,124,450 | 372,900 | 1,224,400 | 6,300 | 428,030 | 109,500 | 11,200 | 100 | 10 | 324,900 |
| | 1986 | 3,509,900 | 910,100 | 375,500 | 1,273,800 | 7,200 | 366,100 | 114,800 | 14,100 | 100 | --- | 438,100 |

**SPACE**
TRANSPORTATION
**SYSTEMS**

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1986 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT

SPACE TRANSPORTATION SYSTEM PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | | (Thousands of Dollars) | | | |
| Shuttle production and operational capability........................ | 1,646,300 | 1,465,600 | 1,492,100 | 976,500 | SF 1-1 |
| Space transportation operations....... | 1,452,000 | 1,339,000 | 1,314,000 | 1,725,100 | SF 2-1 |
| Shuttle operations.................. | (1,402,000) | (1,339,000) | (1,314,000) | (1,725,100) | |
| Expendable launch vehicles.......... | (50,000) | (---) | (---) | (---) | |
| Total..........................… | 3,098,300 | 2,804,600 | 2,806,100 | 2,701,60G | |

Distribution of Program Amounts By Installation

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| Johnson Space Center................. | 1,302,600 | 1,047,200 | 1,124,300 | 910,100 |
| Kennedy Space Center................. | 439,900 | 349,300 | 372,900 | 375,500 |
| Marshall Space Flight Center.......... | 1,259,700 | 1,260,100 | 1,207,000 | 1,245,900 |
| National Space Technology Lab......... | 800 | --- | 6,300 | 7,200 |
| Goddard Space Flight Center........... | 48,500 | 600 | 900 | 1,100 |
| Jet Propulsion Laboratory............. | 1,300 | --- | 2,300 | --- |
| Lewis Research Center................ | 2,000 | --- | --- | --- |
| Langley Research Center.............. | 200 | --- | 100 | 100 |
| Ames Research Center................. | 3,200 | 2,500 | 2,600 | 3,100 |
| Headquarters......................... | 40,100 | 144,900 | 89,700 | 158,600 |
| Total............................. | 3,098,300 | 2,804,600 | 2,806,100 | 2,701,600 |

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1986 ESTIMATES

**OFFICE OF SPACE FLIGHT** **SPACE TRANSPORTATION SYSTEM PROGRAM**

**PROGRAM OBJECTIVES AND JUSTIFICATION**

The Space Shuttle is the key element of a versatile Space Transportation System (STS) that is available to a wide variety of national and international users. The Space Shuttle is the first reusable space vehicle and is configured to carry many different types of space applications, scientific experiments, and national security payloads. The Space Shuttle offers unique capabilities that cannot be achieved with today's expendable launch vehicles--to retrieve payloads from orbit for reuse; to service and repair satellites in space; to transport to orbit, operate, and return space laboratories; to transport materials and equipment to orbit; and to perform rescue missions.

Shuttle production and operational capability provides for the national fleet of Space Shuttle orbiters, including main engines, and provides for the launch site facilities, initial spares, production tooling, and related supporting activities to meet the needs of NASA, the Department of Defense (DOD), and other domestic and international users of space. This line item contains orbiter production for three flight orbiters; full modification of Columbia (OV-102) to its operational configuration; the procurement of major structural orbiter components to be used as spares for the operational orbiter fleet; the residual development tasks for the orbiter, main engine (SSME), external tank (ET), and solid rocket booster (SRB); Johnson Space Center (JSC) mission support capability development; the equipment provisioning of the facilities for launch and landing at the Kennedy Space Center (KSC); the development of the filament wound case (FWC) solid rocket booster; the initial lay-in of spares and ground support equipment; and the rate tooling for the ET and SRB. Modification of two orbiters, two Mobile launch platforms (MLP) and both launch pads for the conduct of the planetary missions (Galileo and Ulysses) in 1986, using the Centaur as an STS upper stage, are also funded under this budget item.

Shuttle operations provides the standard operational support services for Space Shuttle, the primary U.S. launch system. Within Shuttle operations, flight hardware is produced, refurbished and repaired; and manpower, propellants, and other materials are furnished to conduct and support both flight and ground operations. The Space Shuttle operations program provides €or the launch of NASA missions and on a reimbursable basis DOD, other U.S. Government, commercial, and international missions. The launch schedule calls for ten to eleven flights in FY 1985 and thirteen to fourteen flights, including the first launch from the west coast, in FY 1986, and a planned seventeen flights in FY 1987. The flight rate is planned to reach twenty-four launches per year by 1989.

The Space Shuttle provides launch services to non-NASA users on a reimbursable basis as determined by the greater of each payload's length or weight. For flights launched during the first pricing phase (through FY 1985), standard commercial launches services are priced at $18.3M (75$) with a $4.3M (RY$) use charge. DOD launches in this phase are priced at $16.0M (75$). Launches occurring in the second pricing phase (FY 1986 through FY 1988) are priced at $71.0M (82$) for commercial launches and $55.5M (82$) for DOD launches. The Bureau of Labor Statistics' indices are used to convert base year pricing (75$ and 82$) to real year dollars for billing purposes.

The expendable launch vehicle program consisting of the Scout, Delta, Atlas Centaur and the Atlas E/F Vehicles provides for the procurement of expendable launch vehicles and launch support services for NASA's spacecraft missions and, on a reimbursable basis, for other agencies and organizations utilizing these systems and services. Potential privatization of these systems is being actively pursued as NASA no longer has a requirement and the programs are now being conducted on a totally reimbursable basis.

**STATUS**

In the orbiter production: Discovery (OV-103) was delivered in November 1983 and brought to three the number of orbiters available for flight, Columbia (OV-102) and Challenger (OV-099) having been previously delivered; OV-102 is being modified at Palmdale to place the vehicle in its fully operational configuration; and Atlantis (OV-104) is now in the final assembly phase at the contractor's Palmdale facility.

Support of the flight program has also been a major activity of the orbiter program. Orbiter flight anomalies are resolved under the sustaining engineering effort and support to the launch site contractor is provided through the launch support services contract. The emphasis on the orbiter logisitics program is ongoing with effort proceeding to support the provisioning of orbiter spares for the initial lay-in at the launch site.

The procurement of structural spares is also progressing. This program will provide major structural spares for the four orbiter fleet and includes elements such as wings, mid-fuselage, and payload bay doors.

At KSC, the second line of vehicle processing stations is being phased in to support the parallel launch processing of orbiters. Parallel processing can be done in the Orbiter Processing Facility (OPF) and Vehicle Assembly Building (VAB). Parallel processing at the launch pad will be possible after Pad B completion in January 1986. This date is consistent with the requirements to support the separate Centaur launches of both Galileo and Ulysses in May 1986. The third MLP is planned for a September 1986 operational readiness date.

At JSC, the training capacity is being expanded by modification of a Gulfstream II into a third Shuttle training aircraft and continued modification to the simulators. Mission Control Center systems monitoring and flight control capability will be expanded to twenty-four flights per year by October 1985. Pacific area contingency abort sites will be brought to operational status during FY 1986 in time to support Shuttle launches from the Vandenburg launch site (VLS).

The initial certification of the Space Shuttle Main Engine (SSME) in a full power level (FPL) configuration was completed in FY 1983. During the course of that certification, it became apparent that the SSME configuration required additional design modifications in order to achieve an acceptable level of reliability and maintainability. The modifications focus on the high pressure pumps and the hot gas manifold. Development of the pump modification was essentially completed in FY 1984 and the new pumps will begin certification at the FPL thrust level early in the second quarter of FY 1985. The re-design of the hot gas manifold is complete and the changes will be available for test in FY 1986. A major re-planning of the SSME program was completed last year. The primary result of the replanning was initiation of engine improvement study activities which involve alternative rocket engine contractors and of a technology engine effort at the Marshall Space Flight Center. During the past year four flights of the Space Shuttle (up to and including Mission 41-D) were completed with no SSME anomalies which impacted flight performance.

The experience with the Solid Rocket Boosters (SRB's) during early flights indicated the need for design improvements to reduce the amount of water impact damage to the SRB aft skirt and the hydraulic power units mounted internal to the aft skirt. Design improvements implemented to date have proven to be successful in reducing structural damage. Problems still exist with water intrusion damage to the thrust vector control (TVC) servo actuators. Modifications are being implemented to the TVC system to eliminate this problem. In order to reduce the water impact velocity which is the major contributor to the damage at water impact, larger main parachutes were developed and successfully used on STS 41-F and STS 51-A and will continue to be used on subsequent flights. A redesign of the recovery system to separate the main parachutes at water impact is underway and will be incorporated on the first flight from the Vandenberg launch site. This change is being implemented for diver safety during recovery operations. Development tests on a redesigned drogue parachute for flights using the filament wound case are also in progress.

The first high performance SRB motor was successfully flown on STS-8. The performance characteristics of the motor were well within specifications and achieved design goals. Post-flight inspection of the motor indicated more than desirable erosion, as a result some minor changes to the manufacturing process for the carbon phenolic nozzle material may be necessary. Efforts are underway to correct this design margin problem.

Continued emphasis is being focused on cost-reduction/producibility/production efforts to identify improvements in processes required to satisfy production rate requirements. Recompetition of the booster assembly/refurbishment contract was completed, and the incumbent contractor, United Space Boosters Inc. (USBI) was selected. As a result, significant program cost savings are expected. A second source study for the Solid Rocket Motor (SRM) is also being done to determine if a second source would reduce overall production costs.

Performance of the External Tank (ET) on all Shuttle flights to date has been excellent. The Vandenberg Launch Site (VLS) received its first flight tank in October 1984. All ET flight hardware has been delivered on or ahead of schedule. Weight savings on the lightweight tanks have been greater than baselined and should continue to be realized as additional planned improvements are implemented. Cost reduction and production readiness efforts continue to be a high priority, as additional tooling and equipment is introduced to meet production requirements of twenty-four tanks per year.

The development of the Filament Wound Case (FWC) for the Solid Rocket Motors (SRM) achieved several major program milestones during the past year. The full segment development hydrotests were successfully concluded and design verification data on the composite and composite to metal joint strength was obtained thus demonstrating the required margin of safety. Following a preliminary design review the design and manufacturing process was adjusted and the processing of the segments for the first flight set was initiated. By the end of the year, all segments for the first flight from the VLS were wound and the first static test successfully completed. In addition, all four case segments for the second static test were manufactured and delivered to Morton-Thiokol for propellant loading. The Structural Test Articles (STA) were also delivered to MSFC for testing of dynamic loading under pressure. The weight savings were affirmed and an improved payload carrying capability resulting from the FWC is estimated at 4600 lbs. Significant progress has been made in recovering from technical problems and schedule difficulties and delivery of the initial flight set to the VLS will support the need dates for the first flight.

The Shuttle operations budget provides funding in three principal areas: flight operations, flight hardware, and launch and landing operations. Flight operations includes training, mission control, flight operations planning, payload integration analysis, mission analysis, post-flight anomaly resolution, sustaining engineering and launch support services. A consolidated operations contract covering most of the flight operation functions performed at JSC is in preparation; award date is anticipated to be early 1986.

Flight hardware includes the procurement of orbiter flight spares, external tank disconnects, SRB rate gyros, ET's, solid rocket motors, booster hardware, and propellants; and engineering and logistics support for external tank/solid rocket booster/main engine hardware elements and maintenance and operation of flight crew equipment. The funding requested for the ET, solid rocket motors and boosters (including production of filament wound cases) includes long lead time raw materials, subassemblies, and subsystems required to sustain production.

At KSC, four operational flights were procressed and launched in FY 1984. The first two flights included vehicles which were stacked, processed and launched during the Shuttle Processing Contract (SPC) transition, a six month period when the incumbent contractors and the SPC (Lockheed) worked together toward a March 1984 turnover. The full transition was completed on schedule after the successful launch of STS 41-B. The remaining two flights were processed by the SPC and included STS 41D, the maiden voyage of Discovery. KSC planning includes launch of an additional ten to eleven flights in FY 1985, including the first flight of the fourth orbiter, Atlantis. In addition, during FY 1985, KSC will be responsible for processing Discovery at KSC for preparation for the first flight at the Vandenburg launch site.

NASA Expendable Launch Vehicles reached a milestone in 1984, exceeding 400 launches since 1960. The most active NASA vehicle, the Delta, was used in four launch attempts during CY 1984 and reached a new record of 43 launch successes in a row. It is planned that the current NASA Expendable Launch Vehicles will be phased out or turned over to private operations before the end of this decade.

# PRODUCTION AND OPERATIONAL CAPABILITY

## BASIS OF FY 1986 FUNDING REQUIREMENT

SHUTTLE = U r n = OPERATIONAL CAPABILITY

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | | (Thousands of Dollars) | | | |
| Orbiter.............................. | 724,900 | 606,800 | 655,300 | 333,600 | SF 1-4 |
| Launch and mission support.... ........ | 277,700 | 234,800 | 229,800 | 163,900 | SF 1-6 |
| Propulsion systems................... | 638,200 | 599,000 | 582,000 | 454,000 | SF 1-9 |
| Changes and system upgrading.......... | 5,500 | 25,000 | 25,000 | 25,000 | SF 1-13 |
| Total.............................. | [illegible] | 1,465,600 | 1,492,100 | [illegible] | |
| **Distribution of Program Amounts by Installation** | | | | | |
| Johnson Space Center................. | 871,900 | 697,300 | 741,400 | 371,400 | |
| Kennedy Space Center................. | 111,200 | 86,800 | 103,200 | 56,700 | |
| Marshall Space Flight Center.......... | 633,400 | 588,300 | 572,600 | 449,800 | |
| National Space Technology Laboratories | 800 | --- | 6,300 | 7,200 | |
| Lewis Research Center................ | 2,003 | --- | --- | --- | |
| Langley Research Center.............. | 100 | --- | --- | --- | |
| Goddard Space Flight Center........... | 400 | --- | --- | --- | |
| Jet Propulsion Laboratory.............. | 1,300 | --- | 2,300 | --- | |
| Headquarters...... .................... | 25,200 | 93,200 | 66,300 | 91,400 | |
| Total.............................. | 1,646,300 | 1,465,600 | 1,492,100 | 976,500 | |

**OBJECTIVES AND STATUS**

The objectives of this program are to provide for: the completion of the national fleet of Shuttle orbiters: the production and capability development of the propulsion systems; the mission preparation, mission control, and launch site capabilities; and, the potential changes and upgrading of the Space Transportation System.

The planned four-orbiter fleet includes: Columbia (OV-102), the orbiter vehicle developed and flown on the four test and evaluation flights: Challenger (OV-099), the second flight orbiter, which was fabricated using elements of the structural test article: and, two orbiters - Discovery (OV-103) and Atlantis (OV-104) of a lighter-weight configuration. OV-103 was delivered in November 1983. The planned delivery date for OV-103 is April 1985. The final phase of operational modifications for OV-102 will be complete in FY 1985. Work was initiated in FY 1982 on modifications to orbiters and the related systems integration analyses for the use of the Centaur and its payloads. The provisioning of orbiter spares is an on-going activity to support the requirements for the initial lay-in of line replaceable units of equipment at the launch site. In addition, the budget provides for the extensive acquisition of orbiter structural spares to support the four-orbiter fleet.

Launch and Mission Support provides for the second set of processing stations at KSC to support parallel orbiter processing; the additional astronaut training, mission preparation and mission operation capabilities required for higher flight rates; the modifications to the launch site capabilities to accommodate the new Centaur upper stage; and, studies and analyses of program level improvements for the operations and management of the STS. The first line of KSC facilities (provided as part of the DDT&E program) supports the launch processing and checkout of one orbiter vehicle at a time from landing through launch. The second line of processing stations allows for parallel processing of orbiters to meet the East Coast launch rate of up to twenty flights per year. A Gulfstream II aircraft is being modified into a third Shuttle Training Aircraft (STA) to support increased training requirements and to permit the existing two aircraft to be overhauled when structural fatigue considerations make this necessary. The upgrading of the Mission Control Center (MCC), the Shuttle Mission Simulator (SMS) complex, the flight planning and preparation facilities and other data handling systems will provide a full rate capability for flight operations. Support for the Vandenberg launch site, including provisioning of abort landing facilities, is proceeding.

Propulsion Systems provide for the production of the SSME and the development of the capability to support operational requirements established for the SSME, SRB, and ET. The SSME program includes: production of the main engines necessary to outfit and provide spares for the orbiter fleet, ground testing in support of engine development, and an anomaly resolution capability. The SRB production and capability development activities include: the development of the solid rocket motor's filament wound case, the redesign of hardware to meet reusability and cost savings requirements, and the procurement of tooling and equipment to support a flight rate of twenty-four flights per year. In the

ET program, the objectives are to provide manufacturing tooling and equipment to support the twenty-four per year flight rate and to improve manufacturing techniques and management processes in order to reduce the time and cost of producing tanks. Systems engineering support and main engine testing in the main propulsion test article configuration are both provided in system support.

Changes and Systems Upgrading provides funding for potential changes and system modifications as well as unanticipated new requirements not covered in the budget estimates for the above activities and other program elements.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

ORBITER

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Orbiter production.................... | 423,600 | 226,600 | 234,800 | 117,000 |
| Systems integration.................... | 46,500 | 48,700 | 50,300 | - |
| Orbiter spares........................ | 254,800 | 331,500 | 370,200 | 216,600 |
| Total............................ | 724,900 | 606,800 | 655,300 | 333,600 |

**OBJECTIVES AND STATUS**

Successful continuation of the orbiter production activities remains the objective of this program. This production program will provide the authorized four orbiter fleet plus a group of selected major structural spare elements for that fleet.

With the delivery of OV-104 (Atlantis), the number of orbiters available for flight will be increased to four: OV-102 (Columbia) from the DDT&E phase and OV-103 (Discovery), OV-099 (Challenger), and OV-104 (Atlantis) from the production phase. OV-102 is in a final period of modification to bring it to its fully operational configuration during 1985. OV-104 is in final assembly and will be delivered in early 1985.

The structural spares program initiated in FY 1983 maintains a continued production capability and assures adequate structural repair capability in the event of damage to one of the four orbiters. Fabrication of these major elements is underway and will continue throughout the year. Structural assemblies include the wings, aft thrust structure engine compartment, crew module (including the nose and cockpit), mid and aft fuselage sections, payload bay doors, vertical tail, and the orbital maneuvering system pods. Incremental funding provided in FY 1985 allows further completion of the major structural assemblies.

The procurement and fabrication of the orbiter spares inventory to support twenty-four flights per year is ongoing. A concerted effort has been made to better define the spares requirements and production capability at various vendors. A study is underway to determine logistics depot and maintenance requirements. An interim depot system is being implemented utilizing the Air Force

Logistics Command, NASA facilities, and contractor facilities while the study is being completed and a long-term configuration identified.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The increase of $48.5 million consists of an $8.2 million increase in production due primarily to upgrading the General Purpose Computer (GPC) and partially to an increase in navigation equipment; an increase in systems integration for work deferred from FY 1984; an augmentation of $40 million to the structural spares program consistent with Congressional action on the FY 1985 budget; and re-pricing of initial lay-in spares.

**BASIS OF FY 1986 ESTIMATE**

FY 1986 funding provides for continued procurement of major structural components as spares for the orbiter fleet. These structural components include elements such as wings, vertical stabilizer, crew module, payload bay doors, and aft thrust structure. These items are being assembled into varying stages of completion. FY 1986 funding will also be utilized for performance augmentation activities primarily to conduct orbiter loads analysis in support of the filament wound case development and to support the modifications of OV-099 and OV-104 to accept, boost, and deploy the Centaur upper stage. Ground support equipment and test hardware are also being provided to support KSC activities. In FY 1986, systems integration activities will have been completed on the engineering analysis and integration support for vehicle capability changes; analysis of compliance of performed results to system including the investigation/resolution of flight.problems; and support of the Vandenberg launch site activation.

Logistics support to the Space Shuttle program requires the lay-in of orbiter initial spares and rate spares to meet the twenty-four per year flight rate and for support to ground processing operations as the fleet size and flight rate increase. The funding for orbiter spares covers not only the cost of orbiter flight spares and ground support equipment spares, but also the logistics support to analyze requirements and procure these spares. In addition, acquisition of maintenance test equipment will be initiated to support establishment of depot maintenance capabilities.

FY 1986 funding will also be utilized for the continuation and improvement of flight software, the acquisition of navigational aids for the trans-Atlantic abort sites, refurbishment of the Remote Manipulation System (RMS) qualification hardware and the development of the upgraded General Purpose Computer.

BASIS OF FY 1986 FUNDING REQUIREMENT

LAUNCH AND MISSION SUPPORT

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Launch site equipment..... ............ | 109,800 | 86,800 | 103,200 | 56,700 |
| Mission support capability........... | 77,400 | 98,000 | 80,200 | 64,300 |
| Mission operations capability......... | 90,500 | 50,000 | 46,400 | 42,900 |
| Total.......................... | 277,700 | 234,800 | 229,800 | 163,900 |

OBJECTIVES AND STATUS

The first line of facilities at KSC activated during DDTE supports the launch processing an3 checkout of an orbiter vehicle from landing through launch. The second line of processing stations is being phased in to support parallel launch processing of more than one orbiter through the various work areas. The second high bay of the Orbital Processing Facility (OPF) and the second mobile launch platform (MLP) were activated in late FY 1982 to support parallel processing of OV-102 and OV-099. The second set of high bays in the VAB, the software production facility, and the second control room were activated in FY 1983 to enable parallel processing through orbiter - ET mate. A solid rocket booster processing and storage facility was activated in FY 1984 to facilitate SRB handling including off-loading of segments from rail cars, segment rotation capability, storage capability for two flight sets (sixteen segments) and the assembly of SRB aft segments. When Pad B is activated in FY 1986, parallel processing will be possible from the start of OPF flow through launch. A third MLP will be activated in late FY 1986 to help meet the flight rate scheduled in 1987 and beyond. Facility modifications supporting the FY 1986 Centaur launches are in process.

Also under Launch and Mission Support are the necessary investments at JSC to support twenty-four flights per year. Among these capabilities are the ability to rapidly configure the ground data handling system encompassing mission planning, simulations, and flight design. This is accomplished through the acquisition of an electronic data network, additional hardware, and refined and expanded software.

Other investments necessary to meet STS program objectives include the installation of inflight refueling capability for the Shuttle Carrier Aircraft (SCA), completion of the hardware inventory for the extravehicular mobility units (spacesuits), other government furnished crew-related equipment, the completion of the upgrade/capability expansion of the Mission Control Center (MCC), the service life extension refurbishment of all T-38 aircraft, and the ongoing program to replace and refurbish aging and obsolete equipment. The latter incorporates technology advances to solve maintenance and operating problems stemming from outdated hardware and software subsystems that manufacturers can no longer support with spares and viable operating systems. At the same time, the use of this advanced technology will permit more rapid reconfiguration from flight to flight, with considerable improvement in responsiveness to manifest and requirements changes.

As operational flights continue to increase at KSC, it is planned that logistics will become an increasingly routine on-site function under the responsibility of the Shuttle Processing Contractor (SPC). As such, a Launch Complex 39 Logistics Facility is with design stage and will be constructed and ready by FY 1986. Funding is provided in this budget to provide special furnishings and equipment such as an automated warehouse storage and retrieval system.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

Launch and Mission Support has decreased by $5.0 million since the FY 1985 budget. Launch site equipment increased due, in part, to the requirement to provide support equipment to the new logistics warehouse facility at Launch Complex 39, improving the processing and storage capability at KSC. Funding is required to purchase and install an automated storage and retrieval system as well as general support equipment. Also, additional improvements to KSC's capability to function as an efficient launch and landing complex include modernizing the meteorological capability €or more accurate weather prediction for short term launch and landing decisions; an avionics test capability to allow on-site checkout of shuttle avionics equipment and training of the ground crew; and, a fiber optics cabling network to interface with the updated, digital intercommunication system.

The increase in launch site equipment was more than offset by a reduction in mission support capability and in mission operations capability. This decrease was due to improved program definition and an expectation of less change activity, both of which permitted a lower level of funding. For example, the EVA cadre has been limited to twenty astronauts which will result in reductions to future hardware procurements and provide greater stability to the program. Also, due to experience with the current spacesuits gained from the two satellite retrieval missions conducted during 1984 (SMM and PALAPA/WESTAR), the advanced EMU project has been deferred. The only funding remaining is to meet contractural obligations. The decrease in mission operations capability is due principally to both a reduction and rephasing of contingency landing site investments offset partially by an increase in equipment replacement activities resulting from a deferral of planned work from FY 1984.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, the major activity in the launch site equipment area will include activation of Launch Pad B in preparation for an operational readiness date of January 1986, completion of the third mobile launch platform by September 1986, and completion of the final modification to all of the Centaur-related facilities. Both the Galileo and Ulysses missions are scheduled for launch in the last half of FY 1986 and their Centaur stages require special handling during the processing stage. The modification and preparation of these facilities continue on schedule. Another major activity in FY 1986 is continued upgrades to the operational intercommunications system connecting all major Shuttle facilities at KSC. The current system, which was installed €or Apollo, falls short in capability to support the planned flight rate and is becoming increasingly difficult to maintain. The new system will use state-of-the-art digital equipment and will interconnect with updated switching systems using fiber optic cabling.

Mission support capability requirements reflect the beginning of the phase-down in crew equipment (principally EMU) production and post-OFT testing. STS operations effectiveness work and other support functions continue to support the Space Transportation System, as currently defined, including the twenty-four per year flight rate capability.

Mission operations capability provides for completion of the inflight refueling modification to the SCA, full flight rate capability in the MCC, and more rapid reconfiguration of the SMS and other flight preparation systems as progress is made toward full flight rate capability. Effort will continue on the replacement on outmoded and inefficient equipment and the T-38 service life extension project.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

PROPULSION SYSTEMS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Main engine........................... | 418,100 | 432,600 | 419,000 | 357,600 |
| Solid rocket booster................. | 140,500 | 103,700 | 101,000 | 43,000 |
| External tank........................ | 74,400 | 61,600 | 60,400 | 53,300 |
| Systems support...................... | 5,200 | 1,100 | 1,600 | 100 |
| Total.............................. | 638,200 | 599,000 | 582,000 | 454,000 |

**OBJECTIVES AND STATUS**

Propulsion systems provides for the production of the Space Shuttle Main Engine's (SSME) and the implementation of the capability to support operational requirements established for the SSME, Solid Rocket Booster (SRB), and External Tank (ET). The SSME program includes the production of the main engines required for the orbiter fleet, the procurement of spares, ground testing operations development and certification activities to improve operating margins, reliability and durability, and anomaly resolution capability. In the SRB, the development of the filament wound case (FWC) solid rocket motor and the redesign of the hardware to meet program requirements for reusability and operational cost reduction are being pursued. Included within SRB requirements is the procurement of manufacturing tooling and equipment to support fabrication and transportation for meeting the twenty-four per year flight rate. In the ET program, the objective is the procurement of manufacturing tooling and equipment to support the twenty-four/year flight rate. Systems support primarily provides for the testing of the SSME in the main propulsion test article configuration in addition to providing systems integration engineering support.

The main engines continued their record of superb flight performance with the four flights of the Space Shuttle completed last year. These flights were completed with no SSME anomalies that impacted flight performance. The total SSME ground test experience now exceeds 1,170 tests, totaling approximately 226,000 seconds of test time. This experience includes 420 tests, exceeding 50,000 seconds of operation, at the Full Panel Level (FPL).

During the course of FPL testing over the past several years, it became apparent that design margins are inadequate for routine full power level flight operation and that the current SSME configuration requires an unacceptable amount of maintenance at that power level. Consequently, the SSME program has been re-structured into three areas: (1) flight support, (2) product improvement and (3) advanced development.

The flight support element involving both production and operations is charged with producing all engine hardware, conducting the acceptance, certification extension and flight anomaly resolution tests which are directly related to the flight program, providing all logistics support (including engine/component overhauls), and conducting the flight readiness assessments.

The product improvement element continues the work begun in FY 1983 to reduce the SSME operating costs and increase the SSME operating margins. Work to reduce to operating costs is concentrated in the high pressure oxygen and hydrogen pumps. The testing of design modifications to the two pumps is well underway and has shown good progress toward achieving better pump life. Modified design pumps are expected to begin certification testing early in the second quarter of FY 85 and will be phased into the fleet beginning in mid FY 86. A redesign of the hot gas manifold (HGM) is underway to provide better flow conditions, and hence lower resistance and lower pump loads. These HGM changes will be available for test in FY 1986 and for subsequent introduction into the fleet beginning in FY 1989 during routine engine overhauls.

The advanced development element has to assure viable alternative sources for SSME class rocket engines, (i.e., high thrust, high performance, cryogenically fueled engines) and/or components, and to provide an independent means to evaluate the technical advances arising from the the Space Research and Technology program, from the current SSME contractor, and from alternative sources. The details of the advanced development effort will be defined during FY 1985 following the completion of two study contracts began in late FY 1984. The initial alternative engine study effort is expected to be completed by mid FY 1985.

Additional SRB design improvements are required to reduce the damage being incurred during booster water impact. Although the effort to strengthen the aft skirt structure has been effective in minimizing structural damage, problems with damage and salt water intrusion into the thrust sector control system components still require resolution. Larger main parachutes have been developed and were implemented on flight STS-41D to reduce the water impact velocity which is the major factor affecting hardware damage. Hardware damage has been reduced as a result of the introduction of the larger chutes. Modifications are also underway to prevent salt water intrustion into the thrust vector control system. The new high performance motor was successfully flown on the STS-8 flight, although post-flight inspection indicated that erosion on one of the nozzles was greater than nominal. Modifications in manufacturing procedures and configuration are being evaluated as possible solutions to this recent problem.

The SRB program includes the development of a FWC motor case. This development effort will enable the replacement of the heavier steel motor case segments for high performance launches. The performance increase is achieved by a reduction in the Shuttle lift-off weight resulting in a payload capability improvement of approximately 4600 pounds. The full scale development hydrotests were completed, the first static test firing (DM-6) was successfully conducted, structural test articles have been delivered to MSFC €or dynamic load tests and all segments to support the first flight from VLS have been wound.

Transition to the production mode in the ET program is well underway. Production readiness activities continue to smooth this transition and favorably improve production capability. The producibility program has already provided substantial cost savings. Rearrangement of existing tools and new tools to eliminate manufacturing "choke points" and smooth the production flow for the buildup to twenty-four tanks per year has been emphasized and is nearing completion.

In systems support, preparations are underway for the test of the engines at FPL in the main propulsion test stand at NSTL in early 1985. This test will provide for a check of the main engines' performance in conjunction with the main propulsion system test hardware mounted in the aft end of the simulated orbiter.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

Propulsion system requirements have decreased by $17.0 million from the FY 1985 Budget Request. The decrease in funding for the main engine is the result of restructuring the development/certification program and reducing related test hardware requirements. One development/certification engine was deleted as well as long lead materials previously designated for future critical components and new engines. The program has been modified so that it includes not only improvements in component life and increased reliability to the current configured engine but also an advanced development effort that will evaluate and promote new technical advances for future engines. In addition, manufacturing tooling improvements have been added to increase manufacturing capability to produce quality hardware more efficiently.

The decrease in funding required for the SRB is related to a rephasing of some FWC activity to later years to maintain a continuous production rate, partially offset by the development of a parachute separation system to disengage the parachutes from the boosters upon water impact. There has also been some rephasing of tooling activity to the later years due to mission model changes.

ET funding requirements decreased as a result of rephasing rate tooling requirements in accordance with revised flight hardware delivery need dates.

The increase in systems support is attributable to the extension of the Main Propulsion Test (MPT) for full power testing to FY 1985. Following completion of these tests, the MPT stand will be converted to a single engine capability to support the SSME development/production program.

**BASIS OF FY 1986 ESTIMATE**

In FY 1986, funding for the SSME provides for those activities necessary to support the orbiter production, flight schedules, and ground testing. New mechanisms for increased production capability will be in place and operating. Product improvement testing will continue as will certifcation of new SSME component design modifications. Other on-going activities also provided for within the SSME budget estimates include flight lay-in and rate spares, anomaly resolution testing, and continued Block II Controller development.

In the SRB, efforts will continue on the improvements to the thrust vector control system and other program elements to minimize flight damage and improve turnaround times on reusable hardware. Procurement of manufacturing tools, transportation support equipment, and related items will continue in support of reaching a twenty-four per year flight rate capability. In the FWC development activity, funding in FY 1986 provides for reusability/refurbishment studies, completion of development testing, and fabrication of flight articles.

In the ET program, enhancement of manufacturing processes will continue through production readiness efforts. The major thrust €or FY 1986 will be continuing procurement and installation of tools and equipment to support the build-up to a production rate of twenty-four per year.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

CHANGES AND SYSTEMS UPGRADING

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Changes and systems upgrading...... .. | 5,500 | 25,000 | 25,000 | 25,000 |

**OBJECTIVES AND STATUS**

Management, technical flight experience, and cost reviews of the Space Shuttle program have stressed the need for providing an adequate allowance for changes and modifications which inevitably are required in a large, complex, and technically demanding space system.

The changes and systems upgrading budget represents the estimated requirement for potential changes and systems modifications and unanticipated developments which are not included in the program element budget estimates. Such funds are necessary to provide for programmatic and technical changes, such as modifications to the orbiters to improve flight performance and system reliability, changes and upgrading of ground systems to reduce turnaround time between missions, and replacement/modification of hardware elements to achieve increased operating economies.

As the changes and upgrading requirements are identified and approved, funds are allocated to the appropriate budget activity. The remaining FY 1984 funding will be transferred to Space Station in response to Congressional direction included in the FY 1985 budget.

## BASIS OF FY 1986 ESTIMATE

The funding requested for FY 1986 will provide for those changes which are considered to have the highest priority. The objectives are to improve reliability, increase operating efficiency, and reduce costs. Changes and upgrading areas of interest include modifications to flight and ground systems; design and development of hardware/software systems which meet requirements for improved safety, reliability, performance and cost-effectiveness; and changes which will reduce operational costs by extending operational life, by facilitating improved mission-to-mission turnaround time, and by improving mission performance margins.

OPERATIONS

**BASIS OF FY 1986 [illegible]**

## SPACE TRANSPORTATION OPERATIONS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | | (Thousands of Dollars) | | | |
| Shuttle operations | 1,402,000 | 1,339,000 | 1,314,000 | 1,725,100 | |
| Flight operations | (343,300) | (316,000) | (315,200) | (425,200) | SF 2-3 |
| Flight hardware | (729,500) | (758,000) | (722,900) | (964,000) | SF 2-5 |
| Launch and landing operations | (329,200) | (265,000) | (275,900) | (335,900) | SF 2-6 |
| Expendable launch vehicles | 50,000 | --- | --- | --- | |
| Total | 1,452,000 | 1,339,000 | 1,314,000 | 1,725,100 | |

Distribution of Program Amounts by Installation

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| Johnson Space Center | 430,700 | 349,900 | 382,900 | 538,700 |
| Kennedy Space Center | 328,700 | 262,500 | 269,700 | 318,800 |
| Marshall Space Flight Center | 626,300 | 671,800 | 634,400 | 796,100 |
| Goddard Space Flight Center | 48,100 | 600 | 900 | 1,100 |
| Langley Research Center | 100 | --- | 100 | 100 |
| Ames Research Center | 3,200 | 2,500 | 2,600 | 3,100 |
| Headquarters | 14,900 | 51,700 | 23,400 | 67,200 |
| Total | 1,452,000 | 1,339,000 | 1,314,000 | 1,725,100 |

**OBJECTIVES AND STATUS**

Shuttle operations direct appropriated funding is combined with the reimbursements received from other U.S. Government, commercial, and international users to support the launch and flight operations requirements of the Space Shuttle. Through FY 1984 eight Shuttle Operational missions were successfully flown. These missions demonstrated many of the Shuttle's capabilities, including deployments of spacecraft and their upper stages, satellite repairs, satellite retrieval and operations using the remote manipulator, a dedicated Spacelab, extravehicular activity operations, a night landing, and a widening of the Shuttle's performance envelope. In FY 1985, another ten to eleven missions are scheduled to be flown. Thirteen to fourteen flights are scheduled for FY 1986.

The flight operations activity is divided into three major elements: mission support, integration, and support. Mission support includes a wide variety of planning activities ranging from operational concepts and techniques to detailed systems operational procedures and checklists. Integration includes launch support services and sustaining engineering for orbiter systems, cargo analytical integration, and STS systems integration. The support element includes base operational support at JSC and systems activity at JSC, Headquarters and Goddard Space Flight Center.

The flight hardware program element provides for the procurement of ET's, solid rocket motors, booster hardware, and propellants; spare components for the SSME; orbiter spares; ET disconnect and SRB rate qyros, sustaining engineering and logistics support for the external tank, solid rocket booster, and main engine flight hardware elements; and maintenance and operations of flight crew equipment. Included in the funding request for ET's, solid rocket motors, and boosters are the long lead time raw materials, subassemblies, and subsystems necessary to sustain the production of elements in a manner consistent with the increasing flight rate.

Launch and landing operations provides for the launch preparation and the launch and landing operations of the Space Shuttle and its cargo.

Expendable Launch Vehicle Missions will continue on a reimbursable basis. Since the Delta's first use in 1960, this vehicle has been utilized in 177 launches and has experienced a success record of over 93 percent. The last 43 launches in a row were successful. It is presently operational with two- and three-stage configurations. The first stage is an elongated Thor booster with three, six, or nine strap-on solid motors for thrust augmentation. The second stage Delta, which provides a multiple restart capability, uses an inertial guidance system for guiding the first stage booster and the second stage Delta. With the use of a Payload Assist Module (PAM/SSUS-D) solid motor attached to the spacecraft, this vehicle is capable of placing a 1,100 kilogram payload (2,400 pounds) or, in the 3920 configuration, a 1,270 kilogram (2,800 pounds) payload into a synchronous transfer orbit. This vehicle in its three-stage configuration is approximately 35 meters in length (115 feet) and has a diameter of 2.44 meters (8 feet). The Active Magnetospheric Particle Tracer Explorer (AMPTE), the last NASA mission on Delta, was launched in August 1984. ELV programs are now being completed on a fully reimbursable basis.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

FLIGHT OPERATIONS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Mission support.................. ..... | 176,500 | 142,500 | 162,400 | 182,900 |
| Integration.......................... .. | 102,900 | 72,900 | 84,000 | 126,300 |
| Support.............................. | 63,900 | 100,600 | 68,800 | 116,000 |
| Total.............................. | 343,300 | 316,000 | 315,200 | 425,200 |

**OBJECTIVES AND STATUS**

Flight operations is divided into three major areas of activity: mission support, integration and support. Mission support includes a wide variety of planning activities ranging from operational concepts and techniques to detailed systems operational procedures and checklists. Tasks include flight planning, preparation of development system and software handbooks, flight rules, detailed crew activity plans and procedures of Mission Control Center (MCC) and network systems requirements for each flight, and operations input to the planning for the selection and operation of Shuttle payloads. Specific flight planning activity encompasses the flight design, flight analysis, and software activities. Flight design products include conceptual flight profiles and operational flight profiles which are issued for each flight. The flight design task also includes supporting the crew training simulations and development flight techniques. The software activities include the development, formulation, and verification support of the guidance, targeting, and navigation systems software requirements in the orbiter and MCC. In addition, the flight-dependent data located in the erasable memory (mission-to-mission changes) is developed from the flight design process for incorporation into the orbiter software, Shuttle mission simulator, and MCC systems. Integration includes vehicle, payload and system integration and launch support services. Support includes base operations support to Shuttle Operations at JSC and systems level support at JSC, Headquarters, and Goddard.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

Direct funding requirements for flight operations have decreased by $800,000 from the budget estimate. A major addition in integration was for launch support services to be provided to the launch site by the development contractor. The adjustment in mission support and support reflect increases in flight planning due to the number of manifest missions and software changes effort offset by the application of program reserves.

**BASIS OF FY 1986 ESTIMATE**

The flight operations portion of the Shuttle operations budget provides the maintenance and operation of the onboard avionics software and the mission control systems; maintenance and operations of the training and flight proficiency aircraft and simulators for crew training; and analysis and generation of the mission planning necessary to conduct and control the mission and instruct the flight crew. Planning includes conceptual level profile development and analysis, beginning about two years before the flight; and operational profile development and analysis, accomplished in the period immediately prior to the flight. Further, flight operations - mission support includes the flight crew mission requirements and the safety certification at JSC; other activities are the updates to and verifications of flight software, post-flight assessment, and ground turnaround evaluation. The operations and maintenance of the SAIL are provided to test and verify the ongoing operations software and hardware modifications. The SAIL is a core facility which is a key element in the capability of the system to investigate and resolve anomalies experienced on the ground or in flight. The core level of SAIL operations are funded through the Engineering and Technical Base budget element.

Integration includes the identification of operational requirements For the design of improved future spacecraft and STS component systems; the development of flight techniques for utilization of these systems; the sustaining engineering required to integrate all flight elements and to assure systems safety and integrity; the analytical integration of the payloads into the orbiter and the planning to assure compatibility and verification of interfaces; the orbiter sustaining engineering required to ensure vehicle maintainability, reliability, and anomaly resolution during operations. Launch support services provides development contractor expertise on-site at the launch and during pre-launch processing.

Funding for support elements provides for: JSC base operations activities related to Shuttle operation, that are the additive (to the core engineering and technical base) operations and maintenance support, printing, equipment rentals, and supplies and materials; the "Getaway Special" payload cannister effort performed by GSFC: Headquarters programs including assessments for agency-wide activities, and efforts by the Space Shuttle Projects Office associated with system-wide activities necessary to achieve the planned flight rate and schedule reliability required for mature system operations.

## BASIS OF FY 1986 FUNDING REQUIREMENT

FLIGHT HARDWARE

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Orbiter.............................. | 153,200 | 153,200 | 147,600 | 238,400 |
| Solid rocket booster................. | 336,800 | 323,900 | 294,000 | 401,500 |
| External tank........................ | 239,500 | 280,900 | 281,300 | 324,100 |
| Total.............................. | 729,500 | 758,000 | 722,900 | 964,000 |

## OBJECTIVES AND STATUS

The flight hardware program element provides for the procurement of external tank (ET); solid rocket motors, booster hardware, and propellants; spare components for the SSME's; orbiter spares; sustaining engineering and logistics support for external tank/solid rocket booster (SRB)/main engine flight hardware elements; and maintenance and operation of flight crew equipment. Included in the funding request for ET's, solid rocket motors, and boosters are the long lead time raw materials, subassemblies, and subsystems necessary to sustain the production of these elements in a manner consistent with the increasing flight rate. Production phasing of these elements is based on the current flight traffic model and is structured to maintain as smooth and efficient a buildup of the production capability as possible. In the ET, an efficient and nondisruptive production process continues to be developed which enables manufacturing, assembly, and checkout operations to proceed on a basis which allows for timely delivery of flight hardware to the launch site. The orbiter line element includes: orbiter spares for replenishment of line and shop replaceable units, and the manpower for supporting this logistics operation; SSME overhauls, retrofit hardware, and procurement of replacement spare parts; and provision for the fixed level of annual support for the liquid hydrogen plant; and, replaceable spares, field support, and maintenance of crew-related equipment. Some examples of orbiter spare equipment are fuel cells, tiles for thermal protection, tape recorders, leading edge support structures, wheels, brakes and pyrotechnics. The crew-related equipment activities include support to the pre-flight training and flight usage of the extravehicular maneuvering unit, emergency portable oxygen systems, radiation instrumentation, survival radios, closed-circuit television cameras, medical support and food and other galley-related items.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### LAUNCH AND LANDING OPERATIONS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Launch operations..................... | 299,600 | 215,300 | 245,100 | 294,200 |
| Payload and launch support........... | 29,600 | 49,700 | 30,800 | 41,700 |
| Total.............................. | 329,200 | 265,000 | 275,900 | 335,900 |

**OBJECTIVES AND STATUS**

Launch and Landing Operations provides for the launch preparations and the launch and landing operations of the Space Shuttle and its cargo. The orbiter, external tank (ET), solid rocket boosters (SRB), main engines(SSME), and payloads are checked out, integrated, and launched from KSC at Cape Canaveral, Florida. The SRB's are retrieved from the Atlantic Ocean after separation from the Shuttle. Space Shuttle landing support is furnished at KSC and contingency landing sites as required. The major facilities used for launch and landing operations include: the launch control center, orbiter processing facility, vehicle assembly building, mobile launcher platforms, SRB processing and storage facility, payload processing facilities, launch pads, and the Shuttle landing facility.

Funding for launch and landing operations provides the propellants (excluding SRB propellants), manpower and support services required to accomplish the integration and processing of the Shuttle and its payloads. Under launch operations, manpower is provided to process, integrate, and check out the orbiter, ET, solid rocket motors/boosters and the SSME into the proper launch configuration preparatory to each flight. Support manpower is also included to conduct the SRB retrieval operations, engineering support, logistics, central data system support, facility and equipment modifications, spares procurement and the maintenance and operation of the ground systems, structures and equipment. Funding for payload and launch support provides for the processing and integration of the payloads, propellants for launch operations and base support (excluding SRB propellants), and Shuttle operations at the Dryden Flight Research Facility.

Contractual arrangements at KSC which consolidate responsiblity and incentives based on performance have successfully provided the framework for achieving a truly operational STS with improved productivity and increased reliability. The KSC Base Operations Contractor (BOC), has successfully completed its second full year of providing support to shuttle programs as well as institutional organizations at KSC. The Shuttle Processing Contract (SPC) was awarded in September 1983, and, following a successful six-month transition, has processed and launched two missions from KSC, one of which returned from orbit to land at the launch site. The SPC contract is a target cost per flight, incentive fee mission contract to process the Space Transportation Systems both at KSC and at the Vandenberg Launch Site (VLS) in California. VLS activities are funded by the Department of Defense.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The Launch and Landing Operations direct budget requirement increase of $10.9 million is due to reduced anticipated reimbursements associated with future flights. The total funding requirement, direct budget and reimbursable payments decreased as the result of operational efficiencies for the Shuttle Processing contractor and Payload processing contractors. The savings in total were offset by the reduced reimbursements resulting in an increase to direct funding.

With implementation of the SPC contract there has been a rebalancing of work bwteen the Launch Operations and the Payload and launch support activities to agree with the SPC internal organization and the SPC/BOC division of work. For example, in the FY 1985 Budget, the payload and launch support category included procurement of ground support equipment spares. Since the Shuttle Processing Contract covers the responsibility for this effort, spares are now accounted for in the launch operations category.

**BASIS OF FY 1986 ESTIMATE**

Launch operations funding in FY 1986 provides for manpower and support services necessary for processing the 11 to 12 launches from KSC. This includes manpower to process the build-up of the SRB's, mate the boosters and tanks; process the orbiter; mate the orbiter to the integrated SRB's and tank; process and checkout integrated flight elements through launch; retrieve the SRB's for refurbishment; and support landing of the orbiter either at KSC or at a contingency landing site when required. Funding also supports the manpower required for sustaining engineering, spares provisioning, logistics, launch processing system operation and maintenance, and maintenance/modifications of all other shuttle related ground support equipment and facilities.

Payload and launch support funding provides: propellants for launch operations and base support, and contractor support for the assembly of individual payloads into a total cargo. This element includes providing launch site support managers to payload customers, verifying cargo-to-orbiter interface, and providing operations maintenance and logistic support to cargo support equipment-- such as cargo integration test equipment and multi-mission payload support equipment--and the payload support areas--such as the Vertical Processing Facility, Operations and Checkout building, and cargo hazardous servicing facilities. Support required for maintaining the Dryden Flight Research Facility as a contingency landing site is also included.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

Direct funding requirements for Flight Hardware in the current estimate reflects a net decrease of $35.1 million from the budget estimate. The reduction is in all areas of flight hardware is primarily the result of reduced flights. Within the Orbiter Project, funding reductions stem from revised methodology for determining spares requirements and anticipated cost savings in hardware procurements resulting from increased investment in manufacturing capability improvements funded in the Production budget. Reductions in the SRB Project have been achieved through labor and subcontract savings realized at the SRB contractors. Reductions in total funding required from the ET were offset by lower anticipated reimbursements associated with the reduced flights.

**BASIS OF FY 1986 ESTIMATE**

Requirements for orbiter flight spares, crew equipment spares, and logistics are based on calculations involving flight rates, maintenance schedules, operational hours, turnaround times, and lead times to procure spares. The budget provides replenishment line and shop replaceable units, as well as the manpower to support the overhaul and repair activity required to support the project flight rate. Main engine hardware provides for manufacturing and delivery of overhauled engines and engine component spares. A revised engine overhaul plan is in place that includes inspection and removal of engines based on the anticipated average mean time between replacement rate for powerheads and main combustion chamber components. Flight hardware requirements activity for!the SRB and ET include the procurement of the materials and labor required for refurbishment and fabrication of units which will be flown after FY 1986, as well as the support of the production of units which will be flown in that year.

TRACKING AND
DATA
ACQUISITION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1986 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRACKING AND DATA SYSTEMS    SPACE AND GROUND NETWORKS, COMMUNICATION AND DATA SYSTEMS

SUMMARY OF RESOURCES REQUIREMENTS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate | Page Number |
|---|---|---|---|---|---|
| | (Thousands of Dollars) | | | | |
| Space network.......................... | 253,100 | 386,500 | 378,300 | 400,300 | SF 3-4 |
| Ground network......................... | 249,300 | 223,600 | 233,200 | 219,300 | SF 3-9 |
| Communications and data systems........ | 165,600 | 185,530 | 184,200 | 188,200 | SF 3-19 |
| Total.......................... | 674,000 | 795,700 | 795,700 | 808,300 | |

Distribution of Program Amounts by Installation

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| Marshall Space Flight Center........... | 13,200 | 17,400 | 17,400 | 27,900 |
| Goddard Space Flight Center............ | 357,416 | 434,800 | 427,130 | 365,000 |
| Jet Propulsion Laboratory.............. | 95,889 | 106,600 | 107,200 | 124,800 |
| Ames Research Center................... | 5,500 | 5,700 | 8,600 | 11,000 |
| Headquarters........................... | 200,285 | 228,200 | 235,200 | 279,600 |
| Johnson Space Center................... | 610 | --- | 150 | --- |
| Lewis Research Center.................. | --- | --- | 23 | |
| Total | 674,000 | 795,700 | 795,700 | 808,300 |

OFFICE OF SPACE TRACKING AND DATA SYSTEMS SPACE AND GROUND NETWORKS, COMMUNICATIONS AND DATA SYSTEMS

## PROGRAM OBJECTIVES AND JUSTIFICATION

The purpose of this program is to provide vital tracking, telemetry, command, data acquisition, communications and data processing support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided on a reimbursable basis for projects of the Department of Defense (DOD), other Government agencies, commercial firms, and other countries and international organizations engaged in space research.

Support is provided for Earth orbital and planetary missions, research aircraft, sounding rockets and balloons. The program includes support of the Space Shuttle and Spacelab flight programs. The various types of support provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of scientific and space applications data from on-board experiments and sensors; (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems; (d) reception of television transmissions from space vehicles; (e) transmission of commands from ground stations to the spacecraft; (f) communication with astronauts; (g) transfer of information between the various ground facilities and control centers; and (h) processing of data acquired from the launch vehicles and spacecraft. Such support is essential for achieving the scientific objectives of all flight missions, for executing the critical decisions which must be made to assure the success of these flight missions and, in the case of Shuttle missions, to insure safety of the crew.

Tracking and acquisition of data for the spaceflight projects is presently accomplished through the use of a worldwide network of NASA ground stations, and by the first of a system of three tracking and data relay satellites in geosynchronous orbit working with a single highly specialized ground station. Ground facilities are interconnected by terrestrial and communications satellite circuits which are leased from communications carriers, both domestic and foreign. This interconnection provides the communications capability needed between spacecraft and the control centers from which the flights are directed.

To meet the support requirements levied by the wide variety and large number of flight projects, NASA has established three basic support capabilities to meet the needs of all classes of NASA flight missions. These are the Spaceflight Tracking and Data Network (STDN), which supports Earth orbital missions; the Deep Space Network (DSN), which supports planetary and interplanetary flight missions; and the Tracking and Data Relay Satellite System (TDRSS), which will provide all low Earth orbital mission support when it becomes fully operational. The STDN will continue to provide Earth orbital support until three TDRSS spacecraft are launched, properly positioned, and have completed pre-operational testing to ensure reliable mission operations support.

When the TDRSS is fully operational, a phaseout of selected STDN ground stations will be initiated. This is presently planned for the last half of 1985. Certain facilities of the STPN will be retained to provide support to geosynchronous and highly elliptical missions which cannot be supported via the TDRSS or to provide Shuttle launch and landing support. These remaining facilities, except for the launch and Shuttle landing support facilities, are being consolidated with the DSN stations under the management of the Jet Propulsion Laboratory (JPL). The consolidation, when completed in February 1985, will provide a single network to support geosynchronous, highly elliptical, and planetary missions, as well as supporting those spacecraft, now in low-Earth orbit, which are not compatible with TDRSS.

Computation facilities are maintained to provide real-time information for mission control and to process into meaningful form the large amounts of scientific, applications, and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of aeronautical research aircraft.

The Space Flight, Control and Data Communications appropriation includes the Space Network, Ground Network, and Data Processing and Communications elements of the program, and provides funds for: (a) the cost of TDRSS service; (b) operations and maintenance of the tracking, data acquisition, mission control, data processing and communications facilities; and (c) the engineering services and procurement of equipment to sustain and modify the various systems to support continuing, new, and changing flight project requirements.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

The current estimate for FY 1985 is $795.7 million which is the same as the overall budget estimate. Within the initial operating plan level of $795.7 million, adjustments were made to provide for the operation of the STDN stations through the end of FY 1985. These adjustments are addressed in more detail in subsequent sections of the program justification.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### SPACE NETWORK

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Tracking and data relay satellite system (TDRSS)...................... | 204,300 | 319,900 | 316,600 | 335,600 |
| Space network operations....... ....... | 31,300 | 40,800 | 35,900 | 37,100 |
| Systems engineering and support....... | 23,500 | 25,800 | 25,800 | 28,100 |
| Total | 259,100 | 386,500 | 378,300 | 400,800 |

## OBJECTIVES AND STATUS

The Space Network consists of the Tracking and Data Relay Satellite System (TDRSS) and a number of NASA ground elements to provide the necessary tracking, telemetry, command, and communication services to low Earth orbital spacecraft. The TDRSS itself will consist of a three-satellite system in geosynchronous orbit and a single ground terminal located at White Sands, New Mexico. The satellites communicate with the user spacecraft in space and relay information to and from the ground terminal. From the ground terminal, satellite and ground communication links interconnect the NASA elements of the network and any remotely located user facilities.

The FY 1986 request includes funding for: repayment, including a $30M pre-payment, of the loans extended by the Federal Financing Bank (FFB) for TDRSS development; payments to the TDRSS contractor for continuing TDRS production, TDRSS services and for maintenance and operation of the White Sands Complex; manpower and services necessary to operate and maintain the other NASA elements of the network; and systems engineering, engineering analyses and other support services to the network elements, such as mission planning, logistics, and documentation.

| | 1984 Actual | 1985 Estimate | 1985 urrent Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Tracking and data relay satellite system.................... | 204,300 | 319,900 | 316,600 | 335,600 |

## OBJECTIVES AND STATUS

The Tracking and Data Relay Satellite System (TDRSS) objective is to provide communication services between the user spacecraft and ground facilities. The Tracking and Data Relay Satellites (TPRS) provide space-to-space communications to and from the user satellites and relay these communications to the ground via a single ground terminal which is interconnected with the other elements of the Space Network. From their position in geosynchronous orbit, the TDRS can provide nearly a six-fold increase in the orbital coverage provided by the existing complex of ground stations and can accommodate extremely high user data rates ranging up to 300 megabits per second. These capabilities will provide tracking, command, telemetry, and communication services to the flight missions of the Shuttle era.

The TDRS-1 was launched in April 1983, and the Inertial Upper Stage (IUS) booster failed to deliver the TDRS spacecraft into the correct orbit. In late June 1983, the mission was recovered through a complex sequence of maneuvers and the spacecraft was placed into its nominal orbit. Since that time, the spacecraft has supported subsequent Shuttle missions, including Spacelab-1 and Landsat 5, while continuing the test and checkout of the TDRSS spacecraft and ground terminal. The TDRS-1 spacecraft experienced partial failure of the Ku-Band forward link that provides communication from TDRSS to the user spacecraft. The cause of this failure has been isolated and a modification has been implemented on subsequent spacecraft.

The launches of TDRS-2 and -3 have been delayed while modifications are being made to the IUS to rectify the causes of the anomaly experienced during the first launch. Current plans anticipate launch of the second TDRS in February 1985, with the third launch following in the second half of 1985. These launches will complete the operational constellation of two TDRS's with TDRS-1 being used as an on-orbit spare. The first ground spare spacecraft has completed environmental testing and is now in storage. Current planning provides for launch of the initial four spacecraft using the IIJS and the launch of subsequent spacecraft using a competitively procured upper stage.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

The net decrease in FY 1985 of $3.3 million resulted from a delay in the launch of the second and third spacecraft (TDRS-2 and -3) due to the anomaly experienced during the first launch. This delay has resulted in the rescheduling of some testing and launch-related activities.

## BASIS OF FY 1986 ESTIMATE

Under the terms of the TDRSS service contract, loans were extended by the Federal Financing Rank (FFB) to the Space Communication Company (SCC), the owner-operator of the TDRSS, for program development. Under the terms of the loan agreement and assignment, NASA repays these loans directly to the FFB. In addition, NASA will make payments to SCC for TDRSS services, for continued spacecraft production, for maintenance and operation of the White Sands Ground Terminal and other support to be provided during the year. Current planning provides for launch of the initial four spacecraft using the IUS and the launches of the two subsequent spacecraft using a competitively procured upper stage. Activities associated with integrating the TDRS with an upper stage other than ITJS are planned in FY 1986.

Of the amount requested in FY 1986, approximately $257 million is for loan repayments to the FFB. The $257 million includes, as requested by the Appropriation Subcommittees, a pre-payment of $30 million on the loans in order to reduce the total interest cost and thereby reduce the total project cost. Approximately $57 million of the request provides for TDRSS service payments, TPRSS integration with an upper stage and other changes and support activities. Another $22 million is included in the request for the maintenance and operation of the White Sands Ground Terminal. These estimates are predicated upon the successful launch and checkout of TPRS-2 and TDRS-3 in February 1985 and the second half of 1985, respectively.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Rudget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Space network operations... ........... | 31,300 | 40,800 | 35,900 | 37,100 |

## OBJECTIVES AND STATUS

The objective of Space Network Operations is to provide for the operation and maintenance of the associated NASA ground systems which, when combined with TDRSS, provide a full array of reliable tracking, telemetry, command, and communication services to user spacecraft in low-Earth orbit. Each of these NASA systems perform specific functions for the Space Network.

The NASA Ground Terminal (NGT) monitors TDRSS performance and provides fault isolation monitoring for the network. The Network Control Center (NCC) schedules TDRSS services for all user spacecraft, and the Operations Support Computing Facility (OSCF) provides orbit determination, trajectory analysis, and position location for flight missions supported either via the Space Network or by the current Spaceflight Tracking and Data Network (STDN). The Bilateration Ranging Transponder System (RRTS) provides precision position location and orbit determination €or the TDRS. The Simulation Operations Center (SOC) and the Compatibility Test Vans (CTV) provide necessary pre-launch testing, simulations, and interface verification for both user spacecraft and the various network elements to assure the operational readiness of the network to support a given mission.

The individual elements are designed to function as an integrated operational system. Currently, the overall system is in an integration and test phase and is providing service to the user community on a limited basis. Effort is also continuing on achieving an operational configuration that is capable of supporting an expanded workload in the late 1980's.

## CHANGES FROM FY 1985 ESTIMATE

The decrease of $4.9 million is due to the launch delay and changes in operational support requirements, primarily for the Operations Support Computing Facility and the Network Control Center (NCC). The delay in the TDRSS program, along with schedule slips in user programs, has resulted in a reassessment of support requirements and a stretchout in the projected support workload.-

## BASIS OF FY 1986 ESTIMATE

The funding request provides for contractor personnel to operate the network systems 24 hours per day, seven days per week, and to provide requisite hardware and software maintenance. A contract has been competitively awarded to provide these operations and maintenance services. In addition, a variety of support services is provided in the areas of logistics, mission planning and documentation.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Systems engineering and support.. ..... | 23,500 | 25,800 | 25,800 | 28,100 |

## OBJECTIVES AND STATUS

The objective of Systems Engineering and Support is to provide the engineering services and requisite hardware systems to implement and sustain the NASA elements of the Space Network. Engineering services are supplied primarily through the operations contract and a number of small, highly specialized engineering service contracts. Current emphasis is on the completion of systems implementation for the ground network elements and integration testing in preparation for initial operations of the Space Network. Major activities include implementation of reliability enhancements at the White Sands Ground Terminal (WSGT), development of a high data rate switch for the NASA Ground Terminal (NGT), implementation of a NGT scheduling system, replacement of the Network Control Center (NCC) Digital TV system, and the conduct of end–to–end testing with all Space Network user facilities.

## BASIS OF FY 1986 ESTIMATE

Requested funding will provide for engineering support in the areas of systems engineering, performance and operations analyses, minor facility modifications, network integration testing and interface verification, sustaining engineering support, test equipment, and vendor maintenance for specialized equipment and subsystems within the Space Network. Design and analytical studies will be conducted on a wide array of items ranging from subsystem modifications to meet new mission requirements or to correct system deficiencies to the analysis of the radio frequency environment for potential impact on TDRSS and other network systems. Funds are also requested for continued software development for the NCC, replacement of the high data rate switching system for the NASA Ground Terminal (NGT), replacement of the NCC Display System, and to continue WSGT system enhancements.

**BASIS OF FY 1986 FUNDING REQUIREMENT**

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Spaceflight tracking and data network systems implementation....... | 8,500 | 6,300 | 6,600 | 2,700 |
| Spaceflight tracking and data network operations... ................. | 119,748 | 83,300 | 93,000 | 55,700 |
| Deep space network systems implementation...................... | 39,800 | 37,100 | 37,100 | 44,400 |
| Deep space network operations......... | 65,500 | 76,800 | 76,800 | 88,900 |
| Aeronautics, balloons, and sounding rocket support systems implementation | 8,600 | a,200 | 8,200 | 11,400 |
| Aeronautics, balloons, and sounding rocket support operations............ | 3,152 | 11,900 | 11,500 | 13,200 |
| Total........................... | 249,300 | 223,600 | 233,200 | 219,300 |

**OBJECTIVES AND STATUS**

As of January 1, 1985, the Ground Network included the Spaceflight Tracking and Data Network (STDN), consisting of 11 geographically dispersed ground stations which support Earth orbital missions; the Deep Space Network (DSN) consisting of three stations approximately 120 degrees apart in longitude, which support planetary and interplanetary flight missions; and support €or Aeronautics, Balloon and Sounding Rocket (AB&SR) programs at the Wallops Flight Facility (WFF), the Dryden Flight Research Facility (DFRF), the Moffett Field Flight Complex (MFFC), White Sands Missile Range (WSMR), and instrumentation support at the National Balloon Facility at Palestine, Texas.

Funding for the ground network provides for operation and maintenance of the worldwide facilities, as well as engineering and procurement of equipment to sustain and modify network systems. The workload in FY 1986 includes ongoing support to Shuttle, Voyager, Dynamic Explorer, International Ultraviolet Explorer (IUE), and the International Sun-Earth Explorers, as well as preparation for support of such upcoming missions as Galileo, the Voyager-Uranus encounter, and the Venus Radar Mapper (VRM). Support will be provided to aircraft programs such as the F-16 and F-Ill, AV-8B, the X-29A forward swept wing, and the use of drones €or aerodynamic and structural testing.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Spaceflight tracking and data network systems implementation..... | 8,500 | 6,300 | 6,600 | 2,700 |

**OBJECTIVES AND STATUS**

The Spaceflight Tracking and Data Network (STDN) systems implementation program encompasses the procurement and implementation of services to sustain network facilities and equipment to insure reliable tracking, command, and data acquisition support to ongoing scientific and applications satellite missions and the Space Shuttle, and to selectively replace obsolete equipment for reliable support in the TDRSS era. Employing systems implemented in past years, the network is currently supporting many missions with highly complex requirements for tracking, data acquisition, command and control.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The increase of $0.3 million is for sustaining STDN systems and facilities for an extended period of time due to the delay in the station closure dates.

**BASIS OF FY 1986 ESTIMATE**

The FY 1986 request includes funds for the replacement of obsolete and difficult-to-maintain equipment at those facilities that remain after TDRSS is operational. These include facilities used for launch and landing support at Bermuda and Merritt Island, Florida, and for orbital support from Greenbelt, Maryland. The requirement for support from these sites will continue for the foreseeable future. Equipment replacements and modifications are required in the network in FY 1986 to maintain a level of proficiency to support the continuing workload and to assure the reliability of the major systems. Accordingly, funds are required for equipment replacements and modifications to correct current deficiencies, and for equipment to be used in operational control of the network. The funds requested also provide for procurement of major subsystem spares, for the provision and modification of test equipment, and for minor equipment modifications resulting from changes in support requirements.

| | 1984 Actual | 1985 Rudget Estimate | 1985 Current Estimate | 1986 Rudget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Spaceflight tracking and data network operations................. | 119,748 | 83,300 | 93,000 | 58,700 |

## OBJECTIVES AND STATUS

The primary function of the Spaceflight Tracking and Data Network (STDN) system is to support NASA Earth-orbital spaceflight missions, including the Space Shuttle. The majority of these missions have near-Earth orbits. This network provides launch support to NASA automated planetary missions, and on a reimbursable basis, spaceflight missions of other nations and other United States government agencies (NOAA and DOD).

The STDN presently consists of 11 geographically dispersed ground stations. These global facilities have the capability to electronically track the spacecraft, send commands for spacecraft and experiment control purposes, receive and display engineering and scientific data from the spacecraft, and in the case of manned flights, maintain voice communications €or crew operations and safety, and other project-related purposes.

There are STDN land stations located at: Greenbelt, Maryland; Merritt Island, Florida; Kauai, Hawaii; Guam; Ascension Island; Canberra, Australia; Dakar, Senegal; Bermuda; Santiago, Chile; and Madrid, Spain. In addition to these 10 stations, there is an Ultra High Frequency (UHF) air-to-ground station located at Yarragadee, Australia to provide voice coverage with the astronauts.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

The net increase of $9.7 million results from the additional six-months of tracking operations in FY 1985 for Shuttle and other support brought about by the delay in the Tracking and nata Relay Satellite System reaching operational status, thus requiring the STDN ground stations to provide Shuttle and other support until the TDRSS is operational.

## BASIS OF FY 1986 ESTIMATE

The FY 1986 funding requirements provide for the maintenance and operation of the residual STDN stations. This represents a planning assumption which is contingent upon the successful launch and checkout of the remaining two TDRS (-2 and -3) in February and the second half of 1985, respectively. Included in the funding request are the related logistics support, network planning, scheduling, engineering, documentation and software programming costs associated with the operation of the network stations.

The initiation of full TDRSS service will permit closure of most STDN stations in FY 1986--Ascension, Guam, Hawaii, Santiago and Dakar--and the termination of the air-to-ground UHF voice station at Yarragadee, Australia.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Deep space network (DSN) systems implementation.............. | 38,800 | 37,100 | 37,100 | 44,400 |

## OBJECTIVES AND STATUS

The role of the Deep Space Network (DSN) is to provide the communication link between each of NASA's distant planetary and interplanetary spacecraft and the Earth. The DSN is responsible for receiving science and engineering data, and providing the navigation, command and control capabilities from the ground to a constellation of spacecraft ranging in distance to over 4.6 billion kilometers from Earth. When the three Spaceflight Tracking and Data Network stations are consolidated with the DSN in February 1985, the DSN will assume support responsibility for numerous spacecraft already in low-Earth orbit and for any future spacecraft that are not supportable by the TDRSS. The new set of spacecraft support requirements will include missions in highly-elliptical and synchronous Earth orbits which are not supportable by the TDRSS.

The systems and facilities required to support spacecraft at the limits of the solar system are highly specialized and include the use of large aperture antennas electronically configured in a phased array for optimum reception of the extremely weak radio signals. The antennas use ultrasensitive, cryogenically cooled receivers and powerful transmitters. Extremely stable hydrogen maser time standards are required for precise navigation of distant spacecraft. Advanced data handling systems are required at both the DSN complexes and the Network Operations Control Center (NOCC).

Since the Galileo spacecraft is the first to utilize a receiver in the X-band frequency spectrum, the ground network must be implemented to transmit commands in the X-band frequency range. By mid 1987, one 34-meter antenna at each of the three DSN locations (Australia, California, and Spain) will be implemented with the capability. Not only will Galileo utilize this new frequency for spacecraft telecommunications, but it will also use a new precision tracking capability to perform experiments designed to detect perturbations in the gravity field caused by collapsing quasars. As all new deep space missions will utilize X-band, it is planned to implement this capability on the remaining antennas in the DSN by 1992.

The four major objectives for the DSM in the 1980's are as follows: (1) to provide communications channels to scientific spacecraft at ever-increasing distances and to provide the capability to receive images at these great distances; (2) to increase the frequency range and data rate capability of the ground network to accommodate new spacecraft requirements; (3) to provide support for a new set of spacecraft which will include highly elliptical Earth orbiters and synchronous Earth orhital missions (both types will be in orbits at altitudes that are beyond the support area of TDRSS); and *(4)* to provide the improved navigation capabilities required for precise spacecraft targeting and probe delivery.

These objectives represent a significant challenge to the DSM, as it will be supporting many more spacecraft than in the past, and it will be working at extremely great distances (beyond the orbits of the known planets) by the end of the decade.

The next major planetary encounter will be of Uranus by Voyager-2 in 1986. This encounter will occur some 2.9 billion kilometers from Earth. At that time, Voyager-2 is expected *to* transmit the first high resolution images ever received from a spacecraft at such a distance. The newly consolidated network will receive its first major test of compound multiple antenna arraying (more than two antennas) during this Uranus encounter. In Australia, this will include the use of the 64-meter antenna of the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO). Further, the follow-on Neptune encounter by Voyager-2 in 1989 will require even greater antenna aperture. *An* expansion of the 64-meter antennas to 70-meters, along with compound multiple antenna arraying and the use of various radiotelescopes, will provide the increased signal capturing capability for our first look at Neptune.

Upcoming deep space missions which will be supported by the network in the 1980's include the Jupiter orbiter and probe (Galileo), the Ulysses mission, and the Venus Radar Mapper (VRM). One or more of the Halley's Comet rendezvous missions will also be supported for the international community.

## BASIS OF FY 1986 BUDGET

Funding in the FY 1986 request provides for continuing the evolution of the DSN into a consolidated, modern, and highly reliable network. Included are new capabilities needed to meet the more stringent navigation and spacecraft-ground telecommunications requirements while reducing overall maintenance and operations costs.

Funds are included for implementing a central signal processing center at each DSN complex in place of independent support facilities for each antenna. This capability will make it possible to support all antennas at each complex from a central operations center. This center will include the digital electronics required for uplink command encoding, downlink demodulation, signal recording, and data transmission for all the antennas in the complex. Centralized, shared maintenance and support facilities will also be provided.

The overall design will allow antennas to operate either independently (with different individual spacecraft) or in an arrayed fashion (more than one antenna targeted on a single spacecraft) to achieve the increased aperture necessary to support the high data rates of missions such as Voyager-2 at Uranus and Neptune. As the distance to the spacecraft doubles, the antenna aperture needed to provide an equivalent signal goes up by a factor of four, resulting in the need for extremely sensitive receiving equipment as well as increased antenna aperture.

In conjunction with the evolution of the consolidated network, modifications are planned at the Network Control Center to facilitate scheduling, spacecraft acquisition and tracking, monitor and control, and overall coordination of the activities of the network. Funding also provides for continued development and improvement of in-flight navigation accuracy.

Concurrent with these important engineering changes, FY 1986 funds will be required to maintain the high level of reliability for support of time-critical spacecraft maneuvers as well as routine ongoing support. This will be accomplished through a continuing program of equipment and facility refurbishment and modifications to assure compatibility of existing equipment with the new systems being implemented in the network.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Deep space network operations.......... | 65,500 | 76,800 | 76,800 | 88,900 |

## OBJECTIVES AND STATUS

The three Deep Space Network (DSN) complex locations--Goldstone, California; Canberra, Australia; and Madrid, Spain--are approximately 120 degrees apart in longitude and permit continuous viewing of planetary spacecraft. Each complex currently consists of one 64-meter and one 34-meter diameter antenna; an additional 34-meter antenna is being constructed both at Goldstone and Canberra. A centralized control center for the network is located at the Jet Propulsion Laboratory (JPL) in Pasadena, California. The DSN will also operate the GSTDN 26-meter antennas in Australia and Madrid after network consolidation.

The expected workload in 1986 on the DSN consists of the two Voyager spacecraft, the six ongoing Pioneer spacecraft (Pioneer 6, 7, 8, 10, 11, and Pioneer Venus), Active Magnetosphere Particle Tracer Explorer, International Sun Earth Explorer-1 and -2, Helios-1, Nimbus-7, Dynamics Explorer, Geosyncronous Operational Environmental Satellite, and the International Sun Earth Explorer-3 (now renamed International Comet Explorer (ICE)) encounter with the Comet Giacobini-Zinner in September 1985. Provision is also being made in the DSN to provide Space Shuttle backup and TDRSS emergency support.

The Voyager-2 spacecraft is on a trajectory for an encounter with Uranus in early 1986, and should provide the first detailed information on that distant planet. Voyager-1 is now about 3.3 billion kilometers from Earth on a trajectory that will take it out of the solar system. Of the older Pioneer spacecraft, Pioneer-10 is now beyond the orbit of Neptune, currently the most distant planet from the Sun. Thus, Pioneer-10 is the first man-made object to leave the solar system. It now takes over nine hours for a radio signal, traveling at the speed of light, to make the round trip between Earth and Pioneer-10. The Pioneer-11 spacecraft, some 2.7 billion kilometers from Earth, continues to he tracked. The Pioneer-6 through 8 spacecraft are provided support during solar conjunctions and gravity wave experiments. The Helios-1 mission is continuing its orbit about the Sun.

The DSN facilities are also used on a noninterference basis for ground based measurements in support of experiments in planetary radar mapping and in the field of radio astronomy. The ultrasensitive network antennas are being used in an attempt to learn more about the mysterious pulsar high energy sources, quasars, and other interstellar and intergalactic phenomena.

In addition to the activities associated with network modifications and the support cited above, the DSN operations workload includes preparation for the Galileo spacecraft (the mission to Jupiter), Ulysses (the former International Solar Polar Mission) and on a reimbursable basis, the European Space Agency (ESA) mission to Halley's Comet). This support preparation requires thorough and complex testing, training, and engineering involving both hardware and software. These activities must he carried out simultaneously with the extensive ongoing DSN workload, and must be done in such a way as to cause minimum disruption to ongoing flight project support. Launch support is also being provided to several foreign projects.

In preparation for the Voyager-2 encounter with Uranus, an additional 34-meter antenna has been constructed at both Goldstone and Canberra. These antennas will be electronically combined with the other facilities at their respective complexes so as to further increase the receiver gain available at these two stations which are both key to capturing imaging and remote science data from Uranus. The DSN complex at Canberra, because of its southern hemisphere location, will have the best view of Voyager-2 at Uranus. At that location, an additional facility will be used at the time of encounter; that facility is the Australian 64-meter Radio Observatory at Parkes, which will be electronically observations by ground-based and balloon-borne instruments will also be continued. Results achieved in the SR&T program will have a direct bearing on future flight programs. For example, the development of advanced X-ray, ultraviolet, and infrared astronomy imaging devices under this program will most likely enable spacecraft to carry instruments for astronomical observations which have increases of orders of magnitude in sensitivity and improved resolution over currently available detectors.

The SR&T program carries out its objectives through universities, non-profit and industrial research institutions, NASA centers and other government agencies. Current emphasis is being placed on studies of advanced instrumentation with increased sensitivity and resolution.

- Advanced Technological Development (ATD): The advanced technological development activities support detailed planning and definition of new potential physics and astronomy missions. ATD activities assure that future missions address the scientific questions most important to the evolution of knowledge in the field, and that those missions use the appropriate technology and techniques. Funding is applied to the definition and preliminary design for specific missions or subsystems/elements critical to eventual mission development in order that technical readiness and resources may be adequately defined before the missions are proposed for implementation.

  Candidate missions for the 1980's and early 1990's that require ATD activities include the Advanced X-Ray Astrophysics Facility (AXAF) and the Space Infrared Telesope Facility (SIRTF). The AXAF mission, which is the first priority new mission recommendation in astronomy by the National Academy of Sciences, will study stellar structure and evolution, active galaxies, clusters of galaxies and cosmology. The AXAF's imaging X-ray telescope is planned to have a sensitivity approximately 100 times that of HEAO-2 and a resolution increase of nearly a factor of twenty. The SIRTF will observe faint, cool infrared sources in the universe and significantly build on the IRAS science foundation. Major Spacelab payloads being considered for future missions and requiring advanced technological development support include the Pinhole/Occulter Facility, a detector for imaging hard X-rays. During FY 1985, major emphasis will continue on the AXAF definition as well as continued technological preparation for SIRTF.

- Data Analysis: The acquisition, analysis and evaluation of data represents the primary purpose of the laboratory, balloon, rocket and spacecraft activities. While a considerable amount of analysis is done during the prime project phase, experience has shown that considerably more time is required to reap the full benefit from these programs. This will come about only when the data is correlated with other projects, when detailed cause-and-effect studies are made with data sets from other sources, when very long-term (e.g., one solar cycle) effects can be studied by using complementary sets of data, and when new ideas that originate from the results of the initial analysis can be tested. For example, astronomical image processing facilities have been developed to take advantage of high technology developed under the Landsat and planetary programs. This

## BASIS OF FY 1986 ESTIMATE

The aeronautical research efforts and scientific experiments using sounding rockets and balloons are programs of a continuing nature which generally require about the same level of support from year to year. To support these programs, WFF provides fixed and mobile instrumentation systems; namely, radar, telemetry, optical, communications, command, data handling and processing systems. To maintain these facilities, replacement parts must be acquired, and test and calibration equipment routinely replaced.

Due to the age of some of the radar, telemetry, and impact prediction equipment, a phased replacement and refurbishment program is underway to insure reliable real-time data collection and handling support to meet current and future requirements.

The increase in funding from FY 1985 to FY 1986 is due primarily to the acquisition of a radar tracking system at the DFRF as a part of the overall effort to develop a capability to support two missions simultaneously in order to accommodate the increase in flight research activity of that facility, replacement of a main processor for the telemetry data processing system at DFRF, rehabilitation of the FPS-16 (Runway) radar at WFF which supports the aeronautics programs as well as some rocket launches, and a wind data system along with updated display systems at WFF.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Aeronautics, balloons and sounding rocket support operations. .......... | 8,152 | 11,900 | 11,500 | 13,200 |

## OBJECTIVES AND STATUS

Fixed and mobile instrumentation systems are maintained and operated to support sounding rocket, balloon, spacecraft, and aeronautical programs conducted by the Wallops Flight Facility (WFF), the Ames Research Center (ARC) at its Dryden Flight Research Facility (DFRF), and Moffett Field Flight Complex (MFFC). These instrumentation systems include radar, telemetry, data processing, data handling, and communications systems, as well as special purpose optical equipment.

The Sounding Rocket program continues to be an active program with approximately 150 launches in FY 1984, the majority of which were conducted at WFF. In addition, there were 44 large scientific balloon flights, along with approximately 115 smaller special purpose balloon flights during the same period. At WFF, the aeronautical programs are primarily related to investigation of aircraft handling characteristics, advanced control and display concepts, spin and stall tests, terminal area guidance and traffic control systems, and storm dynamics studies. During 1984, approximately 260 research missions were conducted. In addition to support of sounding rocket, balloons, and aeronautical programs, instrumentation at WFF will continue to be utilized to support the Shuttle orbital flights with C-Band radar support.

ARC operates aeronautical test ranges at DFRF and MFFC which provide radar, telemetry, optical, and communications support for the performance of aircraft research and development programs. A variety of programs are conducted at these facilities involving high performance aircraft such as the F-111, F-18A, F-16, F-104, F-8, X-29A, and unique research vehicles such as the tilt-rotor research aircraft, composite rotorcraft, X-wing aircraft, the B-720 controlled impact demonstration and drones for aerodynamic and structural testing. Nearly 400 aeronautical research missions were supported at DFRF and approximately 275 at MFFC during FY 1984. DFRF continues to serve as an end of mission and contingency landing site for the Space Shuttle.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

The decrease of $400K is due to minor adjustments in operational activities related to hardware support, communications and off-range programs.

## BASIS OF FY 1986 ESTIMATE

The FY 1985 funding requirements provide engineering and technical services for maintenance and operation of fixed and mobile radar, telemetry, optical, communications, and data handling and processing equipment and facilities to support the ongoing sounding rocket, balloon, and aeronautical research activities. The effort funded represents a continuation of the baseline support provided to the aeronautics, balloons and sounding rocket program. The increased funding level from FY 1985 to FY 1986 is largely due to additional costs at WFF in the operations and maintenance area for off-site range operations and engineering support. Other increases are due to initial spare parts stockage for the Multifrequency Telemetry System procured in FY 1985 and increased costs of engineering support for the Western Aeronautical Test Range at the Dryden Flight Research Facility.

## BASIS OF FY 1986 FUNDING REQUIREMENT

### COMMUNICATIONS AND DATA SYSTEMS

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Communications systems implementation | 5,912 | 6,500 | 6,500 | 6,500 |
| Communications operations............ | 64,600 | 68,200 | 73,000 | 75,700 |
| Mission facilities.................... | 13,545 | 12,400 | 12,400 | 13,300 |
| Mission operations.................... | 18,260 | 21,900 | 21,900 | 27,100 |
| Data processing systems implementation | 23,683 | 26,600 | 24,400 | 24,100 |
| Data processing operations............ | 39,600 | 50,000 | 46,000 | 41,500 |
| Total........................... | 165,600 | 185,600 | 184,200 | 188,200 |

## OBJECTIVES AND STATUS

Funds requested for the Communications and Data Systems program provide for the implementation and operation of facilities and systems which are required for data transmission, mission control and data processing support.

Information is crucial to determining the condition of the spacecraft and payloads for the generation of commands for spacecraft and payload control. Data received from the various spacecraft must be processed into a usable form before transfer to control centers and experimenters. Such support is mandatory for achieving mission objectives. Missions supported include Shuttle, NASA scientific and applications missions and international cooperative efforts.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Communications systems implementation...................... | 5,912 | 6,500 | 6,500 | 6,500 |

## OBJECTIVES AND STATUS

The objective of the Communications Systems Implementation Program is to provide the necessary capability in NASA's Global Communications Network (NASCOM) to meet new program support requirements, to increase the efficiency of the network, and to keep NASCOM at a high level of reliability for the transmission of data. NASCOM interconnects the tracking and data acquisition facilities which support all flight projects; it also links such facilities as launch areas, test sites, and mission control centers.

The major effort underway in NASCOM is the procurement and implementation of a replacement digital voice and data message switching system at the Goddard Space Flight Center (GSFC).

## BASIS OF FY 1986 ESTIMATE

The FY 1986 funding requirements will provide the sustaining equipment and modifications to support the NASCOM network and continue implementation of the replacement digital voice and data message switching system at GSFC. Effort will also continue on the use of advanced digital techniques for Time-Division-Multiple-Access (TDMA) via satellite. Implementation is underway to provide a 15 MBS rate capability at all NASA Centers to meet operational requirements and in FY 1986 the provision of a 60 MBS TDMA capability will be initiated at selected NASA Centers with more extensive operational requirements.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Rudget Estimate |
|---|---|---|---|---|
| | (Thousands of Dollars) | | | |
| Communications operations............ | 64,600 | 68,200 | 73,000 | 75,700 |

## OBJECTIVES AND STATUS

NASA's Global Communications Network (NASCOM) interconnects, by means of leased voice, data, and wideband circuits, the tracking and data acquisition facilities which support all flight projects. NASCOM also links such facilities as launch areas, test sites, and mission control centers. Goddard Space Flight Center (GSFC) operates the NASCOM and serves as its major switching control point. In the interest of economy, reliability, and full utilization of trunk circuitry, subswitching centers have been established at key domestic and overseas locations. The NASA flight projects require the transfer of data between the mission control centers and the tracking sites because of the need for real time control of spacecraft and on-board experiments. In addition, there are requirements to provide experiment data expeditiously to users for analysis.

NASA's Program Support Communications Network (PSCN) interconnects by means of leased voice, data, and wideband circuits the NASA Centers, Headquarters, and major contractor locations for the transfer of programmatic and administrative information. Marshall Space Flight Center (MSFC) operates the PSCN and serves as its major switching control point.

In order to meet high data transfer rate requirements, NASA has implemented and will continue to use digital and other newly developed technology in providing communications support. The continuing availability of new technology provides for the transmission of increasing amounts of data in a cost effective and highly reliable manner.

## CHANGES FROM FY 1985 BUDGET ESTIMATE

The increase of $4.8 million is directly attributable to the need to provide communications with the overseas tracking sites for Shuttle support longer than planned due to the delay in the Tracking and Data Relay System reaching operational status.

## BASIS OF FY 1986 ESTIMATE

The FY 1986 funding requirements for Communications Operations will provide the circuits and service required to operate and maintain the NASA Global Communications Network. International communications satellites and cables will continue to be used to provide digital wideband services to all the overseas tracking stations. The domestic satellite systems and terrestrial networks will continue to service the continental United States stations. These services will provide for real-time transfer of data for all ongoing flight programs.

In addition, funds are included for Program Support Communications Network (PSCN) which provide for the circuits and facilities for programmatic and day-to-day operations such as facsimile, teleconferencing, data transmission, and computer-to-computer data sharing for NASA Centers and Headquarters. In FY 1986, funds are required to complete implementation of the PSC Network gateway equipment which will provide direct connection to the network from all NASA Centers and Headquarters. Funding increases in FY 1986 are due to programmatic requirements for additional dedicated data circuits for Spacelab Payloads, Space Telescope, Space Transportation System, and the Space Station management information systems.

|  | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
|  | (Thousands of Dollars) |  |  |  |
| Mission facilities.................. | 13,545 | 12,400 | 12,400 | 13,300 |

**OBJECTIVES AND STATUS**

The Mission Facilities implementation program provides the systems capability for the command and control of NASA's unmanned scientific and applications satellite programs. Command and control of the spacecraft and on-board experiments is carried out via the Payload Operations Control Centers (POCC's) and related Mission Support Systems (MSS).

The POCC's are responsible for the receipt, processing, and display of spacecraft engineering data and the transmission of commands. Four POCC's currently monitor and control numerous spacecraft. In addition, a new dedicated control center is being implemented to control the operations of the Space Telescope to be launched in FY 1986. Related Mission Support Systems include a Johnson Space Center/Goddard Space Flight Center Shuttle POCC Interface Facility and a closed-circuit television and data communications system.

**BASIS OF FY 1986 ESTIMATE**

The FY 1986 funding requirements will provide for the continuing development to bring the Space Telescope Operations Control Center to operational status. The control center hardware installation will have been completed and integration testing with the spacecraft on the ground will be conducted. The off-line software which provides the high precision telescope pointing, manipulation of the cameras and spectrographs, pointing of the spacecraft antenna toward the TDRSS, and energy and momentum management of the vehicle itself, will comprise the major remaining developments in preparation for the late FY 1986 launch date.

In addition, FY 1986 funds will provide for modifications to the existing Multisatellite Operations Control Center (MSOCC) for control of the upcoming Gamma Ray Observatory (GRO), Cosmic Background Explorer (CORE), Upper Atmosphere Research Satellite (UARS), plus various Shuttle attached payloads.

| | 1984 Actual | 1985 Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Mission operations .................... | 18,260 | 21,900 | 21,900 | 27,100 |

## OBJECTIVES AND STATUS

The Mission Operations Program provides for the operation of four Payload Operations Control Centers (POCC's), a Mission Operations Center, and the related software and support services necessary for the monitoring and control of nine in-orbit spacecraft.

The POCC's, which are the control facilities for spacecraft/payload operations, contain all of the necessary equipment, software, and personnel needed to monitor, evaluate, and control the performance of spacecraft and experiments. Each POCC is operated 24 hours per day, seven days per week. For Shuttle launches with control center payloads, the POCC will issue commands and receive telemetry through the GSFC Shuttle Payload Interface Facility (SPIF). The SPIF will also process a variety of Shuttle-unique data and display these data to the POCC via closed circuit television.

## BASIS OF FY 1986 ESTIMATE

The FY 1986 budget request includes funds to operate the POCC's and supporting facilities for the control of on-orbit missions. In FY 1986, the Space Telescope POCC will come on-line. Also in FY 1986, POCC and Command Management software development activities will continue to increase for both the Cosmic Background Explorer (COBE) and Gamma Ray Observatory (GRO) missions. Software to enable the POCC to control the Upper Atmosphere Research Satellite (UARS) will begin and efforts will continue on SPIF software development.

Also included in the FY 1986 budget request are funds for software and related support services which include maintenance of a software library, coordination and display of launch data, computer-generated command sequences, equipment maintenance, logistics, documentation, engineering services and operation of a closed circuit television/data communications system.

| | 1984 Actual | 1985 Budget Estimate | 1985 Current Estimate | 1986 Budget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Data processing systems implementation. .................... | 23,683 | 26,600 | 24,400 | 24,100 |

**OBJECTIVES AND STATUS**

The Data Processing Systems Implementation program provides for the procurement of equipment and related services for the large data processing and computation systems at the Goddard Space Flight Center (GSFC) which support both the operational and payload requirements of space missions. To meet operational requirements, these systems determine spacecraft attitude and orbit, and generate on-bnard commands to the spacecraft subsystems. In support of spacecraft payloads, the systems process the data from science and applications experiments for subsequent transfer to the experimenters for analysis.

Significant activities in this program continue at the Goddard Space Flight Center to keep the large systems viable and responsive to project support requirements. The Telemetry On-Line Processing System (TELOPS) is routinely supporting a number of Earth-orbiting spacecraft. The Image Processing Facility (IPF) is generating products for Landsat and Nimbus 7. The Spacelab nata Processing Facility (SLDPF) supported the Spacelab-1 missions and the Shuttle Imaging Radar-R experiment. This facility will have mission unique changes made that are required to support Spacelabs-3, 2, and 4. Implementation continues on a new system to process data from numerous and varied experiments which comprise the payloads of early Spacelab missions and new payloads associated with later missions. The early Spacelab missions may be described generally as multi-discipline missions consisting of a mixture of disciplines such as life science, microgravity, space plasma, etc., whereas the later Spacelab missions place emphasis on a single discipline and are called Dedicated Discipline Laboratory (DDL) missions.

In addition to the operational requirements €or orbit, attitude and control of space missions, a new task is underway to increase mission support productivity. The objective of this task is to develop a prototype/test bed facility to test and evaluate maturing technologies resulting from the Advanced Systems Program. Promising technologies for application to future support will he investigated in the areas of remote operation of POCC's, expert systems, high speed data processing, high level languages, and advanced data base management systems.

## CHANGES FROM FY 1985 ESTIMATE

The decrease of $2.2M results from a rephasing of the hardware required to support the Dedicated Discipline Laboratory (DDL) missions and of the procurement and installation of a mass storage subsystem.

## BASIS OF FY 1986 ESTIMATE

The FY 1986 budget request will provide continued funding for phased replacement of the existing computation systems at the Goddard Space Flight Center which provide real-time support to NASA spacecraft. Included in the support are such critical activities as real-time attitude and orbit determination, memory management for on-board computers, and flight maneuver control.

The FY 1986 funding request provides for continuing the phased replacement program for the Command Management System (CMS) and the Orbit Computation System (OCS) at GSFC. The initial phase of replacing the CMS system is underway and the requested funding provides For continuing the replacement program in FY 1986. Also in FY 1986, funding is included €or replacing terminals, custom displays, and large application software programs for the OCS. In addition, the request provides for the improvement/upgrade of the Flight Dynamics System (FDS) and systems studies in autonomous navigation and support as part of the prototype/test bed activity.

Funds are required in FY 1986 to complete the implementation of a stand-alone Space Telescope Data Capture Facility which will capture, error check, and ship scientific data to the Space Telescope Science Institute. The system is necessary to handle the "Packet" telemetry concept and to assure support over the long mission lifetime of the Space Telescope. The "Packet" telemetry concept allows the scientific data of an experiment to be handled with minimum involvement by the ground system, thus minimizing ground data processing time as well as ensuring faster delivery of data to the experimenters. FY 1986 funds are also requested to continue the development of a general purpose, multimission system to handle packet telemetry with the Gamma Ray Observatory (GRO) as its first user.

Funds are also required in FY 1986 to complete the augmentation of the SLDPF to support missions such as ASTRO-1, -2, -3; Earth Observation missions; and Sunlab. These Dedicated Discipline Laboratory (DDL) missions will be flown more frequently than the earlier Spacelab missions, have a higher average data rate, and require quicker release of experiment data to the scientific community.

There is a continuing requirement to procure and maintain an adequate supply of spare parts to replace failure-prone and high-maintenance electronic nodules, to provide test equipment, and to undertake minor modifications and hardware fabrication associated with new equipment installation and reconfiguration. Funds are included in the request for these activities.

| | 1984 Actual | 1985 Rudget Estimate | 1985 Current Estimate | 1986 Rudget Estimate |
|---|---|---|---|---|
| | | (Thousands of Dollars) | | |
| Data processing operations........... | 39,600 | 50,000 | 46,000 | 41,500 |

## OBJECTIVES AND STATUS

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form before transfer to control centers and experimenters. This transformation and computation process is performed as part of the data processing function and applies to a wide variety of programs, ranging from the small explorer satellites to complex imaging type satellites such as Landsat.

Tracking data is processed to provide orbital information which is used to compute spacecraft position. This is essential for the real time control of spacecraft, for determining when the spacecraft will be passing over the stations so data can be acquired, and for providing precise information that can be used by the scientific experimenters to determine where in the trajectory of the spacecraft the scientific measurements were made. Telemetry data must be processed to separate the information obtained from various scientific experiments aboard the spacecraft, consolidate information for each experimenter, determine spacecraft attitude, and correlate these measurements with the position data. Processed data is the primary product of the spacecraft missions, and it is through reduction and analysis of this data by the experimenters that the planned objectives are achieved.

In addition to the actual processing of the data, upcoming projects require extensive prelaunch orbit analysis including spacecraft position and attitude predictions. Analyses are also required to develop operational sequences and procedures to be used during the actual operation of these complex spacecraft.

As part of the data processing activities, three facilities, the Image Processing Facility (IPF), the Telemetry On-Line Processing System (TELOPS), and the Spacelab Data Processing Facility (SLDPF), have been established at the Goddard Space Flight Center to process different types of raw experimental data.

The IPF, initially established to handle image data from the Landsat-1, has supported Landsat-2 and Landsat-3 and presently is processing residual data from these spacecraft as well as current data from the Nimbus missions. These spacecraft are being supported with an all-digital system using high density recorders and computer compatible tapes. This equipment has reduced the time required to provide data to users and is being used currently to process the ten-year Landsat data archive required for climatic and meteorological studies. This data was processed initially into film and picture products; however, the scientific community requires the data to be reprocessed with the output in the form of digital tapes. The digital data can be manipulated in the scientists's computer with specific algorithms to enhance the interpretation of the data and related phenomena.

The Telemetry On-Line Processing System (TELOPS) handles the non-image data. TELOPS receives satellite data in a digital form from the tracking stations via the NASA global communications network lines and is able to electronically store large volumes of telemetry data, thus eliminating most of the tape and tape handling operations. Facility management, maintenance and operations, and software development support for the image and non-image data processing facilities are also provided. The operation of the Spacelab Data Processing Facility (SLDPF) is included along with software development and maintenance required for attitude determination, flight maneuvers, and mission simulations.

**CHANGES FROM FY 1985 BUDGET ESTIMATE**

The decrease of $4.0 million is due primarily to a reduction in the number of Nimbus and Landsat data products which will have to be processed.

**BASIS OF FY 1986 ESTIMATE**

The FY 1986 budget request includes funds to operate the Image Processing Facility (IPF) and the Telemetry On-Line Processing System (TELOPS).. Also, funds will be required for operation of the SLDPF which requires maintenance of unique hardware and software for Spacelab *and* Dedicated Discipline Laboratory (DDL) missions.

Software development and system testing activities are continuing or will be initiated in support of upcoming space science and applications missions such as Space Telescope, Cosmic Background Explorer, Gamma Ray Observatory, Leasecraft, Shuttle Attached Payloads, and the Upper Atmosphere Research Satellite which will operate with the Tracking and nata Relay Satellite System. Complex software is required for spacecraft on-orbit and attitude control maneuvers and for the related data processing activities.