Presentation to the NASA Advisory Council

Commercial Opportunities in the Vision for Space Exploration

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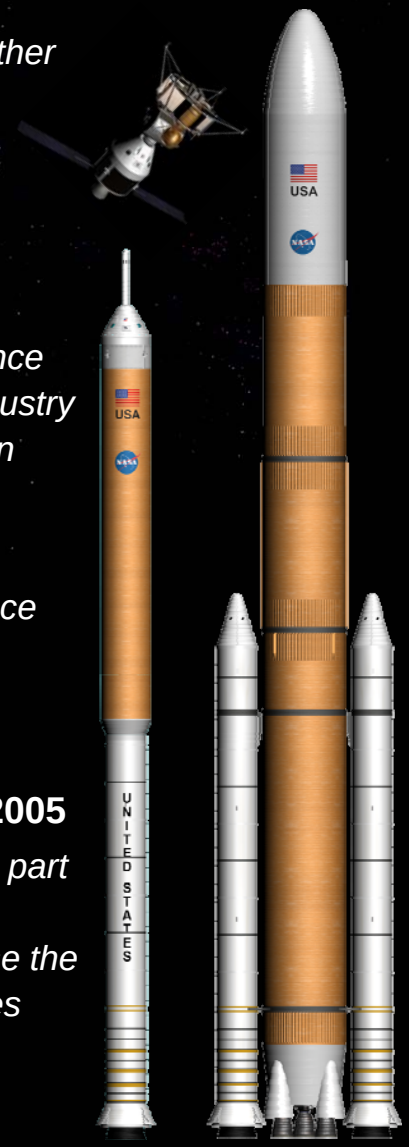
Agenda

- **Overview**
- **Commercial Crew/Cargo Project**
- **Centennial Challenges Program**
- **Suborbital Activities**

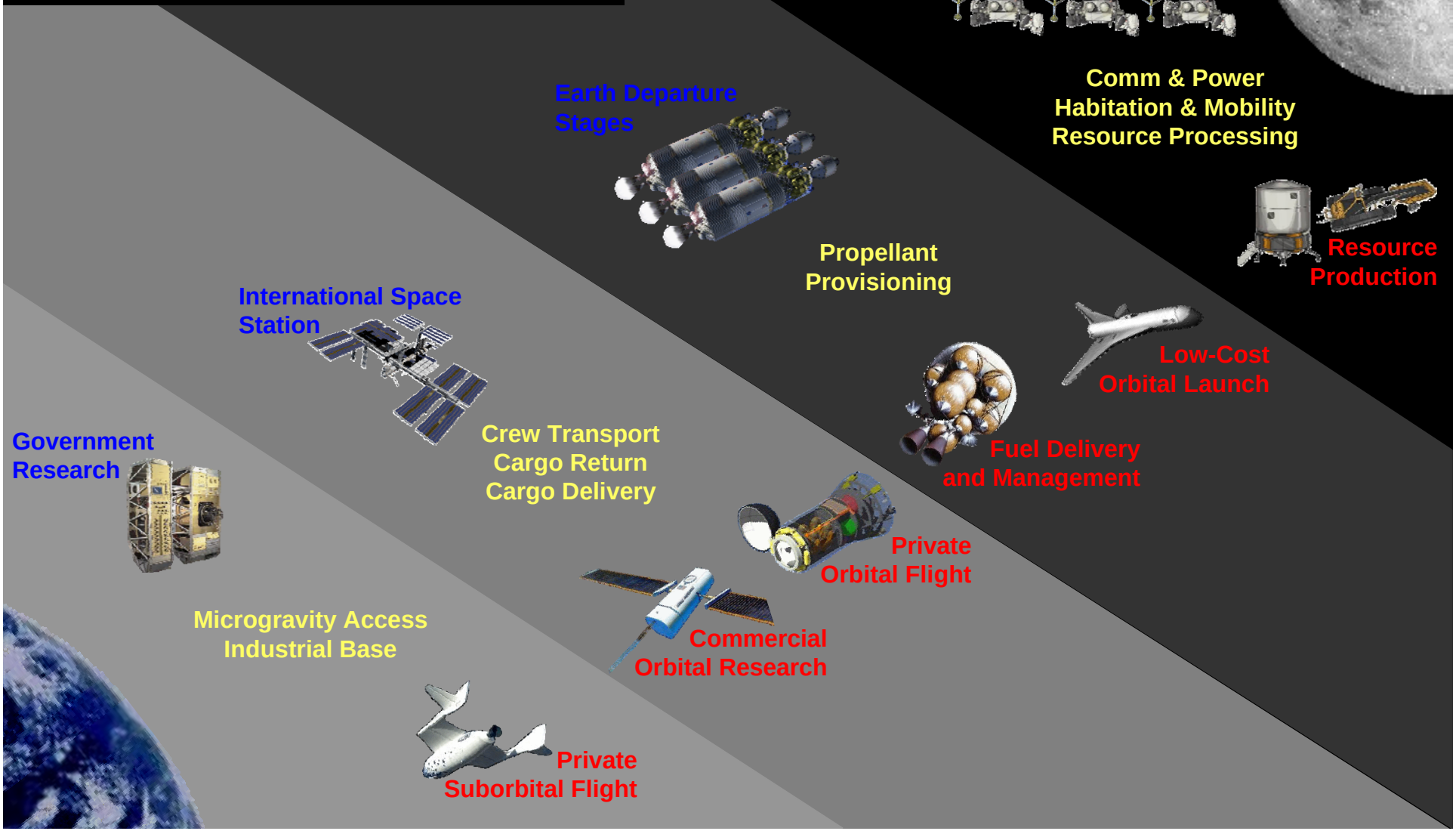
Overview
National Direction

- **National Space Exploration Policy/Vision for Space Exploration**
  - *[The United States will] Promote… commercial participation in exploration… to further U.S. scientific, security, and economic interests.*
  - *[The NASA Administrator will] Pursue commercial opportunities for providing transportation and other services supporting the International Space Station and exploration missions beyond low Earth orbit.*
- **Presidential Commission on Moon, Mars and Beyond**
  - *The Commission recommends NASA recognize and implement a far larger presence of private industry in space operations with the specific goal of allowing private industry to assume the primary role of providing services to NASA, and most immediately in accessing low-Earth orbit.*
- **NASA Authorization Act of 2005**
  - *The Administrator shall establish a program to develop a sustained human presence on the Moon… to promote exploration, science, commerce…*
  - *The Administrator... shall develop a commercialization plan to support the human missions to the Moon and Mars, to support low-Earth orbit activities…*
- **NASA Administrator Mike Griffin, American Astronautical Society, Nov. 15, 2005**
  - *If we are to make the expansion and development of the space frontier an integral part of what it is that societies do, then these activities must, as quickly as possible, assume an economic dimension as well… To this end, it is up to us at NASA to use the challenge of the Vision for Space Exploration to foster the commercial opportunities which are inherent to this exciting endeavor.*



Overview
Commercial Opportunities

Blue=NASA Activities
Yellow=Commercial Opportunities
Red=Future Markets



Overview

Commercial Instruments and Practices

- **Instruments**
  - Service Contracts (FAR)
  - Funded Space Act Agreements (OTA)
  - Prize Competitions (New)
  - Non-Reimbursable Space Act Agreements (OTA)

- **Practices**
  - Accounting and Audits
  - FAA Licensing
  - Foreign Content
  - Intellectual Property
  - NASA Center Participation
  - Termination Terms and Liability
  - Title to Real Property

Commercial Crew/Cargo Project

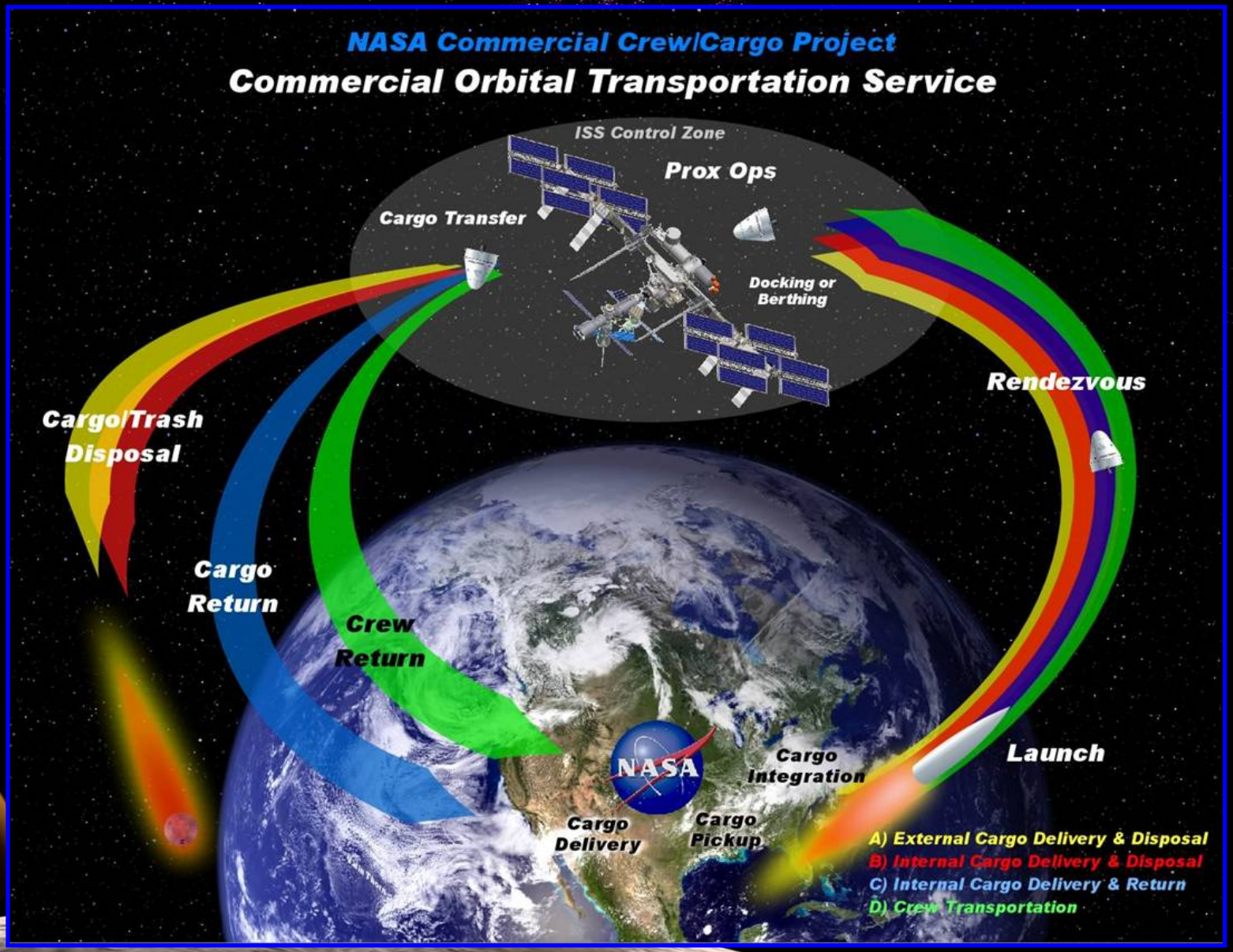
Commercial Crew/Cargo Project

Project Strategy

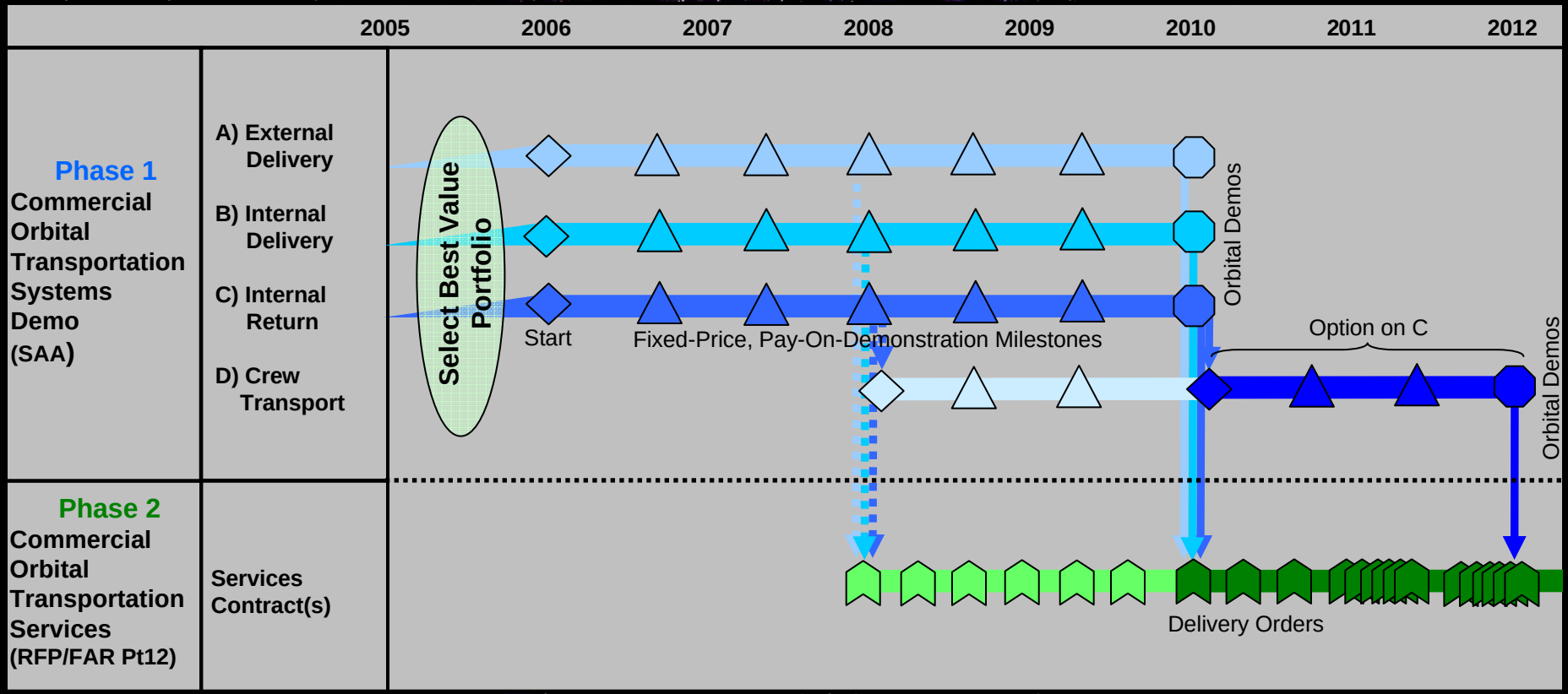
- **Phase 1 – Commercial Orbital Transportation Systems (COTS) Demonstrations**
  - Solicit proposals from industry for Earth-to-orbit space flight demonstrations of any combination of the following capabilities:
    A. External (Unpressurized) Cargo Delivery and Disposal
    B. Internal (Pressurized) Cargo Delivery and Disposal
    C. Internal (Pressurized) Cargo Delivery and Return
    D. Crew Transport
  - Capability A, B, and C demonstrations will culminate in a rendezvous and docking or berthing with the ISS or other suitable orbital test bed and either disposal or reentry and recovery, depending on the selected mission
  - Capability D (Crew Transport) demonstrations will consist of one or more crewed missions to the ISS and will be considered for execution after the successful completion of Capability C
  - Use NASA Space Act authority to enter into funded Space Act Agreements
  - At least one and preferably multiple agreements

- **Phase 2 – Commercial Orbital Transportation Systems (COTS) Services**
  - After successful demonstration of any mission capability under Phase 1, competitively procure orbital transportation services under FAR Part 12 (commercial services contracts).

Commercial Crew/Cargo Project



Commercial Crew/Cargo Project
Roadmap



Commercial Crew/Cargo Project
Phase 1 Summary Performance Goals

- Demonstrate compliance with the COTS ISS Integration and Interface Requirements Document (CI-IIRD).
- Satisfy, to the maximum extent practicable, the performance goals in the COTS ISS Service Requirements Document (CI-SRD).
  - Summary CI-SRD performance goals provided for each capability in the backup to this briefing.
- Provide crew training materials for operation of COTS vehicles.
- Pick up cargo from the NASA KSC depot.
- Provide cargo compatible environment from pickup at NASA to delivery to the orbital test bed.
- Deliver cargo to the orbital test bed within 2 days after launch and, where applicable, return cargo to Earth within 2 days after departure.
- Stay at orbital destination long enough to process cargo (upmass capability dependent).

Commercial Crew/Cargo Project
Frequently Asked Questions

- **Can emergent or established companies propose? Existing or new designs and hardware?**
  - Yes, both emergent and established companies can propose. Proposals can include any mix of existing or new designs and hardware.
- **Is foreign content allowed?**
  - Yes, consistent with U.S. law and policy.
- **Is cost-sharing allowed?**
  - Yes, proposals can include private investment, but financial risk will be evaluated during the selection process.
- **Does NASA have a preferred "last-mile" solution?**
  - No. Proposals can use existing solutions (Soyuz/Progress, ATV, HTV, or Shuttle systems) or propose new solutions, consistent with the COTS ISS Integration & Interface Requirements Document (CI-IIRD).
- **Do proposals have to meet all Space Station needs? Every technical goal for a given capability?**
  - No. Companies can propose demos against one, some, or all cargo capabilities. Crew transport can be proposed as an option to internal cargo delivery and return. Proposals should meet as many technical goals as practicable and clearly articulate limitations where goals cannot be met. Proposals that do not meet all the goals for a given capability will still be included in the evaluation process.
- **How much is NASA spending? How many vehicles will NASA fund?**
  - NASA is budgeting $500 million through FY 2009 for Phase 1 of the Commercial Crew/Cargo Project. Over 90 companies have expressed interest in the Commercial Crew/Cargo Project. The specific number of agreements and vehicles in the portfolio will depend on the proposals received, selections made, and negotiations on individual agreements.

Commercial Crew/Cargo Project
Schedule

- Synopsis Released – October 28
- Draft SAA Release – December 5
- Industry Day – December 8
- Comments Due on Draft SAA – December 16
- Final SAA Release – January 18
- Proposals Due – March 3
- Awards – Target June 6

Centennial Challenges

Centennial Challenges
Program Introduction

What Is Centennial Challenges?

- Prize competitions supporting space exploration and ongoing NASA priorities
  - agency-wide program with focus on exploration
- Builds on Longitude Prize, early aviation prizes, X PRIZE, and DARPA Grand Challenge
- Competitions open to non-federal teams led by U.S. citizens or organizations

Program Goals

- Stimulate innovation in ways that standard federal procurements cannot
  - "Darwinian competition" – do not have select right performer based on proposals
- Enrich NASA research by reaching new communities
  - Such as performers that choose not to compete for contracts or grants
- Help address traditional technology development obstacles
  - Multiple teams trying multiple approaches to same technical problem
- Achieve returns that outweigh program investment
  - Historically teams spend 2x to 16x purse value pursuing well-designed prizes
- Educate, inspire and motivate the public

Program Structure

- Flagship Challenges ($1-50M) – To encourage major private space missions
- Keystone Challenges ($500K-$5M) – To address technology priorities
- Alliance Challenges (~$250K+ with partner orgs) – To encourage collaboration
- Quest Challenges (small/non-monetary) – To promote STEM learning and careers

Centennial Challenges

Program Formulation

Collect Prize Concepts

- Internal Study (NASA personnel interviews generated ~130 prize concepts)
- External Workshop (200 attendees generated ~180 prize concepts)
- External Website (Internet form generated ~80 prize concepts)
- Management and Other Sources

Create Short List

- Relevance to NASA
  - Exploration-specific, cross-cutting, and science- or aeronautics-specific
- Competitor Interest
  - Follow-on opportunities (NASA, other agencies, commercial space, terrestrial applications)
  - Prestige (best in field, record firsts, press and media, NASA association)
  - “Coolness” factor (concepts or technologies)
- Feasibility and Cost of Conducting the Competition

Develop Draft Rules and Prioritize Within Budget

- Consult NASA technical experts
- Balance across technical areas and prize types
- Seek collaborator interest (to cover administration or share purse costs)

Obtain External Inputs on Rules

- Workshop (Alliance $250K or less)
- Formal Request for Comments (Keystone and Flagship $500K-$10M)
- Expert Committee (Flagship $10M or more)

Centennial Challenges
Funded Alliance Prizes ($250K or Less)

Advanced Astronaut Glove
- Collaborator: Volanz Aerospace

High Strength-to-Weight Materials
- Collaborator: Spaceward Foundation
- First annual competition completed in 2005

Lunar Regolith Excavation
- Collaborator: Florida Space Research Institute

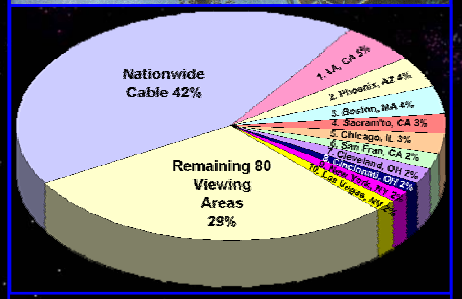
Lunar Regolith Oxygen Extraction
- Collaborator: California Space Authority

Telerobotic Construction
- Collaborator: Spaceward Foundation

Wireless Power Transmission
- Collaborator: Spaceward Foundation
- First annual competition completed in 2005

Personal Air Vehicle
- Collaborator: Comparative Aircraft Flight Efficiency Foundation

Planetary Unmanned Aerial Vehicle
- Collaborator: California Space Authority



First Competition Results
- Wireless Power ($50K)
- High S/W Materials ($50K)
- 11 teams spent $200K
- Small companies, university students, and hobbyists
- No winners but first beam-powered climbers and near-winners on materials
- Fresnel lenses, multi-junction cells, Stirling engines
- 12.5M TV viewers ($570K equivalent in advertising)
- Next year's teams came across country to check out the competition

Centennial Challenges
New Flagship and Keystone Prizes

Legislative Authorization and Draft Rules Release

- NASA Authorization Act of 2005 provides legal authority to conduct larger (over $250K) prize competitions
- Request for Comments and Announcement of Partnership Opportunity released February 7

Fuel Depot Demonstration

- Provide sub-scale amounts of LH2 and LOX after months on orbit

Micro Reentry Vehicle

- Return eggs accurately from orbit without cracking, cooking, or scrambling

Station-Keeping Solar Sail

- Accelerate spacecraft and maintain artificial Lagrange orbit for lunar polar “stare-down”
- Strong interagency interest for solar and Earth polar observation/communication

Human Lunar All-Terrain Vehicle

- First to complete course within crew/payload/power source/mass/stowage limits

Low-Cost Space Pressure Suit

- Withstand rapid depressurization with no leaks

Lunar Night Power Source

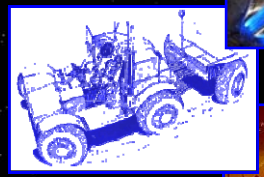
- Provide set power range within mass/volume/lunar night conditions over lunar night

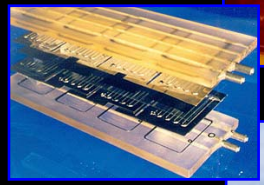
Lunar Lander Analog

- Demonstrate accurate vertical take-off/landing with lunar delta-V
- Collaborator: X PRIZE Foundation (X PRIZE Cup)

Non-Toxic Rocket Engine

- Demonstrate thrust, firing duration, and pulse cycling without hypergolics





Centennial Challenges

Major Prizes Under Study

President's Commission on the Moon, Mars and Beyond

"…increase the potential for commercial opportunities related to the national space exploration vision… by creating significant monetary prizes for the accomplishment of space missions…"

Human Orbital Vehicle Flight

- Two contractor studies completed
  - Industry survey (X PRIZE Foundation)
  - Analytical costing model (Paragon Space Development Corp.)
- Results
  - Three-person, "Gemini-equivalent" capability
  - $100-150 million purse
    - likely divided between 1st and 2nd place prizes
- Resource and safety issues to be addressed

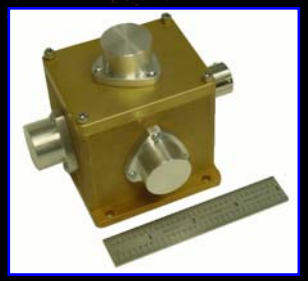
Lunar Robotic Landing

- RFP for studies in work
  - Industry survey
  - Analytical costing model

Suborbital Activities

Suborbital Activities

Recoverable Microgravity Flight Service Pathfinders



- Multiple companies pursuing ~100km, ballistic trajectories for private human space flight in the wake of the X PRIZE
  - Can provide 3-4 minutes of microgravity (versus 30-40 seconds on aircraft)
  - But quality of the microgravity environment is unknown (and will like vary from vehicle to vehicle)
- Two activities in work
  - Non-reimbursable Space Act Agreements to fly NASA's Space Acceleration Measurement System (SAMS) and take data on microgravity environments offered by these vehicles
  - RFI with candidate science payloads to inform potential follow-on microgravity flight services
- Also pursuing aircraft flight services (Zero-G Corp.)

Innovative Partnerships Program

- Non-reimbursable Space Act Agreements for technology transfer or other resource sharing
  - Most recent example is JSC three-year loan of RS-88 engine to RocketPlane Limited, Inc.

Websites and Questions

For Further Information

- Commercial Crew/Cargo Project
  - Homepage
    - http://procurement.jsc.nasa.gov/cots/
- Centennial Challenges Program
  - Homepage
    - http://www.centennialchallenges.nasa.gov
  - Request for Comments on New Prizes
    - http://prod.nais.nasa.gov/eps/eps_data/118924-OTHER-001-001.doc
  - Announcement of Partnership Opportunity on New Prizes
    - http://prod.nais.nasa.gov/cgi-bin/eps/synopsis.cgi?acqid=118923

PE Questions for the NAC

- Is NASA missing important commercial opportunities in the next one to few years?
- How can NASA better structure its activities today to stimulate and leverage the private sector over the long-term (e.g., five and 15 years from now)?
- If NASA had another dollar to spend on commercial opportunities, what are the top few candidates?

Backup

Commercial Crew/Cargo Project
Phase 1 Performance Goals

- **Capability A: External Cargo Delivery and Disposal**
  - Single mission equivalent flight supporting:
    - Ability to deliver up to 5000 kg/yr of external cargo.
    - Safe disposal of up to 5000 kg/yr of external cargo.
  - Two to eight flights per year - to be optimized by the participant.
  - Late cargo loading: 10% of capability at Launch minus 4 (L-4) days.
  - 100 W average, 120 Vdc power to cargo, per payload attachment site.
  - Robotic & EVA compatible cargo handling.
  - Mission reliability of at least 95% for high value cargo at a 50% confidence level.
  - Mission reliability of at least 90% for low value cargo at a 50% confidence level.

- **Capability B: Internal Cargo Delivery and Disposal**
  - Single mission equivalent demonstration flight supporting up to 8,400 kg cargo per yr:
    - Ability to deliver up to 7000 kg/yr of internal cargo.
    - Ability to deliver up to 1100 kg/yr of water.
    - Ability to deliver up to 300 kg/yr of atmospheric gas.
    - Safe disposal of up to 7000 kg/yr of internal cargo.
  - Two to eight flights per year- to be optimized by the participant.
  - Late cargo loading:
    - Unpowered cargo: 10% of capability at L-4 days.
    - Twelve powered Mid-deck Locker Equivalent (MLE) per year, at L-24 hours.
  - 75 W average, 28 Vdc power to cargo, per payload attachment site.
  - Mission reliability of at least 95% for high value cargo at a 50% confidence level.
  - Mission reliability of at least 90% for low value cargo at a 50% confidence level.

Commercial Crew/Cargo Project
Phase 1 Performance Goals (Continued)

- **Capability C: Internal Cargo Delivery and Return**
  - Single mission equivalent demonstration flight supporting up to 8,400 kg cargo per yr:
    - Ability to deliver up to 7000 kg/yr of internal cargo.
    - Ability to deliver up to 1100 kg/yr of water.
    - Ability to deliver up to 300 kg/yr of atmospheric gas.
    - Safe return to Earth of up to 3000 kg/yr of internal cargo.
  - Two to eight flights per year- to be optimized by the participant.
  - Late cargo loading:
    - Unpowered cargo: 10% of capability at L-4 days.
    - Twelve powered Mid-deck Locker Equivalent (MLE) per year, at L-24 hours.
  - 75 W average, 28 Vdc power to cargo, per payload attachment site.
  - Provide cargo compatible environment from pickup at orbital test bed to delivery to NASA.
  - Early cargo access after landing:
    - Four powered MLE per year at Landing + 4 hours.
    - Deliver at least 75% of returned cargo to NASA within Landing + 14 days.
  - Mission reliability of at least 95% for high value cargo at a 50% confidence level.
  - Mission reliability of at least 90% for low value cargo at a 50% confidence level.

Commercial Crew/Cargo Project

Phase 1 Performance Goals (Continued)

- **Capability D: Crew Transportation**
  - Comply with COTS Human System Integration Requirements Document.
    (To be developed by NASA/COTS participants collaboration, based on NASA Human Rating Requirements NPR 8705.2, Man Systems Integration Standard 3000, NASA JSC Design and Procedures Manual - JPG8080.5, and other associated safety resources as appropriate to COTS missions.)
  - Pick up flight crew from NASA JSC and transport to the launch site.
  - Crew transportation support:
    - Maintain 3 crew members at the orbital destination.
    - Provide exchange/rotation of individual crew members at least every 120 days and no longer than every 180 days.
    - Two to four flights per year - to be optimized by the participant.
  - Provide any time return to Earth capability for 3 crew members.
  - Provide contingency support for crew members delivered by COTS.
    - Emergency departure within 10 minutes.
    - Safe Haven for at least 2 hours.
    - Provide the capability to safely return the crew to Earth, without the ability to communicate with the ground, during all mission phases.
    - Provide automated emergency return of the crew members COTS is supporting at the orbital test bed.
    - Provide the capability to perform an emergency return of the crew from the orbital test bed to a Class 1 Earth medical facility within 24 hours or less from time of undocking.
    - Provide the capability for the flight crew to override the automated return regime and manually pilot the COTS.
    - Provide ability to isolate the COTS vehicle internal atmosphere from the orbital test bed atmosphere within three minutes.
    - Provide life support within 1 minute upon COTS vehicle docking hatch closure.
  - Support crew baseline physiological data collection within 1 hour after landing.
  - Crew survival probability of at least 99.9% per mission at a 50% confidence level.
  - Mission reliability of at least 99.5% at a 50% confidence level.
  - Deliver returning flight crews to NASA JSC within 2 days of landing.