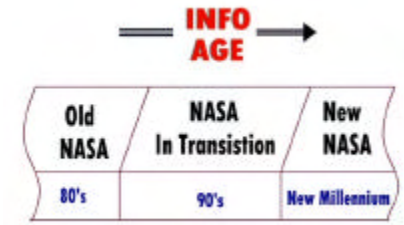

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NASA FBC TASK

FINAL REPORT

March 2000

NASA FBC TASK

Introduction

- This Task was accomplished in the period July 1999 through January 2000 during which interviews/discussions were held at NASA HQ and ten NASA Centers. In October and December, three Workshops were conducted.
- Participating NASA Centers: Ames, Dryden, Glenn, Goddard, Langley, Kennedy, Jet Propulsion Lab, Marshall, Stennis
- Each Center assigned a representative to coordinate their Center's support to this Task. Task support was uniformly good across all Centers. There are good people at all NASA Centers. They want to make FBC work. The same goes for Industry and Academia.
- Center/HQ visits and Workshops addressed these Task objectives:

- **Define FBC**
- **Establish Rules of Engagement for FBC**
- **Identify good examples of FBC**
- **Identify obstacles to FBC**
- **Identify what is most important for the future of FBC**
- **Identify Center-to-Center Teaming Options**
- **Establish metrics for measuring the benefits of FBC**
- **Analyze FBC problems/failures as to lessons learned, common threads, recommended action**
- **Identify the downside to FBC**
- **Provide recommendations**

- Workshop #1 in Oct 1999, involved NASA HQ and Centers, focused on objectives 1-10 above

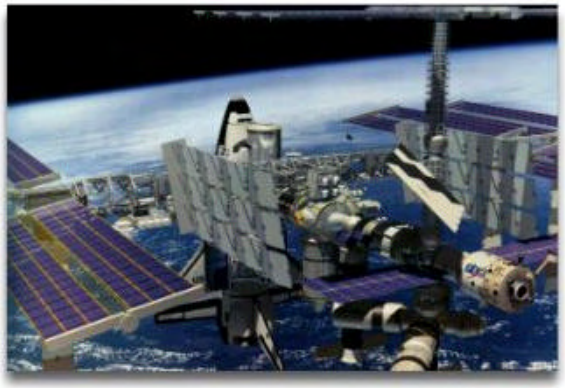
  Workshop #2 in Dec 1999, involved NASA HQ and Centers, focused on Technology

  Workshop #3 in Dec 1999, involved Industry and Academia, focused on Objectives 1-10 above

- More on this Task in the Appendix and at: www.fbctask.com

NASA is even more important in the 21st Century

P = People



Future FBC = PTM

T = Technology

FBC is here to stay

FBC requires both Entrepreneurs and Managers

Entrepreneurs and Managers are Leaders

NASA FBC TASK

We are learning From 1st GEN FBC Missions

NASA Equates to FBC

M = Methods

FBC is a National Imperative

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NASA FBC TASK

Summary

- Of all the hundreds of people interviewed within Government, Industry and Academia, no one said we should discard FBC and go back to the "old ways." They felt we must work harder to make it work, to continue to make cost and schedule a part of the equation in doing Government business- not only focusing on the technical.
- Move over, FBC does not only just apply to NASA work, it applies to all of Government, Industry and Academia. We must innovate and become more efficient if we are to remain a world leader and continue to compete successfully in the global marketplace - being tightly knit together into one World Network as we move into this 21st Century and the Information Age

The question is: "Do we as a nation have the will to succeed with FBC?

- First and foremost, FBC is about people. Leaders and Teams make FBC work not words on paper or memory, and not everyone can pick up the FBC Rules of Engagement and succeed at FBC. It takes the very best, experienced people, their full dedication, and their follow through on all of the details – and still FBC Teams may fail – **SPACE EXPLORATION REMAINS A TOUGH BUSINESS**

- The future of FBC boils down to People, Technology, Methods

If we are to take FBC to a higher level, we must find ways to acquire and keep good people, do a much better job of infusing advanced technology into NASA systems, and do a much better job of incorporating new methods, especially those promised by Information Technology

NASA FBC TASK

- No turning back on FBC

NASA, rest of the nation must respond to global competitive environment

  - ✓ Must succeed in FBC to maintain World Leadership

✓ FBC applies to all work within NASA, the nation
  - ✓ It's both a teaming spirit and methodology
  - ✓ Started with project experiments, now moving into the institution

✓ NASA is in a dynamic transition from old to new
  - ✓ There have been setbacks, but we are learning from mistakes/successes, must incorporate lessons learned and move on
  - ✓ There are many constraints/challenges.
  - ✓ But there is potential for significant future payoff

Future FBC boils down to ⇨ PTM

  - ✓ People – Acquire, Challenge, Empower good people
  - ✓ Technology – Haven't yet scratched the surface on the potential of advanced technology development, especially in Information Technology
  - ✓ Methods – Equipping people with advanced technology, best tools, training, processes, standards, lessons learned databases, effective checks and balances

NASA FBC TASK

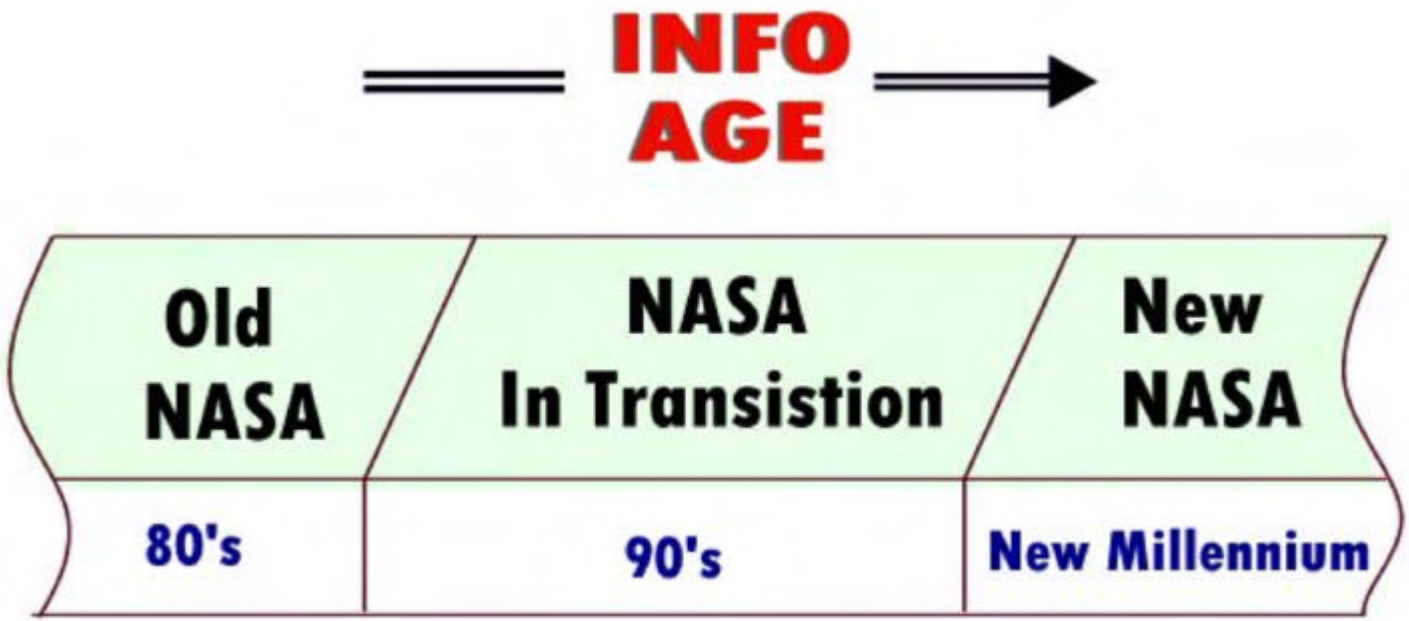
NASA in Transition

- FBC has triggered a major transition from “old to new” within NASA. What started in the early ’90’s as FBC Project Experiments - Clemintine, NEAR, MPF, Lunar Prospector, MGS, Lewis/Clarke, WIRE, etc. has now propagated throughout all of NASA – into all Missions, including Shuttle and Space Station, and into the Institutional support base.

- This transition has put much pressure on the NASA system and its institutional support base which was not prepared fully to handle the increased workload of more Missions and tighter budgets. Almost overnight many more Project Teams were needed, greatly increasing the need for more Institutional Support - including more Peer and Independent Review Boards as well. Institutional management attention has been spread more thinly over more Missions. This includes the extra Institutional support needed for those Missions as well as support for major re-engineering and technology initiatives.

- **In some areas, such as Mars Flight Operations and Launch and Payload services, budget has been cut too much which must be fixed.**

- At the same time, NASA is experiencing a talent drain due to retirements, downsizing, and the loss of people to Industry. This is a major problem which will be hard to fix



- **From Few to Many Missions**
- **Advanced Aero-Space Technology**
- **New Methods**
- **New Rocket Planes**
- **Shuttle and Space Station**
- **Next Gen Observatories**
- **Human-Robotic Colonization**

This Transition has put much pressure on the NASA System, under a declining budget, requiring more project teams, more doers and reviewers, better methods, more productivity

NASA FBC TASK

NASA's future is bright, but we have much work to do

- There is large potential for NASA in the 21st century, and NASA can be ever more important to the Nation. NASA findings could result in a profound change in our perception of ourselves

- We have great roadmaps which plan our future visions, but in our zeal in Program Planning, we have tried to do too much, too fast. We have lost sight of how difficult Space Exploration is and will have to slow down some with more focus on Project Implementation and Design

- **Currently, we have had too many Mission Failures which must be fixed.**

- Mission failures have been a result of mis-management, mis-engineering, breakdown in communications-among Project Team members and within the Institutional support base. This is often due to failure to adhere to established standards, mis-application of FBC, and by placing too much cost pressure on Implementing Teams. Mission failures have not been the result of introduction of New Technology to flight.

- For the 1st Generation of FBC Deep Space Missions, Mission Scope fit well within cost and schedule caps - Clemintine, NEAR, MPF, MGS, WIRE, etc. For the 2nd generation - Mars 98; DS-1,2,3,4;OP/SP; Mars 01, 03; 05 cost caps have been much more severe, placing much pressure on Implementation and Design.

- Better "bottom up" project planning and more realistic Programs of Projects must be implemented

NASA FBC TASK

Significant Future Payoff

- **NASA goals for 21st century are a major challenge, can produce major payoff:**
  - ✓ Increase safety, reduce mission failure rate
  - ✓ Enable cheaper access to space, regaining LV leadership
  - ✓ Establish permanent human and robotic presence in space
  - ✓ Determine if extraterrestrial life exists
  - ✓ Spin-off crucial advanced aero-space technology, foster space commercialism
  - ✓ Protect against hazards to Earth, threats to its environment
  - ✓ Provide for monitoring of earth's environment with increasing INFO RATE
  - ✓ Open Robotic space exploration to many segments of society – Universities, Industry, developing countries, others
    - With Powerful NANO – Spacecraft and Mobile Tracking Stations at drastically reduced cost – Near Earth and Deep Space
  - ✓ Maintain Nation's Air flight Leadership
  - ✓ Lead in Information Technology Implementation and Networking
  - ✓ Improve Mission Design and Implementation Productivity with advanced computer aided databases and tools with significant visualization capability
  - ✓ Bring the adventure and excitement of Remote Space Exploration into

NASA's goals capable of profound impact, NASA will become an even greater factor in maintaining the nation as a world leader – economically, spiritually

S/C = Spacecraft **LV = Launch Vehicle**

NASA FBC TASK

Definition of FBC

With the preceding as an Introduction and Summary, we now turn to the definition of FBC:

- There has been much debate over which should come first. Should it be Better, Faster, Cheaper instead of Faster, Better, Cheaper etc.? Similarly, there has been much debate over "you can have any two, but not all three of FBC, pick any two." These have been healthy and important exchanges, but reduce to only academic exercises when you consider what FBC is really all about.

- FBC is simply a willingness by Leaders and Teams to step out on new ground, to take risk, increase performance, make breakthroughs, innovate and become more efficient. It's a "state of mind," teaming spirit, and a methodology. It's an attitude by Individuals, Leaders, and Teams- that they can do the job, are excited by the challenge, that they are willing to take risk on exciting endeavors; and that they are willing to be held accountable - in success or failure. Team members, empowered by an enlightened but strong Leader, reach out beyond their individual responsibility to look after each other, working together as a closely knit Team toward the larger, common goal. FBC Teams follow an approach, a methodology that comes natural to them, the "FBC Rules of Engagement" which follow.

All people should be in a FBC Mode from HR to Human Space. Are you? Take steps!

NASA FBC TASK

Definition of FBC

- It's both a State of Mind and a Methodology, a Teaming Spirit
  - ✓ It's delivering ever-increasing performance in Human/Robotic Space Missions, quicker, with reduced risk, increased safety, and lower cost
  - ✓ It started as a spirited, people oriented approach to Project Implementation – with a challenging Target, under Cost and Schedule Caps. With safety first, FBC Teams continually strive to:
    - *Innovate*
    - *Maximize efficient use of resources*
    - *Effectively cross organizational boundaries*
    - *Reduce Risk*
  - ✓ Now it's a "healthy virus" spreading throughout NASA's Institutions
    - All centers have it to some degree, but each has a "way to go."
    - They must create the environment for it to spread within Center and among Centers with HQ
    - The ultimate for NASA FBC is increased Center-to-Center Teaming
    - The future is with the Institutional support to FBC

Smaller Core FBC Project Teams are being supported by multi-mission technology, Engineering/Management support Teams, best tools, training, processes, standards, effective peer review, other checks and balances

NASA FBC TASK

Definition of FBC - *Continued*

- Only good Teams with a good Leader can do FBC, and good Teams without a good Leader cannot do FBC well. FBC requires the very best people for Project Leadership and Teaming. There must be a careful mix of scarred experience and bright energetic youth having new methods.

- FBC Projects are like driving a finely tuned, high performance racecar. While margins are adequate, they are tighter to gain performance. There must be a good track, support crew, and most importantly a professional driver.

- In generating future FBC Teams, a quantitative assessment of the Leader and Team's experience/expertise base is essential – **1st Badge of Courage: Leader/Team Certification**

- We are still in the early stages of FBC, completing the 1st and 2nd GEN of Missions. It's one thing to do experimental FBC Projects, it's another to institutionalize FBC. The next Gen FBC Projects will have the 1st and 2nd GEN Lessons Learned Database; a more experienced set of Project Implementers some "hot" off the "firing line" and some already with significant scars

- Like for any human endeavor, FBC Space Projects takes full Team commitment – from winning Super Bowls, to climbing Everest, to competing in today's Info Age Industry. It takes complete, open and candid communication and total dedication from all people involved. All Team Members are System Engineers, looking out for the common good and helping each other. It's difficult to impossible to do FBC Projects with part time help.

NASA FBC TASK

Definition of FBC *- continued*

- ✓ FBC is simply striving to become more efficient and innovative in GOV,Industry and Academia. It applies to all Tasks and Missions, robotic and manned, large and small.
- ✓ It's NOT stuffing a fixed Mission Scope within arbitrary cost and schedule caps
- ✓ In properly implemented FBC Projects, scope, risk, cost and required reserves are determined for a carefully defined mission scope in a thorough upfront planning process. – pre-project phase
- ✓ The FBC Project Team must "own" its plan, including full acceptance of cost and schedule caps.
- ✓ If cost and schedule must be capped at the outset, then Mission scope must be sized to allow for development on a realistic Project Plan - like with Mars Pathfinder

FBC MISSIONS CAN TAKE AS LONG AS <u>25 YEARS</u>! It may take this long to carefully plan and implement a good life detection Mission lead by a proper group of Scientists. FBC Projects should take as long as it's necessary to get the job done – challenged but prudently challenged

NASA FBC TASK

Categories of NASA Missions

- For Projects less than or equal to, say, 200Mil$, the Project Manager and key Project Staff can get their "arms around the Project", know the Team Members personally and closely, and obtain performance/status on a daily and weekly basis - *before* monthly Project Metrics are published. FBC is easier to do for a Project in of this size category. With less investment at stake, more risk can be taken to strive for major breakthroughs. Missions of the size category can function as Trailblazer Missions. But, this is no excuse for failure, and rigorous Project Planning and Control and continuous Risk Assessment and mitigation are still essential. There is no reason to believe that the Mission Success Rate should not be greater than 8/10, and failures due to implementation mistakes are not tolerated.

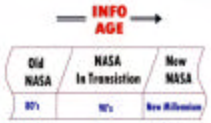
- **The Proposed Mission Success Rates are for failures due to the inherent risk of the Mission and not due to mistakes. Failure due to mistakes is not acceptable and must be a order of magnitude less. Examples of inherently high risk Missions are DSI, Solar Probe, Europa Orbiter, and the Shuttle Tether Mission where the Tether broke.**

- For missions larger than 20mil$, Project Management is further removed from day-to-day action and things get more complicated fast. There are many more interfaces, external spot lights, reviews, need for more structured documentation, etc. Put in the human element and complexity and Project Management challenge are maximized. Now many Agencies outside of NASA get involved with the Human element. These Missions of high national importance cannot fail. However, there is no reason not to employ FBC principles to Project Management and to each of the many Project elements.

- As an example of the degree of difficulty with size, consider a two billion$ Robotic Project. In a rather simplistic manner, this Project can be broken down approaches? But what is the probability of 10 FBC Missions going right? Then add in the many complex interfaces and inter-dependencies that must exist among these ten FBC sub-projects and you can begin to appreciate why larger Projects are much harder to do. A large Project replicates the basic Project Organization structure, say, for a 200mil$ Project, over and over again throughout its total Project structure such that it begins to look like a fractal in a chaotic system.

- **Sufficient large and complex Projects by the nature of their complex structure verge naturally on chaotic behavior.**

NASA FBC TASK



CATAGORIES OF MISSIONS

- Moving to **"NEWGROUNDS"** Technically or Programmatically
- Challenging cost and schedule caps
- Higher Risk • Potential for Major Payoff
- Flexible • Less Oversight and visibility
- Run by an Entrepreneur/Leader

PROPOSED MISSION SUCCESS RATES

TRAILBLAZER ROBOTIC
<200mil$

> 8/10

- Higher Nation Priority/Cost • More Margin
- Lesser risk • Potential for major payoff
- More formal methods
- More oversight and visibility
- Run by a Manager/Leader

CLASSIC ROBOTIC
>Billion$

> 95/100

- Highest national priority/cost • Most Margin
- Least risk • Potential for major payoff
- Most formal methods
- Most oversight and visibility
- Run by a Manager/Leader

HIGHEST PRIORITY
Human
Multi-billion$

> 999/1000

THE HIGHER THE NATIONAL PRIORITY, THE LARGER NUMBER OF "SPOTLIGHTS." THE HIGHER THE COST AND COMPLEXITY, THE HIGHER THE MANAGEMENT CHALLENGE. BUT ALL PROJECTS ARE IMPLEMENTED WITH SPIRITED TEAMS USING FBC METHODS

NASA FBC TASK

Rules of Engagement for FBC Projects

- In the past, with fewer Missions, Project Managers gained “on the job training” over ten to twenty years, working up through the ranks. Project Management principles were handed down from one generation to the next through this “on the job” experience accrual process. Today, with many Projects, this is not usually the case, and mentors, training, checks and balances and guideline documents like NASA 7120 and JPL’s Design Standard become much more important

- Still, a certain degree of experience and expertise must reside with each Project Team and certification is essential including training. The best way to teach Rules of Engagement for FBC Projects is having new Project Teams hear the stories, the lesson learned from experienced Teams. This should be a mandatory process for Project Team certification and building taught by NASA’s Academy of Program and Project Leadership

- The Rules of Engagement for FBC Projects are nothing new and have been applied throughout the history of NASA - being built up from the 60’s over hard Lessons Learned. FBC rules go back to basics, use common sense, stress the need for good up front planning, a stable environment, good execution with thorough space qualification, test, simulation and training, and effective checks and balances

NASA FBC TASK

Rules of Engagement for FBC Projects

- ✓ Form and motivate an excellent team, a mix of experience and bright energetic youth with new methods
  - Go to the best sources of expertise in NASA, Industry, Academia
  - Co-locate physically and/or electronically, do concurrent engineering
  - Team with Mission Assurance to develop the Project Mission Assurance Plan

***Certify each Team - BADGE OF COURAGE #1**

- ✓ Establish a challenging but realistic Mission Target
- ✓ Establish Upfront Agreements and maintain them
- ✓ Size Mission Scope within resources to provide for acceptable risk and adequate reserves
- ✓ Develop a thorough Project Plan according to NASA 7120.5A, tailoring its rules/guidelines to Project's needs
- ✓ Conduct rigorous system and subsystem engineering to established standards (like JPL's Design Standards)
- ✓ Conduct continuous, rigorous Risk Assessment and Mitigation throughout development and operations

***Establish/Maintain a Mission Risk Signature - BADGE OF COURAGE #2**

- ✓ Balance use of available and advanced technology to maximize Mission Success *(Note 1)*
- ✓ Establish/maintain metrics for Mission Risk and Technical/Cost/Schedule Performance

***Establish/Maintain Rules of Engagement Check List - BADGE OF COURAGE #3**

- ✓ TEST, TEST, TEST and TEST as you FLY *(Note 2)*
- ✓ Then TRAIN, TRAIN, TRAIN *(Note 3)* Flight OPS Teams must contain key members of the Development Team
- ✓ Best: Designers become testers become operators
- ✓ Work openly and candidly inside the Team with thorough communication. Communicate openly and candidly externally to the Project

Support yearly Independent , Formal Reviews, but also Peer-Review all key decisions, results and events, responding to all action items. Projects own their Peer-Review Process

Note 1: It may be that Demo's of Advanced Technology are included in Mission Scope and Upfront Agreements

Note 2: Early proof of concept tests, early end-to-end flight-ground functional/interface tests, extensive subsystem and system space QUAL an performance tests and burn-ins, using flight operations H/W and S/W in spacecraft system tests

Note 3: Initiate Flight Operations Training, both standard and contingency sequences, in the Test Bed and with the Flight System in ALTO before launch

ALTO = Assembly, test, launch operations

NASA FBC TASK

Rules of Engagement for FBC Projects *Continued...*

- There is nothing new here in these FBC Rules of Engagement
  - ✓ It's just back to basics, lots of hard work, Team effort and follow through on the details
  - ✓ Its never thinking that you are done. You can never stop penetrating into how things work, how they reflect reality, match the expected environment
  - ✓ Its being paranoid about failure, staying humble, never getting smug or complacent
  - ✓ Its never thinking that you know it all, that you really know anything. Its asking for help from others, getting your work critiqued, no matter the bruised ego
  - ✓ Its thoroughly debating all hard issues, no one person usually knows the answer. It must be a collective effort by a Team
- A "Green, Yellow, Red" metric chart does wonders
  - ✓ Use them to track procurements, deliveries into Spacecraft Integration and Test, Etc
  - ✓ On Pathfinder, a vendor seeing that we carried his delivery status at "Red" asked: "Does that chart go to NASA HQ?" The answer: "Yes"

NASA FBC TASK

Example

Rules of Engagement

Project Performance Check List Metric for Year _____

- Stable Agreements
- Certified, Capable Team
- Funding Availability
- Project Plan and Implementation Status
- Adequate Reserves
- Mission Assurance Pan and Implementation Status
- Risk Assessment and Mitigation Plan and Implementation Status
- Mission Engineering to Standards and Implementation Status
- Flight-GND System Engineering to Standards and Implementation Status
- Sub-System Engineering to Standards and Implementation Status
- System/Sub-System Space Qual Plan and Implementation Status
- FLT-GND S/W Development Plan and Implementation Status
- SUBS/SYS Test, SIM, PERF Demo Plan and Implementation Status
- GDS/OPS DEV Plan and Implementation Status
- Flight OPS Training Plan and Implementation Status
- Peer Review Plan and Implementation Status
- Problem Resolution Status
- Documentation Status
- Configuration Control Status

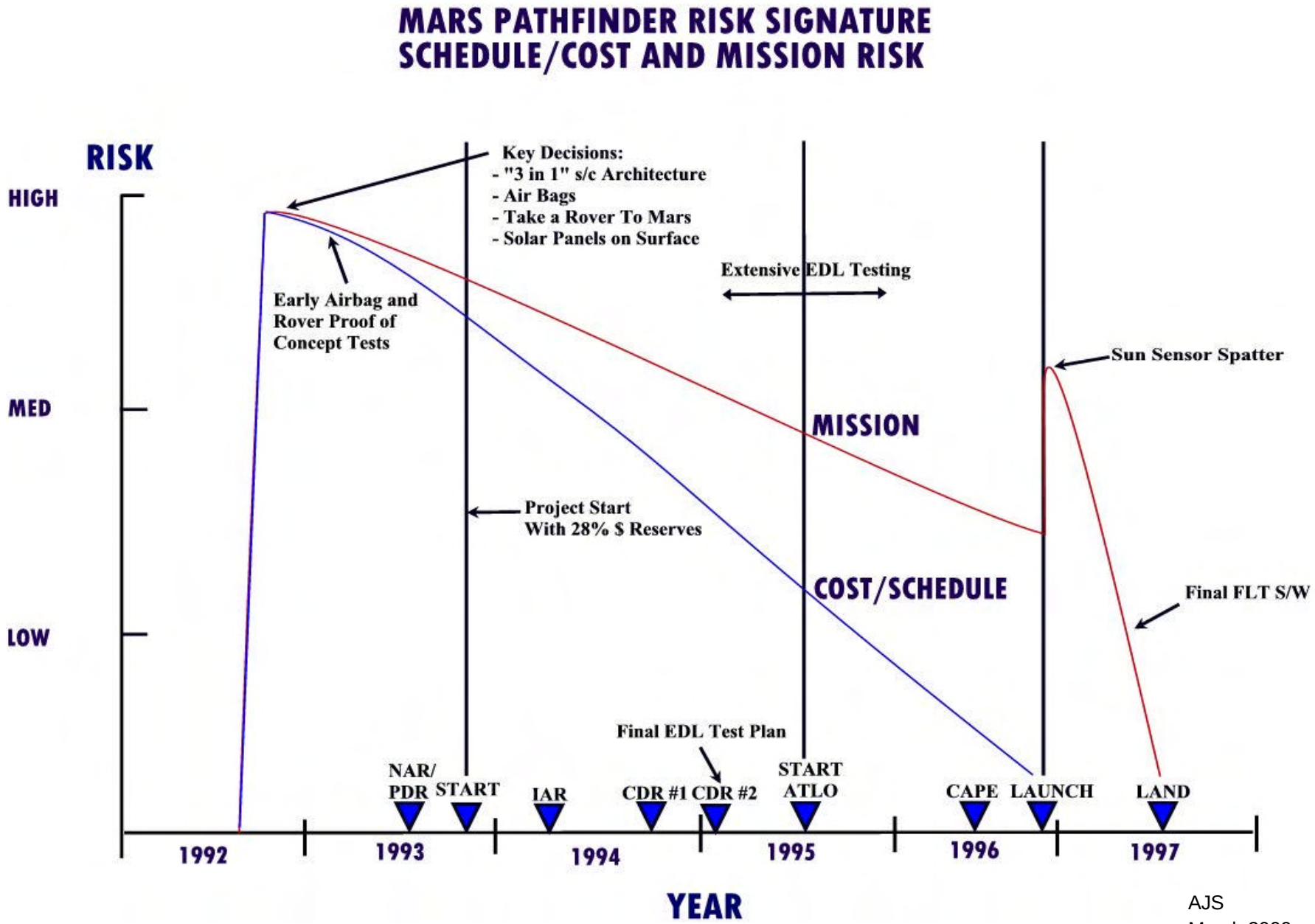
AJS
March 2000
9b

NASA FBC TASK

Risk Assessment and Mitigation

- ✓ The currently high Mission Failure Rate will be reduced by:
  - ✓ Eliminating mistakes, mis-management, mis-engineering by re-emphasizing Project Implementation and Design, especially in ensuring a Mission scope match to resources.
  - ✓ Certifying of Project Teams, including thorough training and exposure to the 1st GEN FBC Mission Lessons Learned
  - ✓ Ensuring that Project adhere to FBC Rules of Engagement, including effective checks and balances through Peer reviews and Independent Annual Reviews
  - ✓ Providing Project Teams with improved Institutional support, especially in Advanced Technology and Methods
- ✓ Project and Program Risk Assessment and Mitigation is a continuous activity throughout development and operations. There is nothing magic or overly complicated about this process. Again, it's simply back to basics, common sense, discipline and <u>follow through</u> on details. Good Project Management has always been about Risk Mitigation. See the FBC White Paper, dated July 1999, in the Appendix for an outline of a Project Risk Assessment and Mitigation Process.
- ✓ Each Project must generate and maintain a Risk Signature, both for Programmatic cost and schedule and for Mission Risk. It's ok that a FBC Project starts out with high technical and programmatic risk. This is what FBC is all about – as long as there is a good Risk Assessment and Mitigation and this initial risk is retired prior to launch and continuously throughout operations to acceptable levels. The FBC Project Manager and the Project Team are obligated to state when risk cannot be reduced to acceptable levels.
- ✓ Mission failure due to mistakes, mis-management, mis-engineering is never acceptable. Mission failure for a difficult Mission where everything was done correctly to mitigate Risk is at least "honorable," while still very traumatic for the Project Team.

Example



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March 2000
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NASA FBC TASK

FBC Rule of Engagement for Institutions

- Institutionalizing FBC is the hard next step we are currently facing, but where major strides can be made to take FBC “up a notch” to the next level.

- It must start with people. NASA needs an infusion of leaders at NASA HQ and within the Centers – a method to incentivize Leaders to join NASA’s ranks. NASA must also start with the Universities to motivate young talent to join NASA – and sufficient resources need to be made available to hire young people. More Open Engagement of Universities in Research and Advanced Technology Development and in University-managed Space Projects must be given higher priority – with more NASA assistance and mentoring to make them work.

- Presently, there issome but too little open exchange and debate of ideas within NASA HQ and between HQ and the Centers. An outstanding example of the type of “blue sky thinking” that should be popping up all over the place, even at HQ, is the study ”Grand Challenges for Space Exploration“, Space Times, May-June 1999, that Wes Huntress accomplished prior to his retirement. The Mars Colonization Study Carrier out by Doug Cook and Norm Haynes has brought JSC and JPL closer together than ever before. Such activities must continue under careful guidance by NASA HQ across all Centers. The Decadale Study may also be a good example of good HQ and Center Teaming, but why does it have to be done so secretly? Why can’t all of NASA be involved via the Internet? Sometimes in our haste, we display a lack of sensitivity to good people’s fine efforts. The 1999 Mars Airplane Study sequence of events left many good teams and motivated people “hung out to dry” and thoroughly de-motivated.

NASA FBC TASK

FBC Rules of Engagement for Institutions

- ✓ Make acquisition of, sustaining, motivating key personnel a major priority
  - ✓ Start by placing more emphasis on engaging Universities in Research and Advanced Technology Development and university-managed space missions
  - ✓ Put a premium on people, they are the reason for FBC successes
  - ✓ Create an environment which promotes Personal and Team initiative and creativity
  - ✓ Trust and empower people, listen to their feedback
  - ✓ Move from adversial/formal to open relationships, where issues are openly and candidly debated, where people can express themselves without fear
  - ✓ Breakdown organizational barriers to progress, especially for NASA HQ and center teaming
  - ✓ Recognize outstanding work with significant rewards
  - ✓ Do not overreact to problems, but incorporate lessons learned effectively
  - ✓ Align NASA HQ and Centers to:
    - Identify apportion, and then maintain Core Competency throughout the Centers - Important
    - Accomplish an Integrated Information Technology Thrust- Important
    - Accomplish an Integrated Advanced Technology Thrust - Important

Continually evaluate the effectiveness of policies, rules, procedures, processes, evolving them to be consistent with the dynamic environment, eliminating those that are no longer relevant

NASA FBC TASK

FBC Rules of Engagement for Institutions – *continued*

- As with acquiring and maintaining good people, settling the NASA Center Core Competency Problem is a major priority. This must occur before major strides are made in affecting Center-to-Center Teaming on such important thrusts such as linking NASA into one Information Exchange and accomplishing a much more robust Advanced Technology Initiative – both important for the future of FBC

- Each Center must have a well-defined role which is respected and supported by the other centers. Lead Centers then have the responsibility of leading other involved Centers in development of effective Center-to-Center Implementation Plans and Teams. NASA Centers must continue to have an “in house” technology and project management experience base. There must be a balance between competition of technology and maintaining stable, important core competencies within the Centers that are constantly checked to ensure world case status. Mission Centers must maintain an “in house” capability at world class, in all technical areas necessary for Mission Implementation-at least from mid to high TRL levels.

- NASA HQ, especially the Enterprises, must be involved in and supportive of resolution of the Center Core Competency Problem- buying into and supporting the final resolutions

- We need to educate the public more clearly on the challenge and risk as well as the exciting, potential return on their Space Exploration Investment

NASA FBC TASK

FBC Rules of Engagement for Institutions – *continued*

- Support smaller core Project Teams with multi-mission pools of technical/management expertise, advanced technology, best tools, training, processes, standards, lessons learned databases, effective checks and balances
  - ✓ **Resist temptation to over-review, be sensitive to not stifling initiative and productivity**
  - ✓ **Electronically wire NASA with advanced IT technology so that all Centers become one Information Exchange**
  - ✓ **Obtain incentives for the incorporation of advanced Technology in Flight Projects**
  - ✓ **Standardize to extent possible across NASA**
- Conduct frequent symposiums to share experiences and lessons learned, new ideas – bring in outsiders
- Develop a realistic approach, with proper incentives, encouraging the mobility of both technical and management people within NASA
- Incentivize inter-Enterprise and inter-Center Teaming, especially in Information Technology
  - ✓ **Enforce Lead Center Roles**
  - ✓ **Get NASA HQ Managers and Center's directors to buy in to Teaming with clear and "committed to" plans and measurable deliveries**
  - ✓ **Make enterprise and Center Yearly Performance Evaluations dependent on their Teaming initiatives and**

Also Reach Out to the Public

IT = Information Technology

NASA FBC TASK

FBC Rules of Engagement for Institutions – *continued*

- Programs provide a major opportunity to build upon individual Missions to accomplish larger, Program Objectives, to infuse advanced technology into a sequence of Projects, to exploit cost effective use of multi-mission equipment, and to gain the efficiencies of multi-buys, and combined Teams. However, as with the individual Projects, significant up-front Program Planning is necessary including Program Architectural System Engineering, i.e. system engineering over the set to Missions to ensure that each Mission adequately supports the next Mission. This up-front Program Planning and Engineering is challenging, especially in establishing a well-scoped, budgeted and planned set of Missions that fit the Program Funding Profile.

- There is an important give-and-take/ Program vs. Project negotiation that must be in place for all Projects within the Program. Each Project must stand alone, be empowered and be accountable to meet its Mission Objectives, but at the same time be motivated, incentivized, to wear the bigger "Program Hat," to implement program unique requirements such as use of multi-mission technology and to accept program unique engineering and science requirements.

NASA FBC TASK

Rules of Engagement for Institutions – *continued*

- Place more emphasis on thorough and realistic program planning
  - ✓ Conduct Independent Reviews of Program Plans as well as the individual Project Plans
  - ✓ Conduct careful Program System Engineering across the set of Missions to insure that the projects collectively achieve Program Objectives
    - Establish and maintain a Program programmatic and Mission Set risk signature, as with the Projects
  - ✓ Resist placing too many Projects under the program funding profile
  - ✓ Place higher priority on thorough and realistic project planning within the Program
    - Establish "bottoms up" project budgets, including reserves, developed by and "owned" by the Project and Project Plans that meet both the individual Project as well as Program Unique requirements
    - Establish well understood project requirements prior to project start
    - Maintain Project requirement stability throughout development
    - Fund Projects according to their required funding profile including reserves

NASA FBC TASK

Rules of Engagement for FBC Technology Development

- Infusion of advanced technology is of major importance to the future of FBC and must receive higher priority and funding. There has been a shift of technology funding from research and advanced technology to focused technology development to meet immediate Mission Objectives – "eating the seedcorn."

- **Is this the proper technology strategy for NASA?**

  Does NASA then rely on other Government Agencies, Industry and Academia to provide this research and advanced technology component? Has this strategy been adequately studied and debated?

- The issues associated with "Center Core Competency" and "Competition of Advanced technology" also bear on this Research and Advanced technology issue. All three must be dealt with together to effect an integrated solution. This is the major NASA problem which must be solved for the future of FBC.

NASA FBC TASK

Rules of Engagement for FBC Technology Development

- Maintain a culture of innovation
- Stimulate and Reward “Out Of The Box” and entrepreneurial thinking
- Provide long-term funding stability for a balanced research and advanced technology and focused technology development Program
- Ensure sufficient level of technical management and reporting
- Encourage Peer Reviews, and external Peer-Reviewed publications
- Encourage partnerships with academia, other government agencies, national laboratories, and industry
- Set the technology development priorities based on NASA Strategic Goals and Vision. Help define the future NASA vision which ten drives both research and advanced technology development as well as focused technology development
- Set a world-class standard of excellence with peers and scientists
- Establish a balance between research, advanced development, and focus technology development. Also establish a correct balance between competed and stable in-house technology development. Accomplish early incremental, prototyping and technology demonstrations throughout the technology development cycle
- Initiate early up-front planning with project team members for technology infusion into flight projects
- Accomplish technology transfer to industry
- Manage technology development throughout the complete life-cycle, from concepts to technology infusion, with appropriate level budget and schedule plans

“Be on the look out” for technologies high payoff to society, and suggest them for major NASA and other Government initiatives, that is, “Mini-Manhattan Projects.”

NASA FBC TASK

Technology Perspective for FBC

- Infusion of advanced technology into Project Development is accomplished – as with any successful human endeavor – by early and thorough communication amount the disparate Technology and Project groups. Involvement of project people early to gain their ownership is essential. A good example of this type of process, initiated at JPL, is modification of their TEAM X, pre-project design and planning activity to include Advanced Technology insertion at this stage of Project Planning – calling it TEAM XT.

- All Government Agencies in advanced technology development must be on the lookout for technologies that have the potential for high payoff for space exploration and for the nation in general. Yearly “Out of the Box” Workshops that flag potentially, high payoff technologies for accelerated development by the Government in “Mini-Manhattan Projects” should be conducted throughout with Government, Industry and University participation – with prizes given to the winners of the best ideas.

NASA FBC TASK

Technology Perspective for FBC

- NASA needs the will to lead, to be first in the world in creating revolutionary new SPACE TECHNOLOGY.

- FBC is here to stay. Some implementation changes are needed, but stay the course. Revolutionary advances in SPACE TECHNOLOGY are essential to NASA's future in FBC.

- At present, the agency's strategic SPACE TECHNOLOGY investment is tragically small, most often overstated, and has no operational champion within the agency.

- At the critical cross-cutting and early innovation stages, support for NASA SPACE TECHNOLOGY development is in disarray and Balkanized. There is minimal focus or coordination. The current approach has no provision for new technology initiatives.

SPACE TECHNOLOGY development should be managed as a single body of work, led by a strong technology advocate, and have the organizational equivalency of Enterprise Missions.

NASA FBC TASK

Information Technology Perspective for FBC

- First, we must solve the Enterprise/Center Core Competency issue before we can proceed to development of a more effected Integrated Technology Program-balancing Research and Advanced Development vs Focus Technology Development; balancing stable, Center of Excellence Technology Development vs Competitive Technology Development

- Again, a NASA HQ Leader must be assigned to develop this Integrated Technology Plan. This person could be the same Leader in settling the Enterprise/Center Core Competency Problem which must be solved first.

- An important element of this Integrated Technology Plan is an Information Technology Program which integrates all related IT thrusts into one Plan – IS, ISE, COSMOS. This IT Program must again be balanced between Research and Advanced Development and Focused Technology Developments

- **This IT Team Program is the best HQ and Center-to-Center Teaming Arrangement to bring NASA into the INFO AGE as "one" NASA Center**

NASA FBC TASK

NASA Information Technology Programs need an integrated direction. All of the Information Technology Related thrusts- ISE, IS, IT, Cosmos- Must be folded into one Program with strong leadership that reports directly to the NASA Administrator

- This IT Program must have higher priority and sufficient funding
- ISE remains in a conceptual state. Level Requirements are not mature. ISE Must:
  - ✓ Be more that a set of tools and components
  - ✓ Start with a vision linked to a set of system Architectures that support Enterprise Missions
  - ✓ Be accepted into and supported by Enterprises
  - ✓ Be developed into a Program, integrated with IT/IS/COSMOS, which has:
    - A strong Research and Technology Thrust keyed to Uniform System Architectures
    - A strong system Engineering Function
    - Clearly defined System architecture Requirements which drive phased subsystem & integrated subsystem capabilities, tools, networks, etc. deliveries
    - A well-organized and motivated NASA, Industry, University Team
    - Working agreements/interfaces with Enterprises, other NASA codes, NASA Centers, Science Community, Industry and Academia
    - An integrated Program Schedule supporting the IT vision which forecasts phased, incremental, end-to-end performance demonstrations leading to major system Architecture deliveries– constrained to available funding
    - Yearly reviews by a Review Group comprised of NASA, Industry, University representatives

IT will be the largest and most important NASA Center, Industry, Academia Teaming initiative for the next decade

NASA FBC TASK

IT Deliverables

- The IT Program must be comprised of both basic research and Near Team developments of infrastructure driven by Enterprise Mission Architectures

- Basic research, aimed at breakthroughs, is thoroughly planned, prioritized, and subject to continual peer review scrutiny as to relevancy, need for redirection, etc.
  They work to a schedule too!

- For the Near Team, 3-5 years, it is a shame that no schedule exists for delivery of important IT deliveries utilizing currently available and maturing technology at both ends of the Mission Sequence – at the front end in visualizing the design and simulation flight operations before Project Start, and in the final stages, in flight operations, in graphic visualization of the distant encounter site.

NASA FBC TASK

MARS OPERATIONS/PUBLIC VIEWING DOME

An example of an Information Technology Delivery Target

AJS
March 2000
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NASA FBC TASK

NASA Center Teaming

- As we proceed into Info Age, NASA Enterprises and NASA Centers will become less and less stand-alone entities. Their individual lines of distinction will become more and more blurred as electronic networks of co-operative work between them advance to make all of NASA effectively one Center- comprised of "Specialty Centers" which combine to make the total products. And this will expand to encompass both Industry and Universities as well – one NASA – Industry – University Center

- The same is happening with the commercial sector throughout the world:

Networks of companies, each with its "Core Competency" compete worldwide against other networks of Companies in a "One World"

- All "stovepipes", "fiefdoms", and "castles" will come tumbling down. Mobilization – movement of key personnel from other Center to other, including HQ is important to this dynamic transition.

- A HQ Leader with clout must be assigned to facilitate this dynamic transition, especially in settling on the roles and Core Competencies of each Center relative to the Enterprises at HQ

- Yearly performance evaluations must include how well all Enterprises and Centers are doing in affecting this Teaming transition. Facility decisions, for example, must be made from a NASA view as opposed to a Center View.

- **All of NASA must stop thinking in terms of individual entities but instead of themselves as important parts which contribute to the whole picture**

NASA FBC TASK

- Currently, Center Teaming exists in established roles where historically there's a clear advantage for each center. Also, some new Center Teaming Initiatives are working which don't need fixing

But in general, Centers are stand-alone and protective, especially in transitioning to new Roles which are not so clearly defined or accepted in the NASA Community

- Downsizing, competition, threat of closure, longstanding feuds are obstacles
  - ✓ Center Core competency and Lead Center roles need work before we can proceed further
  - ✓ Research Centers need clearly defined and accepted roles and stability
- Incentives, clear objectives and payoff must be established for Center Teaming
  - ✓ Must start at HQ, in particular with the Enterprises
  - ✓ Team only when there is a major advantage
  - ✓ Remove adversial, and formal barriers to effective Teaming
  - ✓ Mobilize the NASA Workforce to breakdown HQ and Center Barriers

Most important HQ/Center-to-Center Teaming Trust: Information Technology (IT)

  - ✓ Currently, there are somewhat independent pockets of IT and associated re-engineering work ongoing inside Centers and among the Centers
  - ✓ There is much uncertainty as to Core Competency Roles. Clarify and facilitate
  - ✓ ISE, IT, IS, COSMOS and related engineering/management initiatives, must be integrated into a united Research, Development, Implementation Plan
- NASA must become a worldwide leader in IT

IT = Information Technology
IS = Intelligent Systems
HQ = Headquarters
ISE = Intelligent Synthesis Environment
COSMOS = Linking of NASA Center "Super Computers"

NASA FBC TASK

Industry Perspective for FBC

- The Industry Workshop represented a broad section of the aerospace community:
  - ✓ Senior professionals from industry and academia
  - ✓ An unconstrained and open discussion
- Industry and academia fully support the strategy behind NASA's "Faster, Better, Cheaper" initiatives.
- However, the pendulum has swung too far
- Programs budgets are too lean and design teams are moving too fast
- The most important element of the strategy is better – the best we can do with available funds.
- Success depends upon a strong industrial and academic base.
- The future is bright for a steady pace towards less expensive more reliable, and higher performance spacecraft.

NASA FBC TASK

Industry Perspective for FBC *continued…*

- "Only do what industry can't do":
  - ✓ Drive this awareness down throughout the institution.
  - ✓ NASA should exit the infrastructure business as soon as practical
- Establish firm objectives for all programs in terms of how FBC practices are to be applied
- Subject NASA to the review process:
  - ✓ More external independent assessments to ensure scope and balance of NASA's programs
  - ✓ Renew and strengthen internal program review practices
    - Improve quality of "Independent Cost Reviews"
- Expand adequacy and stability of technology program budgets.
    - Re-prioritize funds as necessary
  - ✓ Close the gap between flight projects and technology projects
  - ✓ Help industry mitigate risks

NASA FBC TASK

Industry Perspective for FBC *continued...*

- Review agency policies regarding data buys:
  - ✓ Unless exceptional conditions can be proven, *ALL* Earth remote sensing programs should be structured as data buys
  - ✓ Explore the concept of commercial planetary remote sensing missions
  - ✓ Examine potential opportunities within existing series (Discovery, SMEX…) for data buys
- Maintain a commitment to science and technology programs aimed at American universities:
  - ✓ Steady pace of small experiments with assured launch
  - ✓ Restore university involvement
  - ✓ Step-up funding of grants aimed at advanced technology
- Be a serious enabler of low-cost and reliable access to space.
- Fight for initiatives that allow the NASA to retain a staff of smart-buyers.

NASA FBC TASK

Industry Perspective for FBC *continued...*

- NASA emphasis is on Faster and Cheaper, Better is arguable:
  - ✓ NASA should focus on Better, recognizing that faster developments and lower life-cycle costs will invariably result
  - ✓ …and we can measure better!
  - ✓ Remember: price and value are not the same
- Current RFP practices promotes risky competition, not mission success:
  - ✓ Contrary to the spirit of FBC
  - ✓ Ensure that procurements establish clear and complete evaluation criteria and scope:
    - a fair and common basis on how contractor will be judged
    - all factors that ensure mission success, including reviews, testing, etc.
  - ✓ Improve communications between NASA and industry on RFPs:
    - additional bidders conferences to ensure that requirements and scope are clearly understood
  - ✓ Only way of getting realistic, comparable costs.

NASA FBC TASK

Industry Perspective for FBC *continued...*

- Reform approach to risky procurements:
  - ✓ Recognize that fixed price contracts on one-of-a-kind s/c costs more
  - ✓ GFE technology elements on fixed-price contracts
  - ✓ Cost-plus on first item or one-of-a-kind spacecraft
- Exploit opportunities for spacecraft series (Explorer, surveyor, etc.):
  - ✓ This will assist with team continuity.
  - ✓ And permit common buys.
- Fund more pre-Phase A /Phase A initiatives
- Publish a more detailed 5-year plan with budget-follow the Air Force's Program Objective Memorandum (POM) model.
- Stop wasting resources through program false starts:
  - ✓ NASA overuses the RFI process
  - ✓ Industry views this as theft of intellectual property
  - ✓ RFPs only w/budget – 95% probability of release.
  - ✓ Let contractor set CDRL, review, and test requirements

NASA FBC TASK

Industry Perspective for FBC *continued...*

- Be realistic right-up front:
  - ✓ Quantify requirements up-front and tell the contractor quantitatively what NASA is willing to accept in the way of risk
  - ✓ Establish risk reserves at the program level (e.g., Discovery program level)
  - ✓ Strengthen test & integration budgets
  - ✓ If industry is being asked to carry some of the risk, provide a potential for higher profit
- Support and be flexible with private sector parts selection:
  - ✓ Retain NASA excellence in the monitoring and availability of EEE parts, materials, and processes
- Perform an Improved “lessons learned” practice:
  - ✓ Make sure that contractors can fully access existing NASA systems
  - ✓ Generate and maintain a living database
  - ✓ Prepare mission case studies to help educate engineering students

NASA FBC TASK

Industry Perspective for FBC *continued...*

- NASA maintains unrealistic expectations:
  - ✓ NASA wants “Class A” performance with “Class C” cost
  - ✓ The strategy “take risk – don’t fail” doesn’t work!
- Current design and implementation reviews are inadequate and must be made more effective:
  - ✓ Structure reviews to aid projects and not protect NASA
  - ✓ Reduce oversight costs and trade for more reserves to support technical reviews
  - ✓ Add $ for adequate external peer reviews
  - ✓ Ensure that RFP evaluation criteria promote adequate reviews
  - ✓ Make senior NASA technical staff available to support design/ops review process
- People are the Key to the success of the space program
- Ensure that FBC is not built upon a false economy:
  - ✓ Burnout is a serious threat on many teams; it’s a theme echoed throughout industry, academia, and government
  - ✓ Continuous workloads are well in excess of what’s reasonable
  - ✓ Essentially violates FBC rules because it costs more in the long-run:
    - Promotes an error-prone environment
    - Heroic efforts cannot be repeated
    - Loss of more competent people that depart for other industries
    - Increases risk through loss of continuity.
  - ✓ NASA should partner with industry to sponsor joint government/industry program management training

NASA FBC TASK

In closing, the following provides Major Obstacles, Top 10 Challenges, Recommendations, Final Observations

Major Obstacles to FBC

- Attempting to do too much, too soon. Some cuts are too deep
- Open Core Competency Issues
- Shifting out of basic research
- Lack of an Integrated Technology Plan, including IT
- Depletion of Talent
- Facing into necessary culture changes- achieving interdependency and trust at multiple levels

NASA FBC TASK

TOP 10 NASA CHALLENGES

- This Top 10 NASA Challenges chart is meant to maintain perspective. This type of chart needs to be updated, understood, and maintained collectively by all involved with NASA. Each challenge should be address in a NASA Action Plan.
  - ✓ Clearly the Space Station must be perceived as top priority within NASA
  - ✓ With so much payoff at stake, why isn't reduction of Launch Vehicle Cost a larger National Priority?

NASA FBC TASK

TOP 10 NASA CHALLENGES

- Complete Space Station safely
- Reduce mission failure rate
- Acquire, maintain, motivate good people
- Regain launch vehicle leadership – reduce cost by 1/10 or more
- Reshape NASA Enterprises/Centers for 21st century – Core Competency – Centers of Excellence
- Transition from from largely an Operations agency to a Research and Development Agency
- Make advanced technology development a higher priority, implement a more effective Integrated Technology Plan
- Align Enterprises and Centers to implement an Integrated Information Technology Thrust-combining IS, ISE, COSMOS other IT related activities into one Program
- Affect better industry and academia partnership
- Outreach to public more effectively, engage them, involve them, get them to understand both the risk and the major payoff potential for NASA

NASA FBC TASK

Recommendations

- Place higher priority on people acquisition, motivation, training
  - ✓ Develop incentives for attracting good people and well-respected Leaders to come to work for NASA
  - ✓ Expand the role and clout of NASA 's Academy of Program and Project Leadership Academy
  - ✓ Certify Project Managers, and Teams as to experience and expertise **Badge of Courage #1**
  - ✓ Continue symposiums on lessons learned, re-engineering, information technology cultural change, Teaming, etc. bringing in experts from within/outside NASA
  - ✓ Acquire outside help on cultural change and organizational issues
- Assign responsibility to NASA Academy of Program and Project Leadership Academy for:
  - ✓ Consolidating the findings of this report with the Mars Program and MCO Investigation Reports deriving composite FBC Project Lessons Learned, FBC Rules of Engagement and Project Implementation check lists
  - ✓ Generating training material for FBC Training workshops for FBC Project Team Leaders and Teams which is first subjected to a "dry run" in front of experienced FBC Project managers from each Center, Industry and Academia
  - ✓ Conducting these FBC Training Workshops throughout NASA Industry, Academia

3. Take aggressive steps to effect better teaming among NASA Centers, Industry, Academia
   - ✓ Start with strengthening NASA HQ Management, Teaming among Enterprises, establishing better NASA HQ relationships with Centers
   - ✓ Form a NASA Center Office at HQ to bring NASA into the 21st Century - **Assign a NASA Center Champion**
   - ✓ Resolve Center Core Competency and Center of Excellence Role Issues and Operations
   - ✓ Place higher priority on funding University research and advanced development and their Space Flight Missions

4. Place higher priority on Advanced Technology Development - **Assign a Technology Champion**
   - ✓ Form a Code T Technology Office led by a results-oriented CTO – must have as much stature/clout as Missions
   - ✓ Balance Research and Advanced Technology Development with focused Technology Development
   - ✓ Balance Competition of Technology Development with placing stable Technology Development at NASA Centers of Excellence.

NASA FBC TASK

Recommendations – *Continued*

5. Move out more aggressively on Information Technology Development – the most important HQ and Center-to-Center Teaming Arrangement

Assign an Info Champion

- ✓ Form an Information Technology program integrating ISE, IT, IS COSMOS Program into one
- ✓ Place Program Leadership at HQ

✓ Strike better balance between FBC Challenge and Risk

- ✓ Initiate Program Reality checks
- ✓ Implement FBC Rules of Engagement and the associated Performance Metric **Badge of Courage #2**
- ✓ Ensure Project Teams "own" their Project Plans built from the "ground up"
- ✓ Develop Programmatic and Mission Risk Signatures for each Project **Badge of Courage #3**
- ✓ Expand Safety and Mission Assurance responsibilities at NASA HQ and at the Centers for verifying:
  - Team Certification
  - Risk Signature
  - FBC Performance Metric
  - Project Readiness for Start, Launch Flight OPS
  - Compliance to FBC Lessons Learned
- ✓ Give immediate relief to understaffed Mars OPS and Launch Services/OPS

7. Strike a better balance between Empowerment and Checks/Balances

- ✓ Consolidate all Independent Review Objectives into one Independent Review per year for all Programs and Projects
- ✓ Continually evaluate the effectiveness of NASA policies, rules, procedures, etc. – like being accomplished for NASA 7120.5

Bring in outsiders to review NASA"s approaches

- Assign the HQ Safety and Mission Assurance Office the responsibility for an Industry/Academia Workshop to effect better NASA Teaming arrangement – including Contracting and Incentives
- Assign JPL the responsibility of forming and conducting a NASA-Wide Methods Working Group to share and evolve re-engineering products

NASA FBC TASK

Final Observations

- FBC is here to stay. It's a National imperative. Let's get with it to make it work
  - ✓ NASA and FBC equate to the same thing
- Lots of work remains in transitioning to the new NASA, especially in bringing in more Leaders
- This will take extraordinary teaming among NASA HQ, Centers, Industry, Academia
- Communications and teaming are at the core of every matter
  - ✓ Breakdowns in communication and teaming are behind most failures
  - ✓ Good communication and teaming are 99% the reason for successes
- Mission failure rate is too high – must be reduced
  - ✓ Mainly a result of mis-management and mis-engineering, not a result of new technology
  - ✓ Trying to do too much for too less
  - ✓ With great visions and roadmaps, we now need to focus more on the somewhat mundane implementation details

- For 1st GEN of FBC Robotic Deep Space Missions, scope fit reasonably well within the cost cap. For 2nd GEN of missions cost caps were made much more severe for many of these Missions
- In addition for many of the 2nd GEN of missions, there is more technical challenge. Consider, for example: DS-1, 2, 3, 4; Mars Sample Return, Europa, SIM, X-series launch vehicles, Next GEN Telescopes
- Need a balance between Leadership at NASA HQ and with the Centers
  - ✓ Leadership at NASA HQ must be stronger, in particular, for solving the Core Competency Problem, Center Teaming, and forming an effective Advanced Technology Development Program
    - NASA leadership at HQ must be done in a new way, with a new spirit, with a results-oriented, can-do, outgoing highly communicative approach. Not standoffish, aloof, adversarial, bureaucratic, but a more sensitive to," in tune with" center needs, supportive of center core competency responsibilities, bridging the relationship gap that exists and affecting closer teaming arrangements
  - ✓ Strike a better balance between Program management at HQ and Centers
- **Key Leaders need to be assigned ASAP to solve NASA's long standing problems**

Is there an Earth-Like Planet in Here?

AJS
March 2000
25b