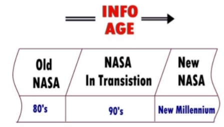


NASA FBC TASK FINAL REPORT

Preface

In the early 1990s, NASA adopted the Faster, Better, Cheaper (FBC) approach to project management of its Space and Earth Science Missions. The goal was to shorten development times, reduce cost, and increase the scientific return by flying more missions in less time. One of the first Faster, Better, Cheaper missions was Mars Pathfinder, which touched down on Mars on July 4, 1997, and became a resounding success. The Project Manager for Mars Pathfinder was Tony Spear, who recently retired after a long and successful career at the Jet Propulsion Laboratory. In mid-1999, Administrator Daniel S. Goldin met with Tony and asked him to undertake a personal study of the Agency s implementation of FBC. He was formally tasked in July 1999 to assess best practices through a series of interviews and workshops. These coupled with his personal experiences and expertise have led to the following observations.

Introduction

This report summarizes the results of the NASA FBC TASK conducted from July 1999 through February 2000. NASA Headquarters, ten NASA Centers, industry, and academia participated in interviews and lively discussions during visits and three workshops, one held in Maryland and two in California. Industry and academia participated in one workshop held in California.

Task Objectives:

1. Define FBC and develop "rules of engagement"
2. Identify major challenges for FBC
3. Identify what is most important for the future of FBC
4. Propagate FBC throughout NASA identifying more effective Center-to-Center teaming arrangements
5. Provide recommendations in response to 1. through 4. above
6. Identify good examples of FBC
7. Provide metrics for measuring FBC

Background

In 1992, NASA Administrator Dan Goldin challenged all of NASA, including its industry and academia partners, to do Projects in a Faster, Better, Cheaper (FBC) mode crystallizing what already was taking root in NASA s SMEX and Discovery Program thrusts, with BMDO s Clementine Mission, etc.

Moving into the last decade of the 20th Century, it was already clear that for NASA to remain viable and credible, it must become more business-like, treat cost and schedule as important as Mission performance, and deliver on time for the advertised cost.

Dan Goldin quickly followed with these important directives to facilitate FBC:

- Focus on smaller Missions; stop putting all of our "eggs in one basket"
- Incorporate advanced technology into Missions
- Reduce NASA HQ Management, moving more Program responsibility to the Centers

- Construct exciting VISIONS and ROADMAPS in aggressive planning for future Missions
- And, Dan Goldin said: "It's OK to fail!" (This was not well understood, but is clarified in this report.)

All of this triggered a major transition from an "old" to a "new" NASA, which is continuing to this day as we move into the 21st Century.

So how well are we doing?

Well, as with any major upheaval, NASA is being turned over in every sector like fields in spring to bring new growth. As with any major human endeavor, there have been successes and failures in the stress and strain of venturing onto new ground, trying new things, taking risk to gain significant return.

However, of all the hundreds of people interviewed, outside and inside NASA, no one said we should turn back. All realized that NASA must continue to improve its performance if NASA is to stay a world leader.

All Government Agencies, industry, and academia are at it, too, realizing they need to improve, if this Nation is to compete in the Information Age, in the new World Economy.

We must stay the course, benefit and grow from our lessons learned, and move on to the next level for FBC.

Just what is FBC? Its Definition

Of all our sessions, the ones defining FBC were the most animated. Everyone had his or her pet definition, and it was difficult to get consensus.

Examples of favorite debates: Should the Better go before Faster and Cheaper? Or is the other way around? Another argument was that you could pick two, but you can t have all three and on and on.

However, the FBC Team concluded it is not true that only two of three in FBC can be obtained. A good example is Lunar Prospector. It was certainly "Faster" and "Cheaper," and its "Better" was the ingenious simplicity of its spacecraft system design to make such important measurements. "Better" for future FBC Missions will be achieved from advanced technology and methods. We haven t scratched the surface yet.

However, most agreed that FBC boils down to two basic things:

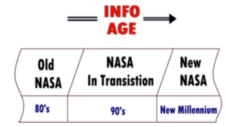
1. FBC is simply attempting to improve performance by being more efficient and innovative, and it applies to everything and everyone.

and

2. There s an intangible element there is a team spirit associated with doing FBC, and people are the most important ingredient.

You can imagine the argument between the strict technicians and the humanists in our debates as to whether item 2 above was an essential part of the definition, but over and over, every successful FBC Team told us that people are most important and close team work was essential.

The FBC Teams became a family with extensive communications among the members. They fussed and fumed like a family, but reached out to help each member, as well, while still doing their own job. They



became totally excited about their work and remarked they were having fun! And this extended outside of the home base team to the industry, university and other NASA Center partners. This "team spirit" became infectious. Some FBC Teams, however, reported that the fun had gone away after having their resources cut too deeply. Physical co-location is best, but virtual co-location via the Internet is working well.

FBC is <u>not</u> trying to fit a challenging Mission scope within arbitrary schedule and cost caps. For the first generation of FBC Projects, mission scope fit fairly well within the caps that is, for Clementine, Near Asteroid Rendezvous, Mars Pathfinder, Mars Global Surveyor, Lunar Prospector and Stardust, for example.

However, in our zeal to do FBC, and in learning to do Programs at the NASA Centers, the challenge bar was raised too high for some of the second-generation Missions. The cost cap challenges were made too great, along with a mix of unstable funding and escalating requirements.

We need to slow down some, not rush too quickly into important Programs and Projects, plan and implement them more carefully, and move away from fixations on cost and near term gain.

To assist the learning process of doing Programs at the NASA Centers, better reality checks of the feasibility of implementing the Mission set under the Program funding profile are needed.

An FBC Project in a pre-project phase must be permitted to develop correct cost and schedule caps for the Mission scope by working estimates from the "bottom up" with all members of the Project Team participating, who then own their Project Plan.

<u>Or, if it’s necessary to set cost and schedule caps at the outset, then:</u>

An FBC Project Team must be given the flexibility to define the Mission Scope that fits properly within the given caps this was the case with Mars Pathfinder when NASA HQ gave the project flexibility to adjust Mission scope to fit.

In one of our workshops, the definition of FBC was "nailed" by two separate presentations from an unlikely pair:

- In a presentation made by Col. Pete Rustan, Clementine Project Manager, he strongly made the point that a challenging Mission scope can t be stuffed into arbitrary caps, that careful FBC pre-project planning and costing are as important as ever before.

- After an exciting presentation on how to look for life on other planets, and giving his support to FBC, Ken Neilson, a Caltech Life Scientist, pointed out that an FBC Mission could take as long as 25 years citing this example: a carefully planned Planetary Life Detection Program, led by the proper group of scientists, could take as long as 25 years to complete its sequence of Missions, all in an FBC mode.

So FBC is not resting on your laurels, not just accepting past ways without good reason. It’s questioning the reason for every practice, it s continuously looking for improvement, it’s stepping out with new methods, new technology, and taking risk prudent risk. FBC is <u>not</u> taking undue risk by taking shortcuts under pressure around important tests and qualification.

At the same time, it means discipline, doing careful upfront planning, design and implementation, keeping past lessons learned out in front at all moments, and being checked, balanced and mentored by those scarred by experienced it’s maintaining a delicate balance between old and new. It means being humble, respecting how hard this business is, not automatically discounting others and their methods, and never thinking you know it all.

As evident in the FBC Rules of Engagement at Attachment A, there isn t anything magic about doing FBC. It s back to basics, lots of hard work, follow through on the details, working openly and candidly, and total dedication by the Team, as with winning the Super Bowl or starting up an Internet company.

And notice that the FBC Rules of Engagement include the need for important checks and balances such as are provided by Independent and Peer Reviews.

And it’s important to get this straight:

The Project Manager is "Captain of the Ship." The buck stops with him or her. The Project Manager and Team are responsible for ensuring that all elements of a Project are being implemented with acceptable Risk for those Project elements under their control and also for those outside their immediate Project control possibly the launch vehicle, a major instrument, etc.

While Project risk at the outset may be high, it must be sufficiently assessed and mitigated throughout development and operations. Not having enough funding or schedule resources are never excuses for failure, and it takes a Project Manager with good judgment and courage to declare under pressure that the Project is not doable for the available resources. This ability to judge, to walk the fine line between challenge and risk, is even more important in today s environment for FBC Projects.

FBC equates to all of NASA, to all sizes and categories of Missions, robotic and human, large and small and to the institutional support of Missions from re-engineering to human relations, from individuals to teams. NASA will continue to have a mix of large and small Missions, each employing FBC methods. An important Rule of Engagement for the institutional support to FBC Projects is ensuring a people-oriented environment that facilitates candid and thorough communications by the FBC Project Team to create an environment that encourages the Project Manager to speak up, to ask for help when needed.

An open, candid environment is important at NASA Headquarters, at the NASA Centers, and with the industrial and academic partners, where forums for healthy debate need to be established. As a rule, in this day and age, most NASA studies should be done openly by the Study Team placing its objectives and status on the Internet to give a wider audience the opportunity to participate electronically, to chip in with their ideas, recommendations and critique.

Have all Projects wear "Three Badges of Courage":

1. Certification of the Project Manager and Team as to experience and expertise
2. Programmatic and Mission Risk Signatures the Project Risk "fingerprints"
3. Rules of Engagement Performance Metric a periodic tally as to how well the Project is implementing and operating according to the FBC Rules of Engagement

Examples of items 2 and 3 are attached to this paper as Attachments B and C. These "Project Badges of Courage" are powerful graphic measures of Project Performance, but must be implemented by the institution constructively to help, not hinder, the projects. This process, as with all NASA Policies and Procedures, needs to be frequently checked as to effectiveness and evolved to make it even more relevant as being accomplished with NASA 7120.5A, as an example.

MAJOR CHALLENGES FOR FBC

1. The current Mission failure rate is too high and must be reduced. This is not due to the introduction, say, of exotic technology or due to a difficult, unknown space environment. Most failures over the last decade can be attributed to poor communication and mistakes in engineering and management. This was not what was meant when Dan Goldin said, "It's OK to fail."

   Failing due to mistakes is not tolerable. Dan Goldin s "It's OK to fail" statement was made to encourage Project Managers to step up bravely to difficult, risky, but potentially highly rewarding Missions. Failures here can be honorable, even if still traumatic to the Project Team.

2. In the current NASA transition, we have moved from few to many Missions requiring many more Project Managers, Project Teams and institutional support including Review Teams. Also, management attention has become diluted across these many Missions. As before with few missions, Project Managers worked through the ranks for many years to gain significant experience before they became Project Managers. Now with many missions this is not always possible, making training, mentoring, and peer review even more important.

3. At the same time there is a talent drain due to retirement, downsizing, and loss of people to Industry.

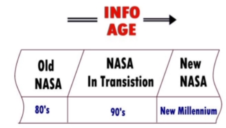
4. We must remake the NASA institution to match business in the 21st Century Information Age. Importantly, each NASA Center must focus on a few core competencies for which they are world-class, and rely on other NASA Centers, other government agencies, industry, and academia for other capabilities to paint the full picture. In addition, a long-term stable funding environment must be established to foster these world class centers. This is critical.

   In a management interview, PRICE, WATERHOUSE and COOPERS, a worldwide management consultant firm, forecasts that sets of global companies networked together, each company with its particular specialty, will compete with other sets of networked companies. This too will be the future structure for NASA HQ and the Centers.

   NASA Mission Centers must retain the expertise to do in-house Projects. This "corporate history," represents a sustaining expertise that is the foundation for space exploration; it is an important national asset.

5. NASA must guard against any effort to shift from basic research to development solely in support of the near term Missions. While the near term development is very important, a better balance must be struck to ensure that some "seed corn" is left over for research and advanced development to trigger revolutionary approaches to space exploration. A better NASA Integrated Technology Plan is needed.

   NASA and other government development agencies must be on the lookout for potentially high payoff technology breakthroughs whose accelerated development by the nation in "mini-Manhattan-like projects," but run openly with peer review, could give this nation a decided competitive advantage. Some candidates: carbon nanotubes and quantum dots. Yearly "out of the box" technology workshops should be conducted nationwide giving awards for the best ideas.



6. Existing or soon-to-mature Information Technology (IT) can be used to develop important advanced, computerized, design visualization aids for the front end of project development. The designers walk around their "virtual spacecraft" as they design it.

   This same technology can then be used, also, at the other end of the project, to develop Visualization Domes which, through tele-presence, immerse the Flight Operations Team, the press, the public on the distant planet, say, on the surface of Mars at the lander and rover site the ultimate armchair adventure!

   Sadly, there exist no plans to produce these productive and exciting products any time soon. These are needed now and require the requested funding to bring them into being as quickly as possible. There are good but fragmented pockets of exciting IT developments in NASA, but presently the IT work is localized. It s not integrated into an effective, NASA-wide Development Plan with a schedule committing to a set of incremental demonstrations leading to delivery of a major Mission IT architecture. Current IT related activities like Intelligent Systems, Intelligent Synthesis Environment, Consolidated Super Computing Management Office, etc., need to be folded into this integrated plan.

7. All work in NASA can be treated like Projects with a task objective, a plan, a cost estimate, risk management and importantly, a schedule of delivery commitments. This goes for research and advanced development activities as well. There is a reluctance in this community to projectize, but more structure in these can make them much more productive in an FBC mode. That is not to say breakthroughs or inventions can be scheduled. However, a research schedule can be produced which targets periodic peer review assessing relevance and possible need for new direction.

   Early involvement of the project team with the technology team in technology development, with lots of good communication, is necessary to facilitate acceptance and ownership by projects to fly new technology. A good example of this process is being accomplished at JPL in their TEAM X pre- project planning function. It’s now called TEAM XT.

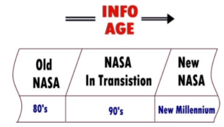
8. **WE MUST DRIVE DOWN THE COST OF LAUNCH! THIS MUST BE A MAJOR NATIONAL PRIORITY**
   see below

WHAT IS MOST IMPORTANT FOR THE FUTURE OF FBC

Future FBC = PTM   People Technology Methods

1. **Acquiring, motivating and keeping good people**. Generating interest in NASA must start early in the schools. While there is good work here, it needs higher priority. There is nothing better than involving students in real live Missions, with some managed by students, with strong, encouraging assistance and mentoring by NASA expertise to give them a good chance to succeed. Let them navigate rovers on the Moon and Mars.

2. **Infusion of Advanced Technology.** Soon Projects, who now develop their own up-links and down-links, will be provided proven, advanced, low cost multi-mission data systems with "bug free" software this will be like not needing to build your own phone every time you call home.



Advanced micro-electronics will bring the cost of small but powerful spacecraft, matched to an automated, internet driven ground data system, down to a few million dollars so that universities, the world s developing countries and companies can explore space on their own.

Electrons and photons cannot tell if they are participating in a reconnaissance mission or making noble scientific measurements at Mars. All spacecraft share most of the same equipment functionality. A common multi-agency, Internet Store for high quality, modular, advanced components, supplied by multiple vending sources, must be a top national priority. This store would be fed by multi-agency advanced developments.

And as already understood by many, an accompanying reduction in launch cost is essential and must be a top national priority to drive FBC to a higher level, as well as keep this Nation the Space Leader this is the single most important factor standing in the way of a "big bang inflationary-like" expansion of the nation and the world into space.

This is what NASA in the FBC mode must be about paving the way for others to do space explorations cheaply, reliably, safely by effectively accomplishing high risk, but high payoff, enabling advanced developments.

3. **Infusion of Advanced Methods.** This deals with expanding the multi-mission infrastructure in support of FBC Project Teams.

   Core FBC Teams, becoming smaller in size, will be supported by:

   - Multi-mission pools of technical and management expertise for consulting and peer review
   - Best computer aided tools, processes, templates, model based design and management standards, training
   - Lessons learned data bases
   - Risk evaluation tools

   as well as

   - The advanced, multi-mission technology mentioned above

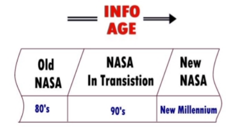
PROPAGATE FBC THROUGHOUT NASA IDENTIFYING MORE EFFECTIVE CENTER-TO- CENTER TEAMING ARRANGEMENTS

It s propagated! The message is there loud and clear at NASA Headquarters, every NASA Center and throughout industry and academia. The challenge lies with institutionalizing it.

It’s one thing to do an FBC Project experiment, it s another thing to instill this cultural change throughout the complete organization.

But every organizational element is facing into this challenge. There are many good people within NASA and its support partners. There is still a lot of the right stuff.

Dan Goldin is right on with his FBC thrust. He has set the stage, created the environment. Now all we need to do is follow through on implementation of the exciting Roadmaps and Visions that have been generated.



The key word now is "implementation." This requires careful planning and lots of work in the trenches. _No Mission before its time._ This requires unprecedented teaming and open, candid communications. No one person has the answer. It takes a lot of debate and evolution of ideas to get there. It takes courage to admit a wrong path and the need to move in another direction.

And if we do, NASA will be even more important in the 21st Century, looking for life out there, building the bridge for humans to cross over to space.

But there are many challenges, and a lot of hard work to do, and a lot of teaming to do.

Here are three examples of cultural change that need more work to take FBC to the next level:

1. _How to motivate individuals to team?_ Getting them to align their direction, their ego vectors, in the same direction of the Project, if only for a short while, the duration of the Project.

2. _How to motivate hard-crusted Project Managers to accept a larger role outside their immediate project responsibility?_ Getting them to cooperate with the institution re-engineering support and technology development activities. Getting them to infuse new technology into their Project. Getting them not only to accept, but own larger institutional and Program requirements.

3. _How to motivate NASA Headquarters and Centers to team better?_ Dan Goldin s great desire is for the Enterprises and Centers to take the initiative on self-management as for example if a team of Centers come in with, say, an Integrated NASA IT Implementation Plan showing a schedule of deliveries, who's in charge, and who does what. If this would happen, then one of Dan s major objectives for the "new" NASA would be fulfilled.

ON CENTER TEAMING

Currently, Center teaming exists in established roles where historically there s a clear advantage for each Center. But there are new Center Teaming initiatives being implemented effectively. Where things are working, don t fix them.

But in general, Centers are stand-alone and protective because of the downsizing they have had to face, periodic threat of closure and the need to compete for scare resources.

The solution to better Headquarters and Center teaming will come with Information Technology the wiring of NASA into one electronically networked NASA Center. With workers from the Centers and Headquarters, networked together and cooperating to accomplish a Project, each contributing with its specialty, then the lines of distinction for Headquarters and the Centers will become more and more blurred. They will begin to act more as a whole not as single entities. The "stovepipes," "fiefdoms," and "castles" will come tumbling down.

As with inside NASA, better outside partnerships with industry and academia need to be worked, including involving them in workshops and listening to their feedback.

Yearly performance evaluations must include how well all Enterprises and Centers are doing in affecting these teaming transitions.

<u>Here's what has to happen to bring this into reality. We need to:</u>

1. Solve the long-standing NASA Center core competency problem, establishing what each Center does and motivating all Centers to utilize other Center s competencies. Establish stable funding.
2. Motivate each Center to neck down to, focus on, and become world class in its smaller set of core competencies.
3. Promote mobilization of key personnel around NASA, both technical and management. Rotate them on assignments between the Center and Headquarters.
4. Develop a NASA Integrated Technology Development Plan which balances research and advanced development with Mission focused technology development.
5. Balance competition of Technology Development with stable Center funding for their world-class core competencies.
6. Develop a NASA Information Technology Plan encompassing the likes of Intelligent Systems, Intelligent Synthesis Environment, CoSMO and all related IT activities.
7. Interact more closely with Industry and Academia to establish more effective partnering arrangements. Listen to their feedback.
8. Balance the Leadership of Programs between NASA and Headquarters.

There is a need for more Leaders at NASA Headquarters, more of a balance of Program Management responsibility between NASA Headquarters and the Centers especially in resolving the Center core competency problem and developing more effective NASA Technology Plans.

Recommendations

1. **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 — see below

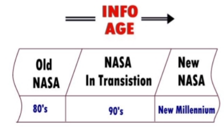
   - Certify Project Managers, and Teams as to experience and expertise — *<u>Badge of Courage #1</u>*

   - 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, core competency, and organizational issues

2. **Assign responsibility to NASA Chief Engineer for:**

   - Consolidating the findings of this report with the Mars Program and Mars Climate Orbiter Investigation Reports, deriving composite FBC Project Lessons Learned, FBC Rules of Engagement and Project Implementation check lists



3. **Assign responsibility to NASA Academy of Program and Project Leadership for:**

    - 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

4. **Take aggressive steps to effect better teaming among NASA Centers, Industry, and academia.**

    - Start with strengthening NASA HQ Management, providing the "champions" as designated below
    - Implement more effective NASA HQ relationships with the Centers
    - Form a NASA Center Teaming 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 and supporting University research and advanced development and their space flight Missions
    - 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 conducting a NASA-Wide Methods Working Group to share and to further evolve re-engineering products. Use the NASA FBC Task Center Representatives already established

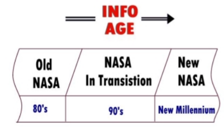
5. Place higher priority on Advanced Technology Development —*Assign a HQ Technology Champion*

    - Form a Technology Office led by a results-oriented Chief Technology Officer — must have as much stature/clout as Enterprises
    - 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

6. Move out more aggressively on Information Technology development — the most important NASA HQ and Center-to-Center teaming arrangement -- *Assign a HQ Info Champion*

    - Form an Information Technology Program encompassing Intelligent Synthesis Environment, Information Technology, Intelligent Systems, Consolidated Super Computing Management Office into one integrated plan.

7. Strike better balance between FBC Challenge and Risk



- Initiate Program reality checks
- Implement FBC Rules of Engagement and the associated performance metric
- Ensure Project teams own their Project Plans <u>built from the "ground up"</u>
- Develop "Badges of Courage" for each Project
- Expand Safety and Mission Assurance responsibilities at NASA HQ and at the Centers for verifying:
  - Team Certification
  - Risk Signatures
  - FBC Performance Metrics
  - Project Readiness for Start, Launch, Flight Operations
  - Compliance to FBC Lessons Learned
- Give immediate relief to understaffed Mars Operations, Launch and Payload Services
- 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 7120.5A

<u>Bring industry, academia and outside consultants in to review NASA’s approaches.</u>

<u>Some Good Examples of FBC</u>

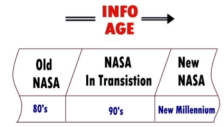
A short set, not the complete set of good examples of FBC, is given in Attachment D. This set illustrates the diversity of FBC activities throughout NASA. Hats off to <u>all</u> the FBC individuals and teams, who are taking FBC to the next level. The complete list starts with the young people and extends to Center Directors to Associate Administrators to the NASA Administrator.

<u>Metrics for Measuring FBC</u>

How to measure the value of FBC is a much-debated subject, too, and there have been a number of attempts at constructing this metric.

Here s another list of measures:

- Mission Success Rate greater than 8/10
- The degree to which both launch and spacecraft costs are reduced
- Number of Peer-Reviewed Scientific papers published, resulting from NASA Missions
- The degree to which an effective, NASA-wide Technology Development is achieved, including IT
- The extent to which NASA HQ and the NASA Centers are teamed together as one NASA Center and teamed effectively with Industry and Academia
- The degree to which the public is excited with and involved in Space Missions.



Rules of Engagement for FBC Projects **Attachment A**

- Form and motivate an excellent team, a mix of experience and bright energetic youth bringing enthusiasm and new methods
    - Go to the best sources of expertise in NASA, industry, academia — ***<u>Certify each Team - BADGE OF COURAGE #1</u>***
    - Co-locate physically and/or electronically, do concurrent engineering
    - Team with Mission Assurance to develop the Project Mission Assurance Plan
- 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 each 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

    <u>Establish/Maintain a Mission Risk Signature - BADGE OF COURAGE #2</u>

- Balance use of available and advanced technology to maximize Mission Success *(Note 1)*
- Establish/maintain metrics for Mission risk and technical/cost/schedule performance

    <u>Establish/Maintain Rules of Engagement Check List - BADGE OF COURAGE #3</u>

Rules of Engagement for FBC Project *Attachment A continued*

- TEST, TEST, TEST and TEST as you FLY *(Note 2)*
- Then TRAIN, TRAIN, TRAIN *(Note 3*). Flight Operation Teams must contain key members of the Development Team
- Best Project Development to Flight Operations arrangement: Designers become testers become operators

- Work openly and candidly inside the Team with thorough communication. Communicate openly and candidly externally to the Project

<u>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.</u>

Note 1: It may be that demonstrations of advanced technology are included in Mission requirements

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

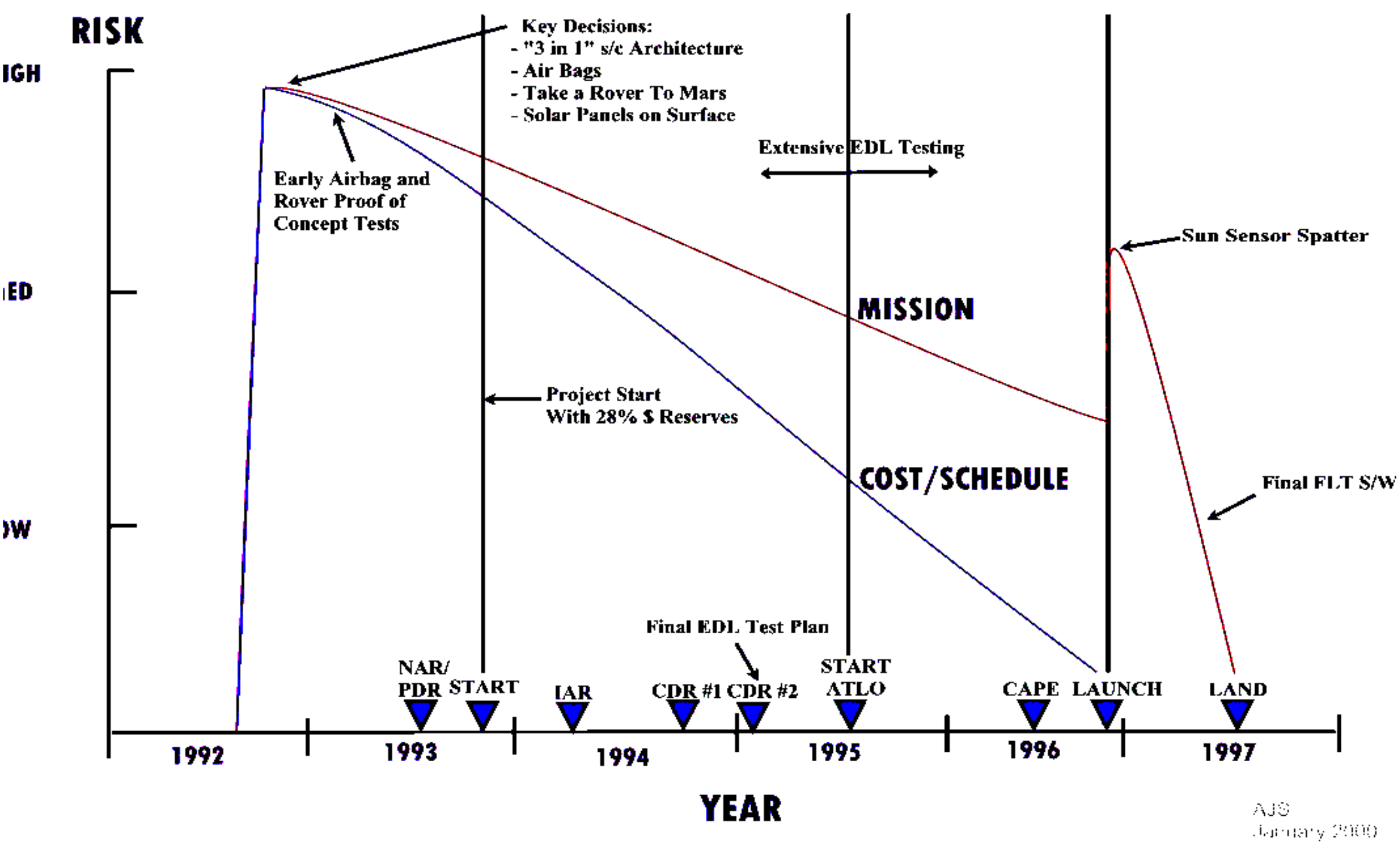
Note 3: Initiate Flight Operations Training, both standard and contingency sequences, in the test bed and with the Flight System in ALTO before launch.

ATLO = Assembly, test, launch operations

Attachment B

Example

MARS PATHFINDER RISK SIGNATURE
SCHEDULE/COST AND MISSION RISK



NASA FBC TASK FINAL REPORT

Rules of Engagement Performance Check List for Year

1. Stable Agreements		11. System/Sub-System Space Qual Plan and Implementation Status	
2. Certified, Capable Team		12. FLT-GND S/W Development Plan and Implementation Status	
3. Funding Availability		13. SUBS/SYS Test, SIM, PERF Demo Plan and Implementation Status	
4. Project Plan and Implementation Status		14. GDS/OPS DEV Plan and Implementation Status	
5. Adequate Reserves		15. Flight OPS Training Plan and Implementation Status	
6. Safety and Mission Assurance Plan and Implementation Status		16. Peer Review Plan and Implementation Status	
7. Risk Assessment and Mitigation Plan and Implementation Status		17. Problem Resolution Status	
8. Mission Engineering to Standards and Implementation Status		18. Documentation Status	
9. Flight-GND System Engineering to Standards and Implementation Status		19. Configuration Control Status	
10. Sub-System Engineering to Standards and Implementation Status			

= Acceptable   = Cautionary   = Major Problem

SOME GOOD EXAMPLES OF FBC ACTIVITIES

Example	Leader (s)	Center
Lunar Prospector	Allan Binder, Scott Hubbard, Sylvia Cox	Ames
Pathfinder/ Helios Solar Powered A/C	John DelFrate, John Sharkey	Dryden
High Speed Research Study	Ed Graber	Glenn
Small Explorer Program	Jim Watzin, Orlando Figueroa	Goddard
S/C Design & IMP Standards	Tom Gavin	JPL
TransHab	Donna Fender	Johnson
Expendable Launch Vehicles & Payloads	Bobby Bruckner	Kennedy
Discovery Program	Mark Saunder, Dave Gilman	Langley
Fastrac Engine	Danny Davis	Marshall
Academy for Program/Project Training	Ed Hoffman	NASA HQ
Near Earth Asteroid Rendezvous	Tom Coughlin, Bob Farquhar	Applied Physics Lab
NASA 7120.5A	Carolyn Griner, and Team	All Centers Support To HQ

S/C = Spacecraft
A/C = Aircraft
IMP = Implementation

NASA FBC TASK FINAL REPORT

Acronyms

SMEX = Small Explore Program
BMDO = Ballistic Missiles Defense Office
HQ = Headquarters
FBC = Faster, Better, Cheaper
IS = Intelligent Systems
ISE = Intelligent Synthesis Environment
CoSMO = Consolidated Super Computing Management Office
IT = Information Technology
HR = Human Relations

I wish to thank many, many good people in NASA, Industry and Academia who supported this Task.

All were responsive, open and candid, want to make things better and are excited about NASA s future.

In particular, I wish to thank the following people who spent much time and support in formulating and critiquing Task results:

§ Leon Alkalai	§ Glen Cunningham	§ Art Murphy	§ Dave Smith
§ Jeff Bauer	§ Charlayne Fliege	§ James Ortiz	§ Randy Taylor
§ Alan Binder	§ Ed Graber	§ John Peterson	§ Oscar Toledo
§ Mark Carley	§ Ed Hoffman	§ Steve Prusha	§ Pete Vrotsos
§ James Clawson	§ Rhoda Hornstein	§ Dave Quinn	§ Toan Vu
§ Dave Collins	§ Brian Keegan	§ Gregory Robertson	§ Steve Wall
§ John Costulis	§ Satish Khanna	§ Mike Sander	§ Gordon Wood
§ Silvia Cox	§ Jeff Leising	§ Liam Sarsfield	§ Sam Zingales
	§ Jim Moore	§ Joel Sercel	

I wish to thank Gail Cargill for her essential, timeless support in assembling draft after draft of reports throughout this Task.

Tony Spear
FBC Task Master