Thoughts on NASA Science Project Management

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Thread of Today's Talk

- How has NASA changed?
- How is the aerospace business changing?
- Understanding process and risk.
- Surviving between projects.
- Selling your organization.
- Developing a winning proposal.
- Successfully executing your project.

"From Giant Leaps to Baby Steps"

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Houston

TO read and listen to the coverage about the space shuttle, you would think NASA's mission team has taken careless risks with the lives of the seven astronauts who went into space on the Discovery last Tuesday. During the launching, foam fell off the external tank. For the risk-averse, the only acceptable thing to do now is retire the shuttle program immediately and wait for the divine arrival of the next generation of spacecraft. I am disgusted at the lack of courage and common sense this attitude shows.

All progress involves risk. Risk is essential to fuel the economic engine of our nation. And risk is essential to renew American's fundamental spirit of discovery so we remain competitive with the rest of the world.

My take on the current mission is very straightforward. The shuttle is in orbit. To a great extent mission managers have given the spacecraft a clean bill of health. Let us remember that this is a test flight. I consider it a remarkably successful test so far.

The technical response to the Columbia accident led to a significant reduction in the amount of debris striking this shuttle during launching. Mission managers have said that the external tank shed 80 percent less foam this time than on previous launchings. Only in the news media, apparently, is an 80 percent improvement considered a failure. Rather than quit, we must now try to reduce even more the amount of foam that comes off the tank.

The instruments and video equipment developed to assess the launching and monitor debris falling from the tank worked superbly. For the first time, the mission team knows what is happening, when it is happening and the flight conditions under which it occurred. This was a major mission objective, and it is an impressive achievement.

Having spent more than three decades working in the space program, I know that all of the flights of the early days involved some levels of risk. Some of those risks, in hindsight, seem incomprehensible by today's timid standards. If we had quit when we had our first difficulties in Project Mercury, we would have never put John Glenn on the Atlas rocket Friendship 7 in 1961. Two of the previous five Atlas rockets test-fired before Friendship 7 had exploded on liftoff….

Our Eroding Technical Base

- **A recent Space News article listed the 10 most influential people in space- *not a single working scientist or engineer was on the list.***
- **NASA has made measurable progress under Dr. Griffin but remains encumbered by the Space Shuttle, ISS and the manned aspect of the Moon-Mars initiative.**
- **The documented failures and criticisms of the manned program elements (in combination with other factors) have resulted in a trend toward risk-averse management and engineering philosophy spanning NASA's full range of programs including its scientific missions.**

Our Eroding Technical Base Cont.

- NASA’s approach toward risk has also been affected by its own true-cost initiatives as well as the inability of its contractor base to consistently deliver on its cost and schedule commitments.
- The cost/schedule problem is equally serious in the commercial and defense areas where the technical base is inadequate in both number and skill to fully support the many scientific and engineering challenges of the space program.
- Retaining and expanding the technical base at Universities is essential if NASA is to have the technical capabilities required to meets it future program commitments.

Process Mentality

- NASA's response to risk, both true and perceived, is a series of process initiatives in system engineering, review methodology, risk management and other areas with some positive results but many unintended consequences.
- System engineering improvements are measurable and mostly beneficial although uncontrolled "process rigor" can also stifle creative concepts or result in unnecessary complexity.
- "One size fits all" process approach has tended to overwhelm smaller programs traditionally executed by University teams.
- Process rigor is not a substitute for the quality of ideas and design that are the traditional hallmark of small expert University teams.

The Myth of Risk Management

- The space program has been successful because experienced engineers and managers accepted the calculus of reasonable risk and were not deterred by the prospect of failure.
- There is a mistaken assumption that project success can be optimally achieved through risk management operated as a debit function where key resources are allocated (and often wasted) with the goal of mitigation.
- Programs managed with risk-aversion as the driving consideration inevitably de-optimize a project by cutting cost, capability or other resources to create what ultimately proves to be artificial margin.

The Myth of Risk Management Cont.

- The “real world” project management challenge is to optimally manage risk without becoming risk-averse.
- For a science driven programs, superior ideas, careful engineering and passionate motivated people are worth far more than over-reliance on imposed risk management strategies.
- A preferred method of risk management, especially on smaller projects, is to “kick down the door” in a limited number of key risk areas by aggressively attacking technical problems while maintaining a clear set of backoffs tied to a timeline for execution.

Surviving Between Projects

- NASA's science program faces extremely tight budgets with the prospect of relatively few new science initiatives over the next decade.
- The survival of University groups will depend on their ability to weather dry times as well as their ability to win and then successfully execute increasingly complex science missions.
- Survival pressures can create a competitive advantage if University groups commit themselves to investing in people and technology with the objective of being "best of class" in one or more key discipline areas.
- Future projects are likely to be team efforts involving multiple groups where each have a unique capability rather than a complete range of capabilities.
- NASA must strongly fund research and technology initiatives that maintain healthy University groups capable of science, engineering and project implementation.

Selling Yourself

- The art of "selling" your organization with the objective of participation in future projects is a continuous process that should involve the key members of your team working with and for NASA.
- Familiarity with an organization and its key people is an important *hidden discriminator* within the proposal review and selection process.
- NASA can greatly benefit when your science and engineering experts participate in its planning and review processes.
- Your team also benefits from first-hand participation in NASA processes, especially through direct observation of how NASA and other organizations do business.

Developing Winning Proposals

- A proposal has both qualitative (the potential) and quantitative (the achievable) elements.
- Winning proposals result from the effective marriage of a project's qualitative and quantitative elements in combination with other key attributes.
  - A compelling theme that is repetitively woven through all proposal elements.
  - A key discriminator relative to competing proposals.
  - A clear system engineering thread that quantifies the science measurements and also converts them into an achievable set of lower lever requirements.
  - A carefully constructed and believable implementation plan that connects all organizations and activities.
  - A clear method of presentation that leads the reader/reviewer step-by-step through the proposal in a way that emphasizes the positive and clarifies the negative.
- Qualitative aspects are often the basis for project selection although the quantitative aspects usually determine whether a project will ultimately be successful in meeting its objectives.

Formulating Your Ideas

- **A winning proposal starts with a clear set science objectives, describes a realistic technical approach for meeting the objectives and ends with a believable implementation plan.**
- **Some suggestions on a winning strategy:**
  - **Nature of Science Objectives**
    - **Compelling Science and/or Enabling technology**
    - **Present a clear set of prioritized questions that the investigation will answer.**
    - **Promise discoveries.**
    - **Prove that the proposed mission is related to a critical question that is part of NASA's science program.**
  - **Approaches to Presenting Objectives**
    - **Concentrate on a highly focused set of prime objectives.**
    - **Emphasize discriminators that make the science unique and especially compelling.**
    - **Present competing theories between which the mission will differentiate.**
    - **List expected discoveries**
    - **Distinguish between primary and secondary objectives.**
    - **Avoid a shopping list of objectives or questions.**
    - **Back up what you say.**

Formulating Your Ideas Cont.

- **Your proposal must demonstrate that it recognizes and is executable within both programmatic and technical constraints.**
  - **Clear flow down of requirements from Level 1 through Level 3.**
  - **Adequate margins and reserves.**
  - **Clear explanation of management and development strategy.**
  - **Clear descope and backoff approaches that retain critical capabilities.**
  - **Detailed schedule that identifies hard points and critical decision points.**
  - **Ability to “test as you fly” and “fly as you test”.**
- **Teaming Relationships are a Critical Component of a Successful Proposal.**
  - **Provides clear programmatic and/or technical benefits.**
  - **Well defined organizational interfaces.**
  - **Clear lines of responsibility and lines of communication.**
  - **Detailed agreement between parties that documents receivables, deliverables (REC/DEL) and associated schedule.**

Presenting Your Ideas

- **Your proposal must tell a clear, complete and well-conceived story.**
  - Develop script and page outline with a story board to develop presentation.
  - Thoroughly Red Team proposal at middle and end stages of preparation.
- **Provide a quantitative basis for the technical approach.**
  - Determine the physical parameters characterizing the objective, question or theory.
  - Analyze which parameters must be measured with their intensities, spatial scale, temporal characteristics or other critical features necessary to make a definitive measurement.
  - For competing theories or approaches provide the specific parameters that will differentiate between them.
- **Clearly explain instrumentation required to implement technical approach.**
  - Demonstrate that the proposed instrumentation can make necessary measurements.
  - Provide credible basis for expected instrument performance.
  - Show simulations based on key measurement and performance parameters.

Closing the Deal

- **Costing should be realistic with backup data that is clearly related to a detailed WBS.**
  - A drawing tree to the assembly level is a good adjunct to the WBS for costing purposes since it helps to identify documents and number of manufacturing drawings.
  - Cost models will be going down to level 4; So should your cost estimate.
  - An independent cost model can assist in achieving cost reality. It will also establish a known baseline for the proposal review team's cost assessment.
- **An External Standing Review Board with known experts can reduce the perceived risk and also be a strong discriminator relative to other proposals.**
  - Perform internal management and technical reviews.
  - Operate as Red Team ahead of major project reviews.
  - Chair and/or participate in Peer Reviews.
  - Provide management and technical backstop for key areas.
- **Go all out on site visit to acquaint reviewers with the team, facilities and development approach.**
  - Have all key personnel and delivering organizations participate.
  - Address all questions, issues and risks with clear, concise and truthful answers.
  - Prepare demonstrations, models and backup materials in order to address perceived weaknesses and to project your team's capabilities.

Executing Your Project

- **Take the time to establish a clear *Philosophical* basis for *complete* activity.**
  - Design the Project.
  - Establish the Why, Who, What, and How.
- **Ensure that your *Management* activity is *Value-Added.***
  - *Coordination* and *Enabling* function oriented toward team's achievement of Project *Objectives*.
- **Emphasize *Individual* and *Team* responsibility at all levels of the Project organization.**
  - Establish a "contract" with team members to at all levels.
- **Develop a customer relationship based on *Communication, Honesty, Integrity* and *Trust***
- **Encourage and *Reward Excellence* in all Activities and at all Levels.**
  - Develop a strong System Engineering approach that connects all requirements from Mission Science objectives down to the Functional Engineering level.
  - Encourage *thinking* and *attention to detail*.

Executing Your Project Cont.

- **Provide incentives for technical success and timely closure.**
  - **The objective of every project activity must be to end (successfully!).**
- **Use your schedule as a tool.**
  - **Schedule aggressively but plan conservatively.**
  - ***Conserve slack* at every opportunity; A lost day is a lost opportunity.**
- **Manage critical risks through aggressive action and by maintaining realistic backoff and recovery options.**
- **Concentrate on Achieving *"First Time"* fit and function.**
  - **Iteration wastes time of many more people at the next level of assembly.**
- **Organize the design and its functional interfaces to be simple and to minimize test time at Integrated System Level.**
  - **Test early and at lowest practical level of assembly.**
  - **Validate subsystem performance to both design and requirements.**
  - **Maintain technical efforts *Parallel* and *Independent* as long as practical.**
- **Perform comprehensive End-to-End testing and validation at the Integrated System Level in a "Test As You Fly" configuration.**

Key Management Principles

1. **Establish a clear *Philosophical* as well as *Operational* basis for your Program.**
2. **Work with your Customer within a framework of *Communication, Honesty, Trust and Integrity.***
3. **Follow *Consistent* and *Coherent* management principles with the objective of *Enabling* success.**
4. **Apply *Common Sense* to all processes and activities.**
5. **Establish a *Strong Top-Down System Engineering* function tied to core scientific objectives with clear flowdown from Mission → Science → System → Subsystems → Components.**
6. **Develop *Quantitative Metrics* for technical performance at all levels of the requirements flowdown.**
7. **Work relentlessly to achieve *Simplification* within all systems and activities.**
8. **Be *Unsentimental* regarding non- “value-added" project elements.**
9. **Establish a realistic *risk identification and risk mitigation* strategy that is appropriately matched to your program.**

Key Management Principles Cont.

10. Establish and nurture a *Tight Seamless Technical Organization* that accepts both *Personal* and *Team Responsibility* for project and mission success.
11. Scale level of technical *Sophistication* to the team's *Capabilities.*
12. Apply your best people to most technically difficult problems.
13. Establish *Clear* hardware and management *Interfaces* between participating organizations.
14. Optimize subcontractor selection process through *Early Managed Competition.*
15. *Design, Build And Test* to both *Design and Requirements; Test, Test, Test* at every stage of development.
16. Perform Detailed *Independent* Technical and Management *Reviews* at appropriate time intervals.
17. Incorporate applicable *JPL "Design Principles"* and GSFC *"Golden Rules"* into Engineering Process at an early stage.
18. Be *passionate* and show *leadership* in everything you do.