Success Strategies for Research and Flight Projects

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Synopsis

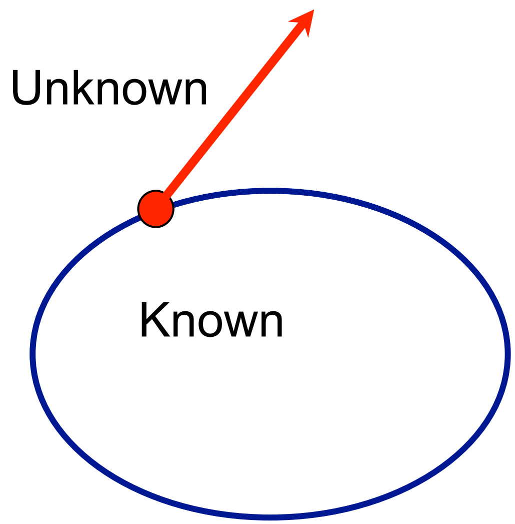
The AO process asks the PI to focus on science and viable concepts in the proposal THEN, after award, it asks the PI to shift modes and focus on project execution. I will discuss some strategies for making this shift.

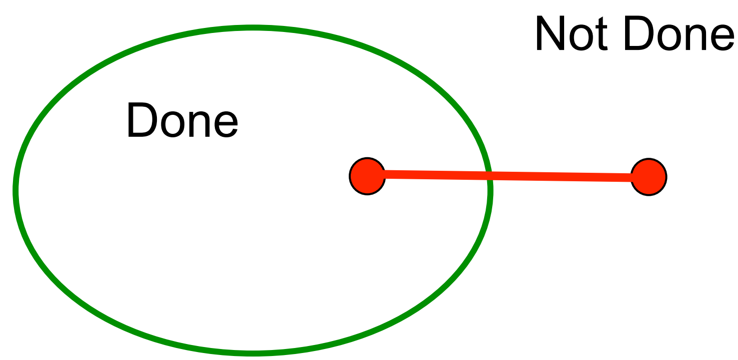
The methods and motivations of research and flight projects are different. Trying what has proven successful in one domain to the other usually yields disappointing results. Acknowledging these differences and their ***motivations*** will improve your project's prospects for success.

AO Mission Selection Process Requires an Abrupt Change

- AOs solicit missions that offer the best science within constraints - so PIs first seek creative way of maximizing the science per dollar while developing viable mission concepts to meet the science objectives.
- After down-select the PI must shift modes and define what is needed for the awarded science then work with the engineers as they develop the system design.
- Anticipating this shift will help the team be successful.

A Simplistic Science and Engineering Comparison





Science - Exploring from the frontier with a direction

To explore you need to know where you are on the frontier and the direction you are headed.

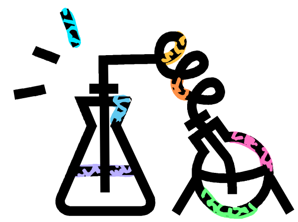
Engineering - Building a bridge from what has been done to what has not.

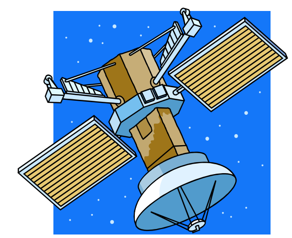
To build this bridge the end points must be defined - quantify success first.

Success Strategies for Flight and Research Projects are Different

Flight and research projects have different methods and motivations so proven success strategies are different.

So how do flight and research projects differ?



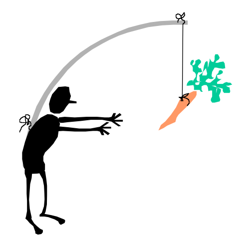


Research project ≡ new science or advance the SOTA

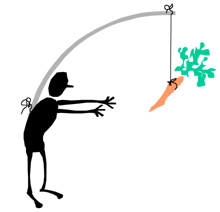
Flight project ≡ Perform a set of predetermined tasks in space

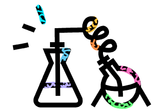
Motivation ≡ Why do the project?

Method ≡ How is the project brought into being?

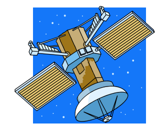


Some Thoughts on Project Motivations





- More is better
  - Research continually pushes the knowledge frontier; drives to advance the state-of-the-art
  - Research has no end-point



Versus

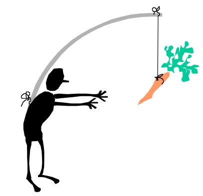
- Better is the enemy of good enough
  - Quantify success at the beginning
  - Focus on what must be done, *not* what could be done

Will it lead to archival publication? ***Versus*** Will it perform in space?

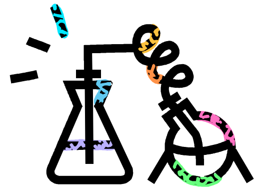
In research uniqueness is a necessary quality and publication is an acceptable end product

Flight project engineers design only those subsystems that need to be new - most 'design' is re-design

Some Differences Between Research and Flight Project Motivations



Research Projects



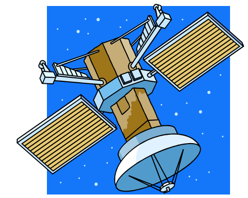
1. More is better.

2. Will it contribute to science?

3. Is it original and complete from a scientific perspective?

4. Will it lead to archival publication (or more research $)?

Flight Projects



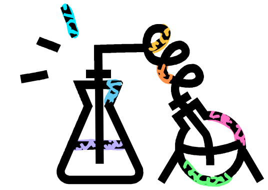
1. Better is the enemy of good enough.

2. Will it meet its requirements?

3. Is it integrated into the system from an engineering perspective?

4. Will it perform in space?

Some Thoughts on Research Project Methods



1. Individual or small teams do it all

   Decomposition within a single ‘head-full’

2. Design and operations optimized during development

   Manage ripples real time

3. Solve roadblock issues as they occur

   Flexibility and focus on relevant analysis

4. Level-of-effort with project performance goals

   LOE projects are always on cost and on schedule

5. Is it original work (unique solution)?

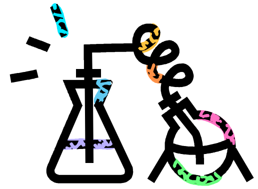
   May not seek to adapt successful past solutions

Some Thoughts on Flight Project Methods

1. Can we leverage existing designs?
   - Know the success and limits of the past designs
2. The need for project discipline
   - Incremental system maturity with baseline reviews
   - Pre-planned allocations, schedule, cost and performance thresholds so subgroups can work their designs autonomously and in parallel
   - Changes discouraged due to ripple effects, e.g., cost and schedule
   - Identify and manage risks up front
3. The cost of system decomposition
   - Large teams - required system decomposition, delegation and performance (re)allocation

Some Differences Between Research and Flight Project <u>Methods</u>

<u>Research Projects</u>



1. Individual or small teams do it all
2. Design and operations optimized during development
3. Solve roadblock issues as they occur
4. Level-of-effort with project performance goals
5. Is it original work (unique solution)?

<u>Flight Projects</u>

1. Large teams - required system decomposition, delegation & discipline
2. Changes discouraged due to ripple effects, e.g., cost and schedule
3. Identify and manage risks up front
4. Performance requirements, pre-planned allocations, schedule & cost
5. Can we leverage existing designs?

Some Unique Costs of Large Systems - Reductionism

Reductionism is a basic premise of systems engineering. It claims that large complex problems (projects) are easier to solve by breaking them down into smaller more manageable pieces. But there is a cost that comes with reductionism - new problems are created.

The larger and more complex a project is, the greater and more significant the new problems are.

Small projects can usually ignore problems of reductionism.

The Three Costs of Reductionism

1. New interfaces are created between the pieces (subsystems). They must be defined and managed (especially those that cross organizational, maturity or philosophical boundaries).

2. System resources are allocated to the subsystems. Initial allocations will be suboptimal, so they must be reallocated as alternatives are investigated and subsystems mature.

3. System performance is also allocated to subsystems,so confidence must be established that if all of the subsystems perform as desired that the system will perform as desired. This creates the need for system performance modeling and iterative subsystem and system verification.

Can a PI Use These Differences to Improve Their Approach to Flight Projects?

What has worked in a research setting may not work on a flight mission.

A PI should acknowledge the need for new perspectives and the differences in how success is achieved.

This may be hard because it requires different behavior from what has proven to work in the past.

Some strategies:

- Learn how flight missions have been developed and the motivation for standard methods.
- Leverage past success - lessons, designs and operations.
- Acknowledge the need for and cost of system decomposition.

More Strategies to Improve a PI's Approach to Flight Projects

- Delegate and trust those with flight mission experience.
- Be creative in the investigation and the application of existing technology (TRL 6+), but not in project development techniques.
- If you propose to do it faster, better or cheaper, the project plan must be very compelling on why this will be the case (extraordinary claims require extraordinary evidence).
- Take 'lessons noted' to heart.
- Manage margins using historically based depletion tables.

Summary

- Flight and research projects have different methods and motivations, so success strategies may not transfer.
- Systems engineering is the response to the unique technical needs of flight projects.
- Large projects benefit from:
  - Defining success first
  - Knowing the performance and limits of past projects
  - Knowing the cost of system decomposition
  - Project discipline

Questions or Comments?

Backup Slides

Some References

1. Principal-Investigator-Led Missions in the Space Sciences, 2006; NRC
2. Steps to Facilitate Principal-Investigator-Led Earth Science Missions, 2004; NRC
3. NASA: Principal Investigator Led Missions in Space Science, 2005.; National Academy of Public Administration
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7. NASA Discovery, Explorer, ESSP, New Frontiers lessons learned workshops; e.g., see: http://discovery.larc.nasa.gov/lessonslearned.html and
8. http://explorers.larc.nasa.gov/mel.html
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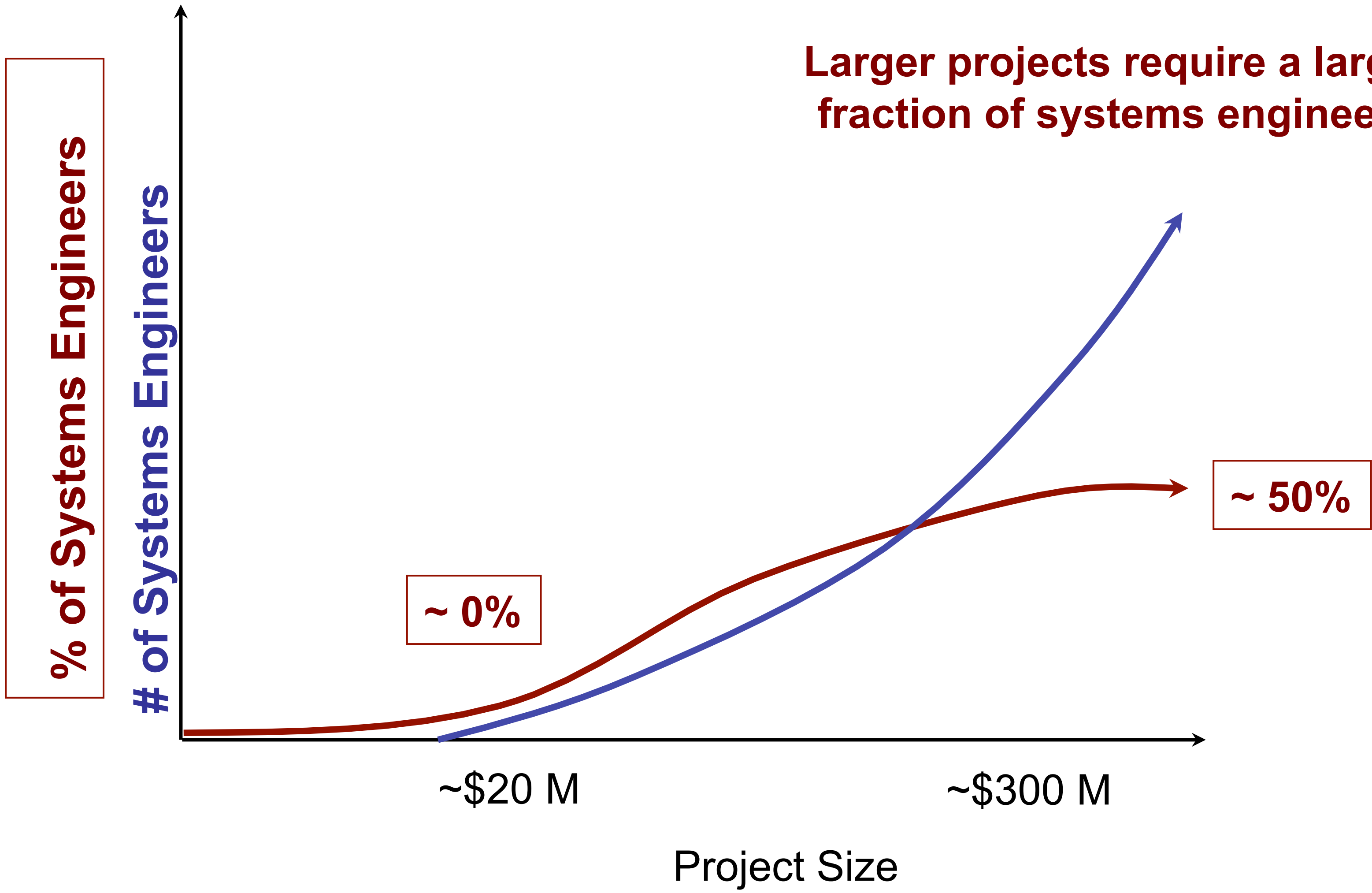
The Unique Costs of System Decomposition are Captured by Systems Engineering



Common Factors Contributing to the Success or Failure of NASA Programs

- Rigorous requirements management
- Rigorous interface control
- Streamlined boards and panels
- Rigorous systems engineering process and reviews
- Strong government-contractor teaming
- Experienced personnel
- Thorough testing
- Systems level approach throughout program levels
- Rigorous risk management

- Inadequate requirements management
- Convoluted boards and panel process
- Poor systems engineering processes
- Inadequate reviews and oversight
- Inadequate heritage design analysis
- Inadequate systems engineering and integration expertise
- Inadequate testing and interpretation of data
- Inadequate systems-level risk management

Source: NASA, Office of Program Analysis and Evaluation, *Systems Engineering and Institutional Transitions Study, Final Report*, April 5, 2006 reprinted in: Building a Better NASA Workforce: Meeting the Workforce Needs for the National Vision for Space Exploration; NRC; 2007

Self Introduction and Paul's Perspective - What I Do

NASA experienced practitioner in systems engineering helping to improve performance of NASA projects

Consultant for civil space project pursuit and execution

Systems engineering professional development and teaching (NASA, CU Boulder)

NASA and NOAA independent technical review, proposal red teams and architecture development

Significant involvement in the development of ~40 civil space proposals including SMEX, MIDEX, Discovery, ESSP, COTS, NPOESS and GOES

Self Introduction and Paul's Perspective - What I Have Done

Ball Aerospace (WIRE, Sciamachy, NPOESS OMPS)

- Chief engineer for OMPS - concept to detailed design
- Civil space new business development

Hughes Space & Communications - systems engineer (MGN)

- LA, Lockheed (CO), KSC (STS ATLO), JPL (operations)

Academics

- MS, PhD Astronomy & Astrophysics (Cornell) IRAS & KAO
- BS Applied & Engineering Physics (Cornell)