PI Team Masters Forum - 2

The Successful Team Composition - Engineering of Systems

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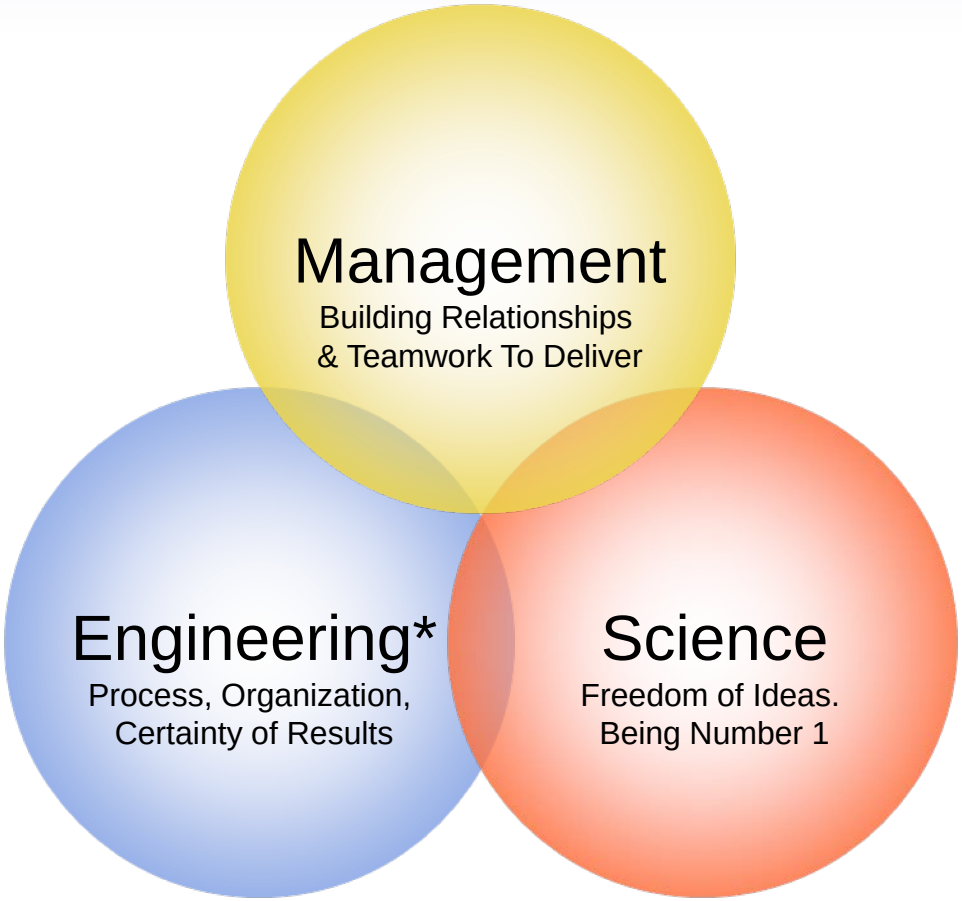
Engineering of Systems

"The objective of systems engineering is to see to it that the system is designed, built, and operated so that it accomplishes its purpose in the most cost-effective way possible, considering performance, cost, schedule and risk."

NASA Systems Engineering Handbook SP6105

- Systems engineering is a methodical, disciplined approach for the design, realization, technical management, operations, and retirement of a system.
- A "system" is a collection of different elements that together produce results not obtainable by the elements alone.
  - Elements can include people, hardware, software, facilities, policies and documents.
- Systems engineering is the art and science of developing an operable system capable of meeting requirements within imposed constraints.

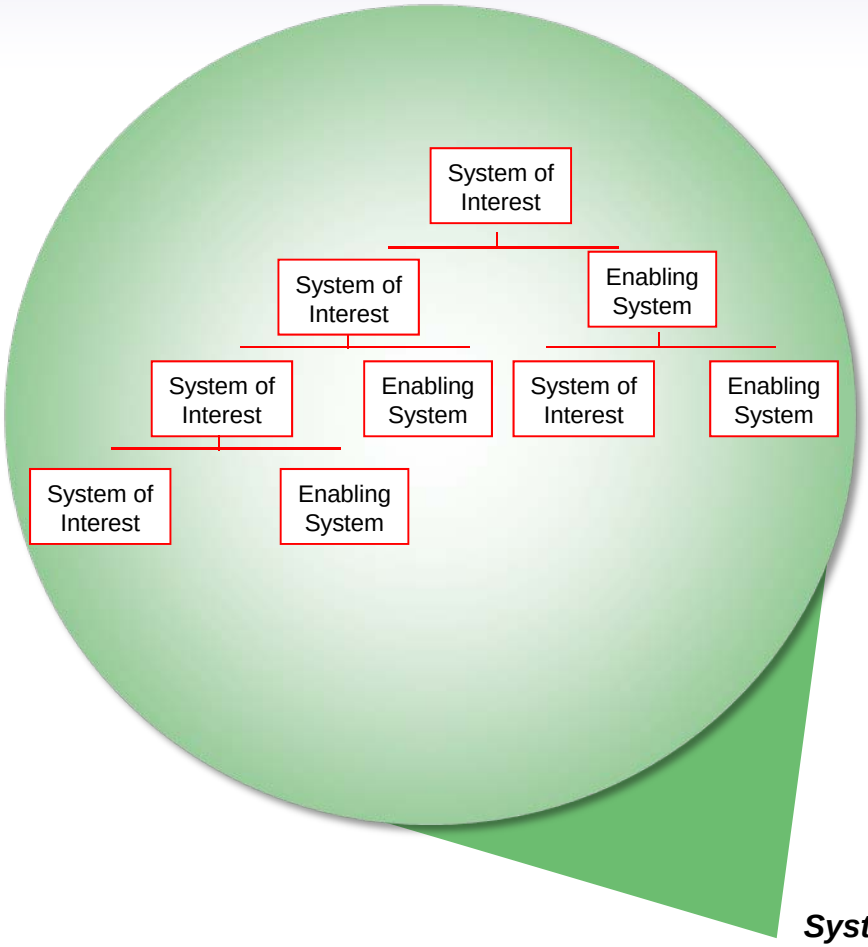
Space Mission Triage

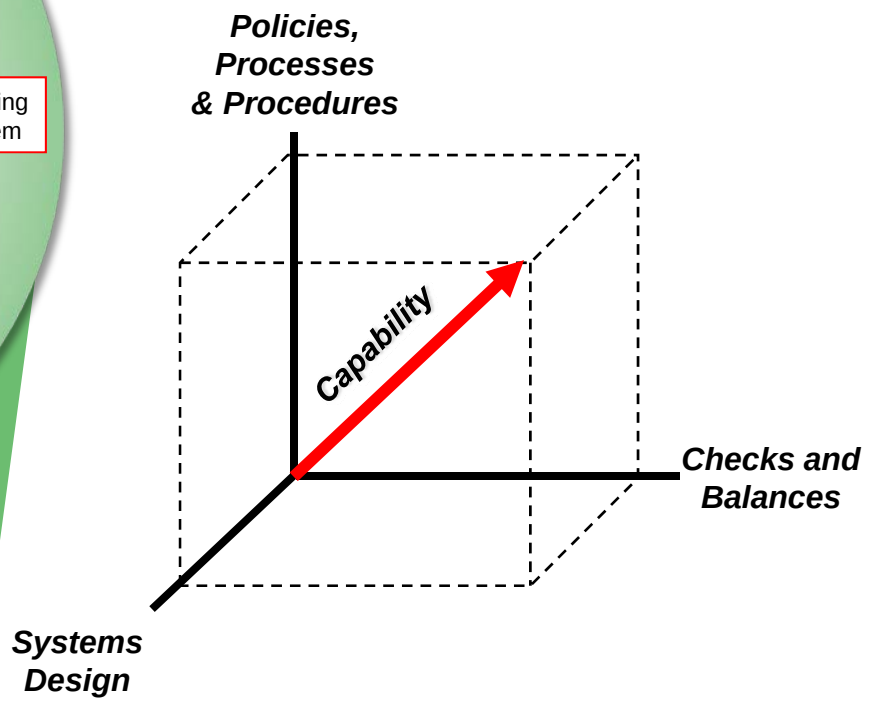


* Including Safety and Mission Assurance

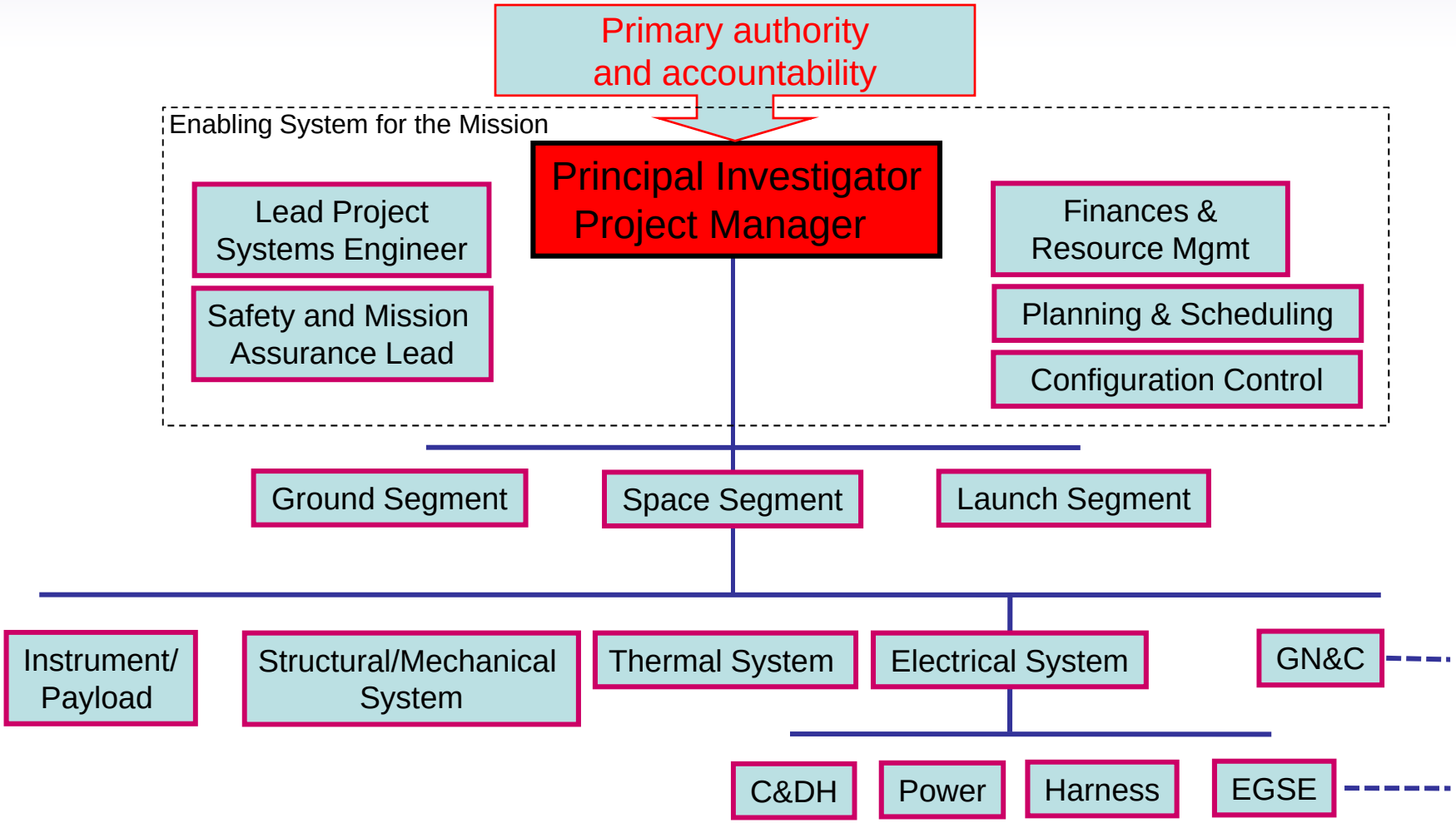
Credit: Definitions adapted from “How NASA Builds Teams” by C. J. Pellerin

System Design Environment





The Typical Project From A Systems Perspective



Choosing the Right Engineering and Technology Expertise

- Mission Systems Engineering
- Instrument Systems Engineering & Management
- Access to Space Carrier Systems
- Materials
- Mechanical/Structures & support equipment
- Electromechanical Systems
- Thermal Systems
- Machining/Fabrication Technologies
- Contamination Control
- Environmental Testing
- Optics
- Lasers & Electro Optics
- Cryogenics & Fluids Systems
- Detector Systems
- Microwave Instruments Technologies
- Avionics Architecture & Implementation
- Communication Systems
- Systems Integration, Verification & Validation
- Autonomy
- Computing Environments & Technologies
- Data Management & Analysis
- Command and Data Handling Systems
- Power Systems
- Microelectronics
- Signal Processing
- Electrical Systems & support equipment
- Ground Support Equipment Design & Implementation
- Guidance, Navigation & Control Components & Systems
- Spacecraft Propulsion
- Flight & Ground Software Systems
- Radiation
- Electronics parts

Systems Engineer Responsibilities Across the Mission Lifecycle

Systems Engineer

Lifecycle Focus
on Risk Management & Mission Success

Technical Architect

- Requirements Identification
- Architecture and Design
- Operations Concept

Technical Implementer

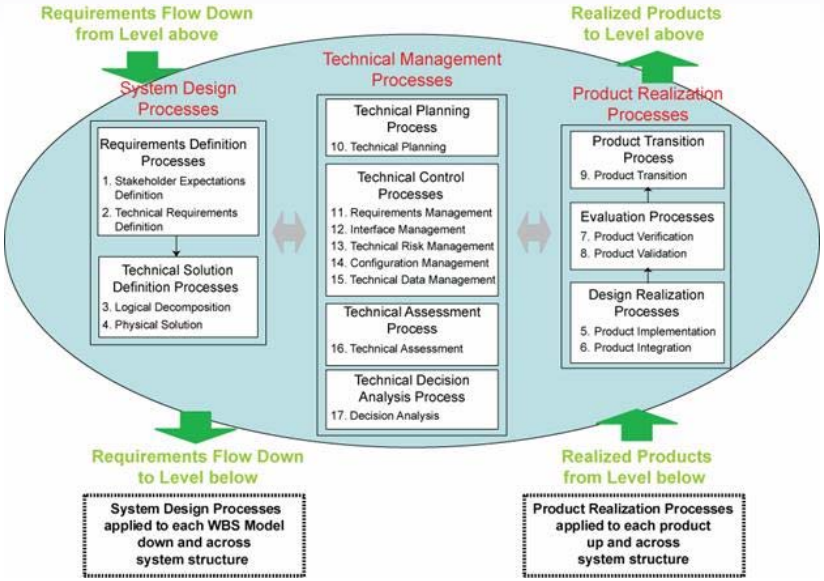
- "Proper Paranoia"
- Track Resources and Margins
- Verification and Validation
- Anomaly Resolution (Make it Work!)

System Engineering Processes/Training

System Engineering Handbook (SP-6105), GPR 7123.1 Systems Engineering

(CM, Risk Mgmt, Req'ts Mgmt, I/F Mgmt, Anomaly Resolution)

NASA System Engineering Processes NPR 7123.1 and SP-6105 Handbook



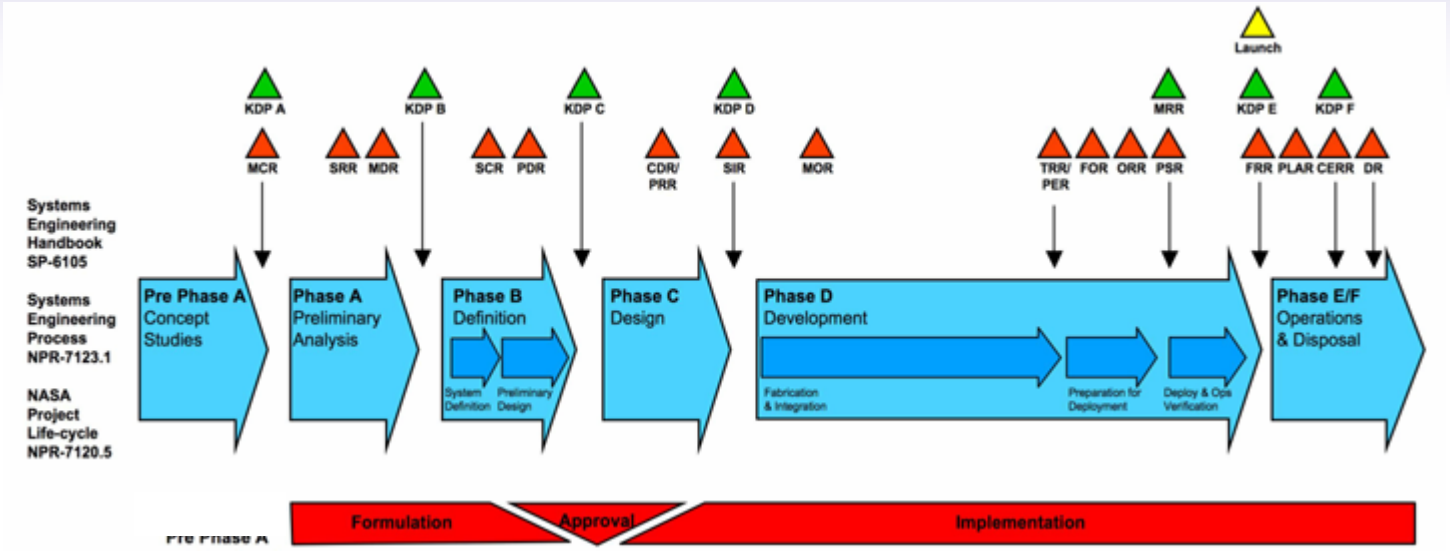
- **NPR 7123: Systems Engineering Processes and Requirements**
- **NASA-SP-6105: NASA System Engineering Handbook**
  - Policy and Guidelines for the Various System Engineering Processes Shown in Figure Above
- **GPR 7123.1 Systems Engineering**
  - GSFC-Tailored Approach to NPR 7123: System Engineering Processes and Requirements
  - "Guidance" for the systems engineering of Goddard Missions

For a direct link to the document:

http://nen.nasa.gov/nasa_nas/ops/systems_community/NASA_SP-2007-6105_Rev_1_Final_31Dec2007.pdf

Systems Engineering Lifecycle

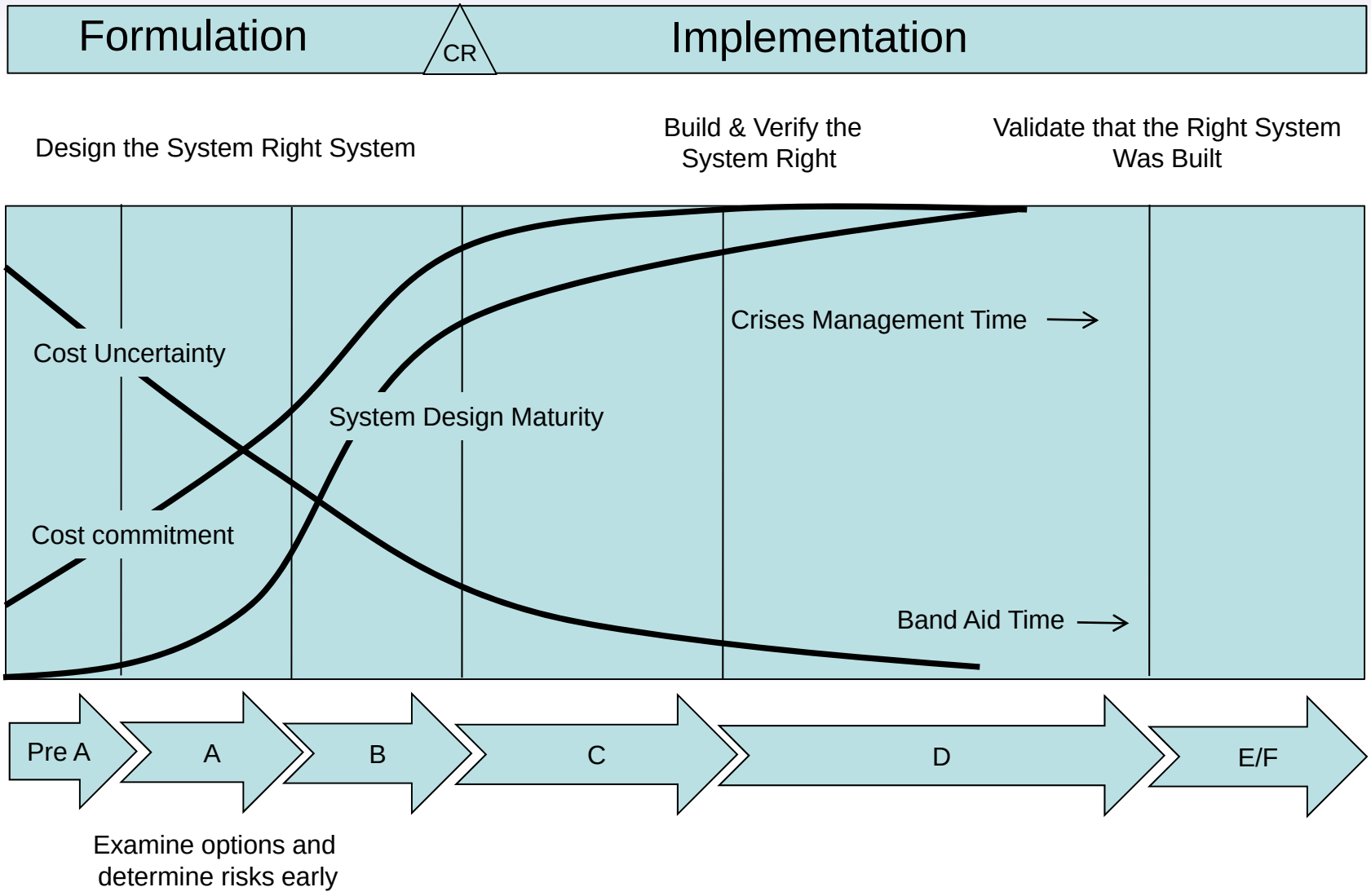
Planned activities grounded in established and proven methods to develop and operate systems



- Logical Life Cycle, “Crawl before you Walk, Walk before you Run”
  - A. Define Goals, Evaluate Multiple Approaches, Select a Single Best Approach
  - B. Decompose System to Lower Elements, Validate (Build the Right System)
  - C. Detailed Design (Build the System Right)
  - D. Build, Integrate, Verify
  - E. Operate
  - F. Dispose

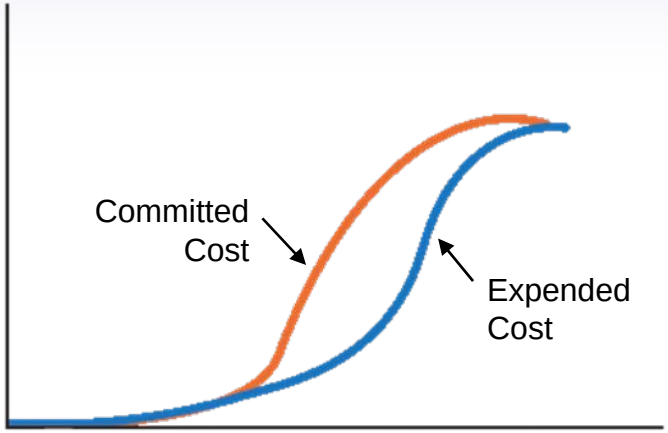
- Requirements, Design and Operations Concept Consistent with Cost, Schedule and Acceptable Risk *(Objective of NPR 7123.1 and Systems Engineering SP6105)*
  - Achieving this balance is the heart of the “Engineering” Activity.
  - Where creativity of the multidiscipline team is necessary

From Architecture and Design to Verification and Validation

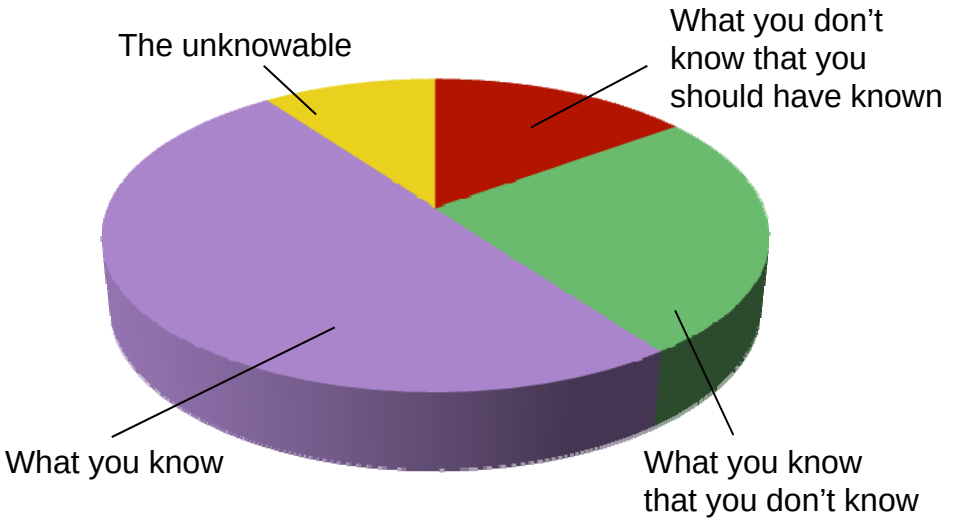


Progress Against Plans, Margins, and Reserves

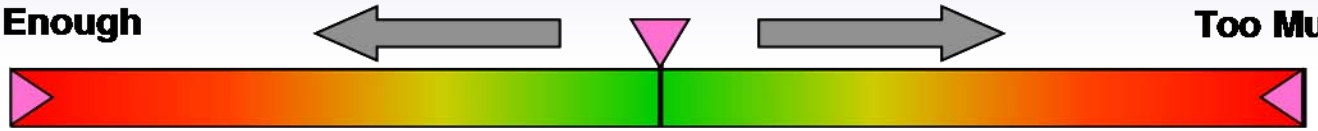
- Reserve profiles
  - Schedule and cost reserves require careful planning and active management
  - Treat mass, power, volume, and computer memory/processing capabilities like money
  - Technical folks must understand resource challenges/decisions and resource folks must understand technical challenges/decisions
  - Contractor or civil servants, when it comes to commitment, we we are all the same



Decisions are most effective early



A Healthy Commitment to Technical Excellence - "Proper Paranoia" – Gentry Lee, JPL



Complacent Infallibility

It has never failed before!
What can go wrong?
It can't fail!

Proper Paranoia

Know and Learn "How" and "Why" System works (or fails!)
"Closet Optimist!"
"Great Communicator"

Paralyzing Fear of Failure

It will never work!
The sky will fall!
We have never done this before!
We do not do this anymore!

What is "Proper Paranoia"? (Taken from Gentry Lee's JPL Lecture)

- Challenge Technical Inputs/Claims with Appropriate Vigor
  - Good News and Bad News Treated with Equal Emphasis
- Analyze and Get to Know System, Including Failure Modes and Contingencies
  - Know Essential Requirements for Mission Success (Pointing, Stability, Repeatability, etc.)
  - Failure Modes and Effects Analyses (FMEA's) Great Tools
- Get to Bottom of All Anomalies – Especially in Critical/High Risk Areas
- Minimize the "Known Unknowns" – Reducing Uncertainties Reduces Risk
- Listen to Everyone – Managers, Engineers, Technicians, QA, Safety
  - Effective Communication is **Paramount** to Ensuring Mission Success

In the End We Are All Engineers of Systems

- Listen to your customers/stakeholders
- Discern between desires, and the requirements (R3= ratable, relationship, rationale) for the mission
- Build a team (the Project and the supporting organizations)…, the most important asset
- Establish clear roles and responsibilities
- Flow down/decompose requirements into a traceable system design—view requirements as decisions
- Develop a credible plan (technical, cost and schedule) with adequate margins
- Establish checks and balances through review, reporting, and active listening
- Monitor progress against the plan, and act decisively to preserve or adapt it as needed
- Communicate progress against the plan in traceable ways
- Verify and validate—"test as you fly - fly as you test" or have defensible options
- Celebrate early wins and acknowledge your team mates for their contributions