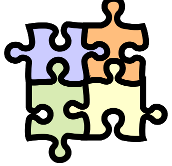

Systems Engineering Awareness

MFPT 2019

John Lucero
NASA Glenn Research Center
King of Prussia, PA
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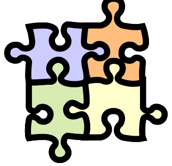


Presenter

John Lucero

(32 years exp.)

Facilities Testing Division

NASA Glenn Research Center

Brook Park, Ohio 44135

Office 216 433 2684

Cell 440 915 9277

John.M.Lucero@nasa.gov

Question to audience

- Why are we sitting here?

Possible Answer

- Seeking greater success in project endeavors.

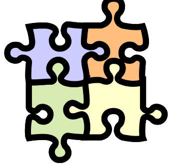
Proposed solution

- Performing activities defined by Systems Engineering methods will greatly increase project success.

Introduction

History– Wikipedia

1. Systems Engineering can be traced back to Bell Telephone Laboratories in the 1940s
2. The development and identification of new methods and modeling techniques
3. International Council on Systems Engineering (INCOSE) 1995
4. The conception, design, development, production and operation of physical systems



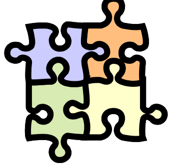
Definitions and Terms

System:

- NASA: A set of interrelated components which interact with one another in an organized fashion toward a common purpose.

- DOD: An integrated composite of people, products, and processes that provide a capability to satisfy a stated need or objective.

- INCOSE: A construct or collection of different elements that together produce results not obtainable by the elements alone.



Definitions and Terms

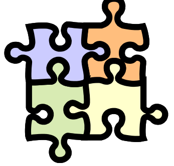
Systems Engineering:

- MIL-STD-499B: An interdisciplinary approach encompassing the entire technical development effort to evolve and verify an integrated and life-cycle balanced set of system, people, product and process solutions that satisfy customer needs. Systems engineering encompasses:
  - Technical effort (develop, manufacture, verify, operate, etc)
  - Define and manage the system configuration
  - Translate the system to a work breakdown structure
  - Develop information for decision making.

Definitions and Terms

Systems Engineering:

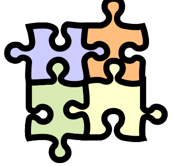
- INCOSE: An interdisciplinary approach and means to enable the realization of successful systems, focusing on customer needs early in the design cycle, document requirements and proceed to design synthesis and system validation. Consider the complete problem: operations; performance; test; mfging; $ and time; training/support; disposal.



Definitions and Terms

Systems Engineering:

- NASA: Requires the application of a systematic, disciplined engineering approach that is quantifiable, recursive, iterative, and repeatable for the development, operation, maintenance and disposal of the systems integrated into a whole throughout the life cycle of a project or program. The emphasis is on achieving stakeholder functional, physical, and operational performance requirements in the intended use environments over the system’s planned life within cost and schedule.



Definitions and Terms

Systems Engineering is:

- Multidisciplinary
- Systematic
- Processes
- Development/operation
- Complex product
- Limited resources
- Constraints

Process:

- Complex work activity
- Transforms inputs into outputs
- Consumes resources

Definitions and Terms

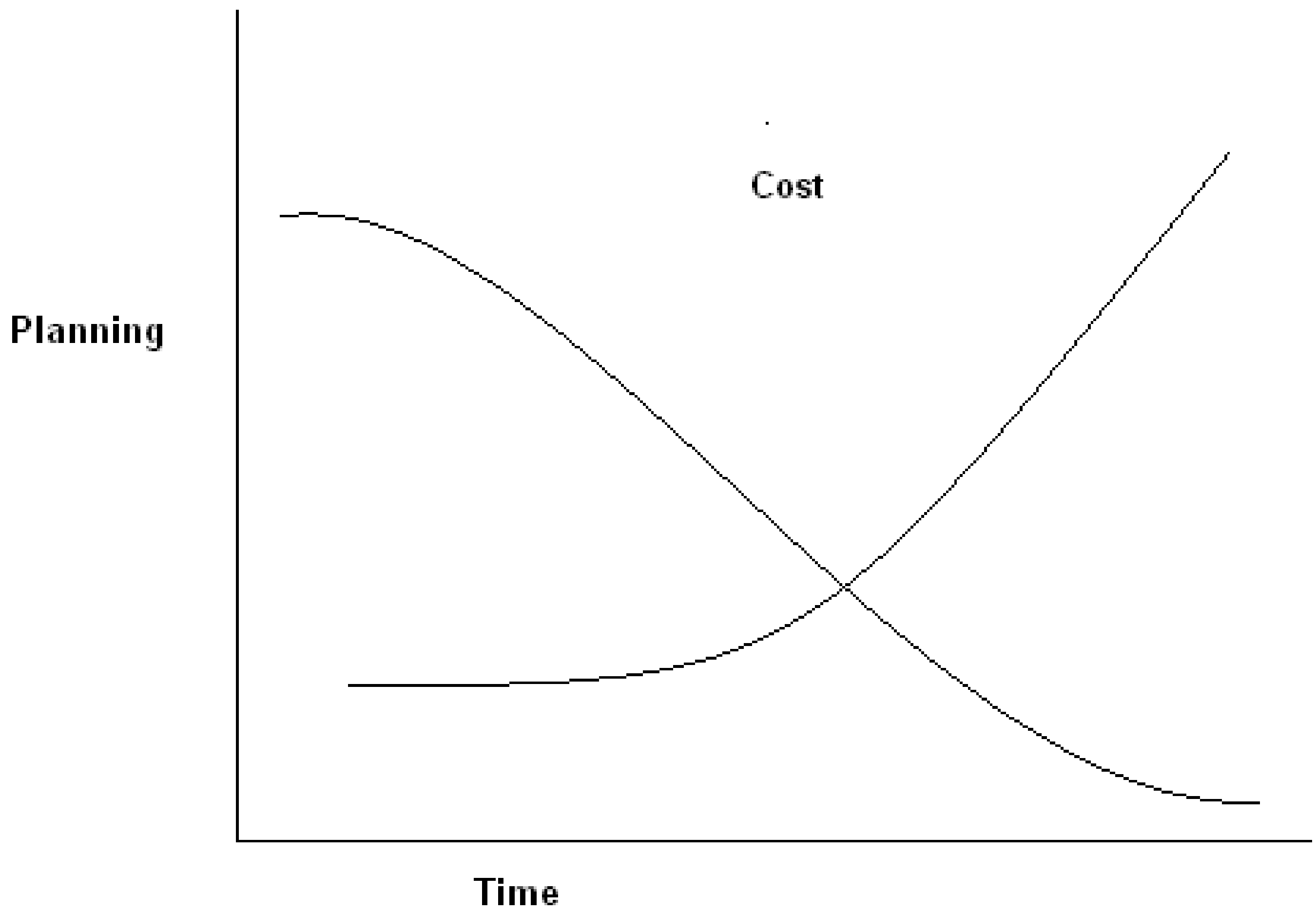
Three Types of Systems Engineering:

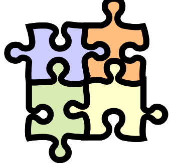
1. Product Systems Engineering (PSE) is the focus on the design of physical systems consisting of hardware and software.

2. Enterprise Systems Engineering (ESE) pertains to the view of enterprises, that is, organizations or combinations of organizations, as systems.

3. Service Systems Engineering (SSE) has to do with the engineering of service systems.

Benefit of SE





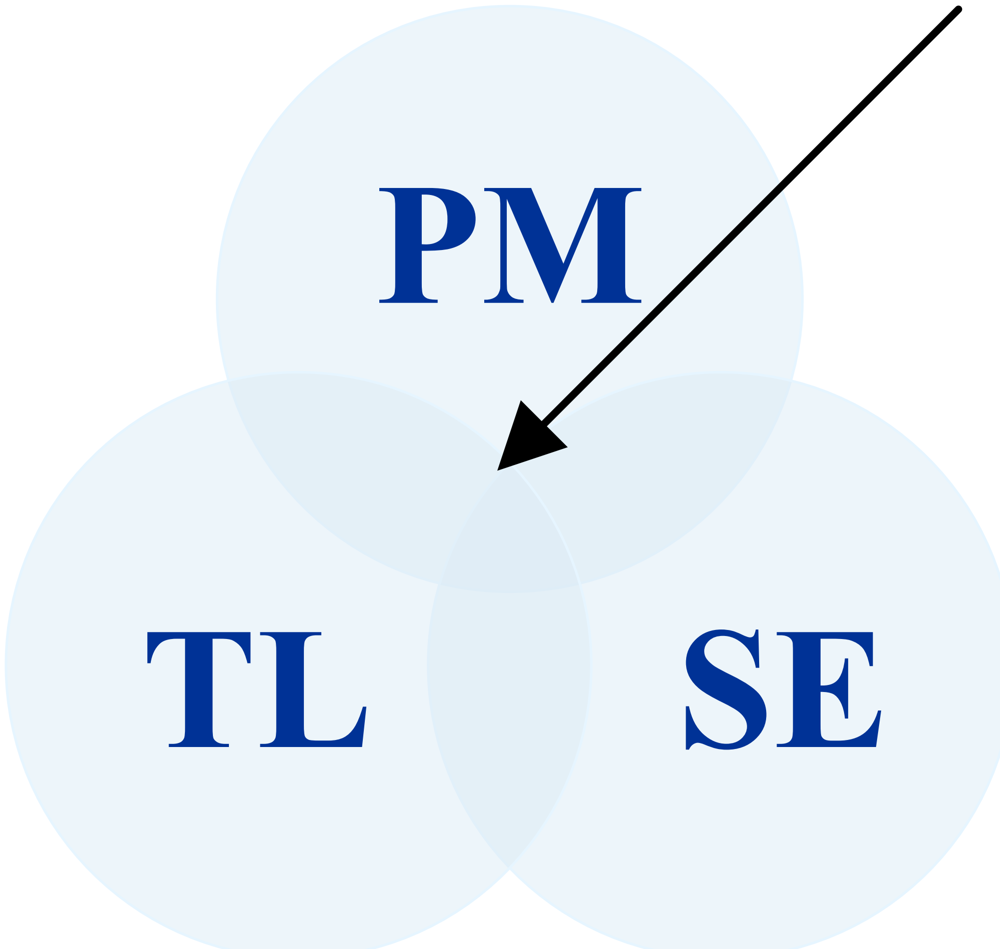
Definitions and Terms

Systems Engineering Leadership:

- Knowledge base
  - What do you know about the subject?
- Engineering judgment
  - Experience, successes
- Effective Communication
  - Written, verbal, diplomacy
- Systematic Processes
  - Company policy
  - Examples: CMMI, ISO, NPR 7123.1A

Definitions and Terms

Interaction of PM, SE, and TL = WBS creation:



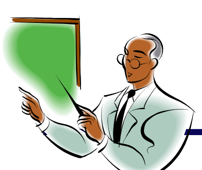
SE Dilemma

MUST BALANCE

Risk (R)! Performance (P)! Cost (C)!

C*R = P

1. Reduce C at constant R = P drops
2. Reduce R with constant C = P drops
3. Reduce P at constant C = Risk drops
4. Reduce P at constant R = Cost drops
5. Reduce C at constant P = Risk increase
6. Reduce R at constant P = Cost increase
7. Etc.

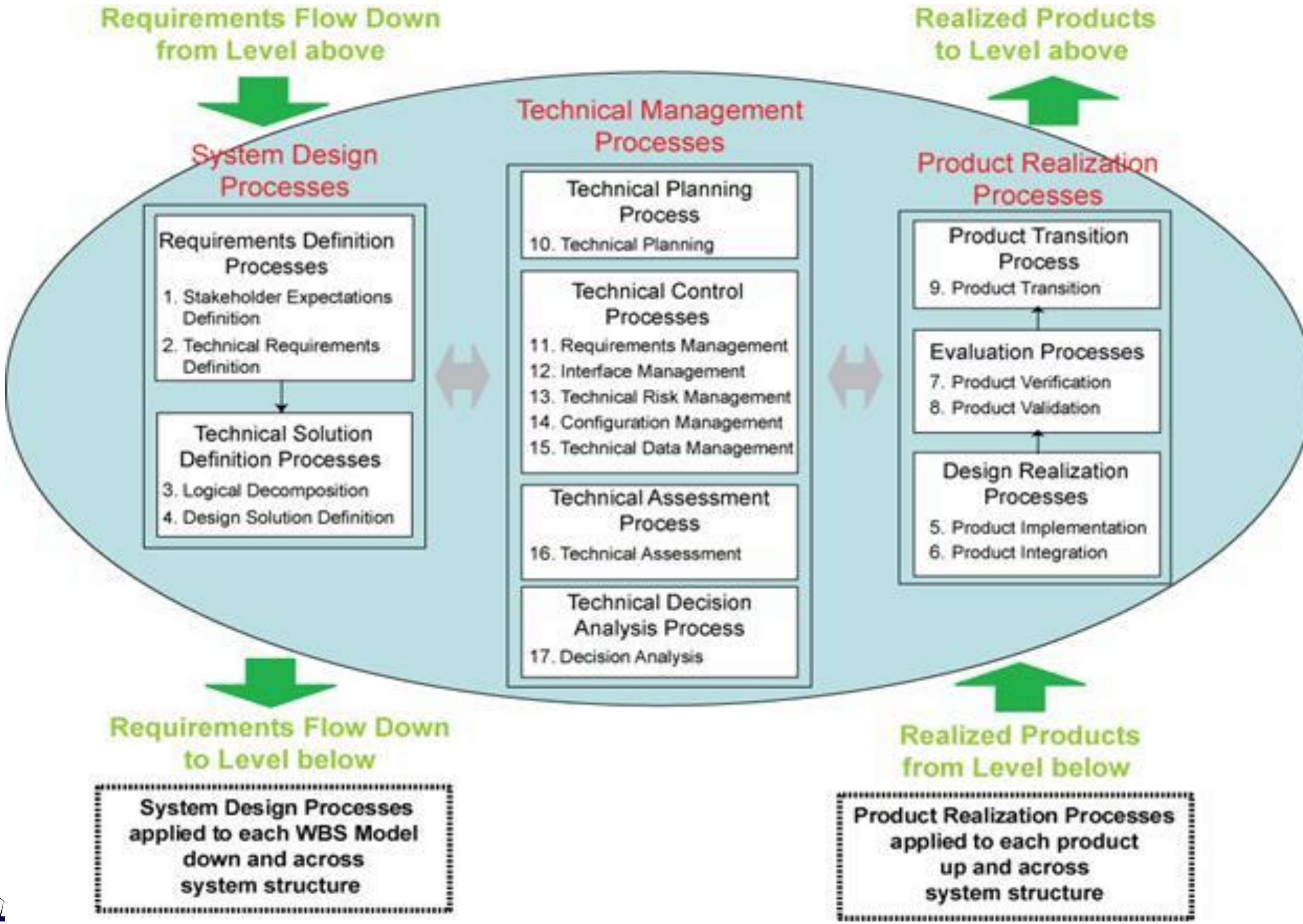


Design Engineering Dilemma

<u>Engineers want a solution NOW!</u>

- General statements lead to detailed design on first step.
- Difficult to step back and look at BIG picture
- Up front requirements definition and systems engineering planning are PARAMOUNT before designs start getting built.
- Late design changes cost $$$$$
- Communication is KEY.

NASA Procedural Reqmt. 7123.1A

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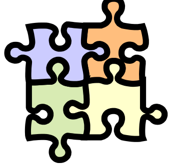
Systems Engineering
Handbook



This handbook consists of six core chapters:

(1) Systems engineering fundamentals discussion

(2) the NASA program/project life cycles

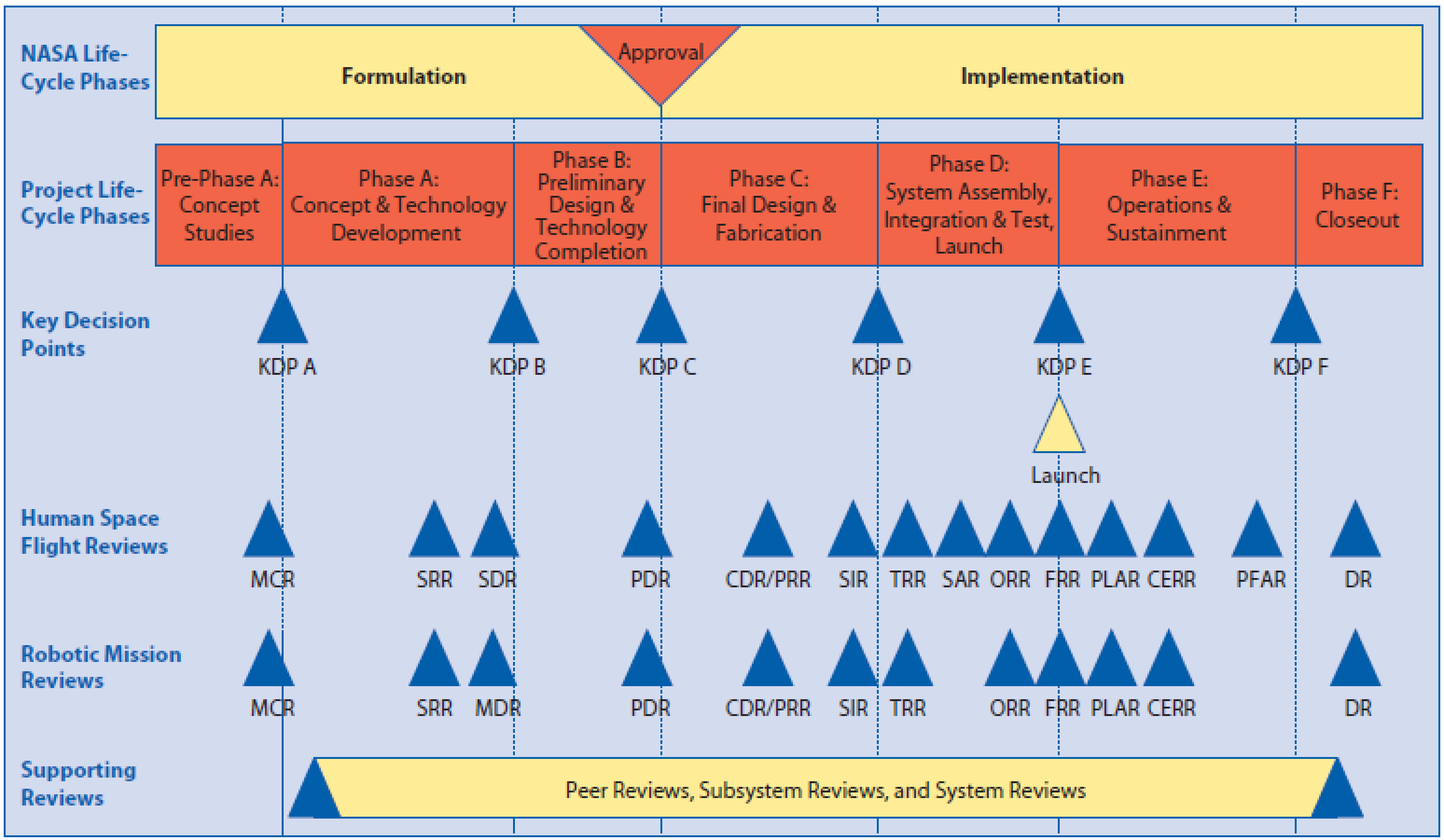
(3) systems engineering processes to get from a concept to a design

(4) systems engineering processes to get from a design to a final product

(5) crosscutting management processes in systems engineering

(6) special topics relative to systems engineering

CDR	Critical Design Review
CERR	Critical Events Readiness Review
DR	Decommissioning Review
FRR	Flight Readiness Review
KDP	Key Decision Point
MCR	Mission Concept Review
MDR	Mission Definition Review
ORR	Operational Readiness Review
PDR	Preliminary Design Review
PFAR	Post-Flight Assessment Review
PIR	Program Implementation Review
PLAR	Post-Launch Assessment Review
PRR	Production Readiness Review
P/SDR	Program/System Definition Review
P/SRR	Program/System Requirements Review
PSR	Program Status Review
SAR	System Acceptance Review
SDR	System Definition Review
SIR	System Integration Review
SRR	System Requirements Review
TRR	Test Readiness Review



Purpose of PDR

- To determine the feasibility and desirability of a suggested new major system and establish an initial baseline compatible with strategic plans.

- Develop final mission concept, system-level requirements, and needed system structure technology developments.

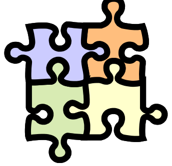
- Mature requirements for all products in the developing product tree, develop ConOps, preliminary designs, and perform feasibility analysis of the verification and validation concepts to ensure the designs will likely be able to meet their requirements.

Output of PDR

End products in the form of mockups, trade study results, specification and interface documents, and Prototypes.

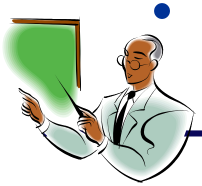
How to get to PDR

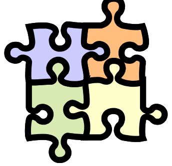
- Concept of Operations
- Develop High Level Requirements
- Identify Key Driving Requirements
- Define Verification Methods
- Identify Design Solutions
- Perform Trade Studies
- Develop a Work Break Down Structure (Product Based)
- Cost and Schedule
- Risk Management and Mitigation
- Technical Performance Measures
- Configuration Management



Most "key" valuable lessons

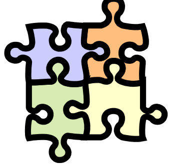
- Techniques on calling, holding, and archiving meetings/action items
- Human interface, stakeholder education for synthesis of requirements document (design by requirements is bad)
- Functional Analysis (gives insight, interfaces, WBS, PBS based on product architecture)
- Clarity (no vague requirements wording)
- Plan to iterate
- Diplomacy
- One shall per requirement
- Validate – use it
- Verify – feasible and affordable





Most “key” valuable lessons

- Golden Rule of Requirements – who is going to pay?
- Integration and test – plan what to test, test it, plan early (test what you fly, fly what you test)
- Trade Study Methodology– always iterate
- WBS – product oriented, based on architecture
- PLAN EARLY !!! System Engineering Management Plan (SEMP)



Keys to Success

- Strong SE effort early in project
- Plan and Baseline at each step
- Iterate often
- Strong Risk Management Plan
- Keep an eye on Technical Performance Measures

Conclusions

- Proper application of SE methods upfront in a project life cycle will greatly increase success.
- Paying close attention to the Stakeholder Analysis will greatly increase project success.
- Performing activities defined by SE methods will increase chances of obtaining funding to complete your project.
- Verification and Validation is key at every level in the project.