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Las Vegas, NV
June 30 - July 3, 2014

RAPID DEVELOPMENT CASE STUDY

Lessons Learned From Arming the C-145A Skytruck

Presented By

Col Timothy D. West

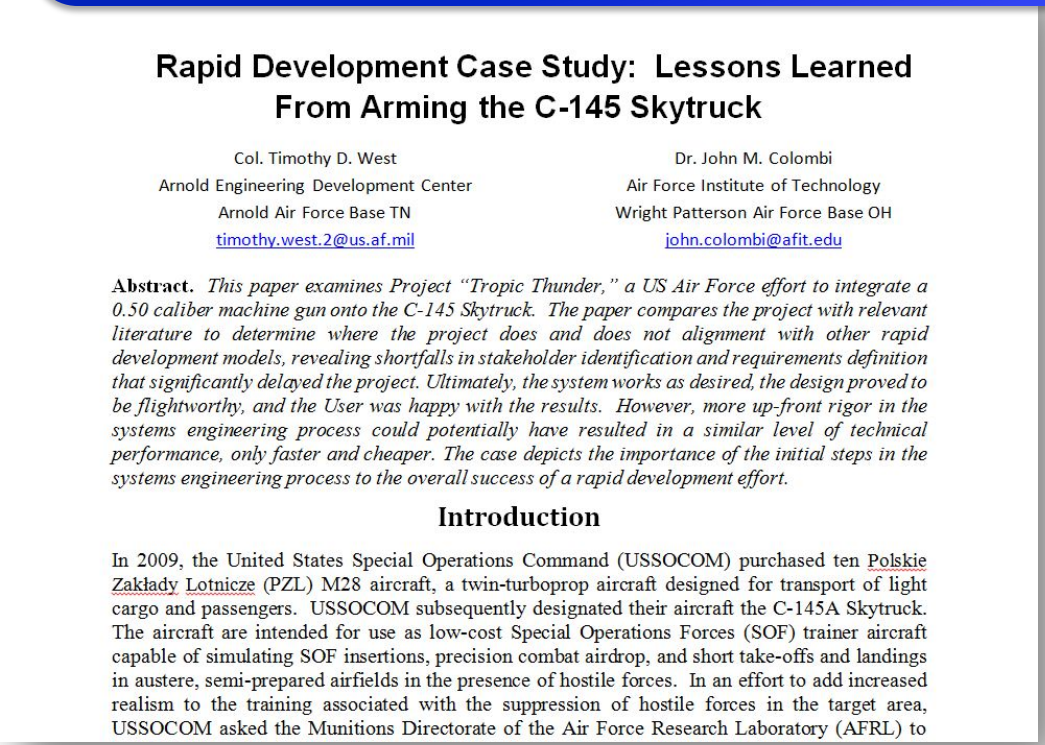
US Air Force

Official Disclaimer

The views expressed in this presentation are those of the author and do not reflect the official policy or position of the U.S. Government or the Department of Defense.

The Story Behind the Story

Does AFRL do "Rapid"?
If so, what does it look like?



Rapid Development Case Study: Lessons Learned From Arming the C-145 Skytruck

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Abstract. *This paper examines Project "Tropic Thunder," a US Air Force effort to integrate a 0.50 caliber machine gun onto the C-145 Skytruck. The paper compares the project with relevant literature to determine where the project does and does not alignment with other rapid development models, revealing shortfalls in stakeholder identification and requirements definition that significantly delayed the project. Ultimately, the system works as desired, the design proved to be flightworthy, and the User was happy with the results. However, more up-front rigor in the systems engineering process could potentially have resulted in a similar level of technical performance, only faster and cheaper. The case depicts the importance of the initial steps in the systems engineering process to the overall success of a rapid development effort.*

Introduction

In 2009, the United States Special Operations Command (USSOCOM) purchased ten Polskie Zakłady Lotnicze (PZL) M28 aircraft, a twin-turboprop aircraft designed for transport of light cargo and passengers. USSOCOM subsequently designated their aircraft the C-145A Skytruck. The aircraft are intended for use as low-cost Special Operations Forces (SOF) trainer aircraft capable of simulating SOF insertions, precision combat airdrop, and short take-offs and landings in austere, semi-prepared airfields in the presence of hostile forces. In an effort to add increased realism to the training associated with the suppression of hostile forces in the target area, USSOCOM asked the Munitions Directorate of the Air Force Research Laboratory (AFRL) to

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Aviation Foreign Internal Defense

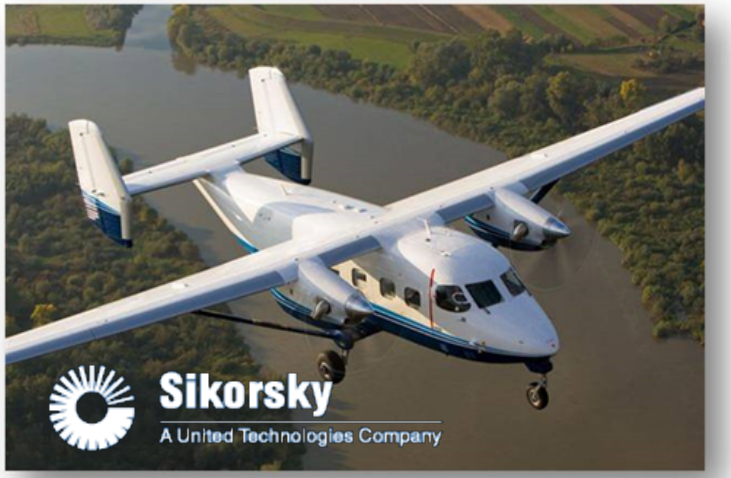
- USSOCOM tasked to assess, train, advise and assist foreign aviation forces in airpower employment, sustainment and force integration
- In FY2010, US Congress authorized the purchase of 16 light twin engine aircraft to support the “AvFID” mission
- The PZL-M28 was selected for this role

PZL-M28

A.K.A. The C-145A Skytruck

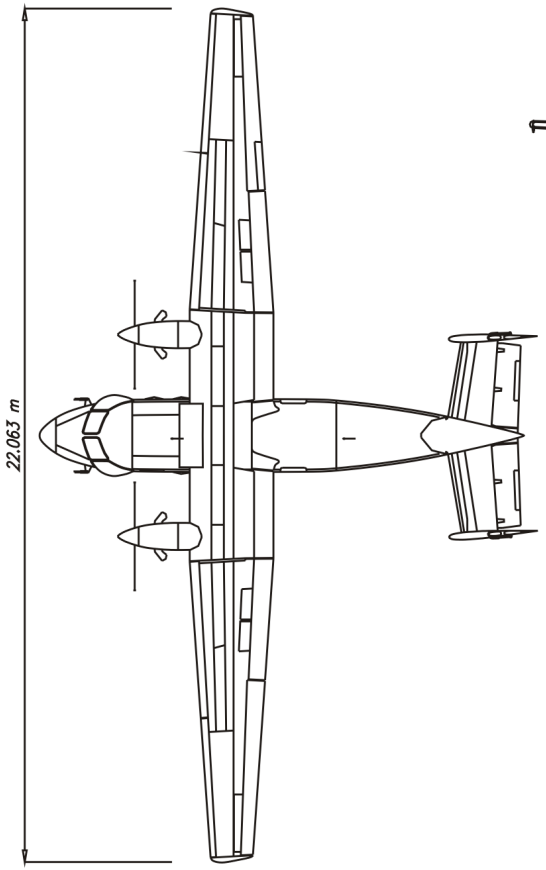
C-145A Design Features

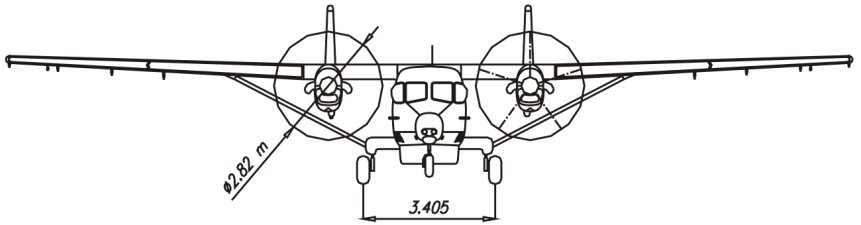
Builder: PZL Mielec (Polskie Zakłady Lotnicze - Polish Aviation Works)
Power Plant: Two Pratt &Whitney PT6A-65B Turboprops
Thrust: Takeoff power 1,100 shaft horsepower
Max Takeoff Weight: 16,534 lbs. (7,500 kgs)
Max Cruise Speed: 223 knots
Max Range: 1,010 nautical miles
Service Ceiling: 25,000 feet (7,622 m)
Crew: 3 (2 pilots, 1 loadmaster)
Unit Cost: Approx. $14M per aircraft
Inventory: 10 (End state: 16 by Oct 2014)



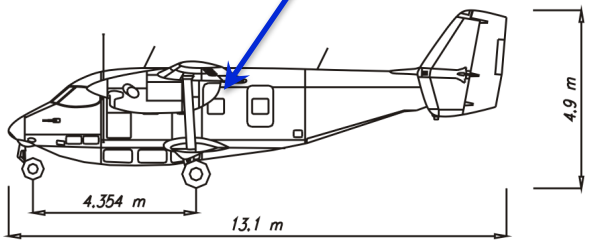
Aircraft Dimensions

WINGSPAN: 72.3 ft / 22 m





REMOVABLE WINDOW



HEIGHT: 16.1 ft / 4.9 m

LENGTH: 43 ft / 13.1 m

C-145A Mission Statement

Provide a low-cost capability to simulate SOF insertions, precision combat airdrop, and short take-offs and landings in austere, semi-prepared airfields *in the presence of hostile forces* in support of USSOCOM's AvFID mission

AIR FORCE SPECIAL OPERATIONS COMMAND

AFSOC

LT GEN ERIC FIEL, AFSOC/CC

The Birth of "Tropic Thunder"

- Sep 2012 – AFSOC poses idea to AFRL
- Nov 2012 – AFSOC approves program
- Objective: Design and demonstrate a prototype C-145A machine gun capability
- AFRL Tasking:
  - Conduct a ground test of the prototype system within 90 days of project initiation
  - Provide subject matter expertise for the airborne tests to follow

Planned vs. Actual

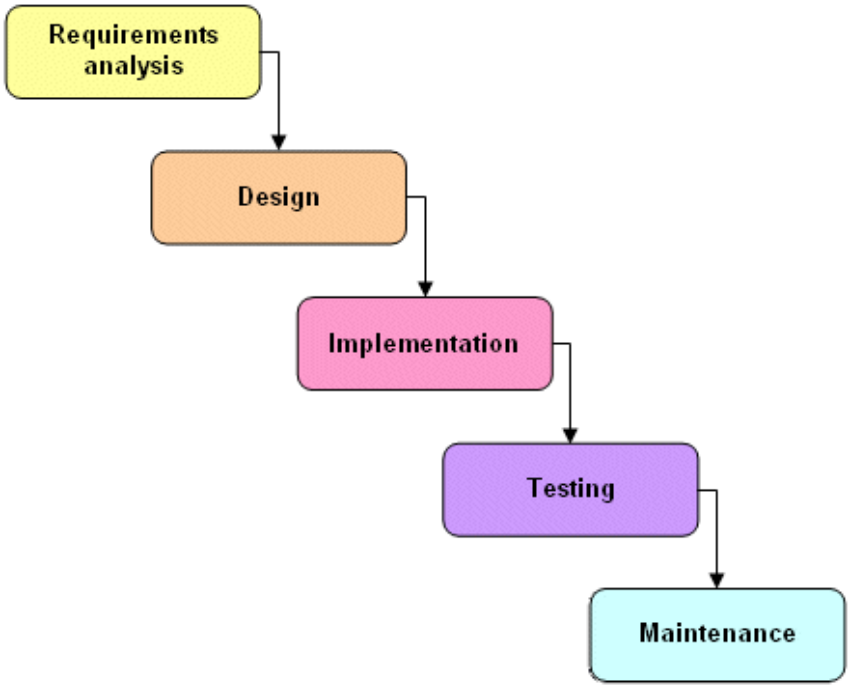
- 30 Nov 2012 – Program Initiation
- 20 Feb 2013 – Initial Design Review
- 20 Mar 2013 – "Proof of Concept" Demo
- 09 Apr 2013 – Ground Test #1 (Off Aircraft)
- 09 Apr 2013 – Technical Interchange
- 10 Apr 2013 – Detailed Design Review
- 25 Jul 2013 – Ground Test #2 (On Aircraft)

"90 Day Program" Took Seven Months to Complete

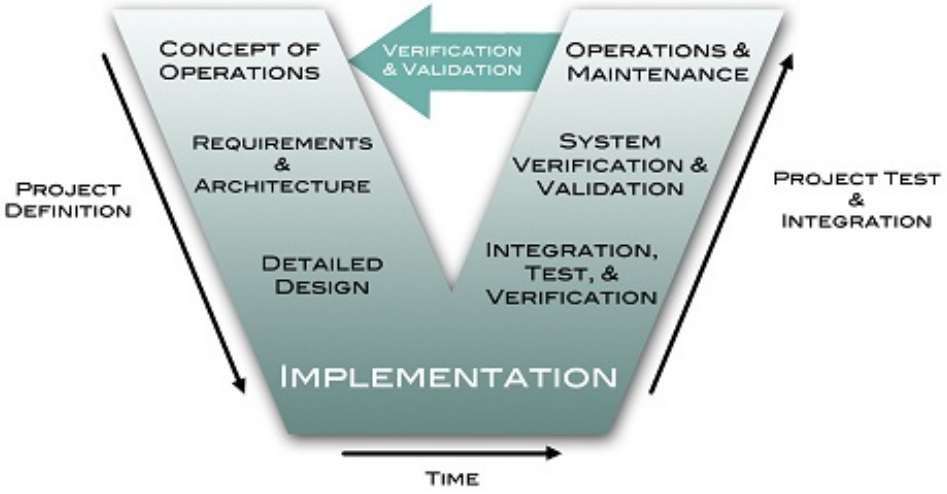
So Where Did My "Award Winning" Rapid Development Program Go Wrong?

History of Rapid Development

Waterfall Development

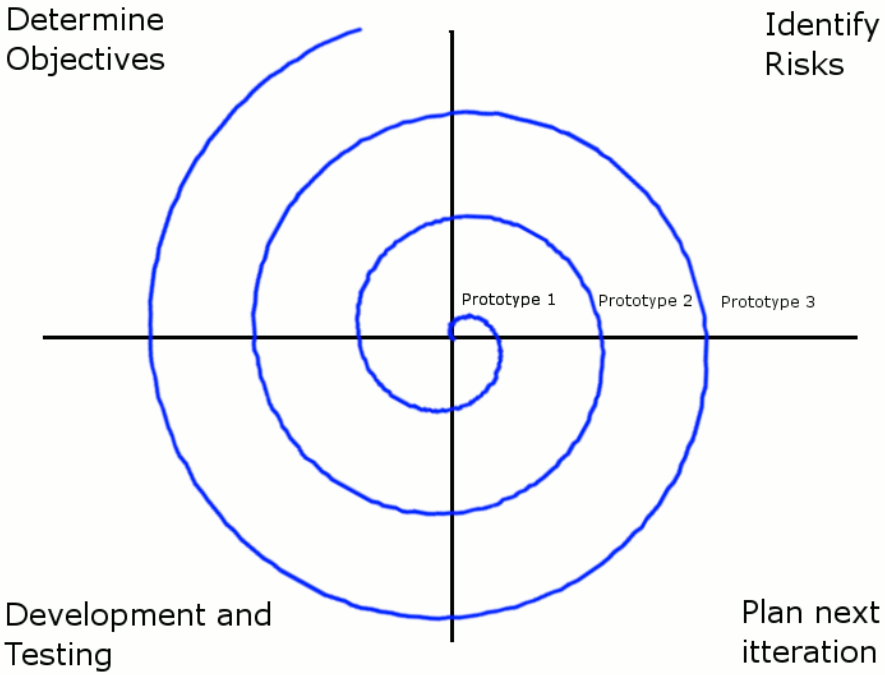


Vee Model



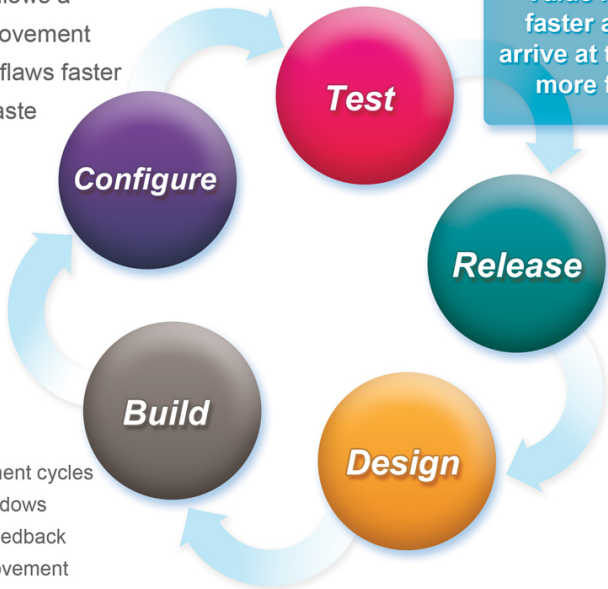
History of Rapid Development

Spiral Model



Agile Development

Development follows a continuous improvement cycle, exposing flaws faster and reducing waste



Value is achieved faster as releases arrive at the customer more frequently

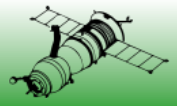
Advantage:

- Shorter development cycles
- Wider market windows
- Early customer feedback
- Continuous improvement

The Goal of All These Models

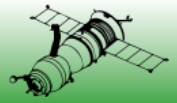
1. Build the Right Thing
2. Build the Thing Right
3. Accelerate the Development Process

Speed Doesn't Matter if You Fail at #1 or #2


Characteristics of “Rapid”

- A systematic approach to “building the right thing” and “building the thing right”
- “Just enough” bureaucracy to prevent chaos without handicapping flexibility
- Multi-disciplinary teaming and collaboration
- Delivering a capability “within 24 months” or “half the time of traditional acquisition”




DoD Directive 5000.01

The Defense Acquisition System

- 5 Tenets: flexibility, responsiveness, innovation, discipline, & streamlined/effective management
- Emphasizes satisfy user needs "*in a timely manner*, and at a fair and reasonable price"
- Plainly states that "there is no one best way to structure an acquisition program"
- Directs MDA & PM to "tailor program strategies and oversight…to fit the particular conditions of that program, consistent with the applicable laws and regulations and time sensitivity of the capability need."

DoD Instruction 5000.02

Operation of the Defense Acquisition System

- Proposes four models "tailored to the dominant characteristics of the product being acquired"
- Model #4: Accelerated Acquisition Program
  - Prioritizes schedule over cost or tech. performance
  - Acknowledges the "potential for inefficiencies" in order to field capability on a compressed schedule
  - Does not absolve PM from applying disciplined SE
  - PM must develop a SE Plan; conduct trade-off analyses and design reviews; identify, track and mitigate key program risks; & manage system config.

The Defense Acquisition Guidebook

Technical Processes

- Stakeholder Requirements Definition
- Requirements Analysis
- Architecture Design
- Implementation
- Integration
- Verification
- Validation
- Transition

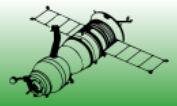
Tech. Mgmt Processes

- Technical Planning
- Requirements Management
- Interface Management
- Risk Management
- Config. Management
- Tech. Data Management
- Technical Assessment
- Decision Analysis

AF Instruction 63-114

Quick Reaction Capability Process

- Provides an “overarching framework used to satisfy warfighters’ urgent and compelling requirements” in an accelerated manner
- Presents a streamlined approach to field a QRC within 180 days of identifying an urgent need
- Exempts QRCs from traditional milestone reviews
- Delegates decision authority to the “lowest level appropriate to rapidly field” the proposed solution
- Acknowledges that a streamlined, accelerated program will have an elevated level of risk

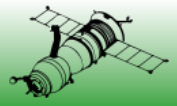

AF Instruction 63-114

Quick Reaction Capability Process

- Provides an "overarching framework used to

"The MDA must streamline the acquisition program to the maximum extent possible and accept appropriate risk to provide rapid capability to warfighting commanders. This explicit MDA authority and responsibility is central to QRC acquisition. The MDA, testers, lead command, and warfighters shall accept a level of risk higher than normal to satisfy urgent needs."

program will have an elevated level of risk


Air Force Research Laboratory Systems Engineering Guidebook

- Recognizes "Big A" acquisition rules are overly cumbersome for SciTech research
- Offers a streamlined SE process utilizing the "Eight Key Questions"
  - Based on Dr. George H. Heilmeier's Catechism
  - Used to assess/prioritize SciTech opportunities
  - Also used to regularly assess the health of programs previously approved for execution
  - Detail of answers varies depending upon project size, cost, risk, and technology maturity

AFRL's Eight Key Questions

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AFRL's Eight Key Questions	Questions from Heilmeier's Catechism
1. Who is your customer?	Who cares?
2. What are your customer's requirements?	What are you trying to do? If you are successful, what difference will it make?
3. How will you demonstrate that you have met those requirements?	What are the midterm and final "exams" to check for success?
4. What are the technology options?	How is it done today? What are the limits of current practice?
5. Which is the best approach?	What's new in your approach?
6. What are the risks to developing the selected technology?	What are the risks and the payoffs?
7. How will you structure your program to meet requirements & mitigate risk?	Why do you think [your approach] will be successful?
8. What is your business-based transition plan that meets customer approval?	How much will it cost? How long will it take?

1. Who is your customer?

Technical Processes		Tech. Mgmt Processes
Stakeholder Rqmts Definition	Q1	Tech. Planning
Rqmts Analysis	Q2	Rqmts Mgmt
Arch. Design	Q3	Interface Mgmt
Implementation	Q4	Risk Mgmt
Integration	Q5	Config. Mgmt
Verification	Q6	Tech. Data Mgmt
Validation	Q7	Tech. Assessment
Transition	Q8	Decision Analysis

2. What are your customer's requirements?

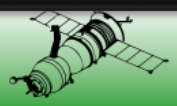
Technical Processes

- Stakeholder Rqmts Definition
- Rqmts Analysis
- Arch. Design
- Implementation
- Integration
- Verification
- Validation
- Transition

- Q1
- Q2
- Q3
- Q4
- Q5
- Q6
- Q7
- Q8

Tech. Mgmt Processes

- Tech. Planning
- Rqmts Mgmt
- Interface Mgmt
- Risk Mgmt
- Config. Mgmt
- Tech. Data Mgmt
- Tech. Assessment
- Decision Analysis


3. How will you demonstrate that you have met those requirements?

Technical Processes

- Stakeholder Rqmts Definition
- Rqmts Analysis
- Arch. Design
- Implementation
- Integration
- Verification
- Validation
- Transition

Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8

Tech. Mgmt Processes

- Tech. Planning
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- Interface Mgmt
- Risk Mgmt
- Config. Mgmt
- Tech. Data Mgmt
- Tech. Assessment
- Decision Analysis

4. What are the technology options?

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Technical Processes

- Stakeholder Rqmts Definition
- Rqmts Analysis
- Arch. Design
- Implementation
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- Transition

Q1
Q2
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Q7
Q8

Tech. Mgmt Processes

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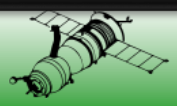


5. Which is the best approach?

Technical Processes

- Stakeholder Rqmts Definition
- Rqmts Analysis
- Arch. Design
- Implementation
- Integration
- Verification
- Validation
- Transition

- Q1
- Q2
- Q3
- Q4
- **Q5**
- Q6
- Q7
- Q8

Tech. Mgmt Processes

- Tech. Planning
- Rqmts Mgmt
- Interface Mgmt
- Risk Mgmt
- Config. Mgmt
- Tech. Data Mgmt
- Tech. Assessment
- Decision Analysis

6. What are the risks to developing the selected technology?

Technical Processes

- Stakeholder Rqmts Definition
- Rqmts Analysis
- **Arch. Design**
- Implementation
- Integration
- Verification
- Validation
- Transition

Q1
Q2
Q3
Q4
Q5
Q6
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Q8

Tech. Mgmt Processes

- **Tech. Planning**
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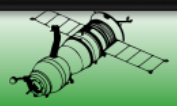


7. How will you structure your program to meet requirements & mitigate risk?

Technical Processes

- Stakeholder Rqmts Definition
- Rqmts Analysis
- Arch. Design
- Implementation
- Integration
- Verification
- Validation
- Transition

- Q1
- Q2
- Q3
- Q4
- Q5
- Q6
- **Q7**
- Q8

Tech. Mgmt Processes

- Tech. Planning
- Rqmts Mgmt
- Interface Mgmt
- Risk Mgmt
- Config. Mgmt
- Tech. Data Mgmt
- Tech. Assessment
- Decision Analysis

8. What is your business-based transition plan?

Technical Processes

- Stakeholder Rqmts Definition
- Rqmts Analysis
- Arch. Design
- Implementation
- Integration
- Verification
- Validation
- Transition

Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8

Tech. Mgmt Processes

- Tech. Planning
- Rqmts Mgmt
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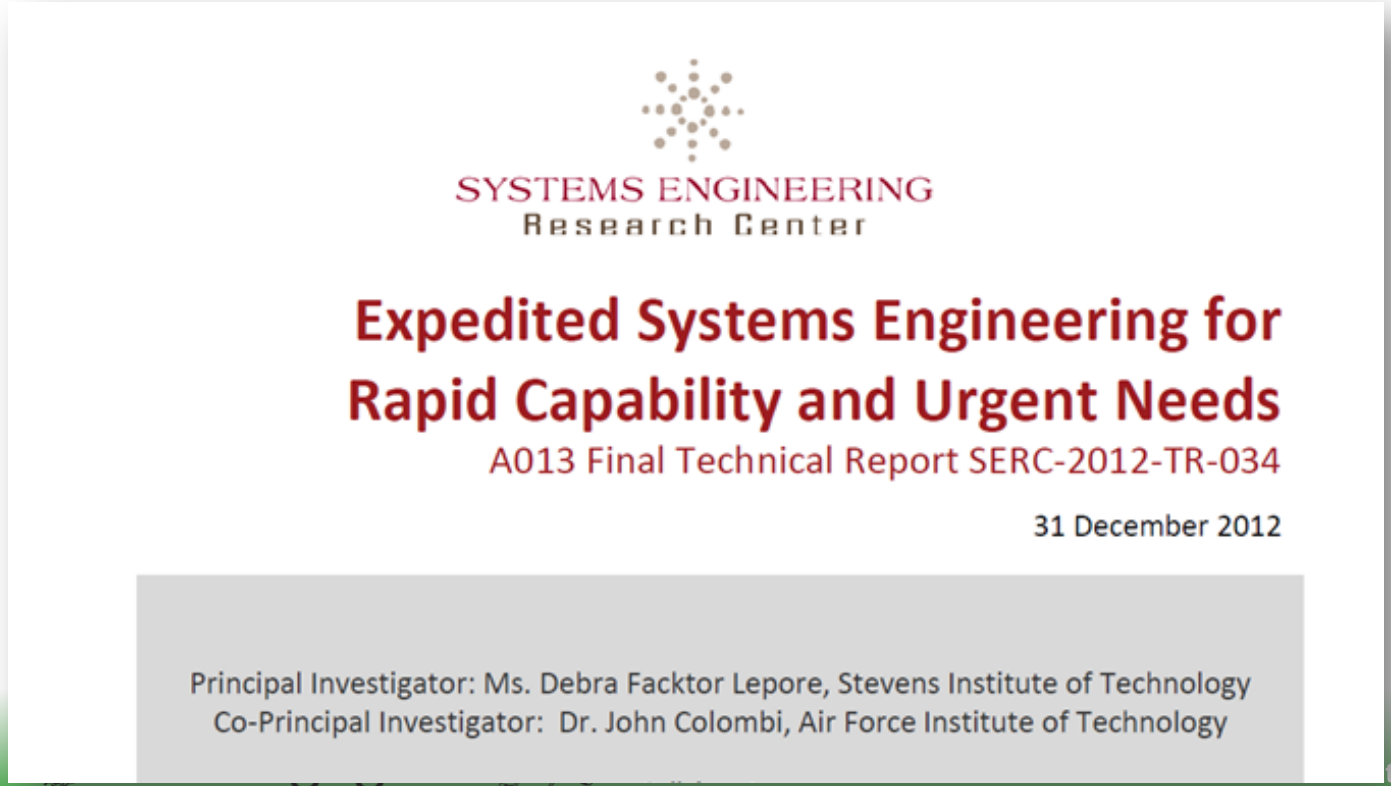
- Decision Analysis

Other Thoughts on Rapid
Ward's "FIST" Model

- "[A] decision-making framework…to help people make good decisions by guiding them toward opportunities to **streamline, accelerate, & simplify** various dimensions of the program."
- Define clear requirements that can be satisfied in short order by small teams w/ small budgets

Other Thoughts on Rapid
SERC Research Topic 34 (RT-34)

- Assessed the people, processes, & products associated with successful rapid acquisition programs



SYSTEMS ENGINEERING
Research Center

Expedited Systems Engineering for Rapid Capability and Urgent Needs

A013 Final Technical Report SERC-2012-TR-034

31 December 2012

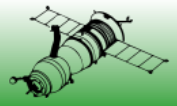
Principal Investigator: Ms. Debra Facktor Lepore, Stevens Institute of Technology
Co-Principal Investigator: Dr. John Colombi, Air Force Institute of Technology

RT-34's "Lanes" of Rapid Acquisition

- Laboratory Demo / Operational Prototypes
- Rapid Platform Engineering
- Rapid Integrated Solutions
- New Rapid Development

RT-34's Eleven Observations

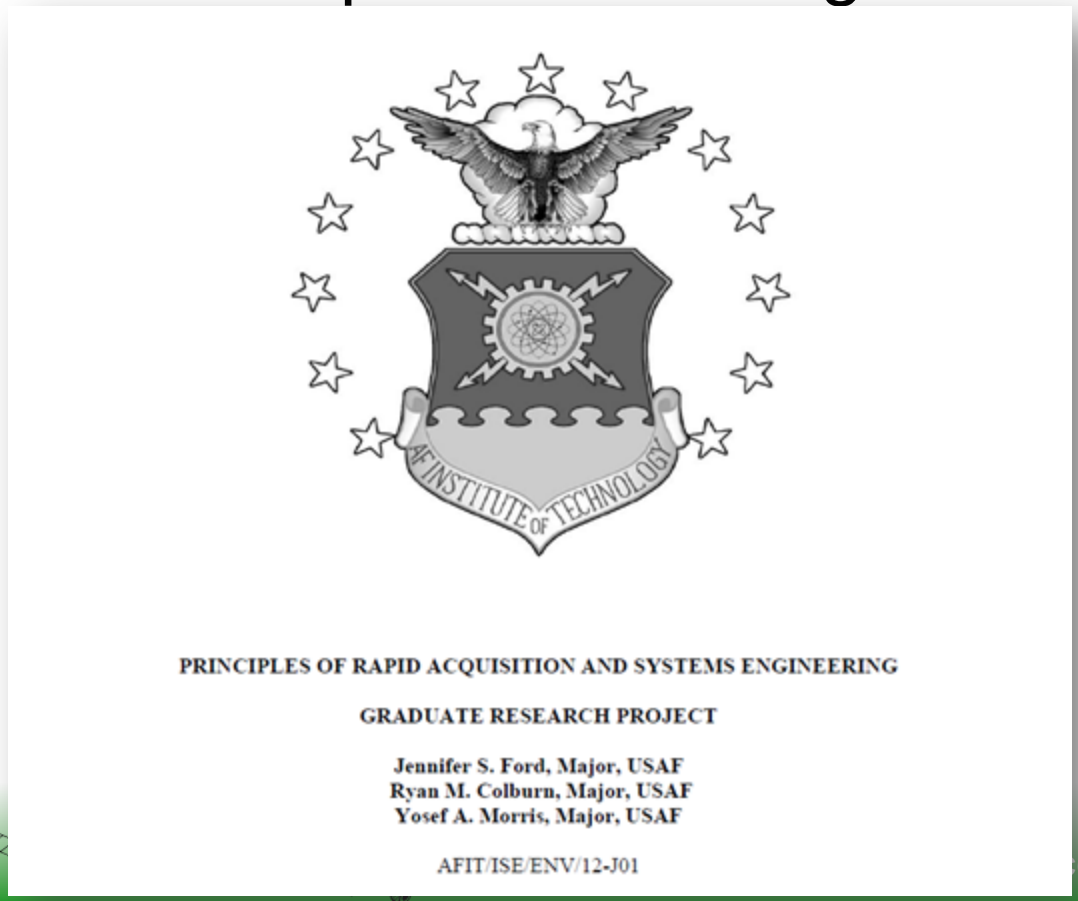
1. Use mature technology – focus on the state of the possible
2. Incremental deployment (development) is part of the product plan
3. Strive for a defined set of stable requirements focused on warfighter needs
4. Work to exploit maximum flexibility allowed
5. Designing out all risks takes forever – accept some risk
6. Keep an eye on normalization
7. Build and maintain trust
8. Populate your team with specific skills and experience
9. Maintain high levels of motivation and expectations
10. The Government team leads The way
11. Right-size the prgm – eliminate or reduce major prgm oversight


Other Thoughts on Rapid

AFIT's Twelfth Principle

- Emphasized the use of "small teams" that are "co-located to facilitate face-to-face interaction in order to facilitate problem solving and work"



PRINCIPLES OF RAPID ACQUISITION AND SYSTEMS ENGINEERING

GRADUATE RESEARCH PROJECT

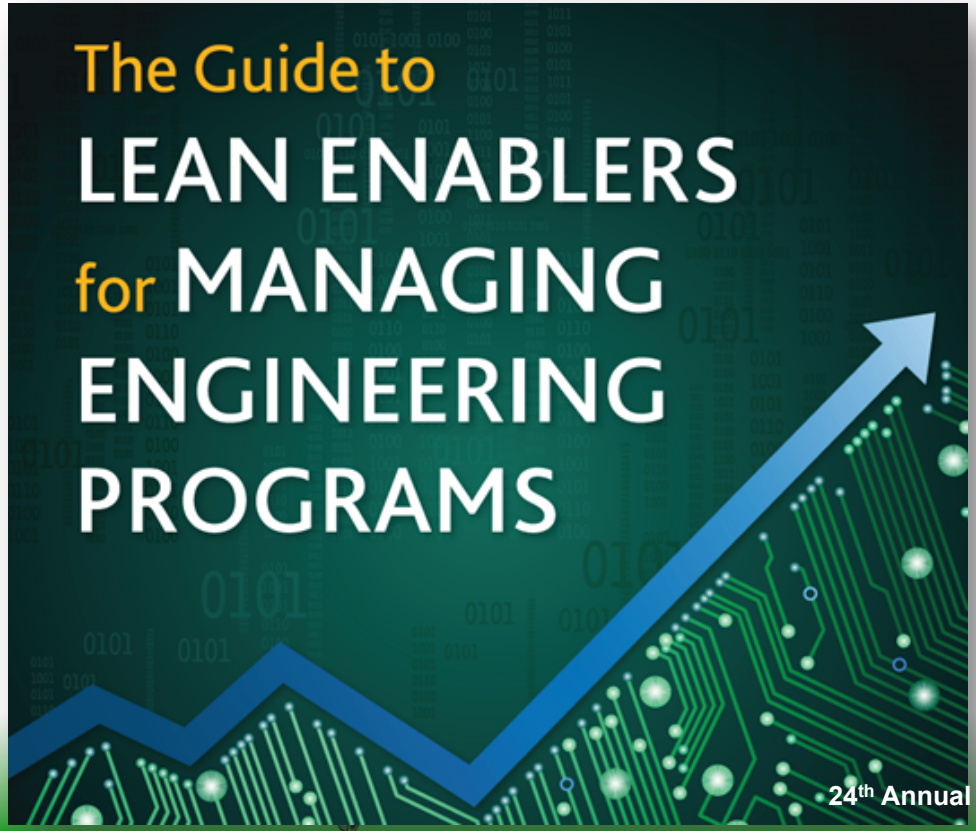
Jennifer S. Ford, Major, USAF
Ryan M. Colburn, Major, USAF
Yosef A. Morris, Major, USAF

AFIT/ISE/ENV/12-J01

Other Thoughts on Rapid

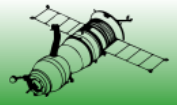
Lean Enablers for Managing Engineering Programs

- Examined the "top challenges that engineering programs face today"
- Grouped challenges into "10 Major Themes"



Other Thoughts on Rapid Lean Challenges – Ten Major Themes

1. Firefighting – reactive program execution
2. Unstable, unclear and incomplete requirements
3. Insufficient alignment & coordination of the extended enterprise
4. Locally optimized processes that are not integrated across the entire enterprise
5. Unclear roles, responsibilities and accountability
6. Mismanagement of program culture, team competency, and knowledge
7. Insufficient program planning
8. Improper metrics, metric systems, and key performance indicators
9. Lack of proactive program risk management
10. Poor program acquisition and contracting practices


Other Thoughts on Rapid Lean Challenges – Ten Major Themes

1. Firefighting – reactive program execution
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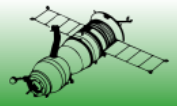
4. Locally optimized processes that are not integrated across the entire enterprise
5. Unclear roles, responsibilities and accountability

Applying RT-34's Eleven Key Observations of agile organizations appears to be an effective way to combat the majority of the 10 Major Themes

9. Lack of proactive program risk management
10. Poor program acquisition and contracting practices

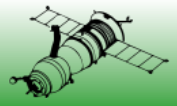

So Where Did My "Award Winning" Rapid Development Program Go Wrong?

Other Players

- Air Force Lifecycle Management Center
  - The System Program Office or “SPO”
  - Responsible for airworthiness certification and verifying mods met crash safety standards
- Air Force Test Center
  - The “Tester”
  - Responsible for developmental test planning and execution, and overall test safety
- Air Force Special Operations Command
  - The “User”

Initial Requirements

- A “palletized” machine gun system
- Side-firing installation with a remote trigger
- Lightweight, durable, inexpensive, simple to produce, and easy to install and remove
- No permanent aircraft modifications
- Acceptable range and accuracy
- Utilizes existing support equipment

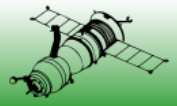




Defense Acquisition University

Twelve Attributes of a "Good" Requirement

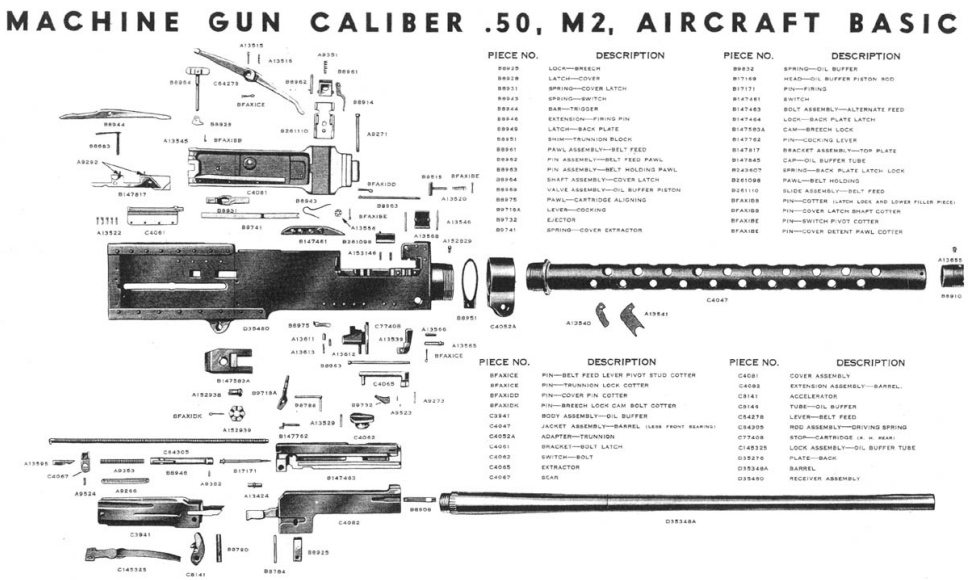
- Necessary
- Unique
- Unambiguous
- Complete
- Consistent
- Technically feasible
- Traceable
- Measurable/quantifiable
- Verifiable
- Able to be validated
- Operationally effective
- Singular

Tropic Thunder Requirements Definition Was Conversational and Informal; An Actual Requirements Document Was Never Generated


Design Approach

- Heavy reuse of combat-proven components
  - 0.50 caliber GAU-18 selected … WWI lineage
  - Tandem GAU-18s mounted in a Mk-95 Receiver atop a M93 helicopter gun mount



Design Approach

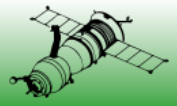
- No permanent aircraft modifications
  - Port side window removed to provide a temporary portal for the gun barrel
  - Aircraft cargo track system would serve as structural attach point for gun assembly
  - Required design/fabrication of a “pallet/riser” to interface the M93 mount to the track system
- Raw material selection considered weight, machinability, durability, and availability
  - Selected 6061-T6 aluminum for pallet design

Design Approach

- Virtual design, assembly, and analysis
  - Pallet designed w/ SolidWorks 3D Simulation
  - Components fit-checked in virtual aircraft
  - CAD file converted into Finite Element Model for 3D structural analysis & design refinement
- Multiple technical design reviews with SPO, Tester & User participation
- Leveraged Lab's rapid prototyping facility
  - CAD file transferred to CNC milling machine where prototype pallet was quickly fabricated

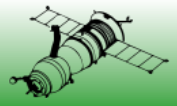
"Proof of Concept" Test
– 20 March 2013 –

- Test Objectives:
  - Instrumentation "shake-down"
    - Pressure probes to measure blast overpressure
    - Strain gauges on pallet to measure recoil load
  - Validate the test configuration for future "off aircraft" ground testing
- Test accomplished without incident

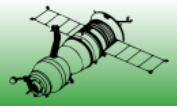

Ground Test #1
– 9 April 2013 –

- Test Objectives:
  - Measure recoil loads transmitted through pallet and into “simulated” cargo track system
  - Measure GAU-18 blast overpressure
- Post-Test Analysis
  - Assess “system effects” on the aircraft floor
  - Determine whether blast overpressure from the gun would be detrimental to aircraft skin
- Test accomplished without incident

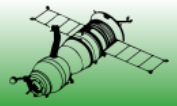

Post-Test Debrief
– 9 April 2013 –

- SPO asked Lab engineers when the blast overpressure analysis would be complete
- Lab had assumed that either the SPO or the Tester would perform the analysis
- Challenges
  - Significant change in Lab's scope of work
  - Required technical expertise nobody on the Lab, SPO, or Tester teams possessed

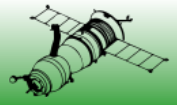

Detailed Design Review
– 10 April 2013 –

- New issue: cargo track structural integrity
  - Info on track system was “spec sheet” level
  - No analysis provided to back up the specs
  - No certification that track system had been fabricated & assembled IAW the specs
  - Aircraft had been designed in one foreign country, and manufactured in another
- The SPO mandated an increased factor of safety on the cargo track’s limit-load


Detailed Design Review
– 10 April 2013 –

- The SPO also mandated a litany of airworthiness requirements on the Lab
  - The SPO defined these requirements in February but did not share them until April
  - Many of these requirements were outside the Lab's area of expertise
  - Other requirements demanded far more work than the Lab had envisioned for the project

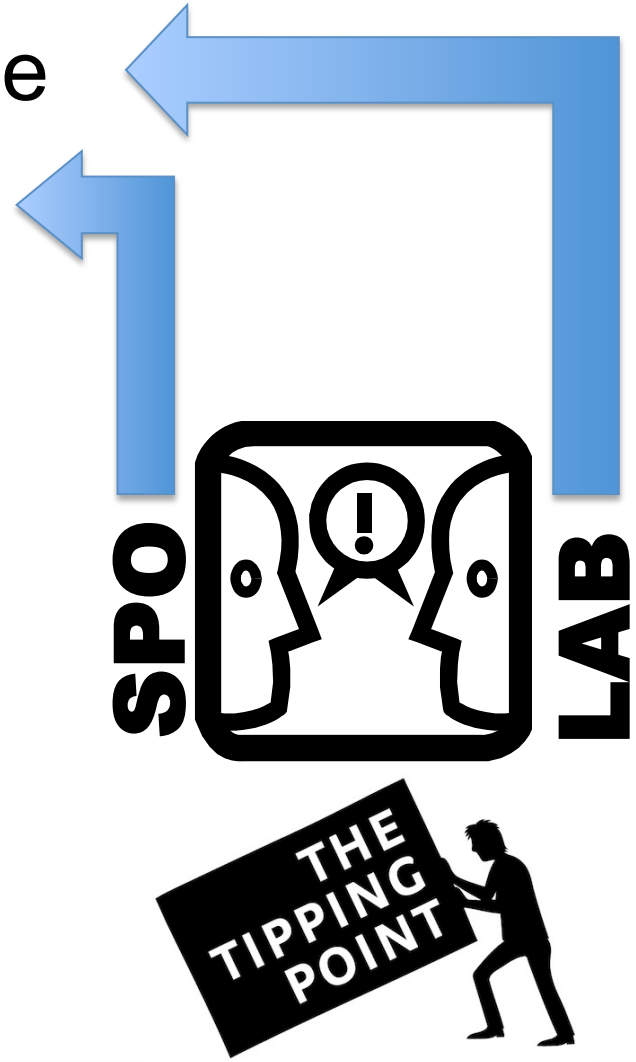




Time to Redesign

- Baseline design exceeded new limit load
- Resolved via 120 lb weight reduction
  - Replaced tandem design with a single .50 cal
  - Replaced the Mk-95 dual-barrel receiver with a Mk-94 single-barrel receiver
  - Analysis confirmed stresses now within limits
- The Lab further reduced floor stress by adding another floor tie-down point
  - The SPO demanded the analysis be redone

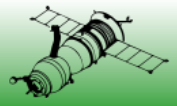
Which “Lane” Are We In?

- Laboratory Demo / Prototype
- Rapid Platform Engineering
- Rapid Integrated Solutions
- New Rapid Development



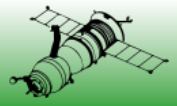
Ground Test #2
– 25 July 2013 –

- Test Objectives:
  - Measure recoil loads transmitted through pallet and into aircraft cargo track system
  - Perform end-to-end check of installed system
  - Assess readiness for flight test
- Test accomplished without incident
  - All parties agreed to proceed to flight


Airborne Test #1
– 12 August 2013 –

- Test Objectives:
  - Assess any changes in the aircraft flying qualities associated with the gun installation
  - Perform end-to-end check of installed system by “dry-firing” the gun in flight
  - Assess readiness for “live-fire” mission
- Test accomplished without incident
  - No significant changes in flying qualities noted
  - All parties agreed to proceed to “live-fire”

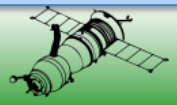

Airborne Test #2
– 14 August 2013 –

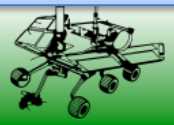
- Test Objectives:
  - Perform end-to-end check of installed system by “live-firing” the gun in flight
  - Assess readiness for limited fielding
- Test accomplished without incident
  - System cleared for limited fielding

Program Participation Matrix

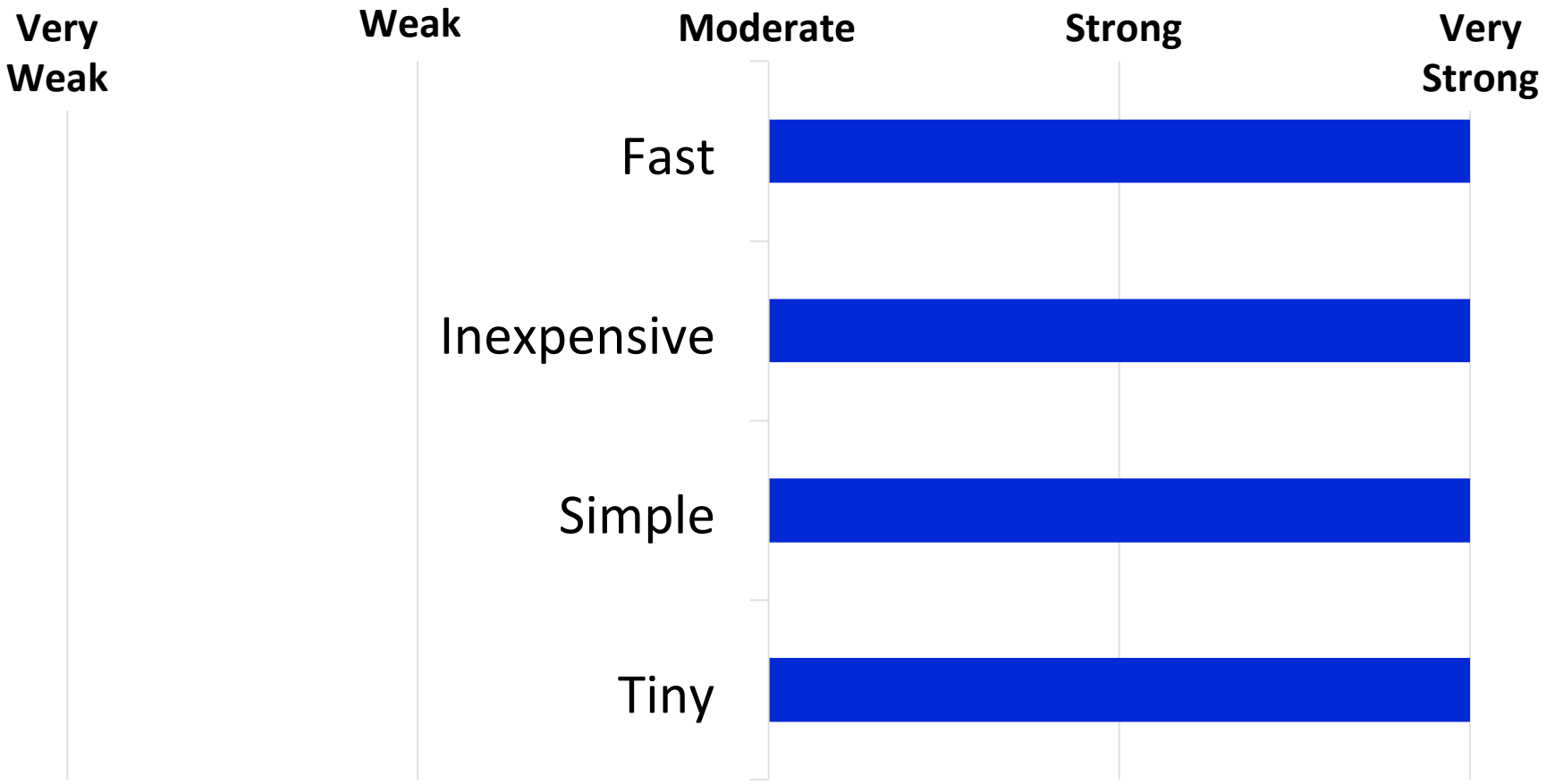
Date	Event	Participants			
		Lab	SPO	Tester	User
Mid Sep 2012	Project Conception	–	–	–	L
Late Nov 2012	Design Initiation	L	–	–	S
20 Feb 2013	Initial Design Review	S	L	O	O
20 Mar 2013	Lab "Proof of Concept" Demo	L	–	S	O
09 Apr 2013	Ground Test #1 (Off Aircraft)	S	O	L	O
09 Apr 2013	Technical Interchange	S	S	O	L
10 Apr 2013	Detailed Design Review	S	L	–	O
02 Jul 2013	Ground Test Risk Mgmt Board	S	O	L	O
25 Jul 2013	TW Ground Test #2 (On Aircraft)	S	O	L	O
29 Jul 2013	Flight Test Risk Management Board	S	O	L	O
01 Aug 2013	Non-Nuclear Munition Safety Board	O	O	L	O
07 Aug 2013	Flight Test Technical Review Board	–	O	S	O
12 Aug 2013	Flight Test #1 (Captive Flight)	S	O	L	O
14 Aug 2013	Flight Test #2 (Live-Fire Test)	S	O	L	O

LEGEND: L – Lead Organization; S – Supporting Organization; O – Observer




Ward's "FIST" Model



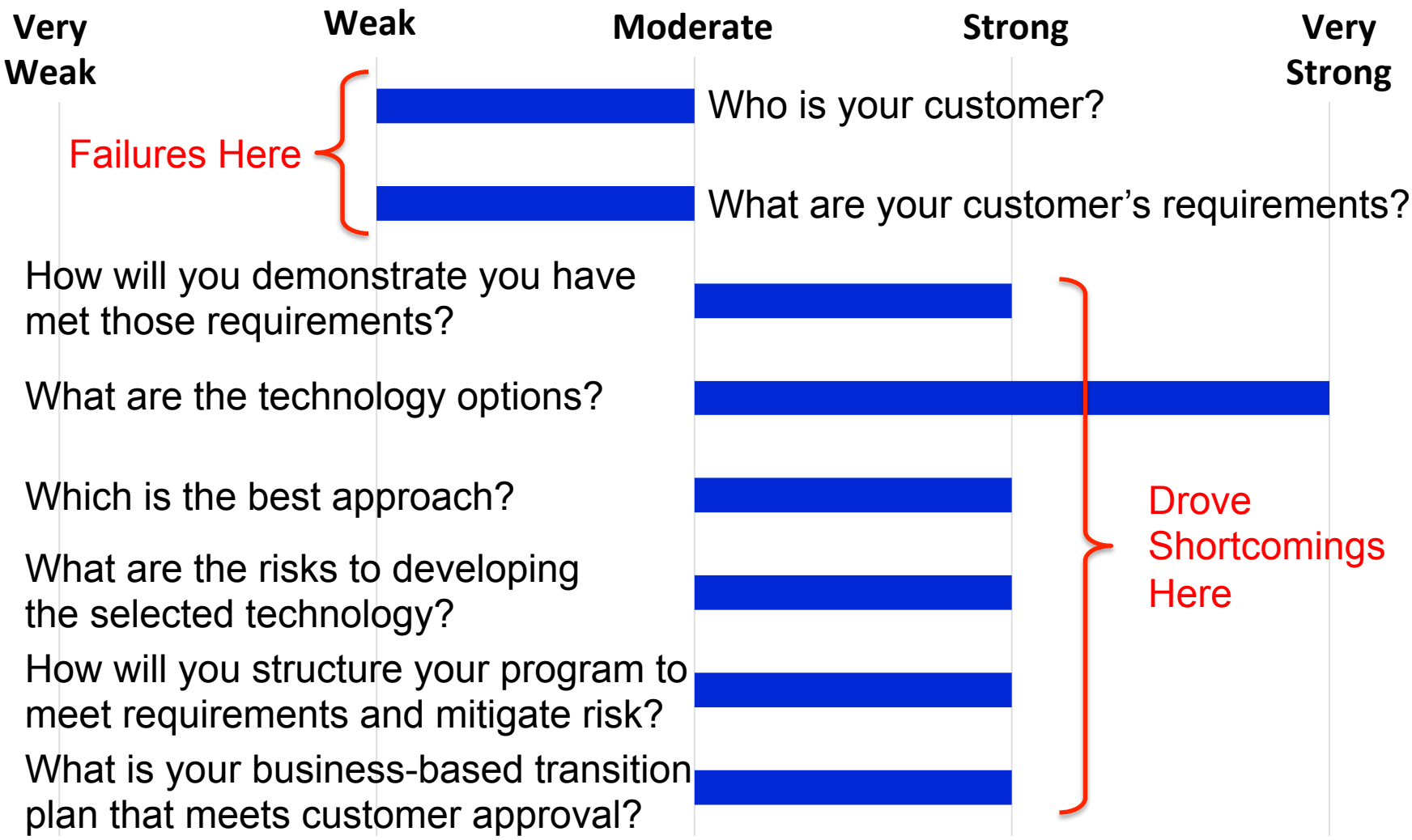
Ward's "FIST" Model

- FAST: Initial estimate was three months
- INEXPENSIVE: Initial estimate was $100K
- SIMPLE: leveraging existing technologies, battle-proven hardware, and raw materials that readily available and easy to machine
- TINY: small team, low cost, short schedule

Tropic Thunder Was the Epitome of FIST…

…So What Went Wrong?

AFRL's Eight Key Questions



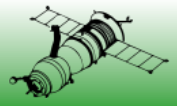
AFRL's Eight Key Questions

INCOSE International Symposium
Las Vegas, NV
June 30 - July 3, 2014

Technical Processes		Tech. Mgmt Processes
Stakeholder Rqmts Definition	Q1	Tech. Planning
Rqmts Analysis	Q2	Rqmts Mgmt
Arch. Design	Q3	Interface Mgmt
Implementation	Q4	Risk Mgmt
Integration	Q5	Config. Mgmt
Verification	Q6	Tech. Data Mgmt
Validation	Q7	Tech. Assessment
Transition	Q8	Decision Analysis

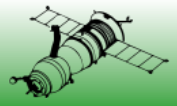
AFRL's Eight Key Questions

- In order to establish a new case file, the project team must answer the 8 questions
- The PM by-passed the 8 Q's by using an existing project case file … his logic:
  - This was a simple, low-risk project
  - He knew exactly what he needed to do to accomplish the mission
  - The case file was a bureaucratic, non-value-added process that would delay project start


AFRL's Eight Key Questions

- A more comprehensive assessment would have considered all stakeholders and their requirements, not just the user's input
  - The SPO's requirement for a robust design package, not just a "proof of concept" demo
  - The SPO's airworthiness requirements
  - The SPO's concern about the structural integrity of the aircraft cargo track system
  - The SPO's expectations RE test data


RT-34's Eleven Observations

INCOSE International Symposium
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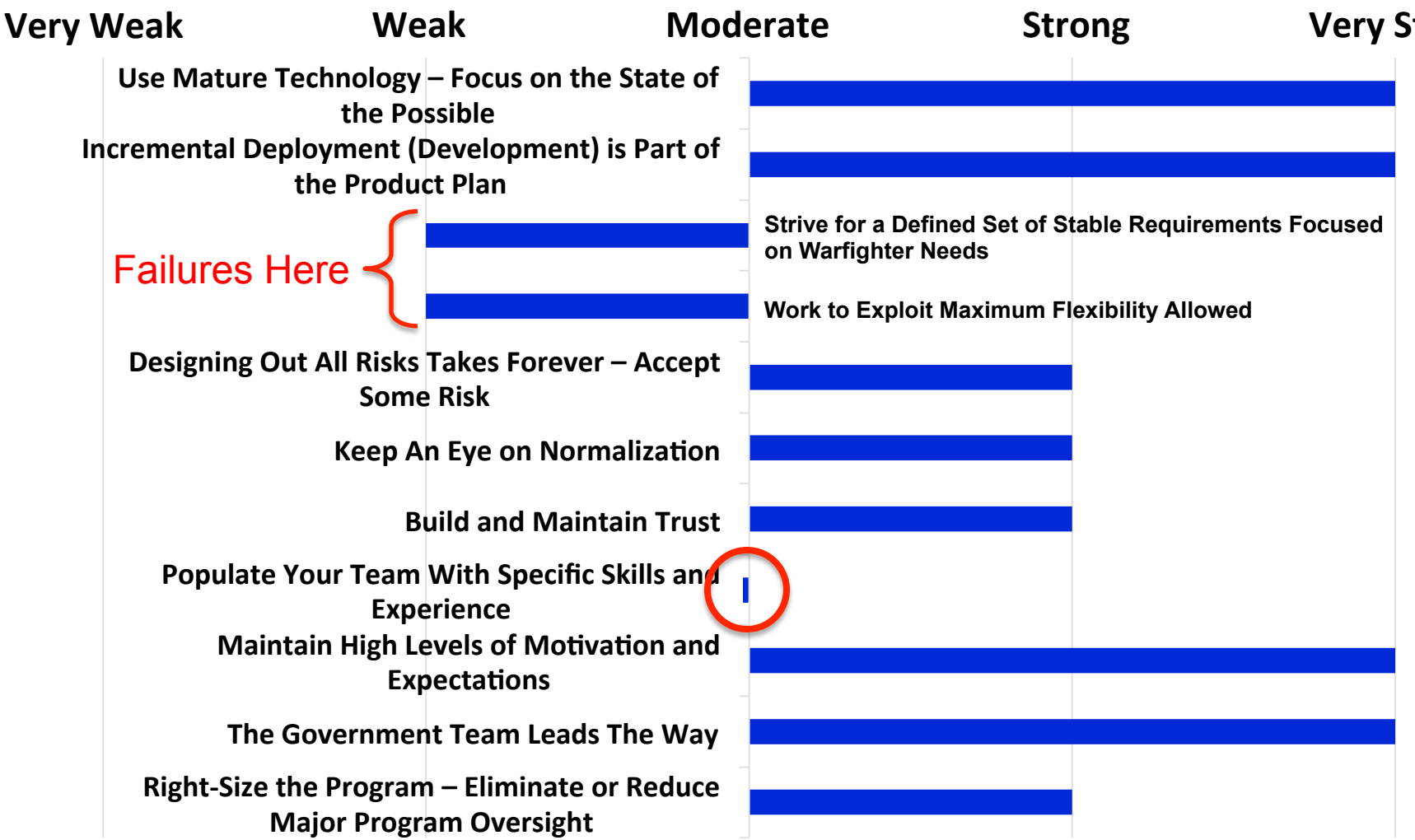
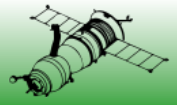


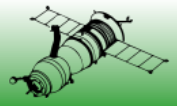
The AFRL Team

- Four (4) civilians and one (1) junior officer
- PM: non-supervisory engineering technician
  - 20-year career in explosive ordnance disposal
  - No formal engineering or PM credentials
  - 5 years in current position
  - Became very ill during the program
- Lead Engineer: BS in Civil Engineering
  - BS emphasized structural mechanics
  - 4 years in current position

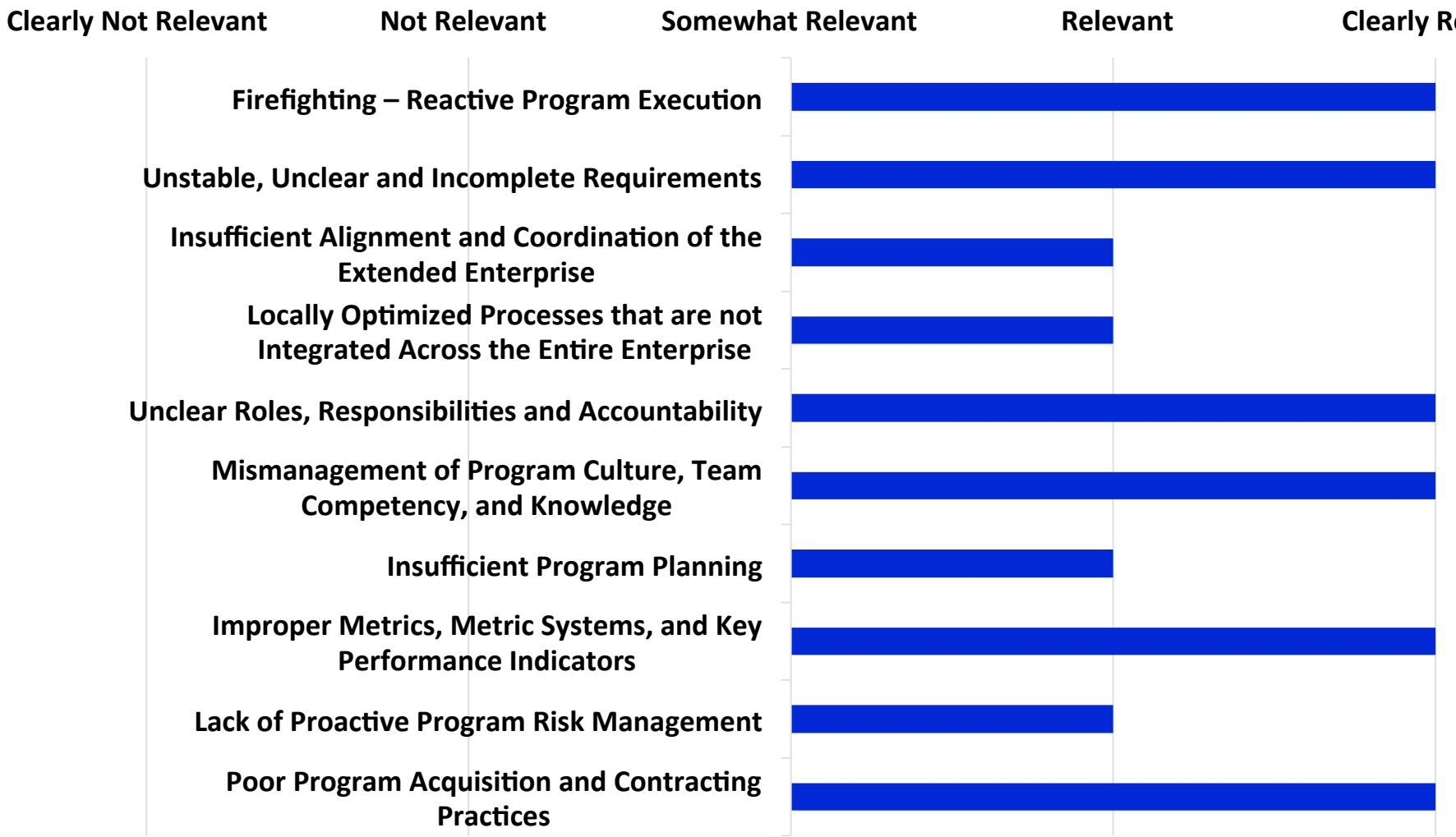




The AFRL Team

- Junior Engineer: BS in Mechanical Engineering
  - BS emphasized structural mechanics
  - 1 year in current position
  - Served as acting PM when assigned PM became ill
- Engineering Technician #1
  - Associate Degrees in Engineering Technology
  - 5 years in current position
- Engineering Technician #2
  - Associate Degrees in Engineering Technology
  - 3 years in current position

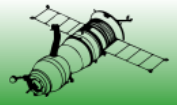




Lean Challenges – Ten Major Themes



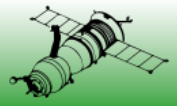
Similarity to other AFRL Projects

- Project urgency – greater than typical
- User engagement – higher than typical
- Level of oversight – less than typical
- Team demographics – *very* atypical
- Project alignment with AFRL core competencies – less than typical

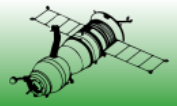

Lessons Re-Learned

- Sometimes you have to go slow to go fast
  - Engineers often like to leap to the solution
  - In leaping to a solution, AFRL failed to fully ID all the stakeholders and their requirements
- Early customer involvement is ineffective if they do not engage in the design process
  - SEs should push stakeholders to contribute
- A valid requirement must be measurable
  - Writing them down is a good idea, too!


Lessons Re-Learned

- Testing is more than collecting data
  - Must have a plan for how to use that data
  - The plan must address roles & responsibilities
- Must understand the "system effects" of modifications to existing systems
  - Can be a challenge if the "system" is COTS
- Sometimes a situation is not as it seems
  - Must dig into the details to get the full picture


Q & A