Large-Scale Federal Weapons Programs Continue to Experience Unprecedented Cost and Schedule Growth

This is a Huge Loss
To both Warfighters and Taxpayers

How Big is this Loss?

$295B

Total Cost Growth

21 months

Average Schedule Delay

Ref. GAO-08-467SP, "Assessments of Selected Weapons Programs" (2008)

Best Project Management and Systems Engineering Practices for Large-Scale Federal Acquisition Programs

Steven Meier, Ph.D., PMP

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The Golden Axiom

One of the golden axioms of project management remains true – namely, most unsuccessful programs fail at the beginning

Pre-Acquisition Phase

Early pre-acquisition phase activities – *those activities prior to program initiation (authority to proceed (ATP) shown as milestone B below)* – can significantly reduce the risk of cost and schedule growth on large-scale acquisition programs

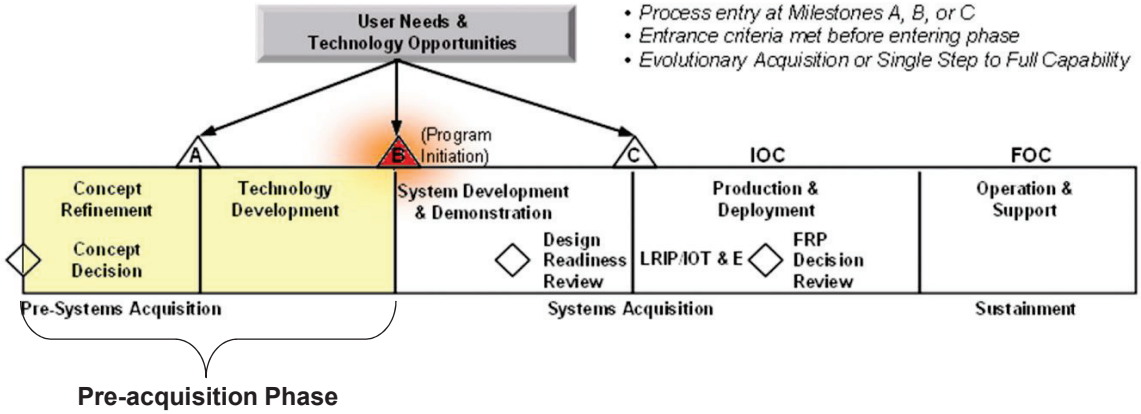

Fig. 1. Defense Acquisition Management Framework. Department of Defense (DOD). (2005). Integrated Defense Acquisition, Technology, & Logistics Life Cycle Management Framework. Defense Acquisition University Publication, www.dau.mil.

Study Background

- **A study was undertaken to improve internal organizational acquisition processes**
- **It focused on large-scale federal programs that included tanks, aircraft, satellites, missiles, and information systems**
- **The data sources for this study included:**
  - 6 Requests for Information (RFIs) from industry
  - 30 Reports, documents, and studies
  - 42 Interviews with federal and industry executives
  - 3 National laboratories
  - 2 Think tanks
- **This study added to the existing knowledge base of best acquisition practices – the data confirmed other studies' results and provided new information on common causes of cost and schedule growth**

Common Causes of Cost and Schedule Growth for Large-Scale Systems

1. **Overzealous Advocacy**
2. **Immature Technology**
3. **Lack of Corporate Roadmaps**
4. **Requirements Instability**
5. **Ineffective Acquisition Strategy and Contractual Practices**
6. **Unrealistic Program Baselines**
7. **Inadequate Systems Engineering**
8. **Inexperienced Workforce and High Turnover**

1. Overzealous Advocacy

- **What is it?**
  - Unquestioned, overly enthusiastic support of a program that over promises capabilities and leads to optimistic program estimates
- **Why does it occur?**
  - Frequent senior management turnover
  - An agency's desire to gain positive political light by taking the lead
  - Group think (drinking the corporate Kool-Aid)
  - Personal promotion (either GS or military rank)
  - Consolidation of aerospace industry → low bids by industry
- **Study Comments**
  - The program suffered from "excess optimism"
  - Frequent turnover makes it "hard to establish accountability"
  - Decision makers need to "re-examine decisions as new information is disclosed"
  - The "prime contractor should not fear retribution for bearing bad news"

Overzealous Advocacy (cont.)

- **Additional Impact**
  - Program baselines that include optimistic cost, schedule, & performance estimates
  - No risk management plan
  - In the worst scenarios, suppression of bad news
- **Recommendations**
  - Conduct rigorous internal and external panels prior to the authority to proceed (ATP) acquisition milestone and other key milestones
  - Develop a detailed end-to-end risk management plan prior to ATP
  - Develop a robust, timely communication plan
  - Empower a corporate “devil’s inquisitor” who questions the program’s assumptions
  - Ensure all ATP milestone entrance and exit criteria are adhered to

2. Immature Technology

- **What is it?**
  - Beginning a program without adequate verification that the program technologies have reached the proper maturity level prior to entering the execution phase
- **Why does it occur?**
  - The desire to incorporate state-of-the-art technology to improve system performance
  - A cutting-edge technology program is more appealing to stakeholders
  - The pressure to adhere to a short, demanding program schedules
  - The belief that system and technology development can be accomplished in parallel
- **Study Comments**
  - There is a “huge economic multiplier in making the up-front investment to ensure that the technology is mature prior to acquisition”
  - That the “government pushes the state of the art in technology, operates with unstable requirements, and doesn’t adequately develop technology before using it”
  - Cost growth occurred because we “counted on technology that had not been adequately developed prior to ATP”
  - Examples: F-22A, NPOESS, Future Combat System (FCS)

Immature Technology Impacts (cont.)

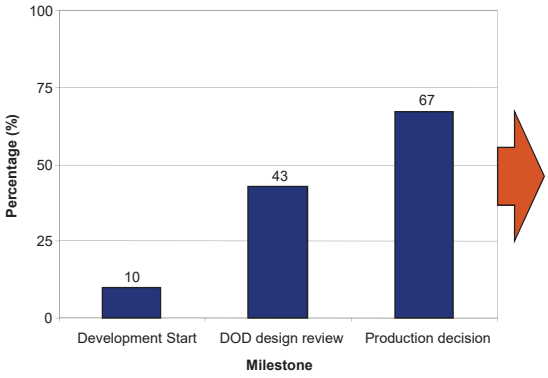

Fig. 2. Percentage of programs that achieved critical technology maturity levels at key milestones from GAO-06-391 (2006).

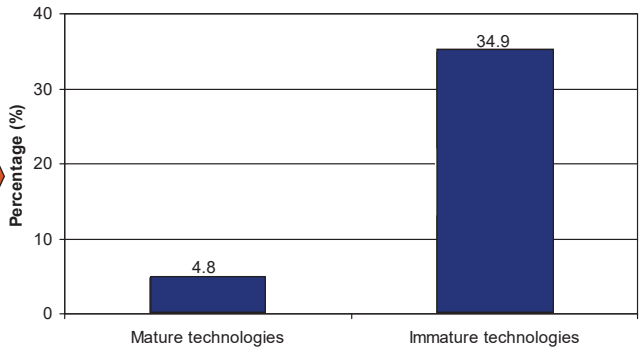

Fig. 3. Average program research, development, test, and evaluation cost growth from first full estimate from GAO-06-391 (2006).

Developing and maturing dependent technologies in parallel with system development post-ATP leads to cost growth

* Development Start is roughly equivalent to Authority to Proceed Milestone (ATP)
* DOD design review is roughly equivalent to Preliminary Design Review (PDR)
* Production Decision is roughly equivalent to Critical Design Review (CDR)

Immature Technology (cont.)

- **Additional Impact**
  - Cannot achieve mission performance
- **Recommendations**
  - Conduct internal and external technology assessments prior to ATP
  - Mature all technologies to a Technology Readiness Level (TRL) 6 *(system/subsystem model or prototype demonstration in a relevant environment)* prior to ATP
  - Review the industrial base to support the program and mature all manufacturing processes to a Manufacturing Readiness Level (MRL) 6 *(system, component or item in prototype demonstration beyond bread board, brass board development)* prior to ATP

3. Lack of Corporate Roadmaps

- **What is it?**
  - Many organizations have no clear corporate investment strategy that links research and development (R&D) to operational systems
- **Why does it occur?**
  - DoD starts many more programs they can afford (GAO-06-110)
  - A lack of empowered and insightful personnel to develop roadmaps and clearly identify the technical risk areas
  - A lack of corporate support for internally funded planning activities
- **Study Comments**
  - The DoD and IC need "an evolutionary plan to evolve capabilities with future technologies commensurate with risk"
  - That "establishing the program baseline discipline is not easy as it requires a comprehensive strategic business plan vetted through senior leadership"
  - Industry and government need to "fund technology development through qualification prior to incorporation into an operational development program"

Lack of Corporate Roadmaps (cont.)

- **Additional Impact**
  - Technology development extends into the execution phase
  - No prioritization of the program portfolio which slows decision making
  - Total system performance can be affected
- **Recommendations**
  - Federal agencies – in coordination with industry – need to develop corporate technology roadmaps with well-defined technology maturation and insertion dates
  - Regular reviews of industrial base and government laboratories technology developments and capabilities

4. Requirements Instability

- **What is it?**
  - The addition, modification, or relief of system requirements during the acquisition lifecycle
- **Why does it occur?**
  - Too many stakeholders with divergent needs and wants
  - No program approved requirements baseline
  - Agencies routinely accept requirements changes post-ATP with no understanding of system impacts
  - Technology maturity activities initiated too late (post-ATP)
- **Study Comments**
  - The Navy and contractor "didn't seem to on the same page in terms of what the requirements were and what exactly the contractor was required to deliver"
  - The "larger user community involvement in defining interfaces and requirements drive us to new technologies and use of large systems of systems"
  - One study states "4-5 Key Performance Parameters (KPPs)* are sufficient"

*KPPs are defined as those attributes or characteristics that are considered critical or essential to the development of an effective military capability

Requirements Instability Impacts

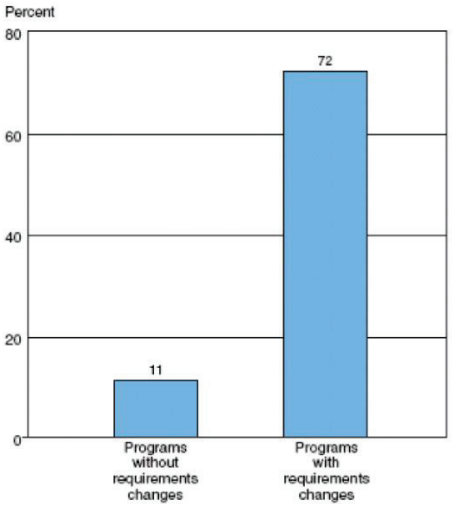

Fig. 4. Average RDT&E cost growth for programs over initial estimates (GAO-08-4675P)

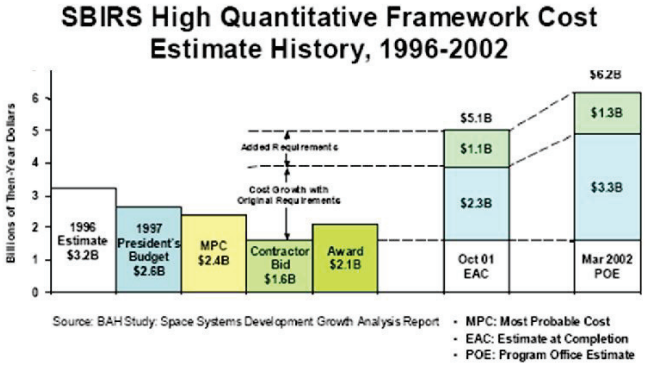

Fig. 5. SBIRS-High cost growth due to requirements instability. BAH Study on Space Systems Development Growth (2002)

Requirements changes lead to cost growth.

Requirements Instability (cont.)

- **Additional Impact**
  - Underestimation of system impacts
  - Cannot achieve technical mission performance
- **Recommendations**
  - Have a vetted, approved requirements baseline prior to ATP – "lock them down at the System Readiness Review (SRR)"
  - Implement a no change requirements policy and stick to it – the program objectives were "clearly stated in the proposal and were not allowed to creep upward"
  - Focus on what is most important – limit program KPPs to six
  - Implement a government led change control board (CCB) and require a cost/benefit evaluation for any suggested change

5. Ineffective Acquisition Strategy and Contractual Practices

- **What is it?**
  - Flawed buying strategy coupled with contract practices that do not facilitate understanding or motivate contractors
- **Why does it occur?**
  - No government corporate roadmaps with investment strategy
  - Inexperienced government workforce
  - Ineffective award fee plans and criteria (objective vs. subjective)
  - Ambiguous statement of work (SOW) – the government doesn't know what it wants
- **Study Comments**
  - The government should consider block buys since this would "permit cost efficiencies" and "retain workforce"
  - Consider "shoulder-to-shoulder Alpha contracting" since "Alpha contracting saves time"
  - The Government should consider a "metrics-based award fee criteria"
  - The Government should "align incentive structures with program objectives" and use a "tailored mix of base, award, and incentive fees"

Ineffective Acquisition Strategy and Contractual Practices (cont.)

- **Additional Impact**
  - Miscommunication between government and industry resulting in slow or bad decisions
  - Loss of economies of scale and retention of workforce
  - Ineffective incentives that do not motivate contractors
- **Recommendations**
  - Consider block buy approaches
  - Conduct face-to-face contract negotiations
  - Develop metrics based award fees with a mix of incentives that align with the program objectives
  - Develop clear and concise statements of work

6. Unrealistic Program Baselines

- **What is it?**
  - Failure to adequately conduct early studies, trades, and analysis that leads to an inaccurate cost, schedule, and performance program baseline
- **Why does it occur?**
  - Overzealous advocacy that rejects realistic cost, schedule, and performance baselines
  - Contractors submit low bid proposals to win a proposal
  - Inexperienced workforce and high turnover lead to an inadequate review proposals and an inability to generate a credible program baseline
- **Study Comments**
  - That “unrealistic cost estimates lead to unrealistic budgets and unexecutable programs”
  - Early on “advocacy dominates the program formulation phase”
  - The government has a blind “reliance on contractor proposals”
  - There exists “inadequate technical, operational, and system understanding in the pre-acquisition phase”
  - That “unrealistic cost and schedule expectations during proposal result in catastrophic consequences”

Unrealistic Program Baselines (cont.)

Program		Initial estimate	Initial quantity	Latest estimate	Latest quantity	Percent of unit cost increase
Joint Strike Fighter		$189. 8 billion	2,866 aircraft	$206.3 billion	2,458 aircraft	26.7
Future Combat Systems		$82.6 billion	15 systems	$127.5 billion	15 systems	54.4
F-22A Raptor		$81.1 billion	648 aircraft	$65.4 billion	181 aircraft	188.7
Evolved Expendable Launch Vehicle		$15.4 billion	181 vehicles	$28.0 billion	138 vehicles	137.8
Space Based Infrared System High		$4.1 billion	5 satellites	$10.2 billion	3 satellites	315.4
Expeditionary Fighting Vehicle		$8.1 billion	1,025 vehicles	$11.1 billion	1,025 vehicles	35.9

Table 1. Examples of DoD programs with reduced buying power (GAO-06-391 2006).

Unrealistic program baselines inevitably lead to cost and schedule delays

Unrealistic Program Baselines (cont.)

- **Additional Impact**
  - Unexecutable program
  - Reduced buying power
  - Lost opportunity costs
- **Recommendations**
  - Establish the program baseline prior to releasing the RFP and include, at a minimum, an Integrated Master Schedule (IMS), approved requirements baseline, and high confidence cost estimate
  - Conduct independent cost estimates and senior advisory panels at key program milestones, especially prior to ATP
  - Incorporate management reserve into the program budget; keep a portion in the program office and release a portion to the contractor
  - Implement rigorous trade studies of cost and schedule versus system impacts prior to ATP
  - A common practice of limiting cost growth is to “establish an early program baseline that is maintained throughout the entire development”
  - Review the industrial base and parts obsolescence issues prior to ATP and delay ATP if the base is not mature enough to handle the development

7. Inadequate Systems Engineering

- **What is it?**
  - Incomplete definition and processes to translate customer needs into a specific capability
- **Why does it occur?**
  - Decline in federal and industry systems engineering expertise which has led to an inexperienced government and contractor workforce
  - Insufficient training and knowledge to decompose a system into its parts and address lower level risks that can significantly impact the total system
  - Emphasis on building large, complex systems that satisfy all user requirements without a generating a cost/benefit evaluation
- **Study Comments**
  - The government and contractor "underestimated the complexity"
  - That "clear tradeoffs among cost, schedule, risk, and requirements have not been well supported by rigorous upfront systems engineering"
  - The "fact finding skill has atrophied. The government must know exactly what it wants – it must work system specs, interface control documents (ICDs), component specs in parallel with engineering development - including test verification (test is 40-60% of cost) to a mature state before RFP release. ***The seeds of failure are sown before RFP release***."

Inadequate Systems Engineering (cont.)

- **Additional Impact**
  - Underestimation of technical complexity
  - Risks are not realized or understood
  - Inadequate flow down of requirements from prime to subcontractors, vendors, and suppliers
- **Recommendations**
  - Hire experienced systems engineers, in-house or retired
  - Follow the INCOSE Handbook guidelines and complete fundamental systems engineering documents (SRD, SEMP, CONOPs) prior to ATP
  - Prior to ATP the government and contractor should invest in systems engineering training and develop specifications, interfaces, technology, trades, and risks before acquisition RFP release
  - Develop an end-to-end test program guideline
  - Programs that did not suffer cost or schedule growth cited "extensive systems engineering and performance trades in the pre-acquisition phase"
  - Track, monitor, and control all interfaces – focus on "well-defined interfaces" and to "take great care to minimize any interface changes internally and externally"

8. Inexperienced Workforce and High Turnover

- **What is it?**
  - A human resource system that: 1) places inexperienced personnel in decision-making positions and 2) values frequent assignment rotations
- **Why does it occur?**
  - Federal and military downsizing in the 1990's and retirements
  - An emphasis on producing "well-rounded" personnel that lack any specific expertise
  - 1990's DoD adoption of Total System Performance Responsibility (TSPR) that relegated the government to observer versus active participant
  - Inexistence of any formal succession planning and career management
- **Study Comments**
  - The "importance of a competent and experienced government program office cannot be underestimated"
  - It is "hard to establish accountability with high turnover"
  - We "don't need process- we need decision makers who know what they are doing"
  - There is a "need for active mentoring – assign juniors to seniors – put mentoring in performance reviews
  - Average program manager tenure for large weapons systems ~17 mos. (GAO-08-467SP 2008)

Inexperienced Workforce and High Turnover (cont.)

- **Additional Impact**
  - Optimistic source selections that lead to unrealistic program baselines
  - Reliance on contractors who are not ultimately responsible for mission success
  - Slow and/or bad decisions
- **Recommendations**
  - Extend program management tours as one RFI suggests that "5-6 year rotations was about right" and "continuity was key"
  - Hire back experienced federal and industry retirees, even part-time
  - Implement small, experienced, and consistent teams throughout the entire acquisition – "the primary key to success was the exemplary partnership demonstrated by the experienced and lean government and industry team."
  - Government and industry should establish active mentoring programs that connect senior-level with junior-level personnel

What Needs to be done Prior to ATP – The Pre-acquisition Checklist

The Pre-acquisition Checklist

- ☑ Review and ensure all technologies are mature to a ***TRL of 6 and MRL 6*** and do not require extensive rework to be integrated into the system
- ☑ Review all program office personnel with a focus on length of tour and experience level to ensure experienced personnel will be available for a minimum of ***4 years***
- ☑ Require a ***government approved requirements baseline*** which includes realistic inputs from users and mission partners following a cost/benefit analysis
- ☑ A review of the number and detail of Key Performance Parameters (KPPs) and keep it to a ***maximum of 6 KPPs***
- ☑ Completed system and technology ***trades*** that cover performance, cost, and schedule, and complete an end-to-end program risk assessment
- ☑ Completed system specification ***(A-Spec), CONOPS, SOW, SRD, and SEMP***
- ☑ Establish an ***end-to-end test guideline***, including software description documents
- ☑ Identify ***parts issues*** and establish dual sources if a part is on the critical path
- ☑ Establish ***interface specifications*** for all hardware and software
- ☑ Establish the ***acquisition strategy*** and contract vehicle with an appropriate incentive structure and use alpha contracting when appropriate
- ☑ Establish a ***high confidence cost and schedule baseline*** with identified management reserve that links the integrated master schedule to the full lifecycle cost
- ☑ Establish a ***comprehensive stakeholder communication plan*** that expedites the timely communication of accurate program information for the execution phase
- ☑ Review the ***industrial base*** capability for completing the program by reviewing the prime, subcontractors, vendors, and suppliers for parts obsolescence and mission assurance

Closing Thoughts

- **This study has detailed the common causes of cost and schedule growth on large-scale systems**
  1. Overzealous Advocacy
  2. Immature Technology
  3. Lack of Corporate Roadmaps
  4. Requirements Instability
  5. Ineffective Acquisition Strategy and Contractual Practices
  6. Unrealistic Program Baselines
  7. Inadequate Systems Engineering
  8. Inexperienced Workforce and High Turnover
- **Establishing a proper baseline *in the pre-acquisition phase* offers the greatest impact on the success of large-scale acquisition programs**

Contact Information

Steven Meier, Ph.D., PMP
Email: meierste@nro.mil or srmeier@hotmail.com
Phone: 703-808-1460