Stronger Practices Needed to Improve DoD Technology Transition Practices

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GAO Review of Technology Transition Practices

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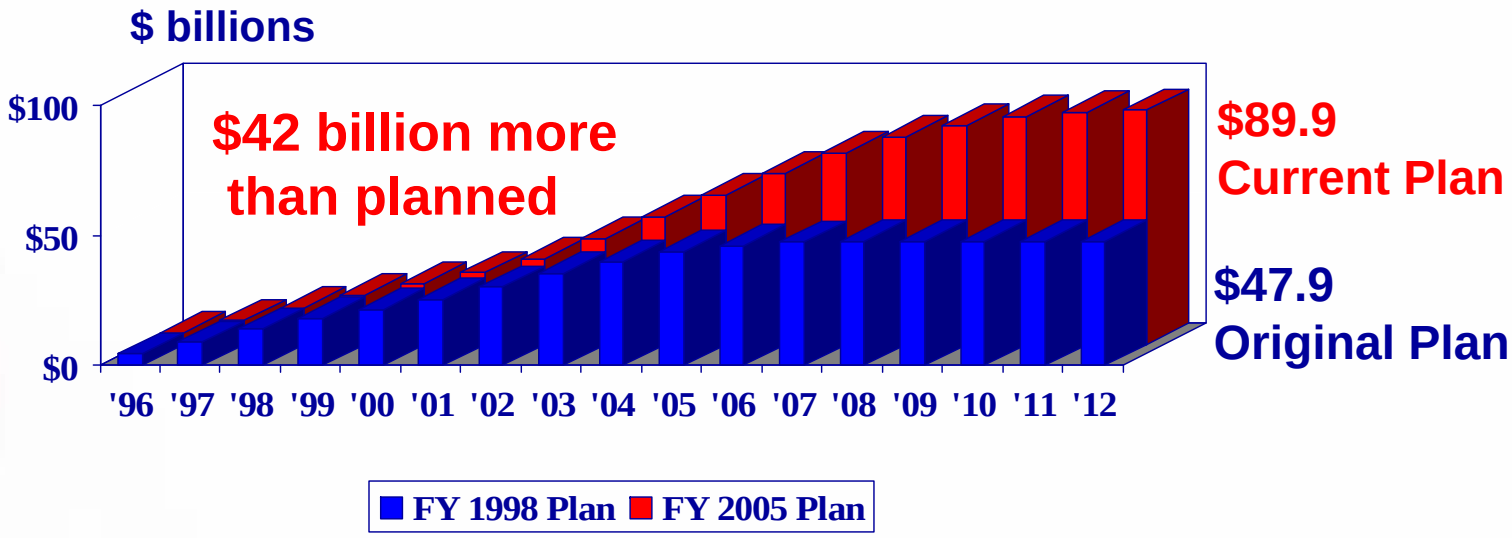
Prologue: GAO Recommends Change To Tech/Prod Development Practices – Circa 1999

- Adopt a disciplined, knowledge-based method, evolutionary acquisition process.
- Set standards—such asTRLs--for assessing technology readiness that are based on a technology's demonstrated readiness for integration and its criticality to the weapon system.
- Require that technologies demonstrate a high readiness level –TRL 7-- before Milestone B of a major acquisition.
- Provide more flexibility to acquisition programs with regard to a weapon system's performance requirements.
- Consider requiring S&T organizations to mature technologies further and empower them with additional funding and improved organization.

Outcomes Since Then:
Outcomes From DOD Development Efforts Circa 2005

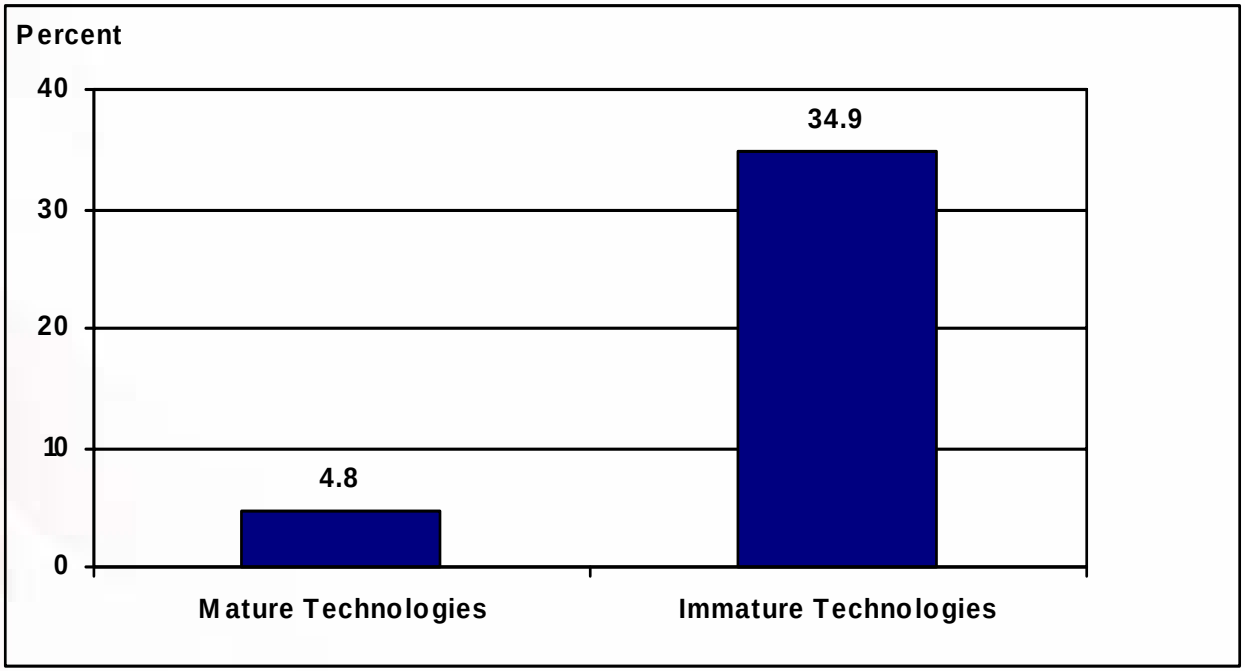
- While future demographics will demand more from DOD's investment accounts, current practices yield systems at unexpectedly high cost, diminished results



Source: Selected Acquisition Report data (12/31/96 and 12/31/03) on the 8 weapon systems among the highest R&D budget requests for FY 2003. Note: All dollars are in constant FY 2005 dollars.

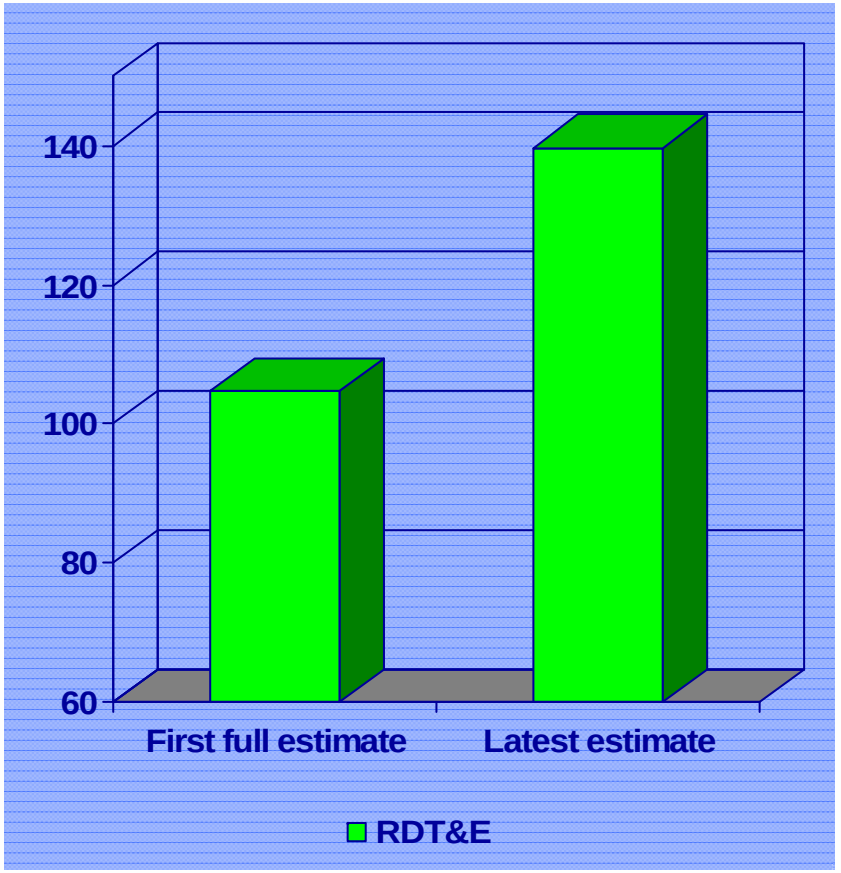
Outcomes Since Then:
Immature Technologies Impact SDD Circa 2006

- **Average Program Research, Development, Test and Evaluation Cost Growth From First Full Estimate**



Source: *Defense Acquisitions: Assessments of Selected Major Weapon Programs.* GAO-06-391. Washington, DC.: March 2006.

Outcomes Since Then:
Cost Growth on 27 Current Programs Circa 2007



Latest Review:
Objective, Scope, and Methodology

- Objective was to identify best ways to transition technologies to product lines, assess practices used by the military services, and determine potential improvements for DOD.
- Visited 4 best practice companies (IBM, Motorola, 3M, and Boeing), met with key science and technology (S&T) and product development officials to identify best practices for technology transition and supporting tools.
- Met with DOD S&T officials from OSD, services' acquisition programs, and services' labs. Also reviewed several lab & acquisition programs.
- Conducted our review from July 2005 through May 2006 in accordance with generally accepted government auditing standards.

Private Industry Findings:
Key Enablers

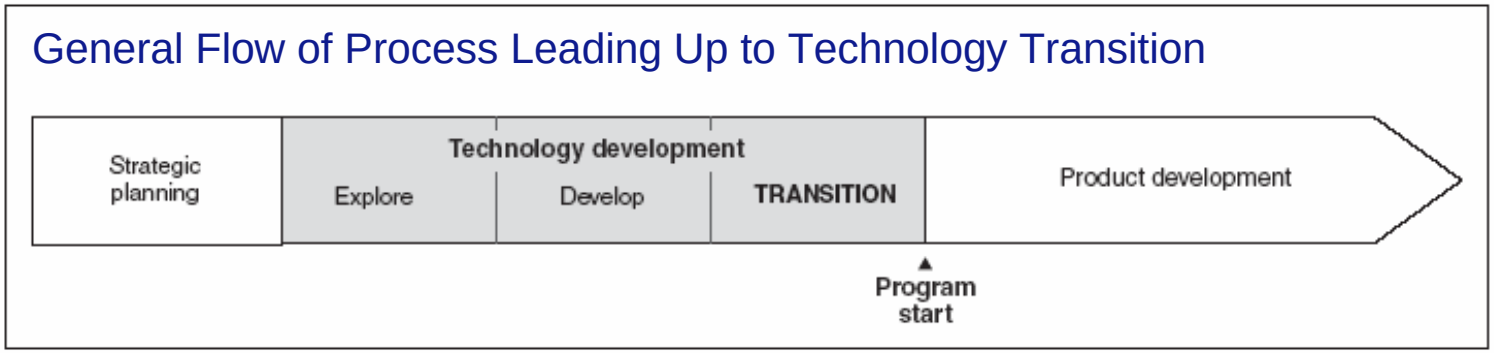
- Have strong strategic planning to prioritize technology needs and a structured technology development process as precursor to transition.
- Merge technology development and product development activities prior to product launch.
- Use 3 tools to support technology transition:
  - Relationship managers
  - Technology Transition Agreements
  - Metrics

Private Industry Findings:
Strategic Processes Smooth Path To Transition

- Strong strategic planning processes used to identify and react to market needs quickly.
- Structured, gated technology development process.

TECHNOLOGY DEVELOPMENT GATES		
Explore Technology ideas and concepts are being explored	**Develop** Technology development activities are underway	**Technology transition** Technology is ready to transition from lab to product line team
Review	*Review*	
Deliverables • Technology is consistent with overall business strategy • Technology is promising and is likely to meet needs for potential product lines • Lab identifies potential products where technology can be used • Key cost, benefit, risk, marketing, manufacturing, and life cycle management issues are identified • Scalability approaches are identified • Technologies considered to be intellectual property are identified	**Deliverables** • Technology is consistent with technology strategy and other relevant strategies • Labs have high degree of confidence the technology will work • Product line team agrees that the technology will meet its needs • Technical requirements are identified • Cost, benefits, and risks are quantified • Scalability approach is selected • Strategies for addressing intellectual property rights are selected	**Deliverables** • Technology project complies with technology strategy • Technology is sound • Technology meets product requirements • Cost, benefit, and risks are well understood • Technology can be scaled to a magnitude appropriate for practical application • Product line team agrees technology is ready • Intellectual property rights methods have been pursued • Technology is demonstrated in an operational environment • Technical documentation is ready to be given to product line team

Private Industry Findings:
Hybrid Phase Merges Tech and Product Development

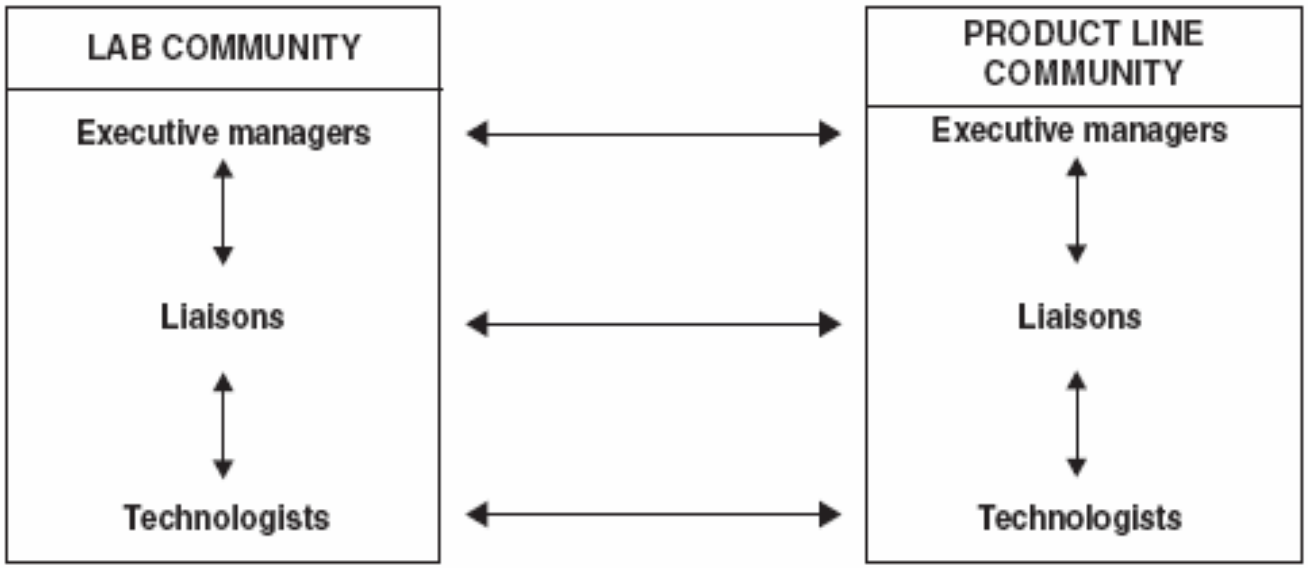


Source: GAO analysis and presentation of leading companies' practices.

- Hybrid phase used to merge technology development and product development activities prior to product launch.
- Responsibilities for managing and funding technology development gradually shift from labs to product line during this phase.

Private Industry Findings:
Relationship Managers Provide Communications Link

Relationship managers from labs and product lines serve as a communication link between the two communities and work out transition issues.



Source: Motorola; GAO (analysis and presentation).

Private Industry Findings:
Technology Transition Agreements/Metrics

- Technology transition agreements document decisions made between labs and product lines:
  - Contain specific quantifiable cost, schedule, performance, and manufacturability metrics the labs must demonstrate before product line acceptance.
  - Feasibility, relevancy, and application of each technology are assessed in an effort to identify potential barriers to technology transition.
  - Identify lab and product line funding commitments, including recurring manufacturing costs associated with integrating the new technology on a product.
  - Some agreements may include loaning key lab technologists to the product line for a period of time in order to maintain momentum once a technology has transitioned to product line management.

DOD Findings:
More Effort Needed

- DOD does not adequately prioritize the technologies that are most critical to acquisition programs.
- DOD does not merge S&T and product line activities prior to product launch; Transition often occurs at product launch irrespective of whether technologies are mature.
- New tools to support transition are being used, but:
  - Not as comprehensive as industry best practices.
  - Use is not widespread.

DOD Findings:

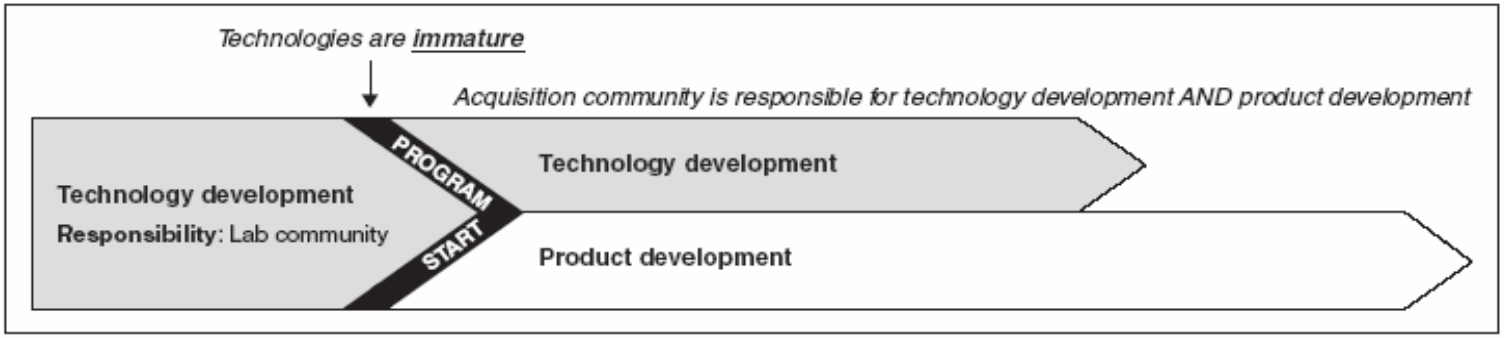
Inconsistent Prioritization and Dev Processes

DOD is not well positioned to develop and mature needed technologies on time.

- Strategic planning process does not consistently prioritize technologies most critical to acquisition programs.
- Military services have established S&T boards to select and oversee new technology projects, which increases visibility for some technologies, but the scope varies across military services.

DOD Findings: Technology and Product Development Still not Effectively Aligned

DOD does not have a structured, gated S&T technology development process with deliverables to guide investments.



Source: DOD (data); GAO (analysis and presentation).

- S&T and acquisition communities do not communicate well and are not aligned in a way to effectively meet priorities, resulting in:
  - Irrelevant technologies advancing to final stages of lab development without commitment to field the technologies.
  - Technology not being ready to transition when needed.
  - Acquisition not being prepared to take over funding responsibilities.

DOD Findings:

Technology Transition Tools Underutilized

- **Relationship Managers**
  - Generally used to market lab technology; not as a communication tool to assist in technology transition.
- **Technology Transition Agreements**
  - Use and coverage vary greatly among service S&T programs
  - Contain some of the same elements seen in industry, but typically do not require the technology developer to demonstrate cost metrics.
  - Tool used mainly by labs; not highly valued by acquisition community.
- **Metrics**
  - Few metrics used to gauge the impact of investments or the effectiveness of processes used to develop and transition technologies.

DOD Findings:
Some Promising Initiatives For Transition

- **Advanced Concept/Joint Concept Technology Demonstration** (ACTD/JCTD) -- Goal is to get technologies that meet critical needs to users faster and at lower cost, refine the the selection process to better match user priorities, and provide more funding in early stages of demonstration.
- **Manufacturing Technology Program** -- Aimed at quickly identifying and solving technology transition problems; focusing on affordable, low-risk development and production
- **Foreign Comparative Testing & Technology Transition Initiative** -- FCT identifies, evaluates, and procures technologies developed by other countries. TTI speeds transition of DOD lab developed technologies to acquisition programs.

Recommendations

- Develop gated process that establishes a transition phase and defines activities that should occur during this phase.
- Allocate more 6.4 funds for S&T to manage technologies to higher readiness levels before they move to acquisition programs.
- Expand the use of technology transition agreements DOD-wide.
- Include additional metrics in technology transition agreements.
- Expand the use of relationship managers and define responsibilities.
- Adopt additional process-oriented metrics to measure the effectiveness of S&T processes and the impact of S&T investments.

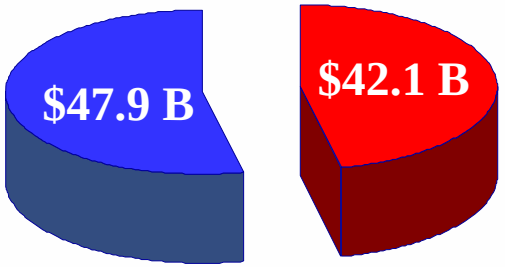
Questions?

For further details, see GAO report: GAO-06-883, Best Practices: Stronger Practices Needed to Improve DOD Technology Transition Processes (September 2006) at www.gao.gov, or contact Michael Sullivan at sullivanm@gao.gov.

Context: The Fiscal Environment

FY ’05: $89.95 billion total RDT&E $

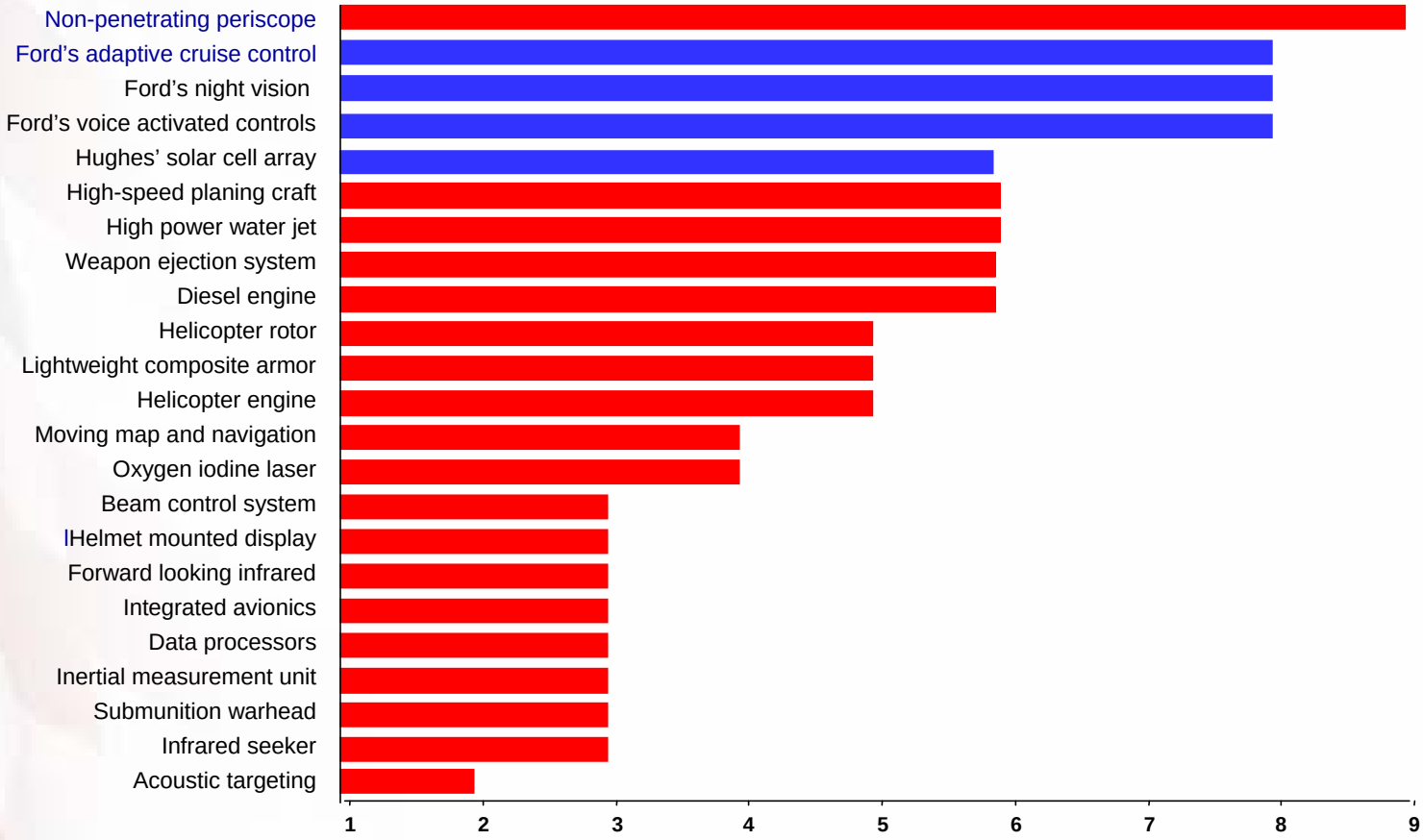
FY 1998 plan for completing development of 8 programs



Additional investment needed under FY 2005 plan for completing the 8 programs

Source: Selected Acquisition Report data (12/31/96 and 12/31/03) on the 8 weapon systems among the highest R&D budget requests for FY 2003. Note: All dollars are in constant FY 2005 dollars.

Current Condition: TRLS for Technologies At The Time They Were Included In Product Designs



Prologue: Outcomes of Past Major Weapon System Acquisitions

Product development and Associated technologies	TRL at program launch	Product development	
		Cost growth	Schedule slippage
Comanche helicopter		101 percent[a]	120 percent[a]
Engine	5		
Rotor	5		
Forward looking infrared	3		
Helmet mounted display	3		
Integrated avionics	3		
Brilliant Anti Armor Submunition		88 percent	62 percent
Acoustic sensor	2		
Infrared seeker	3		
Warhead	3		
Inertial measurement unit	3		
Data processors	3		
Hughes HS-702 satellite		None	None
Solar cell array	6		
Ford Jaguar		None	None
Adaptive cruise control	8		
Voice activated controls	8		

[a]The Comanche, in particular, has experienced a great deal of cost growth and schedule slippage for many reasons, of which technology immaturity is only one. Other factors, such as changing the scope, funding, and pace of the program for affordability reasons, have also contributed.

Outcomes Since Then:

Constructive Policy Changes, Implementation Challenges

- **DOD 5000 policy says most of the right things about separating technology development from system development**
  - Calls for technology maturity to TRL 6 (relevant environment)
  - Calls for evolutionary approach as a check on reqts.
  - Short development cycle times (5 years or less)

- **However,**
  - Best practice standard is TRL 7 (operational environment)
  - Most individual programs do not even abide by policy
  - Many programs fall outside: satellites, MDA, ships
  - Those within are unique: eg., FCS, JSF
  - Preference is still for revolutionary, not evolutionary
  - Knowledge gaps and optimistic estimates at MS B are the norm and are reinforced with approval and funding

Prologue:
DSB Report on the Effect of Immature Technology

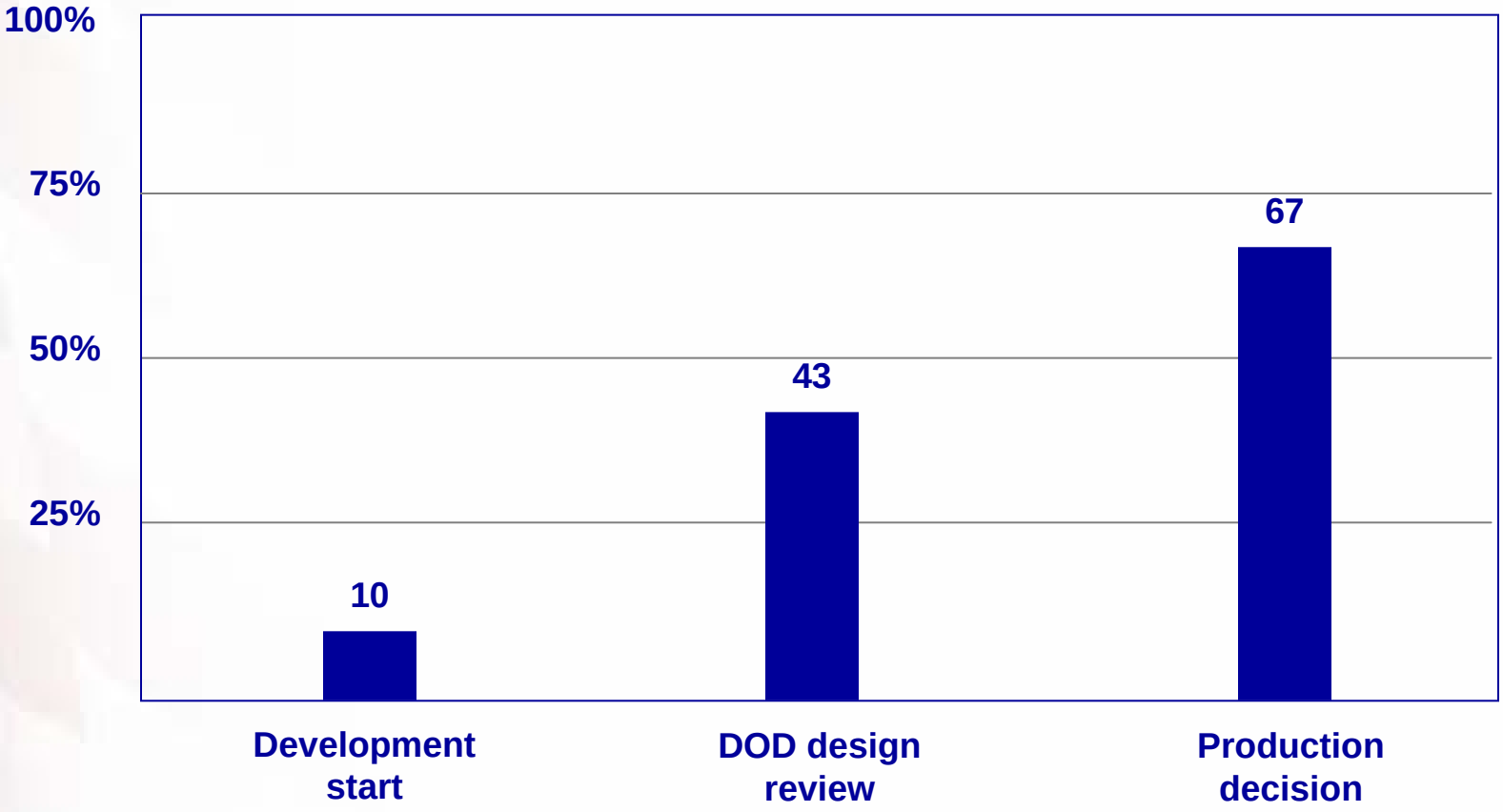
"Immature technologies and manufacturing challenges have a significant impact on DOD's ability to rapidly and affordably transition technology to the war fighter."

"S&T program managers often believe that affordability and manufacturing issues are not relevant concerns in 6.3 programs, focusing instead on fabrication of test and evaluation and prototype articles. But this line of thinking leads to higher costs later in a program, when manufacturing concerns are addressed after technical designs are considered 'ready.' "

"In order to achieve the objective of lower cost equipment, manufacturing concerns must be addressed earlier in the program life cycle. Production and support costs need to become a component of key technical design requirements, before the final stages of development when technologies are released for prototyping."

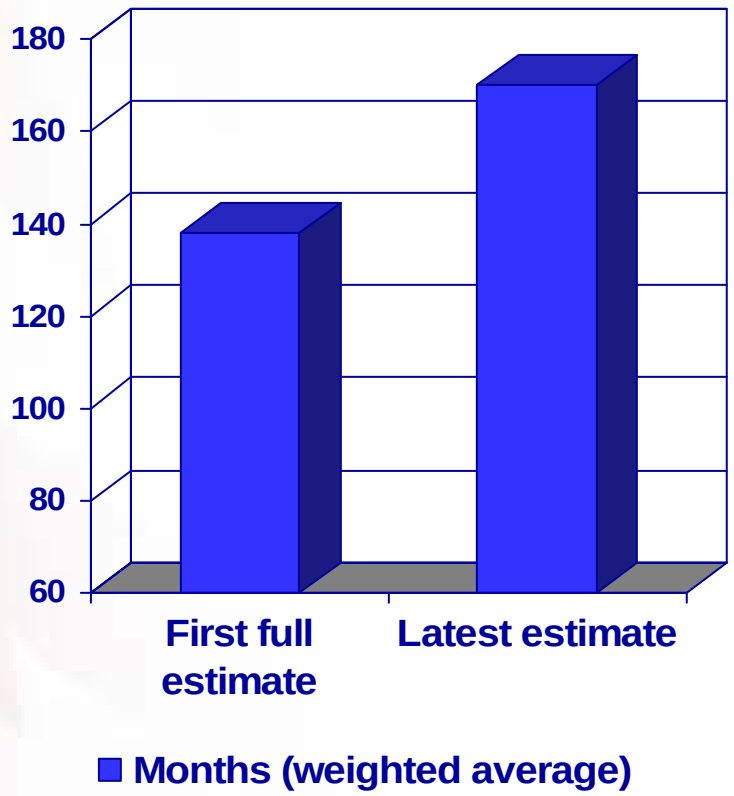
Source: Defense Science Board study (data); GAO (presentation and analysis).

Current Outcomes: % Programs that Achieved Technology Readiness at Key Junctures



Source: *Defense Acquisitions: Assessments of Selected Major Weapon Programs.* GAO-06-391. Washington, DC.: March 2006.

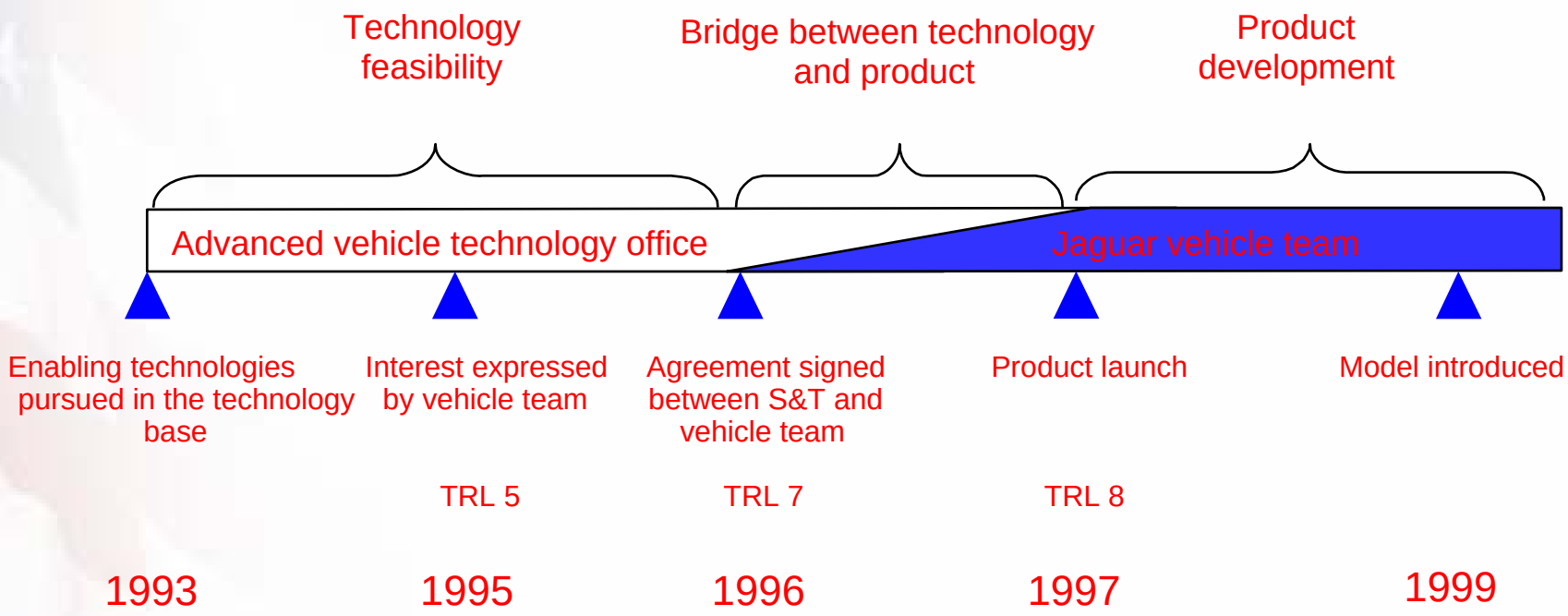
Current Condition: Schedule Growth for 27 Programs



- 23.5% change in weighted average cycle time.

Programs included in cost and schedule analysis: AEHF, MUOS, NPOESS, WGS, Patriot/MEADS, ARH, Excalibur, FCS, Warrior UAS, EA-18G, EFSS, V-22, AESA, E-2D, AHE, JTRS HMS, JTRS GMR, Land Warriior, WINT-T, ERM, CVN-21, C-5AMP, C-5 RERP, F-22A Mod, Global Hawk, JSF Reaper, P-8AMMA. We limited analysis to these because all data including cost, schedule, and quantities were available for comparison purposes.

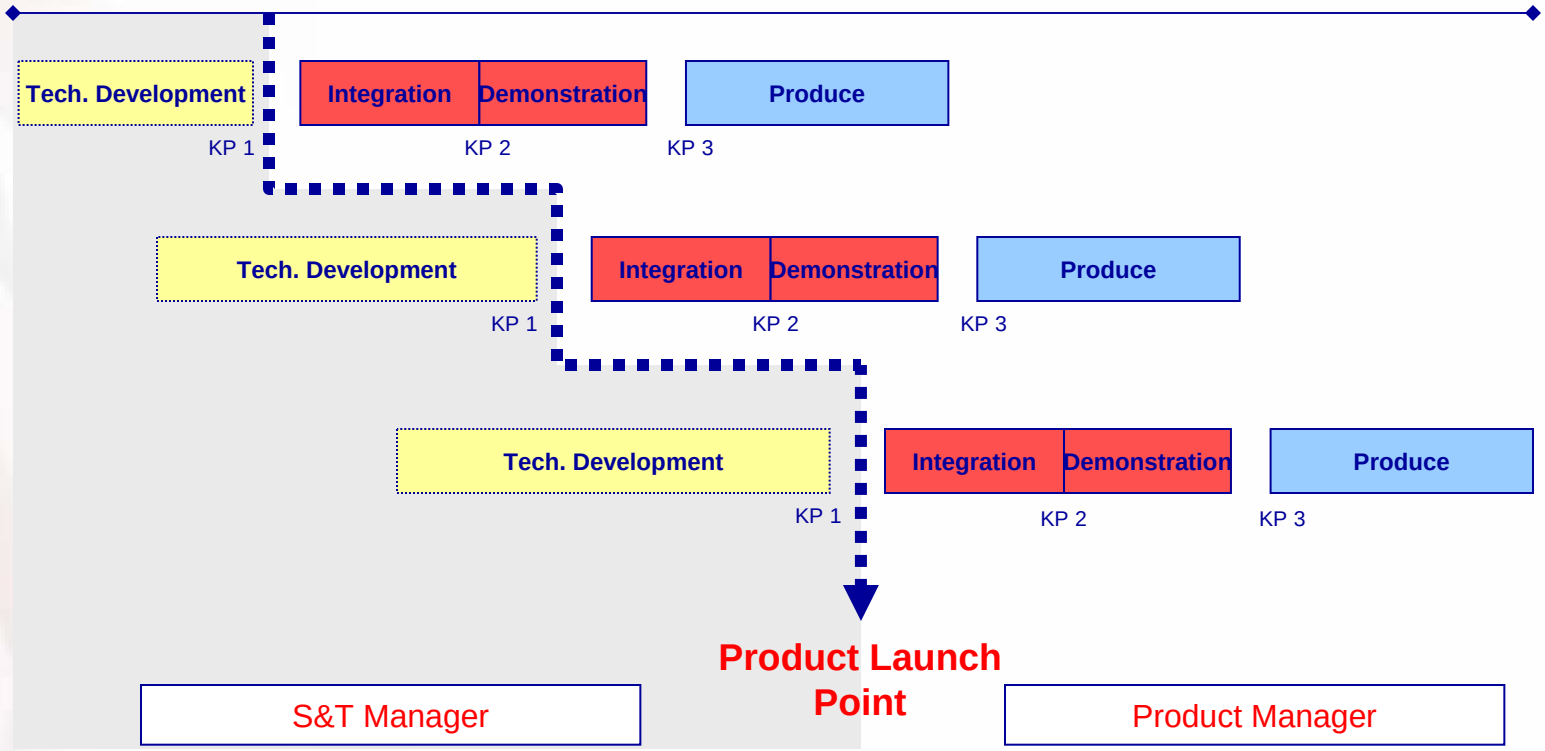
Private Industry Findings: Adaptive Cruise Control Technology and Jaguar Requirements



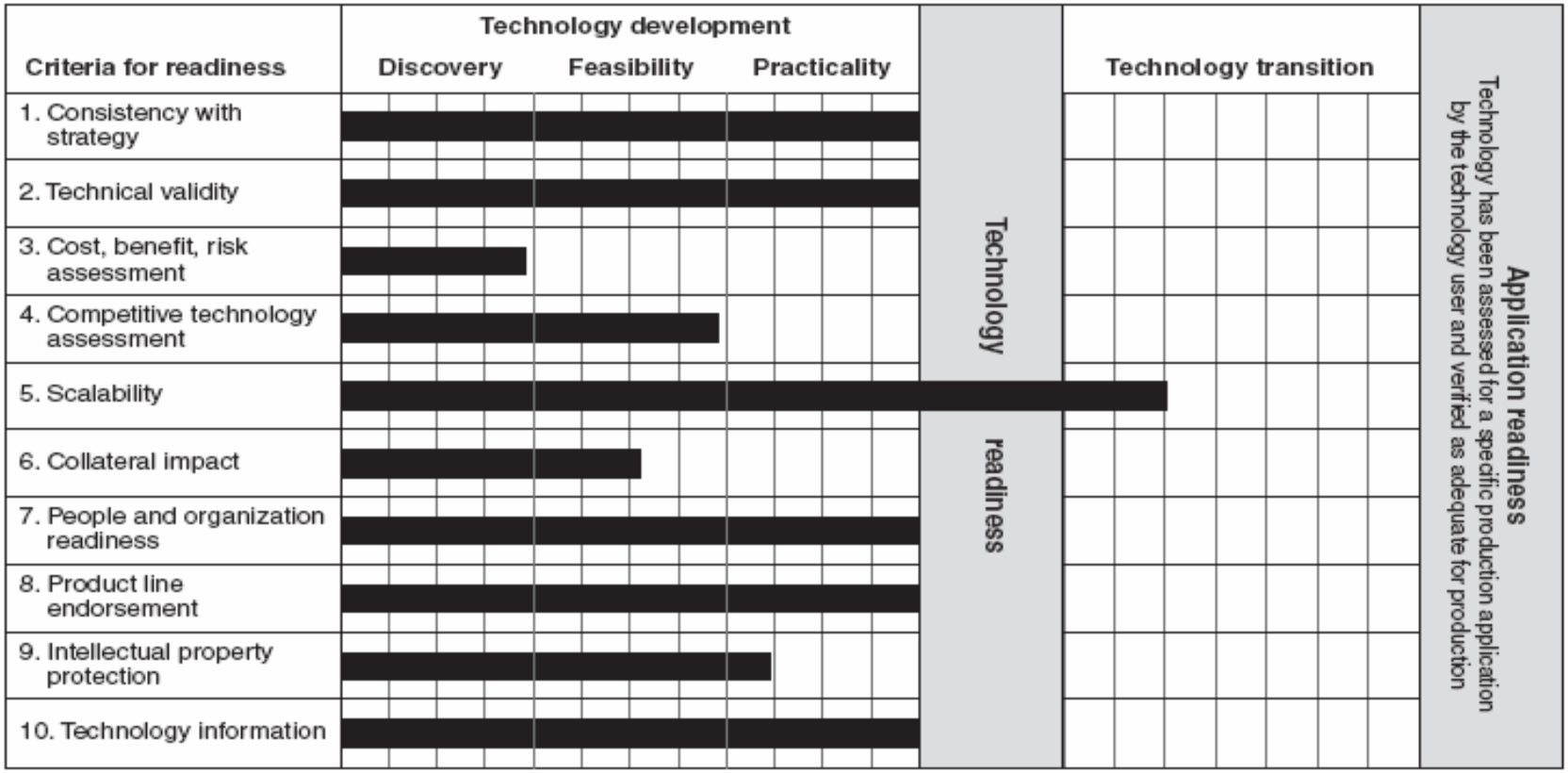
Private Industry Findings: Use of Project and Process Metrics

- Project metrics used to assess the status of technology development and whether the technology meets product needs
  - Size, weight, power, and reliability, as well as nonrecurring development and/or manufacturing costs.
- Process metrics provide information on the status, timeliness and impact of technology development efforts.
  - Return on investment, cycle time, technology yield, number of technologies commercialized, customer survey results.

Private Industry Findings: Knowledge-Based Evolutionary Product Development



Private Industry Findings: Notional Boeing Technology Maturity Scorecard



Source: GAO analysis based on The Boeing Company's scorecard.

DOD Findings: Use of Technology Transition Agreements Increasing

- Technology transition agreements are starting to be used; however, use and coverage vary greatly among service S&T programs.
  - About 65 percent of technology projects identified by the services as transition candidates had agreements. This is a small portion of the total S&T project portfolio.
- Agreements contain some of the same elements seen in industry, such as technology description, key personnel, and performance characteristics required by the prospective user.
- Typically do not require the technology developer to demonstrate cost metrics.
- Tool used mainly for S&T; Acquisition community does not value as highly.

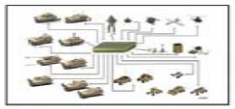
DOD Findings: Metrics Are Underutilized

- Metrics continue to be acknowledged as a problem for the services.
  - Transition agreements include many of the same metrics as leading companies, but are not available for most technology projects.
  - Few metrics are used to gauge the impact of investments and the effectiveness of processes for developing and transitioning technologies.
  - DOD Foreign Comparative Testing Program has established metrics to measure health, success, and cost-effectiveness of the program.

DOD Findings: Use of Relationship Managers is Underutilized

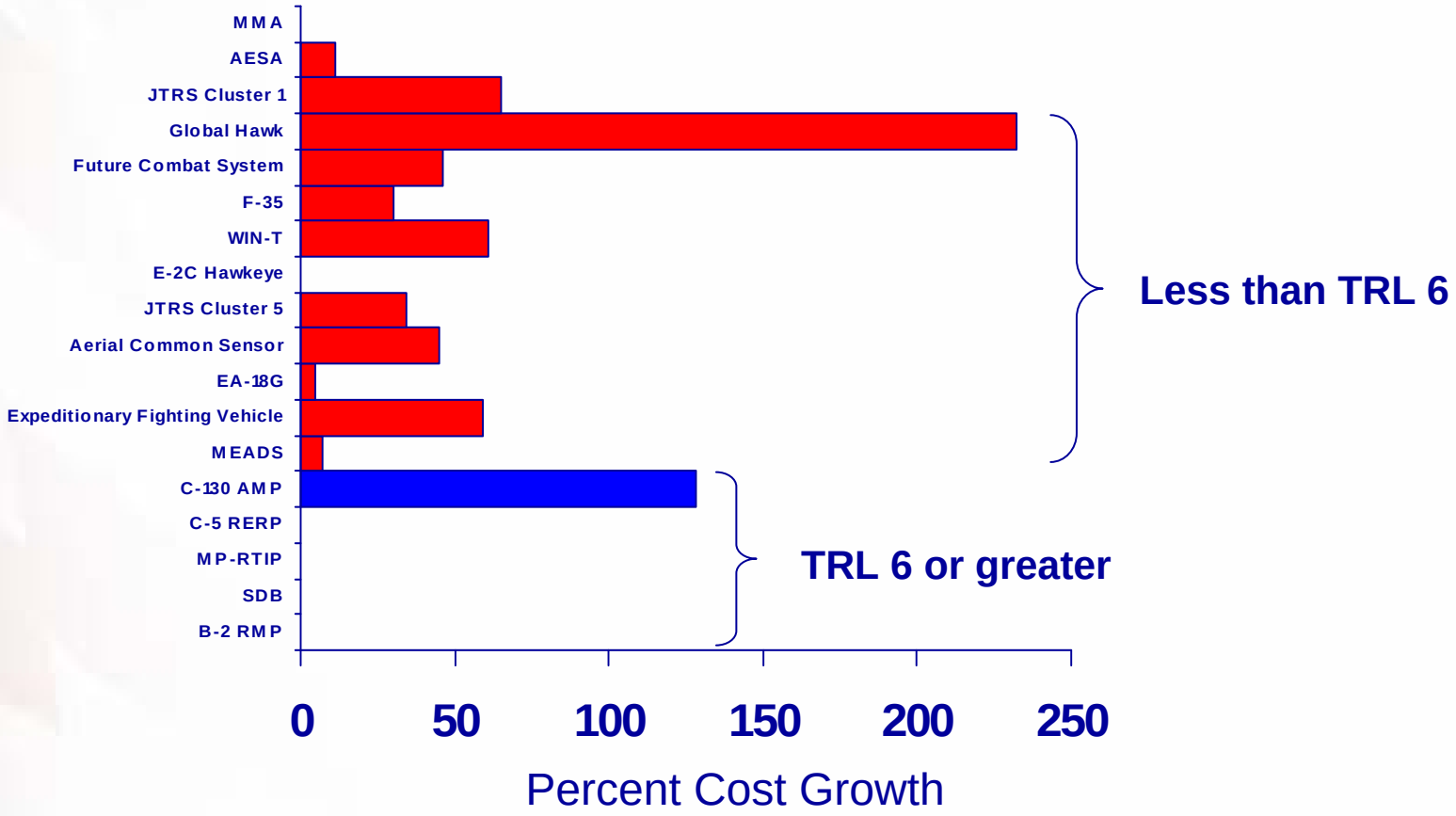
- DARPA uses relationship managers in a manner consistent with leading private companies.
- When used, relationship managers generally are used by the military to market lab technology; not as a joint communication vehicle between labs and acquisition to assist in technology transition.
- DOD depends on Integrated Product Teams and annual corporate board reviews to communicate technology development activities.

Outcomes Since Then:
Reduced Buying Power For Major Programs

Program		Initial estimate →	Initial quantity	Latest estimate →	Latest quantity	Percentage of unit cost increase
Joint Strike Fighter		$196. 5 billion	2,866 aircraft	$223.3 billion	2,458 aircraft	32.8
Future Combat Systems		$85.5 billion	15 systems	$131.7 billion	15 systems	54.1
V-22 Joint Services Advanced Vertical Lift Aircraft		$36.9 billion	913 aircraft	$50.0 billion	458 aircraft	170.2
Evolved Expendable Launch Vehicle		$16.0 billion	181 vehicles	$28.6 billion	138 vehicles	134.7
Space Based Infrared System High		$4.2 billion	5 satellites	$10.4 billion	3 satellites	311.6
Expeditionary Fighting Vehicle		$8.4 billion	1,025 vehicles	$11.3 billion	1,025 vehicles	33.7

Source: GAO analysis of DOD data. Images sourced in their respective order: JSF Program Office; Program Manager, Future Combat Systems (BGT); V-22 Joint Program Office; (Left) © 2006 ILS/Lockheed Martin, (right) © 2003 The Boeing Company; Lockheed Martin Space Systems Company; General Dynamics Land Systems.

Outcomes Since Then:
Same Problems Under Revised Policy Circa 2006



Source: Defense Acquisitions: Major Weapon Systems Continue to Experience Cost And Schedule Problems Under DOD's Revised Policy. GAO-06-368. Apr. 13, 2006