



Software Acquisition

Facing the Challenge, Valuing Velocity!

NDIA SE Division Meeting

Washington DC

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OUSD (R&E) / DASD (Systems Engineering)**

Department of Defense

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Classical Engineering/ Project Management

Code of Hammurabi (~1754 BC)

If a builder build a house for some one, and does not construct it properly, and the house which he built fall in and kill its owner, then that builder shall be put to death.

Code of Hammurabi, 229, <http://avalon.law.yale.edu/ancient/hamframe.asp> Accessed Sept 17 2017

De Architectura on Cost/Schedule Overruns (~15 BC)

- [...] When an architect [in Ephesus] was entrusted with the execution of a public work, an estimate thereof being lodged in the hands of a magistrate, his property was held, as security, until the work was finished. [...] **But when more than one-fourth of the estimate was exceeded, he was required to pay the excess out of his own pocket.** [...]
- Would to God that such a law existed among the Roman people, not only in respect of their public, but also of their private buildings, for then the unskillful could not commit their depredations with impunity, and those who were the most skillful in the intricacies of the art would follow the profession. Proprietors would not be led into an extravagant expenditure so as to cause ruin; architects themselves, from the dread of punishment, would be more careful in their calculations, and the proprietor would complete his building for that sum [...]

Marcus Vitruvius Pollio. "De Architectura", Liber X, Introduction, paragraphs 1-2. Translation by Bill Thayer. ~15 BC . http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Vitruvius/10*.html. Accessed 17 Sept 2017



Software Is Everywhere

- DoD relies on software to provide decisive advantages to our forces
- The complexity required to achieve this advantage demands specific capabilities and tight coupling
- Partial solutions are inadequate
- **We can't omit requirements**
 - Because they don't fit the schedule
 - Because it simplifies refactoring



image credit SPAWAR.navy.mil

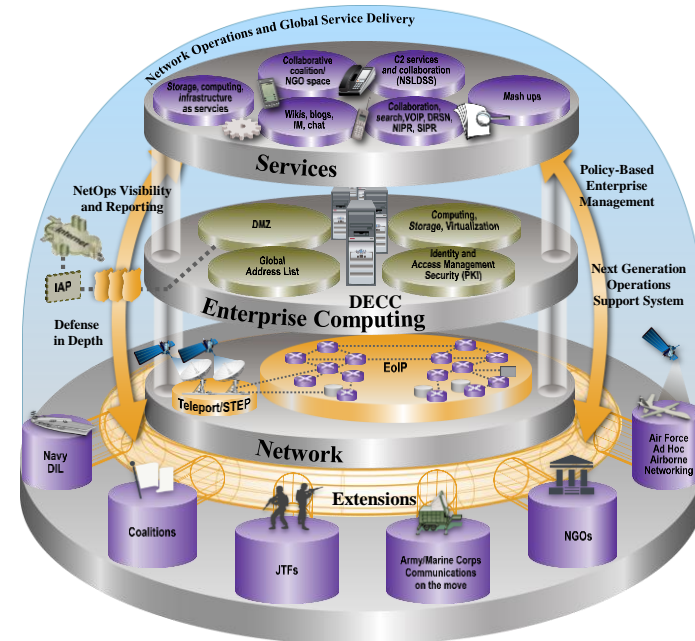
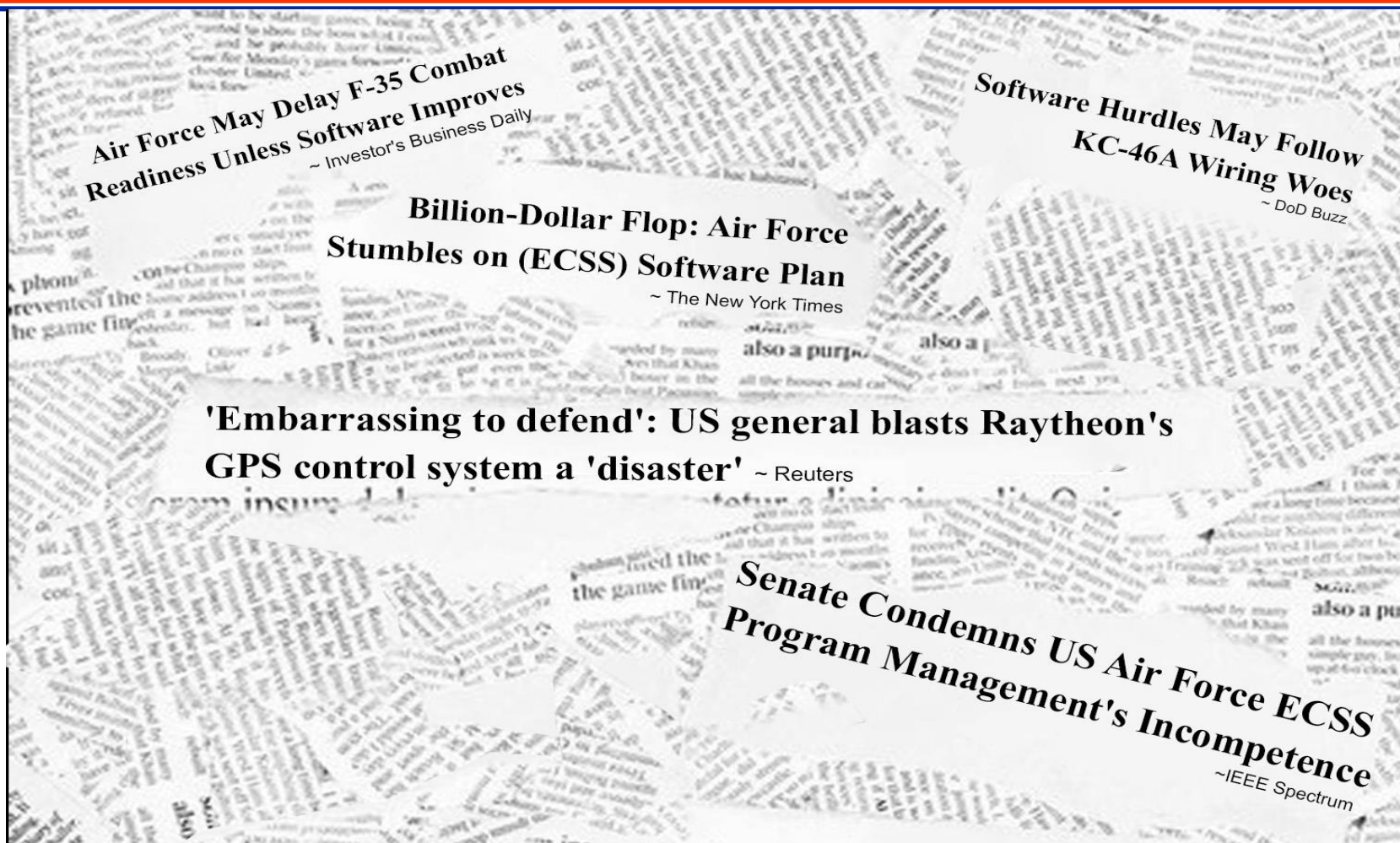


image credit DISA.mil



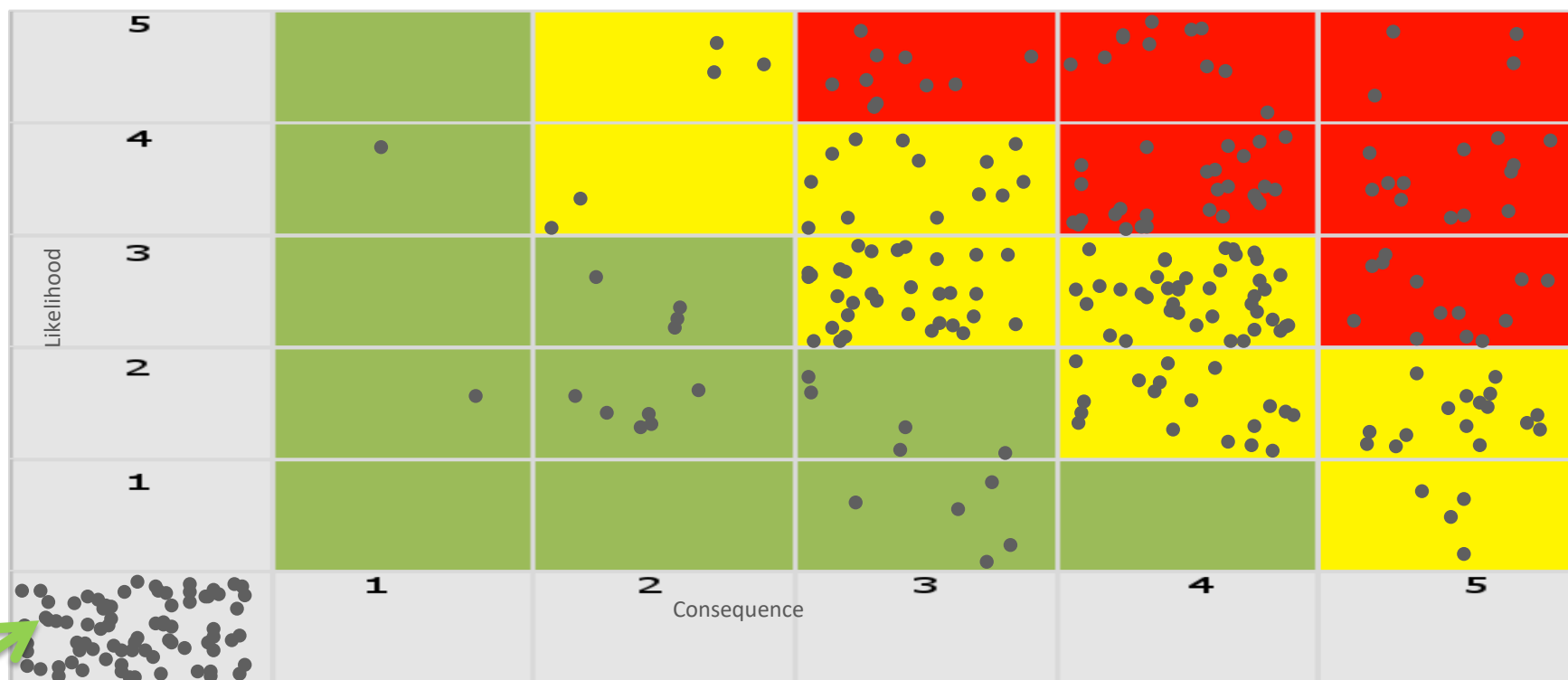
DoD Software Failures in the Press



Also, many successful software programs



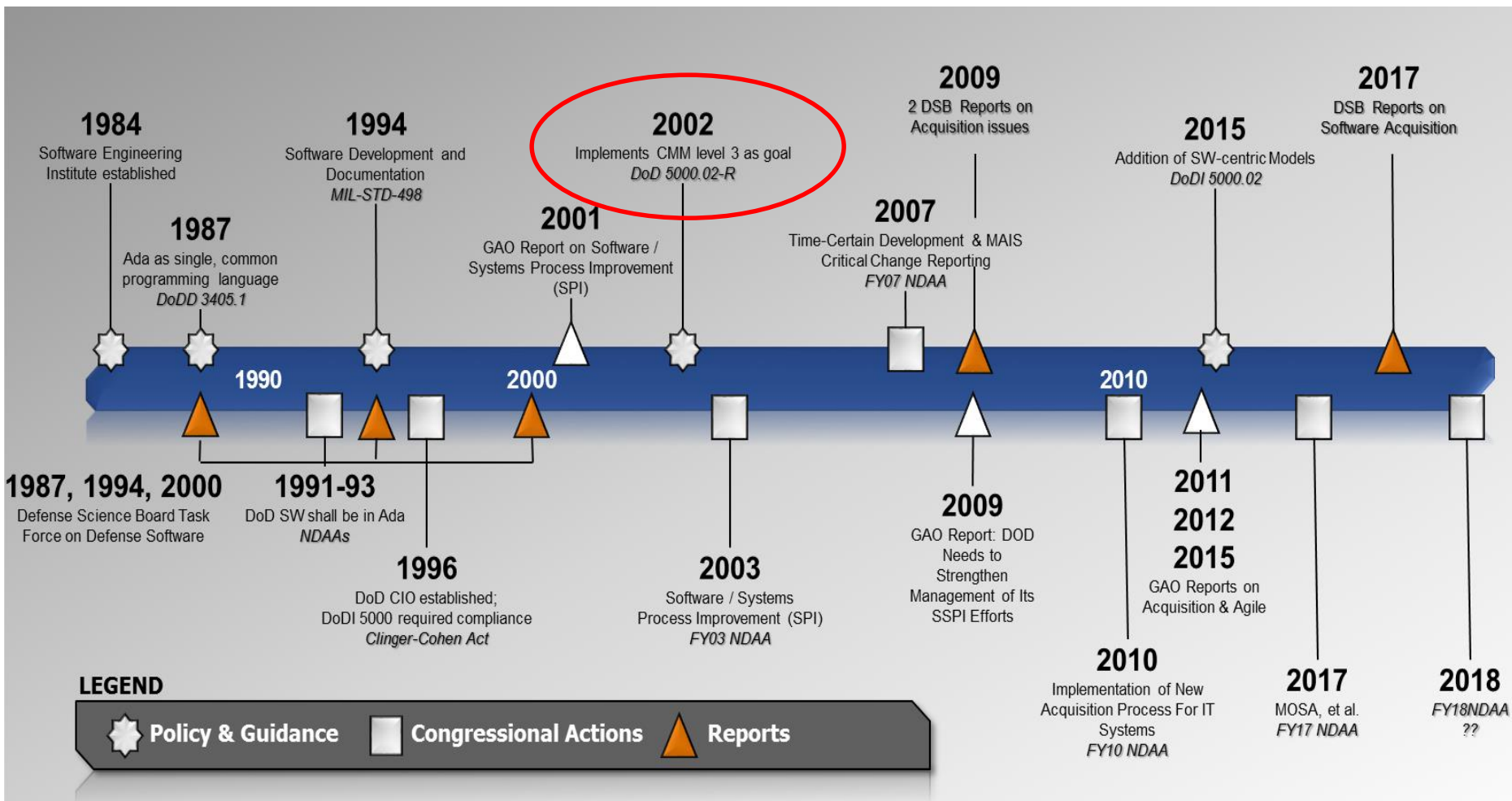
Software Risk Assessed by DoD Program Offices



Software among most frequent and most critical challenges, driving program risk on ~ 60% of acquisition programs

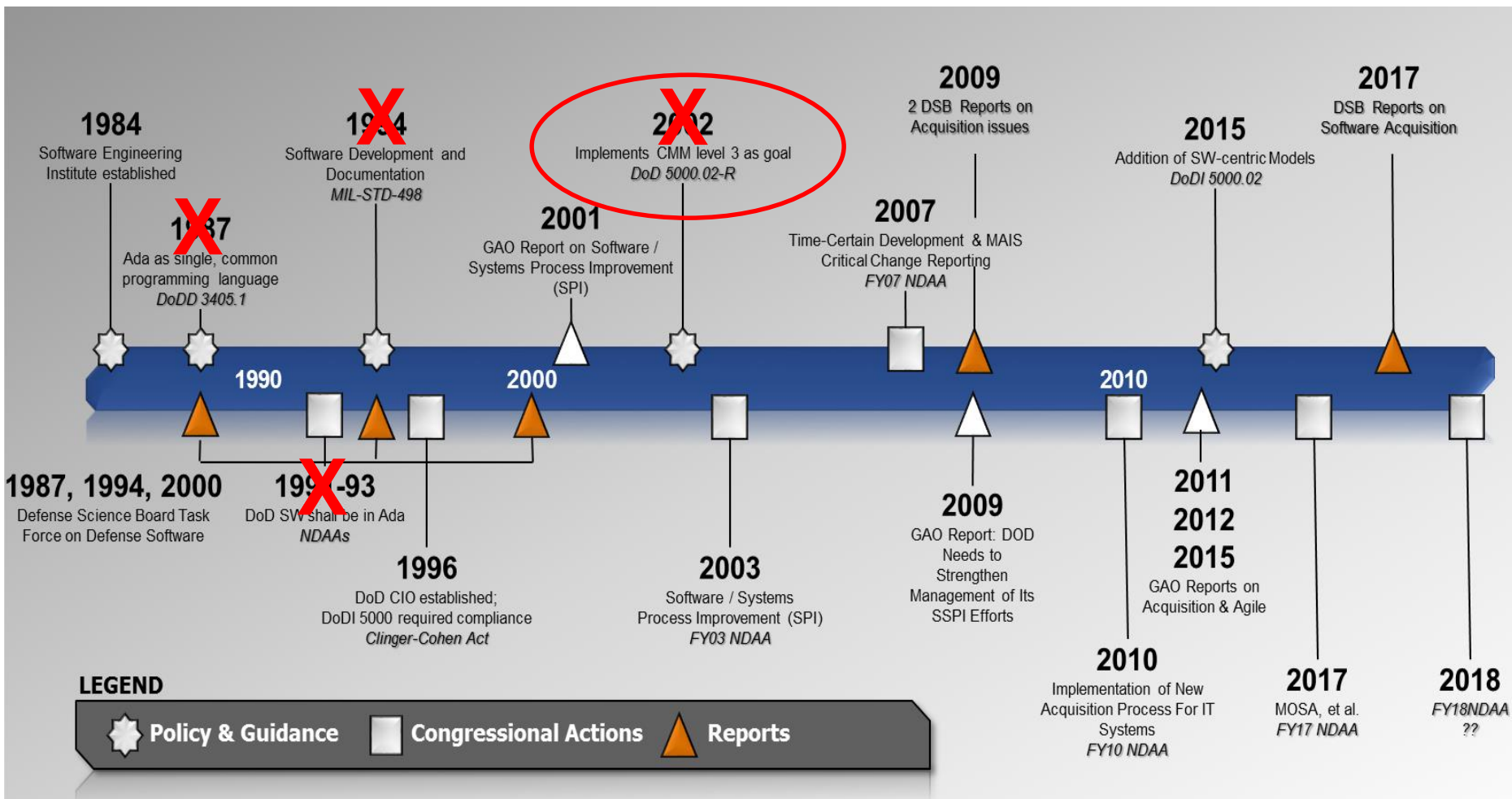


Historical Approaches to Address DoD's Software Challenges





Historical Approaches to Address DoD's Software Challenges



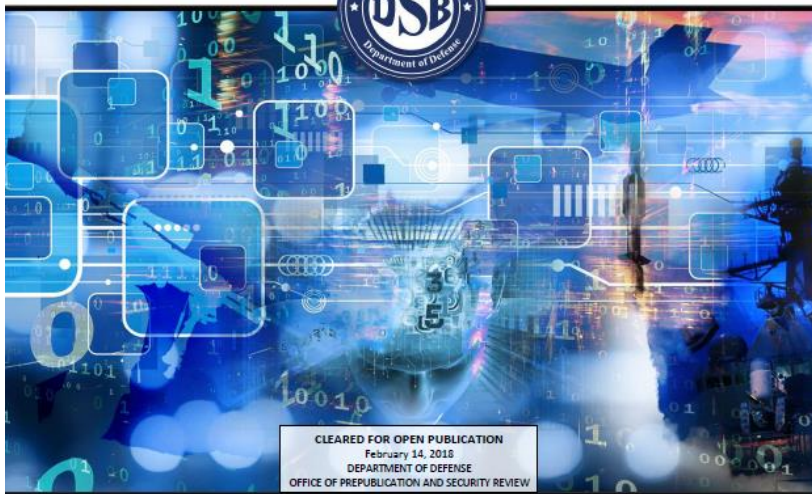


DSB on Software Acquisition

DEPARTMENT OF DEFENSE
DEFENSE SCIENCE BOARD

DESIGN AND ACQUISITION OF SOFTWARE FOR DEFENSE SYSTEMS

February 2018



CLEARED FOR OPEN PUBLICATION
February 14, 2018
DEPARTMENT OF DEFENSE
OFFICE OF PREPUBLICATION AND SECURITY REVIEW

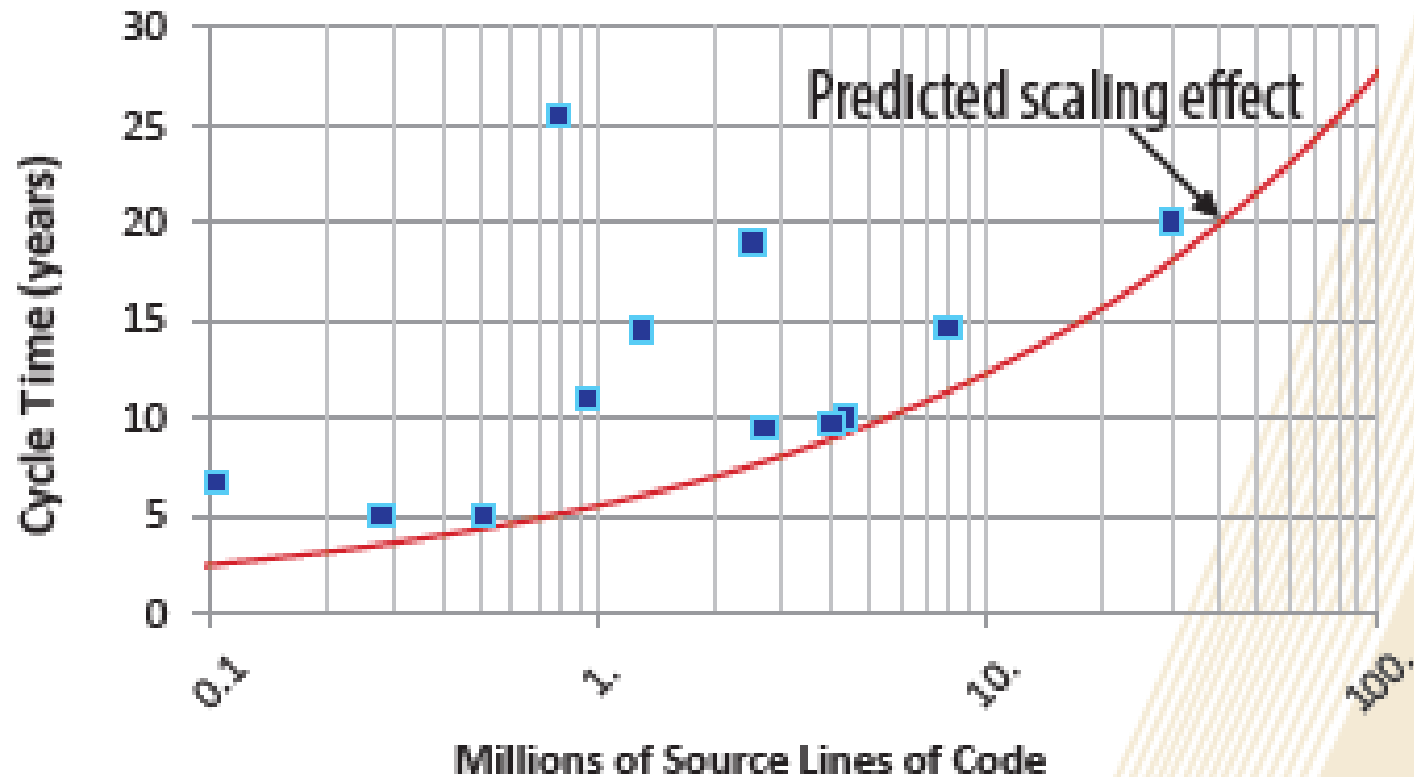
OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING
WASHINGTON, D.C. 20301-3140

- **“Software Factory”**
- **Continuous Iterative Development**
 - Requirements/MVP
- **Risk Reduction & Metrics**
 - Competition
 - Cost/schedule scoping estimation techniques
 - Execution metrics framework
- **Transition to Current and Legacy Programs**
- **Workforce improvement**
- **Software is Immortal - Sustainment**
- **Machine Learning – IV&V, Cyber**

https://www.acq.osd.mil/dsb/reports/2010s/DSB_SWA_Report_FINALdelivered2-21-2018.pdf



Software Cycle Time for Recent Programs

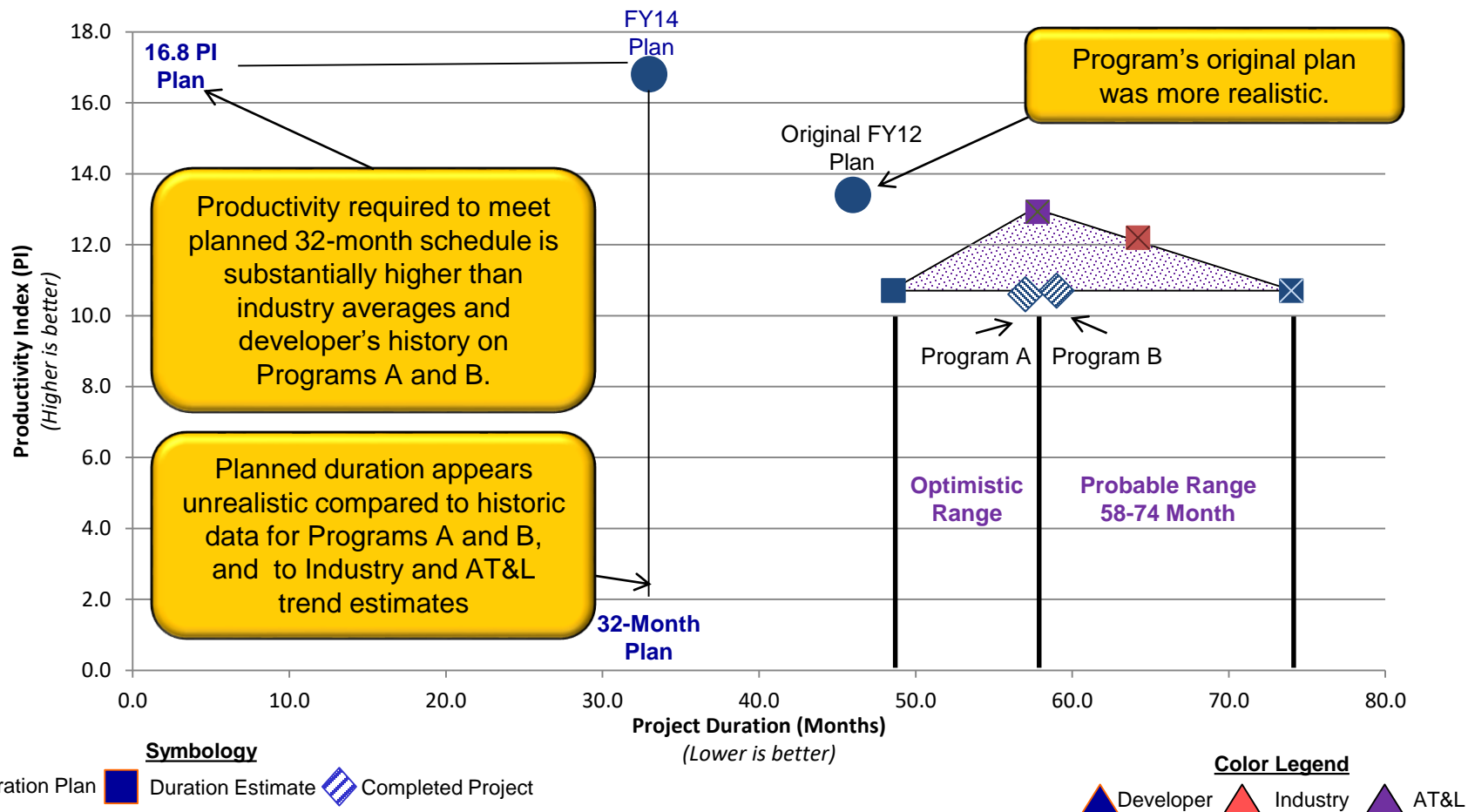


Software size & cycle time for recent programs

David M. Tate, Software Development May Drive Future Acquisition Cycle Times, (Revised)IDA Document NS D-8053 (Revised) October 2016
Log: H 16-000790 - Approved for public release; distribution is unlimited.



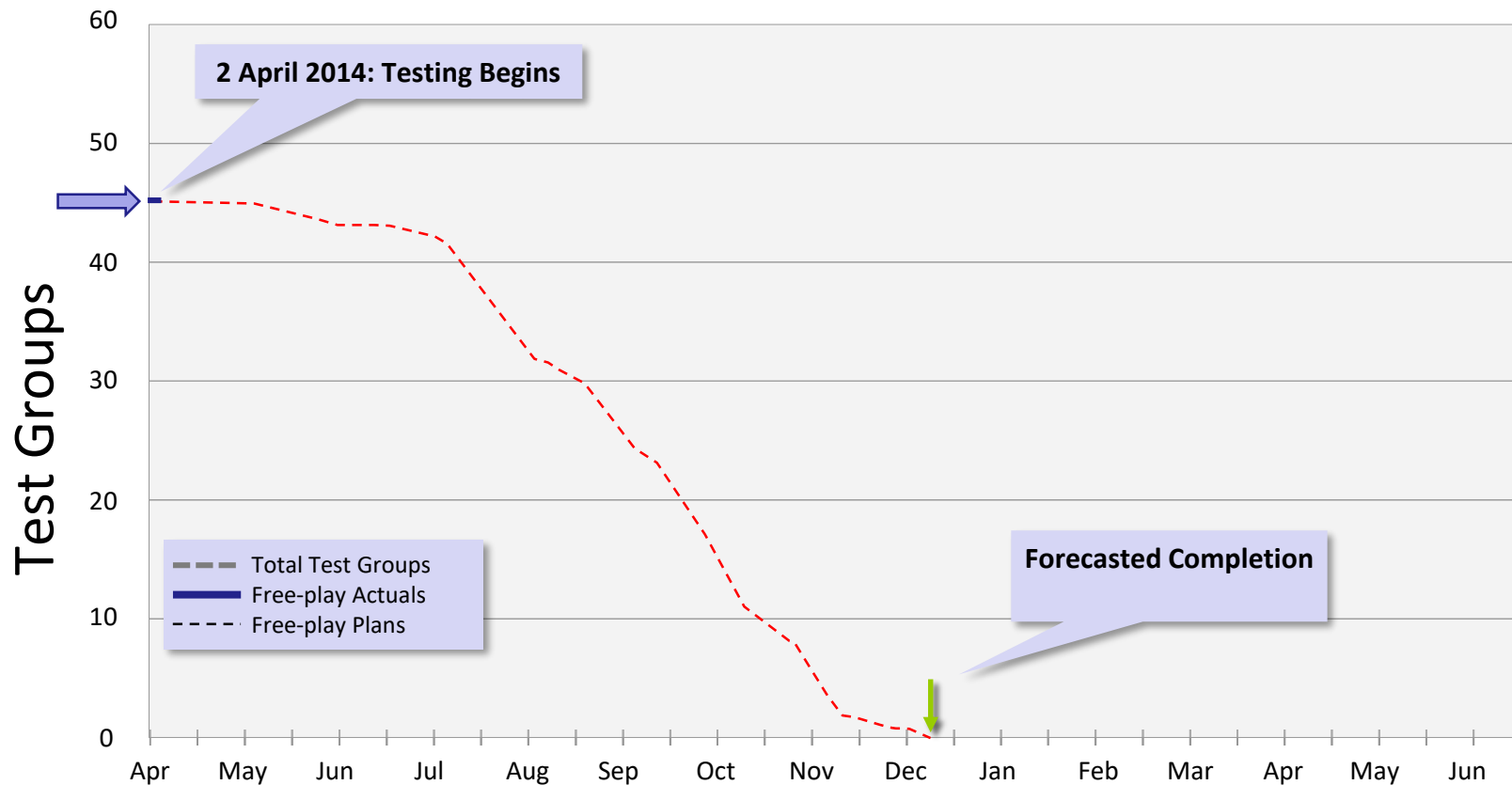
Estimated Schedule Durations for a Software Development Effort



Software benchmarks promote credibility in scoping,
enable data driven decisions

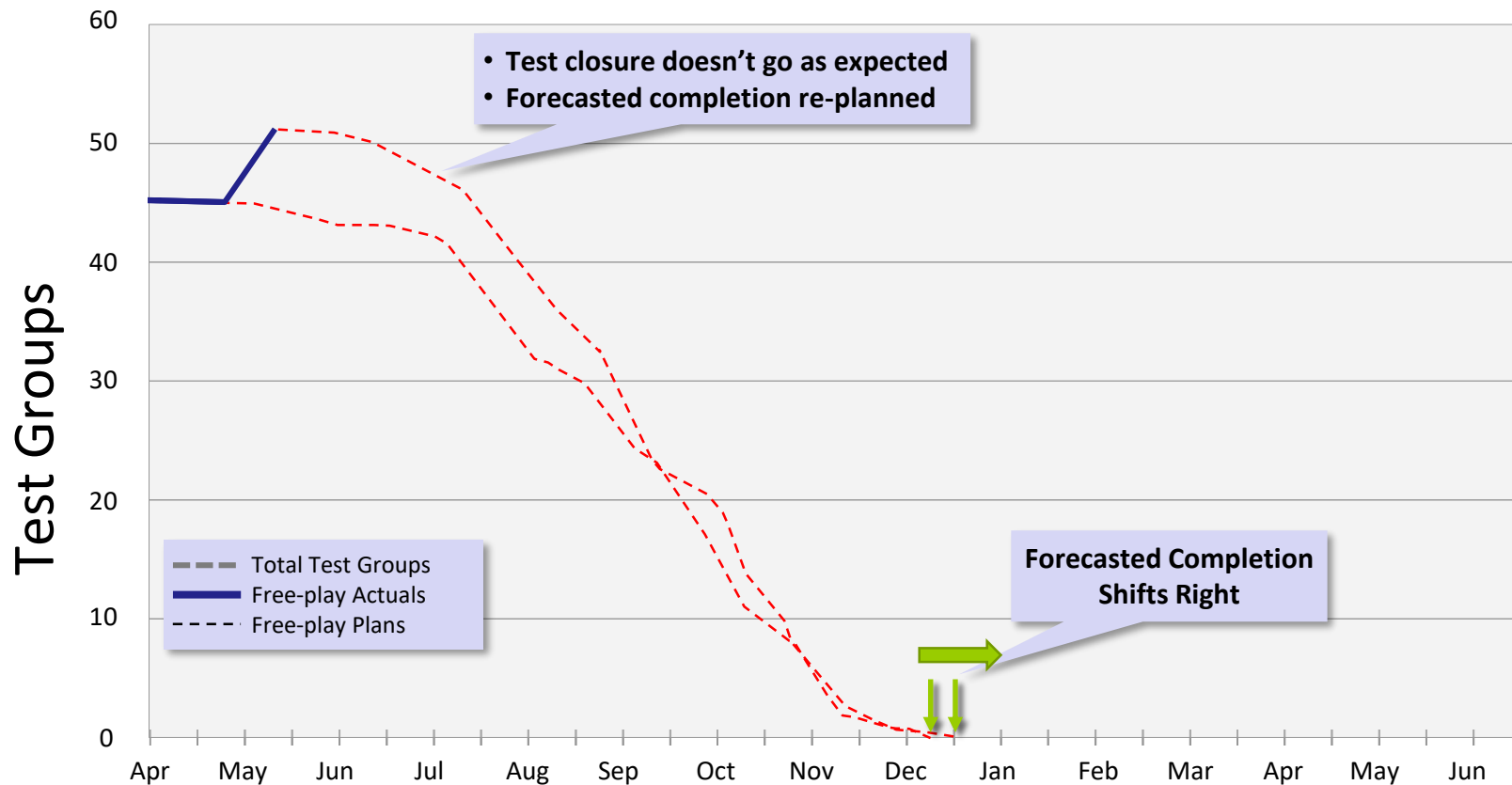


Sample Metrics Testing Optimism



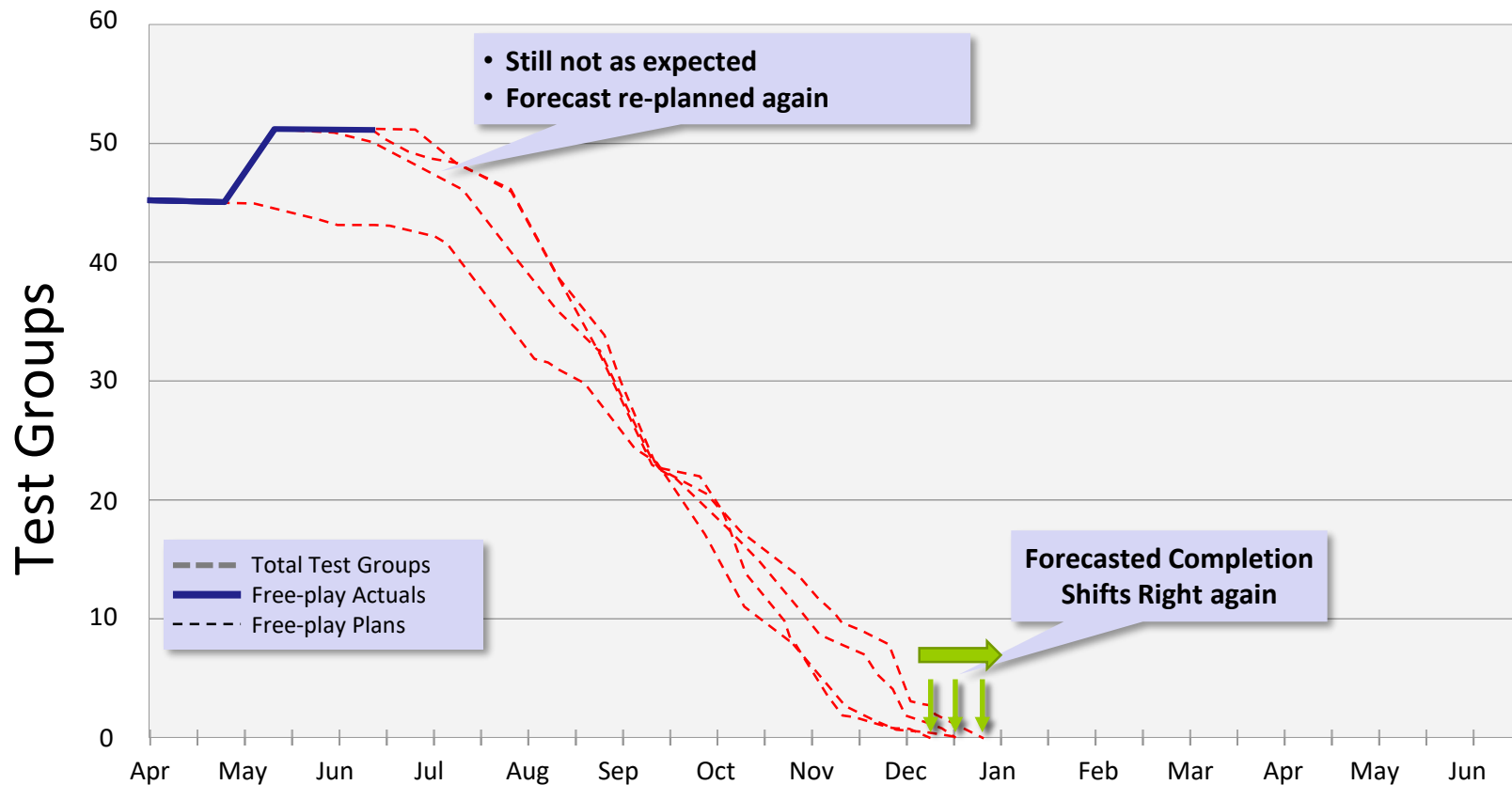


Sample Metrics Testing Optimism



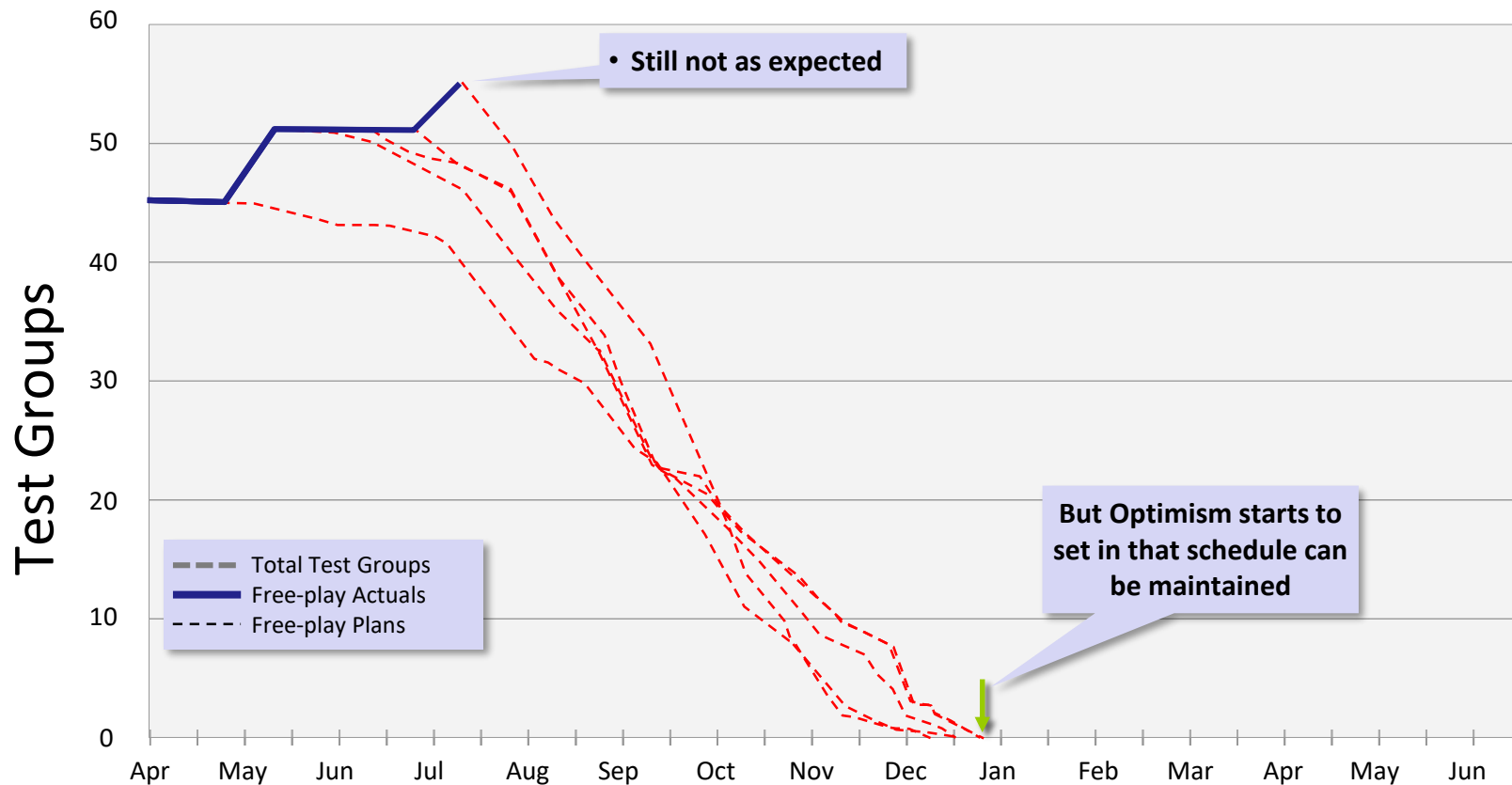


Sample Metrics Testing Optimism



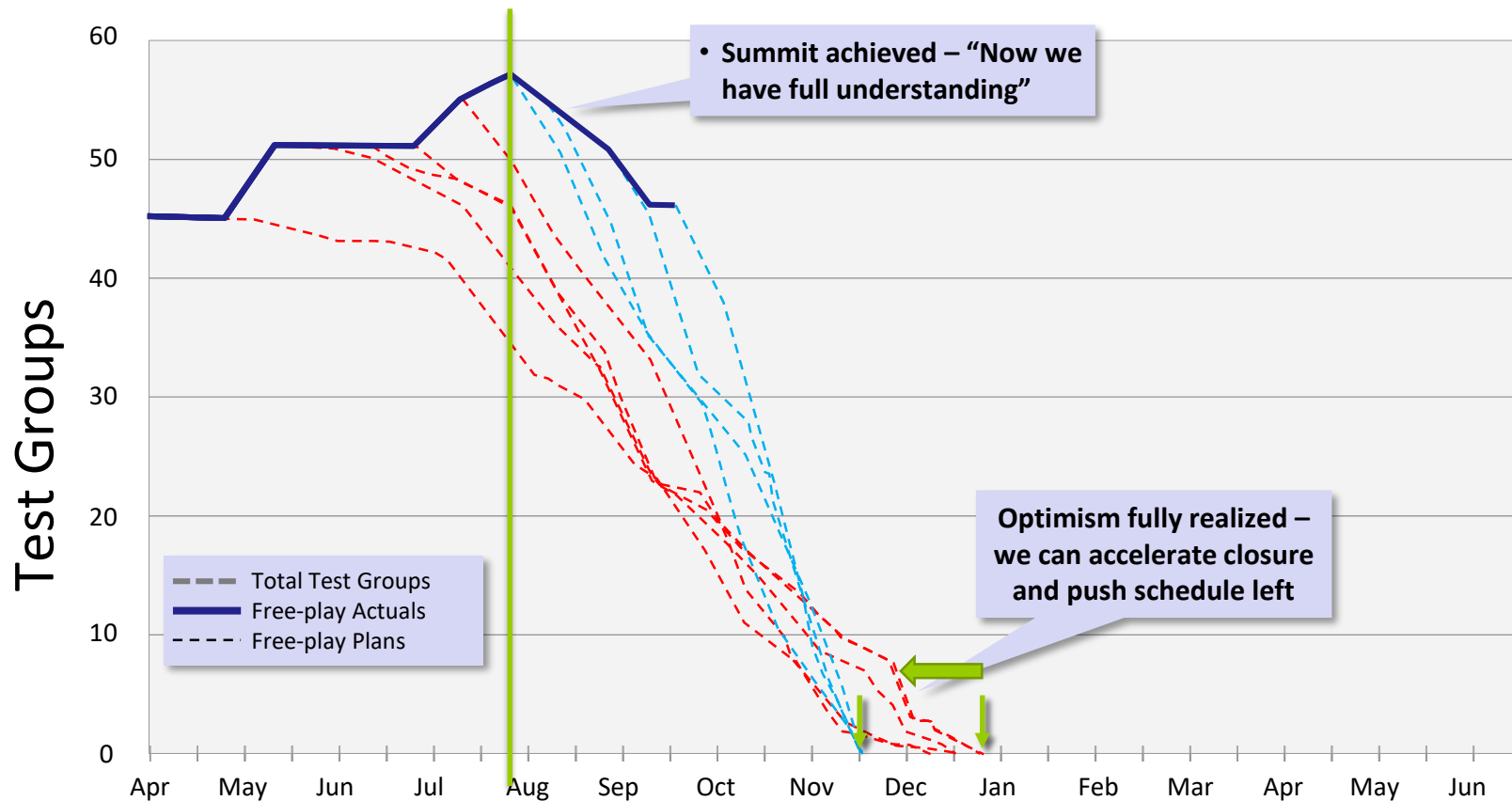


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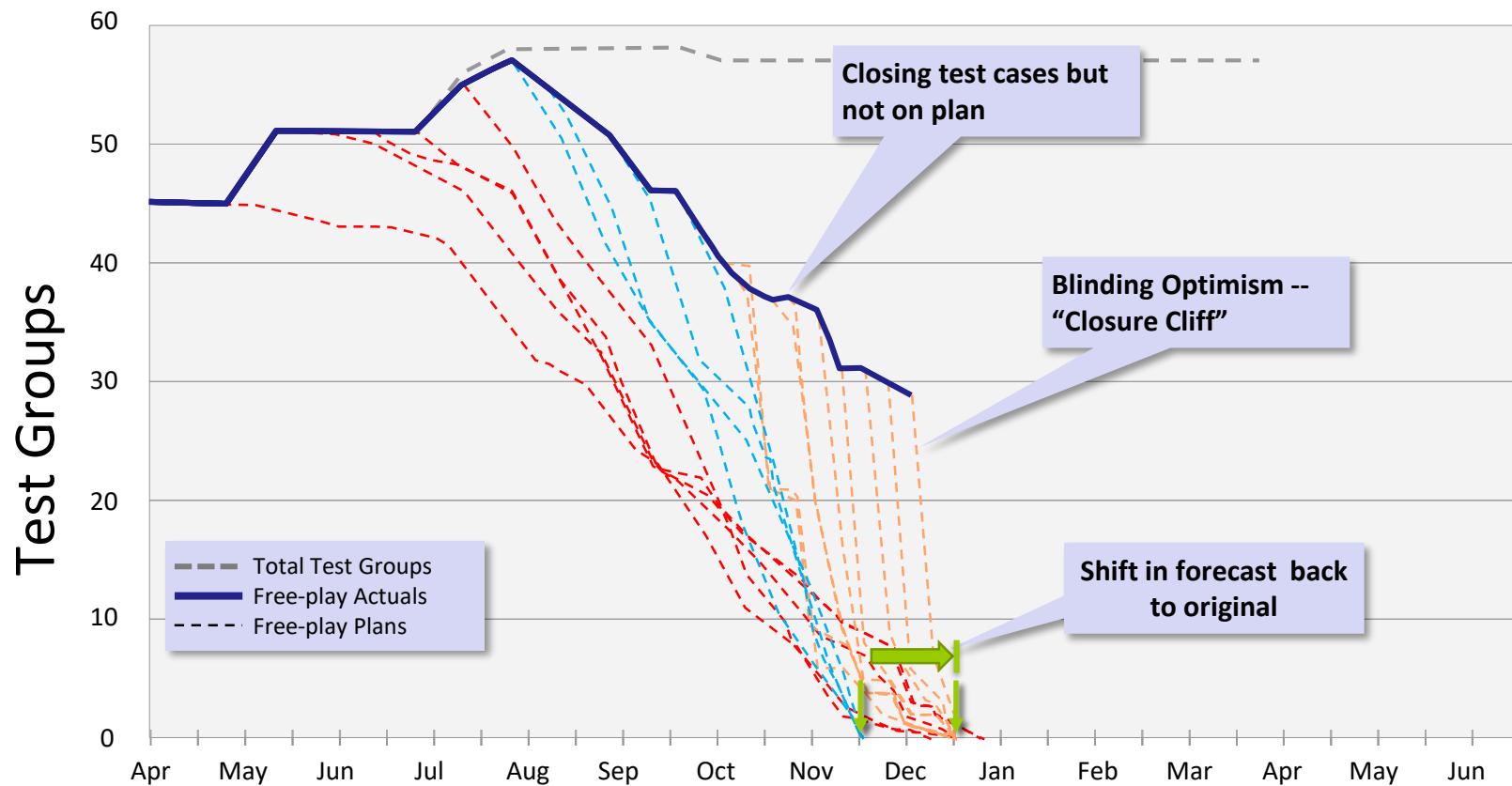


Sample Metrics Testing Optimism



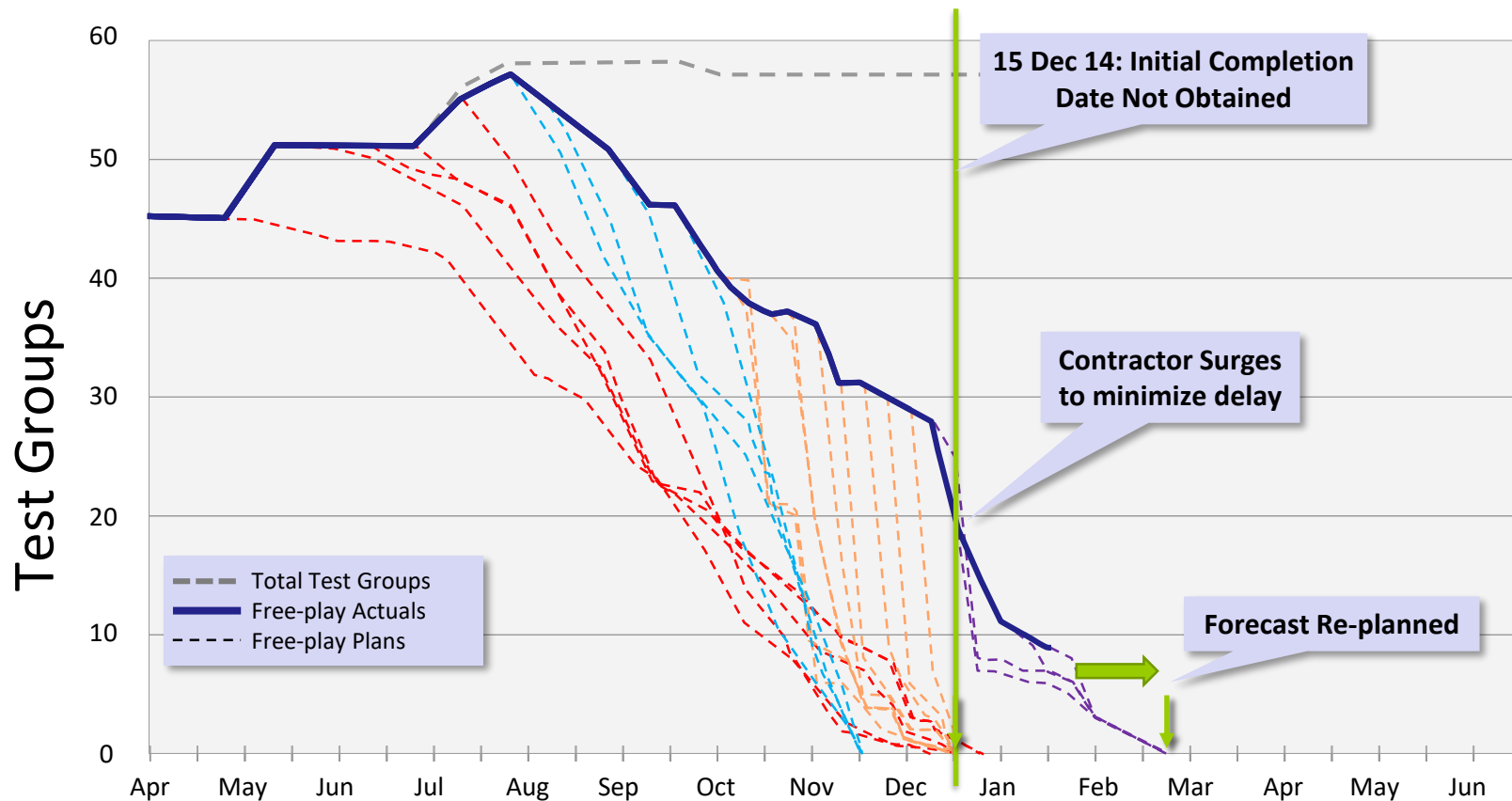


Sample Metrics Testing Optimism



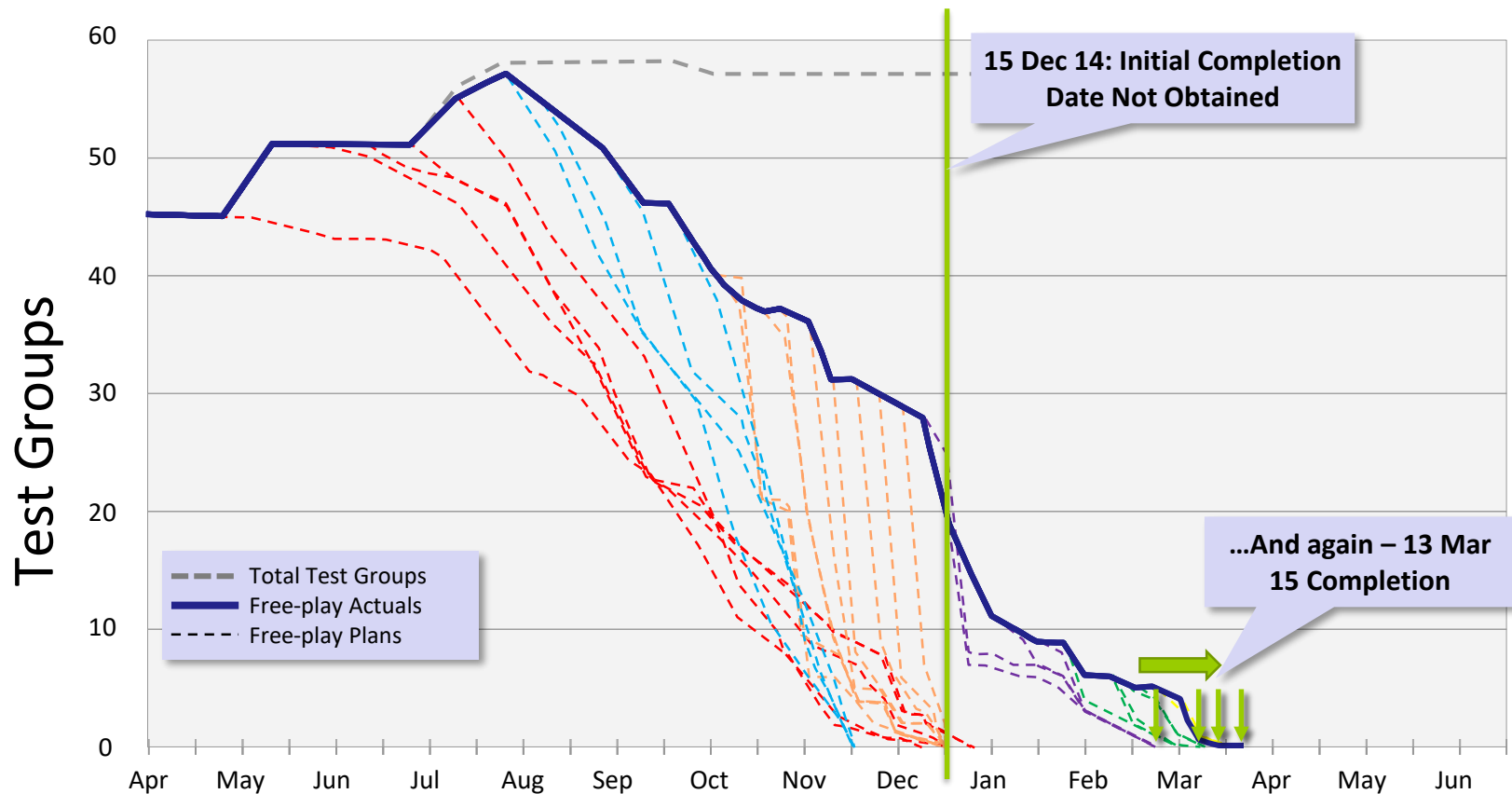


Sample Metrics Testing Optimism





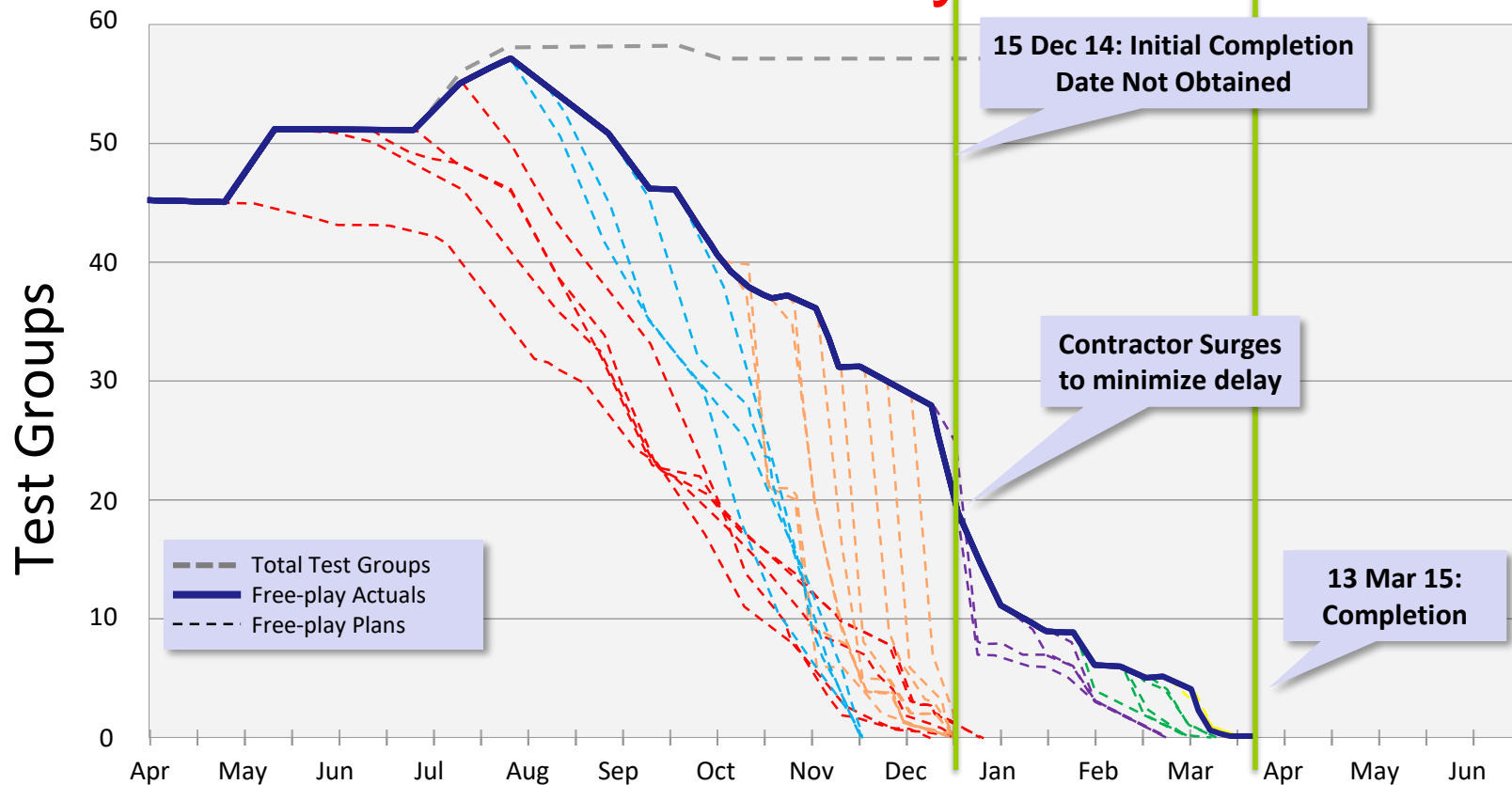
Sample Metrics Testing Optimism





Sample Metrics Testing Optimism

Summary





Opportunities

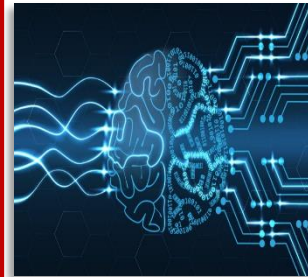
AUTONOMY

- **DSB: Autonomous solutions mitigate mission challenges**
 - Enable rapid decision making
 - Manage a high volume of data
 - Coordinate complex actions
 - Ensure persistence and endurance



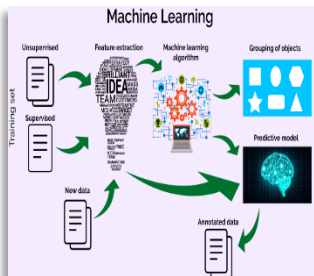
ARTIFICIAL INTELLIGENCE

- Improve on-board sensing
- Exploit time-critical intelligence from seized media
- Manage a dynamic spectrum for protection missions



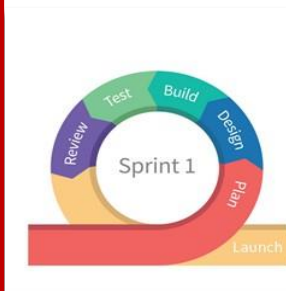
MACHINE LEARNING

- Adapt acquisition and sustainment to rapid deployment
- Attain predictive logistics and adaptive planning



CONTINUOUS CAPABILITY DELIVERY

- Software “immortality”
- Iterative development and sustainment
 - Agile





Opportunities

MODELING & SIMULATION

- **Enable warfighting capability and acquisition**
 - Reduce risk
 - Accelerate programs
 - Save lives and \$



MODEL BASED SYSTEMS ENGINEERING AND TEST

- **System requirements, design, analysis, verification and validation across the life cycle**
 - Improve communication
 - Manage increased complexity
 - Improve quality



EXPANDING SOURCES

- **National SW resources and capabilities**
 - Embrace U.S. leadership in SW
 - Utilize Silicon Valley



Challenges

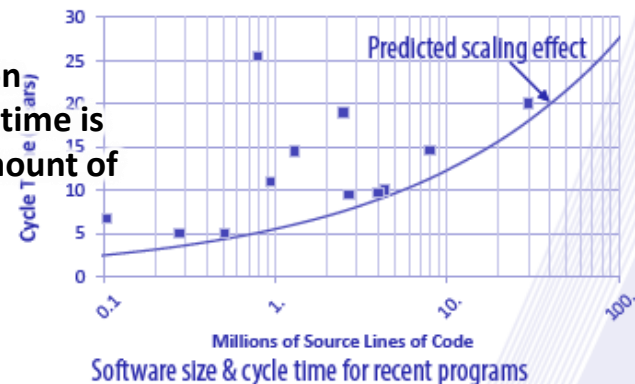
Cyber-attack

- Increased SW provides a vulnerability path to a master OFF switch
- Need to protect key mission components from malicious activity
- As SW increase the potential for vulnerabilities increases exponentially
- Ensure key data is protected from adversary collection
- Strengthen Supply Chain Activities



SW is rate controlling step in acquisition

DoD acquisition program cycle time is dictated by amount of SW



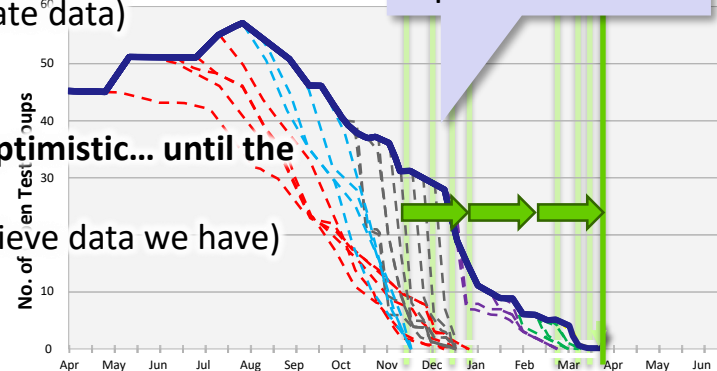
David M. Tate, Software Development May Drive Future Acquisition Cycle Times, (Revised)IDA Document NS D-8053 (Revised) October 2016; Log: H 16 000790 - Approved for public release; distribution is unlimited.

Inadequate insight – performance to plan

Never quite sure where we are during development (inadequate data)

Optimism blinds reality... Believe closure is imminent despite data

Always optimistic... until the end (can't believe data we have)





Challenges

Defects / unintended consequences

Impossible to exhaustively test systems

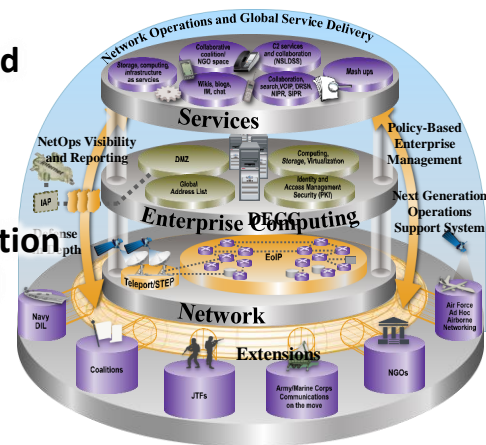
How do we establish and maintain trust in SW systems?



Grand architectures

Grand scales and unified architectures hamper timely solutions

Need to modify acquisition processes for “Minimal Viable Product”

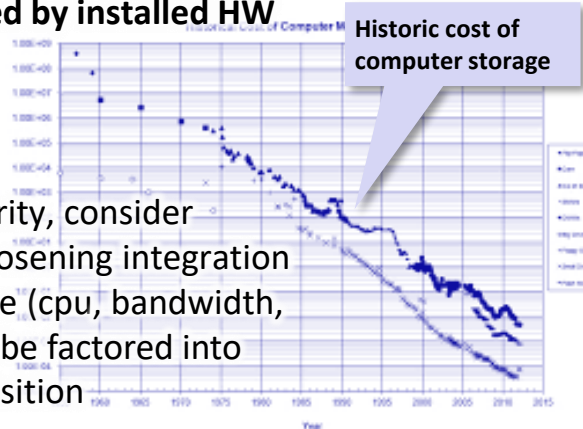


SW – HW coupling

Current: HW is static in a system; SW evolution is limited by installed HW

Next Gen:

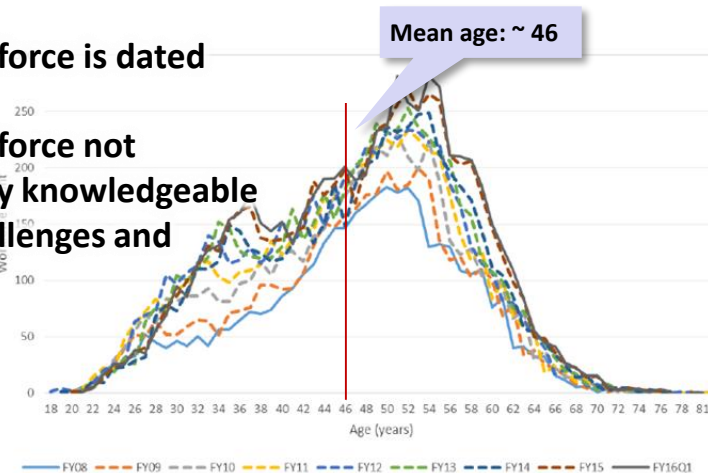
- Value modularity, consider decoupling/loosening integration
- HW abundance (cpu, bandwidth, etc.) needs to be factored into iterative acquisition



Software / data / skills are critical resources

DoD workforce is dated

DoD workforce not sufficiently knowledgeable to SW challenges and solutions





Agile/Classic Concepts

Conditions	Agile	Classic DoD
Customer Involvement	<ul style="list-style-type: none">Stakeholder Involvement	<ul style="list-style-type: none">Integrated Product Teams
Approach	<ul style="list-style-type: none">Continuous Iterative Development	<ul style="list-style-type: none">Build a little, test a little, learn a lot
		<ul style="list-style-type: none">Pre-Planned Product Improvement
Modularity	<ul style="list-style-type: none">Incremental, “vertical slice” productsIncremental developments have value, and customers can use them.Work can be broken into parts and conducted in rapid, iterative cycles.Late changes are manageable.	<ul style="list-style-type: none">Chunk the problemCustomers cannot start testing parts of the product until everything is complete.Late changes are expensive or impossibleMOSA
		<ul style="list-style-type: none">In-phase defect containment
		<ul style="list-style-type: none">Total Quality Management

**Incomplete data on agile at scale, with some exaggeration – However...
Empirical data and strong industry movement to agile development across
all domains strongly motivates DoD to move to agile development**



Addressing the Challenge!

Valuing velocity

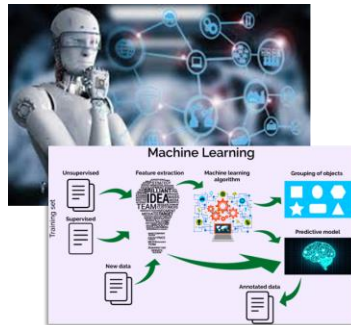
Challenge/Opportunity	Approach
Software/data are critical assets, software/related fields are critical skills	<ul style="list-style-type: none">•Cultivate workforce, centers of excellence, capabilities, base•Software Factory, repository•Outreach to industry, academia
Software has become rate controlling step in acquisition	<ul style="list-style-type: none">•Credibility in planning & execution – improve scoping & metrics framework•Establish/demonstrate Software Factory early (TMRR), use in evaluations•Common production/mission representative development and test environments•Harness technology (e.g., automation (build, test), machine learning, etc.))
Grand scales and unified architectures are challenging	<ul style="list-style-type: none">•Modify requirements process - “Big R” - enable MVP / P3I•Modify acquisition processes - right-size programs and approaches•Value modularity, consider decoupling/loosening integration•Reduce customization (enterprise optimization)•Promote multi-functionality
Software enables opportunity for continuous capability delivery	<ul style="list-style-type: none">•Software is immortal•Iterative development – initial development and sustainment
Hardware limitations are barriers	<ul style="list-style-type: none">•Hardware abundance (cpu, bandwidth, etc.) supporting iterative acquisition•Promote hardware/software independence
Cyber/program protection / resilience add layers to challenge	<ul style="list-style-type: none">•Build in capability•Refresh opportunity•Manage risk•“Software by the pound”

Implement on current and legacy programs



Conclusion

- Unrelenting demand for SW in DoD
- SW is the fuel for innovation and future capabilities
- Action needs to be taken to meet challenges
 - Diversify the Department's approach and sources
 - Embrace opportunity in a change-rich environment (threats, technology, process improvements)



Shift to threat-based acquisition demands *enhanced velocity*
Shift SW acquisition to an enabler of speeding capability



Fearless workers who stood with their back to a TANK roaring towards them to prove its stopping power

Link: http://video.dailymail.co.uk/video/1418450360/2014/01/1418450360_3121005887001_tank-brake-test.mp4





Systems Engineering: Critical to Defense Acquisition



Innovation, Speed, Agility
<http://www.acq.osd.mil/se>



What About Agile?

- **Can Agile address the complexity of DoD systems?**
 - Can we **decompose** tightly-coupled technical requirements into Agile user stories and controlled interfaces?
 - Can we **identify authoritative customers** - among many diverse stakeholders, including the Adversary - for feedback and iteration?
 - Can we **learn** from small, agile teams and scale to complex projects?
 - Can we support formal, **independent testing** over long test cycles?
 - Can we deliver **capabilities**?
- **Can Agile address regulatory challenges?**
 - Can we provide enough **“up-front” cost, schedule, and risk** analysis to satisfy DoD regulatory and statutory requirements?
 - Can we support the **persistent oversight and management** requirements of DoD acquisitions?
 - Can we mix **contractual negotiation** with customer collaboration?

DoD Systems tend to be complex, with independently-developed, highly-coupled components



CMMI Thoughts

- **Previous experience with CMMI “good in theory, but not so much in practice”**
 - Chasing maturity levels vs. continuous performance improvement.
- **Concept of the “Software Factory” (consistent, realistic outcomes for schedule, cost, quality and functionality performance of SW)**
 - Make “Software boring”
- **Agile also not without its issues – still comes down to discipline, if the discipline is missing, still poor quality of code, no matter how soon it can be done.**
- **Move beyond Agile / DevOps – e.g., Software Lifecycle Automation**
- **Acquisition Challenges: Greater reliability and consistency (and insight) into contractor’s abilities to meet the mission requirements for SW, Systems, etc.**
 - Being able to distinguish the real differentiators between contractors re: performance