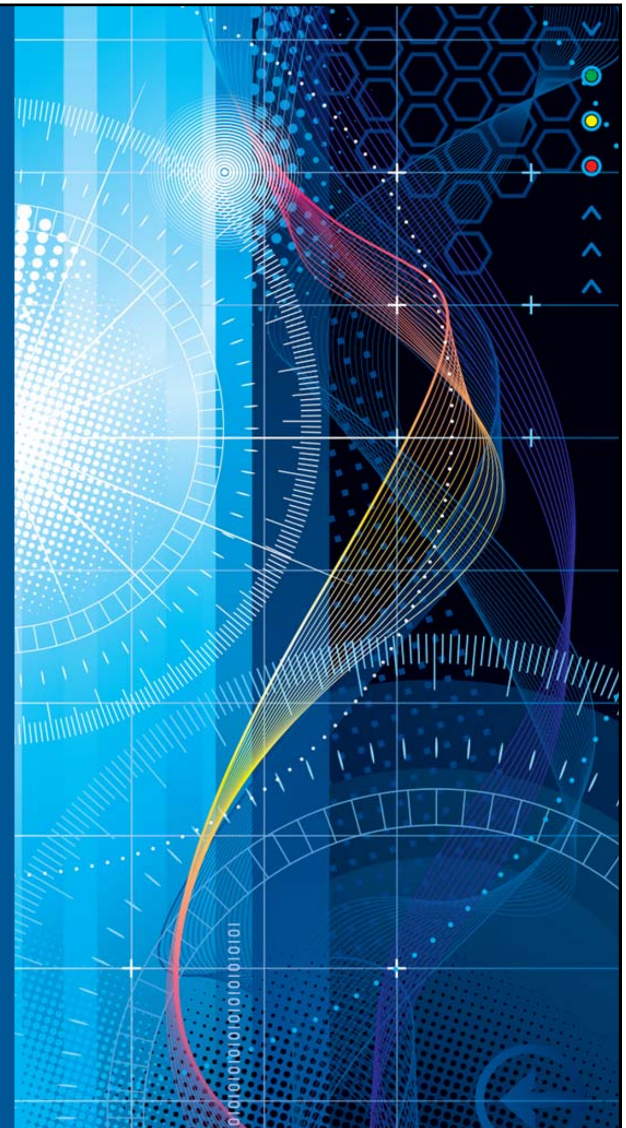
Measurement Challenges: Engineering-In Software Quality Assurance to the System Acquisition Lifecycle



Dr. Kenneth E. Nidiffer

Eighteenth Practical Software and Systems Measurement Users' Group Workshop
Measurement in a Complex Environment

Lockheed Martin Global Vision Center
Crystal City, Arlington, VA

12-16 June 2017
Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213

Software Engineering Institute | Carnegie Mellon University

Measurement Challenges: Engineering-In and Transitioning Software Assurance into the System Acquisition Lifecycle

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Software-Enabled Systems Are Today's Strategic Resource

Dr. Bill Scherlis*

"Software is the building material for modern society"

Software

Oil

Steam

Water

Manual Labor

Source: SEI

Increasing Globalization, Productivity, and Complexity

Engineering-In Software Quality Assurance Throughout the SDLC* - Measurement Challenges

1. Increasing complexity of software
2. Satisfying unique operational mission and business needs
3. Solving the vulnerability identification chasm
4. Addressing system sustainment
5. Handling the expanding code base
6. Understanding attack patterns, vulnerabilities, and weaknesses
7. Increasing vulnerabilities
8. Designing-in software quality over the lifecycle
9. Reducing technical debt
10. Working in the infancy of software engineering discipline

*** SDLC: System Development Life Cycle**

Context: Software Assurance/Cyber Imperative

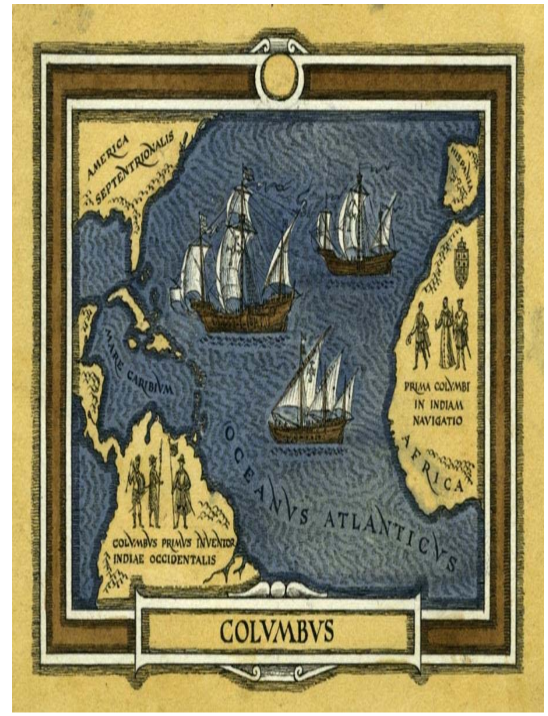
- In early 2017, the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)) updated DoDI 5000.02 to include a new Enclosure 14. The policy states, in part,

  “Program managers, assisted by supporting organizations to the acquisition community, are responsible for the cybersecurity of their programs, systems, and information…”

- Persistent pursuit of software quality assurance is a constant struggle in part because processes, methods, and measurements across the lifecycle are not mature
- Program managers’ guidebooks for engineering software quality assurance into the system acquisition lifecycle are being worked on

Context: Increasingly Software Quality Assurance Is a Moving Target

- **Definition*:** The level of confidence that software functions as intended and is free of vulnerabilities, either intentionally or unintentionally designed or inserted as part of the software throughout the lifecycle
- **Moving target:** The changing and expanding role that software plays in cyberspace means that the development of software-enabled systems must continue to evolve while we pursue software quality

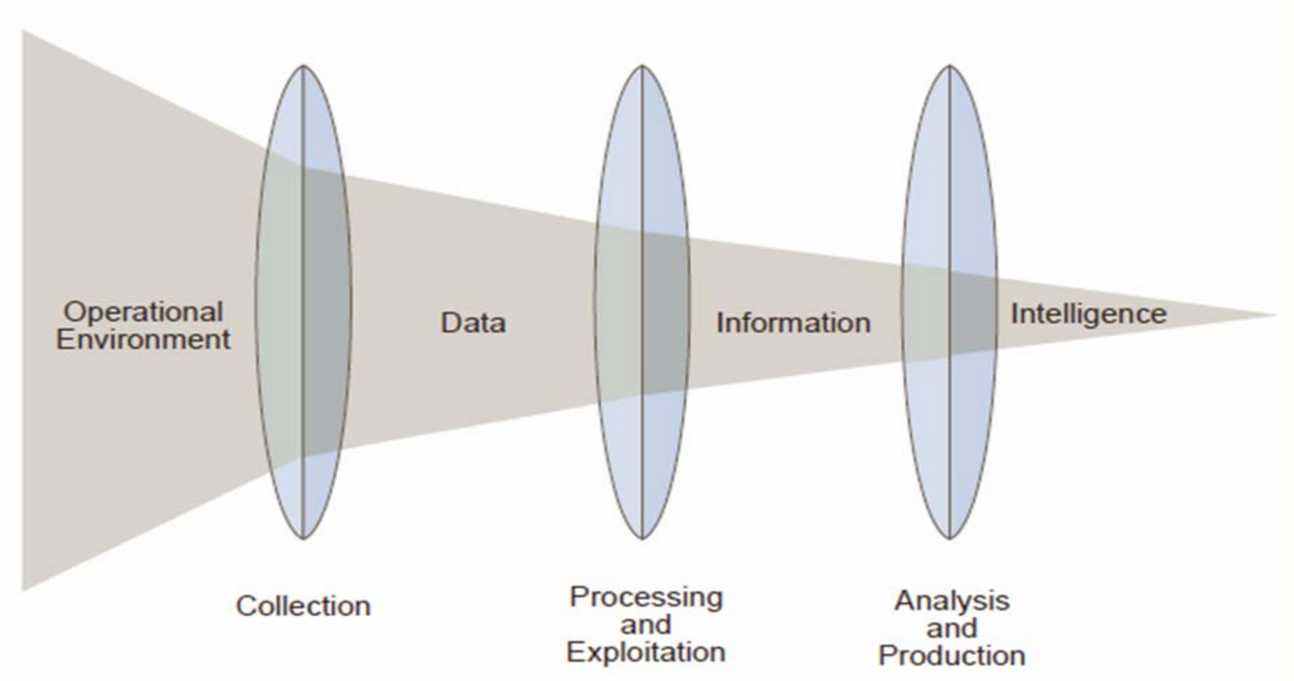


***Source:** DoDI 5200.44 Protection of Mission Critical Functions to Achieve Trusted Systems and Networks (TSN), and 2013 NDAA S933

Source: SEI

Intelligence Model – Support for Decision Making

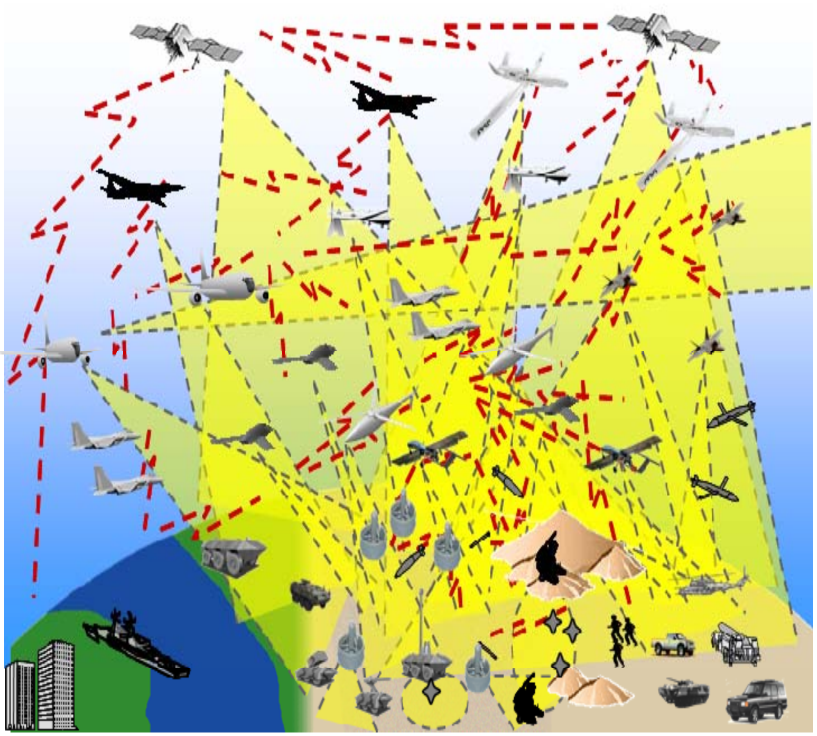
Relationship of Data, Information and Intelligence



Source: Joint Intelligence / Joint Publication 2-0 (Joint Chiefs of Staff)

Context: Enduring Questions That Drive Hard Choices About This Imperative

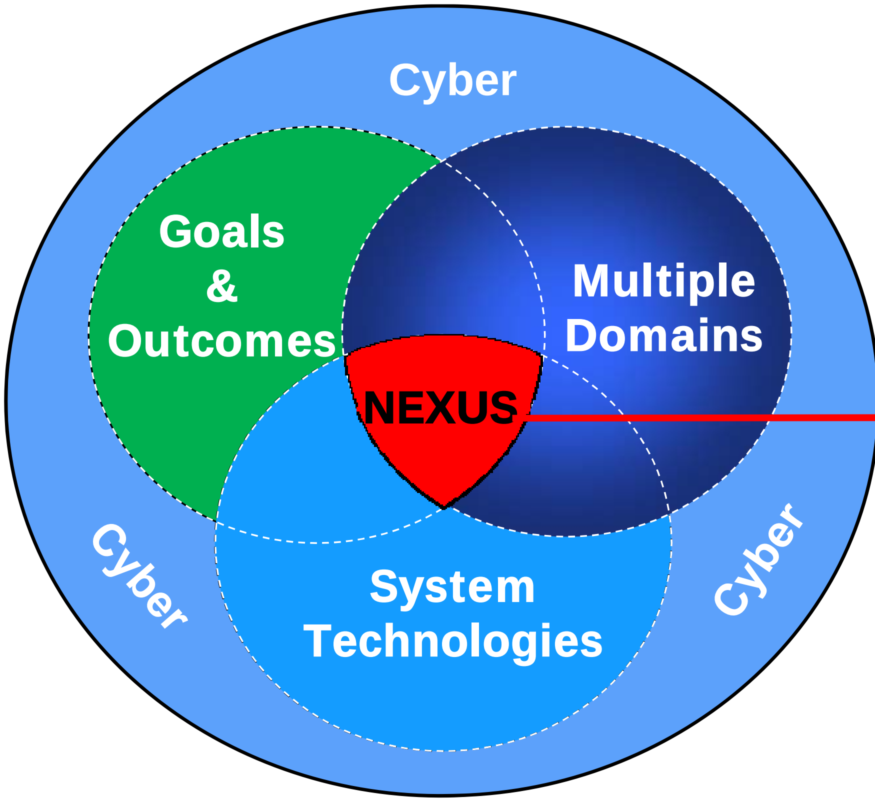
- How much is enough?
- How much does “enough” cost?
- Is “enough” affordable?
- How does one decide?
- How does one evaluate the “goodness” of the decision?



Measures Supporting Advancements in Program Management, With Operational Participation, are Needed

Source: SEI

Context: Traditional Project Measures Integrated with Big Data Measures



Source: SEI

Nexus Drivers

- **Dynamic policies and domain characteristics**
- **Rapidly changing needs**
- **Blurring of traditional organizational lines**
- **Complex governance**
- **$, resources, workforce constraints**
- ***Technology optempo!***
  - ***big data collection***
  - ***processing information***
  - ***analytics and production***
- ***Measurement model may be domain dependent***

Context: Example Domain - Autonomous Systems

- Algorithmically driven agents will work in **5%** of economic transactions
- **20%** of all business content will be authored by machines
- **6 billion** connected things will be requesting support
- **50%** of the fastest growing companies will have fewer employees than smart machines
- More than **3 million** workers globally will be supervised by “robobosses”

DoD is increasingly employing autonomous capabilities across a diverse number of systems

Source: DSB Study – June 2016

Autonomous Systems in Use Today Are the Result of Decades of R&D

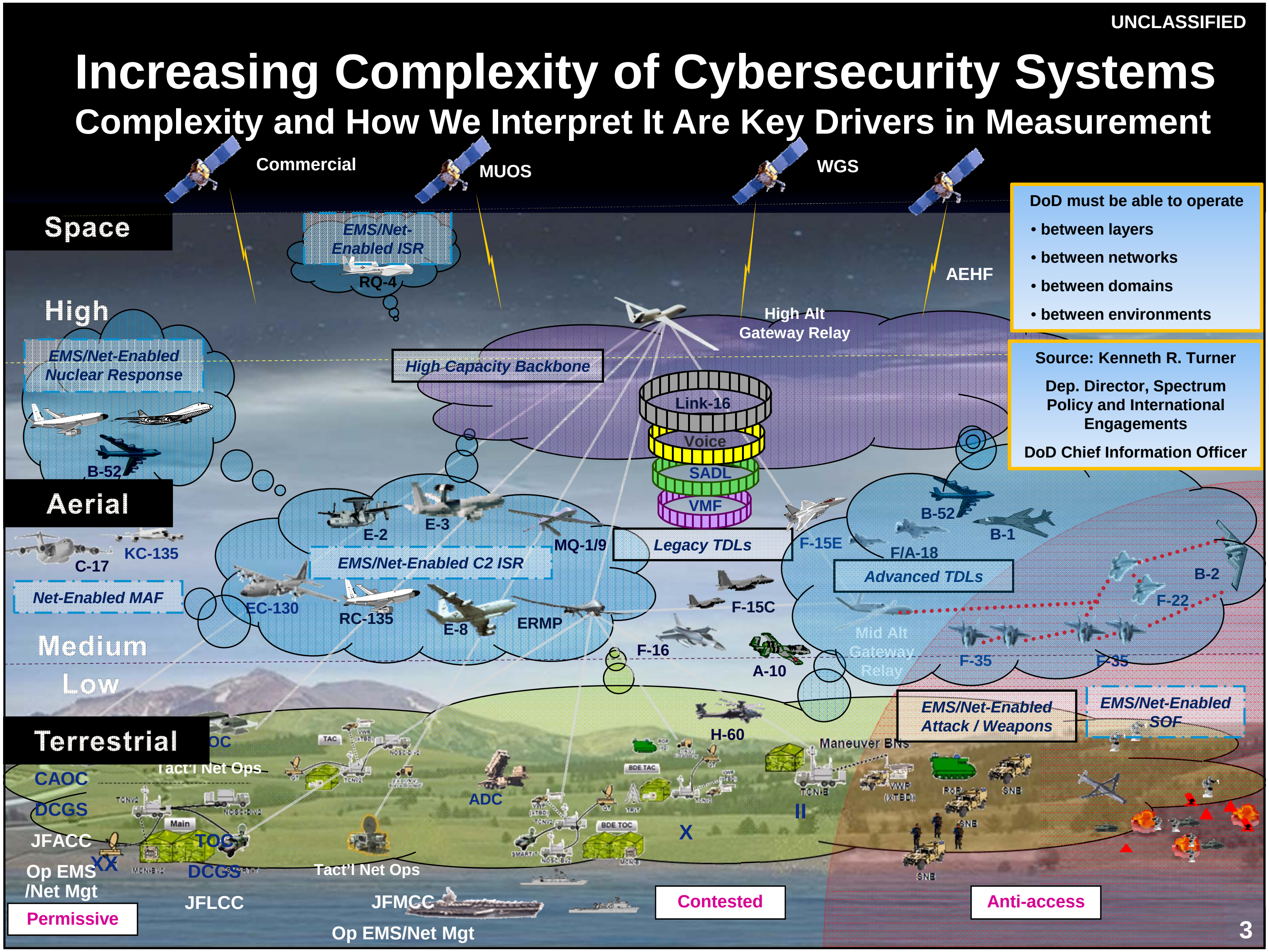
R&D areas include

- digitization of sensors
- adaptive algorithms
- natural user interfaces
- machine learning
- machine vision
- data analytics

Source: SEI

Impact of Increasing Software-Intensive Autonomous Systems

- Emergent behavior
- Continuous and asynchronous delivery
- Continuous system evolution
- Hard-to-define system boundaries
- Human-machine interface issues
- Data-rich environment
- Growing gap between information obtained using traditional project measures and project managers information needs


UNCLASSIFIED
Increasing Complexity of Cybersecurity Systems
Complexity and How We Interpret It Are Key Drivers in Measurement
Commercial
MUOS
WGS
AEHF
Space
High
Aerial
Medium
Low
Terrestrial
EMS/Net-Enabled ISR
RQ-4
EMS/Net-Enabled Nuclear Response
B-52
High Capacity Backbone
High Alt Gateway Relay
Link-16
Voice
SADL
VMF
Legacy TDLs
Advanced TDLs
DoD must be able to operate
• between layers
• between networks
• between domains
• between environments
Source: Kenneth R. Turner
Dep. Director, Spectrum Policy and International Engagements
DoD Chief Information Officer
E-2
E-3
MQ-1/9
C-17
KC-135
EMS/Net-Enabled C2 ISR
Net-Enabled MAF
EC-130
RC-135
E-8
ERMP
F-15E
F/A-18
B-52
B-1
B-2
F-22
F-35
F-15C
F-16
A-10
Mid Alt Gateway Relay
H-60
Maneuver BNs
EMS/Net-Enabled Attack / Weapons
EMS/Net-Enabled SOF
Tact'l Net Ops
CAOC
DCGS
JFACC
Op EMS /Net Mgt
TOC
DCGS
JFLCC
ADC
Tact'l Net Ops
JFMCC
Op EMS/Net Mgt
Permissive
Contested
Anti-access
3

Satisfying Unique Operational Mission and Business Needs

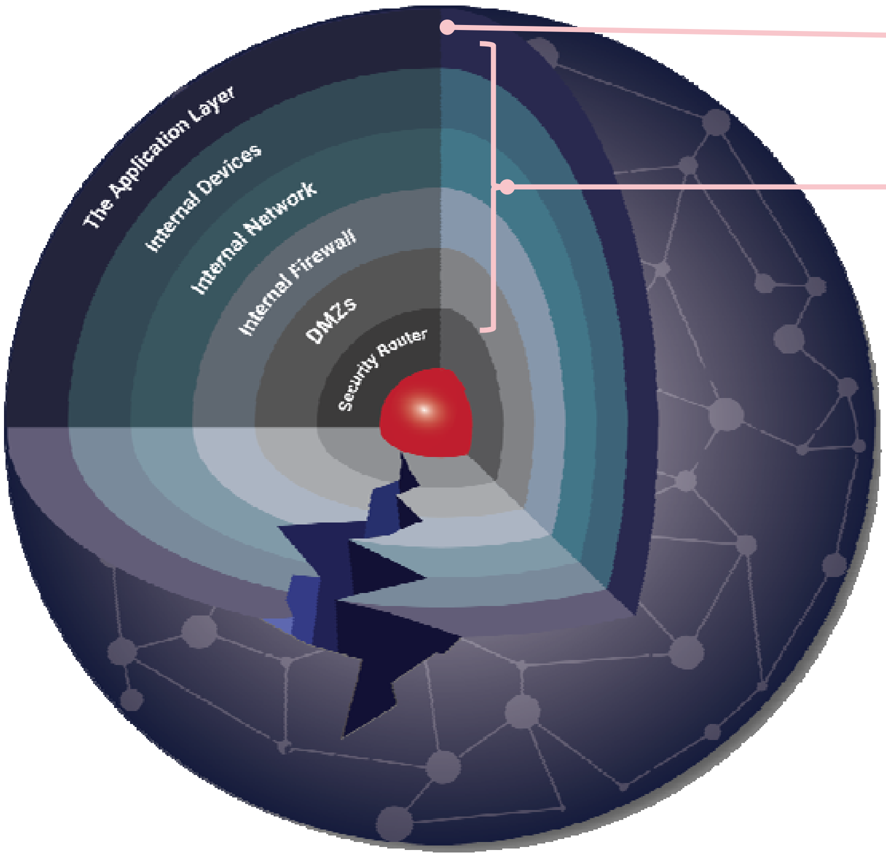
Practical measures for a complicated world:

Reassessment of information measures

Source: SEI

Solving the Vulnerability Identification Chasm

First line of defense in software assurance is the application (software) layer: Classic Issue – Tacking action on the measurement data we have



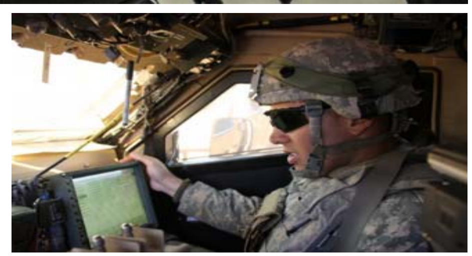
84% of breaches exploit vulnerabilities in the application[1]

Yet funding for IT defense vs. software assurance is 23 to 1[2]

1. Clark, Tim, "Most Cyber Attacks Occur from This Common Vulnerability," *Forbes*, 03-10-2015
2. Feiman, Joseph, "Maverick Research: Stop Protecting Your Apps; It's Time for Apps to Protect Themselves," *Gartner*, 09-25-2014. G00269825

Addressing System Sustainment

Software development and sustainment require planning: Applying software assurance (SwA) measures across SDLC



Break point where software is handed off for sustainment is increasing blurred

Involves coordinating processes, procedures, people, and information

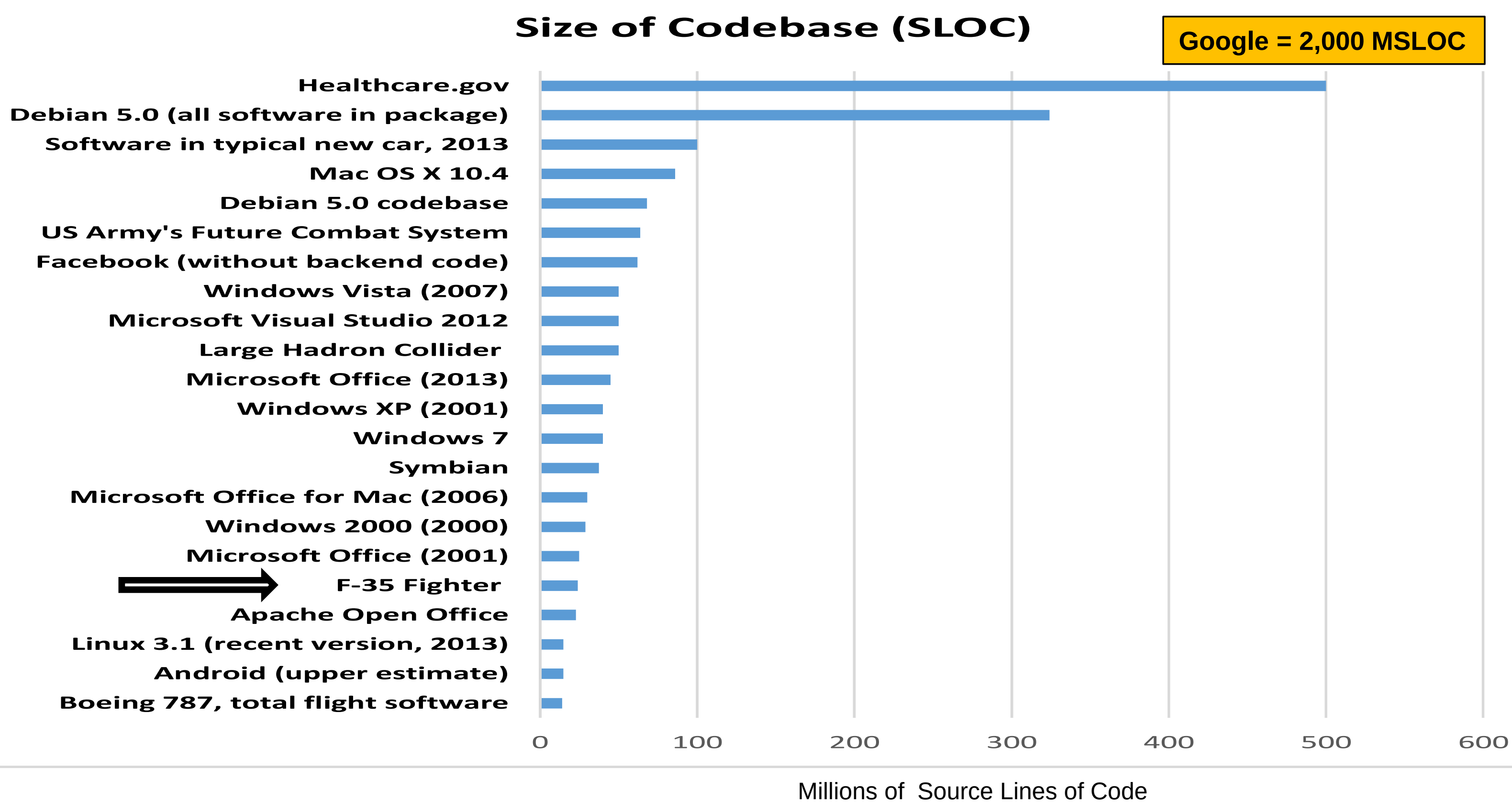
Challenges include

- rising costs
- Recertification/retesting
- dynamic operating environments
- legacy environments
- SDLC SwA measures

Source: SEI

Handling the Expanding Code Base

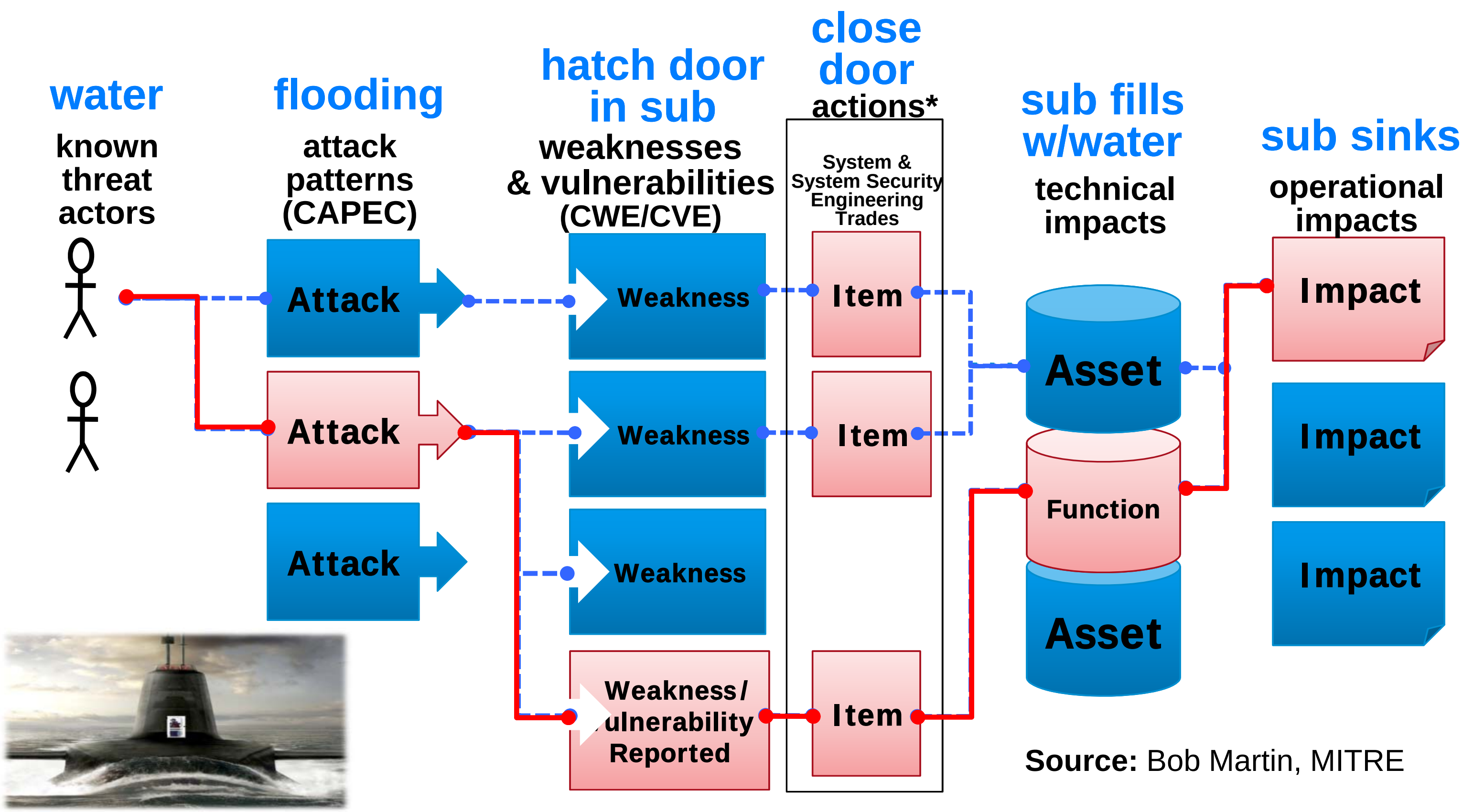
Software is dramatically expanding with limited natural governance: Finding measures that scale is a bigger issue



Source: David McCandless, "Information is Beautiful," 21 September 2016 web retrieval

Understanding Attack Patterns, Vulnerabilities, and Weaknesses

Defining cybersecurity measurements to satisfy information needs

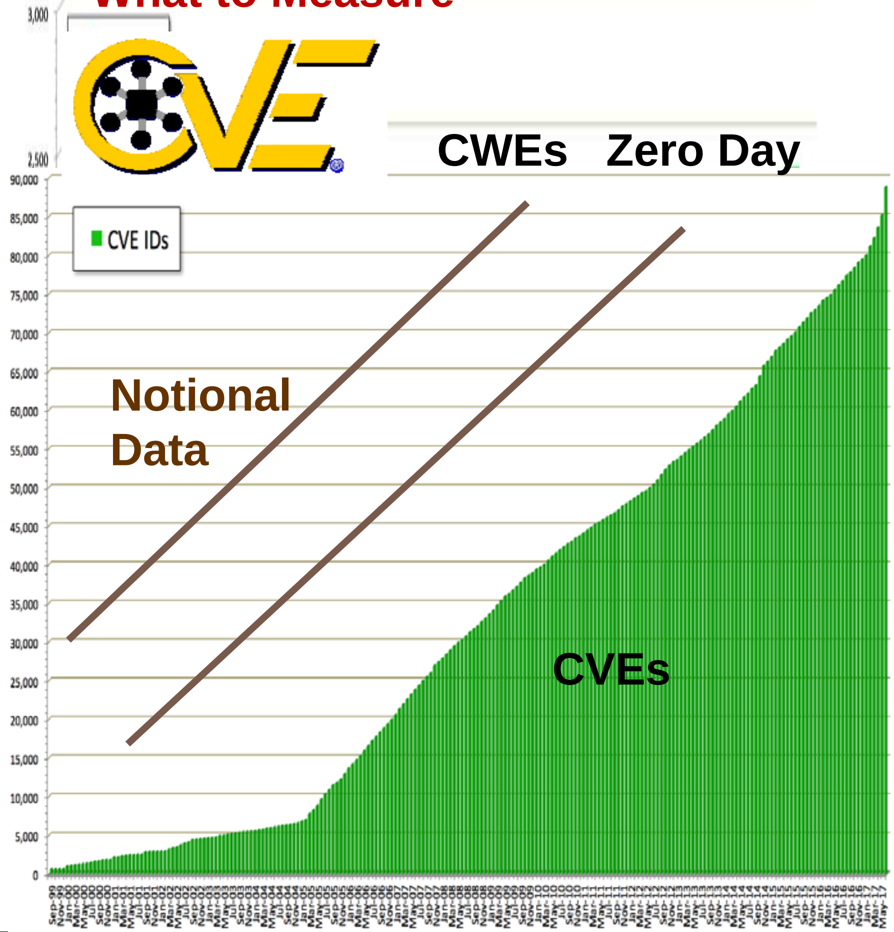


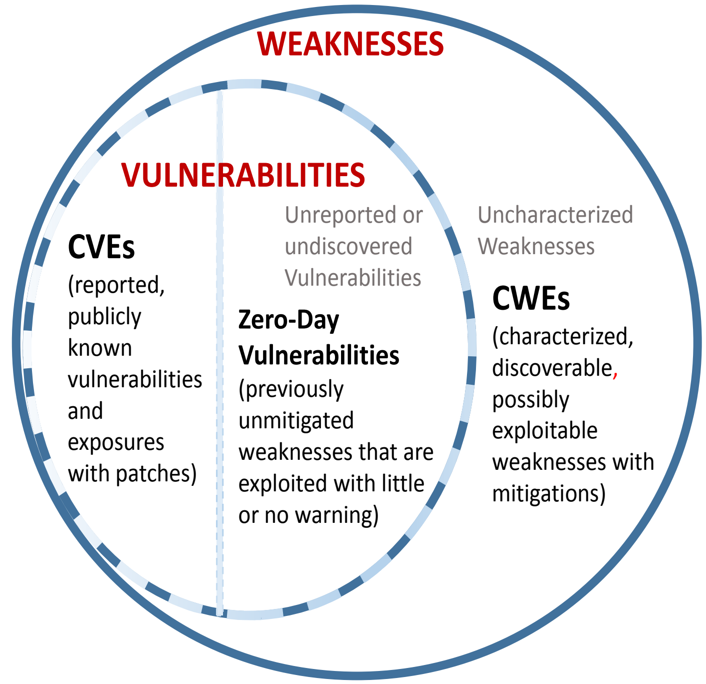
Source: Bob Martin, MITRE

- **"Actions"** include architecture choices; design choices; added security functions, activities, and processes; physical decomposition choices; static and dynamic code assessments; design reviews; dynamic testing; and pen testing.
- **Vulnerability** is the intersection of three elements: a system susceptibility or flaw, attacker access to the flaw, and attacker capability to exploit the flaw.

CVE 1999 to 2017 : Reported Common Vulnerabilities and Exposures (CVE)

What to Measure

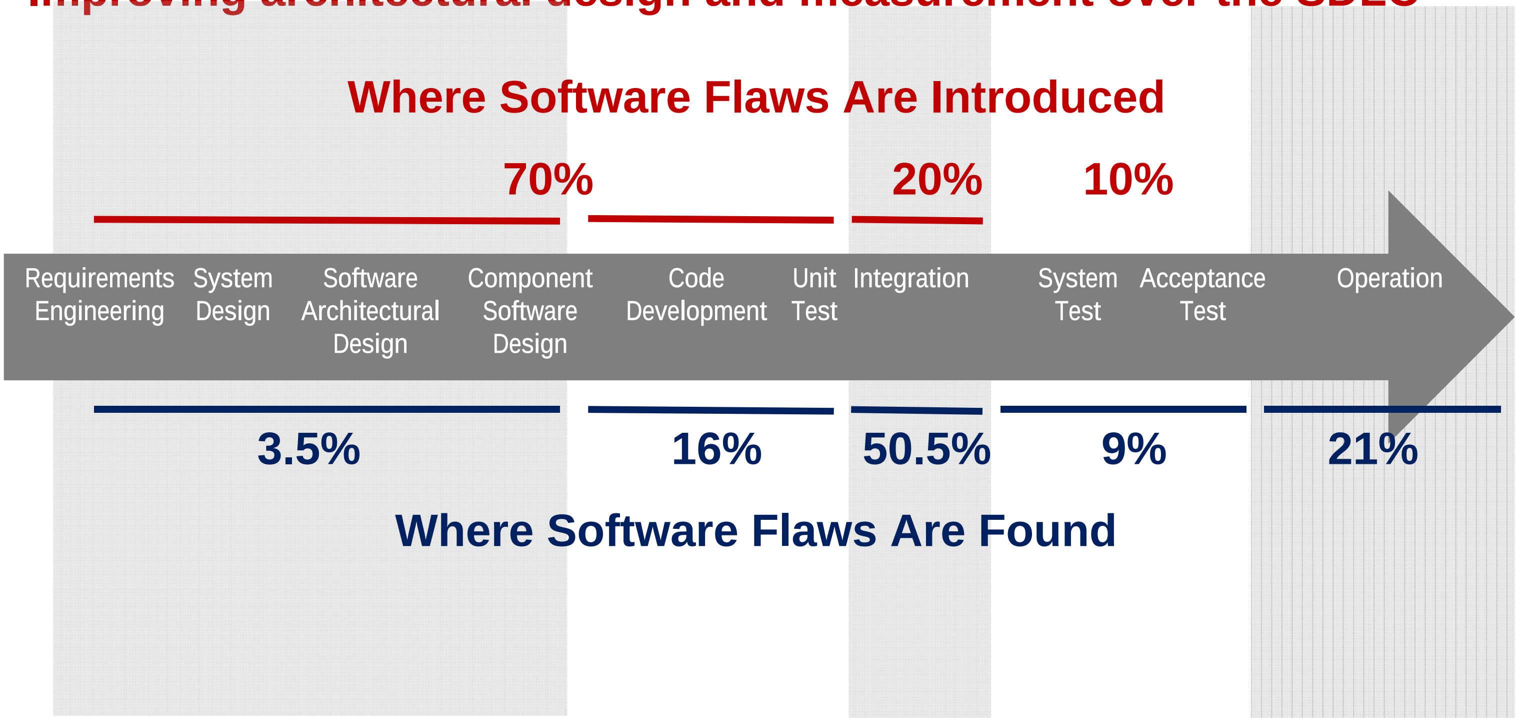




Source: Dr. Robert A. Martin, MITRE Corporation, May 2017

Example: Software Quality Measurement over the SDLC

Improving architectural design and measurement over the SDLC

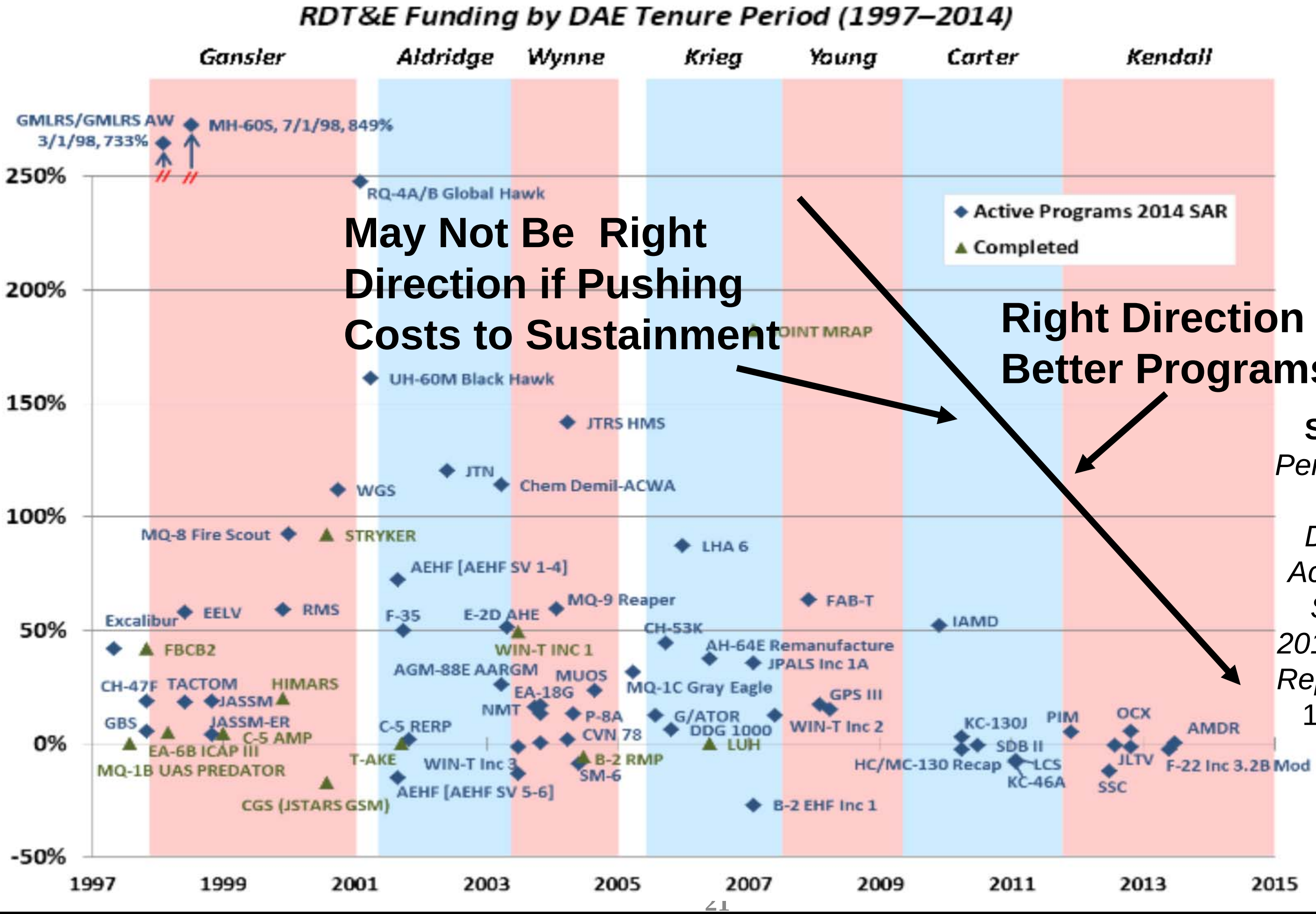


Modern development and testing tools will be critical

Sources: *Critical Code*; NIST, NASA, INCOSE, and Aircraft Industry Studies

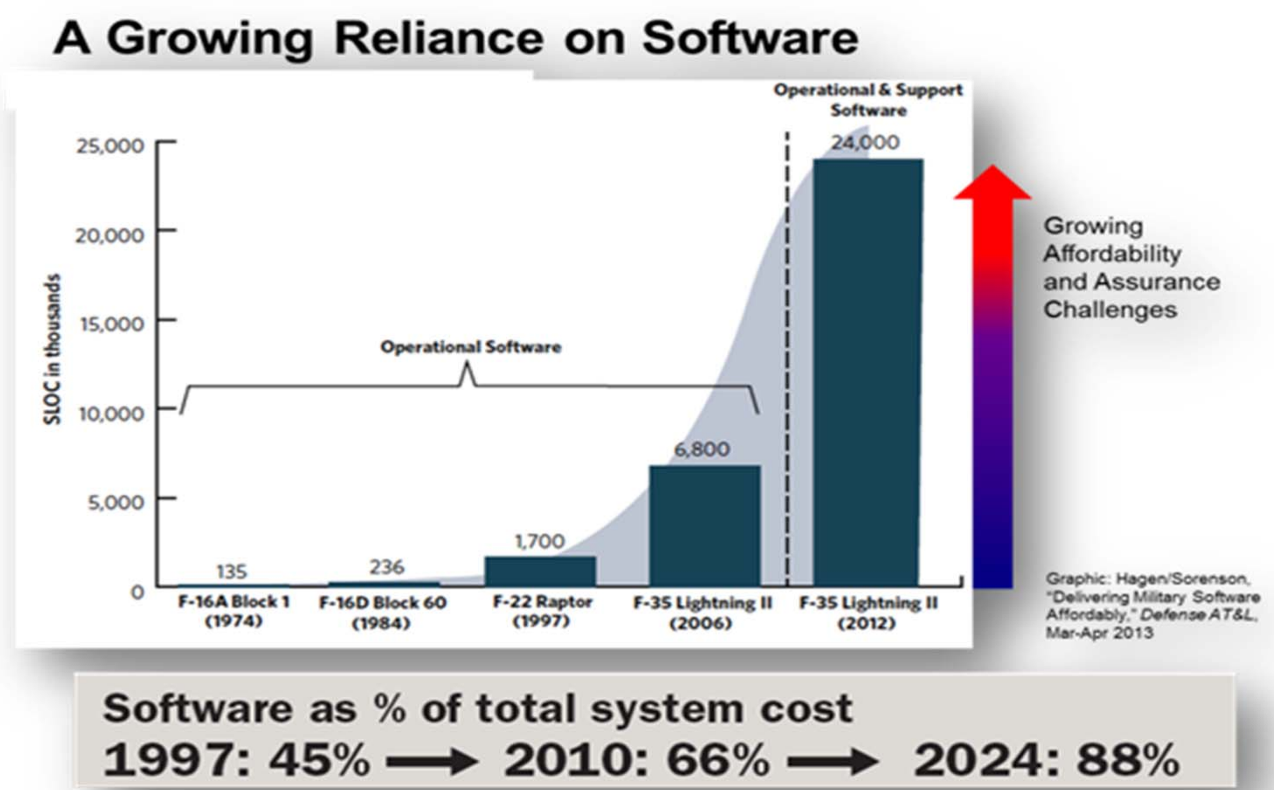
Example: Reducing Technical Debt

Measures of accumulating software assurance technical debt?



Source: *Performance of the Defense Acquisition System 2015 Annual Report*, Sep. 16, 2015

Example: Measuring Technical Debt - the Expanding Code Base - OSD Weapon Systems



Source: U.S. Air Force Scientific Advisory Board. *Sustaining Air Force Aging Aircraft into the 21st Century* (SAB-TR-11-01). U.S. Air Force, 2011.

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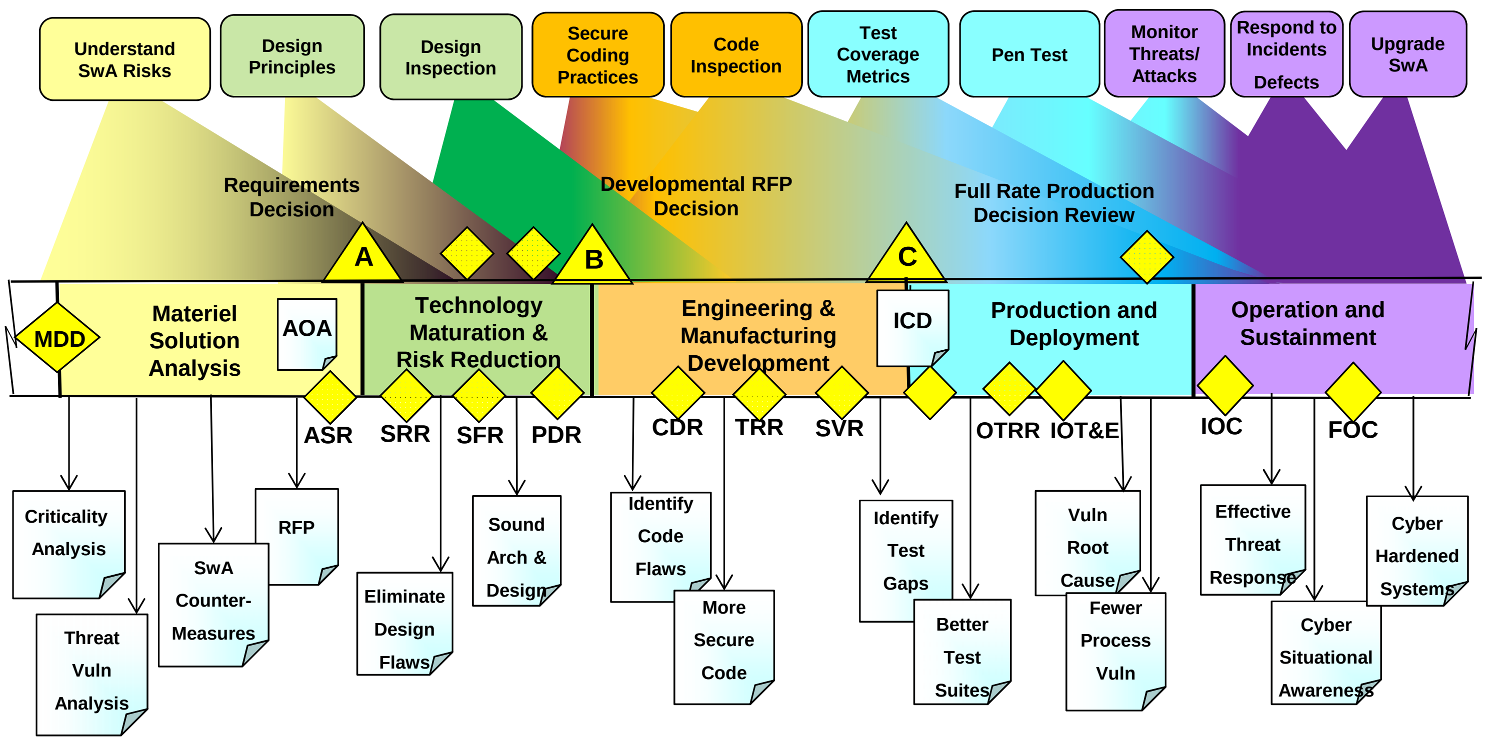
Engineering-in Software Assurance Over the Lifecycle

Engineering Artifacts Provide Opportunities for More Integrated Measurement



Working in the Infancy of the Software Engineering Discipline

Improving the workforce by developing software core competencies and career field

	Physical Science	Bioscience	Computer/Software/Cyber Science
Origins/History	Begun in antiquity	Begun in antiquity	Mid-20th century
Enduring Laws	Laws are foundational to furthering exploration in the science	Laws are foundational to furthering exploration in the science	Only mathematical laws have proven foundational to computation
Framework of Scientific Study	Four main areas: astronomy, physics, chemistry, and earth sciences	Science of dealing with health maintenance and disease prevention and treatment	• Several areas of study: computer science, software/systems engineering, IT, HCI, social dynamics, AI • All nodes are attached to and rely on a netted system
R&D and Launch Cycle	10–20 years	10–20 years	Significantly compressed; solution time to market must happen very quickly

HCI: human–computer interaction; AI: artificial intelligence

Source: SEI

Source: SEI

Example: Human-Machine Teaming

In the real world, autonomy is usually granted within some context—explicit or implicit

- parents and children
- soldiers, sailors, marines, and airmen

How do we do this for machines?

- Explicit may be easy, but implicit is hard for machines
- Commander’s intent
- Mission orders

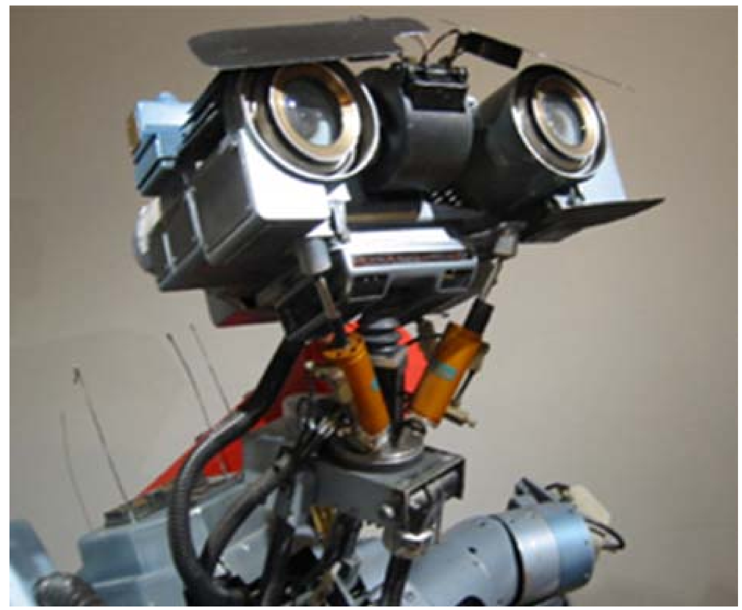
Related to need for explainability and predictability

So Where Does This Lead Us?

- A more robust measurement approach will be needed…
- Decision makers will need insight and understanding about the meaning of the data
- As software-dominated system projects become larger in scope/complexity … capitalizing on opportunities for making better decisions will become more important
  - Critical to shift from "what happened?" which is a question of information based on sparse data
  - To seeking insight by asking "what happened, why, how do we solve the problem, and can we evaluate that it has been solved?"
- Enabling an analytics based framework that seeks to leverage traditional measurement, metrics, data, and information - if done right will provide meaningful understanding and insight

Final Thought: Measurement of Advanced Program Management, With Operational Participation,

Will determine if we create C3PO and Johnny 5 . . .



Source: SEI

…or the Borg

Source: SEI

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