Software Assurance vs. Security Compliance:

Why is Compliance Not Enough?

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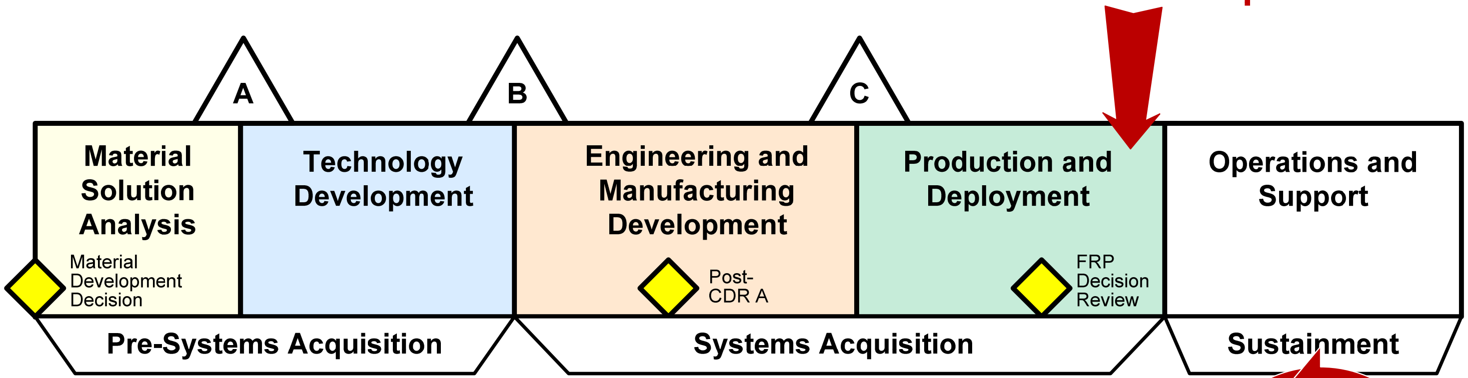
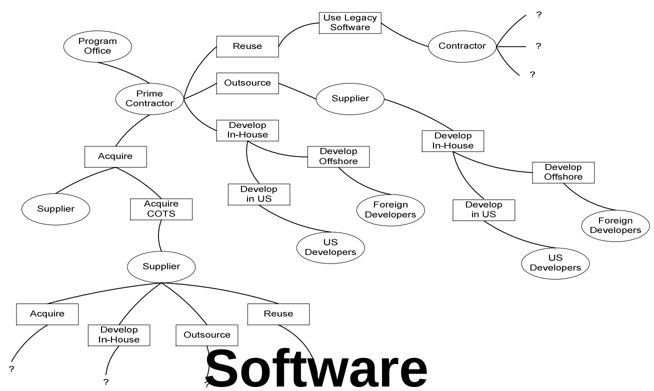
Current Challenge for Security Compliance

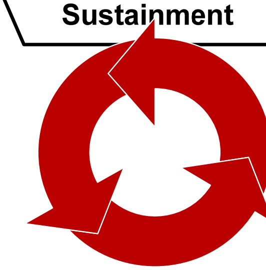
Acquisition Life Cycle

Certification and Authorization to Operate

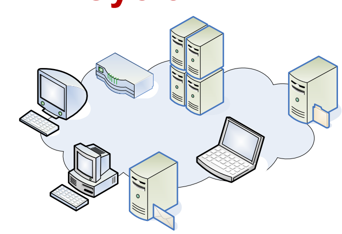




Software Supply Chain



Software Patch Cycle



How is Security Compliance Addressed?

Reliability, quality, and effective systems engineering are considered sufficient to address security

Security requirements are

- Established at the system level based on concerns for confidentiality, integrity, and availability (CIA)
- Assigned to components through system engineering decomposition
- Not required until Milestone B

Security Compliance Limitations

CIA principles were developed in 1974, and much has changed since then

Effective software engineering is not being addressed by system engineers

Many acquisition decisions affecting security are made before Milestone B

Origins of CIA - 1

Saltzer and Schroeder, “The Protection of Information in Computer Systems,” *Communications of the ACM,* 1974

Defined security as

- “techniques that control who may use or modify the computer or the information contained in it”

Described the three main categories of concern:

- confidentiality, integrity, and availability (CIA)

Origins of CIA - 2

Technology environment in 1974

- S360 in use from 1964-1978
- S370 came on the market in 1972
- COBOL & BAL programming languages in use
- MVS operating system released in March 1974

Origins of CIA - 3

What's missing?

- Internet
- Morris worm, which occurred in November 1988
- 49,296 common vulnerabilities and exposures (CVE)
- Java, C++, C#
- Mobile computing
- Bluetooth
- Stuxnet attack on isolated supervisory control and data acquisition (SCADA) systems
- Cloud computing
- etc.

Software Assurance

Picks up where compliance leaves off

Definition: Software assurance

(DHS Software Assurance Curriculum Project)

> Application of technologies and processes to achieve a required level of **confidence** that software systems and services function in the intended manner, are free from accidental or intentional vulnerabilities, provide security capabilities appropriate to the threat environment, and recover from intrusions and failures.

7 principles must augment CIA

7 Principles for Software Assurance

1. **Risk**: Perception of risk drives all assurance decisions.
2. **Interactions**: Systems are highly inter-connected and share the risks of all connections.
3. **Trusted Dependencies**: Your assurance depends on other people's assurance decisions and your level of trust for these dependencies.

7 Principles (continued)

4. **Attacker**: A broad community of attackers with growing technology capabilities can compromise any and all of your technology assets - there are no perfect protections, and the attacker profile constantly changes.
5. **Coordination**: Assurance requires effective coordination among all technology participants and their governing bodies.

7 Principles (concluded)

6. **Dynamic:** The threat is always changing. Assurance is based on governance, construction, and operation and is highly sensitive to changes in each area.

7. **Measurable**: A means to measure and audit overall assurance must be built in. If you can't measure it you can't manage it.

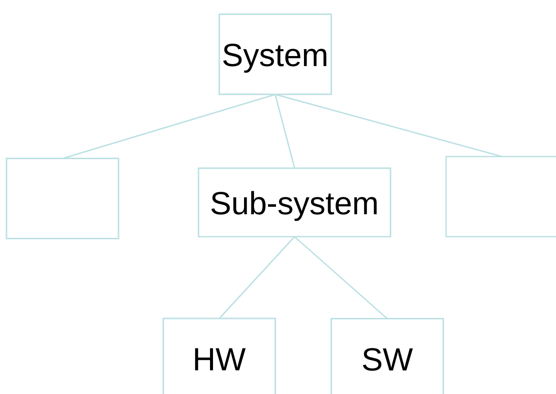
Systems Engineering vs. Software Engineering

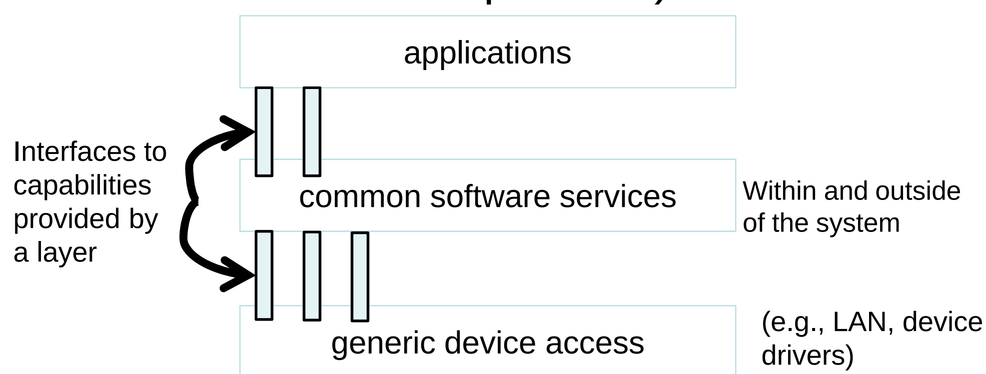
Systems Engineering Assumptions

- Systems can be decomposed into discrete, independent, and hierarchically-related components (or subsystems)
- Components can be constructed and integrated with minimal effort based on the original decomposition
- Quality properties can be allocated to specific components

Software Engineering Realities

- Software components are often related sets of layered functionality (one layer is *not* inside another)
- Interactions of components (*not* the decomposition) must be managed
- Security properties relate to composite interactions (*not* to individual components)





Role of Software in Systems

From the *NRC Critical Code Report* *

"Software has become essential to all aspects of military system capabilities and operations" p.19

1960 – 8% of the F-4 aircraft functionality

1982 – 45% of the F16 aircraft functionality

2000 – 80% of the F-22 aircraft functionality

* Committee for Advancing Software-Intensive Systems Producibility; National Research Council (NRC). *Critical Code: Software Producibility for Defense,* 2010

Systems Engineering vs. Software Engineering

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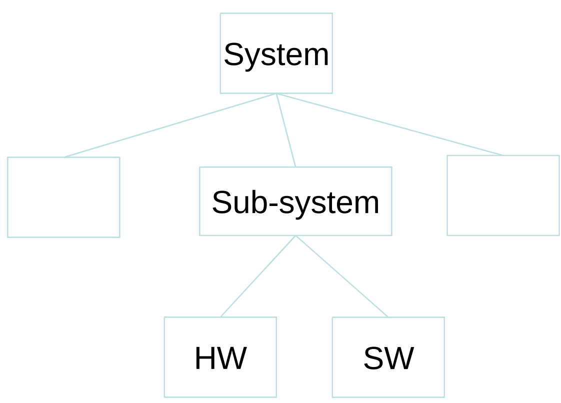

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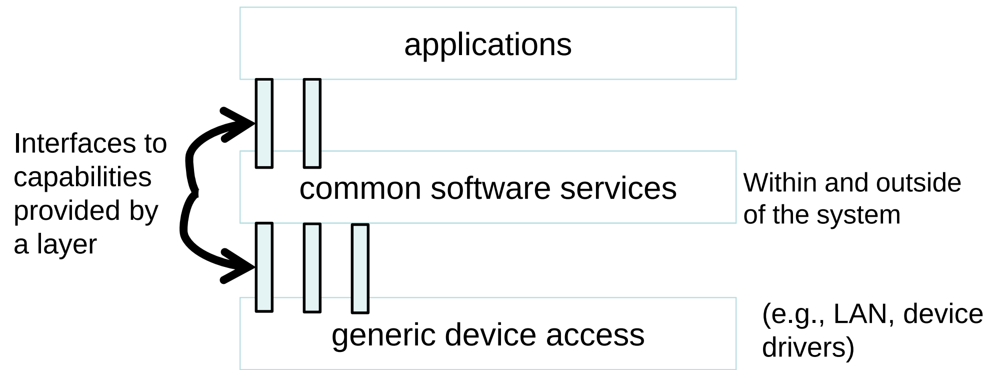


Systems engineering is insufficient for software-reliant security

Software Assurance Impact on C&A

Focusing on individual systems is insufficient

- Critical services used by the software are not considered
- Differences in security controls for systems tied to the same mission are not considered

Software development is increasingly in the supply chain, and security controls must be considered during acquisition

Missions, which extend beyond a single system, define the functionality that is intended

Software assurance methods are required to build effective operational security

Software Assurance Methods

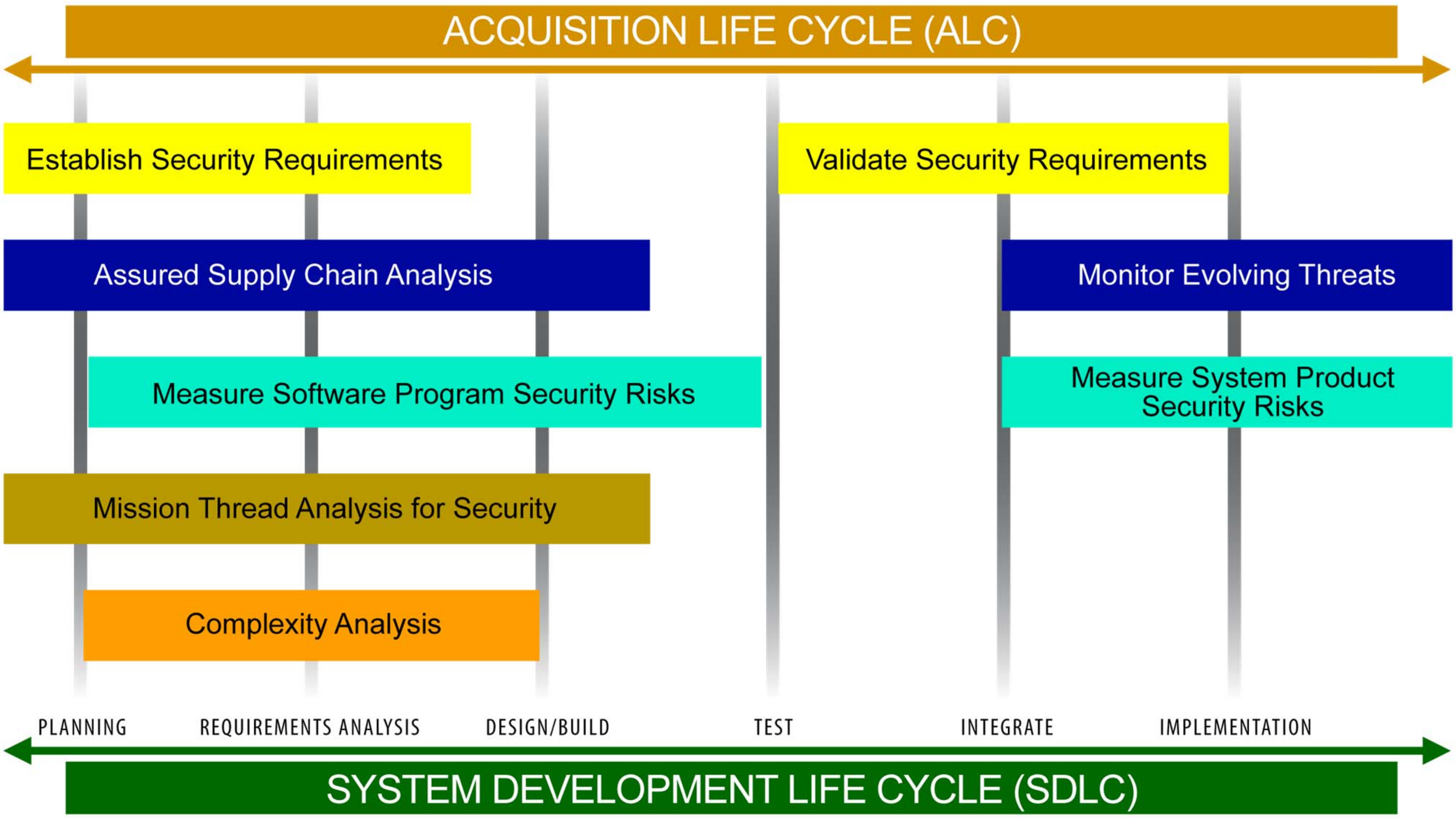
Mission Thread Analysis

Supply Chain Risk Management

Security Requirements Elicitation (SQUARE)

Measurement

Software Assurance Across the Life Cycle



Mission Thread Analysis

Mission Thread Analysis

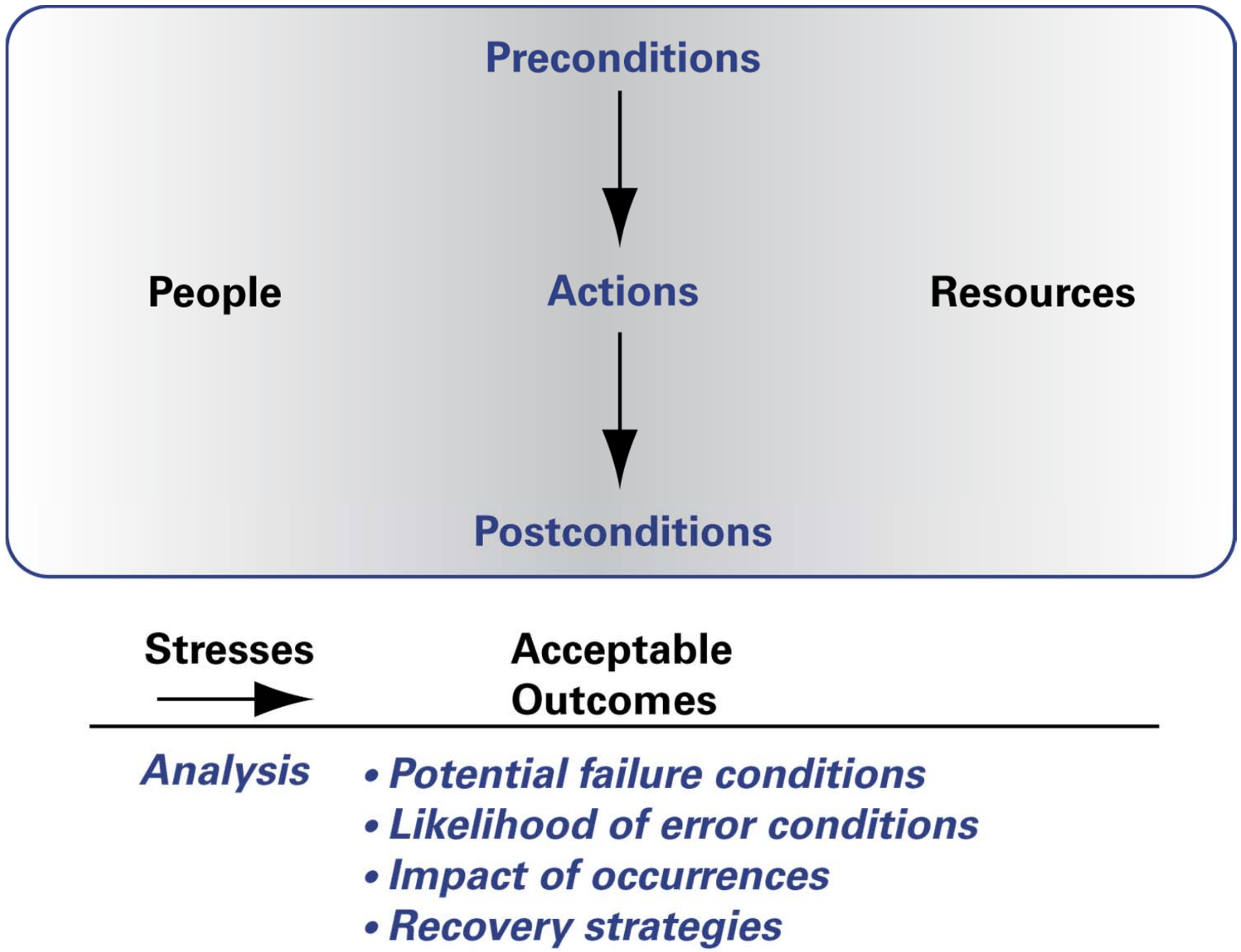
Establish the role of mission success (functioning as intended) for system and software assurance

Analyze potential mission failure

Connect the software and systems to the operational mission

- How is security defined and validated?
- Will the mission survive a security compromise?

Tool: Survivability Analysis Framework



Analysis of Mission Failure Potential

Who identifies and manages an error?

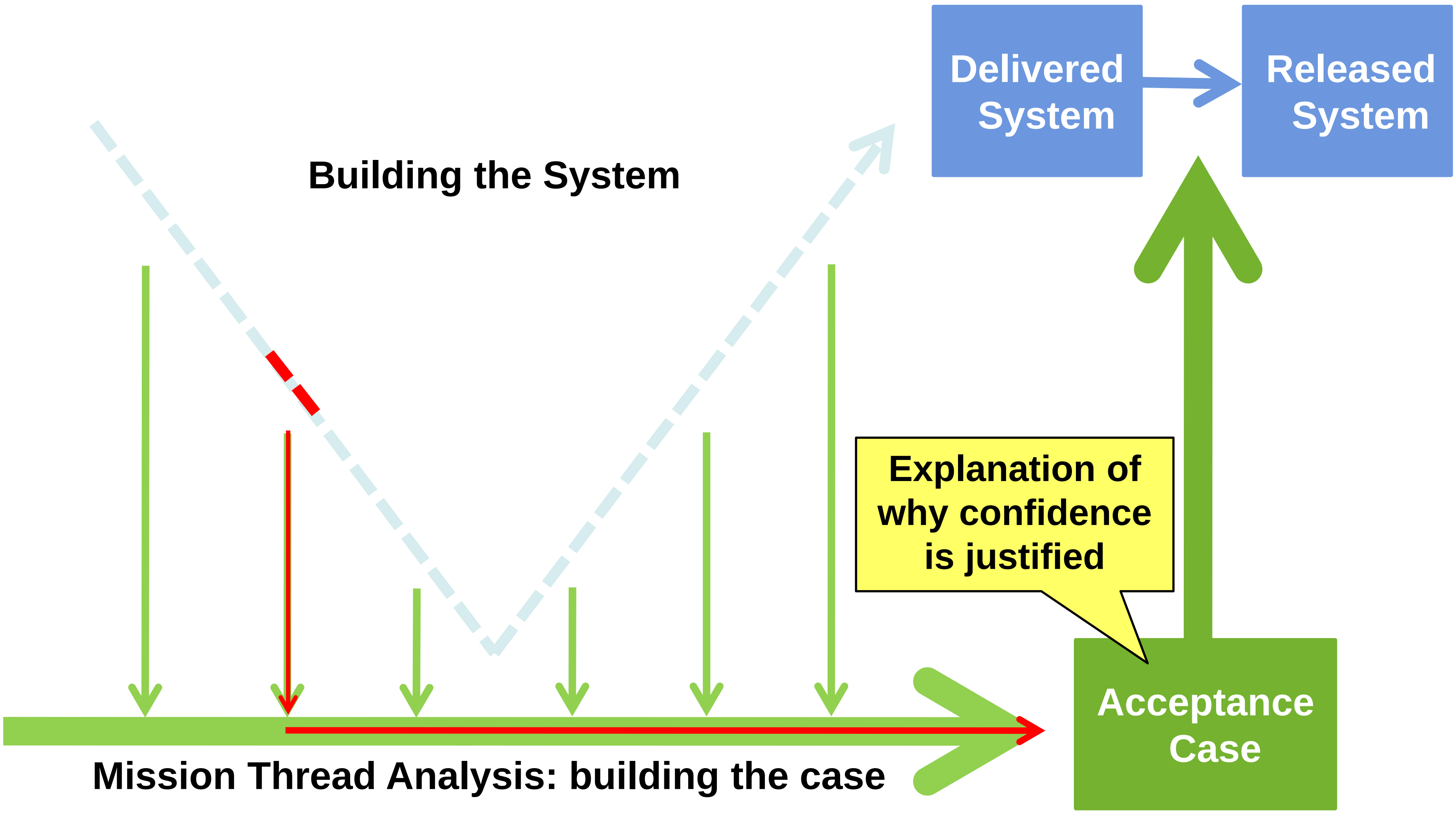
- Human or technology control?
- Coordination of responses across multiple components (multiple contractors?)

Which faults should be reported and how?

- Logging and alerting can easily overload resources
- Will the receiver understand an error and know what to do?

How could an attack go undiscovered in the “cracks” between systems?

Building Justified Confidence



Mission Thread Resources

Survivability Analysis Framework, Robert Ellison & Carol Woody. (CMU/SEI-2010-TN-013), June 2010.
http://www.sei.cmu.edu/library/abstracts/reports/10tn013.cfm

Survivability Assurance for System of Systems, Robert Ellison, John Goodenough, Charles Weinstock, & Carol Woody. (CMU/SEI-2008-TR-008), May 2008.
http://www.sei.cmu.edu/library/abstracts/reports/08tr008.cfm

Supply Chain Risk Management

State of Security in Software Products

MITRE has documented over 700 software errors in commercial products that have led to exploitable vulnerabilities: Common Weakness Enumeration (CWE)[1]

58% of all products submitted to Veracode for testing did not achieve an acceptable security score upon first submission[2]

Forrester reports in *Application Security: 2011 And Beyond*[3]

- 47% do not perform acceptance tests for third party software
- 46% follow a homegrown application security methodology instead of one that had been independently validated
- 27% do not perform security design

1. http://cwe.mitre.org
2. Fall DHS SwA Forum 2010
3. http://go.microsoft.com/?linkid=9777219

Limits for Supply Chain Risk Mitigations

Total prevention is not feasible because of the sheer number of risks; limited development visibility; uncertainty of product assurance; and evolving nature of threats, usage, and product functionality

Responding exploit by exploit is a losing game

- Skilled attackers know system weaknesses better than defenders
- As networks and operating systems are hardened, attackers exploit application software

Identify the risks, establish evidence for what has been mitigated, monitor gaps

Acquisition of Products

Supply Chain Factors

Supply chain risks for a **product** is reduced to acceptable level

Supplier Capability

Supplier follows practices that reduce supply chain risks

Product Security

Delivered or updated product is acceptably secure

Product Distribution

Methods used to transmit product to the purchaser guard against tampering

Operational Product Control

Product is used in a secure manner

Acquisition of Systems and Components

System Security Must Be Added

Supply chain risks for **system** reduced to acceptable level

System design should ensure that externally developed products including legacy software are used in a secure manner

Addressed at the product level

Supplier Capability

Supplier follows practices that reduce supply chain risks

Product Security

Delivered or updated product is acceptably secure

Product Distribution

Methods used to transmit the product to the purchaser guard again tampering

System Security

Component products are assembled for effective system security

Operational Product Control

Product is used in a secure manner

Stronger Integrator Criteria is Needed

Integrator is providing a unique product

Applying practices such as threat modeling at the system level can be more demanding than it is for a product

- Product development
  - long product life - incremental
  - focus on software weaknesses appropriate to that supplier's domain and products, guided by product history
  - relatively small and stable set of suppliers
- An integration contractor or custom system developer
  - multiple one-off, relatively short-lived efforts
  - multiple functional domains
  - multiple sets of software products, suppliers, and subcontractors

Supply Chain Resources

Software Supply Chain Risk Management: From Products to Systems of Systems, Robert J. Ellison, John B. Goodenough, Charles B. Weinstock, & Carol Woody. (CMU/SEI-2010-TN-026), December 2010.

http://www.sei.cmu.edu/library/abstracts/reports/10tn026.cfm

Evaluating and Mitigating Software Supply Chain Security Risks, Robert J. Ellison, , John B. Goodenough, Charles B. Weinstock, & Carol Woody. (CMU/SEI-2010-TN-016), May 2010.

http://www.sei.cmu.edu/library/abstracts/reports/10tn016.cfm

Webinar: *Securing Global Software Supply Chains*, Robert Ellison, June 2010. http://www.sei.cmu.edu/library/abstracts/webinars/Securing-Global-Software-Supply-Chains.cfm

Security Requirements Elicitation (SQUARE)

SQUARE

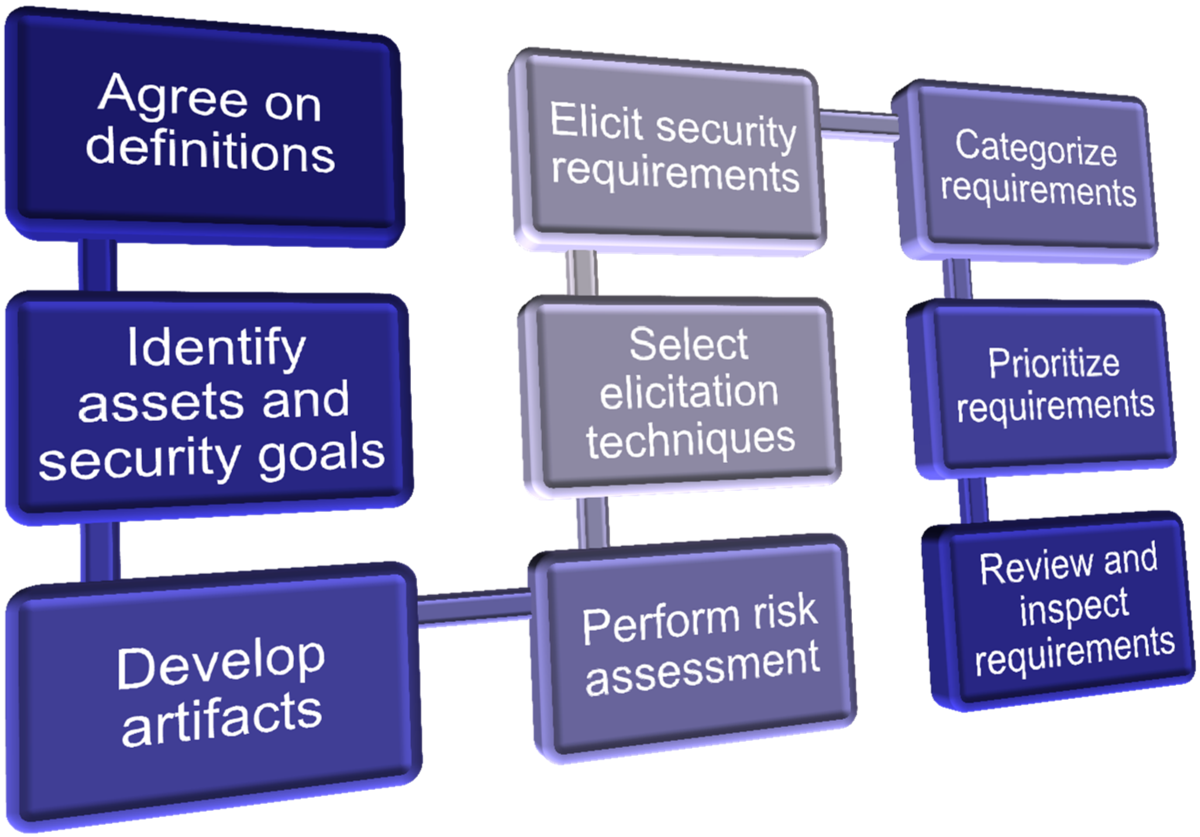
Methodology to help organizations build security into the early stages of the production life cycle

Addresses eliciting, categorizing, and prioritizing security requirements

Security requirements are

- treated at the same time as the system's functional requirements, *and*
- carried out in the early stages
- specified in similar ways as software requirements engineering and practices
- carried out through a process of nine discrete steps

The SQUARE Process



A robust SQUARE tool is available for download from
http://www.cert.org/sse/square.html

SQUARE Resources

Software Security Engineering: A Guide for Project Managers. Julia H. Allen, Sean Barnum, Robert J. Ellison, Gary McGraw, & Nancy R. Mead. Addison Wesley Professional, 2008. (Available from Amazon.com.)

U.S. Department of Homeland Security. *Build Security In: Requirements Engineering.* U.S. Department of Homeland Security. https://buildsecurityin.us-cert.gov/daisy/adm-bsi/articles/best-practices/requirements.html

Security Quality Requirements Engineering , Nancy R. Mead, Eric Hough, & Ed Stehney. (CMU/SEI-2005-TR-009), November 2005. http://www.sei.cmu.edu/library/abstracts/reports/05tr009.cfm

"Identifying Security Requirements Using the Security Quality Requirements Engineering (SQUARE) Method," Nancy R. Mead, in *Integrating Security and Software Engineering: Advances and Future Visions*. Edited by H. Mouratidis and P. Giorgini. Idea Group, pp. 44-69, 2006 (ISBN: 1-59904-147-2).

SQUARE Case Study Reports

SQUARE-Lite: Case Study on VADSoft Project, Ashwin Gayash, Venkatesh Viswanathan, & Deepa Padmanabhan. Faculty Advisor: Nancy R. Mead. (CMU/SEI-2008-SR-017), June 2008.
http://www.sei.cmu.edu/library/abstracts/reports/08sr017.cfm

Security Quality Requirements Engineering (SQUARE): Case Study Phase III, Eric Hough, Don Ojoko-Adams, Lydia Chung, & Frank Hung. (CMU/SEI-2006-SR-003), May 2006.
http://www.sei.cmu.edu/library/abstracts/reports/06sr003.cfm

Privacy Risk Assessment Case Studies in Support of SQUARE, Varokos Panusuwan & Prashanth Batlagundu. Faculty Advisor: Nancy Mead. (CMU/SEI-2009-SR-017), July 2009.
http://www.sei.cmu.edu/library/abstracts/reports/09sr017.cfm

Security Measurement

Definitions

Measurement

A set of observations that reduce uncertainty where the result is expressed as a quantity[1]

Measure

A variable to which a value is assigned as the result of measurement[2]

1. Hubbard, Douglas W. *How to Measure Anything: Finding the Value of "Intangibles" in Business*. John Wiley & Sons, 2007.
2. International Organization for Standardization. *ISO/IEC 15939:2007, Systems and Software Engineering – Measurement Process,* 2nd ed. ISO, 2007.

Drivers

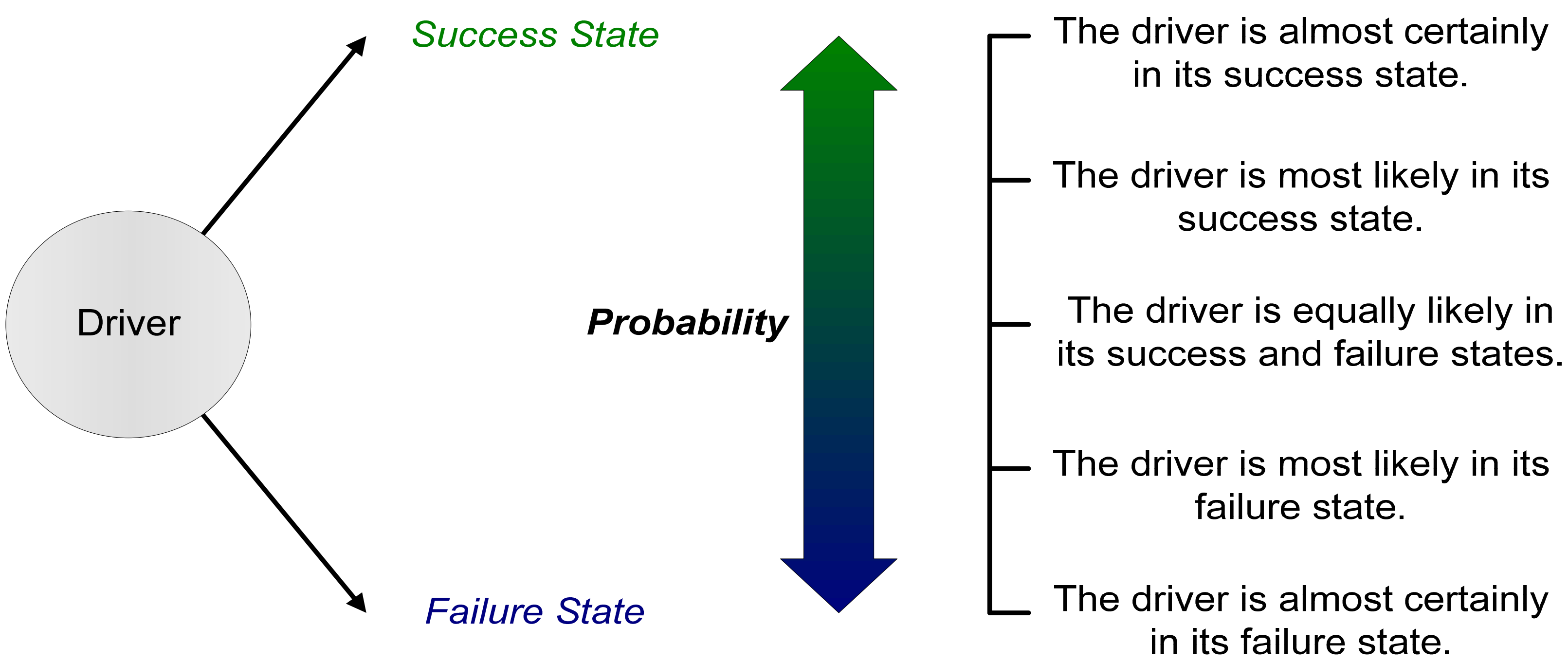
Definition

A factor that has a strong influence on the eventual outcome or result

Examples

- ***Security Process***: The process being used to develop and deploy the system sufficiently addresses security
- ***Security Task Execution***: Security-related tasks and activities are performed effectively and efficiently
- ***Code Security***: The code will be sufficiently secure

Drivers: *Success and Failure States*



The objective when analyzing a driver's state is to determine how each driver is currently acting.

Drivers for Secure Software Development

Programmatic Drivers

1. Program Security Objectives
2. Security Plan
3. Contracts
4. **Security Process**
5. Security Task Execution
6. Security Coordination
7. External Interfaces
8. Organizational and External Conditions
9. Event Management

Product Drivers

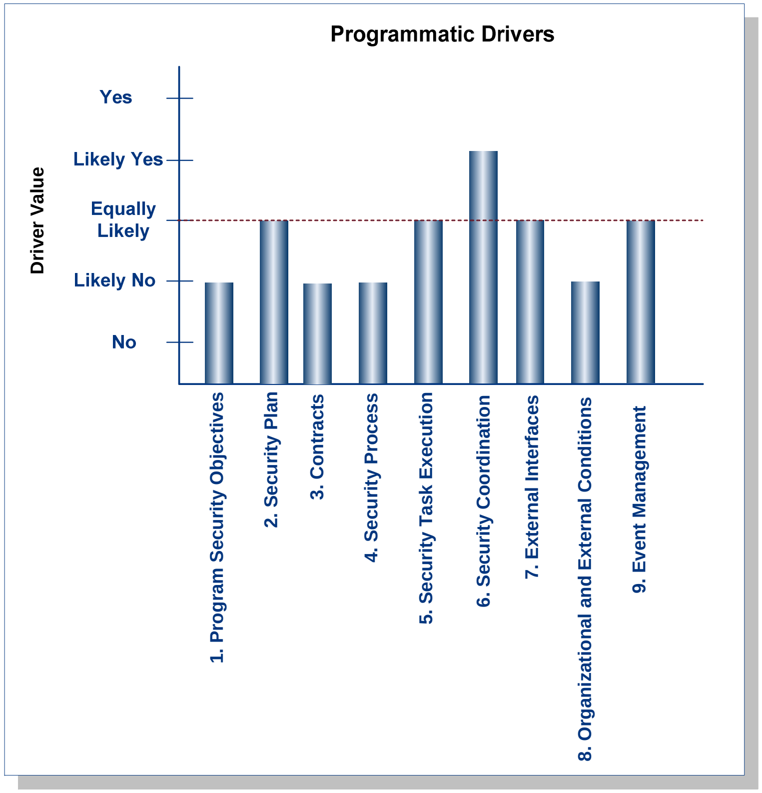
10. Security Requirements
11. Security Architecture and Design
12. Code Security
13. Integrated System Security
14. Adoption Barriers
15. Operational Security Compliance
16. Operational Security Preparedness
17. Product Security Risk Management

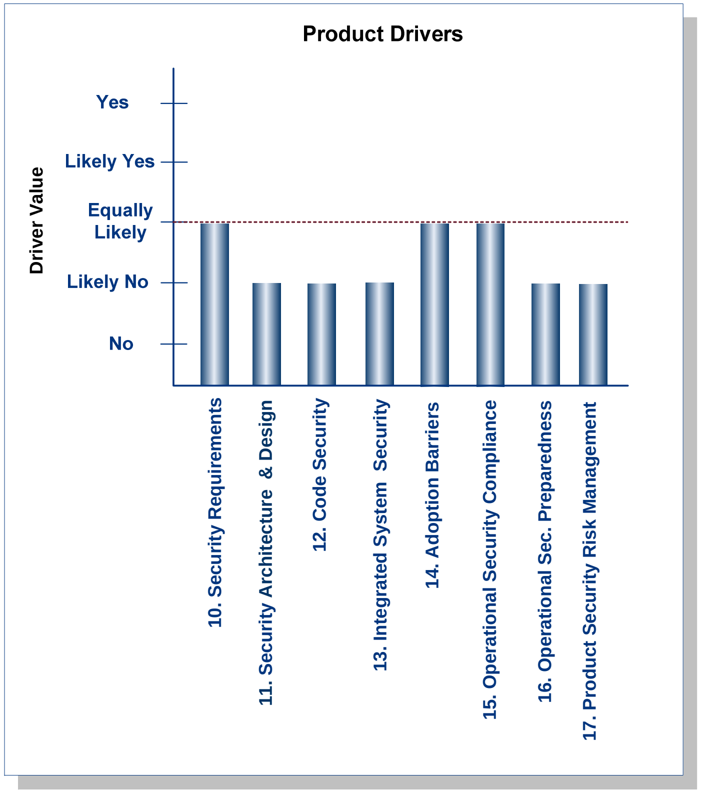
Evaluating Drivers

Directions: Select the appropriate response to the driver question.

Driver Question	Response
4. Does the process being used to develop and deploy the system sufficiently incorporate security? *Consider:* ▪ Security-related tasks and activities in the program workflow ▪ Conformance to security process models ▪ Measurements and controls for security-related tasks and activities ▪ Process efficiency and effectiveness ▪ Software security development life cycle ▪ Security-related training ▪ Compliance with security policies, laws, and regulations ▪ Security of all product-related information	❑ Yes ❑ Likely Yes ❑ Equally Likely X Likely No ❑ No

Driver Profile

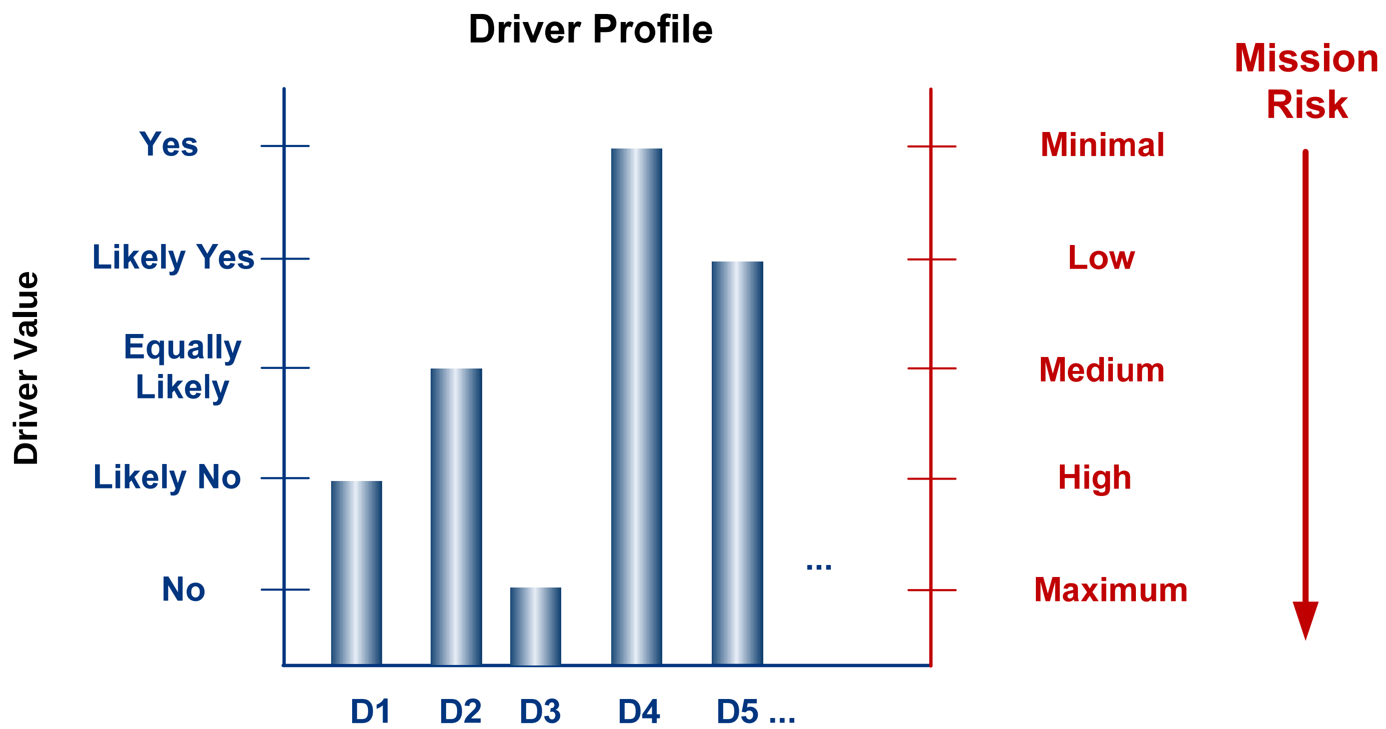




The driver profile provides an indication of systemic risk to the mission.

It can be used as a dashboard for program decision makers.

MRD: *Focus on Mission Risk*



Systemic risk to the mission (also called *mission risk*) is defined as the probability of mission failure (not achieving key objectives).

From the MRD perspective, mission risk is the probability that a driver is in its failure state.

Measurement Resources

Integrated Measurement and Analysis Framework for Software Security, C. Alberts, J. Allen, & R. Stoddard. (CMU/SEI-2010-TN-025), September 2010. http://www.sei.cmu.edu/library/abstracts/reports/10tn025.cfm

Risk Management Framework, Christopher Alberts & Audrey Dorofee. (CMU/SEI-2010-TR-017). August 2010. http://www.sei.cmu.edu/library/abstracts/reports/10tr017.cfm

Summary

Compliance Limitations

Based on principles that were developed in 1974 and much as changed since that time

Does not address security for software-reliant systems

Does not address the security risks of software acquisition decisions

Focus on Software Assurance

Ensure that systems and software function as intended and are free from vulnerabilities

Key areas for risk mitigation:

- Mission Thread Analysis
- Supply Chain Risk Management
- Security Requirements
- Measurement