Software Security Engineering
Lecture 1

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Outline

About this course

Software assurance challenges

Foundations for software assurance

Software assurance guiding principles

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Course topics

- Security models and methods in the areas of:
  - lifecycle process models
  - risk management
  - requirements engineering
  - architecture and design
  - coding and testing
  - governance and management
- If time permits, acquisition of newly developed and COTS software will also be discussed.

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Prerequisites

- Undergraduate software engineering course
- Undergraduate information security course
- Equivalent background

- Note: The course will tend to assume that students have software engineering background, such as knowledge of common lifecycle models

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Educational Activities

- Class will be lecture and discussion, with guest lectures on some topics
- Readings from textbook, papers, reports
- Homework assignments
- Project including selected software development activities:
  - Lifecycle security management plan
  - Selection of process model (Agile, Spiral, etc.) and rationale
  - Security risk analysis
  - Development of misuse cases/attack trees
  - Security requirements elicitation
  - Architectural Trade-off analysis/QAW
  - Design of security features (e.g. Access control mechanisms)
  - Inspection

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Text and other sources

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

- U.S. Department of Homeland Security. *Build Security In Website*

- Additional papers, SEI reports, CERT podcasts, webinars, etc. as needed

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Grading Criteria

- 50% individual assignments
- 50% team project

- Grading will take into consideration completeness, creativity, deep insights, thinking outside the box. Sources must be cited. Material lifted from another source must be in quotes.

- Assignments are to be turned in or posted to Blackboard BEFORE class on the day they are due. Assignments not turned in on time will lose 10% for each day late.

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Software Assurance Challenges

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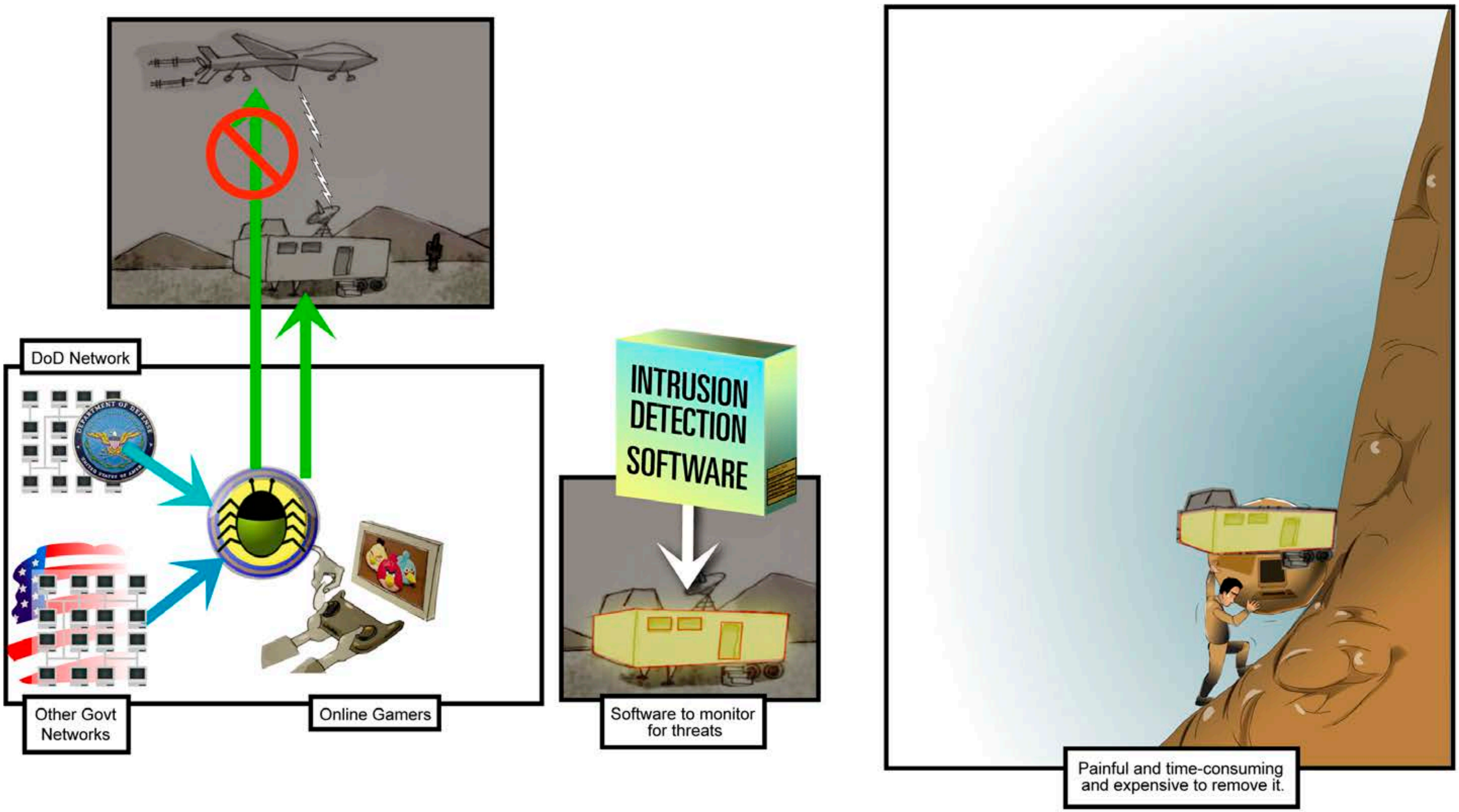
Scenario – Drone Virus Attack



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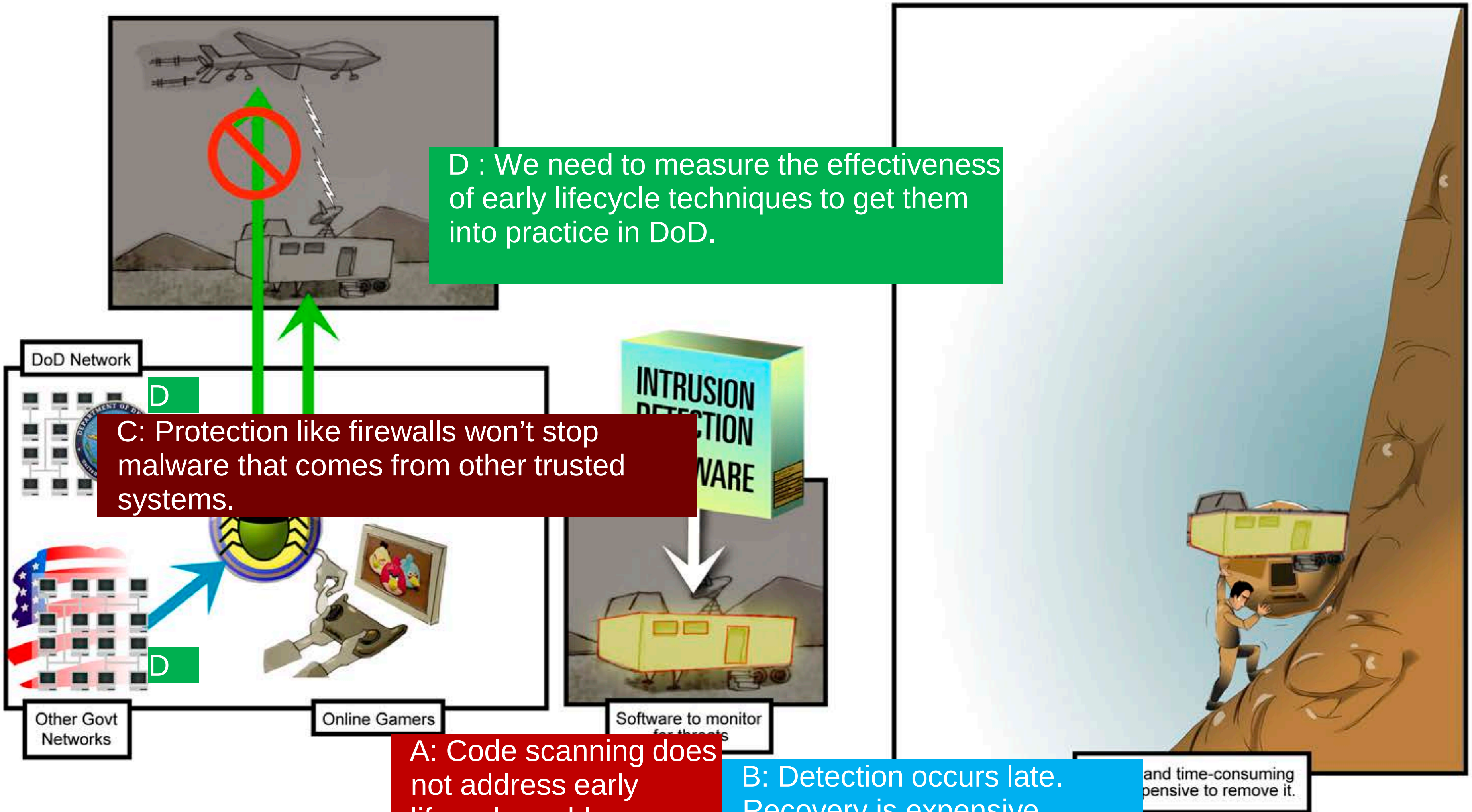
Drone Scenario – Key Challenges



D : We need to measure the effectiveness of early lifecycle techniques to get them into practice in DoD.

C: Protection like firewalls won’t stop malware that comes from other trusted systems.

A: Code scanning does not address early lifecycle problems

B: Detection occurs late. Recovery is expensive.

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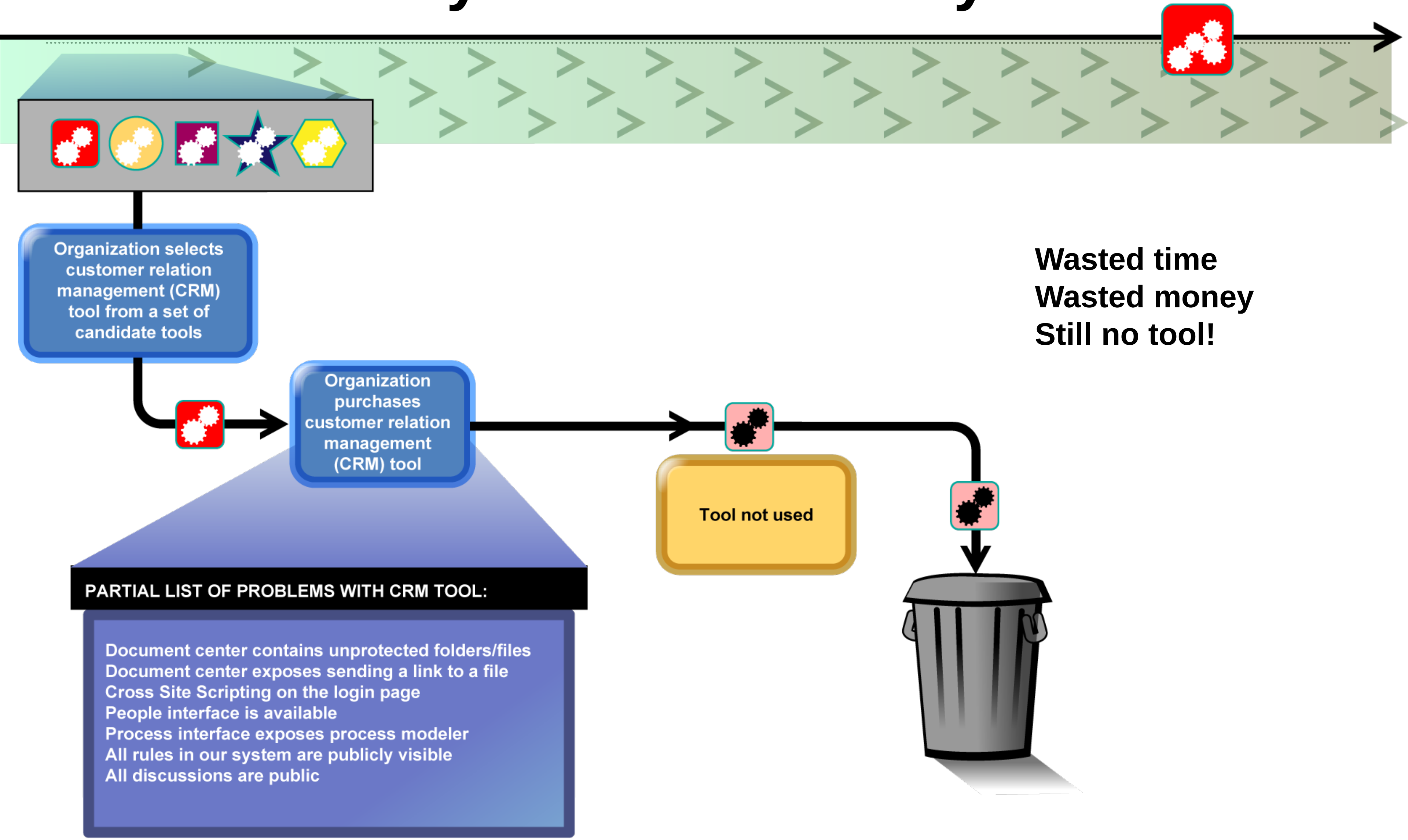
Is There Really a COTS Security Problem?



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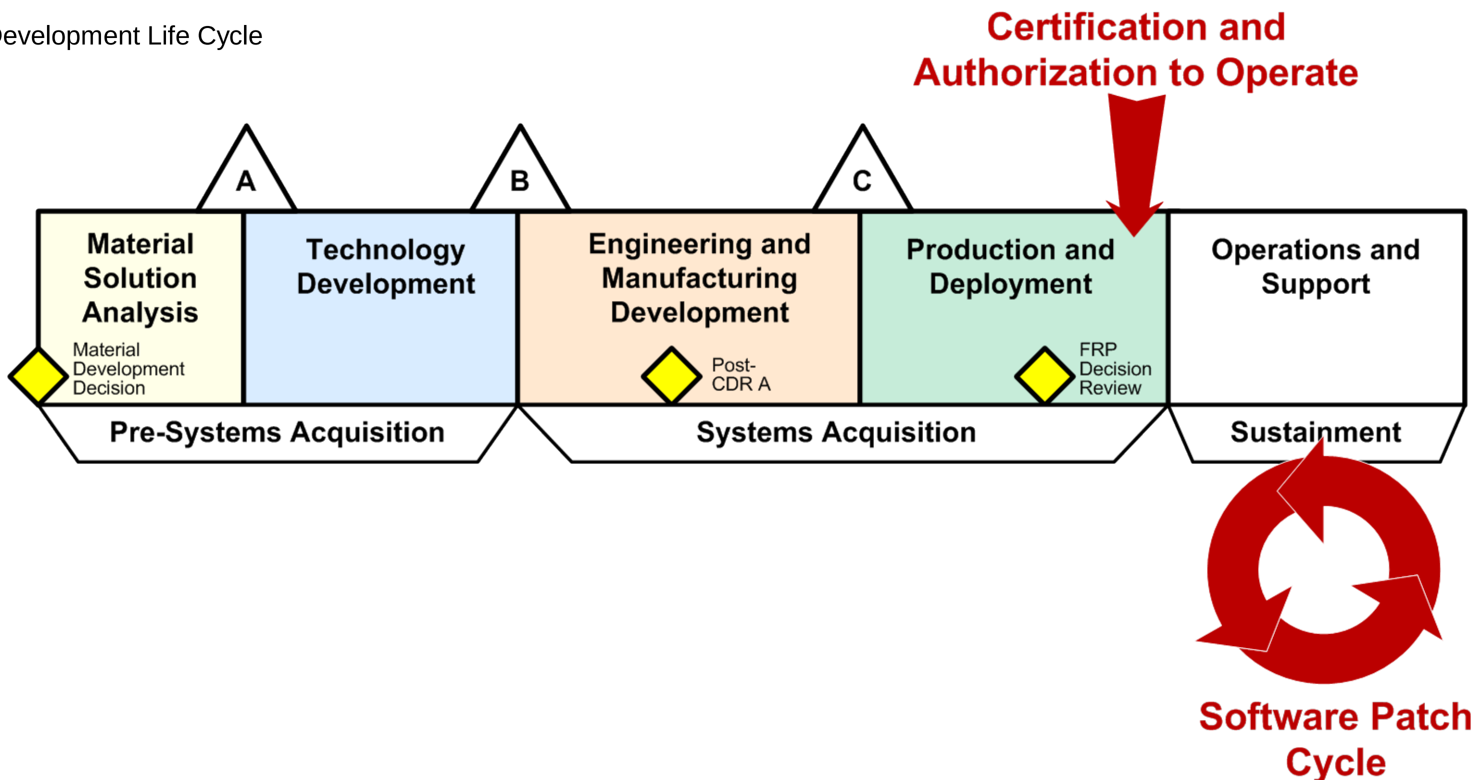
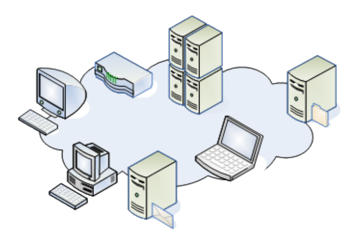
Current Challenge for Software Assurance

Development Life Cycle



Patch & Pray



47,202 known vulnerabilities as of 9/17/11

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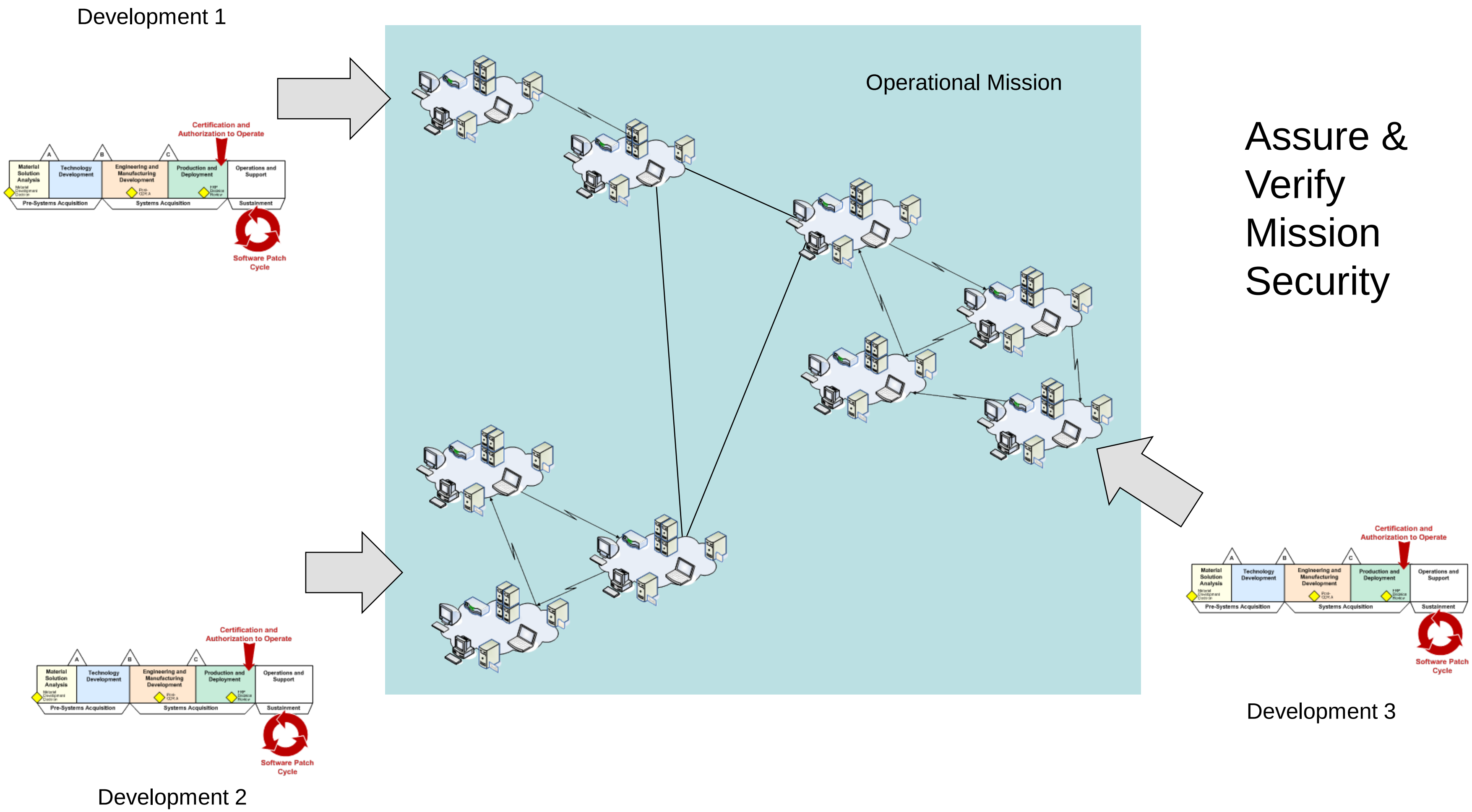
Operational Mission Reality – Systems of Systems



Assure & Verify Mission Security

Foundations for Software Assurance

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Information/IT Security Point of View

- Typically dealing with an organization’s infrastructure provider, their management chain, & the CIO
- End objective is to provide a functional, available, secure operational infrastructure & applications for all users
- Information protection & privacy are demanding increasing attention (regulatory, marketplace pressure)
- Software/application security may or may not be on the radar screen

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Software Security Point of View

- Dealing primarily with software/application developers & their management chain
    - in-house, service provider, purchased software
- End objective is to produce working systems & applications, on schedule, on budget
- Security typically addressed (if at all):
    - During coding and testing
    - During operations/production as an “after the fact” add-on; reactive
    - For COTS, open source, or third party software, as a provider/vendor responsibility

COTS: Commercial Off The Shelf

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Why Software Security? - 1

- Developed nations' economies and defense depend, in large part, on the reliable execution of software
- Software is ubiquitous, affecting all aspects of our personal and professional lives.
- Software vulnerabilities are equally ubiquitous, jeopardizing:
  - Personal identities
  - Intellectual property
  - Consumer trust
  - Business services, operations, & continuity
  - Critical infrastructures & government

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Why Software Security? - 2

- Most successful attacks result from:
  - Targeting and exploiting known, non-patched software vulnerabilities
  - Insecure software configurations
- Many of these are introduced during software design & development
- Increasing trend of assembling systems from purchased parts means getting software acquisition* right with respect to security

- Refer to Polydys & Wisseman. "Software Assurance in Acquisition: Mitigating Risks to the Enterprise." 2007. https://buildsecurityin.us-cert.gov/daisy/bsi/resources/dhs/908.html?branch=1&language=1

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So What Is Software Security?

- Not the same as security software
  - Firewalls, intrusion detection, encryption
  - Protecting the environment within which the software operates
- Engineering software so that it continues to function under attack
- The ability of software to recognize, resist, tolerate, and recover from events that threaten it

- The goal: Better, defect-free software that can function more robustly in its operational production environment

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Security Perspectives

https://www.securecoding.cert.org/confluence/display/seccode/Top+10+Secure+Coding+Practices

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Software Needs to be Trusted

- Exploitation of software defects is estimated to cost the U.S. economy $60 Billion annually
- Software development and sustainment activities must follow proper practices, but there is no authoritative point of reference
- In 2005, U.S. Dept of Homeland Security (DHS) created a group to define a common body of knowledge (CBK) for secure software assurance

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Definition: Software Assurance

- Software assurance (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.

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Goal of the CBK

- Serve as a basis for
- "defining workforce needs and competencies, leveraging sound practices, and guiding curriculum development for education and training relevant to software assurance"
- Reference: Redwine, S., Software Assurance: A Guide to the Common Body of Knowledge to Produce, Acquire and Sustain Secure Software V1.1, https://buildsecurityin.us-cert.gov/bsi/dhs/927-BSI.html

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Strengths of the CBK

- Provides help for the U.S. government to ensure that it is getting secure software
- Provides 300 pages of recommendations for *what* practices are needed

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Limitations of the CBK

- Missing:
  - Information about ***why*** the practices are required
  - Guidance as to ***how*** the practices should be applied to a range of situations

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Addressing the Gaps

- DHS enlisted the SEI CERT program to coordinate the development of a curriculum for a Master of Software Assurance (MSwA) degree program (***what*** and ***how***)
  - Built on the CBK and other sources to develop a curriculum body of knowledge and associated outcomes
  - Identified the need for a coherent set of guiding principles for secure software assurance
- SEI CERT and the Software Engineering Program at Oxford University, UK collaborated to build a set of principles (***why***)

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Security Principles

- Saltzer and Schroeder* 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
    - Availability

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

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Technology Environment in 1974

- S360 in use from 1964-1978
- S370 came on the market in 1972
- COBOL & BAL programming languages
- MVS operating system released in March 1974
- Patches were carefully tested to minimize operational disruption

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Changes since 1974

- Internet
- Morris worm – November 2, 1988
- 50,000+ software vulnerabilities and exposures (CVE)
- Java, C++, C#
- Mobile computing
- Cloud
- Etc.

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Software Assurance Guiding Principles

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Principles of Software Assurance

- A set of principles to guide learners in understanding the WHY of software assurance

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Principle 1: Risk

- Perception of risk drives assurance decisions
  - Assurance implementation choices (policies, practices, tools, restrictions) are based on the perception of threat and the impact should that threat be realized
  - Perceptions are built based on successful attacks – the current state of assurance is largely reactive – more successful organizations react and recover faster, learn from the reactive responses or others, and are more vigilant in anticipating and detecting attacks
  - Misperceptions are failure to recognize threats and impacts – "how could it happen to us?"
  - Risk decisions must be shared among all stakeholders and technology participants to ensure a consistent and effective implementation

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Principle 2: Interactions

- Highly connected systems (e.g. Internet) require alignment of risk across all stakeholders otherwise critical threats will be unaddressed (missed, ignored) at different points in the interactions
  - There are costs to addressing assurance which must be balanced against the impact of the risk
  - Risk must also be balanced with other opportunities (performance, reliability, usability, etc.)
  - Interactions occur at many technology levels (network, security appliances, architecture, applications, data storage, etc.) and are supported by a wide range of roles – effective assurance requires consist risk recognition and response at all levels

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Principle 3: Trusted Dependencies

- Your assurance depends on other people's assurance decisions and the level of trust you place on these dependencies (system of system problem based on interactions)
  - Each dependency represents a risk
  - Dependency decisions should be based on a realistic assessment of the threats, impacts, and opportunities represented by an interaction
  - Dependencies are not static and trust relationships should be reviewed to identify changes that warrant reconsideration
  - Using many standardized pieces to build technology applications and infrastructure increases the dependency on other's assurance decisions

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Principle 4: Attacker

- There exists a broad community of attackers with growing technology capabilities able to compromise the confidentiality, integrity, and availability of any and all of your technology assets - there are no perfect protections and the attacker profile is constantly changing.
  - The attacker uses technology, processes, standards, and practices to craft a compromise (socio-technical responses).
  - Attacks are crafted to take advantage of the ways we normally use technology or designed to contrive exceptional situations where defenses are circumvented

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Principle 5: Coordination and Education

- Assurance requires effective coordination among all technology participants and their governing bodies
  - Protection must be applied broadly across the people, processes, and technology because the attacker will take advantage of all possible entry points
  - Authority and responsibility must be clearly established at an appropriate level in the organization to ensure effective participation

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Principle 6: Well Planned and Dynamic

- An adaptive response is required for assurance (justified confidence that software functions as intended) because the threat is always changing. Assurance implementation must represent a balance among governance, construction, and operation and is highly sensitive to changes in each of these areas
  - Engineering challenge: Assurance cannot be added later; you must build to the level of acceptable assurance that you need
  - No one has resources to redesign systems every time the threat changes
  - Assurance cannot be readily adjusted upward after the fact

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Principle 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
  - All elements of the socio-technical environment must tie together (practices, processes, procedures, etc.)
    - Measuring individual elements may be useful but not sufficient evidence for overall assurance
    - Each participant will address only the assurance for which they are held accountable
  - Effective measurement is well supported by sound engineering and organizational principles - well formed and consistently applied processes are critical to ensure an appropriate measurable response

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Questions?

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Looking Ahead: Lecture #2

I. Software assurance practices

II. Software assurance lifecycle models

III. Software assurance maturity models

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Reading Assignment

- Software Security Engineering book – Chapters 1 & 2: http://www.amazon.com/Software-Security-Engineering-Project-Managers/dp/032150917X

- Saltzer & Schroeder paper: http://web.mit.edu/Saltzer/www/publications/protection/

- HICSS Principles paper: http://csdl.computer.org/dl/proceedings/hicss/2012/4525/00/4525f368.pdf

- Drone attack articles:
  - http://www.informationweek.com/government/security/air-force-says-drone-virus-is-no-threat/231900741?queryText=Air%20Force%20Says%20Drone%20Virus%20Is%20No%20Threat
  - http://csdl.computer.org/dl/mags/co/2011/11/mco2011110015.pdf

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Homework Assignment # 1

1. (80%) Surf the web and find 4 different actual examples of successful intrusion
   - one that resulted from human error, such as giving out a password or downloading a virus
   - one that resulted from a system configuration error
   - one that resulted from software provided an intrusion opportunity because of a flawed development process
   - one that resulted from a vulnerability in a COTS product

Describe how each of these attacks could have been avoided. Consider changes in policy, configuration management, software development practice, and COTS acquisition practices.

2. (20%) Compare and contrast the HICSS Principles paper with the Saltzer and Schroeder Principles paper.

Turn this in BEFORE the next class

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