NASA's IV&V Program
Safety and Mission Assurance (SMA) Office
Information Assurance/Cybersecurity Support

Addressing SW Security
11/30/15
Brandon Bailey
brandon.t.bailey@nasa.gov
304-629-8992

http://www.nasa.gov/centers/ivv
Introduction

• Historically security within organizations was thought of as an IT function (web sites/servers, email, workstation patching, etc.)

• Threat landscape has evolved (Script Kiddies, Hackers, Advanced Persistent Threat (APT), Nation States, etc.)

• Attack surface has expanded – Networks interconnected!!

• Some security posture factors
  – Network Layer (Routers, Firewalls, etc.)
  – Computer Network Defense (IPS/IDS, Sensors, Continuous Monitoring, etc.)
  – Industrial Control Systems (ICS)
  – Software Security (COTS, FOSS, Custom, etc.)
Custom SW – Gets Exploited!

Source: Microsoft Security Intelligence Report, Vol. 17, June 2014
CCSDS was founded in 1982 by the major space agencies of the world, the CCSDS is a multinational forum for the development of communications and data systems standards for spaceflight.

Security Threats Against Space Missions was developed to provide mission planners with an overview on threat assessment as well as the common threats and threat sources that exist for various categories of civilian space missions.
CCSDS was founded in 1982 by the major space agencies of the world, the CCSDS is a multinational forum for the development of communications and data systems standards for spaceflight.

Security Threats Against Space Missions was developed to provide mission planners with an overview on threat assessment as well as the common threats and threat sources that exist for various categories of civilian space missions.
# Threats in Space

## Applicable Threats to Space Missions

<table>
<thead>
<tr>
<th>Applicable Threats to Space Missions</th>
<th>Impacts</th>
<th>Could Software Be Involved?</th>
</tr>
</thead>
</table>
| Data Corruption | • Modification of information  
• System damage | Yes; SW attacks could result in data corruption |
| Ground Facility Physical Attack | Loss of command, control and data | No |
| Interception | Loss of sensitive data | No |
| Jamming | • Loss of Command telemetry link  
• Loss of access to resources | No |
| Denial-of-Service | Loss of access to resources | Yes; SW DoS attacks are common and can affect both ground, flight and web applications |
| Masquerade | • Potential to disrupt operations (uplink)  
• Potential to receive false information (downlink) | Yes; SW protections can be placed to prevent |
| Replay | System damage (possible safety of life issues) | Yes; SW protections can be placed to prevent |
| Software threats | • Undesirable events  
• System damage  
• Enable other threats | Yes |
| Unauthorized Access | • Disruption of operations  
• System damage (possible safety of life issues) | Yes; SW protections can be placed to prevent or SW can be used to gain unauthorized access |
| Tainted Hardware Components | • Hidden, Malicious capabilities  
• System instability  
• System damage  
• Undesirable System effects | No |
• NASA knows that software is one of many vulnerabilities that could adversely impact Mission Ops

• Levying requirements from the top (NPRs 2810, 7150.2B, 7120.5E, and the SW Assurance Standard/Handbook)

• Software security “defects” are arguably preventable in most cases
  – During custom code development
    • Awareness, Training, Tooling (i.e. SCP)
    • Secure Development
    • Rigorous SwA (Project and IV&V)
  – Software supply chain
    • COTS and Open Source (i.e. Origin Analysis)
Secure Coding Portal (SCP)

Background

- Recognizing the need to counteract the threat of exploitation of custom developed software
- A single touch point for NASA developers was established to learn how to develop code securely
- Utilizes existing NASA Engineering Network (NEN) infrastructure
  - Initial deployment is behind NASA firewall
- Partnerships established with experts
  - CMU-SEI
  - Robert Seacord (Author of CERT C Std.)
  - Safari Books Online (custom secure coding tutorial)
- Launched July 20, 2015
  - Two Newsletters Distributed (can be shared)
  - Custom Secure Coding Tutorial Deployed
  - Contact securecodingportal@lists.nasa.gov for additional information
Secure Coding Discussion Forum – providing a friendly environment to discuss all aspects of Secure Coding with fellow engineers and experts

Vulnerability Updates – containing information about the latest software vulnerabilities and any insight into what systems, or types of systems, could be affected along with how to detect and mitigate these vulnerabilities
  – Vulnerability Newsletter will also be distributed directly to stakeholders

Tools – containing information about tools utilized by NASA for security analysis of software, including references, available training, and any relative insight/lessons learned from NASA practitioners

Links – containing references to security standards, documentation, and information

Top 25 CWEs – using CWSS to classify Top 25 CWEs for ground and flight

Tutorial – custom made tutorial by secure coding experts

Ask an Expert – providing the ability for any community member to request assistance from field experts
Secure Development

• Utilize **Best Practices** from Secure Coding Portal
  – Coding Standards (Ex. CERT C, C++ or JAVA Stds)
  – Integrate tools into development environment
    • Code Analyzers (i.e. Klockwork, Fortify, Flexelint, CodeSonar, Sonatype, BlackDuck, etc.)
    • Great resource for identifying tools ([Report](#) | [Spreadsheet](#))
  – Common Weakness Enumeration (CWE), Common Vulnerabilities and Exposures (CVE), and Common Attack Pattern Enumeration and Classification (CAPEC) information
  – Defense in Depth
  – ...

• Training
  – Secure Coding Tutorial
  – Defensive Programming (available online in SATERN)
  – Codiscope
**CWE:**
- Serves as a common language for describing software security weaknesses in architecture, design, or code
- Provides a:
  - Standard measuring stick for software security tools targeting these weaknesses
  - Common baseline standard for weakness identification, mitigation, and prevention efforts
- Utilize CWE to better understand, identify, fix, and prevent weaknesses and vulnerabilities

**CVE:**
- Identifies publicly known information security vulnerabilities and assign them a CVE_ID.
- Scored 1 to 10 on CVSS scale

**CAPEC:**
- Community-developed list of common attack patterns
- Comprehensive schema and classification taxonomy
- International in scope

Taking into account attack pattern and any other factors to generate list of CWEs that are critical. Tools report findings in CVEs (known) and CWEs (potential) -> Identify then Fix!
Project SwA – Assuring Security

- Currently updating SwA Standard and SwA Handbook
- Educating SwA personnel
  - Educate on importance of SW security
  - SwA personnel can leverage the same training as developers (i.e. SCP)
    - In order to “assure” it, you must understand it!
- Not a clipboard exercise – SwA needs to use tools or ensure tools are being used to ensure SW is secure
  - Tools have latest security signatures and integrate industry’s best practices
  - Dynamic & static code analysis as well as binary analysis (i.e. identifying CWEs/CVEs)
- Verify and validate project is accounting for security during requirements, testing, etc.
  - Ex: Security Requirement Traceability Matrix (SRTM), Whitebox/Blackbox Testing, Negative Testing, PenTesting, etc.
IV&V’s Mission


- Perform the “information system and security control assessment and monitoring” techniques that NIST attributes to the IV&V assessor role in its Risk Management Framework for the design, development, implementation, operation, maintenance, and disposition of federal information systems.

- Perform **Security Analyses** throughout the development life-cycle per IEEE-1012 Standard for System and Software V&V

- Counteract the threat landscape throughout the system life-cycle
  - Ground, Satellite, and Command & Control systems

- IA Techniques deployed throughout project life-cycle phases
Origin Analysis

• From Institute for Defense Analyses (IDA) SOAR Report – “Origin analyzers are tools that analyze source code, bytecode, or binary code to determine their origins (e.g., pedigree and version).”

• NASA IV&V is beginning to invest in Origin Analysis to reduce the software supply chain risk
  – Identifies CVEs that may be present in re-used open source libraries/code
  – Providing scanning as a service as a part of the Secure Coding Portal – performed by SCP team

• Tools being used
  – Sonatype (auditor version)
  – Black Duck HUB
  – OWASP Dependency Check
  – Work being performed to automate and consolidate report creation from all three tools

Developers should be using tools BUT IV&V / SwA could also use tools!!
Summary

- NASA starting to make conscious effort to reduce the number of vulnerabilities in their missions
  - IV&V is now looking at security as a part of mission assurance approach
  - NASA Procedural Requirements (NPRs) now have “security” requirements
  - SwA assurance standard security updates are being worked
  - OCIO Provided Security Training (i.e. Codiscope)
  - Secure Coding Portal
  - Blue Team Vulnerability Assessment Program (BT-VAP) assesses mission survivability to cyber attack
    - Custom SW assessments are integral part of approach but is accompanied by network exposure (i.e. Threat Pairing)
BACKUP SLIDES
Example SW Impacting Mission

Developers can’t assume protection from Firewall. Need “Defense in Depth”. Can’t assume if knocking on door, that they are supposed to be there.

Signs onto Rogue Wife, Click Phishing Link, Etc.
Then Signs onto VPN

Can Now Route Thru F/W via Laptop

Exploits Custom S/W
Establishes persistent foothold on Mission Asset

Mission Asset
Launch Attacks (DoS, Brute Force, Extract Data, etc.)

Mission Critical Assets

This example will depict how unsecure software within a network can potentially impact critical mission assets
Sample Exposure

VPN Landing Zone, Internet, Or “Untrusted”

Vulnerable Custom SW

Demonstrates that a pathway exists from the VPN Landing Zone, Internet, Or Untrusted. Has network access to a vulnerability that was identified by software analysis (binary and source).
Sample Exposure

Demonstrates all outbound access paths (**Pivoting**) from the vulnerable asset.
Sample Exposure

Demonstrates potential vulnerabilities that could be exploited from this server

Mission Critical Asset that “wasn’t” network accessible from VPN, Untrusted, Etc.

Vulnerable Asset “Pivot Point”
• Blue Team Vulnerability Assessment Program (BT-VAP) Defined:

An evaluation to ascertain the operational security posture of an agency’s critical mission systems/networks; focusing on the IT assets & supporting infrastructures that enable the mission to operate

• Blue Team refers to the tactics and techniques employed: a blue team is done in full coordination with the mission elements being assessed in a transparent manner with no impact to mission ops

• As BT-VAP evaluates missions “end-to-end”; it is often perceived (incorrectly) as duplicative of other assessment type activities:

<table>
<thead>
<tr>
<th>Blue Team VAP Evaluation Focus</th>
<th>Focus of Other Assessment Type Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine Operational Security Risk Posture</td>
<td>FISMA: State of Regulatory Compliance (per NIST 800-53)</td>
</tr>
<tr>
<td>Assist Mission Elements to understand/mitigate Security Risks</td>
<td>Audits: Detecting fraud or error/ evaluate adequacy of controls</td>
</tr>
<tr>
<td>Comprehensively Assess all factors (backups, infrastructure etc)</td>
<td>Pen Test: Simulate attack on asset(s) to discover vulnerabilities</td>
</tr>
<tr>
<td>Fully evaluate without disrupting mission operations</td>
<td>IG: Examine actions of a government agency; focus on misuse</td>
</tr>
</tbody>
</table>
BT-VAP Team

• Need for a Blue Team to comprehensively evaluate CS-IA factors in a methodical manner results in needing Subject Matter Expertise across multiple areas to focus on this specific evaluation

• Use of a “risk jury” with SMEs from multiple disciplines with varying perspectives to provide a comprehensive “360°” assessment view

Five Key Role Specialists on this BT-VAP Risk Jury:

- Security Analyst/Threat Protection
- Network Security/Information Assurance
- ICS/SCADA/Computer Network Defense
- Space Systems/Program Protection
- Software Security/Cybersecurity Operations

We evaluate an organization “top to bottom” (from policy/plans to operational posture) to examine IF and HOW they address CS-IA risk factors to determine what their operational security posture is compared to other similar environments

CS-IA = Cybersecurity - Information Assurance
BT-VAP Testing Capabilities

- **Cybersecurity Evaluation:** determine critical assets, model the “mission thread” that these critical assets use to enable the mission – then do a selective “deep dive” on potential points of vulnerability based on a test plan & approved rules of engagement to cover:
  - Space/Mission Systems (ground)
  - Industrial Control Systems/SCADA
  - Supporting Infrastructure: (Layer-2/Layer-3 Network Devices, Controlled Interfaces/Firewalls, Cybersecurity Defense (CND) mechanisms, etc)

- **Software Security Evaluation:** analyze the software code base which supports critical assets and mission threads
  - Source Code Analysis
  - Binary/Compiled Code Analysis (S/W Origin Analysis)

- **BT-VAP Testing Techniques** involve a combination of three principal methods:
  - Analytic/Tabletop Analysis
  - In the Lab Testing (modeling-simulation environment)
  - On-Site with a “flyaway” team with mobile assets

We evaluate an organization to examine IF and HOW they address CS-IA risk factors to determine what your operational security posture is compared to other similar environments