AEROSPACE
Assuring Space Mission Success

Session 9: Changing Paradigms and Challenges
Tools for Space Systems
Cyber Situational Awareness

Wayne A. Wheeler
The Aerospace Corporation

GSAW 2015, Los Angeles, CA, March 2015

© 2015 The Aerospace Corporation

Agenda

- Emerging cyber threats to space systems
- Defense-in-Depth shortfalls
- Tools for Cyber Situational Awareness
- Example Approaches
- Summary

© 2015 The Aerospace Corporation

Open Source Reported Space Cyber Incidents

The age of the space cyber attack is here

- ROSAT— satellite disabled (1998)
- Landsat 7— “cyber interference” (2008)
- Terra EOS AM-1— “cyber interference” (2008)
  – *”achieved all steps required to command the satellite”*
- IntelsatONE— DDoS (distributed denial-of-service) attacks (2011)

© 2015 The Aerospace Corporation

Factors Driving Cyber Threats to Space Systems

- Space systems are distributed networks of $COTS_1$, and can share vulnerabilities with any commercial infrastructure
  - *Aging ground infrastructure can be less secure that current commercial systems (no remediation for emerging threats)*
- "100% closed systems" assumptions for space systems are not realistic, in light of Advanced Persistent Threats
  - *APTs- highly resourced and motivated attackers*
  - *Supply chain, $FOSS_2$ or commercial software, applications software, upgrades, links to other systems, and insider threats are potential attack vectors*
- Threats development has moved up from "hackers" to organized crime and resourced State actors
  - *Computing power amplifies asymmetric power*
  - *Estimated 82,000 new malware discovered daily in 2013*
- Potential adversaries are known to be developing (and are sometimes demonstrating) sophisticated cyber attack capabilities against space systems

© 2015 The Aerospace Corporation

[1] Commercial-of-the-Shelf
[2] Free-and-open-source software

The Advanced Persistent Threat (APT)

The highly resourced and motivated adversary

- The Cyber Threat is active and evolving
  - *Cyber attacks are ongoing and continuous as a means by which adversaries attempt to exfiltrate information, test system responses and identify exploitable attack surfaces*
  - *Space, ground, and user segments must be resilient to the persistent probing, penetration and exploitation attempts by adversaries throughout the stages of a space system life cycle*

- Space Architectures must be **cyber resilient** to all types of threats
  - *"Known" Cyber Threats*
    - Identified "in the wild" as a known vulnerability
    - Usually similar to previous malware
  - *"Unknown" Cyber Threats*
    - Only identified after exploit
    - Zero-day attacks

© 2015 The Aerospace Corporation

Tools for Cyber Situational Awareness and Response

It isn't that they can't see the solution. It is that they can't see the problem.

G.K. Chesterton

© 2015 The Aerospace Corporation

Cyber Threats Landscape

Known
Identified Vulnerabilities

- Available technologies
- Global industry response
- Best-practices
  - ✓ Defense-in-Depth
  - ✓ Network Segmentation
  - ✓ Layer 3 Firewalls
  - ✓ Aggressive Patch Management
  - ✓ Boundary Enforcement
  - ✓ IDPS
  - ✓ 7x24 Top-tier Security Ops Center
  - ✓ Current Software/Hardware

Unknown
Zero Day, APT

- Emerging technologies
- Industry struggling to respond
- Cyber Analytic Tools
  - ✓ Layer 7 Firewalls
  - ✓ SIEM
  - ✓ Virtualization Sandbox
  - ✓ Cyber Visualization
  - ✓ Auto respond systems
- Ineffective without development and Ops expertise
  - Significant costs for start-up Ops

Zero Day- Cyber exploit not previously seen
APT- Advanced Persistent Threat
DPDS- Intrusion Detection & Prevention
SIEM- Security Information & Event Management

© 2015 The Aerospace Corporation

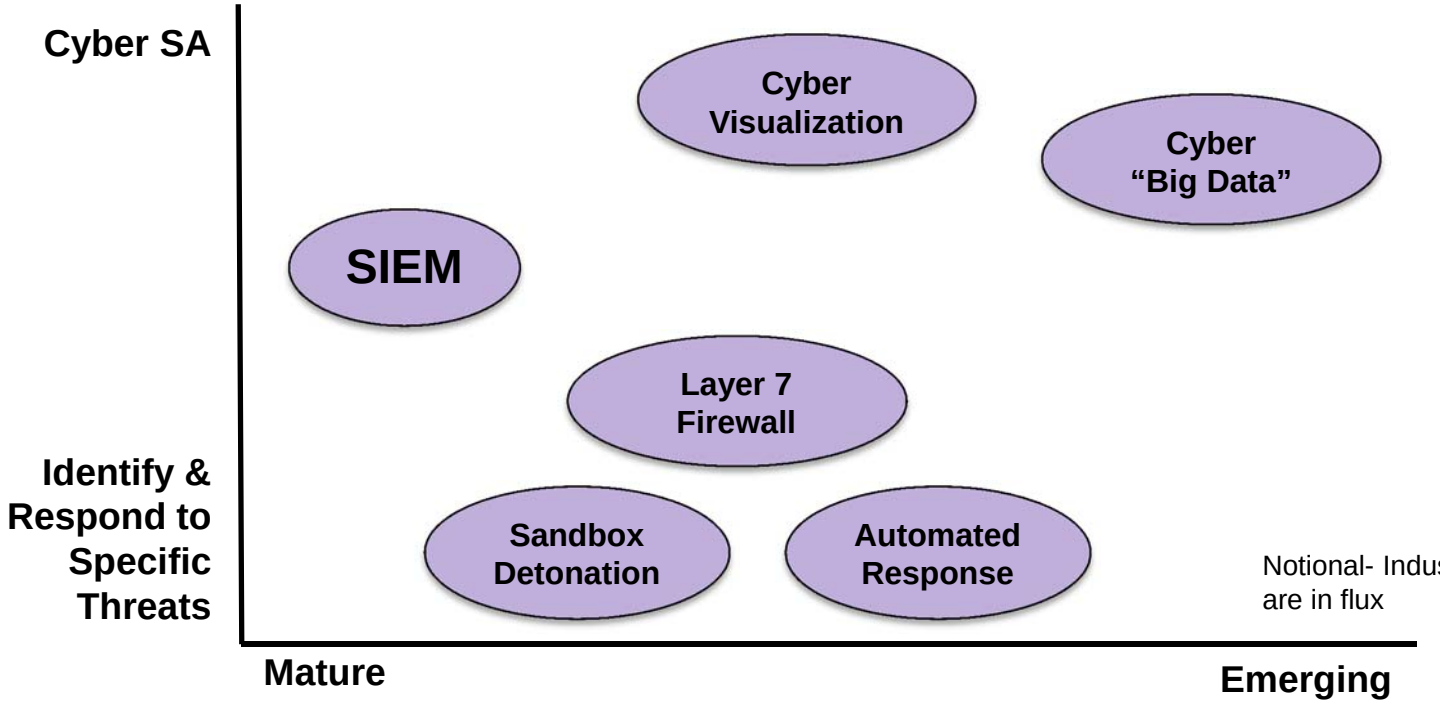
An Arsenal to Counter 21st Century Cyber Threats

- "Defense-in-Depth" security architectures are necessary, but not sufficient
  - *Need to assume that attackers can find a way inside (APTs)*
- Cyber Situational Awareness is critical
  - *Instrument computers and networks to report ongoing state and activity*
  - *Leverage advanced Cyber Analytics Tools to correlate and interpret vast amounts of available data*
  - *Ensure operator training and procedures to utilize available tools*
- Enforce system state of "stacks" through automated tools
  - *Leverage global knowledge base developing mitigations to emerging threats and vulnerabilities (i.e. patch management)*
- Implement processes to continually review and enhance cyber security protections to space systems
  - *Operating budgets need to allocate resources for continual enhancements*

© 2015 The Aerospace Corporation

Cyber Analytic Tools for Advanced Threats

- **Industry has developed various real-time cyber analytic tools to identify and respond to advanced threats**
- **Instrumentation highlights patterns of a cyber attack – subtle changes in state on a number of systems can be correlated to facilitate early discovery of an attack**
- **Data-Driven Security- emerging capabilities such and Big Data cyber analytics and cyber visualization may enable automated analysis and response to advanced threats**



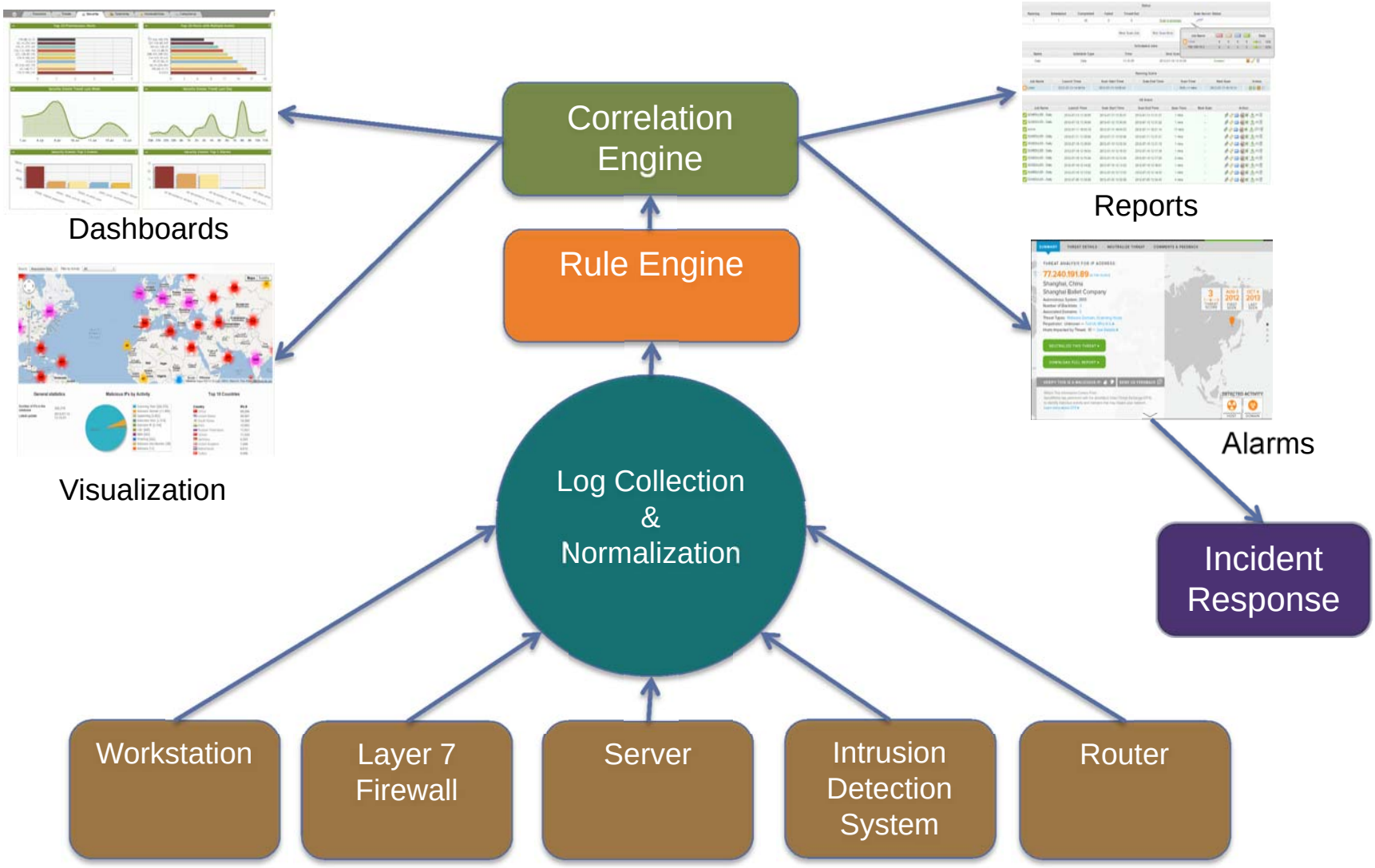
Notional- Industry technology areas are in flux

SIEM – Security Information & Event Management

© 2015 The Aerospace Corporation

AEROSPACE

Security Information & Event Management (SIEM)



© 2015 The Aerospace Corporation

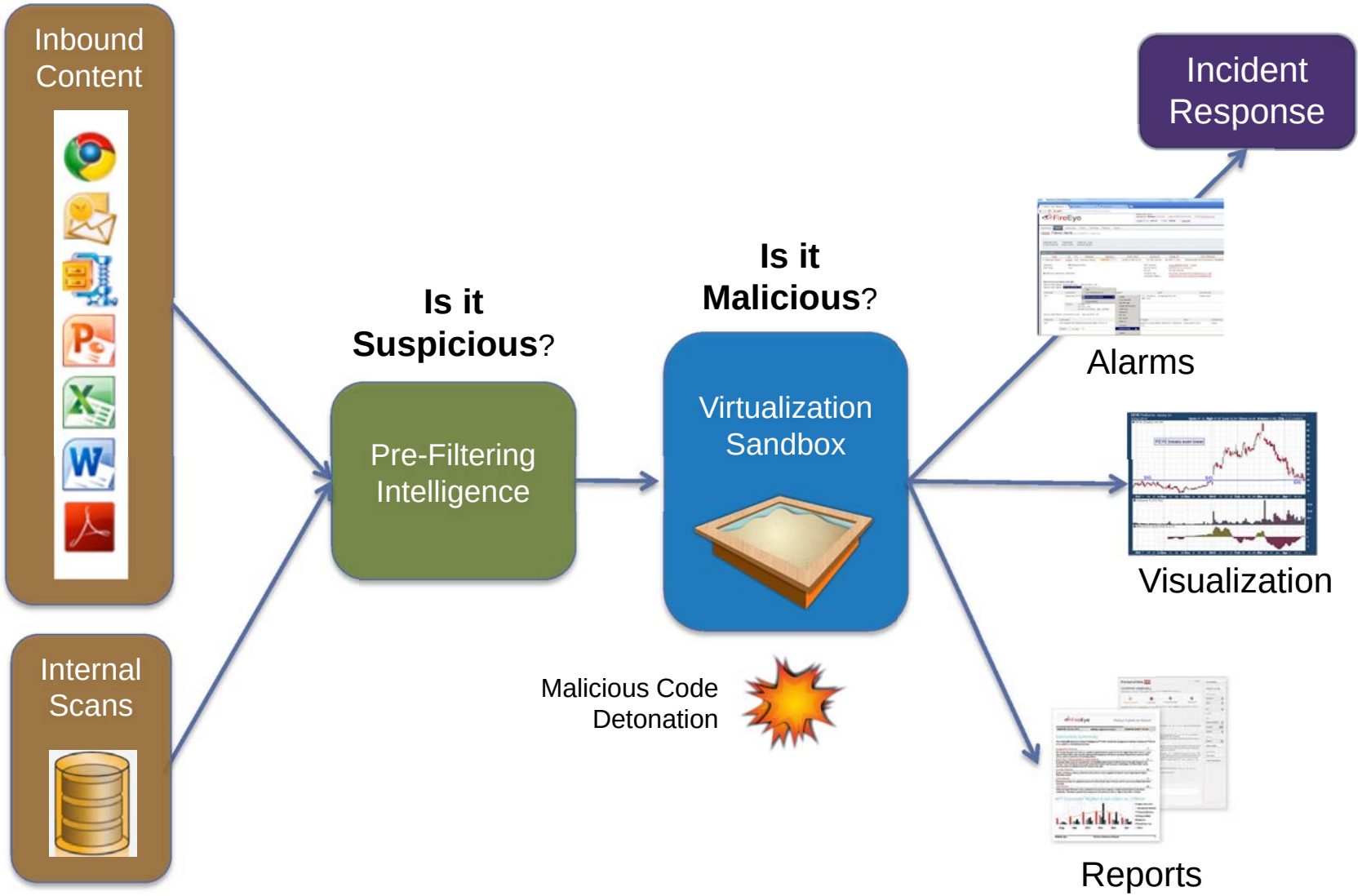
AEROSPACE

Challenges to Implementing SIEM

- Custom SIEM log interfaces need to be built for legacy/unique systems
- SIEM outputs are only as good as the logs generated and the rules defined for the implementation
- Advanced tools do not negate the need for training and procedures
- SIEM tools need to be paired with incident response systems/procedures (I know we're under cyber attack- so now what are we supposed to do?)
- SIEM itself can be compromised (e.g. insider attacks)
- Cloud providers may not provide logs needed for in-depth SIEM

© 2015 The Aerospace Corporation

“Sandbox Detonation” for Zero-day Attacks



© 2015 The Aerospace Corporation

AEROSPACE

Case Study: Target Data Breach

- Attackers gained access to the Target network via weak security at a Target vendor
- Except for the final data exfiltration, almost the entire attack took place within the Target corporate infrastructure
  - *Target computers were turned into agents for the attackers*
- Target never realized the attack on their own
  - *Complete lack of cyber situational awareness*
- Despite having installed advanced security systems, Target missed multiple opportunities to thwart the attack
  - *Lack of skills to architect, deploy, and manage advanced cyber analytic tools*
- To date, there has been no attribution (charges/arrests)

© 2015 The Aerospace Corporation

Summary

- The cyber threat to space systems is real will continue to evolve with increasing capabilities for potential attackers
- Cyber Situational Awareness is critical for all segments of a space system (space, ground networks, ops centers, user terminals)
  - *Required to identify, mitigate, and attribute advanced cyber attacks*
- Cyber Analytics Tools can provide significant insight into cyber situational awareness
  - *Instrument the network*
  - *Implement analytics to support security team*
  - *Must develop (or contract for) expertise necessary to integrate and operate cyber analytic tools*
- Cyber Analytic solutions are evolving— resources must be provided for an “evergreen” refresh approach to cyber security

© 2015 The Aerospace Corporation

Questions?

© 2015 The Aerospace Corporation