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Applying Cause-Effect Mapping to Assess Cybersecurity Vulnerabilities in Model-Centric Acquisition Program Environment

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Monterey, California. Naval Postgraduate School

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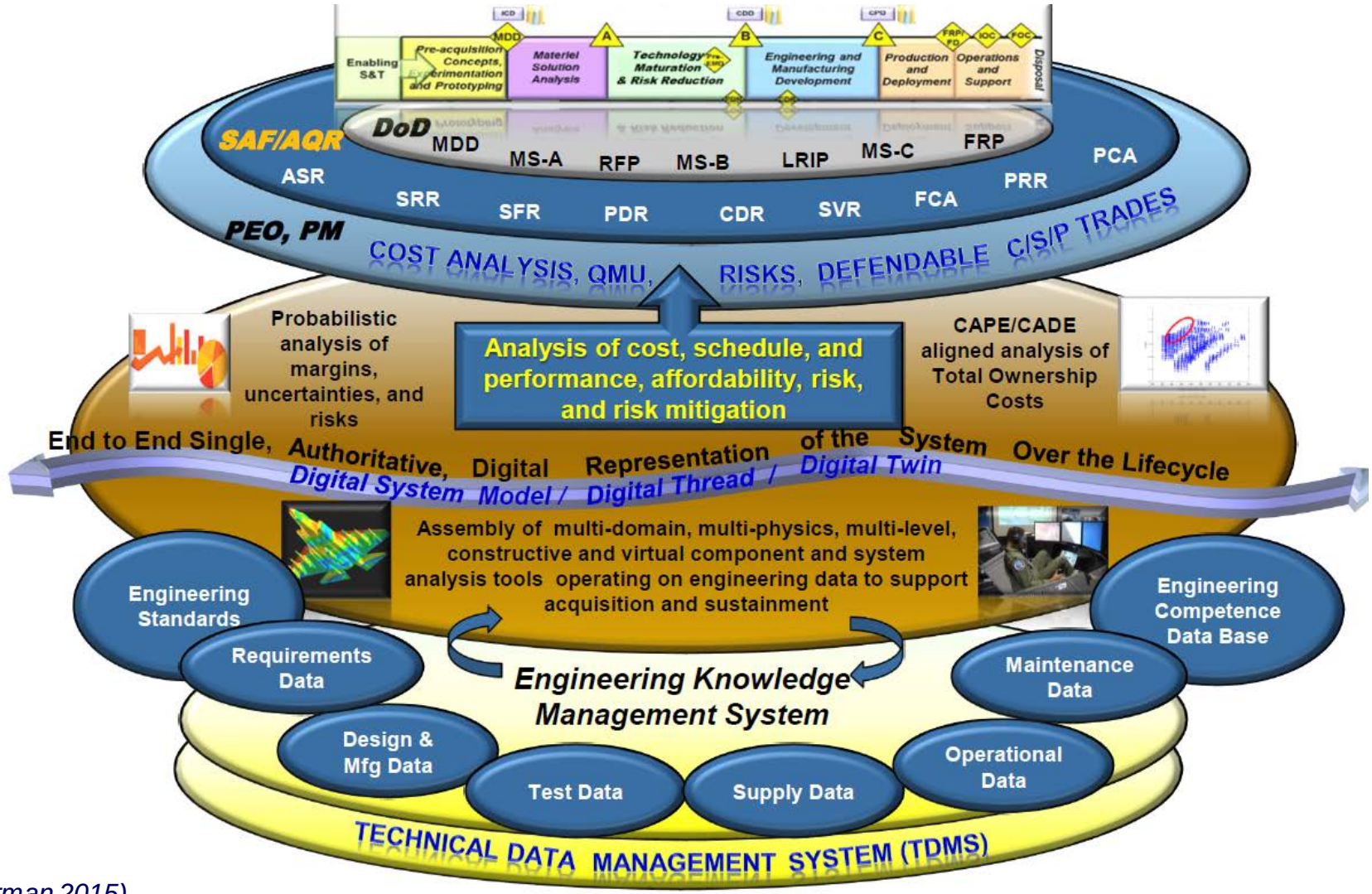
Applying Cause-Effect Mapping to Assess Cybersecurity Vulnerabilities in Model-Centric Acquisition Program Environment

Jack Reid, Donna Rhodes
Massachusetts Institute of Technology

Acquisition Research Symposium
May 9-10, 2018
Embassy Suites Monterey Bay Seaside
Monterey, California

ACQUISITION RESEARCH PROGRAM
NAVAL POSTGRADUATE SCHOOL

Model-Centric Engineering (MCE)



(Zimmerman 2015)

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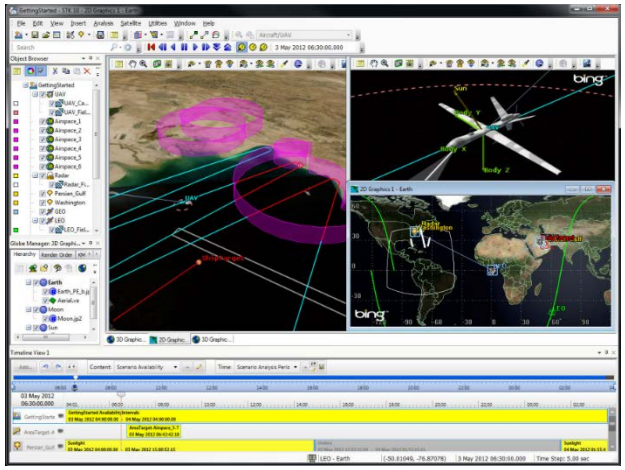
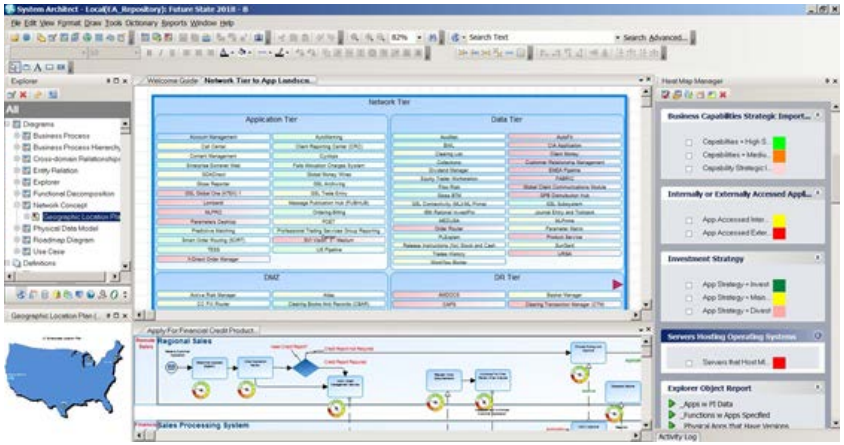
Current State of MCE

STK



UNICOM System Architect



JPL Team-X

NAVAIR

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MCE and Cybersecurity

(Some) Benefits

Cybersecurity Concerns

System-level optimization and "authoritative source of truth" → "All eggs in one basket"

Increased collaboration across teams → More points of entry

Removal of barriers between stages

Design
▼
Manufacturing
▼
Testing
▼
Operation

→ Tampering in design can make its way into the field

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MCE and Cybersecurity

MCE make[illegible] *program* even more important

The Telegraph

Kremlin returns to typewriters to avoid computer leaks

The Kremlin is returning to typewriters in an attempt to avoid damaging leaks from computer hardware, it has been claimed.

Cyber-[illegible]: A case st[illegible]

Logan D.
Robert P[illegible]

Boeing production [illegible] ransomware attack

The widespread and devastating cyberat[illegible]

By Nick Statt | @nickstatt | Mar 28, 2018, 7:23pm EDT

Convicted in [illegible] Trade Secrets

[illegible]PM EST Bloomberg

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Motivating Questions

MCE introduces vulnerabilities beyond cybersecurity

1. What are program managers doing now in the face of external hazards and uncertainties?
2. How can they be prepared to tackle the new vulnerabilities that MCE introduces in the **program**?

These general questions led us to a focus on cybersecurity

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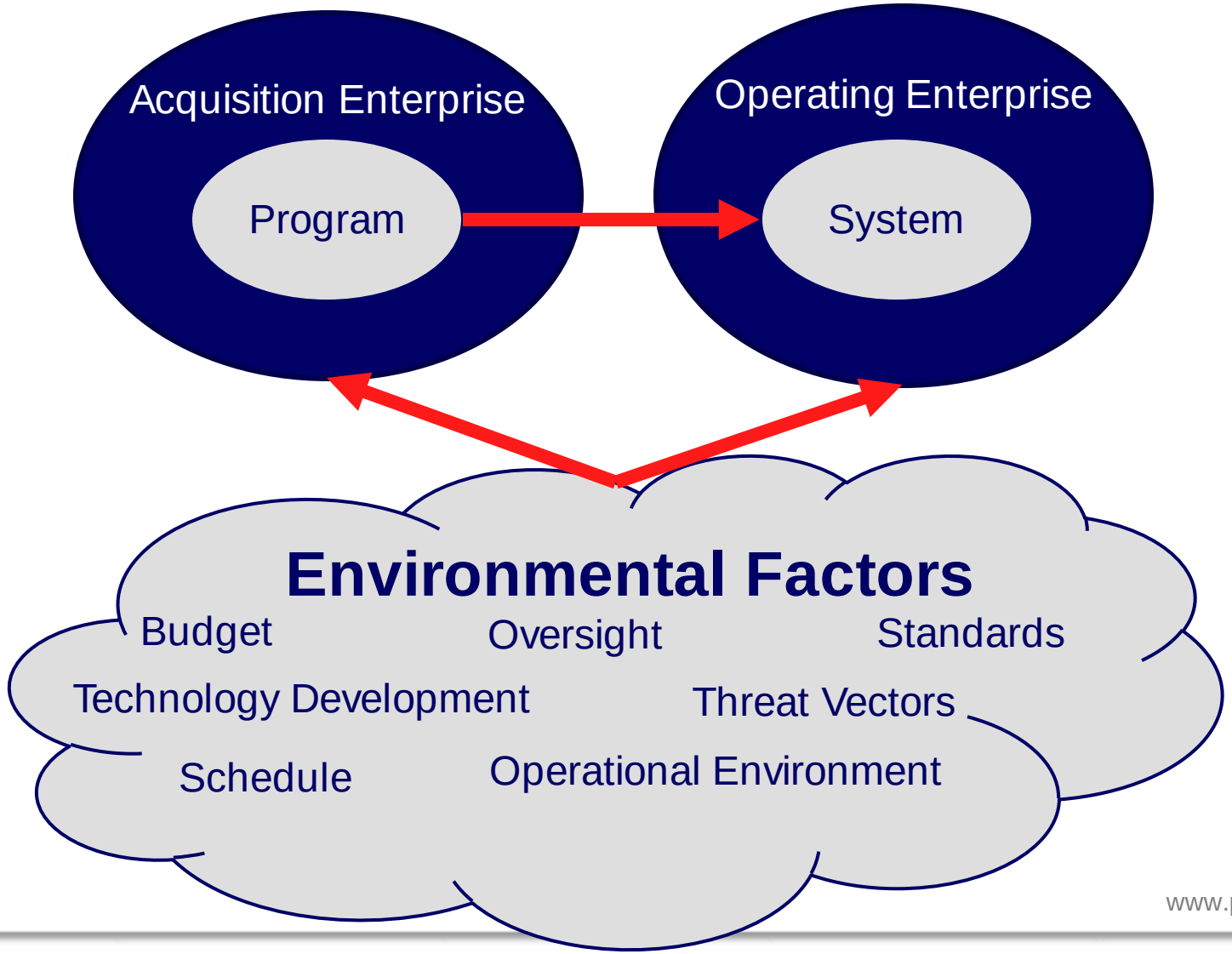
Program vs System



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Definitions

- **Hazard:** A system or environmental state that has the potential to disrupt the system
- **Vulnerability:** The causal means by which the hazard results in the system disruption / value loss
  - "Systems with microprocessors utilizing speculative execution and branch prediction may allow unauthorized disclosure of information to an attacker with local user access via a side-channel analysis" (CVE-2017-5753)
  - "We are vulnerable to man-in-the-middle attacks"
  - "A schedule delay would cost us $10M."

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Vulnerability Chain

- **Causal Chain:** A series of events, with each event causing or being an integral part of the cause, or the next “link” in the chain
- Enables easy dissection of a vulnerability and identification of interventions

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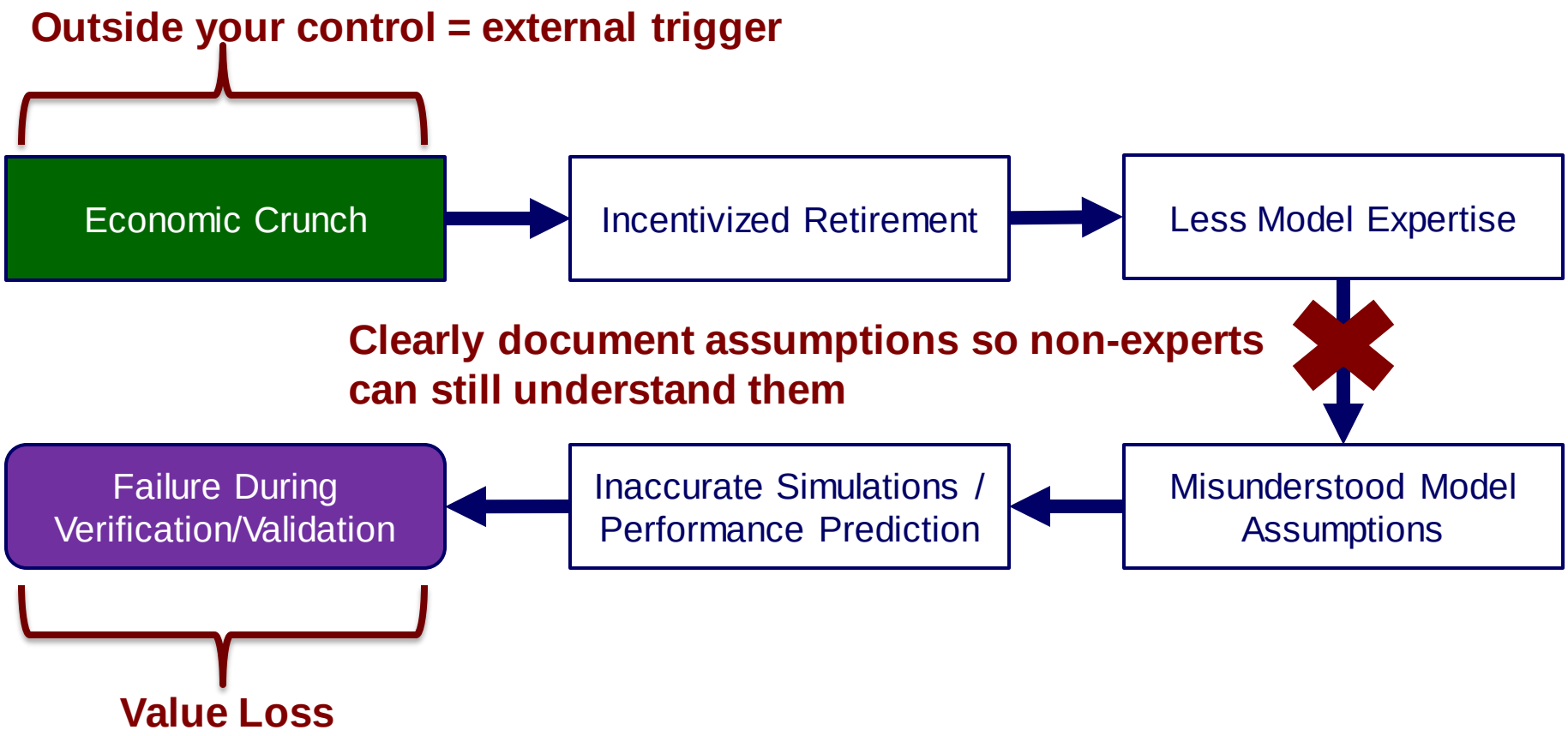
Causal Chain



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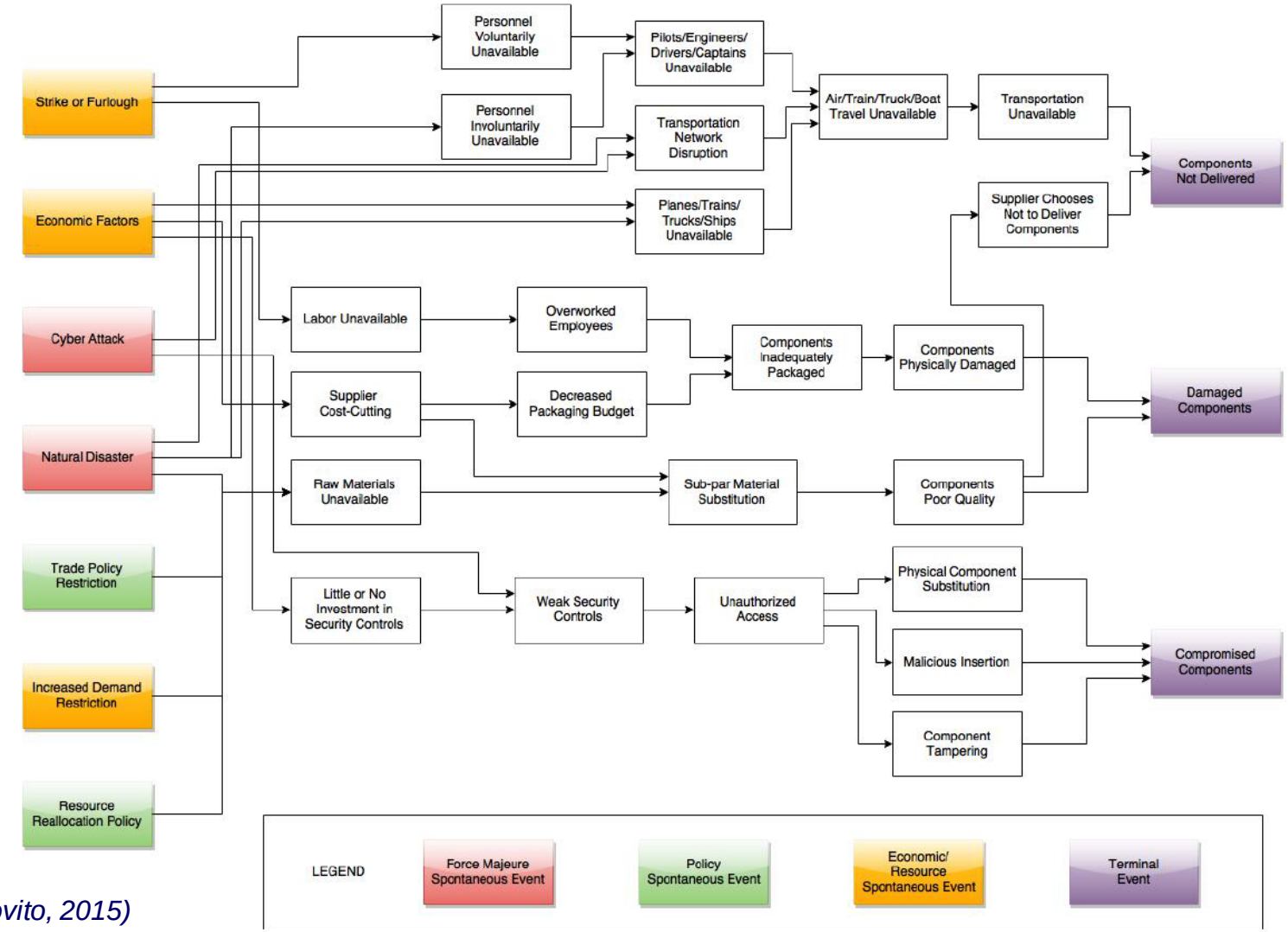
Cause-Effect Mapping (CEM)



(Rovito, 2015)

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Uses of CEM / Typology

- Enables identification and understanding of
  - Connections between vulnerabilities
  - Priority forms of intervention
- A CEM is made with a particular user in mind
- Does not assign “blame,” focuses on action

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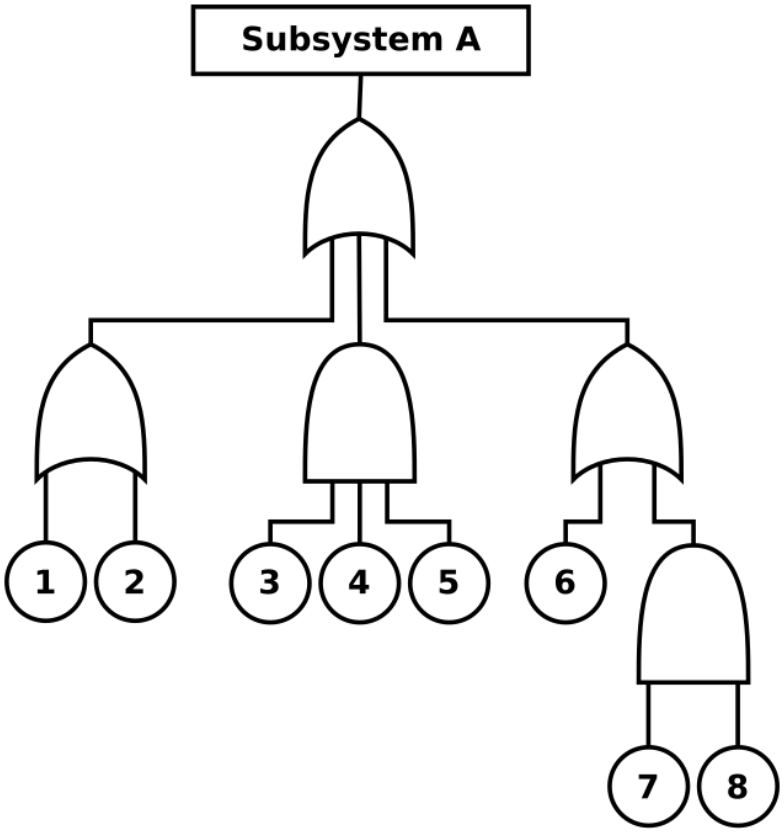
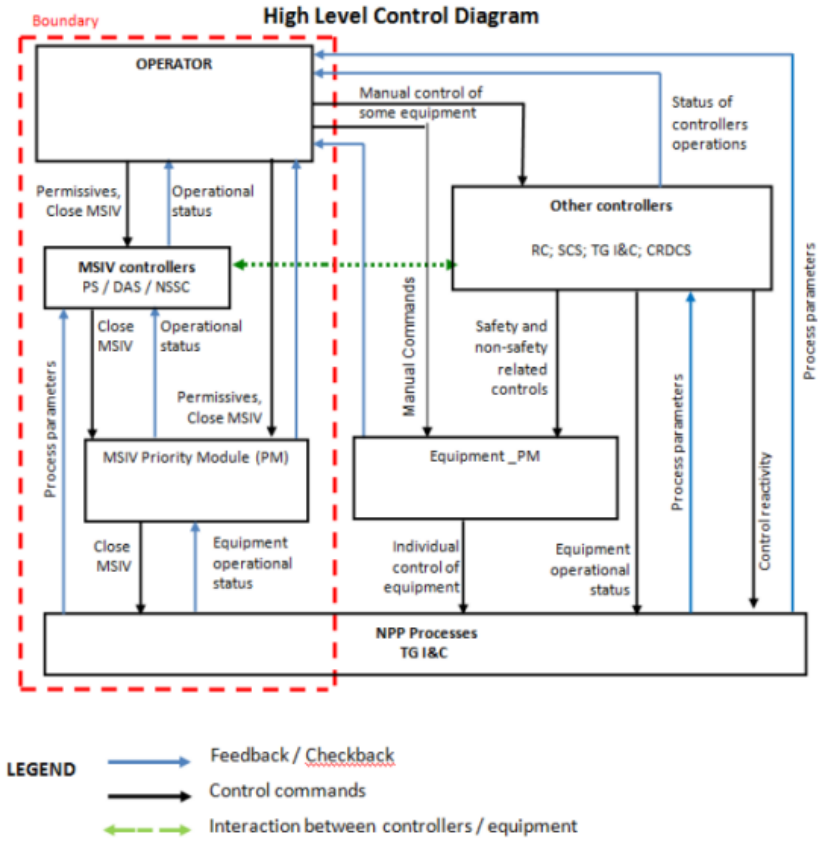
Comparisons





(Leveson 2013)

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Interviews

- Disciplines
  - Aerospace
  - Nuclear Physics
  - Automotive
  - Oil & Gas
  - Medical
  - Defense
- “Networking and MCE is hard to do while staying secure. Particularly when dealing with large groups across departments.”
- “The environment keeps changing and it is always getting bigger. You have to protect yourself from old threats and vulnerabilities, while continuing to adapt and move forward.”

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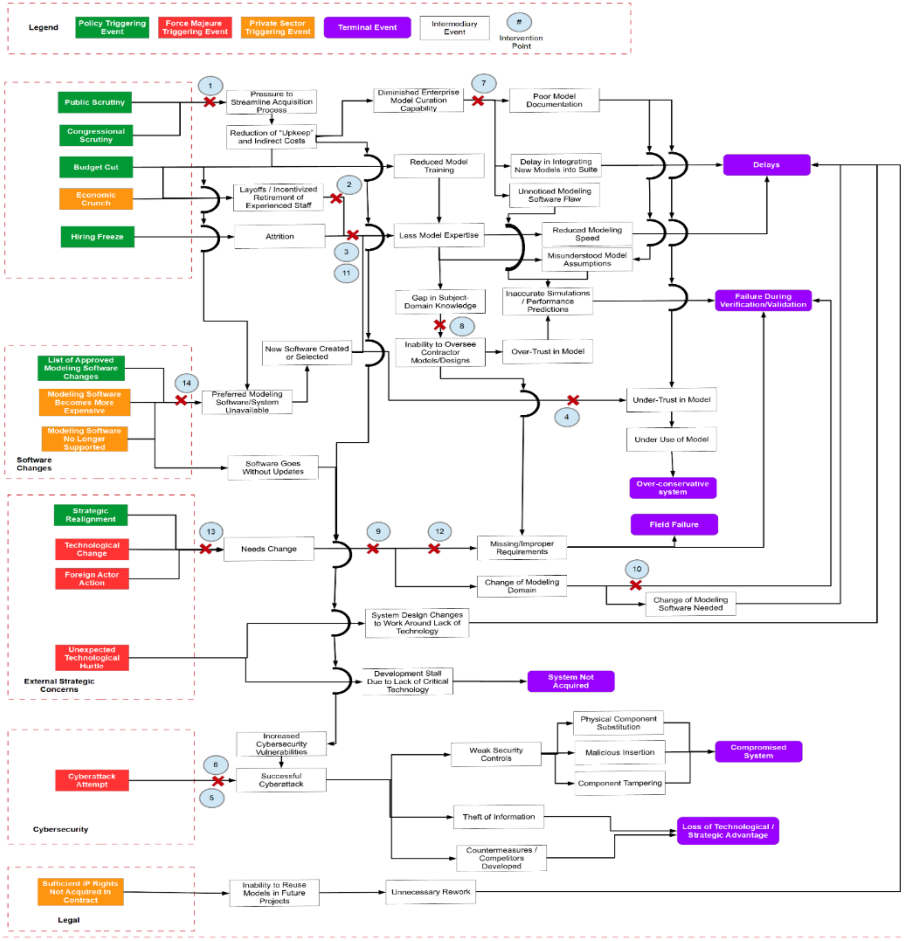
MCE Cause-Effect Mapping



Intervention Points

1) Initiate Internal Assessment and a PR Strategy
2) Initiate various non-monetary benefits (such as allowing pets at work or a 9/80 schedule) to encourage employees to stay
3) Seek to share resources and employees with other programs
4) Hire employees with prior experience with the new software
5) Actively conduct security training and monitor compliance
6) Isolate critical data
7) Create documentation and curation processes within the program
8) Institute handover periods to benefit from contractor expertise
9) Reevaluate training regime and needed fields of expertise
10) Increase the amount of testing conducted
11) Increase use of contractors/consultants (including previous employees) to maintain expertise level
12) Reevaluate requirements with the client and other stakeholders
13) Design for modularity to minimize impact on system
14) Negotiate with client to see if they are able to pay for the software

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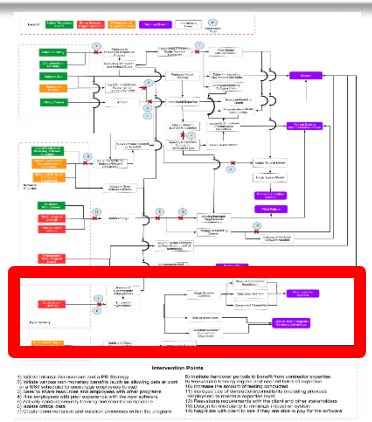
Cause-Effect Mapping - Cybersecurity



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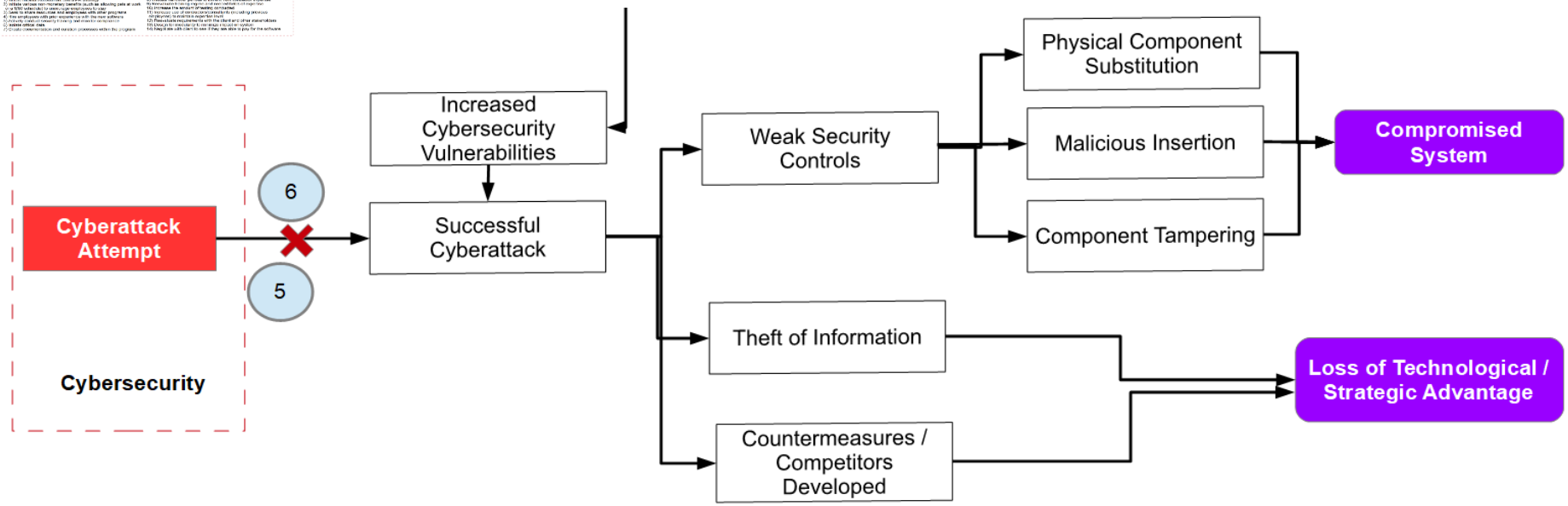

5) Actively conduct security training and monitor compliance
6) Isolate critical data

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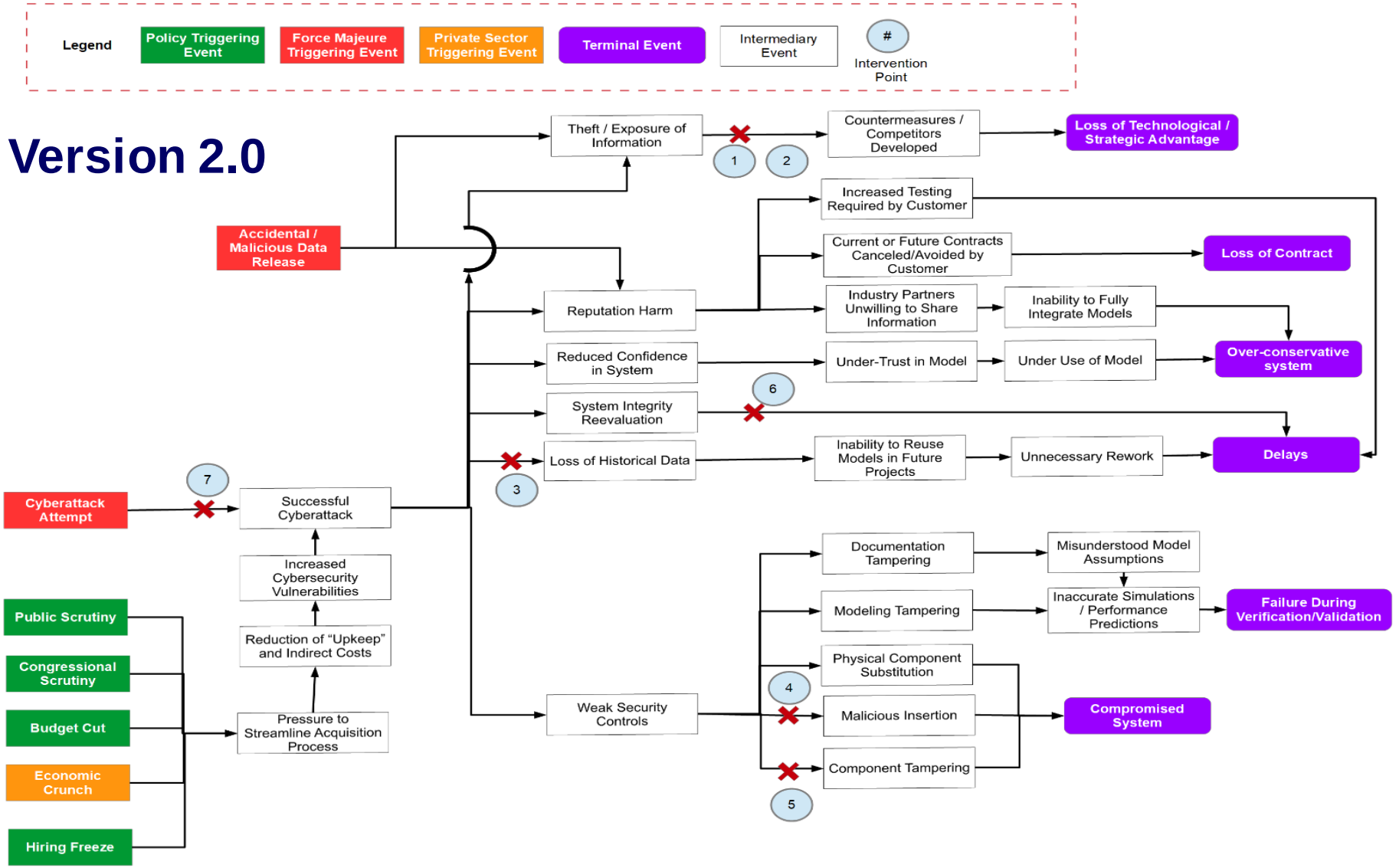
CEM - Cybersecurity



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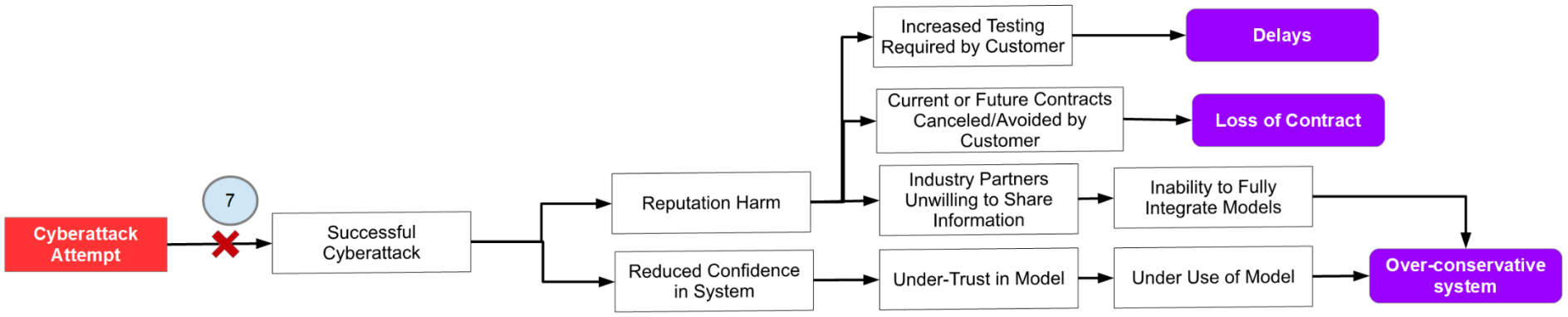
Discussion

Program Managers are not solely interested in the technical impacts of cyberattacks…



Issues like harm to the reputation of the organization and reduced confidence in the modeling environment's integrity are also quite important

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Next Steps and Recommendations

Take-Aways / Recommendations

- Causal Chains provide additional insight into vulnerabilities
- Program managers know that cybersecurity is important
- PMs need tools to understand the threat and take action
- PMs also need better knowledge on how to *respond* to attacks
  - Responsibility for this also lies at the organizational level

Next Steps

- Discussions with MCE tool developers and organizational leaders
- Develop a prototype interactive CEM to use as a training tool
- Generate analogy case studies from other industries

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Questions?

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SUPPORT/BACKUP SLIDES

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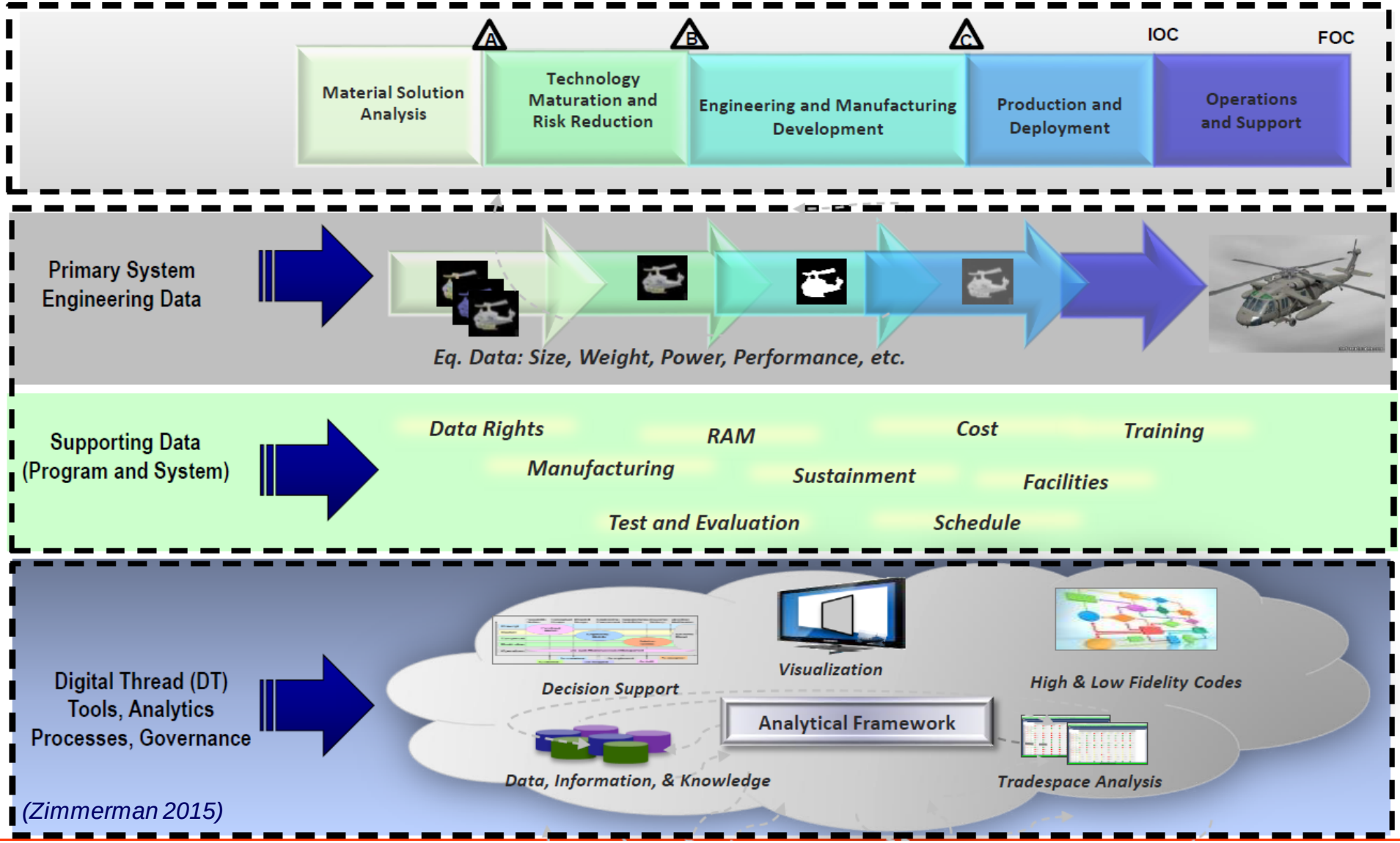
Model-Centric Acquistion



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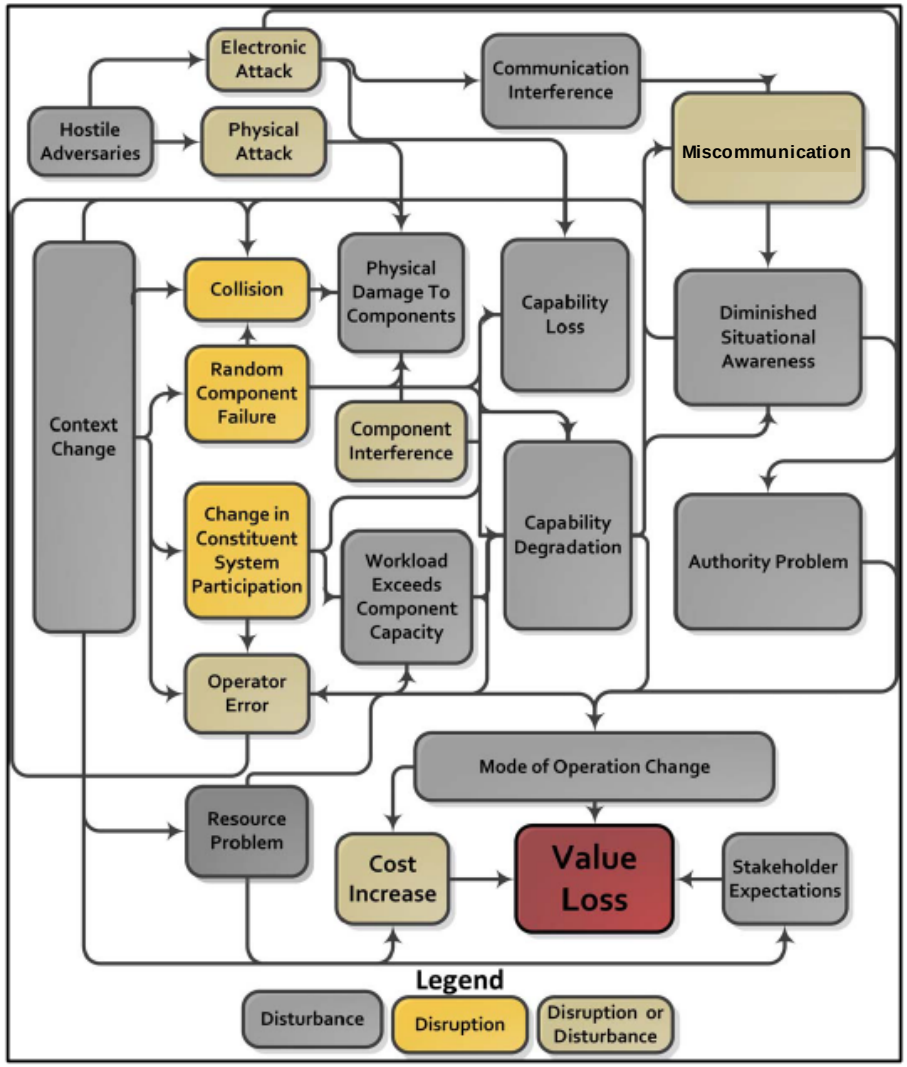

(Mekdeci, 2012)

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Cybersecurity Interventions

Intervention Points

1) Compartmentalize sensitive information
2) Obfuscate sensitive data with false or misleading information
3) Isolated but readily accessible back-ups of data
4) Reviews/Comparisons of models between lifecycle stages
5) Multiple, independent simulations or component checkers
6) Isolated, independent backup equipment that can be switched to while primary equipment is being evaluated
7) Conduct regular "red-team" / penetration test exercises

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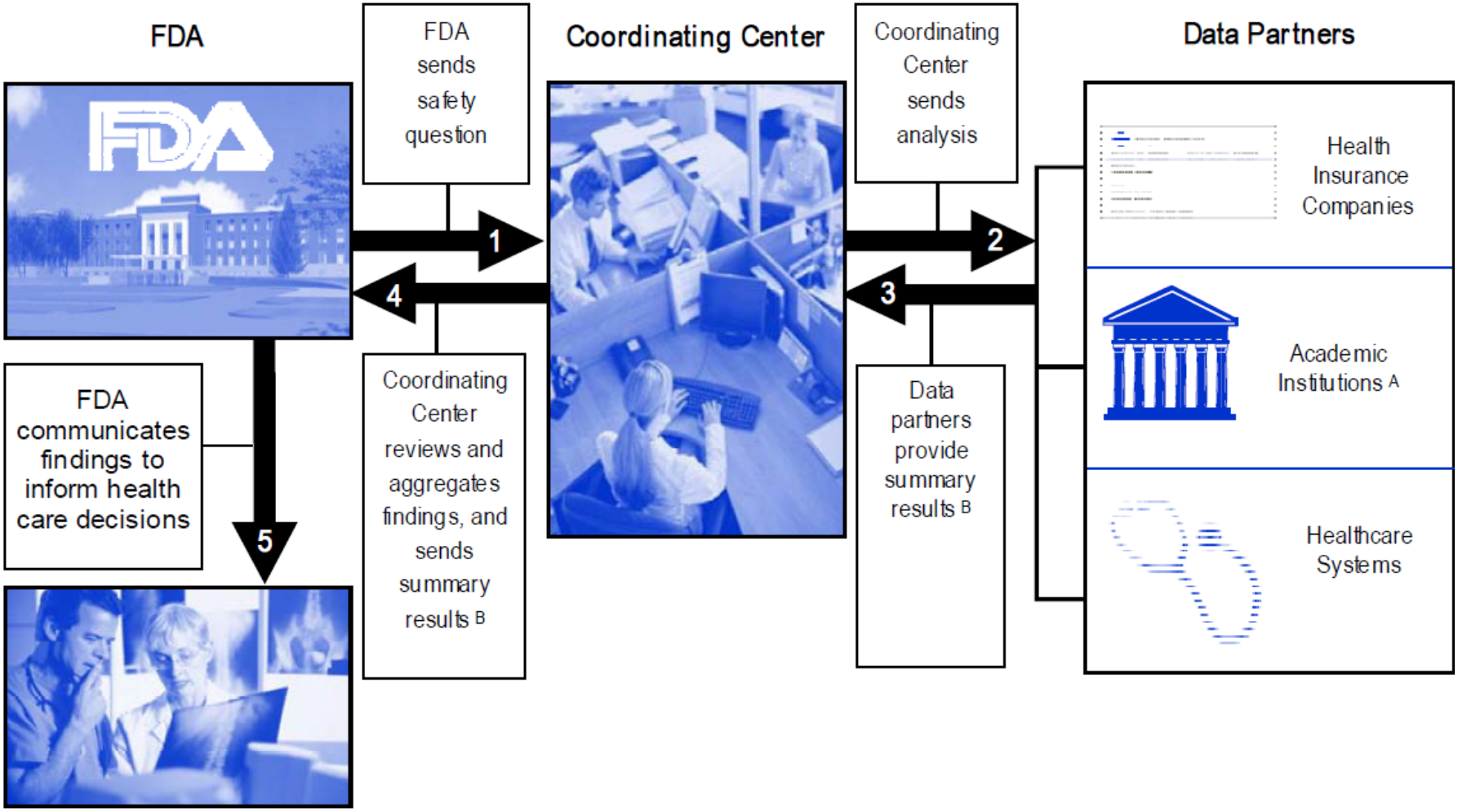
FDA Sentinel Intiative



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