



**34<sup>th</sup>** Annual **INCOSE**  
international symposium

hybrid event

Dublin, Ireland  
July 2 - 6, 2024



Session 2.2 Security

# **Building a Scientific Foundation for Security: Multilayer Network Model Insights for System Security Engineering**

Security threats are not  
always what or who you  
expect...



Linda Davidson/The Washington Post/Getty Images

A REPORTER AT LARGE <https://www.newyorker.com/magazine/2015/03/09/break-in-at-y-12>

## BREAK-IN AT Y-12

By Eric Schlosser

March 1, 2015

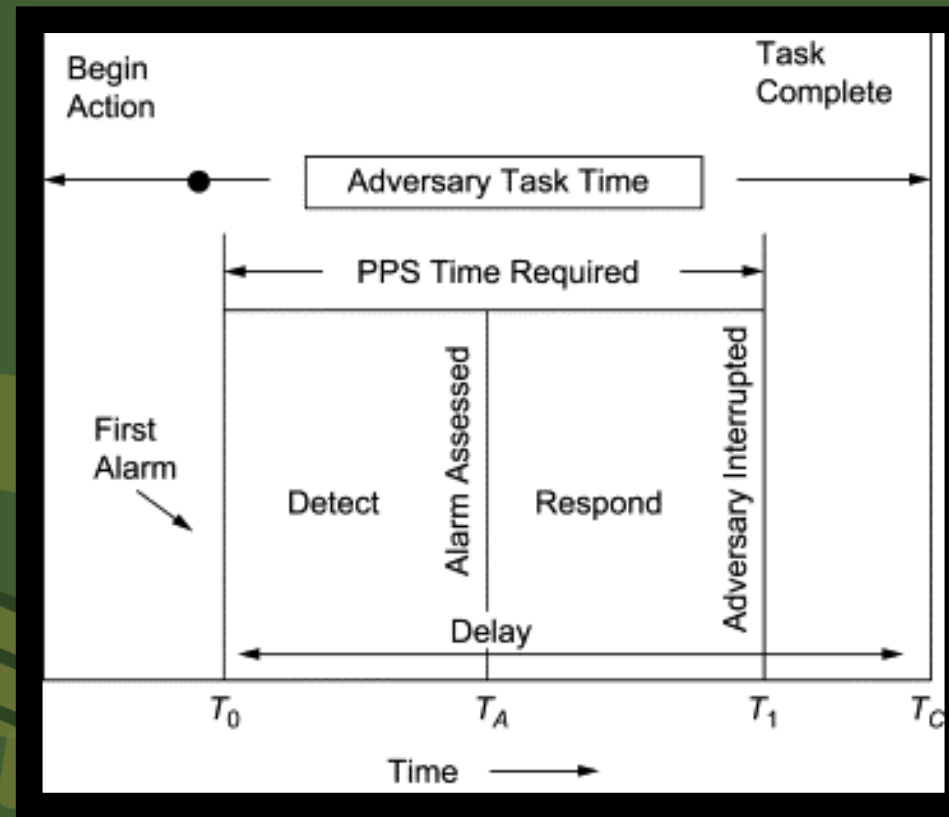


The Flowshares movement was inspired by Dorothy Day, a Greenwich Village bohemian who converted to Catholicism and urged resistance to all wars. In the Vietnam era, Philip Berrigan led actions to symbolically destroy the nuclear arsenal. Illustrations by Alex Williamson; Left to Right: Getty (Dorothy Day); Bettman / Corbis (Philip Berrigan and Protest March)

The Y-12 National Security Complex sits in a narrow valley, surrounded by wooded hills, in the city of Oak Ridge, Tennessee. Y-12 and Oak Ridge were

# Traditional/Historical World View

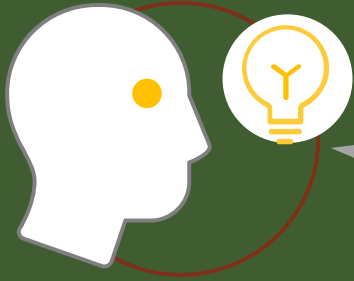
## Security System Performance



(Smith & Brooks, 2013)

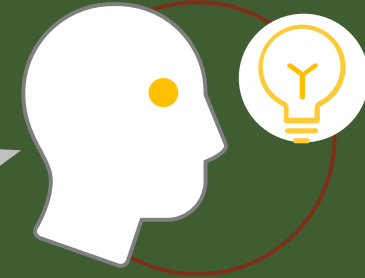
# Time for a paradigm shift

Human-machine  
interactions for  
security expert



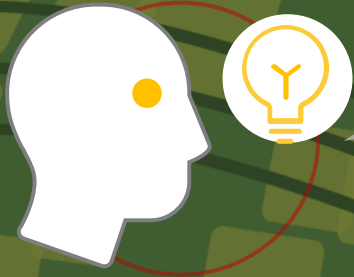
“Historically, [it is] likely [that we] had rich conversations about the [security assessment] framework and associated caveats and assumptions...[while] the framework has been passed on, ***the continuous improvement process has not been retained***”

“... a systematic view is needed that looks **beyond compliance** with the regulations, but also considers emergency response, cyber vulnerabilities, as well as safety and security issues.”

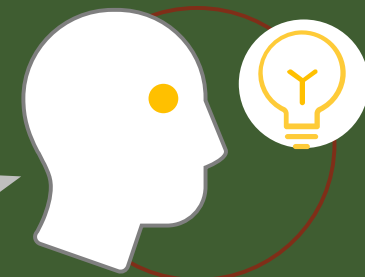


Evaluation of  
security  
assessments

Resilience  
frameworks and  
systems analysis  
expert



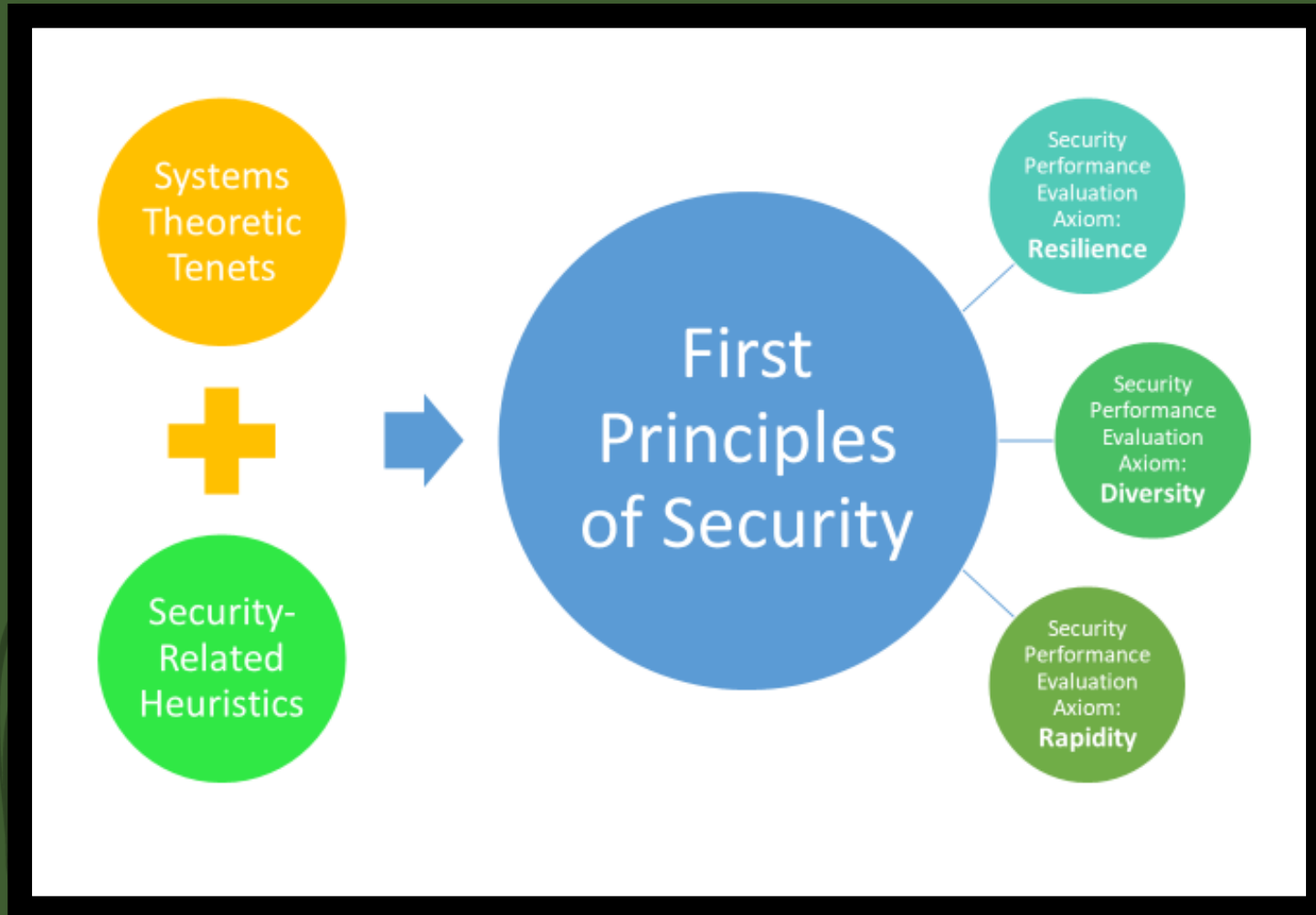
“...ensure that consequences are looked at **over time**: temporal disconnects between threats and consequences are **assessed dynamically**.”



Systems safety  
and security  
analysis expert

“We need to consider changing the end state from just stopping the bad guys to **include considering how they may be changing...and measure the overall system stability and flexibility**.”

# Needed: a scientific foundation for security



*A generalized description of science – based on established theory and principles that explain—and can be validated by—observation and experimentation*



# INCOSE's systems security engineering working group's world view

## Trustworthiness

Systems security tends to have a singular focus on risk

A return to modeling trust as an evidentiary core aspect of system security

## Loss-Driven

Systems security tends to focus on risk & too late in the development process

An approach to include security earlier in development & focus on preventing "loss"—not risk

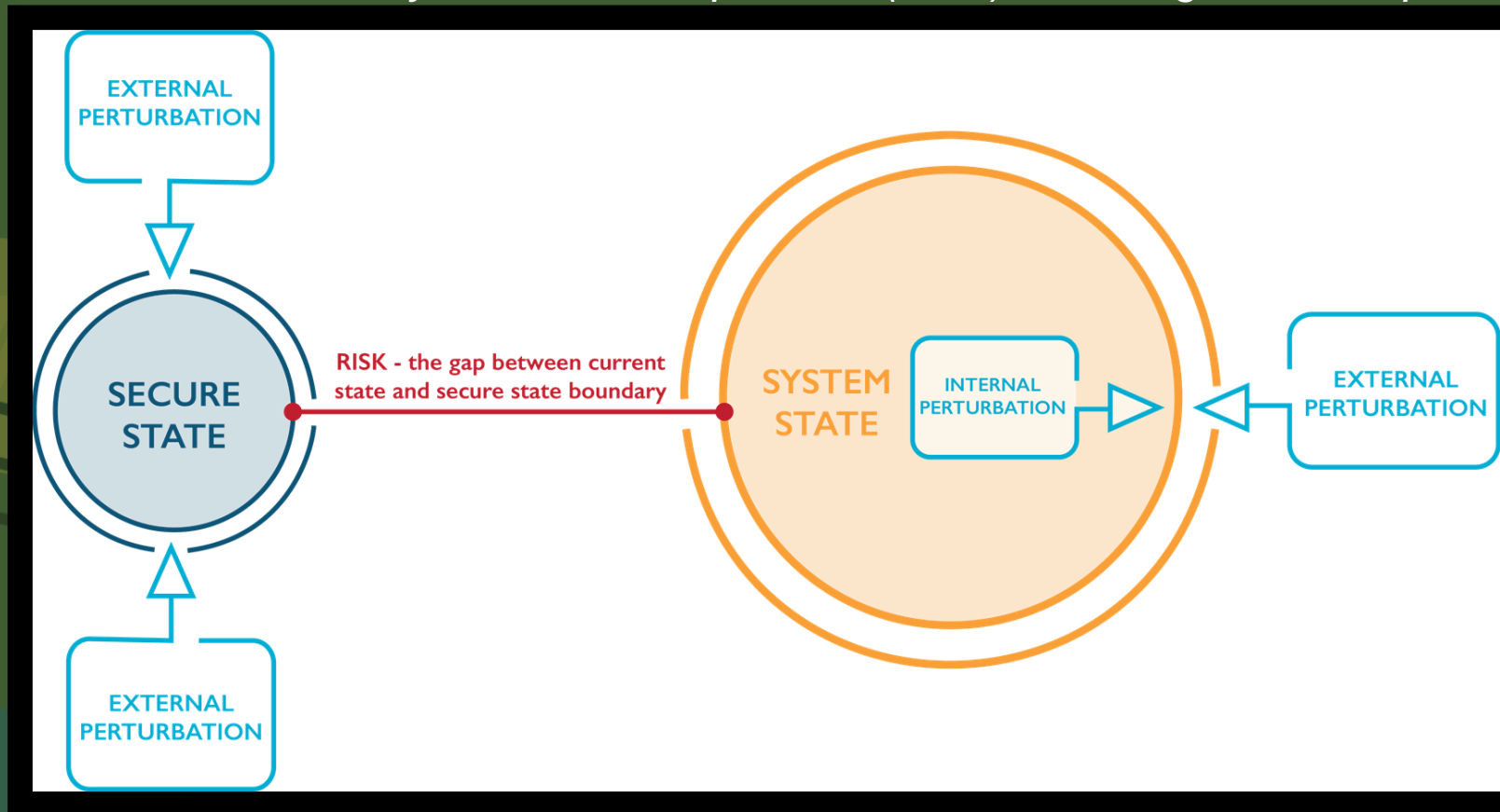
## Capabilities-Based

Systems security too often starts with available solutions rather than desired results

A top-down paradigm that defines systems security in terms of desired results

# A proposed definition for security risk

*a failure to mitigate vulnerabilities that could intentionally be exploited to allow for the successful theft of or destruction of structures, systems, or components (SSC), resulting in unacceptable loss*

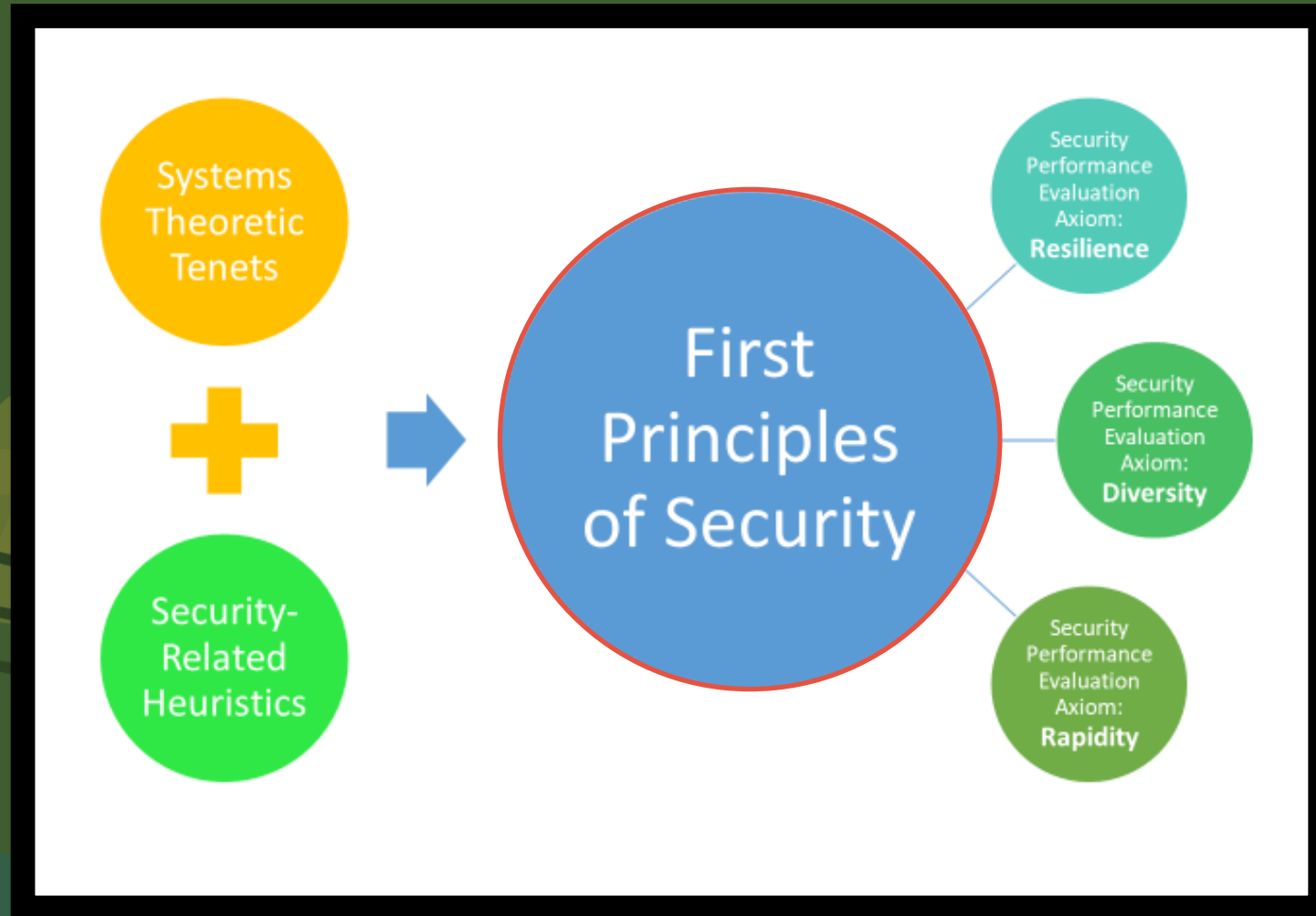


# Security System Heuristics





# Needed: a scientific foundation for security



# Proposed 1<sup>st</sup> Principles of System Security

## Detection

- Known or estimated specificity and sensitivity based on normal operations
- Be resilient to environmental and internal perturbation
- Evaluated within each layer of protection and across the entire system to decide if and where weaker detection elements or gaps may exist

## Signaling

- Must be prompt, resilient, and provide clear information regarding time and space
- Evaluated within each layer of protection and across the entire system to determine if and where weak signaling or gaps may exist
- Confidence in data signals and detectors impacts the sensing and assessment, driving a need to know specificity and sensitivity over time and space

## Assessment

- The assessment process must be resilient to internal and operator perturbations and provide rapid reporting

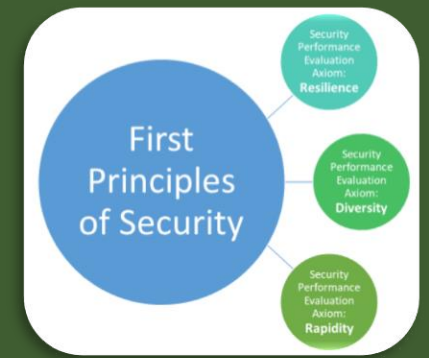
## Response

- Systems security response is only effective with rapid and resilient communication and actions

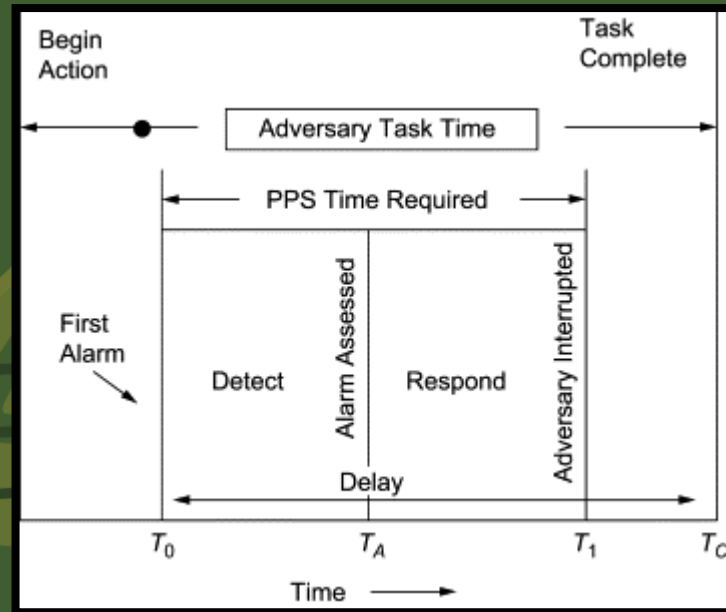
## System

- System security must support rapid and resilient communication between all related organizational systems
- System security must support the organization and its mission

# Security Performance Evaluation Axioms



## Traditional Performance Evaluation

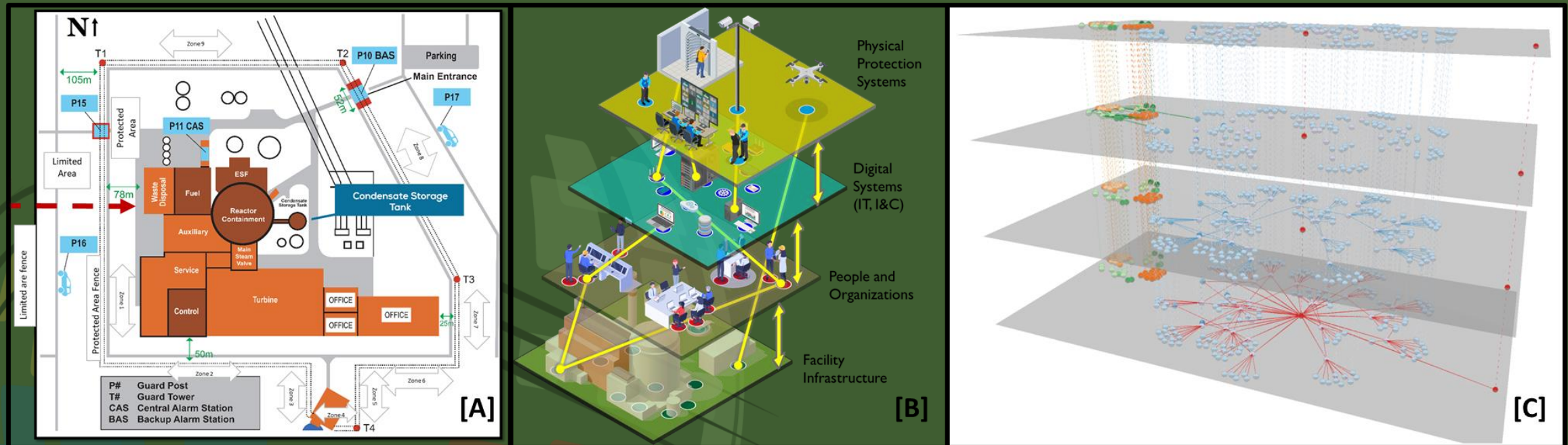


## Axiomatic Approach

Axiom Name	Axiom Description
Confidence	The level of trust in the information being generated and transmitted to support systems security decision-making.
Criticality	The importance of various components or elements within the systems security solution to ensure adequate performance
Diversity	The ability to balance the use of the same technology for different systems security purposes and the use of different technologies to support the same security function
Human Performance	Incorporates human actors' role(s) on systems security solutions in terms of security "performance influencing factors."
Rapidity	The speed, accuracy, and structure of information flow throughout systems security solutions
Reliability	How well a component correctly provides valuable information (e.g., sensitivity) and how well a component does not provide incorrect information (e.g., specificity)
Resilience	The ability of the systems security solution to maintain (e.g., absorb, adapt, or recover) desired performance levels against a range of perturbations

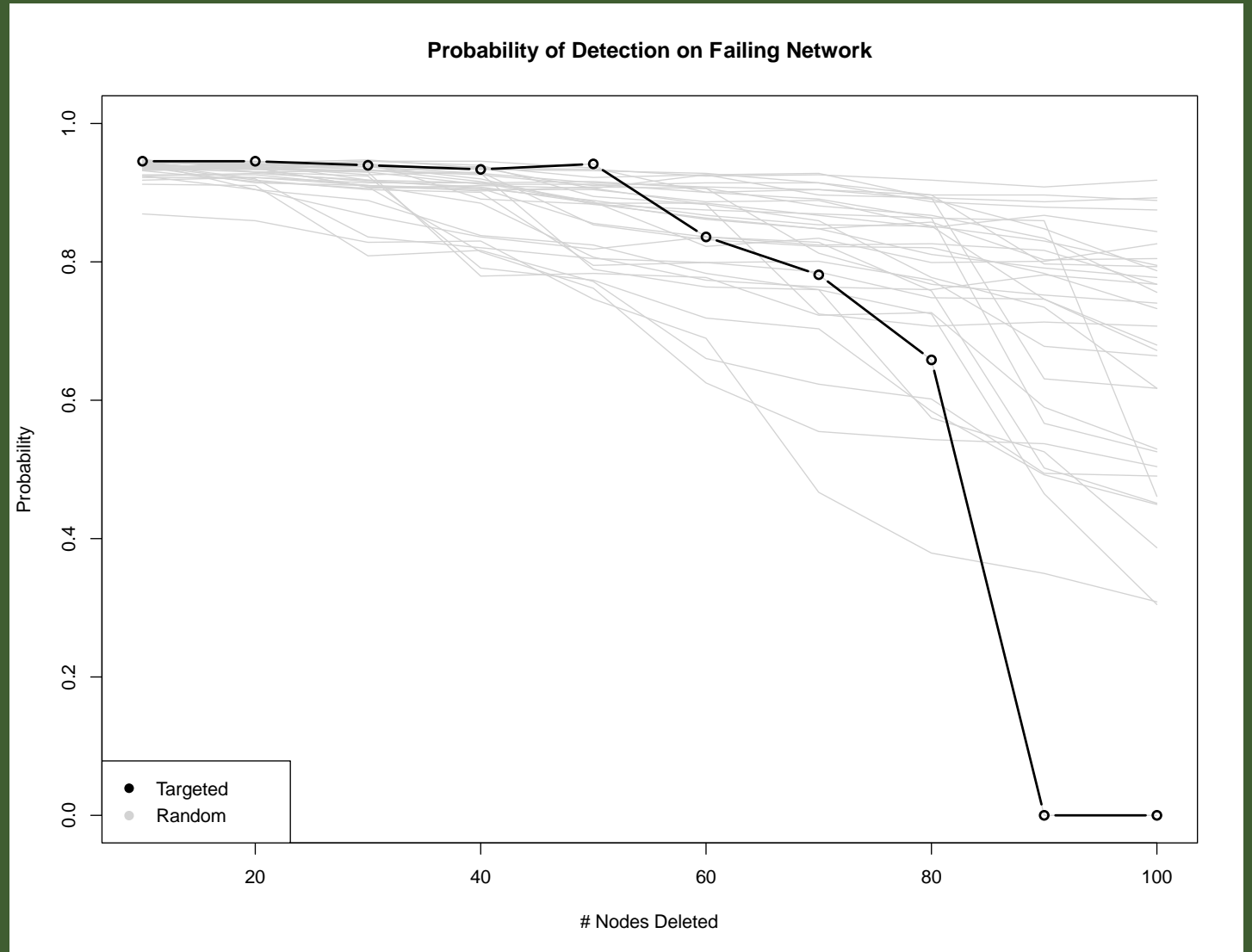
# A generalized description of science – based on established theory and principles that explain—and can be **validated by—observation and experimentation**

Experiment: Utilize an MLN reflecting the physical, digital, infrastructure, and people that create a security system for a hypothetical nuclear power plant and use observations and metrics to consider the proposed security performance axioms



# Example Results

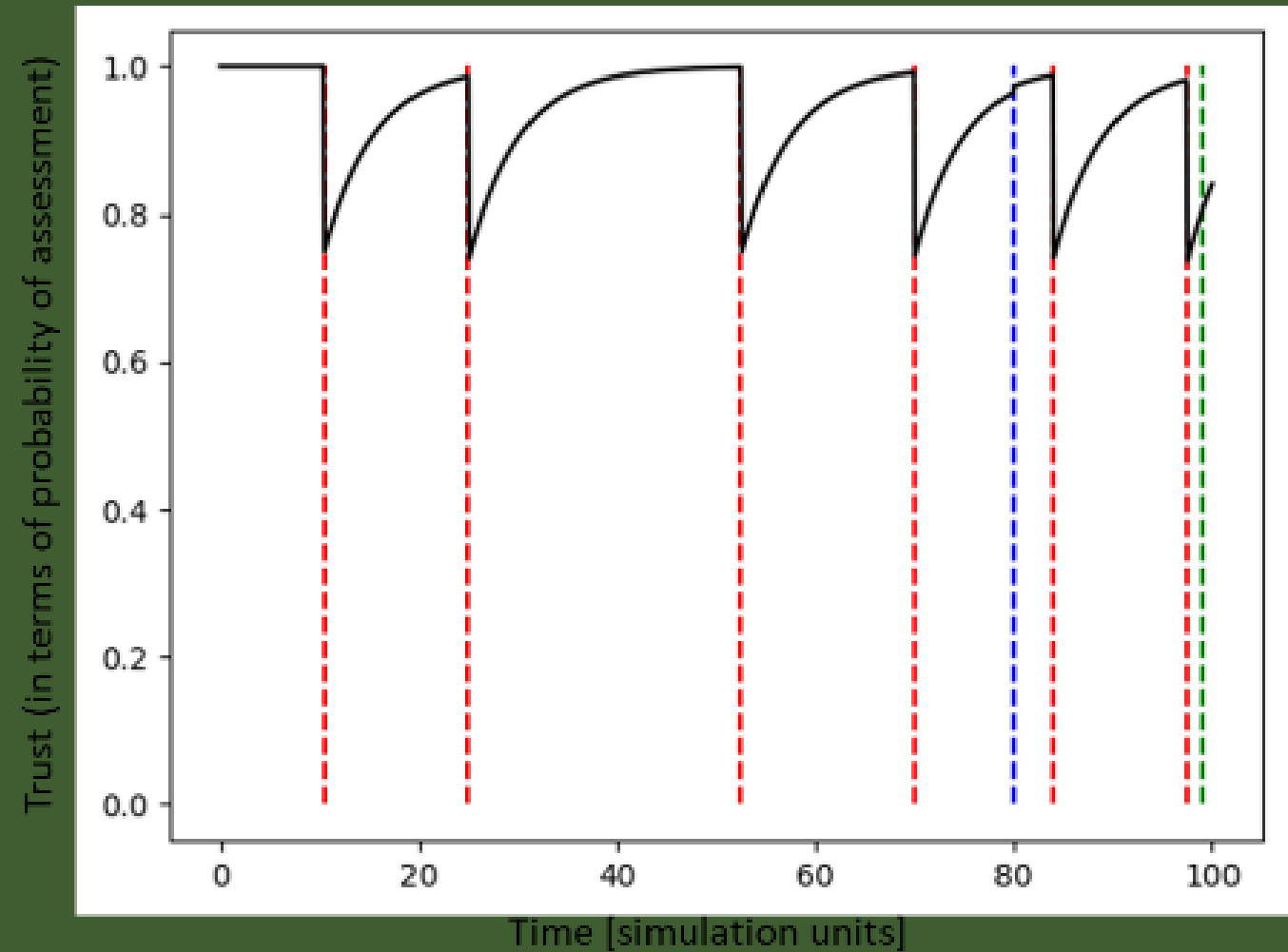
## Criticality





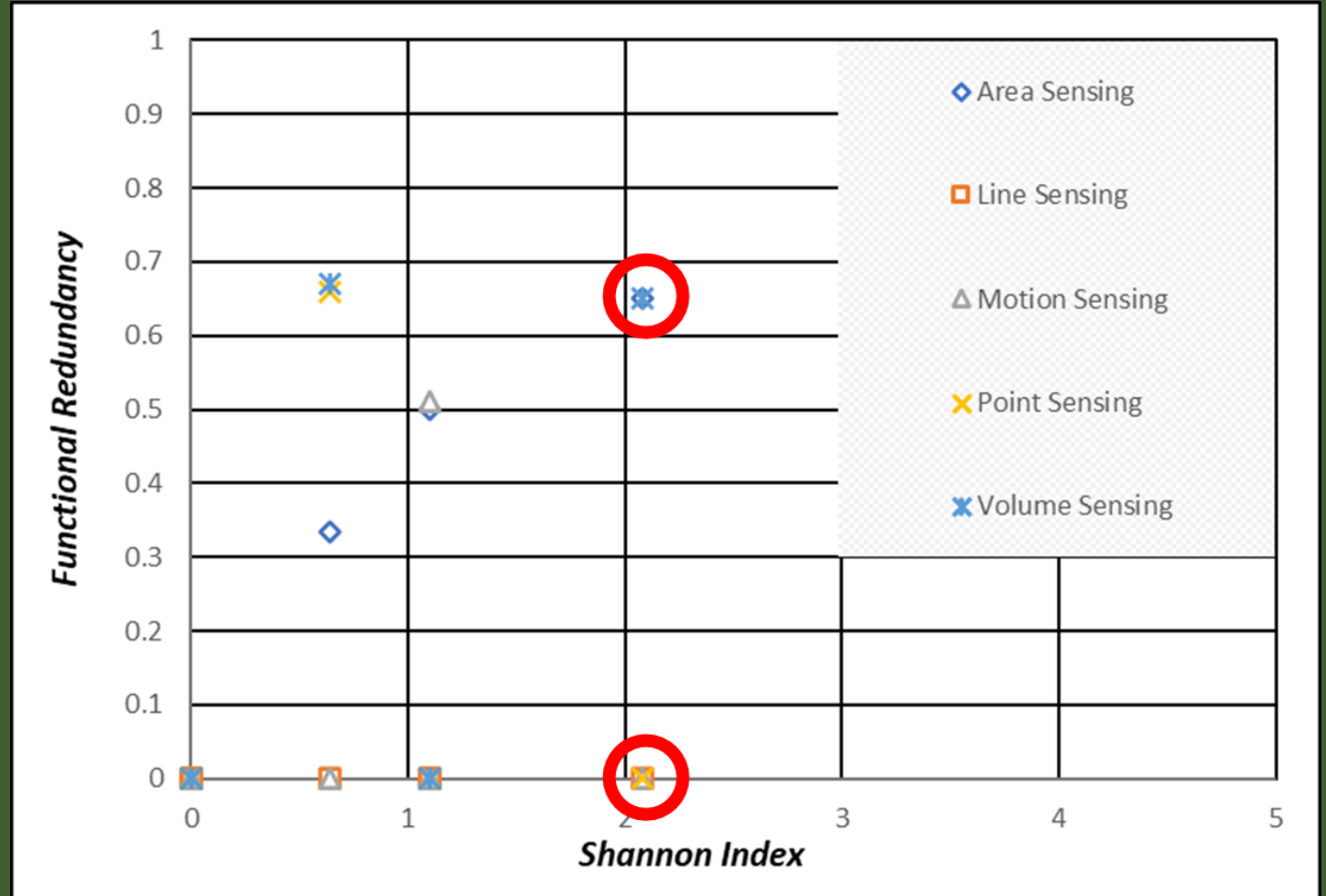
# Example Results

Confidence



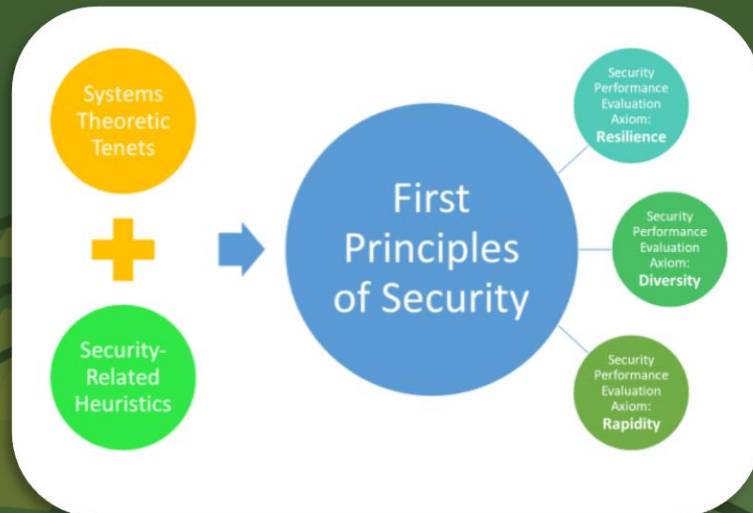
# Example Results

Diversity

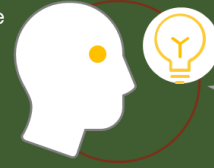


# Conclusions

Our proposed 1<sup>st</sup> principles and security performance axioms create an opportunity to shift from “just stopping the bad guys” to “measur[ing] the overall system stability and flexibility”

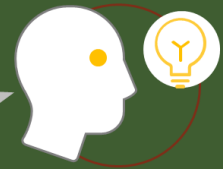


Human-machine interactions for security expert



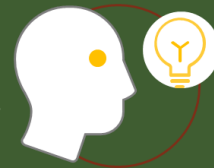
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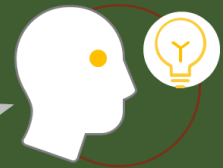
Evaluation of security assessments

Resilience frameworks and systems analysis expert



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Systems safety and security analysis expert



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