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Virtual Presence and Extended Defenses in a Physical Security System
ICCST
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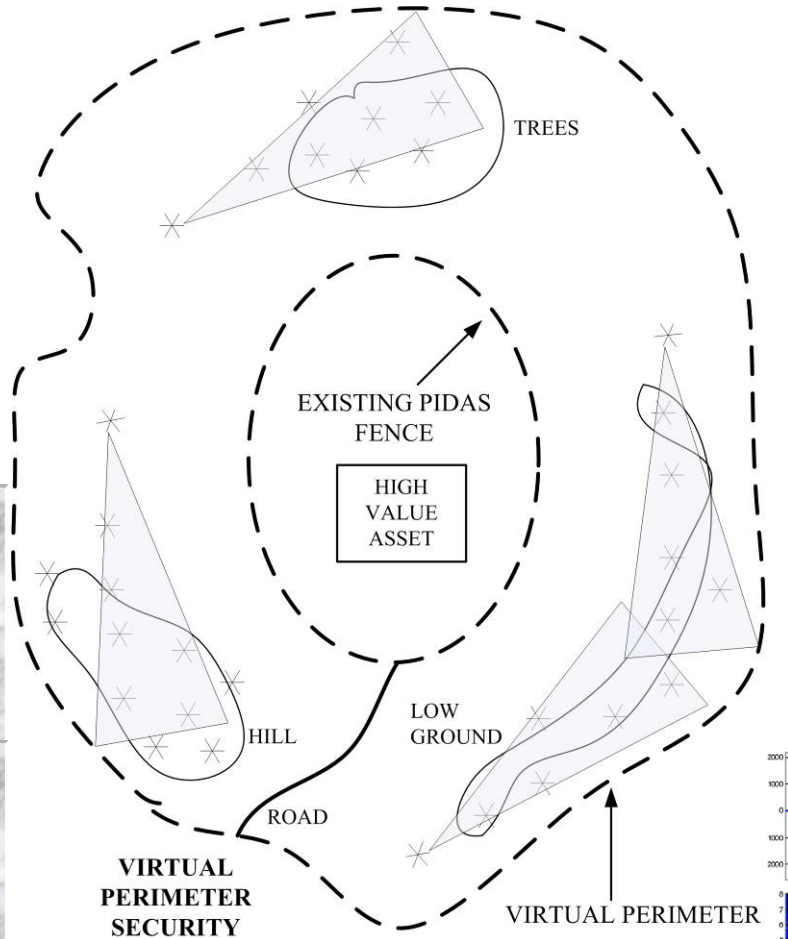
Presentation Overview

- Virtual Presence and Extended Defenses (VPED) System Overview
- VPED system components
- Wireless sensors (sensor nodes)
- Wireless video (cluster nodes)
- Multilevel sensor fusion
- Empirically based simulations
- Conclusion

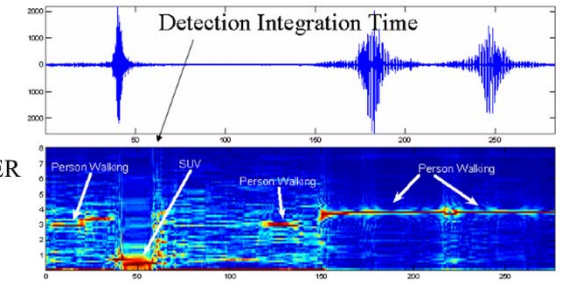
Extended Detection & Presence Beyond the Fence

A new approach to site security at High Consequence Facilities

Inside the Fence: PIDAS



Beyond the fence: SNL's VPS



Why is Extended Detection Important?

Detection **Delay** **Response**

$$p_{\substack{sensor \\ activation}} \times p_{\substack{sensor \\ process}} \times p_{\substack{sensor \\ comm}} \times p_{\substack{sensor \\ display}} = p_{sense}$$

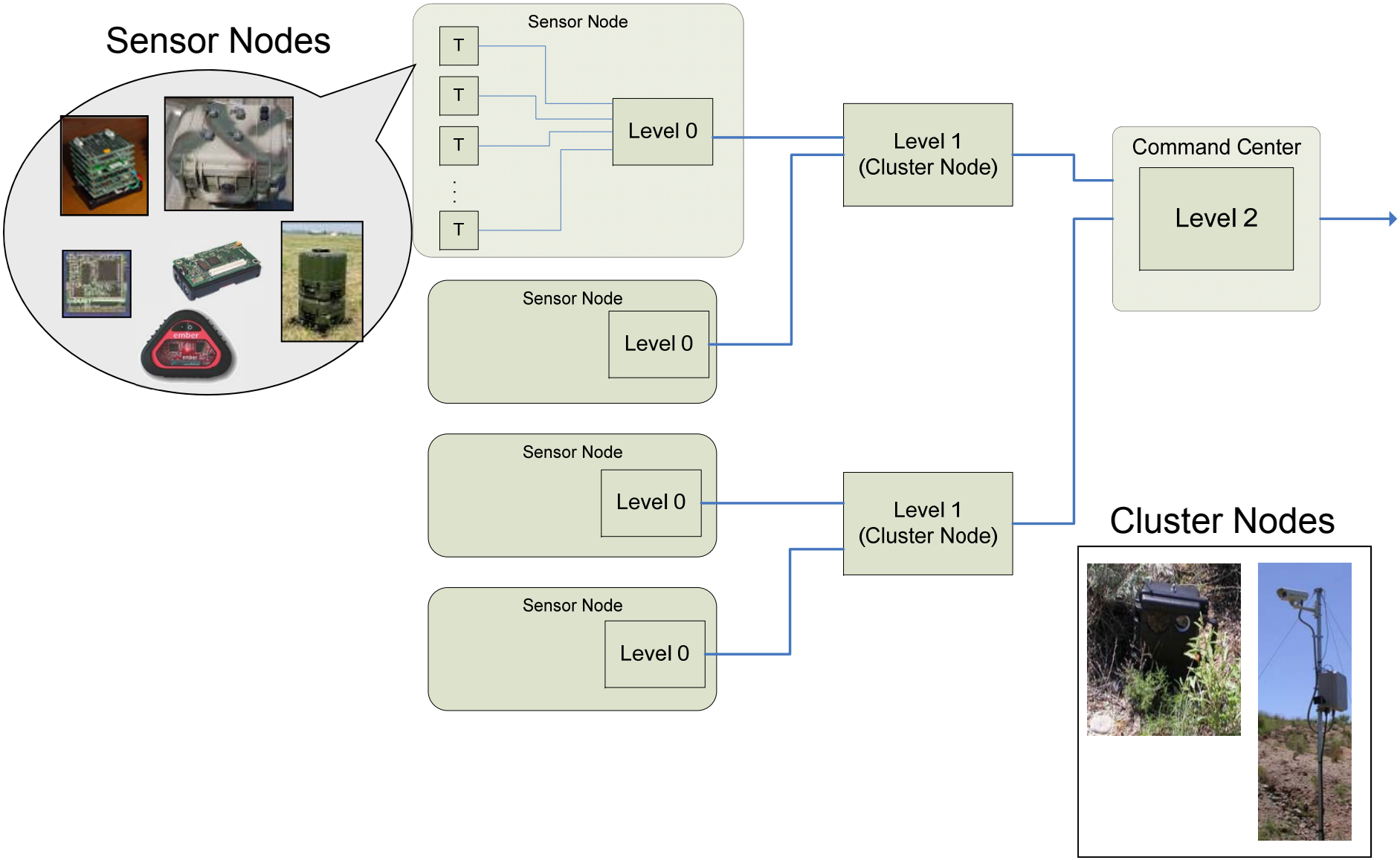
$$t_{\substack{sensor \\ activation}} + t_{\substack{sensor \\ process}} + t_{\substack{sensor \\ comm}} + t_{\substack{sensor \\ display}} = t_{sense}$$

$$p_{\substack{image \\ capture}} \times p_{\substack{image \\ process}} \times p_{\substack{image \\ comm}} \times p_{\substack{image \\ display}} = p_{\substack{assessment \\ imagery}}$$

$$t_{\substack{image \\ capture}} + t_{\substack{image \\ process}} + t_{\substack{image \\ comm}} + t_{\substack{image \\ display}} = t_{\substack{assessment \\ imagery}}$$

$$p_{\substack{correct \\ assessment}} \times p_{\substack{response \\ force}} = p_{interruption}$$

VPED Architecture



VPED-SNL Sensor Nodes

2005

- SNL fielded a combination of COTS & GOTS – from other programs
- Sensors nodes demonstrated advanced sensor algorithms & fieldability

2006/2007

- Facilitate time gated fusion
- Transducer / signal-level fusion (capable)
- Sensor node will have more features, be low-cost, have a long lasting power supply, and allow sensor transducers to be remotely tuned

Sensor Node (Now and Future) Capabilities

Now (or easy to do):

Seismic	Footstep, ATV, vehicle, rain, thunder, animals, helo, aircraft
Magnetic	Weapon, vehicle, ATV
Passive IR	Heat signature, low res. (point) or medium resolution (shapes)
Microwave	Motion
Acoustic	Vehicle, helo, aircraft, weapons fire, speech, listening, intercom
Disturbance	Tilt, tamper, fault
Clock	Sync'd to1 usec
Temp/pressure/humid	Environmental conditions
Remote actuation	Active delay/denial, flash/bang, relay-closure
PV-solar/battery	Use common batteries, lifetime limited by battery wear-out
Battery voltage, current	State-of-health
Strobe light	Repel animals, warn adversaries
Ultrasonic emitter	Repel animals
Loudspeaker	Repel animals, warn adversaries, use as half-duplex intercom
Short-range RF comm	100m in foliage, 50-100 kbits/sec, low power, secure
Day/night sensor	Can use PV array voltage
Ad-hoc routing	Data Source Routing protocol, self-discovery, self-healing

Future:

Ultra Wide Band	Future radar, secure communications
EMI/RFI	Radio emissions, engine emissions
Inhalation	Chemical detection, human scent, future option?
IR data port	No exposed terminals
Imaging	Snapshot, compression, transmission, live-optional/future

Cluster Node Hardware

2005

Wireless video / imaging / snapshot
Solar Powered and fielded for 12 months

Cluster Node Hardware

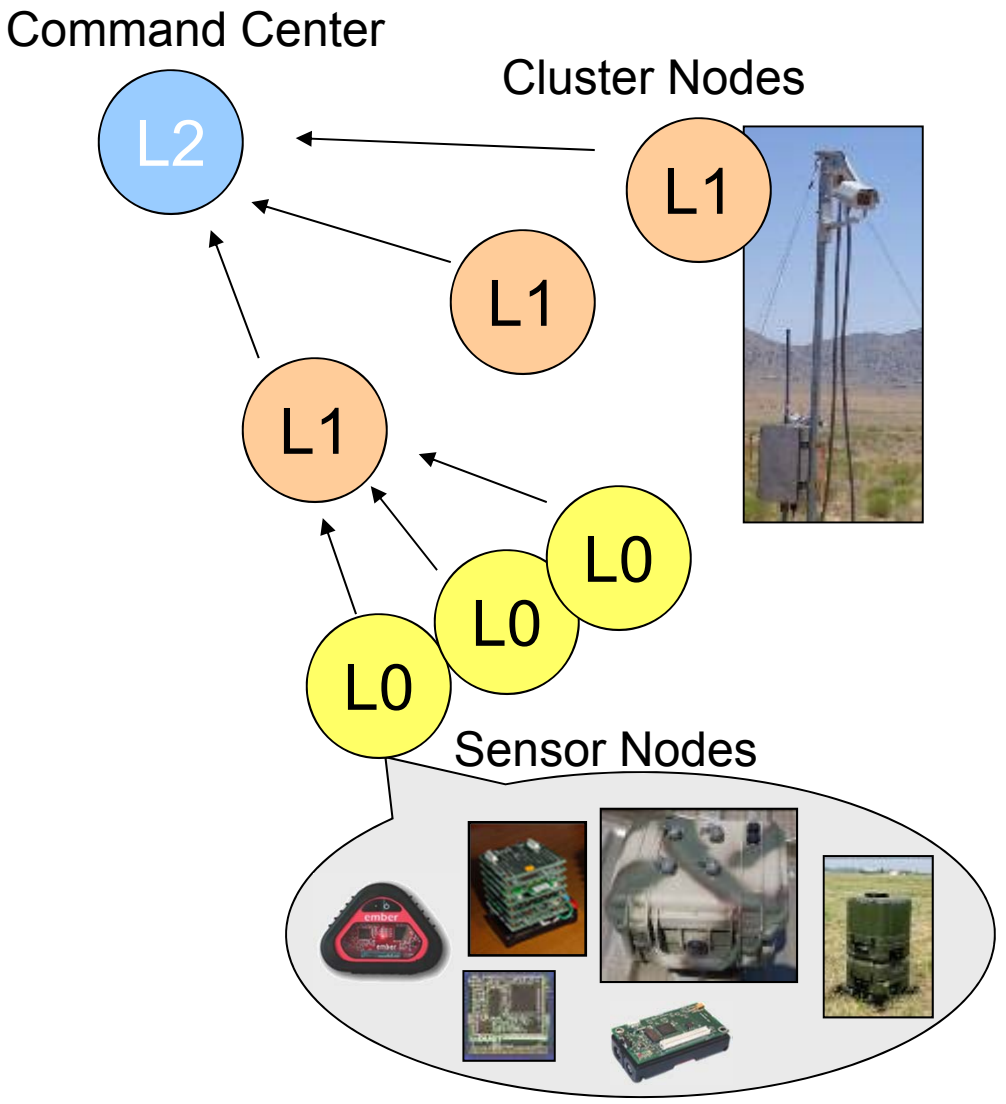
2006/2007

- Wireless Imager
- Three different packaging concepts
- Video Motion Detection
- Stand-off Illuminator
  - Sensor Node Control
- Sensor localization / beam forming (enabled)

Sample Cluster Node Images

VPS System Components and Sensor Fusion

- VPS architecture maps into the first three “standard” levels of sensor fusion
  - **Level 0 fusion:** Sensor Node
    - Transducer / signal-level fusion
    - Time-gating of triggers
  - **Level 1 fusion:** Cluster Node
    - Video / imaging / snapshot
    - Correlating sensor reports
    - Preliminary adversary tracking
    - Localization / beam forming
  - **Level 2 fusion:** Site-Wide
    - “Global” threat analysis
    - Adversary force prediction
    - Awareness of site operations
    - Decision support



Wireless - Basic Receive Power Equation

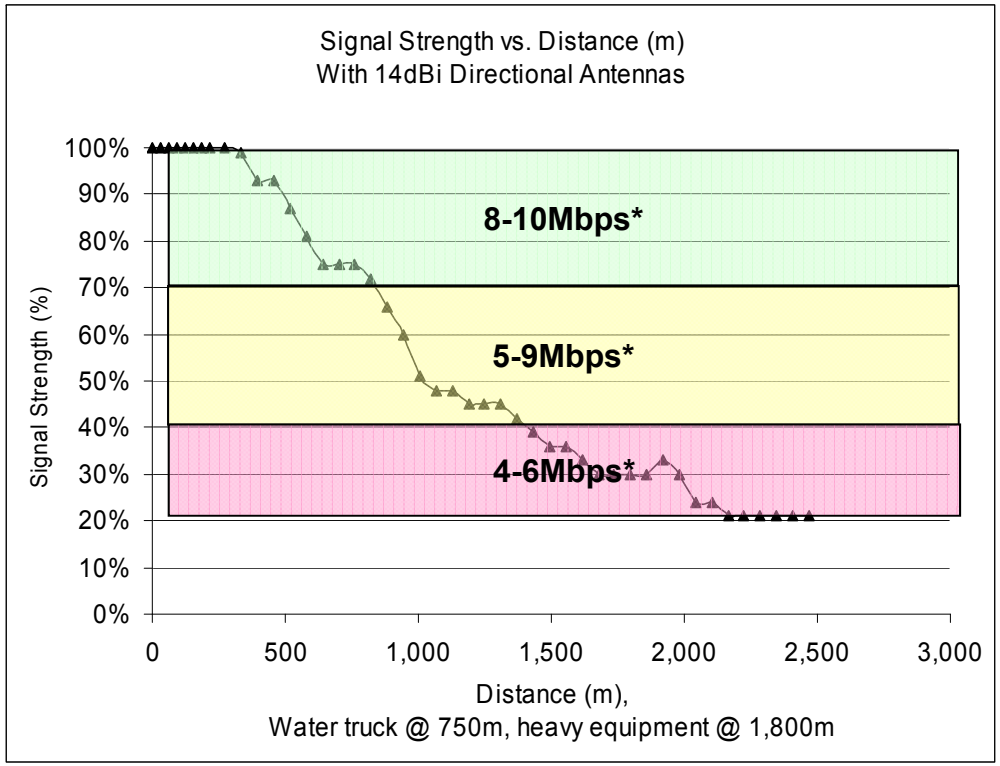
$$P_r = P_t(G_t)(G_r)\lambda^2/(16\pi^2 d^2)$$

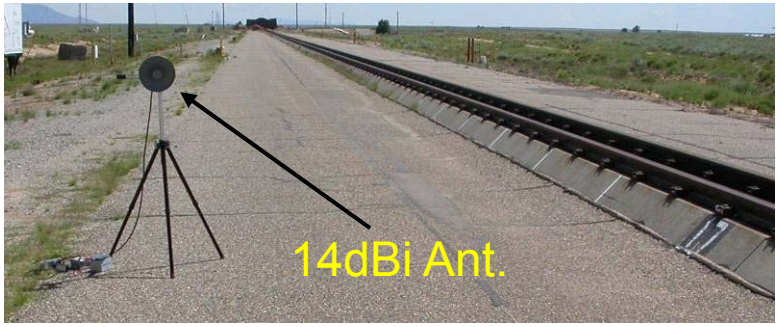
P_r is the received power, **P_t** is the transmitter output power, **G_t** is the gain of the transmitting antenna, **G_r** is the gain of the receiving antenna, **λ** is the wavelength in meters, and **d** is the range or distance.

Ways to increase distance:

1. Use a lower frequency
2. Increase transmitter power
3. Increase receiver sensitivity
4. Use directional antennas
5. Minimize obstructions

802.11g (2.4GHz) Radio Evaluation at Kirtland

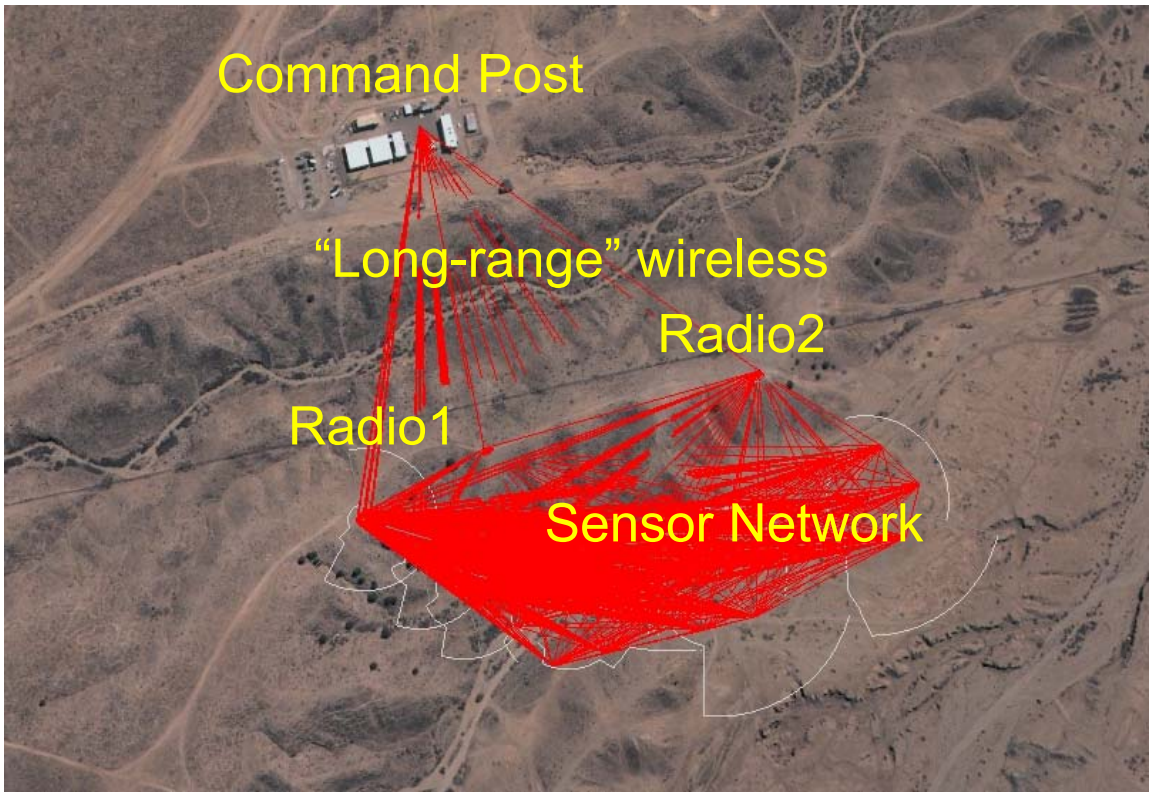




- Performance was satisfactory to 2,500m,1.55miles
- Notice the signal degradation at 750m and 1,800m
- Throughput with 256 bit Advanced Encryption Standard (AES)
- 100mW (-10dB) transmitter and 14dBi antenna

Sandia's Extended Detection Simulation Capabilities

- Simulate radar, seismic, video geographic coverage, and detection patterns
- Model network performance, however, site surveys typically still need to occur for all wireless deployments
- Solar power & other renewable energy modeling
- Model validate by industry and utilizes 30 years of historical NOAA weather data



VPED Summary

- Virtual Presence and Extended Defenses (VPED) System provides:
- Wireless sensors (sensor nodes)
- Multilevel sensor fusion
  - Reduce nuisance alarms and track adversaries
- Wireless video (cluster nodes)
- Sandia's empirically based simulation capabilities

Questions?

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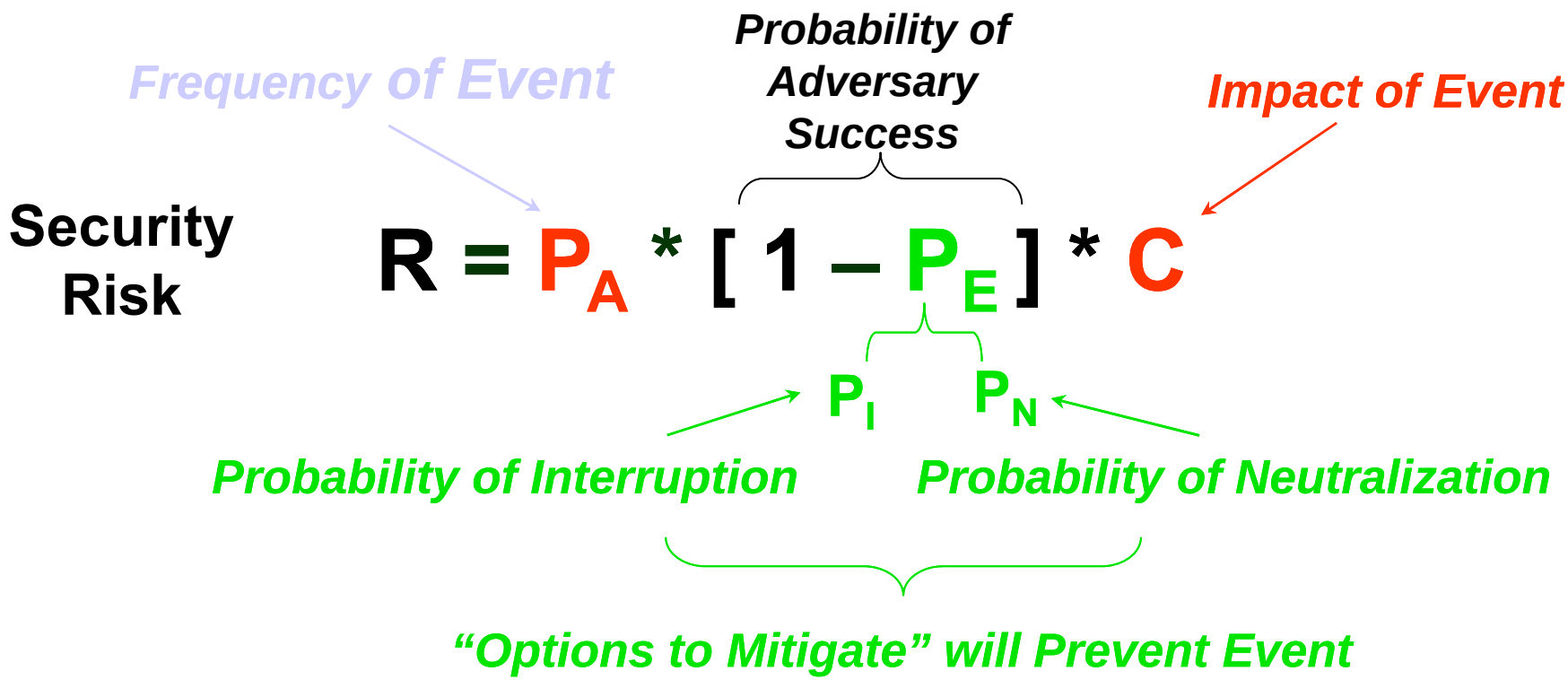
Backup slides



Assessed Detection

$$\left(p_{sensed} \times p_{imagery}\right) \times p_{\substack{correct \\ assessment}} = p_{\substack{assessed \\ detection}}$$