This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 608090.

HyRiM

Risk Management for APTs
A Water Utility Case Study

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Novel Approaches in Risk and Security Management for Critical Infrastructures

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Case study description

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- European water utility organisation
- Provide its services to more that a hundred municipalities in its region
- Responsible for planning, building and maintenance of the whole network -- focus on the water quality
- The management, storage and delivery of water is supported by an ICS

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Assume the threat of an APT

- Collect information using Open-source Intelligence (OSINT)
- Deploy spear phishing attacks to individuals
- Try to visit the facilities or contact external contractors for alternative entry points
- Review collected information for potential attacks

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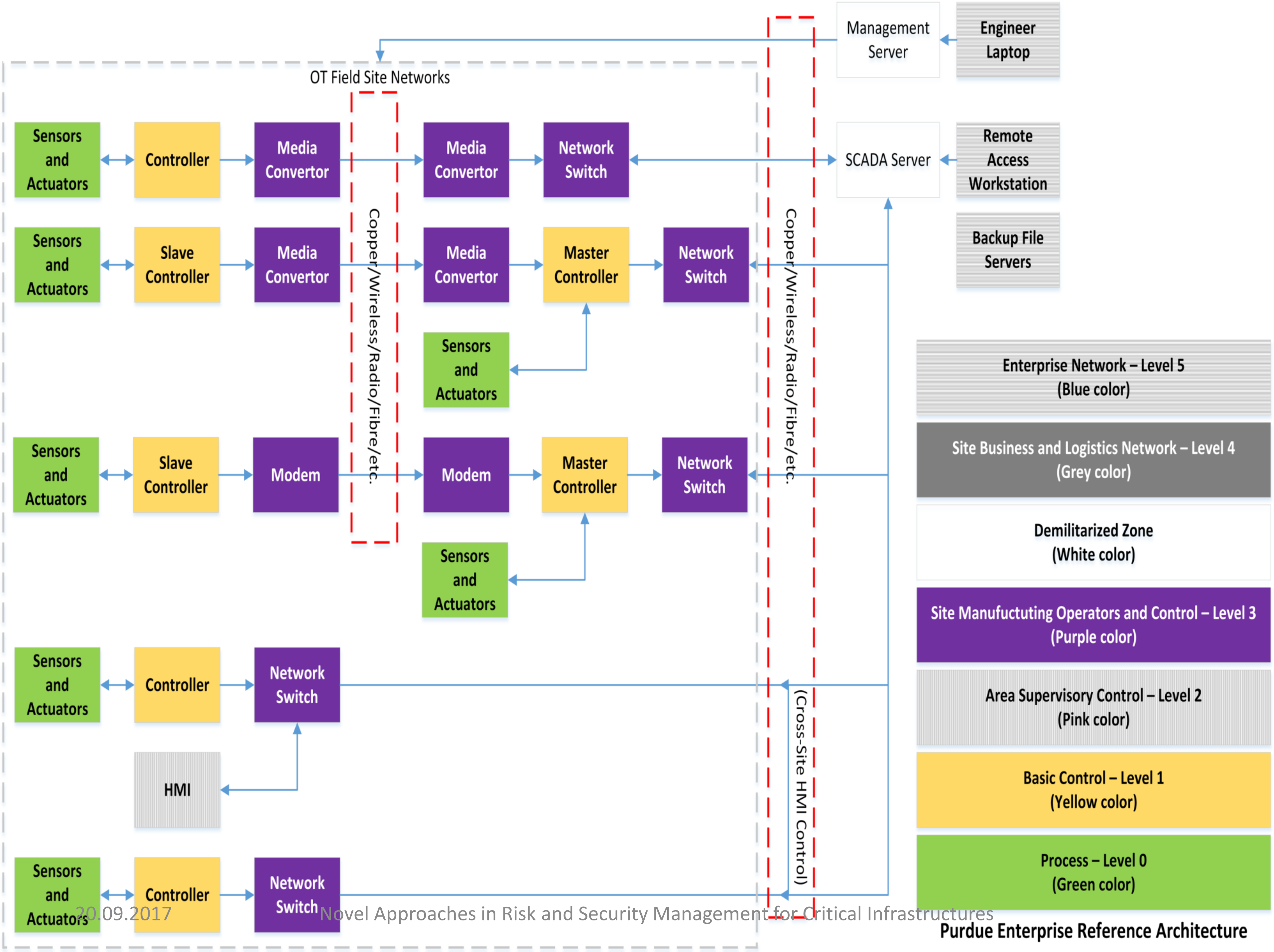
Establish the context

- Define objectives that should be achieved; understand internal/external factors that may influence the goals

- Main goals
  - Minimise the damage caused by an attack to the provided service
  - Minimise monetary damage caused by the attack (e.g. technical or legal nature)
  - Minimize reputation damage
- Multi-level analysis: Purdue enterprise reference architecture, social review analysis, business process analysis



Enterprise Network – Level 5
(Blue color)

Site Business and Logistics Network – Level 4
(Grey color)

Demilitarized Zone
(White color)

Site Manufucting Operators and Control – Level 3
(Purple color)

Area Supervisory Control – Level 2
(Pink color)

Basic Control – Level 1
(Yellow color)

Process – Level 0
(Green color)

Purdue Enterprise Reference Architecture

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Risk identification

- Understand a range of scenarios describing what could happen, how and why
- Threats on main assets
  - Radio jamming/data manipulation
  - Becoming a HMI/master
  - Backup servers
  - Target external resources
  - …
- Identify potential vulnerabilities

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Vulnerability identification*

- ClearSCADA server: CVE-2014-5411, CVE-2014-5412, CVE-2014-5413
- Network switches: CVE-2001-0895, CVE-2014-5412
- Controllers: Siemens SIMATIC S7-300 , S7-1200, ET 200S PLC, …
- Management server: SIMATIC STEP 7, Connecter Components Workbench, TIA Portal, ...

* Vulnerabilities as identified in Lancaster's emulated ICS testbed

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Risk analysis

- Develop an understanding of each risk, its consequence and the likelihood of these consequences

- Investigate the likelihood of events
  - Vulnerability assessment (CVSS)
    - Exploitability metric

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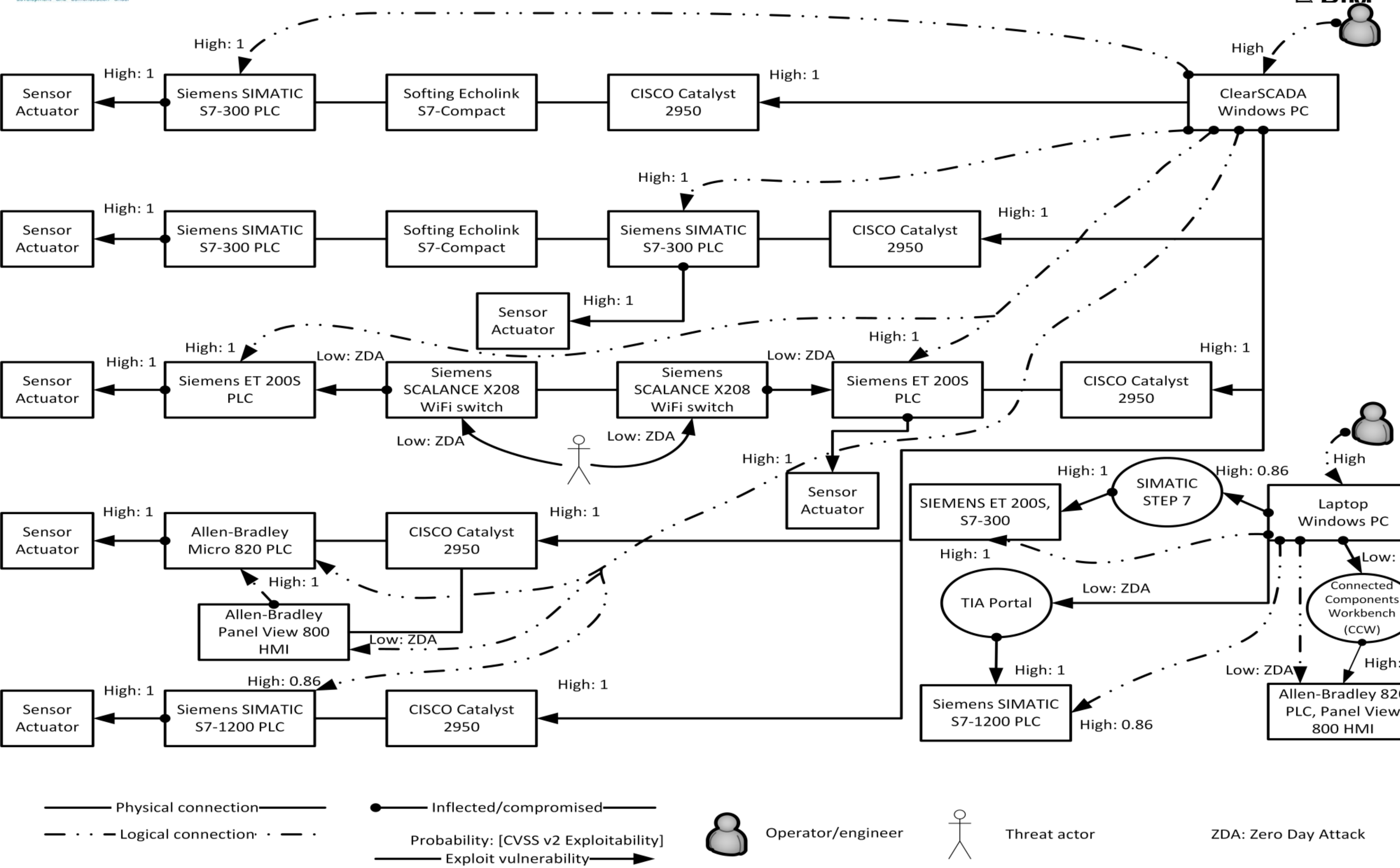
Estimation of likelihood via CVSS



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Risk treatment

- Identify optimal set of controls to reduce the maximum damage that can be caused by an attacker to a minimum

- Define attack strategies/vector – 4 main categories
  - Operator -> ClearSCADA/Windows PC -> Cisco Catalyst
  - Operator -> ClearSCADA/Windows PC -> Siemens SIMATIC S7-300 PLC -> Sensor/Actuator
  - Engineer/contractor -> Laptop/Windows PC -> SIMATIC STEP 7 -> SIEMENS ET 200S PLC -> Sensor/Actuator
  - Threat actor -> Siemens SCALANCE X208 -> Siemens SIMATIC ET 200S PLC -> Sensor/Actuator

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Defence strategies and frequency

- **Do not change anything**
- **Training**: Annually, per 2 years, new personnel
- **Password change**: Annually, when device is changed, when people are changed
- **Update**: automatic, annually, major updates
- **Patch/replace**: upon failure to operate, annually, major vulnerabilities
- **Manual checking of water**: Daily, weekly, monthly

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Damage estimation

- Collect experts opinion for each scenario defined of a defence strategy and an attack strategy

- Damage is assessed by experts on a 5-tier scale
  - Very low, low, medium, high, very high

- 4 experts were asked to estimate the damage for each of the goals

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Game-theoretic optimisation

- Set up a game to find the optimal defence strategy and worst-case damage
- Computation of equilibrium (`R` package `HyRiM`)

	Train annually	Train new personnel	Apply major updates	Patch devices upon failure	Patch major vulnerabilities
Frequency	2.8%	0.1%	88.3%	0.2%	8.6%

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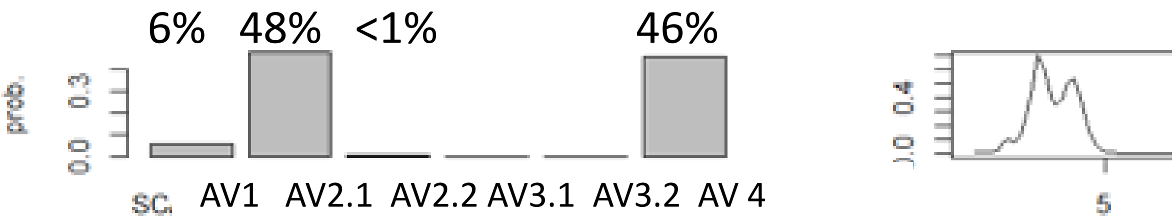
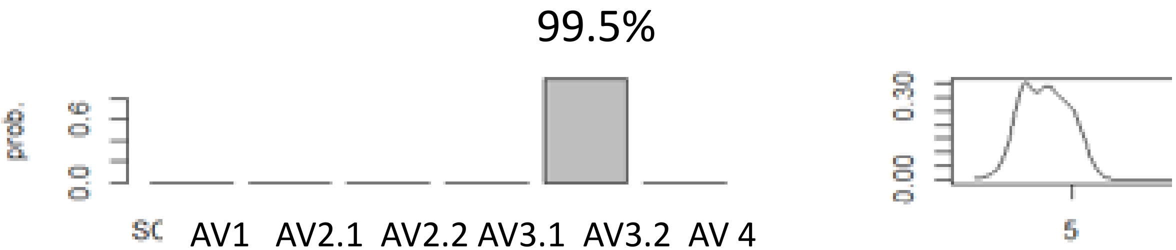
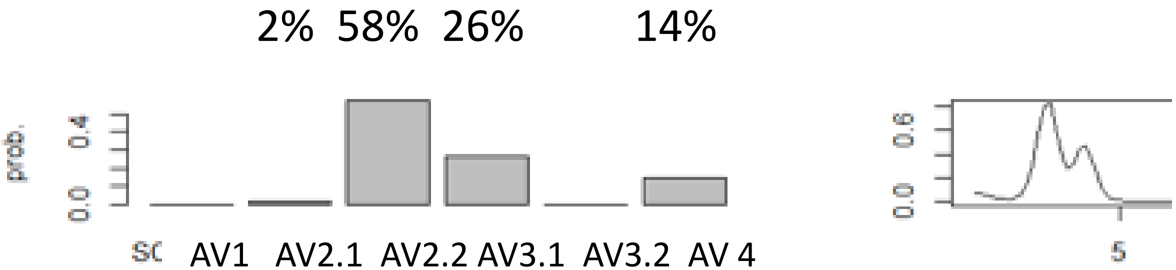
Worst case damage



worst case for goal 'Service'



worst case for goal 'Cost'



worst case for goal 'Reputation'

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Concluding remarks

- The HyRiM process resulted in defining an optimal protection strategy in the treat of an APT
  - Improve security posture of the organisation
- Based on the collected data
  - Many defence strategies do not contribute in reducing the damage (only 5 out of 16 does)
- The frequency of the selected 5 strategies was determined and worst-case damage has been estimated per goal

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Thank you!