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SPARKS
SMART GRID PROTECTION AGAINST CYBER ATTACKS

Risk Assessment for Cyber-Physical Smart Grid Systems

The SPARKS project approach

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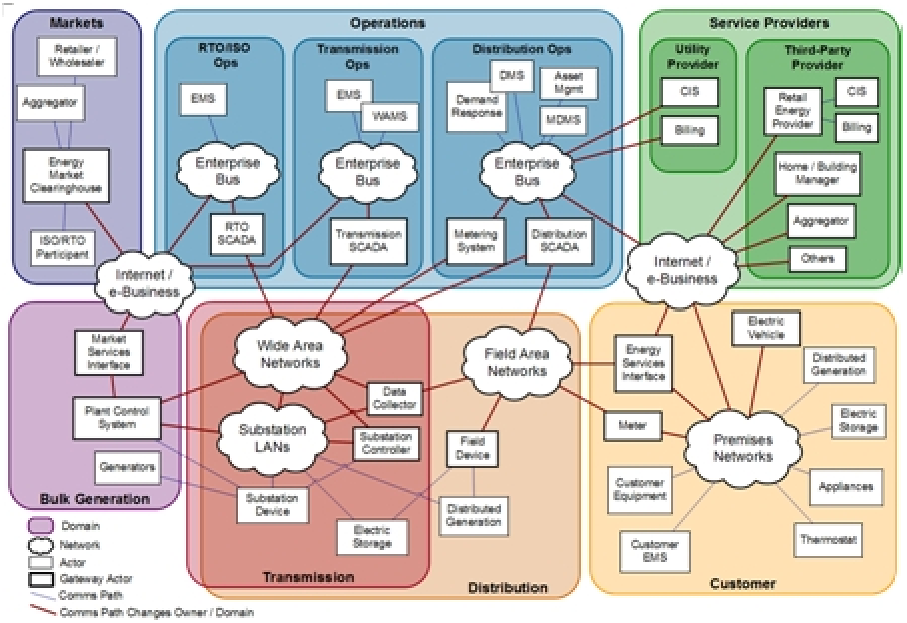
EU FP7 Programme Contract No. 608224

Risk assessment for the smart grid

sparks
SMART GRID PROTECTION AGAINST CYBER ATTACKS

- The smart grid is a networked cyber-physical system
  - heterogeneous (technology, ownership, functionality)
  - complex dependencies (data network, grid, administrative)
- An adequate risk assessment considers
  - multi-stage attacks → SPARKS demo
  - combined attacks → Ukraine 2015



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The SPARKS risk assessment approach

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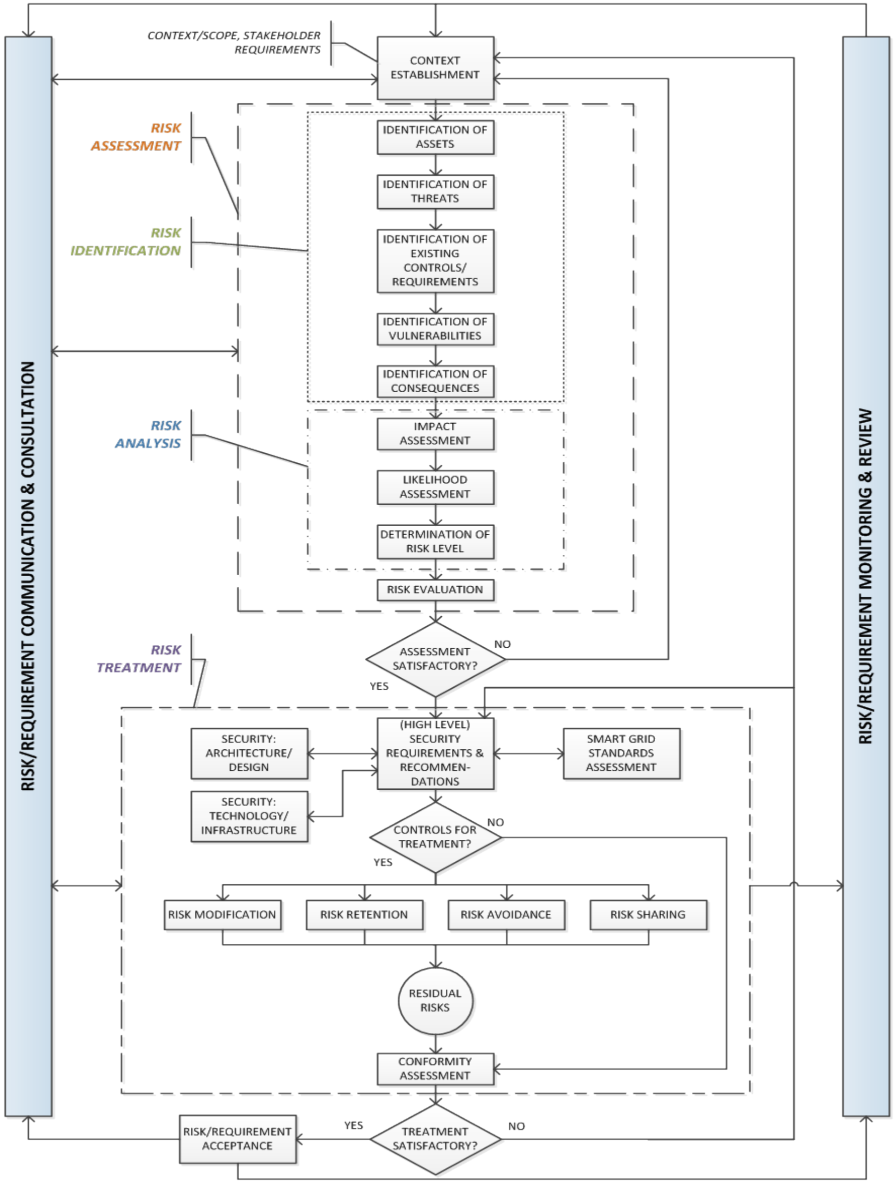
SMART GRID PROTECTION AGAINST CYBER ATTACKS

- ISO 27005 framework
  - asset driven approach
- we populate various steps with smart grid specific implementations
- partially from existing methods where useful
  - SGIS Toolbox
  - HMG IS1
- own methods
- supporting tools



RISK/REQUIREMENT COMMUNICATION & CONSULTATION

CONTEXT/SCOPE, STAKEHOLDER REQUIREMENTS

CONTEXT ESTABLISHMENT

RISK ASSESSMENT

IDENTIFICATION OF ASSETS

IDENTIFICATION OF THREATS

RISK IDENTIFICATION

IDENTIFICATION OF EXISTING CONTROLS/ REQUIREMENTS

IDENTIFICATION OF VULNERABILITIES

IDENTIFICATION OF CONSEQUENCES

RISK ANALYSIS

IMPACT ASSESSMENT

LIKELIHOOD ASSESSMENT

DETERMINATION OF RISK LEVEL

RISK EVALUATION

RISK TREATMENT

ASSESSMENT SATISFACTORY?

NO

YES

SECURITY: ARCHITECTURE/ DESIGN

(HIGH LEVEL) SECURITY REQUIREMENTS & RECOMMEN-DATIONS

SMART GRID STANDARDS ASSESSMENT

SECURITY: TECHNOLOGY/ INFRASTRUCTURE

CONTROLS FOR TREATMENT?

NO

YES

RISK MODIFICATION

RISK RETENTION

RISK AVOIDANCE

RISK SHARING

RESIDUAL RISKS

CONFORMITY ASSESSMENT

RISK/REQUIREMENT ACCEPTANCE

YES

TREATMENT SATISFACTORY?

NO

RISK/REQUIREMENT MONITORING & REVIEW

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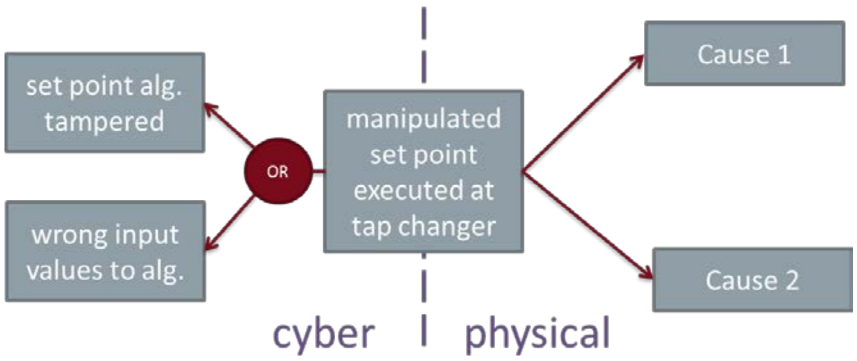
Identifying assets and security objectives

SPARKS
SMART GRID PROTECTION AGAINST CYBER ATTACKS

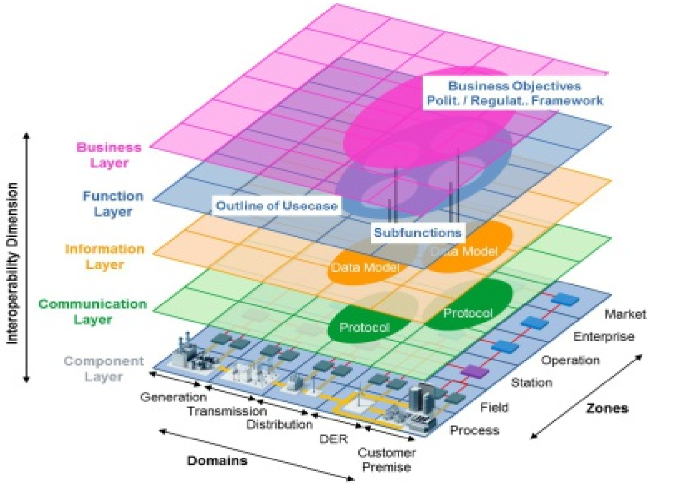
- In the smart grid the most important assets are located at the edge between “cyber” and “physical”
  - integrity has direct impact on grid stability
  - standard IT: confidentiality is more in the focus
- Start analysis with focus on these primary assets
  - security analysis (“likelihood”)
  - consequence and impact analysis
- Reduces the number of assets for the analysis
- Secondary assets are implicitly identified by the threat analysis

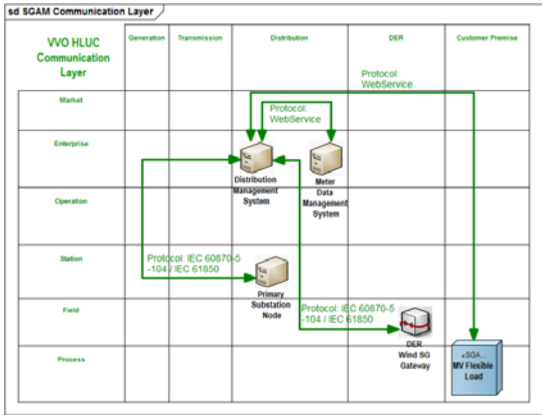

set point alg. tampered
wrong input values to alg.
OR
manipulated set point executed at tap changer
Cause 1
Cause 2
cyber
physical

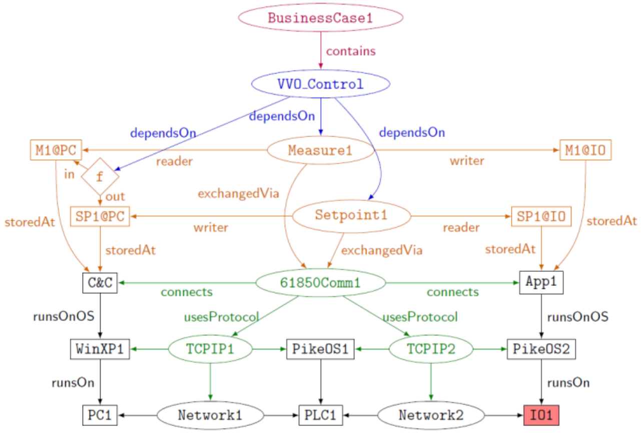
Model-based approach for asset identification and threat analysis

SMART GRID PROTECTION AGAINST CYBER ATTACKS

- Description in the Smart Grid Architecture Model (SGAM)
- Precise language (Ontology representation of SGAM elements)
- Tool:
  - Plug-in for Enterprise Architect
  - Export to RDF







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Handling the complexity of threat analysis

- Complex attack vectors
  - multi-stage attacks
  - combined attacks
- Many assessment methods look on individual assets only
  - neglects these interdependencies
  - are not able to capture countermeasures such as isolation or zoning
- Attack trees
  - allow representation of these scenarios
  - become quickly intractable with growing system size
- SPARKS: Tool-based approach
  - use machine-based reasoning to identify attack vectors
  - implicit representation
  - uses ontology-based description
  - reusability
  - combination with vulnerability databases, threat catalogues

Impact categories

SMART GRID PROTECTION AGAINST CYBER ATTACKS

Category	PM	P	ICTP	ESCO	TSO	DSO
Economic		●		●	●	●
Safety	●					●
Quality of Supply				●	●	●
Infrastructures	●					
Regulatory	●		●	●	●	●
Reputational		●	●	●	●	●
Data Protection and Privacy		●	●	●	●	●
Equipment		●	●		●	●
Population	●					

Impact is stakeholder-dependent!

policy makers (PM), producers (P), ICT equipment producers (ICTP), energy service companies (ESCO), transmission system operators (TSO), distribution system operators (DSO)

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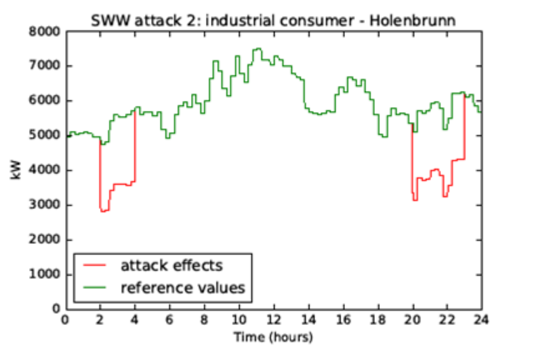
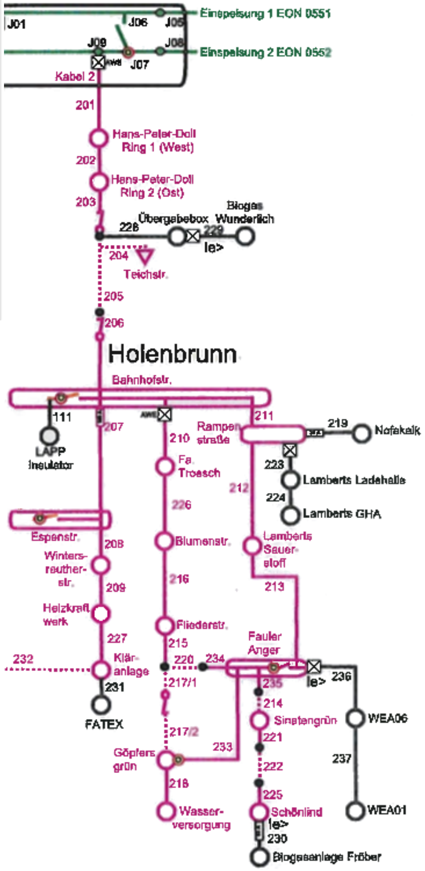
Impact analysis

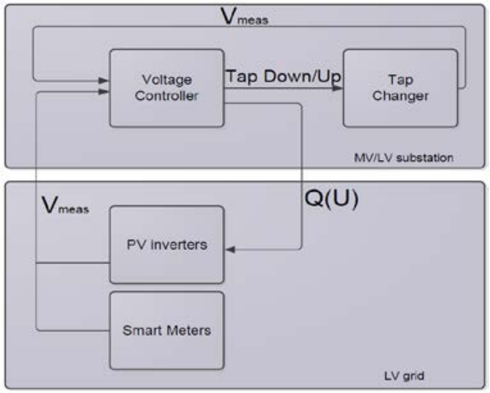
- Expert Analysis
- Safety and Security Analysis
  - Event tree analysis
  - FMVEA
  - System theoretic process analysis (STPA)
  - Bayesian networks.
- System analysis
  - mathematical (differential) equations to model the electrical system
  - looks for analytical solutions to these equations
- Simulation
  - allows solutions for systems that are too complex for an analytical solution
  - allows combination with data network simulation (co-simulation)
  - allows including real hardware in the simulation (hardware-in-the-loop).

SPARKS Impact Analysis

- Co-simulation environment for MV grid
  - SWW Holenbrunn area
  - attack: price manipulation scenario
- System theoretic impact analysis on LV grid
- Simulation of LV grid
  - simulation with hardware in the loop
  - voltage control use-case
- Customized impact tables

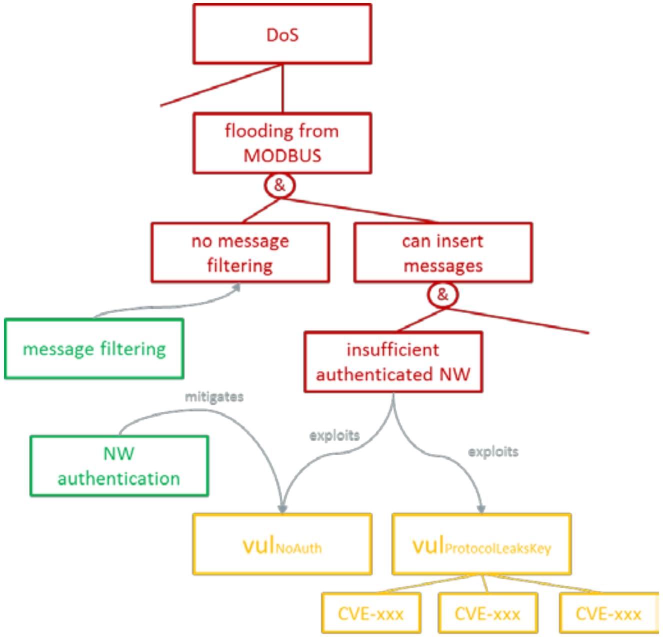






Risk treatment

- Problem with existing risk assessment methods: missing link between technical risk analysis and mitigation measures
  - often measures are based on risk level only
  - connection to actual threats gets lost
- Semantic threat graphs
  - offer possibility to deduce tailored countermeasures by machine-based reasoning
  - combination of attack graphs and semantic threat graphs
  - input from best-practice catalogues



Summary

- SPARKS risk assessment
  - ISO 27005 framework
  - context establishment using SGAM modelling
  - security analysis with machine-based reasoning
  - impact analysis: simulation, analytical
  - deduction of countermeasures with semantic threat graphs
- Exercised the method on the SPARKS demonstration sites
  - Stadtwerke Wundsiedel
  - NIMBUS Microgrid

Thank you for your attention!

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