LarGo! – Large-Scale Smart Grid Application Roll-Out
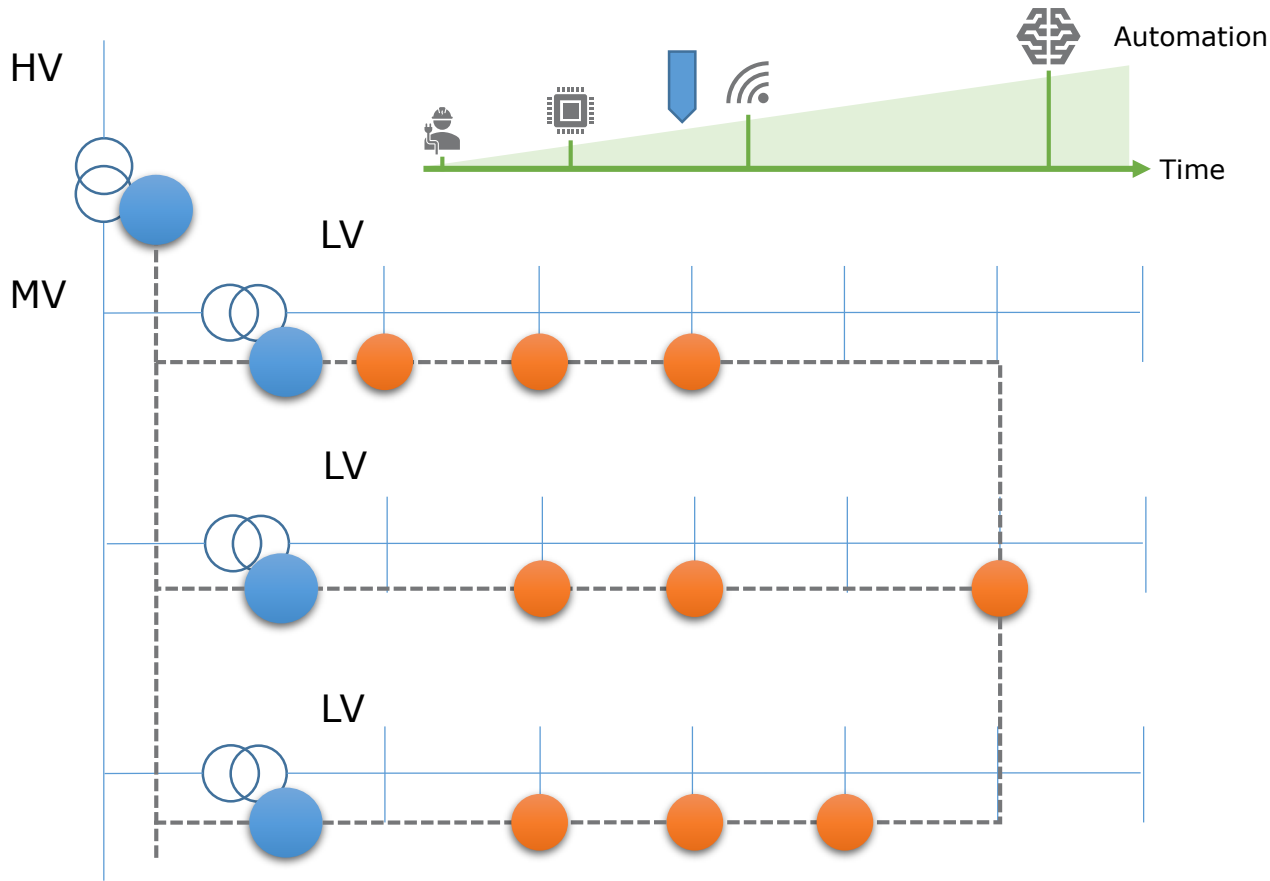
Overview and Main Results

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HV

MV

LV

LV

LV

Automation

Time

LarGo!

● Substation Controller

● Building Energy Management System

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Future Challenges
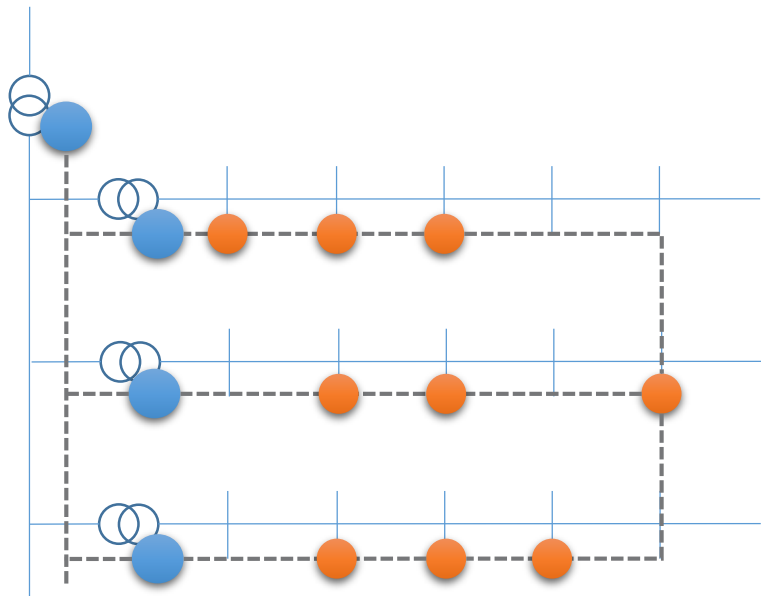
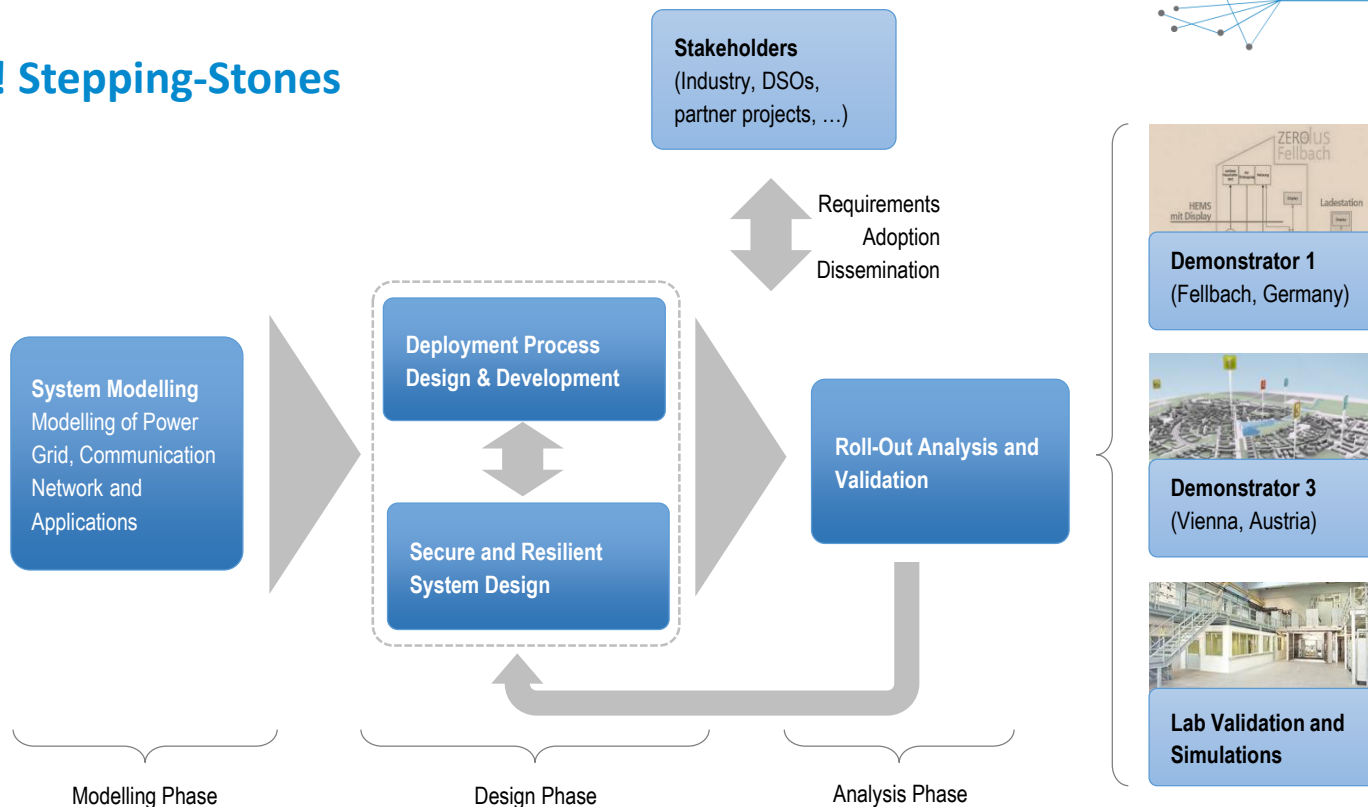- Power system and ICT dependent
  - Mutual effects
- Commonly used ICT with
  - Smart Grid runtime operation
  - Smart Grid application maintenance
- Software deployment/updates
  - High software complexity
- Software has bugs
  - ➔ Effects on the power system?
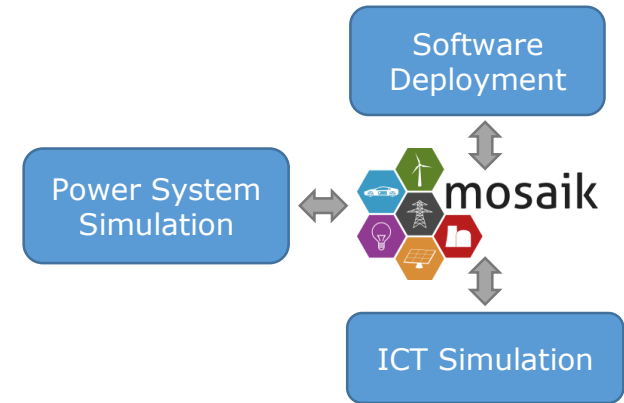
Objectives & Goals

- Prepare **mass rollout of Smart Grid software applications**
  - Facilitate energy-related deployment services for Building Energy Management Systems
    - Energy management, aggregation, flexibility
  - Support integration of renewables
    - Monitoring & control, efficiency, increase of hosting capacity

- Analyse technical side-effects of rollouts on ICT and power system infrastructure
  - **Large-scale and highly accurate system emulation**
  - Employment of Controller- & Power-Hardware-in-the-Loop (C/P-HIL) methods

- Design of secure infrastructure & **robust applications** for fail-safe and resilient system operation
  - Analysis and improvement of existing Smart Grid software applications

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LarGo! Stepping-Stones

Stakeholders
(Industry, DSOs,
partner projects, …)

Requirements
Adoption
Dissemination

System Modelling
Modelling of Power
Grid, Communication
Network and
Applications

Deployment Process
Design & Development

Secure and Resilient
System Design

Roll-Out Analysis and
Validation

Demonstrator 1
(Fellbach, Germany)

Demonstrator 3
(Vienna, Austria)

Lab Validation and
Simulations

Modelling Phase

Design Phase
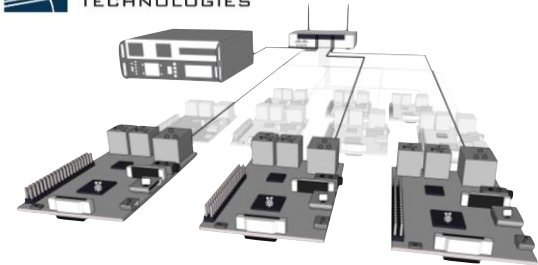
Analysis Phase

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System Modelling

- Large-scale and highly accurate grid and ICT system emulation
  - Influence on ICT and power system infrastructure

- Employment of real-time and Controller-Hardware-in-the-Loop (C-HIL) methods
  - Realistic emulation of field situation
  - Application deployment process

Secure and Resilient System Design

- Risk analysis
  - Use-cases and misuse-cases
  - Safety and security co-analysis process: System Theoretic Process Analysis (STPA)
- Development of safe and secure system design methods
  - Simulations and proofs
- Rollout scheduling
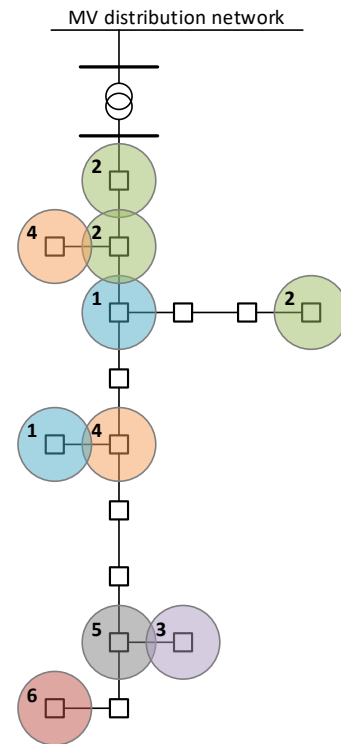 - Minimum-time software rollout subject to cyber-physical constraints

Scheduling Problem [PSCC'20]

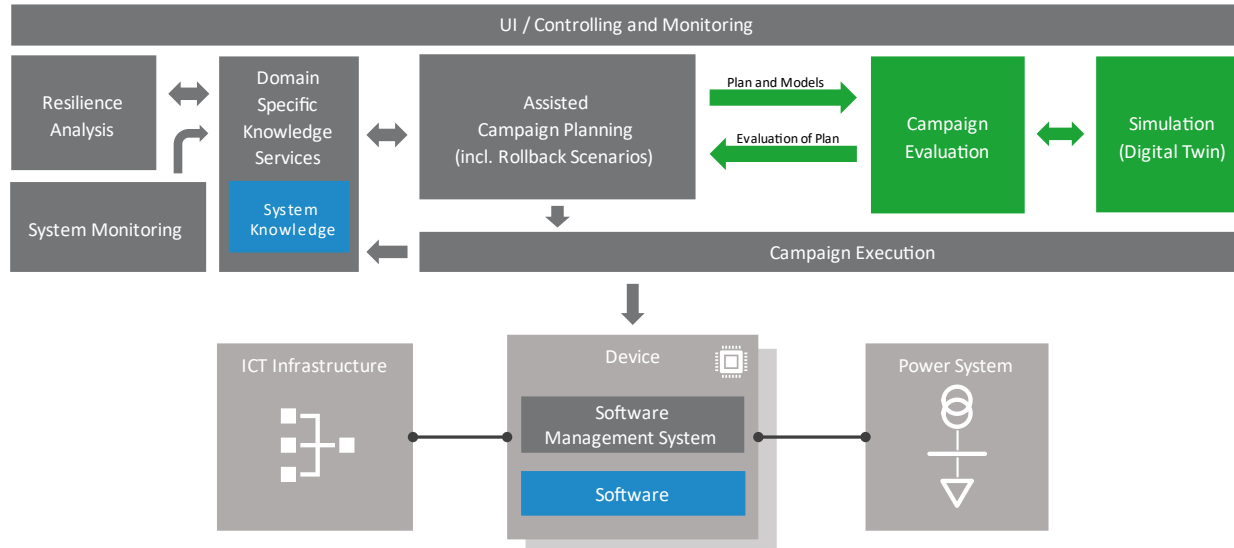(Multi-resource Bin Packing/Integer Linear Program)

$$\text{minimize} \quad T \qquad \textbf{(total number slots)}$$

$$\text{subject to} \quad \mathcal{J}_1, \mathcal{J}_2, \ldots, \mathcal{J}_T \text{ partition } \{1, 2, \ldots, N\} \qquad \textbf{(slot assignment)}$$

$$\sum_{j \in \mathcal{J}_k} H_{ij} \leq 1, \quad \forall i, \ \forall k \in \{1, 2, \ldots, T\} \qquad \textbf{(safety)}$$

MV distribution network

Unified Deployment Process

- Seamless, safe and secure deployment process for Smart Grid applications
 - What to deploy and when? How to handle exceptions?

Roll-Out Analysis and Validation

- Large-scale application analysis
  - Analysis of utility-scale scenarios
- Lab-based roll-out and integration tests
  - Real-time validations of power system, ICT, and deployment process
  - Realistic emulations of field situation
- Test-bed roll-out analysis
  - Customer Service Deployment @ Fellbach Demonstration Site
 - Smart Grid Gateway Rollout @ Smart City Aspern

Lab-based roll-out and integration tests

1. Update of the droop control parameters for PV controllers in BEMS
2. New controllers cause instabilities in the grid (overvoltage, voltage oscillations)
3. Voltage anomalies are being detected on all BEMS
4. Evidential network reports that system is in erroneous state
5. Rollback is being issued
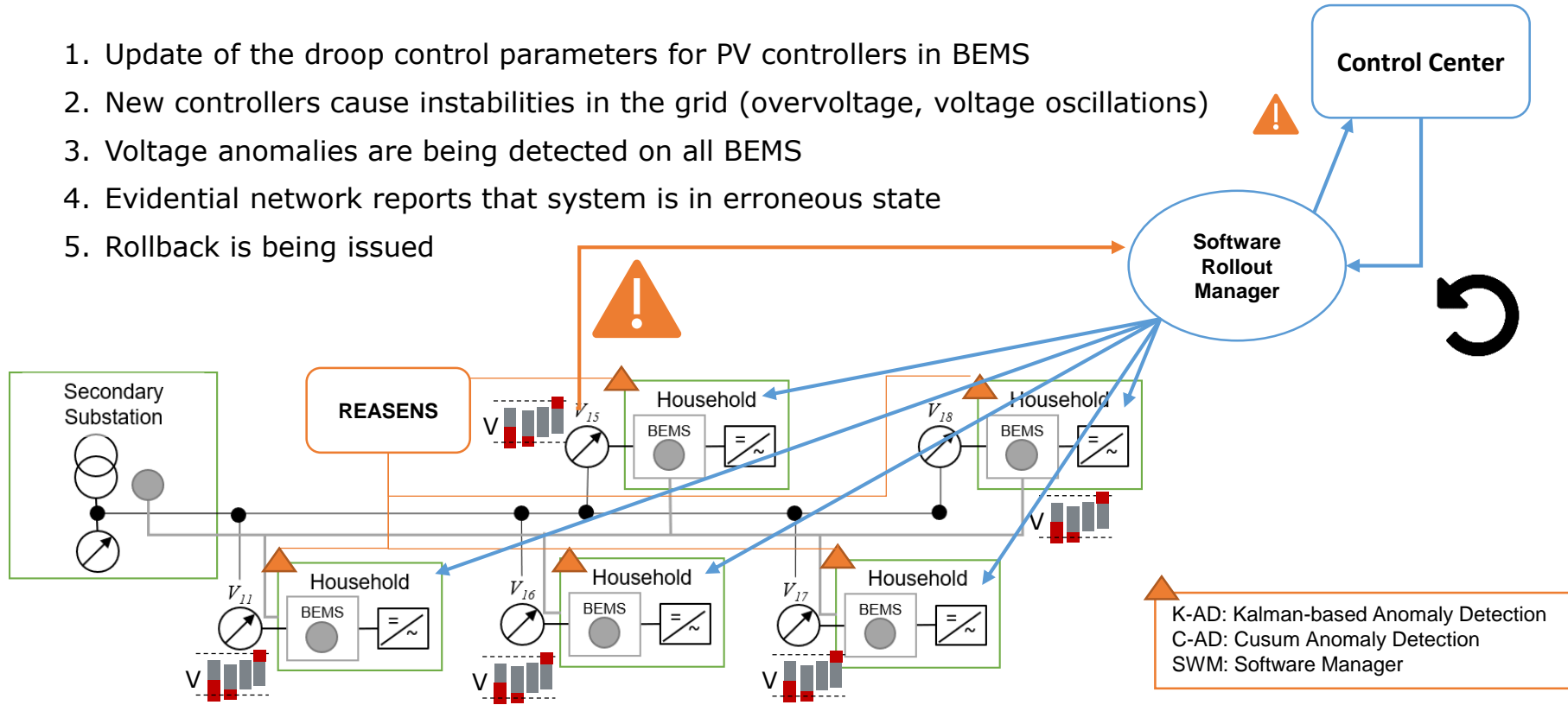
Conclusions and Outlook

- **LarGo!** shows how poorly managed ICT and software rollouts can lead to critical power system failures

- **LarGo!** enables the mass rollout of smart grid applications by defining a seamless, safe and secure application deployment process

- **The output of LarGo!** will have a strong impact on the efficiency of smart grid rollouts and the adoption potential of new smart grid solutions
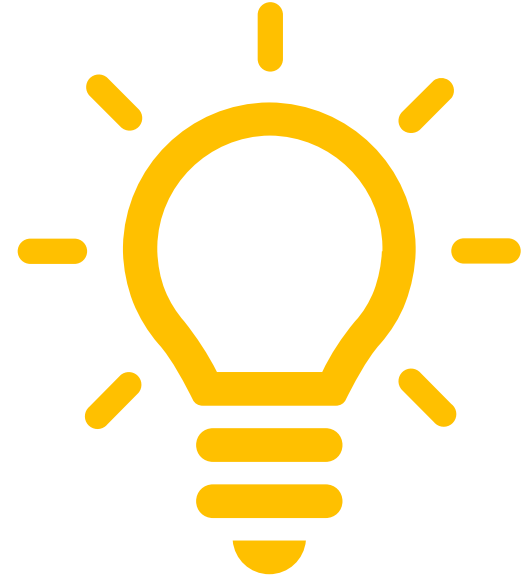
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ERA-Net Smart Grids Plus is an initiative of 21 European countries and regions. The vision for Smart Grids in Europe is to create an electric power system that integrates renewable energies and enables flexible consumer and production technologies. This can help to shape an electricity grid with a high security of supply, coupled with low greenhouse gas emissions, at an affordable price. Our aim is to support the development of the technologies, market designs and customer adoptions that are necessary to reach this goal. The initiative is providing a hub for the collaboration of European member-states. It supports the coordination of funding partners, enabling joint funding of RDD projects. Beyond that ERA-Net SG+ builds up a knowledge community, involving key demo projects and experts from all over Europe, to organise the learning between projects and programs from the local level up to the European level.

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