



**13. Seminar GIS & Internet – UniBw München,  
12. – 13.09.2012**

**Intelligent Solutions for Smart Grids**

- Control Center for Distribution Networks with Integration of GIS-Systems
- Solutions and scenarios for GIS Integration
- Project Examples

**Dipl. Ing. Thomas Vogl, Siemens AG  
Infrastructures and Cities, Smart Grid**

## Agenda

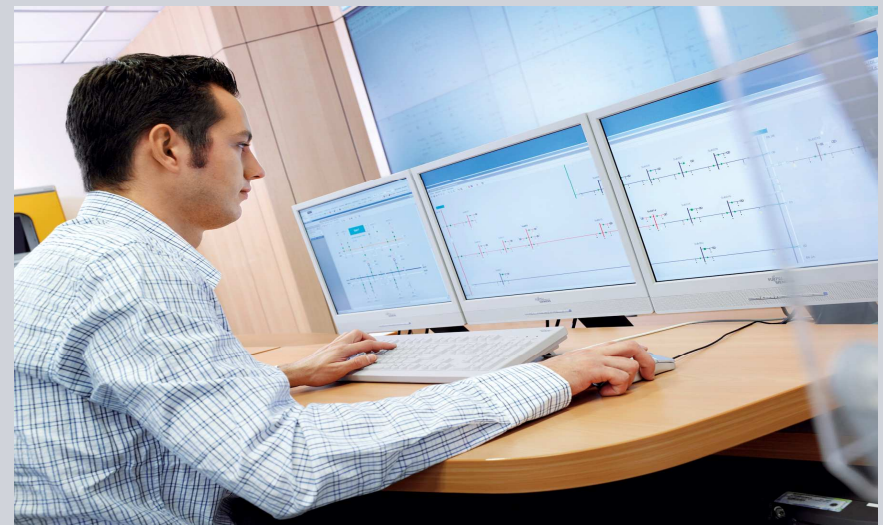
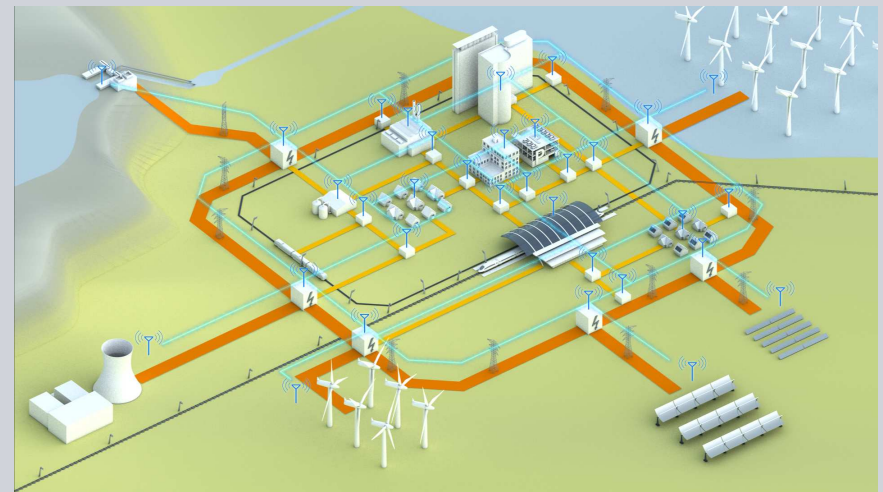
### Grid Control Center and Graphical Information Systems (GIS)

Smart Grid –  
Grid Control Center by Siemens

GIS-Integration -  
Customer Requirements

GIS Integration –  
Solutions and Scenarios

GIS-Integration -  
Project Examples



## New Sector Infrastructure & Cities within Siemens



### Attractive markets driven by megatrends

**Climate change**

**Demographic change**

**Globalization**

**Urbanization**

1) Listing planned

## Smart Grid

### Energy Automation



- Products, systems and solutions for Substation automation
- Distribution and feeder automation
- Telecontrol
- Power quality
- Protection for power grids
- Micro grids
- Demand response
- Energy Market Mgmt. Systems
- Energy Management Systems
- Distribution Management Systems
- Distributed Energy Management Systems

### Services



- Network services and substation modernization
- Monitoring and diagnostic
- Cable-, transformer- and switchgear services
- Smart metering solutions
- Grid metering, Commercial & Industrial metering
- Communication network solutions
- Network consulting, software solutions and training

### Rail Electrification



- Products, Systems and Solutions for AC and DC Traction Power Supply
- Products, Systems and Solutions for Contact Lines (Mass Transit and Mainline)

## IT Solutions

# Energy and Distribution Management Systems

## Elements of a Grid Control Center

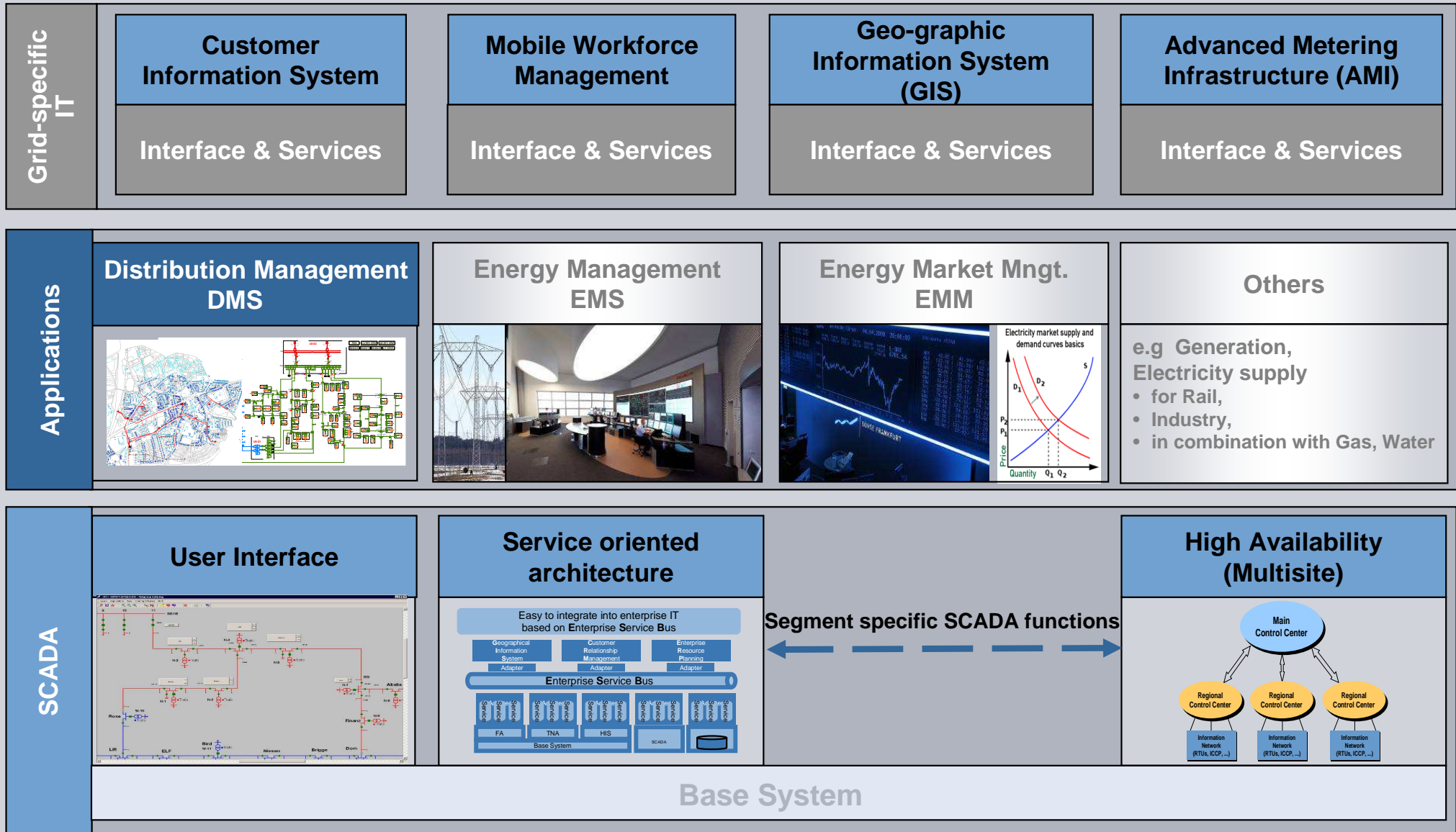
**SIEMENS**



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# Energy and Distribution Management Systems

## Functional Overview of a Grid Control Center

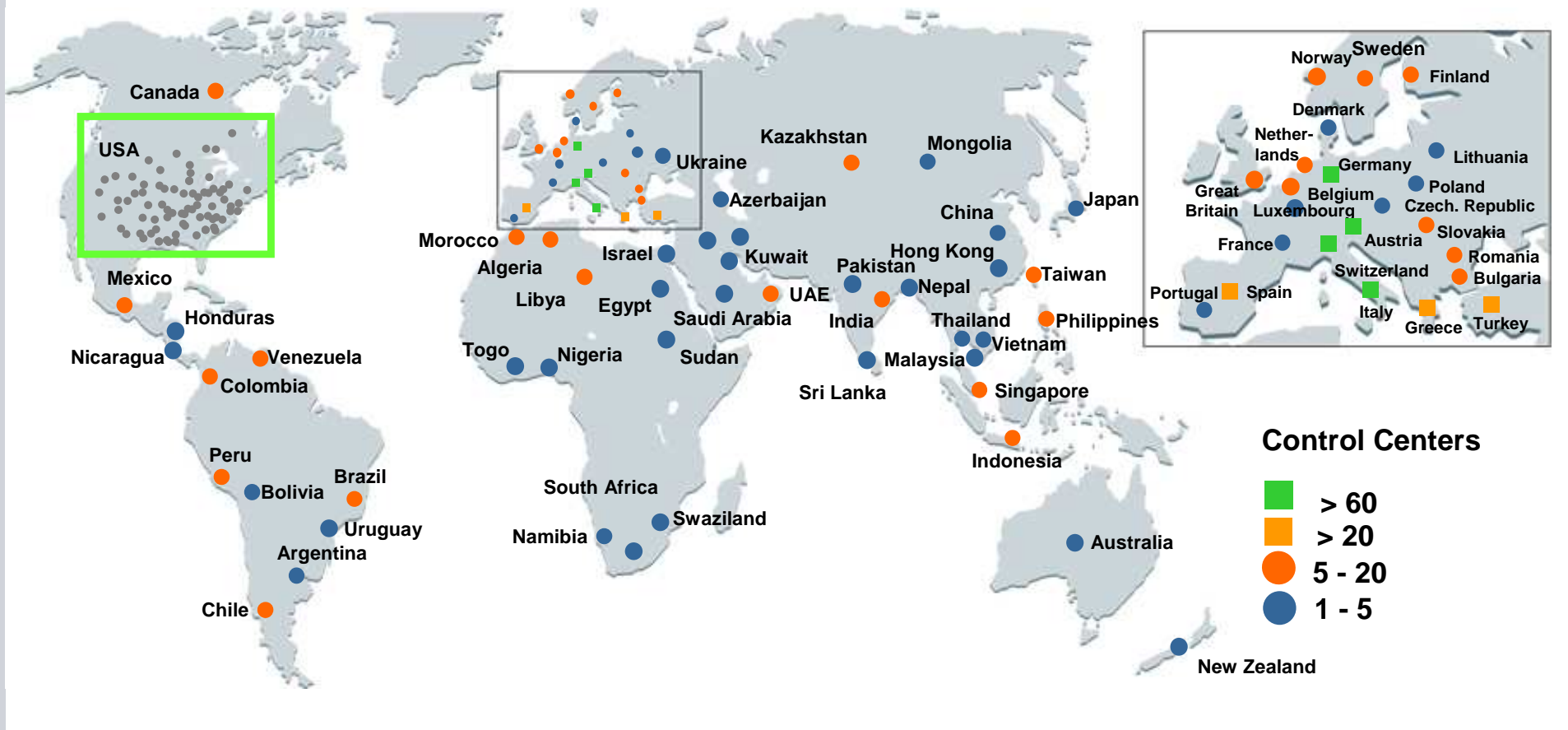


# Divivion Smart Installed Base for Grid Control Center



## Spectrum Power Control Centers ...

... are field proven: More than **1.600** control centers world wide



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## Agenda

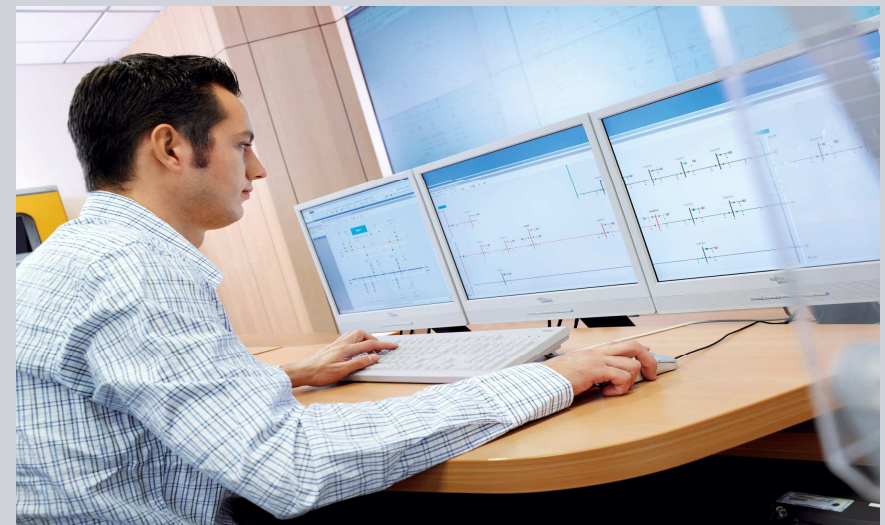
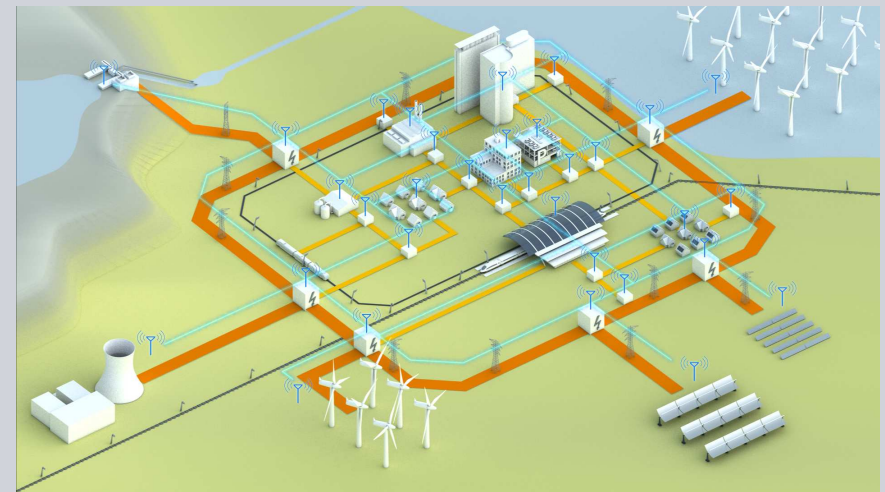
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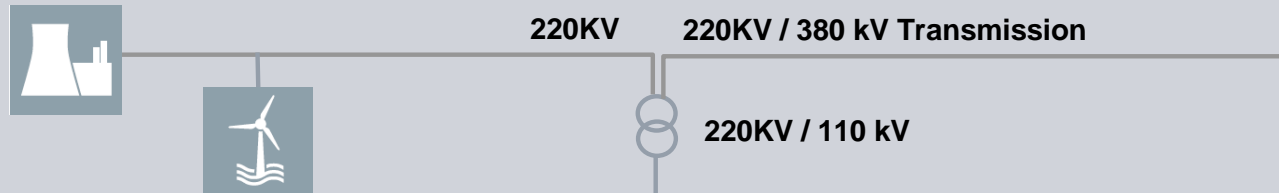
GIS-Integration -  
Project Examples





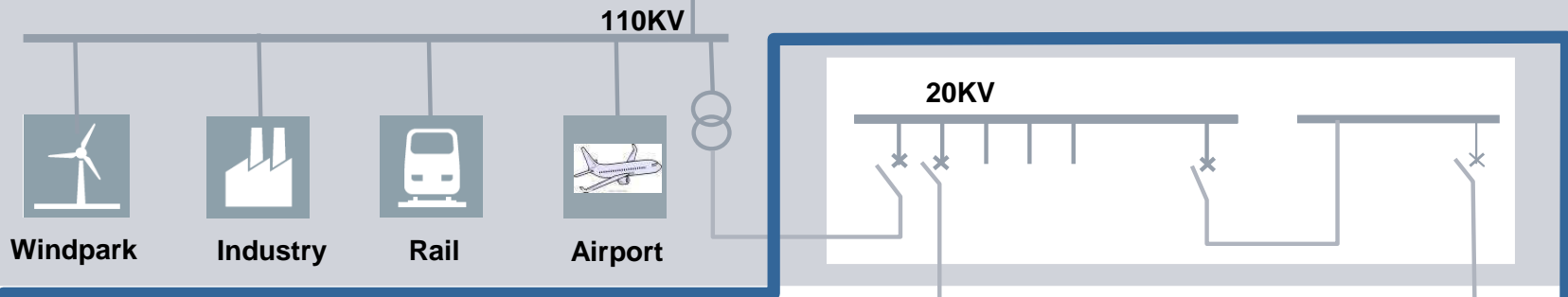
# Reliable Power Supply – From the Power Source to the Consumer

**Generation and Transmission ( High Voltage)**



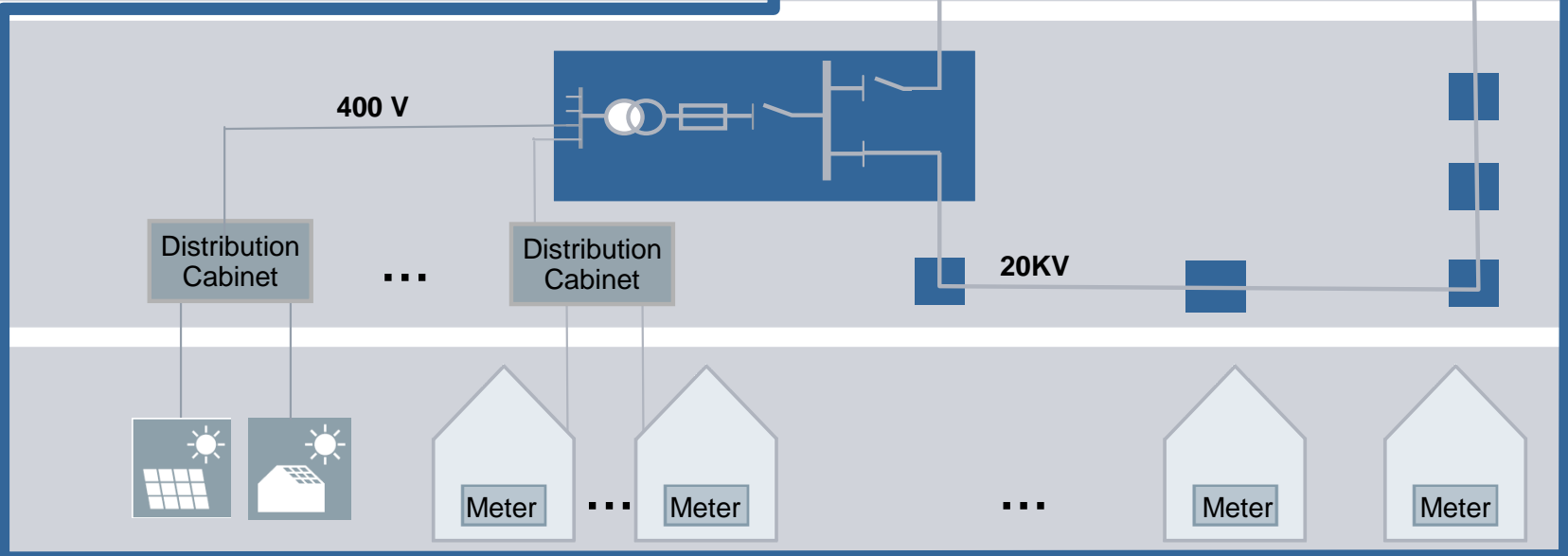
**Distribution (Medium voltage)**  
• Distribution substation

Mixed Behaviour :  
• Generation  
• Consumption



**Distribution & Feeder Automation:**  
• Transformer Station  
• Pole top-mounted

Mixed Behaviour :  
• Generation  
• Consumption

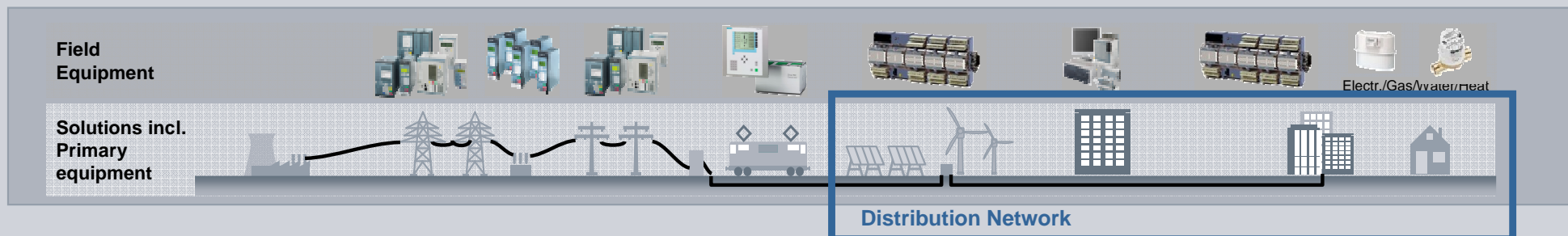
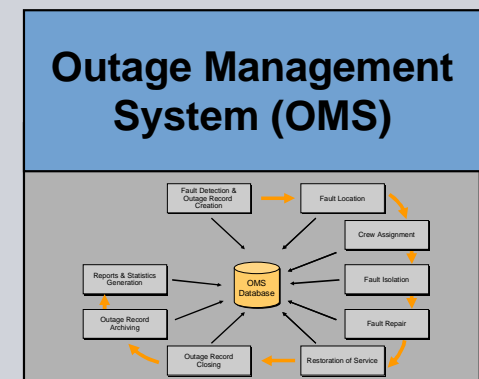
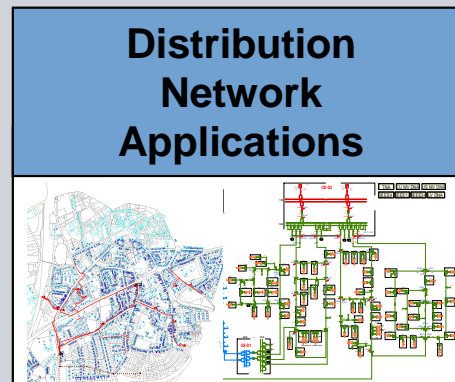
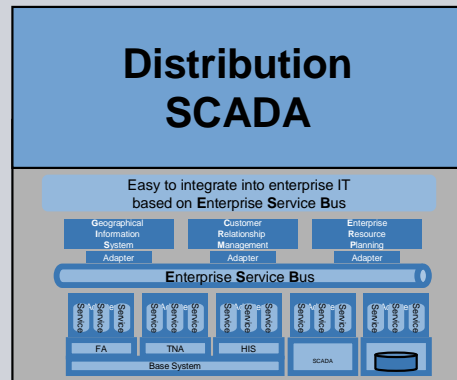
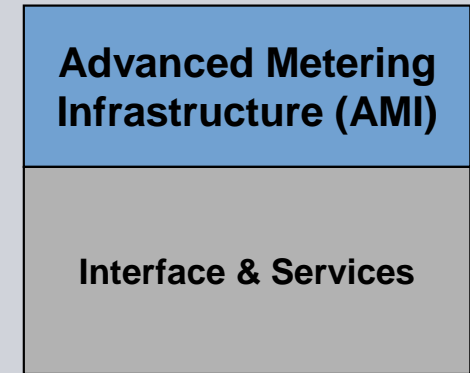
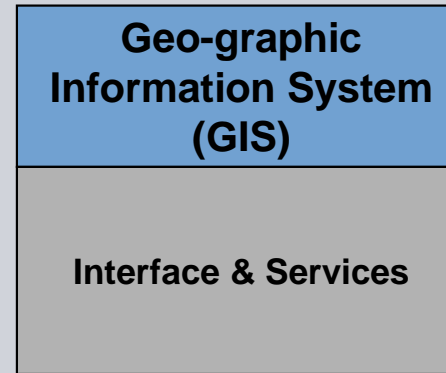
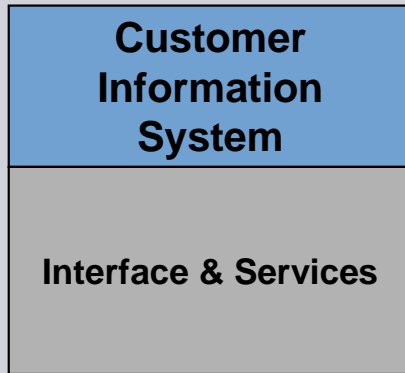


**Distribution ( Low Voltage )**

Mixed Behaviour :  
• Generation  
• Consumption

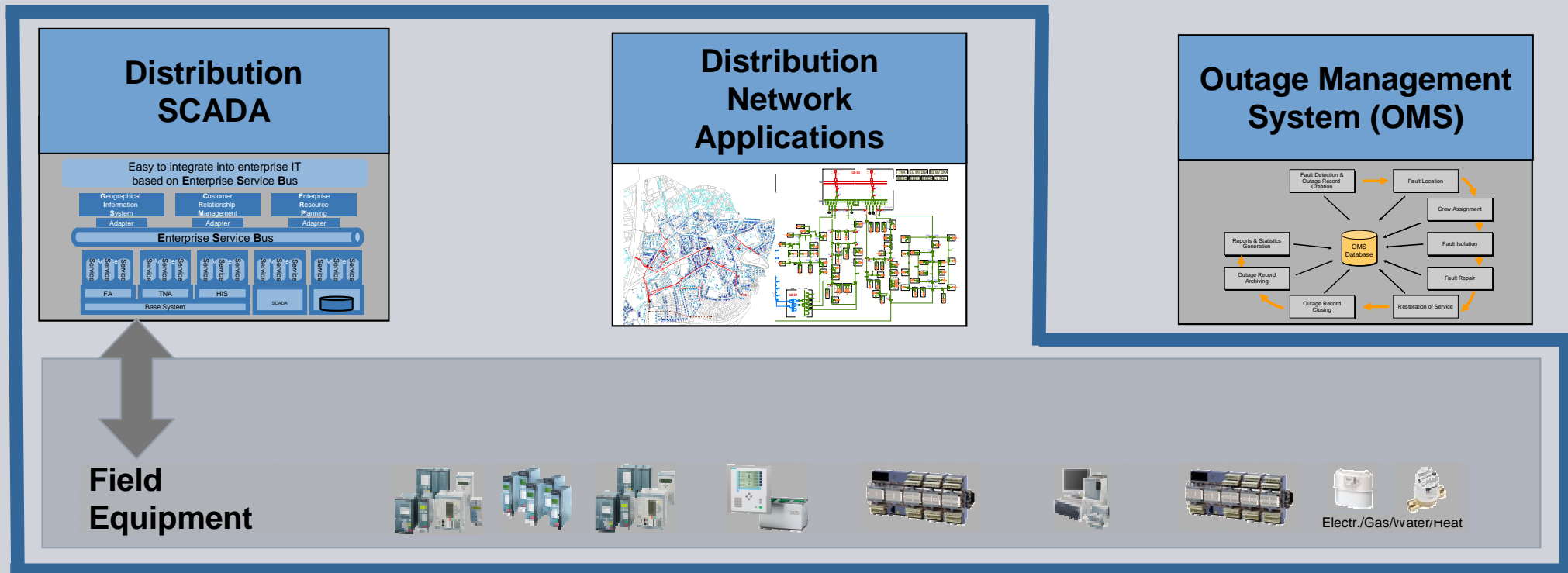
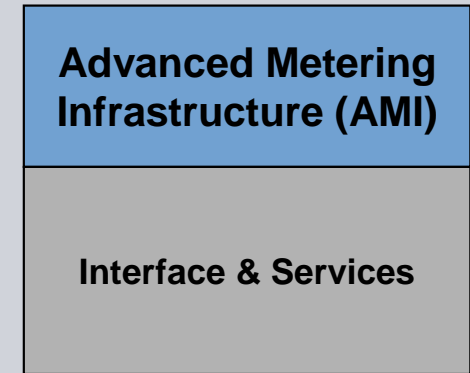
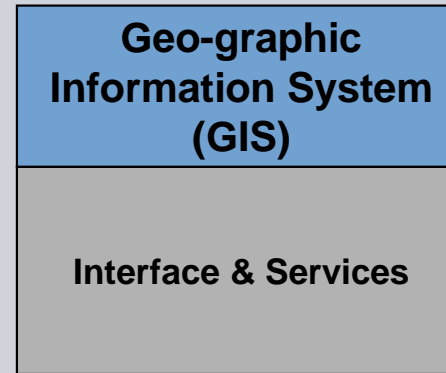
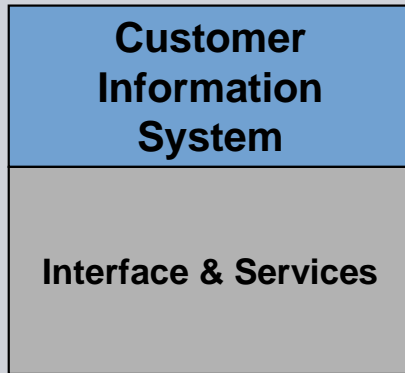
Distribution Network

# Grid Control – Building blocks for Distribution Network Operation



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# Grid Control – The Distribution Management System (DMS)



# Grid Control – The Combined DMS/OMS Solution

**Customer Information System**

Interface & Services

**Mobile Workforce Management**

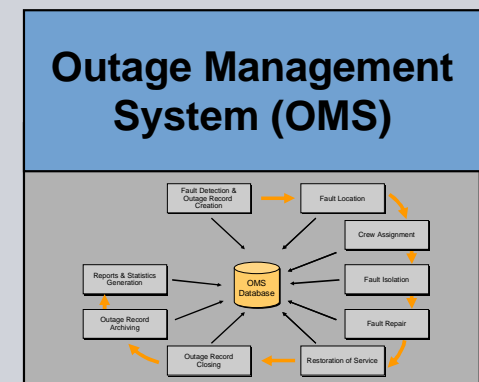
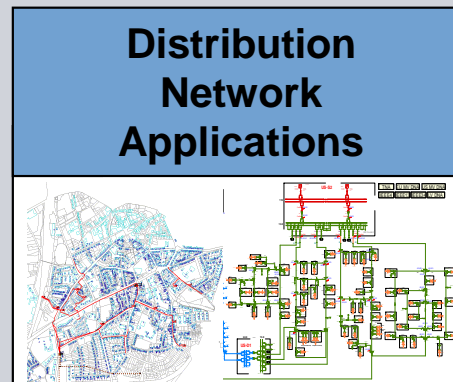
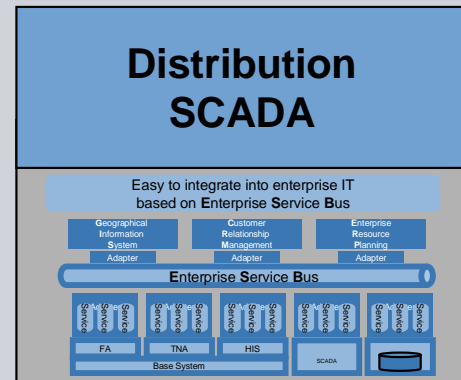
Interface & Services

**Geo-graphic Information System (GIS)**

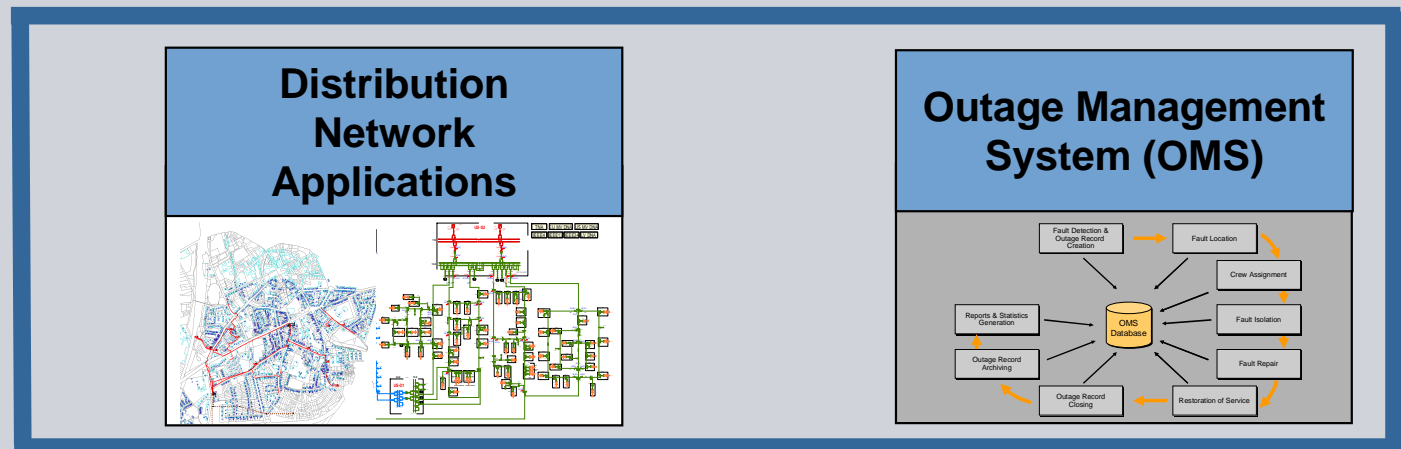
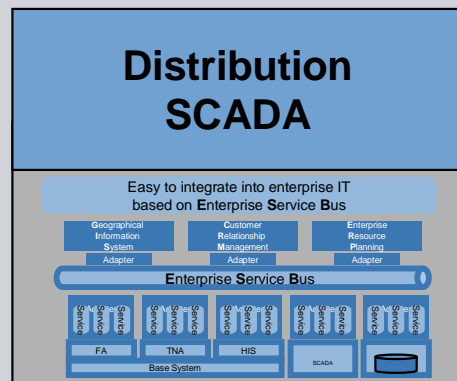
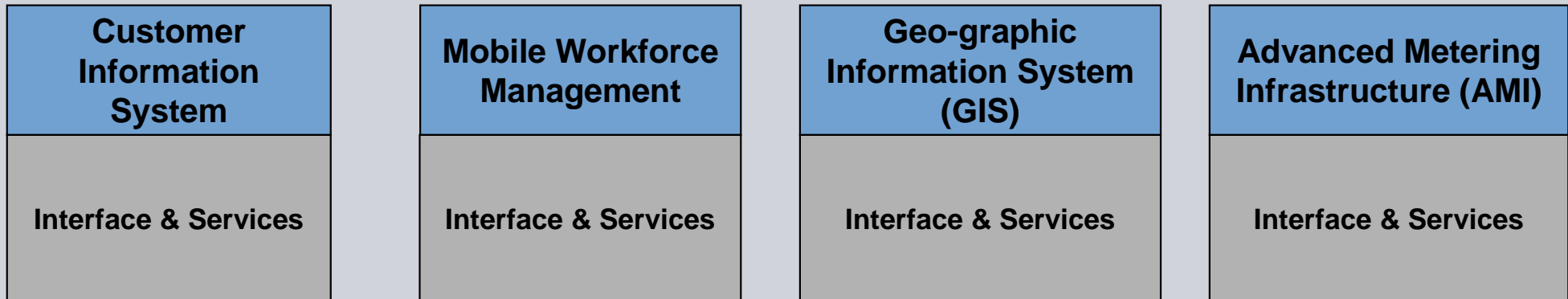
Interface & Services

**Advanced Metering Infrastructure (AMI)**

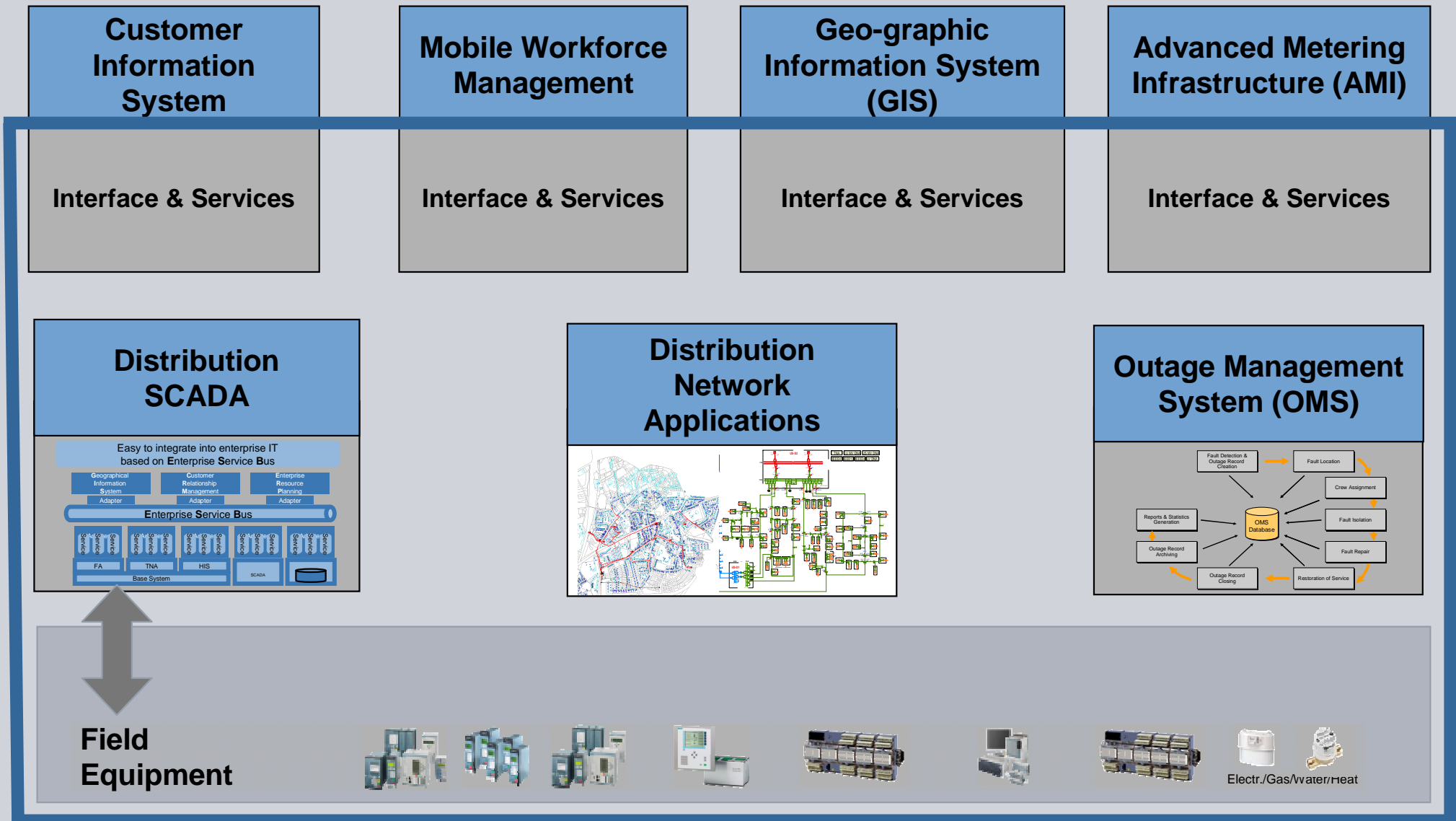
Interface & Services



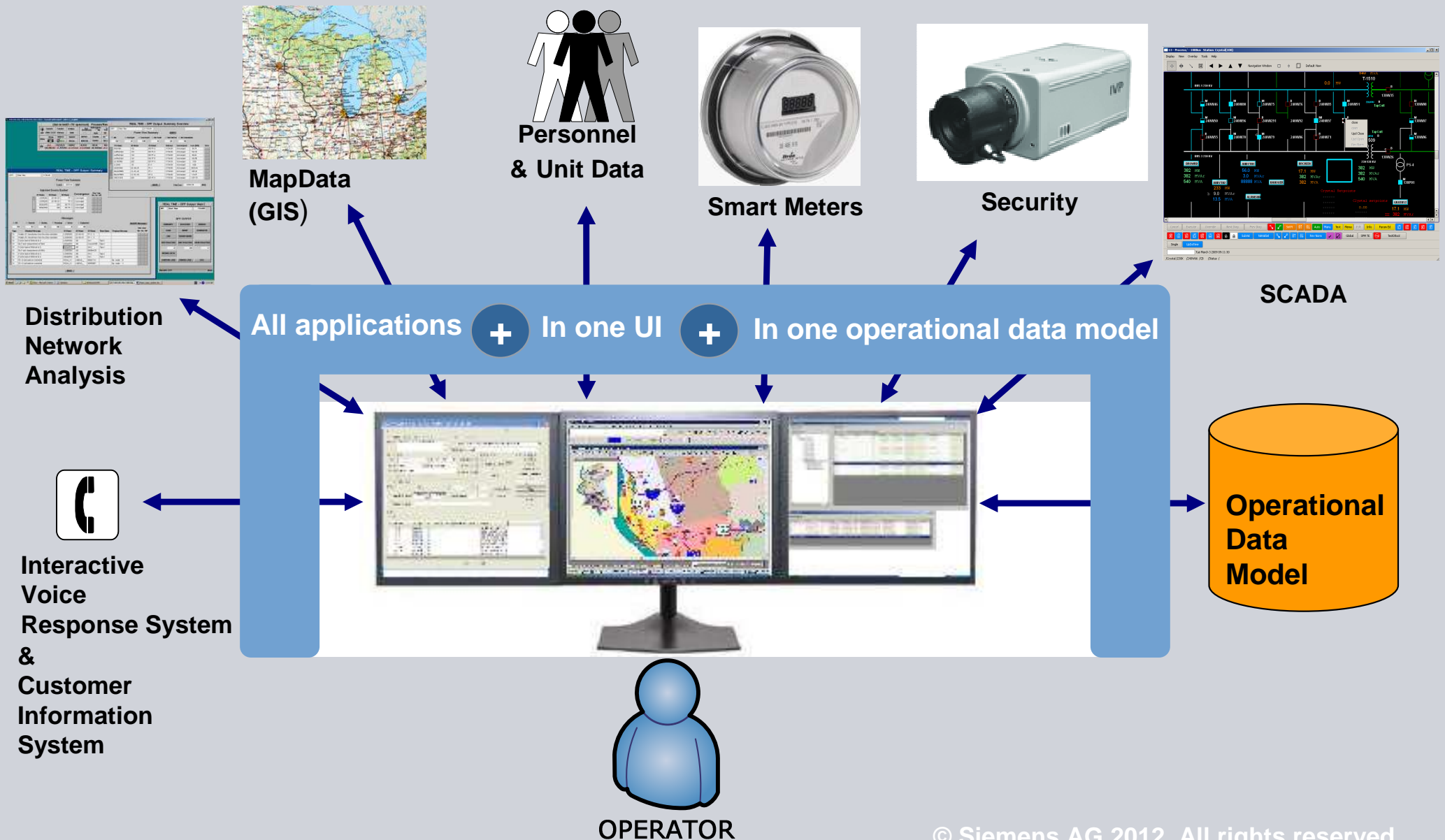
## Grid Control – The OMS Solution with Distribution Network Applications



# Grid Control – The Full-blown Distribution Management System



# Grid Control – Requirements from the Operator of a Distribution Network



## Agenda

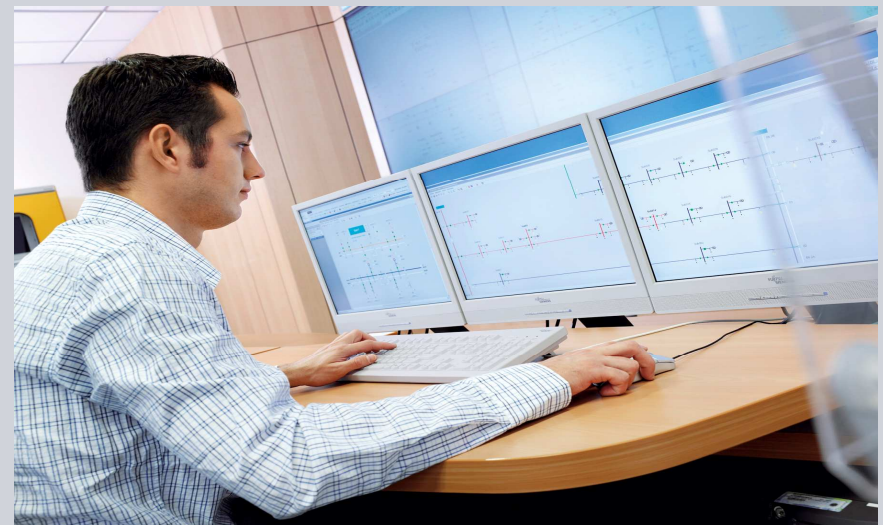
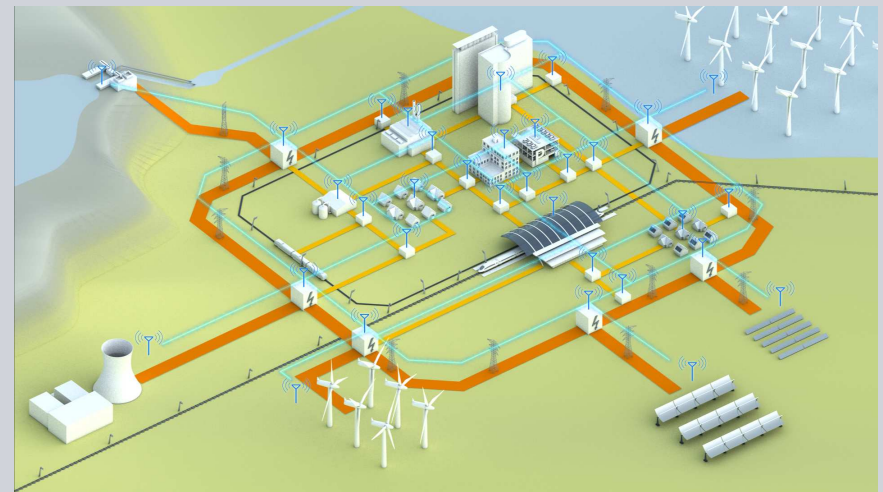
### Grid Control Center and Graphical Information Systems (GIS)

Smart Grid–  
Grid Control Center by Siemens

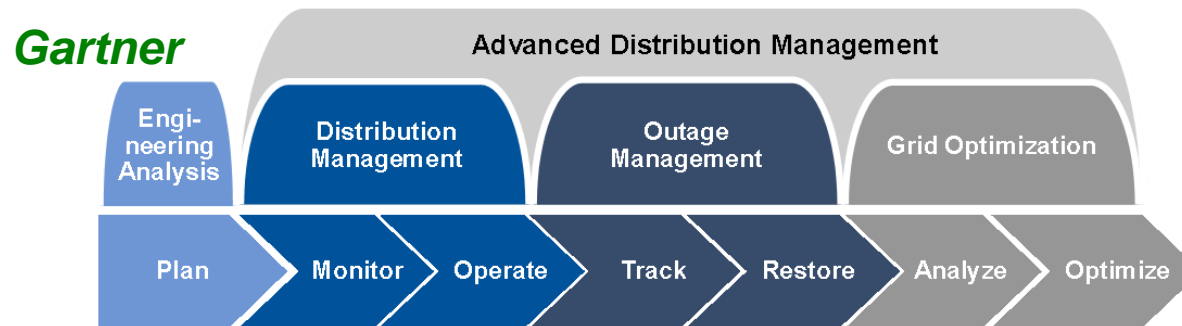
GIS-Integration -  
Customer Requirements

GIS Integration –  
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GIS-Integration -  
Project Examples



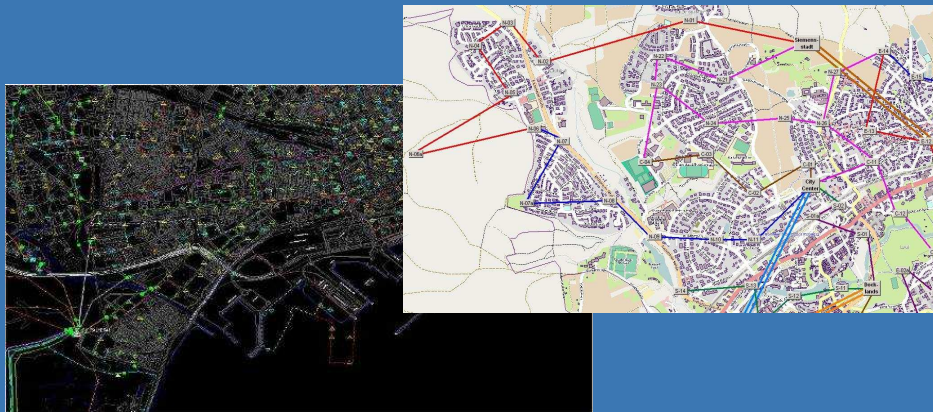




### Solutions for Advanced Distribution Management Systems

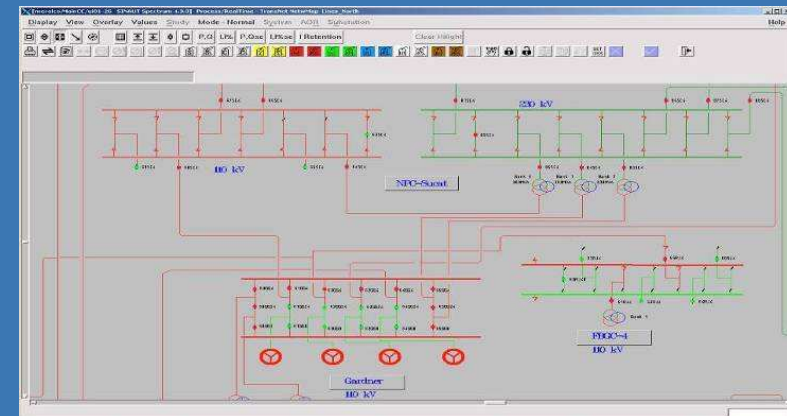
- 1 Integrated, highly-available and user-friendly HMI for Visualization of geographic and schematic Network Displays (based on GIS – Geographic Information System)
- 2 Unified and integrated Data Model for SCADA, Outage Management Systems and Applications for Distribution Networks Analysis
- 3 Advanced Applications for Distribution Grid Analysis & Optimization
- 4 Outage Management Systems (OMS) incl. integration with SCADA and for very large Distribution Management Systems
- 5 Interfaces and Service Oriented Architecture for IT Integration

## Geographic View



- **Navigation** in the network is based on the **geographical coordinates** of the equipment.
- Geographic display layout uses **land-based maps** to access **equipment** for operation and control based on their **geographic position**.
- **SCADA operation & control actions** require an entire, **properly scaled network view** on the screen.
- This **properly scaled network view** is often difficult to achieve with geographic displays and the underlying geographic coordinate-system.

## Schematic View



- **Navigation** in the network is based on the **status of the equipment**
- Schematic display layout is **optimized for network control and operation**
  - Removing details not needed for operation
  - Adding details needed for operation
  - Optimizing layout & location of equipment
- Advanced DMS solutions include **Automatic Display Generation** of schematic displays based on geographic displays of GIS-systems

# Grid Control Center

## Example for Integrated Visualization

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### SCADA

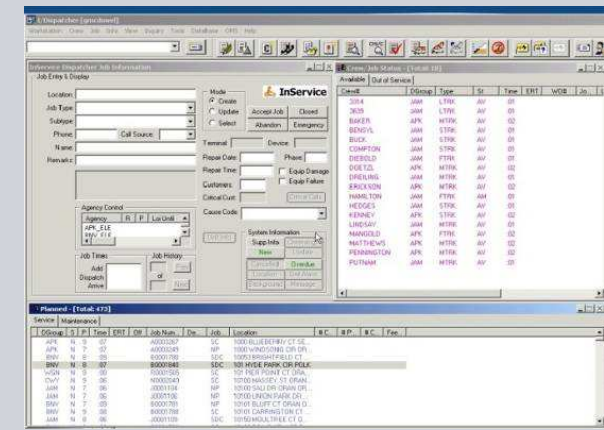
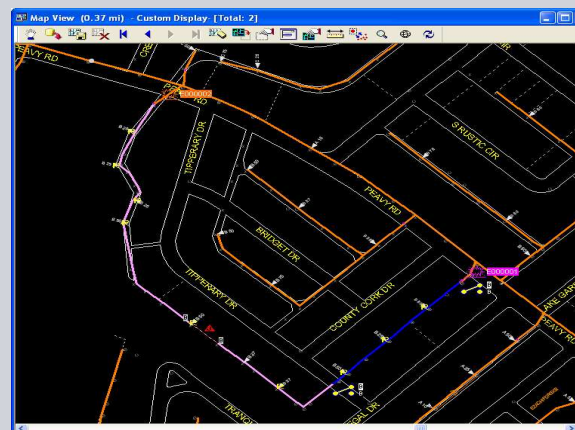
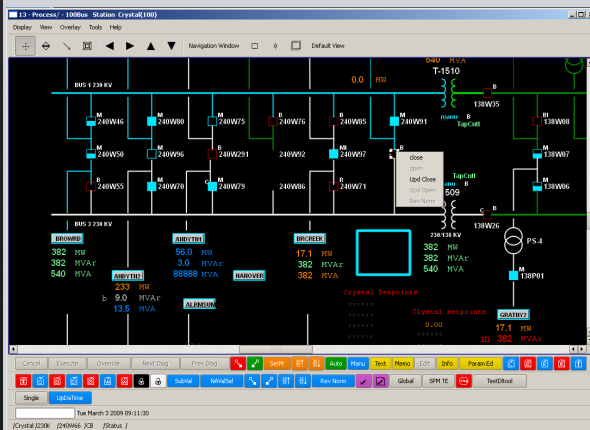
1. Operate device from Schematic Display.

### GIS

2. Show change to device in GIS view

### OMS

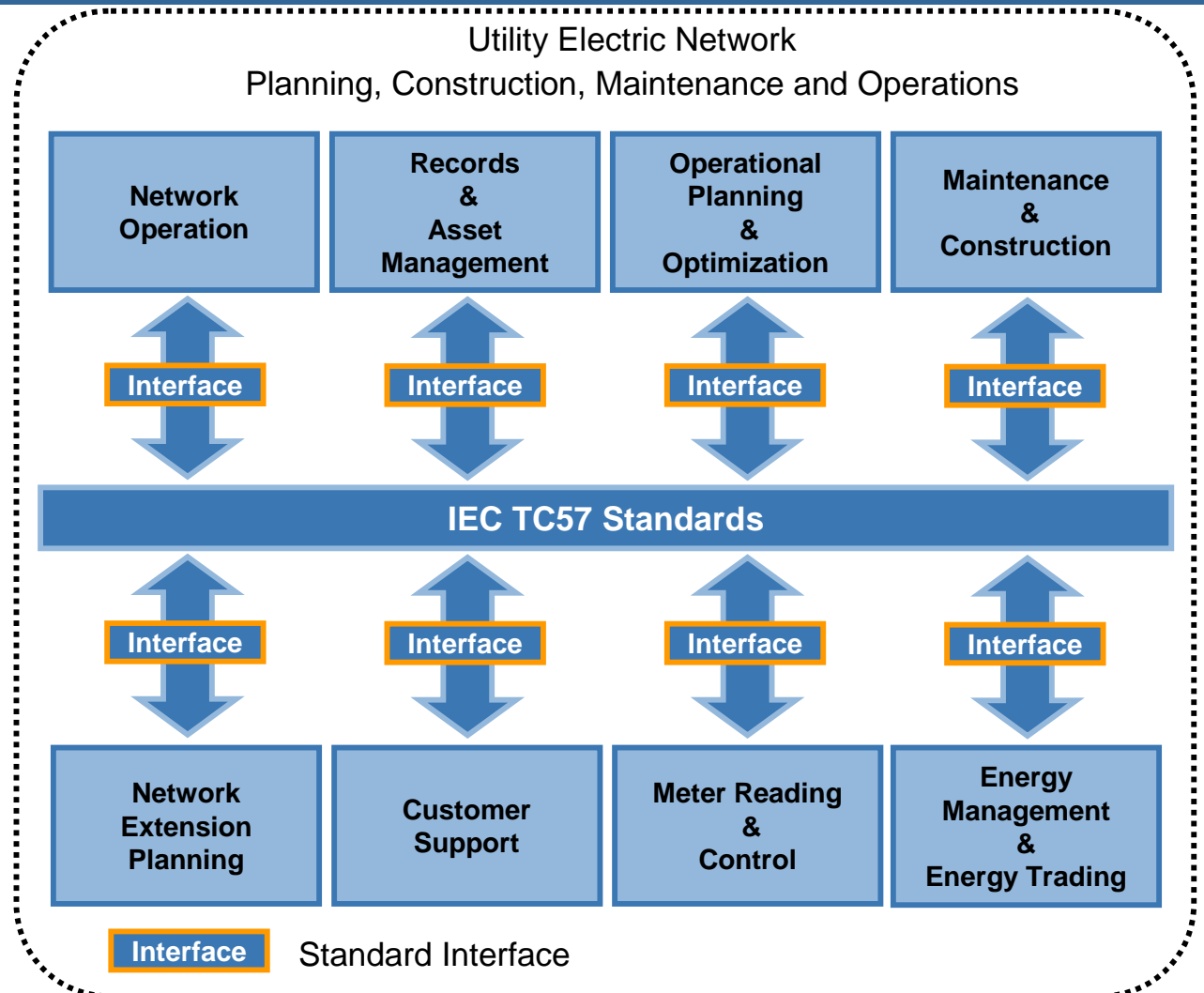
3. Analyze outages and generate outage reports



### IEC-Standard and Common Information Model (CIM)

There are three **main standards** within CIM:

- **IEC 61970** – EMS Application Program Interface
- **IEC 61968** – System Interfaces for Distribution
- **IEC 62325** – Energy Market Communications

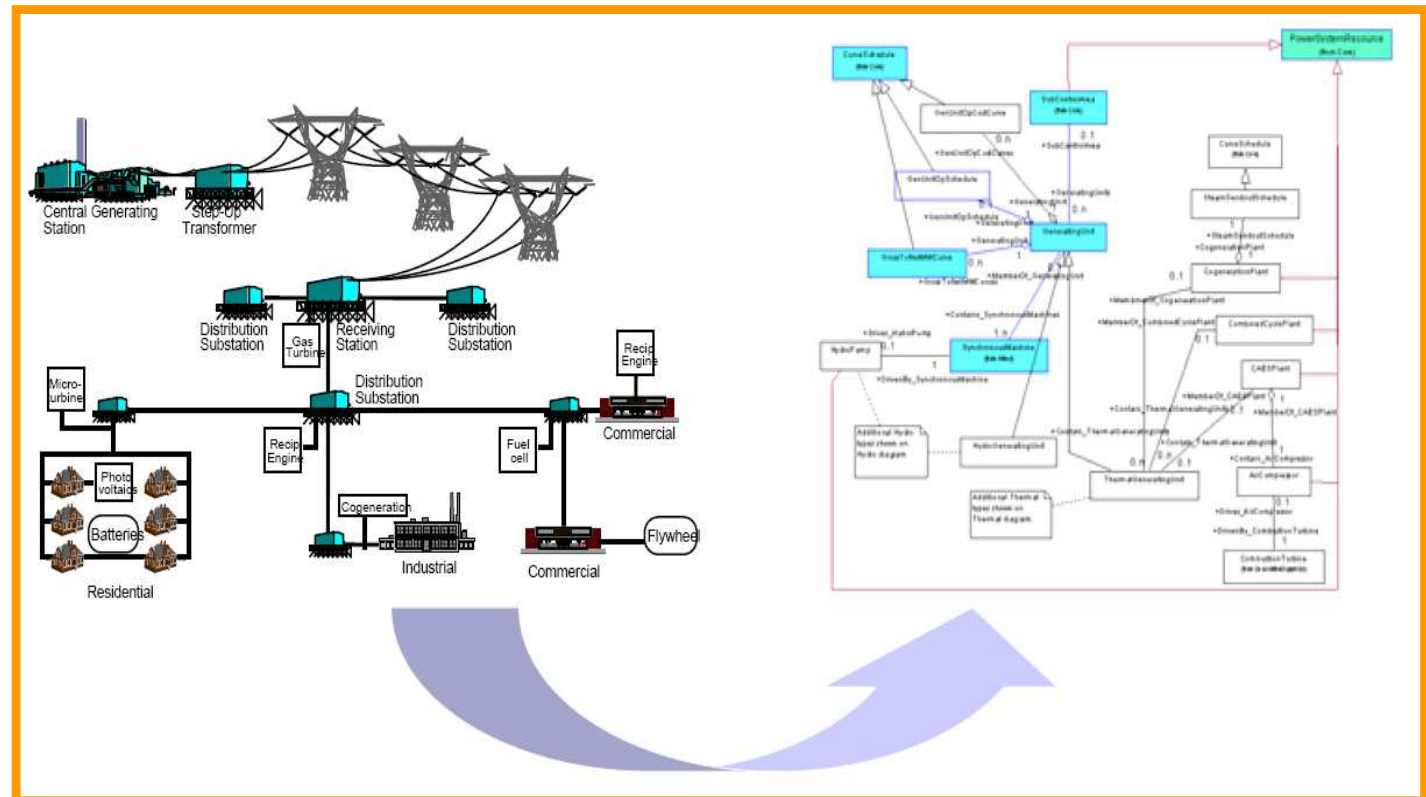


# Grid Control Center

## Unified and integrated Data Model

CIM ( IEC 61970 ) is an object oriented information model of the power grid

- Classes describe the **objects**, **their attributes** and **their relations** with other objects (i.e. a transformers is included in a substation, has a name, nominal voltage, etc...)



- Instances describe the **concrete objects** of a class as they **exist** in the system

## IEC 61968 – Defines System Interfaces for Distribution

61968-1	Interface Architecture and General Requirements
61968-100	Enterprise Service Bus (ESB) Profile
61968-2	Glossary
61968-3	Network Operations
61968-4	Asset Management
61968-5	Operational Planning and Optimization
61968-6	Maintenance and Construction
61968-7	Network Extension Planning
61968-8	Customer Support
61968-9	Meter Reading& Control
61968-11	Common Information Model (CIM) for Distribution
61968-12	Compliance and Interoperability Testing
61968-13	CIM RDF Model Exchange Format for Distribution (CDPSM)
61968-14-1	Mapping between MultiSpeak and IEC 61968
61968-14-2	CIM profile for MultiSpeak

## IEC 61968 – Defines System Interfaces for Distribution

61968-1 Interface Architecture and General Requirements  
**61968-100 Enterprise Service Bus (ESB) Profile**

61968-2

61968-3

61968-4

61968-5

61968-6

61968-7

61968-8

61968-9

61968-11

61968-12

61968-13

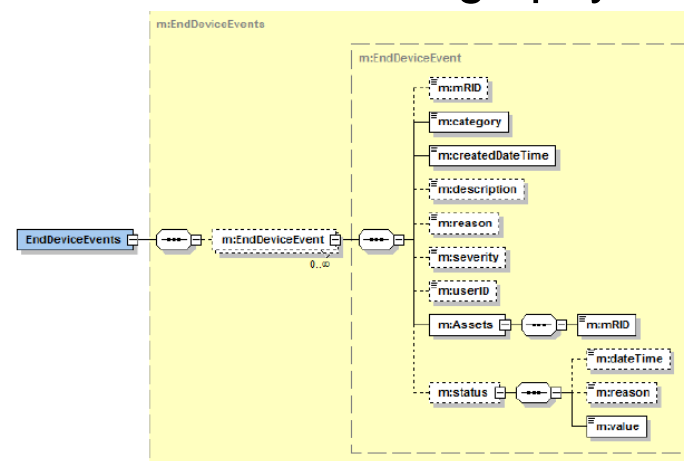
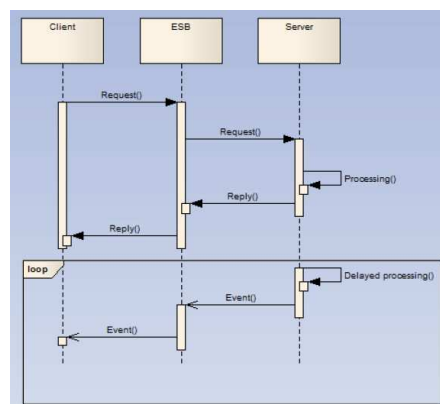
61968-14-1

61968-14-2

### 61968-100 defines Enterprise Service Bus (ESB) Profile

Defines the general concept and design of messages for integration via an Enterprise Service Bus.

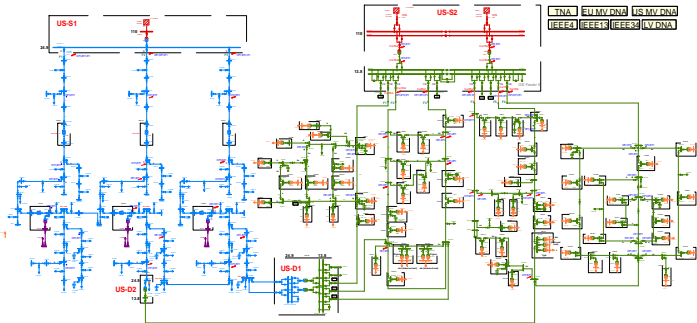
Defines how the messages shall be derived based on CIM – message structure: message header and message payload.



# Grid Control Center

## Advanced Applications for Distribution Networks Analysis

- One Distribution Network Application Suite for all distribution networks



- Integration with OMS/DMS systems via SOA (**S**ervice **O**riented **A**rchitecture)
- supports different network types
  - Balanced / unbalanced
  - symmetrical / unsymmetrical
  - radial / meshed
- covers the drivers in a Smart Grid:
  - Increasing network sizes
  - Increasing performance requirements
  - Closed loop operations
  - Need to know real-time operation conditions better – state estimation
  - Distributed generation

### Fault Analysis

#### Fault Location (FLOC)

#### Fault Isolation & Service Restoration (FISR)

### Network Analysis & Optimization

#### Distribution System Powerflow (DSPF)

#### Distribution System State Estimator (DSSE)

#### Short Term Load Scheduler (STLS)

#### Volt-/Var Control (VVC)

#### Short Circuit Calculation (SCC)

#### Optimal Feeder Reconfiguration (OFR)

#### Optimal Capacitor Placement (OCP)

#### Distribution Security Analysis (DSA)



# Grid Control Center Outage Management System ( incl. integration with SCADA)

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4 of 5

**1** Problem in the Field ...

**2** ...enforces trip of a Circuit Breaker  
e.g. generates SCADA Alarm

**3** OMS creates Outage Record  
ensures transparency and triggers  
further workflows

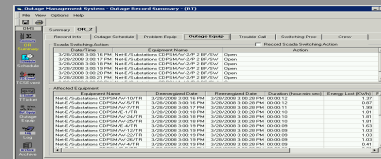
**4** Generating a Switching Procedure  
to isolate the fault and  
to re-supply power to customers

**5** Assigning the Crew  
to execute the switching procedure(s)

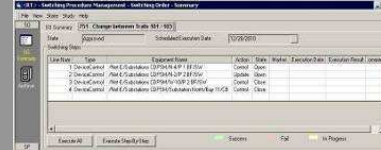
**6** Generating the Outage Report  
for outage-specific documentation



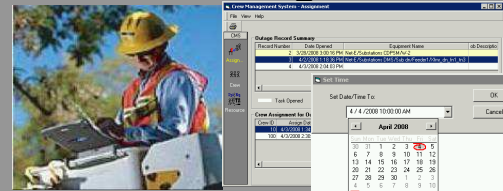
## Create Outage Record



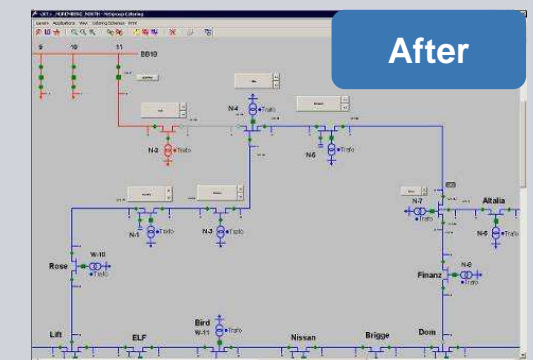
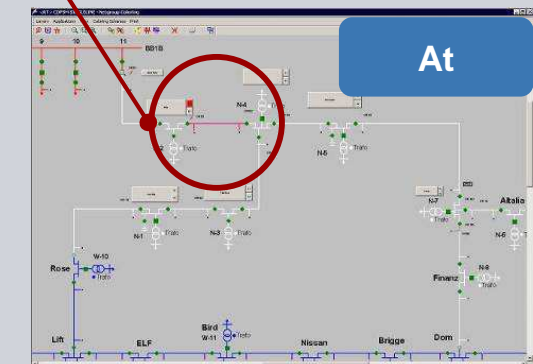
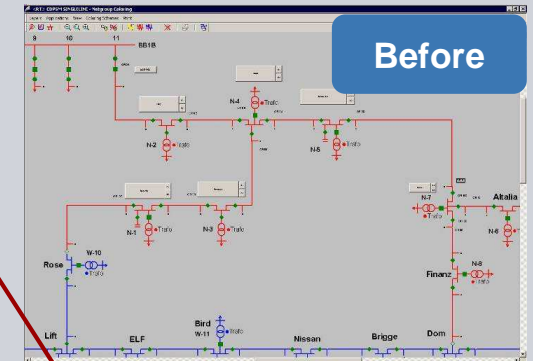
## Switching Procedure



## Crew Management



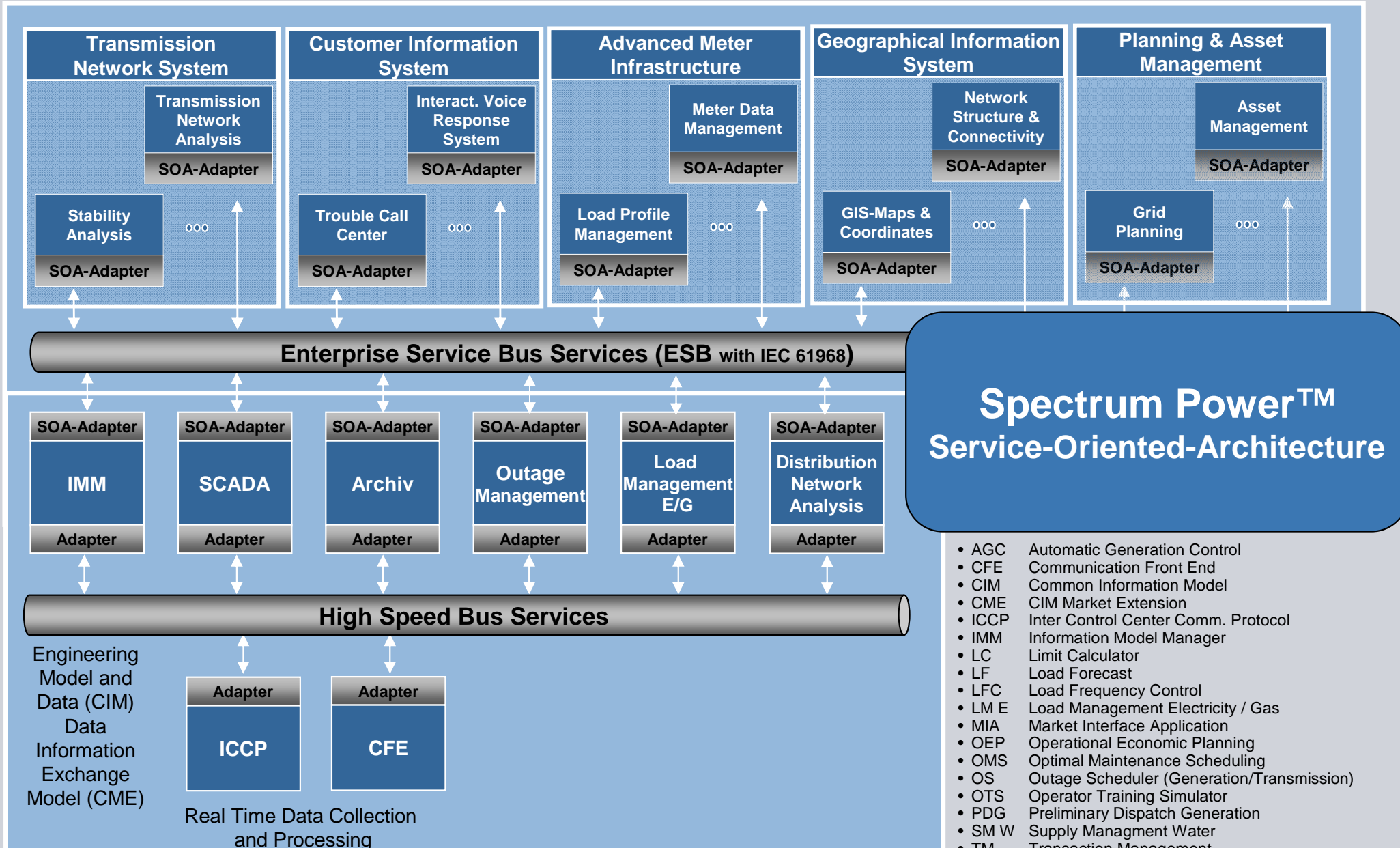
## Generate Outage Report



# Grid Control Center

\*) Services IEC 61968

## Interfaces and Service Oriented Architecture for IT Integration



## Control Center with SCADA and Applications

## Agenda

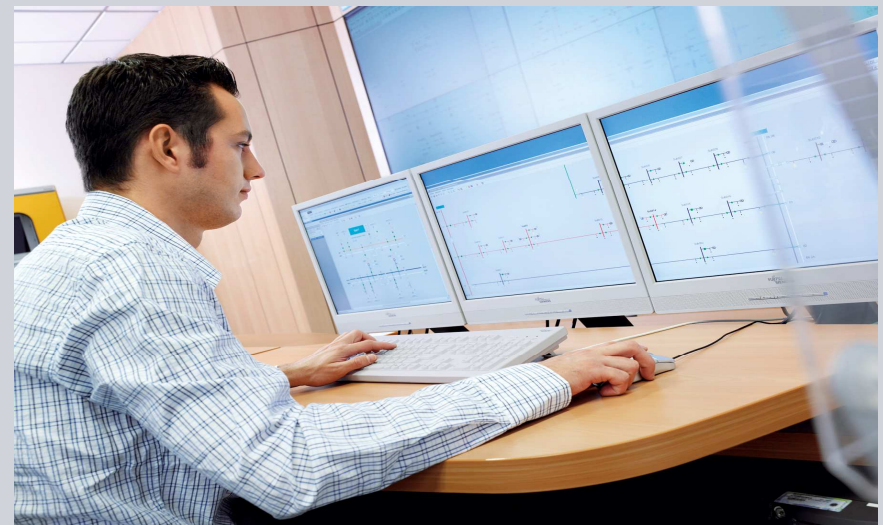
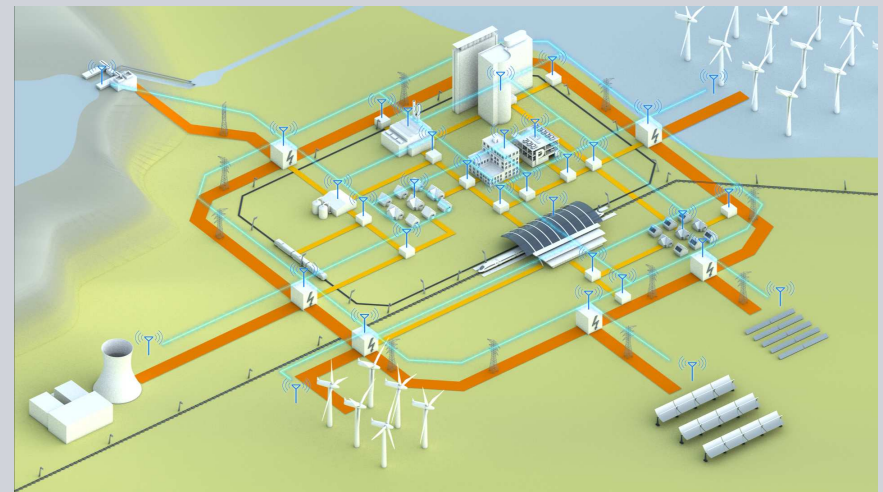
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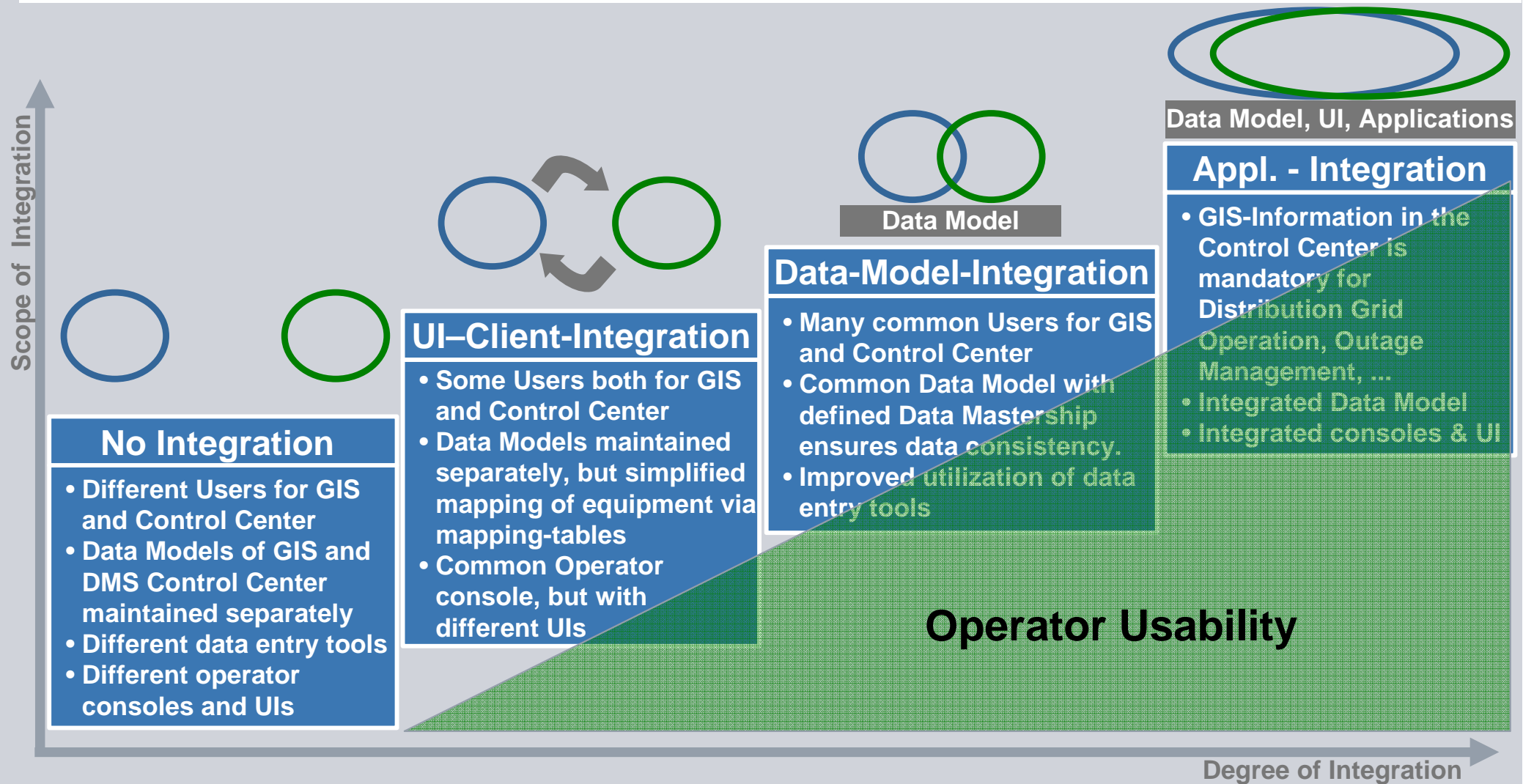
GIS-Integration -  
Customer Requirements

GIS Integration –  
Solutions and Scenarios

GIS-Integration -  
Project Examples



## Grid Control Center - How much GIS-Integration is needed ?



The answer is ...

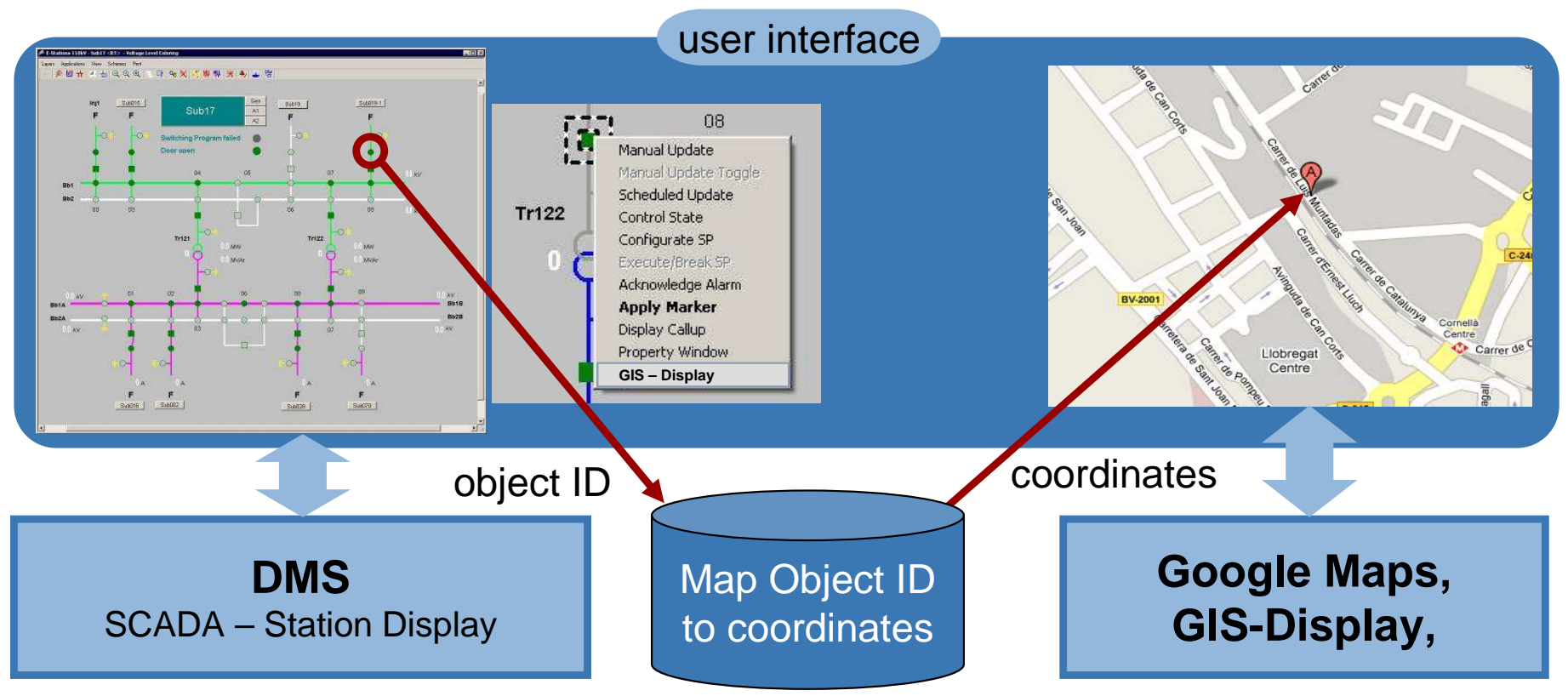
... this is heavily dependant on the utility workflows for operating the distribution grid

# Project Example (# 01)

## UI-Navigation between DMS and Google-Maps

### UI Integration Scenario between DMS and GIS-Display, Google Maps

**Use Case** Show geographical location of equipment to operator



# Project Example (# 02)

## GIS as Data Source

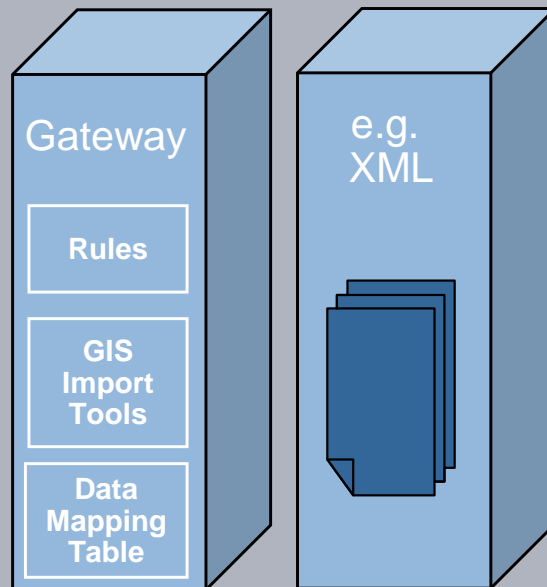
### GIS as Data Source

GIS-Data-Model with

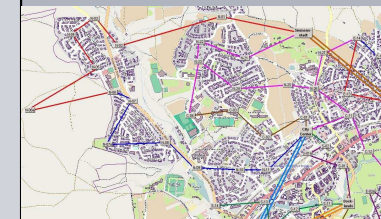
- Land-based GIS-Maps with Geographic coordinates
- Network Structure & Connectivity, (Substations, connectivity, attributes,..)
- Electrical and Equipment- Data ( power lines, line-length, line-impedances, transformers, .. )



### GIS Data Import

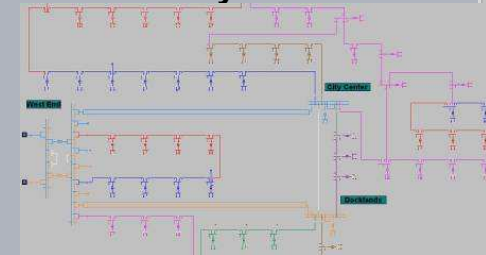


### DMS Control Center

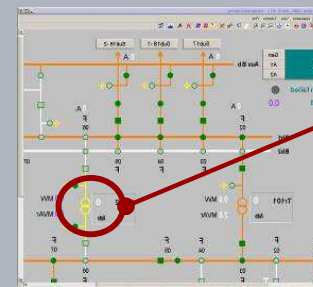
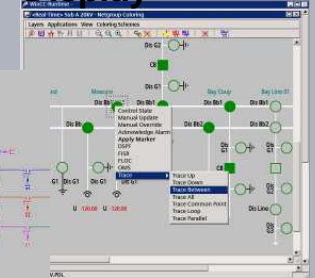


Geographical Map with Network

### Network Connectivity



### Substation Display

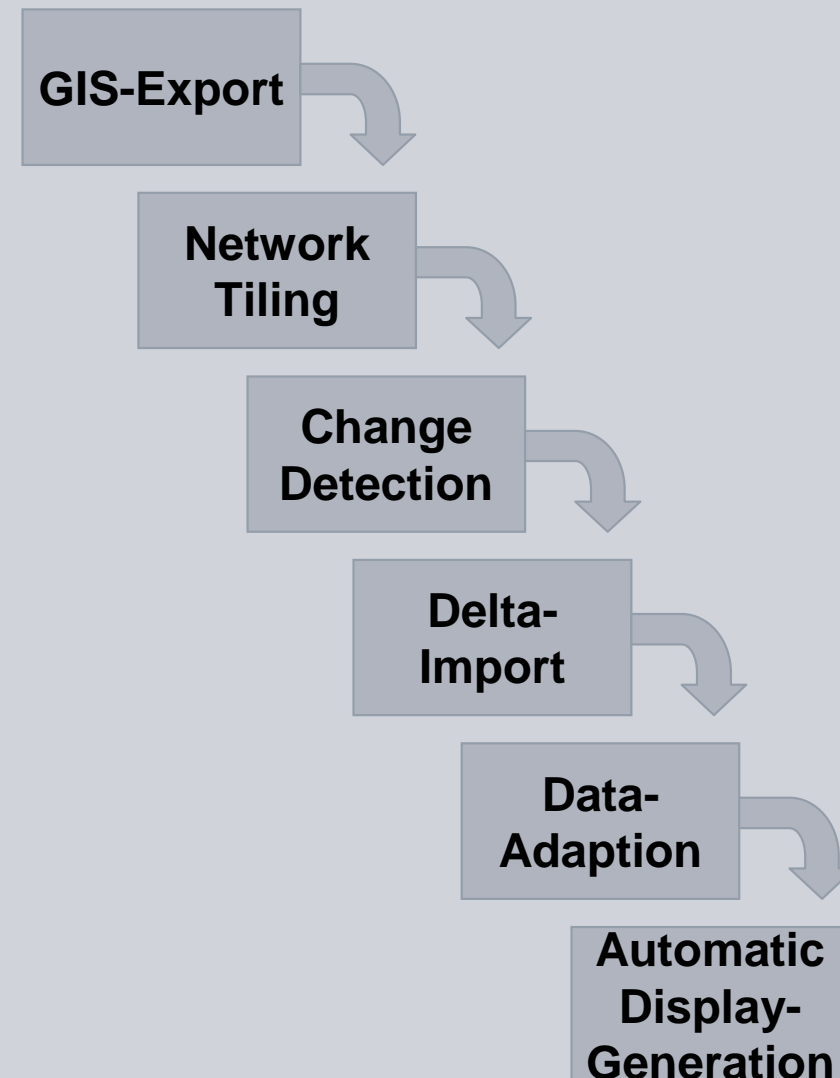


**Distribution PowerFlow** detects overload based on static attributes of power lines and transformers modeled in GIS

# Project Example (# 02)

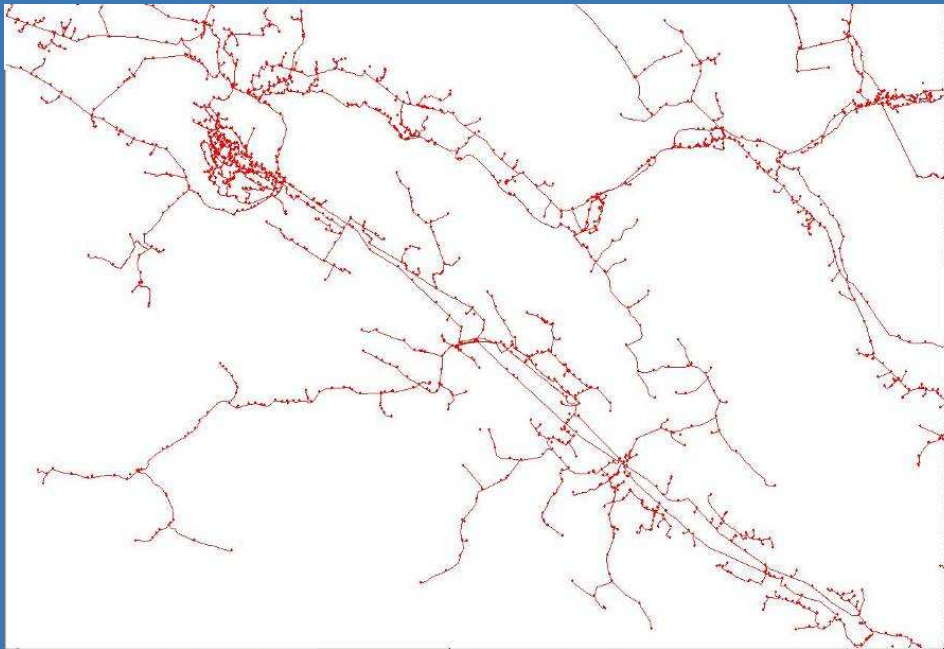
## Workflow for a complete GIS Data Export

- 1 Complete export of GIS Database
- 2 Tiling the network
- 3 Change detection => comparing the GIS database versus last data import
- 4 Delta-Import Only Tiles with changes will be imported
- 5 Data-Adaption to Control Center DMS Import Format
- 6 Auto-Display Generation for Geographical and Schematic displays

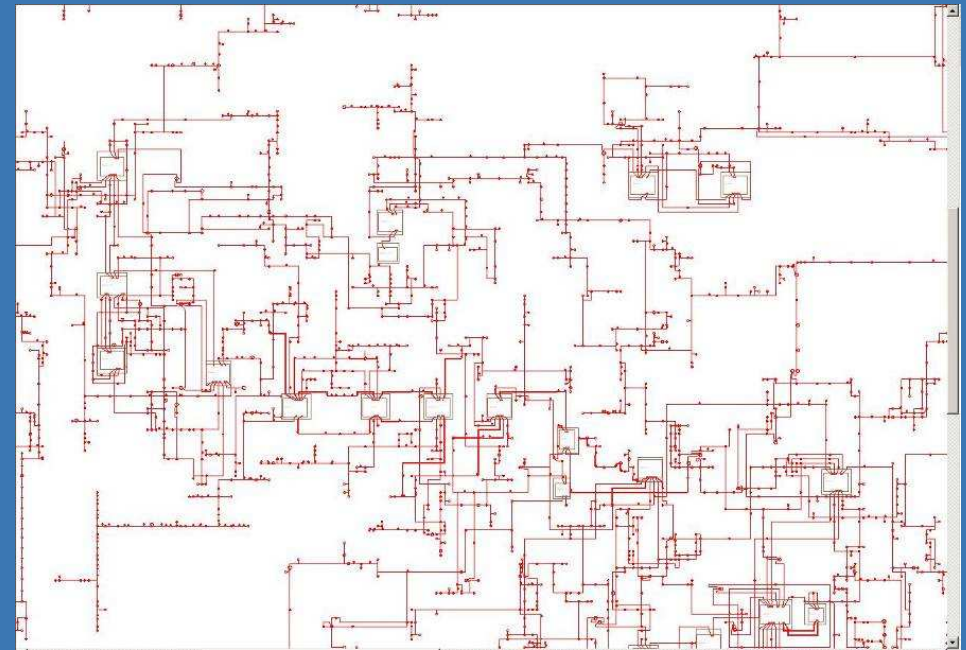


**Project Example (# 02)**  
**Automatic Display Generation**

**Geographic Display  
 (Imported from GIS)**



**Schematic Display  
 (Auto-generated from GIS)**



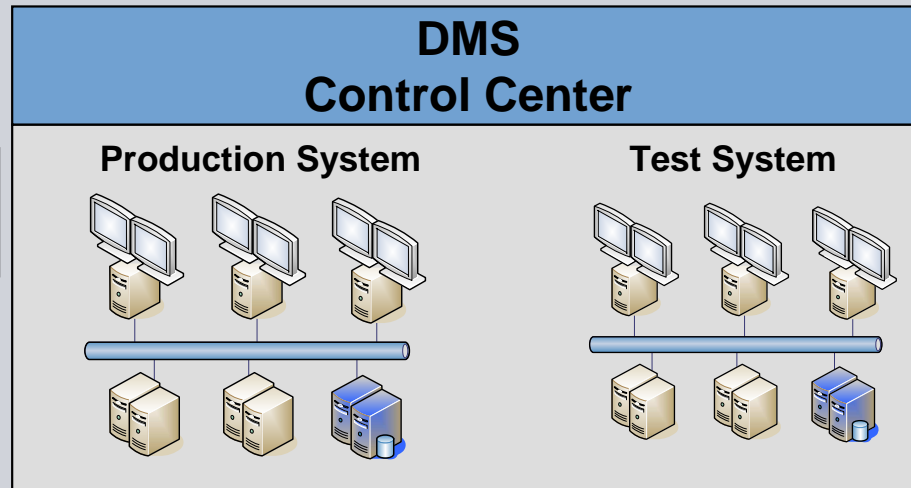
**Automatic Layout and Schematizing**

A Layout – and optimization algorithm auto-generates the schematic displays based on the geographic displays



# Project Example (# 03)

## Overview of Components and Data Flows



Data for DMS Control Center

- GIS-Displays
- Network Data
- Equipment Data

1



Data for

- Trouble Call Mgmt.
- Distribution Power Flow

2

**Geographic Information System**

- GIS-Maps with Geographic coordinates
- Network Structure & Connectivity , (Substations, attributes,..)
- Electrical and Equipment-Data ( power lines, line-length, line-impedances, transformers, .. )



3



Data for association between

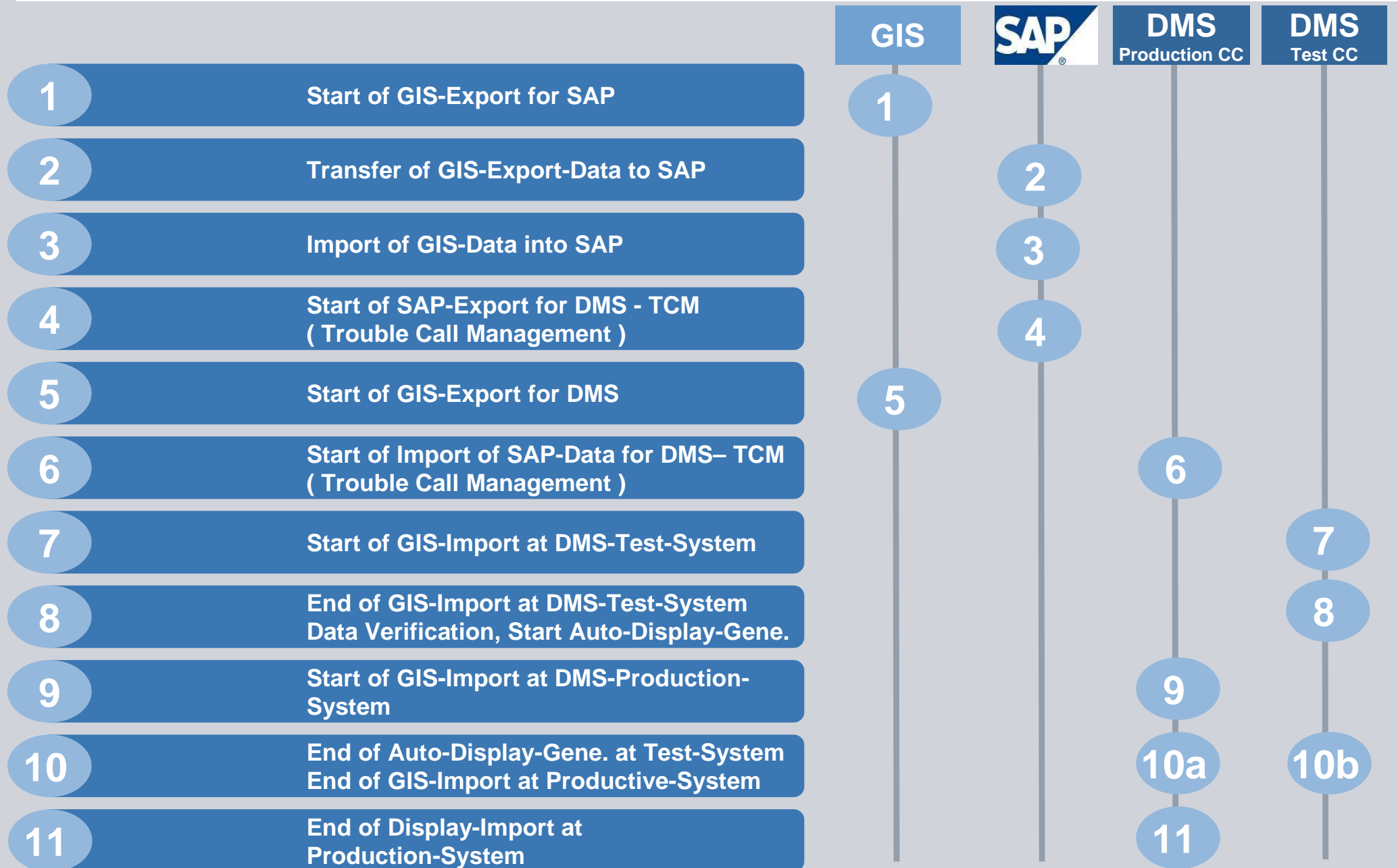
- Customer and
- Distribution Transformer Station

**SAP**

- Customer- Access-Data
- Customer Load Profiles

# Project Example (# 03)

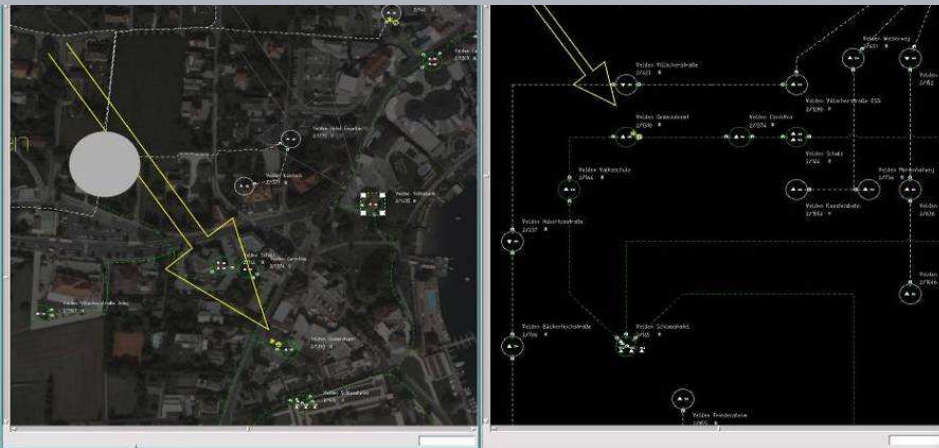
## Utility-Workflow



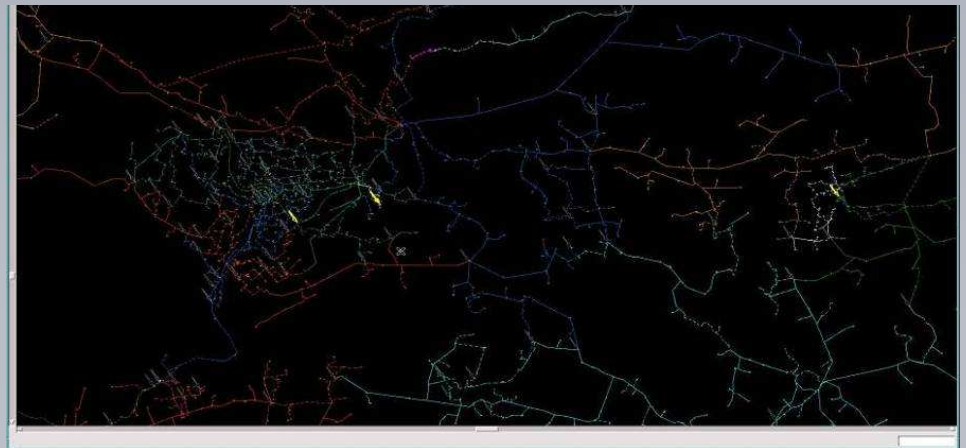
# Project Example (# 03)

## User Interface for Network Displays

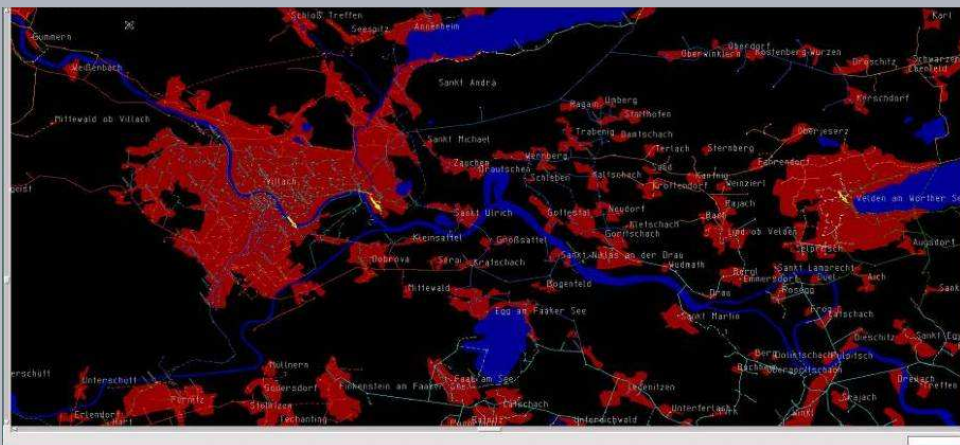
**Geographic and corresponding Schematic Display**



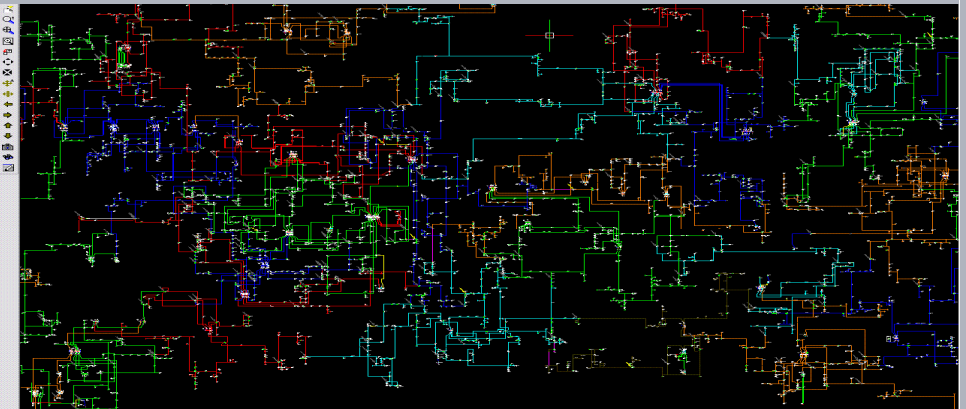
**Imported Geographic Display**



**Geographic Display with special Info for Urban Area**



**Auto-Generated Schematic Display**



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## Summary and Outlook

### Efficiency

Integration between GIS and Grid Control Center helps to **increase efficiency** for **Grid operation** in the Control Room and to **shorten reaction times**

### Process & Workflows

The scope and the degree of GIS-Integration has to follow **the utility process** and the **utility-specific workflows** to manage and operate the **distribution grid**

### Intelligent Technologies

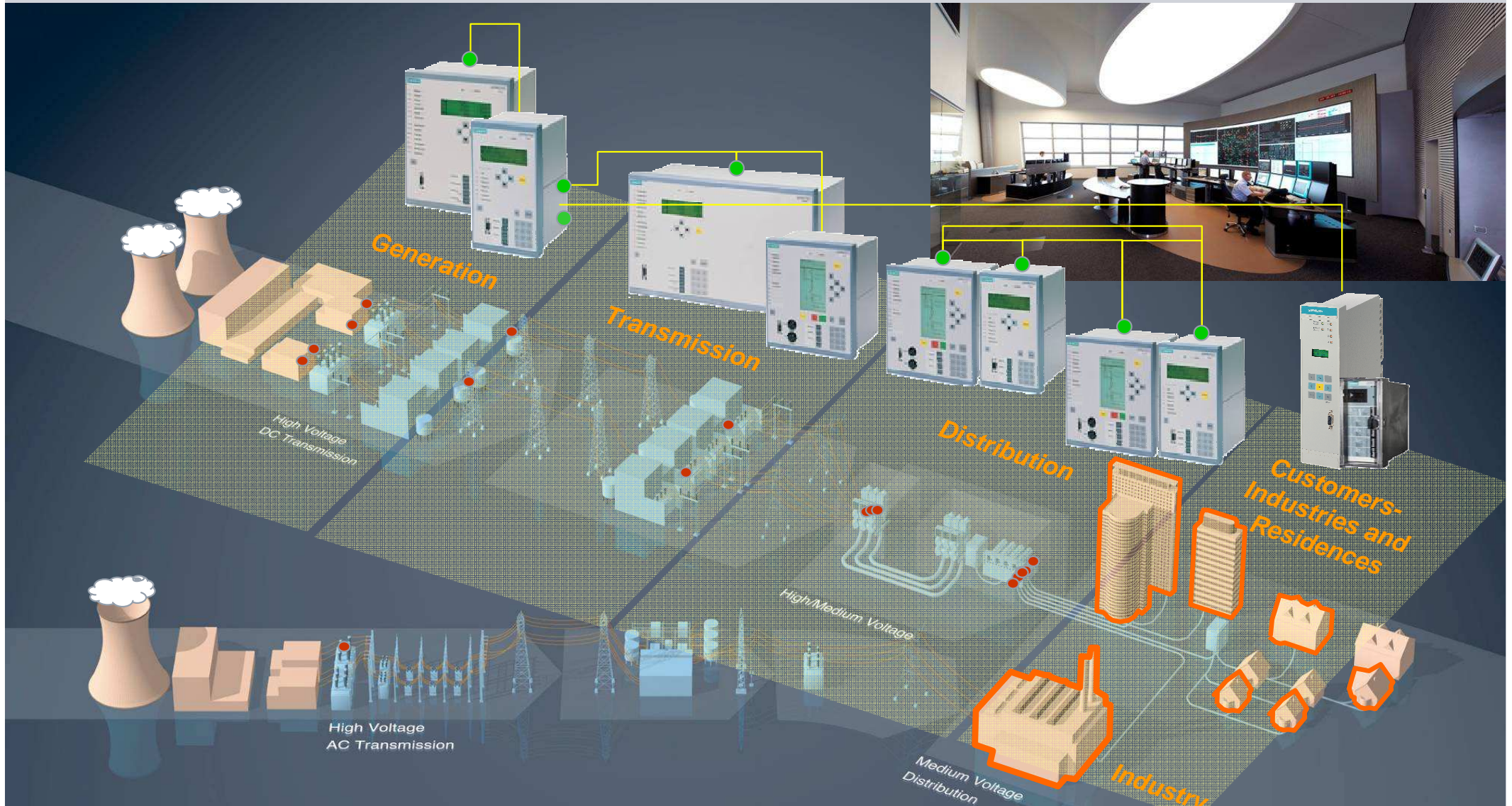
The usage of GIS-systems varies from utility to utility. **Intelligent Technologies** like Change-Detection, Delta-Import, Auto-Display-Builder help to improve **engineering efforts** for GIS-Integration

### Standards & Services (SOA)

Compliance with **standards** leads to more **robust solutions** and **increased openness** for utility-IT Integration with a Service Oriented Architecture. The basis is CIM / IEC61970 (EMS-Power Grid) and IEC 61968 (System Interfaces for Distribution)

# Fit for the Smart Grid ...

## ... with integrated solutions for Grid Control Center



# Thank you for your attention!