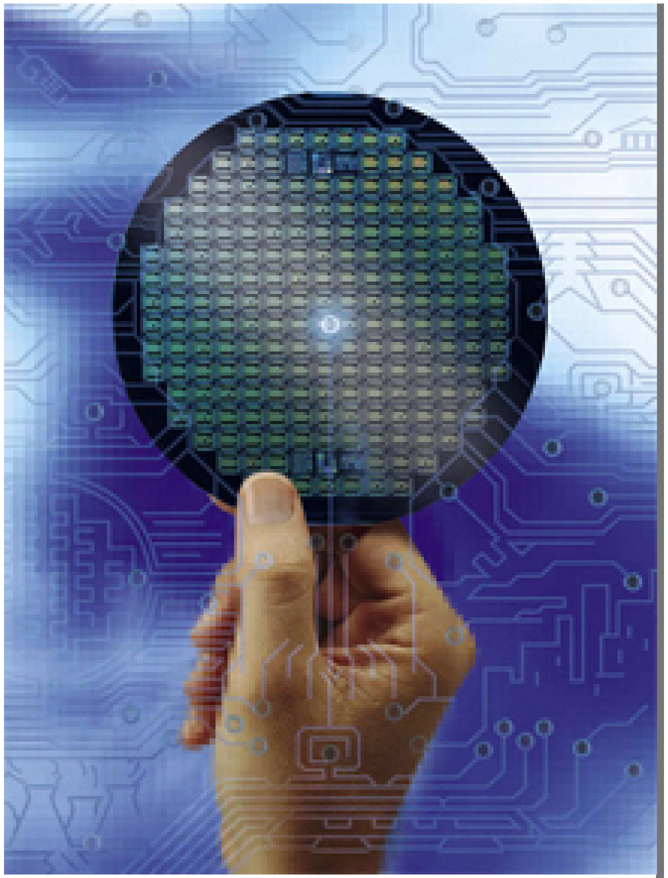

CEIDS

Integrated Energy and Communications Systems Architecture (IECSA)

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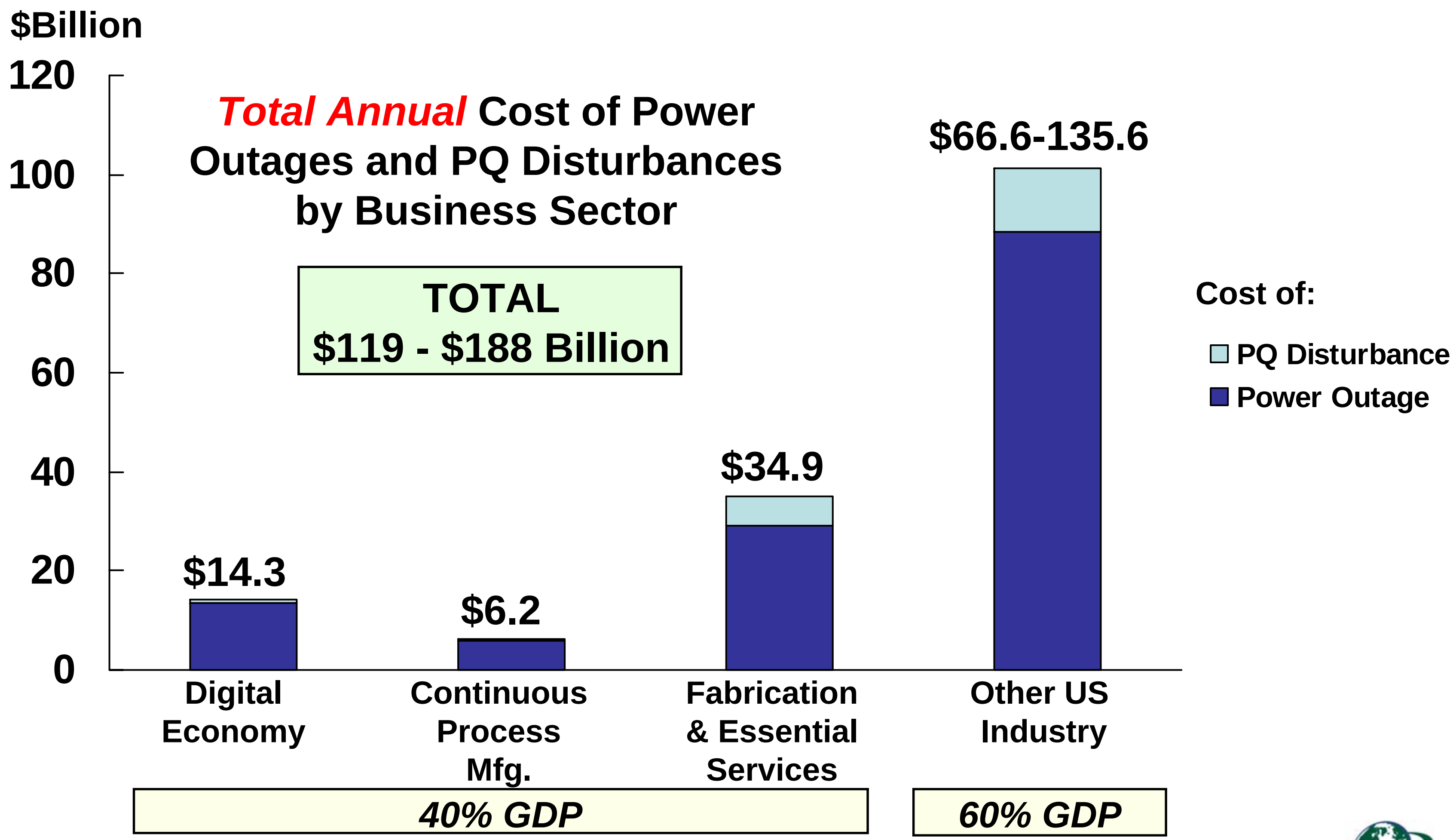
Poor Power System Reliability: A Toll Felt Throughout the US Economy



Source: Primen Study: The Cost of Power Disturbances to Industrial & Digital Economy Companies

The Electric Grid Faces Real Challenges

Infrastructure Constraints

Grid Constraints
Operational Constraints
Market Constraints
Aging Infrastructure

Vulnerability

Security
Maintenance
Vandalism

Natural Disaster

……. Acts of God

Stability of the grid ………….. Ongoing challenge

The 2003 Blackout Was a Wakeup Call

Safety, social, economic, and political impacts

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Contributing Factors to the Blackout

Infrastructures

- Inadequate methods for security assessment
- Lack of a unified grid operational view
- Lack of remotely executable preventive control actions
- Inadequate communication infrastructure

Applications

- Inefficiency of security constrained dispatch
- Inadequate sizing and design of under-frequency under-voltage load shedding
- Lack of means for adaptive automated service restoration

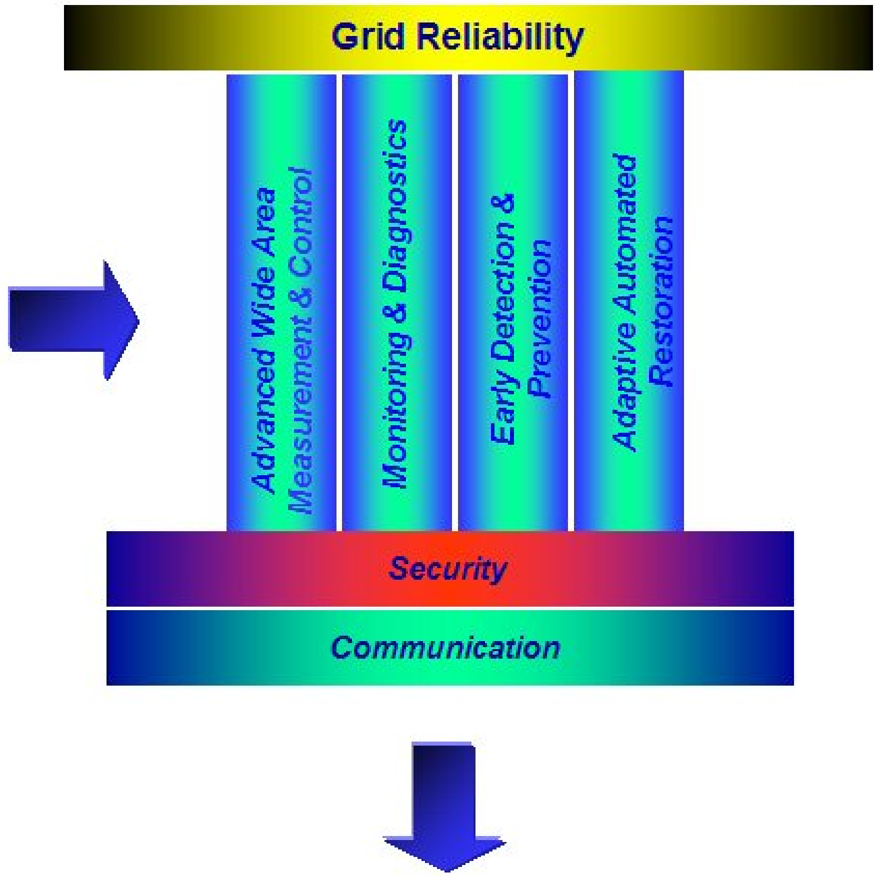
Grid

- Lack or under-utilization of distributed generation
- Lack or under-utilization of adaptive control and remote monitoring
- Lack or under-utilization of intelligence devices

Challenge to eliminate deficiencies – Overall approach is essential

Fundamentals of Grid Reliability

- Proactive failure detection
- Self-healing grid
- Dynamic consumer interface



The key to reliability ….. proactive diagnosis and reactive healing

Requirements for Grid Reliability

- Remote monitoring
- Early detection & decision support
- Prevention & recovery
- Fault isolation & restoration
- Crew management
- Emergency backup
- Transfer of authority

Grid reliability = grid rehabilitation – protective + preventive
+ modern integrated energy and communication infrastructure

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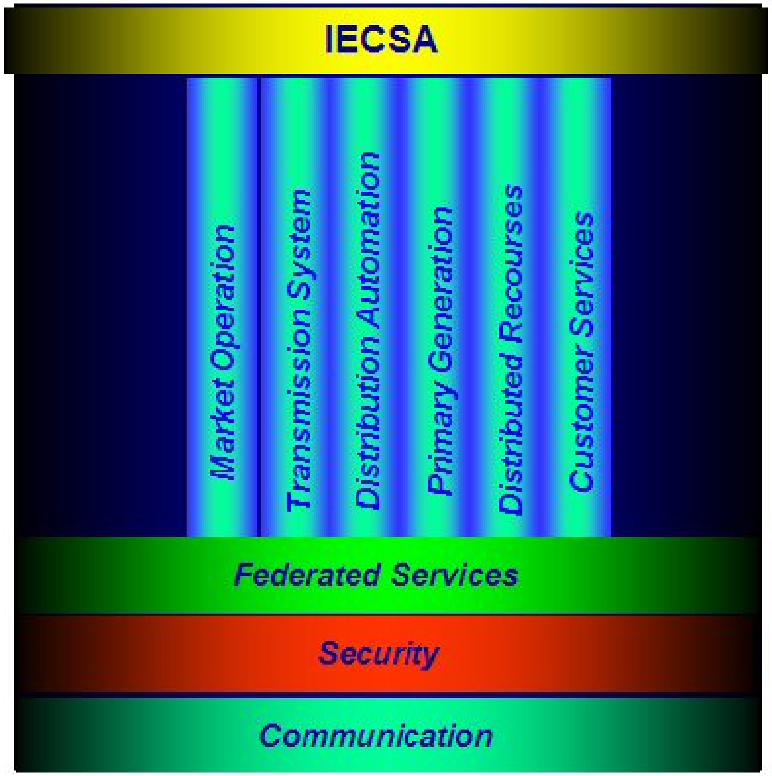
A New Culture is Needed for Grid Reliability

Emerging needs for an Integrated Energy and Communication System Architecture (IECSA)

*A next generation power system consisting of automated transmission and distribution systems supporting efficient and reliable power system operations and handling emergency conditions with automated **"self-healing"** actions, while at the same time responding to the present and future utility business enterprise, energy market place requirements, and end-customer needs*



IECSA: Making the grid smart enough to react to problems before they spread

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What is IECSA?

A next generation power system consisting of automated transmission and distribution systems that support efficient and reliable power system operations and handle emergency conditions with automated "self-healing" actions, while at the same time responding to present and future utility business enterprise, energy market place requirements, and end-customer needs.

IECSA is an open, standards-based set of blueprints for integrating the data communications networks and intelligent equipment necessary to support the power delivery infrastructure of the future to meet the demands of a digital society.

The IECSA Concept

Tomorrow's Utility Network

The Self-Healing Grid

- Optimization in real-time
- Intelligent islanding
- Simulation and modeling
- Online contingency analysis
- Network-level visualization
- Asset management
- Wide-area monitoring & control

Integrated Consumer Communications

- Load management
- Real-time pricing
- Equipment monitoring
- Customer-sited generation
- In-building networks
- Power trading and marketing
- Micro-grids

Integrated Energy and Communications Systems Architecture

Project Background

- New computing and communications technologies have significant potential for improving utility operations however…
- An open industry-wide distributed computing infrastructure for integrating intelligent equipment is not complete…
- Portions of infrastructure have been under development but significant gaps exist …

Integrated Energy and Communications Systems Architecture

Background: Needs…

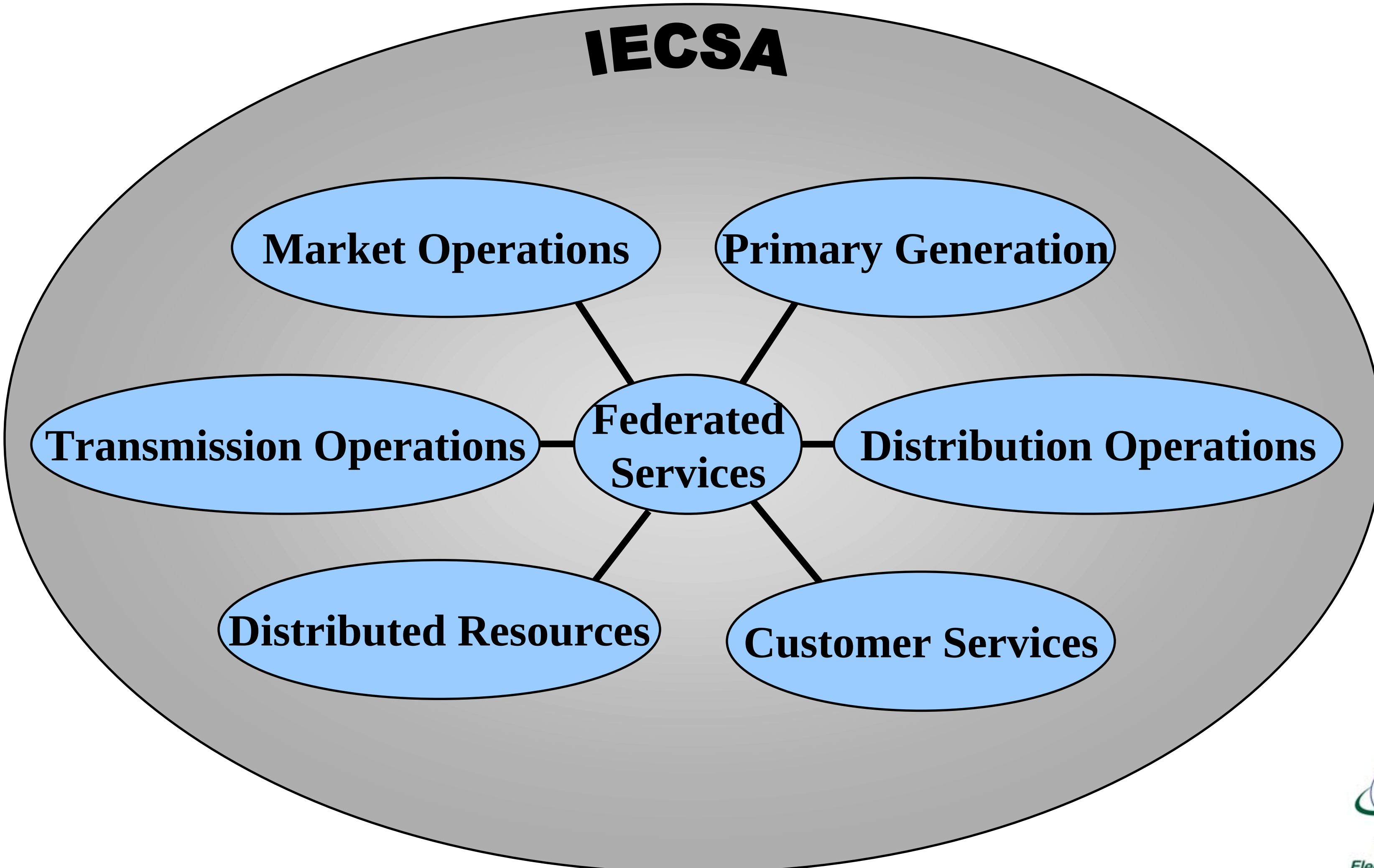
- A robust overall technical architecture for data communications and equipment interoperability
- Vendor-neutral, based on open systems and industry standards
- Built upon related ongoing and industry infrastructure and standards work
- Apply latest advancements in systems engineering approaches

Integrated Energy and Communications Systems Architecture

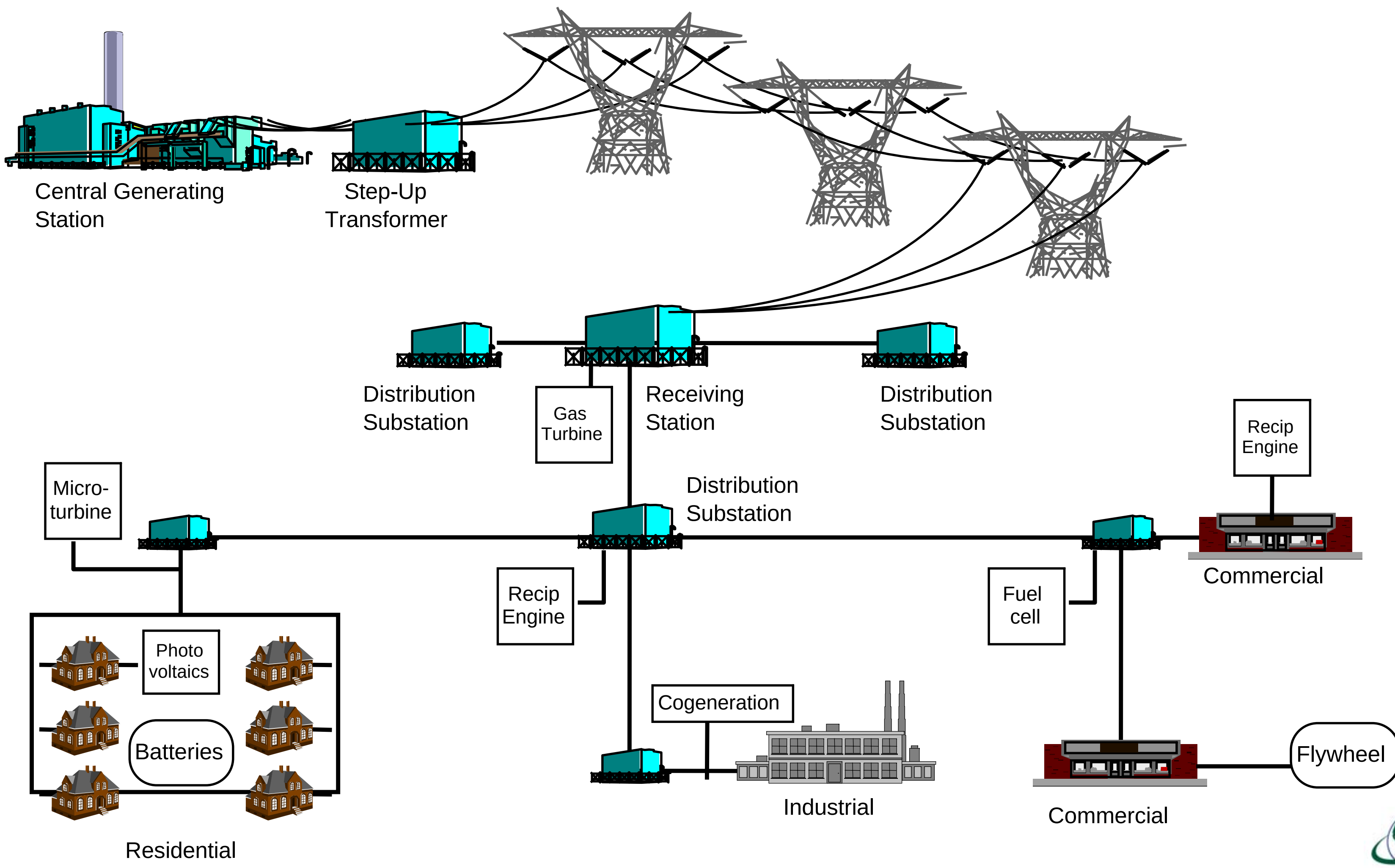
Objectives

- Develop a complete set of system requirements for the future power system and connecting consumers to energy markets
- Define an overall system architecture based on analysis of the requirements
- Evaluate proposed architectures and develop recommendations for next phases
- Contribute to relevant standards development organizations as appropriate

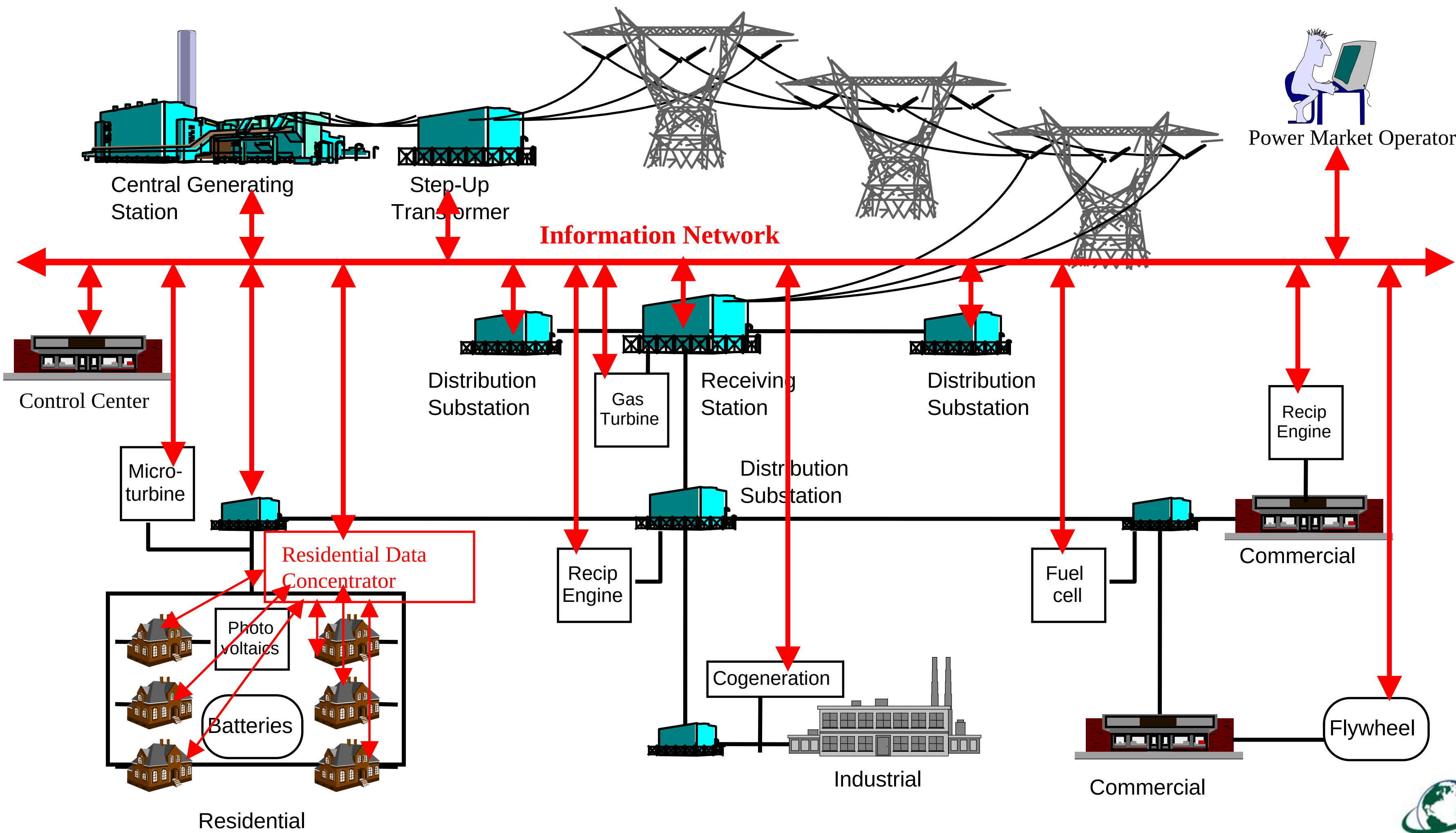
Scope of IECSA



Dual Infrastructure: Power System Infrastructure



Dual Infrastructure: Power System Infrastructure and Information Infrastructure



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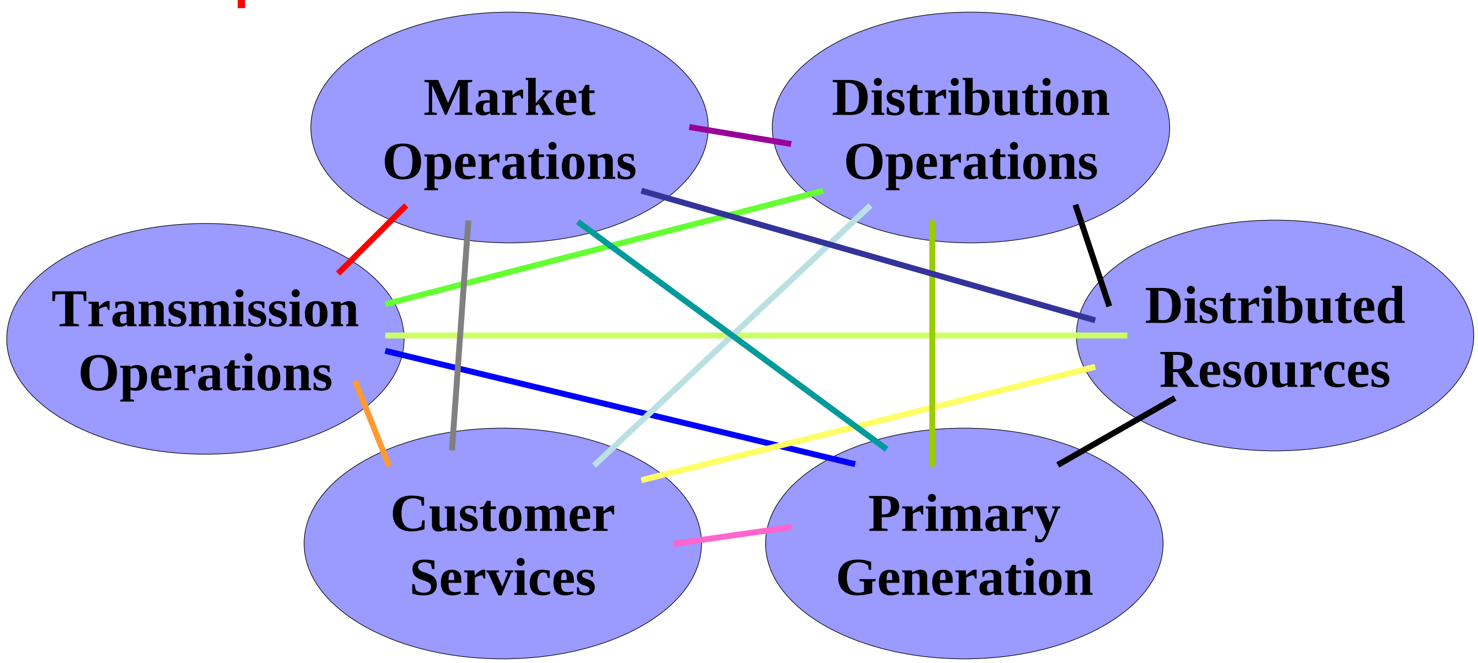
Why Do We Need an Architecture?

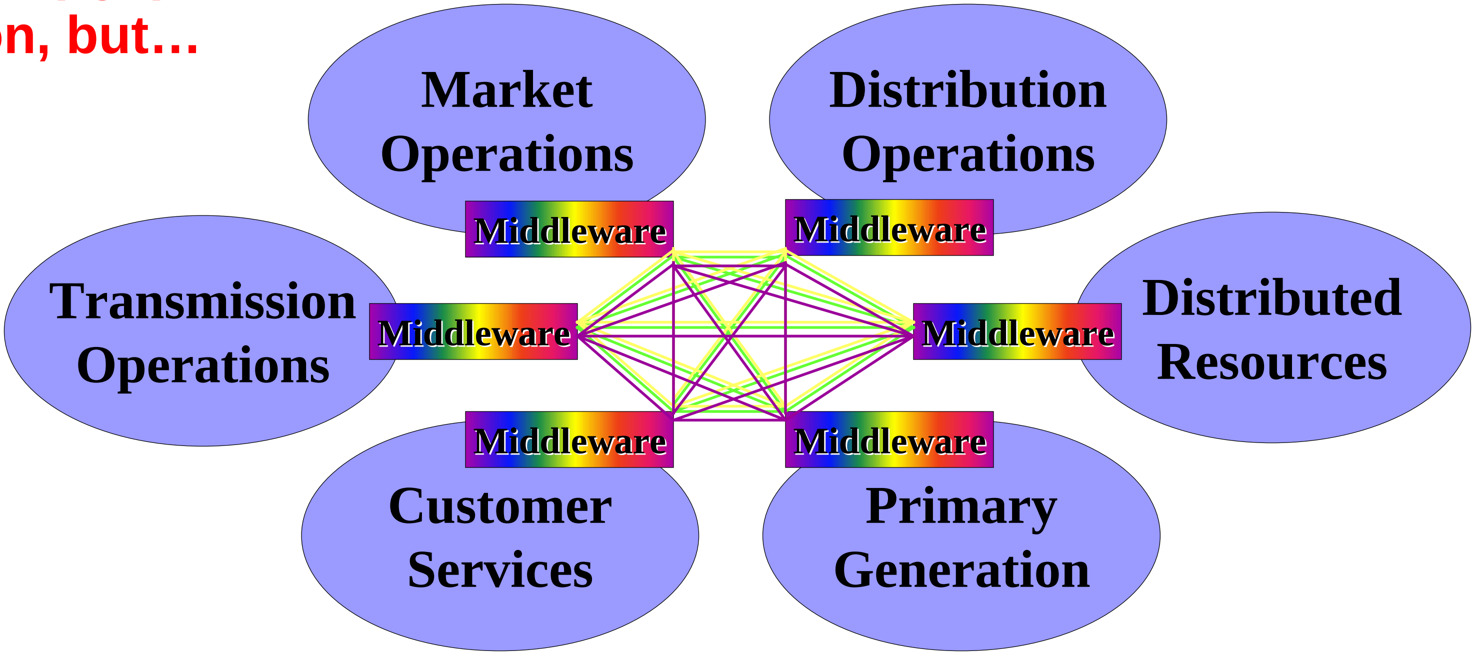
Lack of interoperability creates a huge integration problem!



- Everything must know how to talk to everything else
- Culminating explosion of complexity
- System integrators find many solutions for the same thing – no consistency – no leveraging of knowledge

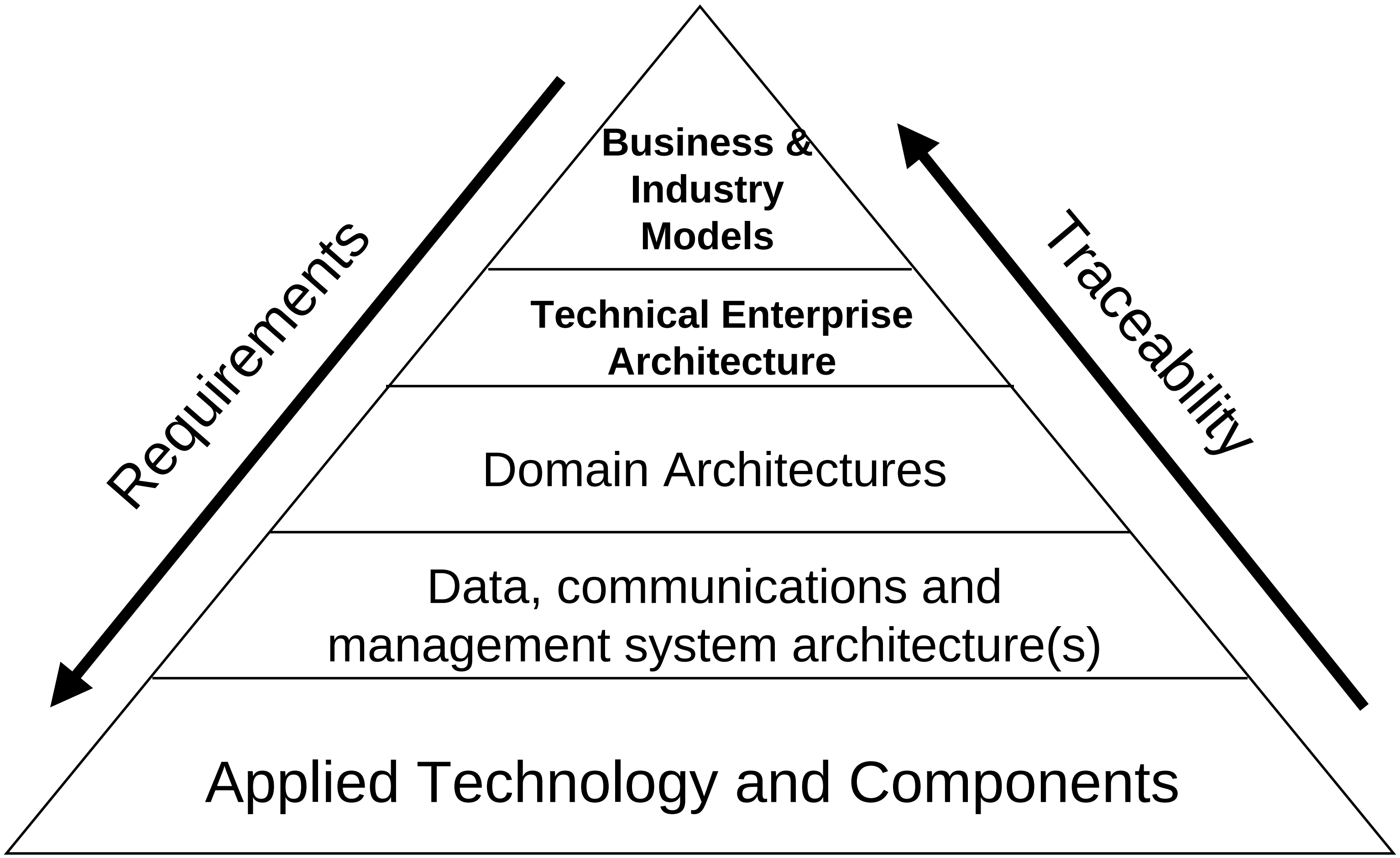
The Status Quo Functions (Sort Of)

"Middleware" is a good stopgap solution, but…



- Interoperable does not always mean interworkable
- Incompatibility between vendors sometimes exists
- Incomplete or ambiguous requirements often lead to poor system integration solutions

IECSA has an Architecture Development Focus



IECSA Will be an Integrated Architecture

Self-Healing and ***Adaptive***

Interactive with consumers and markets

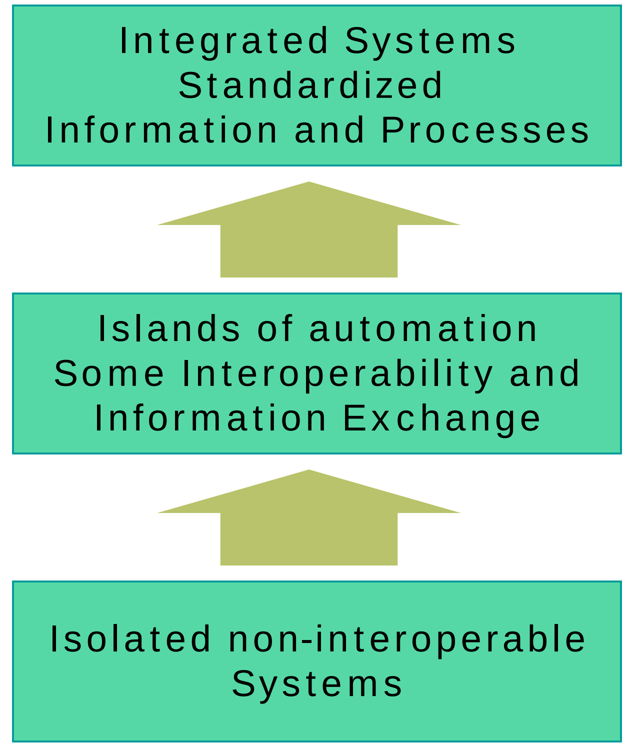
Optimized to make best use of resources and equipment

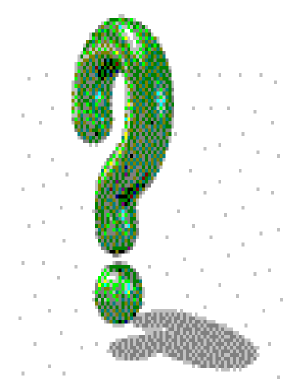
Predictive rather than just reacting to emergencies

Distributed across geographical and organizational boundaries

Integrated, merging monitoring, control, protection, maintenance, EMS, DMS, marketing, and IT

Secure from attack - Some utilities implement these functions now, but not on a wide enough scale to address the needs of the grid as a whole.





How is the Architecture Being Developed?

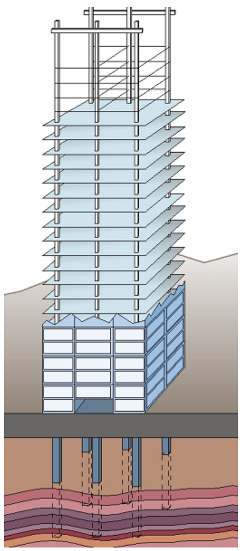
Identify
•Stakeholders
•Applications
•Domains

Functional Requirements

Analysis

Architecture Design

Example of a Building:



•Owners, workers, Firemen, cafeteria, etc..

•Emergency vehicle access, possibility to have lunch…

•Structure of the building, electrical, data & comm., HV&AC, etc…

•Capacity: 5000 people
  •Each person has: telephone, internet, electricity etc…
•1 bathroom for 10 people
•…

•Minimum 37 floors
•6 bathrooms per floor
•Access 30 ft large
•Water pipes 8inch. diam.
•…

Blueprints for Plumbers, Electricians, Carpenters
…

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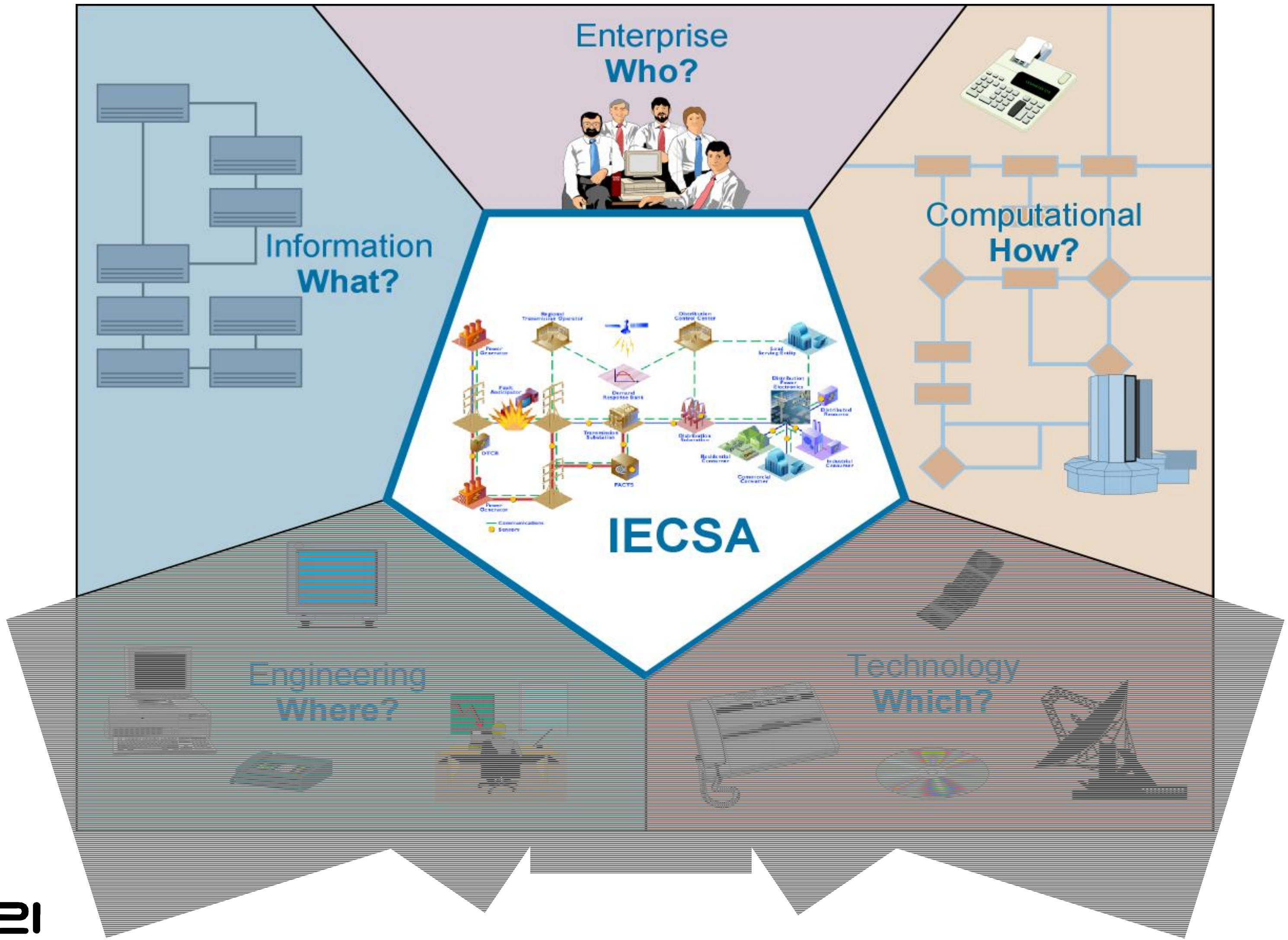
IECSA Architecture Focus

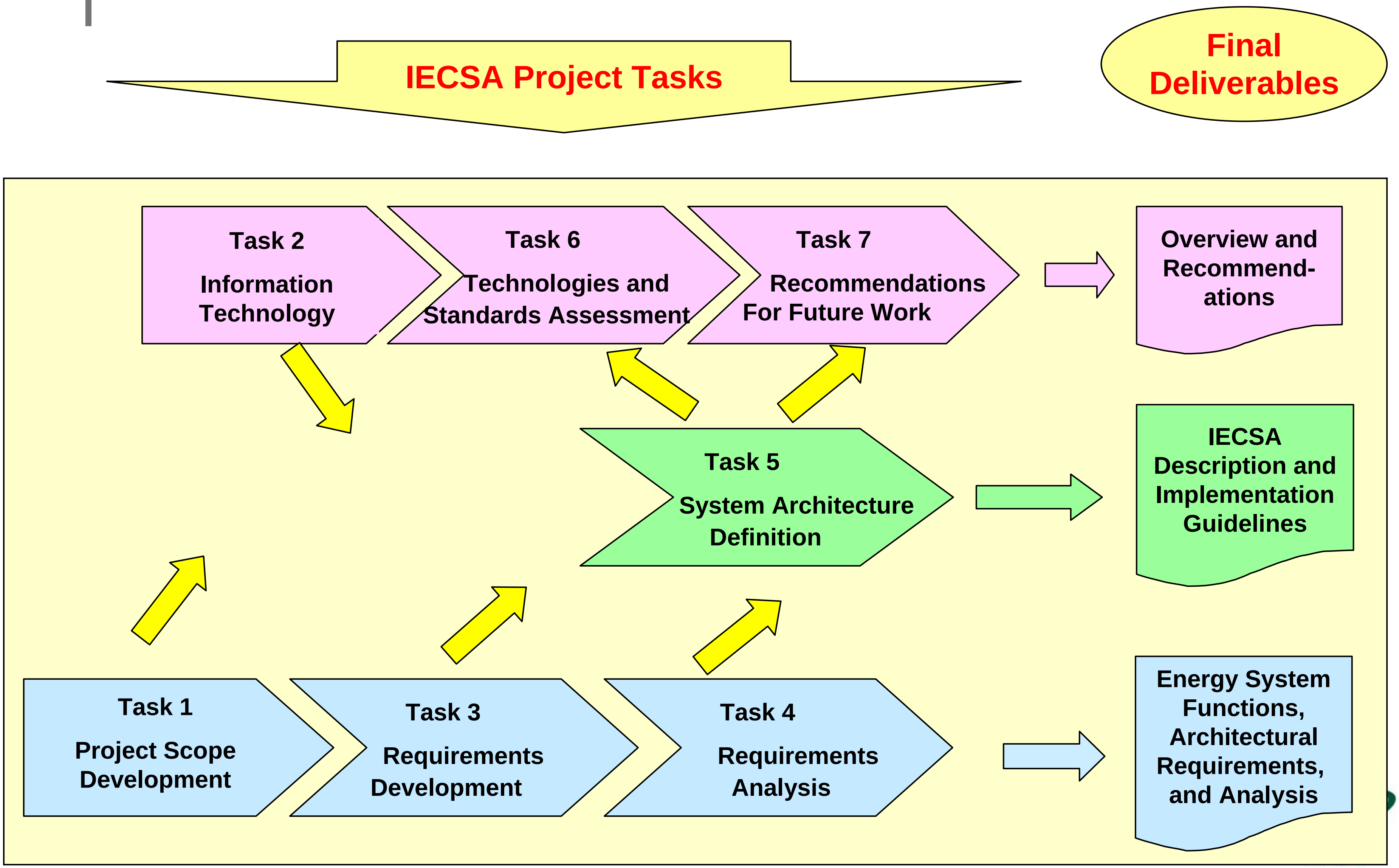


Integrated Energy and Communications Systems Architecture

Approach as Defined in RFP

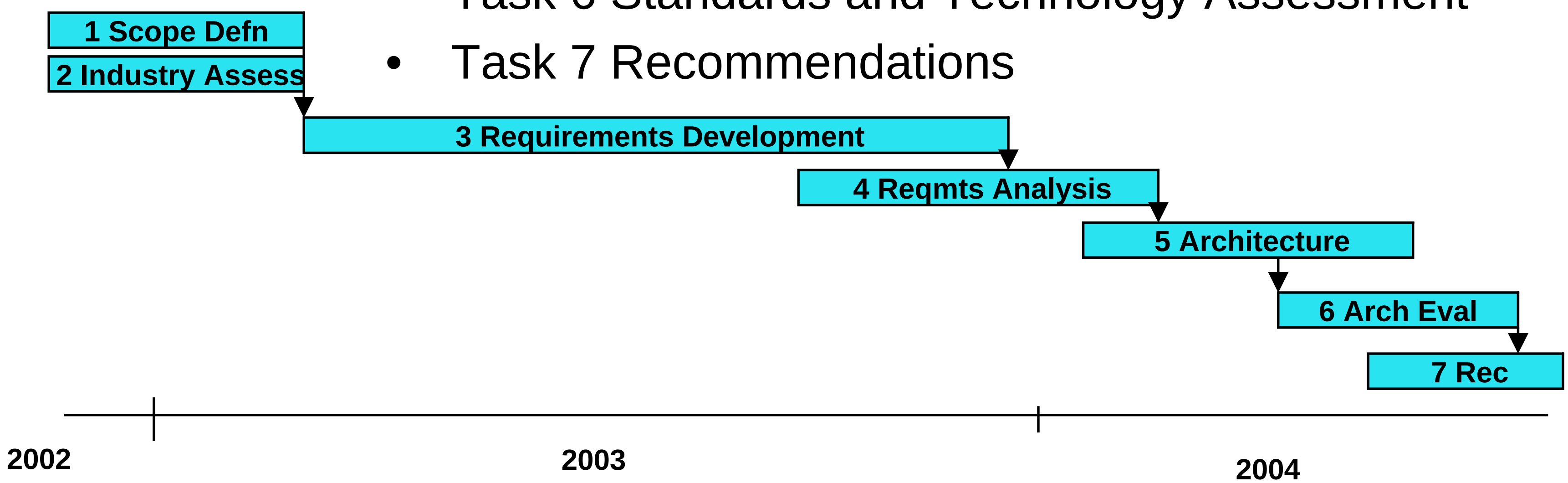
- Task 1 Initial Scope and Stakeholder Definition
- Task 2 Assessment of existing Infrastructure Development
- Task 3 Requirements Development
- Task 4 Requirements Analysis
- Task 5 Architecture Definition and Analysis
- Task 6 Standards and Technology Assessment
- Task 7 Recommendations

IECSA Overall Process Flow



Integrated Energy and Communications System Architecture Project Schedule

- Task 1 Initial Scope and Stakeholder Definition
- Task 2 Assessment of Existing Infrastructure Development
- Task 3 Requirements Development
- Task 4 Requirements Analysis
- Task 5 Architecture Definition and Analysis
- Task 6 Standards and Technology Assessment
- Task 7 Recommendations



Integrated Energy and Communications Systems Architecture

Prior Industry Work to Integrate/Build Upon

- Utility Communications Architecture (UCA®) foundation work and field trials
- IEC TC 57 Working Groups: 9-16
- IEEE SCC-36,21,22,31 PES and CS
- ANSI C12 series, X12,
- EPRI/DOD Complex Interactive Networks
- Object Management Group (OMG) Utilities TF
- ISO JTC1 WG 25, CMU/SEI, INCOSE, EIA
- ASHRAE SPC135
- Other

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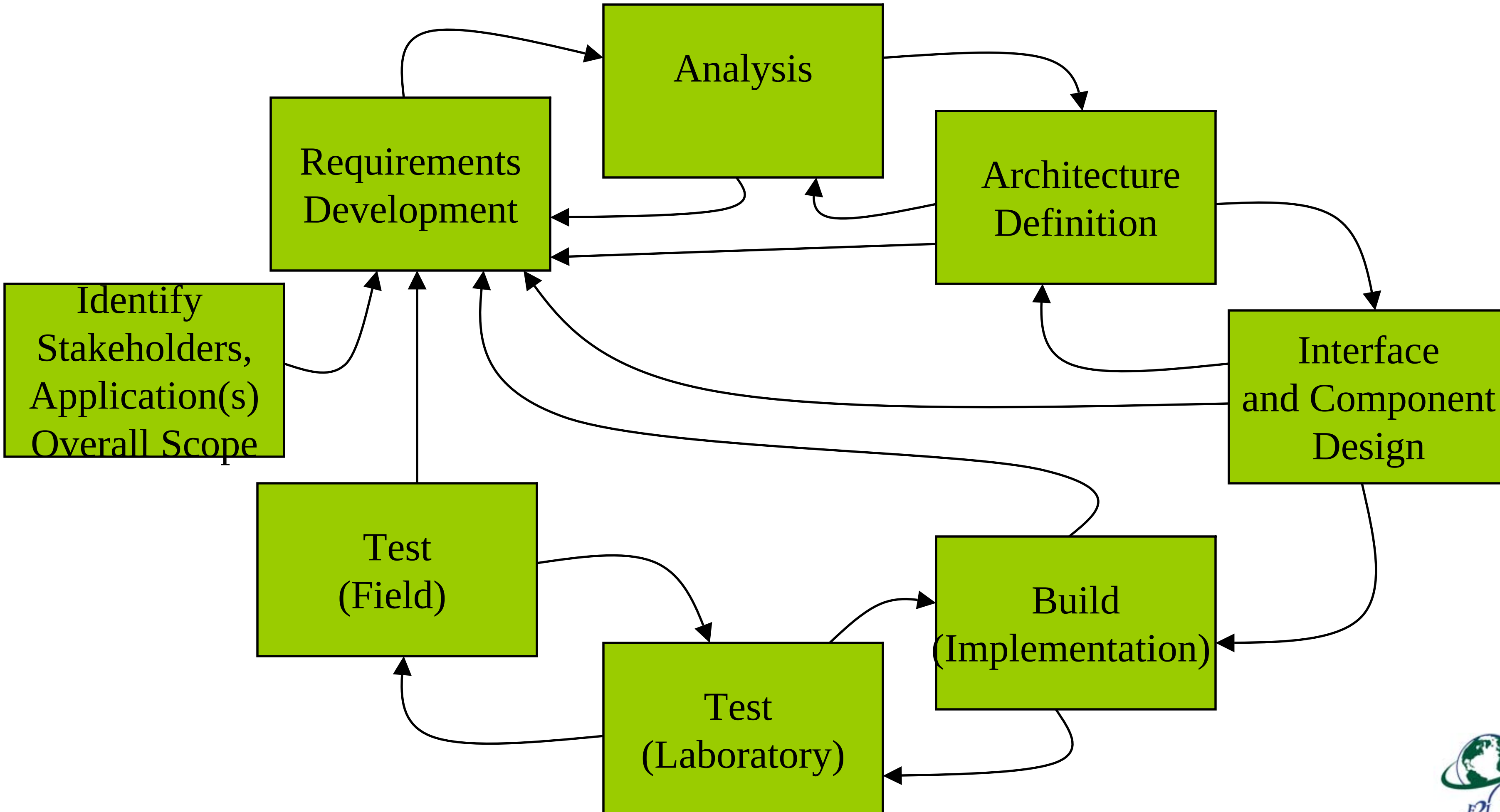
Systems Engineering Processes



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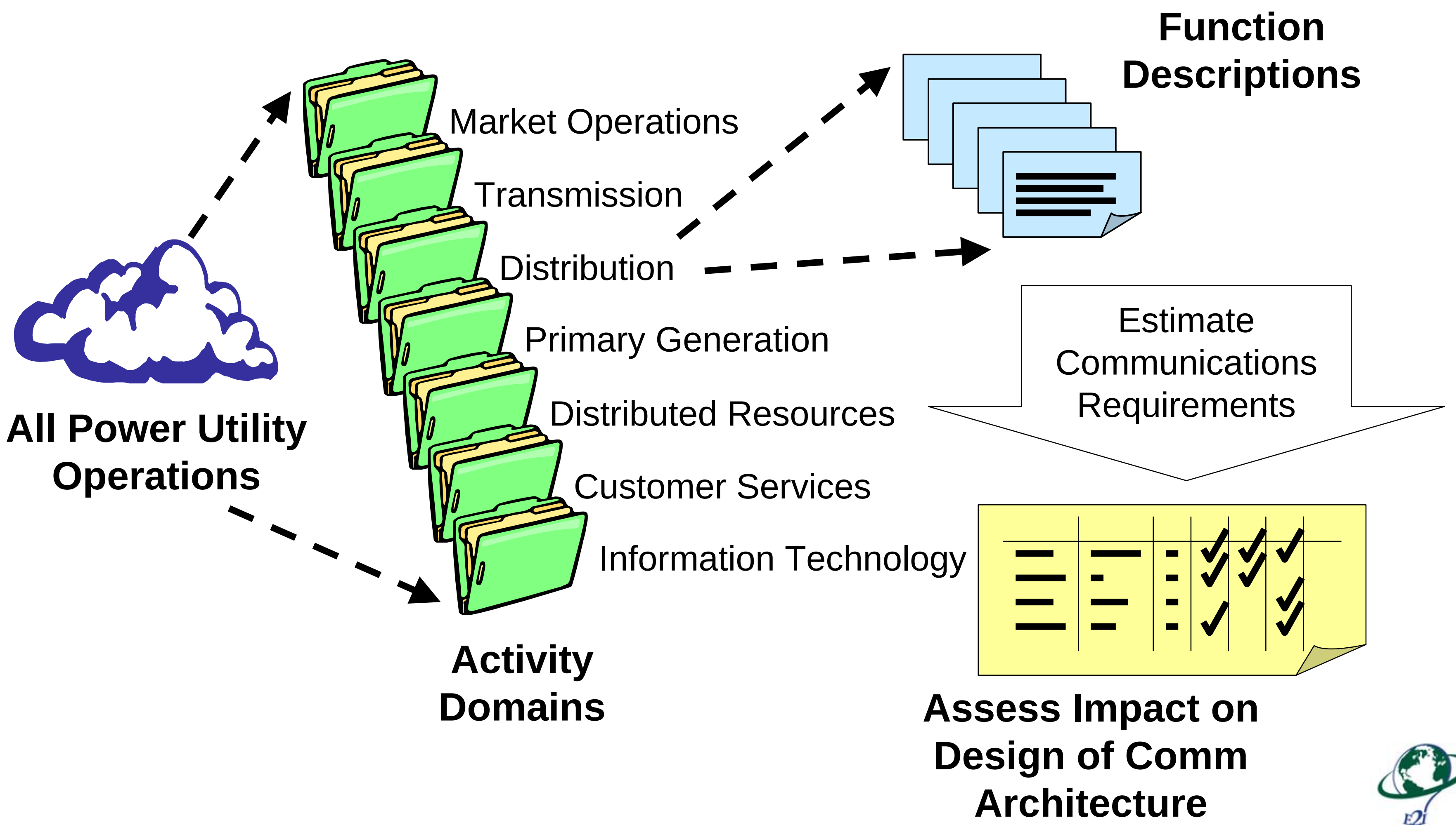
IECSA Task 1 – Process

- **Define the scope and identify priorities**



IECSA Task 1 Methodology

- Develop a high-level process for capturing and describing all of the functional and system management requirements of electric energy operations
  - Organize operations into domains (e.g. market operations)
  - Identify all functions (e.g. distribution automation, generation dispatch) that are/will/could be used for operations
  - Describe each function very briefly
  - Identify key interfaces between entities for each function
  - Determine all system management requirements (data management, security, etc.) for supporting each function
- Evaluate and rate the impact of each functional and system management requirement on the design of an architecture
- Identify and briefly assess those functions that could have significant impact on architectural designs

Task 1 – Analyzing Function

***Day Ahead Market:** Energy Marketers Submit Day-ahead Energy Schedules*

Enterprise Activity Spreadsheet

PURPOSE of SCHEDULING COORDINATORS SUBMIT DAY-AHEAD ENERGY SCHEDULES function
IS TO for Scheduling Coordinators or other entities to submit 24-hour energy schedules in the Day-Ahead market, and the RTOs/ISOs to validate the submittals (depending on market design),
DIRECTLY INVOLVING Scheduling Coordinators (or other entities), RTOs/ISOs, Auditors, Other Market Participants,
PERFORMING Energy schedule submittal and validation,
WITH KEY INTERFACES between
1. Scheduling Coordinators and RTOs/ISOs
2. RTOs/ISOs and neighboring RTOs/ISOs
3. RTOs/ISOs and Web Server for Market Participants,
WITH COMMUNICATION CONFIGURATION REQUIREMENTS of One to many WANs (probably Internet-based) between RTOs, Scheduling Coordinators, other Market Participants, Regulators, and Auditors,
WITH COMMUNICATION SERVICE QUALITY REQUIREMENTS of High availability, rapid response, high data accuracy, and high data frequency needed for interactions between RTOs and Market Participants to ensure fairness in any energy scheduling process,
WITH SECURITY REQUIREMENTS of High security in all areas because of fairness requirements with market rules and financial implications,
WITH DATA MANAGEMENT REQUIREMENTS of Large database for energy schedules, requiring timely access, frequent updates, and data exchanges across organizational boundaries,
WITH CONSTRAINTS/CONCERNS of a few special constraints, since WAN connections to Market Participants, but systems and applications are new and/or changing to meet changing market environments.

Analysis Results Range: 0 to 3

- **Configuration = 0** because using pre-existing communication systems and/or the Internet
- **Performance = 3** because timely delivery and response (on the order of minutes) between RTOs/ISOs and Market Participants is critical to meeting market rules.
- **Security = 3** because interactions with Market Participants involves many only partially trusted parties, possibly with connections over the Public Internet.
- **Data Management = 3** because Market Participant characteristics will change frequently and large volumes of new types of data
- **Constraints = 2** because systems and applications are new and/or changing to meet changing market environments

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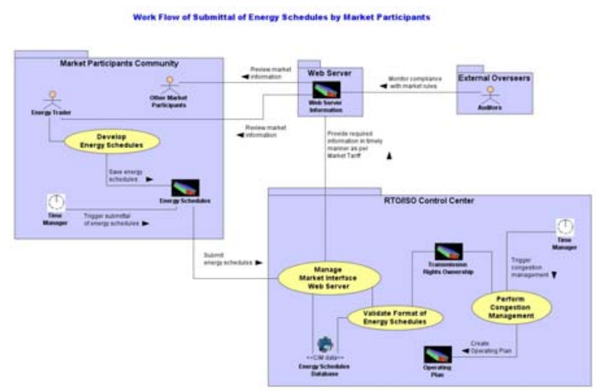
Overview of the Domains

- **Market operations**, including energy transactions, power system scheduling, congestion management, emergency power system management, metering, settlements and auditing.
- **Transmission operations**, including optimal operations under normal conditions, prevention of harmful contingencies, short term operations planning, emergency control operations, transmission maintenance operations and support of distribution system operations.
- **Distribution operations**, including planning and real-time timeframes, optimal operations under normal and emergency conditions, support of transmission system operations, asset management, advanced distribution automation of distribution systems with significant DR penetration.
- **Customer services**, including AMR, time-of-use and real-time pricing, meter management, aggregation for market participation, power quality monitoring, outage management and, in-building services and services using communications with end use loads within customer facilities.
- **Primary generation**, including automatic generation control, generation maintenance scheduling and coordination of wind farms.
- **Distributed resources**, including participation of DR in market operations, DR monitoring and control by non- utility stakeholders, micro-grid management and DR maintenance management.
- **Federated System Management functions**, including bandwidth management, security management, network device configuration, address management, and database replication and management.

Task 1 - Results

- Definition of Project Scope
- Breadth of functions
- Tool Selection
- Collaboration Environment
- Validation of Process
- Examples of Scenarios

Individual Functions



Example of Information Flow
Diagram of Submittal of Energy Schedules

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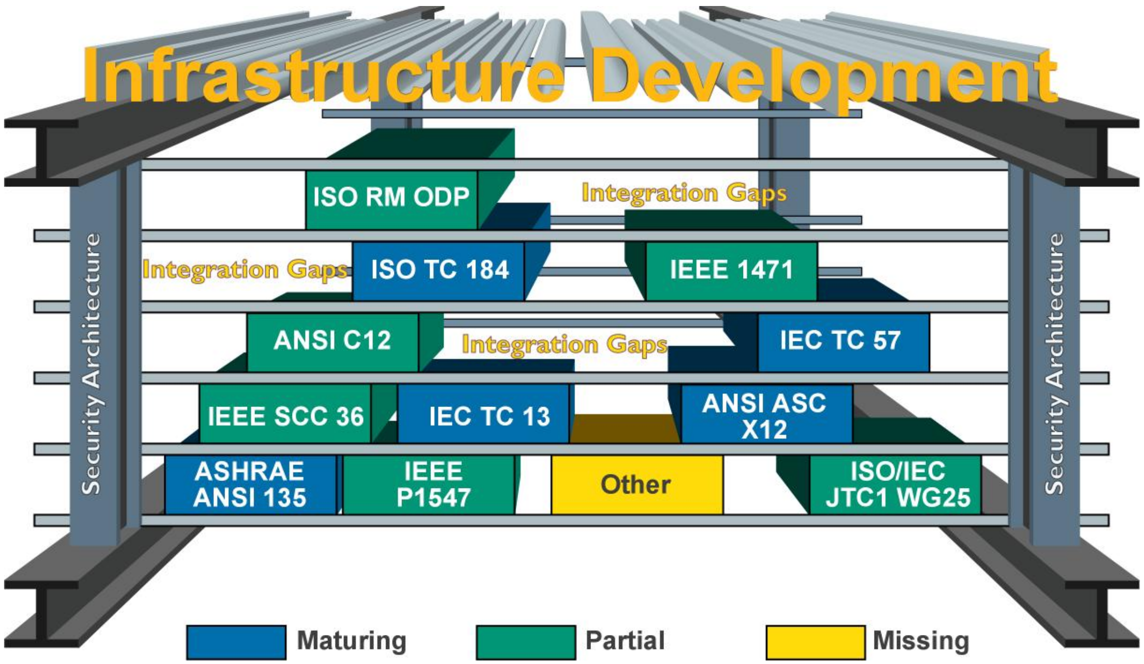
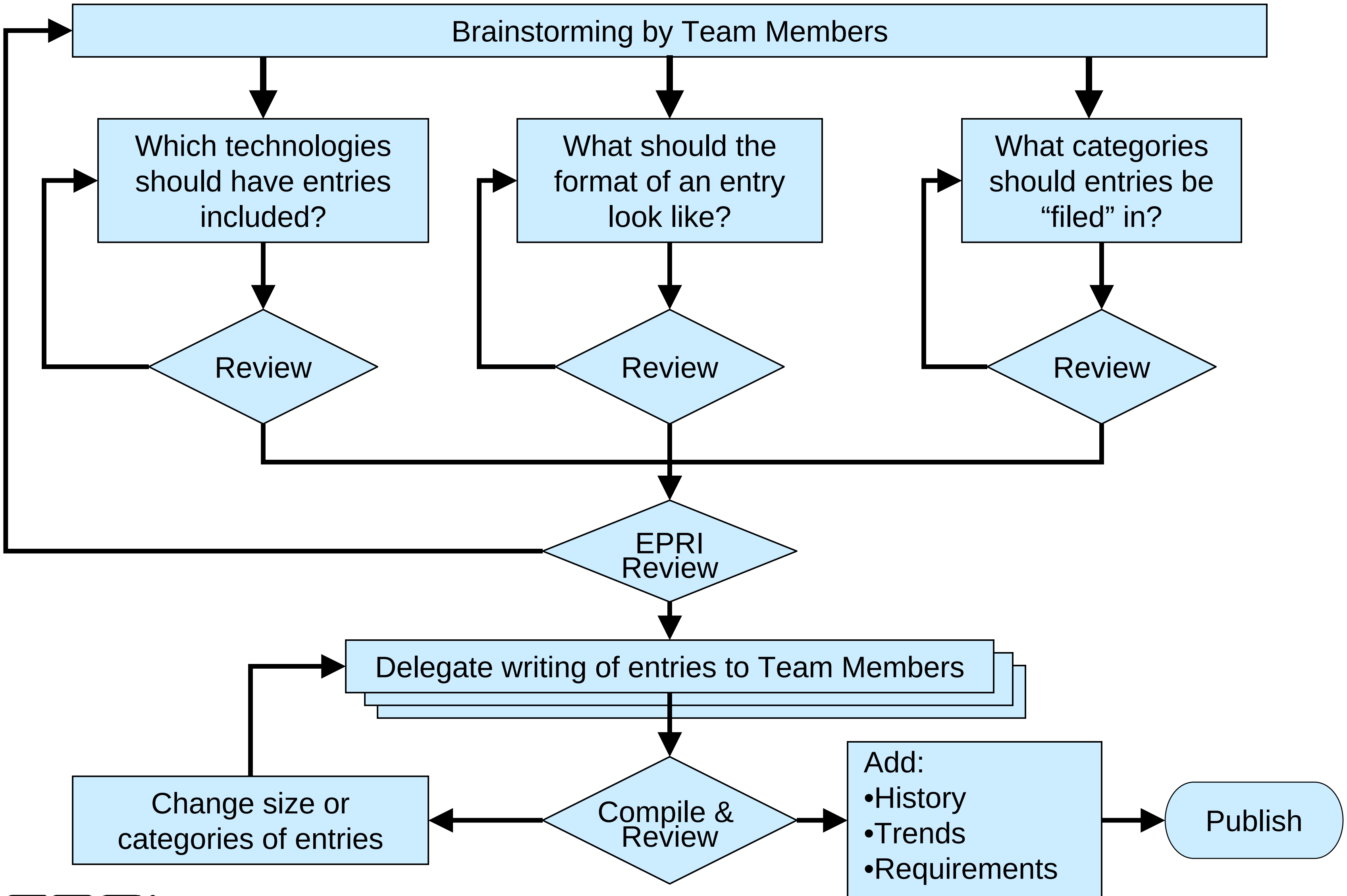
Task 2 – Industry Assessment

- What is the current state of communications technology?
- Which technologies might be suitable for the architecture?
- Which organizations are developing appropriate technologies?
- What is the scope of the work ahead, especially Task 6: Standards Assessment?



Task 2 - Process



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Task 2 - Results

Table of Contents

5.1.2.3. IEEE 802.11 Wireless Local Area Network (LAN)

URL: http://www.wirelessethernet.org/OpenSection/index.asp

Description: This standard provides wireless connectivity to a mobile or portable equipment within a LAN area. The IEEE 802.11 standard specifies both the physical (PHY) and medium access control (MAC) layers of the network. The physical layer can use either direct sequence spread spectrum, frequency hopping spread spectrum, or infrared (IR) pulse position modulation. The MAC layer specifies CSMA/CA protocol. Security is one of the major concerns of wireless LANs in general and this technology in particular. IEEE 802.11a and 802.11b are have data rate of 55 and 11 Mbps respectively. IEEE 802.11b is currently in widespread use. Wireless Fidelity (WIFI) Alliance certifies interoperability of WIFI technology product using 802.11b.

Keywords: LAN, Wireless, Physical layer, MAC layer, Spread spectrum, Infrared, Mobile computing, Technology VP

Task 3 Process and Interim Results

Identify key functions from Task 1 Enterprise Activity Spreadsheet to shine a spotlight on (Cones)

Develop domain template as a guideline for domain experts to provide functional and non-functional requirements, bridging expertise Between power systems and distributed computing systems

Capture requirements of these key functions in the domain template using IECSA Team and Stakeholder domain experts. Make sure to Identify architecturally significant issues for analysis in Task 4

Iteratively refine the information captured until both power engineering and distributed computing experts are satisfied with the details of the Enterprise Activity requirements and architectural issues.

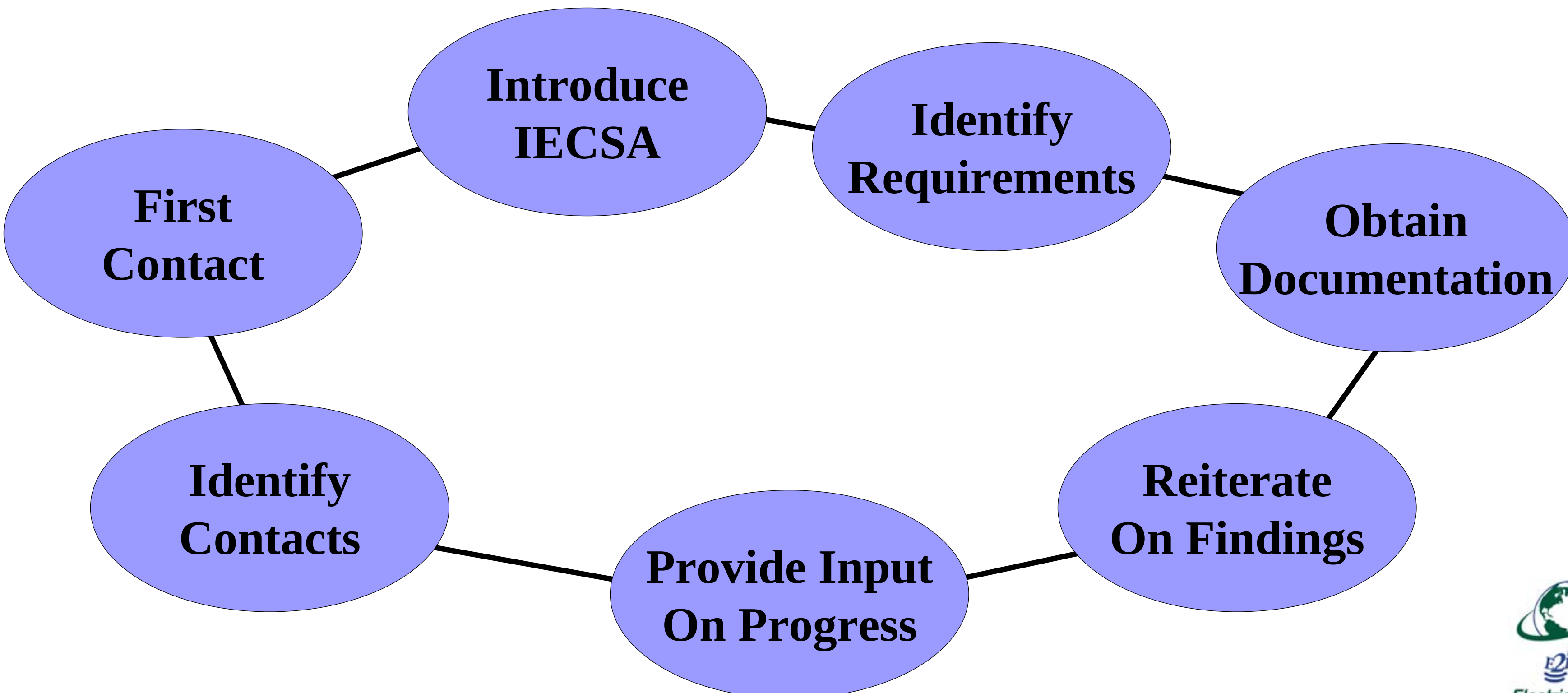
Develop functional and information flow diagrams of these key Enterprise Activities

Document the results to be reviewed by stakeholders and used in Tasks 4+.

Task 3 - Stakeholder Engagement

Process under way

- Covers breadth of stakeholder communities
- Priority is identifying those who can
  - complement current analysis
  - provide quality input on analyses



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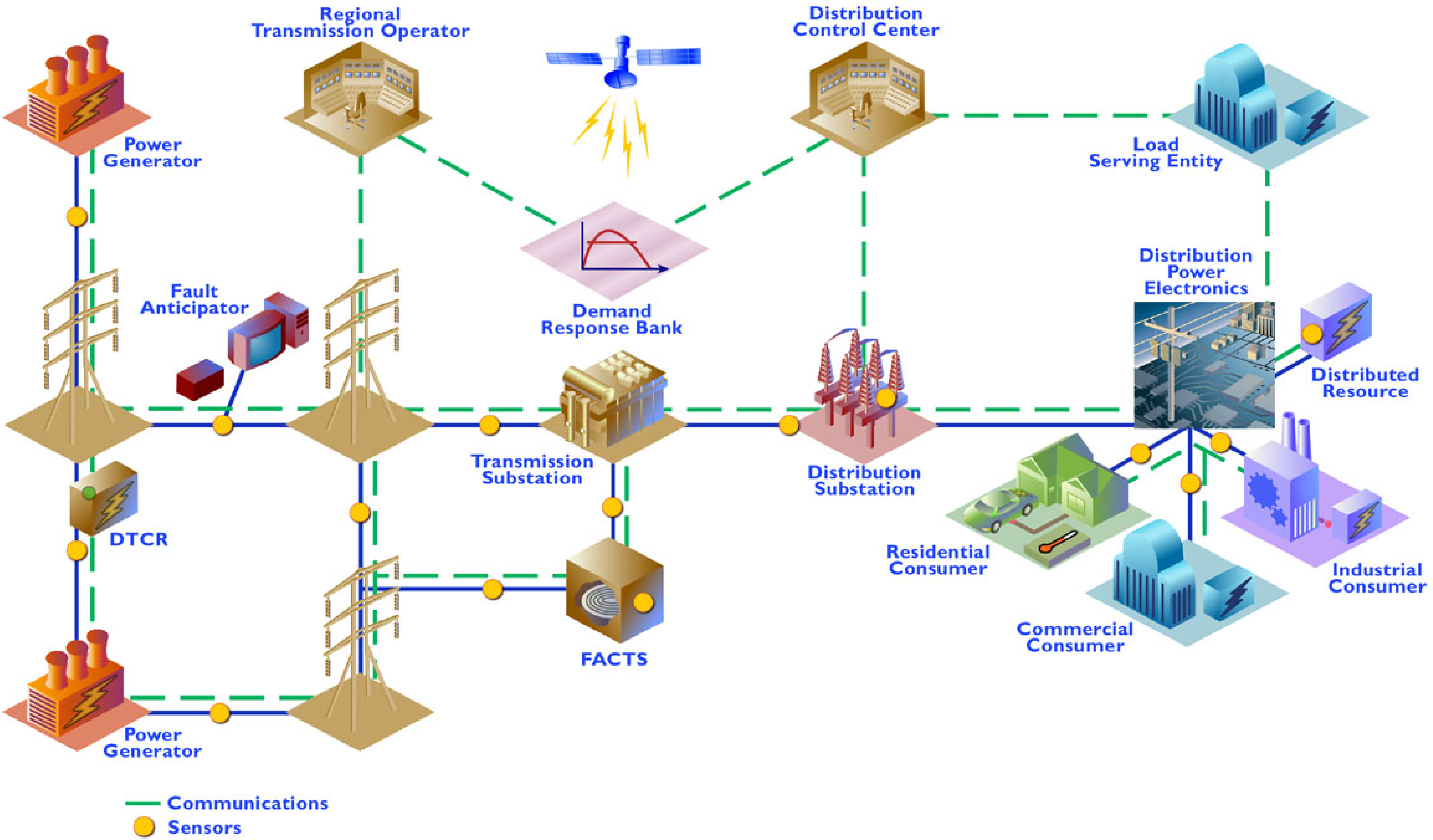
Stakeholder Targets

- Business: Project funders, government (GSA, DOD), utilities, vendors
- Regulatory: PUCs, FERC, NERC, FBI, NIST
- Technical perspective input
  - Standards participation colleagues – esp. utilities
  - User group participants
  - Selected organizations (NIST, NSA, DOD, GTI)
  - Standards outside of traditional “utility”…(ITU, API, …)

Focusing on the Electric Grid



Wide Area Protection and Control

State Measurement

EMS applications for self-healing grid

Data Synchronization & Control Coordination

Input Data:

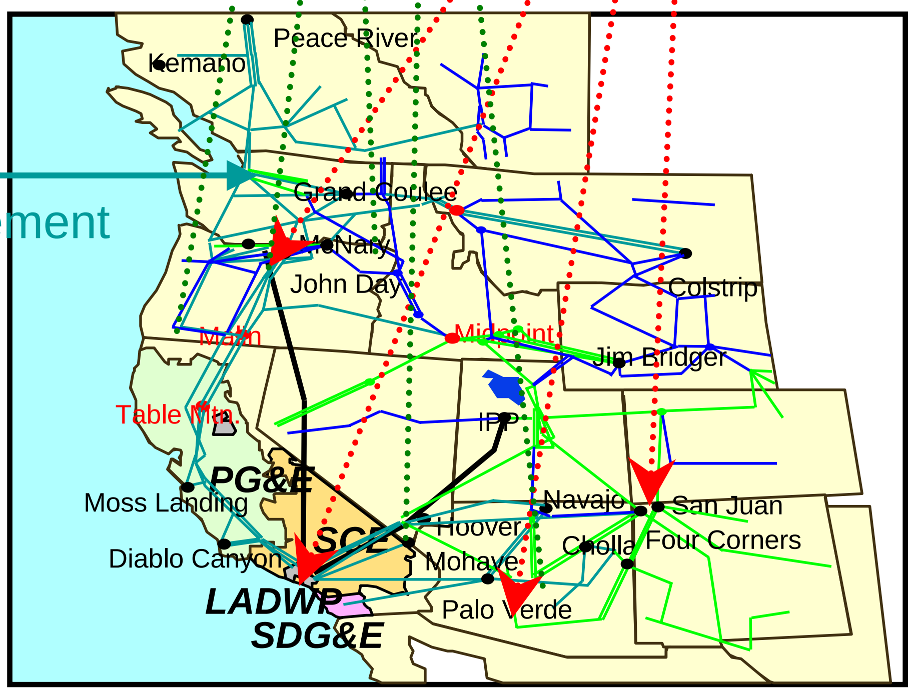
- 12-60 Phasors/sec
- Control Range
- Control Device Status

Wide Area Control

- Operate Point change
- Linear Control
- On/Off

C O N T R O L

Phasor Measurement Units



Transmission Paths

- 500kV Lines
- 345kV Lines
- 230kV Lines
- DC Lines

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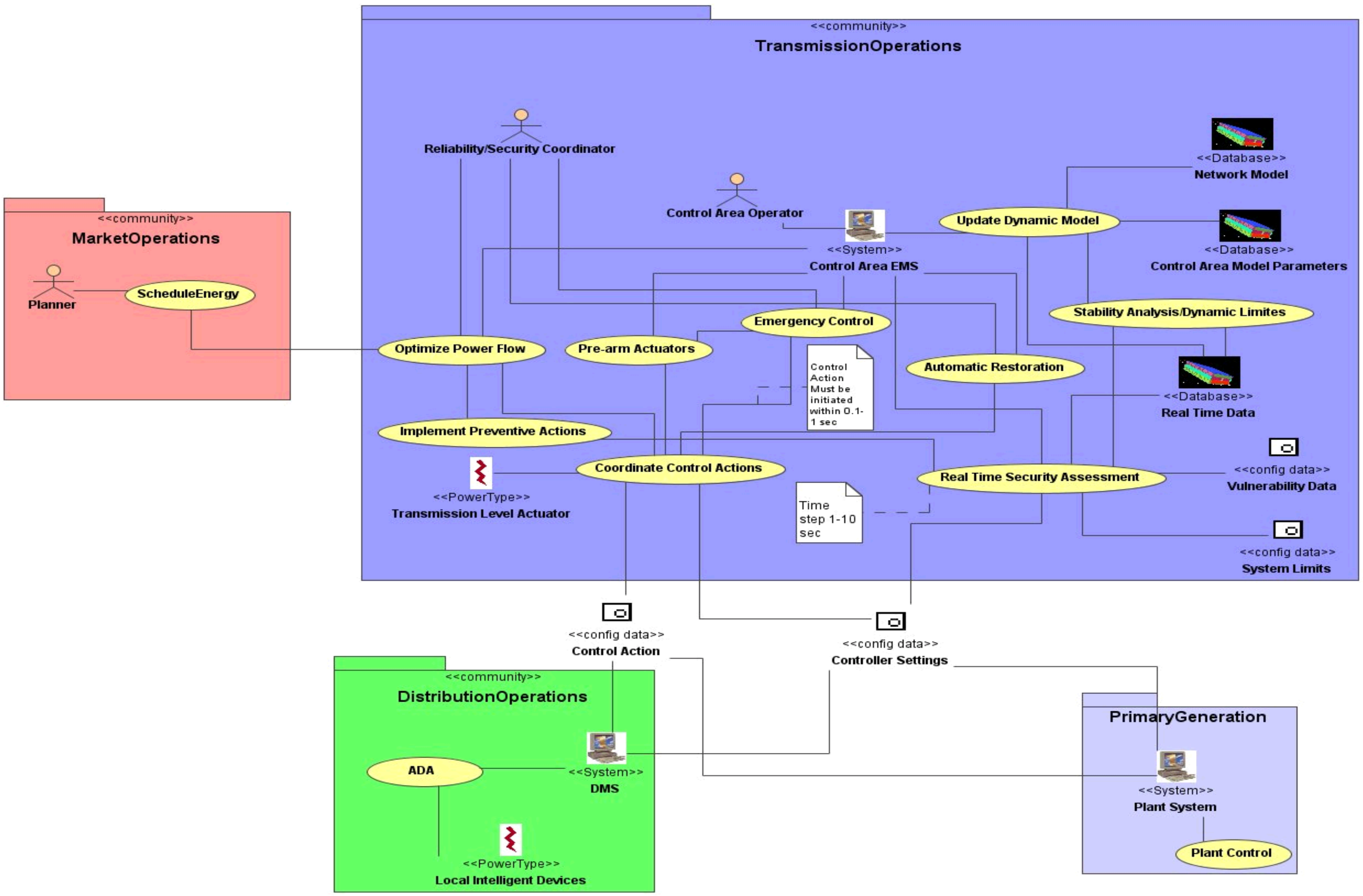
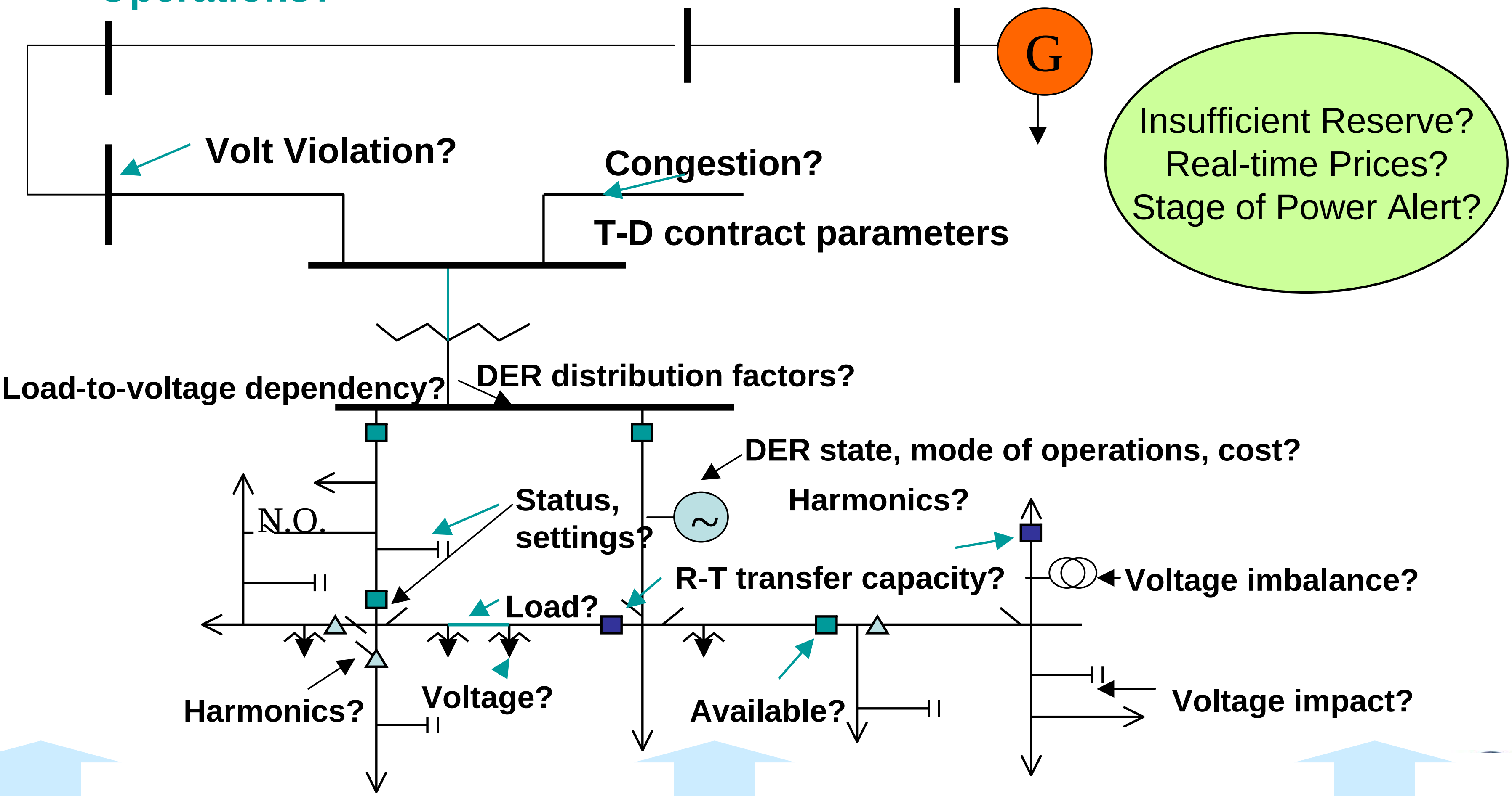
WACS-WAMS Information Flow Diagram



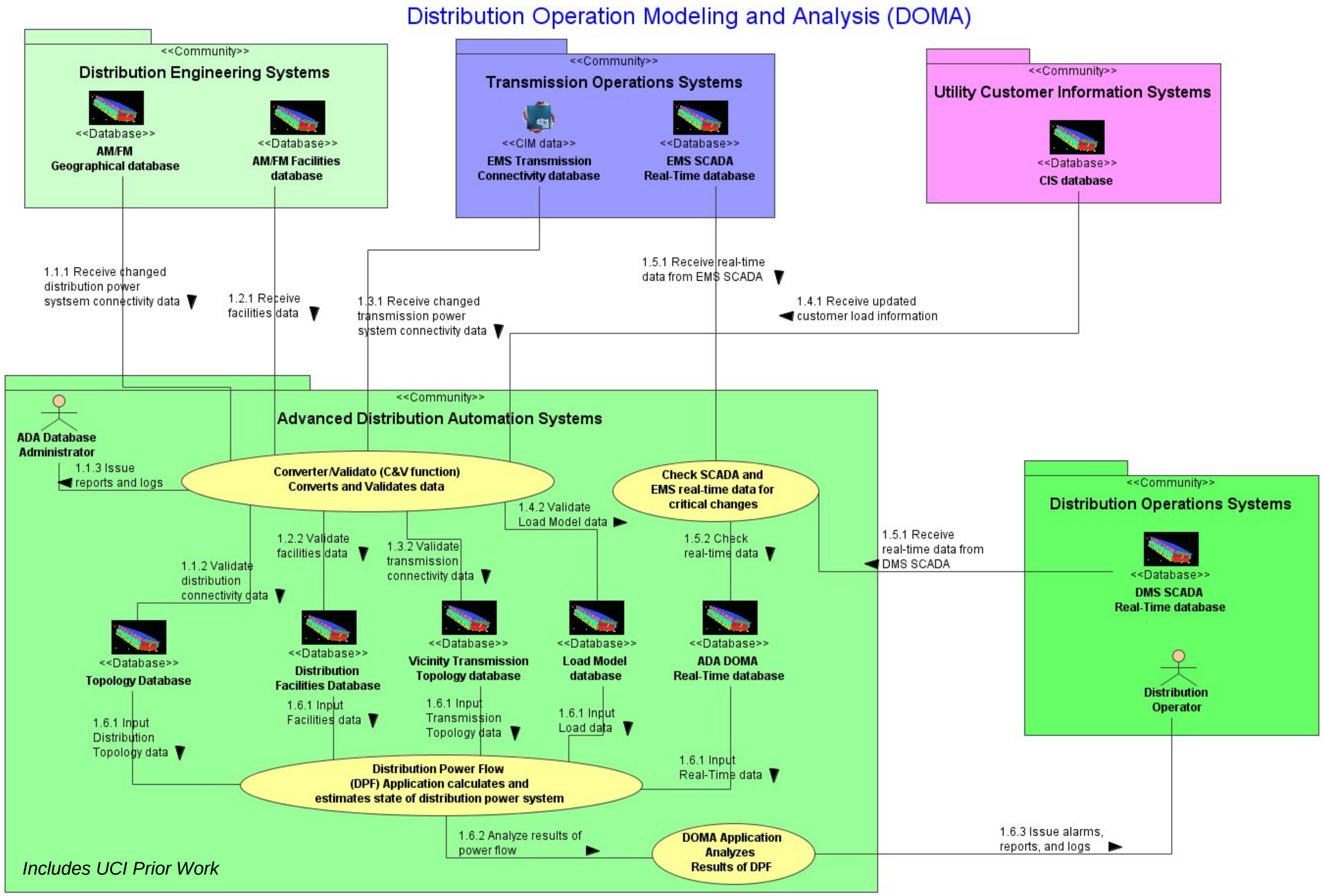
Advanced Distribution Automation (ADA)

What Do We Need to Know to Optimally Control Distribution Operations?

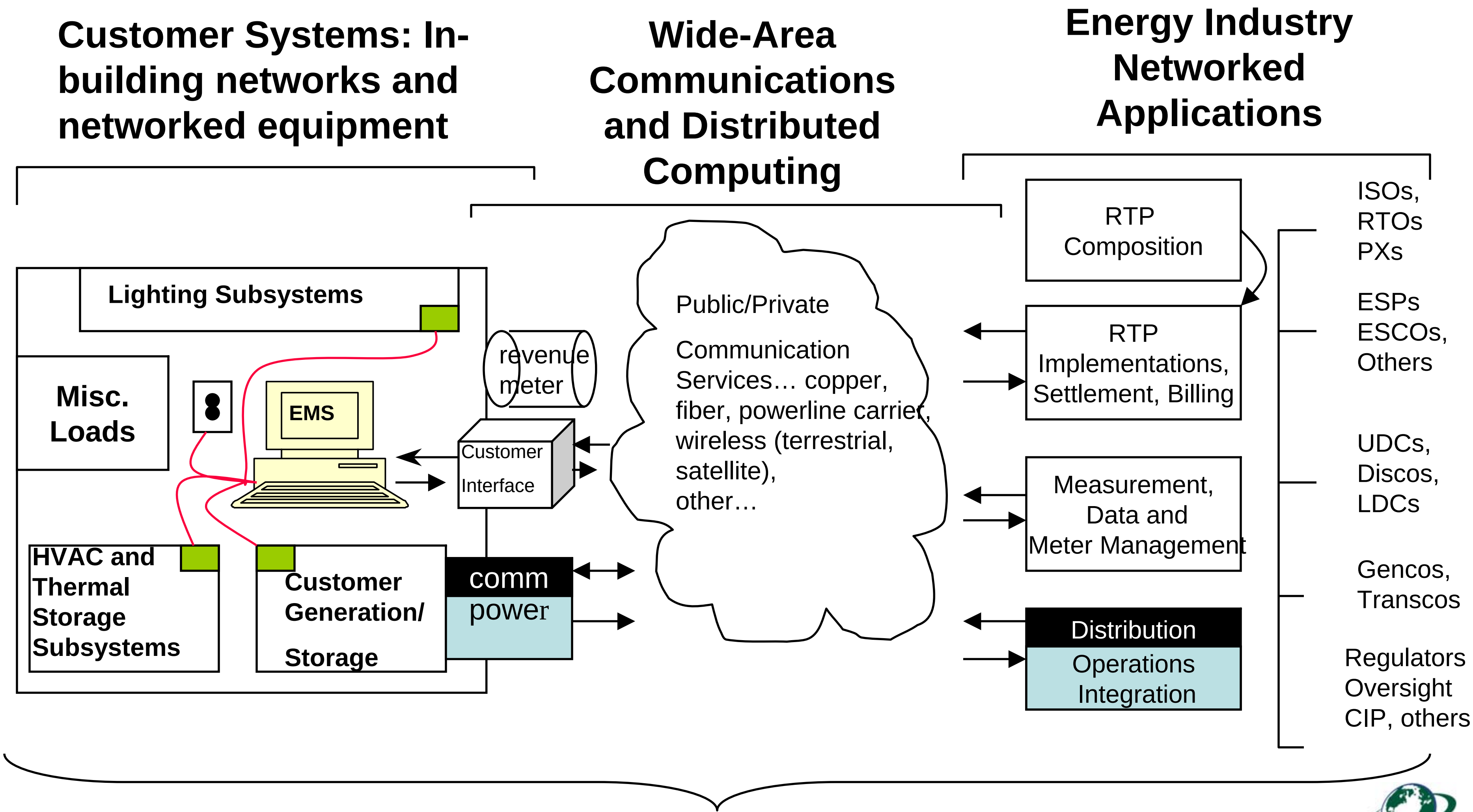


Distribution and Transmission facility parameters, and Customer load data

Distribution Operation Modeling and Analysis



Customer Interface and Operations



Customer Communication System Architecture

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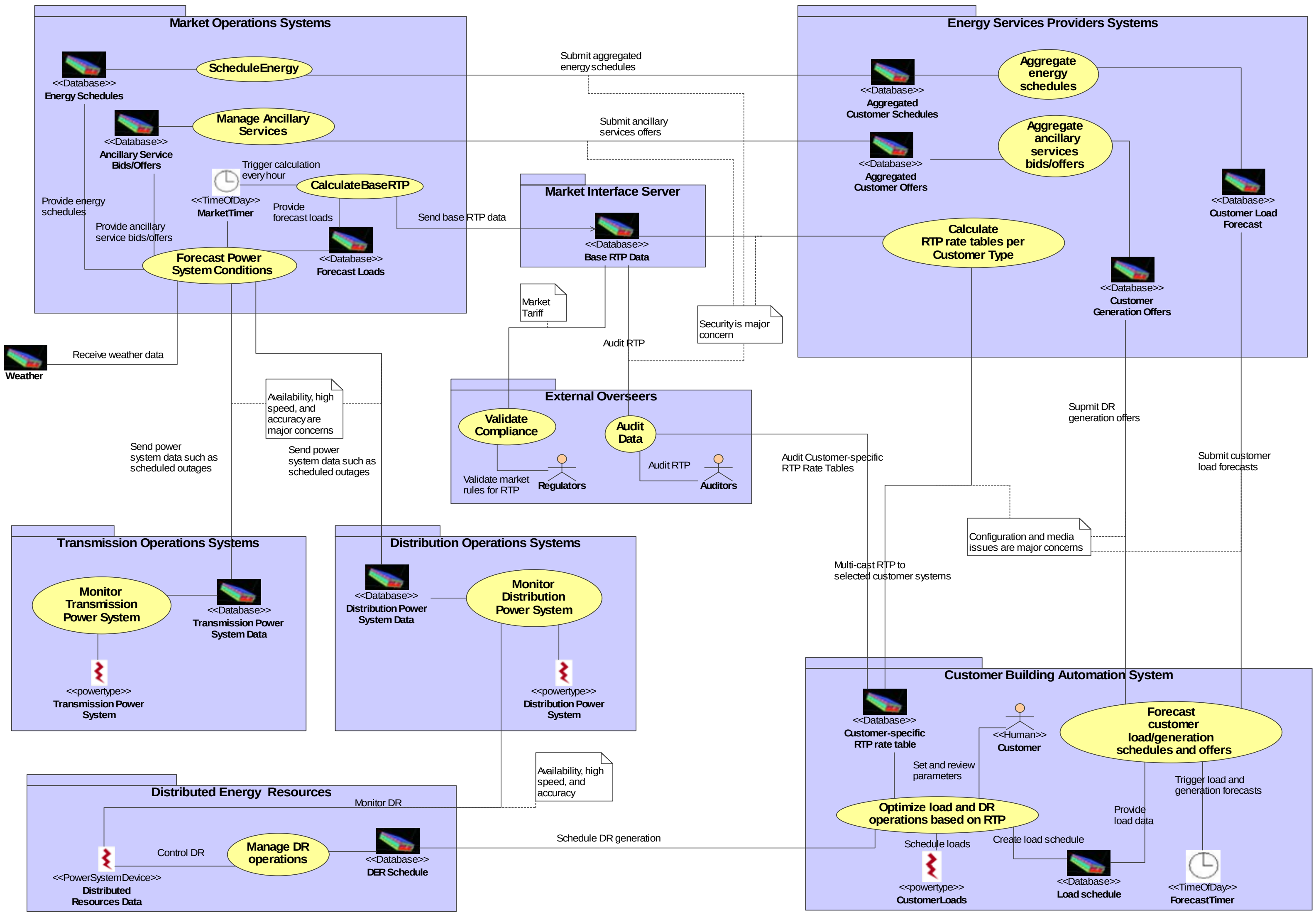
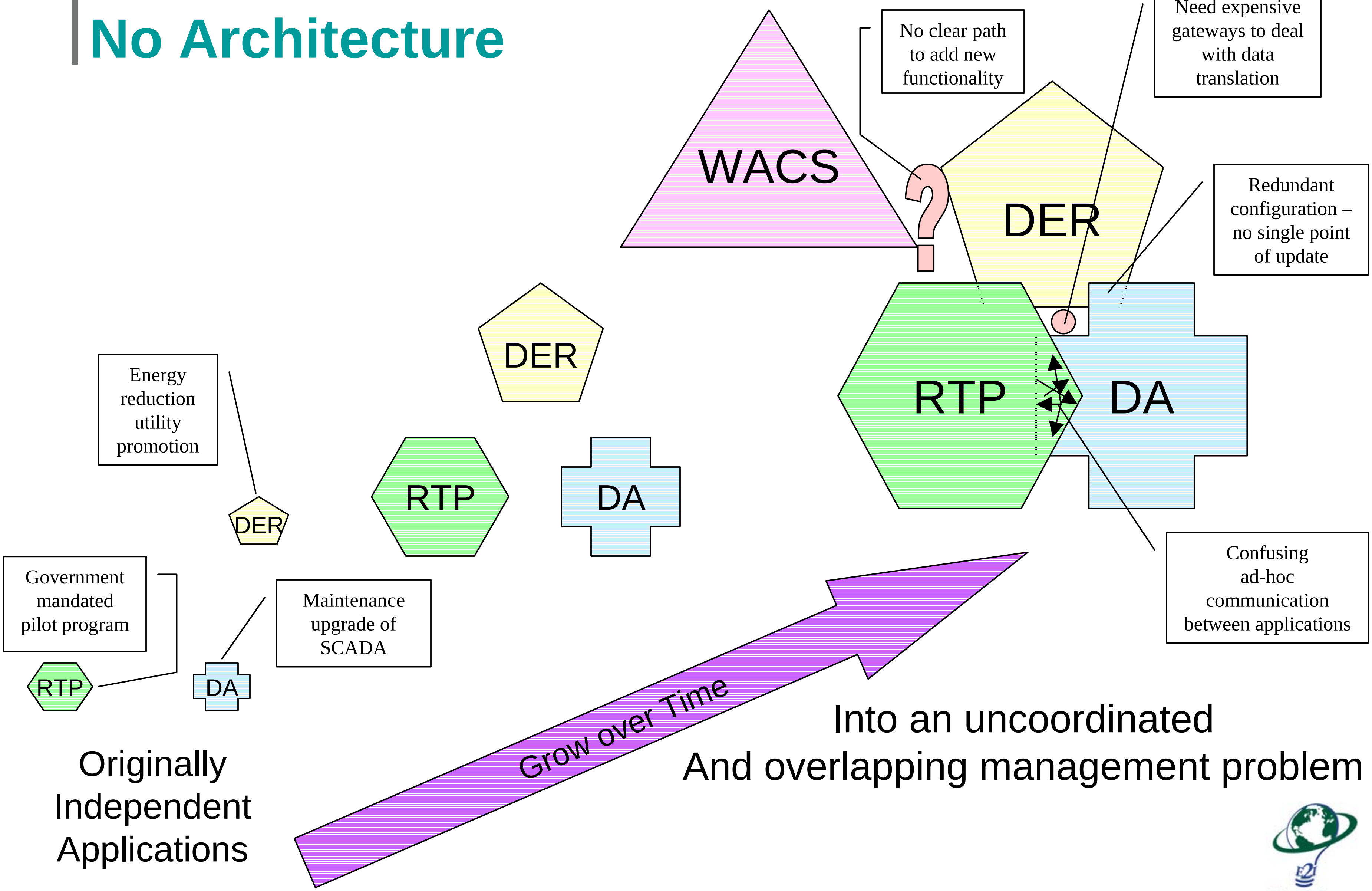
RTP Function Work Flow

Real-Time Pricing Enterprise Activity (RTP Function)
Showing Interactions and Information Flows between Applications



Future With No Architecture



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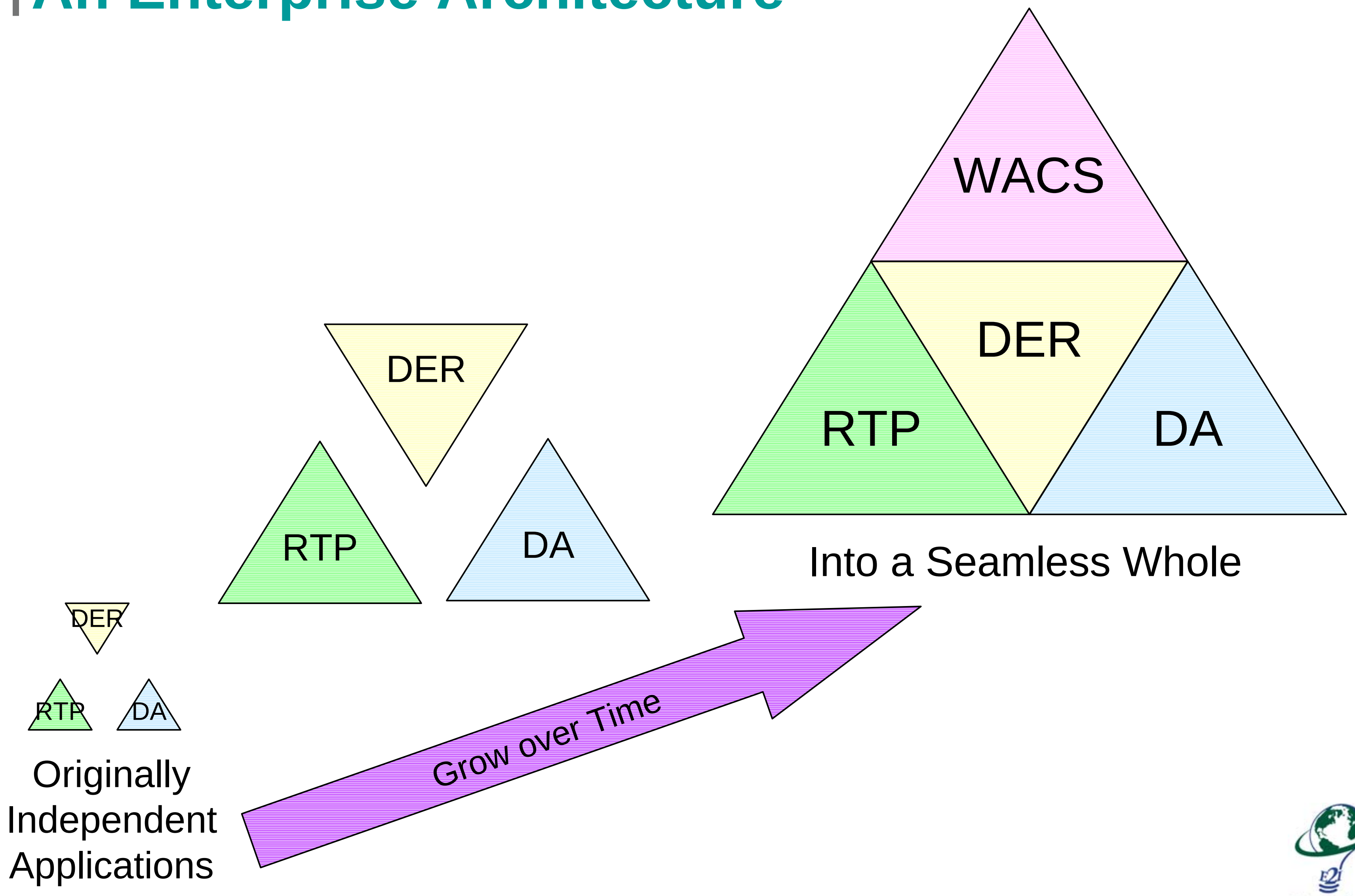
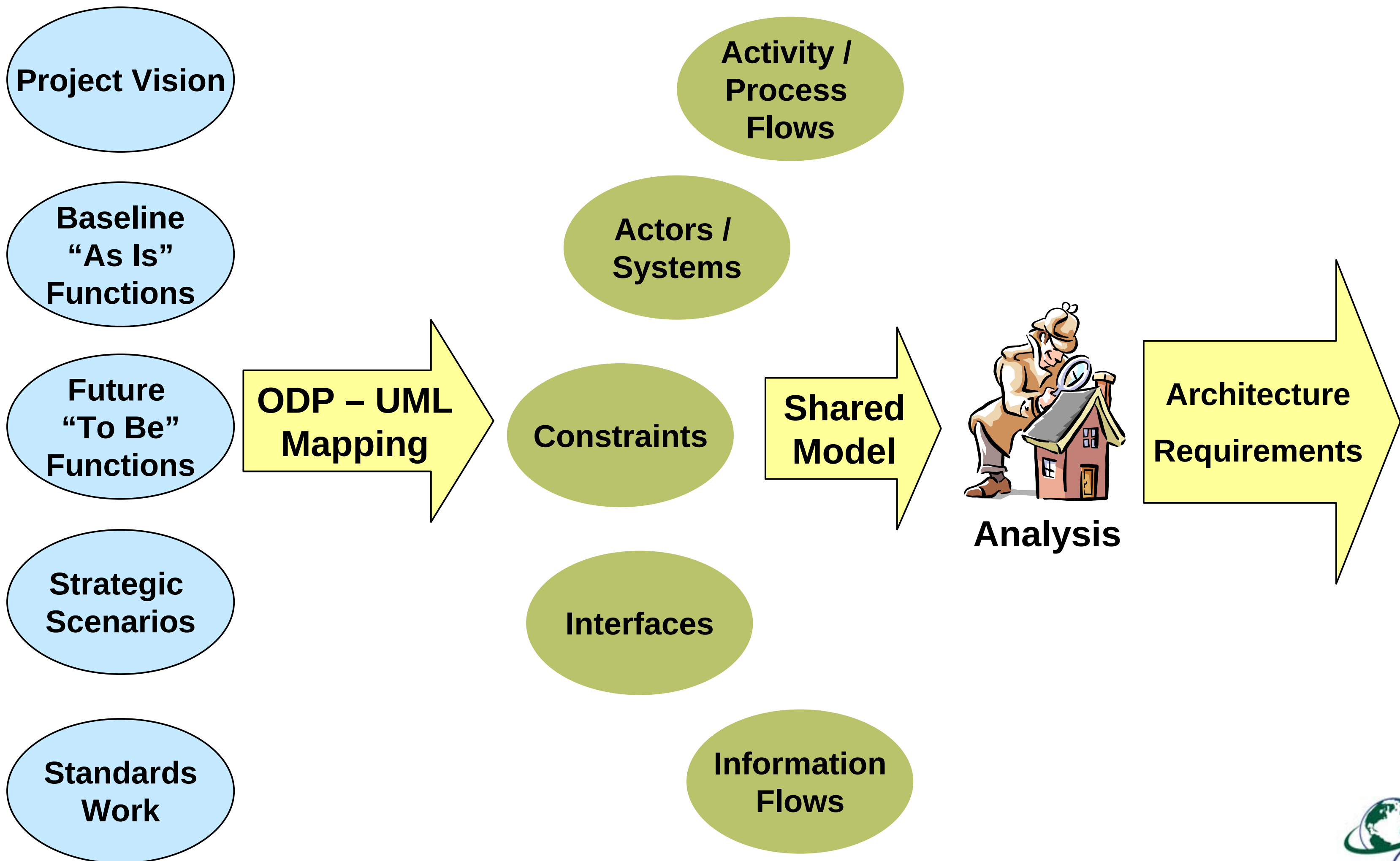
Future With
An Enterprise Architecture



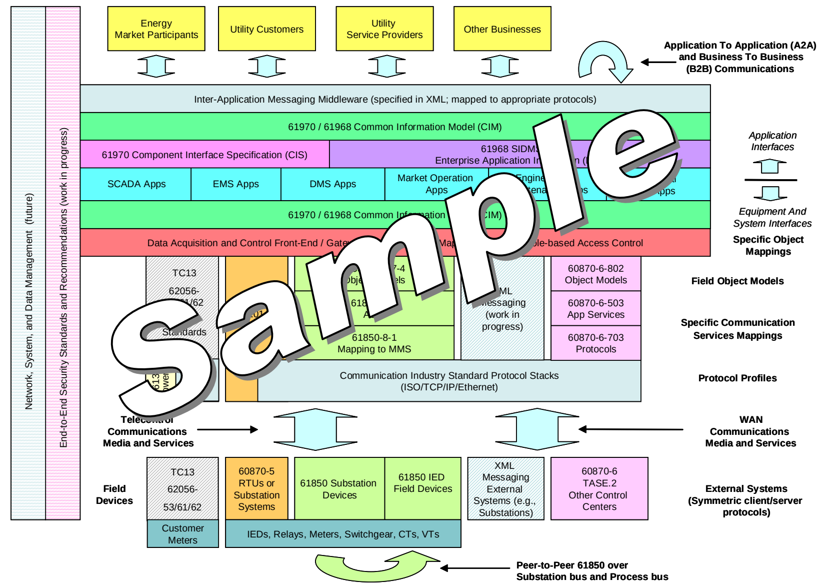
Task 4 Process: Requirements Analysis



Tasks 5-7 Expected Processes

- Pick up from Task 2 list of existing technologies
- Extract architectural requirements from Task 4 RM-ODP/UML analysis
- Evaluate existing industry standards, including CIM, 61850, Web services, ebXML methodologies, security techniques and solutions, network management, data management, etc.

IEC TC57 Protocol Reference Architecture Diagram



- Develop cross-reference between the architectural requirements and the possible technology solutions, referring back to Task 3 results for validation
- Identify gaps and alternatives, and analyze expected future directions of these technologies
- Develop IECSA Reference Architecture, covering existing solutions, future probable solutions, gaps and issues, legacy system migration strategies, etc.

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Final Deliverables

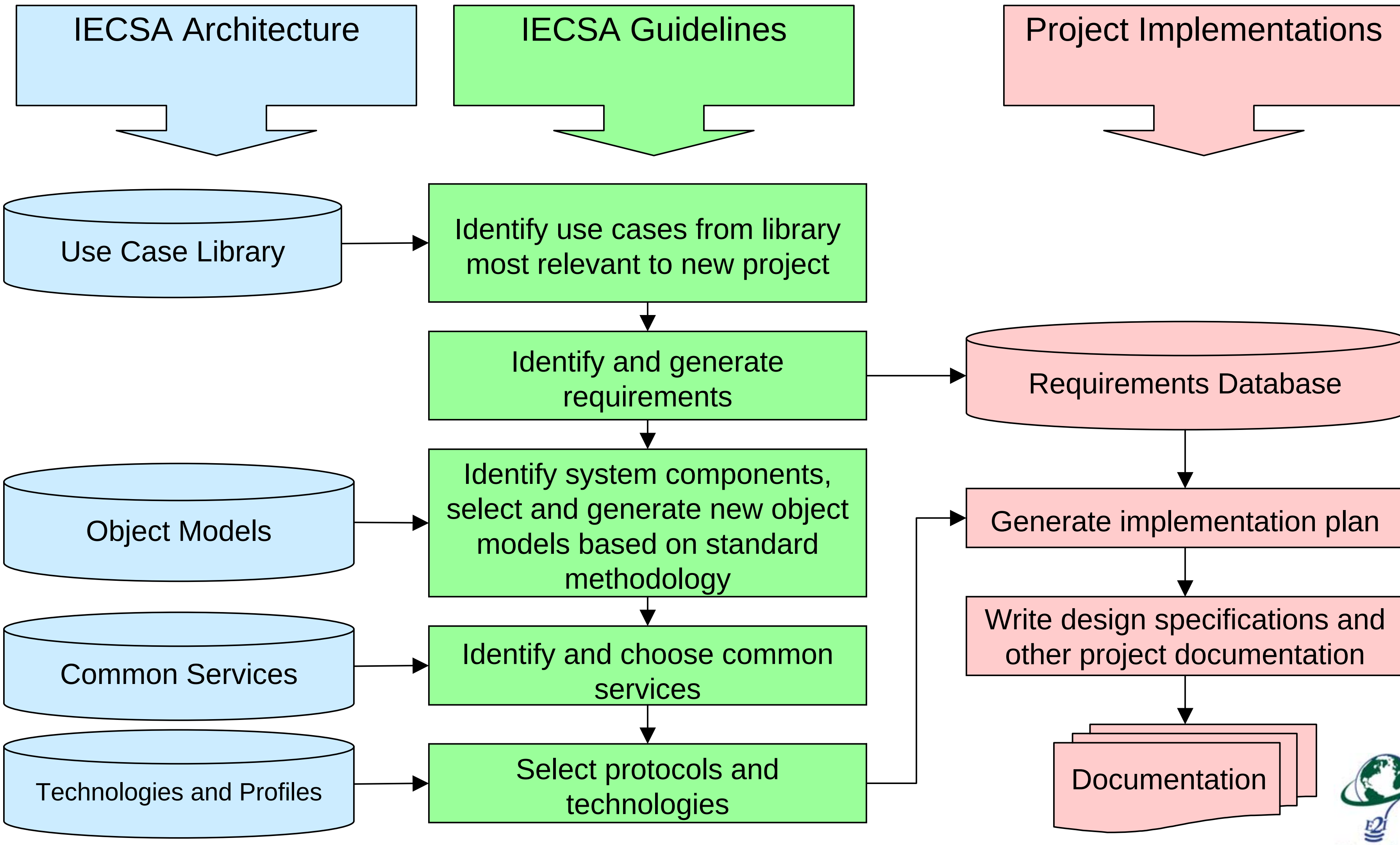
- **IECSA Executive Overview and Recommendations**
  - Value Story
  - Methodology used by Project Team
  - Executive level overview of the IECSA
  - Recommendations for standard bodies
  - Recommendations for future efforts
- **IECSA Description and Implementation Guidelines**
  - Guidelines for Using the IECSA Documentation Set
  - The IECSA – A Reference Architecture
    - **Architecture Definition**
    - **Common Services and Standard Protocols**
    - **Specific Technologies and Standards**
  - Example Usage Scenarios for the IECSA
- **Energy System Functions, Architectural Requirements, and Analysis**
  - Energy System Domains and Related Functions
  - Key Requirements of Energy System Functions
  - UML Models of Functions and their Architectural Issues
  - Analysis of Architectural Requirements
  - Analysis of Key Existing Standards and Technologies

IECSA Executive Overview And Recommendations

IECSA Description and Implementation Guidelines

Energy System Functions, Architectural Requirements and Analysis

How to Use the IECSA



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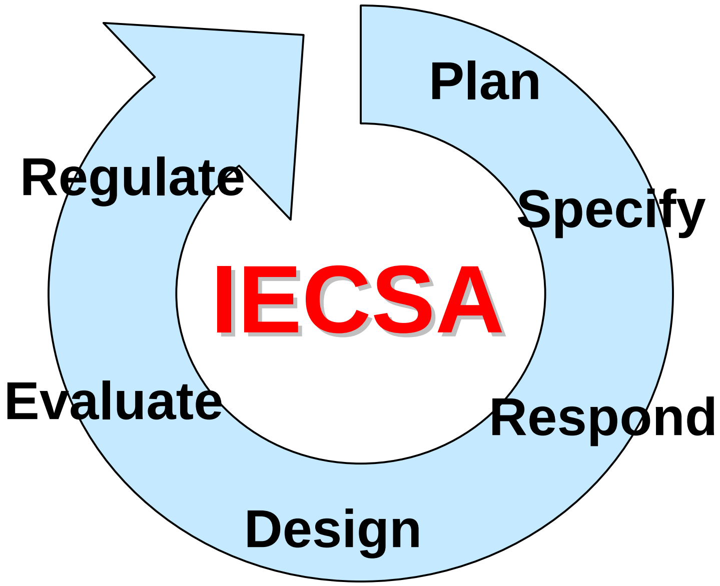
When to Use the IECSA – Some Examples

- Utility ***develops requirements*** for a new SCADA system
- Systems integrator ***responds to an RFQ*** for a utility communications network
- Hardware vendor ***plans new product*** development
- Regulator ***develops new legislation*** for real-time pricing
- A&E firm ***designs a facility*** linked into the utility communications network
- Facility engineer ***considers options*** for real-time pricing



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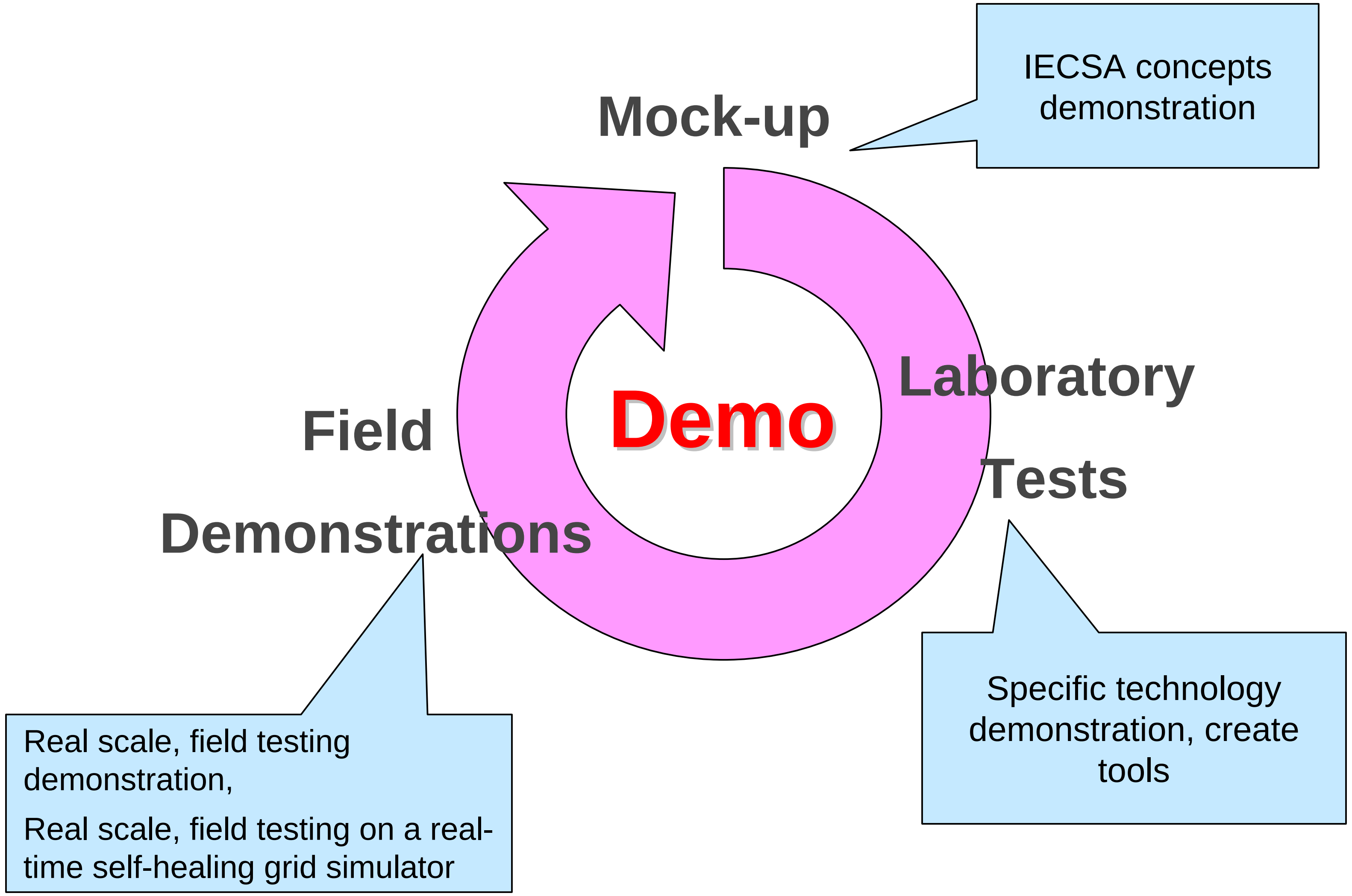
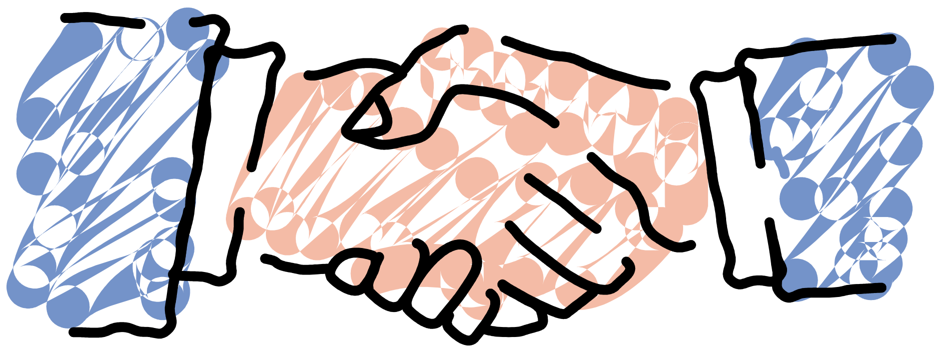
IECSA Demonstration Projects



IECSA Demonstration Goals

Use as much as possible:

- Existing demonstration projects
- On-going standards efforts
- Partnerships
- Incremental demonstrations
- Technology transfer opportunities
- Opportunities
  - Location
  - Facilities
  - Funding
  - Support
  - Other resources



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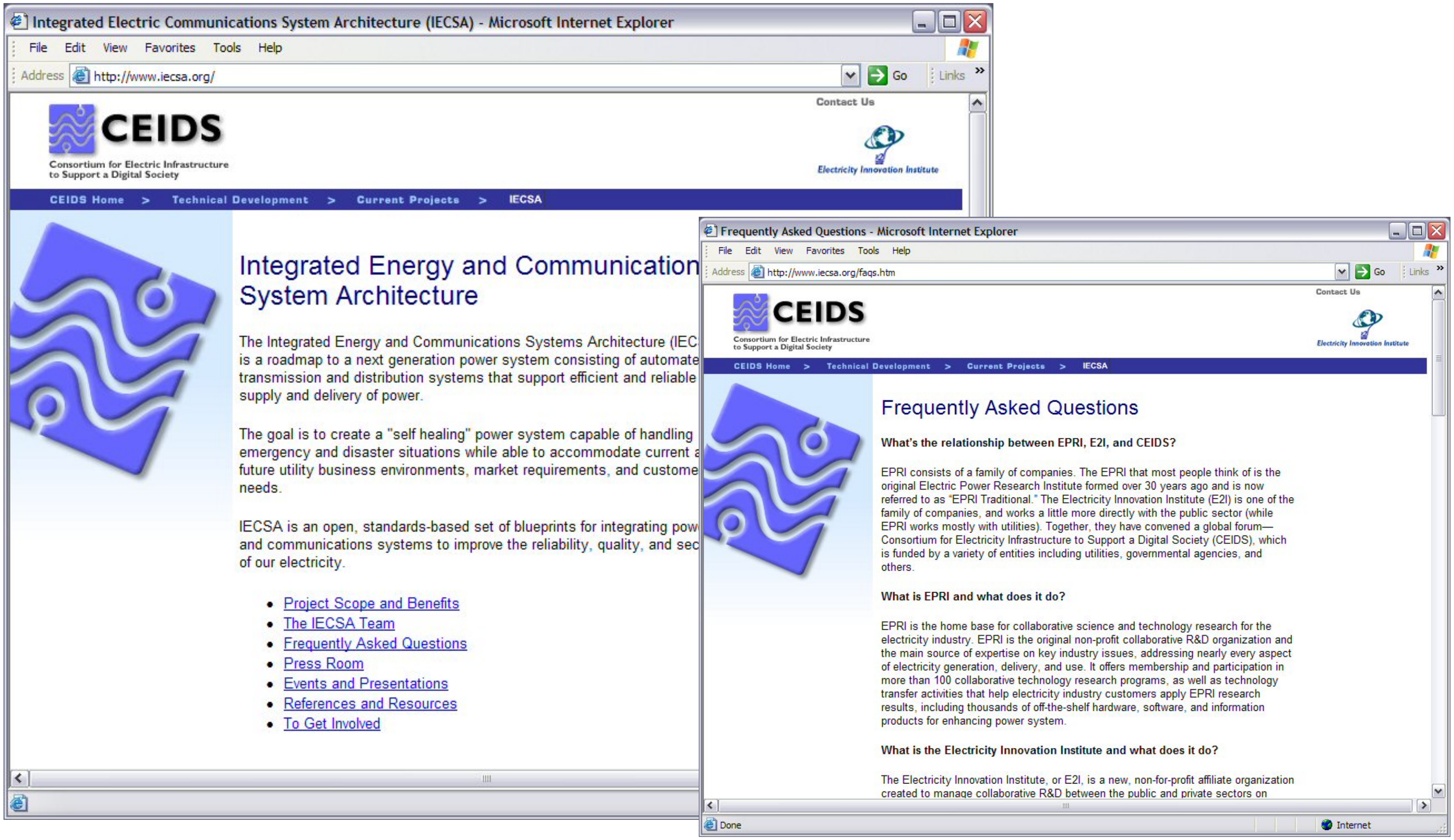
The Public Face of IECSA



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