Smart Grid Architecture Development

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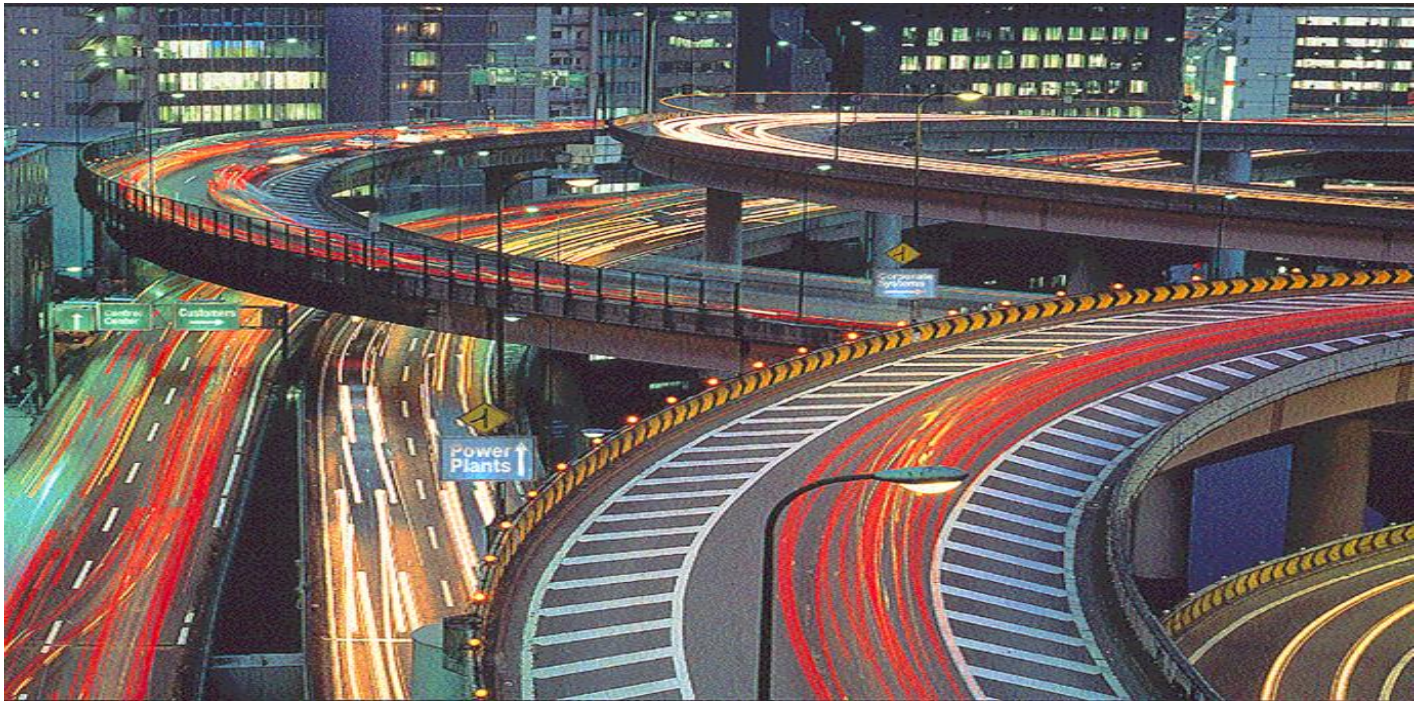
Joe Hughes, CEO

Reef Energy Systems, LLC

Some Definitions

Architecture: The Structure of Components, their relationships, and the principles and guidelines governing their design and evolution over time*



*DoD Integrated Architecture Panel, based on IEEE Std 610.12

Developing Architecture for the Smart Grid

- Why: Business and Technical Drivers Behind Architecture Development
- What: Architecture Development: Some Basics
- How: Smart Grid Architecture Development Processes

Drivers for Architecture development

More automation equipment is required to be integrated and interwork…

…Across more functional and department "boundaries"

…with more robust implementations against future obsolescence…

…to be operated seamlessly into an enterprise/industry wide system..

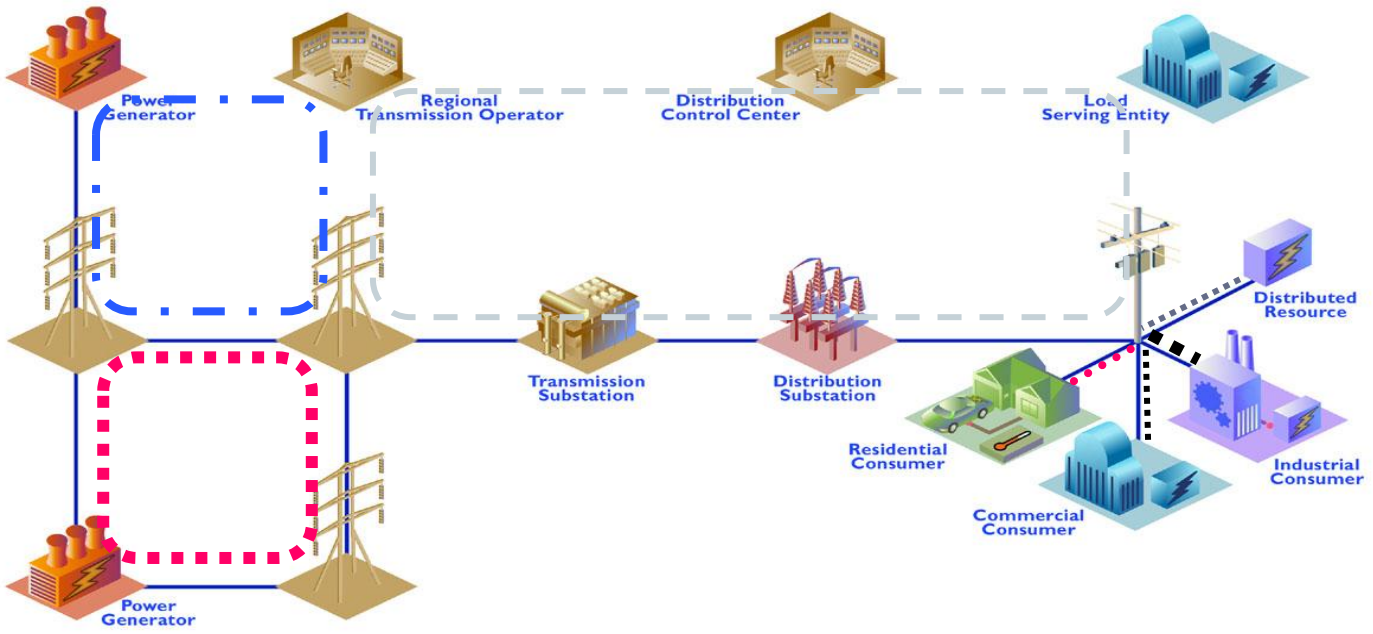
…to be well managed and adequately secure…

…and all to be supported by fewer people

TODAY'S SITUATION: "SMART" COMMUNICATION AND AUTOMATION SYSTEMS…

"Islands of Automation"

Little Integration Across the Industry

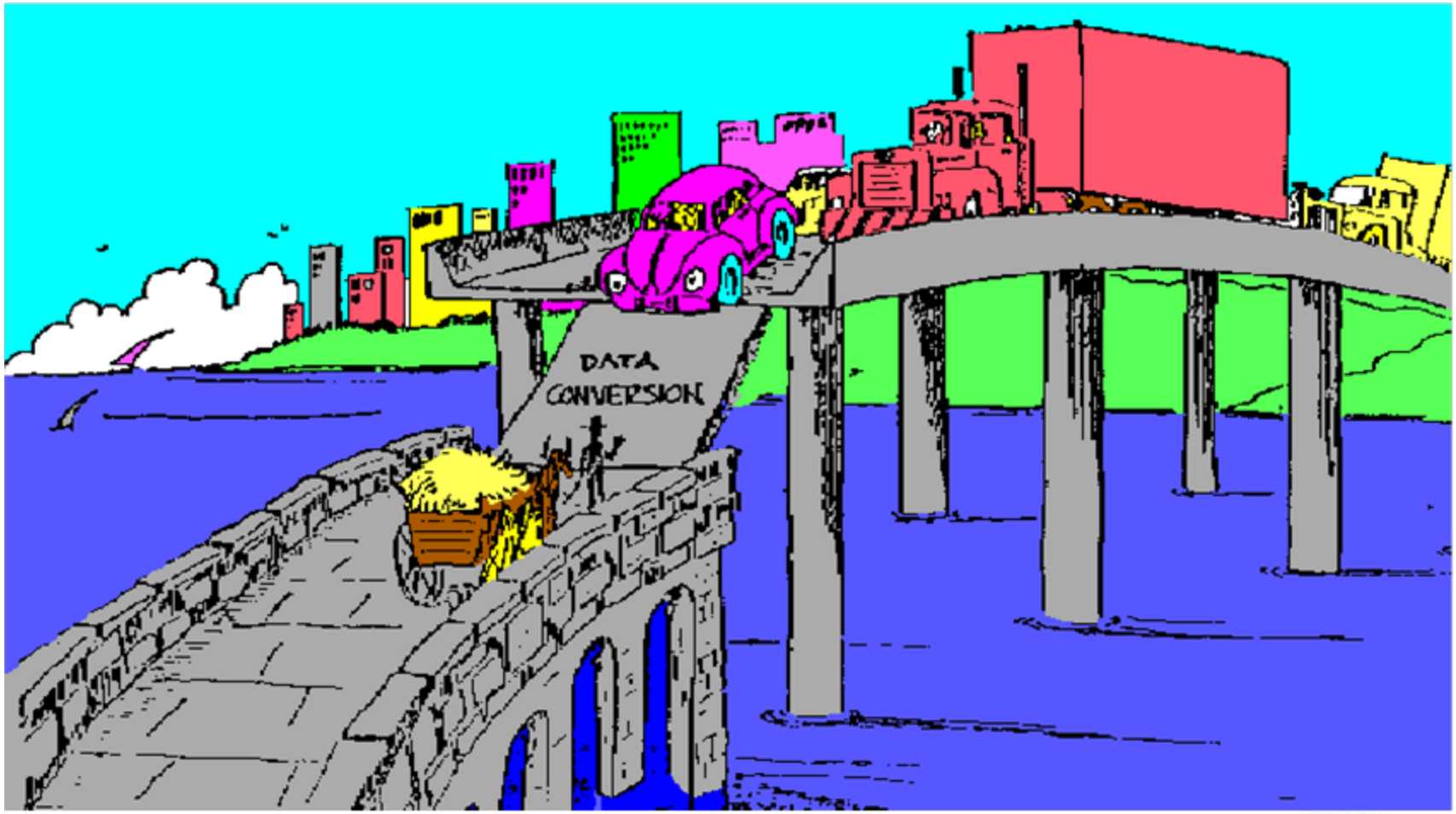


Proprietary Systems

No Integration with Consumer Equipment

Where's the Architecture?

WITHOUT ARCHITECTURE…



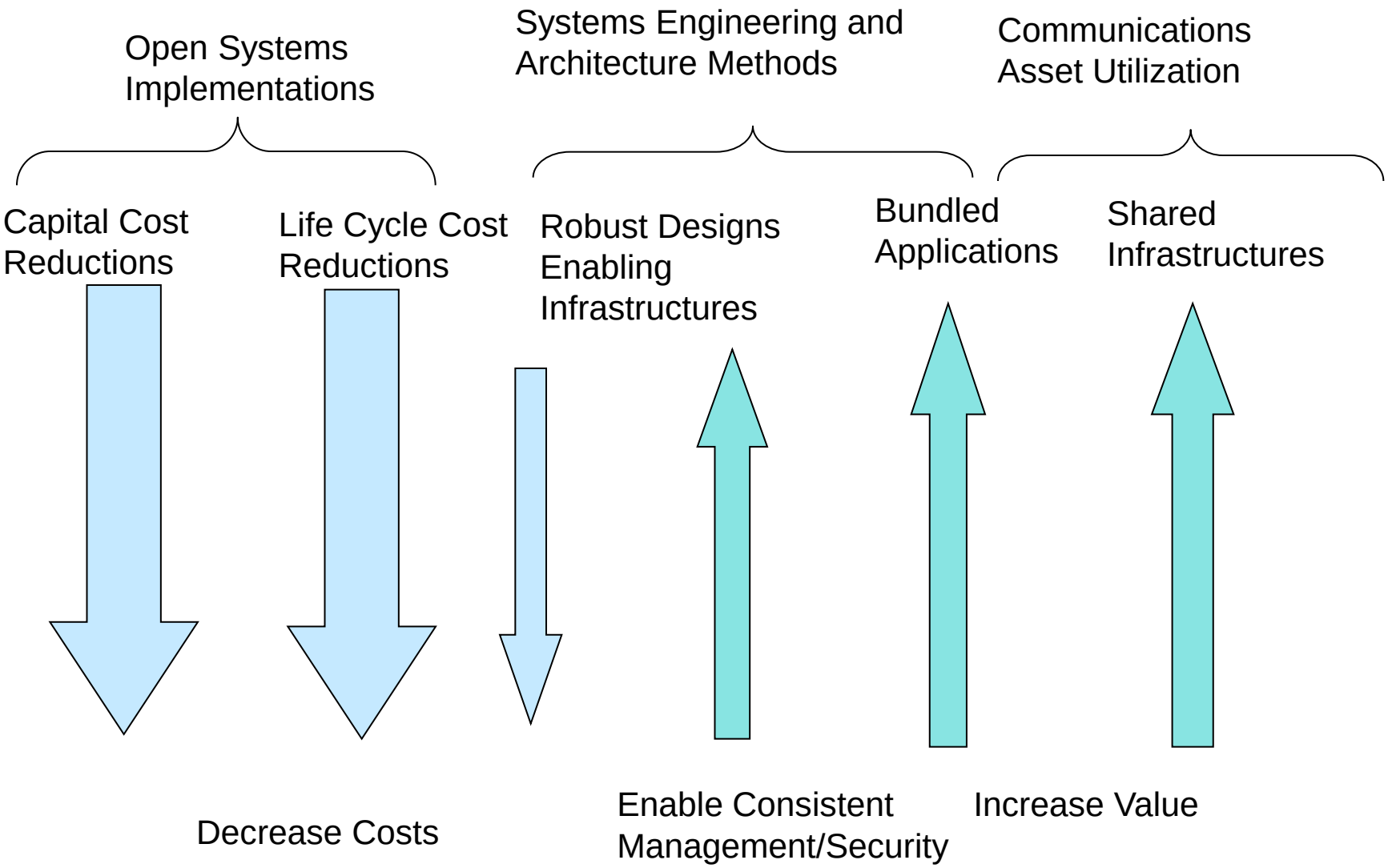
Business Drivers For Open Standards

- **Capital Cost Savings**
  - **Competitive Procurement of intelligent equipment through Standards and Open Systems**
  - **Multi-vendor support and avoidance of single vendor “lock-in”**
  - **Extensible and Scalable “Industry-wide”**
- **Life-Cycle Cost Savings**
  - **More uniform Standards based systems**
  - **Extensible for the Future**
  - **More capable systems, easier to maintain**
  - **Immune to single vendor limitations**
- **Security Policy Implementation**

Open Standards Are Not Enough…Without Architecture…

- Many existing "solutions" are not solutions…
  - …cannot be integrated with other systems
  - …cannot be scaled up to large numbers
  - …lack critical capabilities such as managing security policies consistently across domains
  - …devices and networks cannot be effectively managed on the required scale
  - …data cannot be effectively managed on the required scales
  - …systems cannot be maintained at reasonable costs over the long term
  - …cannot be effectively extended for future needs

General Economic Drivers For Architecture



Architecture Development is Required to Effectively Integrate Open Standards

- Multi-vendor procurement of interoperable equipment (Capital $)
- integration of equipment from different vendors..(Avoid single vendor “lock-in”)
- Avoid functional lock-in, minimize obsolescence
- Save life-cycle costs: system upgrades and maintenance (O&M $)
- Leverage available Human Resources
- Consistency in minimum sets of critical requirements
- Avoiding “Forklift Upgrade” (O&M $)

- Bottom Line: Architecture Development is Requirement for the Smart Grid to Exist

Why do an architecture?

- Necessary to manage complexity
- More completely and accurately link: goals, business models, drivers and stakeholders with supporting technical development and management processes
- Provides approaches to enterprise and industry level development and documentation
- Enables understanding of synergies/problems that lower level views miss
- Primary approach for consistently establishing and implementing security policies across the enterprise/industry
- Currently there is no complete open architecture for smart grid

ARCHITECTURE IS CRITICAL TO MEET SPECIFIC GOALS

"Section 1305(d) of the Energy Independence and Security Act of 2007 directs the Commission to institute a rulemaking proceeding to adopt such standards and protocols as may be **necessary to insure *smart-grid functionality and interoperability* in interstate transmission of electric power, and regional and wholesale electricity markets** once it is satisfied that the work of the National Institute of Standards and Technology has led to "sufficient consensus" on smart grid interoperability standards."

UNITED STATES OF AMERICA FEDERAL ENERGY REGULATORY COMMISSION

[Docket No. RM11-2-000] Smart Grid Interoperability Standards

(Issued July 19, 2011)

Architecture Development is the only way that Specific Stakeholder and Policy Goals can be achieved

- Security Policy Management
- Systems Management
- Industry Level Integration
  - ISO/RTO Operations across ISO lines
    - Wide Area Situational Awareness
  - Customer End Use Equipment Integration
    - Electric Vehicles
    - Heating, Ventilation, and Air Conditioning
    - Appliances
    - Other
- Other

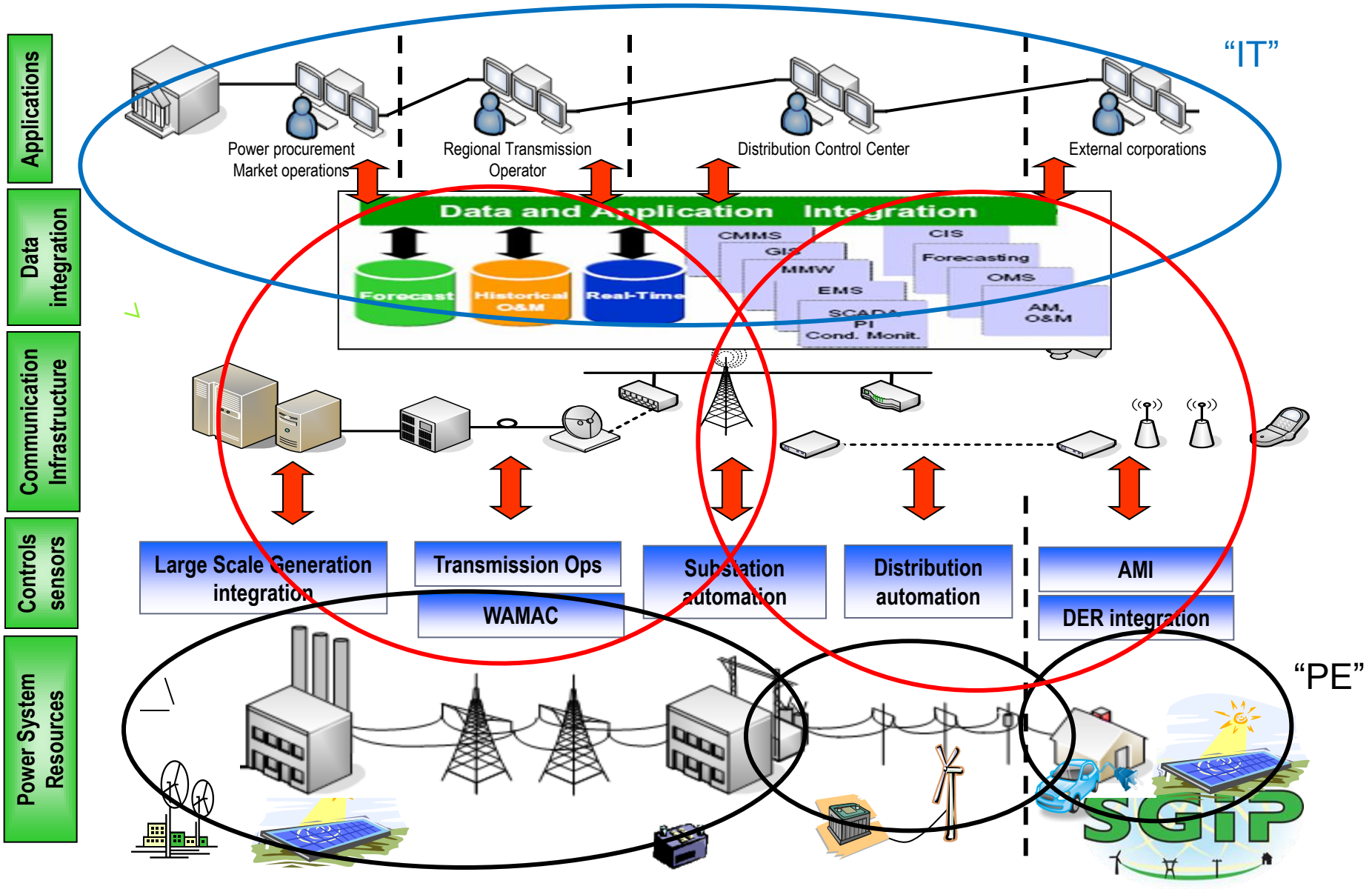
Presentation Overview

- Why: Business and Technical Drivers Behind Architecture Development
- What: Architecture Development: Some Basics
- How: SGIP Smart Grid Architecture Committee

Architecture is Necessary for Large Scale Development

- Standards, User Implementation Agreements, Technology Guidelines and other documents are important building blocks but are insufficient in themselves for large scale integrated systems like smart grid
- Architecture provides the integration necessary to bring together the full vision of the intended system
  - Identify key domains and domain interfaces
  - Identify where open standards need to be harmonized, unified or otherwise integrated
  - Identify and manage how legacy systems should be integrated
- Architecture is necessary to ensure a minimum levels of completeness in system requirements including the following categories:
  - Systems and Network Management
  - Security Management
  - Applications Development
  - Requirements Traceability to Identified Stakeholder Needs

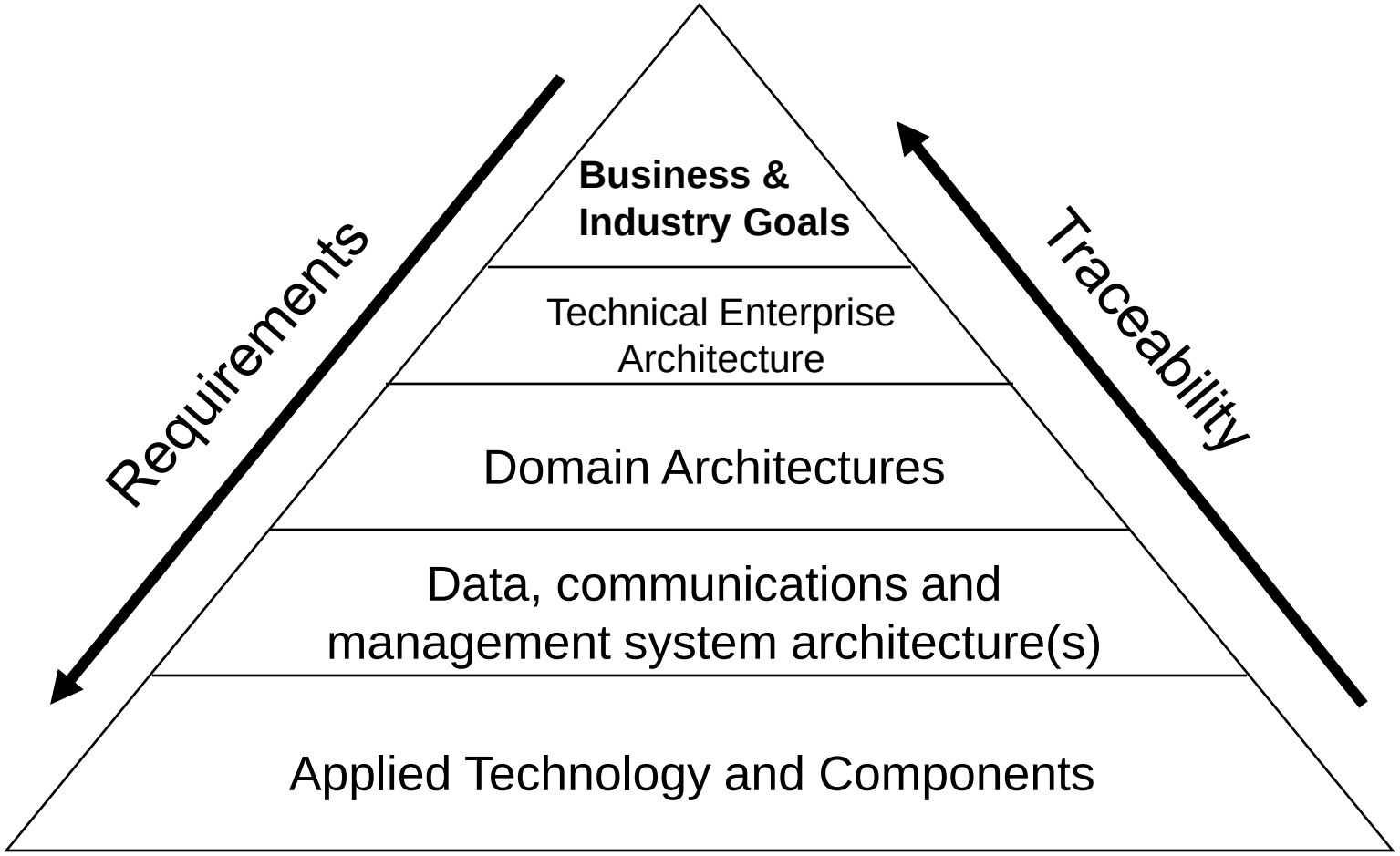
Architecture: Developing and Managing Integration Across the Greater Smart Grid Industry



Enable Integration across Different "Environments"

System Type	Information Systems	"Soft" Real-time	"Hard" Real-time
Application Delay Tolerance	Delays are tolerable	Short delays are tolerable	Delays can fail an application, delays must be predictable "deterministic"
Examples	E-mail, Internet Document Distribution	Database access over a LAN	Automated Control Functions

Architecture Development Focus



Developing Architecture for the Smart Grid

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Systems Engineering: Requirements Development

- Requirements Types
  - Functional
    - Describe the functions of the application: What the Application Should do for the end-user
  - Non Functional
    - Describe the supporting functions to enable the application to properly execute
    - Also includes systems and networking management as well as security

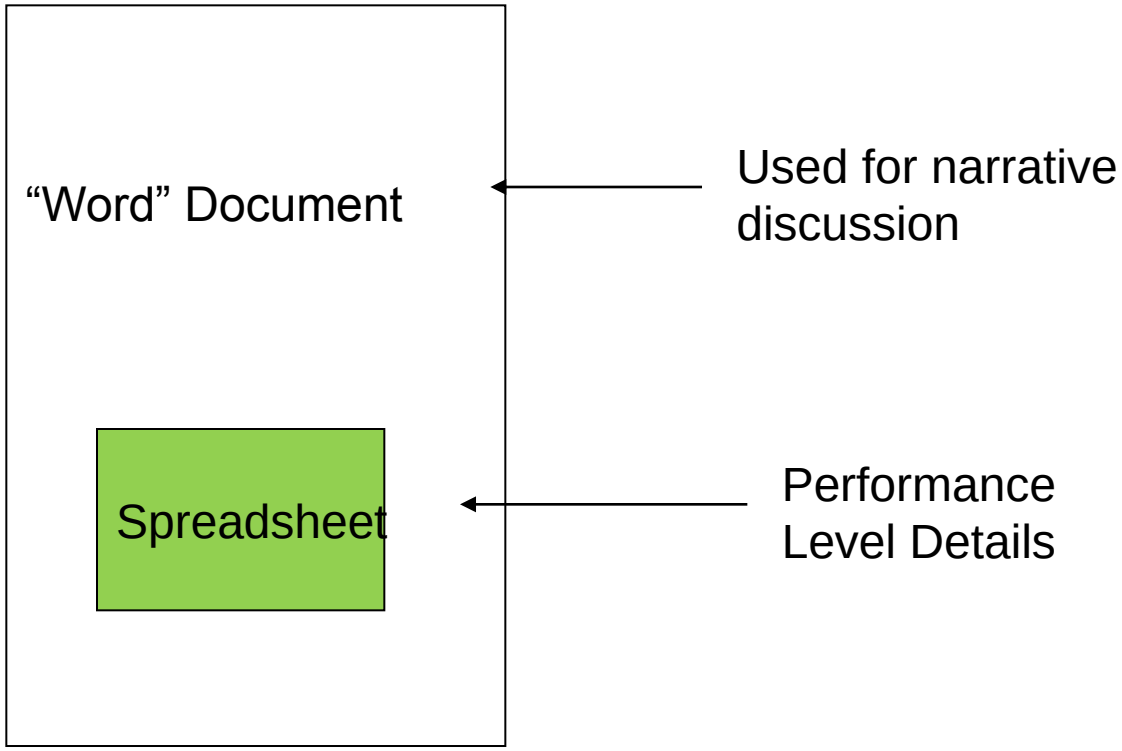
Recommended Approaches: Develop Functional and Non-Functional Requirements Together

- Applications:
  - System must support the requirements coming from power engineering needs
- Systems and Network Management:
  - Installed communications networks and intelligent equipment must be able to be observed and maintained
- Security:
  - System must include adherence to security policies and include system “hardening” as well as managing residual risk

Requirements Sources

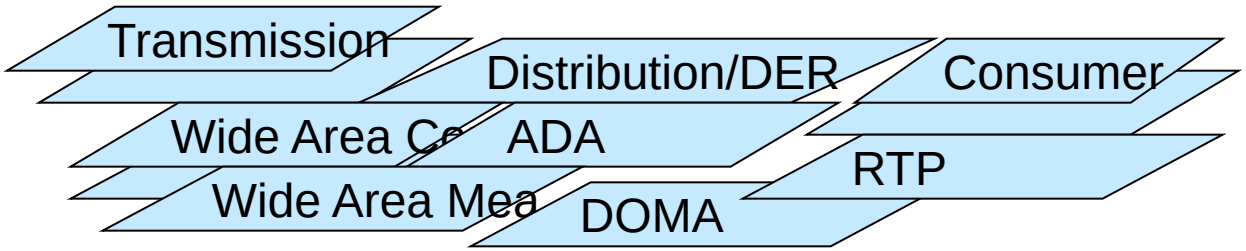
- From Existing Systems Documentation
- System and Technology Plans
- Stakeholder Interaction
  - Power Engineers
  - Systems Administrators
  - Security Personnel
- Standards and Consortia
- Industry Plans and Documents For Future Systems
  - EPRI Reports and Project Results
- Ideally:
  - A combination of Text and Graphical Representation
  - Standardized Terminology to the extent possible
  - Use of Computer Based Tools and a “Model” of system characteristics

Requirements Development: Use Case and Requirements Development Template

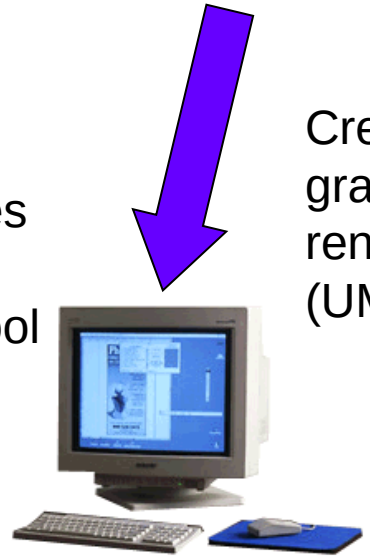


Conversion from Requirements to Industry Models…One Method

"Use Case Templates"

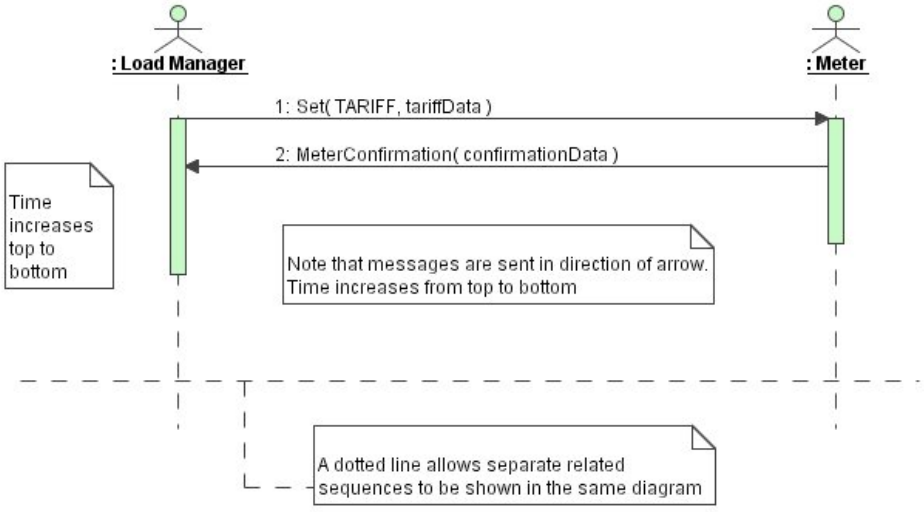


Import Word Templates into the CASE Tool



Computer Aided Systems Engineering (CASE) Tool

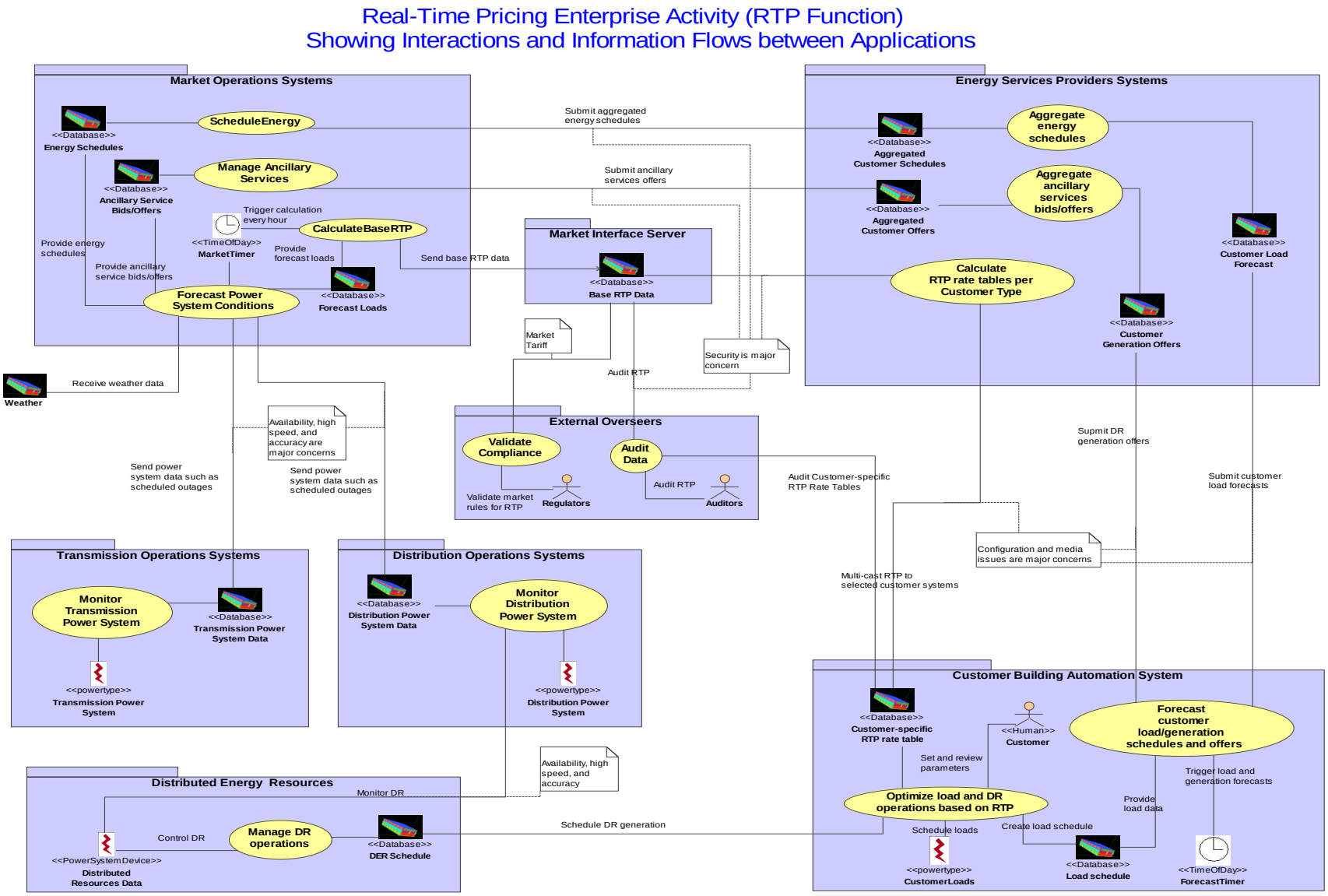
Create a graphical rendering (UML)



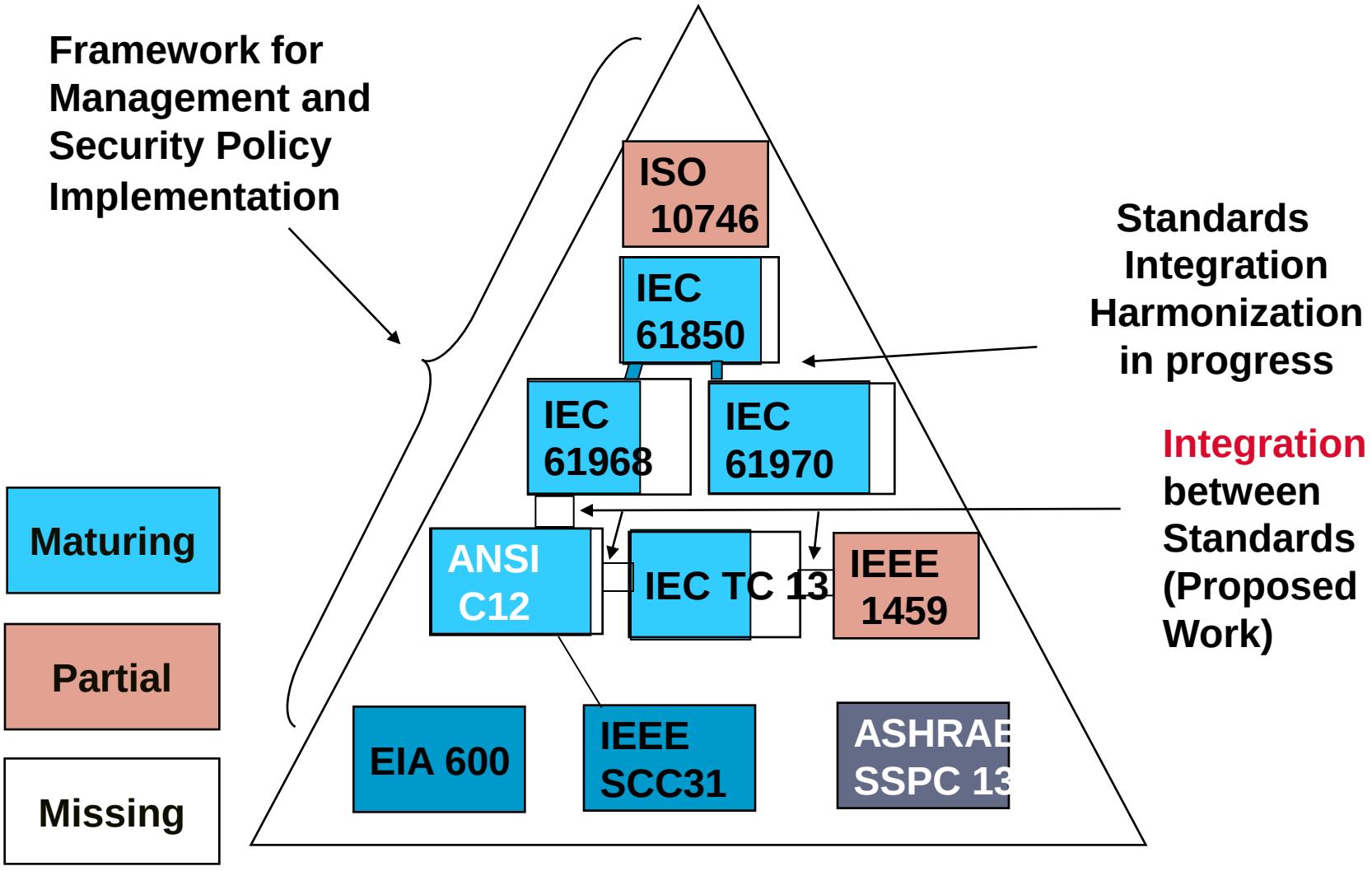
Architecture How: Enables More Complete Requirements Development

- Necessary to encompass different stakeholder perspectives
  - Applications Development
  - Security
  - Technical Management (includes Life-cycle management)
- Thorough Requirements are Critical for
  - Field Equipment with limited resources
  - Forward looking and Robust Network and Physical Communications Designs
  - Developing Robust Standards leading to robust system designs
  - Deployments of field equipment must last 20 to 30 years
- Consequences of weak or incomplete requirements
  - Cost of incomplete requirements…caught at design time….caught at implementation time…caught after deployment….

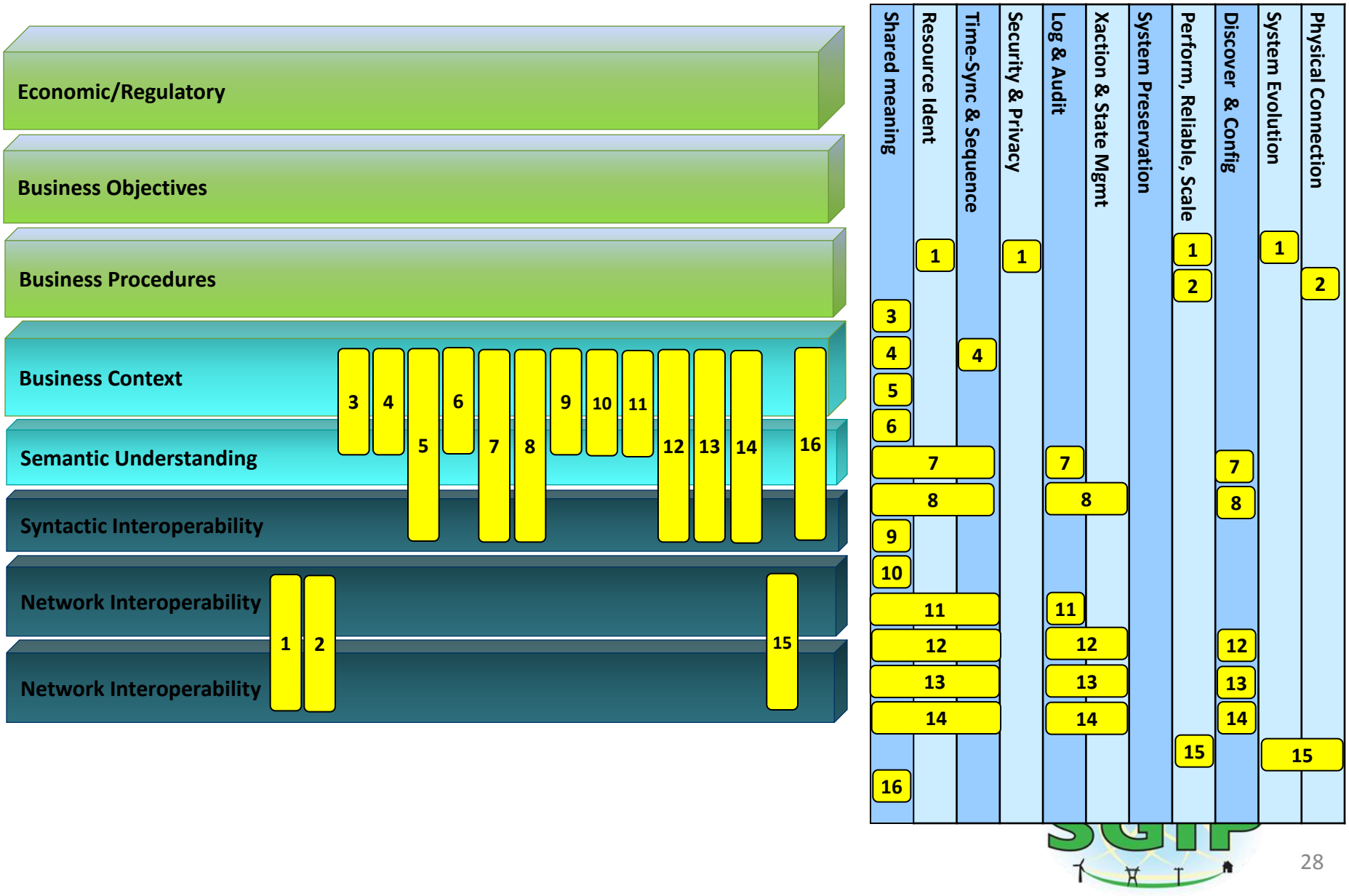
UNDERSTAND THE COMPLEXITIES WITHIN THE REQUIREMENTS



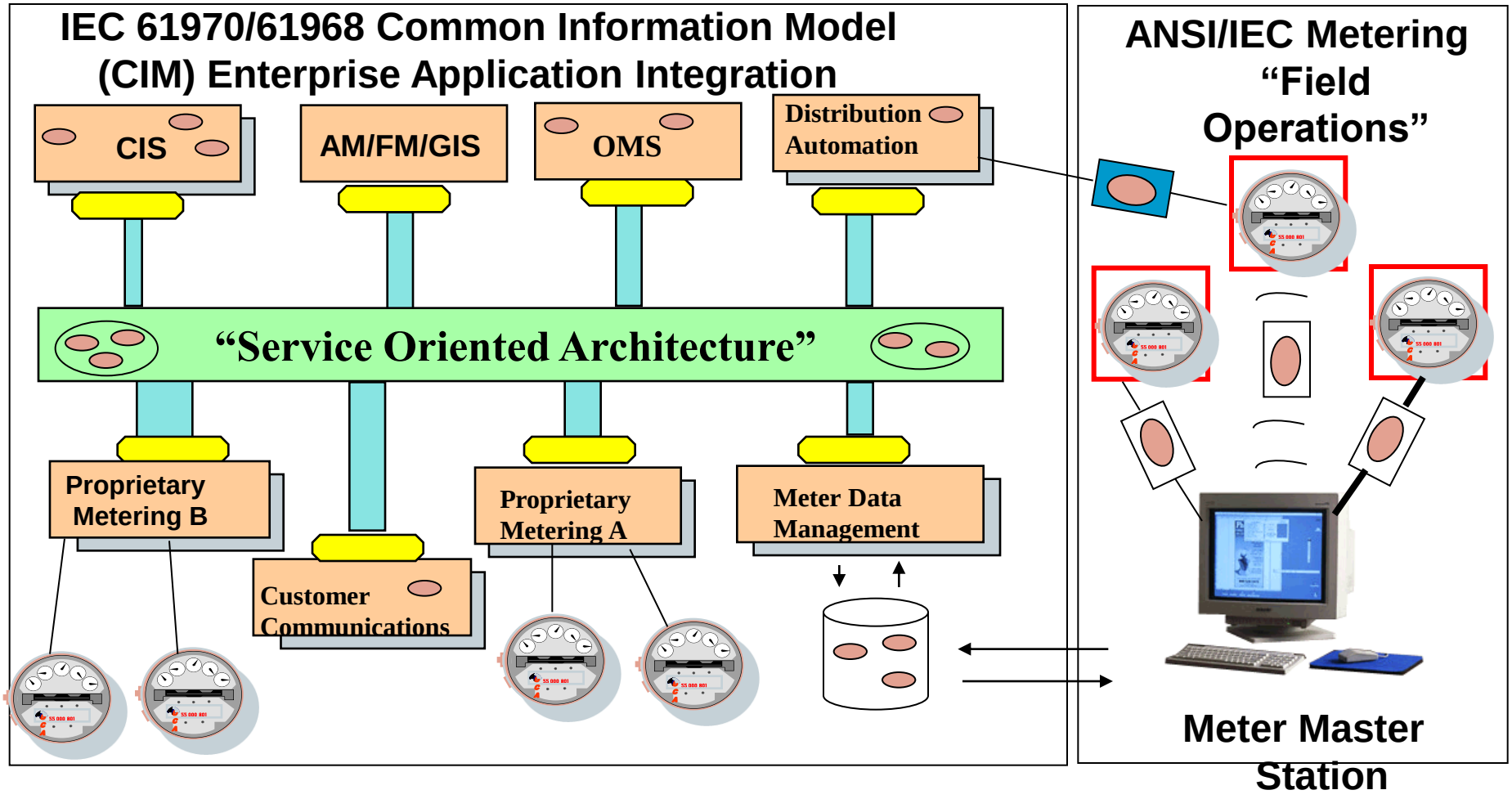
Industry-Level Architecture Seeks to Integrate Between Standards



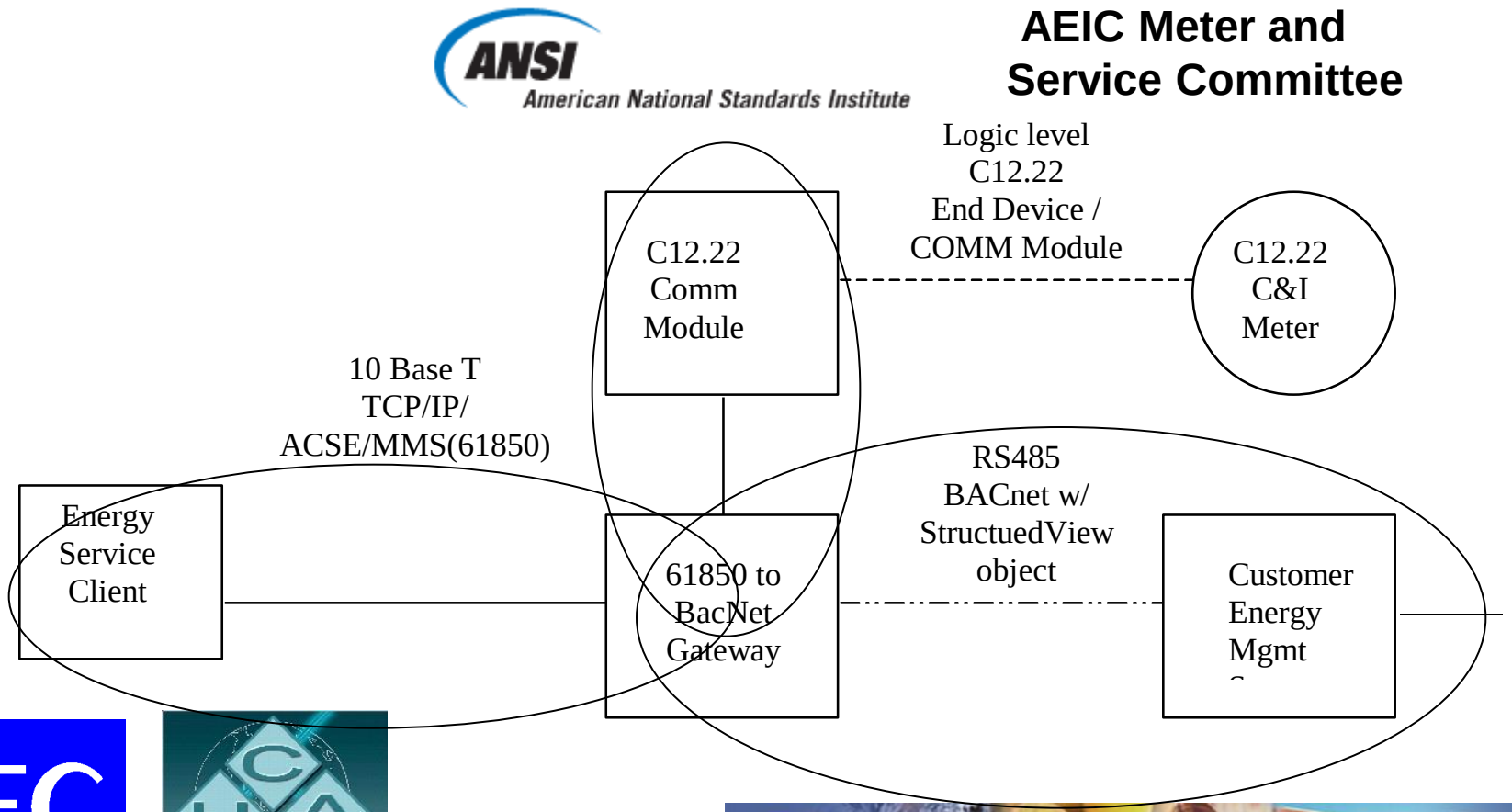
Gridwise Architecture to SGIP Priority Action Plan Map



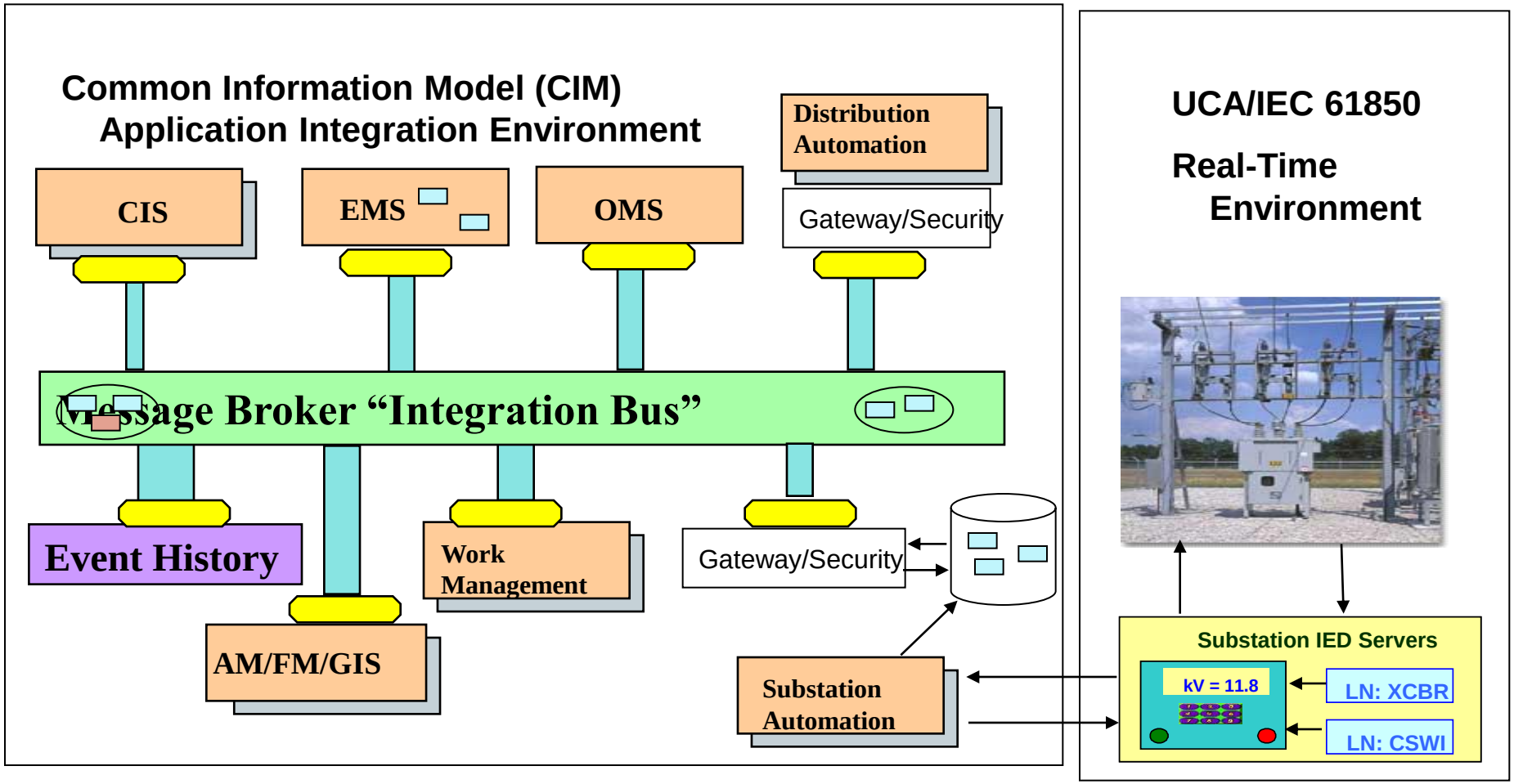
Example Architecture Development Task: Develop Common Meter Data Models



Prototype “Gateway” Implementation: Integrating Major Metering, Utility Automation and Building Automation Standards

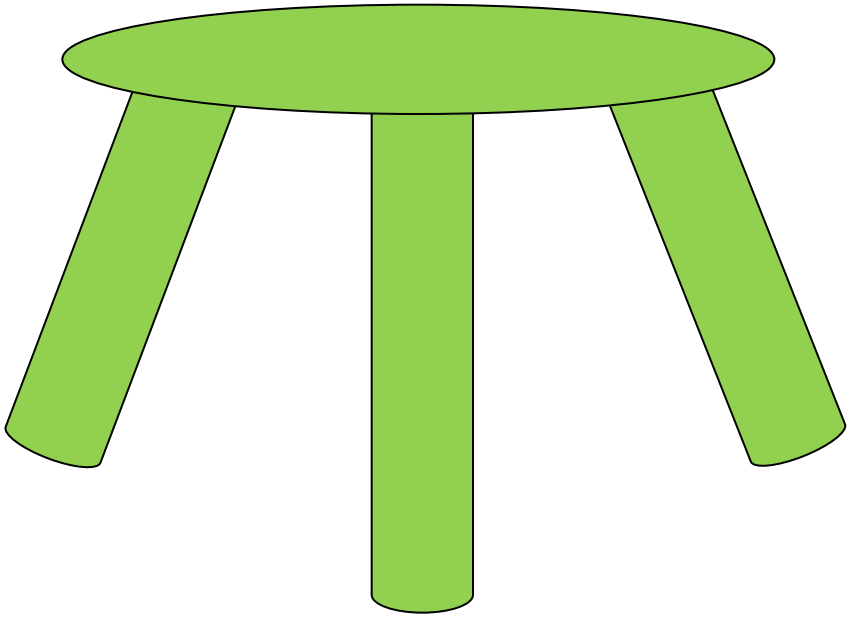


Architecture Perspectives on Standards Integration



Three Legged Stool: Necessary Ingredients for Successful Interoperable Systems Development

Interoperable products and services

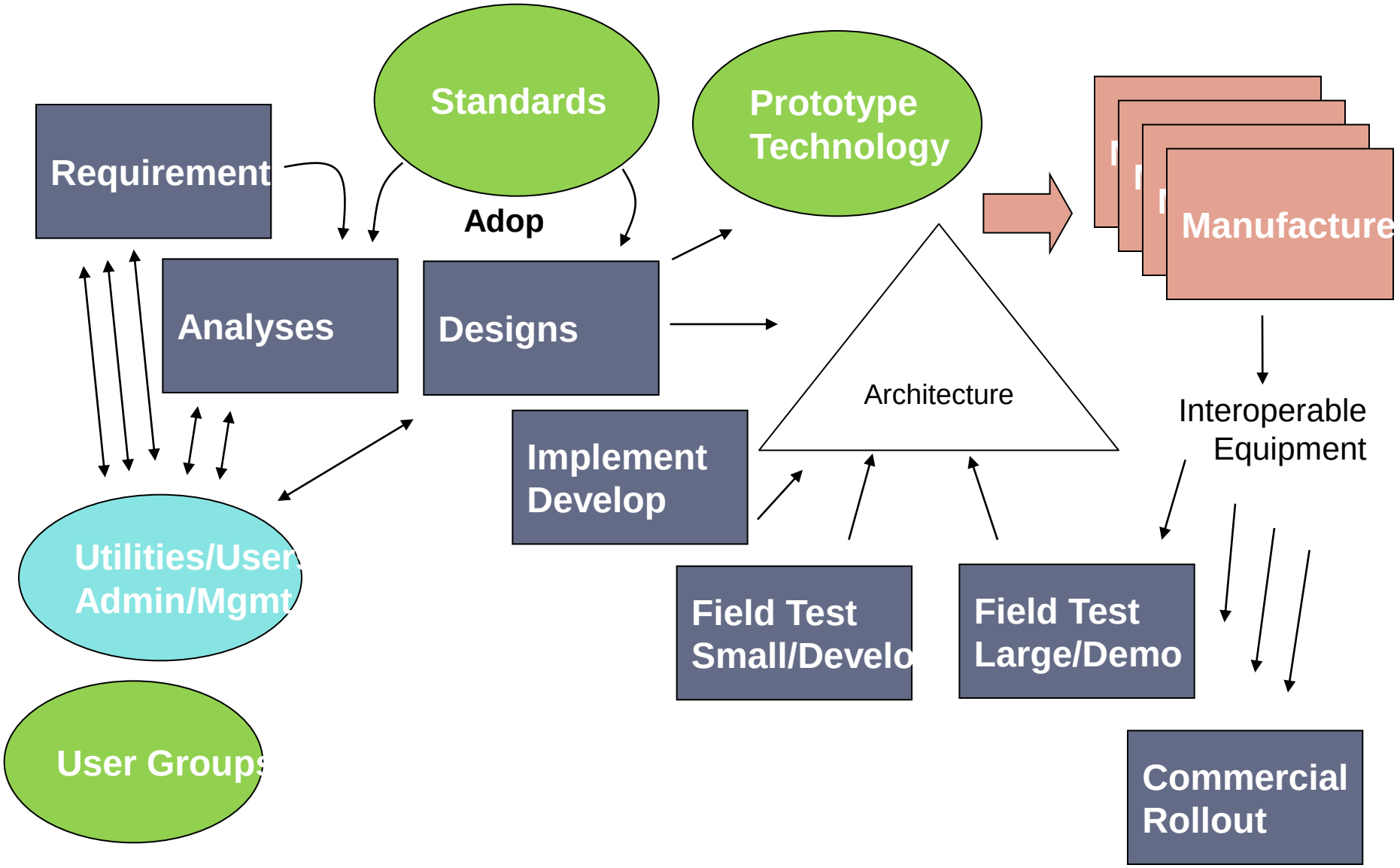


1) Open standards: Protocols, test schemas, object models
IEC TC57,
ANSI C12,
ASHRAE SPC135

2) Involved User Group: Interoperability Agreements, Labeling, Testing, Marketing
UCA International,
BACnet Mfgs. Assoc.
Assoc. of Edison Illuminating Cos

3) reference implementations: Developer Tools, Standards Implementations and test implementations
AMRTools, openAMI, …

INFRASTRUCTURE DEVELOPMENT PROCESSES



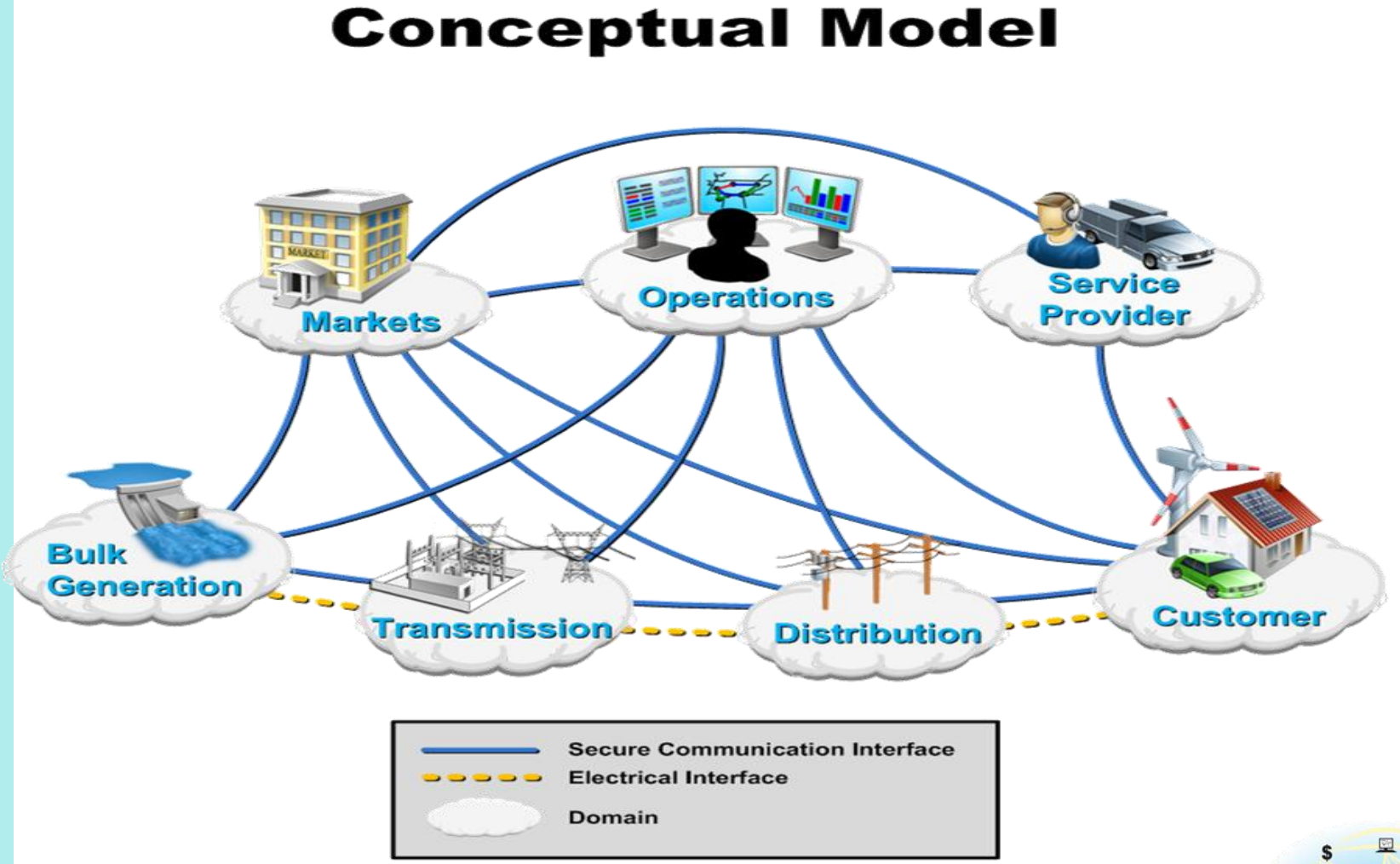
Architecture Provides a Framework for Consistency where it is needed to:

- Enable effective system designs, and documentation
- Develop, implement and manage security (and systems management) policies across the enterprise/industry
- Manage scale and scope of deployed systems
- Integrate systems across traditional operating boundaries e.g. IT and Power Engineering
- Integrate systems across ownership boundaries e.g. utilities and customer systems
- Provide a systematic approach to Life-Cycle management of systems
- Provide a means of requirements traceability

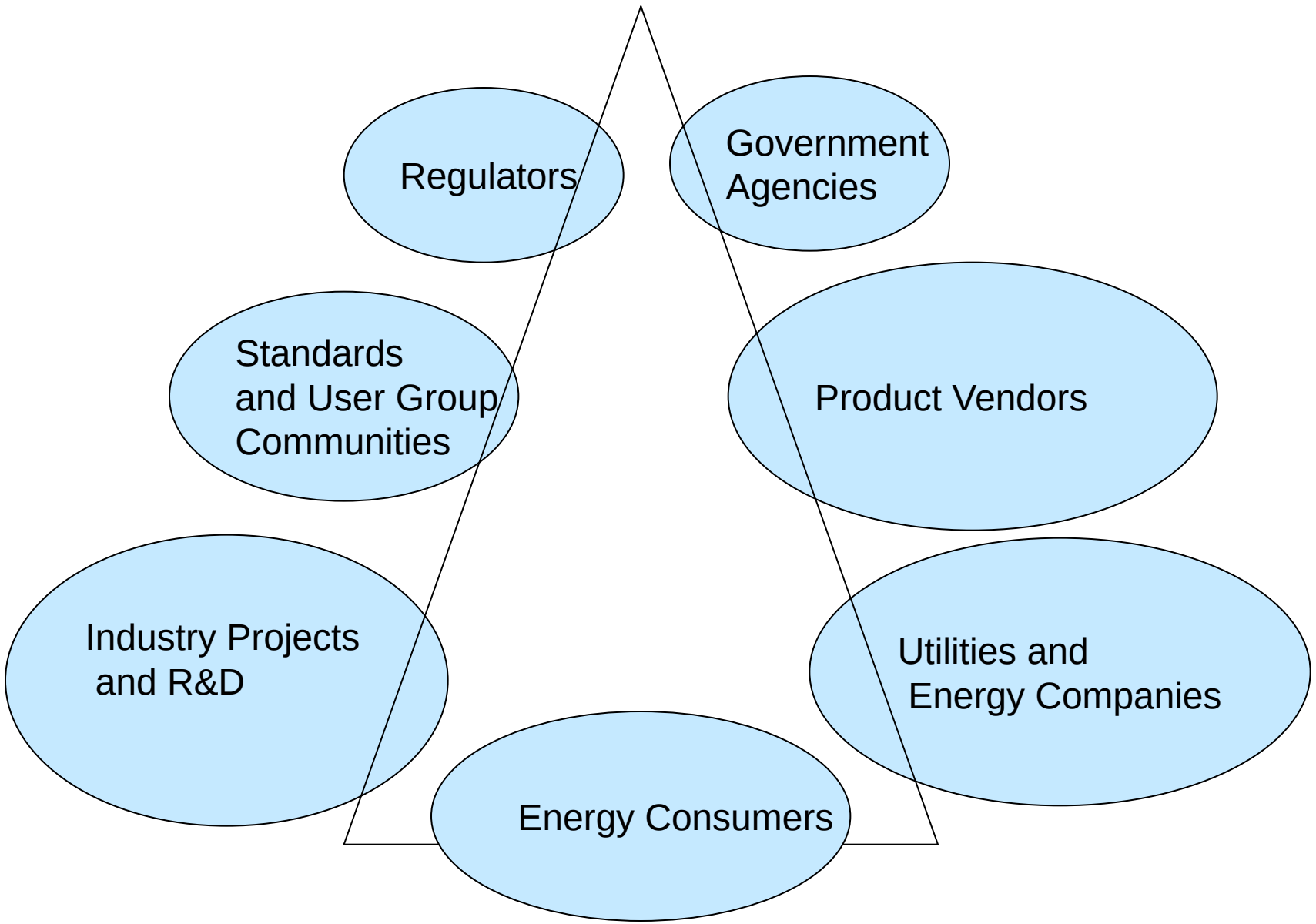
Smart Grid Architecture Development

- Electric Power Research Institute: Utility Communications Architecture (UCA) 1.0 (1991) UCA 2.0 (1997)
- Natural Gas UCA (Joint between GRI and EPRI circa 1993)
- Water UCA (Joint between American Water Works RF and EPRI circa 1994)
- MMS Forum (1992)=>UCA Forum (1996)=>UCA International Users Group
- IEEE Standards Coordination Committee 36 (1996)
- IEC Technical Committee 57 “Architecture Document”
- EPRI Integrated Energy and Communications System Architecture (IECSA) (2004)
- EISA Legislation (2007)
- SGIP Smart Grid Architecture Committee (2009)
- IEEE P 2030 (2010)
- IEC Smart Grid
- Other

SGIP Smart Grid Architecture Committee (SGAC)



Architecture Puts a Technical Framework around Key Relationships…



Contact Information

Joe Hughes, Reef Energy Systems, LLC

reefarch@gmail.com

925 786 2775

SGIP SGAC Website:

http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/SmartGridArchitectureCommittee