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IntelliGrid Methodology for Developing Requirements for Energy Systems

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IntelliGrid Methodology for Developing Requirements for Energy Systems

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IntelliGrid Methodology for Developing Requirements for Energy Systems

1. Scope and Objectives

This section describes the scope, purpose and objectives of this specification and the architecture on which it was based.

1.1 Scope of the Specification

This Publicly Available Specification (PAS) defines a methodology for power system domain experts to determine and describe their user requirements for automation systems, based on their utility business needs. This methodology was originally developed as part of the IntelliGrid Architecture developed by the Electrical Power Research Institute (EPRI), as a means to implement the "IntelliGrid vision" of the automated, self-healing, and efficient power system of the future.

1.2 Overview of the Methodology

1.2.1 Concept of System Engineering

The IntelliGrid methodology is a subset of the science of systems engineering. Systems engineering methodology separates the concepts of "user requirements" from "technical specifications": **user requirements** define "**what**" is needed without reference to any specific designs or technologies, while **technical specifications** define "**how**" to implement the automation systems in order to meet the user requirements.

1.2.2 IntelliGrid System Engineering Methodology

The overall IntelliGrid systems engineering methodology is illustrated in Figure 1 and consists of the following types of people and project steps:

- **Executives or other utility managers review business cases** which describe and justify a perceived business need. They then approve specific projects.
- **Domain experts and project engineers are tasked to develop a project team** to undertake the project. As one of the first undertakings of the project team, all power system experts and other stakeholders (users) that could impact or be impacted by the project should be identified and represented (full time, part time, or as applicable) on the project team.
- **Domain experts review the existing IntelliGrid Use Cases** for applicability and ideas. These Use Cases can be found at http://intelligrid.info/IntelliGrid_Architecture/Use_Cases/IECSA_use_cases_overview.htm
- **Domain experts develop a list of Use Cases** (functional descriptions), covering not only the specific business need but other user needs and future possibilities that could impact or might be impacted by the project.
- **Domain experts,** with possible assistance by project engineers who understand the Use Case process, **draft the key Use Cases**, capturing all of the necessary user requirements.
- **Domain experts review and update these Use Cases** to ensure their needs are captured correctly and to assess possible misunderstandings, overlaps, holes, and other inconsistencies

- **Project engineers assess and coordinate the Use Cases** from which they develop a comprehensive and detailed user requirements document. This detailed user requirements document contains only user requirements.
- **Information specialists apply the appropriate standards and technologies,** based on the user requirements document. The strategic vision of the IntelliGrid Architecture should be used to determine the key standards and technologies.
- **Design engineers develop the Technical Specifications**, which combine the user requirements from the domain experts, the strategic standards and technologies from the information specialists, and the tactical approach to system development recommended by the IntelliGrid Architecture.

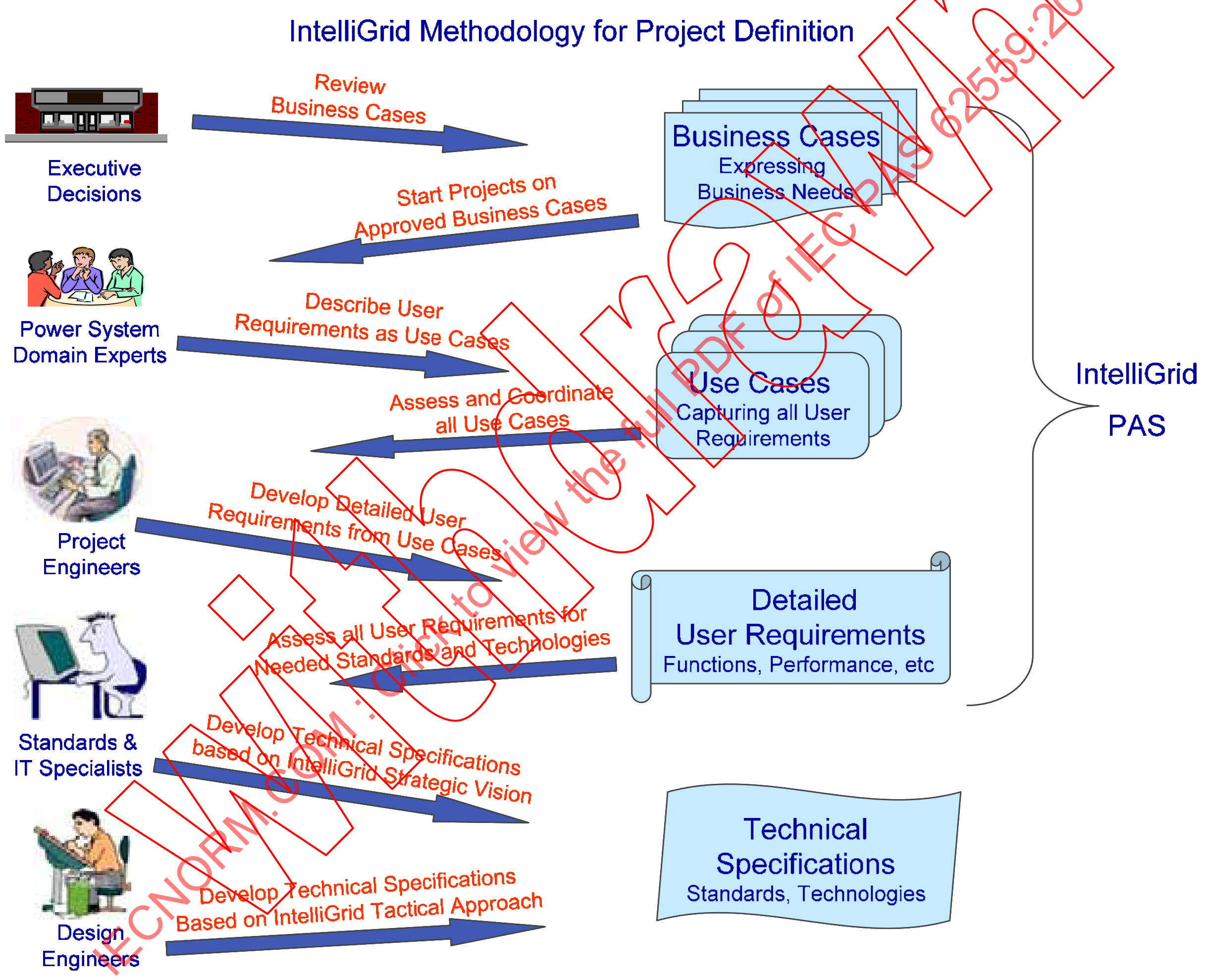


Figure 1: IntelliGrid Methodology for Project Definition

The user requirements as elicited by the Use Case process and ultimately described in the detailed user requirements document cover:

- **Functions** from the user perspective, including functional description of processes, user choices, types of input data, types of results, and possibly display appearance

- **Configuration issues**, such as access to field data, electrically noisy substation environment, control centre LAN, or cross-organizational interactions
- **Performance requirements**, such as availability, response times, latency, precision, frequency of updated results, and other user parameters
- **Security requirements**, such as confidentiality, access restrictions, detection of failures and/or intrusions, failure management, and other safety, security, and failure issues
- **Data management requirements**, such as sizes, numbers of devices, amounts of data, expected growth over time, data access methods, data maintenance, and other data management considerations.
- **Constraints**, such as contractual, legal, regulatory, safety rules, or other issues that could impact the requirements

While a complete systems engineering methodology covers both the identification of user requirements and the development of technical specifications, this PAS addresses only the methodology for determining and documenting the user requirements.

1.2.3 Overview of Phased Approach

Although the IntelliGrid methodology covers the entire process for developing systems, this PAS focuses only on the development of User Requirements, and therefore concentrates on the first 3 phases, although it also addresses the remaining phases as they are applicable to User Requirements.

The IntelliGrid Architecture describes the overall methodology for undertaking projects consisting of the following phases, as illustrated in Figure 2.

- **Phase 1: Executives** use Business Cases to approve projects in order to meet Business Needs. Although this step in the process involves executive decisions based on cost-justification and other non-technical factors, from the IntelliGrid Architecture point of view, the key requirement for these executives in making decisions to approve projects is that they should require all IntelliGrid Strategic Vision issues to be addressed in the Business Cases. Specifically, the Business Cases should explicitly state whether or why not the Strategic Vision issues will be part of the project, including Use Case modeling, use of abstract data models, security issues, network and system management, data management, and integration/interoperability.
- **Phase 2: Domain Expert Stakeholders** describe their User Requirements through the formal Use Case process. Use Cases permit these experts to express their requirements in a formalized manner that can then be coordinated and solidified into more detailed functional and performance requirements in the next phase.
- **Phase 3: Project Engineers** develop the more detailed functional and performance requirements from the Use Cases that were developed by the domain experts.
- **Phase 4: Project Engineers** and **IT Specialists** assess applicability to the project of the standards, technologies, and best practices identified in the appropriate IntelliGrid Environments.
- **Phase 5: Design Engineers** develop Technical Specifications based on Strategic Vision, Tactical Approach, & Standards

1.2.4 Phase 1: IntelliGrid Methodology for Executives

1.2.4.1 Step 1: IntelliGrid Recommendations for Executives

As described in the IntelliGrid Architecture report and web site, the following are the general IntelliGrid recommendations for utility executives:

- **Adopt the IntelliGrid Architecture** as the strategic vision for the utility information infrastructure
- **Ensure that the different users of the IntelliGrid Architecture understand** how to utilize the relevant parts of IntelliGrid Architecture products, including the power system functional descriptions and IntelliGrid Architecture Strategic Vision.
- **Develop a plan for implementing the IntelliGrid Architecture methods and standards-based technologies**, based on the utility's specific business needs, the timeframe appropriate for meeting those needs, and the financial constraints.
- **Provide feedback to EPRI and Standards Organizations** so that the IntelliGrid Architecture can evolve to meet future needs and recommend standards that are created in the future.
- **Ensure all Business Cases explicitly state how or why not the Strategic Vision issues will be part of the project**, including Use Case modeling for functions, abstract data models, security issues, network and system management, data management, and integration/ interoperability.

1.2.4.2 Step 2: Executives and Business Needs

When specific business needs are identified, executives have long used Business Cases as the method for assessing and determining which business needs can and should be met. Business Cases typically describe the business need, provide financial and organizational assessments of potential ways for meeting the business need, and recommend a specific solution with a justification for that recommendation.

As the first phase in the IntelliGrid methodology, executives (or other utility decision-makers) are expected to review the Business Cases and approve those that meet certain justification criteria (often financial payback criteria).

1.2.4.3 Step 3: Establishing a Project Team

Once the executives have approved a project to meet a business need, the first step is to develop a **project team**. This project team should include representatives from all of the main stakeholders, in order to ensure more useful functional requirements and to help ensure "buy-in" by these ultimate users of the function. Not all stakeholders need to be full-time members of the project team, but should always be included in any discussions that are relevant to their areas of expertise.

1.2.5 Phase 2: IntelliGrid Methodology for Domain Experts: Modeling User Requirements with Use Cases

1.2.5.1 Step 1: Identification of All Potential Stakeholders

One of the very first tasks of the project team should be to identify **ALL potential stakeholders**, even if some eventually do not directly participate in the project. Often they may have requirements that may appear peripheral to the main project but could easily be met if designed in from the beginning.

Once identified, all of these stakeholders should have the project explained (briefly) to them, and then asked if they have any user requirements that could impact (or be impacted by) the project. They should be encouraged to think “out of the box”, to brainstorm future scenarios, and to envision new capabilities, rather than just restating existing functions. Thinking “out of the box” and generating “idealized designs” about what a stakeholder really needs can make profound changes in how businesses operate and how projects are implemented. This process can be difficult because understanding what might be possible under different conditions and technologies is very different from stating what is currently done.

Some of the new user requirements could just piggyback on the project without significant technical or financial impact while others might involve changing the overall user requirements to accommodate the new needs. Other requirements might lead to simple accommodations for future expansion of the systems being implemented so that they could handle these new, but possibly not yet justified, requirements in the future. Some brainstorming discussions might cause other stakeholders to rethink their own needs in a new way.

Although not all new user requirements would be implemented immediately, this brainstorming could lead new ways of thinking and eventually new projects to address those needs.

1.2.5.2 Step 2: Reviewing IntelliGrid Architecture Use Cases

The wheel should not be re-invented too many times. The IntelliGrid Architecture project identified over 400 functions: these could serve as a checklist or initiate new discussions on new types of functions. A few are described in more detail, using the IntelliGrid Architecture Use Case template (from which the IntelliGrid PAS Use Case template was derived). These can be reviewed also as illustrations on how Use Cases can be developed clearly and effectively to describe functions.

1.2.5.3 Step 3: Brainstorming List of Functions (Use Cases) with Stakeholders

A list of functions should be developed by the stakeholders that will capture all user requirements associated with the project area, even if some are “peripheral” to the main purpose of the project. This list of functions will ultimately be described by a set of interconnected Use Cases.

However, applying brainstorming to the Use Case process involves not only discarding old mindsets that inhibit creative thinking, but also learning how to use the Use Case process most effectively. The requirements gathering process should use an iterative and stepwise refinement-based methodology. This approach facilitates the requirements gathering process by stimulating stakeholder interest, collaborating on new ideas, and obtaining stakeholder buy-in.

In some cases, the list of functions may need to be pared down, combined, or prioritized so that the primary functions are identified.

1.2.5.4 Step 4: Drafting Use Cases

The functions identified in the list should then be drafted into a **set of Use Cases**. These Use Cases should be the product of domain experts, but often these experts are not experienced in Use Case concepts. Therefore, project engineers who are experienced in the Use Case process could help elicit the requirements from the domain experts.

Drafting Use Cases can also be iterative, with some Use Cases expanded and possibly split into multiple Use Cases, while others are amalgamated into one.

The process of developing Use Cases using the IntelliGrid PAS Use Case template is described in Annex A.

1.2.5.5 Step 5: Reviewing and Updating Use Cases

All domain experts should have a chance to review and comment on Use Cases. Some stakeholders may be more proactive than others, but care should be taken that the requirements of less active stakeholders are not lost.

Some Use Cases may end up being split into multiple Use Cases, while other Use Cases may be combined during this process. Use Cases can be updated multiple times if needed – but the decision when to stop modifying or "tweaking" a Use Case can be more of an art than a science.

1.2.6 Phase 3: IntelliGrid Methodology for Project Engineers: Developing Detailed User Requirements

1.2.6.1 Step 1: Coordinating and Combining Use Cases

Project engineers should coordinate the many Use Cases from the domain experts and possibly combine any common components into "subroutine" Use Cases, while still maintaining the unique components. The results should be reviewed by the domain experts to ensure their requirements did not get left out by accident.

In particular, project engineers should review the characteristics of common components (e.g. types of data, configuration, quality of service, security, and data management), and develop comprehensive and/or coordinated requirements across all Use Cases. For instance, they should identify the most "constraining" requirements, such as the highest level of security needed or the most rapid response requirements, so that either all elements will meet that constraint or the constrained elements are isolated from the other elements.

1.2.6.2 Step 2: Developing User Requirements from the Use Cases

Use Cases are vital to understanding the individual user requirements, but are difficult to view in combination. Therefore, once the individual Use Cases have been finalized by the domain experts and the project engineers, a single (or just a few) **Functional Requirements** documents should be developed that captures all of the (coordinated) user requirements. Just like the Use Cases themselves, these functional requirements address "**what**" is needed, but **not "how"** it is to be provided.

These functional requirements thus form the basis for Technical Specifications which can add additional specific technical requirements.

1.3 Objectives of this Specification

As defined by the IEC, the scope of IEC TC8 is to "*prepare and coordinate, in co-operation with other TC/SCs, the development of international standards and other deliverables with emphasis on overall system aspects of electricity supply systems and acceptable balance between cost and quality for the users of electrical energy. Electricity supply system encompasses transmission and distribution networks and connected user installations (generators and loads) with their network interfaces.*"

IEC TC8 is therefore developing this PAS to with the following objectives:

- To develop a standard methodology for determining and defining user requirements in a consistent and comprehensive manner. Standards often address only the technical issues that are included in technical specifications; however, it is just as vital to develop standards to assist users to clearly and comprehensively define their requirements.

- To clarify the distinction between “user requirements” (the “what” as needed by power system experts) and “technical specifications” (the “how” as technical descriptions of systems, applications, and information flows to meet the “what”). Currently this distinction is an “invisible line” so that often the “what” and the “how” are mixed together – with technology-oriented project engineers jumping directly to the “how” without fully exploring the “what” with the power system experts.
- To emphasize the critical need to determine *all* user requirements first, before any commitments are made on “how” to meet those requirements. Because automation and control systems are so complex and are becoming increasingly so, if all requirements are not clearly defined first, then the premature design of systems can block or seriously hinder meeting those requirements that were not initially recognized.
- To provide a means for testing the systems once implemented to ensure that the user requirements are truly met, regardless of what standards and technologies are ultimately incorporated by the vendors.

1.4 Audience of this Specification

The expected audience of this PAS include:

- Executives who are evaluating business needs and need to understand the overall process for implementing solutions to meet those needs.
- Power system experts who know their areas of power engineering, but are not familiar with methods for expressing their automation requirements in a manner that project engineers can use.
- Project engineers who are familiar with general project management procedures but want to utilize state-of-the-art methodologies to improve the capture of all relevant user requirements, and to minimize the need to make unplanned modifications and replacement of systems and equipment to accommodate unexpected user requirements.

2. Normative References

Users can access the IntelliGrid Architecture documents or the IntelliGrid Architecture web site at http://IntelliGrid.info.

3. Definitions and Abbreviations

Abbreviation	Definition
EPRI	Electric Power Research Institute
IEEE	Institute of Electrical and Electronic Engineers
PAS	Publicly Available Specification

4. Glossary of Terms

4.1 Referenced Sources of Glossary Terms

- IEC TC/SC:ACEA IEC GUIDE 114, ed. 1.0 (2005-05) Ref 3.13
- IEEE STD 1471, 2001

4.2 Terms and Definitions

Term	Definition
4.2.1 Application (Software)	Software designed to fulfill specific needs of a user: for example, software for navigation, payroll, or process control. [IEEE Std 100-1992] Software that is specific to the solution of an application problem. [ANSI X3.172-1996]
4.2.2 Architecture	An architecture is the fundamental organization of a system embodied in its components their relationships to each other and to the environment, and the principles guiding its design and evolution. [IEEE Std 1471]
4.2.3 Business Need	Requirement of a business to meet its mission, goals, and/or objectives. Business needs can be identified in a business case that describes a project or procedure to meet that business need. [Common Usage]
4.2.4 Domain	An area of knowledge or activity characterized by a set of concepts and terminology understood by practitioners in that area. [OMG UML]
4.2.5 Methodology (software engineering)	A methodology is a codified set of practices carried out to produce software. [Common Usage]
4.2.6 Project Engineer	An engineer or team of engineers who undertake a project. [Common Usage]
4.2.7 Project Management	Project management is the discipline of defining and achieving finite objectives. The challenge of project management is the optimized integration and allocation of the inputs needed to meet those pre-defined objectives. The project, therefore, is a carefully selected set of activities chosen to use resources (time, money, people, materials, energy, space, provisions, communication, quality, risk, etc.) to meet the pre-defined objectives. [Common Usage]
4.2.8 Design Specification	Document or set of documents that describe the organization and functioning of an item, and that are used as a basis for the implementation and the integration of the item IEC 62138, ed. 1.0 (2004-01)
4.2.9 Use Case	Class specification of a sequence of actions, including variants, that a system (or other entity) can perform, interacting with actors of the system IEC 62390, ed. 1.0 (2005-01)
4.2.10 Unified Modeling Language, UML	Modeling language and methodology for specifying, visualizing, constructing, and documenting the artifacts of a system-intensive process IEC 61970-501, ed. 1.0 (2006-03)
4.2.11 User Requirements	Requirements of the function based on the business needs, without explicitly identifying any specific technologies or products. The same document can also cover "non-functional" requirements, such as constraints, performance, security, and data interactions with other applications or systems. [Common Usage]

5. Introduction to the IntelliGrid Architecture

The systems engineering methodology described in this specification is based on the IntelliGrid Architecture. This section provides an overview of the goals and capabilities of this architecture.

5.1 History and Rationale

The Electric Power Research Institute (EPRI) initiated a research project in 2002 which eventually developed the IntelliGrid Architecture. The basic premise of the IntelliGrid Architecture is that both the power system infrastructure and the information infrastructure must be interactively designed if the future vision of the highly reliable, highly efficient, self-healing power grid is ever going to be realized.

Since the public began to use electrical power, utilities have always carefully designed, constructed, operated, and maintained the power system infrastructure. Given the growing need for information and automation of the power system, the information infrastructure now also needs to be carefully designed, constructed, operated, and maintained in close coordination with the power system.

Power engineers have relied on standards and technologies that were developed over the years to build the power system infrastructure; information engineers also must rely on standards and technologies for the information infrastructure that must support power system requirements.

To help determine what standards and technologies should be used, a methodology is needed bridge the gap between power engineers and information engineers. This methodology must permit power system engineers to express their information user requirements without becoming instantaneous “information experts”.

The IntelliGrid Architecture developed this methodology based on the concept of Use Cases, which are a best practice for system engineering in a variety of other industries. A Use Case is simply a “story” about how a system will be used, ideally developed by the people who will actually be using it. Use Cases permit “users” too clearly and comprehensively express their information needs in a manner that can be used by information specialists and design engineers to develop the automation systems that will exactly meet their requirements.

5.2 Basic Concepts

The IntelliGrid methodology is a process for utilities to use when designing communications systems and information systems targeted at transmission and distribution systems and/or the utility customer. Shows the domain space over which the IntelliGrid System Architecture can be applied.

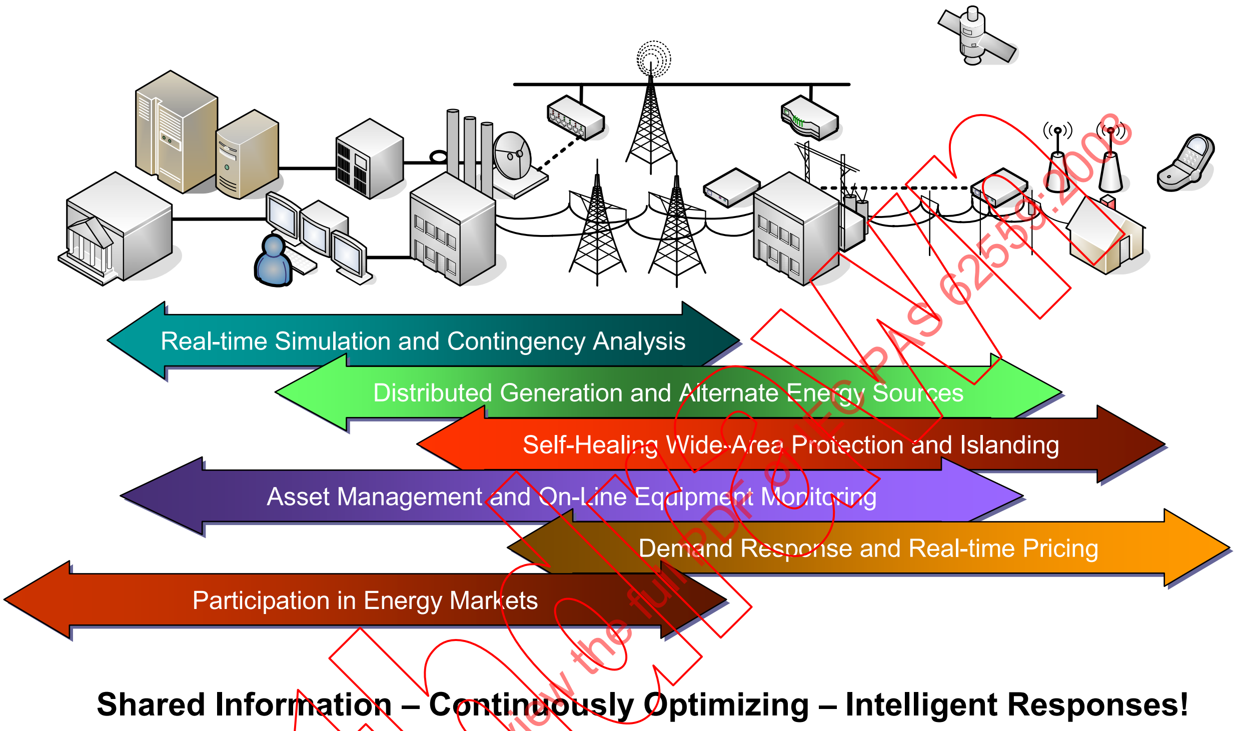


Figure 2: IntelliGrid Applications

There are several high-level concepts and principles that are promoted in the IntelliGrid Architecture:

- Integration of systems, especially the power system and its controlling communication system
- Use of standards-based open systems that interoperate
- User definition of applications and requirements
- Mapping technology solutions to requirements

The IntelliGrid Architecture has developed several tools that can be used when designing utility communications and information systems:

- Templates for capturing and defining requirements
- Recommendations of standards and technologies to use
- Strategies for building security into systems

- Strategies for migrating to open, standards-based systems and integrating new open, standards-based systems with existing systems
- Strategies for developing “layered” solutions that minimize the impact of changing technologies in the future

An application of the IntelliGrid Architecture is the use of any or all of the above tools and high-level concepts.

There are a variety of methods to describe and use the IntelliGrid Architecture. This chapter discusses three of these methods that are useful for gathering requirements, and then explains which portions are applicable to this specification:

- The conceptual pyramid
- Five sequential steps
- Three concurrent streams

5.3 The Pyramid

The concepts and tools of the IntelliGrid Architecture discussed in the previous section can be viewed as a pyramid that consists of the following components. Figure 3 depicts the IntelliGrid Architecture pyramid and identifies how the components build on each other:

- **Business Needs,** typically identified and justified in business cases and approved by executives, drive the undertaking of projects to meet those needs. These projects need to integrate many stakeholder requirements. The IntelliGrid methodology urges these “domain expert” stakeholders to describe their requirements in comprehensive sets of “Use Cases”. These Use Cases can then be used by project engineers to develop a single coherent document of user requirements that reflect all stakeholder requirements.
- **Strategic Vision** focused on abstract modeling, security, network and system management, data management, integration, interoperability, and technology independence. These strategic elements need to be woven into the system design phase, in moving from the user requirements to detailed technical specifications.
- **Tactical Approach** using **Technology Independent Techniques** of information models, common services, and interfaces. This tactical approach identifies the technical concepts and approaches that permit a system design to implement the appropriate strategic requirements.
- **Standards, Technologies,** and **Best Practices** that could be used in different projects. One size does not fit all: the energy industry encompasses many special types of information requirements, some unique to its operational needs and some very common to many industries. Therefore, the IntelliGrid Architecture categorizes these special requirements as the **IntelliGrid Architecture Environments**, defining each Environment according to its common requirements, and identifying possible appropriate standards and technologies.
- **Methodologies for using the IntelliGrid Architecture,** focusing on how different groups can best use the IntelliGrid components. These groups include executives, automation architects, power system planners/engineers, project engineers, information specialists, regulators, and standards organizations.

Figure 3: The IntelliGrid Architecture Pyramid

5.4 Business Needs and Functional Requirements

The uppermost level of the IntelliGrid pyramid is composed of the business needs of the power system. They are the drivers for all subsequent components of the IntelliGrid Architecture pyramid. Projects to meet these business needs are typically identified through business cases, which include the reasons for the project, the expected business benefits, the options considered (with reasons for rejecting or carrying forward each option), and the expected costs of the project, a gap analysis, and the expected risks. Once projects have been authorized at a high level, the next step is to determine the functional requirements.

In the past, the step from project authorization to implementation often involved just asking a few power system engineers to develop and issue a technical specification that would be sent to vendors (or used in-house) to procure the power system equipment and/or some computer-based controllers and software applications. These engineers would describe what they wanted, usually with no attempts to involve any other groups.

That process is no longer the optimal methodology except possibly for the simplest purchases. Most power system equipment, computer systems, and software applications now need to be integrated into a larger whole. Many more users want to take advantage of information flowing from the power system equipment as well as related computer systems. Often this information goes well beyond what the core users are interested in. For instance, operators use SCADA systems to monitor key power system states, and have little or no interest in routine maintenance activities or distribution transformer loadings or customer power quality measurements. However, some systems that may be needed by operators can also benefit these other users if they can access more types of information.

Islands of automation are no longer cost-beneficial. Yet the process for determining and amalgamating all the new requirements from all the new users seems like a very daunting task.

Top-down system engineering provides a solution to this problem. At the start of the project, cross functional teams are assembled to assess what the business and functional requirements are the target of the information system under investigation. These teams use a methodology called Use Cases. Use Cases place particular emphasis on how the information system will actually be used when deployed rather than being constrained by the design of existing products. The utility's intent is to clearly define the desired requirements, leaving vendors as free as possible to come up with innovative solutions.

5.5 Development Phases

Another way to view the IntelliGrid architecture is to think of phases of development. The overall process for undertaking IntelliGrid projects consists of the following phases, as illustrated in Figure 4.

- **Phase 1: Executives** use Business Cases to approve projects in order to meet Business Needs. Although financial needs are paramount, from a technical point of view the key requirement for executives in approving projects is that they should require all IntelliGrid Strategic Vision issues (security, network management, data management, etc.) to be addressed in the Business Cases. Specifically, the Business Cases should explicitly state whether or why not the Strategic Vision issues will be part of the project, including Use Case modeling, use of abstract data models, security issues, network and system management, data management, and integration/interoperability.
- **Phase 2: Domain Expert Stakeholders** describe their User Requirements through the formal Use Case process. Use Cases permit these experts to express their requirements in a formalized manner that can then be coordinated and solidified into more detailed functional and performance requirements in the next phase.
- **Phase 3: Project Engineers** develop the more detailed functional and performance requirements from the Use Cases that were developed by the domain experts.
- **Phase 4: Project Engineers** and **IT Specialists** assess applicability to the project of the standards, technologies, and best practices identified in the appropriate IntelliGrid Environments.
- **Phase 5: Design Engineers** develop Technical Specifications based on Strategic Vision, Tactical Approach, & Standards

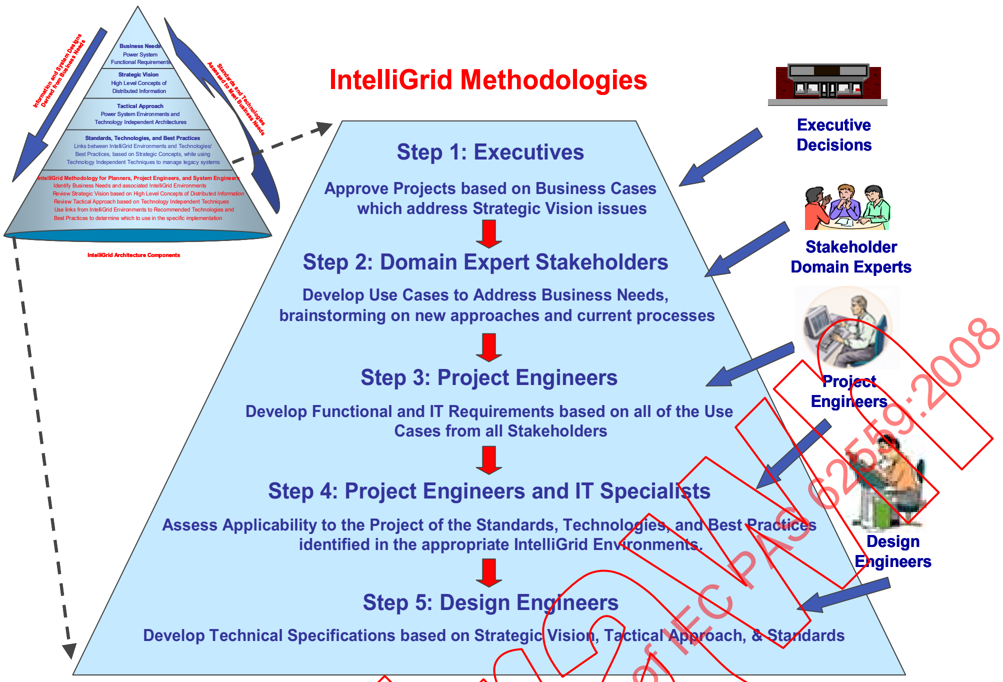


Figure 4: Phases of the IntelliGrid Development Process

5.6 Development Streams

An alternate way to view the IntelliGrid system engineering development process is as three separate streams as shown in Figure 5.

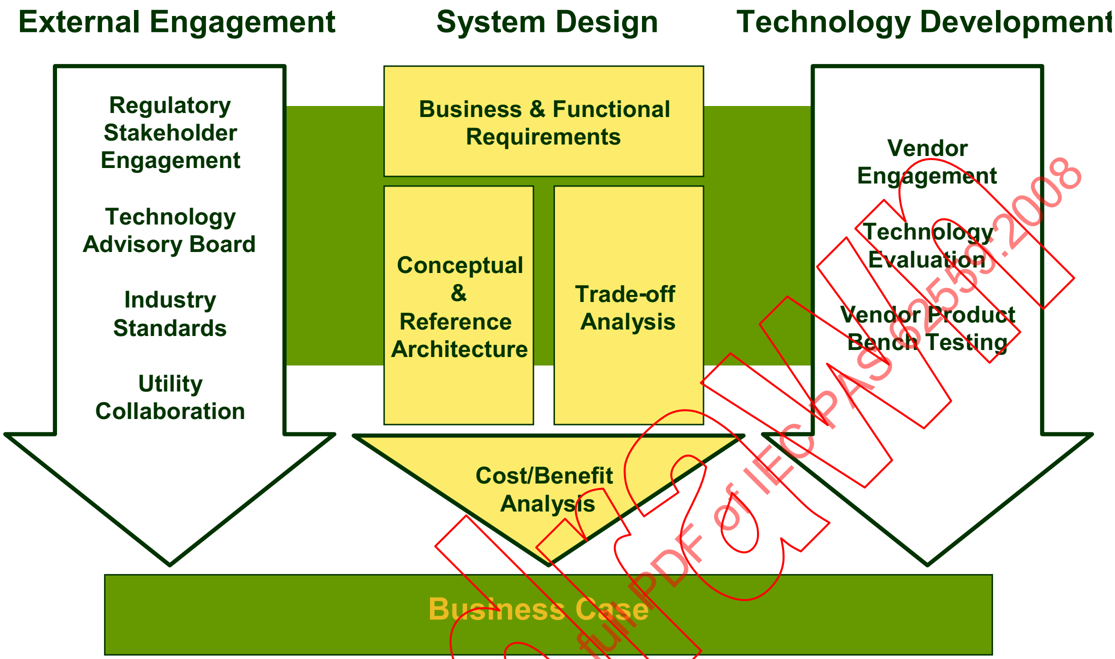


Figure 5: Streams of the IntelliGrid Development Process

The three streams are:

Business and Functional Assessment

The Business and Functional Assessment stream is necessary in order to effectively communicate "**Why** are we investing in the project?", "**What** functions and capabilities does the system have to perform?", "**Who** is involved in the information system, and **Who** will be the users of the information?", "**Where** are the data sources for the required functions?", "**How** are all the organizational and technology components integrated into a logical architecture?", **Which** systems, subsystems and components do we need in order to meet our utility's requirements?", and with "**What** standards, technologies, and vendor solutions will our utility use to accomplish the project goals?" With these questions in mind the utility can start the process of capturing the **Business & Functional Requirements**, create a **Conceptual & Reference Architecture**, and perform the **Trade-off Analysis** and **Cost/Benefit Analysis**.

External Stakeholder Engagement

There are many parties who interact with a utility and have an impact on the utility's operations and provide input to its regulation. These stakeholders include **Regulatory personnel, Technology Advisory Board, Industry Standards,** and **Utility Collaboration and user groups.** These external stakeholders are also sources of requirements that need to be taken into account in the development of systems.

System Technology Development

The IntelliGrid process requires development of the specifications and technology that enables interoperable equipment from different vendors. Projects deploying systems now will do extensive **Vendor Engagement** in order to assess current market capabilities and ability to meet minimum levels of interoperability. This process also requires in-depth **Technology Evaluation,** along with **Vendor Product Bench Testing** against requirements.

Final Business Case & Regulatory Application

In order for management and regulators to support and approve of any implementation of an information system, a strong business case must be assembled that defines the benefits of putting a new system into place and assessing this against total system costs, both initial and on-going. The high-level business case is initially developed early in the Business Needs and Functional Requirements step and is refined throughout the development process so that when the time comes to deploy the system, executives have the information they need for a final go/no-go decision. Some utilities may require a regulatory approval at this step also.

5.7 Scope Addressed in this Specification

As discussed in the previous sections, the ***IntelliGrid Architecture*** *development process can be described either as five phases, or as three separate streams running throughout the process. The five phases can be further simplified into:*

1. ***A METHODOLOGY for addressing business needs through the development of user requirements that reflect all stakeholder needs****. This methodology includes requesting that all stakeholders describe their requirements through formal Use Case methods to ensure that the functional requirements reflect all these needs. These Use Cases also define the constraints, performance, security, and data requirements of all new applications and systems – before any implementation activities are commenced.*
2. ***Strategic and tactical GUIDELINES for meeting these functional requirements based on the Strategic Vision, Tactical Approach, and assessment of standards through "IntelliGrid Environments"****. These guidelines are intended to help engineers assess the applicability of the different standards for meeting the functional requirements, based on an analysis of their specific utility situations, the performance and security implications of different power system "environments", and the capabilities of the various standards and technologies.*

This Publicly Available Specification focuses on just the first of these two elements: the IntelliGrid methodology for addressing business needs though describing user requirements. However, the strategic and tactical guidelines are also described briefly to illustrate how the functional requirements can then be developed into complete technical specifications by project engineers and information specialists.

Similarly, although an IntelliGrid development process involves all three streams of development: business and functional assessment, external engagement, and technology development, this specification will focus mainly on the requirements portion of the business and functional assessment.

The remainder of this document is organized according to the five phases, and discusses the steps to be executed within each phase.

6. Phase 1: Executives Determine Business Needs and Plan Projects

This section describes the initial planning phases of the project, to be performed by upper management.

6.1.1 Determine Business and Regulatory Drivers

It is important that all subsequent steps be driven by the business needs of the organization. Before beginning a utility automation project, it is important to be clear what financial problems or regulatory compliance issues are being addressed. Some examples include:

- Requirements for information sharing with other organizations
- Requirements for improving energy efficiency or reliability
- Potential new service offerings or revenue streams
- Reduction of costs by automating processes that were previously manual

6.1.2 Choose Projects

Within the chosen focus areas, select particular projects to be implemented; for instance, implementing a demand response program or advanced metering system would fall within the category of Consumer Participation.

6.1.3 Identify Candidate Technologies

Determine which international and national standards, industry agreements, best practices, and de facto standards may apply in this environment. The list of applicable technologies on the IntelliGrid Architecture web site may serve as a starting point.

6.1.4 Define a High-Level Business Case

Based on your organization's business and regulatory drivers, determine the high-level benefits and costs you expect to find as a result of implementing the project. This is the first decision point where your organization must determine whether it is feasible to proceed with the project.

6.1.5 Refine Process for Your Organization

Examine the remainder of this process and determine which steps are applicable to your organization and project within your organization. As illustrated in Figure 5 the project should follow three concurrent streams of effort: external engagement, business and functional assessment, and technology development.

6.1.6 Identify Stakeholders

Determine which parts of your organization, and which other organizations, are affected by the proposed project. Pay particular attention to traditional "silos" within your organization and ensure that even groups that would not traditionally be involved in an information technology project are considered. Figure 6 illustrates some groups that should be considered, using advanced metering as an example.

Once identified, all of these stakeholders should have the project explained (briefly) to them, and then asked if they have any user requirements that could impact (or be impacted by) the project. They should be encouraged to think “out of the box”, to brainstorm future scenarios, and to envision new capabilities, rather than just restating existing functions. Thinking “out of the box” and generating “idealized designs” about what a stakeholder really needs can make profound changes in how businesses operate and how projects are implemented. This process can be difficult because understanding what might be possible under different conditions and technologies is very different from stating what is currently done.

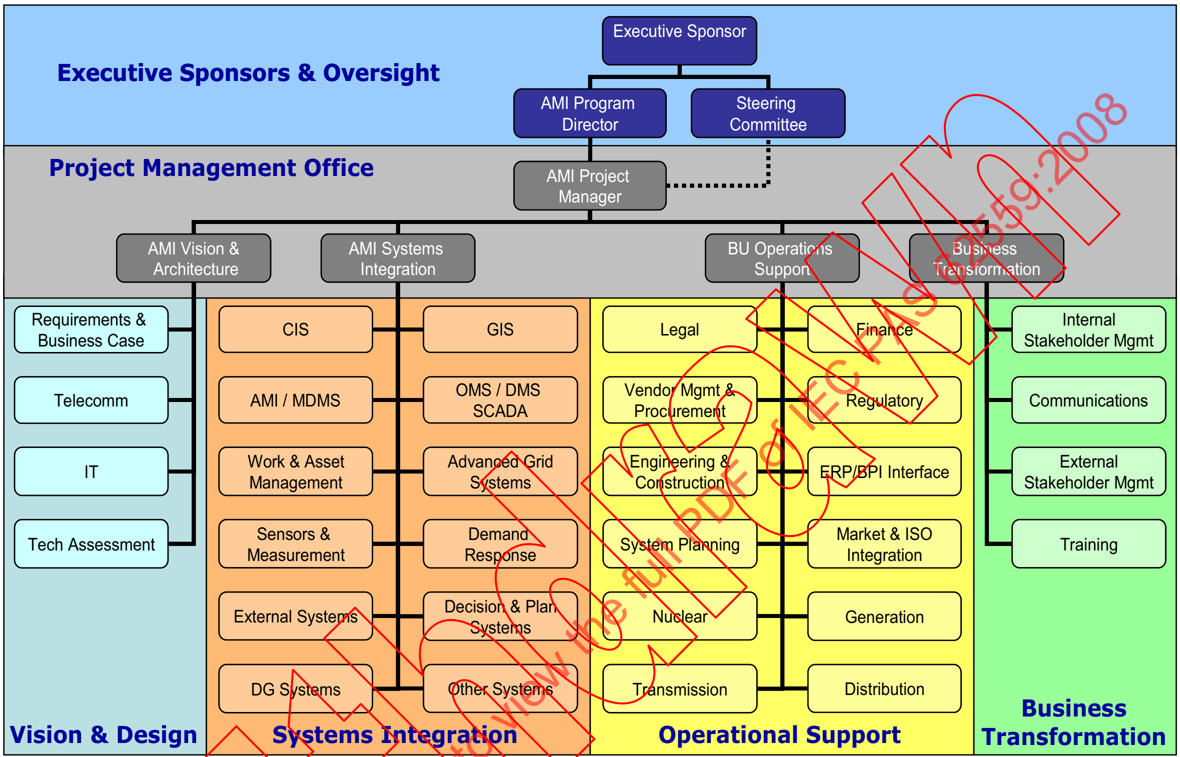


Figure 6: Potential Stakeholders and Requirements Team Structure

6.1.7 Establish a Project Team

Once the executives have approved a project to meet a business need, the first step is to develop a **project team**. This project team should include representatives from all of the main stakeholders, in order to ensure more useful functional requirements and to help ensure “buy-in” by these ultimate users of the function. Not all stakeholders need to be full-time members of the project team, but should always be included in any discussions that are relevant to their areas of expertise.

6.1.8 Select Teams

As suggested by Figure 6, develop cross-functional teams for performing the requirements definition process. These should include both the “go-to” people with technical knowledge, and their managers who can commit to whether a particular idea is a true requirement for the organization, or just a “would be nice” feature.

Key to the team selection is the choice of “systems architecture” or “vision and design” team, whose responsibilities will be to lead the process, provide guidance, develop and document the business cases and the architecture from the information that the requirements teams will produce.

7. Phase 2: Stakeholders Define User Requirements with Use Cases

This section describes the requirements gathering process, to be performed by the cross-functional teams of stakeholders defined in Phase 1.

7.1 Use Case Methodology

To develop requirements based on Use Cases, the utility should organize a process consisting of series of workshops using cross-functional teams, as illustrated in Figure 7. Use Cases place particular emphasis on how the system will actually be used when deployed rather than being constrained by the design of existing products. The utility must clearly define the desired requirements, leaving vendors as free as possible to come up with innovative solutions.

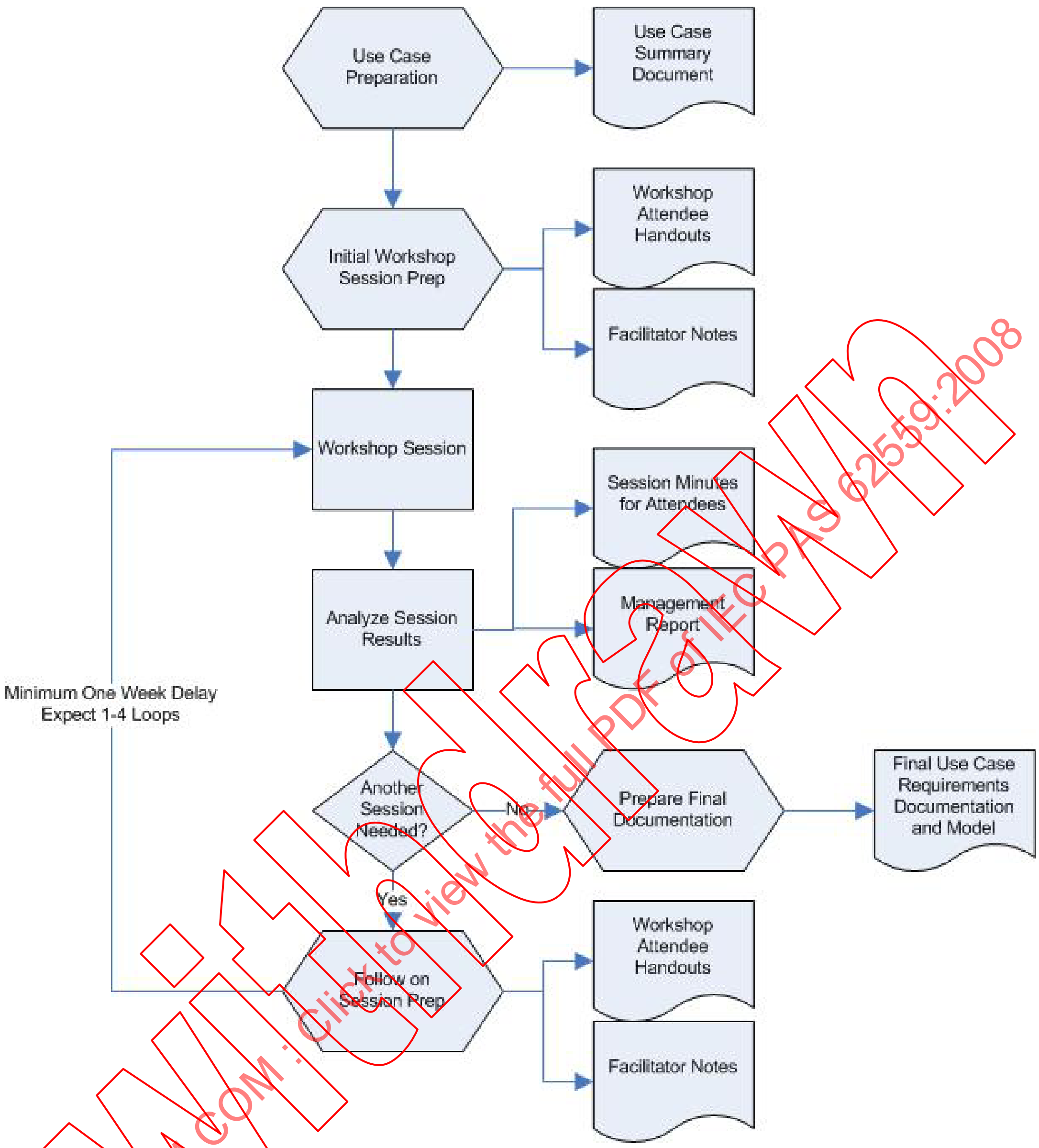


Figure 7: The Use Case Workshop Requirements Development Process

7.1.1 Use Case Introduction

A use case is simply a “story” that includes various “actors”, and the “path” they take to achieve a particular functional goal. By considering the actions of the actors working to achieve this functional goal, a completed use case results in the documentation of multiple scenarios, each containing a sequence of steps that trace an end-to-end path. These sequential steps describe the functions that the proposed systems and processes must provide, directly leading to the requirements for the given use case.

A use case may have many parts, but the following are the most important:

- The **goal** of the use case, which is usually its name. e.g. "Utility remotely connects or disconnects customer".
- The **narrative.** A short English text version of the story.
- The **actors**. An actor is anything in the system that communicates. It may be a person, a device, a piece of software, an organization, or anything else you can think of that acts on its own and can have goals and responsibilities. e.g. a "customer" or a "meter".
- The **assumptions** that the use case is based on. These can constitute requirements in and of themselves.
- The **contracts** and **preconditions** that exist between the actors, e.g. "The customer agrees with the utility to limit demand on selected days in exchange for a lower tariff."
- The **triggering event** that led to the scenario taking place.
- The **steps**. A numbered list of events that tell the story in detail. Each step identifies an actor, what the actor is doing, what information is being passed, and identifies to whom the information is sent. e.g. "7. The operator sends a curtailment command to the meter".

7.1.2 Use Case Selection

The selection of use cases depends on the high-level project goals and business drivers. A selection of use cases with utility wide scope have been identified by the IntelliGrid Architecture Project. The IntelliGrid Architecture team organized the energy industry into six functional domains:

- Market operations
- Transmission operations
- Distribution operations
- Centralized generation
- Distributed energy resources
- Customer services

A seventh domain, federated systems management, was also identified, which consists of technological functions, such as network management and security that cut across all of the other domains. These activities can be used as a basis for the use cases to consider.

7.2 Use Case Workshops to Develop Requirements

This section describes the process of holding use case workshops.

7.2.1 Use Case Workshop Goals

A Use Case is a sequence of events that describes the use a particular system. It is a story about how a particular user (or set of users) of a system reaches (or fails to reach) a goal. There may be several different scenarios within each use case, each telling a slightly different variation of the story, but all talking about the same goal.

When brainstorming system requirements, there are always a few problems:

- It's difficult to tell whether you are listing real requirements, or just a "wish list".
- It's difficult to know if you thought of everything.
- Once you have your list of requirements, it's not always easy to organize or track it.

The Use Case process of defining a use case forces people to find as many true requirements as possible because:

- It's done from the users' point of view, so it's easier to tell what's really necessary.
- It follows a complete path, so you have more confidence you caught everything.
- Because they're based around user goals, there is a natural way to organize them.

As each cross-functional team develops its story about the system, the team members will discover and make a list of requirements.

The utility assembles the Use Case Workshop members and plans a series of Use Case workshops. There are a number of industry tools that help to facilitate the development of Use Cases. The industry has standardized on a technology suite called Universal Modeling Language (UML) to help facilitate this process.

7.2.2 Use Case Workshop Membership

The membership of the use case teams should comprise people from internal organizations who are stakeholders or actors in the use case. The teams should contain both subject matter experts as well as decision makers. The subject matter experts provide the technical knowledge needed to ground the use case in reality and the decision makers should be managers with sufficient seniority to choose new policies. It is beneficial to include a workshop facilitator with experience in the use case and requirements gathering process. Each use case team should also have a leader who can guide the team and represent the team in system architecture meetings.

7.2.3 Use Case Workshop Planning

Prior to holding the use case workshop, the team leader(s) and facilitator should create a narrative that describes the high level goal of the use case. The facilitation team can also create straw man content for the workshop including:

- Actors and stakeholders
- Scenario steps
- Discussion topics that are specifically "in" or "out" of scope

These preparatory materials can be presented to the team members at the meeting using slides or handouts. These materials should be reviewed and updated for each additional workshop to reflect the decisions made by the use case team.

7.2.4 Use Case Workshop Agendas

A lesson that has been learned from earlier applications of the IntelliGrid use case process is to have a formal indoctrination of the stakeholders in the overall requirements capture process. The size of the project will dictate how best to introduce the team members to the use case process.

A focused training session involving all project participants can be used, or the training can occur in the initial use case workshop.

The use case workshops should be structured to engage the team members to participate, keeping in mind that a workshop may have people with widely varying backgrounds and skill sets. A sample workshop agenda is:

- Review and validation of the use case narrative
- Validation of key use case actors and roles
- Discussion of scenarios to be included within the use case
- Discussion of goals for the day's workshop including scenarios to be completed
- General ground rules for the session
- Developing the steps and requirements from the session

For second and following sessions…a review of outcomes of the prior session(s) and updates on any issues, action items, and parking lot items documented previously

The use case team leader provides overall strategic direction during the course of the workshop sessions. The facilitator provides agenda and process management. The workshop discussion generates proposed scenario steps. Upon general agreement the scenario steps are adopted and the discussion continues until the scenario is completed. The following guidelines can be used to ensure scenario completeness:

- **W**hat, not how. Concentrate on **what** needs to be done, not the technology or network that will make it happen. You don't want to limit the design too early in the process.
- **A**ctor's point of view. Are you looking at the system from the primary actor's (usually the customer's) point of view, or as a designer of the system? The wrong viewpoint can lead to usability problems.
- **V**alue for the actor. Are the steps you're discussing going to help the primary actor to accomplish its goal? Are you getting sidetracked?
- **E**ntire scenario. Have you gone far enough back to find the beginning of the scenario, and are you sure you've reached the goal?

7.2.5 Developing Requirements and Business Value

The scenario steps should be evaluated by the group to identify functional and non-functional requirements resulting from the step. The requirements also result in the identification of potential quantifiable or non-quantifiable business benefits that can be made possible by the scenarios included in the use case and should be documented.

It is vitally important as each requirement is identified to qualitatively identify the business value of each requirement. For instance, "Will reduce cost by eliminating the following manual steps…" These qualitative business value statements will be used later in the business case analysis portion of the requirements definition.

The results of the use case workshop should be disseminated to the team members and reviewed for accuracy. Questions and issues that arise during the workshop should be addressed by the architecture team and the answers should be included in the post workshop notes. The workshop process is repeated until the use case is complete.

7.2.6 Writing Good Requirements

A requirement is an expression of a ***perceived*** need that something be accomplished or realized. Note that this definition is intended to encompass ***all*** possible requirements for a project. Be aware that in the real world, a "requirement" may merely be something that someone wants.

The following items help to define "What's a *Good* Requirement?"

Binding

- Makes it clear what is optional and what is not
- Creates a "contract" with the reader

Shows Responsibility

- Identifies what component must take action
- Implies whose job it is to ensure it happens

Consistent in Level

- Target a consistent level: customer, strategic, functional, design, test, etc.
- Should not "jump ahead" to the next level

Measurable

- To be used later in the process to determine whether they've been met

Testable

- So one can determine whether the requirement has been met

7.2.6.1 Components of a Good Requirement

Good requirements are best expressed as complete sentences, in the form Subject-Verb-Object-Qualifier. One should not use "and" because such a sentence links two requirements together that may not actually be linked. Some rules are listed below:

Subject and Object

- Must be well-known parts of the system
- Try not to use "the system" – too vague
- Define your terms ahead of time
- If you involve people, make them ***specific roles*** if possible

- **GOOD**: “operator”, “administrator”, “maintenance worker”
- **NOT AS GOOD**: “user”, or “client”

Verb

- Proceeded by a ***binding*** word: “must” is okay, “shall” is best
- Can use “may optionally” to identify alternatives
- Use “will” only to provide extra info: “this will ensure that…”
- Use an ***action*** word
- ***Passive voice is forbidden***! It is designed to avoid ownership!
- Be as ***precise*** as possible
- **GOOD**: “transmit”, “display”, “activate”, “print”, “notify”, “connect”
- **BAD**: “is”, “be”, “have”, “contain”, “process”, “handle”, “support”
- “permit” is a good action word for user interfaces that puts the responsibility on the system providing the interface

Qualifier

- Specifies constraints or performance
- Must be ***measurable***
- Include a qualifier as often as you can

7.2.6.2 Classes of Requirements

Two types of requirements are developed for the system: functional and non-functional.

- **Functional Requirements** describe what the system must ***DO.*** They are actions in response to events, or actions performed autonomously. They represent operations and features provided
- **Non-Functional Requirements** describe what qualities the system must contain from an ***execution and performance perspective.*** These are also known as “constraints”, “behavior”, “criteria”, “performance targets”, etc. They set limits or controls on how well the system performs the functional requirements. on-Functional requirements include: reliability, security, usability, upgradeability, expandability, scalability, compatibility, safety, performance, and conformance

7.3 Use Case Analysis

The goal of the use case analysis is to produce a coherent set of use cases that can be used for subsequent architecture development. The use case analysis process should begin while the workshop process is still underway. The architecture team should review the output of the workshops to evaluate the preliminary requirements and provide feedback. The architecture team can address questions and issues posed by the use case teams and also identify and address scenario gaps or overlaps among different use case teams.

7.3.1 Global Actor List

The workshop process will produce a list of actors and their roles. The names and definitions of these actors should be reviewed to create a standardized list of actor names and roles. The iterative nature of the workshops and the different views that use case teams may hold will cause the creation of duplicate, redundant and conflicting actors. The standardization process should resolve all of these discrepancies.

7.3.2 Activity Diagrams

Activity diagrams are a graphical method to display the events occurring in a use case scenario. The use of this UML tool can provide several benefits. Displaying a use case scenario in a graphical form can allow users to better understand the sequence of events that are occurring and delineate which actors are performing which tasks. The diagram can also reveal points where the textual list of events is insufficient to describe possible outcomes that should be considered in the scenario. The diagram is also useful for indicating interfaces between actors which can also be captured in the UML sequence diagram. (See Figure 8.)

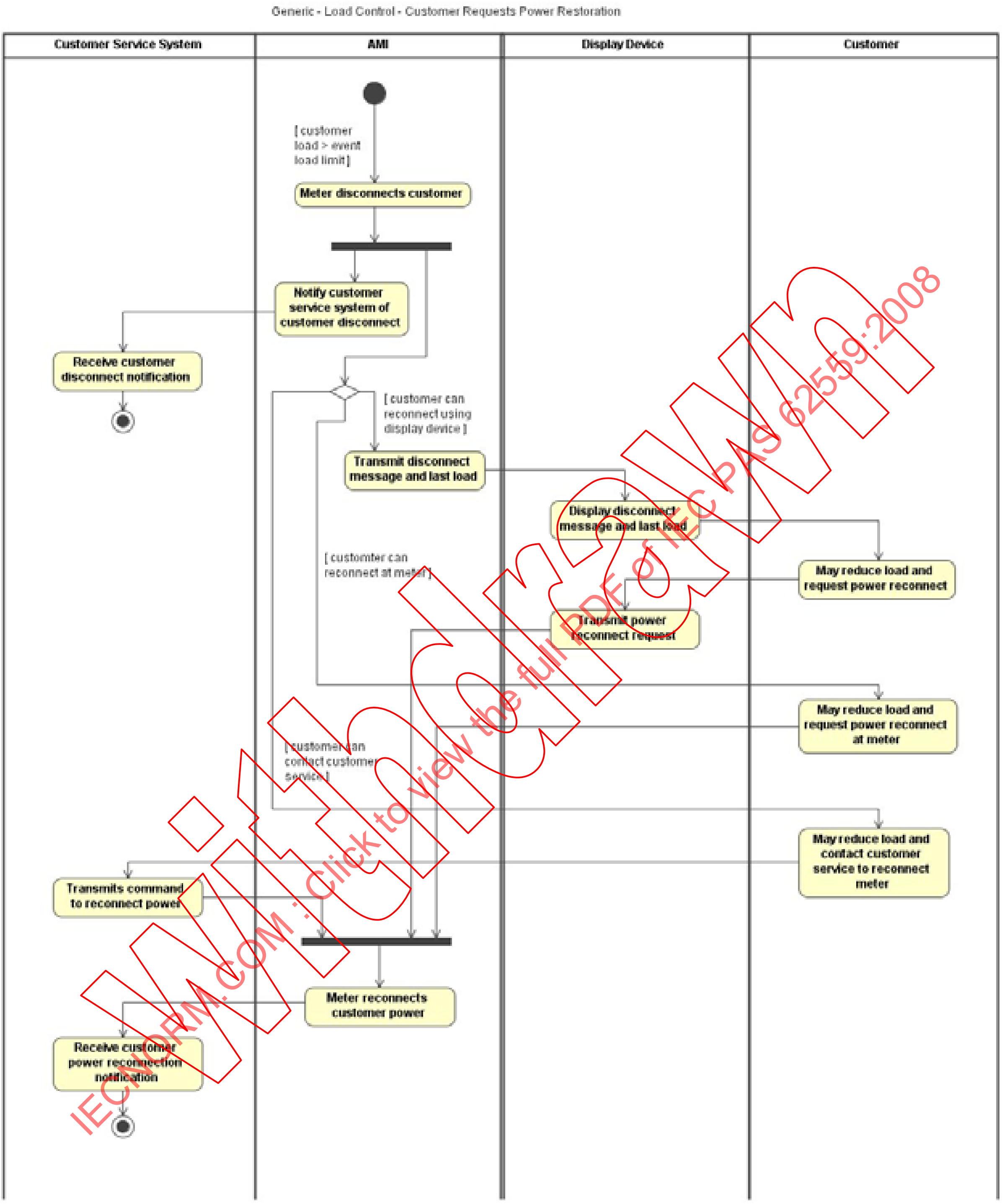


Figure 8: Example of an Activity Diagram

7.3.3 Interface Diagrams

The purpose of the interface diagram is to provide a single conceptual picture that can be used to express the flow and sequence of data within the system. The interface diagram can be derived from the interactions among the actors indicated by the activity diagram. A preliminary interface diagram can be created during the use case workshops by the architecture team to provide a high level conceptual view. The preliminary diagram should use accepted design patterns and should be responsive to changes required by the use case workshops. There is no defined UML diagram for interface diagrams but the Yourdon dataflow diagram has been used with success in previous projects. (See Figure 9)

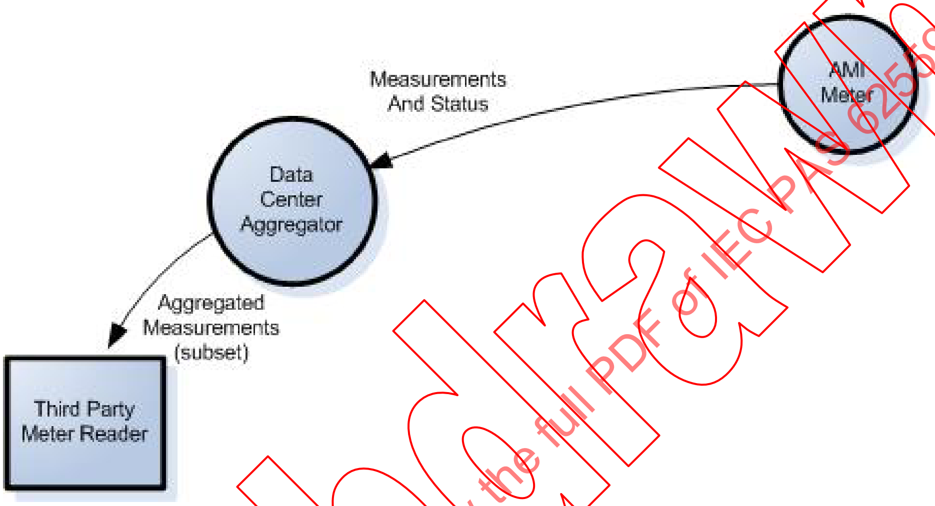


Figure 9: Interface Diagram Example

7.3.4 Message Sequence Diagrams

The message sequence diagram is a standard UML sequence diagram that illustrates the step-by-step interactions between the actors in a scenario. The message exchanges indicate where interfaces between actors exist and the types and frequency of data that are exchanged. The message sequence diagram can be derived from the use case scenarios or from activity diagrams. Checking that the scenarios, activity diagrams and message sequence diagrams are consistent ensures that the use case data has been correctly captured by the diagrams. The messages should also be entered into a spreadsheet or database to facilitate the entry of additional information about the message exchanges and to aid the architecture team in the system analysis. (See Figure 10)

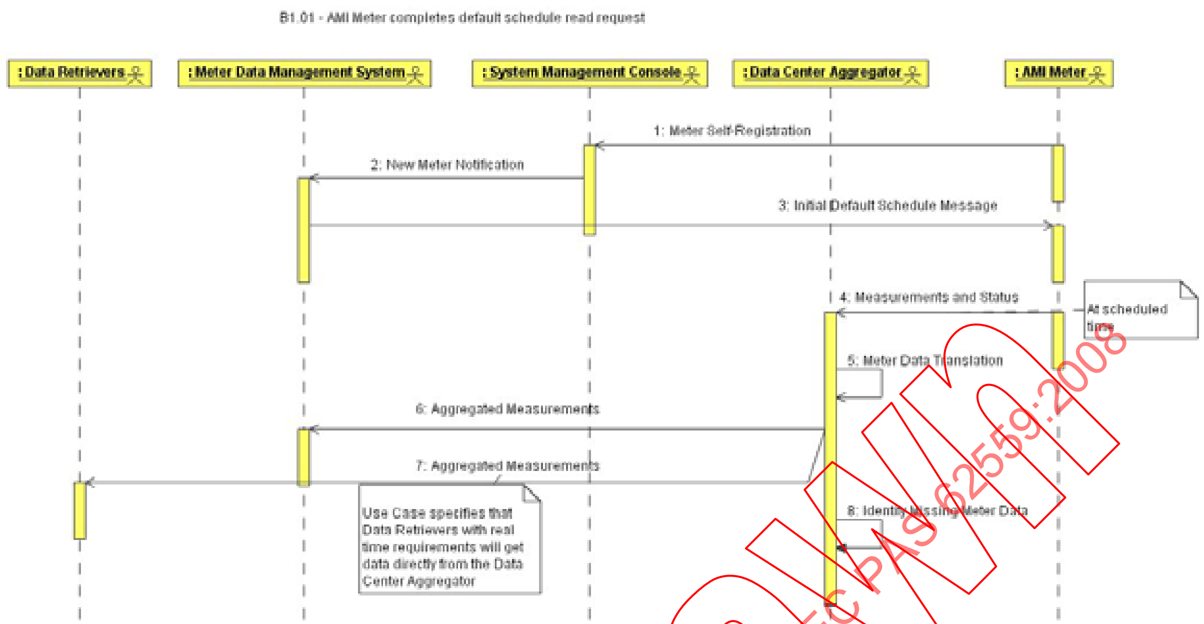


Figure 10: Message Sequence Diagram Example

7.3.5 Use Case Interaction Diagrams

Use case interaction diagrams are versions of the interface diagram for each use case which include only the actors and interfaces involved in the use case. These diagrams are useful to illustrate the core parts of a particular use case and to make comparisons between use cases.

7.3.6 Refining Requirements

Refining requirements is the process of reviewing, classifying and consolidating the requirements. The review process should begin during the use case workshop by the architecture team. The architecture team can provide feedback to the use case teams that the requirements that they are generating are of sufficient depth to satisfy the needs of the project. When the use case workshops are complete the final set of requirements can by classified into groups so that similar requirements can be compared for consistency or removed if deemed redundant. The classification can be done by system component or by interface. Non-functional requirements generated by different use cases may also specify the same metric to differing levels of performance. Evaluation of the associated costs and values will determine which level of performance will be specified as a requirement. The documentation of assumptions made by use case teams as requirements should also occur during this phase so that the assumptions are documented and validated against other system requirements.

7.3.7 Identify Security Risks

Throughout the workshop process, record any potential security risks of each use case. In general, a security analysis will involve the following steps:

- Identify what assets need to be protected.

- Identify the threats the assets need to be protected against.
- Identify vulnerabilities to these threats found in the existing system.
- Identify various security measures to protect the assets.
- Determine which measures are best suited to protecting which assets

This stage begins the security analysis process by identifying assets, threats and vulnerabilities and recording them along with the requirements.

7.3.8 Distill Requirements

The workshop process will identify many requirements, perhaps several hundred. It will be necessary to eliminate duplicates, make wording consistent, and verify business value statements.

7.3.9 Evaluate Requirements vs. Business Case

For each requirement and qualitative business value identified as part of the workshop process, the business case teams begin to assign quantitative benefits and complete lifecycle costs. This work will further distil requirements and eliminate some entire use cases and scenarios from consideration.

It is recommended that even if the organization chooses at this stage to not initially deploy certain requirements or scenarios, the systems architecture team should continue to consider them. It may be that they will be deployed in some later project, and the architecture should be flexible enough to permit this.

7.3.10 Publish Requirements

For the benefit of the industry and other utilities, as well as vendors who may become involved in the project, you should publish your distilled list of requirements at this stage. It may be useful to have your requirements reviewed by an “advisory board” consisting of industry representatives, especially utilities, not immediately involved in the project.

8. Phases 3-5: Technology Selection and Deployment

This section describes how the project planning performed in Phase 1 and the requirements gathered in Phase 2 can be used for architecture development, technology selection and deployment. . Figure 11 illustrates the initial requirements definition and systems architecture development processes, while Figure 12 illustrates the later steps of business case analysis, technology selection, and deployment. This document is intended to be an overview, for the purposes of understanding the general concepts of the process, and a checklist for monitoring the progress of a project.

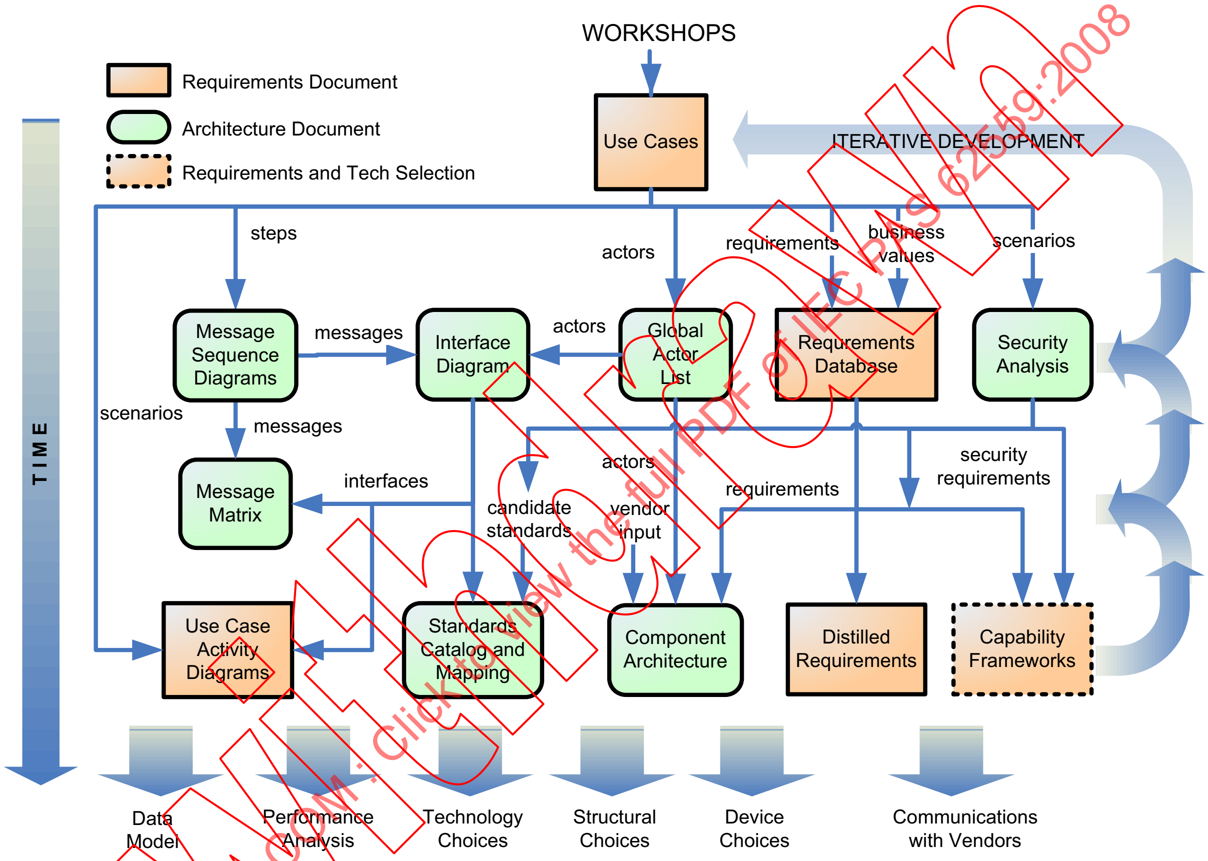


Figure 11: Requirements and Systems Architecture Process

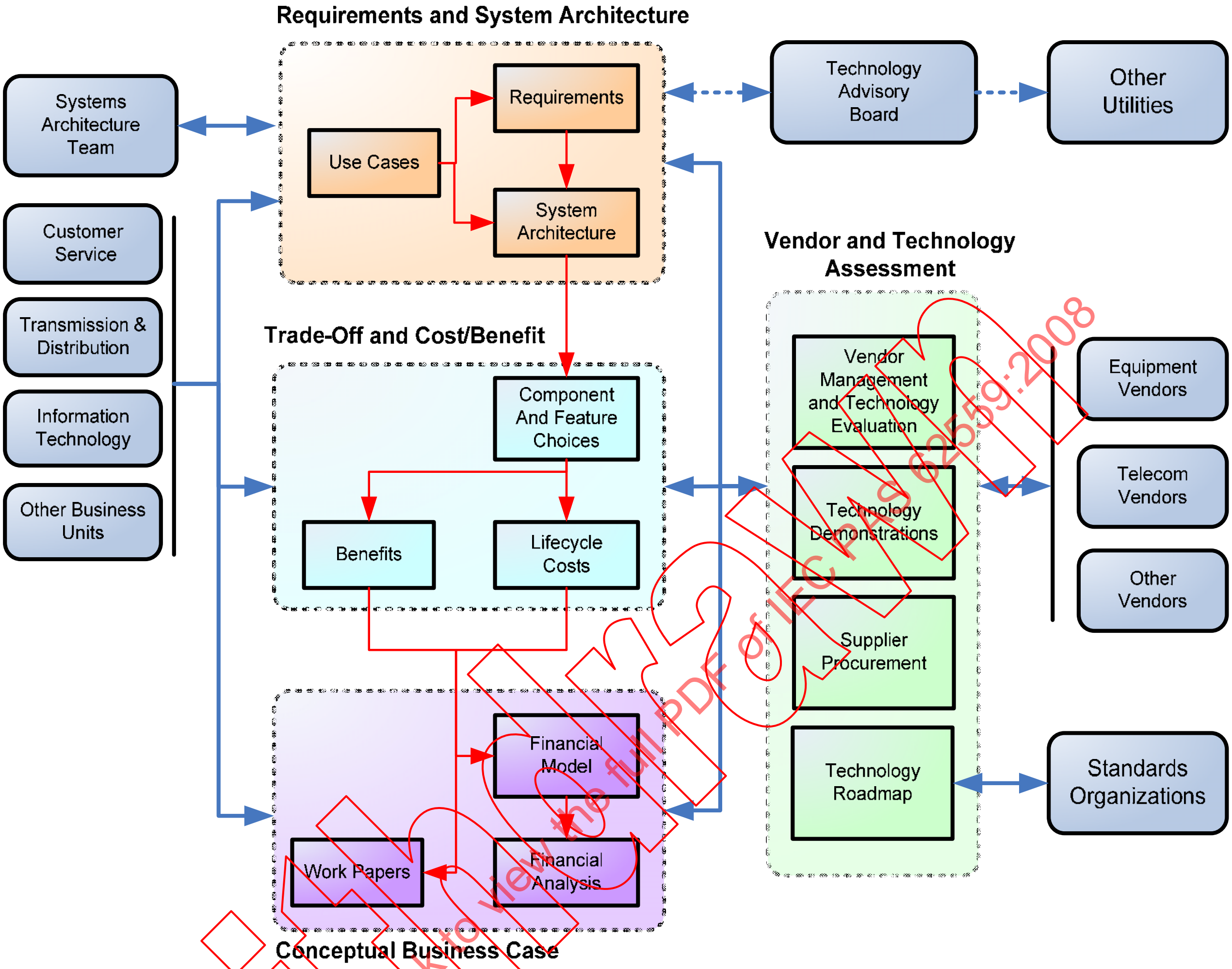


Figure 12: Technology Selection, Business Case, and Deployment Process

8.1 Design an Architecture

This section describes how to define a systems architecture based on the requirements gathered through the use case process. The deliverables described in this section are identified as "Architecture Documents" in Figure 11.

8.1.1 Resolve List of Actors

The list of actors recorded in the use cases typically contains many duplicates and many different names for the same actor. The systems architecture team examines the list, eliminates duplicates, agrees on common names, and by eliminating some actors, and establishes the scope of the architecture being developed. The resulting Global Actor list will be used as a common language for the rest of the architecture development. Ideally, these terms are traceable to industry standardized definitions for functions and components.

8.1.2 Identify Messages Exchanged

For each step identified in the use cases, the systems architecture team identifies what data must be exchanged to complete the step, and estimates how this data might be grouped into messages. The actual type and number of messages exchanged will not be known until after technology selection, but the messages identified here will be useful to determine which technologies are suitable.

As illustrated in Figure 11, two useful tools at this stage are Unified Modeling Language (UML) Message Sequence Diagrams, and a Message Matrix. A Message Matrix consists of a spreadsheet or database identifying the relationship between use cases, scenarios, steps, messages, and the source and destination actors of the messages. It could also track which scenarios and/or steps are currently considered to be part of the business case.

Message Sequence Diagrams are reduced forms of Activity diagrams that simply show the messages between actors in a given scenario.

8.1.3 Define Interfaces

From the actors identified in the Global Actor List and the messages from the Message Sequence Diagrams, the systems architecture team can group messages together into interfaces and identify the interfaces between the actors.

There are several useful tools for identifying interfaces. One could use a UML Collaboration Diagram or Activity Diagram, a data flow diagram, or simply add another column to the Message Matrix, as illustrated in Figure 11.

The set of actors and interfaces is sometimes known as the **Conceptual Architecture** of the system. It is an idea of how the system should work, without considering actual implementations yet.

8.1.4 Define Security Domains

Once the interfaces between actors have been identified, these interfaces and actors can be grouped into security domains having the same potential threats and technological solutions. Security threats and solutions generally fall into one of four categories: availability, integrity, confidentiality, and non-repudiation.

A specialized security team may be needed in order to define security domains. These domains may fall along organizational, geographic, or technological boundaries.

8.1.5 Define Security and Network Management Policies

The organization must decide on a common set of security and network management policies. These policies must define the overall objectives of security measures, the roles of organizations and individuals, and procedures for managing assets and credentials. These policies must also identify how procedures may be modified within each domain while maintaining the overall security objectives.

As illustrated in Figure 11, the domains and policies identified in the Security Analysis are included as further requirements to be considered in vendor consultation and in later steps of architecture development.

8.1.6 Break Down Actors into Components

The actors that were defined in the Global Actor List and used to identify the system interfaces will not be the actual physical components of the system. The functions of some actors may be distributed among multiple devices, or a single physical device or computer system may implement several different conceptual actors.

At this stage of the architecture development, consult with vendors regarding the previously published requirements to determine how different suppliers would implement the conceptual architecture. This process may identify some missing actors or interfaces, requiring a change in the architecture.

8.1.7 Assess Candidate Technologies

Examine the candidate technologies identified in the planning stage and any new technologies identified during vendor consultation. Perform a technology assessment including at least the following factors:

- Level of Standardization - Who recognizes it as a standard?
- Level of Openness – How easy/costly is it to obtain and use?
- Level of Adoption – How widely used is it now? In the future?
- Users' Group Support – Does someone promote it? Improve it? Test it?
- Security – Can it be secured? Is it inherently secure?
- Manageability – Can you control, monitor and/or upgrade it remotely?
- Scalability – Will it work when deployed at a large number of sites?
- Object Modeling – Does it group and structure data?
- Self-Description – Can it automatically configure and initialize itself?
- Applicability to the Power Industry – was it intended for use here?
- Applicability to this particular problem domain

Develop a Standards Catalo that captures this analysis shown in Figure 11.

Naturally, cost is a factor in assessing the candidate technologies also and must be considered as part of the ongoing business case development.

8.1.8 Map Candidate Technologies to Interfaces

Consider which of the candidate technologies should be used on each interface, and within each security domain. Add this information to the Standards Catalogue, or create a separate Standards Mapping document.

It is not necessary at this stage to select a single technology for each interface, any more than one should favor a particular vendors' architecture yet. The architecture at this stage should represent a superset of the best practices in the industry that can meet the requirements of your organization.

8.1.9 Define Integration Interfaces

A key factor at this stage is your organization's existing information technology architecture. You must develop a plan to integrate these existing interfaces to those of the new project. There may also be other similar projects underway that must be integrated with the current project.

Ideally, the groundwork for this step has already been addressed by ensuring representatives from other parts of the organization was included on the requirements teams and has contributed to the development of the architecture.

8.1.10 Test Architecture against Use Cases

The output from vendor consultation and the technology assessment efforts should result in a ***platform-independent architecture*** that can represent most vendors' products and services. Test this platform-independent architecture against the original use cases, and verify that all the scenarios to be included in the business case can be implemented using these components and interfaces.

8.2 Select Technologies

This section describes how to select particular technologies to implement the platform-independent architecture that you have developed, and how to evaluate vendor submissions. As illustrated in Figure 13, the technology selection process actually begins in the earlier phases with the development of requirements and the initial technology assessment.

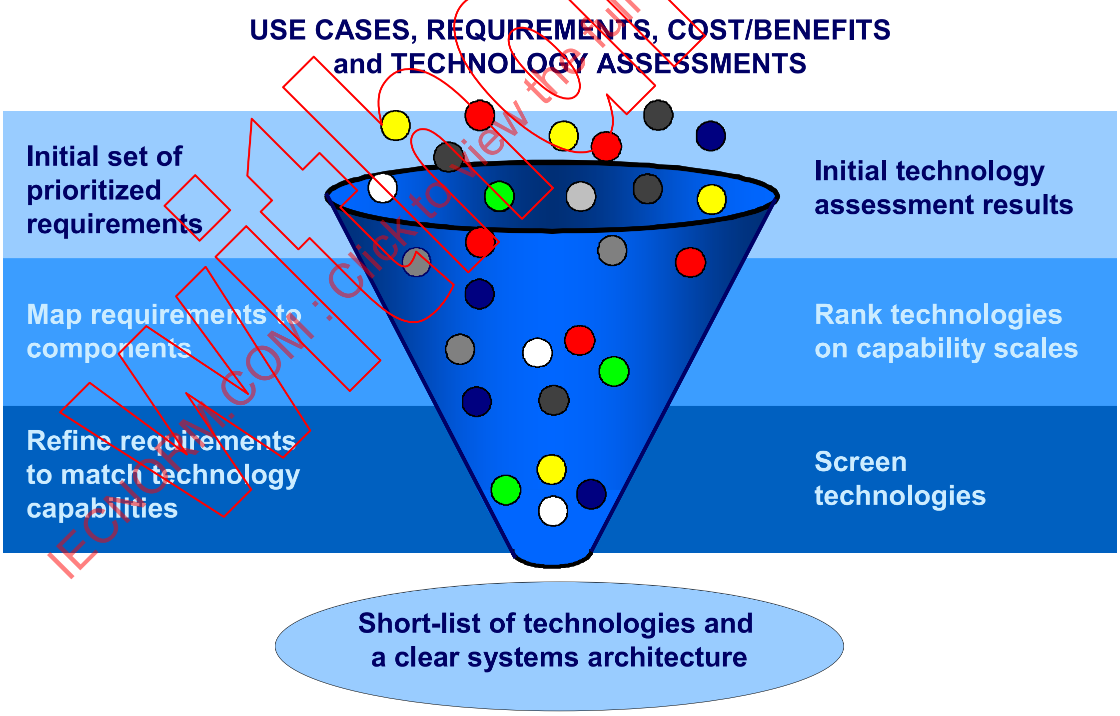


Figure 13: Overview of the Technology Selection Process

8.2.1 Build Technology Capability Scales

Create a framework of Technology Capability Measurement (TCM) scales from the Distilled Requirements and Security Requirements as illustrated in Figure 11. TCM scales are a tool for evaluating any given technology, as one might expect from the name. Perhaps surprisingly, they can and should also be used to evaluate your set of ***requirements.***

A framework of TCM scales is essentially a set of ratings from 0 to 5 in a number of categories that are derived by the system architecture team from the use cases and distilled requirements. For communications technologies, suggested categories might be: interoperability, reliability, scalability, security, throughput, and/or latency. For device technologies, some categories might include configurability, programmability, serviceability, power requirements, security, memory, or display. Cost is not considered on the TCM scales; it is a separate item dealt with as part of the trade-off and business case development process.

A rating of 0 represents an unacceptable solution, 1 the minimum solution, and 5 the best possible solution. An example scale is shown in Figure 14. The chart illustrates which features are required to receive a particular maturity level rating.

Latching Relay Device (Disconnect Device)

Maturity Level	Customer Reset Options	Commercially available & in use now (>10,000 units)	Current limiting with Flexible Set Point Handling	Current Limiting capabilities	On/Off disconnect	Voltage sensing	200 Amp Rating	Integrated device	Collared Solution
5	X	X	X	X	X	X	X	X	
4		X	X	X	X	X	X	X	
3			X	X	X	X	X	X	
2				X	X	X	X	X	
1					X	X	X	X	
0									X

Figure 14: Example of a Technology Capability Measurement Scale

8.2.2 Request Proposals

At this stage, you have a complete set of requirements, a defined minimum set of components and interfaces, a preferred catalog of technology standards and best practices and a set of scales for performing evaluations. Use this information to request proposals from vendors. As illustrated in Figure 12, vendors should be engaged throughout all parts of the design, to give a "reality check" on what is possible with existing technology. When requesting proposals, publish the TCM scales so vendors will know how they will be evaluated.

8.2.3 Evaluate Requirements and Proposals

Use the TCM scales to evaluate not only vendors' proposals, but also the distilled list of requirements. The upper end of the TCM scales should represent the best system that could be envisioned, while the actual requirements of the organization, especially in the short term, may be at a much lower level.

8.2.4 Perform Gap Analysis

Use the TCM scales to determine the difference between your organization's requirements and the technology offered by the vendors. Since vendor technologies were assessed as part of developing the Standards Catalog, there should theoretically not be any new or unknown technologies discovered at this point.

The Message Matrix becomes very useful at this stage for assessing communications technologies. If the technology contains messages and constructs that can carry all of the data and transactions identified in the Message Matrix, it is likely to be suitable for the project.

8.2.5 Trade-Off Requirements

Based on the gap analysis, select vendors and technologies that are the closest to meeting the requirements. Refine the precision of the cost and benefit estimation process now that the equipment and services to be used is known.

Based on the revised cost and benefit information, determine appropriate thresholds for the cost of each component, and trade off functionality against cost. Revisit the set of requirements and determine which cannot be met for this phase of the project. Document the finalized ***platform-specific architecture***.

8.2.6 Identify Missing Standards and Technologies

It is quite possible that some of the requirements of the organization cannot be met by any of the existing solutions at this time, regardless of expenditure. Record each of this missing standards, technologies, or capabilities for inclusion in a Technology Roadmap.

8.2.7 Create Technology Roadmap

When technologies or capabilities are missing the organization generally has the following options:

- Offer to work in partnership with a vendor to develop the technology
- Create a work-around solution in-house
- Try to develop the technology in-house
- Relax or refine existing requirements and define interfaces for future expansion when the technology becomes available.

The option chosen for each component or interface will vary depending on benefits, costs, schedule and the business drivers behind the project.

In addition, there may be a number of external factors affecting the availability of the technology, such as:

- Creation of legislation or regulations to encourage development of the technology.
- Creation of an industry organization or forum.
- Completion of an agreed-upon national or international standard.
- Adoption of a technology by key players in the industry.
- Completion of a pilot project by another set of organizations.

Capture all of these events and choices in a Technology Roadmap, indicating your organization's plan for the future. It should clearly indicate dependencies on external factors, actions the organization could take to influence technology development, and the impact on the current project.

8.2.8 Submit Proposals to Standards Bodies and Industry Groups

One section of the Technology Roadmap should be a set of recommendations to standards organizations or industry groups that would improve the implementation of this project or similar projects in the future. Submit these recommendations and participate in the development of the required standards if possible.

8.2.9 Complete Final Business Case

With vendors and technologies selected, the initial benefit/cost analysis can be expanded into a full business case, including a complete financial analysis, as shown in Figure 12. Methods may vary per organization and application.

A. Annex A: How to Develop Use Cases

A.1 What is a Use Case?

Each Use Case describes a single scenario, business goal, or task. Therefore, typically many Use Cases are needed to cover all scenarios for a particular system. All domain experts who will be impacted or will impact the system need to describe their own requirements through one or more Use Cases.

Use Cases treat the technology aspects of the system as a black box. Domain experts should describe the interactions with the "black box" system from outside the system. This is a deliberate policy, because it simplifies the description of requirements, and avoids the trap of making assumptions about how this functionality will be accomplished. In other words, Use Cases capture the "**What**" of user requirements, but deliberately avoid addressing the "**How**" of technologies.

Developing Use Cases is both a science and an art. Domain experts need to follow the basic rules of Use Case development, but the degree of formality and detail of a particular Use Case can vary significantly, depending upon whether the Use Case reflects relatively standard requirements or very new requirements, whether certain requirements are very stringent or rather loose, the relative importance of the particular Use Case within the complete set of Use Cases, and other factors. The key is to include enough in the Use Case to ensure that the user is comfortable that their real needs are included, but not so much that the result is overwhelming or confusing.

A.2 Purpose of the IntelliGrid PAS Use Case Template

Use Case templates can be used to help domain experts describe their user requirements in the manner needed by the Use Case process.

This IntelliGrid PAS includes a Use Case template that is slightly simplified from the original IntelliGrid Architecture Use Case template. That original template contains additional information that was used to help develop the IntelliGrid Architecture, and also assumed that experienced IntelliGrid project team members were available to help the power system experts in filling out the forms.

Initially in the IntelliGrid project a significantly simpler Use Case template was used to screen the 400 IntelliGrid functions. This simpler template was too imprecise to handle explicit Use Cases, but was adequate to screen the large number of power system functions.

Not all of the detailed information of the larger template is needed for describing many types of User Requirements. On the other hand, the simpler template can be confusing as to what characteristics belong to which function steps. So, a cross between these two templates is more generally useful. This IntelliGrid PAS template is shown in Annex B.

The IntelliGrid PAS Use Case template consists of the following sections.

A.3 IntelliGrid PAS Use Case Template: Setting the Stage

A.3.1 Domain Expert(s) Responsible for Use Case

The primary domain expert who is filling out the Use Case should be identified. In addition, any other domain experts or "Use Case" experts who are assisting in the process should be identified.

A.3.2 Name of Function

The name of the function should be unique within the set of Use Cases so that it can be easily identified.

A.3.3 Scope and Objectives of Function

The scope and objectives of the function address how this particular Use Case fits into the overall set of Use Cases that are being developed for a particular project or system. This section should also identify which business needs are being met by this Use Case.

A.3.4 Narrative of Function

The narrative is where the domain expert describes the function in "English" so that it is intelligible to non-expert readers. This section can range from a few sentences to a few pages, depending upon the complexity and/or newness of the function being described. This section often helps the domain expert to think through the user requirements for the function before getting into the details required by the next sections of the Use Case.

A.3.5 Actors: People, Systems, Applications, Databases, the Power System, and Other Stakeholders

Actors are entities outside the system that interact with the system, like receiving data, sending data, storing data, or manipulating data. These actors can include people, software applications, systems, databases, and even the power system itself.

A.3.6 Legal Issues: Contracts, Regulations, Safety Rules, and Other Constraints

Legal issues, such as contractual constraints, regulatory requirements, and safety rules, can also impact functions. If so, they should be captured so that ultimately the system, when it is implemented, will comply with these external constraints.

A.3.7 Preconditions and Assumptions

In some functions, it is critical to understand what preconditions or other assumptions are being made. For instance, the prior state of the actors and their activities could be crucial to know, or assumptions about the current situation, such as what systems already exist, what contractual relations exist, and what configurations of systems are probably in place. For example, if power system data is required by the function, a precondition to this particular activity might be "normal monitoring of normal power system activities is taking place".

A.4 IntelliGrid PAS Use Case Template: A Picture is Worth a Thousand Words

The old adage, "a picture is worth a thousand words", is absolutely true when working with Use Cases. Drawings or diagrams of the function can help clarify the interactions between the actors and the components of the system. The main caveat is that the drawings should NOT show technical solutions, but should show these interactions abstractly.

The Unified Modeling Language (UML) does specify how formal Use Case diagrams should be drawn, and are clearly a good method for producing these drawings. However, any drawing or diagram that shows the actors, the system components (as black boxes), and the information flows between them will provide most if not all of the necessary information. Figure 15 illustrates a diagram showing the steps and information flows of a function being described in a Use Case.

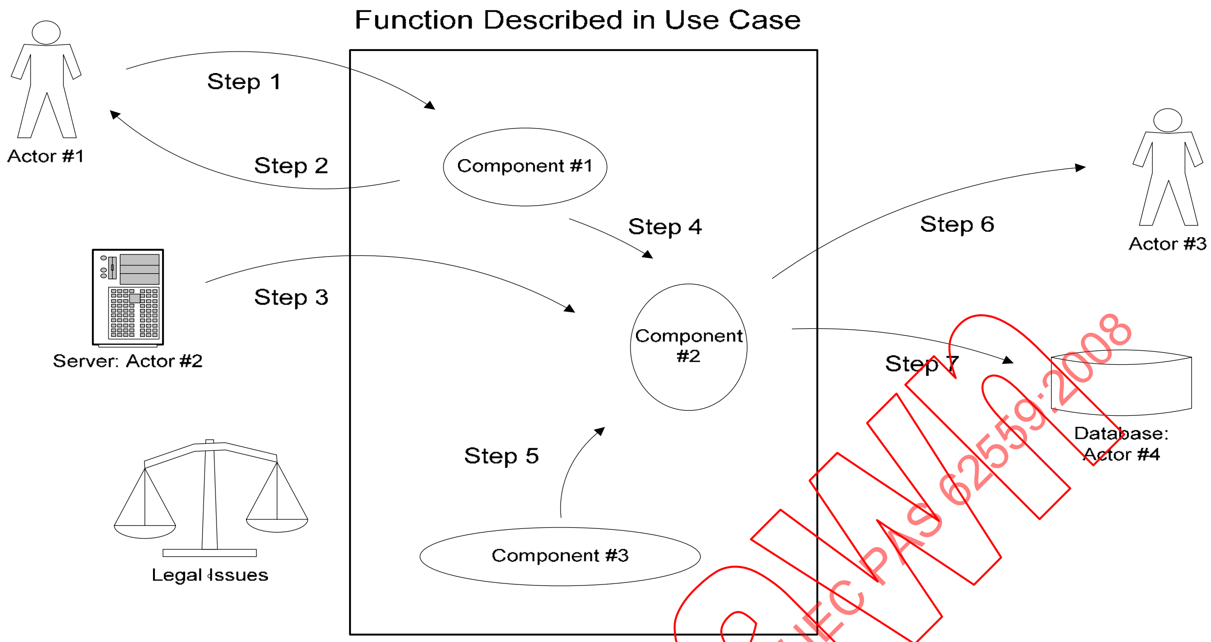


Figure 15: Illustrative Diagram of a Function Described in a Use Case

A.5 IntelliGrid PAS Use Case Template: Step-by-Step Interactions within Function

A.5.1 Steps Describe the Detailed Interactions

The steps of the Use Case template describe what happens in the function, step-by-step. Specifically each step captures the information exchange between one actor and a “black box” component of the system, but can also define exchanges between system components (e.g. sensor sends data to controller, SCADA system stores data in a database, settlement system sends data to billing system, power system modeling application sends new model to an external system). In theory, this information exchange could also include human-to-human interactions (by phone, email, letter, etc.), but the main emphasis is on the automated exchanges between actors and the components of the Use Case.

Again, these steps should avoid “how” the function might be implemented, and address strictly the “what”, although legal and technical constraints can be taken into account.

A.5.2 Contents of Steps

The contents of the IntelliGrid PAS Use Case steps are the following:

- **No.**: This is the number of the step. It could be simple “1, 2, 3” or could include identification of parallel steps if this is relevant, e.g. “1a, 1b, 2, 3a, 3b, 3c”.
- **Event**: The event that starts the step. This might be completion of the previous step, a human requesting the function, data being reported periodically, or a power system event.

- **Description of Process or Activity**: This describes what action takes place in this step. The focus should be less on the algorithms of the applications and more on the interactions and information flows between "entities", e.g. people, systems, applications, data bases, etc.
- **Information Producer:** This identifies the producer or source of the information. This should be one of the Actors identified above.
- **Information Receiver:** This identifies the receiver of the information. This should also be one of the Actors identified above.
- **Information Exchanged**: This describes briefly the information to be exchanged, including information that is:
  - Input to the function from some external source that is not described in this Use Case
  - Internal to the function between different components, such as applications and systems within the function
  - Output from the function that will be used by other entities not included in this Use Case
- **Configuration**: Locations, distances, communications layout, media, network bandwidth, existing protocols, numbers of devices, systems, volume of data items, expected growth, etc.
- **Quality of Service Requirements**: Availability, acceptable downtime of different components, recovery, backup, frequency of data exchanges, flexibility for future changes, response times, latency of data between detection and its display or action,
- **Security Requirements**: Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management
- **Data Management Issues**: Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases
- **Constraints or Other Issues**: This is a catch-all for any additional issues or concerns.

A.6 IntelliGrid PAS Use Case Template: Characteristics of Steps

A.6.1 Characteristics of Steps Capture Constraints and Details of User Requirements

The last five items discussed in the previous clause are termed the characteristics of the steps. These characteristics describe constraints or details of the user requirements associated with each step, such as configuration issues (serial communications, LAN, mobile), quality of service (performance, response times, etc.), security (access control, authentication, encryption, backup, audit logging, etc.), data issues (volume of data, frequency of data, etc.), and any additional constraints (legal, regulatory, safety, etc.). Again, very importantly, these characteristics are the *user requirements* for the transactions taking place within the step, and are not related to specific technologies.

A.6.2 Configuration Issues

Configuration issues reflect the typical, probable, or envisioned communication configurations that are relevant to the use case step. These configuration issues include numbers of devices and/or systems, expected growth of the system over time, locations, distances, communications types, network bandwidth, existing protocols, etc., but only from the user's point of view. In some cases, only one of the possible choices is reasonable, while for other situations, more than one choice is reasonable. For any particular use case step, many will either not be relevant or will be implicit from previous steps.

Table 1 provides the IntelliGrid checklist of configuration issues that domain experts can use to ensure they address all relevant issues.

Table 1: Checklist of IntelliGrid Configuration Issues

IntelliGrid Configuration Issues
a. Numbers of "end" entities or sources of data:
– One
– Two to a few
– Few to a hundred
– Hundreds to thousands
– Thousands to millions
– Significantly varied in different implementations
– Changes frequently
– Other ________________
b. Numbers of "central" entities or users of data:
– One
– Few
– Hundreds
– Thousands
– Millions
– Significantly varied in different implementations
– Changes frequently
– Other ________________
c. Distance between entities:
– A few feet
– A few miles
– Many miles
– Many hundreds of miles
– Varies and/or is not relevant
d. Location of information producer (source of data):
– Operations center
– Corporate building
– Building
– Substation
– Field outside substation
– Customer site
– Another corporation
– Mobile
– Changes frequently

IntelliGrid Configuration Issues
– Other ________________
e. Location of information receiver (user of data):
– Operations center
– Corporate building
– Building
– Substation
– Field outside substation
– Customer site
– Another corporation
– Mobile
– Changes frequently
– Other ________________
f. Communications configuration:
– WAN
– LAN
– One-on-one
– One-to-many
– Many-to-many
– Multi-drop
– Ad hoc
– Other ________________
g. Communications media:
– Any
– Landline preferred
– Wireless possible
– Wireless required
– Other ________________
h. Communications ownership:
– Any
– Utility-owned
– Jointly-owned
– Commercially provided
– Internet
– Other ________________
i. Communication bandwidth:
– < 2400 bps
– 2.4-56 kbps
– 10 Mbps-100Mbps
– 100Mbps - 1 Gbps
– >1 Gbps
– Other ________________
j. Data exchange methods:
– Any

IntelliGrid Configuration Issues
– Master-slave
– Peer-to-peer
– Client-server
– Publish-subscribe
– Through database
– Ad hoc
– Other _________________
k. Communication access services requirements:
– Any or all
– Request-response
– Periodic reporting
– Report-by-exception
– Control command
– Select-before-operate
– Set parameter values
– Query for data by name
– Subscribe
– Broadcast
– Multi-cast
– Data discovery
– Use of data sets
– Query to find location of data
– Query to determine what data is available (discovery)
– Execute application
– Establish and end association
– Logging
– Journaling
– Remote restart
– Remote reconfiguration
– Remote diagnosis
– Other _________________
l. Data exchange pattern:
– Data flow is <10% of bandwidth available
– Data flow >10% but less than 50% of bandwidth available
– Data flows patterns basically even
– Data flows include high volume bursts
– Other _________________
m. Growth:
– 2x number of participating devices - Over the next 5 years
– 10x number of participating devices - Over the next 5 years
– 100x number of participating devices - Over the next 5 years
n. Commonly used data exchange technologies
– Public Internet as communications media

IntelliGrid Configuration Issues
– Internet-based protocols (e.g. HTML, XML)
– Computer Industry Component Technology Standards (e.g. CORBA, EJB, .Net, Web Services)
– Transaction Technologies (e.g. Corba, EJB, .NET, Web Services)
– Database Access Services (SQL, OQL, object browsing)
– Methodologies for process management (e.g. EDI, ebXML)
– NAESB protocols (OASIS, E-tagging, RTO (TBD))
– IEC 61970 Common Information Model (CIM) Standard
– IEC 61970 Generic Interface Definition (GID) Standard
– IEC 61968 Interface Exchange Model (IEM) Message Definition Standards
– IEC 61850 (UCA) Standard
– IEC 60870-6 TASE.2 (ICCP)
– IEC 60870-5 and/or DNP
– Other legacy SCADA protocols
– Building Automation Protocols SSPC135
– Other Building Automation Protocols
– ANSI C12 SC 17 (IEC 62056-53/61/62) Metering Standard
– Graphics data exchange standards
– Through a database using proprietary database interfaces
– Flat files or CSV files
– Other standard technologies ____________
– Other standard technologies ____________
– Vendor proprietary technologies
– Other non-standard technologies
– None since interface has never been implemented
– None of the above/ not relevant/ don't know
o. Relative maturity of current implementation
– Very mature and widely implemented
– Moderately mature
– Fairly new
– Future, no systems, no interactions
p. Existence of legacy systems
– Many legacy systems
– Some legacy systems
– Few legacy systems
– Extensive changes will be needed for full system functionality
– Moderate changes will be needed
– Few changes will be needed
– No changes will be needed

A.6.3 IntelliGrid Quality of Service (QoS) Issues

Quality of service (QoS) issues address availability of the system, such as acceptable downtime, recovery, backup, rollback, etc. QoS issues also address accuracy and precision of data, the frequency of data exchanges, and the necessary flexibility for future changes.

Table 2 provides the IntelliGrid checklist of QoS issues that domain experts can use to ensure they address all relevant issues.

Table 2: Checklist of IntelliGrid Quality of Service Issues

IntelliGrid Quality of Service Issues
a. Elapsed time response requirements for exchanging data:
– 1-4 milliseconds
– 4-10 milliseconds
– Less than 1 second
– 1-2 seconds
– 10 seconds
– More than 10 seconds
– No specific response requirements
– Other ________________
b. Contractual timeliness for exchanging data is required:
– Within 1 second
– Within 1 minute
– Within 5 minute
– Within some longer time:
– No specific contractual timeliness is required
– Other ________________
c. Availability of information flows:
– 99.9999% + availability ~ 1/2 second per year
– 99.999% + availability ~ 5 minutes per year
– 99.99% + availability ~ 1 hour per year
– 99.9% + availability ~ 9 hours per year
– 99% + availability ~ 3.5 days per year
– 90% + availability ~ 1 month per year
– Less than 90%
– Continuous availability not required so long as downtime is scheduled
– Continuous availability not required but must be available at specific times or under specific conditions
– No specific availability is required
– Other ________________
d. Precision of data requirements (normally relevant only for conversions, e.g. analog to digital):
– 100% accurate
– >.5% variance
– >1%
– >5%
– Not relevant
– Other ________________
e. Accuracy of data requirements
– Requires quality flag indicating at least normal and not normal
– Age of data needs to be knowable
– Time skew of data must be known

IntelliGrid Quality of Service Issues
– Adequate accuracy can be assumed
– Accuracy of data not an issue
– Other ________________
f. Frequency of data exchanges:
– Essentially continuous
– Every few milliseconds
– Every few seconds
– Periodicity greater than a few seconds
– Upon event
– Upon request
– Random
– Sparse
– Other ________________
g. Commonly used techniques for meeting quality of service requirements of this data exchange
– Failure detection
– Automatic restart
– Automatic failover to second source of data or function
– Automatic failover of communication channels to secondary channel
– Backup of data
– Transaction rollback
– QoS monitoring
– Alarming on QoS failure
– None
– Not needed or not relevant
– Other ________________

A.6.4 IntelliGrid Security Issues

Security measures are still an evolving science/art, particularly from the user point of view. It is very difficult to evaluate the security needs for any one item, and extremely difficult to assess how different security measures applied to different items can potentially interact and either leave security holes or make user interfaces very laborious and possibly unworkable.

Security must not only protect against the very harmful but quite rare deliberate attacks, but also against the far more likely inadvertent mistakes, failures, and errors.

At the same time, it is necessary to try to identify the requirements and the concerns for implementing security measures. Ultimately, the need for security for a specific information asset is a judgment call, based on:

- The probable risk of the security threat (which is a combination of the attractiveness of the information and the ease of access to it)

- The financial and non-monetary consequences of a successful security attack (during the attack, while recovering from the attack, and financial, legal, and social consequences after the attack)
- The cost of minimizing the security threat, including financial costs, data exchange performance impacts, implementation of methods for detection of attacks, human responses to security measures, etc.

At this high architectural level, only general judgment calls can be made. So, the word "crucial" implies that protection against a threat is generally very, very important, but does not imply what a specific implementation may judge the threat to be.

One of the most useful ways of assessing security requirements is for the domain experts to ask which of the following security issues are important:

- Authentication of user
- Confidentiality
- Integrity
- Prevention of Denial of Service
- Non-repudiation or Accountability

Table 3 provides the IntelliGrid checklist of security issues that domain experts can use to ensure they address all relevant issues.

Table 3: Checklist of IntelliGrid Security Issues

Security Issues
a. Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is:
– Crucial
– Quite important
– Not particularly important
– Detection that a security violation was attempted is crucial
– Other ________________
b. Information integrity violation: Ensuring that data is not changed or destroyed is:
– Crucial
– Quite important
– Not particularly important
– Detection that a security violation was attempted is crucial
– Other ________________
c. Authentication: Masquerade and/or spoofing: Ensuring that data comes from the stated source or goes to authenticated receiver is:
– Crucial
– Quite important
– Not particularly important
– Detection that a security violation was attempted is crucial
– Other ________________

Security Issues
d. Repudiation: Ensuring that the source cannot deny sending the data or that the receiver cannot deny receiving the data is:
– Crucial
– Quite important
– Not particularly important
– Detection that a security violation was attempted is crucial
– Other ________________
e. Replay: Ensuring that data cannot be resent by an unauthorized source is:
– Crucial
– Quite important
– Not particularly important
– Detection that a security violation was attempted is crucial
f. Information theft: Ensuring that data cannot be stolen or deleted by an unauthorized entity is:
– Crucial
– Quite important
– Not particularly important
– Detection that a security violation was attempted is crucial
– Other ________________
g. Denial of Service: Ensuring unimpeded access to data is:
– Crucial
– Quite important
– Not particularly important
– Detection that a security violation was attempted is crucial
– Other ________________
h. This data exchange has the following requirements with respect to proof of conformance and/or non-repudiation with contractual agreements:
– Logging of all information exchanged during this interaction is required
– Logging of only key information is required
– Logging of the source, destination, requesting application, and requesting user of information exchanges is required, but not the data itself
– Logging is not required
– Other logging ________________
i. Security measures commonly used with this data exchange
– Access control through passwords
– Access control through database security mechanisms
– Virtual Private Networks (VPNs)
– Private (secret) key encryption
– Public key encryption (e.g. SSL/TLS)
– Firewalls with Access Control Lists and/or proxy servers
– Dial-back modems
– Bilateral data access control tables
– Time stamping, logging, and data records
– Non-repudiation techniques

Security Issues
– Kerberos
– Network management such as SNMP or CMIP
– Physical isolation
– Backup
– Security policies with procedures to follow
– Trusted parties so no cyber security needed
– None, but needed
– None, and not needed
– Other _______________

A.6.5 IntelliGrid Data Management Issues

Data management is becoming an increasingly important aspect of automation. Data management in this context covers both the management of the data exchanges in each Use Case step and the management of data at either end if that management is impacted by data exchanges. An example of the first type of data management is the initial setting up and on-going maintenance of what data needs to be exchanged, say between a Geographic Information System and the many different applications that use its data. An example of the second type of data management is the need to backup data or ensure consistency of data whenever it is exchanged, such as if new protection settings are issued to multiple field devices, these settings need to be reflected in Contingency Analysis functions.

Again, these data management issues should reflect the domain expert's point of view. Therefore, user requirements for data management should not address database design, but should concentrate on the user requirements for the interfaces to databases and other data handling applications.

Some typical data management issues include types of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, and maintenance of data and databases.

Table 4 provides the IntelliGrid checklist of data management issues that domain experts can use to ensure they address all relevant issues.

Table 4: Checklist of IntelliGrid Data Management Issues

Data Management Issues
a. Type of source data
– Source data was directly measured
– Source data was previously automatically stored in a database
– Source data was previously manually entered in a database
– Source data was calculated or output by an application
– Other _____Not Applicable___________
b. Correctness of source data
– Source data is always correct (e.g. by definition)

Data Management Issues
– Source data is usually correct
– Source data is often not correct (incorrectly entered, out of date, not available)
– Source data is rarely correct
– Correctness of source data is not relevant
– Other ________________
c. Up-to-date data management
– Received data must be up-to-date within seconds of source data changing
– Received data must be up-to-date within minutes of source data changing
– Received data must be up-to-date within hours of source data changing
– Received data does not need to be up-to-date if source data changes
– Other ________________
d. Management of large volumes of data that are being exchanged
– Major part of step involves handling large volumes of data
– Some part of step involves handling large volumes of data
– No part of step involves handling large volumes of data
– Other ________________
e. Data consistency and synchronization management across systems
– Second-by-second synchronization: Data being exchanged must be kept consistent and synchronized with other systems within seconds
– Minute-by-minute synchronization: Data being exchanged must be kept consistent and synchronized with other systems within minutes
– Day-by-day synchronization: Data being exchanged must be kept consistent and synchronized with other systems within hours or days
– No synchronization: Data being exchanged does not need to be kept consistent or synchronized with other systems
– Other ________________
f. Management of timely access to data by multiple different users
– Contractual/required time windows for multiple access are less than one second
– Contractual/required time windows for multiple access are within seconds
– Contractual/required time windows for multiple access are within tens of seconds
– Contractual/required time windows for multiple access are within minutes
– Timely access by multiple users is not relevant
– Other ________________
g. Validation of data exchanges
– All data must be validated on each data exchange
– Data must include quality codes to indicate its validity
– Data from different sources must be validated against each other
– Data mapping of data item names is required for data from different sources
– Data can be assumed as valid (or validity checking is handled elsewhere)
– Data is usually not validated
– Data cannot be validated
– Validity of data is not relevant
– Other ________________

Data Management Issues
h. Management of accessing different types of data to be exchanged
– Each data exchange could entail different types of data (e.g. query a database)
– Numbers or types of data being exchanged are changed or updated every few minutes
– Numbers or types of data being exchanged are changed or updated every few hours
– Numbers or types of data being exchanged are changed or updated every few days or weeks
– Numbers or types of data being exchanged are rarely changed or updated
– Not relevant
– Other _________________
i. Management of data across organizational boundaries
– Data exchanges go across corporate boundaries
– Data exchanges go across departmental boundaries
– Data exchanges go across boundaries between system developed by different vendors
– Data exchanges are within one vendor's system
– Not relevant
– Other _________________
j. Transaction integrity required (backup and rollback capability)
– Data exchanges require the ability to rollback to previous data states
– Data exchanges require full backup for immediate "failover" to a second source of data
– Data exchanges require backup of crucial data for "cold" failover
– Data exchanges do not require rollback or backup
– Other _________________
k. Data format requirements:
– Standard computer formats (e.g. binary, integers and floating pt, files)
– Standard serial transfer formats (e.g. DNP, Modbus, LonTalk, BACnet)
– Graphics formats
– EDI
– HTML-based
– XML-based
– CSV
– Standardized data objects
– Exchange of unstructured or special-format data (e.g. text, documents, oscillographic data) must be supported
– Any formats are acceptable
– Other _________________
l. Management of data formats in data exchanges
– The same data exchanged between different applications have different formats that need to be "converted"
– The same data exchanged between different applications have the same formats
– Conversion of data formats is automatically handled by each application
– Other _________________
m. Naming of data items
– Names of data items are different in different applications and must be "mapped" to each other
– Meanings of data items are different in different applications and must be "converted"

Data Management Issues
– Other ______Not Relevant__________
n. Management across different implementations
– Types of data being exchanged can vary significantly in different implementations
– Types of data being exchanged vary very little in different implementations
– Not relevant
– Other ________________
o. Data exchange maintenance in which a human changes or updates what is to be exchanged
– Data exchanges require maintenance every few hours
– Data exchanges require maintenance every few days
– Data exchanges require maintenance every few weeks or months
– Data exchanges rarely require maintenance
– Not relevant
– Other ________________
p. Database maintenance in which a human changes or updates what is in the database
– Database requires maintenance every few hours
– Database requires maintenance every few days
– Database requires maintenance every few weeks or months
– Database rarely requires maintenance
– Not relevant
– Other ________________
q. Data maintenance effort: human versus automation
– Data maintenance involves significant human time and manual data entries
– Data maintenance is partially automated but involves some human time and manual data entries
– Data maintenance is mostly automated but requires occasional intervention
– Data maintenance is (or can be if so authorized) completely automated (e.g. Live Update of virus definitions or Microsoft updates)
– Not relevant
– Other ________________
r. Commonly used data formats and management techniques for this data
– Standard computer formats (e.g. integers and floating pt, files)
– Standard serial transfer formats (e.g. analog points, status points, control points, such as used in DNP, Modbus, LonTalk)
– Graphics formats
– EDI formats
– HTML-based formats
– XML-based formats
– Comma separated variables (CSV) in a file
– Proprietary data format
– Data updates are done manually by a database administrator or maintenance personnel
– Data is validated automatically
– Data objects have well-known names (e.g. CIM and IEC61850)
– Transaction and data exchanges "discovery" is handled automatically (e.g. ebXML)
– Mechanisms are in place to ensure consistency of data

Data Management Issues
– Transaction rollback capabilities are used
– Not relevant
– Other _________________

A.6.6 IntelliGrid Constraints and Other Issues

Constraints and issues not captured in the previous characteristics may be political, legal, financial, or just very specific to a particular step. For instance, one step may involve data received from another utility that requires special handling: format conversions or manual intervention. This is a catch-all for such special issues.

B. Annex B: Use Case Template

Using the IntelliGrid PAS User Requirements Use Case Template, Version 1

B.1 Description of the User Requirements of a Function

B.1.1 General

*The IntelliGrid methodology separates the concepts of "user requirements" from "technical specifications": **user requirements** define "**what**" is needed without reference to any specific designs or technologies, while **technical specifications** define "**how**" to implement the systems and applications in order to meet the user requirements.*

B.1.2 Domain Expert(s)

*This IntelliGrid PAS User Requirements Template focuses **only** on **what** is needed from a function, as described by those who are experts in their particular domain", and who will ultimately be the users of the function. In filling out the template, these experts may be assisted by other types of experts, but they should keep clearly in mind that the focus must be the **user requirements**.*

Domain Expert	Name	Title	Area of Expertise
Primary			
Additional			
Additional			

B.1.3 Name of Function

Name of the function

Name of Function

B.1.4 Scope and Objectives of Function

Describe briefly the scope, objectives, and rationale of the function. The intent is to put the function in context, particularly in relationship to other related functions, such as piggybacking other functions on this function (or vice versa). This is not necessarily a justification or benefit-cost assessment, but can be used to hit the key points of the function.

Scope and Objectives of Function

B.1.5 Narrative of Function

A complete narrative of the function from a domain expert user's point of view, describing what occurs when, why, with what expectation, and under what conditions. This narrative should be in "English", written so that non-domain experts can understand it.

Narrative of Function

B.1.6 Actors: People, Systems, Applications, Databases, the Power System, and Other Stakeholders

Describe all the people (their roles or jobs), systems, databases, organizations, and devices involved in or affected by the function (e.g. operators, system administrators, technicians, end users, service personnel, executives, SCADA system, real-time database, RTOs, RTUs, IEDs, and even the power system). The same actor could play different roles in different functions, but only one role in one function. If the same actor (e.g. the same person) does play multiple roles in one function, list these different actor-roles as separate rows.

Actor Name	Actor Type (person, device, database, system etc.)	Actor Description

B.1.7 Legal Issues: Contracts, Regulations, Policies, and Constraints

Identify any legal issues that might affect the design and requirements of the function, including contracts, regulations, policies, financial considerations, engineering constraints, pollution constraints, and other environmental quality issues.

Legal Issue	Impact of Legal Issue on Function

B.1.8 Preconditions and Assumptions

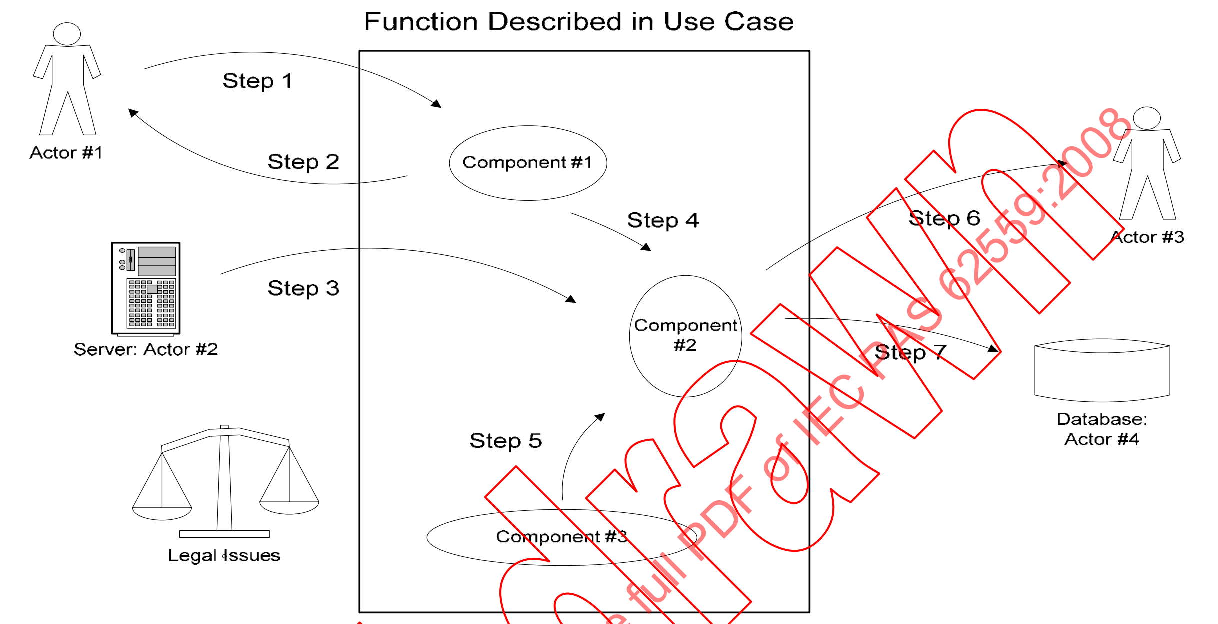
Describe conditions that must exist prior to the initiation of the Function, such as prior state of the actors and activities. Identify any assumptions, such as what systems already exist, what contractual relations exist, and what configurations of systems are probably in place. Identify any initial states of information exchanged in the steps in the next section. For example, if power *system data is being monitored by a SCADA system, a precondition to this particular activity might be "normal monitoring of normal power system activities is taking place".*

Actor/System/Information/Contract	Preconditions or Assumptions

B.2 Drawing or Diagram of Function

For clarification, draw (by hand, by Power Point, by UML diagram) the interactions, identifying the steps where possible.

Drawing or Diagram of Function



B.3 Step by Step Analysis of Function

Describe steps that implement the function. If there is more than one set of steps that are relevant, make a copy of the following section grouping (Steps normal sequence and Steps alternate or exceptional sequences). If more steps are needed than are in the Step Table, add entire Steps (not just another row).

B.3.1 Steps – Normal Sequence

Describe the normal sequence of events, focusing on steps that identify new types of information or new information exchanges or new interface issues to address. Should the sequence require detailed steps that are also used by other functions, consider creating a new "sub" function, then referring to that "subroutine" in this function. Remember that the focus should be less on the algorithms of the applications and more on the interactions and information flows between "entities", e.g. people, systems, applications, data bases, etc. There should be a clear correlation between the narrative and these steps. The entries in the steps are:

- ***No.**: This could be simple "1, 2, 3" or could include identification of parallel steps if this is relevant, e.g. "1a, 1b, 2, 3a, 3b, 3c".*
- ***Event**: The event that starts the step. This might be completion of the previous step, a human requesting the function, data being reported periodically, or a power system event.*
- ***Description of Process or Activity**: This describes what action takes place in this step. The focus should be less on the algorithms of the applications and more on the interactions and information flows between "entities", e.g. people, systems, applications, data bases, etc.*
- ***Information Producer:** This identifies the producer or source of the information. This should be one of the Actors identified above.*
- ***Information Receiver:** This identifies the receiver of the information. This should also be one of the Actors identified above.*
- ***Information Exchanged**: This describes briefly the information to be exchanged: input to the function from some external source that is not described in this Use Case, internal to the function (although could be between different applications and systems within the function), output from the function that will be used by other entities not included in this Use Case*
- ***Configuration**: Locations, distances, communications layout, media, network bandwidth, existing protocols, numbers of devices, systems, volume of data items, expected growth, etc.*
- ***Quality of Service Requirements:** Availability, acceptable downtime of different components, recovery, backup, frequency of data exchanges, flexibility for future changes, response times, latency of data between detection and its display or action,*
- ***Security Requirements**: Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management*
- ***Data Management Issues:** Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization or consistency of data across systems, timely access to data, validation of data across organizational*

boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases

- ***Constraints or Other Issues:*** *This is a catch-all for any additional issues or concerns.*

Function Name:							
#	Event	Description of Process/Activity	Information Producer	Information Receiver	Information Exchanged		Characteristics of Information Exchanges
1						Configuration	
						QoS	
						Security	
						Data Mgmt	
						Constraints	
2						Configuration	
						QoS	
						Security	
						Data Mgmt	
						Constraints	
3						Configuration	
						QoS	
						Security	
						Data Mgmt	
						Constraints	

B.3.2 Steps – Alternative, Error Management, and/or Maintenance/Backup Sequences

Using copies of the Steps Table, describe any alternative, error management, and/or maintenance/backup sequences.

Function Name:							
#	Event	Description of Process/Activity	Information Producer	Information Receiver	Information Exchanged		Characteristics of Information Exchanges
1						Configuration	
						QoS	
						Security	
						Data Mgmt	
						Constraints	
2						Configuration	
						QoS	
						Security	
						Data Mgmt	

Function Name:							
#	Event	Description of Process/Activity	Information Producer	Information Receiver	Information Exchanged		Characteristics of Information Exchanges
						Constraints	

C. Annex C: Example of Transmission Synchro-Phasor Use Case

Using the IntelliGrid PAS User Requirements Use Case Template, Version 1

C.1 Description of the User Requirements of a Function

C.1.1 General

*The IntelliGrid methodology separates the concepts of "user requirements" from "technical specifications": **user requirements** define "**what**" is needed without reference to any specific designs or technologies, while **technical specifications** define "**how**" to implement the systems and applications in order to meet the user requirements.*

C.1.2 Domain Expert(s)

*This IntelliGrid PAS User Requirements Template focuses **only** on **what** is needed from a function, as described by those who are experts in their particular "domain", and who will ultimately be the users of the function. In filling out the template, these experts may be assisted by other types of experts, but they should keep clearly in mind that the focus must be the **user requirements**.*

Domain Expert	*Name*	*Title*	*Area of Expertise*
Primary	Mark A.	Protection Engineer	Transmission synchro-phasor systems
Additional			
Additional			

C.1.3 Name of Function

Name of the function

Name of Function
Synchro-Phasors

C.1.4 Scope and Objectives of Function

Describe briefly the scope, objectives, and rationale of the function. The intent is to put the function in context, particularly in relationship to other related functions, such as piggybacking other functions on this function (or vice versa). This is not necessarily a justification or benefit-cost assessment, but can be used to hit the key points of the function.

Scope and Objectives of Function
This system provides synchronized and time-tagged voltage and current phasor measurements to any protection, control, or monitoring function that requires measurements taken from several locations, whose phase angles are measured against a common, system wide reference. This is an extension of simple phasor measurements, commonly made with respect to a local reference. Present day implementations of many protection, control, or monitoring functions are hobbled by

Scope and Objectives of Function
not having access to the phase angles between local and remote measurements. With system wide phase angle information, they can be improved and extended. The essential concept behind this system is the system wide synchronization of measurement sampling clocks to a common time reference. In addition to providing synchronized measurements, the synchro-phasor system distributes the measurements. Voltages and currents are measured at many nodes throughout the power grid. Any protection, control, or monitoring function can access measurements from several nodes, either by subscribing to continuous streams of data, or requesting snapshots as needed. In principle, any function could request measurements from any node, though in practice most functions require data from only a few nodes.

C.1.5 Narrative of Function

A complete narrative of the function from a domain expert user's point of view, describing what occurs when, why, with what expectation, and under what conditions. This narrative should be in "English", written so that non-domain experts can understand it.

Narrative of Function
The following is an example of how synchro-phasors can be used to perform digital current differential fault protection for a two terminal transmission line. There are two intelligent electronic devices, one at each terminal, taking samples of currents from all three phases. Physically, the two terminals might be any distance at all apart, ranging from a few miles to a thousand miles, for example. It is wished to provide fault protection for the transmission line by summing the phasor values of currents to determine differential current. In order to do that, the two intelligent electronic devices need to measure the phasor values against the same time reference, and exchange the data with each other. This can be done with synchro-phasors. Each intelligent device in this example is both a client and a server of synchro-phasors. As a server, it provides synchro-phasors to its partner. As a client, it requires synchro-phasors from its partner. It is a completely symmetric situation. We will examine the example mostly from the point of view of one of the terminals, call it A. Terminal A requires a steady stream of phasors for three phase currents from terminal B. In this particular case, it is decided to compute phasors every ½ cycle of the power system frequency, and to transmit them once per ½ cycle. To simplify things, it is decided not to perform frequency tracking, but rather to base the sampling frequency on absolute time. For this particular case, it is decided that synchronization between any pair of measurements must be within 10 microseconds in steady state, even though there are other applications that require tighter synchronization, such as to within 1 microsecond. Transiently, much larger synchronization errors are permitted, but each terminal requires an estimate of the least upper bound of the synchronization error if it exceeds 10 microseconds. For correct transient tracking, it is decided that the sampling windows must be aligned. That is, the set of sampling times for each phasor window must be the same at each terminal: overlapping is not allowed. It is understood that there may be some latency involved in the exchange of information, but it should not exceed 24 milliseconds, for example. It is also recognized that some data might get lost or corrupted. A certain amount of lost data is acceptable. The amount is somewhat arbitrary, but experience has shown that 2.5% lost data can be tolerated. For this application, it is not necessary to retransmit the lost data, since more, up-to-date data will be arriving shortly anyway. However, it is necessary to inform the protection application, so that it can move on to the next time slot. It is also recognized that sometimes,

Narrative of Function

communications might be down altogether.

The possibility of corrupted data is a fact of life in this arena. Without even considering abnormal events such as electrical interference from faults, many types of communications are considered to be operating normally with a low, but non-zero bit error rate. Unless some steps are taken, it is possible for bit errors to corrupt the data being exchanged. For this application, corrupted data must be detected and ignored, since incorrect data could very well cause a false de-energization of a transmission line, and move one step closer to a black out. Bad data is worse than no data at all. To that end, protection engineers would either want to see at 32 bit cyclic redundancy code protecting against corrupted data, or have some other assurances that under a credible worst scenario, it would not be expected that a corrupted phasor would sneak through more often than once every 300 years.

During installation of the differential protection scheme, the two terminals are identified to each other, and various parameters are selected, including those that impact the exchange of synchro-phasors. There are GPS receivers at both substations that can be used for sampling synchronization, so the intelligent devices are configured to synchronize to the GPS clock. (That is not always the case.) In this case, the GPS receivers are not deemed reliable enough, so a backup strategy is required in which the intelligent devices can synchronize to other clocks in the network using the network time protocol. Also, the system engineers do not completely trust digital communications, so they insist on two physically independent communications channels between the pair of terminals. That way, the system can continue to provide protection if only one of the communications channels fails.

During commissioning, the two intelligent devices are connected to their GPS clocks and checked out. Various tests are run successfully off-line. The devices are then re-initialized in an on-line mode.

During re-initialization of terminal A, the synchro-phasor service synchronizes the local sampling clock to the GPS clock, and turns on the calculation of synchronized phasors. Terminal A then attempts to connect with terminal B, which in this scenario, has not been initialized yet, so terminal A waits. Finally, both terminals are ready, and begin to exchange synchro-phasor data, and begin to provide digital current differential protection of the transmission line.

Because of the communications latency, the synchro-phasor also provides an alignment service. That is, it matches local phasors with remote phasors that arise from the same time window. This is a non-trivial task, because of the possibility of lost data or data that arrives out of sequence under normal operation.

During normal operation, the synchro-phasor exchange service attempts to exchange phasors redundantly. That is, two copies of the data are transmitted over physically independent paths. That way, if one path fails, data is likely available over the other.

Occasionally the communications network may switch the physical path between the two terminals, thereby changing the latency. In the case of a switch to a shorter path, it is possible to receive data out of order. In that case, it is permissible to throw some data away, on the theory that more will be arriving shortly.

On rare occasions, the GPS clock at one or both of the terminals may become unavailable. In that case, it is desired to automatically throw over to the use of the communications network to maintain the synchronization of the sampling clock(s), although the protection function will need to be informed of the loss of the GPS clock, and will need an estimate of the synchronization error. In the case of loss of clock synchronization altogether, the protection function also needs to be notified.

On resumption of clock synchronization following a loss of synchronization, there are two options: a step reset of the sampling clock, or a gradual ramping. As far as the protection function is concerned, either approach is acceptable, but protection is turned off until complete

Narrative of Function
resynchronization is attained.

C.1.6 Actors: People, Systems, Applications, Databases, the Power System, and Other Stakeholders

Describe all the people (their roles or jobs), systems, databases, organizations, and devices involved in or affected by the function (e.g. operators, system administrators, technicians, end users, service personnel, executives, SCADA system, real-time database, RTOs, RTUs, IEDs, and even the power system). The same actor could play different roles in different functions, but only one role in one function. If the same actor (e.g. the same person) does play multiple roles in one function, list these different actor-roles as separate rows.

Actor Name	Actor Type (person, device, database, system etc.)	Actor Description
General phasor client	function	Any monitoring, control, or protection function that could request phasor measurements on a one-time basis.
Synchro-phasor subscriber	function	Any client that subscribes to a continuous stream of synchronized, time-tagged phasor measurements.
Synchro-phasor requestor	function	Any client that requests a single snapshot of synchronized, time-tagged phasor measurements.
Host device	device	The gathering of data generally requires a host device to provide the basic hardware functions for supporting the measurements, such as sensors, filters, A/D converters, etc.
Time Synchronization Device	function	A globally synchronized local clock that is used to control the timing of data sampling and the time-tagging of phasors. Usually provided by the host device.
Sampling Device	device	A device such as a variable frequency oscillator (VCO), delta-sigma A/D converter, or simple A/D converter, for converting analog information into digital form. Usually provided by the host device.
Communications interface	device	The interface to the wide area communications network. Usually provided by the host device.
Clock monitor	function	A function that monitors the sampling clock to ensure synchronization.
Phasor Measurement Unit (PMU)	device	Phasor measurement unit

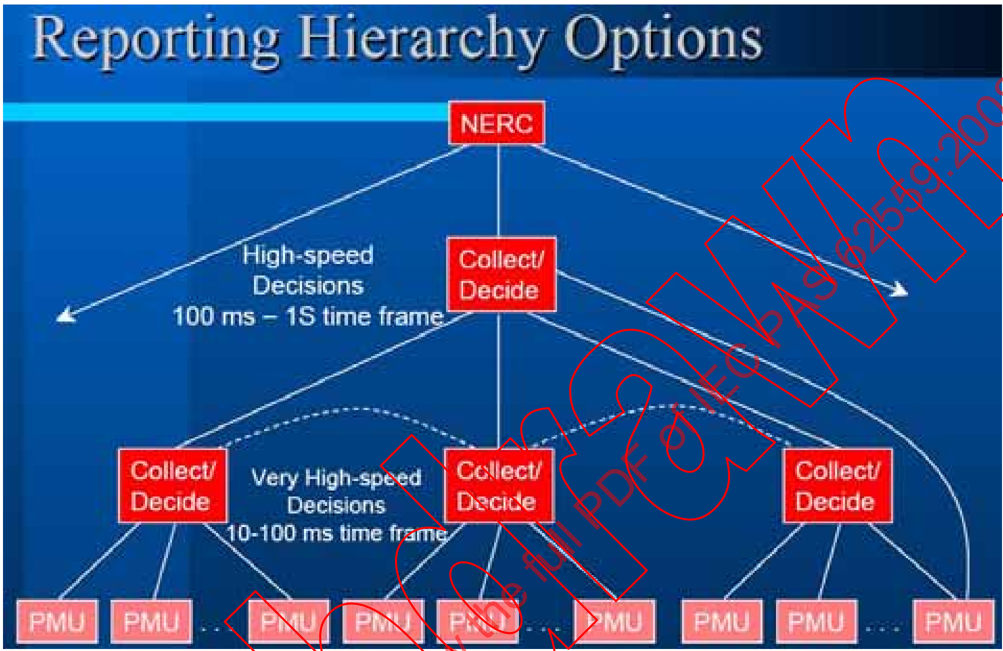
C.1.7 Legal Issues: Contracts, Regulations, Policies, and Constraints

Identify any legal issues that might affect the design and requirements of the function, including contracts, regulations, policies, financial considerations, engineering constraints, pollution constraints, and other environmental quality issues.

Legal Issue	***Impact of Legal Issue on Function***
IEEE 1344-1995	Integrating measurement systems into substation environments, specifying data output formats, and assuring that the measurement processes are producing comparable results
Draft C37.118	The SYNCHROPHASOR standard defines the synchronizing input and the data output for phasor measurements made by substation computer systems. It also discusses the processes involved in computing phasors from sampled data. It is hoped that this standard will be of considerable value to the developers and users of digital computer based substation systems.

C.2 Drawing or Diagram of Function

For clarification, draw (by hand, by Power Point, by UML diagram) the interactions, identifying the steps where possible.

Drawing or Diagram of Function


Step by Step Analysis of Function

Describe steps that implement the function. If there is more than one set of steps that are relevant, make a copy of the following section grouping (Preconditions and Assumptions, Steps normal sequence, and Steps alternate or exceptional sequences). If more steps are needed than are in the Step Table, add entire Steps (not just another row).

C.2.1 Preconditions and Assumptions

Describe conditions that must exist prior to the initiation of the Function, such as prior state of the actors and activities. Identify any assumptions, such as what systems already exist, what contractual relations exist, and what configurations of systems are probably in place. Identify any initial states of information exchanged in the steps in the next section. For example, if power system data is being monitored by a SCADA system, a precondition to this particular activity might be "normal monitoring of normal power system activities is taking place".

Actor/System/Information/Contract	*Preconditions or Assumptions*
Time Synchronization Device	Prior to publication of synchro-phasor measurements, the underlying sampling clock must be synchronized to the other clocks in the system.
Communication interface	Prior to publication of synchro-phasor measurements, the communication interface must be initialized.
Phasor publication enabled	Phasor publication is enabled after the sampling clock is synchronized and the communication interface is ready.

C.2.2 Steps – Normal Sequence

Describe the normal sequence of events, focusing on steps that identify new types of information or new information exchanges or new interface issues to address. Should the sequence require detailed steps that are also used by other functions, consider creating a new "sub" function, then referring to that "subroutine" in this function. Remember that the focus should be less on the algorithms of the applications and more on the interactions and information flows between "entities", e.g. people, systems, applications, data bases, etc. There should be a clear correlation between the narrative and these steps. The entries in the steps are:

- ***No.**: This could be simple "1, 2, 3" or could include identification of parallel steps if this is relevant, e.g. "1a, 1b, 2, 3a, 3b, 3c".*
- ***Event**: The event that starts the step. This might be completion of the previous step, a human requesting the function, data being reported periodically, or a power system event.*
- ***Description of Process or Activity**: This describes what action takes place in this step. The focus should be less on the algorithms of the applications and more on the interactions and information flows between "entities", e.g. people, systems, applications, data bases, etc.*
- ***Information Producer:** This identifies the producer or source of the information. This should be one of the Actors identified above.*
- ***Information Receiver:** This identifies the receiver of the information. This should also be one of the Actors identified above.*
- ***Information Exchanged**: This describes briefly the information to be exchanged: input to the function from some external source that is not described in this Use Case, internal to the function (although could be between different applications and systems within the function), output from the function that will be used by other entities not included in this Use Case*
- ***Configuration**: Locations, distances, communications layout, media, network bandwidth, existing protocols, numbers of devices, systems, volume of data items, expected growth, etc.*
- ***Quality of Service Requirements:** Availability, acceptable downtime of different components, recovery, backup, frequency of data exchanges, flexibility for future changes, response times, latency of data between detection and its display or action,*
- ***Security Requirements**: Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management*
- ***Data Management Issues:** Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases*
- ***Constraints or Other Issues:** This is a catch-all for any additional issues or concerns.*

Function Name:	Synchro-Phasor Measurements						
#	Event	Description of Process/Activity	Information Producer	Information Receiver	Information Exchanged		Characteristics of Information Exchanges
1	Collection of phasor data	Normal, on-going collection of a continuous stream of synchronized, time-tagged phasor measurements.	Phasor measurement unit (PMU)	Host device	Phasor measurements	Configuration	A number < 100 of PMUs in substations spread widely over utility territory; 1 Host device in substation control house;
						QoS	Latency < 24 ms, time synchronization within 10 µs, < 2.5% loss of data
						Security	Bad data detection with equivalent to 32-bit CRC, no encryption, probably no authentication
						Data Mgmt	Rapid data, small data packets but sent every 8 ms
						Constraints	
2	Phasor computation	Compute and provide the synchronized, time-tagged, fundamental power frequency components of voltages and currents for	Host device	Host device	Computation – no information exchange	Configuration	
						QoS	< .5% variance in accuracy of conversion, timestamp within 10 µs
						Security	Integrity required
						Data Mgmt	Very rapid conversion required

Function Name:		**Synchro-Phasor Measurements**					
#	Event	Description of Process/Activity	Information Producer	Information Receiver	Information Exchanged		Characteristics of Information Exchanges
		each phase. The theoretical basis for the calculation is providing a least mean square error fit of a sine wave to the samples over a given time window, using a fixed sampling frequency. Corrections should be made for errors caused by off-nominal frequency.				Constraints	
3	Request for subscription to phasor measurements	Request that local phasor measurements be transmitted to a remote client on a continuous basis	Generic phasor client	Host device	Continuous stream of digital phasor measurements	Configuration	WAN and/or LAN between one Host device in substation and a few Phasor clients located in operations centre
						QoS	Latency < 24 ms, time synchronization within 10 µs, < 2.5% loss of data
						Security	Bad data detection with equivalent to 32-bit CRC, no encryption, authentication of client required
						Data Mgmt	Rapid data, small data packets but sent every 8 ms
						Constraints	

Function Name:		Synchro-Phasor Measurements					
#	Event	Description of Process/Activity	Information Producer	Information Receiver	Information Exchanged		Characteristics of Information Exchanges
4	Cancellation of subscription	Cancellation of a previous subscription request	Synchro-phasor subscriber	Host device	One cancellation message	Configuration	WAN and/or LAN between one Host device in substation and a few Phasor clients located in operations centre
						QoS	Acknowledgement of receipt of cancellation
						Security	Authentication of client required
						Data Mgmt	
						Constraints	
5	Request for single phasor measurement	Request that a single local phasor measurement be transmitted to a local client	Synchro-phasor requestor	Communications interface		Configuration	WAN and/or LAN between one Host device in substation and a few Phasor clients located in operations centre
						QoS	Latency < 24 ms, time synchronization within 10 µs, < 2.5% loss of data
						Security	Bad data detection with equivalent to 32-bit CRC, no encryption, authentication of client required
						Data Mgmt	Only small amount of data
						Constraints	

C.2.3 Steps – Alternative, Error Management, and/or Maintenance/Backup Sequences

Using copies of the Steps Table, describe any alternative, error management, and/or maintenance/backup sequences.

Function Name:	**Synchro-Phasor Measurements**						
#	Event	Description of Process/Activity	Information Producer	Information Receiver	Information Exchanged		Characteristics of Information Exchanges
1	Loss of clock synchronization	Loss of synchronization triggers either censoring of phasor data, or indication that the phasors are not synchronized, or an estimate of the synch error.	Clock monitor	Host device	Loss of synchronization message	Configuration	A number < 100 of PMUs in substations spread widely over utility territory; 1 Host device in substation control house;
						QoS	
						Security	Authentication required
						Data Mgmt	Error management
						Constraints	
2	Clock recovery	Synchronization is established and normal operation is resumed.	Clock monitor	Host device	Synchronization messages	Configuration	A number < 100 of PMUs in substations spread widely over utility territory; 1 Host device in substation control house;
						QoS	Testing synchronization to within latency < 24 ms, time synchronization within 10 µs, < 2.5% loss of data
						Security	Authentication required
						Data Mgmt	
						Constraints	

Example of Distribution Automation Use Case

Using the IntelliGrid PAS User Requirements Use Case Template, Version 1

C.3 Description of the User Requirements of a Function

C.3.1 General

*The IntelliGrid methodology separates the concepts of "user requirements" from "technical specifications": **user requirements** define "**what**" is needed without reference to any specific designs or technologies, while **technical specifications** define "**how**" to implement the systems and applications in order to meet the user requirements.*

C.3.2 Domain Expert(s)

*This IntelliGrid PAS User Requirements Template focuses **only** on **what** is needed from a function, as described by those who are experts in their particular "domain", and who will ultimately be the users of the function. In filling out the template, these experts may be assisted by other types of experts, but they should keep clearly in mind that the focus must be the **user requirements**.*

Domain Expert	*Name*	*Title*	*Area of Expertise*
Primary	Fred	Principal Consultant	Distribution Automation
Additional			
Additional			

C.3.3 Name of Function

Name of the function

Name of Function
Advanced Distribution Automation (ADA) Function

C.3.4 Scope and Objectives of Function

Describe briefly the scope, objectives, and rationale of the function. The intent is to put the function in context, particularly in relationship to other related functions, such as piggybacking other functions on this function (or vice versa). This is not necessarily a justification or benefit-cost assessment, but can be used to hit the key points of the function.

Scope and Objectives of Function
Objective: The objective of Advanced Distribution Automation Function is to enhance the reliability of power system service, power quality, and power system efficiency, by automating the following three processes of distribution operation control: data preparation in near-real-time; optimal decision-making; and the control of distribution operations in coordination with transmission and generation systems operations. **Scope:** The ADA Function performs a) data gathering, along with data consistency checking and correcting; b) integrity checking of the distribution power system model; c) periodic and event-driven system modeling and

Scope and Objectives of Function
analysis; d) current and predictive alarming; e) contingency analysis; f) coordinated volt/var optimization: g) fault location, isolation, and service restoration; h) multi-level feeder reconfiguration; i) pre-arming of RAS and coordination of emergency actions in distribution; j) pre-arming of restoration schemes and coordination of restorative actions in distribution, and k) logging and reporting. These processes are performed through direct interfaces with different databases and systems, (EMS, OMS, CIS, MOS, SCADA, AM/FM/GIS, AMS and WMS), comprehensive near real-time simulations of operating conditions, near real-time predictive optimization, and actual real-time control of distribution operations. **Rationale:** By meeting its objectives in near-real time, the Function makes a significant contribution to improving the power system operations through automation, which cannot be achieved using existing operational methods. **Status**: The methodology and specification of the Function for current power system conditions have been developed, and prototype (pilot) and system-wide project in several North-American utilities have been implemented by Utility Consulting International and its client utilities prior to the IECSA project.

C.3.5 Narrative of Function

A complete narrative of the function from a domain expert user's point of view, describing what occurs when, why, with what expectation, and under what conditions. This narrative should be in "English", written so that non-domain experts can understand it.

Narrative of Function
A. Distribution Operation Modeling and Analysis (DOMA) This application is based on a real-time unbalanced distribution power flow for dynamically changing distribution operating conditions. It analyzes the results of the power flow simulations and provides the operator with the summary of this analysis. It further provides other applications with pseudo-measurements for each distribution system element from within substations down to load centers in the secondaries. The model is kept up-to-date by real-time updates of topology, facilities parameters, load, and relevant components of the transmission system. The Distribution Operation Modeling and Analysis supports three modes of operation: 1. Real-time mode, which reflects present conditions in the power system. 2. Look-ahead mode, which reflects conditions expected in the near future (from one hour to one week ahead) 3. Study mode, which provides the capability of performing the "what if" studies. The key sub-functions performed by the application are as follows: **1. Modeling Transmission/Sub-Transmission System Immediately Adjacent to Distribution Circuits** This sub-function provides topology and electrical characteristics of those substation transformers and transmission/sub-transmission portions of the system, where loading and voltage levels significantly depend on the operating conditions of the particular portion of the distribution system. The model also includes substation transformers and transmission/sub-transmission lines with load and voltage limits that should be respected by the application. **2. Modeling Distribution Circuit Connectivity** This sub-function provides a topological model of distribution circuits, starting from the distribution side of the substation transformer and ending at the equivalent load center on the secondary of each distribution transformer. A topological consistency check is performed every time connectivity changes. The model input comes from SCADA/EnergyManagementSystem, DistributionSCADASystem, from field crews, from DISCO operator, from

Narrative of Function
AM/FM/GIS, WorkManagementSystem, and OutageManagementSystem databases, and engineers.

- Data Management Issues between AM/FM/GIS and ADA Distribution Connectivity Database: Standard interfaces between different AM/FM/GIS Databases, data converters, and ADA database are not developed yet for practical use. The AM/FM/GIS Databases were not designed for real-time operational use. They lack many objects and attributes needed for ADA. The population of the databases is not supported by an interactive consistency check. The existing extractors of data and the converters into ADA databases do not determine all data errors. The ADA applications must conduct additional data consistency checking and data corrections before recommendations and controls are issued. Typically utility do not have established procedures for regular update of the AM/FM/GIS Databases by the operation and maintenance personnel. Therefore many changes implemented in the field remain unnoticed by the databases. Synchronization of the field state with the ADA database is a challenge in modern utilities.
- Data Management Issues between CIS and AM/FM/GIS and ADA Distribution Connectivity Database: For the ADA applications, the AM/FM/GIS data must be associated with the corresponding customer information data from the CIS database. This data include billing data and description of the customer specifics, such as rate schedule, customer code, meter number, address, etc. The critical information is the billing data. This data is updated based on metering cycles (typically one month) and is not well synchronized. In order to synchronize billing data an automated meter reading system should be implemented. In order to update the ADA databases more frequently, which would increase the resolution of ADA functions to individual distribution transformers and even customers, a high capacity communication system should be introduced to gather the data from hundreds of thousands of meters at the same time. Some of the modern procedures enabled by AutomatedMeterReadingDevice conflict with the needs of ADA model. An example is the consolidated bills, where the individual load data of distribution transformers located in different sites of the consolidated company becomes unavailable for the external to CIS world.

3. Modeling Distribution Nodal Loads

This sub-function provides characteristics of real and reactive load connected to secondary side of distribution transformer or to primary distribution circuit in case of primary meter customers. These characteristics are sufficient to estimate kW and kvars at a distribution node at any given time and day and include the load shapes and load-to-voltage sensitivities (for real and reactive power) of various load categories. In real-time mode, the nodal loads are balanced with real-time measurements obtained from corresponding primary circuits. A validity check is applied to real-time measurements. The load model input comes from Distribution SCADA System, from CIS supported by Automated Meter Reading Device and linked with AM/FM/GIS, and weather forecast systems.

4. Modeling Distribution Circuit Facilities

This sub-function models the following distribution circuit facilities:

- Overhead and underground line segments
- Switching devices
- Substation and distribution transformers, including step-down transformers
- Station and feeder capacitors and their controllers
- Feeder series reactors
- Voltage regulators (single- and three-phase) and their controllers
- LTC's and their controllers
- Distribution generators and synchronous motors
- Load equivalents for higher frequency models

All facilities should be modeled with sufficient details to support the required accuracy of Distribution Operation Modeling and Analysis application.

5. Distribution Power Flow

Narrative of Function
The sub-function models the power flow including the impact of automatically controlled devices (i.e., LTCs, capacitor controllers, voltage regulators), and solves both radial and meshed networks, including those with multiple supply busses (i.e. having Distributed Energy Resources (DER) interconnected to the power system). **6. Evaluation of Transfer Capacity** This sub-function estimates the available bi-directional transfer capacity for each designated tie switch. The determined transfer capacity is such that the loading of a tie switch does not lead to any voltage or current violations along the interconnected feeders. **7. Power Quality Analysis** This sub-function performs the power quality analysis by: • Comparing (actual) measured and calculated voltages against the limits • Determining the portion of time the voltage or imbalance are outside the limits • Determining the amount of energy consumed during various voltage deviations and imbalance • Recording the time when voltage violations occur • Performing modeling of higher harmonics propagation and resonant conditions based on information available from the sources of harmonic distortion • Performing modeling of rapid voltage changes based on information available from the sources of voltage distortion The sub-function provides the ability to estimate the expected voltage quality parameters during the planned changes in connectivity and reactive power compensation. **8. Loss Analysis** This sub-function bases its analysis on technical losses (e.g., conductor I^2R losses, transformer load and no-load losses, and dielectric losses) calculated for different elements of the distribution system (e.g., per feeder or substation transformer). For the defined area, these losses are accumulated for a given time interval (month, quarter, year, etc.). They are further compared with the difference between the energy input (based on measurements) into the defined area and the total of relevant billed kWh (obtained from the database), normalized to the same time interval. The result of the comparison is an estimate of commercial losses (e.g., metering errors and theft). **9. Fault Analysis** This sub-function calculates three-phase, line-to-line-to-ground and line-to-ground fault currents for each protection zone associated with feeder circuit breakers and field reclosers. The minimum fault current is compared with protection settings while the maximum fault current is compared with interrupting ratings of breakers and reclosers. If the requirements are not met, a message is generated for the operator. **10. Evaluation of Operating Conditions** This sub-function determines the difference between the existing substation bus voltage and the substation bus voltages limits. The sub-function also estimates the available dispatchable real and reactive load obtainable via volt/var control. The operator or other applications can use this information for selective load reduction. The sub-function provides aggregated operational parameters for the transmission buses to be used in transmission operation models. **B. Fault Location, Isolation and Service Restoration (FLIR)** This application detects the fault, determines the faulted section and the probable location of fault, and recommends an optimal isolation of the faulted portions of the distribution feeder and the procedures for the restoration of

Narrative of Function
services to its healthy portions. The key sub-functions performed by the application are as follows: **1. Fault Location** This sub-function is initiated by SCADA inputs, such as lockouts, fault indications/location, and, also, by inputs from OutageManagementSystem, and, in the future, by inputs from fault-predicting devices. It determines the specific protective device, which has cleared the sustained fault, identifies the de-energized sections, and estimates the probable place of the actual or the expected fault. It distinguishes faults cleared by controllable protective devices from those cleared by fuses, and identifies momentary outages and inrush/cold load pick-up currents. **2. Fault Isolation and Service Restoration** This sub-function supports three modes of operation: • Closed-loop mode, in which the sub-function is initiated by the Fault location sub-function. It generates a switching order (i.e., sequence) for the remotely controlled switching devices to isolate the faulted section, and restore service to the non-faulted sections. The switching order is automatically executed via SCADA. . • Advisory mode, in which the sub-function is initiated by the Fault location sub-function. It generates a switching order for remotely- and manually-controlled switching devices to isolate the faulted section, and restore service to the non-faulted sections. The switching order is presented to operator for approval and execution • Study mode, in which the sub-function is initiated by the user. It analyzes a saved case modified by the user, and generates a switching order under the operating conditions specified by the user. If during execution, there is change in connectivity, the sub-function interrupts the execution and re-optimizes the solution based on new conditions. If during service restoration, there is another fault, the sub-function runs again considering a new fault scenario. When work is completed, the sub-function is instructed to generate a switching order for restoration of the normal configuration. The generated switching orders are based on considering the availability of remotely controlled switching devices, feeder paralleling, creation of islands supported by distributed energy resources, and on cold-load pickup currents. **C. Contingency Analysis (CA)** This application performs an N-m contingency analysis in the relevant portion of distribution. The function runs in the following manners: • Periodically • By event (topology change, load change, availability of control change) • Study mode, in which the conditions are defined and the application is started by the user. The application informs the operator on the status of real-time distribution system reliability. **D. Multi-level Feeder Reconfiguration (MFR)** This application recommends an optimal selection of feeder(s) connectivity for different objectives. It supports three modes of operation: • Closed-loop mode, in which the application is initiated by the Fault Location, Isolation and Service Restoration application, unable to restore service by simple (one-level) load transfer, to determine a switching order for the remotely-controlled switching devices to restore service to the non-faulted sections by using multi-level load transfers. . • Advisory mode, in which the application is initiated by SCADA alarms triggered by overloads of substation transformer, segments of distribution circuits, or by DOMA detecting an overload, or by operator who would

Narrative of Function

indicate the objective and the reconfiguration area. In this mode, the application recommends a switching order to the operator.

- Study mode, in which the application is initiated and the conditions are defined by the user.

The application performs a multi-level feeder reconfiguration to meet one of the following objectives:

- Optimally restore service to customers utilizing multiple alternative sources. The application meets this objective by operating as part of Fault Location, Isolation and Service Restoration.
- Optimally unload an overloaded segment. This objective is pursued if the application is triggered by the overload alarm from SCADA, or from the Distribution Operation Modeling and Analysis, or from Contingency analysis. These alarms are generated by overloads of substation transformer or segments of distribution circuits, or by operator demand.
- Minimize losses
- Minimize exposure to faults
- Equalize voltages

The last three objectives are selected by engineer/planner.

E. Relay Protection Re-coordination (RPR)

This application adjusts the relay protection settings to real-time conditions based on the preset rules. This is accomplished through analysis of relay protection settings and operational mode of switching devices (i.e., whether the switching device is in a switch or in a recloser mode), while considering the real-time connectivity, tagging, and weather conditions. The application is called to perform after feeder reconfiguration, and, in case, when conditions are changed and fuse saving is required.

F. Voltage and Var Control (VVC)

This application calculates the optimal settings of voltage controller of LTCs, voltage regulators, DERs, power electronic devices, and capacitor statuses optimizing the operations by either following different objectives at different times, or considering conflicting objectives together in a weighted manner.

It supports three modes of operation:

- Closed-loop mode, in which the application runs either periodically (e.g., every 15 min) or is triggered by an event (i.e., topology or objective change), based on real-time information. The application's recommendations are executed automatically via SCADA control commands.
- Study mode, in which the application performs "what-if" studies, and provides recommended actions to the operator.
- Look-ahead mode, in which conditions expected in the near future can be studied (from 1 hour through 1 week) by the operator.

The following objectives, which could be preset for different times of the day and overwritten by operator if need to, are supported by the application:

- Minimize kWh consumption at voltages beyond given voltage quality limits (i.e., ensure standard voltages at customer terminals)
- Minimize feeder segment(s) overload
- Reduce load while respecting given voltage tolerance (normal and emergency)
- Conserve energy via voltage reduction
- Reduce or eliminate overload in transmission lines

Narrative of Function

- Reduce or eliminate voltage violations on transmission lines
- Provide reactive power support for transmission/distribution bus
- Provide spinning reserve support
- Minimize cost of energy
- Provide compatible combinations of above objectives

If, during optimization or execution of the solution, the circuit status changes, the application is interrupted and solution is re-optimized. If, during execution, some operations are unsuccessful, solution is re-optimized without involving the malfunctioning devices. If some of the controllable devices are unavailable for remote control, solution does not involve these devices but takes into account their reaction to changes in operating conditions.

G. Pre-arming of Remedial Action Schemes (RAS)

This application receives pre-arming signals from an upper level of control and changes the settings (tuning parameters) of distribution-side remedial action schemes (RAS), e.g., load-shedding schemes (a component of self-healing grid) or intentional DER islanding.

H. **Coordination of Emergency Actions**

This application recognizes the emergency situation based on changes of the operating conditions or on reaction of some RAS to operational changes and coordinates the objectives, modes of operation, and constraints of other ADA applications. For example, Under-frequency Load Shedding Schemes trigger emergency load reduction mode of volt/var control, or the under-frequency protection of DER triggers the pre-armed intentional islanding.

I. Coordination of Restorative Actions

This application coordinates the restoration of services after the emergency conditions are eliminated. For example, ADA changes the order of feeder re-connection based on current customer priorities or inhibits return to normal voltage until there are disconnected feeders.

J. **Intelligent Alarm Processing**

This application analyzes SCADA and DOMA-generated alarms and other rapid changes of the operational parameters in distribution and transmission and summarizes the multiple alarms into one massage defining the root cause of the alarms. For example, multiple sudden voltage violations along a distribution feeder and overloads of some feeder segments may be caused by a loss of DER excitation, or successful reclosing of a portion of feeder with loss of significant load may be caused by miss-coordination of the recloser settings and a particular fuse protecting a loaded lateral.

C.3.6 Actors: People, Systems, Applications, Databases, the Power System, and Other Stakeholders

Describe all the people (their roles or jobs), systems, databases, organizations, and devices involved in or affected by the function (e.g. operators, system administrators, technicians, end users, service personnel, executives, SCADA system, real-time database, RTOs, RTUs, IEDs, and even the power system). The same actor could play different roles in different functions, but only one role in one function. If the same actor (e.g. the same person) does play multiple roles in one function, list these different actor-roles as separate rows.

Actor Name	***Actor Type (person, device, database, system etc.)***	***Actor Description***
DisCos Operator		Person in charge of distribution operations during the shift

Actor Name	Actor Type (person, device, database, system etc.)	Actor Description
Distribution SCADA System		Distribution System Supervisory Control and Data Acquisition
Conversion Validation Function		The C&V function uses standard interface between AM/FM/GIS Database and converts and validates information about incremental changes implemented in the field.
ADA Data Checker		The ADA Data Checker monitors data entered into SCADA database and detects changes. When pre-defined changes are detected, the data checker triggers the ADA Dispatching System.
ADA Dispatching System		The ADA Dispatching System starts corresponding ADA functions based on pre-defined periodicity and events detected by the ADA Data Checker.
ADA Topology Update System		The ADA Topology Update System updates the ADA topology model based on status changes detected by the data checker
ADA Distribution Operation Model and Analysis (DOMA)		Calculation and Analysis of power flow/state estimation results
ADA VVC Controller (VVC)		ADA Voltage and Var Controller: Coordinated optimal control of voltage and var in distribution for different system-wide objectives
ADA: Fault location function		Fault detection and location in distribution
ADA: Fault Isolation and Service Restoration (FLIR)		Isolation of faulted portions of distribution feeders and restoration of services to healthy portions
ADA: Feeder Reconfiguration (FR)		Optimal selection of feeder connectivity for different objectives
ADA: Relay protection coordination		Adjustment of relay protection settings and operational modes of switches to provide a coordinated relay protection under real-time configuration
ADA: Prearming of Remedial Action Schemes (RAS)		Change of RAS settings in anticipation of a probable emergency
ADA Emergency Coordination System		Change of action priorities during the emergency state of the system
ADA Restoration Coordination System		Controlling the priorities of actions during the restorative state of the system
ADA: Intelligent Alarm Processing		Summarizing multiple alarms into one descriptive message.

Actor Name	*Actor Type (person, device, database, system etc.)*	*Actor Description*
Load Management Device		Controlling cycles of cyclic electric appliances (direct load control-DLC), interruptible and curtainable loads
UFLS: Under-Frequency Load Shedding Schemes		Shedding load based on frequency conditions
UVLS: Under-Voltage Load Shedding Schemes		Shedding load based on voltage conditions
SLS: Special Load Shedding Schemes		Shedding load based on specific operating conditions
Outage Management System		Trouble call processing, troubleshoot crew dispatch
Work Management System		Maintenance management in distribution
Field Personnel		Manual operations of field devices, repair and construction work
Field Device		Local intelligence for monitoring and control of automated devices in distribution, communicates with SCADA
Distributed Intelligence Schemes		Distributed Intelligence Schemes (DIS) - Performs operations in a localized distribution area based on local information and on data exchange between members of the group. Can communicate with SCADA.
IEDs of DIS members		IEDs grouped in a Distributed Intelligence Scheme
DER Owner		Maintenance and operations of DERs
TransCOs		Transmission of energy from generation to distribution within distribution-defined constraints/contracts
Energy Management System		Transmission and generation management system providing ADA with transmission/generation-related objectives, constraints, and input data
RTO/ISO		Wide-area power system control center providing high-level load management and other signals for DisCos
Market Operation System		Wide-area energy market management system providing high-level market signals for DisCos
Major customers		Major users of DisCo's services according to regulatory and contract rules
Customer Service Representative		Intermediary entity between DisCos and group of customers

Actor Name	*Actor Type (person, device, database, system etc.)*	*Actor Description*
AM/FM/GIS Database		Repository of distribution system assets, their relationships (connectivity), ownerships, and activities
Customer Information System		Repository of customer information related to DisCos services
Automated Meter Reading Device		Automated Meter Reading interfaced with CIS and AM/FM/GIS Databases
Asset Management System		Asset Management Systems interfaced with AM/FM/GIS
Remedial Action Scheme		Remedial Action Scheme performs local emergency operations based on local information, pre-armed settings and external signals. Can adapt to the changing local operating conditions.
ADA Database		ADA Database contains information on the current connectivity, operational parameters, electrical, economic and other relevant characteristics of the distribution power system
ADA Historic Database		
ADA Test Database		
Environmental daily data collector		
IT Personnel		
Load Forecaster		
DMS SCADA Database		
System Operator		
Prearming of RAS schemes function		
Fault isolation and service restoration subfunction		
ADA load management functions		Including ADA VVC Controller

C.3.7 Legal Issues: Contracts, Regulations, Policies, and Constraints

Identify any legal issues that might affect the design and requirements of the function, including contracts, regulations, policies, financial considerations, engineering constraints, pollution constraints, and other environmental quality issues.

Legal Issue	*Impact of Legal Issue on Function*
Contract between DISCO and TRANSCO	**Operational boundaries**. If the boundaries are at the circuit breaker level, then ADA has no direct access to substation capacitors and voltage regulators within the substation fence. In order to execute coordinated Volt/Var control, feeder reconfiguration, service restoration, ADA needs information about the substation connectivity, substation transformer loading, state of voltage regulators and capacitors, and their controllers. Furthermore, ADA should have capabilities for controlling these devices in a closed-loop mode. If the boundaries are at the high-voltage side of the substation transformer, then ADA has access to the substation devices and corresponding information. **Volt/Var Agreement.** Defines the voltage limits at the transmission side and reactive power requirements for distribution side. If the contractual parameters are not respected, the Volt/Var application may not meet its objectives, and the voltage limits at the customer side may be violated.
Contracts between DISCO and DER Owner	**Schedules**. Defines amount of kW generated by DER at different times and constraints for power flow at PCC. Deviation from schedules must be timely detected and compensated by other reserve capabilities of the distribution system. **Volt/Var control agreement.** Defines modes of DER operation and setting for Volt/Var control. Defines rules for changes of modes of operation and setting (local/remote, DER/EPS). Deviation from agreement must be timely detected and compensated by other reserve capabilities of the distribution system. **Standard 1547.** Defines rules for interconnection between DER and DISCO (EPS). Deviation from the rules may result in violation of power quality limits, delays in service restoration, damage of DER equipment. Deviation from the standard must be timely detected and remedial actions must be implemented.
Contracts between Disco and Customers	**Standard 519.** Defines power quality requirements at customer terminals. ADA functions are designed to respect these requirements. ADA must be capable of monitoring or accurately estimating the power quality parameters at the customer terminals, report and eliminate (or significantly reduce) the violations. **Performance based rates**. Defines the target level of service reliability. The distribution system and the ADA function should be design to meet the target. **Reliability guarantees.** ADA function should distinguish the customers with reliability guarantees from those without and focus the service restoration solution on meeting the guarantees, while providing other customers with target service reliability. Load management agreements. Defines the conditions, amount, and frequency of direct load control, load curtailment, interruption, and shedding.

C.3.8 Preconditions and Assumptions

Describe conditions that must exist prior to the initiation of the Function, such as prior state of the actors and activities. Identify any assumptions, such as what systems already exist, what contractual relations exist, and what configurations of systems are probably in place. Identify any initial states of information exchanged in the steps in the next section. For example, if power system data is being monitored by a SCADA system, a precondition to this particular activity might be "normal monitoring of normal power system activities is taking place".

Actor/System/Information/Contract	***Preconditions or Assumptions***
AM/FM/GIS Database	AM/FM database contains the geographical information of the distribution power system circuit connectivity, as well as the parameters describing the power system facilities. Conceptually, the AM/FM/GIS Database can contain transmission connectivity and facility data and relevant to distribution operations customer-related data.
CIS system (or proxy for CIS data)	CIS contains load data for a customer that is estimated for each nodal location on a feeder, based on billing data and time-of-day and day-of week load shapes for different load categories.
Energy Management System SCADA	Energy Management System contains the transmission power system model, and can provide the transmission connectivity information for facilities in the vicinity of the distribution power system facilities and with outputs from other Energy Management System applications
DMS SCADA database	Distribution SCADA System database is updated via remote monitoring and operator inputs. Required scope, speed, and accuracy of real-time measurements are provided, supervisory and closed-loop control is supported.
Conversion Validation Function	The C&V function extracts incremental changes from AM/FM/GIS/Customer Information System and converts it into ADA database format
Environmental daily data collector	Collects environmental data
System Operator	One who makes decisions on operation of the power system
Load Forecaster	Load forecasting system
ADA Data Checker	ADA Data Checker frequently checks the changes in SCADA database
ADA Dispatching System	ADA Dispatching System is designed to coordinate the ADA functions in a pre-defined manner
ADA Topology Update System	Checks the topology of the distribution system
IT Personnel	Field IT support
ADA Topology Update System	ADA Topology Update System “reconfigures” connectivity models in seconds
ADA Test Database	Database containing test data values
ADA Distribution Operation Modeling and Analysis (DOMA)	**Preconditions:** Distribution SCADA System with several IEDs along distribution feeders, reporting statuses of remotely controlled switches and analogs including Amps, kW, kvar, and kV. System Operator’s ability for updating the SCADA database with statuses of switches not monitored remotely. Substation SCADA with analogs and statuses from CBs exists.