Foundational Report Series: Advanced Distribution Management Systems for Grid Modernization

Implementation Strategy for a Distribution Management System

Energy Systems Division

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Implementation Strategy for a Distribution Management System

by

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FOUNDATIONAL REPORT SERIES

DISTRIBUTION MANAGEMENT SYSTEMS FOR GRID MODERNIZATION

This is one of seven reports on distribution management systems (DMS), their functions, implementation, and importance for grid modernization.

The reports on DMS in this numbered series of Argonne reports are as follows:

1. Importance of DMS for Distribution Grid Modernization (ANL/ESD-15/16)
2. DMS Functions (ANL/ESD-15/17)
3. High-Level Use Cases for DMS (ANL/ESD-15/18)
4. Business Case Calculations for DMS (ANL/ESD-17/3)
5. Implementation Strategy for DMS ((ANL/ESD-17/6)
6. DMS Integration of Microgrids and DER (To Be Published)
7. DMS Industry Survey (To Be Published)

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LIST OF ACRONYMS AND ABBREVIATIONS

DMS	Distribution Management System
EMS	Energy Management System
GIS	Geographic Information System
OEM	Original Equipment Manufacturer
OMS	Outage Management System
RFI	Request for Information
RFP	Request for Proposal
SI	Systems Integrator
SOW	Statement of Work

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INTRODUCTION

Electric distribution utilities encounter many challenges to successful deployment of Distribution Management Systems (DMSs). The key challenges are documented in this report, along with suggestions for overcoming them.

This report offers a recommended list of activities for implementing a DMS. It takes a strategic approach to implementing DMS from a project management perspective. The project management strategy covers DMS planning, procurement, design, building, testing, Installation, commissioning, and system integration issues and solutions. It identifies the risks that are associated with implementation and suggests strategies for utilities to use to mitigate them or avoid them altogether. Attention is given to common barriers to successful DMS implementation.

This report begins with an overview of the implementation strategy for a DMS and proceeds to put forward a basic approach for procuring hardware and software for a DMS; designing the interfaces with external corporate computing systems such as EMS, GIS, OMS, and AMI; and implementing a complete solution.

OVERVIEW OF THE IMPLEMENTATION STRATEGY

The implementation strategy starts with active participation by stakeholders in all departments of the electric distribution utility (generally referred to in this report as the utility). Their engagement from the conception of the project to its implementation is fundamental. High-priority activities are system design review, database and display development, training, factory testing (the “factory” refers to the vendor’s integration facility or staging area), and system integration support. Involvement by a wide range of stakeholders during the early stages of a project gives interested parties an opportunity to influence the design from their own perspective throughout the entire process, making it relatively easy to accommodate special needs along the way. Meeting requests that occur later in a project, after project milestones are passed—for example, during factory testing—will almost certainly result in costly change orders and schedule delays. Another reason for active participation by a core project team (see below) is to provide effective on-the-job, hands-on training that is superior to any form of classroom training that can be conducted after project completion. Active participation ensures that the resultant DMS satisfies expectations and that the utility personnel are well positioned for long-term support.

ESTABLISHMENT OF A CORE TEAM

An essential activity that must be conducted at the beginning of the project is the establishment of a core team that plays a lead role in all project activities. The core team should include senior-level representatives of the key stakeholders. Besides serving as representatives for key stakeholders, core team members are expected to provide project management services, decide on technical and commercial matters pertaining to the groups they represent, and arrange for additional support from within their groups as needed during subsequent phases of the project. Core team members are expected to participate heavily in the project, especially during the planning phase. At times during the planning phase, 100% (dedicated full-time) commitment is expected from them. In addition, some travel may be necessary for some core team members during the procurement and design/test phases.

Risk Management: Lack of Commitment from Core Team Members. The core project team must be committed to successful completion of the project. While the utility may elect to augment its DMS project implementation staff during the project, a significant amount of effort on the part of the utility’s project personnel is unavoidable. This is especially true during the Requirements Definition activity (see Task 2.1), when heavy input from utility personnel is needed. Usually, the principal sources of input are senior-level persons who are already very busy, further aggravating the situation. Core team personnel must be able to provide the necessary information on a timely basis.

At a minimum, the core team should include representatives of the following stakeholders:

- Project management
- Control center operations
- Engineering

- Information technology and communications
- Geographic Information System (GIS) specialists
- Communication specialists
- Procurement specialists (buyers)

THE FIVE PHASES OF IMPLEMENTATION

DMS implementation involves the following major phases:

- Phase 1: Planning.** The planning phase of the project establishes a framework for the entire project. The planning phase identifies the business needs and the specific DMS application functions and technologies that should be implemented to address them. It also establishes the implementation schedule/timeline and budget for the project, resource requirements (technical and financial), and other foundational elements. Another important part of the planning phase is developing the business case for the DMS solution, which is needed to justify moving forward with the project. Once the plan has been developed and approved by all major stakeholders, the implementation project can proceed.

Risk Management: Lack of a Realistic Project Schedule. With aggressive schedules for completing projects, virtually any measurable schedule slippage can impact the DMS in-service date. One of the utility's first tasks should be to establish a detailed schedule, with milestones, that is key to the utility's overall objectives and activities. The detailed project schedule should be closely tracked by the DMS team at all times, followed with minimal exceptions, and updated on a weekly basis. Potential and actual project slippages should be identified and addressed to minimize the potential impact on the overall schedule.
- Phase 2: Procurement.** Once the implementation plan is completed, the next phase is a series of activities to procure the necessary hardware, software, and services from a qualified DMS vendor. For purposes of this report, it is assumed that a competitive bid process is conducted to select the vendor that is best suited to supply the DMS. This phase comprises a formal procedure for describing the necessary hardware, software, and services, soliciting proposals from qualified system vendors, evaluating the proposals, selecting the best vendor to supply the system, and negotiating a contract and statement of work (SOW) with the winning vendor.
- Phase 3: Designing, Building, and Testing.** During this phase of the project, the functional and technical requirements spelled out in earlier phases are converted into a specific, detailed design that spells out how the requirements are to be satisfied. Once this detailed design is mutually agreed upon by the utility and the system vendor, the required hardware and software components are assembled and configured. A thorough battery of factory tests are then conducted to ensure that the system that has been designed and built satisfies the functional and technical requirements established early in the project.

- **Phase 4: Installation and Commissioning.** Following successful completion of the factory tests, the DMS hardware and software are shipped from the system integration facility to the utility sites and installed. Besides the physical placement of the DMS servers, consoles, and other equipment in specified locations, system installation also includes integrating the DMS vendor-supplied components into existing corporate computing systems like the GIS and SCADA facilities. This integration is followed by a series of tests (referred to as site tests) to verify that the system has been properly installed and is operating correctly in the final integrated environment.

Another objective of this phase is to prepare the control center personnel (operators and other stakeholders) for effective use of the new system. Although this is one of the last phases of the project, the activities to prepare control room personnel to use the new system should begin very early in the project. These activities include development of revised use cases and operating procedures for the new DMS, and other “change management” activities that are needed to ensure that the control room personnel understand how to use the new system effectively under normal and emergency conditions. Once commissioning is completed, the new DMS is placed in service for live operation in the control room environment.

- **Phase 5: System Sustainment.** This phase includes activities to keep the DMS hardware and software in good working order over the life of the system, with periodic improvements and upgrades. Sustainment activities also include ongoing training activities for both new and experienced operators.

Tasks to accomplish each phase of the DMS project are detailed in the following sections.

PHASE 1: PLANNING

Most successful DMS implementation projects begin with a thorough assessment of the utility's important business drivers and objectives. These business drivers and objectives provide the foundation upon which all DMS functional and technical design requirements are based. Since the DMS is expected to serve the needs of the utility over a long period (at least 10 to 15 years), it's important to understand both the short-term needs (over the next three to five years) and the long-term needs (over 10 to 15 years).

It's often difficult to anticipate how the business needs of a utility will change in the long term, owing to the potential impact of external influences that are beyond the control of the utility, such as changes in the political, regulatory, and economic environment. To address these uncertainties, the DMS must have a flexible standards-based design that can be expanded as needed in the future to accommodate new requirements that couldn't be anticipated at project inception. Such a design helps to ensure that the DMS doesn't become a "stranded" investment should major new needs arise in the future. The best way to gain a thorough understanding of corporate business objectives is to interview the people who own the problems: the senior-level executives. Besides providing the best available information on current business needs, senior executives are the best resources for obtaining insight into how these business needs are likely to change over the life of the DMS.

Figure 1 shows the proposed activities and deliverables for Phase 1. Descriptions of the major tasks that should be included in Phase 1 are provided below.

TASK 1.1: KICKOFF MEETING AND MOBILIZATION

The primary objective of this task is to get the project started "on the right foot." As soon as possible after the decision to proceed, key project stakeholders should meet to discuss project objectives and goals, review work plan details, and agree on changes. The kickoff can be a meeting, conference call, or webinar. Whatever the venue, it is important that underlying assumptions and constraints are recognized, and documentation and previous studies are distributed and discussed, along with any other information on the development of the project that should be in the stakeholders' files for future reference. An important objective of this meeting is to plan for future information exchanges as the project progresses and to agree on logistics and communications.

FIGURE 1 Diagram of Phase 1 Activities—DMS Implementation Planning

TASK 1.2: DMS TECHNOLOGY SEMINAR/WORKSHOP

Some utilities elect to do a seminar/workshop as the first major activity, and find it to be an effective way to start the project. A seminar/workshop is a convenient way to inform interested parties about recent industry trends, best practices and lessons learned by other electric utilities, and other topics relevant to the project. Having a seminar/workshop early in the project offers a platform for productive dialogue on information exchange. A list of typical topics for a seminar/workshop is shown in Figure 2.

TASK 1.3: INFORMATION EXCHANGE MEETING

Much of the information needed to carry out the DMS project is obtained through a series of interviews with key utility personnel. Persons to be interviewed include managers, operators, engineers, maintenance personnel, and others who have insights about current business and operational practices and problems. Interviews should include discussion of a Study Guide/Questionnaire prepared by the core project team, covering current operational problems

Introduction to DMS Technologies – Key Definitions	
Major DMS Functions	
	Distribution SCADA
	Distribution Automation (auto service restoration, volt VAR control)
	Switch Order Management
	On-Line Power Flow
	Load Estimator
	Topology Processor
	Short-term Load Forecasting
	Emergency Load Shedding
	Distribution Simulator/Study Mode Operations
	DMS Training Simulator
	Others
Interfaces to External Systems	
	Geographic Information System (GIS)
	Outage Management System (OMS)
	Energy Management System (EMS)
	Asset Management/Work Management
	Crew Management/Mobile Dispatch
	Meter data management system (MDMS)
	Corporate data warehouse
Hardware/software/system architecture issues	
Communication and security issues	

FIGURE 2 Preliminary List of Topics for Optional Seminar/Workshop

and deficiencies and other topics relevant to the DMS. Interviews with managers should be directed towards business problems and concerns, long-range plans, and other topics of a “visionary” and regulatory nature. At least one session should be dedicated to a discussion of system interface issues. Each interview should last approximately one hour.

During the Information Exchange Meetings, members of the core project team should visit key locations (control centers, substations, etc.) to gain a better understanding of how DMS functions might be implemented at the utility and to help identify any unique requirements that need to be addressed.

TASK 1.4: INDUSTRY SURVEY AND BENCHMARKING

This task entails identifying and documenting trends in DMS applications, and gathering the operating experiences of other utilities over a period of years. Focus is on the DMS functions and control center applications. The emphasis is on determining the actual benefits that have been realized by other utilities and determining whether their systems have lived up to expectations.

It must be pointed out that many utilities may only be willing to share their experiences anonymously. In such cases, it is important to identify the general experiences, without divulging the name of the utility.

TASK 1.5: DEFINE DMS FUNCTIONAL REQUIREMENTS

The primary objective of this task is to determine how the utility can use DMS applications to address the business problems and concerns, power system performance problems, operational difficulties, and other issues identified during the Information Exchange Meetings.

The project team reviews the information received during the Information Exchange Meetings and prepares a list of the key operational and business problems, concerns, and limitations. Team members then identify ways in which DMS applications can help address each of these key issues.

An important part of this task is defining the functional requirements for DMS applications to support business objectives, improve power system performance, alleviate operational difficulties, and resolve other issues identified during the interviews. A DMS “Opportunity Matrix” can be created to determine which applications apply to specific value drivers (see Figure 3). The project team should provide an unbiased assessment as to whether a DMS solution to each problem is possible, given utility-specific constraints such as budgets and available infrastructure.

When defining the detailed requirements for the new DMS, the utility must always keep the business case in mind. Items that do not directly support the business case may not be required. The DMS technical and functional requirements must represent the business needs of all stakeholders, and there are many potential stakeholders! The utility should be flexible where possible to allow bidders to propose standard products.

DMS Functional Requirements	Enabling Function	Safety	Asset Protection	Reliability	Efficiency	Peak Shaving	Asset Utilization	DER Management	EV Management
Data Acquisition & Control	X								
State Estimation	X								
Graphical User Interface	X								
Historical Information System	X								
Distribution System Model	X								
Load Models	X								
Topology Processor	X								
On-Line Distribution Power Flow	X								
Intelligent Alarm Processing		X	X	X			X		
Control Room Operating Tools		X	X	X	X				
Short Circuit Analysis		X	X	X					
Switch Order Management		X	X	X			X		
Volt-VAR Optimization					X	X	X	X	
FLISR		X		X					
Predictive Fault Location		X		X					
Optimal Network Reconfiguration				X	X	X	X		
Short Term Load Forecasting				X	X	X		X	X
Dynamic Equipment Rating			X				X		
DMS Control of Protection Settings		X	X	X					
DER Management		X	X	X	X	X		X	
Demand Response Management				X		X			
Emergency Load Shedding		X				X			
EV Charging						X			X
Dispatcher Training Simulator		X	X	X	X	X	X	X	X

FIGURE 3 Sample DMS “Opportunity Matrix”

Preliminary Use Cases

Many DMS projects have achieved limited success because the utility did not sufficiently plan for actual use of the DMS functions in the control room environment. As a result, end users often are not clear on how to use the new application software in an actual production environment with existing business processes.

An important first step in the implementation process is development and refinement of business processes to determine the application functions that should be in the DMS major architecture. The utility should conduct a new series of interviews/workshops, similar to those conducted during the start of the DMS roadmap effort. These interviews/workshops should be focused on “to-be” DMS application function details, integration requirements, required workflows, and overall impacts on all the stakeholders. Additional questions must be included to clarify the applicable business processes prior to preparing technical specifications for procuring the necessary vendor-supplied hardware, software, and services.

Following these interviews/workshops, but before preparing procurement specifications, the utility should develop preliminary "use cases" for each of the proposed DMS application functions to ensure that the required workflows and user needs will be reflected in the procurement specifications. Use cases should identify how the DMS end users will actually use the DMS application functions in a live production environment. The use cases should identify the following:

- The stakeholders who use each function,
- The purpose of each function,
- The situations in which each function should be used,
- Information that is required to run each application,
- Application function outputs to be provided to the stakeholders,
- Required actions by the stakeholders in response to functional outputs, including response to error conditions, and
- Other information needed to determine how each application will run in actual production mode.

The high-level use cases that are developed during this stage of the project are generally considered “preliminary” because they are written before selecting the actual DMS vendor. The objective of developing use cases is to ensure that the software to be delivered is compatible with current and planned operating practices. The use cases are also used to identify application and integration requirements for support of those business processes. Use cases should be refined and updated later in the project, when the vendor is known and details about the specific implementation used by the vendor for each key application function have been established.

In addition to preparing preliminary use cases that explain the use of the functions, it is necessary to add detail to the high-level functional descriptions provided for each application function in the DMS roadmap. These additional details should provide sufficient information to enable system vendors to propose application functions that address the specific requirements identified by the utility's stakeholders. Additional details should include the following:

- Required functional characteristics and features of the DMS advanced application software,
- Sources of data required by the application functions,
- Interoperability (especially with legacy systems that are being retained),
- System sizing and performance requirements,

- Specific displays that are required by the end users,
- Access control/cyber security requirements,
- Error conditions that must be handled by the software, and
- Other detailed information that is needed to specify each function in sufficient detail to solicit firm fixed-price proposals from system vendors.

TASK 1.6: DEVELOP CONCEPTUAL DESIGN

This task includes developing the DMS conceptual solution architecture. The core project team should discuss and analyze the needs and requirements of the DMS, applicable business rules and high-level business processes, and integration with other utility energy delivery information systems.

In this task, the team should identify the alternative architectures for implementing a DMS at the utility. Both centralized and decentralized architectures should be considered. Location-agnostic designs and software-as-a-service architectures should also be considered. DMS hardware, software, and system architecture should be described at a “conceptual” level in this phase. Designs that are described in sufficient detail help with the development of budgetary estimates and preliminary implementation plans. Conceptual design lays the foundation for more detailed specifications to be prepared during Phase 2 (Procurement).

The team should produce requirements for the technical architecture, including IT platforms (e.g., server, workstations, database and data warehouse), software, and infrastructure (e.g., cyber security and information protection). Potential future environments should be considered in terms of the following:

- User locations and LAN/WAN infrastructure,
- Database management systems,
- Development and system integration standards,
- Data sharing and distribution requirements,
- Security requirements, and
- Operational requirements (backup/restore, archive, failover, disaster recovery).

The cost of implementing DMS functions depends greatly on the extent to which the utility’s existing SCADA and communication facilities can be used to support these functions. To minimize costs, the proposed DMS facilities should utilize the utility’s existing SCADA and communications facilities to the fullest extent possible. The proposed design should not adversely impact the existing SCADA functions and other applications that currently utilize these facilities.

Use of hardware/software and hardware/software interfaces that are modular, and which comply with international standards that are “open” and well accepted, is key to the long-term

success of the DMS. When a hardware component fails or a software application must be expanded, it should be possible to replace the affected hardware or software module with a new module so that extensive system modifications or total system replacement (“forklift”) is not necessary.

TASK 1.7: DEVELOP INTERFACE SPECIFICATIONS

Another task is the definition of system integration requirements. These will be a consequence of use cases, which determine how the applications are leveraged in support of current/future business processes. The utility should develop an Interface Requirements Document that, as a minimum, contains the following items:

- Conceptual system diagram showing major data flows between DMS and other utility IT systems and applications, and
- An integration summary matrix with these columns for each of the interfaces shown on the conceptual system diagram: Interface Function, Data, From System, To System, Priority (or Implementation Project Phase), Latency/Currency Requirements, Potential Integration Method, and High-Level Design Considerations.

In addition, the utility should prepare a list of major business process changes required to support and leverage the integrated DMS solution. The utility should state how the new applications are to be used by the operations staff in support of business processes—some existing, some new, and some evolving. There are questions that need to be answered at this stage, including identifying the organizational changes that are needed. There are also IT/OT considerations that need to be addressed, like getting the GIS data to where they need to be and ensuring their ongoing maintenance. Also, risks associated with implementation of the DMS and mitigation strategies should be assessed carefully.

TASK 1.8: DEVELOP IMPLEMENTATION/PROCUREMENT STRATEGY

In this task, the project team should develop strategies for implementing the DMS facilities that satisfy the functional and architectural requirements identified in previous tasks. The implementation strategy is intended to serve as a roadmap for the utility’s use in implementing the recommended changes and additions, taking into account limited financial and manpower resources.

Implementing the DMS is a complex process that typically requires several years to complete. Many electric utilities have elected to use a “phased” implementation strategy. The project starts with issues related to installing and commissioning basic DMS functions that provide a stable foundation onto which more advanced functions can be added. The functionality, in the initial phase, typically includes data acquisition and control (SCADA) functions, geographic user interface, alarm processing, data historian, switching orders, and other

Risk Management: Quality of Distribution System Model. Inability to build and maintain a high-quality distribution system model is arguably the most difficult challenge that the utility will face during DMS implementation. For most electric distribution utilities, existing information sources have a considerable amount of missing and erroneous information (e.g., on phasing). The advanced application functions that supply the majority of the tangible benefits of a DMS require an "as-operated" model of the electric distribution system. If the model does not exist or has errors, then the DMS online power flow program will produce inaccurate results or, in the worst case, fail to run altogether. As a result, the DMS will not achieve the benefits identified in the DMS business case. Even small data errors can have a significant adverse impact, because such inaccuracies require the utility to operate its electric distribution system with a larger operating margin than necessary, thus reducing the potential for performance improvement.

A "boots on the ground" line survey to capture the as-operated condition of the electric distribution system is a great way to mitigate the risk associated with having poor-quality data models. To ensure that the data captured during the survey are sufficient for supporting the needs of the advanced DMS application functions, the utility should perform validation checks on the data acquired during the line survey. The utility should develop or procure software tools that can aid in this process. These tools should be able to identify obvious data entry problems, such as the connection of an "A" phase conductor to a "B" phase conductor or the presence of completely disconnected elements. After weeding out the obvious data errors, the utility should construct distribution system models from the information that has been acquired during the survey and use these models, together with its engineering power flow analysis software, to verify that the data being collected are adequate for achieving an accurate power flow solution. These model validation activities should begin immediately after data have been collected from the line survey. This approach can enable the utility to identify changes that are needed in the data collection/survey process to ensure the adequacy of future data collection.

Once the current state of the electric distribution system has been captured and the model is validated, it is essential that new business processes be put in place to ensure that future changes and additions to the electric distribution system are properly documented and modeled as needed to support the DMS applications.

basic functions. A considerable effort may also be dedicated to implementing the GIS-DMS interface that is needed to support building the distribution system model and the DMS geographic displays. More advanced functions, such as on-line unbalanced power flow, VVO, and FLISR are often implemented during subsequent phases.

A phased approach allows the organization to start gaining valuable benefits from the DMS at the earliest possible date and enables the distribution system operators and other DMS end users to become familiar with the DMS operating characteristics and geographical user interface before tackling the more advanced functionality. Phased implementation is often an effective approach for utilities with severely constrained technical and financial resources; it allows the utility to spread out the resource requirements over a longer time period. Deferring implementation of advanced functions also allows other utility installations to gain additional operating experience with new software products, thus minimizing the utility's risk in using these products. However, phased implementation should never be used to postpone deployment of products that are not currently available from the DMS vendor. When a vendor cannot deliver a given functionality, it is often pushed off to a later implementation phase.

The project team should explore the value of phased implementation strategies and recommend the strategy that satisfies the utility's operational needs and available resources in the most effective manner.

Another very important activity is to develop operating procedures with due consideration of the newly acquired DMS.

Procurement strategy should also be addressed as part of this task, including various alternatives for handling the system integration activities.

PHASE 2: PROCUREMENT

After the detailed functional and integration requirements have been identified, the utility should proceed with the Procurement phase of the project. The Procurement phase of DMS implementation should include all activities needed to

- Solicit firm, fixed-price proposals for the required DMS facilities (hardware, software, and services) from qualified system vendors,
- Identify the best proposal, and
- Prepare a contract and SOW for completing the necessary work.

Figure 4 shows some of the major activities that should be included in the Procurement phase. The following subsections describe the major tasks to accomplish this phase.

TASK 2.1: DEVELOP REQUEST FOR INFORMATION

The Requirements Definition activities provide detailed information about the specific hardware, software, and services that are needed to implement the proposed DMS. The Requirements Definition should be based on the findings, conclusions, and recommendations identified during earlier phases of the roadmapping process. Ideally, the information acquired during the Requirements Definition stage of the project is sufficiently detailed to enable the utility to determine the impact of proposed functionality upon existing business processes and labor resources and thus to proceed with the procurement process.

As part of the Requirements Definition process, the utility should consider conducting a Request for Information (RFI) process. The primary purpose of this activity is to solicit information from experienced DMS vendors to enable the utility to identify vendors who are qualified to supply the utility's DMS. These are the vendors that should receive the Request for Proposal (RFP) for supplying the DMS. A second objective is to obtain information about

Risk Management: External Interfaces

Definition. Despite evolution of numerous system integration technologies and the development of international standards (such as the Common Information Model), implementation of DMS external interfaces continues to be one of the major barriers to successful implementation. Ideally, the utility has stressed the importance of such interfaces for the proposed DMS and has included interfaces to its existing EMS, GIS, OMS, and other systems in its technical specifications.

During the Requirements Definition meetings, a considerable portion of time should be devoted to discussion of interface needs so that these requirements can be added to the DMS technical specifications during the procurement phase.

In projects of this type, it is often difficult to gauge each bidder's capabilities for developing the required interfaces. To mitigate this potential risk area, the utility should develop sample data sets for each external system. These data sets can be supplied to bidders, who, in turn, should be required to demonstrate the interface using the sample data set as part of their proposal presentation. (See Task 2.4.)

FIGURE 3 Phase 2: Procurement Activities

current offerings, along with a description of how each vendor would apply its standard design to satisfy the utility's needs.

The RFI, sent to leading DMS vendors, should contain an overview of the utility's DMS requirements and a questionnaire to solicit specific vendor information, such as the following:

- Description of current standard offerings,
- Descriptions of DMS projects of similar scope done during the past five years,
- Suggested approach to satisfying the utility's requirements, especially in difficult areas such as DMS-to-OMS integration,
- Location of system integration facilities,
- Description of available resources (financial and manpower),
- Information about any litigation against the firm, and
- Budgetary pricing.

The utility should review the DMS vendors' RFI responses to identify the most qualified vendors, who, in turn, should be invited to bid. Criteria for selecting the qualified bidders should be agreed upon before receiving the RFI responses, and may include the following:

- Recent experience in supplying DMS systems similar to the utility's desired system,
- Support for the "open system" concept that supports applicable established industry standards such as the Common Information Model,
- Available resources,
- Effectiveness of the approach for addressing the utility's needs, and
- Customer references.

The RFI process should narrow down the list of DMS vendors to be invited to submit proposals to a manageable number of four (or fewer) bidders.

TASK 2.2: DEVELOP REQUEST FOR PROPOSAL AND SOLICIT BIDS

The next step in the system procurement process is to prepare an RFP to be used to solicit actual vendor bids to supply the system. The RFP should describe the technical and commercial requirements for the equipment, software, and services (including integration services) to be furnished by the DMS vendor. The RFP must enable the utility to acquire enough information from the bidders to enable effective comparison of the offerings. In addition to identifying requirements for vendor-supplied hardware, software, and services, the RFP should identify the responsibilities of the utility, the vendors, and other participants in the project. The RFP (especially the commercial and technical specifications) will become the basis of the legal contract with the vendor the utility selects to perform the work.

The RFP should require a standard format for the proposal from all bidders. This requirement simplifies reviewing the proposals and minimizes the time spent searching for responses to given questions. The RFP should provide sufficient detail in the specifications to avoid confusion; it should also be flexible enough to allow the vendor to use standard products. To the fullest extent possible, the utility should avoid the need to customize standard software. If software is customized, even seemingly minor changes can cause problems that can ultimately lead to extra costs, project delays, and potential loss of functionality.

Risk Management: Customization and New Development Activities. The experience of many utilities in the industry has shown that one of the most significant risk factors in DMS deployment is the level of customization and new development efforts required by the system vendor to meet the needs of the utility customer. Even changes to the vendor's standard system that seem minor can have a significant impact on system performance and reliability. This impact may be due to technical problems during development, such as unanticipated program interactions. There is no "cookbook" DMS solution that matches the needs of all utilities, and thus some customization is unavoidable. However, the projects with the lowest risk (and usually the lowest cost) are those that minimize the number of such changes.

The utility should prepare a single specification that covers all project deliverables, placing the ultimate responsibility for the delivery of all hardware, software, and services on a single DMS vendor. The RFP should contain enough information about "what" is needed so that the bidders can prepare firm, fixed-price proposals. RFP sections that dictate "how" a requirement should be met should be avoided, except where the vendor must follow specific utility standards or interface with utility-supplied facilities. This approach allows bidders to use their standard system to the fullest extent, which, in turn, will lower overall cost and minimize risk. Vendor selection should be based, in part, on the firm fixed-price quotations that are received. To the fullest extent possible, the utility should get firm fixed pricing during the competitive bid process, not after the notice of award. Pricing received after a notice of award can be expected to be higher, as the vendor no longer faces competition.

There are some items in the specifications for which pricing may be difficult for the DMS vendor to supply early in the project. In such cases, the vendor should identify all assumptions on which the pricing is based; the utility can then review the proposal assumptions and determine whether they are valid. If assumptions are not valid, a price adjustment should be requested. This request should be made prior to the notice of award.

The RFP should request line-item pricing for all deliverables, showing sufficient detail to reveal the impact on the bottom line. Further, line-item pricing provides a basis for the comparison of multiple proposals.

The RFP should also clearly state that a Conformed Specification (see Task 2.5) must be prepared, using the RFP as a starting point.

The RFP should include the following sections:

- **Instructions to bidders** (project overview, key project dates, summary of vendor and utility responsibilities during the project, proposal due date, required proposal content, proposal forms, and other such information). The RFP must be very specific about the required content and format of the proposals. This specificity ensures that the utility has sufficient details to evaluate and compare each proposal, and that this information is arranged in a consistent and convenient manner. The point is to ensure that the RFP and the selected proposals are sufficient to form the basis for a legally binding contract.

The bidders should be informed that failing to provide all the requested information in the specified format is grounds for rejecting the proposal.

- **Commercial terms and conditions** (standard utility terms plus DMS/SCADA-specific terms such as milestone payments, software licenses, availability of source code, and definition of “acceptance”).
- **Technical specifications** (DMS technical requirements, described by “function” with sufficient detail, while providing flexibility for bidders to propose their standard design). As a minimum, the technical specifications should include the following sections:
 - Functional requirements (data acquisition and control functions, alarm processing, reports and displays, historical data storage and retrieval, special DMS application functions [VVO, FLISR], external interfaces).
 - General requirements (utility IT standards that must be satisfied, system architecture requirements, level of redundancy, need for remote backup control center, equipment service conditions, spare capacity and expansion capability, system performance and response time, maximum equipment utilization, system availability definition and requirements, security classification and requirements).
 - Hardware characteristics (requirements for PCs, servers, printers, local and wide area networks, communication processors, enclosures, uninterruptible power supply, interconnecting cables, special tools, spare parts, etc.). Note that many electric utilities elect to supply their own hardware. In such cases, the vendor is responsible for defining the required hardware features and

characteristics and for approving the specific hardware procured by the utility as suitable for DMS deployment.

- Software characteristics (operating systems, relational database system, database and display maintenance software, on-line and off-line diagnostic software, vendor remote dial-in/VPN interface for future support, network management software).
- Communication interface facilities (communication front-end processors, description of the utility-supplied communication media, minimum data throughput, communication protocols, network management system).
- Documentation and training (user, maintenance, and system administrator manuals; installation and startup documentation; as-built drawings; training for users, hardware and software maintenance personnel, system administrators; training location and cycles).
- Inspection and Testing (factory tests, site tests, availability tests).
- Other vendor-supplied services (maintenance support through and following warranty, project management, installation supervision).
- Appendices (input and output point counts, interface requirements definition, sample displays).

The RFP should require a demonstration of key system functions using actual utility data (see Task 2.4). For example, it should specify that each bidder will perform the following demonstrations during the bid presentation meeting:

- Generation of electrical feeder models and displays from the utility's GIS. The resulting feeder models can be used to perform the advanced application demonstration.
- Comparison of outputs from the bidder's advanced application programs against output from the utility's existing engineering analysis tools using the utility-supplied GIS and simulated measurement data.

It is common practice to request both priced and unpriced copies of the RFP responses. Pricing information is often not distributed to the review team members until the technical review is completed. This approach prevents the team from being biased in its scoring by cost. Alternatively, cost information may be distributed to the review team. Pricing information is often useful in determining the level of development effort needed to meet a particular utility-specific requirement. Pricing information should be distributed to the review team members if procurement practice allows this.

The DMS vendors that have been “short-listed” during the RFI process should receive the RFP. The bidders should be allowed six (6) weeks to submit their responses and prepare for the bid demonstrations. With less time, the response quality may be compromised.

The utility should expect to receive numerous requests from the bidders to clarify some of the requirements contained in the RFP. As with the RFI, all requests for clarification should be in writing, and utility responses should be provided to all bidders. The deadline for submitting questions should be no later than three (3) weeks prior to the proposal due date. This provides adequate time for the utility to respond to the questions and for the bidders to adjust their proposals accordingly.

TASK 2.3: DEVELOP BID EVALUATION METHODOLOGY

The utility should prepare a bid evaluation matrix similar to that used during the RFI process. An RFP matrix is more comprehensive than an RFI matrix, owing to the RFP’s level of detail. Proposal scoring should take into account technical and commercial issues, risk, proposed and evaluated costs, and other such factors. As with the RFI, it is important to finalize the bid evaluation methodology prior to receiving the actual bids. This ensures that weighting factors and evaluation criteria are not biased by the evaluator’s knowledge of the specific proposals.

The bid evaluation methodology should allow detailed analysis of the merits of the solution offered in each response, in the following areas:

- Technical – considers all aspects that refer to the proposal’s technical quality.
- Implementation Services – refers to the bidder’s system integration, documentation, training, maintenance and support services, and project implementation requirements.
- Commercial – considers the bidder’s compliance with the utility’s Instructions to Bidders and Terms and Conditions.
- Risk – is evaluated in terms of the project risk for the utility, considering the major areas that may be affected by vendor performance: possible delays in delivery schedule, functional shortcomings of the delivered system, and potential cost overruns.
- Cost – considers the “evaluated” cost to the utility. The evaluated cost is the initial price quote listed in the proposal, plus price adders to address proposal shortcomings, omissions, and changes requested by the utility during the bid evaluation process.

There should be no additional minimum (“MUST”) requirements to consider during the evaluation. Presumably, all of the short-listed vendors have satisfied all of the MUST issues. MUST requirements can exclude vendors who have good reasons not to meet them and

encourage vendors who may not be able to meet them to accept them anyway. However, if some of the key statements from the RFI process, such as the amount of development effort needed to meet the utility's requirements, are determined to be grossly inaccurate or misleading, this may be grounds for rejecting a proposal.

Sometimes evaluation criteria/scoring systems established for vendor selection are not reflective of key differentiators that are discovered during the evaluation process. Flexibility should be considered when making the final selection.

Keep in mind that the decision factors for selecting the winning vendor should be balanced between functional and technical issues. Integration and architecture capabilities/limitations are often overlooked, with a bias towards end-user functionality. A product may have technical limitations that prevent end-user functionality from ever being meaningfully deployed. The management of changing network models and synchronization of updates is a significant factor that becomes more complex as more systems (GIS, DMS, OMS, EMS, MDM, SAP, etc.) share portions of the model.

"Time to go live" on previous projects of the vendor is a key metric for the effectiveness of the deployment. New products are often sold with combinations of promises and assurances of functionality that is ready for deployment. Some products are said to be "stable," but to undefined levels. "Market entry pricing" can make new products seem economically attractive. The answer is to ask for references that evidence an ability to "go live" within a reasonable time frame. Further, there needs to be a mutual understanding of the definition of "go live." Some projects claim that it has been achieved when the first function is delivered, with years to go for full system implementation.

A useful rule of thumb for assessing the integration capabilities of a DMS vendor is the following: The only capabilities that exist are those that are documented. Integration capabilities should be included in product specifications.

GIS integration is a big differentiator between vendors. A key question to ask is "Is the database schema documented?" Excessive flexibility with respect to integration for a given vendor can be an indication that integration

Risk Management: Need to Separate DMS Vendor "Facts" from "Fiction."

One of the biggest challenges during the vendor selection process is validating the claims made by the DMS system vendors. System demonstrations performed by vendors at industry conferences (e.g., DistribuTECH) often depict applications that are still on the product roadmap and have not yet been deployed at any actual utility location. It is very important to identify products that currently exist and are field-proven. Any product that must be developed or significantly enhanced represents a major risk item. Failure to address these items may result in extensive development activities by the vendor during the project which, in turn, can result in unanticipated change orders, cost overruns, schedule delays, and sometimes failure to deliver required product functionality.

To mitigate this risk, the utility must do all it can prior to award of contract to identify products that meet its needs. The process starts with firm, clearly written proposals from the vendors that do not include "hedge" wording, which lessens the commitment of the system vendor. The utility should never rely on vendor commitments to provide key application functions, which are required now, as a future roadmap item. The utility should assume that any item that cannot be delivered today will not be delivered in the near future.

doesn't currently exist. Another word of caution is that just because two products (e.g., OMS/DMS) are from the same vendor does not mean they are well integrated and work together.

TASK 2.4: PERFORM BID EVALUATION

The proposals should be reviewed and assessed in much the same way as the RFI responses. However, the quantity of technical material being reviewed can be considerably larger. The review team should be comprised of subject matter experts in each of the key areas of the system. The team can be similar in makeup to the RFI evaluation team. However, because the evaluation of commercial terms and pricing is an important part of the RFP evaluation, active participation by purchasing officials and/or legal counsel is needed.

Bid Reviews

Each member of the evaluation team should review the assigned sections of each bidder's proposal. As with the RFI process, each reviewer should only evaluate portions of the proposals that are within that reviewer's field of expertise ("comfort zone"). Reviewers should evaluate all bidder responses within the assigned topics for comparison purposes.

As stated earlier, there must be at least one reviewer with suitable expertise to review commercial aspects of the proposal. The RFP commercial review is much more important than the RFI commercial review because legally binding resource (financial and manpower) commitments and schedule commitments are made in the RFP. Alternatives and exceptions to commercial terms and conditions are common, and all must be carefully weighed and evaluated by a contracts expert who is familiar with computer system procurement.

While reviewing the proposals, each team member should prepare questions to verify key points and solicit clarifications where needed. Such questions are especially important during the RFP process, because the responses to these questions become part of the proposal and (for the winning vendor) part of the contract. The utility should require written responses to these questions. In addition, further discussion of each question may occur during the bid presentation meeting; such additional discussions and verbal agreements and commitments must be followed up in writing.

Bid Presentations and Demonstrations

Each bidder should participate in a bid presentation meeting to summarize the key elements of his proposal and review some or all of his responses to the utility's follow-up questions. The bid presentation meetings should be conducted at the utility's offices. Each meeting should be no more than one day long. If possible, the same meeting room should be used for all presentations; the utility should not have one vendor attempting to squeeze into a small, dimly lit room while another has a luxurious suite.

The meeting agenda should include demonstrations requested by the utility, as discussed below. These should be actual “live” demonstrations, not just PowerPoint® presentations showing the results. As noted above, separating vendor “facts” from “fiction” is a very challenging task: product demonstrations often involve prototype or wireframe versions of products that are still on the vendor’s roadmap. One of the best ways to verify that proposed products actually exist is to conduct a formal demonstration of key application functions. Key points to consider include the following:

- Generic demonstrations of vendor products are only an introduction; they are not sufficient to show utility-specific applications.
- Demonstrations should be set up using data sets provided by the utility, with specific scenarios using that data.
- The model should be updated during the demonstration.
- The vendor’s proposed project manager and other key project personnel should attend the meeting and conduct the demonstration.

The utility should supply the bidders with an actual data set of representative feeders from the utility GIS that includes the data necessary for building the distribution system model. The bidders should be requested to convert the data to their specific formats and then use the models that have been built to demonstrate the actual application software being proposed. Failure to convert the data supplied by the utility indicates a lack of capability to do so in actual production, which of course should be a signal that the bidder does not really have the software that is claimed. The utility should compare the results produced by the bidders against a known solution such as the engineering power flow tool that the utility currently uses. During each demonstration, the bidder should be asked to allow utility representatives to make a change to the model that was built in advance, and then to run the application software on the modified model, demonstrating the ability to change the model “on the fly.” The utility should brief the bidders in advance about the types of changes the utility plans to make during the demonstrations, without revealing the specific details of the changes. In other words, the bidders should not be surprised by the utility’s intentions.

The bidder’s project manager should also provide a walkthrough of the proposed project plan and schedule.

After the bid presentations are completed, the review team should prepare the initial round of scoring, taking into account the initial proposal, responses to follow-up questions, and the bid presentation. The objective of this scoring is to reduce the number of bidders to no more than two (2) finalists.

Site Visits

Before making a final decision about the winning bidder, the utility team should perform site visits. As a minimum, the team should visit the bidder's system integration facility to meet the bidder's project personnel and management team, inspect the system integration facility and staging area, view training facilities, observe quality control procedures, and receive the best possible hands-on demonstration of proposed system capabilities.

Ideally, this activity should include visits to at least one electric utility (per bidder finalist) that has recently commissioned the proposed system with the required interfaces and advanced distribution applications. The purpose of this visit is to inspect the operation of key application functions and to discuss the challenges encountered by the visited utility in implementing the required functionality. The project team should verify in advance that the utilities being visited actually have the relevant application running in full production mode; otherwise, the team should look for other evidence that the function is fully operational. This activity may entail considerable expense on the part of the utility. However, visits to customers who have already implemented the proposed functionality and are willing to discuss the challenges are well worth it.

Final Scoring

After completing all site visits, the review team can complete the scoring process. This process is similar to the RFI scoring process. Any item for which the scoring is significantly different between review team members should be discussed until consensus is reached.

The result of this step is the identification of a single vendor as the recommended DMS supplier.

TASK 2.5: NEGOTIATE THE CONTRACT

The final step in the system procurement process is to sign a contract with the selected vendor, based on a SOW that includes a detailed description of the deliverables (including all hardware, software, and services) to be provided by the vendor, along with the agreed-upon terms and conditions and pricing of the proposed work.

Requirements for new functionality and integration identified in the SOW must not be ambiguous. Also, if development of a large amount of new content is specified in the SOW, the associated project risk needs to be identified and managed.

The SOW should be based on what the utility needs, not on what the vendor wants to supply. Most vendors would, of course, prefer that the SOW that is included in the contract be based primarily on their proposal. A better approach is to build the SOW on the technical specifications and commercial terms that the utility has previously prepared, which are the basis of the original RFP developed by the utility. These initial documents should be modified only as

needed to reflect the agreed-upon alternatives and exceptions identified in the selected vendor's Table of Compliance. If the vendor states "conform" without explanation in response to a requirement in the original RFP, then that requirement becomes part of the contract without any modification. The resulting document, called a "Conformed Specification," enables the utility to retain control over the contract details.

To ensure favorable resolution of disputes, the contract should also contain an "order of precedence" listing that identifies the relative priority of each document in resolving conflicts that may occur during the implementation. Commercial terms should have the highest-order precedence, followed by the Conformed Specification and then by the vendor's proposal material and clarifications and other bid documents.

On the basis of past experience with similar projects, the above process can be completed in one week.

DMS System Integration Strategy

There are four major system integration alternatives that the utility should consider before finalizing the implementation contract with a DMS vendor. These are discussed below.

Alternative 1: DMS Vendor Responsible for System Integration. With this approach, the DMS vendor is given the responsibility for developing and deploying all required interfaces for the project. This option is sometimes considered when the vendor has all the resources required to run the project and develop the required interfaces already identified. If this approach is followed, the utility will have to rely on knowledge transfer during the project to acquire the required information to maintain the interfaces.

With this alternative, the DMS vendor is responsible for:

- project management,
- configuring its product,
- building any special application functionality required,
- leading the interface design and building its half of the DMS interfaces that have been identified,
- testing the functionality of its applications,
- leading the system integration testing process,
- providing technical and end-user training, and

- leading the system deployment process.

The utility would be responsible for:

- building its half of the DMS interfaces,
- supporting the system integration testing process, and
- supporting the system deployment process.

This approach requires that the DMS vendor have adequate technical resources, knowledge, and experience managing the integration of its DMS product with a large number of operational and business support systems that are already in place at the utility. However, most (if not all) experienced DMS vendors have limited IT resources that are focused on product development and system architectural issues. In addition, the DMS vendor may lack the necessary knowledge and experience with some of the systems that need to be integrated with the DMS. Furthermore, there are cases in which two systems that need to be interfaced are supplied by competing vendors, thus adding another dimension of challenge to having the DMS vendor manage the system integration processes.

The **DMS Vendor Responsible for System Integration** alternative is not recommended.

Alternative 2: Internal Utility Resources Responsible for System Integration. With this approach, the utility owns the responsibility of developing and deploying all required interfaces for the project. This option is usually the best choice if the utility has all the manpower resources and technical expertise required to run the project and develop the required interfaces that have been identified. If this approach is followed, the utility will have the required knowledge to maintain the interfaces in the long term, since it was the designer and builder of the interfaces.

With this alternative, the DMS vendor is responsible for:

- configuring its product,
- building any special application functionality required,
- building its half of the DMS interfaces that have been identified,
- testing the functionality of its applications,
- supporting the system integration testing process, and
- providing technical and end-user training.

The utility would be responsible for:

- project management,
- leading the interface design and building of its half of the required DMS interfaces,

- leading the system integration testing, and
- leading the system deployment process.

It should be noted that utility IT personnel are often already heavily involved in implementing and maintaining numerous large-scale computing systems, and may not have the time to take on the lead responsibility for implementing the system integration responsibilities associated with the proposed DMS.

The **Internal Utility Resources Responsible for System Integration** approach is not recommended.

Alternative 3: Internal Utility Staff, Augmented by External Systems Integrator, Responsible for System Integration. This approach is the same as Alternative 2, except that the utility staff is augmented by external system integration resources. This approach would enable the utility to retain ownership of the system integration efforts without the risk of lacking sufficient resources to complete the project. Adding outside resources to the system integration effort provides additional manpower to accomplish the required tasks on a timely basis and enables the utility to enlist outside expertise in areas for which the necessary expertise does not exist within the existing utility staff. The system integration resources selected by the utility must have sufficient depth and expertise in the domains that are important for DMS integration, including:

- Integration of DMS, OMS, and other operations-related systems,
- CIM expertise, and
- Understanding of the usage of operations systems by operations staff and related business processes.

With this alternative, the DMS vendor is responsible for:

- configuring its product,
- building any special application functionality required,
- building its half of the DMS interfaces that have been identified,
- testing the functionality of its applications,
- supporting the system integration testing process, and
- providing technical and end-user training.

The utility staff, augmented by external system integration resources, would be responsible for:

- project management,

- leading the interface design and building of its half of the required DMS interfaces,
- leading the system integration testing, and
- leading the system deployment process.

This approach is well suited for most electric utilities that have a well-qualified IT staff that is already heavily involved in system maintenance and upgrade activities as well as new system (e.g., DMS) deployment. The staff augmentation approach enables the utility to expand or reduce outside staff levels as needs dictate throughout the project.

Hence, the **Internal Utility Staff, Augmented by External Systems Integrator, Responsible for System Integration** approach is usually recommended for utilities.

Alternative 4: Third-Party Systems Integrator Approach. A Systems Integrator (SI) is given the responsibility of developing and deploying all required interfaces for the project. Since a DMS project requires so many integrations, and using the DMS vendor as an SI is not typically a good implementation strategy, bringing in an SI to run the project and own the responsibility for all integrations is a common approach used by many utilities who don't own the required resources themselves.

With this approach, the DMS vendor is responsible for:

- configuring its product,
- building any special application functionality required,
- building its half of the DMS interfaces that have been identified,
- testing the functionality of its applications,
- supporting the system integration testing process, and
- providing technical and end-user training.

The utility would be responsible for:

- supporting the system integration testing process, and
- supporting the deployment process.

The SI would be responsible for:

- project management,
- leading the interface design, building half of the DMS interfaces, and building all of the other interfaces identified for the project,
- leading the system integration testing process, and

- leading the system deployment process.

This approach allows the utility to engage a third party that has sufficient knowledge, experience, and resources to manage the overall system integration process. The SI hired by the utility should have demonstrated experience in implementing all of the DMS interfaces required, and should have adequate resources to implement the necessary resources in accordance with the established project schedule. This approach provides a low-risk path because resources can be added or deleted as needed. However, it is also most likely a higher-cost alternative. In addition, internal staff may not gain experience that is needed for long-range support of the DMS and necessary interfaces. This approach should only be considered if the utility lacks the IT resources to handle the bulk of the SI tasks internally.

The **Third-Party System Integrator** approach is not recommended.

To recapitulate, Alternative 3— **Internal Utility Staff, Augmented by External Systems Integrator, Responsible for System Integration**—is the recommended approach. This approach represents the best balance between cost, resource management, and risk. Strategic use of internal IT resources versus external system integration resources enables the utility personnel to gain valuable "on-the-job" implementation experience for these complex interfaces, and prepares the utility for building, operating, and maintaining these interfaces over the lifetime of the system.

The final decision on the proper split of activities between internal and external SI resources requires a thorough review of current commitments and capabilities of the existing IT staff. This decision should be made after the DMS vendor is selected, because different DMS solutions may require different levels of system integration activities.

PHASE 3: DESIGNING, BUILDING, AND TESTING

During this phase of the project, the DMS is configured, assembled, and tested in the DMS vendor's factory. The vendor performs design and development activities, acquires the necessary hardware, integrates the system components, develops documentation, performs factory testing, and trains the utility's core team personnel in the operation and maintenance of the system. The utility should review the vendor's design, provide information in response to the vendor's questions, develop databases and displays, participate in training, and witness (or help conduct) and approve the factory testing. Typically, this phase of the project lasts from 6 to 12 months. Following completion of this phase, the equipment should be shipped to the location designated by the utility. (Some exceptions are noted under Tasks 3.2 and 3.5.)

During this period, the utility project team is expected to supply information requested by the vendor, attend training classes conducted by the vendor, and witness factory testing. The following sections summarize the major tasks during the design and test phase.

Throughout this phase of the project, the utility's project manager should closely monitor the terms and conditions of the contract to ensure compliance. The assigned project manager should participate in project meetings, manage the activities of the utility personnel who are working on the project, and coordinate communications with the DMS vendor.

Active participation by utility personnel throughout this phase helps to detect problems as early as possible and prepare utility personnel to assume responsibility for maintenance and operation of the system following installation and commissioning. The utility needs to be sure to maintain continuous communication with the vendor during the course of the project, at all levels of technical responsibility, motivated by the project manager, to drive the integration process.

Preparation of data is a major undertaking. If significant development work by the vendor is needed, a regular utility presence is needed at the vendor site to be sure that appropriate resources are being devoted to the project and that the requirements are understood.

TASK 3.1: DESIGN REVIEW

As one of the first activities during the designing/building/testing phase of the project, the utility should review and approve (on a timely basis) the technical documents pertaining to the design of the new system, such as the format of DMS application displays. During this phase of the project, the vendor requires a significant amount of information from the utility about existing facilities (physical space, power supply, HVAC, etc.), external systems, construction and IT standards, display guidelines, areas of responsibility, and other details that are needed to complete the DMS design. The utility's project team needs to spend considerable time during this period gathering and submitting the requested information in accordance with an agreed-upon (and usually aggressive!) schedule.

TASK 3.2: STAGING THE SYSTEM AT THE FACTORY

Once the DMS design is approved by the utility, the DMS vendor procures the utility hardware and installs equipment along with relevant “standard” software in the vendor’s factory. Ideally, the complete set of hardware deliverables is assembled and integrated in the staging area to support design and testing activities. However, some equipment that is not absolutely needed to perform system integration and factory testing may be shipped “early” (prior to successful completion of the factory tests) to the utility. The utility does not need to be involved in this activity. However, the utility’s quality control personnel may elect to inspect and inventory the equipment.

TASK 3.3: INITIAL TRAINING

A suitable training program is needed to prepare end users and maintenance personnel for operation of the system and self-sufficient maintenance. The DMS vendor should be required by the contract to provide a complete set of training courses to prepare utility personnel to install, operate and maintain the system hardware and software with minimal assistance from the vendor. The training courses should be performed in several cycles so that the utility’s core project team members are not all occupied in training courses at the same time. Maintenance-related courses are usually conducted at the vendor’s facilities; end-user training is usually held on site (at the utility offices).

The core project team members should receive the vendor’s standard hardware/software training early in the project, before system delivery, to prepare them for building databases/displays/reports/electrical models and actively participating in the design reviews and factory testing.

The bulk of end-user training should be conducted just prior to commissioning the DMS. This approach ensures that there is not a large gap in time between the training and the live use of the system.

Owing to the number of end users that need training on the system, it will be necessary to perform end-user training cycles, with activities repeated a number of times for different subsets of end users. The utility should consider a “train the trainer” approach, in which senior-level operators or dedicated training resources within the utility perform the bulk of the initial end-user training, as well as refresher training later in the project as needed.

TASK 3.4: DEVELOP DISPLAYS, DATABASES AND MODELS

Another significant activity during the designing/building/testing phase is building utility-specific databases, displays, reports, and electrical models. This activity can be done by the DMS vendor personnel, using information supplied by the utility. Alternatively, this activity can be done by the utility personnel, with the DMS vendor supplying the software tools needed to create these items, loading the utility data, and ensuring that the DMS runs properly with

utility-supplied items. The utility should be responsible for maintaining and updating the databases, displays, reports and models from time to time using the software tools supplied by the DMS vendor. The latter approach provides valuable training to prepare utility personnel for system maintenance. The DMS vendor should supply suitable software and/or a web browser environment to enable utility personnel to perform these activities from a home office.

TASK 3.5: EARLY SHIPMENT OF EQUIPMENT

On DMS/SCADA projects that involve a considerable amount of field and communication facilities, it is common practice to ship some equipment to the field immediately after the equipment has undergone the DMS vendor's checkup and quality assurance procedures. The objective of early shipment is to enable the utility to begin equipment installation and site testing activities as soon as possible so that the field devices are ready for remote monitoring and control when the DMS control center equipment is shipped following successful completion of factory testing (Task 3.6). Early shipment can only be approved for components that are not required during factory testing to demonstrate that the functional and performance requirements have been completely satisfied.

Since the utility's system does not include any field or communication equipment, early shipment of system hardware and software may not be needed, except for the software needed to support utility database/display development activities.

TASK 3.6: FACTORY TESTING

Prior to shipping the DMS hardware and software to the utility, the DMS vendor must thoroughly test the DMS and demonstrate to the utility's satisfaction that all specified requirements have been addressed and all DMS functions are operating correctly. This is a critical task, because a major milestone payment to the DMS vendor is typically associated with the successful completion of factory testing. It is also important and more efficient to identify and resolve problems and discrepancies while the system is still in the factory, where the DMS vendor's technical experts reside.

Test plans should be submitted to the utility for approval at least six weeks prior to the start of factory testing. The test plans typically include the following:

- Definition of individual tests to be performed and the purpose of each test,
- Test schedule,
- Responsibilities of the utility and DMS vendor personnel,
- Methodology for correcting variances,

- Copies of certified test data to be used in lieu of testing,
- Block diagrams of the hardware configuration(s) to be used during testing,
- Description of test equipment to be used during testing,
- Method used to simulate facilities that are not available during factory testing (such as the EMS, GIS, and other external systems and field communication facilities), and
- Method used to simulate the ultimate system loading during the performance tests.

The testing should include (as a minimum):

- Demonstration that all hardware operates by a thorough exercising of devices, both individually and collectively,
- Demonstration of proper functioning of all DMS system software, including test cases with normal and exception data,
- Simulation of alarm and status change conditions,
- Simulation of field inputs from convenient test panels that allow analog inputs to be varied over the entire signal range and allow status inputs to be acquired,
- Simulation of control outputs using test panels or other suitable indicators,
- Demonstration of the application software, especially OLPF, SOM, VVO, and FLISR,
- Demonstration of all user interface functions, including responses to erroneous user entries,
- Simulation of DMS interfaces to external systems that may not be available in the factory, such as the EMS, GIS, AMI, OMS, and others,
- Simulation of failure conditions and failure of each system device that has a backup unit,
- Demonstration of the database, display, and electrical model editor software,
- Tests to ensure that the program and installation scripts are free from malicious or unauthorized code (liability rests with the vendor),

- Tests of security controls, including penetration testing, and
- Demonstration of system performance during normal activity and peak loading conditions by creating appropriate loading on the system and monitoring the response time, equipment utilization, and other parameters to determine the system performance under these conditions.

Factory testing should include “structured” testing in accordance with formal test procedures, as well as “unstructured” testing directed/conducted by the utility personnel without formal (prepared in advance) procedures. At least 20 percent of the scheduled test time should be reserved for unstructured testing. Note that “unstructured” does not mean “bang on the keys until something fails.” The unstructured tests must be performed in an organized and repeatable manner. Usually, the objectives for unstructured testing evolve during the structured testing (i.e., apparent “anomalies” need further exercising to see if a real problem exists).

Utility personnel should be heavily involved in developing factory test plans and procedures, and conducting the factory testing in accordance with these test plans and procedures. As a minimum, the utility should thoroughly review and approve the procedures and witness and approve the test results. If possible, utility personnel should work closely with the vendor in conducting the factory testing. The utility should control the pace of testing, thus ensuring that problems are not overlooked. Also, conducting testing is an excellent learning experience.

The DMS vendor should conduct a complete dry run of the factory testing, following the corresponding test plans and test procedures. The intent is for the vendor to detect and correct design, integration, database, display, and performance problems prior to the formal test. The objective is to avoid wasting the utility’s time while the vendor debugs the procedures and test result variances. The vendor’s project manager must sign off on each test. The completed dry-run test results should be sent to the utility for inspection before personnel travel to the vendor’s facilities for the actual factory testing.

PHASE 4: INSTALLATION AND COMMISSIONING

This phase of the project includes installing the equipment at the utility's facilities, performing site tests to confirm that the system has been properly installed, conducting end-user training, and placing the system in service. End-user training and placing the system in service are commonly referred to as "system commissioning" activities.

Following the receipt of the DMS equipment at the utility's site(s), it needs to be carefully unpacked, inspected, and installed in accordance with the DMS vendor's directions. It is assumed that utility personnel will provide the actual labor to perform these activities, with technical direction from the DMS vendor.

TASK 4.1: INSTALLATION TESTING

After the DMS has been installed and interfaced to external systems, the utility personnel should perform site testing to ensure that the DMS was not damaged during shipment and installation, and operates correctly when interfaced to the field communication system and the full complement of field equipment. Typically, the site testing includes a subset of the factory tests, with particular emphasis on testing those items that were "simulated" in the factory, such as interfaces to external systems and the communication network.

Risk Management: Testing Before and After Shipment. To avoid problem discovery following system commissioning, a thorough battery of tests must be performed prior to shipment (factory tests) and following installation (site tests). It is important to identify and correct hardware and software problems prior to shipment, when the utility project team has maximum financial leverage. The factory is also the best place to resolve such problems, since most of the vendor's experts reside there. However, a full complement of tests should also be performed in the field, with emphasis on issues that could only be simulated during factory testing, such as interfaces to communication media and external IT systems.

TASK 4.2: AVAILABILITY TESTING

Following successful completion of the installation testing, an availability test should be conducted to verify the ability of the DMS to meet its availability requirements. The availability test should be conducted under normal system operations without special test equipment or procedures. The DMS should exhibit an availability of at least 99.9% over a two-week period, in accordance with the availability criteria identified in the General Requirements section of the technical specifications. Total system availability should be computed after adjusting for "hold" time. Hold time includes contingencies that are beyond the control of either party, and which therefore are not considered "down" time for the purposes of measuring system availability. Examples of hold time include power interruption, service response time, and failures in utility-supplied facilities. Such periods may be declared hold time by mutual agreement of the utility and the vendor. The utility is responsible for conducting the availability testing.

TASK 4.3: CUTOVER/COMMISSIONING ACTIVITIES

Cutover/commissioning refers to the activities related to placing the DMS in service. “Cutover” (the process of connecting the DMS components to the substations and distribution feeders) must be accomplished without adversely impacting the ongoing system operations. However, it may be necessary to have a planned outage of selected components during cutover to enable the complete end-to-end checkout of DMS control facilities prior to commissioning. It is not practical to implement DMS monitoring and control on all substations and feeders at the same time, owing to the impact such a project would have on the utility’s manpower resources; rather, the schedule should allow for system deployment over a period of three to five years.

Typically, cutover priority is given to the worst-performing feeders. When the principal business driver is improved efficiency, feeders and substations with low power factors (highest losses) should be connected first. Alternatively, cutover priorities may be based on a combination of low efficiency and poor reliability.

TASK 4.4: MODIFICATION OF BUSINESS PROCESSES

The DMS has great potential to transform many existing manual, paper-driven business processes into electronic, computer-assisted business processes. An effective change management program is needed to prepare users for the new business processes that are associated with the new application software. End users need to know how the new system will change as experience with the technology changes existing business practices; these go beyond the initial functions of the newly installed programs. The utility needs to plan the transition from existing operations, which rely on SCADA and OMS, to a full suite of functionality with the new DMS.

PHASE 5: SYSTEM SUSTAINMENT

The DMS is expected to have a lifetime of at least 10 to 15 years. During this period, many changes can occur that will affect the useful lifetime of the system:

- Individual components can fail. It should be possible to replace an individual failed hardware or software component without having to replace the entire system.
- New functional requirements, such as additional field devices and substations and expanded use of advanced applications, can arise that can overburden the initial software platform. It should be possible to address these expansion requirements without having to replace the entire system or make a massive number of changes throughout the initially delivered system.
- New versions of Original Equipment Manufacturer (OEM) hardware and software may become available, rendering the installed equipment and system software obsolete. The utility should be able to take advantage of the improved equipment.

5.1 HARDWARE/SOFTWARE MAINTENANCE STRATEGY

Hardware

The vendor has responsibility for maintenance of all hardware until the successful completion of the warranty period. Maintenance may be performed under a contract with OEMs or other parties or by vendor staff using spare parts from the vendor's stores or other sources. The vendor's maintenance responsibilities during this period include:

- Providing trained staff, responsible for call-out when problems occur,
- Performing preventive and corrective maintenance and installing engineering changes on the equipment, and
- Providing spare parts for the equipment.

Following the completion of the warranty period, hardware maintenance responsibilities should revert to utility personnel, with support, as needed, from the vendor. The vendor should guarantee the availability of spare parts and hardware maintenance support services for all DMS system equipment for a minimum period of ten years after the expiration of the warranty. Subsequent to the support period, the vendor should be required to provide the utility a minimum of one year's advance notice of its intent to terminate such services.

Software

Software falls into two categories:

- Category 1: DMS vendor software, including standard DMS software and software created specifically for the utility. Commercial third-party software, such as operating systems and RDBMS, is included in this category.
- Category 2: Database files, displays, reports, electrical models, and other software files created by utility personnel during system implementation. Category 2 software also includes all application programs created by utility personnel.

Software maintenance through the completion of the warranty period must conform to the terms of the warranty sections of the contract. The vendor has responsibility for maintenance of all Category 1 software through the completion of the warranty period. Maintenance may be carried out under a contract with OEMs or other parties or by the vendor's staff.

The utility should have responsibility for maintenance of all Category 2 software during the warranty period. The utility can make changes to databases, displays, reports, and utility-developed application programs (if any) as necessary to meet its operational needs. During the warranty period, the utility should agree to inform the vendor of all such changes at least 24 hours prior to installation of the changes. If the vendor believes that the changes may adversely affect the operation of software for which the vendor is responsible, the utility should be notified of the potential problem and the changes reviewed. Both parties should work towards a mutually agreeable implementation of desired changes.

Following the completion of the warranty period, all software maintenance responsibility reverts to utility personnel, with support from the DMS vendor. The vendor should provide the following post-warranty maintenance services for all software:

- 1) A subscription to the change notification services of the vendor and all software subcontractors. The service includes transmission of service bulletins and notices of the availability of corrections, modifications, upgrades, revisions, patches, hot fixes, and new releases. The service for each software supplier should be quoted separately. These bulletins and notices describe:
 - a) The version of the previous software to which the upgrade is applied,
 - b) Prerequisites for the upgrades, including a complete list of the minimum release or version of all other software and hardware necessary to support the new software,
 - c) Problems with the previous releases corrected by the upgrade, and
 - d) New features available with the upgrade.As part of this service, the vendor maintains and periodically publishes a list of the current release of its standard products and the compatible releases of all software supplied by subcontractors.
- 2) A subscription to the software upgrade services of the vendor and all software subcontractors. The service includes the change notification services as described above, as

well as a copy of the new software, appropriate licenses for the new software, installation instructions, and a reasonable amount of support for the installation of the upgrade. The service provided by the vendor and each software subcontractor shall be quoted separately.

- 3) A contract for upgrades to be performed by the vendor and all software subcontractors. This contract includes the software upgrade service described above, plus on-site installation service to be provided by the vendor and each software subcontractor. This contract should specifically include “re-installation” of all custom software supplied by the vendor.

The vendor should guarantee the availability of upgrades, technical support for all DMS software, and announcements of software and hardware releases applicable to the system for a period of ten years after the expiration of the warranty. Subsequent to the minimum support period, the vendor and/or the RDA system software subcontractors should provide a minimum of one year's advance notice of intent to terminate such support.

Delivery and Use of DMS Source Code

The DMS vendor should be required to supply source code for command files, scripts, databases, displays, reports, electrical models, and utility-specific applications. However, neither DMS software/firmware source code nor third-party software/firmware source code should be supplied unless it was expressly developed by the vendor for the utility.

It is common practice for the DMS vendor to store a copy of the DMS source code along with all suitable software developers' documentation in a secure independent location (in “escrow”). Alternatively, the DMS vendor may wish to provide an encrypted version of the source code along with a suitable key and decryption software on a DVD or other suitable off-line media. The encrypted source code should be required to be updated and the previous disk and key returned whenever future changes to utility software are made. The utility will be authorized to utilize the encrypted software and key along with the associated source code documentation (or items held in escrow) if the DMS vendor goes out of business or decides to no longer support the software products installed on the utility's DMS.

5.2 ONGOING TRAINING

System sustainment also includes ongoing training activities for both new and experienced operators. One purpose of ongoing training is to familiarize new operators with the DMS product, its functionalities, interfaces, and hardware and software maintenance.. In addition, training should be conducted whenever the utility decides to update to new software or upgrade the system with new hardware or technology.

RISK ASSESSMENT AND MITIGATION

Risk assessment involves classifying and identifying risks, assessing their likelihood and severity, estimating their effects on the project, and addressing medium and high risks via a risk management strategy.

Discussions on risk identification and mitigation should be an integral part of all work activities and should be recorded. The risk management strategy encapsulates the records of risks and risk mitigations, and is a living document which should be part of the project management plan.

The most important element of successful risk management is having an experienced project team that has conducted DMS projects of similar scope and magnitude and an experienced system vendor who has successfully implemented critical DMS functions required by the utility, including interfaces to major external systems (GIS, OMS, EMS, etc.). The proposed bid evaluation methodology and scoring system place a high weight on minimizing risk in choice of a system vendor. As a minimum, factors considered in assigning a risk value to each bidder include the following:

- Bidder's recent experience delivering similar projects within schedule and budget,
- Bidder's resource capacity (technical and financial),
- Project manager experience,
- Maturity of the software product offered,
- Expansion capability of proposed hardware and software beyond that needed for the initial implementation,
- Use of open system concepts and industry standards, and
- Other factors.

Lessons learned on other similar projects are key to the success of the project. Lessons learned from stumbling blocks encountered by utilities that have implemented DMS-OMS systems in the past are particularly helpful in understanding the process, avoiding mistakes, and reaching a timely and successful completion of the project. Learning these lessons helps a utility avoid similar problems and roadblocks during its deployment efforts.

Throughout this report, we have cited perceived risks associated with DMS projects, along with a suggested approach to mitigate each risk.

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