A Common Language

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Standards-Based Enterprise Information Management for Utility Assets

LONG ISLAND POWER AUTHORITY (LIPA) OPERATES WITH A BUSINESS model of fully outsourcing its electric business operation, including system operation and asset maintenance. Such a model, in which LIPA has the role of asset owner and the shared role of asset manager, adds complexity in managing the data and critical IT systems needed to support both LIPA and its service provider business processes. One key issue is the possibility of a periodic change of service providers for all or part of the business. This is one of reasons that LIPA decided to develop and implement a comprehensive and strict enterprise information management (EIM) strategy along with the supporting business processes. LIPA's EIM strategy has been developed with the goal of being used both internally and externally, by LIPA's service providers for services and by the IT infrastructure that provides services to LIPA.

This article describes the experience and motivation that drove the specific solutions developed for LIPA's EIM and data management strategy. LIPA's EIM has at its core a common information model (CIM)–based enterprise semantic model (ESM), a customized software development life cycle (SDLC), process templates, and LIPA's IT technical architecture design. Data modeling and technical architecture are based wherever possible on open design concepts with standards-based solutions that aim to achieve near-plug-and-play interoperability for future data and systems integration. The development of technology and requirements for future IT projects is supported with a process-and-governance structure and includes centralized management of both the enterprisewide data model and architecture development. We discuss some of the lessons learned from this significant implementation to support energy trading along with our continued work in implementing LIPA's EIM concepts for system operation and asset maintenance.

Background

Historically, most of the critical IT systems and infrastructure required for LIPA business and system operation were owned and operated by LIPA's service provider. Similarly, that same service provider has managed most of the business processes, including energy trading, system operation, customer and retail information systems, and financial reporting.

Recently, LIPA awarded energy-trading services to two new service providers: one to manage the front and back energy-trading offices and the other to perform middle-office and performance-reporting functions. Critical transmission and distribution (T&D) business systems continue to be managed by the original service provider. The process of switching from one to multiple service providers required decisions about how to manage data and IT infrastructure in this new and more complex business structure. LIPA used this as an opportunity to leverage its existing multiyear effort in developing and testing concepts of standards-based open design architecture to implement and internally manage the new IT infrastructure to support the new energy-trading services contracts. LIPA is continuing with its implementation for T&D system operation.

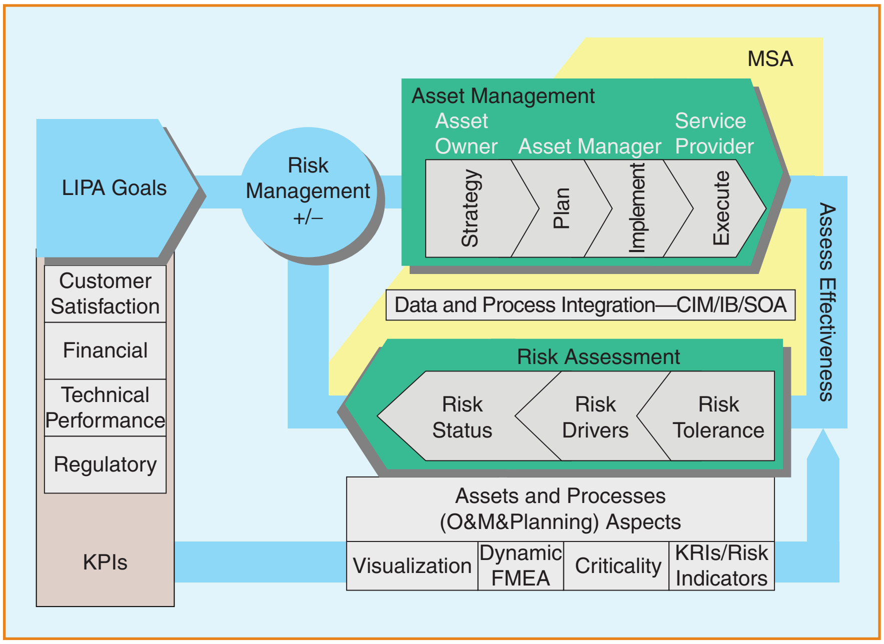

figure 1. LIPA's risk-focused asset management concept.

This first larger-scale implementation of standards-based infrastructure at LIPA required significant project management. It was complex due to the direct involvement of three independent service providers and a development team consisting of four independent consulting companies specializing in various aspects of development and implementation of new infrastructure. LIPA deliberately introduced the organizational complexity so that recognized experts in the field could coordinate their efforts as they worked on the project. This complex implementation of standards-based infrastructure also leveraged the lessons LIPA learned from previous pilot projects in the T&D area and was used as a both a real-life and test case for development of LIPA's EIM strategy. The project also included the development of supporting IT development business processes to be used for future implementation of the infrastructure that will be required for LIPA's T&D business.

Evolution of Standards-Based Infrastructure for LIPA Asset Management

LIPA is a state authority created by New York State. It went through a municipalization process in 1998, becoming Long Island's primary electric service provider. It is the third-largest public power utility in the nation in terms of customers served (more than 1.1 million). The LIPA system, with a peak load of close to 6,000 MW, consists of approximately 9,000 mi of overhead transmission lines, 5,000 mi of underground cable, more than 550,000 poles, 900 distribution circuits, and 180 substations operating at 345, 138, and 69 kV (transmission); 33 and 23 kV (subtransmission); and 13.2 kV (primary distribution voltage). LIPA has been a leader in distribution automation and operates as one of the most reliable utilities in the United States.

While LIPA is clearly the owner of the T&D assets, it shares the role of asset manager with a contracted service provider. LIPA's primary roles consist of strategy development, responsibility for company and assets performance and risk management, capital budgeting and asset life cycle cost management, project prioritization, and guidance for maintenance and operation of key assets.

Dynamic Asset and Risk Management: The Need for Service-Oriented Architecture and Data Integration

Asset management, from LIPA's perspective as an asset owner and manager, needs to be focused on managing risk related to four key performance areas: technical performance (such as reliability of assets and the system), financial performance (cost and revenue), customer satisfaction, and regulatory compliance. All four areas are interrelated and need to be considered simultaneously. This requires the availability of related operational and nonoperational data. From the data and data analysis perspective, historical performance is important—but even more important is the anticipated and probabilistic assessment of future performance and risk.

In LIPA's asset management concept, the emphasis is on performance risk management in an environment that is changing dynamically in both the short and long term. This assumes, for example, continuous updates of data supporting near-real-time probabilistic performance and risk assessment across various assets and performance goals. LIPA's concept of dynamic asset risk management (DARM) requires the integration of operational and nonoperational data. These data include cost figures (labor, materials, and so on); information about asset performance (operation, control, configuration, measurement, condition, among other factors); planning and forecasting data (weather, customer needs, and so on); and event data (see Figure 1). DARM requires the availability and integration of tools for performance modeling, optimization, and performing what-if analysis of viable options and scenarios for longer-term planning and near-real-time operation. From the data availability and data integration perspective, this translates into the need to integrate data currently available through and within various specialized company-wide systems. These systems include those used for outage management, work management, and energy management as well as intelligent electronic devices used in transmission and distribution substations, distribution automation, and system and asset condition monitoring.

The concept of dynamic asset management underscores the need for process automation and the ability to effectively combine data from different sources in (or close to) real time while assessing risk and available options based on current and forecast operating conditions and including the historical and anticipated performance of assets and the system. This further assumes, among other things, the integration of tools used for planning, operation, transmission, and distribution; integrated system and network modeling; tightly coordinated short-term and longer-term analysis; and risk optimization. These integrated tools would incorporate probabilistic and statistical analysis in determining "least-risk" options and "most likely" scenarios for near-real-time operation and longer-term planning.

The requirements for data in this concept include the availability of data for prioritization and criticality analysis based on asset, system, operation, financial, and customer data—all in the forms and formats, quality, and quantities required for credible statistical and probabilistic analysis in (or nearly in) real time. As an illustration: advanced metering infrastructure (AMI) is considered to be an important and cost-effective data acquisition and communication system, assuming it will also be used for T&D assets and system monitoring and operation.

In terms of currently available technology for data integration and process automation, LIPA is recognizing that service-oriented architecture (SOA) is essential for DARM.

LIPA's Business Model: The Need for Standards-Based Infrastructure

LIPA's business model, involving as it does the contracting of service providers, assumes clear definition of data ownership and requirements for data management. These requirements are essential to other business models, too—for example, where IT upgrade cycles must be managed at low risk to the firm. But shortcomings are more apparent in LIPA's case. This is due to potential periodic changes of service agreements and/or service providers. LIPA insists on data ownership. At the same time, the ownership of companywide systems and IT infrastructure takes various forms, ranging from LIPA owned to shared ownership to systems fully owned by service providers.

This mixed ownership and the possibility of periodic change of service providers introduce the need for data and systems mobility. Cost-benefit analysis and investment decisions must include consideration of the cost and efficiency of data and systems migrations. This highlights the need for low-cost and efficient "switching" from one service provider to another and from one system and application to another while preserving critical data and history and avoiding a significant impact on system operation. The result is a reinforced need for solutions enabling "near plug-and-play" for data; systems, applications, and tools; and service providers.

LIPA believes that one of the answers to this situation is a model-centric, standards-based integration of data and critical systems. The concept of model-driven integration includes LIPA's commitment to centrally manage, maintain, and document its data model. The concept of using standards-based modeling requires LIPA's commitment to keeping its model updated to the latest version of industry standards; it also requires methods of updating the model as standards evolve. The expected benefits of such an approach include the ability to clearly specify data, interface, and interoperability requirements to contractors for both new projects and mobility between service providers. It is LIPA's expectation that standards-based products from vendors that follow known standards will reduce overall cost and company risk by improving the efficiency of systems replacements, new product installation, and systems migrations, as well as the integration of disparate architectures.

Bearing in mind the number of systems that need to be periodically updated and/or replaced and the number of affected users and business processes, it was recognized that strict processes and tools are needed to support effective IT infrastructure development and maintenance. For a highly integrated infrastructure where the expected benefits will be dependent on compliance with interoperability and industry standards, it is extremely critical to have practical solutions in place for continuous updates of the enterprisewide model and to be able to effectively propagate changes across various systems using the same data and/or interfaces. The LIPA solution includes computerized model management to minimize human errors and reduce cost. Additionally, an important benefit of the selected solution and tools is that process of model development and/or model change incorporates automated testing and impact analysis for all systems of the integrated infrastructure. This further minimizes cost and reduces probability of problems in updating data models and interfaces across integrated infrastructure. The concept requires fully documented processes and solutions, and limits the use of proprietary solutions/tools/applications in favor of standard-based (or "de facto" standards), open architecture products, and solutions supported by commercially available services at competitive market pricing.

Early Pilot Projects and Lessons Learned

In the early 2000s, LIPA joined leading utilities in testing and implementing the CIM for applications in the control center. This project was initially focused on extracting system connectivity from the energy management system (EMS) and measurements from supervisory control and data acquisition (SCADA) to provide a system model in a CIM environment. The goal was to support simultaneous and near-real-time use of models for both planning and operations. The first installation of Siemens's ODMS tool is operational and in

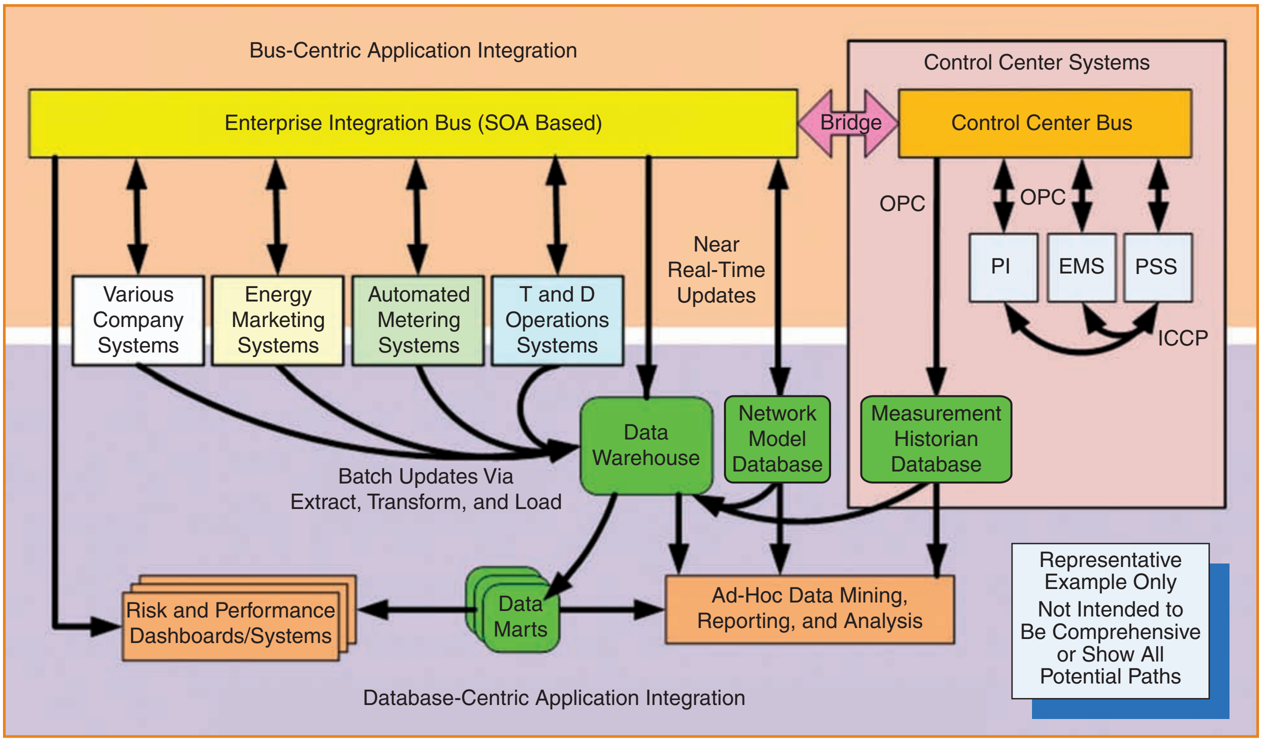

figure 2. High-level concept of LIPA IT integration.

current use. One of the practical applications developed was to continuously monitor the accuracy of the transmission and substations system model and planning simulations by comparing modeling with actual SCADA measurements. Another practical application was the use of time-stamped archived electric system configurations and associated parameters for past events and what-if analysis. LIPA is currently evaluating options to extend the use of this concept to distribution network model management and to integrate network models of transmission, distribution, and substations. This effort is focused on enabling the use of a single, accurate system model for operation and planning, enabling the use of planning and operational tools closer to real time, and supporting dynamic analysis and optimization. One of the new applications being tested, for example, is near-real-time stability analysis and prioritization of contingencies for system operators.

In parallel with the CIM control center project, LIPA pursued a project with EPRI to evaluate the feasibility of combining integration/message bus technology and the CIM for T&D operational and nonoperational data. One of the goals was to test performance of larger data-mining tasks required for maintenance and asset management where larger amounts of data from various systems were retrieved and transported using an integration bus and CIM data modeling. After multiyear development and testing, it became clear that the optimal solution is to use a combination of integration buses: one customized to support the near-real-time needs of the control center environment (a "high-speed, performance, security" solution) and the second supporting asset performance and risk management in combination with data warehousing and ETL technology (see Figure 2).

The lessons learned from multiyear CIM-related pilot projects involving different developers and vendors were of significant help in successfully managing the first major implementation of standards-based infrastructure. These lessons included the following:

- ✔ Standards and standards-based data modeling and naming can be implemented in various ways. Therefore, centrally managed data modeling and model maintenance is needed.
- ✔ Standards are still in development and do not cover all data needs. Therefore, an effective process for maintaining and updating data models and managing updates across various applications is required.
- ✔ Performance can be a significant issue for applications requiring multiple data translations and/or exchange of larger models. Therefore, high performance may require the use of highly specialized solutions from data modeling, infrastructure, and process automation perspectives.
- ✔ Centrally managed and coordinated IT architecture development is needed.
- ✔ The limited availability of specialized resources and services for standards-based solutions necessitates careful management and may undermine the goals of achieving cost savings and the flexibility of plug-and-play, open architecture, and standards-based solutions at this early phase of standards-based technology

development. Therefore, it is critical to avoid being "locked into" proprietary solutions in order to ensure commercially available support and services with competitive pricing.

- ✔ The interaction of multiple specialized IT disciplines can lead to accountability gaps. Therefore, a strong project management overlay on implementations is necessary.

LIPA's CIM pilot projects and the associated lessons learned provided valuable input for the development of LIPA's smart grid road map. The road map includes plans for further data and process integration to enable near-real-time performance assessment and risk management using standards-based, open design architecture with near-plug-and-play interoperability of systems, applications, and service providers.

Development of the LIPA EIM and the First Major Implementation of Standards-Based Infrastructure

The lessons learned from the early CIM pilot projects and the availability of an already established team of consultants with experience in developing standards-based IT infrastructure enabled LIPA to use the same technology for the new infrastructure required for its energy trading. This step also involved newly selected service providers. The need to integrate the data and systems of four independent companies increased the complexity of developing the new infrastructure. Further adding to the project's complexity, LIPA's development team combined recognized experts from four consulting companies; each expert took responsibility for specific tasks such as business process modeling, architecture development, data modeling, systems integration, system testing, and project management.

In parallel with the goal of developing and implementing the infrastructure required to support new service providers for energy-trading services, the project included development of LIPA's EIM, IT governance processes, and process documents. After the first successful implementation of infrastructure for energy trading, it was planned to extend use of the LIPA EIM to all LIPA internal projects and to all T&D business processes managed by service providers. We discuss key elements of the LIPA EIM development and lessons learned from LIPA's first major effort in implementing standards-based IT infrastructure in more detail below.

Model-Driven Integration

To accomplish LIPA's objectives of companywide data integration, a holistic information management methodology is needed that facilitates the resolution of semantics across numerous systems, industry standards, and various sources of its enterprise (including data from its service providers). At the same time, the methodology must allow for leveraging industry standards such as the International Electrotechnical Commission (IEC) CIM, and it must also support resolving semantic ambiguities inherent in the CIM and resolving the CIM to numerous reference models.

LIPA selected Xtensible Solutions' Model Driven Information, Integration, and Intelligence (MD3i) as the methodology for creating an ESM and using it to design a semantically consistent data warehouse and integration solution across projects (shown in Figure 3). It provides a repeatable process for incorporating numerous enterprise and industry references, thereby allowing an enterprise like LIPA to define, control, and own the semantics for information required to operate its business. It is realized using the Unified Modeling Language (UML) and uses standard UML modeling constructs to capture semantic concepts and traceability across systems. Incorporated into this methodology are design principles borrowed from controlled vocabulary and ontology development. This disciplined approach to semantic modeling not only captures the current state of enterprise semantics, it lays a strong foundation for adopting future implementation technologies as they mature, particularly those technologies typically associated with the semantic web, i.e., Web ontology language (OWL) and the Resource Definition Framework (RDF).

Controlled Vocabulary

The overarching philosophy of this methodology and LIPA's use of it is that numerous information references in various forms should be used to arrive at a controlled vocabulary that

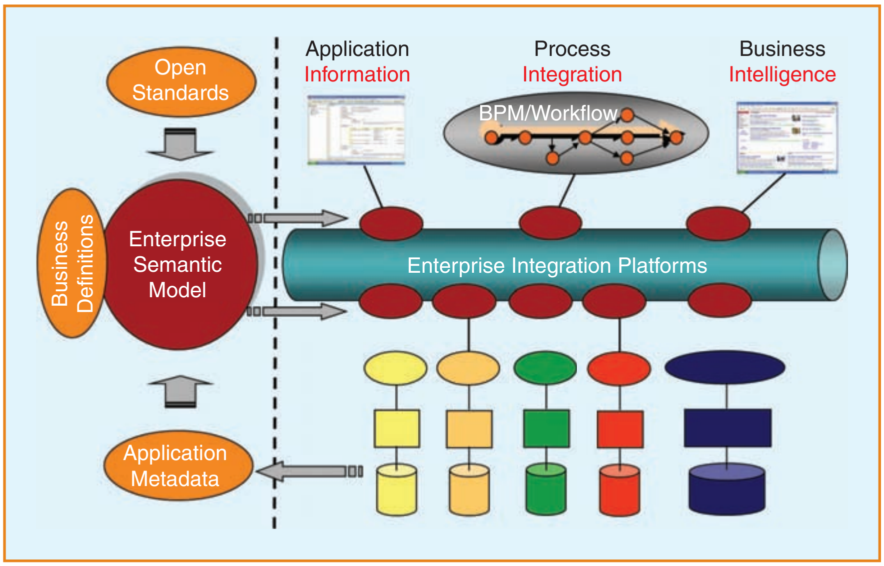

figure 3. LIPA ESM and integration concept.

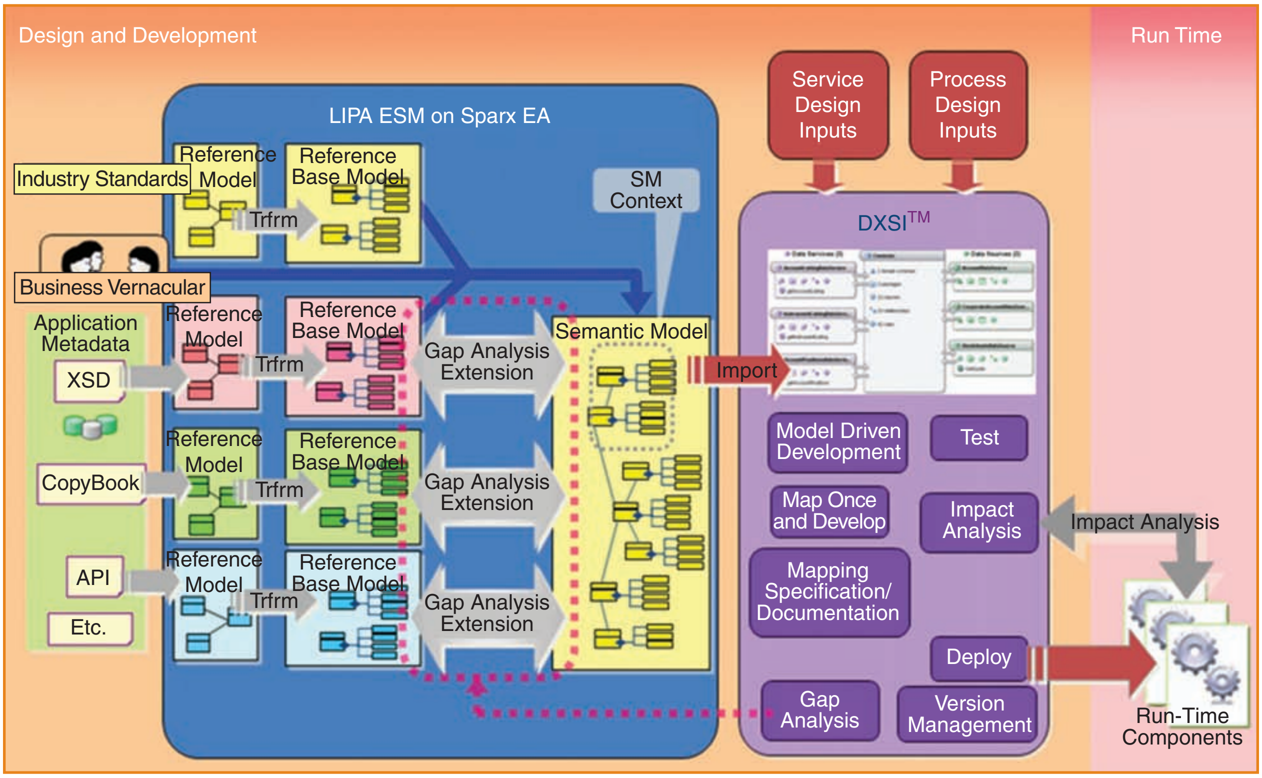

figure 4. LIPA tools and data model maintenance.

is then used to model semantics relevant to the enterprise—the ESM. While the ESM is a design model, it is used to generate run-time artifacts, such as database and message schemas. A controlled vocabulary is easily understood as a glossary where every significant term used in definitions is also a defined term in the glossary. By basing an ESM on a controlled vocabulary, semantic ambiguities are driven out before being modeled, which results in greater semantic clarity and a lower cost of information management.

Creating a controlled vocabulary is a collaborative process that requires participation from both business and IT staff. The typical references used to create a controlled vocabulary and model an ESM include:

- ✔ business terms and definitions in a given domain
- ✔ relevant information standards, including the IEC CIM, MultiSpeak, and various ANSI/ISO publications
- ✔ LIPA's enterprise- and application-specific metadata and definitions, initially built for power system management (PSM) and later extended for T&D to cover, among other things, the requirements expressed in this paper, with AMI to follow in the future.

Subject matter experts are consulted during the semantic resolution process to ensure a consistent semantic layer built into the enterprise architecture to facilitate business processes, function, and service reuse across various implementation and integration projects.

The ESM is used to generate implementation models for different purposes, e.g., process integration messaging, data services canonical schema, database design models, and so on. Implementation models typically vary in structure (canonical form), but they all represent the same business semantics, as defined in the ESM. Other uses of the ESM include driving data quality and integrity assessments as part of bulk data transfers or data warehouse initiatives; impact analysis when planning system replacement; and publication of specific integration requirements to business partners, vendors, and contractors.

Use of De Facto Standard Tools (with Exceptions)

LIPA selected Sparx Systems' Enterprise Architect; many would argue it has become a de facto industry-standard UML tool. It uses a set of Xtensible add-ins to provide additional functionalities required for effective ESM management. The ESM serves as the base model, both for generating implementation artifacts such as data warehouse schemas and integration message schemas and as the primary model of the LIPA-controlled vocabulary. The resulting LIPA-controlled vocabulary will serve as the data interface design specification in future requests for proposal (RFPs) for LIPA system acquisition and integration.

In order to ensure flexibility for future development and the availability of competitive development services, LIPA has developed two parallel paths for model development. One is based on readily available tools that could be used by most service providers, but it requires more manual work and project time. The second is based on

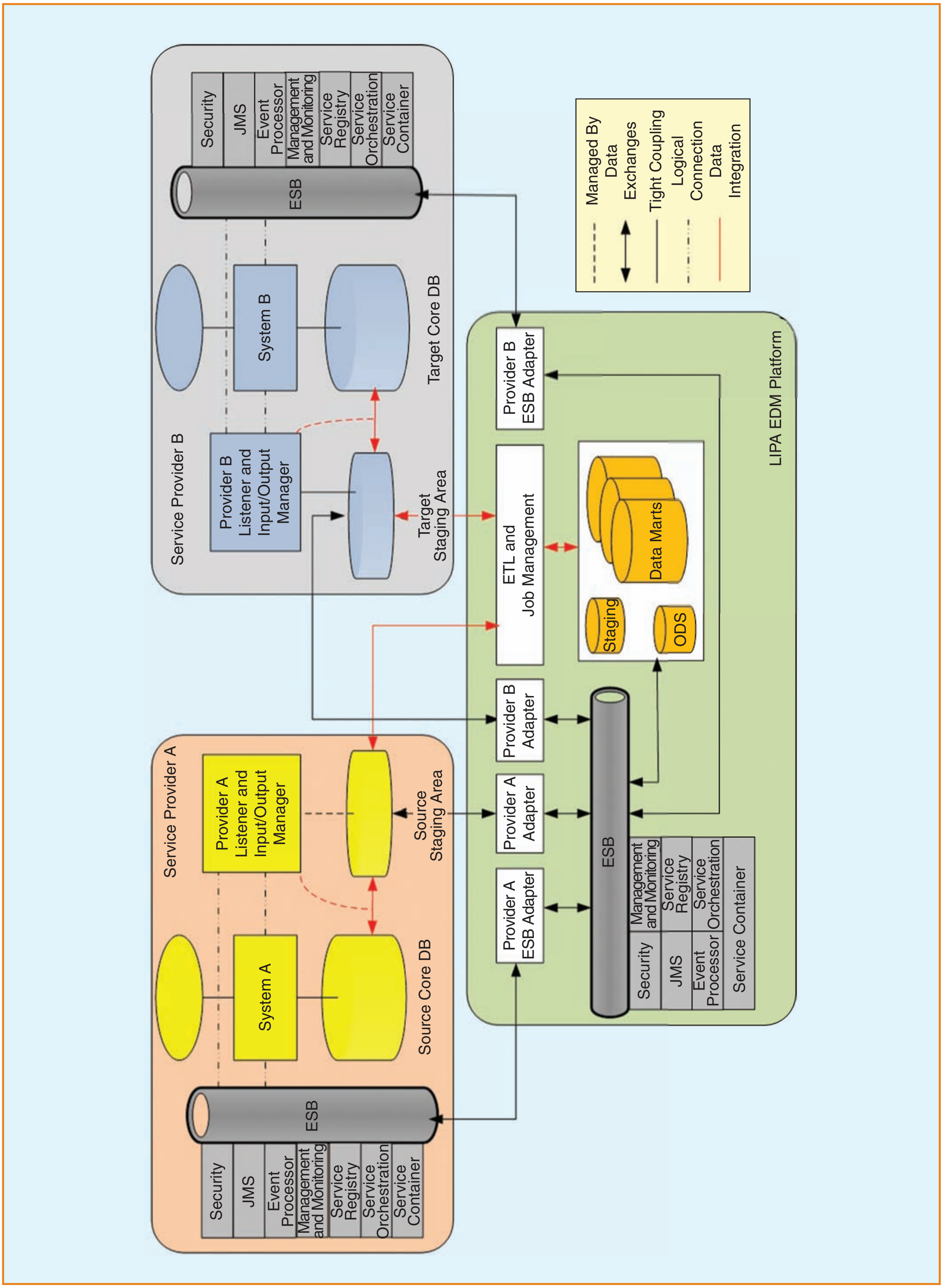

figure 5. Patterns for service provider data integration.

MD3i tools developed and used by Xtensible Solutions and is supported with an arrangement ensuring the long-term, no-fee availability of the tools for LIPA's independent use.

Another set of relatively new tools is used for computerized data model maintenance and updates. It is a commercially available tool (from Progress) providing process automation in developing and maintaining the enterprisewide data model that, as estimated during product evaluation, offers significant savings in programming and development time for the energy-trading project. Again, these tools and the associated processes are used in parallel with more traditional, well-documented, and commercially supported options.

LIPA's EIM approach requires managing the mapping of numerous systems and interfaces to the LIPA ESM. Progress's DataXtend SI Designe (DXSI) software is a complete graphical design environment used at LIPA for creating and managing exchange models (mediations between applications and services with different structures and semantics), rules, and data services. DXSI establishes a systematic development approach that works with LIPA's data-modeling methodology and interface design process extended through creation of operational mappings among the data interfaces. DXSI Designer and the corresponding run-time components are used for semantic integration, but their use is efficiently extended to manage change in design and run-time environments and improve governance throughout the life cycle. The design, development, and deployment process, from a DXSI perspective, is shown in Figure 4.

Use of Repeatable "Patterns"

The development of LIPA's companywide "top-down" processes, tools, and data models takes into account the needs of T&D asset management, energy trading, AMI, and smart grid programs. Broader implementation is expected to produce benefits from common base solutions and the use of repeatable "patterns," templates, and tools for the integration of individual applications and sets of data.

Another advantage of using repeatable patterns is in giving LIPA the ability to clearly communicate a preferred approach and specific requirements for integrating data and systems to its service providers. The solution used for infrastructure development to support energy trading is based on using "staging areas." Service providers exchange data with LIPA through their own staging areas by using a predefined LIPA data format and naming convention. In this way, all participants can simultaneously and internally develop their own staging areas without needing to understand or coordinate with the IT infrastructures of other participants (see Figure 5).

Process and Governance Improvement

LIPA believes that companywide data integration must be supported by well-defined governance and processes that will ensure discipline in the implementation and maintenance of the long-term integrity of data model and companywide infrastructure for future near-plug-and-play interoperability. Key components include a formal SDLC process, enforcement of a centrally managed data model, and centrally coordinated IT architecture development.

LIPA's SDLC is based on publicly available documents and includes clearly identified steps and templates from the initial project request through developing, testing, operating, and retiring systems and IT infrastructure components. One of the lessons LIPA has learned is the importance of SDLC and the need to support it with professional and effective project and project portfolio management in order to ensure effective management of all three aspects of successful project implementation: scope, cost, and schedule.

Conclusions

LIPA's role as both asset owner and asset manager and its business model of fully contracting operation and maintenance of its assets require data integration across systems owned and managed by LIPA and/or its service providers. Applying lessons learned from pilot projects, LIPA is implementing an EIM strategy that enables it to effectively leverage standards-based infrastructure with near-plug-and-play flexibility for data, critical systems, and service providers. LIPA's new EIM strategy combines standards-based data modeling and integration, use of the latest tools enabling more effective deployment and a centrally managed enterprisewide data model, and formal SDLC processes as the base for building infrastructure. All of these are building blocks of infrastructure to enable future dynamic asset and performance probabilistic risk management. This approach is expected to significantly reduce the life cycle cost and total cost of ownership of infrastructure and critical systems, including data and systems migrations, integration, maintenance, and changes of service providers.

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