

# Enterprise Business, Computing, and Information Services in a Multi-Agency Environment: A Case Study in Enterprise Architect-Engineering

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**Abstract**—The modernization of computing, communication, and information services is a high-risk venture in any environment. It has proven even more difficult to fully align these services with the high-performance operational objectives of enterprises. Enterprises are expected to have information environments that fully integrate business processes and systems to deliver optimal products and services, and high-quality business outcomes for both internal and external stakeholders. Many of the challenges faced by modern society – international trade, health care, national security – require even more complex multi-agency responses involving public and private networked institutions cooperating on a global scale. The effective integration of their information systems with modernized business processes is an absolute requirement and a major engineering and governance challenge.

This paper describes a Case Study developed in a research program sponsored by The MITRE Corporation (MITRE) that applies Enterprise Architecture and Engineering tools and methods to monitor and manage international trade in an environment of heightened security risk. The approach uses web service and semantic technology as “Enterprise Middleware” to integrate Enterprise Architectures with Geographic Information System (GIS)-based business performance modeling and planning tools in an Integrated Enterprise Engineering Workbench (IEEW). Full alignment of enterprise information services with business processes is achieved by applying governance principles of Activity-Based Management (ABM) and Enterprise Resource Planning (ERP).

**Keywords**—Information Systems, Management, Architecture, Modernization, Managed Service, Multi-agency, Performance Analysis

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## I. INTRODUCTION

GOVERNMENT and commercial operations increasingly require the integration of a complex mix of business activities, and services from multiple public and private organizations, to perform missions (and deliver services) of high national importance. When these operations are to be modernized to reach higher levels of performance through new business processes supported by advanced technology and information systems, they present unique engineering and governance challenges that demand increasingly powerful analytical capabilities.

Programs to modernize computing, communication, and information services are high-risk ventures with very low success rates. It has proven especially difficult to align these services fully with new business processes that are often deployed at the same time. The enterprise transformation that is required involves all elements of an enterprise – management, organizations, technology, and information. Further complicating these efforts are the rapid pace of technology advancement and the emergent behavior it facilitates within and external to the enterprise. Increasingly, the required performance of enterprise information systems is fully known only in retrospect. Hence the enterprise architect needs to plan for uncertainty and build in agility. While organizations are “groping and coping” with these challenges, the increased demand for multi-agency services is raising risks to an even higher level.

A number of management and engineering tools and methods have been developed and employed for specific aspects of enterprise planning and analysis. This paper describes the results of a Research program sponsored by The MITRE Corporation (MITRE) that surveyed this range of tools and methods, and then selected a set to comprise an Integrated Enterprise Engineering Workbench (IEEW) with the scope needed to address the very complex multi-agency operational environment. The IEEW implements a web based enterprise planning and management approach that allows decision makers to visually plan for operations performance. With this integrated planning tool set, and web enabled

capability, one can readily drill down to the lower level details of principal elements of the IEEW, including:

- Enterprise Architectures – describing tangible, and some intangible, aspects of an enterprise using a variety of common frameworks
- Business Process simulation models – for dynamic representation and measurement of business operations and supporting services and resources required to perform the enterprise mission and/or deliver services to the citizen
- Geographical Information System (GIS) – to portray the spatial, environmental, and demographic dimensions of the operations
- A common repository to assure consistent information content across the tool set, and to integrate tools and methods using web services and semantic technologies

Multi-agency operations vary in their complexity and are increasingly “networked” at stakeholder, organizational, business process, and information services levels (the “Net-Centric Enterprise”). Their missions range from planned operations performed on a continuous or repetitive basis (veterans’ health care, cargo and passenger clearance in international trade) to those performed on an intermittent, reactive or proactive basis in response to an emergency (joint military missions, disaster recovery). Continuous or repetitive tasks allow for constant organizational improvements; under these circumstances, the IEEW may be applied at regular planning intervals to manage and measure such progress, and when major investments are planned related to business processes and/or information services. For intermittent tasks, a gaming approach may be used in conjunction with applicable elements of the IEEW, particularly in cases where the situation may vary, requiring ad hoc responses, and organizations must interact in new ways.

The IEEW was developed and is applied to the Case Study from the perspective of governance of multi-agency operations. “Governance,” in its largest sense, deals with all management aspects of an enterprise, including stakeholder relations and the public good [1].

*“A good corporate governance regime helps to assure that corporations use their capital efficiently. Good corporate governance helps, too, to ensure that corporations take into account the interests of a wide range of constituencies, as well as the communities within which they operate, and that their boards are accountable....”*

These corporate governance principles apply equally to the government sector, to both individual and multi-agency “enterprises.” The working definition of governance applied in the Case Study focuses on the important mission-oriented aspects of managing operational activities and modernization programs with significant technological content in a way that meets management’s obligations to stakeholders—in short, the efficient use of capital, both human and financial. This working definition is drawn from the Information Systems Audit and Control Foundation [2]:

*“The set of responsibilities and practices exercised by the*

*board and executive management with the goal of providing strategic direction, ensuring that objectives are achieved, ascertaining that risks are managed appropriately, and verifying that the enterprise’s resources are used responsibly.”*

A sound governance structure is essential in the multi-agency environment where responsibilities, authorities, and accountability for both technical and operations management are widely distributed and must be coordinated for effective performance. This situation can involve varying degrees of centralization of governance authority ranging from an overall operations manager (or coordinator) to the other extreme of a distributed collaborative management team. The IEEW applies across this spectrum and encompasses mission descriptions as well as all the assets and resources needed to perform the mission. As such, the IEEW represents a major planning and analysis asset for governance in complex operational situations.

The definitions for governance establish specific requirements for the IEEW to fully describe mission activities and their performance objectives along with the management structures, human resources, tangible assets and information services required to perform an enterprise mission.

The objective of the IEEW is to support a complex governance environment for very close coupling of strategic planning, and technical and operational management, by integrating the basic planning and management tool set within a performance dashboard. It provides the ability to continually identify potential operational capabilities associated with technology modernization, strategic plans, and performance plans.

## II. THE INTEGRATED ENTERPRISE ENGINEERING WORKBENCH (IEEW)

The Integrated Enterprise Engineering Workbench provides a suite of Commercial-Off-The-Shelf (COTS) and MITRE-developed planning and analysis tools for the governance of enterprise transformation. Because the multi-agency environment generally involves a spectrum of such commercial products, the emphasis in the IEEW is on utilizing common standards and protocols, including semantic principles, so that the tools, whether COTS or custom, can share information working off a common planning repository.

Integration of these tools is accomplished through a consistent definition of planning content covering business and mission operations as well as the supporting information services and their technical features. The use of Activity-Based Management [3] principles in describing the mission and business operations of the enterprise are key to defining supporting information services to improve the operational performance of the enterprise. Activity-Based Management methods, coupled with integrated planning, management, and execution systems such as Enterprise Resource Planning (ERP), play an important role in enterprise management and governance supported by the Workbench design.

For the purposes of this case study, Mission Activities are defined as: A combination of people, technology, raw materials, methods and environments producing a given product or service. Activities defined in Enterprise Architectures can provide a common definition for organizational roles and responsibilities, performance monitoring, financial reporting and operations management.

Coupling mission performance with business and information services and systems is based on a full definition of the business, computing, communications, and information services (e.g. workflow management, account management, Enterprise Resource Planning, image processing, analytical processes, data management, secure messaging), that are required to support the mission and business activities.

The core elements of the IEEW are illustrated in Figure 1 and include the following elements applied in sequence:

### **1. Operations Plans and Scenarios**

The initial plan and operations scenario for the multi-agency mission provides the focus and content for the simulation and architecting steps to follow. The plans and scenarios will be updated and improved as a result of the analyses performed using other elements of the IEEW, particularly the performance analysis capabilities.

### **2. Performance Simulation Models – Mission Activities and Information Services**

Process models are employed to simulate the performance of business operations using the precise business activities represented in the Operations-Centric Architecture. Information services are modeled using computing and communications system tools such as capacity planning, network simulation, and data management.

Linkages between information services and business process performance are defined through Operating Level Agreement (OLA) and Service Level Agreement (SLA) specifications that serve as requirements statements for selecting systems and components or managed commercial services. Information services are modeled using capacity planning tools for distributed computing along with network design tools for communications and other conventional information systems design and simulation methods.

### **3. Operations-Centric Architecture to integrate essential features of Enterprise Architectures for participating organizations.**

The Operations-Centric Architecture (Figure 2) integrates the applicable elements of the Enterprise Architectures of individual agencies at all enterprise levels defined in various architecture frameworks [4,5]. The more recent OMB-FEA Reference Models [6] provide descriptive elements encompassing all aspects of an enterprise—Performance, Business, Services and Components, Data and Information, and Technology (infrastructure). The Operations-Centric Architecture uses these same categories, and Case Study results are discussed for each.

Integration of the individual Enterprise Architectures into the Operations-Centric Architecture is driven by the linked activities carried out and the information services employed by multiple agencies to perform the mission.

### **4. Geographical Information System (GIS)**

Multi-Agency operations are generally performed on a widely distributed, sometimes global, scale. Accordingly, the geographic aspects of operations, service delivery, and resource location are of great importance. The use of the GIS provides for the portrayal of all architectural assets and enterprise resources for the multi-agency operation, and supports their intelligent allocation.

### **5. Performance Dashboard**

The Performance Dashboard portrays all geographic and organizational aspects of the Multi-Agency operations. It presents the performance results of simulations to identify strengths and weaknesses in technical and governance capabilities, as well as gaps and/or overlapping organizational responsibilities and information services.

### **6. Readiness Model**

This is a structured method [7] for defining and evaluating the readiness of agencies participating in multi-agency operations to interact at the level required for performance. Five levels are defined, ranging from the least stringent requirement that agencies merely be aware of each others' activities in an operational region or with respect to a citizen service, to the most extreme case where joint management and a central point of operational control is required.

### **7. Web Services Repository and Environment—“Enterprise Middleware”**

It is important that consistent definitions be used to share appropriate information on a timely basis among all elements of the IEEW. This is accomplished using a common repository for planning information, along with Web Services technology which enables aggregation and re-branding of heterogeneous services across the enterprise. Web Services provides a single common framework for business services and mission partners.

Other standards applied in the IEEW include the Business Process Executable Language for Web Services (BPEL4WS) and Semantic Web Services using the Resource Definition Framework (RDF) and Web Ontology Language (OWL). Semantic technologies are important to application integration solutions because they provide a shared and common understanding of data, and achieve knowledge sharing by formalizing the application semantics between multiple organizations and agencies. The use of the BPEL offers additional capabilities for the IEEW to integrate processes and businesses based on a standard format, metadata, and a common set of notations [8].

Application of a consistent set of mission/business activity and information service definitions across the set of tools in

the IEEW, and in a form that can be embedded in ERP and other management systems, positions the IEEW as major analytical asset for supporting enterprise governance. Specific functions of enterprise governance that are supported are noted in Figure 1.

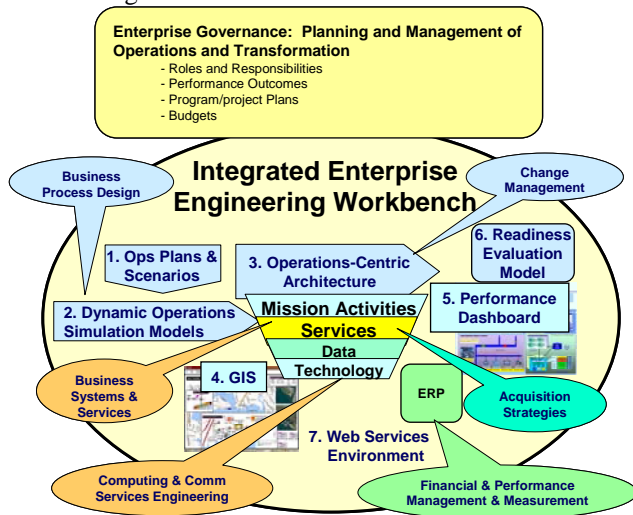


Fig. 1. Elements 1 through 7 of the Integrated Enterprise Engineering Workbench (IEEW), related to functions of enterprise governance.

**Operations-Centric Architecture**

- Represents Activities performed in the operations, and Information Services utilized
- Includes data and infrastructure selected from agency resources

*Extract applicable Activities & Services*

*Select Data and Technical Resources*

**Agency Enterprise Architectures**

- Activities & Services have semantic "tags"
- Data & Infrastructure Technology associated with Services
- Use different frameworks, DoDAF, RIMS

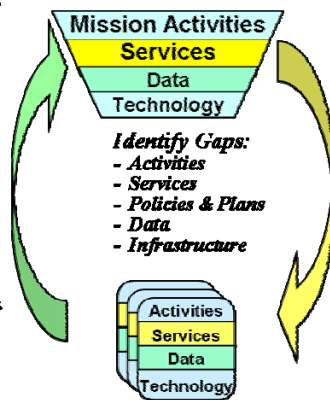


Fig. 2. Operations-Centric Architecture, the central element of the IEEW. All mission activities, resources, and assets are described. Explicit relationships are established here with the architectures of the agencies, bureaus, and/or commercial entities that support the mission activities as described in the Case Study.

III. ARCHITECT-ENGINEERING CASE STUDY:

MULTI-AGENCY PLANNING IN INTERNATIONAL COMMERCE

*End-to-End Mission Activities in International Commerce promote economic growth and security.*

This Case Study describes the major elements of a demonstration exercise using representative public data sources on the processes involved in international commerce. The description is intentionally at a generic level so as to apply to any geographic region engaged in secure global commerce. The Case Study exercise serves to develop and apply the IEEW Architect-Engineering approach to international commerce—a sector of major economic importance that poses serious security concerns. Specific activities (and related information services) defined include:

- Cargo import and export processing (account maintenance, data mining, and inspection services)
- Passenger security processing at departure and arrival (image processing, data mining, and decision support services)
- Apprehension and identification of individuals (biometric, data mining, and communication services)
- Financial flows in international commerce (workflow, data mining, and decision support services)

Each activity is the responsibility of an individual public agency or private entity, and must be coordinated with effective information sharing (within security and privacy constraints) to meet the overall mission objective of furthering economic growth while protecting nations from the illegal entry of people and goods. The IEEW elements provide a complete description of the mission activities performed by the participants in the multi-agency mission. Figure 3 illustrates the end-to-end activities involved in cargo and passenger flow between continents mapped onto a GIS.

The primary objective of the Case Study is a Proof of Concept for the planning and analysis capabilities of the IEEW to support the governance of complex multi-agency mission operations and modernization planning. General results of the more detailed activity and process modeling conducted for selected business processes are described below.

- Enterprise Architectures constructed at the single-agency level focus primarily on the technical infrastructure, and there are gaps in the mission and business activity descriptions. The Operations-Centric Architecture described here uses the activities simulated in the process models and identifies specific activities to be added at a consistent level of detail across participating agencies.
- Critical organizational interactions are identified, along with overlaps in roles and responsibilities among participating agencies conducting a specific activity. These can be resolved in the Operations-Centric organizational view.
- Duplicative information services employed to perform similar activities across agencies are identified. The performance simulation models allow a comparative analysis of duplicative services as the basis for selecting a "service provider" for that activity, and enable measurement of the improvement resulting from the introduction of technology.

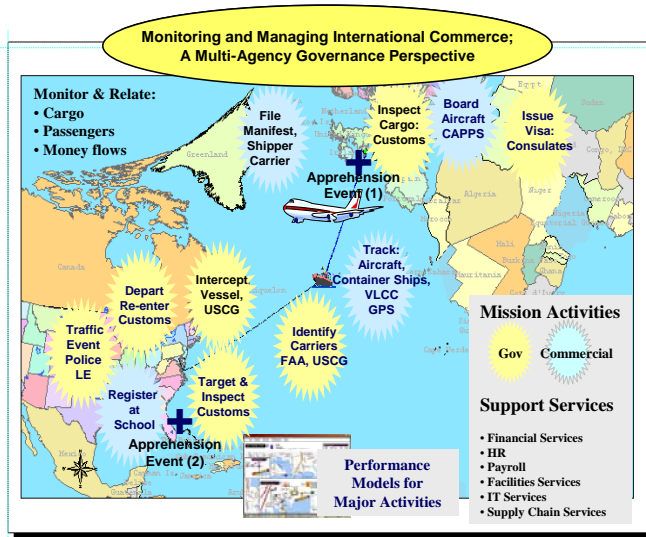


Fig. 3. Case Study example defining end-to-end activity sequence for a multi-agency mission in international commerce: Monitoring all governmental and commercial aspects of global commerce and indicating two possible “apprehension events”.

The Case Study examines performance issues in selected activities of the mission operations incorporated in the Operations-Centric Architecture and performance simulation. Representative data from public sources has been used for purposes of a realistic Proof of Concept of the IEEW. The analytical results do not apply to any specific nation, agency, or location. Examples of the general findings and results of applying the IEEW for all aspects of the enterprise scope as outlined in the OMB-FEA Reference Models include:

**Performance Analysis and Management:** The modernization vision of this multi-agency mission is illustrated as a collaborative environment for monitoring all aspects of international commerce involving imports/exports between the U.S. and Europe. This includes government systems as well as private sector supply chain management systems. The individual process simulation models, linked in an end-to-end cargo and passenger flow sequence, represent the throughput and cost performance at each step, as well as the overall flow sequence. Bottlenecks due to peak workload, staffing, and other resource limitations are identified. Overall operations performance improvements resulting from new processes and information services are estimated in selected processes for specific technical changes.

Figure 4 illustrates the application of the IEEW to operations for a law enforcement “apprehension events” within a given operational scenario, using a process simulation model to describe the multi-agency reactions, and a network control and decision process layer that describes the time delays in both the communications network and the decision processes that control the organizational response. In this illustration the performance of the decision making processes and technical infrastructure were such that the individual could be identified and apprehended within the

given time window of opportunity. This example illustrates the capability of the IEEW Architect-Engineering approach to address major organizational and system aspects of performance management within the governance and decision model employed.

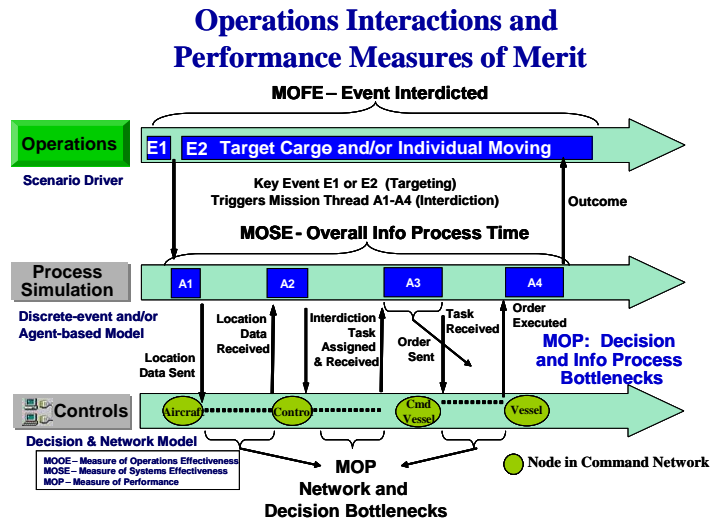


Fig. 4. Portrayal of performance analysis using the IEEW to link operations, response process, and management control functions for a law enforcement event (illegal entry at a coastal port represented as “apprehension events” in figure 3).

The organizational interactions required for mission performance may be planned and analyzed using the Readiness Model [7].

Figure 5 portrays resource and performance assessments (Red Yellow, Green) for the operations in a Dashboard format. The objective is that participating agencies and commercial entities are “networked” for effective organizational coordination as well as for sharing critical information. In this example all agencies met or exceeded the multi-agency collaboration objectives and are rated Green.

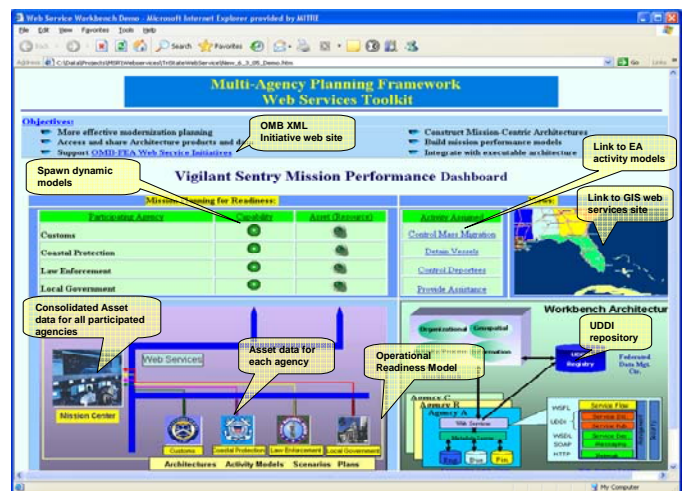


Fig. 5. The Resource and Performance Dashboard—a Web Services Toolkit for Multi-Agency Mission Operations Planning and Analysis.

**Mission/Business Level:** Major mission activities in the end-to-end activity sequence are covered in the integrated IEEW environment. This integrated approach serves to plan and define:

- A complete representation of government agency and commercial activities that are linked together in or related to multi-agency missions, e.g., commercial supply chain practices, import and export applications, visa applications for vessel or air crews, and port inspection and release processes
- Organizational Roles, Responsibilities, Authorities, and Accountability (R2A2) for specific activities
- Resources – staffing, technology, and information – needed to perform the mission activities at each step for specific workloads, and potential areas for reallocation or process improvement
- Gaps or disconnects among activities and organizational responsibilities related to the mission
- Services, databases, and computing/communications infrastructure supporting the activities along with format, protocols, and security/privacy measures for sharing and integrating data
- Structured architectural information for a large portion of the data and information required for performance modeling and analysis

**Services and Components:** Both business services (case management, account management, financial management, and e-government services) and IT services (commercial web services, data and applications sharing, communications, and seat management) are defined and related to specific mission activities. Operating Level Agreements (OLA) and Service Level Agreements (SLA) define the specific requirements for information services to support mission performance, whether assembled using commercial and custom software components, or as commercially available managed services. This integrated approach:

- Identifies government agency and commercial managed services related to commerce, passenger, and financial accounts
- Provides a basis for integrating like services and identifying gaps and disconnects that hamper integration
- Provides a basis for comparing and selecting the most effective managed services in developing acquisition strategies, including outsourcing

**Data Management and Supporting Infrastructure:** Specific solutions and components defined include technologies and systems such as ERP and Customer Relations Management systems, data repositories and warehouses, wireless communications, and biometric data collection to implement specific business and IT services. This integrated approach:

- Documents data management and communication services performed by government agencies and commercial partners

- Establishes a basis for the data sharing strategy with defined authorities and accountability for data management, along with constraints related to privacy and security
- Characterizes the computing workload and communications bandwidth required to support specific mission activities – the highest loadings are identified for the retrieval and synthesis of biometric data, and for the search of related cargo and financial accounts
- Guides technology assessments and modernization strategies

**Tool Integration:** Several classes of visualization, information management, and simulation tools are applied in the IEEW Case Study. Data sharing and interoperability is enabled by the web services “Enterprise Middleware”.

- Operations, process, systems, and network simulations are federated to provide a comprehensive integration of the environment, the enterprise business rules, and the enterprise information infrastructure. The federated simulations impose the spatial and temporal dependencies and constraints of the real world, allowing enterprise managers to perform resource allocation and positioning, manage time-space relationships among entities, and determine the overall timing of decision and directive processes.
- The GIS interface provides improved and more accurate geospatial locations to the planners and the models. GIS can also provide a wealth of environmental and demographic information that impacts the planning exercise and the Enterprise Architecture. GIS is further leveraged in the IIEW using two MITRE-developed technologies, SimServer [9] and Simulation Over GIS (SOGIS) [10], which provide a convenient and near-universally accessible method for providing the simulation results to a widely dispersed exercise audience. This is very useful for bringing in state and local agency planners, and for reaching small- and medium-sized business stakeholders.
- A Metadata Server – Metadata are described using Resource Description Framework (RDF) and RDF schema. An open source Java Framework, Sesame, [11] is used for storing, querying and reasoning with this metadata and to translate the agency and simulation federate-specific syntax into some agreed common multi-agency syntax. This clarifies entity and action reference and helps with fusing like observations reported by different exercise participants. A similar approach has been applied by the U.S. General Service Administration (GSA). The GSA is leading the work on ontology and XML-based web services mark-ups for Enterprise Architectures [12]. The GSA work will facilitate the search and retrieval of information in Enterprise Architectures for incorporation in the Operations-Centric Architecture, and business process simulation models.

## IV. CONCLUSIONS

*Planning and managing business and technical change in very complex environments*

The IEEW includes and integrates the basic tools describing the mission operations, business processes, enterprise resources, and information services and components needed to plan for improved capabilities and to support the governance of complex enterprises. The Workbench is scalable and extensible, using web services “Enterprise Middleware” for information sharing and access to other enterprise engineering and planning tools in the integration environment, including process optimization, resource allocation, and decision-support tools. The basic tools have been demonstrated for governance of the most complex operations – the multi-agency environment. They are equally applicable to individual agencies or commercial operations with complex operations and processes.

Multi-Agency missions are extremely demanding from both the organizational and technical perspectives. As such, they require the integrated efforts of executive managers, operations managers, and engineering managers. This is especially critical in the case of highly “networked” multi-agency operations – The Net-Centric Enterprise – where both organizational and policy coordination and technical interoperability of information and communication services are required. Specific enterprise governance functions that can be integrated and that benefit from the scope and content of the IEEW include:

- Strategic planning
- Performance planning
- Operations planning and management
- Engineering management
- Information systems planning and management
- Training

The IEEW supports the concept of a multi-agency governance environment that builds on the capabilities of individual agencies for a very close coupling of strategic planning, technical management, and operational management. The IEEW approach, with a strong focus on mission activities, can deal effectively with complexity and challenges in achieving this objective. It provides the comprehensive systems perspective of the modernization technologies and mission activities necessary for successful engineering management in a multi-agency environment.

The IEEW enables the Line-of-Sight approach to performance planning where the role of all business and information assets and services, existing and proposed, is described and analyzed in the context of the simulated mission operations. In this way the value of specific technologies and services may be gauged with a “Line-of-Sight” to analyze how effectively they support mission performance [13].

Many alternative management options are available during both modernization and operations. Regardless of the option selected, achieving successful multi-agency governance dictates a robust governance structure operating on a

comprehensive information base. An architecture-based approach to governance can help resolve this complexity and the many organizational accountability and control issues that arise in the multi-agency environment. This approach assures that routine management tasks are integrated across the multiple agencies and are responsive to strategic direction and assigned responsibilities.

Defining the required level of organizational and technical interoperability is a major factor in multi-agency missions. The level of interoperability depends on the specific mission, and can vary among the specific activities performed. It is always a strong factor in the assignment of responsibilities and accountability. Specifically, the level of information sharing and provisions for accountability, information quality, privacy, and security are tied closely to the level of organizational and technical interoperability required.

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