RISK.998

An Enterprise Architecture Approach to Project Optimization

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ABSTRACT—This paper introduces the use of enterprise architectural models as tools for project performance improvement. Enterprise architecture (EA) provides detailed descriptions of enterprise structures (such as: organizations, business units, or complex projects). EA practitioners identify system risks and opportunities by documenting system financial, social and technical aspects. Closely associated with information technology, enterprise architecture is commonly utilized to enhance maturity in heavy manufacturing projects, government programs, and aerospace projects. It also has applications in business optimization and performance management. Much research has been done on project success and performance. Although metrics and checklists have merit, each project is unique and thus distinct approaches are needed to optimize complex projects' performance. Enterprise architecture strives to mature the organization's ability to complete projects on schedule and budget, by optimizing performance. The focus of EA, in this context, is on locating and addressing root organizational causes for performance failures. This paper advocates an enterprise architecture approach in the world of complex capital projects. Conclusions will focus on implications for practitioners, and project-specific applications of the methodology.

Table of Contents

Introduction

Enterprise architecture (EA) is a detailed and rigorous description of the structure of an enterprise, identifying system risks and opportunities by documenting financial, social and technical aspects of the system, and the relationships between them. The principles of systems engineering, operations research, and enterprise architecture have been applied in business settings since the 1960s. Closely associated with information technology, enterprise architecture is commonly used to enhance maturity in heavy manufacturing, government programs, and aerospace. It also has applications in business optimization and performance management. It is a tool used to communicate the vision, processes and goals of an organization to its members, and foster positive change.

The practice of enterprise architecture can benefit any field that encompasses complex or complicated development practices and processes, offering an systematic and holistic approach to project planning, implementation and maintenance/operations. With mega-projects, where problems are identified through failure or audit, and simpler approaches to project optimization are typically ineffective, enterprise architecture may be the solution. Much research has been done on project success and performance. Although metrics and check-lists have merit, each project is unique and thus distinct approaches are needed to improve the performance of complex projects. The principles of enterprise architecture can be applied to the project enterprise, locating and addressing root organizational causes for performance failures in order to increase effectiveness and efficiency, thus optimizing performance.

What is Enterprise Architecture?

The practice of enterprise architecture is vast, and incorporates elements from a range of established traditions from systems engineering to project management, including strategic planning, operation maintenance, and more. The systems engineering approach to management involves studying the activities of an enterprise, and effecting beneficial change so the overall objectives can be realized as efficiently as possible [1]. Enterprise architecture itself is the rigorous and detailed description of an organization, in which the structure and dynamics of the enterprise are documented, beginning with its objectives and goals. 'Artifacts' (models) generated by the enterprise architect are used to further describe, in increasing detail, the various functions, capabilities, processes, systems, resources, environment, information flow, interdependencies, and other aspects of the business. "The usefulness of architecture is in breaking down the complex animal, called 'the enterprise', into components, and putting them back together in context [2]." In this context, the 'enterprise' may be any company, business, or endeavor; this includes initiatives or projects engineered to accomplish organizational goals. In government agencies, the enterprise architect serves the public's interest by working with organizations and entities to create sustainable value, assisting the enterprise to effect positive change and produce "an economic, social, and environmental output that is measurably greater than the opportunity cost of all the inputs it consumes [3]." This is typically achieved by applying systems engineering principles at the level of the enterprise.

The principles of systems engineering, operations research, and enterprise architecture have been applied in business settings since the 1960s, building upon pioneering efforts in the 1950s by Bell Telephone Laboratories and RAND Corporation [4]. Companies, such as General Electric, Federal Express, Intel, and Progressive Insurance, have applied enterprise architecture methods at many levels of their organizations, resulting in simplified bureaucracy, faster responsiveness, greater accountability and transparency, staff autonomy, and elimination of wasteful work [5]. The recent growth of enterprise architecture in government-related fields can be traced to the Clinger Cohen Act of 1996, which emphasizes rigor and structure in how government agencies approach the selection and management of information technology projects [6]. Although the act was created to mandate the use of enterprise architecture by government agencies and define the role of the Chief Information Officer (CIO), the advice is sound and has also been applied in non-government fields. Over the past 20 years, the proliferation of new technology spending without a positive benefit (and with substantial cost and schedule overruns) has driven information technology companies to adopt enterprise architecture principles. Using these methods to address sets or families of problems and solutions simultaneously allows improvement of business processes and better management of projects.

Applications

The practice of enterprise architecture can benefit any field that encompasses complex or complicated development practices and processes, offering a systematic and holistic approach to project planning, implementation and maintenance/operations. “The problems of real-world practice do not present themselves to practitioners as well-formed structures. Indeed, they tend not to present themselves as problems at all but as messy, indeterminate situations [7].” Where simpler approaches to project optimization fail, such as with mega-projects, enterprise architecture may be the solution. Here, problem structuring can play a crucial role in project improvement. The principles can be applied in many instances, especially where there is a need to selectively integrate new technology, desire to allow innovation and adaption, clear indication of redundancy, need to reduce complexity, or situation where the project exists as part of (and is subject to the requirements of) a dynamic larger system. The larger system could be a program, organization, or industry regulated by government.

The methodology may also be applied to discrepancies between expectations and current performance [8]. In these instances, standards can be developed which represent desired performance, policies and procedures written to establish rules by which activity is controlled, a comparison made of actual results against the standards, and corrective action taken [9].

‘What to optimize’ is a key question, and may be identified through risk assessment. In a large, complex project, likely focus areas include: project organization, scope management, interoperability of software packages, policies and procedures, and compliance.

The Basics of Modeling

Modeling is the engine that supports enterprise engineering. The model is achieved as part of a systems learning cycle, in which the enterprise architect becomes acquainted with the situation (including the cultural and political aspects), identifies stakeholder-focused areas of risk to be modeled, discusses the situation in the context of organizational goals, and takes action to improve the situation [7]. Enterprise architecture models are designed to be adaptable.

Frameworks have already been built for fields such as defense, emergency response, and homeland security, as well as for business practices, and may soon emerge in the field of project performance management. Although the frameworks are designed to be universal, each model must be adapted first to the field in which it is being applied, and then to the specific project. The growth of common modeling language and frameworks helps enterprise architects to communicate across different groups. Using a common ontology and models, they construct elements that describe the enterprise to all the participants in the project. This allows the participants to influence the growth of the project, and fosters transparencies in decision-making, cost management, and direction.

One of the most comprehensive standard systems architecture structures is the US Department of Defense Architectural Framework (DoD-AF). The DoD-AF is a structure for "organizing architecture concepts, principles, assumptions, and terminology about operations and solutions into meaningful patterns to satisfy specific Department of Defense (DoD) purposes [10]." These frameworks describe the basic architecture of the system, establishing and documenting scope and boundaries, documenting current and desired best practices, and defining generic performance metrics. Using a shared vocabulary, this architecture can then be applied to current problems, enabling the team to document and describe potential solutions. Other framework variations have been developed for specific fields, such as the MoD-AF (British Ministry of Defence Architectural Framework) and PS-AF (US Department of Homeland Security, Public Safety Architectural Framework), which build upon the basic DoD-AF. In time, specific variations may be developed for additional fields, creating new frameworks that follow similar rules.

The common modeling language and frameworks from other complex project areas can be applied to the complexity and scale of today's construction project challenges. Similar approaches are already being used in diverse fields, including medical technology, information technology, communications and aircraft design. Project performance models may encompass technology, financial systems, compliance issues, business processes, and environmental areas. "The key to the operational approach of modern systems engineering is that changes in equipment and manpower content; in interrelationship structure, in information flow; and in management and control of these systems must be accomplished not only in terms of their own improvement but in terms of their impact on total effectiveness [11]."

As a starting point, the project enterprise model should focus on boundaries, interfaces, rules and interactions of the entities, such as: information sources and flow; decision authority; identification of stakeholders, requirements, and values; characterization of legacy systems;

and workflow processes, policies and procedures [12]. For project optimization, a number of maps ('views') should be created at different levels of the enterprise. For example, this selection of DoD-AF views includes:

- The 'architectural overview' (AV -1), which describes and communicates the overall vision to staff, managers within the company, and the stakeholders in the project. This is achieved by documenting the project's visions, goals, objectives, plans, activities, events, conditions, measures, and outcomes, including the objects produced.
- Several 'capabilities views' (CV 1 - 6), mapping out capabilities the enterprise must develop, and correlating them to both the architecture and the project. These views should encompass dependencies between the capabilities and the organizational growth and activities. These views support project optimization by supporting and enabling better resource management, assisting the organization to understand the abilities and resources it must have in order to create the project, how and when they will be acquired or developed, and how they interrelate. If needs or tasks should change, the impact of the change can be mapped to suit the changed capabilities, needs, and costs.
    - 'Vision' (CV-1) provides the overall vision for transformational endeavors, including a strategic context for the capabilities described and high-level scope.
    - 'Taxonomy' (CV-2) lists a hierarchy of capabilities, specifying all the capabilities that are referenced in the architectural descriptions.
    - 'Phasing' (CV-3) may be necessary for very large undertakings, but is not always used.
    - 'Dependencies' (CV-4) identifies the dependencies between capabilities and the definition of logical groupings of capabilities.
    - 'Mapping of capability to organizational development' (CV-5) shows the planned solution for the phase, in terms of performers, locations, and their associated concepts. And,
    - 'Capability to operational activities mapping' (CV-6) is a mapping between the capabilities required and the operational activities that those capabilities support.
- 'Operational views' (OV 1 - 4), which provide the operational concept at a high level, with organizational and operational mapping to the activities that will take place. These are useful to project and program managers, as well as stakeholders.
    - 'High level operational concept graphic' (OV-1) provides a graphical / textual description and overview of the operational concept.
    - 'Operational resource flow' (OV-2) is a description of the resource flows exchanged between operational activities. And,
    - 'Organizational relationships chart' (OV-4) shows the organizational context, role and other relationships among organizations.
- 'Project view' (PV-1), to examine the relationship of the organization to all current projects. This allows the project team to leverage expertise, learn from other projects, and capture feedback for future process improvement.

Key to the modeling process is an understanding of why it is important to model the organization. When modeling, it is imperative to remember that the goal of enterprise architecture is to find ways to strengthen the processes, systems, and organization that enable the entity to function optimally. If the model does not serve that purpose, the model should be realigned.

Modeling in a Project Environment

To illustrate how enterprise architecture concepts can be applied in the project environment, here are four examples. Additional modeling opportunities can be identified by first conducting a risk analysis. This is a good first step in identifying the areas to be modeled, in order to understand the project, its challenges, and possible approaches to both risk reduction and optimization.

Much research has been done on project success and performance. Although metrics and checklists have merit, each project is unique and thus distinct approaches are needed to optimize complex projects' performance. In this instance, a top-down approach can be taken, in which project performance is modeled. This approach "takes a more holistic view, where the assessment team identifies the critical data needs that are required for the enterprise to be successful and then seeks the most appropriate applications to support the business strategy, goals, objectives and the work processes, independent of what the company already has in place [13]." Using as a starting point the business case for the project and definitions of success, specific performance measures can be developed and tracked.

In contrast, a "bottom-up approach takes an overview and inventory of all existing systems to determine what is currently being used and to identify where streamlining or rationalization of applications can take place [13]." This approach can be applied to the project organization chart, identifying both redundancies and gaps in staff resources. The bottom up approach incorporates the "as-is" of a partially or fully developed project, and enables change to improve optimization and maturity.

Similarly, the bottom-up approach can be taken in the assessment of information technology systems. Often, a project report cobbles together information from multiple sources, including information from multiple project sites, financial accounting or ERP systems, project collaboration systems, project management/controls software, and other sources. These sources are typically not interconnected, or some bridge has been built to enable data to be transferred. "Budgeting, forecasting, asset optimization, production totals, project management overviews, and other critical processes rely on the aggregation of data [13]." This is a more traditional application of enterprise architecture modeling, returning to its roots in information technology. In all cases, the different systems are interdependent and the enterprise architecture approach allows the manager to understand and best leverage these dependencies. Project failures and inefficiencies often develop due to failure to integrate the diverse systems areas of projects. In the fast-moving information technology world, expensive failures have resulted in a government mandate for the enterprise approach.

Lastly, the bottom-up approach can be applied to policies and procedures, with an eye toward designing or adapting project governance processes to avoiding redundancies and improving both efficiency and flexibility by ensuring the uniform application of best practices. “As project execution has been long recognized as one of the most important factors in providing business value, organizations have established project offices that define the processes, methodologies, techniques and metrics to be used enterprise-wide. In some cases these project offices simply provide this definition and some degree of project administration (metrics gathering) only; in other cases, the project office has project governance responsibilities and implements processes to ensure standard project management techniques are used, including the proper project initiation process.” [14] Processes can be improved by empowering employees to make decisions, revising or pooling existing assets, resources, and systems, streamlining and automating processes, and redeploying staff resources.

Given those four examples, and remembering that the project itself is a system with many interdependencies and processes, any portion of the project can be modeled and systematically analyzed. For large and complex mega-projects, it is not reasonable to attempt to model the entire project. Instead, enterprise architecture modeling efforts should be focused on areas of risk, stakeholder concern, or inefficiencies.

When an organization uses these types of approaches, a maturity model can be used to assess the development of the entity’s processes and their application through the development of its enterprise architecture and execution of it. Complementary to audits is a Capability Maturity Assessment of how well an organization can prevent problems instead of detecting them through audits.

Discussion

The enterprise architecture approach can be used to effect organizational maturity and flexibility. Enterprise maturity occurs as processes are captured, disseminated, understood, and improved through feedback from staff, management, and stakeholders. Mature business entities and project organizations must thus be flexible, capturing lessons learned and using them to plan ahead for the future. The basic framework approaches proposed here allow the project entity to capture the learning process and improved business processes from previous projects, and apply them to new circumstances. This flexibility supports a more mature, cost efficient project structure that better satisfies stakeholder needs. In the enterprise architecture model, the architectural view and operational view can be used to begin to change project and organizational culture. The changes which make the project more self-aware and adaptable can be considerable, even if only a few frameworks are developed. Once the first views are created and used to disseminate data and foster discussion, additional views (such as capability views) can provide crucial information to support action by project managers and stakeholders as well as staff.

As a part of the modeling process, the enterprise architect will develop an information model describing the resources used from program development and a roadmap. These tools are

essential to implementing phased enterprise architecture approaches. It is not reasonable to attempt to create the entire set of view for a framework at the start of a project, and it may be best to continue to develop these views over a multitude of projects in a company's portfolio or within a large program. The evaluators will learn to rely on and modify these views to help communicate new information.

The introduction of architectural views and models begins a chain of events that, ultimately, changes the business process if the models are used in an iterative fashion. Where it is possible to model those changes and their impacts, it becomes easier for the organization to become more adaptive. Although each level of architecture requires an overhead expense to create the models, implement, and evaluate the data, once a model has been developed and used by an entity, it becomes a permanent part of that entity's portfolio and can be used as part of an ongoing cycle of feedback. Repeatedly modeling project outcomes, to include changes effected and lessons learned, improves the modeling toolkit and templates for better use on future projects. The subsequent models also provide a long term road map of change, which serves as both a historic record and an audit trail.

When applying the models, the team needs to take some care. In industries currently using the DoD-AF process, there has been some over-burdening of projects with pre-existing processes that may no longer be relevant. This has resulted in rigid definitions of solutions from the top level, which are then imposed upon the bottom level. This is, in part, because of a strict adherence to requirements management rather than following a true enterprise engineering approach. The enterprise architect and project team must take care when using systems and enterprise approaches, applying them judiciously while avoiding defining the problems of the enterprise at too low a level, thus fostering innovation within the scope of each task.

The architectural views must be fit to the purpose, thus leveraging their power without burdening the program. The project manager should not specify which hammer a framer is to use, but could describe how strong and true the framing must be. At the top level, guidance and governance are provided that will reward the correct solution, but the thinking about the solution will need to come from people in the roles most familiar with the problem. In addition, for long duration projects in rapidly evolving industries, one can identify capabilities and their interplay without specifying the exact design and approach until that design and approach are needed, so the project is not forced to use older or outdated products and processes. By phasing in architectural frameworks and avoiding constraints at too low a level, adaptation to new products and situations is fostered.

Conclusion

Enterprise Architecture provides a toolbox to describe communicate, and measure the overall organizational approach to project development and management. This rich set of tools has allowed diverse businesses, from government defense branches to computer companies, to develop faster and better responsiveness to market and regulation. The models developed as part of the enterprise architecture process allow companies to adapt to change, enable

efficiencies, plug resource gaps, and incorporate new technologies where there is a clear cost-benefit.

The examples of views, models and approaches illustrated here can be utilized to enhance the project optimization and audit process. Existing frameworks, such as the DoD-AF, are good initial toolkits that can be modified to better support the world of complex projects. As these frameworks are further developed, maturity models can be applied to supplement current audits. The expectation is that the enterprise as a whole will mature, and lessons learned and process improvements will be carried over to future projects, thus reducing risk.

References

1. Jenkins, G., & Youle, P. (1968). A Systems Approach to Management. *Operations Research, 19*, 5-21.
2. Rao, P., Reedy, A., & Bellman, B. (2011). *FEAC Certified Enterprise Architect CEA Study Guide.* New York, NY: McGraw-Hill Osborne Media.
3. Center for the Advancement of the Enterprise Architecture Profession. (n.d.). *Enterprise Architect's Professional Oath*. Retrieved February 13, 2012, from CAEAP: http://caeap.org/HippocraticOath.aspx
4. Checkland, P. (1983). O.R. and the Systems Movement: Mappings and Conflicts. *The Journal of the Operational Research Society,, 34*(8), 661-675.
5. Kozmetsky, G., & Yeh, R. T. (2000). Zero Time. *Zero Time Seminars 2000.* Zerotime Labs LLC.
6. United States Department of Defense. (2006). *Chief Information Officer Desk Reference.* Washington DC: United States Department of Defense.
7. Winter, M. (2006, July). Problem Structuring in Project Management: An Application of Soft Systems Methodology. *The Journal of the Operational Research Society, 57*(7), 802-812.
8. Nutt, P. C. (1983). Implementation Approaches for Project Planning. *The Academy of Management Review, 8*(4), 600-611.
9. Smith, D. B. (1965, May-June). Systems Engineering: Implications for Management. *Financial Analysis Journal, 21*(3), 119-127.
10. United States Department of Defense. (2009). *DoD Architecture Framework Version 2.0.* Washington, DC: United States Department of Defense.
11. Feigenbaum, D. S., & Sasieni, M. (1968, August). The Engineering and Management of an Effective System. *Management Science, 14*(12).
12. Rose, C., & Brenner, A. (2011). Enterprise Architecture of Emergent Complex Adaptive Systems. *14th Annual Systems Engineering Conference.* San Diego, CA: National Defense Industrial Association.
13. Habib, Q., Zaheer, A., & Ashish, A. (2011, March). Gaining Competitive Advantage—Aligning Enterprise Architecture with Business Value. *Journal of Petroleum Technology*, 52-55.
14. Leganza, G. (2003, December). Project Governance and Enterprise Architecture Go Hand in Hand. *Planning Assumption*.

Recommended Reading

1. Grady, J. O. (1994). *System Integration.* New York, NY: CRC-Press.
2. Kaplan, R. S., & Norton, D. P. (2000). *The Strategy-Focused Organization: How Balanced Scorecard Companies Thrive in the New Business Environment.* Boston, MA: Harvard Business Review Press.
3. O'Sullivan, D. (1994). *Manufacturing Systems Redesign: Creating the Integrated Manufacturing Environment.* Upper Saddle River, NJ: Prentice Hall.
4. Office of Management and Budget. (2006). *Capital Programming Guide, Supplement to Circular A–11, Part 7: Planning, Budgeting, and Acquisition of Capital Assets.* Washington, DC: Executive Office of the President of the United States.
5. Rouse, W. B. (2006). *Enterprise Transformation: Understanding and Enabling Fundamental Change.* (A. P. Sage, Ed.) Hoboken, NJ: Wiley-Interscience.
6. Stephenson, H. L. (2011, October). Cost Engineering Maturity Model. (M. Gelhausen, Ed.) *Cost Engineering, 53*(10), 13-36.
7. Yeh, R. T., Pearlson, K. E., & Kozmetsky, G. (2000). *Zero Time: Providing Instant Customer Value - Every Time, All the Time!* Hoboken, NJ: Wiley.

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