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Utilizing Strategic Project Management Processes and the NATO Code of Best Practice to Improve Management of Experimentation Events

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Abstract

Systems engineering and project management are two core engineering management processes supported by core "quantitative" disciplines within engineering management problems. Traditional approaches to systems engineering focus on a single system being engineered and managed (i.e., project managed), while challenges addressing composition of systems of systems and the reuse of systems for new solutions require a strategic management approach that promote a process flow in which the outputs of one project (e.g., deliverables, knowledge, work documents) are captured for the benefit of other projects within and outside the project-based organization. Two other core processes of engineering management are therefore critical to be incorporated into this process flow: knowledge management and strategic management. Consequently, when applying complex simulation system or federations of simulation systems for experimentation, knowledge management and strategic management are needed.

The NATO Code of Best Practice (COBP) for Command and Control Assessment is dealing with similar challenges. Within a project in support of PEO Soldier, Old Dominion University and the United States Military Academy developed new system engineering processes in support of system selection and orchestration that allow merging the knowledge and strategic management ideas with NATO's recommended best practices.

1 Introduction

The study underlying this paper was motivated by the need to aid managers of projects focused on developing complex simulation systems as well as federations of systems to cope with the challenges of addressing the multiple constraints set by the customer and sponsor. In particular, the authors wanted to evaluate if it is possible to use the structure of the NATO Code of Best Practice (COBP) for Command and Control (C2) Assessment (NATO, 2002) to guide the use of strategic project management and knowledge management application in support of the re-use of simulation resources beyond the scope of a single project or even across the different domains of the originally application domain (procurement, development, training, education, support of operations, etc.)

Litwin, et al (2008) suggest a set of key constraints in research and development projects focused on building complex simulation systems:

(a) the essential tasks to be used for strategic decision making should be identified to support the selection or development of relevant simulation scenarios;
(b) simulation systems should be selected based on their ability to support the evaluation of these tasks;
(c) the simulated system capability should be the driver for the decision;
(d) the process should be applicable to evaluate alternatives for supporting simulation components and enable the project manager to make informed decisions;
(e) the federation of these simulation systems should be supported utilizing the best middleware available for the task;
(f) this decision should be driven by the functionality of the middleware and its necessity in the federation development process;
(g) the integration of systems and middleware should be supported to the maximum extent;
(h) the decisions of model integrators should be reduced to a minimum, thus avoiding ambiguity of interpretations;
(i) existing solutions should be reused as much as possible;
(j) minimize the number of supporting simulation systems that represent the scenario;
(k) minimize the costs of obtaining the simulation systems and supporting data;
(l) maximize the use of simulation system under governance of the project manager;
(m) maximize the acceptance of systems.

Because this set of constraints is common in projects tasked to develop complex simulation models, and because meeting these constraints will require a considerably amount of effort in deploying a systematic project management approach, the authors believe that it is critical to take a strategic approach that promotes not only the success of a single project, but of a series of projects within the project-based organization. Furthermore, a strategic approach is always needed if objectives are project overarching, as such objectives are not necessarily correlated with project objectives. In other words: if an objective is of strategic importance, it is often counterproductive to leave accomplishing this objective to projects without additional guidance and incentives. This requires strategic project management.

In the conducted investigation we intended to answer the research question: what are the tools, processes, and methods that support the strategic project management of research and development projects tasked to build complex simulation systems? One of these questions of particular interest to the C2 community was to what degree the framework developed for the NATO COBP could be used in this context, as the COBP already addresses re-use of study results in related and relevant domains.

In the next sections, we provide fundamental background on the concepts of knowledge management and strategic project management that we applied in the development of the answer of our research question, followed by a proposal of a comprehensive systems engineering approach that is based on the latest developments in the field of project management.

2 Knowledge Management and Strategic Project Management

Knowledge management aims to address the challenges faced by modern organizations of competing and improving performance through knowledge (Davies, 2000). Knowledge management is intended to use, improve, maintain, and create organizational capabilities to generate sustained competitive advantage in organizations (Yeung, et al, 1999). Knowledge management is commonly defined as the processes, tools, and techniques that make available the right knowledge to the right knowledge worker, at the right time. Another definition of knowledge management comes from Luthans, he redefines Knowledge Management as *"the development of tools, processes, systems, structures, and cultures explicitly to improve the creation, sharing, and use of knowledge critical for decision making."* Knowledge management in support of project management is a relativity new discipline. Researchers are currently developing and improving methods and tools to acquire, store, and disseminate information and tangible and intangible knowledge throughout project-based organizations (Love, et al, 2003).

This is valid in the military context as well. In particular the advancement of the Internet supported that all of the military services are currently developing and applying web portals as single point access. Examples are the Army Knowledge Online and the Navy Knowledge Online portals the authors are familiar with. These portals are used to train soldiers on their duties, prepare them for deployments, etc. They are also used for transferring a working knowledge of an individual person, their experiences, and education to another person whom may be replacing them within an organization. It is also needed to align projects, introduce project overarching standards and procedures, and support the transfer of project results for reuse. Although knowledge management initiatives have been lately supported by the need to address the knowledge loss that faces organizations due to the retirement of their baby boomers, knowledge management is more than that, it is important to the immediate organization (project organization) to avoid re-inventing the wheel and have to solve the same problem again and again. For the overarching organization (project-based organization) it provides the opportunity to build a social capital that will support the intellectual capital and consequently lead to enhanced performance, capabilities, and competitiveness (Landaeta, 2008).

Strategic project management has been a term lately used by researchers and practitioners of project and program management to refer to the effective and efficient management of project-based organizations. Strategic project management focuses on the *providing means to the management enabling them to provide guidance for more than one project at a time in a way that the strategic intent of the project-based organization is met* (Callahan & Brooks, 2004; Green, 2005; Grundy and Brown, 2002). Strategic project management focuses on the best utilization and alignment of the resources of the project-based organization to meet its vision and goals.

Knowledge and information have been suggested as being resources of projects (PMBOK, 2002). Therefore, they are one of the key aspects of strategic project management because projects rely on information and knowledge (feedback) from previous projects executed within the project-based organization. Information and knowledge are traditionally captured in documents like project plans, project journals,

lessons learned, best practices, etc. They all contribute to the knowledge base of a project-based organization and therefore enable the effective and efficient utilization of the organization body of knowledge across projects (i.e., the strategic management of projects' knowledge). Project management and technical implementation success of a single project hinges on past experiences and the transfer of knowledge from preceding projects.

Knowledge management and strategic project management are taught within the Armed Forces in project management courses and in leader education. However, their applicability for the management of "virtual systems," such as the simulation systems used for training and education, analysis, and experimentation (and in the future hopefully increasingly for support of operations as well) has not been the focus of published research. The studies underlying this paper were targeting to close this gap. The hypothesis to test was that *"it is possible to significantly improve the reusability of simulation resources in cross domains if the recommendations of knowledge management and strategic project management are applied in addition to traditional M&S project management."*

3 The NATO Code of Best Practice for C2 Assessment

The NATO COBP for C2 Assessment is rooted in operations research methods. It recommends best practices for the structure of C2 evaluation projects. Since 2007 the COBP has been adapted as a standard within the Joint Staff and Office of the Secretary of Defense (OSD) Networks and Information Integration (NII).

Figure 1 shows the structure of the COBP processes and their main domains.

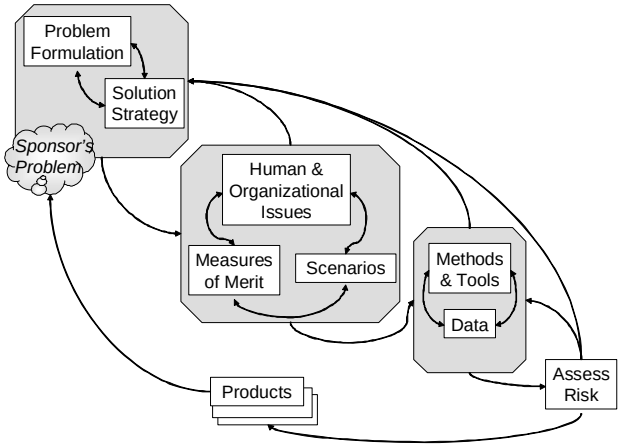

Figure 1: Overview NATO COBP

Within the first phase of a C2 related operations research study, the problem formulation and the proposed solution strategy is conducted based on the sponsor's problem. Understanding the problem on the researcher's side and how it is going to be solved on the customer's side are the main points. In the second phase, the scope and constraints for

the study are captured: what are the main issues to address, what scenarios to use for the evaluation, and what metrics can be used to measure success. The third phase conducts the evaluation using tools (one of them can be simulation) and using and producing data. In the final phase, the risk is assessed and the products for the sponsor are prepared.

Since the COBP deals with similar challenges as explained in the introduction, we wanted to evaluate in particular to supporting knowledge management and strategic project management can be guided by the processes recommended by the COBP. In other words, the hypothesis was: *"It is possible to use the structure of the COBP to identify phases and required support that can be provided knowledge management and strategic project management enabling cross-domain re-use of simulation resources."*

4 Proposal for a Systems Engineering Approach

While evaluating on the one hand side traditional project management methodologies and artifacts – e.g., the statement of work (SOW), work breakdown structure (WBS), resource management – and on the other hand's side NATO's recommended COBP phases, three core phases were recognized and linked to develop a reusable project specific strategic project management process (SPMP). This process opens the way for reusability of the simulation resources of a single project for re-use by other projects and as such should enable the project-based organization to become more effective and efficient over time.

captures these identified core phases to illustrate a SPMP flow that can be utilized for modeling and simulation (M&S) federation development or the integration of simulation resources into other domains. The three core phases are initial planning, refining, and implementation. Each phase requires supporting documentation and sub-processes to deliver a product:

Table 1. SPMP Core Phases and Outputs

Core Phase	Output Product
Initial Planning	Project Proposal
Refining	Project Work Plan
Implementation	Final Product

Supporting documentation noted in Table 1 contains key information and necessary knowledge required to take an M&S conception to reality – i.e. development cycle. It should be noted that each phase has sub-processes where several reiterations may be needed to facilitate proper coverage of the requirements and to apply lessons learned, best practices, and near-miss events from previous projects i.e. knowledge management.

Project management and the technical implementation success of a single project hinges on past experiences and the transfer of knowledge from preceding projects. Different artifacts are identified to promote this continuous improvement cycle: study plan, project journal, and risk management. A study plan and/or project journal maintained,

communicated, and socialized to all members promotes a well informed team. Risk analysis and management is recommended in order to avoid unforeseeable difficulties and/or setbacks and is enabled by using knowledge collected from previous projects to assess and address the consequences of reducible and irreducible uncertainty.

Standardizing the project management products in order to support their understandability, transparencies, and reusability is a necessity to enable a strategic project management approach as recommended in this paper. If introduced correctly, no additional work is required within the project, as the project management products are needed within the project in any event. However, by doing them in a standardized way increases the reusability and sharing across the boundaries of a project and of the project-based organization, but this latter topic lies outside the boundaries of this paper.

The resulting requirements enabling an overarching integrative approach assume that M&S services need to be accessible via a knowledge repository in which they are described in a standardized way. A recommended systems engineering approach, the Model Driven Architecture TM (MDA), aid the management of knowledge in this type of projects. Here requirements are used to formally capture M&S models in descriptive artifacts to realize captured knowledge of used components and how they are contributing to the process builds the knowledge repository with valuable information. However, it should be pointed out that this does not imply that a technical MDA approach is mandatory as well.

The proposed SPMP illustrated in Figure 2 may be utilized as a management tool for M&S federation development; however it can be adapted for any project requiring dynamic development of software or simulation models. It contains three core phases: Initial Planning, Refining, and Implementation with each providing a different product: Project Proposal, Project Work Plan, and Final Product respectively.

From Figure 2
it can be noted that there are two domains which the SPMP functions in – the overall domain, Project-Based Organization, and the inner domain, the Project. These boundaries define where individual projects are part of a collective project-based organization. It is imperative to utilize a reusable Knowledge Repository during a development cycle in order to capitalize on previous project outcomes. Queries may be called to retrieve data and submissions should be made to a repository to ensure feedback (e.g. lessons learned, best practices, near-miss events, and supporting documentation) within the project. This practice allows overarching project-based organizations to expand critical knowledge and become more efficient over time.

For a project to be initiated, a sponsor must present a problem by explicitly annotating the strategic importance of the problem to be solved. Only then, upon completion of the strategic importance documentation, the SPMP can commence. The first phase of the SPMP – Initial Planning – contains two sub-processes: Problem Formulation (What?) and Solution Strategy (How?). These two sub-processes will aid in developing and refining supporting documentation to evaluate what the system will do in support of which

missions, Table 2, ultimately leading to a Project Proposal. It should be noted that several reiterations may be needed to resolve any outstanding issues and to close the gaps of any missing requirements in order to provide a robust and complete project proposal.

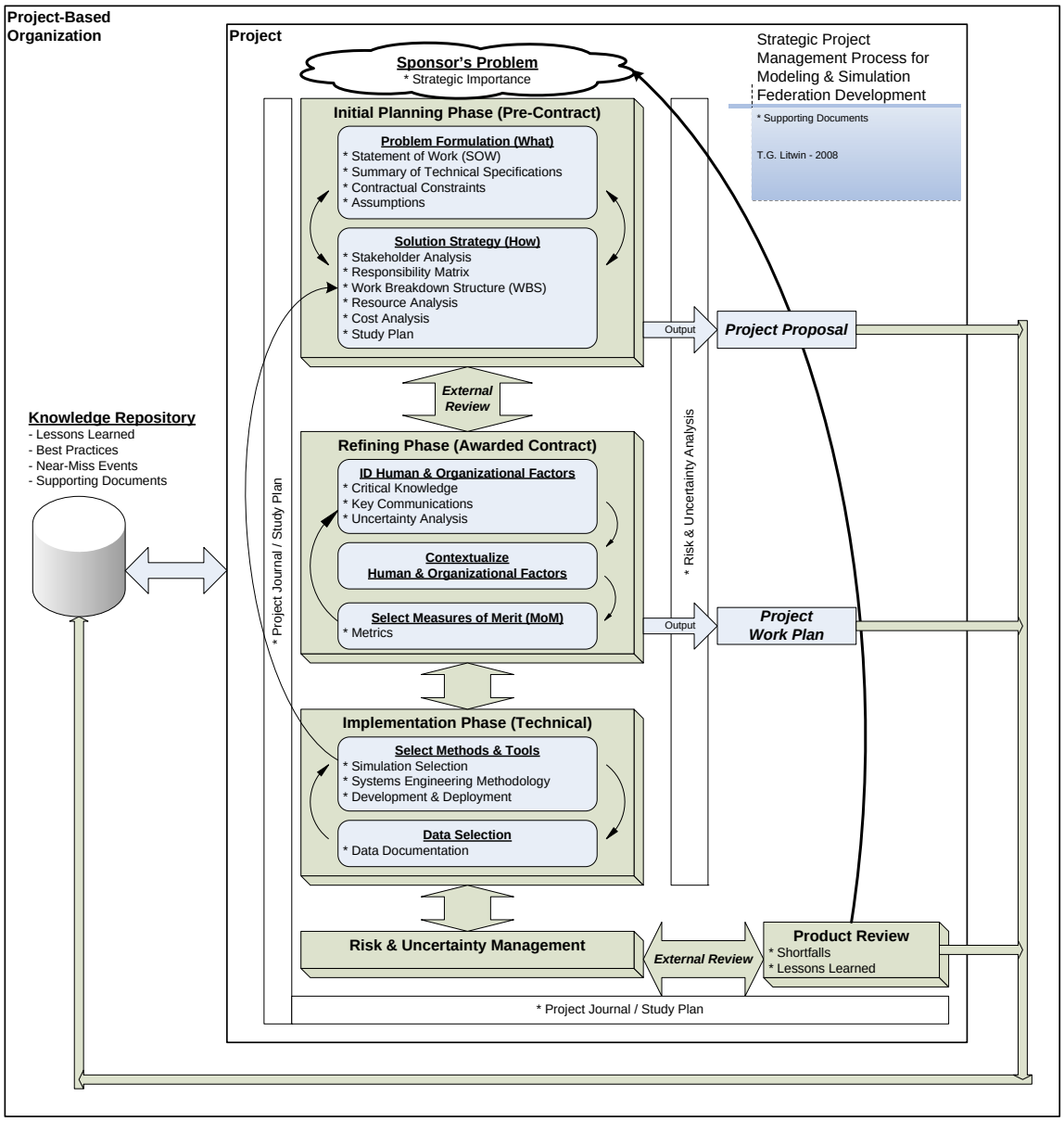

Figure 2: Strategic Project Management Process (SPMP) for the Research and Development Projects Focused on Building Complex Simulations

Table 2. Initial Planning Supporting Documentation

Supporting Documentation
Statement of Work (SOW)
Summary of Technical Specifications
Contractual Constraints
Assumptions
Stakeholder Analysis
Responsibility Matrix
Work Breakdown Structure (WBS)
Resource Analysis
Cost Analysis
Study Plan

The second phase of SPMP – Refining – commences after a contract has been awarded and refining spatial and contractual elements is required. There are three sub-processes: Indentify Human and Organizational Factors (evaluating where they are now and how they operate), Contextualize Human and Organizational Factors (placing them into the overall scenario), and Select Measures of Merit (MoM) (identifying the important concepts and processes, their role, and how to measure success or failure). These develop additional supporting documentation, as shown in Table 3**Error! Reference source not found.**, and ultimately deliver a Project Work Plan. During the contextualization sub-process several supporting documents (e.g. responsibility matrix, resource analysis) from the previous phase must be revised to add/change information pertaining to the awarded contractual constraints.

Table 3. Refining Supporting Documentation

Supporting Documentation
Critical Knowledge
Key Communications
Uncertainty Analysis
Metrics

To produce results, MoM is undoubtedly required. The need for MoM – explicit or not – is to classify a result (e.g. states, events) by the assignment of success or failure. Applying formal MoMs, provide a better understanding of the project and allow the results to be compared against each other and with other projects within the project-based organization. Also, the use of formal standardized MoMs, provides the knowledge repository with feedback and input for future projects.

The final phase of SPMP – Implementation – starts immediately after the project work plan is complete and the project development work begins. There are two sub-processes: Select Methods and Tools and Data Selection which develop additional supporting documentation for the project, as shown in Table 4**Table** , and delivers a product to the sponsor for review. Again several iterations of the sub-processes may be required to rectify any missing data requirements identified in the data selection. It should be noted that during the selection of methods and tools sub-process, revisits may be required to the solution strategy sub-process to update previous supporting documentation (e.g. WBS, resource analysis, study plan) to maintain a consistent and complete SPMP solution.

Table 4. Implementation Supporting Documentation

Supporting Documentation
Simulation Selection
Systems Engineering Methodology
Development & Deployment
Data Documentation

Before a product is released to the sponsor, a final Product Review is required. During the review, the product is tested and compared to the previously selected MoMs and requirements set forth by the sponsor. During the review, key information about the project should be filed in supporting documentation, as shown in Table 5**Table**. Beside the supporting documentation other key information (e.g. major findings, recommendations) should be annotated and communicated to the teams and the sponsor.

Table 5. Product Review Supporting Documentation

Supporting Documentation
Shortfalls
Lessons Learned

Risk and Uncertainty Analysis is an ongoing progression as a project moves through the SPMP. Every phase of the SPMP introduces new forms risk and uncertainty pertaining to the project. A project manager needs to take all aspects of risk into consideration and document the process along the way. Proper analysis of risk and uncertainty provides invaluable supporting documentation to top-level management and all stakeholders. If the appropriate documentation is provided, risk and uncertainty management deliver valuable support enabling the project team to deliver their product on time and as described by the specifications.

There are two critical points – called External Reviews – within the SPMP flow where the teams/stakeholders should review all available supporting documentation and/or products. These reviews should occur between the initial planning and refining phase and between the implementation and product review phase. External review promotes team

cohesiveness, cross-functional communication, and provides an avenue for decision makers to become informed about the process and project status.

As Figure 2 depicts several transition points to previous processes, it should be noted that depending on the project, process, PM, etc. additional decision points may be required to "revisit" previous stages or to refine supporting documentation. For example, if a project is midway through its development cycle and the PM determines a change to the proposal and/or contract is warranted – due to technical limitations – a review of and changes to supporting documentation may be required. Therefore, the labeling of Initial Planning Phase (Pre-Contract) and Refining Phase (Awarded Contract) may be deceiving to the reader.

The final two elements of the SPMP that are noteworthy are the Project Journal and Study Plan. A project journal is a chronological continuous document of key events containing information (e.g. meeting time and location, who attended, agenda, what was accomplished, what was outstanding, lessons learned by those who attended). The project journal should commence with the first event in the first phase – initial planning. A study plan is considered a "playbook." It contains problem formulation and solution strategy plans for all stakeholders and especially for the PM (NATO, 2002). This study plan is a management tool which provides detailed guidance with a time phased execution plan linking all of the supporting documentation (e.g. SOW, WBS, etc.) together promoting a smooth flow for the solution strategy.

The above recommended SPMP provides a reusable project specific process flow for PMs to develop an intelligent strategy and a "plan-of-attack" to solve complex M&S federation problems based on past experiences. This allows project-based organizations to become more effective and efficient over time and expand their critical knowledge.

5 Summary and Recommendations

Both hypotheses were validated within the study, although the validation is limited to the results within the study. The findings, however, were applied in support of the Program Executive Office (PEO) soldier under realistic constraints, as the team conducted experiments and research in support of a real study. Based on our observation, several recommendations can be justified:

Several project's knowledge management tools and methods that support the strategic management of projects were identified during the investigation. We recommend senior managers and program and project managers of organizations focused on performing research and development projects tasked to build complex simulation systems to evaluate the implementation of Project Journals, Lessons Learned Processes, and a Knowledge Repository:

- **Project Journal:** Loo (2002) conducted a study on project journaling and proved it to be beneficial for project management. He concluded that "journaling can facilitate learning specific skills including interpersonal communication, conflict

management, managing effective meetings, managing stress, and leadership skills." This learning is accomplished by "reflecting" thoughts in a project journal. Reflecting is carried out in three stages:
(1) self awareness of the stimulated learning situation (positive or negative and/or uncomfortable circumstances),
(2) self criticizing of the situation, and
(3) self development of new perspectives based on the above discoveries.
Project Journaling is an excellent learning tool for all personnel within a project and/or project-based organization. Journaling may be used by organizations to build teams, improve management skills, and improve organizations overall (Loo, 2002).
Project Journals can be extended beyond personal use – they can be used to capture important events (e.g. bi-weekly meetings, technical reviews, and brainstorming sessions) that take place during a project's development cycle. Possible elements to capture within a project journal, combined with the above mentioned, should allow project and project-based organizations to study: how events occur, how the events were performed, why were the events performed in that way, etc. The knowledge gained during this process should then be captured in a knowledge repository and transferred across projects within a project-based organization. As Loo discovered with individuals, applying project journaling to projects should allow project-based organizations to improve their performance by reflecting on past experiences and applying those experiences to future projects. However, as this paper is based on one supported project, the amount of re-use could not be measured as a success factor for our activities.

- **Lessons Learned (L/L):** U.S. Army defines Lessons Learned (L/L) as "knowledge or an understanding gained by experience either by a negative or positive experience (Center for Army Lessons Learned, 2008). Before capturing L/L, it should be determined the L/L are noteworthy, valid, and relevant to a particular subject before they are officially documented. L/L are developed at the macro level (management) and the micro level (technical), each having their scope of detail (finer details of implementation go into technical L/L). L/L may enclose or address topics of interest, provide information of an event, etc. and not restate doctrine or policies. Examples of L/L are: what should have been available, what was available, what current solutions could have helped to close the gap, etc.
  During PEO Soldier's task it was determined that the technical teams should have used Platform Independent Models (PIM) during the planning phase instead of theoretical Unified Modeling Language (UML) diagrams. The diagrams proved to be too voluminous for real-world use and caused delays. This example is an excellent point to be made for follow-on projects. For strategic project management, project-based organizations must have a plan in place to capitalize on the full potential of L/L – they must accumulate, validate, store, disseminate, and reclaim L/L to achieve organizational goals and objectives. Accumulation of L/L should be garnered from sources internal and external to the project organization and contain positive and negative experiences. Established

guidelines and standards permit a streamline process for validating L/L. During the validation process, key personnel and subject matter experts (SME) review and tailor the L/L preparing them for storage in the repository. Captured L/L may be applied to a project-based organization via a knowledge repository. However, some standardization is required to ensure proper data matching is maintained within the repository and the organization. Without standards of validating, storing, and reclaiming those L/L cannot be effective. Project-based organizations are responsible for organizing L/L and developing plans to disseminate and applying L/L to follow-on and/or recurring projects. New projects benefit from previous experiences by reducing the "learning" curve and ultimately reducing the development time of a project – especially those within the same project-based organization. The L/L process is an ongoing process starting from the beginning of a project and should not be left until the end of a project to begin capturing L/L. Every noteworthy event should be documented, organized, and stored for future use enabling project-based organizations to improve over time. Within our project, we applied these principles but did not define explicit metrics to capture the improvements. Such metrics are topic of ongoing research.

- **Knowledge Repository:** The resulting requirements enabling an overarching integrative approach assume that M&S services need to be accessible via a knowledge repository in which they are described in a standardized way – these ideas are based on Model Driven Architecture ™ (MDA) (Object Management Group (OMG), 2007). Requirements to formally capture M&S models in descriptive artifacts realize the captured knowledge of used components and how they contributed to the process. This builds the knowledge repository with valuable information.
  However, it should be pointed out that this does not imply that a technical MDA approach is mandatory as well. Sinclair suggested a common data infrastructure, **Error! Reference source not found.**, which allows organizations to "reuse" knowledge within a project-based organization by utilizing a repository (Tolk and Sinclair, 2002). This infrastructure is not exclusive and is considered a static model. However, for MDA methodologies to be applied to this framework, a model needs to be modified and adapted to allow dynamic content. For example, not all M&S federation projects are the same (e.g. different requirements, ideas, data) and need to be handled in different ways. Therefore, the common data infrastructure may need to be modified to accommodate these differences.

Tolk and Sinclair (2002) used the COBP to motivate the use of data repositories to enable re-use of operational research study results in other studies. Figure 3 summarizes the recommended approach. It can be seen that the *Data Available* element is correlated to the knowledge repository and the *Study Data* element is information from the current project – therefore transferring knowledge from the repository and applying it to the current project. If this structure is extended respectively, it does not only serve the sharing of data to be used, but all study results and artifacts.

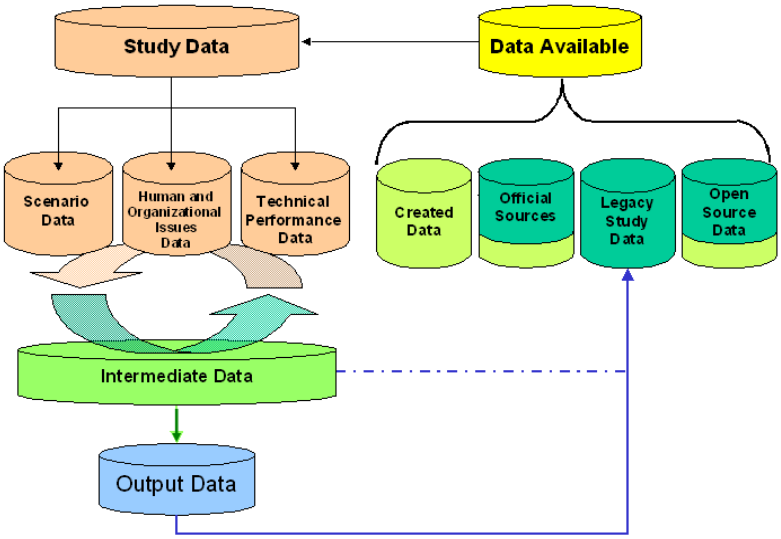

Figure 3: Common Data Infrastructure for Reuse of Knowledge

Finally, as the community is currently moving towards net-centric organizations, services that are offered to the community have to be described allowing their identification, selection, and orchestration. This descriptions need to annotate the services as metadata and describe services, the necessary inputs, the resulting outputs, and how to access these services. This description is posted to a repository. Service consumers go to this repository and search for potential solutions to their problem. If they find a fit based on the description, they use the mechanisms described to access the service. The more agreement we achieve regarding the artifacts we use to describe the systems and services, the easier this communication will be.

The recommended Strategic Project Management Process (SPMP) shown in Figure 2 and document in section 4 of this paper merges the ideas of strategic project management, knowledge management, and the NATO COBP enabling cross-domain re-use of simulation resources. This shows a new and successful application of the ideas captured in the NATO COBP and its broad applicability in support of warfighter challenges.

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