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Infrastructure Operations to Support Environmental Management

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Shougi Suliman Abosuliman

Department of Port and Maritime Transportation
Faculty of Maritime Studies, King Abdulaziz University
P.O. Box 80204, Jeddah, 21589 Saudi Arabia.

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ABSTRACT

This case study concerns National Engineering and Environmental Laboratory, which developed a technical baseline for its infrastructure operations for environmental remediation work. The purpose was to structure operations to comply with stringent regulations and to satisfy a range of stakeholders, plus containment of costs. To achieve the objective, systems engineers were introduced as part of the Environmental Management Integration team. The initial attempt to structure operations through systems engineering was not successful due to lack of clarity in scoping requirements and poor prioritization. The case study clarifies the system process to identify drivers and functional units which contribute the baseline for environment remediation within set budgets. In addition, stakeholders' concerns are addressed.

INTRODUCTION

Systems engineering processes commence with identifying the desired outcome. In this case, the existing model for environmental remediation is deficient, not fit for its purpose. The problems need to be resolved, therefore the work is classified as an ‘existing system' project. As a result, when the perceived deficiency is resolved, the need is satisfied (Blanchard, 1998), or as similarly described, "acquisition is characterized by the user's need and the supply is characterized by the perceived solution" (INCOSE, 2000, s4.1). In the case study, the problem statement is a need for improvement (acquisition) and the solution is applying appropriate systems engineering processes in the existing system project.

Requirements, as the basis of systems engineering, must be comprehensively determined in the initial stages to prevent future variations and higher costs. In this case, although a systems engineering process was undertaken, insufficient information in scoping requirements, poor prioritization of services and inattention to processes led to the lack of a technical baseline. Further, the identified requirements were not necessarily aligned with the system purpose. According to INCOSE (2000), all assumptions, interpretations, and data regarding each requirement should be documented for tracking purposes and future updates, but in this case, such attention to detail was not strictly followed. Hence, it resulted in problems and ambiguities in an allocation of requirements and functional allocation.

Recording processes and inputs is a necessary part of systems engineering. As part of the purpose of systems engineering, that is, to place the order in complexity and to move projects forward to completion, all documents should be continually updated and matched with work plans. If comprehensive records are not kept, when changes occur in the system the process cannot respond, causing greater expenditure and perhaps regulatory difficulties.

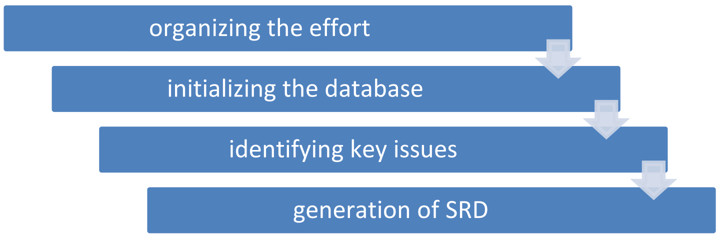
A technical baseline, or full technical documentation, is necessary to maintain control over requirements and specifications. Baselines are a comprehensive tool to compare actual and documented work and identify gaps; they are also useful in identifying variations. A well-defined baseline is critical for system configuration management; it also creates technical integrity for updating purposes. In the case study, creating a technical baseline to achieve appropriate systems planning is the project mission. It includes requirements, interpretations, assumptions, and deliverables; it allows elements to be traced from the point of origin to implementation.

A number of goals are defined in the case study to achieve the mission. Since the system requirements are derived from the customer's point of view, comprehensive identification of the underlying requirements leads is necessary. This is fundamental to the system engineering process and to the efficiency and effectiveness of other processes which will be dependent on it. In the case study, the author categorizes requirements in two distinct groups *what* and *how*; the *what* requirements relate to function and the *why* explains the existence of that particular function. *How* requirements define the manner in which a function must perform. Next, the element of time is entered (e.g. regulatory milestones, agreements between governmental agencies and so on) so that *what* requirements fall into two categories: time-based and *other*: *other* being procedural and strategic objectives.

Record-keeping and data analysis is thus of considerable importance to systems engineering. INCOSE (2000) requires a decision database to record and manage a technical database. In the case study, a formal requirements management system was employed to organize work elements to permit well-defined environmental remediation requirements.

BUILDING BLOCKS

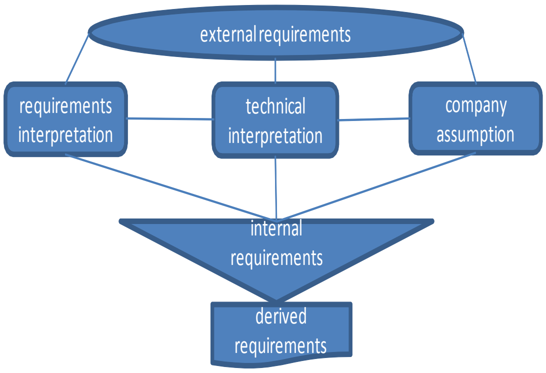
Source or top-level requirements should be captured, extracted, clarified and prioritized. In the case study, a hierarchy system was used, with driving requirements at the top and external and derived requirements at the lower levels. This model assists in interpreting requirements and identifying their relationships, particularly for change and quality management. In change management, the system immediately reflects any variations and responds with actions necessary to control the variation at all levels of the system. Thus, a small change in the system is analyzed and its outcomes are taken into consideration. In the case, quality control management through the system could maintain and control requirements, interpretations, assumptions and any details related to them. The processes are shown in figure 1.



Source INCOSE Systems Engineering Handbook 2011, s.

Figure 1 Identifying and capturing requirements

In the case study, a hierarchy requirements system was formed to accommodate these processes. Figure 2 shows the elements of requirements flow.



Source INCOSE Systems Engineering Handbook 2011, s.

Figure 2 ***Elements of requirements flow-down***

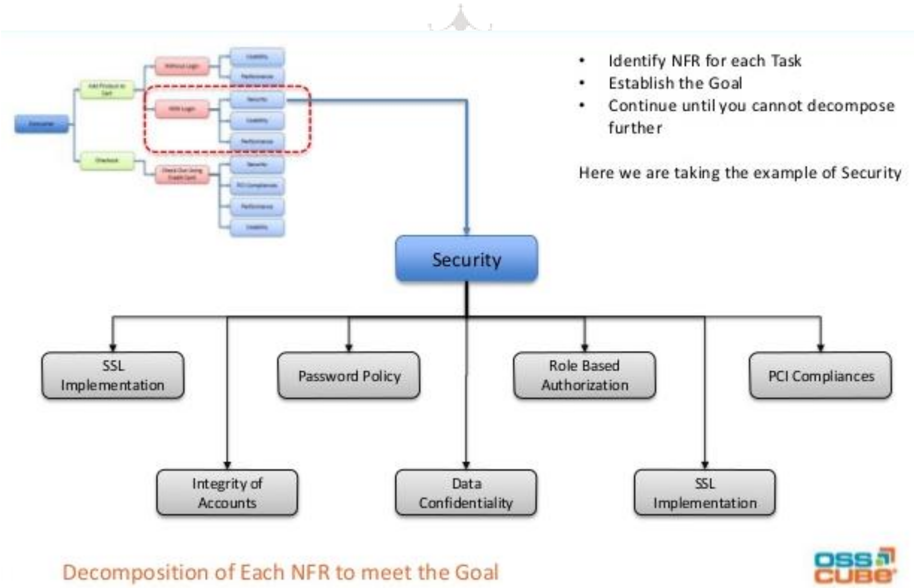


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Figure 3 ***Identification of Non Functional Requirements***

Characteristics of systems engineering design

In systems engineering, models are used to illustrate the pathways for the defined parts of the project, that is, a hard system methodology; however, in infrastructure operations the re are usually less defined soft systems involved. Measurements are the preferred means of control in this system.

To build a technical baseline, identification of relationships and interactions between elements of the system is so important (INCOSE, 2000). The requirements management system described above fulfill this purpose, linking work breakdown structures to their requirements elements, referred to as RDD-100.

Identify and resolve complexity

The number of stakeholders involved in the process and the influence they exert within the system contributes to complexity. Each work package should be identified and the requirements for that particular box captured and maintained; then each box is treated as a function to clarify and organize the system. This involves a high number of individual and interlinked functions which require analysis; provided by the technical baseline and a formal system management.

Where complex analysis is required, particular requirements or functions are deconstructed further to lower levels to simplify the process. For systems engineers, the process involves working with infrastructure operations and programmers to obtain an accurate hierarchy of information for the requirements management system. After validation of requirements, they are then reviewed to reduce the risk. Finally, all requirements, activities, and costs are put together under one configuration control process. This configuration control of technical baseline identifies the cost for each work package, the adequacy of cost controls, and, focusing on critical project requirements, validates the integrity of the system.

Evaluate the application

The case study related to an environmental remediation systems engineering application to establish a technical baseline to record, analyze and review the data and regulatory interfaces. As this objective has a high-interest factor among its stakeholders, a successful system engineering application is vital.

CONCLUSION

Creating a technical baseline is central to systems engineering for infrastructure operations, and in this case, study provides a comprehensive database of functions which underlie the process. Hence, environmentalists can benefit from system engineering in terms of requirements necessary to keep the processes safe and cost-effective, particularly disposition and closure of obsolescent facilities. The lesson is that infrastructure operations can support environmental management by identifying relationships and analyzing components within systems engineering methods. Further, the importance of requirements allocation and baseline development are clear.

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