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Systems Engineering: Success Stories and Lessons Learned

Abstracts of technical papers (Revision 8 August 2008)

Ad Sparrius, Ad Sparrius System Engineering and Management *The Economy is not a Toaster*

Every engineering discipline, including system engineering, is based on a number of assumptions. These assumptions are often unstated, usually taken for granted and seldom scrutinized for their validity. These assumptions also predetermine the range of applicability of that engineering discipline. This paper clearly identifies the taken-for-granted assumptions of system engineering, and tests their validity against a range of typical application areas. This investigation will clearly delineate the applicability area of system engineering.

Cobus Oosthuizen, ESTEQ PLM *Product Lifecycle Management as a tool for Construction Management*

Delivering a plant or mechanical subsystem in a mining environment can be a daunting task. Taking a product from the estimation through engineering, procurement, delivery and installation to the commissioning phases is not trivial. Traditional methodologies focus on Project Management tools and principals to try and manage these hundreds of tasks through completion to deliver a working plant or subsystem.

Every system, subsystem or component in the plant, however go through a very specific lifecycle as it gets estimated, engineered, procured, delivered, installed and commissioned. Using PLM (Product Lifecycle Management) principles, the hundreds of tasks can be structured in a Product Centric way to represent the system or subsystem. The components making up the system can then be managed individually through its lifecycle using PLM and BOM (Bill of Material) management methodologies.

Managing mechanical construction projects using PLM gives the Project Manager complete visibility with regards to the status of all the deliverables on the project as well as control over the financial implications of changes throughout the product lifecycles and thus the project phases. Linking specific scheduled tasks to deliverables not only as single deliverables but specific deliverables in a lifecycle phase enables the project manager to accurately monitor progress and pick up potential problem areas very early in each specific project phase.

This paper covers the concepts of PDM (Product Data Management), PLM and the integration of Project and Product data to create a methodology to manage large scale mechanical construction projects from a product centered basis.

Ray Jenkins, RDL Technologies

Valuable Lessons Learned Performing WLC Analysis for the UK MoD

The author's initial Whole Life Cost (WLC) estimate for the product system he was analysing produced a reaction likened to "so what!" from the Price Forecasting Group (PFG) - UK MoD. But what could be wrong? The author had meticulously included all plausible cost elements and analyzed each of them thoroughly. Frantic investigation revealed that PFG were equally if not more concerned with the cost distribution i.e. what is the probability of the cost being larger or smaller than the actual estimate. For "Main Gate" project submissions 10, 50 and 90th percentile WLC estimates are required. But how do we go about producing these estimates on a grand scale i.e. for a complex product system from cradle to grave?

This paper addresses the typical WLC approach required by PFG. It examines the standard UK MoD Cost Resource Breakdown Structure (CRBS), the structure of bespoke WLC spreadsheet models, the use of the Monte Carlo @Risk spreadsheet add-in, the use of the Master Data and Assumptions List (MDAL), the identification of "levers" and the inclusion of risks in the WLC model. Baseline WLC models are subject to scrutiny by peers and audit by the treasury.

The WLC model remains an integral part of the decision making process of the IPT until the product system is disposed of. The model is continually updated and very often has a dedicated resource assigned to it.

This paper gives a refreshing perspective of WLC or rather Life Cycle Costing (LCC) as we know it, something that the SA Defence Industry should take cognisance of.

Dr Karen Marais, Marike Nel & Jacobus Slabber, University of Stellenbosch

Lessons that should have been learnt: Common Systemic Factors in Accidents

Organisations that poorly manage safety expose themselves to many undesirable outcomes. Accidents directly lead to loss of life and property, adversely affect employee morale and create negative public perception of the organisation. Indirectly it leads to a less motivated workforce, fewer customers, and inherently less profitable financial indicators. Most accidents can be shown to be caused in part by shortcomings at the organisational level such as poor communication and the incapability to realise important precursor information and consequently take the appropriate corrective action. The accident at BP's Texas City plant occurred in part because of deficiencies in ensuring adequate management and board oversight, measuring process safety performance and investigating incidents and near misses.

In this paper we use several notorious accidents to draw general lessons for developing and operating safer systems. First we review several classic as well as more recent accident modelling approaches. Next we use aspects of these models in combination with several real-life accidents to show how factors such as organisational culture and corporate structure influence safety and may ultimately contribute to accidents.

We argue that many accidents result from a failure to consider safety from a systems viewpoint and to better manage safety it is necessary to take a broad systemic view of safety and the way safety systems influence day-to-day processes within an organisation. The work can be used by managers to become more aware of safety matters and their importance in complex socio-technical systems, to better understand what precursors to look for in systems safety and what cultural aspects of an organisation, concerning safety, to identify for the process of implementing corrective changes.

**Charl Petzer, Pebble Bed Modular Reactor
PBMR Design for Nuclear Safety Process**

In the Nuclear Power Plant design environment, the derivation of Safety Functions and design criteria is to a large extent based on experiential or legacy data. The Light Water Reactor Technology is used as basis for most commercial nuclear power plants and has matured through an evolutionary process over the last fifty years. More than ten thousand reactor years of experience exists. Accidents happened, of which some were catastrophic, and some were not. It is essential to take note of this experience and build new designs on these lessons learned. The Light Water Reactor technology also forms, to a large extent, the current licensing basis for nuclear reactors.

Reality, however, is that when a new technology is developed, this legacy is not always applicable and a systematic approach is required to design a safe Nuclear Power Plant and to assess the plant design against relevant regulatory requirements.

The intent of this paper is to demonstrate how a systematic approach, using Systems Engineering Principles could be used to develop a Design for Nuclear Safety Process, where the industry best practices and experiential data are married with that which was developed using an analytical approach.

**Francois Retief, FALK Systems Engineering and Consulting
Practical Experience in the Successful Delivery of Large Scale Software Based Systems**

According to the findings of the Standish Chaos Report based on data of more than 50,000 software projects, most software projects are still seriously challenged or fail completely. Yet there are groups that consistently deliver on time, within budget, and manage to keep customers and management happy. This paper presents an overview of the process elements that has been found to ensure the desired predictability, visibility and stakeholder satisfaction in telematics systems development - a large, complex software development environment. It includes an introduction to the agile and iterative software development practices that form the basis of the approach followed. Project phases, team composition, levels of responsibility and involvement at various stages are discussed. Tools and artifacts to improve communication and efficiency are presented, combining theory with practical experience.

**Duarte Gonçalves, CSIR DPSS
Coordination : Processes and Beyond**

Systems engineering is about coordination, amongst other things. To coordinate is to bring the different elements of a complex activity or organization into a harmonious or effective relationship as a whole system. This paper views coordination in the context of unprecedented or innovative systems and attempts to focus some attention on important social issues relating to how work gets done. A framework of coordination mechanisms is developed. Coordination can be performed using processes, work products, skill/knowledge and mutual adjustment (personal or group communication). Under conditions of high task uncertainty, high task interdependence and dynamic environments, mutual adjustment is favoured as opposed to process. Under these conditions this is not a choice. Most methodologies use *some combination* of the basic coordination mechanisms. The paper presents a case study illustrating certain aspects of coordination.

**Madalein Young, Armscor
System Development: a Few Lessons Learned**

The Systems Engineering (SE) process is well defined for the development of a system which is readily identifiable as a hardware or software system and as such can easily be classified as the “created system”. The SE process and discipline are still not readily accepted as being applicable to the management of change or a “creating system”. Unfortunately, management still assumes that SE and SE Management can not address the organisation as a system itself. This paper addresses what not to do in development of complex systems seemingly not focused on what is more traditionally perceived as hardware or software system components, e.g. a creating system vs. the created system. The importance of utilizing structured development processes and suitable system architectures are stressed, arguing that it provides sanity when chaos would otherwise prevail and shares valuable lessons learned through practical experience and careful observation.

Piet de Klerk, Deksystemtech
Systems Design in Different Industries or Markets

This paper attempts to illustrate the differences between the approach used for systems design in the traditional environment for systems engineering, (e.g. the defense industry), and the practices in a commodity market where cost is often the prime driver for the design.

The example used is the electricity metering industry, which is moving towards systems installations due to requirements for Automatic Meter Reading (AMR) and Demand Side Management (DSM). This movement is driven by the concern about increasing use of non renewable resources and the effect thereof on the environment.

In some industries the change towards geographically distributed systems requires an approach that is unfamiliar to the commodity designers, like the need to clearly define complex interfaces between subsystems. Systems engineers who are not necessarily expert designers of these products can provide valuable inputs until suitable new standards emerge and are accepted.

Although the inherent value system of the project is often not explicitly defined, the techniques utilized by the systems engineering discipline are implicitly applied by designers of commodity products when complexity increases, albeit in different forms and to different degrees of detail. The Life Cycle Approach is strongly driven by business imperatives, from market research through to product phase out and disposal of materials.

Systems engineering expertise is certainly required to manage the increasing complexity emerging in industries that were until recently focused purely on the design and manufacture of well defined products with standardized interfaces.

André Labuschagne, Pebble Bed Modular Reactor
Product Development – Structuring for Success

The impact of incorrect and/or non-aligned project management structures is often underestimated. The Product Breakdown Structure (PBS), Work Breakdown Structure (WBS) and Contract Breakdown Structure (CBS) in product-based projects are often alienated from each other due to the fact that different role players/disciplines in the project take ownership of these structures. Each structure has a purpose to fulfill, but as in most engineering challenges, there are few aspects which can be considered in isolation. Understanding the basis and interaction between these structures will put a project on a course for success. Techniques, pitfalls and good practices are discussed.

Dr Ben van Tonder, Consultant
From Bid Winning to Project Closure: System Life Cycle Management for Business Success

Business success and technical project success both require an environment that can reconcile the need to keep risks under control with what is required to stimulate innovation in the business and technical environments. Business success is a prerequisite for the existence of engineering projects in the private sector. From a business project perspective the development, implementation and assurance of processes to meet client requirements and business needs at the same time, are critical success factors.

The concepts of life cycle phases and system hierarchy are fundamental concepts not only for the understanding and management of engineering projects, but also for business projects. Effective ways and means to assure the integrity of system management processes determine to a large extent the probability of success in an environment where conflicting external requirements often start to dominate. Without effective process assurance, unrealistic tailoring and organizational politically correct reporting often becomes the norm. Baseline reviews to support reasonable milestone decisions play a major role in preventing the often-encountered schedule and cost optimism and unrealistic resource allocation leading to engineering project crises and even disaster.

The value and importance of project gate reviews on the different levels of the business hierarchy is often underestimated and neglected as a result of haphazard processes and crisis management. At the same time there is a need to understand and address problems caused by differences in terminology and different representation of similar processes in the acquisition, system engineering and business management environments and its impact on internal and external business and engineering communication.

In this paper the requirements for successful project life cycle management and gate reviews, barriers to communications and cooperation, decision-making processes at gate reviews as well as experiences during the implementation of acquisition and business review processes are discussed.