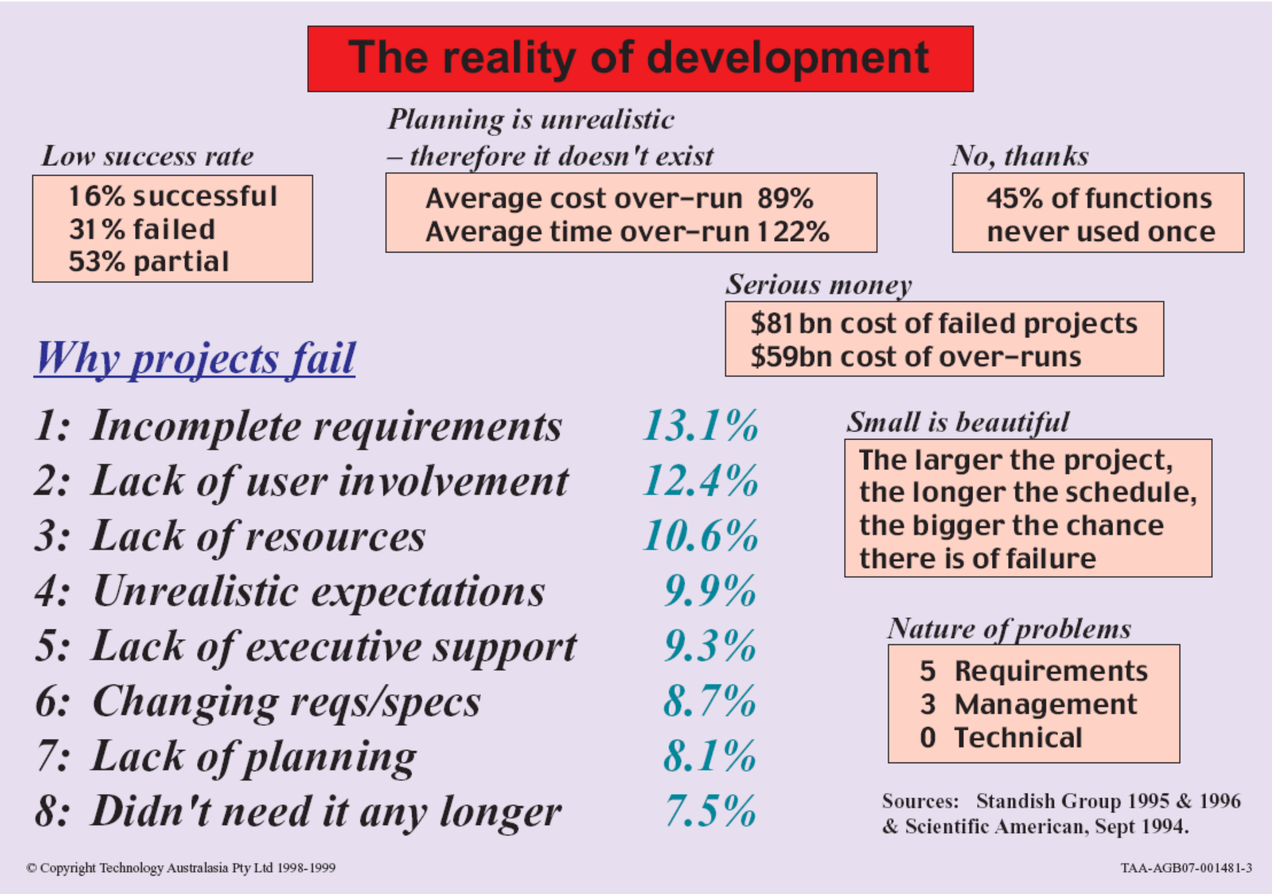

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ISSUE 2

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21 Principles of Systems Engineering

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Introduction

Thirty five years of practicing the engineering of systems, and thirteen years of teaching the discipline worldwide through public and in-house training courses to the world's best enterprises, has lead me to the conclusion that principles are everything.

A principle is a guideline. A principle provides the direction.

Principles are not laws. Laws are immutable, typically governed by the physics of the universe. But principles – they are the shining lights, the beacons that guide us to the promised land. From principles flow processes. Sound processes implement valid principles. From processes flow software tools. Tools, selected wisely, can bring about efficiencies that are not otherwise possible in implementing principles.

I have found that the principles of systems engineering apply to the engineering of any system, whether a new military capability system, a public infrastructure system, or a chip for use within a cell phone. This short article outlines 21 principles that I have found to be the most valuable for achieving great results in the engineering of systems.

The 21 Most Important Principles in the Engineering of Systems (Systems Engineering)

Principle 1: Capture and understand requirements, measures of effectiveness (MOEs), goals and relative values of outcomes before committing to the solution to a problem.

Principle 2: Ensure that the requirements (must be met) are consistent with what is believed will be possible in solutions at the time of physical implementation, i.e., are feasible.

Principle 3: Treat as goals desired characteristics that *may* not be feasible. Note that "treat as a goal" means that solution alternatives will be sought and alternatives evaluated in pursuit of the goal, to an extent which depends on the relative importance of the goal in relation to other goals.

Principle 4: Define system requirements, measures of effectiveness (MOEs), goals and solutions having regard to the whole of the (remaining) life cycle of the system of interest.

Principle 5: Design a solution by dividing the big problem into a set of individually well-defined smaller problems, i.e., by defining the required characteristics of each element of the solution (including both product and process elements).

Principle 6: Use sequential solution development (waterfall, grand design, "big bang", etc) for design, where requirements (etc) are well defined and stable, and solutions are relatively simple or well understood.

Principle 7: Use incremental development where requirements (etc) are well defined and stable, but solutions have risk due to technology and/or due to complexity.

Principle 8: Use evolutionary development where requirements (etc) are as well defined as is possible in the circumstances, but remain inadequately defined, or are subject to change.

Evolutionary development should not normally be used as an alternative to capturing what is known and knowable about the problem.

Principle 9: Use a stage-based, stage gate, risk (and opportunity)-driven style of development as an overall strategy for solution development.

Principle 10: The systems engineering process elements (requirements analysis, physical design, logical design, effectiveness evaluation and decision, specification writing, verification, validation, system integration and engineering management) exist within the context of sequential, incremental, evolutionary and risk-driven styles of development. Design the development process to match the nature of the problem, using the SE process elements as building blocks.

Principle 11: Maintain a distinction between the statement of the problem to be solved and the description of the solution to that problem, for the system of interest and for each element of the selected solution. Note that "the statement of the problem to be solved" is expressed in terms of requirements, measures of effectiveness, goals and value relationships.

Principle 12: Baseline the statement of the problem to be solved and the description of the solution to that problem. Control changes to requirements (etc) and to design, maintaining traceability to the applicable baseline.

Principle 13: Identify and develop solution alternatives that are both feasible (i.e. can meet requirements) and are potentially the most effective.

MOEs could include, for example, development cost, unit cost of production, time-to-market and other measures unrelated to capability of the solution when used.

Principle 14: Respect, nurture, and reward knowledge of relevant solution technologies, creativity and innovation.

Engineering processes are worthless without knowledge of relevant solution technologies. Creativity and innovation enable better solutions. Other SE principles help transform good/great ideas into good/great solutions.

Principle 15: Develop solutions for relevant enabling systems concurrently, and in balance, with the solution to the system of interest.

An enabling system is a system which makes possible the creation, or ongoing availability for use, of the system of interest during some part of its life cycle, e.g. a production system, a maintenance system.

Principle 16: Except for simple problems, develop logical solution descriptions (description of the logic of how the solution is to meet requirements) as a means of developing physical solution descriptions (description of how to build the solution).

Principle 17: Be prepared to iterate in design to drive up the benefit, to the stakeholders we are serving, of the outcomes of design.

Principle 18: Select between (feasible) design alternatives, based on the evaluation of expected benefit to applicable stakeholders, i.e., on expected effectiveness. The term "expected effectiveness" refers to effectiveness which incorporates uncertainty, thereby reflecting risk and opportunity.

Principle 19: Subject to level of risk, independently verify work products (is the job being done right, i.e., does the work product meet the requirements for that work product, with optimum effectiveness?).

Principle 20: Subject to level of risk, independently validate work products (is the right job being done, i.e., does the work product meet the need for that work product?).

Principle 21: Some management (planning, organizing, motivating, measuring and exercise of control) is needed to achieve the effective and efficient transformation of requirements (etc) into solution descriptions - this is unlikely to *just happen*.

In Closing

Having considered these systems engineering principles, now consider their application to the engineering of software. It is any surprise that systems and software engineering are converging, as evidenced by the Rational Unified Process (RUP) – strongly based on systems engineering principles. As evidenced by CMMI, for which a common reference model of systems and software engineering has been the outcome. As evidenced by SysML, running parallel with UML under common leadership by the OMG, with inevitably the two converging.

Now consider the applicability of these principles to the engineering of non-systems: engineered items that are not usefully viewed as being constructed of interacting components. Email me with your thoughts.

A New Approach to Systems Engineering

Jeremy Dick, Jonathon Chard, Renate Stuecka, Telelogic

What is the relationship between requirements management and system modeling? How should they work together? Answers can be found by discussing these questions from a process perspective. Requirements management and systems modeling complement each other, together delivering advantages to the systems engineer.

To precisely understand the needs of a system engineer the following definition by INCOSE is helpful: "Systems Engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem[1].

Systems Engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation."

From this description, it is clear that system engineering is a wider discipline than software engineering alone, covering the development of complex entities of which software forms only a part. There is a strong emphasis on requirements management, starting very early in the development cycle with business and customer statements of need. As the system is designed into sub-systems and components, the need for software components is identified, and the disciplines of software engineering become relevant as part of the overall systems engineering approach.

A key feature of systems engineering is the use of layers of design to manage complexity. Figure 1 — drawn from Telelogic's training course entitled "Effective Requirements Management" — shows a typical division of the systems development process into layers. The top layer addresses the overall need, and is a definition of the problem in the language of the stakeholders — those who benefit from, use, or are otherwise affected by the system. Subsequent layers address the solution to be provided, at first abstract, then becoming more and more detailed.

Requirements Management Essentials

Requirements management covers the following key concerns:

- Requirements capture: How to elicit, capture and express requirements in a clear, unambiguous way.
- Requirements presentation: How to organize and present sets of requirements as documents.
- Requirements analysis: How to trace the effect and satisfaction of each requirement through the design layers.
- Change management: How to understand the impact of changes up and down the levels of requirement.
- Configuration management: How to manage the evolution of sets of requirements relating to version and variants of a system.

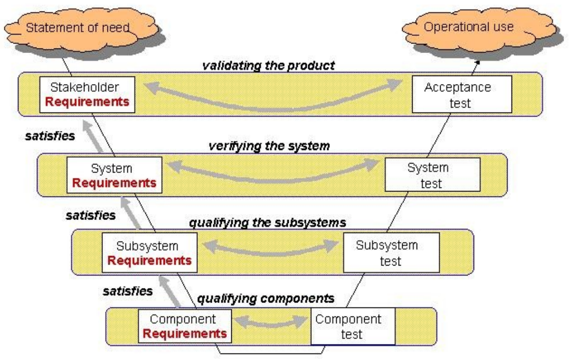

Figure 1: Typical layered approach to systems engineering

Requirements management has a role to play at each level of system engineering. The traceability of requirements between layers is a key discipline.

Systems Modeling

Modeling supports the analysis and design process by introducing a degree of formality into the way systems are defined. Rather than relying purely on text and pictures, modeling allows the definition and structure of a system to be visualized using diagrams. It is essential to distinguish between pictures and diagrams: Pictures are informal graphical representations and can be used in an entirely ad-hoc way. Although frequently used as an aid to communicating ideas, they usually require explanation of the meaning to be useful. Diagrams, on the other hand, are a formalized graphical representation where graphical entities have standardized syntax and in some cases semantics.

This makes diagrams a much more suitable medium for understanding and communicating, as the explanation of a diagram's meaning is standardized.
Some of the major benefits of modeling are:

- It allows system specification and design to be visualized in diagrams using a precisely defined vocabulary consistent across the system.
- It allows consideration of multiple interacting aspects and views of a system.
- It allows validation of some aspects of the system design through animation.
- It allows progressive refinement towards detailed software design, permitting test case generation and code generation.
- It encourages communication between different organizations by using common standard notations (in the case of UML 2.0).

UML (the Unified Modeling Language™) which is an industry-standard managed by the Object Management Group™ (OMG™) (www.omg.org), supports the definition of many aspects that can be found in almost all systems.

Tying Requirements Management and Systems Engineering

How are requirements management and systems engineering tied together? Figure 2 summarizes the key concept by comparing the relationship between requirements management and systems modeling to a club sandwich.

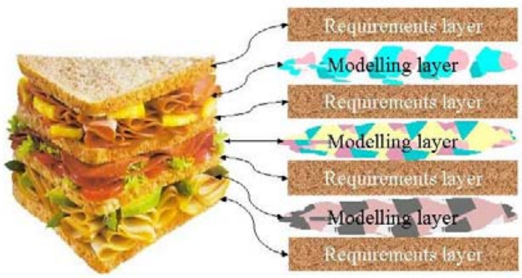

Figure 2: Requirements management/modeling sandwich

In this analogy, requirements management is the "bread and butter" of the development cycle. What is a sandwich without the bread? However, requirements alone are a little dry; the filling provided by system modeling holds the bread together, and makes the whole rather more interesting. It is both the bread and the filling that make the sandwich.

Requirements management and system modeling are entirely complementary. Requirements management traditionally focuses on the capture of concise expressions of atomic textual requirements and supporting informal pictures contained in documents. It also covers change management through impact analysis enabled by traceability. A key strength of Telelogic DOORS, the market leading requirements management tool[2] , is the ability to create and publish sets of requirements as documents, and yet be able to process the individual statements in those documents as valuable items of data for the purposes of change management, version control and traceability.

In contrast, modeling is concerned with the graphical representation of multiple views of structured information offering the ability to check coherence across the whole system through use of a central data dictionary. Thus modeling can assist the engineer in developing a consistent terminology across all requirements. The notations used assist in the elicitation of system information and structure, by guiding the engineer to ask the right kinds of question to complete the model. These capabilities are provided in the DOORS/Analyst tool.

In this context it is relevant to mention that full-blown UML 2.0-based systems and software development tools such as Telelogic TAU offer additional powerful capabilities not available in DOORS/Analyst. This includes the possibility of simulating and animating the model to aid in the validation process, and the ability to generate code when the model is detailed enough to constitute a complete software design.

However, the system model is not the requirement. Many engineers make the mistake of believing that the system model is itself a sufficient statement of the requirements. This is not the case. Even if the UML model is detailed enough to allow code generation, there are aspects of the system — especially non-functional requirements, such as performance, safety, ease-of-use, etc. — which are not captured in the system model. These additional requirements have to be tracked and test cases designed against them. This requires the existence of an RM activity along side the modeling.

There are also difficulties in using the model alone as a contractual statement; in most cases, customer/supplier agreements still expect or require the use of textual documents to express the contract. The models may appear in the form of diagrams within those documents, but the diagrams alone are usually an insufficient basis for a contract.
The typical layered approach to systems engineering is a way of dividing and conquering the complexity involved in many of today's systems: an essential prerequisite to facilitate an engineering process which nearly always spans multiple organizations. A different organization may be carrying out each layer of engineering. The layers represent levels of abstraction.

Modeling should occur at all levels, but at different degrees of abstraction. This means that the same entity may play a different role in the models at each layer.

Attempting to manage several layers of abstraction in a single model adds complexity. So rather than attempt to combine various representations of the same entity in a single UML model, an approach is to build separate models at each level. Some details of the last model will be used to seed the next model, but the role of the various entities will evolve and become more detailed through the layers. Techniques of traceability can be used to map the correspondence between the models across layers.

Modeling provides the design rationale and supports the design activity. It assists the engineer in understanding enough of the system to decompose the requirements at a particular level into the next level down. The requirements themselves are a complete snapshot of what is required at increasing levels of detail. Modeling is where most of the creative work takes place, resulting in a design document containing the diagrams of the model and textual explanations, rationale and context.

Conclusion

Interlocking of the disciplines of requirements management, represented by the capabilities of DOORS, and of system modeling using UML 2.0 respectively is provided by DOORS/Analyst. The following benefits are accruing from an effective process integration of requirements management and system modeling:

- System modeling adds formality to the design process that lies between each layer of requirements.
- System modeling supports the construction of a consistent vocabulary for the textual expression of requirements.
- The design rationale gathered around the system model becomes the rationale for traceability between layers of requirements.
- The structure of the system model can be used to give structure to the requirements document.
- System models can be embedded in system design documents. These can provide textual context for the system model, giving rationale for design choices, explanations of diagrams, etc.
- Impact analysis can be carried out uniformly through requirements and models.
- Non-functional and performance requirements not captured in the model can be managed as textual statements.

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[1] (http://www.incose.org/practice/whatissystemseng.aspx)
[2] "What are your requirements?" 2003, The Standish Group. 2003. www.standishgroup.com

A clear audit trail justifies key decisions - Making the right choices for achieving value for money (VfM)

John Thompson CEO - Commerce Decisions Ltd UK john.thompson@commercedecisions.com www.commercedecisions.com

Throughout any major procurement project it is necessary to make a series of vital decisions. First, decisions have to be taken to initiate the project. Then decisions regarding the procurement route and the feasibility of the project have to be taken. Further decisions have to be made about the nature of the contract to be awarded.

Ultimately prospective partners have to be chosen based on the assessment of various proposals and presentations. At each point valuable resources are being committed. It therefore makes good business sense that a proper audit trail clearly justifies why each and every key decision is taken.

Perhaps the most contentious decision is that of the appointment of the preferred bidder and the subsequent trade-off decisions in the negotiations leading to financial close. It is at this point in the programme that the successful project manager can drive value for money (VfM) in the final contract by taking informed, auditable decisions.

These decisions need to be well informed in order to provide an optimal basis for moving forward with the preferred bidder. In the case of government contracts they need to be auditable to comply with legislation, and to protect the awarding authority from legal challenge.

Recent EU legislation presents various options for challenge by losing consortia, and such legal challenges are becoming commonplace in Europe just as they have been for many years in the more litigious US market. These legal options are available to UK bidders under European law.

Speed and cost

The need to apply rigour to the process of decision-making must not result in slow or indecisive progress in the procurement. All the time that multiple suppliers are engaged in the process, the eventual losing bidders are incurring costs that they can not recover from the project.

A failure to minimise bidder's costs can damage future business relationships and may reduce competition on future competitive procurements. We believe that to achieve significant improvement in the quality, auditability and timeliness of decision-making, the use of best practice methodologies, supported by purpose-built software tools, is required.

The challenge

If it is accepted that decision-making must be transparent and executed against a best practice methodology, achieving it is actually a task of considerable difficulty both in terms of administration and as an intellectual exercise.

The decision to appoint a particular consortium as preferred bidder will depend on many factors. The largest project we have supported analysed 1,750 factors (or criteria). Even a relatively simple scheme may involve the analysis of each proposal against 150-200 key criteria in order to differentiate the competitors, and determine the most promising areas for negotiation.

No single person or advisor is likely to be expert on each of the factors. So it is necessary to take a collaborative approach, with subject-matter experts scoring appropriate criteria. These experts may work for different organisations at multiple locations. Best practice suggests that each criterion should be analysed independently by multiple experts, who then develop a consensus score, ensuring there is no individual bias.

Against each criterion, multiple scores may need to be recorded. As well as recording a basic score, a more robust decision can be taken if other information such as the risks, uncertainties and innovations associated with the bidder's approach to the particular issue are recorded.

The total number of scorecards required can therefore be calculated from the following formula:

> Number of score cards = [number of criteria] * [average number of independent assessors per criterion] * [number of score types (e.g. score, risk)] * [number of bidders]

Most major public or private procurements require the completion of thousands, or even tens of thousands of scores to properly and robustly analyse all the issues involved in the proposal before awarding a contract. Each of these scores needs to be based on auditable evidence, and the scores themselves need to be collated into a defensible report for decision makers, with the extraction of the key differentiators between consortia from the mass of data.

When presented with this administrative challenge many project directors and managers turn to the spreadsheet and, as the spreadsheet starts to grow in complexity, the problem of managing it is sometimes handed over to external advisors.

The use of spreadsheets has been found to be problematic, and purpose-built commercial off-the-shelf (COTS) software products are now emerging to enable the procuring organisations and their advisors to better tackle the problem.

Lack of a trail

Spreadsheets do not keep good audit trails. They can record a score, but the rationale behind the score and links to the evidence from the bid documents are not well supported. The reasons for arriving at a particular consensus score for a factor, after collaboration between appropriate experts, is usually lost, leaving the project open to accusations of arbitrary scoring of proposals.

Secondly, spreadsheets do not support the various roles and workflows involved in complex procurements. It is essential to separate the process of creating and weighting criteria structures from the process of recording scores against criteria. If an assessor is simply answering questions without prior knowledge of how the answers are to be analysed, it is much easier to make a case that the analysis has not been biased. Additionally a spreadsheet does not tell its users what work they need to do, and which tasks are most important. A spreadsheet is also not good at coping with incomplete data, making it hard to make early conclusions, even if competing proposals are well differentiated.

Tools such as AWARD™ provide much more appropriate support to the project teams. Once an evaluation model is established in the tool, scorecards are automatically issued to the appropriate people, either to their web-browser or via email for off-line users. The scorecards capture rationales and evidence links back to the bid documents. Web-search-type capabilities are provided to rapidly locate relevant information in proposals. Tools of this nature ensure that important criteria are addressed first, reducing the time required before a bidder can be accepted or rejected.

The manager of the evaluation can closely monitor the progress of his team, and see the results as soon as they emerge. Feedback from users indicates that, on average, the proposal evaluation can be completed 40% more quickly, and that losing bidders can be provided with robust debriefs, so helping to maintain relationships in the future.

Methodological difficulties

In addition to the administrative difficulties in making procurement decisions there are also a number of 'intellectual' or methodological difficulties in arriving at a transparent verdict.

The first is how to measure and audit decisions concerning 'soft' issues. The very nature of major procurements means that soft issues beyond technical requirements are often extremely important. However, these issues are not always addressed in a manner which would stand up to scrutiny or, in the case of public sector procurements, in court. 'Gut feel is just not good enough'. Decision parameters must be laid out before proposals are returned and, critically, strong evidence must be presented to justify value judgements made by the team or individual.

It is quite acceptable to reject a bidder due to poor perceived performance on 'soft issues' such as partnership or trust. However, to do this there must be an objective framework established to measure the soft issue. For example, partnership could be measured by taking up and recording references from the supplier's other partners, or by measuring various aspects of the past performance of the supplier on similar contracts.

Even measuring more straightforward, hard, requirement-led criteria can be challenging. If the requirements and criteria are too prescriptive, the project may not benefit from the technical and innovative expertise of the bidding organisation. If the requirements are too open-ended or high-level, key issues will be missed until after the contract is signed, creating expense and embarrassment for all concerned.

Additionally, establishing decision-making models is made more difficult because of the need to engage a potentially wide stakeholder group in agreeing the criteria, weightings and measurement scales to be used.

There are a number of best practice methods available in the public domain for addressing these challenges. Fundamentally all of these methodologies can be described as hierarchical decision-making processes (HDMP) an example of which is multi-attribute choice elucidation (MACE) which is the methodology preferred and published by the UK MOD in their Acquisition Management System (AMS), and used widely on major defence projects.

At their heart, these methods provide a mechanism for measuring and optimising the value for money (VfM) offered in supplier proposals. What is meant by value clearly varies significantly between projects. The value of a leisure centre is different from the value in a school or defence system. Processes such as MACE instil the discipline of building the value-for-money (VfM) model early in the project.

The model, and plans for how it is to be used once bids are returned, should, critically, be owned by the procuring authority. This is considered best practice and recent documentation from the UK Office of Government Commerce (OGC) also emphasises planning of the decision-making process.

We believe that wider application of auditable decision-making processes such as MACE, particularly in the PFI/PPP community, would result in better value-for-money (VfM) schemes and a more motivated supplier base.

Conclusion

Thoroughly and comprehensively understanding bidders' proposals and comparing them properly and fairly are very difficult. However, when the stakes are so high financially and politically for both procurer and bidder in the public sector, the task has to be done properly. Often, to provide ease of administration and audit, the task is performed in an over-simplistic manner which leads to a weak negotiating platform and unnecessarily high legal bills. This is because a thorough understanding of the proposal is not grasped early enough in the process.

Best practice processes, such as UK MOD's MACE, do exist in the public domain, and using them results in a much more auditable and robust approach to bid assessment and supplier selection. However, until recently the lack of appropriate tools has meant these approaches can be unwieldy and time consuming, increasing bidder's costs.

Recent developments in the software industry have led to the creation of software tools which specifically address the business problem of making high-value auditable decisions. These allow best practice to be followed, but also enable the process to be untaken more quickly, saving costs for both procurer and bidder.

Commerce Decisions' AWARD™ software has supported private and public-sector procurement projects worth over £16 billion, including £4 billion of PFI in the defence, education and leisure sectors. Contact in Nordic is Hannu Snellman; hannu.snellman@middleware.fi

The application of sound systems engineering principles to Pre-Feasibility Study for Talvivaara Mine

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Introduction

Talvivaara Project is aiming to open a cost-effective Talvivaara Mine operation in year 2009. This 300 MEUR major mining project requires a well defined project guidelines and processes. From the beginning of the project it was clear to the Management of the Talvivaara Project that better end results would become with applying systems engineering principles. Despite the Talvivaara Mine do not require substantial system development a sound systems engineering will give instrument for easier project management and later on a good base for systems acquisitions.

This article describes the scope of work required during the Pre-Feasibility phase of the project (figure 1).

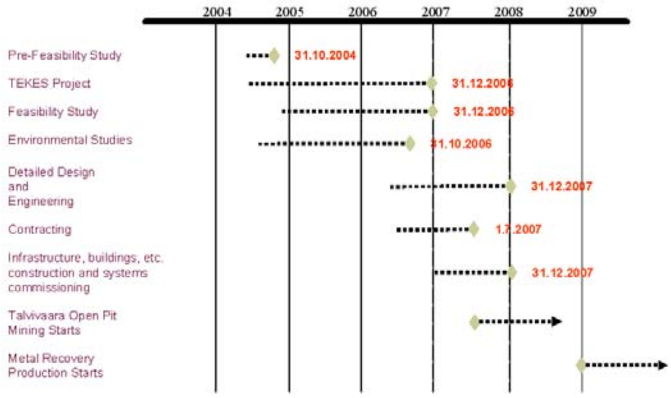

Figure 1 The Master Schedule of the Talvivaara Project.

Talvivaara Mine

The Talvivaara Ni-Cu-Zn-Co-S deposit occurs in the southern part of the Kainuu schist zone. The anomalous grades of black schists have been known from geological mapping and prospecting carried out in the early 20th century. Geological Survey of Finland decided to continue exploration of the Talvivaara area in 1977. This exploration program was a systematic evaluation of the black schist zone in the area and led to the first estimation of the mineral resources of the Talvivaara deposit. Talvivaara ore contains several metal sulphides: pyrite, pyrrhotite, pentlandite, sphalerite, chalcopyrite and alabandite. The average metal content (cut-off 0.15% Ni) in Kuusilampi and Kolmisoppi deposits (figure 2) is fairly close to each other being 0.29% Ni, 0.15%Cu, 0.57%Zn, 0.024% Co, 8.6-10.6%S and 7.5-8.3%C.

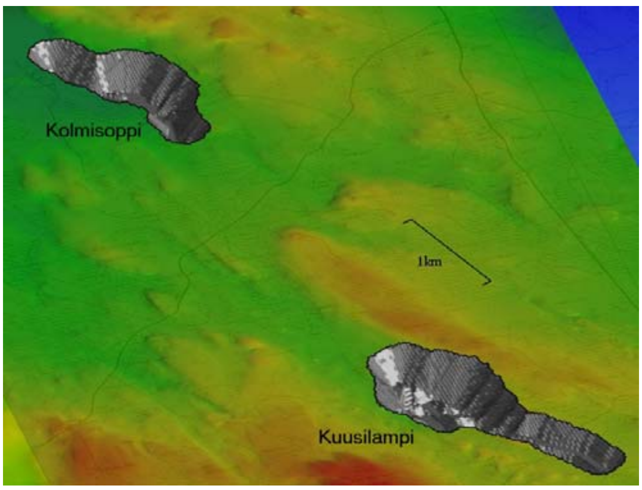

Figure 2 Kolmisoppi and Kuusilampi open pits.

Pre-Feasibility Study

The Talvivaara Mine main process is described in Figure 3. It consists of 8 different processes, each performing one or more of the 4 generic primary functions: Transform, Transfer, Store or Manage.

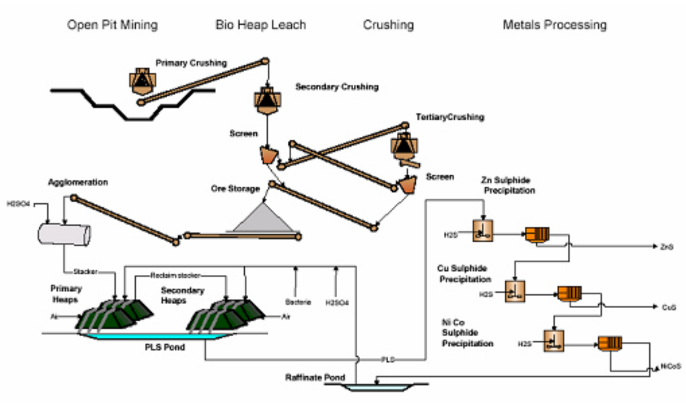

Figure 3 The main process of the Talvivaara Mine

Each process requires a system (figure 4) to satisfy the need to perform (execute) the functions of a process and to deliver the required outputs. Performing (executing) and delivering the required outputs each system has its specific costs (acquisition and utilization costs) and effectiveness.

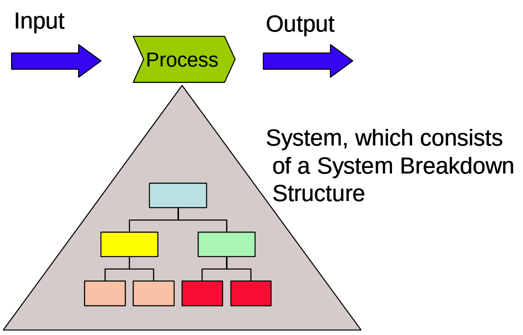

Figure 4 A System and a System Breakdown Structure

The following Systems have been identified from the main process (figure 3):

- Mining System
- Materials Handling I System
- Bioleaching System I
- Materials Handling II System
- Bioleaching System II
- Metal Recovery System (combination of Cu,Zn, Ni, Co and S)

Administration and Infrastructure processes are required to support the main process.

Figure 5 shows the Scope of Work (all high level work) required for the Pre-Feasibility Phase study of the Talvivaara Project.

The main purpose of the breakdown of the work is to create deliverables (documents and models) such a way that they are easier to manage and maintain during the Pre-Feasibility Study process. The final integration of the work is done when combining all relevant information to the Talvivaara Pre-Feasibility Study document.

For each process (figure 3) and its system (figure 4) a User Requirement Statement (URS) and following list of documents/models shall be created:

- Operating Concept Report
- Support Concept Report
- System Breakdown Structure Model
- Life Cycle Cost Model
- Effectiveness Model

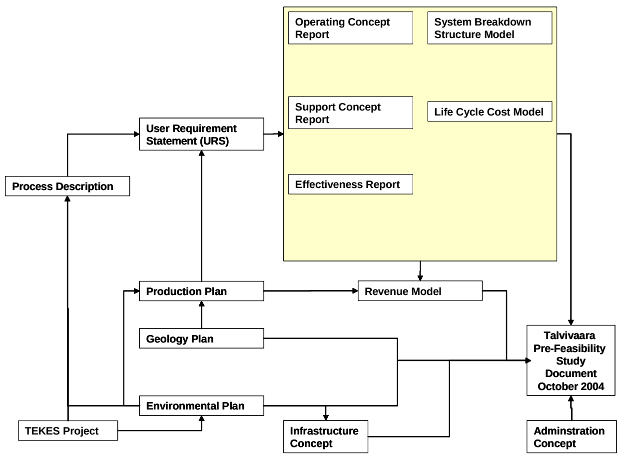

Figure 5 The Scope of Work for Pre-Feasibility Phase

Summary

One of the purposes of the Pre-Feasibility Study is to produce documentary that each statement or parameter can be easily traced and justified ie. audited by third party. On the other hand the work will produce a good knowledge base for acquiring the required systems from the suppliers in the future.

Systems engineering principles give a sound basis for both above purposes and easier control of the project.

More information:

- www.talvivaara.com
- www.saptech.fi

KOKEMUKSIA VAATIMUSHALLINNAN JA VAATIMUSMÄÄRITTELYN SOVELTAMISESTA

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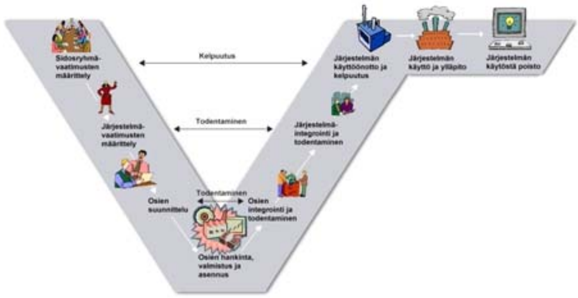
Yrityksiin, tuotteisiin, järjestelmiin sekä palveluihin kohdistuvien odotusten ja vaatimusten merkitys on alettu ymmärtää yhä paremmin - erityisesti epäonnistuneiden hankkeiden seurauksena. Vaatimuksia asettavat lukuisat eri tahot. Sidosryhmiksi kutsutut tahot voidaan jakaa sisäisiin ja ulkoisiin. Ulkoisia sidosryhmiä ovat omistajat, rahoittajat, toimittajat, alihankkijat, viranomaiset, tarkastuslaitokset jne. Parhaimpana esimerkkinä sisäisistä ovat tietysti käyttäjät.

Vaatimusten systemaattinen hallinta onkin eräs projektien laadun ja riskienhallinnan parantamisen keino. Hyvin hoidettuna se tuottaa yrityksille hyötyinä onnistuneet projektit ja tuotteet, mikä näkyy varmasti myös taloudellisessa tuloksessa. Tätä mieltä ovat RAMSE Consultingin konsultit Markus Renlund, Veli Taskinen, Mikko Horto, Miika Hyvärinen ja Riitta Sutinen, jotka ovat soveltaneet vaatimushallintaa erityyppisissä investointi ja kehitysprojekteissa.

Mistä vaatimustenhallinnassa on pohjimmiltaan kyse?

Eikö jokainen työssään hallitse vaatimuksia päivittäin? Eikö vaatimuksia tiedetä ilman vaatimustenhallintaakin? Kyllä, jokainen hallitsee jotenkin vaatimuksia päivittäin, mutta sitä ei aina tehdä systemaattisesti. Tavoitteita ja toiveita ei kuitenkaan mielletä vaatimuksiksi. Vaatimuksista tiedetään ja määritellään osa, mutta niitä ei ole osattu ilmaista selkeästi. Kaikkia sidosryhmien odotuksia ei useinkaan ole ilmaistu vaatimuksina ennen tuotteen tai palvelun hankintaa, suunnittelua ja toteutusta. Ne tulevat valitettavan usein esille vasta järjestelmää tai palvelua käytettäessä, mikä näkyy käyttäjien tyytymättömyytenä ja lisäkustannuksina sekä toimittajalle että sidosryhmille. Suuren vaatimusjoukon hallitseminen onkin vaikeaa ilman oikeita menettelytapoja ja -työkaluja.

Vaatimustenhallinta voidaan nähdä välineenä, jonka avulla muunnetaan eri sidosryhmien tarpeet, odotukset ja toiveet yksiselitteisiksi, suunnittelijoiden ymmärtämiksi vaatimuksiksi sekä hallitaan tätä vaatimusjoukkoa hankkeen kaikissa elinkaaren vaiheissa. Kyseessä on siis tapa välittää sidosryhmien tarpeet suunnittelijoille heidän ymmärtämässään muodossa. Tämä voidaan tehdä pienessä projektissa hyvinkin vähäisellä dokumentoinnilla, mutta suurissa ja monimutkaisissa hankkeissa tarvitaan enemmän systematiikkaa ja panosta.



Millaisissa hankkeissa systemaattista vaatimushallintaa sitten kannattaa soveltaa?

Periaatteessa sitä voidaan soveltaa melkein minkä tahansa hankinta- ja kehittämisprojektin tai hankkeen yhteydessä. Vaatimushallinnasta saadaankin suurta hyötyä mm. kehitettäessä uutta järjestelmää, hankittaessa suuria järjestelmiä sekä esim. turvallisuuteen liittyvien järjestelmien suunnittelussa. Samoin ulkoistettujen palveluiden hankinnassa vaatimusmäärittelyillä saadaan selkeät ja yksikäsitteiset ehdot ja laatumittarit sopimuksiin. Tietojärjestelmien valinta- ja hankintaprosessiin RAMSE on sisällyttänyt vaatimusmäärittelyn ja tarvittaessa projektinaikaisen vaatimushallinnan.

Mitä hyötyä vaatimushallinnan soveltamisesta on?

Tietojärjestelmän valintahankkeissa systemaattinen vaatimushallinnan menetelmä on edellytys kattavalle tietojärjestelmän määrittelylle, joka varmistaa sen, että sekä toimittaja että asiakas tietävät millaista tietojärjestelmää ollaan valitsemassa. Hyvin määritelty tietojärjestelmä mahdollistaa vertailukelpoisten tarjousten saamisen ja vaatimusdokumentaatio on myöhemmin apuna myös sopimuksen laatimisessa. Vaatimushallinnan avulla saadaankin parempi kokonaiskuva tuotteeseen tai järjestelmään kohdistuvista vaatimuksista, tuotteen testaus ja hyväksyntä helpottuu, tuotteet vastaavat paremmin eri osapuolten tarpeita sekä pystytään paremmin hallitsemaan muuttuvia vaatimuksia. Merkittävänä hyötynä pidetään myös sitä, että käyttäjät ovat tyytyväisempiä hankittuun järjestelmään, kun he ovat päässeet vaikuttamaan siihen jo aikaisessa vaiheessa. Sidosryhmien osallistaminen kehittämistyöhön onkin yksi tärkeimmistä onnistuneen muutoksen hallinnan tai järjestelmän käyttöönoton edellytyksistä. Osallistuminen auttaa myös projektin läpiviemistä ja näkyy aktiivisena projektityöskentelynä.

Vaatimushallintaprojekteissa esiin tulleita käytännön haasteita ovat hyvien, yksiselitteisesti ilmaistujen vaatimusten kirjoittaminen, tärkeiden sidosryhmien edustajien saaminen mukaan, osapuolten mahdollisten eturistiriitojen havaitseminen, vaatimusten kommunikointi sekä vaatimusmäärittelyiden aloittaminen oikeassa vaiheessa (ei liian myöhään eikä liian aikaisin). Hyvän vaatimuksen pitäisi olla todennettavissa eli osoitettavissa, että vaatimus on täytetty. Vaatimushallinnan soveltamisen haasteena nähdään lisäksi suunnitteluorientoituneisuus: lähdetään mielellään heti suunnittelemaan järjestelmää tai palvelua ennen kuin kunnolla tiedetään, mitä sidosryhmät todella odottavat ja tarvitsevat. Vaatimushallinnan ja vaatimusmäärittelyn yleistymiseen erilaisissa hankkeissa voidaan vaikuttaa mm. lisäämällä vaatimushallinnan koulutusta sekä korkeakouluissa että yrityksissä, ottamalla vaatimushallinta nykyistä näkyvämpänä menetelmänä projektiprosesseihin, palkitsemalla vaatimusten määrittelyyn osallistuvia henkilöitä tekemästään työstä sekä ottamalla sidosryhmät mahdollisimman kattavasti mukaan projekteihin.

Mitä vaatimusmäärittely on?

Vaatimusmäärittely on osa vaatimushallintaa ja siihen voidaan katsoa sisältyvän sidosryhmien tunnistaminen, sidosryhmävaatimusten määrittäminen, sidosryhmävaatimusten katselmointi, järjestelmävaatimusten määrittely, järjestelmävaatimusten katselmointi sekä vaatimusten allokointi järjestelmän osille.

Sidosryhmien priorisointi on monesti haasteellinen tehtävä, ja eri sidosryhmillä voi myös olla hyvinkin erilaiset intressit, jotka voivat aiheuttaa ristiriitaisia vaatimuksia. Vaatimusmäärittelyistuntoihin ei useinkaan ole mahdollista ottaa mukaan kaikkia sidosryhmiä vaan täytyy keskittyä tärkeimpiin. Määrittelytyön ulkopuolelle jääneiden sidosryhmien vaatimukset tulee kuitenkin huomioida. Sidosryhmiä analysoitaessa tulee huomioida myös ne sidosryhmät, joilla on negatiivinen intressi järjestelmää kohtaan. Näitä ovat tyypillisesti esim. ryhmät, jotka kokevat uuden järjestelmän olevan uhka tai ryhmät, jotka uhkaavat järjestelmää kuten varkaat.

Sidosryhmävaatimusten määrittäminen liian yksityiskohtaiselle tasolle voi johtaa siihen, että ’hukutaan’ vaatimuksiin ja kokonaisuutta ei hahmoteta selkeästi. Liian yksityiskohtaiselle tasolle viedyt vaatimukset voivat olla seurausta siitä, että mahdollinen ratkaisu tunnetaan etukäteen. Asiantuntijat esittävät usein myös järjestelmävaatimuksia tai –ratkaisuja. Vaatimushallinta-asiantuntijan tehtävänä on selvittää näiden takana olevat sidosryhmävaatimukset. Vaatimusten määrittämisen yhteydessä on syytä määrittää myös niiden todentamistavat, mikä on tärkeää myöhemmin, kun halutaan varmistua järjestelmän ja vaatimusten vastaavuudesta.

Vaatimusten priorisointi on suhteellisen selkeää, kun järjestelmä rakennetaan yksille markkinoille. Useille markkinoille tarkoitetun järjestelmän kyseessä ollessa vaatimusten priorisointi on huomattavasti vaativampi tehtävä.

Määritetty sidosryhmävaatimusjoukko hyväksytään katselmoinnissa. Katselmointi on samalla hyvä tapa sitouttaa henkilöt ja antaa heille kommentointimahdollisuus.

Järjestelmävaatimukset liittyvät johonkin ratkaisukonseptiin. Ratkaisukonsepteja voi olla useitakin, joista sitten valitaan joku järjestelmävaatimusten kirjoittamisen pohjaksi. Yleensä tehdään konseptivertailu valinnan helpottamiseksi. Konseptiksi tulisi valita parhaiten vaatimuksia vastaava konsepti.

Kaiken kaikkiaan voidaan todeta, että hyvin hoidettu vaatimushallinta antaa hyvät eväät niin projektin suunnitteluun kuin toteuttamiseenkin.

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