Focusing on The Bottom Line

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Abstract. The purpose of this paper is to briefly explore an approach to linking system design more closely to the objectives of the business in which the system is to be deployed. It is proposed that all stakeholder requirements on a system can be traced back to a single, high-level requirement - maximising the profit generated by the operation of the system. However, to do so, a link needs to be established between systems engineering and business, and it is argued that there are two ways in which systems engineers can take the lead in developing this link. Firstly, using the systems engineering methodology to develop the business model. Secondly, to use their understanding of the system to extend the model so that the business objectives are expressed in terms of system design parameters.

INTRODUCTION

Background. Sinclair Knight Merz is a leading Australian technology consultant, delivering technology-based solutions that meet the needs of its clients. As with all businesses subjected to the competition of a free market, Sinclair Knight Merz continually endeavours to increase the cost-effectiveness of its operations, with the effectiveness being measured by the extent to which the clients deem that their needs have actually been met once projects are completed. Therefore, the first question we asked ourselves was "What is involved in achieving client satisfaction?"

A program of market research and analysis of the collected data soon identified a number of issues that required attention, and one that appeared consistently as being of high importance was the requirement to have the consultant take an active interest in, and have a high degree of understanding of, the client's business. It was no longer enough for us to deliver solutions that met the requirements; the clients wanted us to take an active part in determining those requirements and providing at least some part of the assurance that the requirements were indeed the ones most appropriate to meeting their business objectives. And, what was more, for us to help manage those requirements in the light of changing business objectives, an issue that was becoming increasingly important given the increase in the rate of change of the business environment.

The Profit Concept. Given this situation, the proposition put forward here is that the initial and most universally applicable approach to linking requirements and business objectives is to link the requirements to the *profit* of the business. It must be remembered that while the INCOSE approach to Systems Engineering is dominated by Defence and other government applications, where profitability and shareholder value play little or no role, this is quite different. in commercial / industrial projects.

Even so, at a first glance this may seem an extremely simplistic view; what about the concept of "the balanced scorecard" and such important measures as public perception, safety record, employee satisfaction, just to name a few? Well, that leads us to the first aspect of this proposition - in a modern business, existing in a dynamic and highly competitive environment, the concept of profit is a very complex one, and its elicitation, capture, and analysis is a fruitful field for the application of the Requirements Management methodology developed in Systems Engineering. The net profit, as shown e.g. in annual Profit and Loss statements, is the condensation of a large number of parameters; its breakdown into its component parameters is an example of the partitioning process so familiar to systems engineers, with the choice of partitioning at each level determined by both current accounting practice and the usual demands for orthogonality, completeness, and contextual appropriateness.

The Business Framework. However, profit is generated within a business framework, and before we proceed to the second aspect of this proposition, which is that there is a step missing in our current approach to requirements, we need to look at the relationship between the system and the business operation. The general situation can be illustrated in Figure 1:

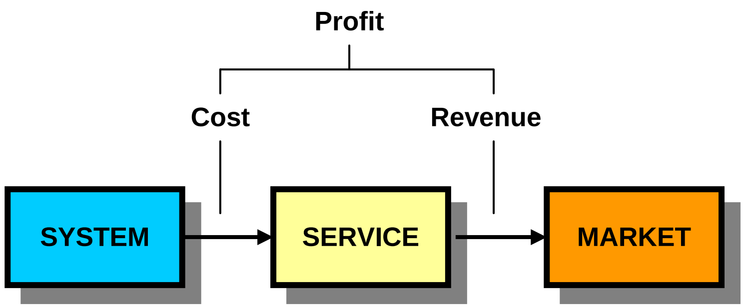

Figure 1. The entities involved in producing a profit.

When the system is operating, it provides a service which, when presented to the market, generates a revenue. Having an operating system comes at a cost; this will include no only the usual costs, such as development costs, production costs, sales and marketing costs, and the like, but also a number of parameters that relate to the market and the environment in which the system operates. The service concept must be understood in a generalised fashion - i.e. it might be the provision of a product rather than strictly a service. To the business person it is the service - its cost and the extent to which it meets market needs - that is important; the system is simply the means of acquiring that service. To the engineer, the system is the important thing; it is his or her solution to meeting the performance requirements. Somewhere in the block labelled "Service" the two worlds meet.

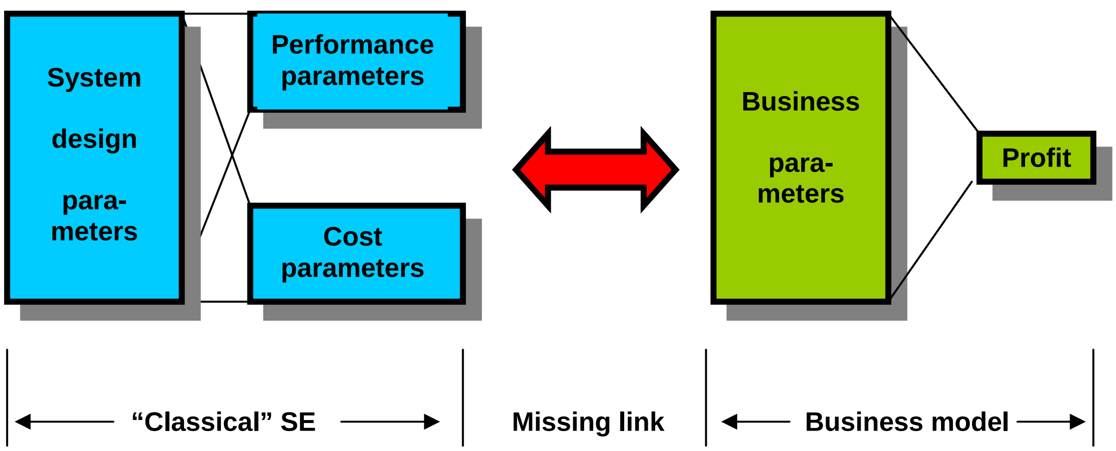

Figure 2. The link between the systems engineering and the business worlds.

THE MISSING LINK

With this understanding of how the system participates in the business process, Figure 2 shows where the requirements come in. On the right is the business model - the expression of the profit concept by means of a number of parameters - and from the previous figure, it is clear that some of these parameters will relate to the market. The involvement of systems engineers in developing business models is the aspect we looked at earlier, that of getting the real requirements to stand out; the second aspect is the "missing link", the linking of the business parameters with the system parameters.

Currently, system design often consists of choosing a system architecture and then allocating values to the design parameters such that the required performance is achieved at the lowest cost. Sometimes it is the other way around, with the cost being fixed and the design adjusted to give the best performance for the cost ("design to cost"), and sometimes there is a trade-off between cost, schedule, and performance (a recent good overview is given in (Brady 2001)), but only rarely is this trade-off carried out based on the impact on a measure of profit. Two of the situations that are likely to arise out of this are, firstly, that the business people, in particular marketing, will formulate mandatory requirements on the service to be provided without any idea of what the impact on system design and cost might be. The system designer sees what the impact is, but has no means of knowing if this requirement is worth the cost or not. The result is a system that is less than optimal because the cost is too high (point *a* in Figure 3).

Secondly, the systems engineer makes cost / performance trade-offs to bring the cost down, based sometimes on intuition and sometimes on previous experience, and in the belief that he is delivering a system that is "fit for purpose". However, he has no means of knowing what the real impact of his trade-offs are, and the business people have no insight into the engineering process, so the result is again a less than optimal system; this time because the performance is too low (point *b* in Figure 3).

What is missing is the link between the parameters describing the business outcome, i.e. profit, and the system performance parameters. For example, for a passenger railway operation, what is the impact of lowering the fatality rate from accidents by 50 %, or of

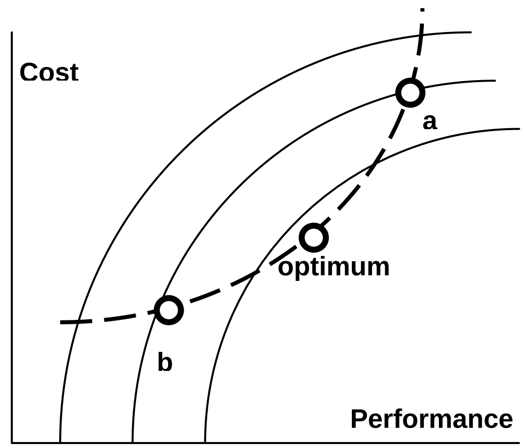

Figure 3. Lines of constant profit, and the curve (dashed) representing the realisable trade-offs between cost and performance.

lowering the passenger-delay minutes per month to half its current value? Only when that is known can one make truly rational decisions about control systems, safety features, and the like.

The conclusion we can draw from our proposition is a simple rule - simple, that is, in concept, but more difficult to practice:

A real requirement is one that has a positive impact on the bottom line!

SOME ISSUES ARISING FROM THIS PROPOSITION

Determining Business Parameters. The process of determining the business parameters appropriate to a particular project is in some ways similar to a process well known to systems engineers - risk management. The first step is element identification, and that is carried out by a combined top-down and bottom-up approach, as shown in Figure 4, just as in risk identification. The main categories of cost and revenue are determined in a top-down fashion by selection from a list of known categories (determined largely by accounting practice), and then the elements that make up these categories in the particular project are determined bottom-up by brainstorming or a similar activity. The next step is the analysis, or assessment, in which each of these elements is then characterised by a set of parameters, typically characterising quantity, quality, degree of complexity, and the like.

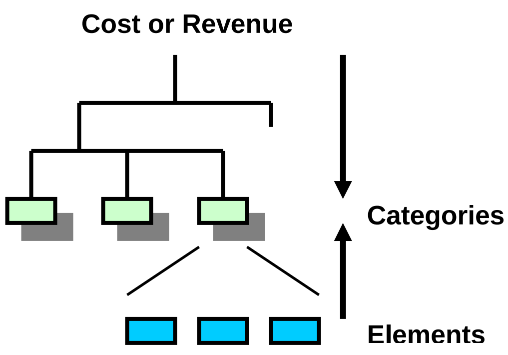

Figure 4. The identification of business elements.

Linking Business Parameters with Design Parameters. This process relies largely on experience with similar projects, and therefore involves interviews, questionnaires, workshops, and such techniques as the Delphi method. However, a useful way to display and keep track of the linkages is in the form of an influence matrix, with the columns labelled by business parameters and rows by system design parameters. The values of the matrix elements give the strength of the influence of a design parameter on the corresponding business parameter, and should a column be empty, then the choice of design parameters needs to be reconsidered. An example of such a matrix is given in (Aslaksen 1996).

System Life Cycle. Both cost and revenue need to be considered on a through-life basis, using the approach to Life Cycle Costing described in most textbooks on systems engineering (see e.g. Aslaksen and Belcher 1992). In particular, the method of financing and the drawdown of funds during construction can have a significant influence on the cost (Aslaksen 1996).

The Relationship to CAIV. There has been considerable interest in recent years in a concept called *Cost As an Independent Variable*, or CAIV, and an excellent overview is given in (Brady 2001). As defined by the US DoD, CAIV is a program management discipline that establishes an aggressive but realistic manufacturing cost target for a system, trades off cost against schedule and performance, and manages risk to attain the cost goal. While a few of the ideas and processes involved are quite similar in CAIV and business modelling, there are some significant differences. First of all, CAIV is oriented towards a production environment, whereas commercial projects are very often individually designed and constructed (e.g. a mine, a factory, privately financed highways, railways, and airports, and so on). Secondly, in the defence application it is more difficult to give a monetary value to the benefits arising from functionality and/or performance, so that trade-offs are generally highly qualitative on the performance side.

Relationship to Use Cases. Use cases, as one of the tools included in UML, have gained something akin to cult status over the last few years, and are sometimes being applied uncritically to situations where they have no real justification. However, there is a relationship between use cases and business modelling in the sense that a business model can be seen as an extension of a set of use cases, as illustrated in Figure 5.

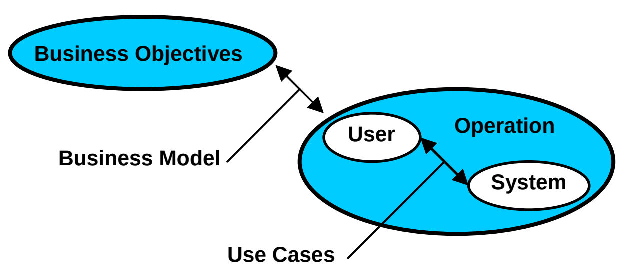

Figure 5. The business model as an extension of use cases.

Use casesdescribe the various ways in which users interact with the system, thereby describing the operation of the combined entity consisting of users and system. The business model describes how the business “uses” the operation to reach its business objectives.

Two Contrasting Examples. A particular iron ore shipping facility loads iron ore received by train from three mines onto bulk carriers by means of three ship-loaders, with provision for stockpiling, sampling, washing, and screening. The three ore types are different, and each type comes in two grades - lumps and fines. To allow for all combinations of ore types and operations would require a very large number of conveyors and transfer points, so that, at a million dollars in acquisition costs and very substantial maintenance costs per conveyor, it would be important to determine exactly what is justified in terms of market requirements. However, despite having identified over-specification as one of the major project risks, and a cost to develop and run a business model of only $25,000, the Client decided to rely on previous experience and gut feeling in determining the system requirements.

A very successful application was the development of a business model for an ore handling system in a copper mine (Aslaksen 2002). In this case, a business model was developed and related to the system design parameters, and it was used to evaluate every choice between design options. The result: What is arguably the lowest production cost metalliferous underground mine in the world today.

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