Additional Systems Engineering Roles

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Abstract. To date, the systems engineering roles described focus on those within an engineering firm and ignore the need for a systems engineer who advises, and acts in behalf of, the client separate from the organization building the system. The software systems engineering community has failed the customers by not providing a process for bridging the gulf between the contractor and the customer in an objective manner. The additional systems engineering roles described, that of the Contracting Officer's Technical Representative and the Client's System Engineer, bridge that gulf and improve the integrity of the process. The focus of this paper is on Department of Defense contracts but the prinicple is true for major software systems efforts.

INTRODUCTION

Since the inception of INCOSE, much has been written about the purpose of systems engineering and specifically, the role of the systems engineer. Twelve systems engineering roles have been proposed and are frequently cited as accepted roles [Sheard 96a]. The focus on these systems engineering roles has been primarily in the context of the enterprise constructing the system. This paper argues that two additional roles exist, the Contracting Officer's Technical Representative and the Client's System Engineer. Although this paper is primarily focused on software engineering, the principles apply to all systems engineering arenas.

THE TWELVE ROLES

Twelve roles proposed by [Sheard 96a] are shown in Table 1. The roles are grouped by type of function performed within the development organization. For brevity, this paper will focus on the roles of the Requirements Owner and the Customer Interface. Both of these roles are internal to the organization developing the system.

The Customer Interface "represent[s] the point of view of the customer," to ensure that the "right" system is built and "that the details are as customer-friendly as possible" [Sheard 2000a]. This role is responsible for determining the client's needs and intent, and communicating that to the Requirements Owner [Sheard 2000a].

Table 1. Systems Engineering Roles

Role	Name	ABBR
1	Requirements Owner	RO
2	System Designer	SD
3	System Analyst	SA
4	Validation/Verification Eng.	VV
5	Logistics/Ops Engineer	LO
6	Glue Among Systems	G
7	Customer Interface	CI
8	Technical Manager	TM
9	Information Manager	IM
10	Process Engineer	PE
11	Coordinator	CO
12	Classified Ads SE	CA

The Requirements Owner "translate[s] customer needs into specific, well-written requirements to which systems and subsystems…can be architected and designed" [Sheard 2000a].

THE ENVIRONMENT AND PLAYERS

Client side—An operational need is developed by personnel engaged with an adversary. We call these people…

Operators who carry the product into engagement. In the most fundamental sense, operators are war-fighters, and their job is fighting wars, not designing or procuring gadgets. Operators pass their operational needs through the chain of command to…

acquisition and program management (A&MP), which is charged with the responsibility for providing the operators in the field with the matériel needed for them to do their job. Some A&PM people are veterans of adversary operations and press their influence on the desires of the operators. This is analogous to having the operational requirements of an F-16 pilot approved by a person who once mastered the F-86. But it does not end there. A&PM organizations invariably hire "think tanks" known as…

Technical monitors to back up their judgment relative to the technical oerformance and allocation of funding for the procurement of the material that resolves the operational need. Think tanks are primarily populated by veterans of the adversarial process. Thus the views of the B-52 pilot relative to the needs of an F-16 driver are substantiated by a person who may have once flown O-2s in Vietnam. So the modified and distorted need gets passed through a…

buyer/contracting officer to…

the *contractor* who employs…

marketing people to act as initial contacts with the client's buyer/contracting officer, and …

project managers, who orchestrate the development of a product to the contracted specifications, relying upon the…

systems engineer to provide stewardship of the technical development of the product by …

domain engineering organizations wherein lies the development techincal expertise needed to create the product that fills the operational need. Sometimes it is necessary to invoke a …

buyer to hire …

subcontractors to provide expertise in some esoteric technical field that the prime contractor doesn't choose to hold in-house. Subcontractors respond to work directions provided by a …

subcontractor project manager to a …

subcontractor engineer from work authorization of the contractor's buyer and technical direction from the contractor's system engineers.

A SCENARIO

A subcontractor engineer discovers an apparent ambiguity or error in the work order that has wended its way down the chain. Clarification is needed. What better way to clarify an uncertainty than to have the subcontractor's engineer talk briefly with the client's operators? There is no better way, but what typically happens is the following:

The engineer requests permission of the subcontract project manager to contact an operator on the client's staff. The subcontractor project manager is opposed to the contact. Who is to pay for the time, travel and materials unless the subcontract is modified to allow such contacts? So…

An official request is made for modification to the subcontract. On the prime contractor's side, the buyer is immediately suspicious. Why is the subcontractor wanting to go directly to the client? Is this an attempt to displace the prime contractor? The request is passed to the prime contractor's project manager (who, in any event must authorize the expenditure of funds for the contact).

After consultation with the prime contractor's systems engineer, the project manager is convinced that the meeting is necessary and valuable, but before issuing a task order…

The project manager wants to check with the counterpart in the client's buyer staff. On the client's side, the buyer/contracting officer is immediately suspicious. Why is the contractor wanting to go directly to the operators? Is this an attempt to avoid complinace with some specification? Or, worse yet, is the prime contractor daring to question the expertise of our staff and technical monitors?

The request is passed to the technical monitors, who asserts that such questions as those posed are their responsibility to answer. Somebody wakes up the F-86 pilot and solicits an opinion.

After some days delay, the technical monitor reports to the client's project manager that the questions should be passed to the operators in the field.

This poses another problem for the client's project manager who may see those operators in the field as an unruly lot who may grab the ear of the contractor and fill it with changes to the specifications—changes for which no funding exists.

Reluctantly, and under pressure from both sides, the client's project manager allows the meeting under strictly controlled conditions and with assurances that nothing taken form the meeting may be construed to commit the client to any change in contract terms.

The meeting takes place. The war-fighters are surly at having their fighting of wars interrupted. The subcontractor engineer, under strict supervision, is allowed to ask the question. Having obtained an answer, the answer wends its way back along the path by which it came.

SYSTEMS ENGINEERING HAS FAILED THE CUSTOMER

A key element in developing a system is establishing the "right set of requirements, requirements that reflect the true customer needs and are consistent with the [client's] strategic goals and objectives" [Motley 2000]. In the current process, the customer provides the initial set of requirements to the developer and then the RO and CI engineers further define these requirements and prepare the requirements document. There is a fallacy in this design and development concept as it applies to software intensive systems

"In the first decades of computer system development, most users of computer systems were engineers and programmers" [Grønbæk et al.]. The engineers thoroughly understood the needs of the user/customer. This has changed dramatically as systems have become more specialized and programming has transitioned from an art to a science. Additionally, the problem is exacerbated by the outsourcing of systems development in both the government and the private sector arenas. The internal design and development entities were the corporate knowledge-base for the client's systems and requirements. The loss of this internal store of knowledge exacerbates the systems engineering and requirements problem. There now exists a large gulf between the engineers and the customer/user.

However, systems engineers still assume the customer knows enough about available technology, how that technology can benefit them and how to articulate their needs in the form of unambiguous requirements. In far too many instances this is not true and therefore "systems engineers must enter the customer's environment, discover the detail and explain it to them" [Bahill et. al. 1995]. To aggravate this challenge, "very few [engineers] are well-versed in the application domain…" [Zowghi 1995]. In other words, few systems engineers have a background sufficient to understand the customer's business, business processes, and how the customer's strategic goals and objectives can be enhanced using technology. The systems engineer doesn't understand the client's needs and the client doesn't understand how to express those needs to the systems engineer.

Couple the above with the conflicting interest of the customer and the contractor. "The [customer] wants to minimize the cost of external resources, while the [contractor] wants to maximize it" [Bergey et. al. 1999]. The issue goes beyond mere cost. Often the customer is not willing to divulge sensitive internal information and strategies to the contractor that may impact the system design.

Not only is the gulf between the customer and the engineer wide, they have conflicting interests, needs, and desires. It is now easy to understand why "30% of software development projects are canceled before completion, primarily because of inadequate user design input" [Standish Group 1995]. The software systems engineering community has failed the customers by failing to provide a process for bridging the gulf between the contractor and the customer in an objective manner.

THE CONTRACTING OFFICER'S TECHNICAL REPRESENTATIVE

This challenge has been partially addressed by DoD and some industries by using a Contracting Officer's Technical Representative (COTR). The COTR is an employee of the customer who physically resides on the contractor's premises. The COTR performs non-contract, administrative-service technical duties and provides liaison, guidance and assistance on systems and programs. Although one might argue that the COTR is a version of the CI, the difference is that the COTR is employed by the contracting officer and not the contractor.

The COTR is on-site to ensure that the project complies with specifications and to monitor project completion. The COTR's goal is to ensure the customer gets what it paid for and to answer technical questions. The COTR is used extensively in DoD and the airline industry. Airlines use a COTR to ensure that the aircraft ordered is delivered according to specifications. Financially, they can't tolerate any downtime and warranty work.

THE RIGHT SYSTEM (?)

This does not necessarily guarantee that the customer gets the desired system. Small governmental organizations often lack their own contracting office and must rely on the contracting services of other organizations. This takes the direct control of the project away from the ultimate customer.

Granted, the contracting officer and project manager should ensure that the end-user is involved in the decision making process. Experience has shown that major decisions are frequently made by the contracting officer and the systems engineer on behalf of the customer, without consultation with the customer. Their view has been that once the requirements are stated, that the consumer should have no further input.

This is similar to what happens when a commercial developer receives a contract and completes the requirements definition. The customer loses direct insight and valuable input into the project and the development.

BUSINESS PROCESS REENGINEERING

When implementing software systems, organizations typically conduct business process reengineering (BPR). In the past, business processes were, to a degree, dependent on available technology. As a result, many business policies and processes were modified to fit the technology selected. That has changed significantly. Today, businesses need to make few concessions to technology.

While it may or may not be necessary, if BPR is conducted, it should be done independently of the contractor. It is virtually impossible for a development house to employ experts in every field of technology. Likewise it is virtually impossible for the development house to employ domain experts for every business type. As previously stated by Zowghi, systems engineers are rarely business domain experts. This means that few development houses have the expertise to objectively advise a client on how to best implement the desired solution or to truly understand the client's domain. Given the void between engineers and clients, a new systems engineer role is necessary.

THE CLIENT'S SYSTEM ENGINEER

As the title implies, the Client's System Engineer (CSE) focuses on the client and the client alone. The CSE may be an employee of the client or may be an outside contractor experienced in the client's domain. The ideal CSE has an MBA as well as being a graduate systems engineer. The role of the CSE is to be the bridge between the customer and the contractor.

However, the CSE may not be affiliated in any way with the organization developing the system. The role of the CSE is to walk the client through the initial systems engineering steps, particularly the problem definition, the statement of need and the high level requirements. Because the CSE is independent of the contractor, all the issues can be laid out in an objective manner so that the client can make an educated decision. Contractor preferences, or the tendency of a contractor to stear the client into the contractor's core competincies, are avoided.

If BPR is performed, the CSE is involved in the process to assist the domain specialists in understanding how technology can aid the business and what trade-offs, if any, will be required. The end results are better requirements definitions, and a system specification, that truly meets the needs of the client.

THE CSE AND THE DEVELOPER

Customers should consider having a CSE physically on-site at the development house on large and lengthy projects. This is the same as the COTR, provided that the individual reports directly to the customer and not the contracting officer. When corporations engage in large software projects, they normally are tied to a business goal, marketing plan, and/or the roll-out of a new product/service. If the software is delivered late or with defects, that has a significant impact on the business plan.

In this capacity, the CSE monitors development processes, confirms quality goals, and resolves conflicts in regard to the requirements. This greatly enhances the probability that the software will be delivered on-time, defect free and with the features specified. This is not the same as hiring a firm to count lines of code or function points to ensure progress. The CSE should take a holistic view of the entire project. The customer should view the CSE as part of their risk management team.

By performing in this manner, the CSE narrows the gulf between the customer and the contractor and ensures the optimal system for the customer is specified.

CONCLUSION

Much has been written about the role of systems engineers within the developing organization. However, this focus ignores the gulf between the customer and the systems engineer. Also, there are conflicting interests, needs, and desires between the two parties. The new roles for systems engineers provide a process for bridging the gap between the contractor and the customer in an objective manner. The result should be an overall fine-tuning of requirements and quality of the desired products.

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