Improving the Practice of Systems Engineering: Boot Strapping Grass Roots Success

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Abstract - This paper describes how to use a positive deviance-inspired process for improving the practice of systems engineering, and how positive deviance fits into an evolutionary improvement strategy. It illustrates the process with examples from both systems engineering and cases studies outside of systems engineering.

In particular we cite the experience of the team that authored the DoD Systems Engineering Guide for Systems of Systems (SoS) [Ref 1]. They developed a representation of how successful SoS engineering practitioners view and do systems engineering that is substantially different from their individual system counterparts. The cases outside of systems engineering relate to an anti-starvation program in rural Vietnam and a 150-year old problem of inadequate hand scrubbing and infections in hospitals [Ref 2]. Even with substantial progress in technology, processes, and efficiencies, complex problems from enterprise systems engineering to nutrition to medical needs still stubbornly resist improvement. By using a positive deviance-inspired approach, this can be reversed.

I. INTRODUCTION

The slow progress and poor success rate in the development of an information technology enterprise to support net-centric operations within the United States (U.S.) Department of Defense (DoD) has undermined the credibility of systems engineering as currently practiced. Bringing net-centric capabilities to fruition awaits a change in that practice.

Calls for change in DoD systems engineering range from "revitalizing the classic practice" to "the need for a whole new way of engineering systems." The former view is rooted in the belief that the essential nature of the systems engineering problem has not changed. Instead, practitioners have either "lost their way" or gotten sloppy. In the latter view, classical systems engineering is seen as outmoded and systems engineering practitioners are challenged to develop modes of engineering better aligned with the new technology landscape. Either way, the call for change is clear.

Responses of the systems engineering community are varied. Many accept one of these two conclusions and attempt to address them. After all, systems engineers are pre-eminent problem solvers. What more attractive problem is there than improving or re-inventing one's own art? Others argue that systems engineering, like any technical discipline, is shaped and delimited by the environment in which it is embedded. In this view, substantive changes to systems engineering must be enabled by expansive changes to government policies and statutes for the acquisition and engineering of systems.

This paper takes the point of view that there already is ample room for expanding the practice of systems engineering within a defense department environment, that in many instances the know-how already exists within its organizations, and that the real job is to find that know-how and amplify it across the department.

In point of fact, the acquisition process for the U.S. defense department demands this expansion of systems engineering and, in general, the policies and high-level regulations governing acquisition and systems engineering processes enable it. Yet the systems engineering community continues to operate within a relatively small portion of its allowable spectrum. The root cause of the limited space in which defense department systems engineering operates is an inability of the community to push the boundary of the culture, mindsets, beliefs and incentives of the environment in which it functions.

II. A TRADITIONAL SOLUTION METHODOLOGY

When faced with the question of how to improve or expand the practice of systems engineering within a government department or agency, a common solution approach is to put a spotlight on what has gone wrong in recent, high-profile programs and to posit specific ways to fix the problem. Often, the proposed fixes are variations or adaptations of approaches that have worked well in environments different from that of the department or agency. These differences can be policy or regulatory or in the culture, beliefs, and incentive structures of the department or agency. Within defense departments, proposed fixes are frequently inspired by either commercial business sector practices or those that come from "skunk-works" - a group within a traditional organization that is given a high degree of autonomy and freedom from normal business and engineering rules to work on advanced, highly classified, or urgent-need projects.

The difficulty in transferring approaches that work in one environment to another is in inferring exactly which patterns of an approach must be copied intact, which should be modified, and which may be ignored, to duplicate success in the new environment. In complex social systems many results – both positive and negative – derive from interactions among multiple patterns that are not always fully understood. Attribution of credit in complex systems is fraught with difficulties and this is why solution approaches transplanted from other environments often fail.

III. POSITIVE DEVIANCE

Positive deviance is an approach to improvement based on the idea that every community performing an activity has certain individuals or teams whose attitudes, practices, strategies or behaviors enable them to function more effectively than others with the same resources and environmental conditions [Ref 3]. Because positive deviants are embedded in the same environment as the rest of the community, the problems associated with attribution of credit are less severe than when transferring solution approaches across environments [Ref 4]. Because many communities are reluctant to change fundamental beliefs based on outsider say-so, positive deviant ideas are more likely to be accepted by their community.

Positive deviance has been popularized by the surgeon Atul Gawande in his recent best-seller "Better: A Surgeon's Notes on Performance." Gawande motivates and describes the approach with two examples.

The first example concerns a *Save the Children* Anti-Starvation Program in Vietnam. Despite the fact that the know-how for methods to raise nourishing food and more effectively feed children had been long established, the *Save the Children* effort failed consistently over a period of years. The team came to understand the root cause of the failures was that the approaches they were pursuing were perceived as "outside solutions" which the local population was reluctant to adopt based on their say-so. The team changed the focus to finding solutions from inside the local environment. Despite wide-spread poverty, well nourished children did, in fact, exist in the region. The outsider team formed an insider team consisting of villagers from across the region. The insider team identified families who had well-nourished children – that is, those families who demonstrated positive deviance from the norm of pervasive starvation. The insider team interviewed these families to determine how they fed their children. Positive deviant families were breaking local conventional feeding wisdom in a number of ways. One example is that children in these families who experienced gastro-intestinal problems were fed multiple, small meals a day versus the conventional one or two large meals. Those children were able to retain and digest more of their food. Positive deviant families also added nourishing sweet potato greens to the children's rice despite it being considered a "low class" food. The team identified and packaged these and other patterns of behavior for well-nourished families. They communicated the ideas throughout the region by posting them prominently on village bulletin boards. The team measured malnutrition and posted results for all to see. This created a sort of competition among the villages of the region. Two years later, malnutrition decreased by 75% across the region and the results persisted beyond that.

The second example concerns hand washing and hospital infections. The connection between the two was definitively established in 1847. Yet the problem continues to this day in spite of progress in technology (evolution in efficacy of "soaps"), processes (improvements in hand washing protocols), and efficiencies (e.g., creation and widespread use of hand washing carts in hospital wards). Studies consistently show that doctors and nurses wash their hands one-third to one-half as often as they should. In a way, the culprit is time – the scarcest of all commodities in the medical profession. In 2005, two individuals convinced the Pittsburg, Pennsylvania veterans' hospital to try a positive deviance approach to address hospital infections. They held small group meetings in which the message was "we are here because of the hospital infection problem and we want to know what you know about solving it." They brought no directives, policies or briefings on what experts thought the hospital staff should be doing. The essence of their idea was to build on capabilities the staff already had rather than telling them how to change. Ideas came pouring in. Many hospital employees commented that it was the first time anyone had ever asked them what they thought should be done. Norms began to shift. Nurses who would never think of speaking up when a doctor failed to wash began doing so. The team publicized the ideas and small victories on the hospital web site and in newsletters. Monthly results were posted unit by unit for all to see. A year into the program and after years of failed tries, the entire hospital MRSA (Methicillin-Resistent Staphylococcus Aureus) wound infection rate dropped to zero and stayed there.

IV. POSITIVE DEVIANCE IN SYSTEMS ENGINEERING

Two years ago the Office of the Secretary of Defense undertook an initiative to begin developing guidance for the engineering of systems of systems. A preliminary, quick-look draft of the Guide "extended" each of the 16 technical and technical management processes in the Defense Acquisition Guidebook (DAG) and left the basic V-model construct intact (linear, sequential progression of processes). An example of an extension of an SE process is SoS decision analysis. It is more complicated because it needs to consider potential ripple effects on constituent systems for each major SoS decision. Also, the resolution of any contentions involves greater number of stakeholders with different equities in the outcome than a single system would.

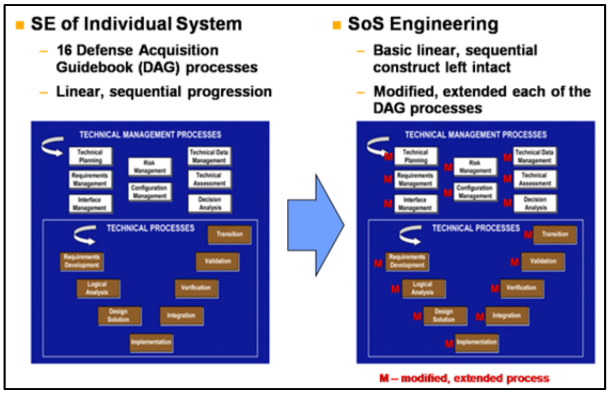

Figure 1. Extending SE to SoS SE – a conventional view

The second, more extensive phase of the Guide development used a positive deviance approach. Approximately 20 acquisition programs were selected from across the DoD and Intelligence Community to participate in a structured review of the early draft of the Guide. These programs all had demonstrated some measure of success in SE of SoS. The interviews consisted of basically a single question: how do you do SE of SoS? After interviewing about a dozen programs a pattern of behavior emerged which the remaining interviews corroborated and brought into greater focus.

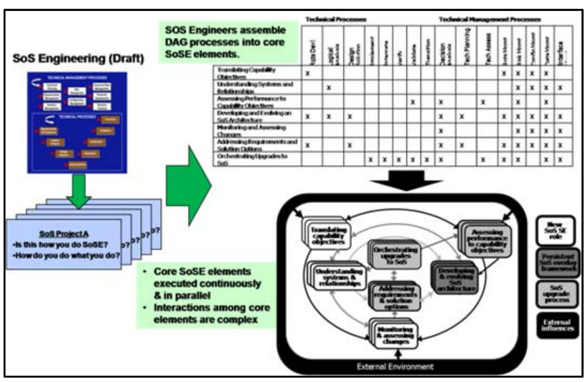

Figure 2. SoS Engineering – how successful practitioners actually view and do it

The view that emerged was that SoS engineering practitioners do use the 16 DAG processes, modified for the complexities of an SoS environment, but the nature of the SoS environment affects the way in which they are employed. It is as if the DAG processes were tools in a toolkit that need to be configured in ways different from SE of a single system to address SoS engineering issues. SoS SE practitioners tend to assemble the 16 DAG processes into 7 core elements. Not all of the core elements have well-developed antecedents or counterparts at the individual system level. Importantly, the core elements are not executed in a linear, sequential fashion so much as they are executed continuously and contemporaneously. The interactions among the core elements are more complex, as well. The overall view is not unlike a system dynamics diagram, with its reinforcing and balancing feedback loops, and is suggestive of why even seemingly straightforward SoS SE problems can display baffling properties when viewed through a conventional, linear systems engineering framework. It is almost certain that the team developing this view of SoS SE would have never conjectured it in advance of the interviews.

As interesting as the details of this view of SoS are, the important point for this discussion is not the specifics of what was discovered about how successful SoS engineering is implemented. It is the way in which that information was obtained. Although the team developing this version of the Guide had never heard of positive deviance, their approach clearly used some of its key principles. Before official release of the Guide, the view of SoS engineering in it was played back to the project teams that were interviewed in its development and to other system engineers. The response has been positive across both government and commercial SoS SE practitioners.

V. POSITIVE DEVIANCE AND EVOLUTION

In an enterprise as large as a defense department, natural variation occurs within the SE practices, processes and procedures used across it. These variations may come from misunderstanding of a systems engineering process by an inexperienced team, shortcuts in established processes to meet deadline pressures, or deliberate attempts to innovate. Many variants do not result in any performance difference of the systems engineering effort, some are detrimental, and a few result in positive gains [Ref 5]. This gets to the essence of a positive deviance approach to evolving the practice of systems engineering. It changes the focus on improving practices and processes from bringing new, unproven ideas from the outside to finding and amplifying solutions that already exist inside an organization.

The response to a demand for an expansion of systems engineering can therefore be based on the evolutionary forces of variation, selection and amplification embodied in the positive deviance approach. The approach may be summarized in the following steps:

1. Identify the few who have succeeded within an environment.
2. Determine how they do what they do.
3. Synthesize, package and communicate their ideas across the enterprise.
4. Set expectations that the ideas will be considered by the rest of the enterprise.
5. Measure and reward change in outcomes and communicate the results across the enterprise.

The approach recognizes that variation naturally exists within an organization [Ref 6]. The focus of the positive deviance approach is to provide selection (steps 1, 2 and 3) and amplification (steps 4 and 5).

SUMMARY AND CONCLUSIONS

This paper has described how to use a positive deviance-inspired process for improving the practice of systems engineering, and how positive deviance fits into an evolutionary improvement strategy. The process was illustrated with examples within and outside of systems engineering.

Even with substantial progress in technology, processes, and efficiencies, complex problems from enterprise systems engineering to nutrition to medical needs still stubbornly resist improvement. By using a positive deviance-inspired approach, this can be reversed.

Wider application of a positive deviance evolutionary strategy offers the promise of improving the practice of systems engineering in complex environments that do not lend themselves to conventional approaches.

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