

Adaptive Systems Engineering: A Medical Paradigm for Practicing Systems Engineering

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Adaptive Systems Engineering: A Medical Paradigm for Practicing Systems Engineering

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Abstract. From its inception in the defense and aerospace industries, SE has applied holistic, interdisciplinary tools and work-process to improve the design and management of “large, complex engineering projects.” The traditional scope of engineering embraces the design, development, production, and operation of structural, hardware, and software systems, and SE, as originally conceived, falls within that scope.

While this “traditional” view has expanded over the years to embrace wider, more holistic applications, much of the literature and training currently available is still directed almost entirely at addressing the large, complex, NASA, defense, and other industry systems wherein the “ideal” practice of SE provides the cradle-to-grave foundation for system development and deployment. Under such scenarios, systems engineers are generally viewed as an integral part of the system and project life-cycle from conception to decommissioning. In smaller, less complex, and far less “ideal” applications, SE principles are equally if not more applicable to a growing number of systems and projects that need to be “rescued” from overwhelming challenges that threaten imminent failure.

The medical profession provides a unique analogy for this latter concept and offers a useful paradigm for tailoring our “practice” of SE to address the unexpected dynamics of applying SE in the real world. In short, we can be much more effective as systems engineers as we change some of the paradigms under which we teach and “practice” SE.

Introduction

In mid-August, 2007, one of the authors spent an entire day experiencing intermittent chest pains and ended up in the emergency room taking blood tests and Cat-scans to see if he was having a heart attack or pulmonary embolism. Following several specialized tests, the problem turned out to be elevated blood pressure, but the procedures uncovered some other conditions that ultimately led to surgical intervention and follow-on, long-term monitoring. This individual is not a hypochondriac, but he does stay fairly close to his doctor. He has regular

checkups and takes routine blood tests to monitor a couple of chemical irregularities. So, it surprised him that the elevated blood pressure and other conditions hadn't been detected earlier. He went back over the entire episode again and again trying to figure out what could have been done to allow earlier detection and correction, but nothing stood out. It was just one of those "unexpected" things.

Three years later, the author was sitting in the audience at INCOSE 2010 listening to Dr. Julian Goldman discuss equipment interface problems he had experience in various emergency and operating rooms around the world. He was fascinated by Dr. Goldman's presentation and began pondering other applications between systems engineering (SE) and medicine. It was then that he found the answer that had evaded him back in 2007, namely, that the paradigms he held regarding health care and its intervention in his life had contributed greatly to not discovering the health problems earlier. The more he contemplated his paradigms, the more he noticed parallels between health care practices during the human life cycle and SE practices during the life cycle of a project or engineered system. It was then that the author realized how much more effective we could be as systems engineers by adjusting the paradigms under which we "practice" SE.

From its inception in the defense and aerospace industries, SE has applied holistic, interdisciplinary tools and work-process to improve the design and management of "large, complex engineering projects." The traditional scope of engineering in general embraces the design, development, production, and operation of physical systems, and SE, as originally conceived, falls within that scope. In this sense, SE refers to the distinctive set of concepts, methodologies, organizational structures, and so on that have been developed to meet the challenges of engineering systems of unprecedented complexity.

While this "traditional" view has expanded over the years to embrace both simpler systems and wider, more holistic tools and applications, much of the literature and training currently available is still directed almost entirely at addressing the large, complex, NASA and defense-sized systems wherein the "ideal," "textbook" practice of SE provides the cradle-to-grave foundation for system development and deployment. Under such scenarios, systems engineers are viewed as an integral part of the system and project life-cycle from conception to decommissioning. In far less "ideal" applications, SE principles are equally applicable to a growing number of complex systems and projects that need to be "rescued" from overwhelming challenges that threaten imminent failure. In essence, the projects need to get their blood pressure checked and other anomalies managed before they suffer a major heart attack. The medical profession provides a unique analogy for this latter concept and offers a useful paradigm for tailoring our "practice" of SE to address the unexpected dynamics of the project life cycle, where SE is typically not ideally applied.

"Ideal" Lifetime Care

"Ideal" Lifetime Medical Care. In most developed countries, human beings are born into this world at the hands of a trained, licensed medical professional who cares for the mother during pregnancy and monitors the development of the growing fetus. Sometimes, tests are performed before birth to detect and resolve suspected fetal issues. Following birth, that newborn receives regular care from a trained, licensed pediatrician who monitors growth and provides the child with every protection necessary (e.g., vaccinations, etc.) to ensure healthy development during the early years of life. As children enter school and participate in extracurricular activities, health care usually lessens and is driven more by necessity (i.e., to treat an injury) or by the team's or school's desire to mitigate potential liabilities.

Ideally, the same level of rigorous medical attention we received as infants would continue far beyond the first few years of life to monitor, predict, and combat conditions that would otherwise jeopardize the survival of the individual. We would regularly check for abnormalities and risk factors; eat specialized, pre-planned diets; exercise regularly; go to sleep and arise on a regular schedule; counsel frequently with health care professionals to maintain top physical and mental condition; and only require medical or surgical intervention on a pre-planned, carefully scripted basis to mitigate an identified health risk before it jeopardizes the healthy, illness-free existence. In other words, our physical “system” would be optimized by the on-going assistance and intervention of medical professionals at each stage of human development with the ultimate performance requirement of living a long, healthy life.

“Ideal” Project Care. Engineered systems and projects aspire to a similar “ideal” life cycle. Project managers who are well versed in the dynamics of project development and execution lead the effort with focused attention on understanding and ensuring the health of the entire system. Ideally, a systems engineer is engaged early on as an active part of all life-cycle activities (i.e., pre-conceptual through decommissioning) to establish project parameters and to monitor, predict, and help combat conditions that would otherwise threaten project success. Projects would have clearly defined requirements based firmly on mutually understood mission objectives. Risks would be defined early in the system life cycle and managed to reduce and/or avoid associated consequences. System options would evolve naturally out of defined requirements and operating constraints. Each system component would be verified and validated at each phase of the system life cycle. Engineered components would integrate seamlessly into fully functioning systems to meet established requirements. In other words, projects and systems would be optimized at each stage of project life by the on-going assistance and intervention of systems professionals who help mitigate emerging risks before they jeopardize system health.

While many practicing systems engineers would likely laugh at this description as “a fantasy,” it clearly portrays the textbook view of a “typical” SE application as documented in multiple SE publications, including the *INCOSE Systems Engineering Handbook*, and taught in various seminars and college courses worldwide. Subsequently, as an engineering discipline, we are conditioning the SE community with a glorified and largely false view of “real” SE. As systems engineers, we spend the vast majority of our writing and training advocating and preparing to practice “ideal” SE when such circumstances typically represent the minority of the actual work in which we are engaged. What we need is a paradigm shift—throughout the entire SE community—that better aligns our writing, training, and practice of SE with the “real world,” adaptive situations within which most systems engineers work.

A “Real World” View

Human Life Challenges. For the author mentioned above, the “ideal” intervention of health care throughout his life ended at about age five. Although his mom was a trained nurse, they only went to the doctor when it was “necessary;” mom took care of the rest. A band-aid for a skinned knee, an aspirin for a headache, cough syrup for a cold, and a needle and pair of tweezers for a splinter. He went to the doctor for scheduled shots and for big problems, like a broken arm, but otherwise, his mom took care of any health issues that arose. The family ate what she fixed, but no one worried too much about calories or fat content. In fact, as long as things “seemed” to be going well, they didn’t pay much attention to the status of their health. He only got back into a routine of regular doctor visits and on-going consultation and monitoring AFTER his scare and subsequent corrective intervention.

Most people were raised on and still follow a similar pattern. Many of us are physically and nutritionally “out-of-shape” and have no real idea of what might be going on inside of their bodies. Other than occasionally stepping on a scale and adding an extra hole to their belt, they don’t regularly monitor the various aspects of their physical health or make any attempt to predict and plan for the various medical interventions that may be necessary to stay alive. In fact, a large percentage of humans in developed countries the world over never seek medical advice until they reach a certain age, have a scare, or digress to a state where they needed to be “rescued” to survive, some in very dramatic fashion.

Medical professionals realize this dilemma and often chastise their patients for not visiting more often. When their patients do seek advice, I’m sure many of the doctors would love to turn back the clock and start over with a comprehensive, systematic regimen that would prevent the current, degraded physical condition of the patient. But that is not possible. Instead, the medical professional must step in and intervene to prevent further deterioration and preserve or restore life to whatever state possible. Often the deterioration results in an emergency, such as a heart attack or stroke, and the initial intervention is administered by an Emergency Medical Technician (EMT) in the field with limited training and resources at their disposal. In these situations, the focus is on stabilizing the deteriorating patient and transporting them for more in-depth diagnosis and treatment by a fully certified physician who has all of the training, tools, and resources necessary to remediate and monitor the problem. Once under the care of the MD, the focus turns to repair and recovery of the deteriorated system.

Emergency medical interventions to “stabilize” a deteriorating condition often occur with multiple victims or multiple conditions at the same time and require that emergency medical professional make deliberate choices regarding which conditions to treat and which to leave unattended until a later time. Subsequently, advanced care and resources (e.g., time, drugs, equipment, personnel) are used on victims with serious but less severe injuries. This process, called Triage, is defined as follows:

Triage is a process of determining the priority of patients treatments based on the severity of their condition. This rations patient treatment efficiently when *resources are insufficient* for all to be treated immediately. [italics added]

Triage typically classifies victims or deteriorating condition into four categories:

- Those that are beyond help
- Those that can be helped by immediate stabilization and transport
- Those that need medical attention but whose transport can be delayed
- Those with minor injuries, who need help less urgently and can wait until resources are available.

This concept of “ideal” versus emergency health care is illustrated in Figure 1.

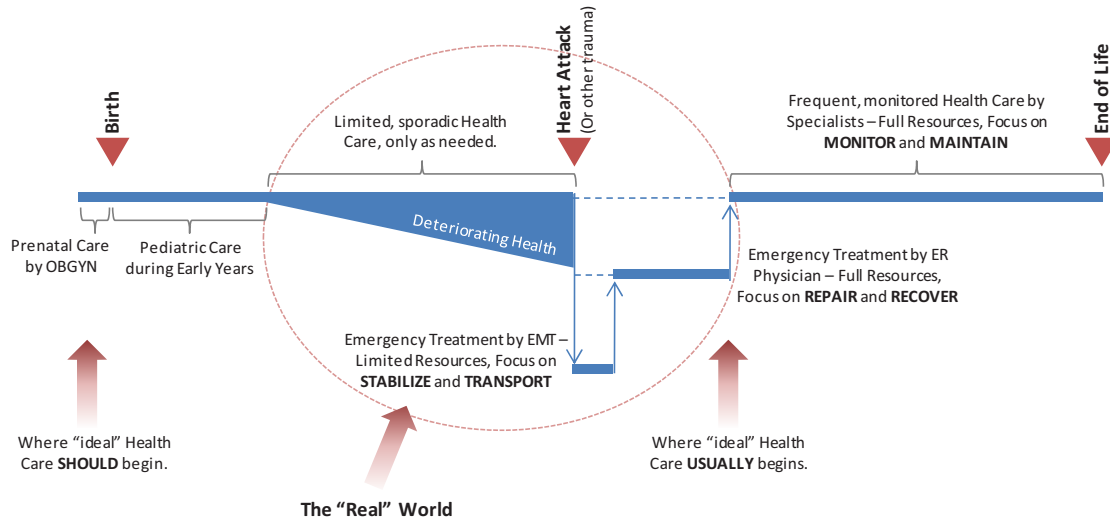


Figure 1. Role of Emergency Health Care in the Typical Human Life Cycle

Once the deteriorated system has been repaired, the individual is again placed under the care of a “regular” physician, often with the support of one of more specialists, to monitor and maintain health throughout the individual’s life. Ironically, this is typically the beginning of a routine, “ideal” health care scenario in the real world. Because the trauma is a significant emotional event, it causes people to re-evaluate the costs and benefits of health care. Some just “give up,” but many others will change their lifestyle and begin including at least some elements of “ideal” health care in their lives. In short, the frequent, monitored approach to health care gets implemented only AFTER the trauma and rescue, rather than as a preventative measure at the beginning of life.

Project Life Challenges. Much like the Emergency Medical professions, systems engineers are frequently called upon to “rescue” projects, both large and small, without the advantage of having been involved in the early stages of development. In many such instances, projects are conceived and executed without the benefit of early SE activities and their resulting products (e.g., mission objectives, system requirements, functional and physical architectures). In other instances, projects follow an SE approach in the early stages but abandon rigorous, on-going SE activities because there aren’t really any problems to deal with. As a result, projects (like people) chose to take care of themselves with few or no interventions to ensure long-term survivability and success. Only when it is “necessary,” such as a regulator querying the status of the project or some other significant emotional event that changes the course of the project, do project participants begin to look closely at the status of the systems and processes in question. At other times, a sudden overrun in cost or schedule indicates that the project is in trouble, causing project managers to re-evaluate the cost and benefit of frequent, long-term analysis and care by a systems engineer. In such instances, resources are often limited such that not all problems can be equally addressed. A “triage” approach to SE proves helpful. Taking the above medical definition, a parallel definition for SE Triage becomes:

SE Triage – A process (or practice) of determining the **priority of project treatments** based on the **severity of the project’s condition**. This **rationes SE application** to the project more efficiently **when resources are insufficient** for all conditions to be treated immediately.

Expanding the analogy, adaptive SE would “triage” key project variables, including but not limited to mission statements; requirements analyses; cost, scope, and schedule baselines; etc., to determine the most critical conditions needing attention. Available resources would then be directed at assessing the magnitude of project deterioration and stabilizing the project such that more detailed analyses can be conducted later on. These efforts typically involve more fundamental SE approaches and tools due to the limited availability of project resources. In some instances, this may even mean letting certain project components “die” so that the overall project can be redirected to meet stated objectives. Exactly which project components get treated and how is unique to the project being “rescued” and will vary from project to project.

To accomplish this, the systems engineer needs to stay cognizant of but operate outside the typical “textbook” approach of mission needs followed by requirements followed by design and so forth and determine which treatments will do the most healing in the least time. Those treatments can then be applied in an orderly and systematic manner to restore project health and gain more significant involvement in the future. Once the project is stabilized, the systems engineer can begin evaluating and repairing the full spectrum of project problems using the full suite of SE tools and techniques. At this stage, projects may require a more detailed mission or requirements analysis using previously defined requirements as a basis for expansion and verification. Similarly, well-defined projects may require detailed modeling and simulation, life-cycle cost analyses, risk analyses, or architectural design applications to address pressing needs. Again, which tools and techniques are applied and how is unique to the project being “repaired” and will vary from project to project.

When the systems engineer is able to step in and manage the hemorrhaging and begin to rehabilitate the problem, most project managers become convinced of the value of SE in ensuring that projects are executed within cost, scope, and schedule and that resulting products meet stated requirements. It then becomes the systems engineer’s role, with the help and full support of the project manager, to monitor, maintain, and improve project and system progress throughout the remainder of the project life-cycle. It also presents a tremendous opportunity for the systems engineer to do a little forensic analysis, in other words, document the lessons learned and move forward with future projects so they don’t suffer similar fates. This concept of “ideal” versus adaptive SE is illustrated in Figure 2.

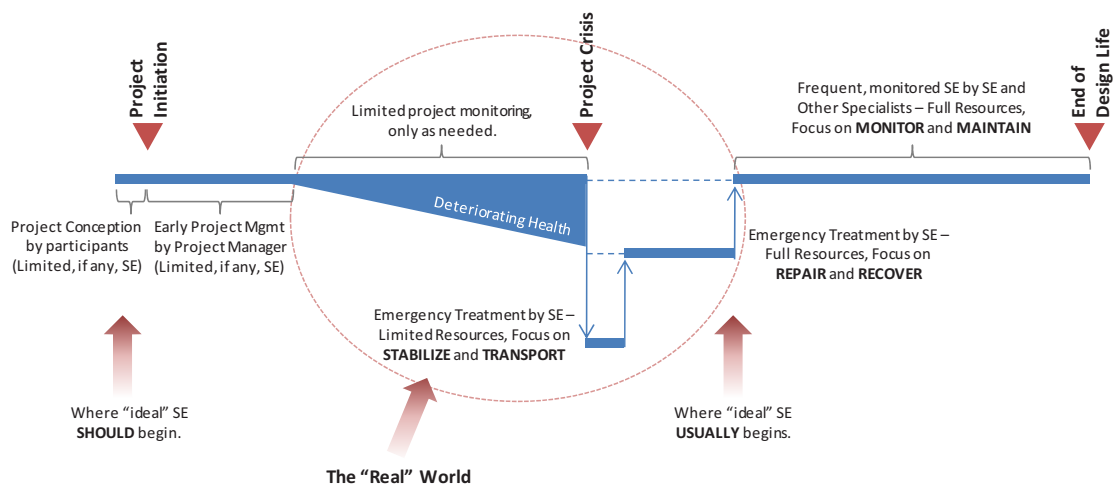


Figure 2. Role of Adaptive Systems Engineering in the Typical Project Life Cycle

Case Studies of Adaptive SE

The following case studies illustrate the application of adaptive SE by the Idaho National Laboratory (INL) SE Department to help address emergent conditions on Department of Energy (DOE) and Defense projects and put them back on track toward project success. A brief description of INL efforts on two of those projects follows. In both instances, INL systems engineers joined the project well into the development life-cycle and at a critical junction where decisions had to be made quickly and without the benefit of prior systems engineering processes. In each instance, the systems engineers were able to adapt to the immediate needs of the customer and deliver results that put the project back on track toward successful completion.

U.S. Army Active Protection Systems Project. The application of an Active Protection System (APS) that will detect and defeat Rocket Propelled Grenades (RPGs) is part of the U.S. Army's Future Combat Systems (FCS) development that will "...provide a versatile family of combat systems that represent the way the Army will fight wars in the future." Original plans were to field one Unit of Action (UA) equipped with all FCS core systems and additional Modular UAs with embedded FCS capability by 2014. In July 2004, Army officials announced plans to accelerate the delivery of FCS prototypes as early as 2008, with full production and fielding of first-stage FCSs commencing to Current Force units in 2010. The INL was asked by the U.S. Army Program Manager – Unit of Action (PM-UA) and Program Executive Officer – Ground Combat Systems (PEO-GCS) to assist the Army in finding a way to meet its new schedule objectives without revisiting the work and progress that had been made to date.

The INL was asked to conduct three specific tasks over a three month period in support of new deployment objectives: (1) conduct an independent, rapid assessment of known APSs, (2) identify risk reduction tasks that would lead to specific improvements in various APSs so that an informed decision could, and (3) develop a roadmap to communicate the relationship of the technology needs, the risk reduction tasks, and need dates to portray a clear temporal picture of the key activities in fielding an APS.

The roadmapping team identified alternative APSs and associated performance data from a variety of sources. Alternatives were then screened against previously established requirements regarding the time that the alternatives could be deployed in the field and the nature of their defense against RPGs. Ten alternatives made the cut. 23 evaluation criteria were developed from existing analyses, field situation reports, and PM-UA personnel discussions. The criteria were then weighted to represent the decision-makers' values. The ten remaining alternatives were evaluated based on the available data with respect to the criteria. Some deficiencies in the performance characteristics of the various alternatives were noted, and some promising alternatives were identified, but no alternatives clearly differentiated themselves from the pack.

Using the evaluation data, the team synthesized a handful of new alternatives by combining the most promising aspects of the alternatives under consideration. Uncertainty in data quality and technical maturity, as evidenced by Technology Readiness Levels (TRL), were quantified for each existing and new alternative. In addition, uncertainty in the cost estimate for each system was assessed based on TRL. These uncertainties were combined with the nominal performance and cost values and plotted to show the range of uncertainty for each alternative. Future APS development activities were then analyzed to identify their contribution to reducing uncertainty and documented in the roadmap. If uncertainty could be reduced as expected (per the roadmap), decisions could be made on an accelerated schedule to eliminate some or most of the

alternatives, thus significantly increasing the likelihood of meeting the 2008 deployment milestone.

As an added measure, the INL evaluated the Army's test and verification plan for APS technologies to determine if additional improvements could be made to reduce cost and accelerate schedule. In many instances, the Army had planned to test each APS technology by launching upwards of 2000 rounds each to verify the performance of the countermeasure. INL analysis showed that the same results could be achieved by launching less than 100 rounds with specific objectives for each launch. The revised test and verification plan resulted in significant cost savings and acceleration of technology readiness and deployment by several months.

One year later, the INL was asked to update the APS Technology Roadmap in light of evolving objectives. Primarily, the FCS wanted to implement a Current Force APS architecture that is forward compatible, or that has a high degree of commonality, with the FCS short-range solution for the FCS Manned Ground Vehicle (MGV) being developed under a separate project. Over 15,000 alternatives architectures had been identified in an independent Science and Technology Trade Study. The INL team screened these alternatives to find viable configurations that could be further evaluated using Trade Study goals and criteria in a multi-attribute utility analysis. Three filters were used to screen out low performing alternatives: timeline, countermeasure accuracy, and compatibility between platforms. Approximately 40 architectures made it through the three screens for further evaluation.

A closer examination of the potentially viable alternatives revealed that all the alternatives shared only two launcher mechanisms. Subsequent to the launcher selection, alternatives require either a guidance system or an enhanced tracker, each with different compatibility to the launcher mechanism. Three primary architecture configurations evolved from these selections and showed good performance against the threat in question. The three primary architectures were evaluated to understand how uncertainty resolution could possibly affect the performance values used to make an architecture decision. The uncertainty analyses showed distinct risk profiles that provide the opportunity to potentially move two of the architectures forward (a primary and a backup) that do not have the same failure/risk mechanisms, thus improving the overall probability of success of the APS effort.

Finally, INL personnel evaluated how the order of FCS decisions would enable the Current Force APS architecture decision to be coordinated with overall FCS architecture decisions. Various decision alternatives were considered resulting in a "strawman" decision precedence that provided the time necessary to resolve higher-risk decisions while quickly making those decisions required to move out on the Current Force solution. In the evaluation, it was identified that the launcher is a key architectural component that, if a decision is made early, could help keep the FCS and Current Force solutions on the same track. This realignment of decision order allowed the program to move forward at a much faster pace.

In a letter to INL management regarding INL SE support to the U.S. Army APS project, Colonel Donald Kotchman, Deputy PEO-GCS, noted the following:

"The INL's roadmapping process gave us the ability to look forward in our technology development and selection processes in a very deliberate manner. It has provided insight into risk areas and has allowed us to explore requirement gaps that will help us prioritize the activities necessary to develop reasoned decisions with a technical basis that we could not previously articulate."

U.S. DOE Biomass Feedstock Project. Biomass pre-processing is a critical operation in the preparation of feedstock for the front-end of a cellulosic ethanol biorefinery. Without this operation, the natural size, bulk density, and flowability characteristics of harvested biomass would decrease the capacities and efficiencies of feedstock assembly unit operations and biorefinery conversion processes to the degree that programmatic cost targets could not be met.

The INL is directly tasked with determining the overall efficiency of the feedstock supply systems, including the harvest and collection, storage, pre-processing (grinding), transportation, and handling unit operations for all feedstock types used in bioethanol or syngas production. In the spring of 2007, an INL systems engineer found the feedstock pre-processing project engineer sitting at his desk surrounded by a dozen SE text books trying to determine a starting point for writing a test plan for the 2007 full-scale feedstock grinding demonstration project. The project engineer explained that the project start date was at risk of slipping, the project requirements were a moving target, the tasks were not defined, and several project deliverables were required by year end. Further, the project needed to collect hammer and fixed cutter grinder performance data on multiple feedstock varieties and moisture levels by purchasing, staging, and ultimately grinding 800,000 pounds of media by the end of the year by three undefined commercial grinder vendors. With only seven weeks remaining until Test Plan delivery, the INL systems engineer offered to apply a few simple SE techniques that would greatly help the project meet its deliverables. The project engineer accepted the offer.

As is often the case, there was not sufficient time or resources to “start over” and gather all of the information typically gleaned through an end-to-end SE approach. Rather, the systems engineer had to devise a simplified way to achieve typical SE outcomes without compromising project budgets or schedules.

The initial SE effort focused on defining the project requirements by parsing the requirements from the project proposal documents. A quick assessment of the effort concluded that it was too late in the life of the project to do a complete requirements analysis. By the time all of the undocumented requirements could be defined and articulated, it would neither help nor add value to the project. A decision was made to accept any and all existing requirements as “valid” and to focus on capturing/validating the project tasks or functions upon which the test plan would be based. It was further decided that a project functional flow block diagram (FFBD) would be the ideal tool to both assess the project stage and to identify gaps in project tasks and functions. The FFBD used for this effort was a simple adaptation of a traditional FFBD delineating the order in which tasks had to be performed and including ancillary notes and explanations, as needed.

Since the “big picture” had never before been articulated to project personnel, it was decided to expand beyond the functional analysis described above and conduct a modified mission analysis to define and present the “big picture” view in a graphical format. Several traditional mission analysis activities were performed. The twist was that resulting mission analysis elements were then superimposed onto the FFBD such that specific mission elements aligned with project functions and tasks. When the customers, industrial partners, and other team members were shown the new diagram and talked through the project, they had both immediate and complete understanding of the project big picture and of their individual role within the biomass feedstock effort. The real benefit, however, was that it provided a baseline from which to build the Project Test Plan.

A functional decomposition of planned tests was developed, patterned after the FFBD, to articulate what was to be done, who was to do it, the resulting deliverable, and any notes germane to the task. These functions were then tied back to existing requirements to ensure that all required test were being addressed and that all planned tests were being driven by a requirement.

This simplified, adaptive SE application for the biomass project resulted in the project successfully meeting all 2007 milestones. Due to successes achieved by the project systems engineers, they were given the opportunity to conduct similar analyses for the overall program, of which the biomass pre-processing project is only a part. Additionally, the project systems engineers were asked to join the project team for subsequent phases of the project to (1) conduct a detailed requirements analysis and ensure project tasks are linked to requirements, and (2) to perform a gap analysis between products, personnel, and system designs.

Changing Our Paradigm

Joel Barker, an organizational leadership scholar and futurist, popularized the concept of paradigm shifts for the corporate world and discovered “that the concept of paradigms ... could explain revolutionary change in all areas of human endeavor.” Simply put, paradigms are thought patterns that determine how we see the world. As a result, they significantly impact how we approach tasks and solve problems, both simple and complex. If we can change our paradigms and see things in a different light, we will approach them differently and find new solutions to old problems.

This is the situation facing the SE community. As SE practitioners, we need to change our paradigm and enhance our abilities to address the emergency, project rescue scenarios with which we are most often faced.

Paradigm Shift 1: Don’t assume the Project “did it wrong,” and don’t force it to “start over.” One of the first mistakes systems engineers make is to disregard all previous project efforts as “wrong” or “not the SE way,” and insist that the project start over and “do it right.” Two things happen in this instance: (1) a wall is built between the SE and other project personnel that hinders progress over the course of the project, and (2) lots of time and money gets wasted repeating work that has already been completed (though maybe not to the level of detail we, as systems engineers, would have liked. When customers perceive the added time and cost that this scenario puts forth, they become soured to the value of SE and resist any future attempts to use SE processes on their projects. Systems engineers need to accept the project status as-is, whatever that status may be, and find ways to move forward rather than starting over.

Paradigm Shift 2: Be cautious of the “quick fix” or “low hanging fruit.” Systems engineers need to become more adaptive and hone our triage and assessment capabilities to target those aspects of deteriorating projects that most need our attention. Too often, project managers and systems engineers spend valuable, limited resources addressing minor problems and pursuing “quick fix” solutions that, while showing progress, don’t do much to mitigate the critical challenges facing a project. It’s like an emergency room physician treating the eczema on the elbow of a heart attack patient before performing the angiogram to fix a blocked artery. Systems engineers and project managers alike need to ask themselves what actions or interventions will have the largest impact on the problem being faced and address those first.

Generally speaking, “quick fixes” can be saved for later and addressed only if there are time and resource available once the real problem is under control. However, project managers are occasionally not yet bought into the level of SE complexity or rigor that it may take to address the real problem. In these instances, it may be advantageous to address a select few of the “quick fixes” or “low hanging fruit” first to establish confidence in SE processes and build rapport between the project manager and the systems engineer. More pressing needs can then be addressed to the appropriate levels of detail and complexity.

Paradigm Shift 3: Don’t overwhelm the project with expensive technology and complicated processes. As systems engineers, we are excited by any new tool or technology that can make our work easier, more specific, more detailed, or more refined, and, when we find them, we tend to insist on using them for every problem we are asked to solve. Many of these tools are highly complex and carry a hefty price tag that most often gets passed on to the projects we support. Customers that don’t understand the intricate details of the SE process or the subtle nuances that such tools are designed to highlight, don’t share the same enthusiasm we do for complicated technologies and processes. This lack of familiarization and understanding can drive customers away, especially in light of the costs many of these technologies and processes carry. Subsequently, part of being “adaptive” in our applications of SE principles is to screen when such technological advances are appropriate and when they are not. In most instances, needed information and adequate results can be gleaned using simple tools and process to which the customer can relate. The “Keep It Simple” principle should be a driving adage for all practicing systems engineers.

Paradigm Shift 4: Look for rescue-type situations where you can have an immediate impact; don’t shy away from an opportunity just because it isn’t an “ideal” project. As stated above, the SE community spends the majority of its writing and training advocating and preparing to practice “ideal,” textbook SE when such circumstances represent the minority of the actual work in which we are engaged. We need to do a better job of understanding and using the growing suite of SE tools and techniques to adapt and respond to the unique emergent needs of the projects we support, and spend less energy positioning ourselves for “ideal” SE scenarios that may never come.

Conclusion

The worldwide SE community can become much more effective as systems engineers by changing the paradigms under which we teach and “practice” SE. Ultimately, our ability to adapt and respond to critical, emergent project needs will grow the reputation of SE among seasoned project managers and organizational professionals and set the foundation by which the more frequent practice of “ideal” SE can be realized.

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Biography

R. Douglas Hamelin is a Systems Engineering Specialist and Technical Writer for the Idaho National Laboratory Systems Engineering Department. He is trained in requirements management and computer-aided decision support, contributes to a wide range of Systems Engineering applications as a requirements and functional analyst, and supports numerous DOE projects and publications as a document specialist. Doug played a significant role developing and implementing a university-accredited, fundamental systems engineering training course for the University of Idaho. He most recently served as editor in the revision of INCOSE Systems Engineering Handbook v3.2 and in its submittal for consideration as an ISO/IEC Technical Report.

Ron D. Klingler is the Systems Engineering (SE) Department Manager at the Idaho National Laboratory (INL). He has over 30 years of project management and SE experience working on a variety of nuclear, security, energy, and infrastructure programs and projects. His current primary responsibilities are identifying and developing SE capability and expertise and provide it to enhance the programs and projects at the INL and for other Federal customers. Ron received a BSEE degree for Brigham Young University in 1980 and a MESE degree from the University of Idaho in 2004.

Christopher Dieckmann has been a Senior Systems Engineer at the Idaho National Laboratory (INL) since the Fall of 2007. Before joining the INL, Chris was a Quality Manager, Systems Engineer, Flight Test Management Engineer, Product Engineer, and Product Assurance Engineer for Honeywell, Analex, the U.S. Army and the U.S. Air Force. He has supported a wide variety of projects including energy systems, ground vehicles, air vehicles and related equipment. His career has taken to several cities and a bunch of remote locations across the country, but he grew up in Chicago and now calls Idaho Falls home.