2014 NDIA GROUND VEHICLE SYSTEMS ENGINEERING AND TECHNOLOGY SYMPOSIUM
SYSTEMS ENGINEERING (SE) MINI-SYMPOSIUM
AUGUST 12-14, 2014 – NOVI, MICHIGAN

Foundational Critical Principles Advancing Systems Engineering

William Maholick SSBB, MBB, CQA, DFSS
Infinitech, Inc
White Lake, MI

Carl J Godell PMP CHRS LSS
CJL Communications, Inc
West Bloomfield, MI

ABSTRACT

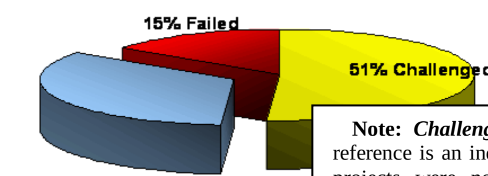
Within any science or study, some aspects recur so reliably that they take on the character of a principle or natural law and their constant observance and inclusion in the application of the science helps to further develop and advance that practice. So it is with study and application of systems engineering and project management, and within that system and application we could itemize those principles and consider them the foundation of project management and systems thinking. This effort results in cumulative knowledge having the properties of a physical system capable of enabling future teams enough specific data to improve risk awareness and reaction.

INTRODUCTION

In developing recurrent behavioral practices we would know that different understandings of the principles invoke varying interpretation. This does not necessarily develop a recipe for success. It is fundamental and necessary and without it success is illusive.

As a parallel, one of the basic tenets of mathematics is the completeness property and while it may not seem particularly pertinent to project management, one does need to consider that the effort must comprise all of the data and particulars required of the project. This balances well with the definition of a good project manager as being one who tirelessly pursues the minutia, and is probably the most endearing quality of anyone who manages, and colloquially, it is commonly considered that the devil is in the details. Six Sigma analyses is clearly a part of this process [1].

In fact the U.S. Department of Transportation, Federal Highway Administration recognizes that the uncertainty on projects is 4 times the original estimate and only 32% of all projects finish on time and in budget. Even so, within a report by the U.S. Department of Transportation, Federal highway Administration, it cites a 10-year study of 280,000 projects by The Standish Group with statistics finding only 34% of those projects would meet the criteria of both finishing the project on time and within budget [2]. This number obviously fluctuates project to project, and it is interesting that the percentages, when observed in these reports do not radically change, year-to-year, project-to-project and means that some of the project data was missing.



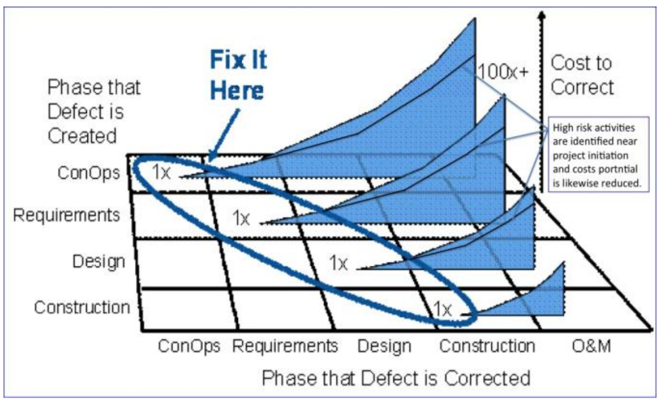
Note: ***Challenged*** in this reference is an indicator that projects were noted to be either; over budget, behind schedule, out of scope, or a combination thereof.

The manifest pursuit of a flawless, on-time product launch is rarely easy to achieve, and in organizing and developing over 800 product development projects, one always wishes for the background and risk data for every element to be incorporated into the timeline. This has been a fastidious search, to look for and correlate data that both supported and detracted from the initial critical path. Our efforts set about methodically mincing each element's attributes, distilling that character set of the data features and then incorporating those into the potential risk to the timeline [3].

This is the path to continuous improvement and it has provided some further insight into the best and worst aspects to every activity. These are then integrated to both provide an insight to the risk and establish some framework for any contingency required.

If something goes wrong there was inevitably an oversight, or incompleteness, to the understanding of the individual event. Something may have been routinely overlooked, or the quality or risk in that event was not captured properly. It is here that we typically determine that a portion of the risk was a known-unknown, that is, it may or may not have occurred, but this must be addressed far before the risk occurred, contingency mitigated, and the risk reduced as much as possible while leaving the integrity of the project intact to scope. Something going wrong might be inevitable due to many factors, time constraints, capital constraints, intellectual capital constraints, and the list goes on.

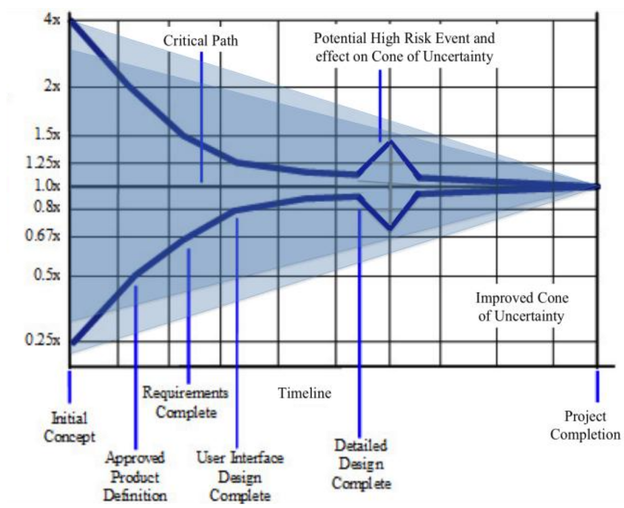
Regardless of the unknown, the optimum time to detect and correct issues is at the earliest stages of the project along with identifying the risk and inherent costs with progressing further. Recognizing those factors the improvements can truly be significant and could certainly lessen the overall uncertainly and costs to the project as identified in the following graphic [4].



Note: *There is an approximate 20% reduction in the costs to correct defects if the detail of risk is better documented and contingencies and resources developed prior to the potential risk event.*

What this has reinforced with us is that every potential detail needs to be apprehended and that the impact of the quality and risk must be captured and entered into the probability of success for the project release to be both on time and within budget. Employing this data then provides significant vision into the flawless delivery of the project and improves the resource planning and project overages by significant margins.

Let us peer a little deeper into the abyss on this subject of identifying risk. As we stated earlier in the introduction, the U.S. Department of Transportation, Federal Highway Administration recognizes that the uncertainty on projects is 4 times the original estimate and only 32% of all projects finish on time and in budget. The Cone of Uncertainty [5] in that report presents a 4 times multiplier to the effort and costs of a project beginning at the conception of the project and further states that the later in the project the correction of the issues begin, the correspondingly larger the increase in costs to correct. Furthering the Cone of Uncertainty graphic, properly identifying the risk elements on the critical path provides for a vastly improved future look at what elements are most dubious of success and by strategically focusing attention and resources on those activities, a certain improvement may be realized in effort, cost, quality and timing to the project completion. It should be noted here that the graphic hints at the potential improvement but even 20% of a $10 Million project is sizeable.



Note: *As illustrated above, knowing the scope of risk at any point on the Critical Path better defines the timing and resources required and reduces the uncertainty and cost.*

This upfront effort to tag high risk activities results in quantifiable improvement to the project however, it also advances the cumulative knowledge and when documented correctly, further offers lessons learned of things gone right (TGR) and things gone wrong (TGW), as well as providing the properties of a physical system capable of enabling future teams enough specific data to improve risk awareness and reaction. In developing a recurrent professional practice we would know that different understanding of the principle will invoke varying interpretation. This does not necessarily develop a recipe for success, but it is fundamental and necessary and without it success is illusive.

Many practitioners of the art of managing the project find themselves having to convince stakeholders to take a step back and look first at the ‘reliable aspects’ of each phase of the project, that is, ahead of the execution phase, in the planning stages of each phase of the project with a common understanding of where these reliable aspects belong and what they can do to build a more reliable foundation towards success. As you continue to read we challenge you to think about the project you are currently working on and how this type of thought process might assist your own process steps.

Reliable Aspects:

1. **Critical**: Consider the critical aspects of all of the features and events of the individual components.
2. **Concise**: the organization and flow of the development forms a compact achievement of end results with minimum critical path.
3. **Predictable**: Predict incongruities and vagaries that creep into a timeline.

Critical

In considering these aspects that take on the character of a principle or natural law, the first of these is that the system organization and management must consider the critical aspects of all of the features and events of the individual component. We could call this the activity character set. Within systems engineering, in considering these aspects, it is important to not be daunted by the amount of work still to be accomplished [6]. Risk will be determined by the effort of the capable team to identify and qualify the extent of what is critical. General George S. Patton purportedly stated: "A good plan violently executed today is far and away better than a perfect plan tomorrow." Remembering that this statement was made during a time when data sharing was a manual process and took many hours for committee decisions. Of course we create a new grouping of constraints with each generation of project managers or systems engineers. Consensus should be faster, better decisions made quicker. We must then consider there are changes in technology, design changes, vendor/supplier changes and when that happens there are personnel changes. All of this builds additional risk into the project.

What if there is no time to consider but only a few of the critical aspects of a given situation. Of course we can reject the project with our accumulated knowledge and make a strategic decision that there is not enough data to proceed at this time, that is, there are too many unknowns with the project and therefore the risk is too high. At the same time we can accept the project under the condition that there will be changes for improvements along the way and that we clearly understand we have the necessary intelligence to make more correct quick decisions than would perhaps outweigh incorrect decisions. It would also be an ideal state to recognize past programs for what went right and what went wrong. Now, we agree, there is a cost to taking on too much risk. The question will be who bears liability for that cost, the management team, the manufacturer, or the customer? We can negotiate risk acceptance, whether it is shared risk, transferred risk, owned risk, or a combination of these to keep a project on schedule and on budget.

Customers will often start any process with the question of cost and how to reduce that particular cost. The premise here is that all major projects have scope creep of some degree and cost can very quickly spiral out of control once contract agreements are established. This is the bottom line. In working backwards from this view costs are driven low at the beginning of the project, clearly a recipe for disaster, risk is immediately elevated. The various experienced engineers and technicians many times can see this coming, this I can guarantee. As a chimney function within many organizations they typically do not communicate cross-functional areas. This is the job of the SE or the PM to tie that information together in a way that reduces risk. We don't know what we don't know, and we cannot know everything. We can learn of course, and learning takes time.

There is an answer. The features and critical aspects of the individual components of the project in general can pretty quickly tell us a great deal about their risk. Quantify, and then qualify, measure critical aspects, and then control what was agreed upon to measure. Looking at just the human element for a moment if there is a shift in the direction of the program due to, let us say, insurgency, we must remember that counter-insurgency is not designed to be a strategy. Whether a military action or a corporate action there are human capital involved. Some things can be controlled some of the time. The longer duration the project the greater the need to continually evaluate the intelligence available and, continually review the risk with repeated measurement and control. The concentrated effort is to manage risk.

Concise

The second of these principles is that the organization and flow of the development must be as compact as possible to accomplish the end result within the minimum of a critical path. Here the divergence to that optimum might encompass parallel processes, cost avoidance practices and resource leveling. However, the pursuit of the optimum path versus additional cost and timing is the consummate solution. This principle is clearly within the art form of managing any system. There is a tipping point in the balance where cumulative knowledge and the developed constraints will provide enough information to determine a degree of favorable risk. That is, the risk plan has sufficient mitigation and contingency efforts in place. Strategy is a system of expedients.

According to Mikel Harry and Richard Schroeder in their book titled 'Six Sigma' they observe in their chapter on DFSS (Design for Six Sigma); "While design typically represents the smallest actual cost element in products, it leverages the largest cost influence." That is, they continue, "…an incremental improvement in the design, through the use of DFSS methodology, has a huge direct impact on actual costs." In their illustration they show that although the actual (hypothetical) cost for design work equates to about 5% of the total project budget, the cost influence is at 70% of the total. The actual cost for material could be 50% but the cost influence over the life of the project is at 20%. Labor cost is 15% of project budget, the cost influence is 20%, and finally overhead has a figure of 30% but the cost influence is actually 5% of the total project [7]. What this means to us is that the real influencer is in the design phase. How concise you are at this phase has great power in enabling project success even when cost influencers work their way into the deadline timing. This is one good example of how to develop favorable risk into your system.

Here, the resource character set identified earlier is once again the primary driver to the process that has evolved as the critical path as each activity exacts a reliability quotient and expands the risk accordingly. One cannot argue with the math unless they know the definition inherent to each activity. Without the activity character set one only has statistics with an inference, while with the character set one can plan an alternate path that is quite nearly as optimum as the original plan.

Predictable

The third and most definitive trait to an optimum plan for systems management is whether it can predict the incongruities and vagaries that creep into a timeline via the understanding that what can go wrong will go wrong, and work with those effectively. This third aspect depends implicitly on the information from the first two principles and is the primary area where all factors and interdependencies are put to the test and where the focus is decidedly on the future probability of negative interventions. At what degree of error was the physical system allowed to develop? Predicting the factors that enter into a timeline necessitates drilling down to the core issues all while maintaining the succinct nature of the timeline and is an ongoing process.

Whether writing about system engineers, project managers, or, military teams in the field, there must be trust and common interest. Strategy is one thing, quick implementation another. Both of those brief statements speak volumes of the subject of cumulative knowledge. We cannot build trust without shared information, whether it lies in skill sets, previous experience, facts, and even emotions. Do we have the knowledge and, then there is, can we personally trust the derived data. You might ask, how do we build personal trust? How do we then apply this trust to work within systems engineering. I may have all the data required to begin the trust process, however, one must ask how much data is necessary to develop a reliable trust? As D. Evans observed; Overwhelming amounts of data stored in disparate systems result in the inability to easily access pertinent data for quality investigations[8]. To each of us this will mean something different. Why? Simple, because with human nature some of us trust more and some trust less. Culture, prejudice, diversity, how exactly in tune we are with that inner voice. Does one ever provide as much information as possible to someone and find that it still was not enough to gain their trust or consensus? Did you ever find yourself believing in someone who charismatically wins your consensus, somehow you just trust them, even though you know they do not have the experience? There is much more than just determining that it will take two weeks to get through design.

After trust comes the issue of common interest? Common interest tells a story about both a mutual affinity for something, and a reality that is shared as well. It is safe to say that many people are in this field not out of desire but as some direction their career has taken, or as a stepping stone or career stop to gain experience [9]. Think about this, how can there possibly be the same level of trust, between multiple parties or groups, the same identical common interest within any program? We may have good strategy but quick implementation is what is needed. This reaction time to any strategy increases the risk to the project in direct proportion to the emotion invested and each of us reacts differently. Counter insurgency theory was never designed to be a strategy. It should trigger a response contingency effort that appears as a strategy, structured in a fashion to circumvent normal thinking and at the same time allow various teams quick input and execution based on historical risk factors.

Conclusion

Critical, Concise, Predictable, are three focus points for any project endeavor that requires any degree of complexity. As foundational elements, these topics can only be developed and executed correctly with consideration of the discussion within the topics touched upon in this paper.

Inadequate systems engineering is repeatedly cited as a major contributor to failed projects especially in the National

Aeronautical & Space Administration and the U.S. Department of Defense (DoD) [10]. This needs to be repeated, it is foundational, fundamental, and the further we advance in our tools and knowledge, especially in considering human capital turnover, cloud storage, and all the other tools we have at our disposal, the more demands will be placed upon the systems engineer, the project manager, and the six sigma practitioner.

Between these two thoughts in the above paragraphs lies the conundrum. Critical components within any project are first to be considered. To get to the most concise solution is to drill down the critical characteristics to an acceptable degree of risk. We can then begin to predict results. It is iterative data throughout the project. Then, we must consider the experience, knowledge, and intuitive nature of the human capital involved.

REFERENCES

[1] D. W. Benbow and T. M Kubiak, "The certified Six Sigma Black Belt handbook", Milwaukee, WI: ASQ Quality Press.

[2] U.S. Department of Transportation, Federal Highway Administration, "CHAOS Report Project Success Rate", Standish Group. 2004 http://ops.fhwa.dot.gov/publications/seitsguide/section3.htm

[3] Project Management Institute (2004). "A guide to the project management body of knowledge (3rd edition)". Newtown Square, PA: PMI Publications.

[4] R. S. Pressman, "Software Engineering: A Practitioner's Approach". 1992.

[5] S. McConnell. "Software Project Survival Guide", Microsoft Press. 1997

[6] J. Kasser, D. Hitchins, M. Frank, Y. Zhao. "A framework for Benchmarking Competency Assessment Models". Systems Engineering Vol. 16. No. 1. 2013. 2012 Wiley Periodicals.

[7] M. Harry, R. Schroeder, "Six Sigma" Doubleday, 2000.

[8] D. C. Evans, "Systems Engineering lessons Learned (SELL)", Evans Optical Engineering, 1989. http://evansopticalengineering.comage00/sysengll.htm. Last accessed Sept 6, 2011.

[9] C. Godell and W. Maholick. "Spectrum of Change, Corporate Contract Work, Creating a Culture of Mutual Respect". CJL Communications, Inc. 2010.

[10] A.T. Bahill and F.F. Dean. "Sandia National Labratories" What is Systems Engineering? A Consensus of Senior Systems Engineers", Sandia National Laboratories, Albuquerque, NM. 1995.