Training to Enhance Design Team Performance:
A Cure for Tunnel Vision

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ABSTRACT

Design Team performance is a function of the quality and degree of academic training and the cumulative, learned experience of the individual members of the team. [1] Teamwork, leadership, and communications certainly are factors that affect the measure of the performance of the team, [2] but they are not addressed here. This paper focuses on accelerating the learned experience of team members and describes an organizational approach that can significantly increase the effective experience level for any engineering design team. The performance measure of the whole team can be increased by increasing the engineering disciplines' cross awareness of each other and by familiarizing them with their affect at the system level. Discipline engineers know their own discipline well, but typically are not intimately familiar with their technical interaction with and dependencies on all the other disciplines of engineering. These dependencies are design integration functions and are worked out well by the discipline engineers as long as they are involved in the design of types of systems that they have experience with.

This approach can be accomplished by an organizational shared vision and effort, and through a focused training curriculum whose design, development, and delivery is centered around increasing the awareness of each of the engineering discipline's sensitivities to each other and to their sensitivities to decisions made at the system level. This requires that the design organization(s) identify all unique engineering disciplines/functions present in the organization, identify the prominent expert in that discipline, and task each to develop and deliver an awareness Minicourse for each discipline. The remainder of this paper will explain an approach taken at the Marshall Space Flight Center (MSFC) in the design, development, and delivery of a Pilot program that has now been delivered four times.

This undertaking is a joint NASA Headquarters and MSFC effort. Other NASA Centers are initiating their participation in this NASA Engineering Training (NET) initiative.

Keywords: Team Performance; Learned Experience; Curriculum; Engineering Disciplines; System Level; Minicourses

1. INTRODUCTION

In this paper the design, development, and delivery of the curriculum for an initiative titled the Comprehensive Systems Skills Initiative (CSSI) will be described. The motivation for the development of this curriculum comes from the realization of a flaw in the experience lifecycle of engineers, lead systems engineers, and program managers, regardless of their affiliation. Whenever a college graduate engineer is hired, he or she is of an academic, or textbook, culture. Most engineering organizations hire graduate engineers of a specific aca-

demic degree to staff up a particular engineering discipline, or job description. Colleges and universities typically do not offer degrees in the narrow specializations of most industry and government organizations that build one-of-a-kind or highly specialized product functions. Therefore, a new hire is placed in a particular discipline within an organization and remains there, usually, for a considerable period of time performing that function. There are two basic scenarios. The first is that the engineer "acquires experience" over time as various projects are completed, and after numerous projects have been completed the engineer is thought of as "highly experienced," but usually in a narrow band of the disciplines of design. The other scenario is where, after much experience has been gained, the engineer is elevated to a lead system engineer or maybe a program/project manager, where much broader experience is acquired as project responsibilities come and go. However, this engineer is still an experienced discipline engineer turned manager. The truth is that our discipline engineers, whenever placed on a program that requires an unfamiliar subset of the disciplines of engineering, may be unaware of the traps waiting. The point is, all new discipline engineers can be given training at the beginning of their careers that will make them aware of all engineering disciplines in the company, how they generally depend on each other, what trades and analyses must be done, many lessons already learned, and how experienced experts go about doing their jobs.

The vision for the curriculum is that "over time it will evolve the engineering culture to one with a more efficient design process" and lead to fewer program cancellations, less schedule slips, and fewer cost overruns. The ultimate target is to increase Center win-rates.

A large percentage of the issues and item discrepancies that are found at major reviews, later in the development lifecycle, could be avoided if the design team participants were, at least, more aware. Herein lies the flaw mentioned earlier regarding the "experience lifecycle (Figure 1)."

Learned experience, through specialized training like we are talking about above will certainly improve the performance of an individual and consequently the overall performance of a design team.

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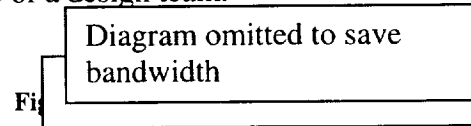
2. DESIGN OF THE CURRICULUM

The design of the curriculum for the CSSI was undertaken by key individuals from each of the four engineering and product line Directorates at the MSFC. This team of approximately twenty members met for two full days, determined the vision for the course curriculum, decided on an approach to take, and arrived at a shopping list of things to be achieved by the curriculum.

To enable the students to compare and contrast easily the differences between and among the various disciplines, the overall strategy was to develop, standardize, and use a common template for the Minicourses. The template provides a list of course topics to be covered by each Minicourse designer and Instructor. The Instructors template follows:

1. **Provide a definition, using the local context of the MSFC, for the discipline(s) that you are covering.**
2. **Identify the points within the project's lifecycle where your discipline typically does, or should, get involved.**
3. **Identify common trades and analyses that you typically do and correlate each to when it should be performed in the project's lifecycle.**

4. List inputs your discipline typically needs from other engineering disciplines, and at the system level.
5. List outputs that are typically required of you, by the other engineering disciplines, and at the system level
6. Discuss your discipline's involvement in current and past projects, and lessons learned, etc.
7. Discuss your discipline's key interfaces and identify when they should be tied down in the lifecycle phases.
8. Discuss typical trade-offs required between this and other, applicable disciplines (intra & inter).
9. Identify key technologies that are typically involved in this discipline (off the shelf, new technology, development of technology, technology roadmaps).
10. Provide Rules of Thumb used in your area (experience driven, instinct driven).
11. Identify the "Lessons Learned" in your discipline (cover management and technical lessons learned).
12. If you were "King For a Day" what improvements would you make that would increase the engineering efficiency at MSFC?

Additional guidelines given the instructors were:

• Attempt to increase the awareness of all other engineering disciplines, engineering management, and program managers of your discipline's definition and associated needs

• Attempt to educate the participant about your discipline's sensitivity to system level constraints and trades

• Provide as many examples of "Lessons Learned" as is possible (include retirees if desired)

Inherent in the design of this curriculum is the utilization of a prominent expert in each engineering discipline as the Minicourse designer and instructor. Also, to regain the discipline experience lost to retirement, instructors are authorized to retain an MSFC retiree to support them and deliver a Minicourse on Lessons Learned. This is a huge success with the participants.

The use of current and retired discipline experts in the delivery of the curriculum topics teaches the existing engineering culture of the organization and the Minicourses are being used back at the instructors office in the training of all discipline staff and new hires. Since this class was designed to bring about more systems awareness, facilitation of each class by an experienced systems oriented engineer keeps the class moving and allows the maximum potential to be achieved. Rotating this function between organizations results in a further training mechanism for senior systems responsibilities. It is recommended that facilitating at least twice allows another potential source of lessons learned that can be factored into the curriculum and a curriculum czar is recommended to assure continuity with the original goals and continuous tracking of the organization's evolution.

A library containing current topics in engineering is growing rapidly and the Agency's "Great Books" program is very popular. Participants in the CSSI are allowed an engineering textbook of their choice after participating in the class and each participant is allowed to order another book on a quarterly basis.

3. RESULTS AND FEEDBACK

On Delivery of the Curriculum:

Training of this magnitude is a major investment of the participants time and in the case of

the MSFC course offering, it takes six weeks at a rate of three half-days per week to get through the MSFC sponsored portion. This, however is a small price to pay for the under-standing, at an awareness level, of the engi-neering design capabilities of the entire Center.

Each class completed specially designed evaluation forms, and the feedback has been used to streamline the curriculum. Participants seem extremely interested in helping with the program and are generous in offering their feedback.

The ideal delivery frequency will vary from one government or industry engineering orga-nization to the next. However, at MSFC, after four deliveries of the program it seems that the above delivery frequency is matched to our day-to-day responsibilities and proven to reach the target audience.

Before undertaking the development of a course like this the organization should under-stand clearly what it wants to accomplish with the curriculum. At MSFC, the desire was to consider the entire Center as "the System" [3] in the curriculum and try to improve the effi-ciency of the existing design process. This means that all Center functions that influence or impact the engineering design function were considered an engineering discipline from the standpoint of CSSI. This was the criteria used in identifying what Minicourses would be pre-sented and assures that each participant gets exposed to all the variables of the design equation. As stated before, it is intended that, over time, this will improve the efficiency of MSFC's engineering process.

Considering the Center as "the System" is a good approach to use if you are setting out to improve the overall culture [4, 5], but other organizations setting out to develop the CSSI have chosen to consider a subset of the engi-neering process as " the System." An example of this is that Systems Engineering would be considered "the System." [6]

4. CONCLUSIONS

The development of the CSSI around the shared vision for the Center has made the Center an ideal learning organization [5] that improves with each offering. The CSSI has been referred to as an engineering process "brillo pad" because when NASA teaches it-self and experts teach experts significant class interactions occur. These are interactions that improve ones understanding and awareness. Instructors get a lot of valuable feedback that causes them to go back and rethink their men-tal models of their process; and, in some cases, instructors have been known to implement changes due to this.

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