The Process of Enhancing a Systems Engineering Training and Development Program[1][2]

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Abstract—The MITRE Institute of MITRE Human Resources, the training and development organization of the MITRE Corporation, was requested by senior management to develop and add new content to our systems engineering curriculum in the area of Enterprise Systems Engineering (ESE). As part of the process of meeting this request, the MITRE Institute base lined our present offerings in the area of systems engineering and then laid out a program to enhance our existing offerings and extend our training and development program to include ESE. During the base lining effort, the MITRE Institute's Technical Group found that while they had significant deep education and training in the area of systems and domain engineering, approximately 70 different offerings over a four-year period, there were some items missing from the program. For example, the systems engineering program was missing an overview course or courses that integrated the whole program, it needed a better continuous life cycle connection across the curriculum, it needed a stronger connection between management, the employee and the MITRE Institute to ensure that the employees who should receive systems engineering training and development do receive systems engineering training and development, and the curriculum needed to be enhanced in the area of ESE. A systems approach was taken and a program plan has been laid out to enhance the systems engineering program by building a competency model for systems engineers and then analyzing by gap analysis for training and development requirements in relation to the required competencies. The MITRE Institute is also working with other internal groups like our Systems Engineering Process Office (SEPO), our Center for Acquisition and Systems Analysis (CASA), and our research program (MITRE Technology Program – MTP) to build the required ESE content. The outputs from this program will be sevenfold, including a competency model for systems engineers, a revised Traditional Systems Engineering (TSE) curriculum, on-the-job activities to build systems engineering competency, long-term metrics for success, a direct tie to staff Performance and Development (P&D) plans in the area of systems engineering, a possible certification program, and a newly developed Enterprise Systems Engineering (ESE) Curriculum.

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1. INTRODUCTION

When the MITRE Institute was asked by the Corporate Officers to initiate a training and development program, which included ESE, the MITRE Institute's Technical Group (MITG) felt that it was important to initiate the project by completing a baseline of existing Training and Development (T&D) activities. The baseline would allow us to better understand our present capabilities and would lead us to developing better products along the continuum from TSE to ESE.

The MITG also felt that we should be taking a systems approach to this systems engineering T&D project – inputs, processes, and outputs. The MITG wanted to use the best practices in competency model development, change management, on-the-job development, instructional systems design, and certification development. To accomplish these goals, we have reached out to groups around the company and to external consultants when necessary. This paper is a "process paper," and it will provide an overview of the process we anticipate to use. At the present time, we are in the first stage – competency model development.

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[2] IEEEAC paper #1384, Version 5, Updated December 8, 2004

2. BODY

The project was initiated by working with the cognizant Corporate Officers who initiated a corporate goal to improve MITRE's ESE capabilities. This involved a four-pronged approach, which included the MITRE Institute, MITRE's process group (Systems Engineering Process Office - SEPO), a tools and methodology group (Center for Acquisition and Systems Analysis), and our research group (MITRE Technology Program – MTP) (Figure 1). Each group was to have a distinct component and set of products for the project, but the areas needed to work together to ensure an overall set of well integrated products. Integration across the groups is occurring at the Officer level.

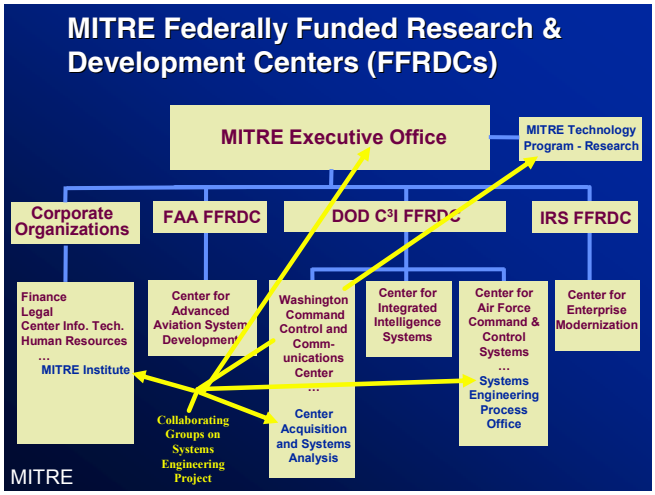

Figure 1 – MITRE Organization

After the initial base lining activity, the MITG wrote a Program Management Plan. The purpose of the plan was to layout the overall project, expected benefits to the company, driving principles for the project, how the MITRE Institute project would work with other MITRE groups, the roles and responsibilities of various team members on the project, and a general time line. The project within the MITRE Institute was named the Systems Engineering Capability Enhancement Project (SECEP).

The SECEP team included twelve team members as follows:

- Manager & Two Technical Staff from MITG
- Director of MITRE Institute
- Competency Model Consultant
- Instructional System Design (ISD) Consultant
- One or two representatives from each of MITRE's five Centers

Selecting the representatives from the technical centers was an important process as they would help us focus the project, organize focus groups in their centers, and be a conduit to senior management in their centers. We were looking for staff members with a high level of technical or technical management responsibility. On MITRE's seven level applied capability (AC) index, which is used for leveling and grading employees, we were also looking for AC levels 4 through 7, which translate to Lead, Principal, Senior Principal, and Consulting engineers or scientists. We were looking for staff with 10-20 years of experience at MITRE and/or other companies and at least 10 years of experience at MITRE. We were looking for "influential thought leaders" from each center, those staff that influence, from a technical or a technical management perspective, how other staff think or work in their center. MITRE has five centers, each with 300 to 1,500 technical staff members. Centers are oriented toward MITRE customers, such as the Air Force, the Army, Federal Aviation Administration (FAA), Internal Revenue Service (IRS), and the Intelligence Community. We have seven Center representatives from the five Centers.

The project is expected to take two to three years to complete. During the first year we completed a number of tasks, including briefed and obtained agreement with the Corporate Officer Team on our approach, wrote an RFP and selected two consultants (competency model and ISD) to help support the project, worked with Corporate Officers to select center representatives to work on the SECEP project, developed a rough draft competency model, conducted a one-day kickoff meeting to bring the project team into alignment with the project goals, and initiated our discussion and understanding of how we would build a competency model for MITRE Systems Engineers.

Program Management Plan

The program management plan laid out a number of tasks and projects to work on over a several year period. The major input sources, team activities, and output products are summarized in Figure 2. The inputs are expected to be of three general types: competency model data input for MITRE system engineers; training and development requirements, which will be developed in conjunction with the competency model and a gap analysis; and inputs from the other portions of the MITRE project, including our systems engineering process office, our methodology and tools area, and our research area. The systems engineering process office and the methodology and tools group are both expected to provide curriculum input into our TSE and our ESE training and development activities. The research area will provide curricular input predominately into our ESE topical area.

The team members will help perform a variety of tasks as outlined in Figure 2, which will lead to seven output products, which are ordered chronologically as follows:

MITRE Institute Overview Plan for Systems Engineering Capability Enhancements

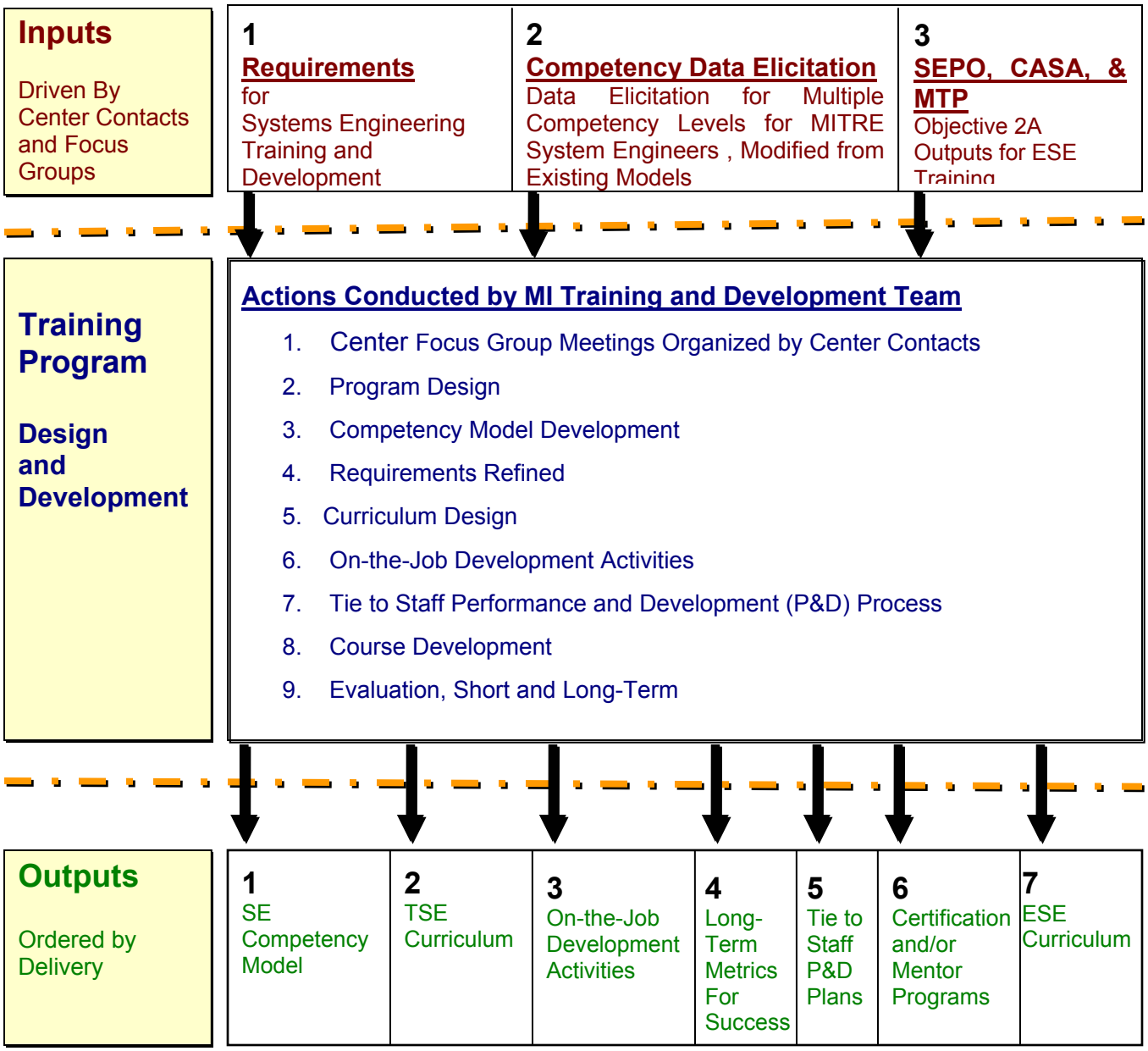

Figure 2 – Program Management Plan Overview

1. Multi-level systems engineering competency Model
2. An enhanced Traditional Systems Engineering training curriculum
3. On-the-job development activities, which will take training and development knowledge out on the job were the learning can be internalized
4. Long-term metrics of success for the project, and a means to measure them
5. A method to tie systems engineering competency development to our Human Resources Performance and Development goal setting and review process to make systems engineering development important for SE staff
6. Possible systems engineering certification program
7. An Enterprise Systems Engineering curriculum

This integrated set of products from the MITRE Institute, along with a larger integrated set of products from our systems engineering process office, our tools and

methodology area, and our research area are expected to enhance the systems engineering capability of the corporation over time. I will discuss the seven individual products expected from this project. The products are discussed in their expected chronological order. We have more information and we have completed more work on the earlier projects than on the later products. However, we have simultaneously initiated work on other portions of the project. For example, we initiated a certification program inquiry, so we could at least understand its basic implications and how it might affect other portions of the project, like competency model development.

Competency Model Development

Once the program management plan was completed and reviewed, we initiated work on the first task, competency model development. Competency models can be used for many activities, for example, recruiting and skills inventories from a recruiting perspective; goal setting and performance feedback from a performance management perspective; and curriculum development, on-the-job development, mentoring, certification, and stretch assignments from an assessment and development perspective. We are building the competency model for use in helping to support curriculum development, on-the-job development, and certification. The model will probably be used for other HR and/or corporate oriented tasks over time.

A competency model provides a description of how successful people complete their jobs by providing a description of the behaviors, skills and knowledge needed to complete their job. These descriptions cover the most important part of the job, they can be related to success factors on the job, they can be measured against other standards, and they can be improved by training and development [1], [2], [3], [4].

There are many approaches to competency models. We are using an adapted approach where we are trying to capture three competency characteristics:

- Behaviors: specific measurable actions (e.g., writes testable requirements),
- Skills: An ability to perform a complex collection of actions with ease, precision, with an adaptability to changing conditions (e.g., understands how to trace requirements through the life cycle),
- Knowledge: A body of understood information possessed by an individual, which is in accord with established fact (e.g., requirements management).

The anticipated approach for developing our competency model is depicted in Figure 3. We initiated the project by looking for sources of information on technical competencies from existing system engineering competency models from commercial companies, government oriented companies like MITRE, and standards bodies (e.g., INCOSE, ISO, & IEEE). We built a draft set of competencies (approximately 25 of them) and then brought this draft set to our Training and Development Committee representatives from our centers for initial review. The committee added approximately 15 more potential competencies. We also worked on a meta categorization of these competencies, so we could better understand how the whole model fits together.

In a like manner, we felt that non-technical competencies were just as important as technical competencies for systems engineers to be successful on the job. In this case, we reached inside our own group at the MITRE Institute to capitalize on work that has been previously completed from our Leadership and Management group on developing a three-tiered competency model for leadership and management competencies at MITRE. We picked approximately 15 competencies for our draft non-technical competency model for systems engineers from the existing leadership and management competencies, especially in the meta category areas of interpersonal skills, people leadership, and personal attributes. Examples of these types of competencies include building relationships/partnerships, building trust, communicating with impact, adaptability, and high quality standards.

At the same time that we have been working on the technical and non-technical competencies, we have also been developing success criteria for systems engineers at MITRE. We plan to use these success criteria to help us determine which of the competencies are most important for successful systems engineers at MITRE.

We made an initial assumption that we potentially have three levels of systems engineering competency within our staff, and hence within the competency model. We have not named those levels as yet, except 1, 2, and 3; because naming the levels, loads them with unneeded burdens. For example, if we named them as lead, principal, and consulting, they could very quickly be tied to our staff leveling and grading system at MITRE, and we do not want that to happen at this early stage. We want the data analysis to help sort out how many levels we have at MITRE and what characteristics can be used to describe them.

These are the completed accomplishments as of the writing of this paper. The continued discussion herein will outline anticipated design and implementation approaches. The technical and non-technical competencies will be merged into one full competency set of approximately 55 competencies. We intend to take these competencies out into our centers for a series of one-day focus group meetings. We plan on carrying out three major activities during these meetings:

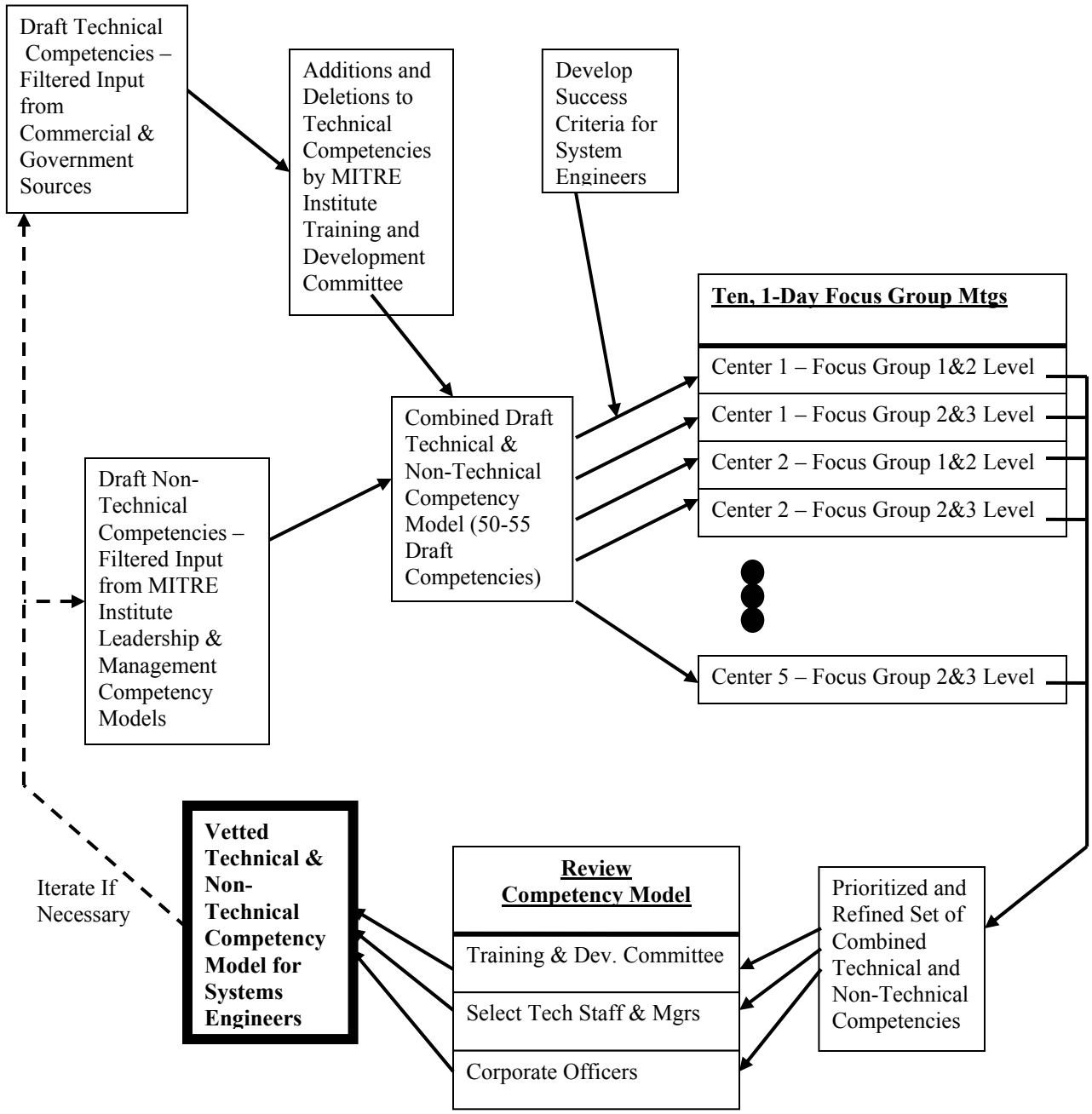

Figure 3. Developing the Systems Engineering Competency Model

- Examine Success Criteria & Add Competencies: we will go over the success criteria with the participants to see if they feel comfortable with our draft success criteria or whether they would like to modify them. We will also ask if they feel there are any other important competencies that we have not listed.

- Prioritize: we plan on asking the focus group participants to prioritize the competencies into three groups – the top 1/3 most important

competencies for successful systems engineers, the middle 1/3 competencies for successful system engineers, and the least important 1/3 competencies.

- Refine the Competencies: Then we plan to break the focus groups into subgroups and work on refining the draft definitions of behaviors, skills and knowledge for "only" the top 1/3 competencies that they have prioritized.

The structure of the focus groups will be to have six to eight systems engineers or technical managers in each group. We will choose two focus groups to help describe the three competency levels, as shown in Figure 4. We feel that the participants should be able to provide valuable input on the level below them and their present level.

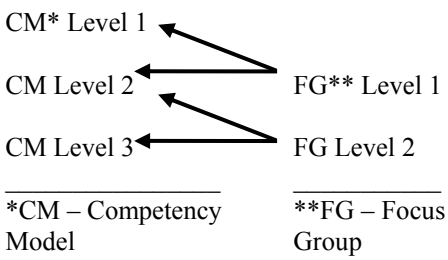

Figure 4. Focus Group Structure

We plan to use our center representatives on the Training and Development Committee to help choose appropriate participants from each center. We are looking for top-flight systems engineers for each focus group level, with characteristics as defined in Table 1 as guidelines for the types of staff for which we are looking. We plan on updating our competency descriptions between focus group meetings, so that the next focus group can benefit from the thinking and work of the previous focus group. However, we will not update the competency titles between focus group meetings. The reason for this is that we want to use the ten focus groups to help prioritize the top competencies across the company. As such, we do not want to change the competencies they are voting on while we are trying to prioritize the whole set. If specific groups suggest new competencies, we will hold onto this data to see if other focus groups suggest adding similar competencies. We will modify the competency set during the final analysis stages, if multiple groups suggest competencies we missed in our draft.

We understand that different groups from different centers will rate different subsets of the competencies as important for systems engineers at MITRE. However, we feel that the most important competencies will emerge out of the total data set of ten focus groups and will lead us to a cutoff of approximately 25 competencies (technical and non-

Table 1. Focus Group Participant Characteristics

- Focus Group 1 Participant Characteristics for Competency Model Levels 1 & 2
- 5-10 Yrs. SE Experience @ MITRE and/or Elsewhere
- 5 Yrs. of this Experience @ MITRE
- Have Worked Predominately on SE Projects
- Nice to Have: Have Worked Multiple Phases of Projects
- Fair Sponsor Interface Experience
- Recognized as Top-flight SEs for Their Level
- Center "Work Leader" (who to go to) & Beginning to Become "Influential Thought Leader"
- Can Take Corporate Citizen View of Problem (non-parochial)
- Ability to Collaboratively Participate in a Group Discussion
- Can Think Out of the Box
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- Focus Group 2 Participant Characteristics for Competency Model Levels 2 & 3
- 10-20 Yrs. SE Experience @ MITRE and/or Elsewhere
- 10 Yrs. of this Experience @ MITRE
- Have Worked Predominately on SE Projects
- Have Worked Most Phases of SE Projects
- Nice to Have: Some External to MITRE SE Experience
- Nice to Have: Some SE Project Management Experience
- Considerable Sponsor Interface Experience
- Recognized as Top-flight SEs for Their Level
- Influential Thought Leader for Center – Technical and/or Mgt. Perspective
- Can Take Corporate Citizen View of Problem (non-parochial)
- Ability to Collaboratively Participate in a Group Discussion
- Can Think Out of the Box

technical combined) that will help to best describe successful systems engineers at MITRE.

After the focus group meetings are complete, we will analyze and compile the data and begin a review cycle. The Training and Development Committee with review the model first for consistency and general reasonableness. We may find a small subset of technical staff and managers, probably from the 60-80 staff in the original focus group set, and ask them to review it. Finally, we will have the cognizant corporate officers review the model, including our Vice President (VP) for Human Resources, the VPs on the officer goal committee, and potentially other general manger VPs.

One of our objectives during this process is to begin to sort out the difference in competencies for our traditional system engineers and our enterprise system engineers. We feel it is a continuum, but there should be a way to describe characteristics that help separate these roles. We feel confident that we can sort out the TSE competencies on the first iteration of this model. However, there is considerable discussion going on in the company concerning ESE, and we may not be able to totally sort out ESE on the first iteration through the model. If that occurs, we should have a reasonable first draft for ESE and we plan to cycle through the model a second time to better understand ESE at MITRE (Figure 3). In addition, this model should be cycled through on some level of frequency, say every 5 years, to examine and update our competencies in relation to the changing field of systems engineering and to further validate the model after its initial use on this project. Finally, we want this model to be forward looking. We do not want just the historic competencies that have made systems engineers successful at MITRE, although some of those competencies will surely be included, but instead, we want the competencies which will make systems engineers successful at MITRE in the future.

Traditional Systems Engineering Curriculum Development and On-the-Job Development Activities

The MITRE Institute's Technical Group has long delivered systems engineering topics. During our base lining effort, we found that we had delivered approximately 70 different systems engineering courses, most multiple times, over a three- to four-year period. In addition we have added many new SE courses last year and many new ones are being prepared for delivery during the first half of this year (Table 2). However, as mentioned in the abstract, our base lining effort also told us that we have gaps, such as no overview course, no continuous life cycle integration, potential gaps in TSE, and the need for definition and content in the ESE area.

In order to help enhance our programs in these areas, we plan on using the competency model in a gap analysis to determine how to best improve our curriculum and how to develop activities that will take systems engineering learning and development out on-the-job (Figure 5) [4]. In order to do this, we will have to measure the existing competencies of MITRE's SE staff. Though not designed yet, some example approaches are that we could have MITRE SEs complete self-assessments, we could ask the managers of the staff to help assess the staff members, we could build a testing instrument, or we could use some type of externally developed test in a non-threatening manner.

Table 2. Recent SE Curriculum Additions

Traditional SE Course Titles Added During FY04
• Program Planning Process (TSE440) • Integrated Process and Product Development (TSE446) • CMMI Basics (TSE434) • Requirements Development & Management Process (TSE436) • Requirements Specification (TSE444) • Risk Management Process (TSE435) • SA-CMM (TSE441) • Integrated Test Process (TSE445) • Configuration Mgt. Process (TSE439) • Configuration Management for Acquirer and Supplier (TSE436)
Tradional SE Courses Added to Fall and Winter Schedule for FY05
• Agile Acquisition (TSE449) • Contracting Principles for SEs (TSE454) • Policy Analysis for SEs (TSE451) • Human Computer Interfaces (TSE463) • Systems/Software Measurements (TSE456) • Quality Assurance & Configuration Mgt (TSE457) • Model Driven Architectures (TSE453) • Integrated Logistics Support (TSE450) • RFP Preparation and Source Selection (TSEnnn) • Software Testing in the System Context
Enterprise SE Courses Added to Fall and Winter Schedule for FY05
• Modeling Complex Systems – Bottom Up (TSE106) • Introduction to Net-Centricity (TSE464) • Introduction to Network Time Service (TSE465) • Introduction to Domain Name System (TSE466) • LISI and InspeQtor Tools (TSE448) • FEAF/DODAF Comparison (TSE458) • Intro to Enterprise Architecture (TSE459) • Enterprise Architecture Products (TSE460) • Architecture Planning (TSE461) • Federal EA Reference & Core Models (TSE462) • EA Case Study, Tools, & Practicum (TSE463) • Activity Based Methodology for System Architect (TSE7nn) • Cross Domain Solutions – Technology, Policy, & Process (TSE4nn)

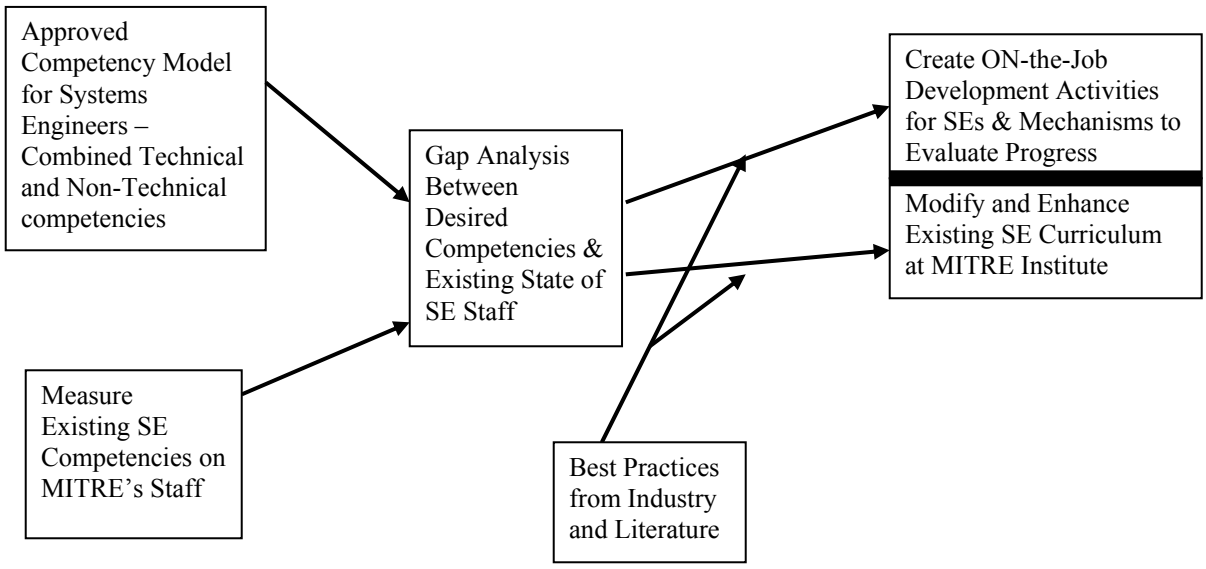

Figure 5. Using the Competency Model (CM) for Curriculum & On-the-Job Training and Development

Once we have a reasonable measure of existing SE capability, both for individuals and for competency levels as a whole, we can begin to see where the gaps are. The competency model will help define what the staff should be capable of and the measurement of existing capabilities will tell us where the staff is at present. We will use this information to make changes to our existing training and development approaches. We want to modify our curriculum and we also want to look at means of taking the SE learning out on the job. In the area of curriculum development, we need to look at gaps that we have in the curriculum as a whole, and try to fulfill that need by developing new offerings. For example, we could determine we need an overview SE course, a system testing course, and a much better understanding of how acquisition and contracting fits into the government's acquisition and funding cycles. We would then initiate instructional systems design (ISD) projects to begin to build the products that do not exist. We should have information about individual employees (from our measurement activities against existing competencies) and, therefore, we should also be able to design programs where staff members only have to improve in the areas where they are not fully capable.

Finally, there are a number of techniques, which can help take the learning out on the job. For example, staff can be assigned projects in their neediest development areas or in their stretch areas. These projects may be associated with an activity that they are completing on their projects, or they may be completely independent and may be involved with some cross-functional group activity. The staff member can be given learning resources to help them (e.g., books, web locations, people, and e-Learning). They can be given contacts or mentors in their center or other centers to help them navigate through their project. The product should be evaluated against some pre-determined criteria, by themselves, their manager, and probably an outside group. Other possibilities are to set up mentoring organizations or structured review processes to evaluate systems engineering products outside of the context in which they were built. We plan on examining existing state-of-the-practice methods (Figure 5) for on-the-job learning and include them in the structure of this program.

Long Term Metrics of Success

As part of this project, we are interested in the change management issues and whether or not we are successful. From the change management perspective, we may produce top-notch technical products that could meet staff needs, but they could fail to be used for some other political or cultural reason within the company. In order to avoid these pitfalls, our Training and Development Committee will initiate internal discussions to identify potential problem areas. We will discuss these with the cognizant officers on this corporate goal and request their help in the solutions [1] [4]. By working to alleviate these potential problem areas with the design of the program, we can increase our chances of success.

In order to know if we are successful, however, we have to set down some criteria for success, baseline those criteria, and then see how we are doing over time. These criteria could be associated with the Training and Development project within the MITRE Institute or with one of the other groups working on SE enhancement within the company. Again, even though one area of the corporate project may be successful, we need to look at measurements that cover

the overall project goals, so that we ensure we are measuring the program at the right level. These success metrics have not yet been designed, but many possible metrics exist. We need to determine which ones will give us the most information, but are also measurable with a reasonable amount of effort. Some potential metrics could include the following:

- Our standard SE processes and information on our tools and methods are written down, including guidance for tailoring for flexibility
- Standard process information and information on tools and methods are incorporated into MITRE Institute's training and development material
- TSE and ESE Training and Development programs are defined, developed, and put in place, and include classrooms and on-the-job development.
- T&D projects are shown to be increasing the SE capability of staff through their manager's evaluation of the staff member's on the job competence.
- Show that MITRE is consistently applying systems engineering knowledge on MITRE projects
- Implements a SE certification program, if appropriate.
- The percent of MITRE managers/staff certified in SE increases over time, if implemented
- The percent of SE academic degrees in the company increases over time.
- The number of managers and staff taking SE training modules at the MITRE Institute increases over time.
- The number or percent of managers and staff participating in and presenting in standards bodies like INCOSE/NDIA/IEEE in the area of systems engineering is increasing over time.
- The number of senior staff in positions of influence in systems engineering in INCOSE/NDIA/IEEE is increasing over time (e.g., board members, working group members, standards members).
- The percent of Performance & Development documents (MITRE's performance management system) with systems engineering goals is increasing over time.
- The number of awards/recognition (both external/internal) for systems engineering increases over time.
- Level of ESE project involvement (as defined by some ESE criteria) is increasing by both number of projects and number of staff members assigned to the projects over time.
- The number of research articles published in referred journals on SE is increasing over time.
- Number of staff teaching in systems engineering topics at universities and at conference workshops is increasing over time.
- The number of internal to MITRE "Technical Exchange Meetings" in TSE/ESE topics is increasing over time.
- Research results from the MITRE Technology Program on ESE are incorporated into MITRE Institute T&D programs and/or are made available to MITRE staff members through other appropriate means.

These and numerous other possible metrics will be discussed within our group and with the officers to determine which long-term metrics of success we should use on this project. We will need to determine how we can measure success factors such as these, and how much effort it will take to complete the measurement. Once selected, these metrics will be measured on a reoccurring basis, and changes will be made to the new programs to further enhance the development of systems engineering capability at MITRE.

Utilizing Our Performance and Development System

One of the gaps that we noticed in our original base lining effort on this project was that we had no idea if the people who should have the training and development in SE were the staff who actually receiving the training. We have a couple of tools, which should help us work on that problem, our HR automation system (PeopleSoft) and our Performance and Development (P&D) system.

MITRE has approximately 25 technical job families. Two of those families, the multi-disciplined general systems engineer and the information systems engineer, account for approximately 18% and 21%, respectively, of all the technical workers in the company (Figure 6). Employees in these two job families would be prime targets for this type of training and development. Having this information within the HR function gives us information on exactly who the target audience is.

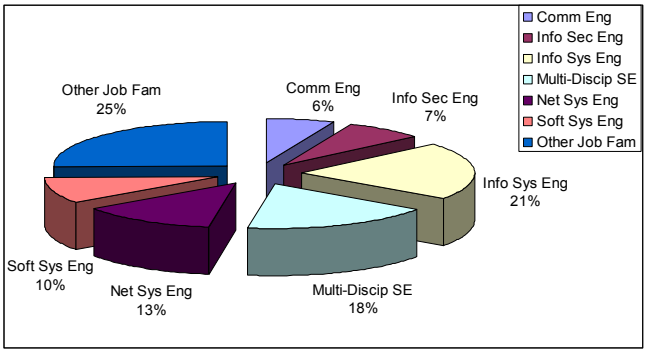

Figure 6. Six Largest Job Families at MITRE

MITRE has a performance management system called Performance and Development, or P&D. The P&D is a system where the employee and the manager set goals each year, review their status a few times during the year, and

have their final review written in relation to the actions associated with the P&D goals at the end of the year. The goals are cascaded from the top of the company for alignment. For example, my goal alignment string each year has four parts: Corporate, HR, MITRE Institute, MITRE Institute Technical Group. There is also a development portion of the P&D, which is a little more free form. We would like to work with these two parts of the P&D instrument and the target audience to target the proper employees and their managers. We would like to have goals on systems engineering development put into both the "P" and "D" parts of the P&D system. For example, one of our project products is to use on-the-job development products to increase learning in systems engineer through activities that are focused toward on-the-job activities. These are the types of "action items" we would like to see under the goals in the "P" part of the P&D. We would also like to see items in the "D" part of P&D, which may be the more traditional training, for example, courses at the MITRE Institute, courses at universities or colleges, attendance at conferences, delivery at conferences, or work on a standards body committee. The "D" part of the P&D may also contain development activities, which are not a mainline activity on the staff member's project, but a stretch goal or a cross-functional goal of some sort, for example, a cross-functional committee.

At this point, we have not designed the part of the program, which will help us with these activities. We feel, however, that the combination of the knowledge about the exact target audience and the use of our P&D system should allow us to better target our training and development activities and hold the employees more accountable in these areas.

Investigate SE Certification Programs

The cognizant officers involved with our goal of enhancing systems engineering capability in the company have asked us to investigate the possibility of SE certification. Certification of any kind is a complex task that must be tied into many other areas of the company besides training, like HR and Legal. Our initial task will be to examine the whole certification process, understand the steps involved in certification, the cost involved in the process, and make recommendations to the corporate officers as to its viability.

While we have only completed a small amount of work in this area at this time, there are some potential benefits, such as:

- Provides personal benefit through accomplishment for the employees
- Increases professional stature of the individual and the company
- Documents professional capabilities
- Enhances marketability and credibility

At the same time, getting "certification right" is not easy to do. There are numerous HR and legal issues associated with certification, such as the relationship between certification and promoteability, "time tables" for staff that must obtain a certain certification level, potential for morale problems, relationship between certification and career paths, "grandfathering" of competencies, and the need for an arbitration method to resolve disagreements. Schrage [5] argues that the effort is not worth the benefits and that it really does not buy the company anything in the long run, assuming that potential sponsors or clients take a serious look at your company.

Our initial view is that like the college entrance process in the United States, certification should not be based on one test. A balanced look at an individual's capability is needed if we are to have a fair evaluation with a credible process that staff can feel comfortable with. Most colleges and universities have moved away from SAT driven admissions and have a balanced program where the student's high school record is extremely important, along with their commitment to extra curricular activities (quality, not quantity), and now, the SATs are more generally used as a normalization factor. Similarly, at this point, we feel that if we develop a certification program, it should have a balanced view of the employee with factors such as the following:

- Training and Development (university and/or internal)
- Work Experience
- Testing
- Recommendations

In addition, whatever certification factors we use, we will need to tie the certification capabilities and levels tightly to our competency model.

There are a number of potential approaches we plan on evaluating. These approaches include combinations of internal work completed by MITRE, the use of consultants, working with certification development companies, and using standards bodies. Our initial investigations have led us to consider the following type of approaches:

- Internal Certification Program Developed and Administered Entirely by the MITRE Institute and/or other MITRE Groups
- Externally Developed Certification, where the process and knowledge to develop the certification program is provided by an external consultant or a

certification development company. The development and administration of the testing aspect would be a combined effort between the consultant/certification company and the MITRE Institute, but the analysis of experience and recommendations would probably reside within MITRE

- External groups, like a standards body (e.g., INCOSE), have certification tests that could be used to administer part of the certification process. The analysis of experience and recommendations could happen within the standards body.

- Hybrid – one level of certification could be externally focused and the other levels of certification (as dictated by the competency model) would be more internally developed and administered. In this type of model, the first level of certification could be associated with a group like INCOSE and the second and third levels of certification (if that is the final number of levels in our competency model) would be developed and administered inside of MITRE, potentially with the help of either a certification consultant or a certification development company.

The MITRE Institute's Technical Group, along with our SE Training and Development Committee, have to take a deeper look at the certification process. We have to better understand the process of developing certification tests, we have to think about minimum criteria for certification levels, we have to determine expected costs to both develop and maintain the program, and we have to consult with both the HR and Legal areas of the company to obtain their input on certification processes. After we have included and analyzed all of these sources of information, we will be better able to make recommendations to the MITRE Corporate Officers as to whether we feel certification is a good idea and what a MITRE SE certification program might look like.

Develop an Enterprise Systems Engineering Curriculum

The last product on this project is to modify existing and develop new ESE curriculum. The MITRE Institute's Technical Group has been delivering ESE training events for almost four years. Most of the early content was in the area of enterprise architecture training for DOD oriented programs. More recently, we have added Federal Enterprise Architecture Training (civil side of Government), interoperability training (both approaches and tools), and domain enterprise services. Some of the more recent titles are in the bottom portion of Table 2. Our longest architecture program was three weeks of training over a four-month period.

There is at the present time, however, significant activity within MITRE's system engineering process group, our methodology and tools group, and in our research group in the area of ESE. All of these groups are expected to turn out work and products, which can be used in our ESE curriculum. We have also reached out to a number of universities (e.g., MIT, UCSD, JHU, and Stevens Institute) for systems engineering relationships in teaching and research, which are expected to bear products that can be used in our ESE curriculum over the next few years. While some of these products may be tools and techniques, we suspect that there will be other training and development needed in the areas of critical thinking skills and broadening exercises to help the staff scale the scope of their work and thinking. There may be some classroom training, but this aspect of the project could also use on-the-job exercises with mentoring or action learning groups, or other approaches.

Our general approach at this time is to define the competencies for ESE. As mentioned earlier, we may be able to define them on the first run through our competency model exercise, but if not, we should have a good draft and we will refine them with a second run through the model. Once the competencies are completed, we will have to identify our target audience, which is expected to be smaller than for the general TSE curriculum audience. Subsequently, we can determine where our audience is compared to our competencies, complete a gap analysis, as previously described in Figure 5, and then determine what combination set of training and on-the-job development activities are appropriate for this group of staff members.

3. CONCLUSIONS

The MITRE Institute has embarked on a process to enhance the SE capability in MITRE. We are partnering with a number of other groups in MITRE, including our Systems Engineering Process Office, our Center for Acquisition and Systems Analysis, and our research area, the MITRE Technology Program. We are working closely with a committee of corporate officers who help to plan and review our work frequently (every six weeks). We have laid out a plan, which will take at least two- to three-years to complete.

The program plan details at least seven products which will be delivered over the course of the project, including the following: SE competency model, enhanced Traditional Systems Engineering curriculum, structured on-the-job development activities to increase the learning, long-term metrics of success, a tie into our performance management system (P&D) to target and hold employees more accountable, a potential certification program, and an improved and enhanced Enterprise Systems Engineering curriculum. This paper described the process that we intend

to use to develop and deliver these products. Earlier products are better defined than later products due to the amount of work that has been completed and reviewed.

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BIOGRAPHY

Dr. Philip N. Trudeau is the Manager of Technical Programs at the MITRE Institute, the corporate education, training, and development group in Human Resources at The MITRE Corporation. Between 1978-1988, Dr. Trudeau worked with four technical divisions at MITRE – environment, energy, advanced transportation, and the Army – as a Technical Staff, a Group Leader, and then a Project Leader. He worked on environment and energy projects for EPA/DOE, hardware and software systems development projects for DOI and NOAA, and communications and information flow projects for the Army. In 1988, he assumed a role as a lead technical development specialist at the MITRE Institute, and concentrated on building curricula in software engineering, advanced operating systems, and advanced tools. Presently, he manages the Technical Program at the MITRE Institute, which includes systems, software and domain engineering; advanced tools; and business applications. Dr. Trudeau holds a BA in chemistry from Boston University, an MS and Ph.D. in biology and systems ecology from University of Massachusetts/Amherst, and an MS in computer science from Virginia Polytechnic Institute (VPI) and State University.