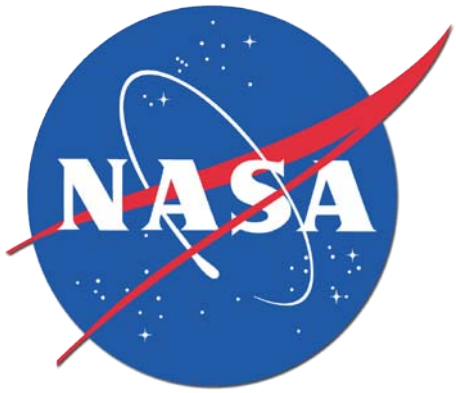

NASA SYSTEMS ENGINEERING BEHAVIOR STUDY

KENNEDY SPACE CENTER

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February 2009

Abstract

The purpose of this study was to identify the behaviors frequently observed by highly regarded Systems Engineers (SEs) at the Kennedy Space Center (KSC). Five SEs were interviewed, observed, and shadowed in order to understand and determine the behaviors and attributes that contribute to their success. Data from this study will be used to identify and support the development of high potential future SE leaders.

This study revealed a variety of competencies which were grouped into five themes: Leadership, Communication, Attitudes and Attributes, Technical Acumen, and Problem Solving and Systems Thinking. This report details the competencies and behaviors for each of the themes.

Introduction

KSC was named an independent NASA installation in 1962 and has served as the departure gate for every American manned mission and hundreds of advanced scientific spacecraft. The center serves as NASA's Center of Excellence for both launch and payload processing systems. In addition to manned missions, KSC coordinates all launches of NASA payloads on Expendable Launch Vehicles (ELV).

Background

The purpose of the NASA Systems Engineering Behavior Study is to identify the characteristics or behaviors frequently observed in highly regarded Systems Engineers (SEs) at NASA. The overall goal of the study is to establish a comprehensive strategy to develop SEs at each performance level. The agency will accomplish this by:

- Developing the capabilities, skills , knowledge and attitudes as described in *The Art and Science of Systems Engineering*
- Establishing a comprehensive development strategy to reach all levels of SE participants, with a special focus on identifying and maturing individuals to become the next generation of model SE.
- Developing SEs both in APPEL Courses and the NASA Systems Engineering Leadership Development Program (SELDP)

Methodology

Five SEs were interviewed, shadowed, and observed. The interviews were one to two hours in duration and were held in private offices or conference rooms. The interviewees were asked the same set of pre-approved questions, with follow-up questions based on their initial answers. The interview questions (see Appendix A) were divided into three

categories: context, relation to self and personal awareness, and the future of systems engineering. The observation and shadowing components occurred primarily during project meetings and Engineering Review Boards. The results of the interviews were analyzed for common themes, which were verified and validated by the interviewees.

As described in Table 1, the study revealed three levels of behaviors: top-level competencies, middle-level competencies, and actual behaviors.

Level	**Description**	**Example**
Top: Themes	Collections of competencies	Communication
Middle: Competencies	Aggregations of related observable behaviors	Translates Information
Lowest: Actual Behaviors	Observable behaviors	Able to boil down communications to their key points

Findings

The study revealed five themes with associated middle competencies and their actual behaviors. The broad themes are Leadership, Communication, Attitudes and Attributes, Technical Acumen, and Problem Solving and Systems Thinking.

LEADERSHIP

- Encourages Teamwork
  - Works well within a team
  - Has experience in leading teams of various disciplines
  - Able to quickly assess the dynamics of a team
  - Supports team members' decisions
  - Understands the various strengths and weaknesses of team members
  - Builds consensus amongst team members

- Influences Others
  - Convinces others to follow a path
  - Influences those over whom he/she has no direct authority
  - Displays confidence in technical abilities

- Creates a Vision
  - Clearly articulates the goals of a project
  - Able to separate the product from the process
  - Makes certain that individuals understand their roles in the project

- Mentors
  - Mentors less experienced co-workers
  - Assists individuals in their professional development
  - Shares knowledge of current trends in Systems Engineering
  - Shares lessons learned and "war stories"

- Motivates Others
  - Encourages others to work to their potential
  - Inspires a belief in the mission of a project
  - Demonstrates a "can-do" attitude
  - Is an advocate for Systems Engineering
  - Recognizes the contributions of others

COMMUNICATION

- Listens Effectively
  - Displays active listening skills
  - Able to "read between the lines" and determine what is not being said
  - Believes that is often more important to listen then speak

- Strong Oral and Written Communication Skills
  - Ensures that written communications are clear and grammatically correct
  - Comfortable when speaking in front of large audiences
  - Effectively summarizes information
  - Adapts his/her communication style to suit the audience
  - Able to communicate up and out

- Encourages Open Communication
  - Encourages discussion amongst team members
  - Welcomes opposing opinions
  - Promotes an open-door policy

- Elicits Information from Others
  - Asks probing questions
  - Able to draw out pertinent information from individuals
  - Establishes rapport so that others comfortable sharing information

- Translates Information
  - Able to boil down communications to their key points
  - Ensures that all of the individuals on a project speak the same language

TECHNICAL ACUMEN

- Technically Competent
  - Is viewed as an authority on Systems Engineering at the center
  - Has gained the professional respect of colleagues and supervisors
  - Has a very thorough understanding of how systems work
  - Understands both the art and science of Systems Engineering
  - Knows the system well enough to know when something is wrong
  - Knows when it is time to move on from a project; knows when he/she has done enough

- Has Experience in Diverse Areas
  - Has knowledge of several engineering disciplines, with expertise in one or two
  - Has years of experience working in both design and operations
  - Able to integrate design with manufacturing, testing, assembly, and operations

ATTITUDES & ATTRIBUTES

- Demonstrates Trustworthiness
  - Has earned the trust of employees, team members, and managers

- Remains honest with co-workers, even when delivering unwelcome information
- Honors his/her commitments
- Admits when he/she makes mistakes

- Works Well Under Stress
  - Does not allow the demands of work to interfere with job performance
  - Able to meet tight scheduling and budget restrictions
  - Does not overreact to setbacks in projects
  - Remains calm when problems arise so that team members are reassured

- Flexible
  - Understands that change is a part of every project
  - Adapts to change quickly
  - Is not disturbed by ambiguity
  - Open to trying new tools and methods
  - Always willing to take on new work; does not turn down projects

- Inquisitive
  - Continuously looking to learn new skills
  - Enjoys getting to the root of problems
  - Enjoys asking questions

- Interpersonal Skills
  - Able to establish rapport with a variety of individuals
  - Understands the politics of organizations
  - Displays a positive attitude
  - Gets to know team members on a personal level
  - Sensitive to the needs of others

PROBLEM SOLVING & SYSTEMS THINKING

- Able to Integrate Diverse Information
  - Able to see how the different components of a project impact each other
  - Looks at each problem from different angles
  - Able to determine why systems fail when their components pass

        - Incorporates constraints such as schedule and budget into problem solving

- Thinks Holistically
    - Able to see the big picture without missing the details
    - Understands projects at the top-level
    - Does not jump to the most obvious solution
    - Thinks about projects in the full life cycle

- Enjoys Problem Solving
    - Sees each project as a challenge
    - Takes the initiative to solve problems

- Asks Many Questions
    - Has a practice of asking more questions than providing answers
    - Questions the problem, the, requirements and the specifications of a project
    - Senses when information is not being communicated and is able to elicit the information through questioning
    - Asks the difficult or uncomfortable questions that others may avoid
    - Knows when enough questions have been asked; when it is time to stop gathering information

Summary and Conclusions

While there are many behaviors that were specific to individual Systems Engineers, the study revealed that there are many shared behavioral competencies. The five SEs in this study all viewed communication skills as critical to good systems engineering. They believe that asking questions, eliciting information, and encouraging open communication as essential components to project success. Leadership behaviors such as mentoring, teamwork, and influence were also shared amongst the participants. The SEs in the study also shared similar attributes, such as inquisitiveness, flexibility, and trustworthiness. Finally, each of the study participants was extremely technically competent and continuously engaged in problem-solving and systems-thinking behaviors.

Acknowledgements

Thank you to the following Systems Engineers who contributed to the success of this study:

Alan Littlefield	Mobile Launcher Chief Engineer
Jorge Rivera	Deputy Launch Vehicle Processing Chief Engineer
David Sollberger	NASA Launch Services Program Deputy Chief Engineer
Regina Spellman	Project Integrator
Steven Sullivan	Launch Vehicle Processing Chief Engineer

Appendix A

Interview Questions

1. How would you describe the role of the SE?
2. On a scale of 1 to 10, how important is the SE in the success of a program or project?
3. Create, in behavioral terms, a statement that would describe you as an SE.
4. Identify the attitudes and attributes a “highly regarded” SE possesses.
5. What leadership behaviors does a “highly regarded” SE possess?
6. On a scale from 1 to 10, how important are these abilities to mission success?
7. How are these abilities (leadership behaviors) displayed?
8. What general knowledge does a “highly regarded” SE possess?
9. On a scale from 1 to 10, how important is this knowledge to mission success?
10. What values drive you as a leader?
11. How are these values reflected in your attitude?
12. Describe to me what goes on in your mind when you are problem solving.
13. What do you look for in determining if someone will make a good SE?
14. How will the job of an SE be different 10 years from now?
15. What will the future SE need to know and do differently?