10.4.3 Jet Propulsion Laboratory (JPL)

INTEROFFICE MEMORANDUM

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To: Ross Jones, Assistant Division Manager for Systems Engineering

From: Mary-Ellen Derro, Sr. Leadership and Organizational Development Specialist

Subject: Behavioral Competencies of Highly Regarded Systems Engineers at JPL

Abstract

This memorandum summarizes the method, findings, and conclusions of my study of behavioral competencies of highly regarded systems engineers at JPL. I interviewed, observed, and shadowed nine systems engineers in order to identify and understand their behaviors. The nine were proposed for this study by members of the JPL Executive Council and other senior JPL leaders. I also administered the Myers-Briggs Type Indicator (MBTI) to these nine to look for any patterns that this instrument might provide.

This study revealed competencies and associated behaviors which were then grouped into five themes: leadership, attitudes and attributes, communication, problem solving and systems thinking, and technical acumen. This memorandum details the competencies and associated behaviors for each theme. The study also found that all nine of the systems engineers fall into either of two of the four Myers-Briggs temperaments: Sensing-Judging (SJ) and Intuitive-Thinking (NT).

Introduction

The Jet Propulsion Laboratory (JPL) is dedicated to improving the way it performs systems engineering. To that end, the practice of systems engineering is being viewed from three angles: Technical knowledge unique to each system engineering domain, processes critical to the success of systems engineers (SEs), and behavioral competencies as displayed by some of JPL's most highly regarded system engineers. The information gathered will assist those interested in developing system engineering talent, either personally or on behalf of the Laboratory.

Nine "highly regarded SEs" were studied in order to identify and understand behaviors of successful SEs. These nine were identified by senior managers, including members of the JPL Executive Council and other selected JPL leaders. Eight are or have recently been project SEs and one is a subsystem engineer. The study was done over four months. From these interactions, generalizations were inferred and then confirmed by each of the interviewees.

Methodology

Nine SEs were interviewed, observed, shadowed, and administered the Myers-Briggs Type Indicator (MBTI). Eight of them are experienced project SEs and one is an experienced subsystem engineer. The interviewees were asked the same questions, with follow-up questions based on their initial answers. (See Appendix A for interview questions.) The interviews were one to two hours in duration and were tape-recorded for transcription. Two additional questions were asked

for recruiting and succession planning purposes. One of the additional questions asked about traits that make an individual a "high potential" SE and the other concerned potential search firms.

All interviews were transcribed and analyzed. For the purpose of this study, three levels of behaviors were identified, as described in Table 1.

Table 1. Behavioral Themes, Competencies, and Actual Behaviors

Level	Description	Example
Top: Themes	Collections of competencies	Problem Solving and Systems Thinking
Middle: Competencies	Aggregations of related observable behaviors	Critical Thinking
Lowest: Actual Behaviors	Observable behaviors	May visualize the system as a whole, then break large aspects down into smaller pieces, then simplify these latter pieces into even smaller pieces. (Reductionism) Slices the pieces horizontally, vertically, and diagonally to see connections and soft spots. Rebuilds parts into a whole. Navigates complexity on multiple dimensions and layers. Sees the big picture and the sum of its parts.

Findings

The study revealed five themes, with associated competencies and their behaviors. The themes are leadership, attitudes and attributes, communication, problem solving and systems thinking, and technical acumen. Each is described in turn. The theme findings are followed by the Myers-Briggs Type Indicator findings.

- Leadership
  - Influences Others
    - Influences actions of personnel not under their direct management control (up, down, and across) by creating synergy among and with people.
    - Presents an overwhelming argument that people will accept. Builds consensus with different team members. Builds an initial version and gets others to agree.
    - Understands underlying political forces that affect the project. Ensures that the project manager, subsystem SEs, etc. have important information.
    - Leads with confidence.
  - Works Well with a Team

        - Motivates team by consistently communicating progress and understanding of the challenges and opportunities faced by the system design.
        - Has experience with successfully leading various SE teams.
        - Assesses each team member's competence and depth of knowledge; tailors assignments based on this assessment.
        - Understands the human factors; makes room for the team to succeed. Ensures successful integration of products produced by others.
        - Genuinely respects people and their talents by encouraging and challenging them to do their best work.
    - Trusts Others
        - Places a high value on trust. Assesses who has the skills and abilities to do the job and delegates to people they can trust.
        - Informs the subsystem engineers of what needs achieving but not how to achieve it.
        - Earns trust of others by demonstrating understanding and appreciation for the challenges and scope of the other's job.
    - Communicates a Vision and Technical Steps Needed to Reach Implementation
        - Sets clear system objectives.
        - Ensures team members understand their roles and responsibilities.
        - Articulates to the team what constitutes system success and mission success and their relationship to each other.
        - Creates a vision of the end-product and, as systems are being developed, weighs trades and balances alternatives against the vision of the final product.
    - Mentors and Coaches
        - Mentors and coaches less experienced systems engineers.
        - Coaches individuals interested in pursing the field of systems engineering.
        - Recognizes "high potential" individuals by understanding and identifying the presence of skills and traits needed to be successful in the field.

- Attitudes and Attributes
    - Possesses Self-Confidence
        - Confident in knowing what they do know and willing to state it and admit what is not known; seeks specialists to fill in missing pieces.
        - Identifies soft spots in a design or argument by asking questions and pursues the question until a suitable answer is reached.
        - Is not afraid to ask questions, even if doing so reveals a lack of knowledge or understanding. Asks right questions, at the right time, to move an argument in a critical direction.

- Sits back and listens to group discussions with one part of the brain, while the other part is building models and connections or identifying disconnects.
- Stays on point until ideas are heard, recognizes when enough information is gathered to make a decision, and then moves on.

- Has an Objective and Comprehensive View of the Job
  - Remains objective and is not fettered by irrelevant, outside influences.
  - Keeps in mind the integrity of the engineering life cycle.
  - Believes the "job is never done" and "my job is the whole thing."
  - Maintains a healthy skepticism with an attitude of "prove it."
  - Strikes a balance between what must happen to obtain success and what must not happen to avert failure.
- Is Intellectually Curious
  - Is fearless and has an authentic and persistent desire to understand how everything works and how it relates to everything else. Can quickly connect dots and identify weak spots.
  - Moves without boundaries from one topic to another, seeking the interrelationships.
  - Is inquisitive and open-minded to learning new concepts. Curious to know What is on the other side?, What else needs to be known?, What might have been overlooked?, What can cause the system to fail?
  - Asks questions artfully. Uses a series of questions that build upon each other to help identify the root of a problem or solutions.
- Manages Change
  - Understands that change is inevitable and takes appropriate actions quickly. May gather other systems thinkers to brainstorm various avenues and approaches to support the change.
  - Interprets, assesses, and anticipates how change will affect the system.

- Communication
  - Advances Ideas
    - Fosters open two-way discussions, brainstorms with others to solicit various viewpoints. Allows and encourages people to state opinions while listening for connections and disconnects in logic.
    - Assesses and communicates technical knowledge to others. Asks a series of probing questions in order to build a picture or framework for understanding and to show linkages.
    - Restates, reframes, and clarifies questions on behalf of someone else in the group to ensure understanding among group members.
    - Is willing to speak up and take charge by articulating clear and concise decisions and directions.
    - Enrolls the team by explaining how the solution or approach was reached.
  - Communicates through Story-Telling and Analogies

        - Uses the world around to build connections and provide explanations by using engineering and non-engineering stories and analogies. For example, relates stories from literature, poetry and everyday experiences to better explain concepts and ideas to others.
        - Helps others design future systems by sharing experiences and "lessons learned."
    - Listens Effectively and Translates Information
        - Is an excellent listener. Is keenly aware of what is being said and of omissions. Listens for themes that continue to surface. This becomes a point where the SE will begin to penetrate by asking questions. If questions are not adequately answered, the SE will begin to focus on the potential soft spot.
        - Sits back and allows a full, free, and unfettered discussion to occur to sense where problems lie.
        - Sees the system from various perspectives. Listens and acts as translator between parties (subsystems, PM, and other customers), ensuring each gets the necessary information from others.
        - Understands that people assimilate information differently. Builds rapport with others by adapting communication styles appropriate for the recipients.

- Problem Solving and Systems Thinking
    - Critical Thinking
        - Moves concepts and ideas easily through artificial borders. Uses intuition and the senses to penetrate the system and discover or synthesize solutions to a problem.
        - Analyzes a topic methodically. May use past experiences to solve problems as well as point out assumptions that are not applicable. Not tied to the first answer that appears.
        - Sees multi-view representations of systems and translates across the views. Views systems from multiple angles. Example: May visualize the system as a whole, then break large aspects down into smaller pieces, then simplify these latter pieces into even smaller pieces. (Reductionism). Slices the pieces horizontally, vertically, and diagonally to see connections and soft spots. Rebuilds parts into a whole. Navigates complexity on multiple dimensions and layers. Sees the big picture and the sum of its parts.
        - Solves problems with the team by listening for the issue, pinpoints problem areas, makes recommendations, and then steps out. Avoids side trips and unnecessary minutiae and focuses on important issues.
        - Bridges technical aspects together.
        - Studies, understands, and articulates the project's overall objectives. Knows what the system must do and be in order to accomplish its objectives.

        - Solves problems with a balance of innovative developments and proven heritage products. May rely on experience and existing design as guides but sees each opportunity as a canvas to design new solutions.
        - Is energized by, and relentless in, sleuthing for problems and finding solutions. While others may allocate time reviewing obvious issues, the SE focuses on subtle issues. "My job is the whole thing," from the broad to the deep.
        - Is creative in the midst of numerous constraints. Example: Some of the best systems designs result from dealing with very tight margins.
        - Is comfortable and willing to push and challenge every aspect of the engineering life cycle.
    - Manages Risk
        - Is risk-savvy. Balances risk with resource allocations tailored to the challenges intrinsic to each area and does not view all aspects of the system as having the same amount of risk.
        - Understands that risk is perpetual and needs to be managed.
        - Anticipates and mitigates future risks in both development and mission execution. Example: Before a clear solution is determined, the SE may request parallel developments to determine which approach will be best.

- Technical Acumen
    - Overall Technical Acumen
        - Is viewed by several JPL senior managers as the "go to person" for system engineering.
        - Successfully expresses technical grasp of system engineering at all levels. Has the highest confidence of the project manager and the technical respect of other key project personnel.
        - Understands the essence of the Design Principles and the Flight Project Practices and understands appropriate deviations based on specific circumstances.
        - Has technical knowledge of flight and ground systems. Knows when a technical solution is obvious and when a more formal decision process is warranted.
        - Knows what peers and counterparts are doing in the field of Systems Engineering. May speak at conferences or hold memberships in technical organizations.
        - Has demonstrated knowledge of systems engineering practices.
        - Is naturally a generalist, with depth in one or two disciplines. Engages specialists for their technical knowledge and abilities.

- Myers Briggs Type Indicator (MBTI) Results

  All of the nine respondents fell into either of two of the four Myers-Briggs temperaments: Sensing-Judging (SJ) and Intuitive-Thinking (NT).* The study population has twice as many NTs as SJs and twice as many Judging (J) preferences as Perceiving (P) preferences. The introversion (I)-extroversion (E) scale was not a significant discriminator.

  While these Myers-Briggs findings are very interesting, a sample of nine is too small for the conclusions to be statistically significant. In particular, those who might not be considered good candidates to be system engineers were not studied. Thus, we do not know their typol-ogies or how they compare with the systems engineers who were studied.

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* Myers, Isabel B., and Myers, Peter B., **Gifts Differing**. Consulting Psychologists Press, Inc. Palo Alto, California 1990.

Concluding Remarks

The nine systems engineers studied typically view the system or subsystem as a non-linear web of connects or disconnects to be solved. They have the ability to view the big picture, zoom in to pin-point the disconnect, and then zoom back out to the big picture, while at the same time looking at the interrelationships and patterns in the system or design. They have a high degree of curiosity mixed with self-confidence and persistence and are achievement-oriented. They may describe themselves as having extraordinary physical insight to see the connections and interrelationships between what they are doing and the world around them. They are drawn to the challenge of solving complex problems and are creative in the midst of numerous constraints.

CC:
SEA-MOG
J. Blowers
A. Ruskin
P. Jansma
J. Beckman
G. Lee
C. Whetsel
C. Guiar
R. Duren
N. Cox
D. MacPherson
G. Reeves
R. Manning
J. Yu

Appendix A

Interview Questions

1. Describe top performing SEs in behavioral terms.
2. As an SE, what leadership abilities do you possess? How are these abilities displayed?
3. What general knowledge does a highly regarded SE possess?
4. What leadership skills does a highly regarded SE possess?
5. What skills do you possess?
6. Identify the attitudes and attributes a highly regarded SE possess.
7. What behaviors do you exhibit concerning your analytical and integration skills?
8. What are your strengths in being an integrator and systems thinker?
9. What makes a candidate a " high potential" with regard to SE?
10. What search firms do you know that specialize in recruiting senior SE's?