



Executive Leadership at NASA: A Behavioral Framework

Study Team:

Christine Williams, NASA HQ, Mary Ellen Derro, JPL

Matthew Jarvis, GSFC, and Linda Morris, NASA HQ

March 2010

**NASA Office of the Chief Engineer
Academy of Program/Project & Engineering Leadership**

Table of Contents

Executive Leadership at NASA: A Behavioral Framework.....	3
1.0 Executive Summary.....	3
2.0 Introduction.....	4
2.1 Purpose.....	4
2.2 Background.....	4
3.0 Methodology.....	5
3.1 Behavior Study Approach.....	5
3.2 Executive Leadership at NASA: Developing A Behavioral Framework.....	6
4.0 Agency Findings.....	6
4.1 Prevailing Themes.....	7
4.2 Myers-Briggs Type Indicator (MBTI) and Temperament Results.....	9
4.3 Themes, Elements and Representative Observable Behaviors.....	11
5.0 Summary and Conclusions.....	23
6.0 Next Steps.....	24
7.0 Acknowledgements.....	25
8.0 Appendices.....	26
8.1 Appendix 1 Executive Interviewees.....	26

Tables

Table 1 Structure -- Behavioral Framework for Executive Leadership at NASA.....	6
Table 2 Agency-wide Systems Engineering MBTI® Scores by Temperament.....	10
Table 3 Snapshot of Highly Effective Executives' MBTI® Scores by Temperament.....	10
Table 4 Leadership Theme.....	11
Table 5 Attitudes and Attributes Theme.....	13
Table 6 Communication Theme.....	14
Table 7 Problem Solving and Systems Thinking Theme.....	17
Table 8 Political Savvy Theme.....	20
Table 9 Strategic Thinking Theme.....	21

Figures

Figure 1 Executive Interview Questions.....	5
Figure 2 Executive Behavior Study Process Milestones.....	6

Executive Leadership at NASA: A Behavioral Framework

1.0 Executive Summary

This is the second of two studies NASA's Office of the Chief Engineer conducted to identify characteristics or behaviors frequently observed in highly regarded systems engineers and technical executives. The purpose of these studies is to develop shared understanding and agreement across the agency regarding the practice of systems engineering, a core competency critical to NASA's success, and of the behaviors and attributes that enable highly regarded technical managers and executives to be successful.

The first study, the *NASA Systems Engineering Behavior Study*, conducted from March through October 2008, included 38 civil servants who were still actively engaged in systems engineering roles at NASA field centers. Study findings on behaviors and attributes of these highly regarded systems engineers are being used in the Systems Engineering Leadership Development Program (SELDP) and elsewhere to design and update systems engineering training, development, coaching, and mentoring programs. The goal of the study was to accelerate development of identified behaviors in systems engineers and to help NASA's engineering leadership more quickly identify and support the development of employees with high potential for future systems engineering leadership positions. (For a copy of the study and information on SELDP, please see: <http://www.nasa.gov/offices/oc/e/appel/seldp/index.html>.)

This current study, *Executive Leadership at NASA: A Behavioral Framework*, was conducted from June 2008 to March 2009. It investigated behaviors and attributes of 14 NASA executives at NASA Headquarters and field centers whom agency leadership identified as highly effective in their roles, and who possessed a technical background or systems orientation that contributed to their success. Study methodology and protocol mirrored that used in the *NASA Systems Engineering Behavior Study*. It included interviewing, observing and shadowing participants. Findings identified a shared set of effective executive behaviors evident across centers, reinforced and extended those of the previous study and resulted in a behavioral framework for technical managers seeking to transition into executive roles.

Data gathered to answer the question "What are the behaviors and attributes that enable individuals to become successful executives at NASA?" clustered into elements within six broad themes. Four of these—leadership, attitudes and attributes, communication, and problem solving and systems thinking—were among the five identified in the earlier study. In the current study, executive presence emerged as a sub-theme within attitudes and attributes, and two new themes, political savvy and strategic thinking, also surfaced.

This extended study has allowed us to identify behaviors and attributes that enable individuals to become successful NASA executives who achieve mission success. These findings, combined with those from the previous study, will contribute to agency efforts to create training and learning strategies that support career-long employee development and to ensure that NASA has executives ready and able to take on the complex work of leading NASA's future missions. This report presents the six broad themes identified from the interviews, observations, and shadowing activities, as well as the associated representative observable behaviors and attributes.

2.0 Introduction

2.1 Purpose

The purpose of this study, *Executive Leadership at NASA: A Behavioral Framework*, was to identify behaviors and attributes exhibited by the agency's most successful executives. Participants included NASA executives who served at some point in their NASA careers as technical managers of projects requiring systems development, possessed a systems engineering orientation, and successfully applied those talents and behaviors in their executive roles.

The information gained from this study will be used to accelerate the development of these critical behaviors in order to enhance the likelihood of mission success and to develop the next generation of highly regarded NASA executives.

Study findings will be used to design or update training, development, coaching, mentoring and knowledge sharing programs and materials to foster these behaviors in technical managers and others across the agency. Moreover, study data will allow NASA to introduce elements of executive development into training curricula used for multiple levels of the workforce. This will enable individuals to begin building knowledge, skills, behaviors and attributes central to executive leadership early in their careers.

Knowing specifically which characteristics or behaviors to target for development also provides the agency with a research-based framework from which to measure an individual's progress and the impact of training and development programs, and to assess individual influence on mission performance.

This study is also intended to provide NASA's leadership with a valid and reliable template from which to evaluate employees' capabilities as they relate to these behaviors and identify areas for development and improvement.

2.2 Background

In October 2008, NASA completed the *NASA Systems Engineering Behavior Study*, designed to identify the behaviors that separate high performing systems engineers at NASA from average performers. This study looked at 38 "highly regarded" practicing engineers to determine the behaviors that helped make them successful. The Office of the Chief Engineer immediately began to incorporate study findings into training programs and into the newly created Systems Engineering Leadership Development Program (SELDP).

Prior to the start of this first study, the Office of the Chief Engineer and former NASA Administrator determined that the differences in the roles and responsibilities of practicing systems engineers and NASA executives using systems engineering skills warranted separate studies.

3.0 Methodology

3.1 Behavior Study Approach

NASA leaders agreed that the study would focus on identifying behaviors that enabled executives to be successful at NASA, i.e., to achieve mission success, and they selected study participants whom they considered “highly successful” executives.

While the majority of those identified were from the systems engineering community, others had different backgrounds (e.g., project management). All, however, had a systems orientation¹ and a technical background in one or more engineering sub-disciplines. One participant was retired. The remaining executives worked at NASA Headquarters or one of the NASA field centers. See Appendix 1 for a list of those interviewed.

The Office of the Chief Engineer (OCE) selected team members with prior experience working on the *NASA Systems Engineering Behavior Study* and with education and experience in organizational development and/or training and development.

The methodology of both the current study and the *NASA Systems Engineering Behavior Study* was based on the work previously done at the Jet Propulsion Laboratory (JPL) for the Systems Engineering Advancement Program. One or more of the study team members interviewed, shadowed and/or observed each of the executive participants. The interviews, conducted and recorded in conference rooms or private offices, were from 60 to 90 minutes long. The questions were vetted and approved by the NASA Chief Engineer prior to the start of the study. Participants were asked identical questions, with follow-up questions based on initial answers. Interview questions were divided into two categories: context and relation to self and personal awareness. See Figure 1 for a list of questions asked.

- | |
|---|
| <p><i>Context Questions</i></p> <ol style="list-style-type: none">1. How would you describe the role of an SE executive <p><i>Relation to Self and Personal Awareness</i></p> <ol style="list-style-type: none">2. Describe top performing executive SE’s in behavioral terms?3. Think of a top performing SE executive who you have worked with, or for. What do you remember most about how they behaved and the impact that behavior had on the organization’s goals?4. Think of a top performing SE executive who you have worked with or for, what do you remember most about how they behaved.5. In what ways, if any, did these behaviors impact the organization’s goals?6. What do you think are the differences between your behavior as an SE on a project and you as a SE executive?7. What distinguishes a SE executive from other NASA executives?8. When you think of someone who failed as a SE executive, what was missing/ different about that person?9. Describe what goes on in your mind when you are problem solving.10. Has this changed since you became an executive?11. Describe top performing executive SE’s in behavioral terms? |
|---|

Figure 1. Executive interview questions.

¹ Systems orientation implies the active use of systems engineering principles and processes.

The shadow process included a minimum of one day of shadowing executives performing their day-to-day activities. In addition, study team members were invited to meetings and events that executives were either leading or participating in. The events observed included, but were not limited to, staff meetings, program, project or technical reviews, one-on-one discussions, brainstorming sessions, press interviews, and strategy meetings.

Figure 2 shows process highlights. The study team transcribed interviews, compiled results, and analyzed them for common themes, identifying elements of each theme and associated representative observable behaviors and attributes. The Chief Engineer then sent draft results to interviewees for validation and verification.

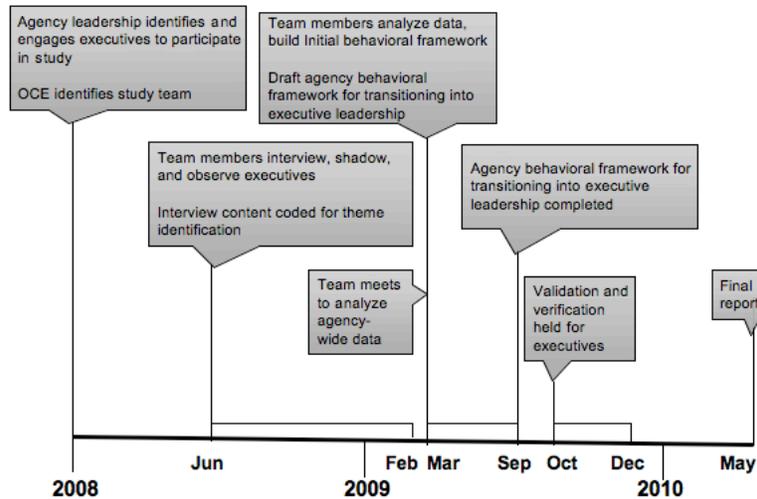


Figure 2. Executive behavior study milestones and time line.

3.2 Executive Leadership at NASA: Developing A Behavioral Framework

The data, observable behaviors/attributes that two or more executives exhibited or reported, were aggregated into elements and themes as indicated in Table 1.

Table 1 Structure -- Behavioral Framework for Executive Leadership at NASA

Level	Description	Example
Top: Themes	Collections of elements	Leadership
Middle: Elements	Aggregations of related representative observable behaviors	Manages At the appropriate level
Lowest: Representative Observable Behaviors	Behaviors/attributes that more than one senior executive exhibited or reported	Makes executive-level decisions, but delegates problem solving to the appropriate functional teams and system owners.

Table 1. Descriptions and examples of themes, elements, and observable behaviors.

4.0 Agency Findings

This study focused on determining behaviors and attributes of highly effective executives who were at one time technical managers, and its purpose was to identify those behaviors and attributes that enable individuals to be successful executives within the agency. The behaviors/attributes exhibited by the 14 participating NASA executives fell into six broad themes—leadership, attitudes and attributes (including executive presence), communication, problem solving and systems thinking, political savvy, and strategic thinking—with associated elements and representative observable behaviors.

4.1 Prevailing Themes

Study findings reinforced and extended those of the *NASA Systems Engineering Behavior Study*. Data gathered to answer the question “What are the behaviors and attributes that enable individuals to become successful executives at NASA?” clustered into elements within six broad themes. Four of these—leadership, attitudes and attributes, communication, and problem solving and systems thinking—were among the five broad themes identified in the earlier study. The earlier study also included the theme of technical acumen. In this study, executive presence emerged as a sub-theme within attributes, and two new theme, political savvy and strategic thinking, surfaced. While participating executives at NASA centers and headquarters shared common sets of behaviors around all themes, team members noted some differences in behaviors related to communications and political savvy.

The sub-themes and elements within each theme provide a broad perspective on the behaviors and attributes of highly effective NASA executives for those who wish to transition to these roles.

Leadership

Highly effective NASA executives focus on the organization and its people. Executives create organizational structures to support mission success, defining roles and responsibilities and identifying resources needed to achieve mission objectives. As they make executive-level decisions, they draw on others’ expertise and involve them in the process; they delegate and facilitate the work of others, and inspire and motivate them by challenging and holding them accountable. Facing adversity they remain flexible and responsive. Identifying critical decisions, they act decisively.

These executives report levels of self-awareness, recognizing their strengths and limitations, and acknowledge that they have blind spots or biases. Acting proactively, they continuously develop themselves. They are able to let go of current roles and prepare themselves to act in new ones.

Attitudes and Attributes

Core attributes include being inquisitive, curious, patient, and organized. Examples include having a passion for learning and remaining open-minded when being presented with new approaches or strategies. They are able to manage large, complex projects.

Participating executives also exhibited “executive presence,” displaying self-confidence and courage when dealing with difficult issues. They remain calm under pressure, for example, maintaining a positive attitude when dealing with setbacks. Aware of how their personal presence and behavior affect others, they act to create safe, open environments.

Communication

NASA’s highly effective executives master communication skills. Communicating throughout the organization, and in some cases to Congress or other government agencies, executives tailor messages for different audiences using stories, analogies and the languages of specific technical disciplines. They practice effective speaking and listening skills, ensuring that meanings are clear and unambiguous. They use humor to build rapport and may make self-effacing statements to put others at ease.

Executives communicate strategically and collaboratively. Linking people, organizations and ideas, they build consensus by encouraging participation and dialogue, seeking expert opinions, and constructing internal and external networks. They use multiple approaches and communication channels and listen to different perspectives. These executives make themselves accessible to others, answering questions and discussing key issues and concerns. They set aside time to meet with others and ensure that they know it is okay to “drop by.”

Problem Solving and Systems Thinking

These highly effective executives take a systems view of their work. For example, they are able to examine a problem from multiple perspectives and look deeply at specific issues while remaining focused on the big picture. They understand how a system works, what it is designed to do, and its functions and requirements.

Highly effective executives facilitate trades to find the right design balance between performance, cost and schedule. These executives are able to analyze a system’s data and to trace implications of a problem in a sequential manner. They recognize what is technically right among many good ideas by using systems thinking skills to compare designs.

Highly effective executives also spend time up front to identify and frame core issues and problems, then actively probe for information and insights that will reveal connections and patterns across the system. Able to deal with and assimilate large amounts of data, they validate facts and question assumptions. Considering all options before deciding, they identify and assess risks and work to remove uncertainty. Remaining open-minded and objective, they use creativity and draw on past experience to solve problems.

Political Savvy

NASA's highly effective executives know how the political system works—who makes decisions, when they make them, and what they need. They have political staying power and are able to maintain momentum over multiple years and administrations. These executives represent or promote NASA's programs in dialogues with employees and external stakeholders across the political spectrum, communicating how programs meet needs, noting consequences and implications of decisions, and, if necessary, quickly informing the Administration and/or Congress when there is a problem. Executives manage multiple demands and opportunities involving internal and external stakeholders, and consider impacts on internal and external organizations before making decisions. They are able to use a historical perspective and lessons learned to provide context for decisions and actions.

Strategic Thinking

Highly effective executives maintain an agency-wide view, keeping the big picture in mind, ensuring that NASA has a plan for maintaining competencies and capabilities needed to be successful, and balancing decisions across portfolios, programs and projects. These executives manage both mid- and long-term goals, and understand the implications of activities at multiple levels. They seek to build and maintain national and international connections and partnerships, and monitor multiple environments to understand issues or priorities that will affect agency goals and missions. They also build informal networks to gather and validate information from multiple sources. To accomplish goals, they connect organizations and individuals that might otherwise remain isolated.

4.2 Myers-Briggs Type Indicator (MBTI) and Temperament Results

Description of MBTI

The Myers-Briggs Type Indicator (MBTI®) was administered to 34 of the 38 systems engineers who participated in the first behavioral study in order to identify their personality or psychological type. In this study 10 of the 14 executives who participated provided MBTI information. Based on David Keirsey's work on Temperament², the MBTI results can be broken down into one of four temperaments: Intuitive-thinking (NT), Sensing-Judging (SJ), Sensing-Perceiving (SP) and Intuitive-Feeling (NF).

MBTI and Temperament Results

See Tables 2 and 3 for information about MBTI results for both studies. The first study population had 19 NTs (56%), 9 SPs (26%), 5 SJs (15%), and one participant with the NF (3%) temperament. In this study 8 of 10 respondents were NTs (80%); the other two were SJs. In addition, while the first study contained almost twice as many respondents who were introverts (22) than were extroverts (12), in this one, 6 of the 10 respondents were extroverts.

Keirsey posited that NTs, intuitive thinkers, possess a problem solving temperament, particularly if the problem has to do with the many complex systems that make up the world around us. While neither survey group is considered large enough to draw any specific conclusions or statistical inferences from this MBTI data, future studies exploring relationships among executive effectiveness and demonstrated behaviors and

² For information see: <http://www.keirsey.com/handler.aspx?s=keirsey&f=fourtemps&tab=1&c=overview>

attributes might benefit from this information about the personality temperaments of highly successful executives at NASA.

Table 2 Agency-wide Systems Engineering MBTI® Scores by Temperament

Temperaments	# By Category	% Of Total
NT (Intuitive / Thinkers)	19	56%
INTJ	6	
INTP	8	
ENTJ	1	
ENTP	4	
SP (Sensing / Perceiving)	9	26%
ISTP	3	
ESTP	5	
ESFP	1	
SJ (Sensing / Judging)	5	15%
ISTJ	3	
ISFJ	1	
ESFJ	1	
NF (Intuitive/ Feeler)	1	3%
INFJ	1	

Table 2. Scores of 34 of the 38 highly regarded systems engineers selected to participate in the *NASA Systems Engineering Behavior Study*.

Table 3 Snapshot of Highly Effective Executives' MBTI® Scores by Temperament

Temperaments	# By Category	% Of Total
NT (Intuitive / Thinkers)	8	80%
INTJ	2	
INTP	1	
ENTJ	3	
ENTP	2	
SJ (Sensing / Judging)	2	20%
ISTJ	1	
ESFJ	1	
ESFJ	1	

Table 3. Scores of 10 of the 14 highly effective executives selected to participate in this study, *Executive Leadership at NASA: A Behavioral Framework*.

4.3 Themes, Elements and Representative Observable Behaviors

See Table 4 through Table 9 for detailed descriptions of themes, elements and representative observable behaviors.

Table 4 – Leadership Theme

Elements	Representative Observable Behaviors/Attributes
Creates Organizational Infrastructure	<ul style="list-style-type: none"> • Identifies the specific combination of skills, talents, and technical competencies required to achieve mission success. • Defines the roles and responsibilities of team members. • Assigns roles and responsibilities and evaluates performance based on team members’ current capabilities and prior work experiences. • Designs and implements standard operating procedures that enable a smooth, consistent, and coordinated workflow.
Gauges Resource Needs to Achieve Mission Objectives	<ul style="list-style-type: none"> • Identifies human, financial, and material resource requirements in consultation with subject matter experts and project owners. • Ensures that mission goals and outcomes are achievable given available resources.
Manages at the Appropriate Level	<ul style="list-style-type: none"> • Makes executive-level decisions, but delegates problem solving to the appropriate functional teams and system owners. • Enables others to get work done. • Holds others accountable for their assigned deliverables. • Gathers information from stakeholders and experts at all levels when making decisions that can only be made at the executive level. • Sets the context for decisions—the "what" and the "how."
Accepts Change and is Resilient	<ul style="list-style-type: none"> • Demonstrates flexibility and responsiveness to changing priorities and critical needs. • Monitors the environment for changes in required outcomes, critical assumptions, available resources, or other factors that could necessitate a change in strategy. • Adjusts direction, strategy, roles, responsibilities and/or schedule to ensure critical organizational needs are met.
Acts Decisively	<ul style="list-style-type: none"> • Identifies decisions that are critical, non-critical, and important to avoid. • Identifies and puts parameters around the amount of information needed to make a given decision. • Makes timely decisions based on experience, resource constraints and available information.
Inspires and Motivates Team Members to Perform at Peak Performance	<ul style="list-style-type: none"> • Encourages team members to accept new challenges and perform to the best of ability in finding solutions to seemingly insurmountable problems. • Promotes creativity and intelligent risk-taking. • Challenges others to ask questions and think “outside the box.” • Helps team members maintain a positive attitude and forward progress toward goals and outcomes when facing adversity while acknowledging threats and challenges. • Monitors, tracks and communicates progress. • Evaluates strategies on the basis of outcomes. • Publicly acknowledges team members’ accomplishments and areas of expertise. • Provides informal praise (verbal, email, thank you card, etc.) of individual and group accomplishments. • Provides appropriate formal rewards and recognition for good performance.

Table 4 – Leadership (cont.)

Elements	Representative Observable Behaviors/Attributes
Builds Trust and Respects Confidentiality	<ul style="list-style-type: none"> • Trusts others' expertise and judgment. • Reevaluates assumptions, judgments, and strategies based on input from subject matter experts and stakeholders. • Designs and implements communication processes that ensure the fair and objective evaluation of ideas and opinions. • During individual and group discussions, identifies proprietary information and reaches agreement with participants on how the information should be managed.
Develops Employee Capabilities	<ul style="list-style-type: none"> • Provides resources, visible support and encouragement to employees to develop knowledge, skills, and competencies. • Identifies and encourages employees with talent, potential and the ability to take a system-wide view to problem solving. • Provides employee work assignments and training opportunities that address critical developmental needs. • Meets privately with employees to review performance and discuss work strategies. • Provides employees constructive feedback on performance by exploring employees' thought and decision-making processes and helping them discover insights. • Delivers corrective feedback on individual performance privately, and in a manner that is objective and non-judgmental.
Reduces Distractions	<ul style="list-style-type: none"> • Deals personally with issues and problems that would otherwise be a source of distraction to project team members. Asks team members, "How can I help? What is getting in the way of your work?" • Negotiates on time and resource issues on behalf of project team members.
Aware of Self and Values	<ul style="list-style-type: none"> • Knows personal strengths, limitations and motivations. • Knows when others need to be consulted. Understands that "getting it right" is always more important than "being right." • Is aware that blind spots or biases might exist in own thinking and asks others to keep him aware of other perspectives. • Adheres to a strong set of values that align with Agency's mission and purpose. • Articulates values so others understand one's perspectives and positions.
Develops Self	<ul style="list-style-type: none"> • Maintains basic working knowledge of technical disciplines. • Maintains contact with current engineers and engineering projects. Seeks opportunities to interact with them and perform limited 'hands-on' work. • Conducts benchmarking of engineering organizations performing cutting-edge engineering work and asks, "How do they do that?" • Judiciously learns what is required in each new position and what it takes to be a successful government executive. Talks to and observes those who do the job best. • Develops a learning plan to gain the knowledge, skills and abilities needed to be successful at each new level.
Lets Go of Current Role to Prepare for New One	<ul style="list-style-type: none"> • Intentionally chooses to move into leadership and stop being technical expert. • Willing to relinquish familiar job functions and develop skills and knowledge necessary to grow and advance to the next level of leadership.

Table 5 – Attitudes and Attributes Theme

Elements	Representative Observable Behaviors/Attributes
Remains Inquisitive and Curious	<ul style="list-style-type: none"> • Has an ongoing passion for learning, enhancing knowledge, skills, and experience in both technical and non-technical subjects. • Participates in a wide variety of formal and informal learning opportunities. • Continually asks questions and probes for information.
Is Patient	<ul style="list-style-type: none"> • Understands that high-performing social and technical systems take time to develop. • Manages and oversees key system functions, but allows other elements of the system to evolve and stabilize over time. • Maintains commitment to chosen path or strategy, even when long-term results are not yet evident. • Is patient and open-minded when presented with new approaches or problem-solving strategies.
Is Organized	<ul style="list-style-type: none"> • Can manage large and complex systems, process extensive amounts of data, and rapidly explore the costs and benefits of a number of alternative strategies. • Effectively compartmentalizes, prioritizes, schedules, delegates, completes, and evaluates the outcome of activities associated with the executive role. • Makes full use of IT tools and technologies to help organize calendar and decisions.
<i>Executive Presence</i>	
Displays Self-Confidence and Courage	<ul style="list-style-type: none"> • Exhibits confidence in technical knowledge, skills, and ability to lead and achieve goals. • Identifies the difficult issues, e.g., “the elephant in the room.” • Willing to be controversial. Fearlessly questions decisions even when in the minority or standing alone. Willing to disagree or push back on senior leadership. • Willing to make difficult decisions by listening to others and then act as final arbiter.
Remains Calm under Pressure	<ul style="list-style-type: none"> • Manages organizational pressures while maintaining team and organizational momentum by identifying the difficult issues and focusing on the solution. • Maintains perspective and a positive attitude in the face of adversity and avoids being defeated by setbacks by focusing on solutions. Holds the belief that “we will get past the problem, in the best way possible, to achieve the greater good.”
Aware of How Personal Presence and Behavior Affects Others	<ul style="list-style-type: none"> • Maintains a high degree of physical energy throughout the day. • Walks in with a no-nonsense style, e.g., “We have a job to do. Let's not waste time. “ Friendly, but to the point. • Aware that others will tend to defer based on executive’s position. Encourages others to state opinions in order to get the best solution. • Creates a safe environment that helps others feel comfortable by, for example, shaking hands, smiling, addressing people by their first names, referring to their previous work, showing humility, letting others take the lead, and engaging others by asking questions.

Table 6 – Communication Theme

Elements	Representative Observable Behaviors/Attributes
Communicates throughout the Organization	<ul style="list-style-type: none"> • Ensures important information is communicated to stakeholders throughout organization. • Communicates downward and laterally by disseminating information on priorities, interdependencies, impacts, and lessons learned. • Communicates appropriate amount and type of information upward. • Where appropriate, helps individuals and organizations gain access to information needed to perform their work effectively.
Tailors Messages	<ul style="list-style-type: none"> • Understands how different audiences interpret information. • Expertly tailors and delivers messages to meet the needs of specific audiences such as the media, Capitol Hill, or other key stakeholders. • Can speak the language of multiple disciplines, i.e., finance, personnel, legal, etc. Consciously and continually learns to communicate with representatives from all functional areas. (HQ) • Knows how to translate information on complex technical programs into non-technical language. Talks to a congressional staffer in the language of Congress; talks to OMB staff in the language of the budget, etc. (HQ) • Uses audience appropriate analogies from discipline when speaking to engineers and analogies from home and office when communicating with non-technical people.
Strives for Clarity	<ul style="list-style-type: none"> • Realizes that clarity is critical to providing facts in a way that ensures that understanding is reached. • Uses clear language to be sure everyone knows what is meant and has a shared understanding. • Compares and contrasts ideas, e.g., "if this then ... if that then." • Summarizes decisions and agreements at meetings. • Practices active listening. Solicits feedback to check that others receive messages that were transmitted. May ask staff to repeat in their own words what was said. When person is more senior, may check with that person's staff to ensure receipt of intended message. (HQ) • Aligns verbal and non-verbal messages to ensure the meanings are clear and unambiguous. Ensures consistency between written charts and verbal communications. • Makes certain that meeting formats are consistent with their purpose, e.g., brainstorming, working an issue, information sharing, decision-making, etc. Ensures those in attendance know why they are there.
Assesses Context	<ul style="list-style-type: none"> • Knows when and how often to communicate. Assesses the context before speaking. Senses others' needs to argue a point, vent a frustration, solicit feedback, etc., and responds accordingly. • Knows what is the right level of communication for each situation. Strikes the right balance in communicating what is needed, but not more.

Note: Behaviors observed only in executives located at Headquarters are noted by **(HQ)**.

Table 6 – Communication (cont.)

Elements	Representative Observable Behaviors/Attributes
Uses Humor	<ul style="list-style-type: none"> • Uses humor to build rapport with individuals and groups and to reduce fear and anxiety among team members. • Keeps the atmosphere light as appropriate when dealing with difficult or challenging issues. • May joke, share personal or humorous anecdotes or make self-effacing comments during or starting meetings. • Smiles and remains energetic, animated, and attentive during discussions.
Practices Effective Speaking and Listening Skills	<ul style="list-style-type: none"> • Continually demonstrates effective speaking and listening skills (e.g., turn-taking, paraphrasing, asking questions, etc.) to ensure a productive exchange of information and ideas. • Listens effectively and gives individuals full attention. Ends conversations with a summary of actions, due dates, and who is responsible. • Sits back and lets the debate happen. Listens to all the various perspectives and then takes action. • Mentors others to help them become better communicators. Explains how others could potentially misinterpret an imprecise statement.
Communicates Through Story Telling and Analogies	<ul style="list-style-type: none"> • Uses personal experience, organizational stories and analogies to explain challenges, issues and situations. • Uses historical references (e.g., Lewis and Clark and their scientific and research goals). • Discusses the history of NASA (e.g., how the field centers came into being) to illustrate the importance of cultural differences and approaches.
Links People, Organizations and Ideas	<ul style="list-style-type: none"> • Makes transition from a program- or project-level systems engineer who concentrates on how technical systems interface to an executive who focuses primarily on how to get people to connect and work effectively together. • Establishes a common infrastructure and provides necessary resources. • Conducts effective meetings. Knows who should be at meetings (individuals/groups) and inquires about those who are missing. Avoids making final decisions until key stakeholders are available. • Uses a variety of communication channels to maintain contact with individuals/groups throughout the day. Will track down experts mentioned in meetings to get their opinion on an issue. • For important decisions requiring consensus, asks each stakeholder to confirm support and/or present objections until consensus is reached.
Encourages Participation	<ul style="list-style-type: none"> • Uses facilitation, coaching, and dialogue skills to ensure all opinions are solicited, points of view are shared and everyone has the opportunity to participate. • Asks open-ended questions, e.g., "What do you think?" vs. "Do you agree or disagree?" • Uses authority (positional, expert, etc.) to facilitate the structure and flow of meetings to provide opportunities for all to participate. • Senses when opinions are being suppressed; takes steps to solicit that input. • Avoids overusing email or any one mode of communication.

Table 4 – Communication (cont.)

Elements	Representative Observable Behaviors/Attributes
Seeks Expert Opinion	<ul style="list-style-type: none"> • Willing to admit what one does not know and seek out technical experts for their opinion. Openly says, "I don't know." • Intentionally identifies and builds networks of experts to call on. Takes time to determine the best expert for a particular problem. • Provides approaches, ideas, and strategies to help others reach their goal but leaves the decision to those responsible. Does not dictate solutions.
Builds Consensus	<ul style="list-style-type: none"> • Connects people, organizations, and ideas to build shared understanding and consensus by ensuring participation and buy-in. Ensures all stakeholders participate. • Facilitates discussion. Listens to different perspectives and ensures everyone is heard. Will restate or rephrase a point someone has made to ensure that everyone understands what was said. • Keeps the conversation going until there is a convergence of ideas. • Does not assume understanding. Summarizes agreements and ensures they are communicated. • Looks for common, unifying goals. Integrates perspectives into the big picture. Openly and honestly explains the rationale for moving in a given direction. • Strategically builds and utilizes formal and informal networks.
Builds Relationships through Interaction	<ul style="list-style-type: none"> • Enjoys interacting and working with other people. Has very good interpersonal skills. • Uses "We need to ..." to correct someone versus "You need to" ... (HQ) • Devotes a portion of conversations to non-work issues. • Stays focused on the individual/speaker and shows genuine interest. • Rarely holds side conversations or lets blackberry be distracting. • Strives to end meetings and conversations on an upbeat/positive note.
Demonstrates Accessibility	<ul style="list-style-type: none"> • Expresses availability to discuss issues, questions and concerns. • Has a strong focus on schedule and being available for important events. (HQ) • Gives people the time they need to explain the issue, tell their story, etc. Does not rush others. Does not show impatience. Willing to engage in hallway or parking lot conversations. • Includes staff in meetings. Ensures anyone who wants to be included is included. • When issues are brought up, ensures actions are taken to address them. • Makes room on calendar to meet with others. Finds "15-minutes on calendar" for same day meetings. Allows for drop-ins and responds positively. Creates a climate where people feel they are allowed to "drop by."

Note: Behaviors observed only in executives located at Headquarters are noted by **(HQ)**.

Table 7 – Problem Solving and Systems Thinking Theme

Elements	Representative Observable Behaviors/Attributes
Uses Systems Perspective	<ul style="list-style-type: none"> • Uses systems thinking in strategy development and to see entire Agency-wide system. • Applies systems engineering principles to mission/programs that have significant political, social, and economic implications. • Applies a systems perspective in the performance of executive roles and responsibilities.
Thinks Systemically	<ul style="list-style-type: none"> • Can look at a problem within multiple frameworks (e.g., ‘change of variables’). • Able to look deeply into a problem while remaining focused on the big picture. Sees the big-picture while demonstrating an overall awareness of the details. • Able to look at all the pieces individually and collectively to meet program, mission and agency-wide needs, and to identify gaps and overlaps/duplications. • Sees multi-view representations of systems to understand how the pieces fit together and interact. Visualizes systems in 3-D. Draws a picture in the mind or on paper. • Focused on developing a system that meets end-item product objectives and successfully integrates the systems pieces into the whole. • Understands how the system works, what it was designed to do, its functions and requirements. • Looks across the entire system and facilitates trades and compromises to get a balanced design. • Recognizes what is technically right among many good ideas by viewing a problem across system boundaries and comparing each design to the other. • Thinks about how components were designed to interact and what other interactions could occur that were not considered in the design. • Is able to analyze the system’s data. Traces implications of a problem in a step-by-step manner across the system. • If having difficulty understanding a scenario, finds a different vantage point that offers a fresh perspective.
Identifies and Defines Core Issues/ Problems	<ul style="list-style-type: none"> • Spends time up front to ensure that he and others understand, frame and define the problem. • Identifies the real issue /problem (whether technical, infrastructure, administrative, executive resource, or other) by asking questions and identifying the key requirements. • Confirms that the problem is identified. (For example, asks: “Are we solving the right problem?” “Has the correct problem been identified?” “Have we defined the problem properly?” “Do we understand the problem?” “Do we understand the constraints?”)
Actively Probes for Information and Understanding	<ul style="list-style-type: none"> • Seeks to understand all aspects of a challenge. • Probes for crucial and critical information that may be missing. • Considers all proposed solutions/perspectives before making a decision. • Continues to question thinking and extract data until all issues have been addressed and there is shared understanding. Asks questions such as: “What is the measure of goodness?” “What has not been looked at?” “Why?” “Does it still make sense?”

Table 7 – Problem Solving and Systems Thinking (cont.)

Elements	Representative Observable Behaviors/Attributes
<p>Finds Connections and Patterns cross System</p>	<ul style="list-style-type: none"> Examines and explores the implications of how technical decisions will affect the larger system architecture. Observes system interfaces and the ripple effect of how changing requirements or how making a changes to one element will affect other elements or the system. Locates and corrects sub-system 'disconnects' or 'inconsistencies' that are having a negative impact on system performance.
<p>Assimilates, Analyzes, and Synthesizes Data and Information</p>	<ul style="list-style-type: none"> Approaches and solves problems in a systematic manner by using tools, processes, procedures in order to find solutions. Ensures decisions made are supported with data. Assimilates and distills large quantities of data from across the organization and ensures all of the data is on the table to solve a problem or make a decision. Breaks data into smaller pieces or parameters, prioritizes, then synthesizes to reach an answer or solution. Determines how to put together all available information in a way to rigorously test mathematically or physically that the problem is adequately understood.
<p>Validates Facts, Information and Assumptions</p>	<ul style="list-style-type: none"> Questions all assumptions that go into a design. Anticipates and looks for problems or issues in the system. Knows where data is missing/needed. Recognizes that seemingly minor miscalculations can lead to significant problems in system performance. Identifies system elements that lack metrics or have metrics that are misleading. Recognizes data has limitations and does not rely on it as the only source of information.
<p>Considers All Options before Deciding</p>	<ul style="list-style-type: none"> Works to understand a problem from all perspectives. Actively seeks and weighs different perspectives. Open and willing to listen to multiple views. Is highly inclusive, drawing on the full knowledge, skills, and experiences of the organization. Considers all types of costs (e.g., technical, schedule, political, human, financial). Identifies what will enable or inhibit the ability to accomplish goals. Looks at all aspects of the organizational system, e.g., facilities, budgets, policies, procedures, etc. Asks: “What would happen if I did nothing?” “What is the worse thing that could happen?” Understands there is always more than one solution. Comes up with several solutions, defines consequences of each and relates impacts to managers and employees.
<p>Identifies, Assesses, and Manages Risk</p>	<ul style="list-style-type: none"> Understands that managing risk is an ongoing process. Asks probing questions to ensure risks have been adequately explored. Uses past experiences to anticipate potential problems that may impact system. Identifies worst-case scenario and works from that point back. Focuses on identifying and assessing risks by creating plans for dealing with those risks effectively. Identifies key indicators and methods of testing for each type of problem. Applies and demands sufficient rigor in the application of analytical processes. Develops mitigation strategies for addressing problems, should they arise.

Table 7 – Problem Solving and Systems Thinking (cont.)

Elements	Representative Observable Behaviors/Attributes
Acknowledges and Manages Uncertainty	<ul style="list-style-type: none"> • Works to remove as much uncertainty as possible by questioning everything. • Analyzes failures (what went wrong) and successes (what went right). • Ensures lessons learned are captured. • Lets others know of own willingness to be comfortable with uncertainty. • Openly and honestly discusses personal and programmatic successes, failures, and lessons learned.
Remains Open-Minded and Objective	<ul style="list-style-type: none"> • Receptive to hearing diverse and dissenting opinions. Is willing to re-think/re-work an issue or to change direction when new information or a better idea is presented. • Evaluates decisions objectively. Maintains flexibility by avoiding attachment to a particular strategy or point of view.
Uses Creativity in Solving Problems	<ul style="list-style-type: none"> • Possesses passion for problem solving and takes initiative to solve problems. Enjoys and is energized by fully concentrating on a problem for long stretches, until solutions are formed and implemented. • Does not adhere to rigid rules or formulas for system design, but may create new ideas and approaches that are necessary to deal successfully with system constraints. • May use intuition and past experiences to solve problems. Supplements traditional problem-solving strategies with those that are creative and non-linear.
Draws on Past Experience	<ul style="list-style-type: none"> • Knows good intuition is based on experience and works to expand that experience. • Uses experience, history, intuition, and sensing to assess situations and develop solutions. • Draws on past successes and failures to develop the proper approach. Knows when something looks right. • 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.

Table 8 – Political Savvy Theme

Elements	Representative Observable Behaviors/Attributes
Knows How the Political System Works	<ul style="list-style-type: none"> • Knows who makes decisions and what they need. Keeps up to date with new Members of Congress and staff and relies on NASA's Congressional experts to represent the agency in the best light. (HQ) • Has a keen sense of timing when opportunities arise. Understands how some opportunities are short lived and quick action is needed. • Knows how to present a design to show near-term gains that will meet current Administration and Congressional goals, while building on a longer-term accomplishment that might be realized over a number of Administrations.
Has Political Staying Power	<ul style="list-style-type: none"> • Able to maintain momentum over many years and several Administrations. Quickly learns the priorities of new Administrations and effectively communicates how NASA is meeting those needs. • Assesses the current political agenda to determine the likelihood of obtaining the budget needed. Assesses the political and budget realities in context of the design, requirements, and potential trades.
Represents/Promotes NASA Programs across the Political Spectrum	<ul style="list-style-type: none"> • Understands and effectively communicates with government leadership on how programs meet agency and national needs. (HQ) • Explains consequences and implications of NASA decisions and how the Administration and Capital Hill may interpret the agency's actions. Helps others understand what the Administration is looking for so they can work more effectively within those constraints. (HQ) • Explains the probable reactions of NASA's stakeholders to decisions that are made or put on hold. • Responsive to upper management's needs. Sends notes, calls and updates as activities occur and issues emerge. • Meets commitments in order to gain credibility and trust. Only makes commitments that NASA can meet. • Lets Administration/Congress know when problems arise; notifies them early. (HQ)
Manages Multiple Demands/Opportunities	<ul style="list-style-type: none"> • Balances the needs and political interests of internal and external stakeholders, weighing what is best for the program with what is best for the agency. Makes decisions based on what is best for both. • Considers impacts of executive decisions and actions on organizations inside and outside of NASA before taking action. • Continually monitors these decisions and makes course corrections to meet high priority goals and objectives. • Asks, "What is my boss and what is the Administration worried about?" • Is aware of what is important to the NASA Administrator and other key players, and keeps them informed.
Provides a Historical Perspective	<ul style="list-style-type: none"> • Knows it is important for those inside and outside the agency to know NASA's history. • Helps others see and understand the historical progression of strategies and decisions. Is mindful that NASA has a wealth of lessons learned and is always working to ensure that the agency does not repeat mistakes.

Note: Behaviors observed only in executives located at Headquarters are noted by **(HQ)**.

Table 9 – Strategic Thinking Theme

Elements	Representative Observable Behaviors/Attributes
Maintains an Agency-Wide View	<ul style="list-style-type: none"> • Ensures that NASA has a plan moving forward to maintain both the competencies and capabilities needed to be successful. • Intentionally selects people with different perspectives, talents and knowledge to form a strong management team. • Assimilates large amounts of information from across the agency. Makes decisions by keeping the big picture in mind. Considers all perspectives and proposed solutions before making a decision. • Decisions are balanced across programs and projects. • Works the larger agency-wide "trade space" to meet NASA's and the nation's highest priorities. Trades are made across missions and/or centers and may involve negotiations across federal agencies.
Manages Near-Term and Long-Term Goals	<ul style="list-style-type: none"> • Keeps the end state in mind while managing day-to-day activities. • Continually looks at near-term activities and assesses how they may impact long-term results. • Proactively anticipates and positions the organization years in advance. Focuses on five years and beyond. • Sets a path and has the ability to stick to that path for the extended period of time. • Is mindful of the critical timing of issues (e.g., "We have 12 hours to make this decision."). Will sometimes define decisions in terms of "shelf-life."
Understands Broad Implications of Activities at Multiple Levels	<ul style="list-style-type: none"> • Understands where NASA's mission connects to the missions of other federal agencies and foreign nations. Considers them potential partners, collaborators and in some cases customers. • Seeks to build and maintain connections and partnerships. Shares information and communicates on shared goals and projects.
Monitors the Environment	<ul style="list-style-type: none"> • Monitors the environment outside NASA to understand national and international priorities and issues that will impact agency goals and missions. • Works to understand larger government-wide issues and problems and find ways in which NASA's work can help solve these issues and problems. • Works with other federal agencies to leverage overall federal program investments (e.g., maturing another agency's technology for use in NASA's programs).
Uses Networks	<ul style="list-style-type: none"> • Builds and uses informal networks to validate and gain additional information. • Looks to many different sources to be sure issues are covered and there are no surprises. • Connects organizations and individuals that need to be connected to accomplish goals. • Probes and tests assumptions by reaching out to individuals on the periphery. Uses the "fringe" (individuals outside of a program or project team but aware of issues and able to lend support) to gain information, test assumptions, and assess the size and scope of issues and problems.

5.0 Summary and Conclusions

The 14 NASA executives interviewed and observed for this study, *Executive Leadership at NASA: A Behavioral Framework*, exhibited a common a set of specific behaviors and attributes that were instrumental to their success. These behaviors and attributes are observable and measurable and are similar to those demonstrated by highly successful systems engineers (as described in the 2008 *NASA Systems Engineering Behavior Study*).

The collection of behaviors and attributes demonstrated by these successful NASA executives fell into six broad thematic categories. Four of these—leadership, attitudes and attributes, communication, and problem solving and systems thinking—were among the five top themes identified in the earlier study of systems engineers. In this study executive presence emerged as a sub- category within attributes and attributes. Two new themes—political savvy and strategic thinking—were unique to executives. Also noted were some differences in communication and political savvy behaviors exhibited between NASA center and headquarters executives.

The study revealed that highly successful executives possess a foundation of technical knowledge in one or more disciplines. At the executive level, breadth of knowledge across technical disciplines is a greater asset than depth of knowledge in a single discipline. As was the case for highly successful systems engineers, technical knowledge provides an essential footing, but the less definable skills in leadership, communication, problem solving and systems thinking set these individuals apart. Attributes such as being curious, inquisitive, patient and organized are also potential indicators of success.

Executive presence is an essential part of leadership at the executive level. For example, participating executives display self-confidence and courage in dealing with difficult issues, and remain calm under pressure. Aware of how their personal presence and behavior impact others, they take steps to create safe, open environments.

Political savvy and strategic thinking also become critical. NASA's highly effective executives know how the political system works—who makes decisions, when, and what they need. They have political staying power and are able to maintain momentum over multiple years and administrations. Highly effective executives maintain an agency-wide view, keeping the big picture in mind, and manage both mid- and long-term goals. They build formal and informal networks to validate and get additional information, and to make necessary connections among organizations and individuals to accomplish goals.

The study yielded valuable information regarding NASA leadership behaviors, and will serve as a basis for further investigation. Future explorations could benefit from: a) having a larger and broader sample, b) more hours of observation, c) possible inclusion of women and minorities, and d) interviews with other personnel in an executive's inner circle.

Executive Leadership at NASA: A Behavioral Framework provides a basis for individual and organizational action. On an individual level, employees can use the findings to help build and structure their career choices and developmental options. An awareness of the behaviors and attributes of highly successful executives will allow technical managers

and their coaches and mentors to make more effective choices in building their development strategy.

On a discipline level, this study provides the Office of the Chief Engineer with a specific, behavioral framework that will allow it to create learning approaches and strategies that strengthen executive development across the agency and build more targeted programs and policies to support mission success.

Since the behaviors and attributes of highly successful executives are consistent with those of highly regarded systems engineers, the behaviors prescribed for technical managers do not need to be unlearned in order to transition successfully to the executive level; rather, employees can build upon those foundational skills.

Successful executive behaviors are mainly relational—they are broad integrative thinking competencies that can be practiced, learned and developed at any level at NASA, given the right experience and exposure. Care should be taken to avoid designating certain behaviors as exclusive for leaders or executives in a way that delays their introduction into the training and development curriculum.

NASA's environment is constantly in flux. Complexity is increasing, and the agency's needs and vision are changing. There are more multi-center and multi-organizational (federal agencies, industry, academia, and international partners) programs, a growing need to keep up with technical advancements, and needs for greater creativity and innovation and improved performance. Social norms are shifting as well. NASA increasingly has less hierarchy in its organizational structures, more participative leadership, greater individual responsibility, and more utilization of a virtual work environment. The next generation of executives will need to address these challenges and more.

To meet NASA's future needs for executive leadership it essential that we begin the immediate development of behaviors and attributes that are critical to their success.

6.0 Next Steps

This study's findings provide a firm direction to plan learning and development activities that help NASA's high-performing technical managers successfully transition to and operate in executive roles. These findings will allow NASA to introduce targeted training and development and experiential opportunities prior to placing individuals in these critical roles, thus enabling them to develop the necessary skills over the course of their careers. The themes, elements, and representative observable behaviors provide concrete realistic examples for employees as they design their Individual Development Plans, which include hands-on learning activities, coaching and mentoring opportunities, training, formal training and knowledge sharing programs and materials.

The Academy of Program/Project & Engineering Leadership (APPEL) will:

- Evaluate NASA curriculum offerings for technical managers and executives against this study and determine how these findings can be leveraged to enhance this learning.
- Update the Systems Engineering Leadership Development Program (SELDP) design, particularly in the areas of communication, executive presence and strategy. Update SELDP selection criteria to be inclusive of additional behaviors reflected in this study.
- Review systems engineering (SE) and program and project management (PPM) curricula to assess where program offerings can be enhanced and updated.
- Seek outside speakers and benchmarks that reflect behaviors and qualities reflected in the study. Purposefully focus on these behaviors and attributes as central to the learning process.
- Add enhanced focused learning, knowledge sharing, and career development materials and activities that address how individuals can learn and develop themselves in these areas.
- Train coaches and mentors in enabling the development of these critical areas.

In addition, OCE will share these study findings widely both inside and outside of NASA. Conference briefings and articles are being developed, and this report will be posted on the NASA Engineering Network.

7.0 Acknowledgements

Many people have contributed to the success of the study and deserve recognition, including the executives who participated in this study and the team members who dedicated themselves to advancing the understanding of the “art of systems engineering.”

In addition, this study would not have been possible without the support from the following people:

Michael Griffin	NASA Administrator
Mike Ryschkewitsch	NASA Chief Engineer
Gregory Robinson	NASA Deputy Chief Engineer
Ross Jones	JPL, NASA Systems Engineering Working Group
Edward Hoffman	Director, NASA Academy of Program/Project & Engineering Leadership (APPEL)
Steve Kapurch	Systems Engineering Program Executive Officer, NASA Office of the Chief Engineer, and Chair, NASA Systems Engineering Working Group
John Blowers	JPL Professional Development Section Group
Nichole Pinkney	GSFC, Training Officer and Chief of the Talent Cultivation Office (TCO/114)
Victoria Person	GSFC, TCO Team Lead
Matt Kohut	Communications Team, NASA Academy of Program/Project & Engineering Leadership (APPEL)

8.0 Appendices

8.1 Appendix 1. Executive Interviewees

Table 10 – Names of NASA Executives Interviewed at Each NASA Center

Center*	Interviewees	Current Position
GSFC	Rick Obenschain	Center Director, Goddard Space Flight Center
	George Morrow	Director, Flight Projects, Goddard Space Flight Center
HQ	Mike Griffin	Former NASA Administrator. Currently Eminent Scholar and Professor Mechanical and Aerospace Engineering University of Alabama Huntsville
	Chris Scolese	NASA Associate Administrator
	Mike Ryschkewitsch	NASA Chief Engineer
	William Gerstenmaier	NASA Associate Administrator for Space Operations
JPL	Brian Muirhead	Constellation Program Chief Architect Chief, Systems Engineering & Integration Design Integration Office
JSC	Mark Geyer	Program Manager, Orion Manager, Johnson Space Center
	Michael Suffredini	Program Manager, International Space Station, Johnson Space Center
LaRC	Stephen Jurczyk	Deputy Director, Langley Research Center
	Ralph Roe	NASA Engineering and Safety Center, Langley Research Center
MSFC	Steve Cook	Manager, Ares Project Office, Marshall Space Flight Center
	Daniel Dumbacher	Director, Engineering, Marshall Space Flight Center
Retired	John Muratore	Retired from NASA. Currently Associate Professor Aviation Systems and Flight Research Program, University of Tennessee Space Institute.

* Center Acronyms in Table 10.

GSFC Goddard Space Flight Center
 JPL Jet Propulsion Laboratory
 JSC Johnson Space Center
 LaRC Langley Research Center
 HQ NASA Headquarters
 MSFC Marshall Space Flight Center