A Behavioral Framework for Developing Highly Effective Technical Executives

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Abstract

Purpose – This paper provides a deeper understanding of the behaviors effective technical managers executives use to lead complex projects, programs and organizations.

Design/methodology/approach – The paper describes a qualitative study to identify and document behaviors and attributes of effective technical executives at NASA. Study methods included observation, shadowing and interviews with 14 NASA executives, who possessed a technical background and a systems orientation, and whom Agency leadership identified as highly effective in their roles. Included also is a review of related theoretical and empirical scholarship on leadership and managerial effectiveness, focusing on research describing leaders' behaviors and competencies and approaches to deal with project and organizational complexity.

Findings – The study surfaced 225 observable behaviors clustered into 54 elements, within six broad themes: leadership, attitudes and attributes (including executive presence), communication, problem solving and systems thinking, political savvy and strategic thinking.

Research limitations/implications – This study included a small number (14) of executives from one organization who were interviewed once and observed for a short amount of time. Moreover, categorization of findings was difficult due to differing researcher perspectives. Future studies might include more executives, from a variety of organizations, and/or employ a quantitative approach based on or incorporating these findings.

Practical implications – The study's rich data will serve as a basis to develop technical executives where complexity and technology drive the need for systems-oriented leaders with technical backgrounds

Originality/value – The study and literature review provide a context for a deeper understanding of technical leaders' behaviors and use of systems thinking within complex situations.

Keywords Technical executives, Management effectiveness, Competencies, Complexity, Systems thinking, Senior management

Paper type Research paper

Introduction

United States' National Aeronautics and Space Administration (NASA) has a broad and compelling mission--to pioneer the future in space exploration, scientific discovery and aeronautics research (2010). To accomplish this mission NASA pushes the edges of science, develops unique software, hardware, machinery and vehicles and executes multi-million dollar projects that last years and even decades. In addition, the recently enacted National Aeronautics and Space Administration Authorization Act directed NASA to extend International Space Station operations through 2020, foster a growing commercial space transportation industry, start work on heavy-lift architecture, develop a multipurpose crew vehicle, continue to invest in green aviation, and, finally, to continue to collaborate with international partners, industry, and academia to build and launch observatories and robotic missions (Weaver, 2010). NASA Administrator Charles

Bolden has cited the importance of NASA's people to achieving this mission noting their "hard work and continued professional excellence," and that they "will continue to be our most vital resource as we implement these plans" (Weaver, 2010). To meet current and future challenges NASA has engendered a renewed focus on workforce requirements, learning needs and development strategies, particularly in the areas of technical leadership development, knowledge sharing, and curriculum development.

In this paper we describe an inquiry that is part of an evolving research effort with multiple studies to identify the behaviors of NASA's highly effective technical managers and executives, who lead and sustain organizational success to achieve NASA's mission. The studies' purposes have been to develop shared understanding and agreement across NASA regarding the practice of systems engineering, a core competency critical to NASA's success. The first study the *NASA Systems Engineering Behavior Study* (Williams and Derro, 2008) identified behaviors and attributes that enable highly regarded technical managers, who were practicing systems engineers. The second study, discussed here, *Executive Leadership at NASA: A Behavioral Framework* (Williams, et al., 2010) focused on those of successful technical executives, including current or previous program and project managers. Methods for both these behavior studies were qualitative and included interviews, observation and shadowing. At this time we are working on a third quantitative, study (in progress) that includes managers and executives from NASA and elsewhere in the aerospace industry to validate the six thematic categories established in *Executive Leadership at NASA*.

According to Williams et al. (2010, p. 3), *Executive Leadership at NASA: A Behavioral Framework,* described here, was guided by the central question, "What are the behaviors and attributes that enable individuals to become successful executives at NASA?" We provide details on the study's approach, execution, results, conclusions, and implications. We relate findings to others' research on critical executive characteristics in technical organizations, including an exploration of managers' and executives' use of systems thinking to address complex problems. The paper's purpose is not only to share results, but also to participate in a broader dialogue on effective technical executives' capabilities.

Initiation and Goals

NASA's Chief Engineer initiated the initial study, the *NASA Systems Engineering Behavior Study* (Williams and Derro, 2008), in March 2008. Its goals were to identify critical behaviors for success and to accelerate development of systems engineers. The focus was on NASA civil servants currently working as systems engineers, whom NASA leadership considered as "go to" people in systems engineering. When this first study was initiated, it was recognized that many of NASA's "best" systems engineers were actually no longer in active systems engineering positions, but had been promoted to executive positions. Because the two positions have substantially different responsibilities, the

NASA Administrator agreed that it was necessary to conduct two separate studies; one with active systems engineers and one with technical executives who once were systems engineers or who had a technical background and a systems engineering orientation.

Thus, from June 2008 to March 2009, NASA's Office of the Chief Engineer conducted the study, *Executive Leadership at NASA: A Behavioral Framework*, with 14 NASA executives, who possessed a technical background and a systems orientation, and whom Agency leadership identified as highly effective in their roles. Methods mirrored those used in the study of behaviors of highly regarded systems engineers (Williams and Derro, 2008) and an earlier investigation at the Jet Propulsion Laboratory (JPL) (Derro, 2008).

Contribution

This continuing research effort is rooted in observations of and interviews with practitioners (Williams and Derro, 2008; Williams et al., 2010). As Williams et al. noted the focus has been on effective technical managers' and executives' behaviors. It includes a literature review to determine what might be learned from theoretical or empirical scholarship to help understand or interpret observational studies' findings. This encompassed an exploration of research on managerial/leadership competencies and effectiveness, the roles of technical executives and managers, including systems engineers and project and program managers, and the relationships between complexity, decision-making, and problem solving/systems thinking.

NASA's executives have broad integrative functions. They are responsible for guiding complex, multi-year, global, billion dollar programs and overseeing projects through all phases of the lifecycle, within time, budget and design constraints. Study findings are being incorporated at NASA to provide NASA project managers and systems engineers with learning experiences and career development opportunities to transition into technical executive roles. Study findings may also be useful beyond NASA, especially where complexity and technology drive the need for systems-oriented leaders with technical backgrounds.

NASA's efforts can be viewed as part of the ongoing efforts of organizations to identify the knowledge, skills and behaviors that lead to managerial effectiveness and as a contribution to that dialogue. Managerial effectiveness, according to Hamlin (2002, p.246) is the "relationship between what a manager (leader) achieves (performance) and what he/she is expected to achieve (aims/purposes/goals) within the constraints imposed by the organization and socio economic environment." Hamlin noted that while a number of studies had explored leadership and management behavior a majority had focused on the amount of time devoted to particular activities or their frequency. In contrast, NASA's study hones in on identifying those behaviors that drive effective leadership at NASA – mission success.

The study's focus on technical leaders highlights the impact of complexity on projects and organizations and surfaces the need to further investigate the role of systems thinking in engineering, program and project management and organizational leadership. Interestingly, *Executive Leadership at NASA* (Williams et al., 2010) identified 58 (25%) specific behaviors as related to problem solving/systems thinking. Additional behaviors illustrative of systems thinking might also be clustered under other themes (e.g. leadership, communications, and political savvy).

Skills and Competencies Related to Managerial/Leadership Effectiveness

Table 1 posits five approaches to explore leadership based on a comprehensive review of empirical and theoretical leadership scholarship by Bear et al. (2005) (Morris, 2010).

Table 1

Five Approaches for Viewing Leadership

Category	Description	Representative Theorists
Approaches Based on Psychology and Biology	Personal characteristics provide unique qualifications for person's ascendancy or success. Focus is on, for example, traits such as vision, confidence, charisma, and openness to learning.	Carlyle, Bennis & Nanus, Kouzes & Posner, Maxwell, Collins, Gardner, Goleman
Approaches Based on Sociology	Includes looking at the group or culture a leader influences, the relationships between leader and follower, informal networks and relational leaders.	Burns, Greenleaf, Block, Covey, Kouzes & Posner, Pearce, Mohrman, & Cohen
Approaches Based on Balancing People and Tasks	Distinguishes between leadership behavior and interaction; identifies leadership continua with situational approaches; examines match between leaders and followers or concern for production and concern for people. Examples include Path-Goal Theory and Normative Decision Theory.	Tannebaum & Schmidt, Fiedler, Hersey & Blanchard, Blake & Mouton. Albano
Approaches Based on Skills and Competencies	Focus is on leadership competencies, knowledge, and skills and on examining differences among leadership levels; reinforced by legal requirements for job analysis and validated selection criteria. Relates ideas of leadership competency and organizational strategy; highlights need to maintain organizational knowledge.	Herzberg, Mausner, Snyderman, Prahalad & Hamel, Weick,
Approaches Based on Complexity	Focus is on ability to understand complex systems and execute organizational change. Emphasizes the organizational life cycle to demonstrate how leadership requirements shift, to diagnose critical business issues and to effectively balance internal and external requirements and interdependencies.	Kotter, Lippitt & Schmidt, Adizes, Lippit, Senge

Source: Morris, L. (2010, p.127), "Transcending the local: Identifying effective technical executives' leadership behaviors and attributes for the global knowledge era", *Proceedings of the 2010 CIAE Pre-Conference*, American Association for Adult & Continuing Education, Annapolis, MD, pp.125-133.

In determining to focus on identifying behaviors that enabled executive, that is, mission success, NASA leaders' approach was most related to Table 1's fourth category--Approaches Based on Skills and Competencies. Because of its focus on technical leadership in large multifaceted and difficult systems, the review also focused on understanding leadership roles in complex systems (category five).

Identifying Behaviors and Competencies for Success at Work

Identifying workplace behaviors, skills and competencies has been a long-standing approach toward understanding work in order to improve organizational performance and human resource processes (Bear et al., 2005; Hamlin, 2002; Partington et al., 2005). Partington et al. pointed to two different focuses, one on the work itself and one on the worker. They noted that work-oriented approaches, dating back to that of Frederick Taylor "start with the identification of work activities and then transform those activities into personal attributes" (Partington et al., 2005, p.88) and cite project management bodies of knowledge developed by the UK's Association for Project Management and the USA's Project Management Institute as clear examples of work-oriented competence research. By making explicit required skills and knowledge, as well as outcomes and key performance indicators, work-oriented approaches and resulting competency frameworks provide valuable guidance for work content and for recruitment, training, appraisal, promotion and self-development (Mitchell and Boak, 2009; Partington et al., 2005). According to Partington et al., the main criticism of work-oriented approaches is that they do not specifically show the worker attributes that are required to effectively apply required knowledge or to efficiently accomplish identified activities.

On the other hand, worker-oriented approaches, such as that used in this study, focus on identifying behaviors, skills, competencies and abilities of competent workers (Hamlin, 2002; Partington et al., 2005; Lawrence et al., 2009), or as in this case, of effective executives. Klemp (2005) defined competencies as the knowledge, skills, and personal attributes that contribute to an individual's success in a particular job or business situation. Hamlin (2002), Hamlin and Barnett (2011) and Boyatzis (2009) provided in-depth reviews of worker-oriented research into management and leadership behaviors and competencies related to organizational performance. Hamlin (2002, p.45) defined effective management performance as "behavior which one would wish all managers to adopt if and when faced with similar circumstances." Boyatzis (2009, p.750) noted that a competency is a capability or ability "a set of related but different sets of behavior organized around an underlying construct called the 'intent,'" and that "behaviors are alternate manifestations of the intent, as appropriate in various situations or times." Partington et al. (2005) noted that results of worker-oriented descriptions of competence have been criticized as too generic and abstract to be useful in specific organizational contexts. This study focused on identifying behaviors within the context of systems-oriented leaders tackling complex problems.

Relational competencies/behaviors

In *Executive Leadership at NASA: A Behavioral Framework*, Williams et al. (2010) contended that the identified behaviors of highly effective NASA technical executives were mainly relational--an assertion that Boyatzis (2009) might agree with. In a *Journal of Management Development* special issue he laid a theoretical groundwork for understanding competencies as a behavioral approach to emotional and social intelligence. Citing his and others' earlier work, he contended that competencies were abilities or capabilities and were related but different sets of behaviors clustered around an underlying construct called an intent, for which the behaviors are alternate manifestations, as appropriate in various situations or times. He posited three clusters of competencies that differentiate outstanding from average performers in many countries of the world (Boyatzis, 2009, p. 754):

1. Cognitive competencies, such as systems thinking and pattern recognition.
2. Emotional intelligence competencies, including self-awareness and self-management competencies, such as emotional self-awareness and emotional self-control.
3. Social intelligence competencies, including social awareness and relationship management competencies, such as empathy and teamwork.

While the executive behavior study team did not use Boyatzis' framework or directly address behavioral intent, the themes and elements identified included behaviors related to all three sets of competencies Boyatzis identified. Additionally, the elements that the behaviors cluster around seem analogous to the intent that Boyatzis described.

Global/international competencies

NASA has a global focus. Thus, an important step in NASA's use of study findings is sharing them with other space agencies and technical organizations. Another is continuing research to provide a basis for dialogue around such questions as: Do highly effective executives in other space agencies/organizations exhibit similar behaviors? Are some specific only to effectiveness at NASA? Might some of the behaviors be effective within NASA, but ineffective in the international arena or for other technical executives?

Some *Executive Leadership at NASA* results (Williams et al., 2010) echo findings from an international study of 1,653 managers from a cross-section of functions conducted by the American Management Association and the Human Resource Institute, *Leading Into The Future: A Global Study Of Leadership: 2005-2015* (Bear et al., 2005). Strategy development and communication skills, two of the executive behavior study's six themes, led the list of competencies viewed as important, in 2005, and expected to still be important in 2015. In addition, authors noted that their research showed that "despite some interesting differences—the competencies required of leaders are fairly consistent around the world and in all sizes of organizations" (Bear et al., 2005, p.44).

In another study, Tucker et al. (2004) assessed intercultural adjustment and, separately, actual job performance, and examined the relationship between the two. They noted that,

> As indicated by the strongest predictive correlations found, those who adjust well to other cultures emerge as having high expectations about the assignment beforehand, are open-minded, are tolerant to different conditions, have an internal locus of control, are flexible, show interest in other people, and are socially adaptable, have high initiative, are risk takers and have a sense of humor. (Tucker et al., 2004, p.247)

These ten factors align with many of the 54 elements identified in *Executive Leadership at NASA* (Williams et al., 2010) including: (a) remains open-minded and objective, (b) considers all options before deciding, (c) accepts change and is resilient, (d) aware of self and values, (e) develops self, (f) manages at the appropriate level, (g) creates organizational structure, (h) encourages participation, (i) builds relationships through interaction, (j) links people, organizations, and ideas, (k) acts decisively, (l) identifies, assesses, and manages risk, and (m) uses humor.

Cross-Cultural Competencies

Spencer and Spencer (as cited in Boyatzis, 2009, p. 761) and Boyatzis (2009) noted that the same competencies appeared regardless of culture and country. Boyatzis explained that this occurred because the competency or behavioral approach to emotional and social intelligence is derived inductively from performance. He went on to point out that the same competencies appeared regardless of culture and country in the set of articles included with his in the *Journal of Management Development* special issue (*Volume 28*, No. 9, 2009). Recognizing that some competencies showed more predictive power than others, he noted the need for further research to determine whether these were cultural differences emerging or the function of specific organizational samples. While also calling for more research to test the universality of competencies, he claimed, “The growing body of research on EI (Emotional Intelligence) would support the notion of the relationship to performance as universal” (Boyatzis, 2009, p 62).

Indeed, the articles Boyatzis referred to provided very similar perspectives on managerial and executive competencies of British naval offices, European managers and executives and Italian managers and leaders (Young and Dulewicz, 2009; Ryan et al., 2009; Boyatzis and Ratti, 2009). Perhaps most pertinent to *Executive Leadership at NASA* (Williams et al., 2010) were findings on competencies of 61 executives in the Italian division of a large multinational firm (Boyatzis and Ratti, 2009). Outstanding executives showed more of the following competencies than average executives: efficiency orientation, initiative, self-confidence, networking, oral communications, persuasiveness, systems thinking, and pattern recognition. Interestingly, all except “efficiency orientation” were behaviors that also emerged from the executive behavior study.

Technical Leaders Bring Experience in Dealing with Complexity

Technical Managers and Executives

Carnevale, Gainer and Schulz (1990, p.3) defined technical workers, including technical professionals (e.g. doctors, scientists and engineers) as those who "use theoretical principles from mathematics or the natural sciences in their work." They noted that, "technical professionals were among the most highly educated of America's professionals" and educated and trained "to make broad judgments, to invent and to apply a particular discipline to problem solving" (Carnevale, Gainer and Schulz, 1990, p.7). Maxwell (1989), focusing on the engineering profession, listed three criteria for technical managers: technical competence, time with the company or past experience and having a bachelor's degree in science or engineering.

The concept of the technical manager or executive is not new. Maxwell (1989) referred to Henry Robinson Towne's seminal paper in the 1886 *Transactions of the Society of Mechanical Engineers, Volume 7*. Towne urged the American Society of Mechanical Engineers to support development of engineering management. He wrote,

> There are many good mechanical engineers; —there are also many good " business men;"—but the two are rarely combined in one person. But this combination of qualities, together…. is essential to the successful management of industrial works, and has its highest effectiveness if united in one person, who is thus qualified to supervise…. the operations of all departments of a business, and to subordinate each to the harmonious development of the whole. (Cited in Martin, 2010, paragraph 2.)

Increasing Complexity Leading to a Systems Perspective

Among many things that have changed since Towne's era is the nature of the programs engineers and program and project managers work on and lead. These are becoming more *complicated* (on larger scales, with a multitude of moving parts or highly dynamic actors, that constantly interact with one another and behave primarily in a linear fashion) and *complex* (non-linear, comprised of multiple, interrelated elements that interact unpredictably) (Berteau et al., 2009, p.3). According to Berteau et al., complex programs are characterized by nonlinear feedback loops and recursiveness, inhibit planning in their emergent phase, and cannot be deconstructed to their constituent elements. Moreover,

> It is a fundamental characteristic of complex systems that the interplay of the various elements brings unique additional capability. Reducing the complexity of a proposed system could mean foregoing the capability it offers. (Berteau et al., 2009, p. 4

Cavaleri and Reed (2008) argued that more than half of all major projects may be dynamically complex and contended that such projects can be more effectively controlled by using a combination of approaches that form the basis to a new approach to project management, an approach “based on principles established in foundational areas, such as system dynamics, leadership, systems thinking, leadership, action learning, pragmatism, and knowledge leadership.” Kapsali (2011), who analyzed 12 projects in two publicly funded EU innovation deployment programs, advocated that systems thinking constructs corresponding to operational flexibility and boundary management (such as causal embeddedness and equifinality) be embedded into conventional project management methods.

At NASA technical managers and executives are responsible for executing large, complex projects and programs, which last for years and even decades. In addition, according to NASA Associate Administrator Christopher Scolese, the majority of NASA’s projects are unique one-of-a-kind efforts (comments at the NASA Project Management Challenge, 8 and 9 February 2011). Such complex projects and programs require *systems thinking* (Watt and Willey, 2006; Hanson, 2007; Richmond, 1993; and Boardman et al., 2009). Boardman, et al. (2009, p.3299) defined systems engineering as a “body of knowledge, both principled and pragmatic, that serves systems professionals, irrespective of domain, in conducting analysis, synthesis and inquiry into identified ‘systems of interest. ”

Engineered systems’ complexity continues to increase, introduced through advancements in technology and the logistics required to design and field systems (Lamb and Rhodes, 2008). Q. Dong (1999) (as cited in Lamb and Rhodes, 2008) reported that with complexity increases, an ever-smaller fraction of the design knowledge is documented. He indicated that 85% of the design knowledge is documented for a basic system component but that only 30% of a simple system's design knowledge is documented, with the remaining 70% being tacit knowledge encapsulated in the experiences of the designers. Jansma and Jones (2006) (as cited by Lamb and Rhodes, 2008) have pointed out that the ability to recall and apply this knowledge to solve design problems is an application of systems thinking. Lamb and Rhodes contended that as systems complexity increases, systems thinking is more important as a means to solve and avoid design problems and that the base of knowledge and experience required also grows. They advocated a move towards exploring systems thinking as a team-based property. Another perspective might be to view technical managerial and executive experience as increasingly vital to an organization’s top tier of leaders.

Systems Thinking and Executive Success

Many consider systems thinking a key component of effective executive behavior and leadership (Boyatzis, 2009; Boyatzis and Ratti, 2009; Senge, 2004; Richmond, 1993;

Hanson, 2007). Brousseau et al. (2006) demonstrated a decisive shift in leading and thinking styles towards integrative thinking (among 180,000 people) as individuals moved towards senior executive levels. Partington et al. (2005, p.87) noted that program managers require a "subtle blend of interpersonal skills and personal credibility, a deep understanding of the political dynamics of the formal and informal networks that form the organizational context," and a great knowledge of the broader strategic context that is "subtler, deeper, and greater" than that of project managers. Shireman (1999) described actions of Bill Coors of Coors Brewing, Gordon Moore of Intel and Tiuchi Kibushi of Hitachi, that illustrated executives viewing businesses as living systems, uniting business and environmental interests and developing innovations such as recyclable packaging (Coors) and the silicon chip (Intel), which brought profits while maintaining sustainability.

Richmond (1993) proposed a set of critical thinking skills to apply systems dynamics and thinking to address global problems. Rebovich (2008), Wojcik and Hoffman (2006) and Mansouri and Mostashari (2010) have espoused using a systemic approach to organizational governance within the context of Systems of Systems Engineering. Within organizations systems thinking principles have been applied to solving complex problems (Lamb and Rhodes, 2008; Middleton, 2010; Ackoff, 2010), improving the ethical climate (Roth, 2002) and reviving a failing safety program (Pierce, 2002). Building on Richmond's operational framework (1993) Maani and Maharaj (2004) found that three systems thinking skills - forest, closed loop and operational thinking- contributed more to the *understanding* of the system and therefore play a greater role in performance. They found that better performers attempted to get an understanding of the system's structure first, develop strategies next and then determine actions. Skarzauskiene', (2010) proposed a systems approach for organizations, a conceptual model of the relationship between cognitive intelligence competencies (such as systems thinking) and organization performance and presented empirical evidence that systems thinking was associated with higher organization performance.

While some have presented evidence of the value of systems thinking to organizations and their leaders, the abundance of different perspectives in these emerging fields makes cross study comparisons difficult (Lamb and Rhodes, 2008). Also, as Maani and Maharaj noted, translating systems thinking measurable elements has remained a research challenge. They cited Richmond's set of systems thinking skills, proposed in 1993 and added to in 1997 as the " sole 'operational guide'" (Maani and Maharaj, 2004, p. 22) See Table 3 for Lamb and Rhodes' compilation of definitions. They noted that though definitions differed, the common themes of complexity, interrelationships, context dependency, emergent behavior, and holism repeated throughout them. The identified themes may be useful in understanding findings across studies.

Table 3

Definitions of Systems Thinking

Definition	Theorist/ Source
A framework for systems with four basic ideas: emergence, hierarchy, communication and control. Human activity concerns all four elements. Natural and designed systems are dominated by emergence	Checkland, 1999
A method of placing the system in its context and observing its role within the Whole.	Gharajedagjhi, 1999
A skill to see the world as a complex system and understanding its interconnectedness.	Sterman, 2000
A skill of thinking in terms of holism rather than reductionism.	Ackoff, 2004
A method and framework for describing and understanding the interrelationships and forces that shape human behavior.	Senge, 2006

Source: Based on information presented in Lamb and Rhodes (2008, p.2).

Boardman et al. (2009) noted that General Systems Theory was meant to be a unifying theory, bringing together ideas associated with specific systems of interest from many disciplines and then evolving into a set of unified theorems. However as Figure 1 illustrates, “What has evolved is a collection of separate practices by which systems in their particular domain, e.g. engineering, social science, and life science, are better understood and manipulated for improved performance” (Boardman et al., 2009, p.3299).

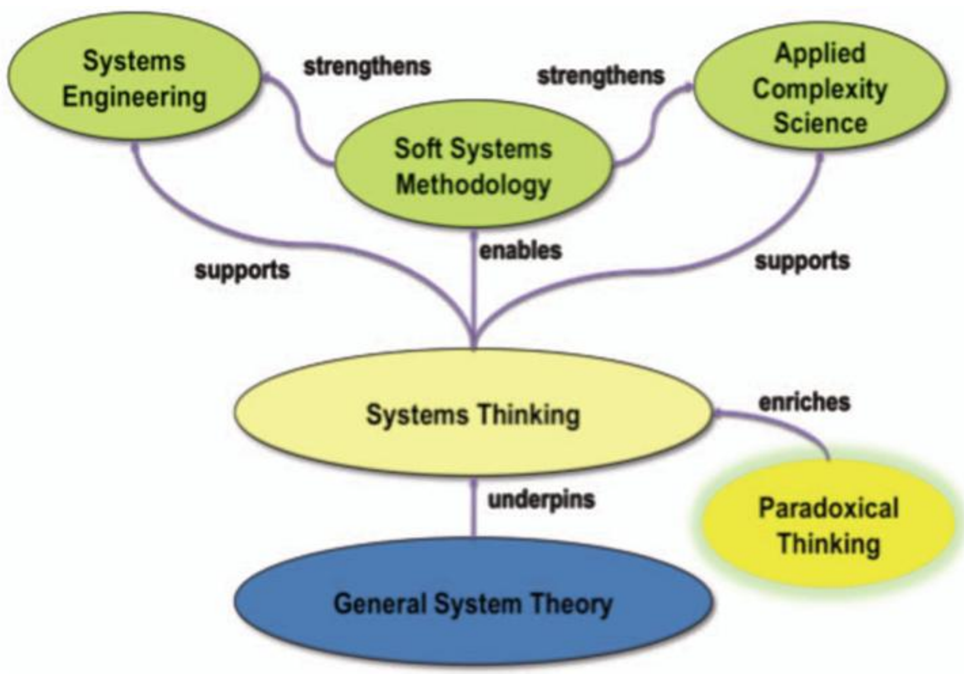

Figure 1. A Systems Roadmap

Source: Boardman et al., 2009, p.3299. Reprinted with permission.

Method

Participants

NASA leaders selected 14 "highly successful" NASA "technical executives" to participate in this study (Williams et al., 2010). Most were from NASA's systems engineering community; others had different backgrounds (e.g., project management). All had a systems orientation[1] 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.

Data Gathering and Analysis

Study team members, with organizational development and/ or learning and development education and experience conducted 60- 90- minute interviews with each executive (Williams et al., 2010). They asked participants identical questions approved by NASA's Chief Engineer, with follow-up questions based on initial answers. See Table 2 for interview questions on context and on relation to self and personal awareness.

Table 2

Executive interview questions

Context Questions	
1.	How would you describe the role of an SE executive
Relation to Self and Personal Awareness	
2.	Describe top performing executive SE's in behavioral terms?
3.	Think of a top performing SE executive whom 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 whom 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?

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

In addition, one or more of the study team members shadowed and/or observed each executive participant (Williams et al., 2010**).** The shadowing process included a minimum of one day observing executives perform their day-to-day activities. Study team members also attended meetings and events that executives were either leading or participating in. 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.

The study team transcribed interviews and listed observable behaviors (Williams et al., 2010). Working individually and together, in a series of meetings the team organized the data and analyzed results. The team discerned common themes, identified elements of each theme and associated representative observable behaviors and attributes. Behaviors had to be heard or observed at least once by all three study members to be included in the analysis. The Chief Engineer then sent draft results to interviewees for validation and verification and the study team addressed a few participants' comments to clarify meaning.

Limitations

The team noted four limitations in study methods employed. However, given the consistency of observations and results from personnel across NASA, these were not seen as critical issues. First, observation time with executives was limited and observers were unable to see how all executives behaved in all relevant work situations. This limited observation time may have caused some observers to not see a behavior that other observers noted. This was important because only behaviors noted by all three observers were included in the final report, and, therefore, critical executive behaviors may not have been included. Second, language in describing behaviors across the three observers was found to be inconsistent. Extensive discussion was required to ensure that the behaviors observed were indeed the same and that the way the behavior was described, in the study actually reflected the specific action. Third, this was an internal study conducted by NASA employees and contractors. The study team acknowledged that they viewed what they saw through the internal lens. External observers may have seen and described what they saw differently. Fourth, the sample size for this study was small (14) due to the limited number of top technical executives performing at this level in NASA.

On the other hand, the selected participants were considered highly effective executives or exemplars by NASA senior management. In addition, participants who reviewed the findings strongly concurred with them and NASA has begun to implement study recommendations

Implications of findings on technical leadership at NASA are meaningful. Leaders with technical knowledge and ability to problem solve and create with others in ever increasing complex systems are crucial to the future of any organization. This study defines specific, proven behaviors that are able to be developed and will enable NASA to improve overall performance by improving executive effectiveness. Hopefully study results and ensuing additional research will be valuable to other organizations as well.

Findings

Overview

The behaviors and attributes exhibited by the 14 participating highly effective NASA executives fell into six broad themes (Williams et al., 2010): leadership, attitudes and attributes (including executive presence), communication, strategic thinking, political savvy and problem solving and systems thinking. 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 communication and political savvy. Within the six themes, the team identified a total of 54 separate elements and 225 representative/ observable behaviors and attributes (Morris, 2010).

The themes, sub-theme and elements, and observable behaviors and attributes provide a broad perspective on the behaviors and attributes of highly effective NASA executives for those who wish to transition to these roles or develop within them (Williams et al., 2010). Findings may also be useful in identifying behaviors that bring success to technical executives in other settings. Figure 2 presents a graphic view of findings.

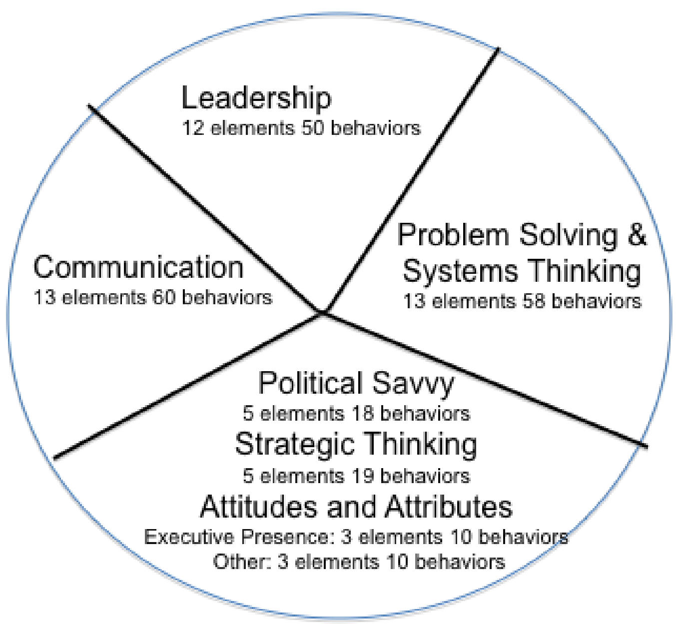

Figure 2. Highly Successful NASA Executives Share a Set of Common Behaviors.

See *Executive Leadership at NASA: A Behavioral Framework* (Williams et al., 2010) for narrative descriptions of each theme (pp. 7-9) and Tables 4-9 (pp. 11-21) for a comprehensive view of themes, elements, behaviors and attributes. Highlights follow (Williams et al., 2010; Morris, 2010).

Leadership. Twelve leadership elements and 50 observable behaviors illustrated that highly effective NASA executives focused on the organization and its people. Elements included: (*a) creates organizational structures to support mission success, (b) gauges resources needed to achieve mission objectives, (c) manages at the appropriate level, (d) accepts change and are resilient* and (*e) acts decisively*. Working with others, an effective executive *(f) inspires and motivates team members to perform at peak performance, (g) builds trust and respects confidentiality, (h) builds employee capabilities*, and (*i) reduces workplace distractions (*for employees). Such an executive is (*j) aware of self and values, (k) develops self*, and (*l) lets go of current role to prepare for new one.*

Attitudes and Attributes. Six elements and 20 representative observable behaviors comprised the attitude and attributes theme. While three elements were more general: *(a) remains inquisitive and curious, (b) is patient,* and (c) *is organized*, the other three clustered in a sub-theme, "executive presence." These included: (*d) displays self-confidence and courage, (e) remains calm under pressure,* and *(f) aware of how personal presence and behavior affects others.*

Communication. The greatest number of representative behaviors (60, with 6 behaviors observed only in Headquarters personnel) appeared within the 13 elements of the communication theme. Many seemed to relate to highly effective executives' mastery of communication. Included were*: (a) communicates throughout the organization, (b) tailors messages, (c) strives for clarity, (d) assesses context, (e) uses humor, (f) practices effective speaking and listening skills*, and *(g) communicates through storytelling and analogies.* Other elements seemed connected to executives communicating strategically and collaboratively: *(h) links people, organizations and ideas, (i) encourages participation, (j) seeks expert opinion, (k) builds consensus, (l) builds relationships through interaction,* and *(m) demonstrates accessibility.*

Problem Solving and Systems Thinking. The problem solving and systems thinking theme, also with 13 elements, included the second highest number of representative behaviors (58). Two of the elements dealt with ways of thinking: *(a) uses systems perspective and (b) thinks systemically*. Others focused on specific actions: *(c) identifies and defines core issues/problems, (d) actively probes for information and understanding, (e) finds connections and patterns across systems, (f) assimilates, analyzes and* *synthesizes data and information, (g) validates facts, information and assumptions, (h) considers all options before deciding,* and *(i) identifies, assesses and manages risks.* Also included were: (*j) acknowledges and manages uncertainty, (k) remains open-minded and objective, (l) uses creativity to solve problems,* and *(m*) *draws on past experience.*

Political Savvy. The political savvy theme included 5 elements: *(a) knows how the political system works, (b) has political staying power, (c) represents/ promotes NASA programs across the political spectrum, (d) manages multiple demands/opportunities*, and *(e) provides a historical perspective.* Four of the related 19 observed behaviors and attributes were observed only in Headquarters personnel.

Strategic Thinking. The 5 elements incorporated in the strategic thinking theme, which contained 19 related behaviors, were: *(a) maintains an agency-wide view, (b) manages near- and long-term goals, (c) understands broad implications of activities at multiple levels, (d) monitors the environments,* and *(e) uses networks.*

Discussion

The 14 NASA executives interviewed and observed for NASA's executive behavior study exhibited a common set of specific observable behaviors and attributes that were considered instrumental to their success (Williams et al., 2010*).* Four of the six thematic categories—leadership, attitudes and attributes, communication, and problem solving and systems thinking—were among the five top themes identified in the 2008 *NASA Systems Engineering Behavior Study* (Williams and Derro, 2008). In this study executive presence emerged as a sub-category within attributes and attributes, while technical acumen fell out. 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 team posited that because many identified behaviors were consistent with those of highly regarded systems engineers, who were technical managers, employees could build upon those foundational skills as they transitioned into executive roles (Williams et al., 2010). The team also contended that the behaviors are mainly relational, "broad integrative thinking competencies that can be practiced, learned and developed at any level at NASA, given the right experience and exposure " (Williams et al., 2010, p 23).

According to Williams et al. (2010), *Executive Leadership at NASA: A Behavioral Framework* provided a behavioral framework for technical managers seeking to transition into or to continue to grow in executive roles. NASA has used study results to enhance development of these critical behaviors via learning and development activities including classes, knowledge sharing, coaching and mentoring.

The study has also served as a basis for further investigation. NASA's Academy of Program, Project and Engineering Leadership (APPEL) is conducting a study to validate the six thematic categories in the findings and is continuing to explore related literature (e.g., on management/leadership effectiveness, problem solving/systems thinking and technical executives) to gain additional insight on study findings (in process). Participants in the validity study were technical managers and executives in the Aerospace Industry who were among those registered for an annual learning and knowledge-sharing event. They included national and international leaders who work in government, industry or academic settings. They completed a 55-item questionnaire based on the qualitative study noting the importance of the behaviors listed in the items as well as their current proficiency. Of more than 1,700 people registered for the event, 740 received invitations to participate in the study and when the study closed, 252 (34%) had done so.

Conclusion

In this paper we described the *Executive Leadership at NASA: A Behavioral Framework* (Williams et al, 2010) study that is part of a continuing research effort to identify the behaviors of NASA's highly effective technical managers and executives, who lead and sustain organizational success to achieve NASA's mission. We also reported the results of an investigation of theoretical and empirical scholarship. This study and literature review has provided evidence about the identified behaviors of effective executives and additional insight on the role of technical executives and the complexity of the problems they address. It has also highlighted executive and organizational uses of systems thinking, systems thinking concepts and recent studies providing empirical evidence of cognitive competencies' (including systems thinking's) relationship to organizational performance.

References

Ackoff, R. L., Addison, H. J. and Carey, A. (2010), *Systems Thinking for Curious Managers*, Triarchy Press, Axminster, Devon, UK.

Bear, D. J., Dennis, D. J., Forcade, J. W., Groe, G. M., Lippitt, M. B. and Vickers, M. R. (2005), *Leading into the Future -- A Global Study Of Leadership: 2005-2015*, American Management Association, New York, NY.

Berteau D., Ben-Ari, G. and Zlatnik, B. (2009), "Organizing for a complex world: The way ahead", Center for Strategic and International Studies, Washington, DC, available at: http://csis.org/publication/organizing-complex-world-way-ahead (accessed 23 February 2011).

Boardman, J., Sauser, B., John, L. and Edson, R. (2009), "The conceptagon: A framework for systems thinking and systems practice", *Systems, Man and Cybernetics, 2009, SMC 2009, IEEE International Conference on*, 11-14 Oct. 2009, pp.3299-3304.

Bourgault, J., Charih M., Maltais D. and Rouillard, L. (2006), " Hypotheses concerning the prevalence of competencies among government executives, according to three organizational variables", *Public Personnel Management*, Vol. 35 No.2, pp.89 -119.

Boyatzis, R. E. (2009), "Competencies as a behavioral approach to emotional intelligence", *Journal of Management Development*, Vol. 28 No. 9, pp.749-770.

Boyatzis, R. E. and Ratti, F. (2009)," Emotional, social and cognitive intelligence competencies distinguishing effective Italian managers and leaders in a private company and cooperatives", *Journal of Management Development*, Vol. 28 No. 9, pp. 821- 838.

Brousseau, K.R., Driver, M.J., Hourihan, G. and Larsson, R. (2006),"The seasoned executive's decision-making style", *Harvard Business Review*, Vol.8 No. 2, pp.111-121.

Carnevale, A.P., Gainer, L.J. and Schulz, E. R. (1990), *Training the technical workforce*, Jossey Bass, San Francisco.

Griffin, M. (2007), " System[s] engineering and the 'Two Cultures' of engineering", Boeing Lecture at Purdue University, 28 March, available at:

http://www.nasa.gov/pdf/173108main_mg_purdue_20070328.pdf (accessed on 24, August 2010).

Hamlin, R., G. (2002), "A study and comparative analysis of managerial and leadership effectiveness in the National Health Service: an empirical factor analytic study within an NHS Trust hospital", *Health Services Management Research,* Vol.15, pp. 245-253.

Hamlin, R., G. and Barnett, C. (2011), "In support of an emergent general taxonomy of perceived managerial and Leadership effectiveness: an empirical study from the UK independent schools sector", in *Proceedings of the 12th International Conference on Human Resource Development Research and Practice across Europe,* 25-27 May 2011, University of Gloucester, Cheltenham England, pp. 208-220.

Hanson, K. A. (2007), *Emerging elements* of *leadership in a complex system***:** *A cognitivist approach* (Doctoral Dissertation), available from Proquest database (UMI No. 3266726)(accessed 1 February 2011).

International Council on Systems Engineering (INCOSE) (2004), "What is systems engineering?*"* available at: www.INCOSE.org (accessed 10 February 2011).

Kapsali, M. (2011), Systems thinking in innovation project management: A match that works", *International Journal of Project Management,* Vol. 29, pp.396-407.

Klemp, G. (2005), "Getting competencies right", available at: http://www.cambriaconsulting.com/category/topic/competencies/ (accessed on 25 July 2011).

Lamb, C., T. and Rhodes, D.H. (2008), "Systems thinking as an emergent team property: Ongoing research into the enablers and barriers to team-level systems thinking", *Systems Conference, 2008, 2nd Annual IEEE,* 7-10 April 2008*, pp.1-7.*

Lawrence, K.A., Lenk P. and Quinn, R.E. (2009), "Behavioral complexity in leadership: The psychometric properties of a new instrument to measure behavioral repertoire", *The Leadership Quarterly,* Vol.20 No.2, pp. 87-102.

Maani, K. and Maharaj, V. (2004), "Links between systems thinking and complex decision making", *System Dynamics Review*, Vol. 20 No.1, pp. 21-48.

Mansouri, M. and Mostashari, M. (2010), "A systemic approach to governance in extended enterprise systems", *Systems Conference, 2010 4th Annual IEEE,* 5-8 April 2010, pp.311-316.

Martin, J. (2010), "The engineer as economist," Transcript of paper by Henry Towne in the 1886 *Transactions of the Society of Mechanical Engineers,* Vol. 7, available at: http://synfluent.wordpress.com/2010/10/16/ (accessed 15 February 2011).

Maxwell, G.C. (1989), "Training and development of the technical manager", *Aerospace and Electronics Conference, 1989. NAECON 1989, Proceedings of the IEEE 1989 National*, 22-26 May 1989, Vol. 2, pp.816-823.

Middleton, P., R. (2010), “What is systems engineering?” In P. Middleton (Ed.), *Delivering public services that work,* Vol. 1, pp. ix-xiii, Triarchy Press: Axminster, Devon, UK.

Mitchell, L. and Boak, G. (2009), “Developing competence frameworks in UK health systems: lessons from practice”, *Journal of European Industrial Training*, Vol. 33, No. 8/9, pp. 701-717.

Morris, L. (2010), “Transcending the local: Identifying effective technical executives’ leadership behaviors and attributes for the global knowledge era”, in *Proceedings of the 2010 CIAE (Commission on International Adult Education) Pre-Conference*, American Association for Adult & Continuing Education, Annapolis MD, pp.125-133.

National Aeronautics and Space Administration (2010), “*About NASA”,* available at: http://www.nasa.gov/about/highlights/what_does_nasa_do.html (accessed 23 October, 2010).

Partington, D., Pellegrinelli, S. and Young, M. (2005), “Attributes and levels of programme management competence: an interpretive study”, *International Journal of Project Management,* Vol. 23, pp.87-95.

Lawrence, K., Lenk P. and Quinn, R. (2009), “Behavioral complexity in leadership: The psychometric properties of a new instrument to measure behavioral repertoire”, *The Leadership Quality,* Vol. 20 No.2, pp.87-102.

Pierce, F. D. (2002), “Applying systems thinking to safety”, *Professional Safety,* Vol. 47 No.6, pp. 49-52.

Rebovich, G., Jr. (2008),“The evolution of systems engineering”, *Systems Conference, 2008 2nd Annual IEEE,* 7-10 April 2008, pp.1-5.

Richmond, B. (1993), “Systems thinking: Critical thinking skills for the 1990s and beyond”, *System Dynamics Review,* Vol.9 No.2, pp. 113-133.

Roth, W. (2002), “Business ethics - Grounded in systems thinking”, *Journal of Organizational Excellence,* Vol. 21 No.3, pp. 3-16.

Ryan, G., Emmerling, R.J. and Spencer, L.M. (2009), “Distinguishing high-performing European executives: The role of emotional, social and cognitive competencies”, *Journal of Management Development,* Vol. 28 No.9, pp.859-875.

Senge, P. (2004), “Building vision: New roles for new leaders”, *Executive Excellence,* Vol.21 No.7, p.16.

Shireman, W. (1999), “Business strategies for sustainable profits”, *Systems Research and Behavioral Science,* Vol.16 No.5, pp.453-462.

Skarzauskiene, A. (2010), “Managing complexity: Systems thinking as a catalyst of the organization performance”, *Measuring Business Excellence*, Vol.14 No.4, pp.49-64.

Tucker, M.F., Bonial R., and Lahti, K. (2004),"The definition, measurement and prediction of intercultural adjustment and job performance among corporate expatriates", *International Journal of Intercultural Relations*, Vol.28 No.3/4, pp. 221-251.

Watt D. and Willey K. (2006), "The complex, chaotic, and fractal nature of complex systems ", *Systems, Man and Cybernetics, 2005 IEEE International Conference on*, Vol.4, 10-12 Oct. 2005, pp. 3155- 3160.

Williams, C., and Derro, M.E. (2008), *NASA systems engineering behavior study*. National Aeronautics and Space Administration, Academy of Program, Project and Engineering Leadership: Washington, D.C., available at: http://www.nasa.gov/news/reports/NASA_SE_Behavior_Study.html (accessed 25 August, 2010).

Williams, C., Derro, M.E., Jarvis, M. and Morris, L.E. (2010), *Executive leadership at NASA: A behavioral framework*", National Aeronautics and Space Administration, Academy of Program, Project and Engineering Leadership, Washington, D.C., available at: http://www.nasa.gov/offices/oce/appel/seldp/resources/exec_leadership.html (accessed 25 August, 2010).

Weaver D. (2010), " NASA Administrator Thanks President Obama and Congress for Agency's New Direction Support", Press Release 10-255, 11 October, available at: http://www.nasa.gov/home/hqnews/2010/oct/HQ_10-255_Admiistrator_President_Auth_Act_1011.html (accessed 24 October 2011).

Wojcik, L.A and Hoffman, K.C. (2006), "Systems of systems engineering in the enterprise context: A unifying framework for dynamics", *System of Systems Engineering, 2006 IEEE/SMC International Conference on*, 24-26 April 2006, pp.22-29.

Young, M. and Dulewicz V. (2009), "A study into leadership and management competencies predicting superior performance in the British Royal Navy", *Journal of Management Development*, Vol.28 No.9, pp.794-820.