Architecting the Next Generation of Technical Leaders

Earl Martin S. Valencia
Raytheon Company
University of Southern California
Earl_M_Valencia@raytheon.com

1. Introduction

Technology and innovation have been the advantages of the United States for the past decades, with applications produced such as the internet, automobiles and computers. More and more, competent technical leaders which drive large technology-oriented organizations to promote further innovation are needed because of the looming lack of technical talent base in the country.

This paper will attempt to model the leader as a system by using appropriate systems architecting tools and heuristics more commonly applicable to engineering-specific systems. Also, the classical, authoritarian definition of leadership will be investigated and contrasted with the current notion of the charismatic leader. A survey was conducted at Raytheon Company, a high-technology organization, to their high potential employees and their top senior executives to map out core competencies of the two focus groups. Common and uncommon responses were analyzed and synthesized to attempt to model the transition from a developing leader to a high potential and ultimately a high potential into a senior technical executive.

2. Motivation of the Study

2.1. Growing shortage of technical talent

There is an alarming threat on the growth of technical talent in the United States. There is a trend over the past years that our competence in math and science in both the elementary and secondary educational systems are lagging in comparison with the rest of the world.   [Gonzales, et al. 2004] According Gibbons, in his briefing to the Raytheon's corporate leaders, "some issues that are facing the aerospace and defense industry in the United States in the next years are: (1) 40% earning doctorates in science and engineering are foreign, (2) 27% of the industry workers are eligible to retire in 2008, (3) 9% of all funded science and engineering jobs are going unfulfilled due to lack of qualified candidates, and (4) Within 10 years, 90% of all scientists and engineers will live in Asia." [Gibbons 2006] With this looming problem over the horizon, there is a need to accelerate the process of producing senior technical leaders that have both technical skills and interests together with the capacity to lead groups and drive innovation.

2.2. Exposure and Discussion with Senior Leaders

There has been a variety of interactions of the author with Raytheon senior leaders through out the company since 2003. These interactions may either be through conferences, discussion forums, one-on-one or at formal meetings. Through their sharing of experiences, there seems to be some common career paths or traits that these leaders exhibit. This study is intended help formally characterize some of the competencies or values of the said group.

3. The Leader as a System

System: a set of different elements so connected or related as to perform a unique function not performable by the elements alone. [Rechtin 1991]

A leader can be modeled and architected using a set of tools and techniques that were formerly used to create complex engineering systems. In a discussion of the leader a system, a collection of applicable heuristics is embedded into the section in which the author used to architect a potential leadership model.

   *Ask **early** how you will evaluate the success of your efforts. [Maier and Rechtin 2002]* In building a leader (as a system), a collection of experiences have to emerge in order to breed leadership. (See Figure 1) One trait that is nearly exhibited by leaders is their ability to set their goals early on in their life. It seems that a big trait is focusing on what they would want to be or self-actualization. Life it seems is one big feedback loop and a series of corrective actions in order to achieve the right solution, or in this term, success.

   How does a potential leader define success? Who are his/her stakeholders to validate performance? Unfortunately it seems that society has already pre-defined success, meaning increasing power, respect and monetary holdings. Success in the terms on technical leaders, especially in the corporate world, is to be able to lead a high performing organization to deliver the best products for the customer but in return growing the organization and the people in it. A successful technical leader inspires and promotes creativity to lead on invention and innovation to create better technology to better mankind's quality of life in the future.

   How will a junior leader know where to get this definition of future technical leadership? In essence society must create some benchmarks or metrics as to who could potentially assume these roles 10 or 20 years beforehand. Some common

Figure 1. Context Diagram that depicts the Leader as a System with Interfaces

traits could be the naturally ability to solve logical problems or early career ambition. Also, an interest in math and science and the urge to create is a key aspect. These potentials are needed to be guided early by exposing them to success stories that could inspire them. Once exposed and the dream is integrated early on, then they could establish a set vision.

   Experience is the hardest kind of teacher. It gives you the test first and the lesson afterward. (Susan Ruth 1993) [Maier and Rechtin 2002] One great thing that a leader must have in order to grow is a mentor, a guide in order to ask them early on in their journey what they would want to be, to challenge them and give them some direction in order to achieve their full potential as engineering leaders and managers. These more senior folks can be looked at as experts of career progression, often people who have more experience in a particular matter and have had to face challenges and failures in order to get into the positions that they wanted. Most of them usually take a high potential under their wings because of a rare connection and respect for the mentee. This respect can be earned either by their ambition, enthusiasm, commitment to the company, or just by pure common interests. These mentors ask the tough question and challenge the framework of the system. [US Marine Corps 2006]
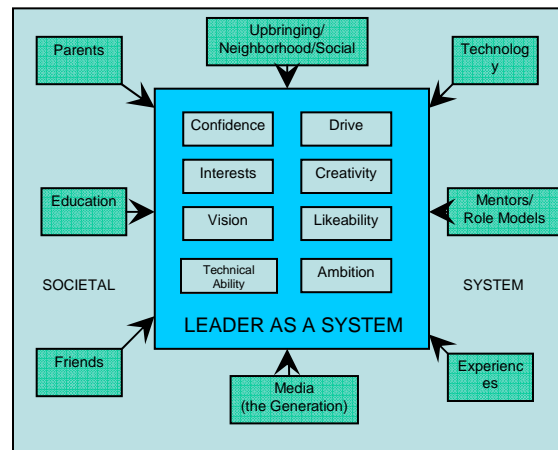
A mentor can also be the maintenance and repair, in a sense a coach or a compatriot to ail falling spirits and still keep the fire alive when an aspiring leader faces the tough challenges and pitfalls of career growth.

When choices must be made with unavoidably inadequate information, choose the best available and then watch to see whether future solutions appear faster than future problems. If so, the choice was at least adequate. If not, go back and choose again. [Maier and Rechtin 2002] With the emergence of new technologies that come out of the commercial sectors, universities and start-ups, there needs to be an openness for anticipating new unproven technologies that would be able to help provide the customers the state-of-the art technologies that will be great standards in the future. Leaders need to be aware and conscious of the new trends that are happening all around them in technology and society. As leaders and engineers develop a broad perspective, they should be able to look and access the different technology roadmaps that industries provide their constituents. The name of the game is to be on the upside of the S-Curve and not be left behind and be obsolete. [Foster 1986]

Choose/Watch/Choose (Marilee Wheaton) [Maier and Rechtin 2002] It seems that over the past years, the new definition of leadership has shifted from IQ to a focus on EQ. [Davies 2006] Technical skills and ability are the minimum requirements for higher level positions, but not the main decision to select an individual. There has been an emphasis on people skills, an ability to handle uncertainties and lead their constituents through these not so comfortable times. [Kemper 1999] With this, when a leader implements change and makes stern decisions, he/she must be observant of the reaction of the team to this as not to disrupt the productivity but rather increase it as what a change agent would want to happen. Technical decisions will always have a people aspect.

Fail Small, Fail Often and Fail Early (Jonathan Hofeller) [Maier and Rechtin 2002] One major characteristic of an emerging leader is their adaptability and capability to handle failure. Although the cliché phrase "learn from your mistakes" was taught to us since the formative years, it is often not practiced to the fullest later in life. Someone who can learn from their failures, take the lessons learned from it, and applies their new findings on their next assignment increases the probability for success. The essence of spiral modeling may apply to a leader's career - iterating by trying out new experiences, a lesson learned in training or a sharing of knowledge by a mentor when handling difficult situation, and incorporating what they have learned from the previous time and see if it will work in the future. The leader tries to see what works and what doesn't work and in the end, would have a tool kit of personal best practices that would make them better and more efficient.

Factors for Technical Leadership Development
Societal Expectation
Education
Life Experiences
Technical Leadership
Recognition
Self-Reflection
Mentoring

Figure 2. Factors of Technical Leadership Development

Have broad interests and an open mind [Maier and Rechtin 2002] A leader's appetite for risk and uncertainty should always be looked at. As huge companies go through a mid-life plateau, more and more the itch for stability and stagnation occurs from both the employees and leaders. Although it seems that a flat line of growth might be acceptable, radical changes and ideas should be looked closely by senior leaders in order to further grow the company. It is inevitable that change will come and that those who don't anticipate change will perish. As junior leaders emerge, they should be trained also into looking at the big picture. Systems Engineers and Architects are lucky that they are trained to see the project right from the beginning and follow through until the end of the lifecycle to get a good broad view of the trade-offs and lessons learned. When talking to top level managers, it is a common stepping stone for them to either be past Systems Engineers and Project Managers at an early point of their career.

One big push of senior management is job rotations. In Raytheon and most large companies it is suggested requirement for executives to rotate to a new position every three years. Also in order to be considered for a senior level positions (Director level up), they should have rotated to a different role at least three times in their career. The key point is that a diversity of experiences brings out better critical decision making.

4. Developmental Process and Career Progression

Based on Maier and Rechtin's model on the Process and Product Waterfall Model for Manufacturing Systems [Maier and Rechtin 2002], a similar model can be deduced for technical leadership development – one for the factors of technical leadership (See Figure 2), which parallels the product waterfall, and another for a technical leader's career progression which could be modeled to the process waterfall (See Figure 3).

Like the synergy of processes and product development to create a unique product, we can model this to create leaders. Instead of the product, we can see a common intersection – technical leadership - which means that in careers of more senior executives, it is a key developmental step and factor that they lead a group of technical individuals which could open up more opportunities for further growth. Like Maier and Rechtin's model of product realization, a spiral model or multiple iterations should be considered in order for this product to succeed. [Gibbons 2006] This could be paralleled into a leadership model as mistakes, was mentioned in the Section III, and the constant learning and focusing on continuous improvement.
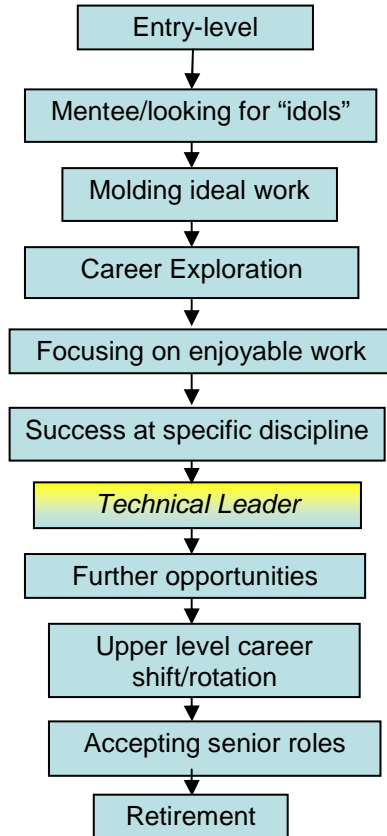

Figure 3. Technical Leader's Career Progression

5. General Leadership Theory

5.1. Authority vs. Leadership

The classical notion of leadership often confuses leadership with authority. This is the age-old questions of personal versus position power. "Authority is often seen as the possession of powers based on a formal role. It may also be because the follower fears the consequence of not following their orders or requests. The possibility of them demoting or disadvantaging the follower may almost assure compliance." [Heifertz 1994] A leader though has authority because someone accepts the authority requested. It is a two way process, meaning, there will only be power if there is someone who consciously or unconsciously accepts and gives this power. Informal authority can be earned through several personal traits exhibited by the leader, including their technical competence, trustworthiness or persuasiveness. [Doyle and Smith 2005]

5.2. The Charismatic Leader

There have been different models of Leadership through out the years. One such notion that has emerged over the decade is the notion of the "charismatic leader." According to Nadler and Tushman, "charisma" is a special quality that enables the leader to mobilize and sustain activity within an organization through specific personal actions combined with perceived personal characteristics or traits. The charismatic leader should possess three groups of essential traits: (1) Envisioning, (2) Energizing, and (3) Enabling. *Envisioning* involves creating a picture of the future, a future state that people can identify with and be energized by the idea. *Energizing* is the direct generation of energy – a motivation to act. This could achieve by demonstrating own personal excitement and energy for the specific vision. Last component is *enabling*, which is to directly give support to the team by empathy and constant expression of confidence on the strengths and abilities of the team. [Nadler and Tushman 1990]

Technical Leaders need a combination of several traits to be able to function and lead co-technical team members. These traits are affected primarily on experience and on the interfaces that they interact through out a leader's life.

6. Leading the next generation of workers

With the current situation, a new type of leader should emerge to serve the next generation of workers. These "cohort groups" have some qualities that are quite different from previous generation and the emerging leader should be able to understand these differences and adjust his/her leadership style to accommodate this. According to Springer, in his research on the different life phases at work, there are several identifying characteristics that identify the Generation X (born 1960-1980) and the Generation Y (born 1980 – present). [Springer 2005]

The *Generation X* profile seems to stress more of individualism and independence. They are self-reliant, want balance and have a casual approach to authority. With respect to managing this group, a leader should expect that have a non-traditional orientation to time and space, meaning they may come in late and leave early, as long as the job gets done, and prefer informality. A great challenge to this generation is their skepticism which translates into sensitivity to commitments and their realization that there are no guarantees in life, especially in the corporate world. [Kemper 1999]

The *Generation Y, Millenials or Nexters* have different values compared to previous generations. They have a self expectation to excel in everything that they do and have a greater awareness of diversity and inclusiveness due to the cross-cultural upbringing and exposure. They are the most connected generation, often multi-tasking, impatient and the most common form of communication is using instant messaging through the internet. One characteristic that a leader should expect out of this generation is their openness or bluntness of communication when it comes to issues on career expectations and having a balance lifestyle. [Gibbons 2006]

7. Survey

7.1 Focus Groups

A survey was conducted to two focus groups: high potential early career engineers and senior executives. The study was conducted primarily at the Raytheon Company due to: (1) the accessibility to the author, (2) its size and revenue, and (3) its focus on technology and innovation.

One of the top technology-based companies, "Raytheon is an industry leader in defense and government electronics, space, information technology, technical services, and business aviation and special mission aircraft providing integrated mission systems to meet the critical defense and non-defense needs of our customers."[Raytheon 2006] In 2006, Raytheon ranked number 97 in the Fortune 500 list, an annual ranking of America's largest corporations based on revenues, with sales of $21.9 Billion. [Fortune 500 2006]

High potential engineering subjects comprised of the members of the Class of 2006 and Class of 2007 of the Engineering Leadership Development Program. Each class comprises of about 60 high potential engineers that have been nominated and identified as future engineering leaders of the company by the Corporate Engineering and Operations Councils.

The senior executives group comprised of the top 92 technical executives in the corporation. The area of expertise covered by study are, but not limited to: (1) Engineering, (2) Operations, (3) Supply Chain, (4) Program Leadership, (5) Performance Excellence, and (6) Six Sigma. The participants have a position that is at most 3 hierarchical levels below the CEO of the Company and designated at least a Business Vice President.

7.2 Survey Design

The survey is divided into two groups: background information and behavior-related questions. In the background information, the author wanted to find out some correlations between leadership and educational experiences. Also, the author wanted to find out if there are potential career limitations if one is not willing to travel for work or explore other areas of the world for pleasure.

The second part of the survey is to be able to synthesize some leadership qualities and see if there are some common behavioral characteristics common or uncommon to the two groups. (Table 1) A series of questions were asked to the leaders could indicate the importance of some early life experiences to potential leadership success.

Table 1. Definition of Leadership Qualities Surveyed [Dictionary 2006]

Leader Quality	Definition
Confidence	A feeling of self-assurance
Drive	A strong motivational tendency that prompts activity to a particular end
Vision	Unusual competence for discernment or perception
Technical Interest	Passion and patience for following quantitative processes and looking for technical solutions
Ambition	An eager or strong desire to achieve something
Likeability	When people feel comfortable and pleased around a leader
Creativity	The power of ability to invent

8. Results and Analysis

About 18 executive and 42 high potential subjects have responded to the survey representing 20% and 30% of the total applicable surveys sent out respectively.
The results represent a number of potential behaviors and attitudes that both high potentials and executives value.

A combined model can be deduced on how to create leaders from a fundamental level and raise them to be high potentials. Another model can be created to shape these high potentials by looking at some secondary or primary traits that distinguish the senior executive subjects from the high potentials. (See Figure 6)

The first model can be created by taking the common intersection amongst the two groups and taking the similar primary values. (See Figure 4) Since most of the questions are taken from the fundamental level, these behaviors or values may be applied to developing these competencies during the formative years of a future engineer or may be applied to the curriculum of engineering education. It should be understood that because the leaders select these high potentials, they may unconsciously or consciously pick the ones who mirror themselves and who adhere to the values that they believe in. Company culture may also play a part at which, each company may value something that another may not, which means, there is a possibility that a mediocre employee at one company maybe adhered as a high potential at another.
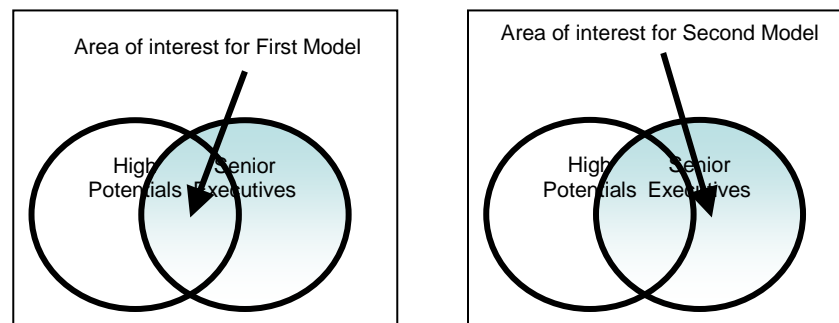

Figure 4. Areas of interest of two models

The second model represents the responses that were exclusive to the senior executives. (See Figure 4) These responses could also be the different secondary responses by the senior leaders that were much different from the high potentials. This model maybe a guide on how to translate a high potential in an organization into the next senior executive. These characteristics are the differentiators that could set apart a junior leader and give them experiences that mirror some key traits that senior leaders possess. In the results, the traits that senior leaders have dissimilar responses are: (1) Values, (2) Pressure, (3) Impact Expectations, (4) Contentment in Individual Contribution, and (5) Travel.

1. *Values.* It seems that the two most important things that a senior leader values, or makes them happy the most, are respect and adventure which tallied 27% of the responses each. This would be of contrast to

the top answer of high potentials which is "love." Adventure is an interesting response, since this could indicate the desire of a leader to take risks and something that's not in the ordinary. The point of career could also be a factor since love and idealism might be a higher priority in the early stages of life.
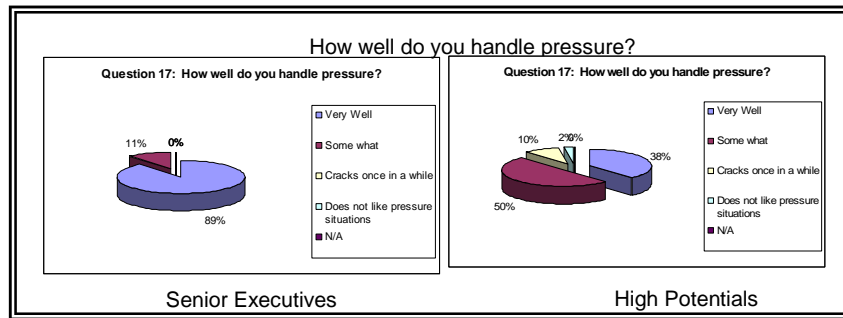

Figure 5. Notable comparison between the responses of senior executives to high potentials with regards to handling pressure

2. *Pressure.* Almost 90% of all senior respondents indicated that they have a significantly higher tolerance for pressure, that is, they handle pressure very well. (See Figure 5) This maybe the X-factor when it comes to moving up the ladder because of the reality that more responsibility is expected as one navigates upward through the corporate ladder. In order to grow more senior leaders, an individual should be constantly exposed to pressure situations and uncomfortable experiences early in their careers.

3. *Impact Expectations.* More than 50% of the senior respondents have answered that they would want to make an impact on a regional or organizational scale, while the highest number of responses at the junior level (34%) is that they would want to make major contribution or Nobel-prize winning discovery. This may indicate that through experiences comes a realization that only a few would be able to discover something big, but in an executive position, there is always a possibility of being a change agent within the organization or the larger geographic area at which they are located. This result could either be positive or negative; meaning the dilution of high personal impact expectations could stunt the creativity and innovation of a company, but may or may not necessarily be realistic or important to a large technology organization.

4. *Contentment in Individual Contribution.* The second highest response of senior leaders to the question: "would you be satisfied to be an individual contributor?" is that 28% of them would be very dissatisfied. This could indicate that a good number of this group would like to see their work related or delegated through other people.

5. *Travel.* A majority of leaders have had the experience of a lot of traveling through out their career (94% have stayed at least one night in more than 40 cities at which more than 50% have experienced at least 1 night in more than 80 cities.) This could indicate that in order to have career progression, an emerging leader should be open to opportunities beyond their immediate geographical area.
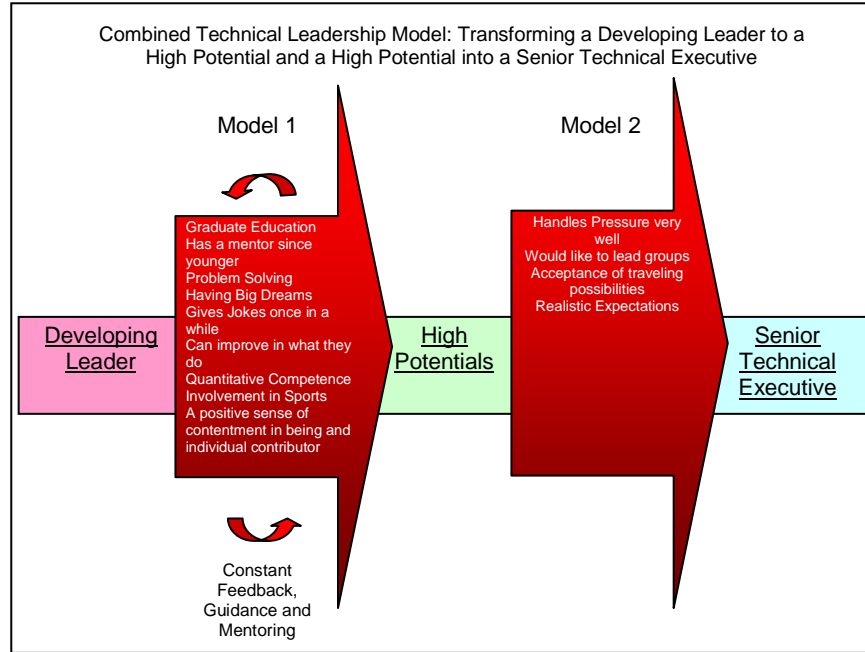
Figure 6. Combined Leadership Model

9. Future Research

9.1. Broader base of companies in study

In order to validate and see more interesting results, multiple high-technology companies should be studied. Each company has its biases and values, and in order to serve the nation as to creating the next technical executive regardless of which company they may fit in, there should be a greater sample size and spread. A standard survey should be sent through these companies to eliminate discrepancies. Also, there might be a difference in commercial and defense sectors when it comes to the results of the study. Another interesting study would be the executives' responses of one company compared to a high potential of another.

9.2. Expand to have a meets requirements control group

With more than two control groups, a group that consists of "meets requirements" or non-early-career high potentials should be tested to see the differences between the characteristics of the high potential and the said group. The data could also validate some of the models and findings of this research.

9.3. Have a more comprehensive survey

The survey was prepared by the author, who did not have formal psychological methods training. With an evaluation and consultation with survey design experts, results from a more rigid questionare may be able to extract more specific information that reflects the characteristics and traits of the control groups.

10. Conclusion

In modeling the leader as a system, a number of tools such as the application of relatable heuristics, context diagrams, functional flows, input-output charts and surveys were used to attempt to provide a guideline to grow future technical leaders in the US. A new leader should be able to lead the emerging generations, the Generation X and Y, and would have the technical competency to also drive further innovation. A survey was conducted amongst the top executives and the high potentials of Raytheon Company to provide data and extract common competencies that may translate a developing leader into a high potential, and a high potential into a future senior executive. Some trends were discovered such as there are very similar results

between the high potentials and senior leaders that could indicate that they usually select high potential subordinates that mirror them. Also, some notable discoveries to translate a high potential into a future senior leader is their capacity to handle pressure and their willingness to travel. A combined model was created in order to reflect the responses of the two control groups. Further research should be conducted to verify and validate the results of the study of this paper, at which both commercial and defense high-technology companies should be evaluated in order to create a more generalized model.

References

Davies, S., 2006, *Emotional Intelligence and Leadership* <http://www.ceoforum.com.au/200110_leadership.cfm> (March 26, 2006).

Dictionary, 2006, <http://www.answers.com/topic/drive?method=8> (April 26, 2006)

Doyle, M. & Smith, M., 2005, *Classical Leadership*,<http://www.infed.org/leadership/traditional_leadership.htm> (April 22, 2006).

Fortune 500 2006: Fortune's annual ranking of America's largest corporations, 2006, <http://money.cnn.com/magazines/fortune/fortune500/full_list/> (April 17, 2006).

Foster, R., 1986, *The S-Curve: A New Forecasting Tool,* Innovation, The Attacker's Advantage, Summit Books, Simon and Schuster (New York, NY).

Gibbons, J., 2006, *New Workers and New Business Realities -* Presented at Raytheon Leadership Forum (San Antonio, TX).

Gonzales, P., Guzmán, J. , Partelow, L., Pahlke, E., Jocelyn, L., Kastberg, D., & Williams, T., 2004, *Highlights From the Trends in International Mathematics and Science Study (TIMSS) 2003 (NCES 2005–005),* U.S. Department of Education, National Center for Education Statistics, U.S. Government Printing Office (Washington, DC).

Heifetz, R. A, 1994, *Leadership Without Easy Answers*, Belknap Press (Cambridge, MA).

Kemper, C., 1999, *EQ vs. IQ*, <http://www.allbusiness.com/periodicals/article/339475-1.html> (March 26, 2006).

Maier, M. and Rechtin, E., 2002, *The Art of Systems Architecting (Second Edition),* CRC Press (United States of America).

Nadler, D. & Tushman, M., 1990, *Beyond the Charismatic Leader: Leadership and Organizational Change*, California Management Review Vol. 32, No.2 (California).

Rechtin, E., 1991, *Systems Architecting: Creating & Building Complex Systems*, Prentice Hall (New Jersey).

Springer, M., 2005, *Life Phases at Work -* Presented at Lecture to Raytheon NCS Florida Leadership Team.

Raytheon Company Profile, 2006*,* <www.raytheon.com> (April 26, 2006).

United States Marine Corps, Marine Corps University, 2006, *User's Guide to Marine Corps Values: MENTORING* < http://www.au.af.mil/au/awc/awcgate/mentor/chap07va.htm> (April 22, 2006).