What is a Chief Engineer?

Carl A. Nardell, November 2013

Our organization and our industry in general, suffer from a shortage of truly great technical leaders. While there have been tremendous technical accomplishments in the aerospace industry in the last 20 years, they are generally outnumbered by tales of seemingly avoidable technical failure. Examples include airliner development programs that are years late, military aircraft programs that are billions of dollars over budget, and space programs that are outright technical failures. We no longer see a jumbo jet that is developed from a clean sheet of paper in less than 2 years or a manned moon shot that goes from nothing to success in under a decade. Technical legends such as Robert Oppenheimer, Burt Rutan, and Chris Kraft are seemingly figures in our history who are not likely to have equals in our time.

Although our industry has changed and the emphasis is now on producing solutions within highly predictable cost and schedule constraints, the need for truly outstanding leaders has never been more critical. The purpose of this paper is to address what it takes to become such a leader, and the expectations that Raytheon places on those leaders. It is critical that the EW business is viewed as viable by the corporation and by those whose responsibility it is to make strategic decisions about investment and where work is done. Gaining the confidence of our management will enable bolder undertakings that provide both richer challenges as well as greater financial growth and rewards. As Raytheon confronts a technical workforce whose most experienced members are retiring in ever-increasing numbers, our collective success depends on our solving this problem. This also represents an opportunity to become the next generation of great technical leaders who do amazing and profitable things that live on beyond the lifespan of our careers.

I believe individuals with the requisite qualifications to provide the needed leadership do exist in our organization. However, I also believe that we have not adequately described our expectations and so their vision of what constitutes required performance differs from that which we desire. It is this root cause that this paper directly addresses.

What is a Chief Engineer?

At SAS the chief engineer role involves both technical and program management elements. The chief engineer is part engineer and part program manager. The chief engineer must have complete cognizance of *everything* that is happening on a program that could impact the product. The chief engineer's sphere of awareness and influence spans all engineering disciplines, supply chain, manufacturing, finance, mission assurance and even contracts. In our organization, when the toughest problems can't be solved by other functions, it is the chief engineer to

whom the organization and the program always turn for a solution. The chief engineer is the only member of the program management team who has both the perspective and the technical background to
make sound technical decisions within all of the constraints that cost, schedule, operations, and the technology place upon a program. While some program managers may be highly technically adept, (which is of course highly desirable) it is not a requirement that a program manager have a technical background, and the program manager almost never has the level of technical knowledge and familiarity that chief engineers must have.

A chief engineer is both an accomplished leader and manager. Chief engineer is a great job for anyone with both broad technical and program management acumen who loves a challenge, and enjoys truly making a difference in the success of a program. Chief engineer assignments are an excellent choice for someone who enjoys a diversity of problems, and gets bored working on a single problem or discipline for extended periods of time. Routine is not something the chief engineer neither seeks nor finds.

Responsibilities

Having defined what a chief engineer is, the next question is what constitutes the responsibilities of the chief engineer.

1. The chief engineer is responsible for the technical integrity of the system or product. The chief engineer ultimately owns the design decisions and the responsibility to ensure that those design decisions are incorporated into the delivered product in a consistent and appropriate manner. The challenge for the Chief Engineer is to determine how he can ensure all technical decisions are sound, when his personal bandwidth does not allow him to review each and every one. Utilization of tools like independent reviews, program performance reviews, change control boards, desktop reviews, gate reviews, EAC's, etc. must be implemented and utilized to provide the needed information to the chief engineer.

The chief engineer is responsible for ensuring that the entire requirements structure holds together. This chain starts with contracts. The chief engineer must ensure that the contractual technical requirements are defined clearly and properly and that they are correctly interpreted by the program. From this understanding comes the unique perspective from which to view the requirements flow-down to the engineering functions, supply chain and manufacturing. The chief engineer also must ensure that the requirements are correctly met in components, assemblies, subsystems and in the final system. The chief engineer is in actuality putting his name on every product or system that is shipped.

2. The chief engineer provides cross-functional technical leadership throughout the entire product life cycle. As stated above, it is the chief engineer, and the chief engineer only who has the purview to do this. It is

for this reason that the chief engineer should strive to have knowledge about as many functional areas as possible. While the chief engineer might not be a true subject matter expert in every discipline employed on the program, he must know enough about each area to know when things aren't adding up.

The chief engineer must also have a strong understanding of program management concepts, and a basic understanding of supply chain, manufacturing, operations, mission assurance and contracts.

3. Effective performance of the engineering team is the responsibility of the chief engineer. While section and department managers are expected to monitor the performance of their direct reports, we have seen escapes on several programs. As the chief engineer it is your responsibility to ensure the appropriate technical decisions and designs are made. Program managers don't generally have the ability to address failures of functional management in a proactive manner either, and won't notify functional management of a performance problem until it has affected program cost or schedule. It is for this reason that the chief engineer fills a critical role, which is that of monitoring each and every engineer's performance to proactively maximize program performance. The chief engineer does this by a combination of work product reviews, spending time with the engineers to assess their approach to and level of skill on what they are working, and arranging mentoring situations as much as possible.

4. The chief engineer is responsible for the planning of the work to be completed on the effort. The chief engineer must maintain a thorough understanding of the business environment in which the work is being executed, and adjust the baseline cost and schedule estimates accordingly. For example, some efforts require a predictable consistently high gross margin, while other strategic endeavors may require a short aggressive schedule with less emphasis on gross margin and a higher acceptance of risk. The standard bid tools that the functions use are generally blind to these business considerations, and it is the responsibility of the chief engineer to ensure that these ancillary factors are considered when generating baseline schedules, BOEs, and risk and opportunity assessments.

From a cost estimation standpoint, the use of historical actuals and bid standards by definition do not facilitate a culture of competitive improvement. The process basically is built around the premise that "this is what it cost last time, and so therefore that is what it will cost next time." The chief engineer seeks opportunities and innovative means to increase the competitiveness of bids and push back on bases of estimate that are inappropriately conservative. It is the duty of the chief engineer to challenge the functions to do better on the next effort than they have on the last, and to identify the difference as a potential risk. The chief engineer is always in search of a better future state, and is never satisfied with the current level of program performance.

The chief engineer is the "voice of reason" when reconciling the natural desire of the program manager for lower cost and short schedule with the desire of the functions for high levels of technical integrity and executable predictable programs. This expected tension between these two opposing forces is to be managed by the chief engineer.

5. The chief engineer serves as the engineering agent to ensure that the required staffing is provided to programs. While the chief engineer isn't actually generating staffing plans, the chief engineer must maintain a cognizance of the staffing posture, and play an active role when required.

6. A good program chief engineer will work to ensure that the product area chief engineer and the program manager are never surprised by any technical, cost or schedule issue. The program chief engineer must facilitate good communication between these entities and be ready to ask for help when it is needed.

7. Both risk management and change control are the responsibility of the chief engineer. Risk management must be thought of as a truly value-added activity and not simply something our program management and financial reporting processes require. The risk management process should be thought of as an opportunity for transparency into the real challenges that are expected, and a means with which to actively mitigate these risks, or formally choose to accept them. The latter is appropriate when the cost of mitigation exceeds the consequence of the risk. The chief engineer plays a key role in this activity.

The chief engineer must ensure that risks are presented in a logically consistent and defendable fashion. For example, probability of occurrence and consequence should always be accompanied by a rationale that is understandable and defendable. The bases of estimate for consequences and mitigation plans also must be clear and substantiated.

8. The chief engineer is integral to tailoring and use of Raytheon processes, and manages the balance between use of rigorous process and the need to operate agilely. There exists a "knee in the curve" where overall program efficiency is maximized. It is the responsibility of the chief engineer to identify and operate at this level of process.

9. In a geographically diverse organization such as EWS, I have observed that aligning the various groups on technical baselines is a unique challenge. These sites often offer different technologies and have differing technical paradigms on the same problem due to historical influences that run very deep. An entire paper could be written on this topic, but in short, it is critical that the chief engineer start the baselining process by genuinely considering the entire spectrum of architectural and technical options at the start of the effort. This will be chaotic, but if it is not done at the start, alternatives will continue to pop up late in the game and debate will continue well into the design and fab process, which will be fatally disruptive to execution. The

chief engineer (with help from the technical director ideally) has a responsibility to drive from chaos to order, and to ensure technical cohesiveness throughout the team.

If the chief engineer happens to have expertise and a strong opinion, it is important to keep this in check, and to not try to be both the adjudicator and a driver of a given approach. That is difficult to do, and will alienate those with opposing technical opinions. The chief engineer must appear solution-neutral and open to all possibilities, narrowing the trade space using facts and data, and considering all factors. Some of these factors might be non-technical, such as marketability, expectation of future capability requirements, investment considerations, or other political factors. Engineers typically don't like to deal with these intangibles, but they are a part of this equation, and will be an increasing component of a chief engineer's decision making space as he ascends from program to product to business area chief engineer roles.

10. Lastly, the chief engineer is always preparing his successor for the day when the successor will be the new chief. Such succession planning is vital to growing organizations and one's professional advancement.

How does the chief engineer do it?

Much of what has been presented in this discussion of responsibilities comes from the observed needs of our programs and the observed behaviors displayed in successful ones . It has been observed that the chief engineer accomplishes his responsibilities through *influence*. How does this influence materialize? It does not come automatically with the title. Influence is accumulated over time by

- building a **track record** of providing good advice and helping make sound technical and business decisions.
- developing good **working relationships** with the team, the program manager and the customer.
- Developing **technical acumen** in the disciplines employed on the program, especially electronic warfare, systems engineering and program management.

Chief engineer skills

A "good" chief engineer has a number of distinctive skills. The key attribute that qualifies one to be a chief engineer is to have lived through and solved tough technical problems that others deemed unsolvable or couldn't close on. A good chief engineer is always a *closer*. It is the chief engineer who is the program leader who has the self-assurance to know that no matter what, we can find a way to get the job done and solve the problem. Period. This is not blind optimism, nor is it "running the sunshine pumps". It is the confidence that comes from having lived through and solved tough problems over and over again. When all others on the program, including the program manager, don't see a way out, it is the chief engineer who keeps the team focused on constructively

working the problem. As Markus Buckingham so eloquently and insightfully observes in the book referenced at the end of this paper, "The opposite of a leader is not a follower. The opposite of a leader is a *pessimist*."

The ideal experiential background for a chief engineer involves both multi-disciplined technical accomplishment as well as profit and loss responsibility. Until one has had to stand in front of a general manager or vice president to explain why the profit numbers weren't achieved, he or he will never understand the perspective and plight of the program manager.

On the technical side, the ability to quickly generate a first-order error or performance analysis will be a powerful tool over and over again. The ability to do so will both provide insight into the physics at play in a given problem and demonstrate to the team that their leader understands his team and the work they do. Many times in the author's career, an engineer or team of engineers have generated a complex analysis using state of the art sophisticated numerical tools; which have subsequently proven to violate basic laws of physics with a few lines of first-order math. The ability to perform this type of analysis quickly and correctly is one of the most important skills a chief engineer can develop.

Similarly, asking simple or "dumb" questions that come from common sense has tremendous value to a chief engineer. These types of questions seem to have the greatest value, as the answers often prove that the question wasn't so "dumb" after all.

The chief engineer has a natural curiosity about how things work, and constantly seeks to understand fundamentals. The chief engineer must have the humility and courage to ask basic questions. The most admirable chief engineers seem to have an incredible memory for all of the things they worked on over their careers, and tend to not ask the same question twice.

Effective chief engineers are good at building good relationships with all of the parties they work with. They understand the criticality of these relationships and work hard to strengthen them with the team, the program manager and the customer. The impact to the relationship is always part of decision making.

A critical attribute of a chief engineer is the ability to communicate technical issues effectively to wide and varied audiences. They need to be able to explain the issues at the detailed technical level to customer experts, while displaying the ability to distill a complex issue down into something that customer executive management can understand.

It takes a high level of courage to be a good chief engineer – the courage to deliver bad news. That can be the hardest thing a chief engineer does. The chief engineer needs to think in terms of facts and data, and assess and communicate news accordingly, without emotional influence. Bad news will not get better with age, and

a good chief engineer communicates bad news objectively and in a timely manner, preferably with options and mitigation plans. The worst thing he can do is downplay the problem or put spin on it because he lacks the courage to state his true assessment of the problem.

The most critical skill a chief engineer can have at all points of his career is to maintain a keen awareness of what he does and doesn't know, and gets help when it is needed.

How can I become a great (or better) chief engineer?

First and foremost, you must be willing to invest in yourself. While your company will make some investment in you, it is not nearly enough. Professionals maintain a constant awareness of what is going on in their field. Physicians read medical journals as part of the maintenance of their acuity. Similarly, our chief engineers must maintain an awareness of what is going on in their field. As a technical professional, you are always either growing or falling behind. You should read as many books, journal articles, and white papers from colleagues as you can. There is a vast library of such material that is not utilized nearly enough in our organization. Additionally, there are always opportunities to sit in on red team reviews, gate 1, 2 3 and 4 reviews, and failure review boards for other programs. These provide an opportunity to broaden technical expertise in ways reading books and journals cannot.

There is also a vast library of books on the subjects of management science and leadership in the literature. Not all are that useful, but if in one book you can find a single great idea that resonates with you, it will be worth having read many other books that revealed little. I have obtained a number of great reading recommendations from leaders I have admired. They all have one or two titles that inspired them and shaped their style.

We should also always try to emulate one or more admirable attributes from leaders we work with, whether they are great leaders or not. In general, all leaders have one or more qualities that are positive, and should be emulated. Conversely, effective leaders always have behaviors that could be improved. These also present a learning opportunity.

We should maximize our technical learning opportunities from those around us. We work with the people who often write the textbooks we read. The number of radar and electronic warfare books that come from Raytheon authors is amazing. These people are our colleagues and are almost always happy to answer questions and help us learn. Whether your colleague wrote a textbook or not, chances are there is a lot you can learn from him or her. Take advantage of that.

Lastly, *learn from your mistakes*. You will make mistakes. Mistakes are almost always costly in some way, but always make the most of the tuition that is paid for these hard lessons. The

most learning value comes not from our successes, but rather our failures.

Recommended reading

There are a few books that I recommend highly. The first and most impressive to me is "The Minding Organization: Bring the Future to the Present and Turn Creative Ideas into Business Solutions" by Moshe Rubinstein. This is a fantastic book that has a number of great concepts that will be useful for a chief engineer.

The book "The One Thing You Need to Know: ... About Great Managing, Great Leading, and Sustained Individual Success" by Marcus Buckingham talks about some very simple ideas that resonate with those of Moshe Rubinstein, and also provide some interesting case studies of great managers and leaders in a variety of industries. He articulates the difference between a great manager and a great leader, and emphasizes the importance and role of both in an organization.

Robert Oppenheimer's life and leadership style are described very well in "American Prometheus" by Ka Bird. Much of the book talks about Oppenheimer's personal life, which is not directly applicable to this paper, but his legendary leadership style and the challenges encountered during the Manhattan Project are interesting and describe a leadership style that is truly inspiring.

Lastly, "Car Guys vs. Bean Counters" by Bob Lutz describes the downfall and subsequent rise of General Motors during Lutz's tenure there as vice chairman. What is interesting about this book is Lutz's argument that world-class businesses can only be run by leaders and managers who know their industry and their roles in it.

All of these books are available on the Kindle, all for under $25.