Instar

Doing Things Right in Space Programs

This article is part of a series started in January, 2000. My intent is to share a philosophy and ideas for how to increase the chances of success in space missions while also reducing total cost. Once these articles are completed, I plan to assemble them into a book. Please send comments to me at Tom.Sarafin@instarengineering.com.

Ten Principles for Doing Things Right in Space Programs

1. **Adopt the right attitude**
2. **Invest in knowledge and understanding**
3. **Instill ownership and responsibility**
4. **Constantly seek ways to improve teamwork**
5. **Follow a sound engineering approach**
6. **Reduce total cost through good engineering**
7. **Keep everything as simple as possible**
8. **Establish an effective quality system that involves everyone**
9. **Be willing to accept risks, but only those you truly understand**
10. **Make sure everyone has enough time, resources, and freedom to do things right**

Article #6

Adopt the Right Attitude

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What business are you in? Are you sure you understand it?

Despite recent attempts to adopt more of a commercial mentality, the space industry is probably farther from it than ever. Despite a competitive-bid procurement system—perhaps because of it—the space industry does not have true commercial competition. If it did, launch-vehicle (LV) organizations would stop treating their customers (payload developers) in a way that says, “You should feel fortunate we’re

letting you ride on our rocket ship." Instead, LV organizations would bend over backwards to provide any needed information and would invite their customer to see how thoroughly they have ensured their system will get the payload successfully to the proper orbit. And, knowing how much their customers typically spend designing and testing for launch environments, LV organizations would engineer their vehicles, or at least their payload-mounting systems, to provide a soft ride.

Too many times have we heard LV organizations proclaim success after putting "pet rocks" in their proper orbits. Why was it these spacecraft didn't work? Could it have been, at least in some cases, because the launch environment was so severe? If your LV puts a nonworking spacecraft into orbit, even the proper orbit, then your mission is not a success!

If you work on a launch-vehicle program,

- You are <u>not</u> in the business of building and launching rockets!
- You are in the business of putting working payloads in their proper orbits!

Sounds simple, perhaps, but what a huge difference that simple change in mindset makes. Buggy-whip manufacturers might not have gone out of business if they had defined their business not as "making buggy whips" but as "making vehicles go." Perhaps then they could have evolved such that their products were gasoline engines or carburetors.[1] What I'm talking about is focusing on the customer rather than the product.

On one space program I supported, predicted launch loads for the payload doubled, well after that payload was designed and built. Loads increased not because of anything the payload developer did, but because the finite-element model of the LV changed. The LV organization finally got around to doing a modal survey test, found things vibrated at different frequencies than had been predicted, and then repeated the coupled loads analysis with a test-verified LV model. I sat in the conference room when the lead engineer for the payload developer lost his cool in response to the cavalier attitude from the LV people and shouted, "You violated the ICD (Interface Control Document)!" The senior manager from the LV side calmly responded, "No, we didn't. We said we would <u>predict</u> loads for you; we never said we could <u>control</u> them." This was just another way of saying, "It's too bad you spent millions of dollars designing to the wrong information, but we're not responsible for making sure the information we give you is right."

I'm picking on LV organizations, here, but you can find a similar attitude in many customer/contractor relationships in the space industry. Washing our hands of responsibility and sticking it to the customer seems to be the norm, at times. What we all need is to adopt a commercial mentality.

What is a "Commercial Mentality?"

I'm sure you've heard something like this before; perhaps you've even said it. You're on a program struggling to do things faster, better, and cheaper. (In other words, you don't have enough time and money to do things right with the existing system.) Someone steps forward with a technical issue that would be costly and time consuming to address. You respond, "Look, we all need to adopt more of a COMMERCIAL attitude, and COMMERCIAL means more risk."

I just want to know one thing: Where did we ever get such an idea about the commercial world?

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[1] Example taken from *Quality or Else: The Revolution in World Business*, by Lloyd Dobyns and Clare Crawford-Mason, 1991, Houghton Mifflin Company

Since I started my own business, in 1993, I've come to understand what "commercial" means. My business—helping space organizations cost-effectively develop quality products and have successful missions, through advice and short courses—is truly commercial. If I give a poor-quality course, word gets out and I go out of business. The companies who reproduce and bind my course books: if they give me books with pages missing or upside down, and then do it again after I point the problem out to them, I fire them. That's commercial. I've been through four printers so far (and finally found a good one!).

Government-funded programs are different. If your company messes up and delivers a product that doesn't work, your Government customer slaps your wrists and withholds some of your profit, but—by law, here in the U.S.—must accept your bid for the next program and give you another chance if your proposal is best. This is the procurement process that has bred the traditional mindset in the space industry.

In the commercial world, the consequence of failure is greater. No one has to give you another chance. You may go out of business. **So why on earth would you take more risk?**

When not obligated to meet Government standards, we are more free to accept risks—and we must accept some if we are to be cost-effective—but we should insist on understanding any risks before accepting them. In the commercial world, we must improve our processes so that the quality of our products goes up and the cost goes down!

How about this instead:

"We need to adopt a commercial mentality, so we have to …

- **Make sure our products work and our missions are successful**
- **Give our customers a fair price**
- **Constantly improve our processes**
- **Invest in our people**
- **Understand the risks better so we can make better decisions"**

If we emphasize cost reduction, we'll drive ourselves out of business. As in all industries, the key is to emphasize quality, which will, in the long term, reduce total cost.

What does "Quality" Mean in the Space Industry?

It's a shame that the word "quality" evokes such distaste in so many engineers! We tend to think of non-value-added tasks that slow things down, that unreasonable Quality Policeperson we can't hide from, or the mounds of documentation we had to generate in order to get certified for ISO 9000. But these requirements and people are there only because we haven't accepted that quality is our job, everyone's job. As a result, our processes—the ways we go about our jobs—are full of pitfalls that could cause the mission to fail or someone to die. Thus, because we haven't taken appropriate actions ourselves, we have standards, audit teams, and the quality police.

So, what is "quality," anyway? To answer that, let's look at how the recognized quality gurus have defined it. Note that they don't quite agree:

"Conformance to requirements"

—Philip Crosby, former Martin Marietta employee and author of *Quality is Free*

"Fitness for use"

—Joseph Juran, founder of the Juran Institute

"What the buyer says it is"

—Armand Feigenbaum, former top quality expert at General Electric

"Just to have the customer satisfied is not enough. Just to meet specifications… no. That won't keep you in business. … You need customers that boast about your product."[2]

—W. Edwards Deming, the man who taught quality to the Japanese in the 1950's and to the American auto industry in the 1980's

We'll let the experts fight it out regarding the proper definition, but I think the above captures the essence. It's fair to assume that a *quality product* (a condensed way of saying "high-quality product") is one that does what it's supposed to do. Overall, though, in the space industry, *quality* really boils down to two things:

- a successful mission
- and a satisfied customer

You might argue that all we need is the first part of that definition, but a closer look tells otherwise. There are countless examples of prime contractors delivering successful missions but also incurring the wrath of their customers. Maybe they spent too much of the customer's money or missed the intended launch date, or perhaps they treated their customer with arrogance or disdain or failed to keep their customer informed.

We *measure* quality at our organization by two things: (1) percentage of successful missions (or working products) and (2) how willing our customers are to work with us again. And we *improve* quality by increasing the likelihood of success in these two areas.

Understanding quality at such a high level is imperative. Everything could be built to print, with perfect conformance to requirements, but if the mission is unsuccessful—or if our customer never wants to work with us again—then we had poor quality. When we look at it like this, we see that quality is the job of anyone on the program who does work that could influence whether the mission will be successful, who interfaces with customer representatives, or who otherwise contributes to cost by being on the payroll. In other words, quality is the job of everyone on the program.

But, even if all the people on the program carry out their assignments perfectly, an organization still can have poor quality. Diligence is crucial, but it's not enough. The system used to develop products at your organization must also be effective. As Deming said, only management can change this system. Doing so in the right direction starts with the right attitude.

It's common knowledge that Americans helped Japan get back on its feet after World War II and taught them how to build quality products. Deming may have had the most influence, but he wasn't the first. The effort began in response to a request by General Douglas MacArthur, who was leading the post-war occupation of Japan. MacArthur wanted every town and village to have working radios so everyone could hear his orders

[2] As quoted in *The Deming Management Method*, by Mary Walton, 1986, The Putnam Publishing Group

and the news he wanted them to hear, but he couldn't find a Japanese manufacturer who could build reliable radios. So he sent for Americans who could teach them how.

Homer Sarasohn and Charles Protzman were two of the first to come to Japan in response. They developed and taught courses on how to manage a factory, and they found it was not easy to communicate the concept of quality. They decided to use as an example the company motto of the Newport News Shipbuilding and Drydock Company, written by company founder, Collis P. Huntington, who was one of the tycoons who had earlier built the transcontinental railroad:

"We shall build good ships here;

at a profit if we can, at a loss if we must,
but always good ships."[3]

This motto is just as relevant today. You can imagine how leadership such as that can lift everyone within an organization. That attitude flows down to all levels, which is where we want it to go. Personal responsibility and commitment on the part of everyone involved are, after all, essential ingredients to success in complex endeavors.

I still remember vividly, as a young stress analyst at Martin Marietta Astronautics in 1980, my supervisor preparing me to sign an engineering drawing for the first time. He was a grizzled stress man nearing retirement. We were supporting the design of the Manned Maneuvering Unit, which would be carried as a payload on the Shuttle. I asked for guidance, and he looked me straight in the eye, pointed his finger at me, and said, "Sarafin, when you sign out that drawing, you'd better be willing to swing from that structure over a den of alligators!"

Managing Risk Responsibly

It may appear that I'm advocating a philosophy of accepting no risk, which of course would drive cost through the roof. Actually I'm not. I'm laying the groundwork for the other principles: first must come the right attitude. Having the right attitude regarding risk means that we accept risk only if we understand it well enough to know we're doing the right thing (Principle #9).

Fresh out of school, we are not able to weigh risks intelligently. It's best to have us thinking of alligators until we understand things better. As we learn through practical experience (as opposed to sitting at a computer, which, if we do all the time, will ensure we never learn)[4], we become better armed to identify risks that we would be wise to accept. It's not that we're losing the right attitude or "selling out;" it's that we begin to see how some things that could go wrong are so unlikely that we shouldn't spend someone's money trying to prevent them. Remember, quality is also about giving the customer a fair price.

What we must resist is accepting risks we don't truly understand. A response such as this to a raised issue—"I understand there is a risk, but I'm willing to accept it."—is not appropriate. If that is all you understand about the risk, it would be irresponsible to accept it!

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[3] The motto, as well as the story of General MacArthur, Homer Sarasohn, and Charles Protzman, were taken from the book *Quality or Else: The Revolution in World Business*, by Lloyd Dobyns and Clare Crawford-Mason, 1991

[4] In a class I taught at a major space company, I overheard one participant ask a senior-looking fellow how many years experience he had. The answer: "One year experience … twenty seven times!"

To understand a risk, you must know the consequence of failure and be able to estimate the probability of failure. Doing the latter requires a thorough understanding of the problem. Recognizing that only through such understanding can we accept risks responsibly, we see that risk-making decisions must be made by knowledgeable engineers, or managers with broad, strong engineering backgrounds, rather than managers who are not technically inclined. We cannot recruit our decision-makers from nontechnical fields and nonaerospace industries. Our decision-makers must thoroughly understand the process and the issues. Acquiring this understanding—which is part of what Deming referred to as "profound knowledge"—is something we must strive for continuously (Principle #2). This will be the subject of my next article.

About the Author

Tom Sarafin has been involved in the space industry full time since 1979, at which time he graduated from The Ohio State University with a BS in civil engineering and took a job as a stress analyst at Martin Marietta Astronautics in Denver, Colorado. While at Martin, he was involved with design, analysis, verification planning, and testing on several spacecraft and launch vehicle programs. After contributing to the book *Space Mission Analysis and Design* [Larson and Wertz, editors, first edition published in 1991], he obtained management's support and funding at Martin Marietta for the development of a book on the interdisciplinary development of structures for space missions, and served as principal author and editor for 23 other authors. He left Martin Marietta in 1993 to complete this book, under the guidance of Dr. Wiley Larson at the U.S. Air Force Academy. The result of nearly four years work—*Spacecraft Structures and Mechanisms: From Concept to Launch*—was published in 1995 jointly by Microcosm, Inc., and Kluwer Academic Publishers.

In 1993, Mr. Sarafin formed his own company, Instar Engineering and Consulting, Inc. Once he finished his book, he began providing review and advice as a consultant to space programs. He also developed a short course based on his book and began teaching it throughout the industry. The course has been quite popular, and the business has grown. Now Instar offers a curriculum of courses taught by experienced engineers and continues to add to that curriculum.

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