LEARNING FROM SPACE ENTREPRENEURS

BY WILLIAM POMERANTZ

On October 4, 2004, Brian Binnie piloted SpaceShipOne above 100 km, marking the third time ever—and the second time in as many weeks—that a civilian astronaut had taken a privately built craft to outer space. In doing so, Binnie and SpaceShipOne captured the $10 million Ansari X PRIZE for Mojave Aerospace Ventures—a small, cutting-edge private enterprise led by legendary aerospace designer Burt Rutan and financed by Microsoft co-founder Paul Allen. Amazingly, this small team, operating only for a short amount of time and spending an incredibly small amount of money, had joined the United States, the USSR/Russia, and China in the exclusive ranks of human space flight powers.

Pixel, a rocket designed, tested, and flown by Armadillo Aerospace in less than six months, flies at the 2006 X PRIZE Cup. The vehicle broke several world records but failed to win the Northrop Grumman Lunar Lander Challenge.

Photo Credit: X PRIZE Foundation

THEY OFTEN GO FROM DRAWING ON THE BACK OF A NAPKIN TO FIRING ENGINES OR EVEN FLYING VEHICLES IN A MATTER OF WEEKS OR MONTHS, LEARNING VALUABLE LESSONS ALONG THE WAY.

Prizes like the Ansari X PRIZE and later efforts like the NASA-funded Northrop Grumman Lunar Lander Challenge and the recently announced $30 million Google Lunar X PRIZE exist to focus public attention and apply innovative new ideas to targeted technical problems. Many of the new ideas are elegant technical solutions, like Burt Rutan's use of feathered wings on SpaceShipOne. Equally, if not more, important are the innovative program management practices that come into play when extremely small and motivated teams put their own money on the line to win a prize. Just as SpaceShipOne is not a replacement for the Space Shuttle or other governmental human space flight programs, prizes like those offered by the nonprofit X PRIZE Foundation will not, and likely cannot, replace government design, development, or procurement methods. But just as SpaceShipOne and its counterparts in the private sector can provide effective lessons and practical applications for government programs, so too can program mangers at NASA and other government agencies take important cues from the teams competing for prizes.

In my two and a half years at the X PRIZE Foundation, I've had the enormous pleasure of working with several such teams. The experience gives me a front-row seat from which to observe breathtaking innovation. The individuals and groups that are attracted to these prize competitions are a particularly fascinating subset of the human species: passionate, strong-willed, risk-taking, and imaginative.

The space industry would benefit from the involvement and enthusiasm of any one of this new class of steely-eyed missile men and women. On their own initiative and with their own funding, these pioneers put an enormous variety of concepts through the tests needed to expose each as a useful tool or a dead end.

With one of our space prizes successfully claimed, another—the Lunar Lander Challenge—just shy of being won, and the Google Lunar X PRIZE recently announced, we can already begin to look at the progress of the teams and draw important conclusions. I won't presume to call them "lessons learned" as the lessons from each still need to permeate the industry and inform decision making across the sector. Instead, I think the struggles of each team have revealed some important lessons that we need to learn.

Build, Test, Fly, Destroy, Repeat

The early days of rocketry and space exploration in the United States were marked by incredibly rapid progress: a seemingly endless parade of firsts. Not coincidentally, this period also saw more than its fair share of failure, especially in the infamous "kaputnik" days prior to the successful launch of Explorer. Without a standard canon of known quantities to turn to, the early pioneers of rocketry and space flight were forced to dream up new ideas that ranged from the elegant to the bizarre and to accept the fact that the price of radical progress is occasional failure.

Nowadays, rapid prototyping and testing have slowed, as we rely more and more on the extensive knowledge gained by our predecessors and on the embarrassment of riches modern engineers get from computational modeling and computer-assisted design. In many cases, this leads to much improved or phenomenally more efficient designs. It also, however, fosters a culture so terrified of failure that we over-engineer and overanalyze everything, often tweaking designs for decades before a new system takes flight. (This is not a problem unique to rockets; the same phenomenon seems to have occurred in high-performance jets.) This is one reason why it was possible for President Kennedy to dream of the completion of the Mercury and Gemini missions and a successful landing on the moon in under a decade, while returning to the moon may take nearly twice as long.

Lacking access to the tremendous computational resources of the national space program—and, just as importantly, removed from the harsh judgment of public shareholders or congressional appropriations committees—the hungry entrepreneurs who

Photo Credit: X PRIZE Foundation

High above the Mojave desert, White Knight carries SpaceShipOne aloft for the first of its two Ansari X PRIZE–winning flights.

compete for our prizes tend not to display such fear of failure. Instead, most of them follow a rapid "build, test, fly" program. They are willing to throw a handful of concepts against the wall and see what sticks. They often go from drawing on the back of a napkin to firing engines or even flying vehicles in a matter of weeks or months, learning valuable lessons along the way. Indeed, our teams have repeatedly learned many of the most valuable lessons after only a few moments of working with real hardware—lessons that could never have been learned from a CAD drawing, like finding the failure modes of different welding practices or tracking down the interference between an onboard camera and a GPS unit. As Paul Breed, the leader of a Northrop Grumman Lunar Lander Challenge team (playfully called Unreasonable Rocket), is fond of saying, "In computer simulations the plumbing never leaks. In real life, it always does."

"Not Invented Here" Leads to "Not Invented"

Aerospace engineers and professionals from other disciplines involved in this sector may be endowed with above-average intelligence—after all, what they do *is* rocket science. But they are still human and still liable to succumb to vanity and pride. This can lead to a variety of actions that, while understandable, slow progress. All too often, members of this industry ignore solutions provided by other sectors of the industry owing to ignorance of those solutions, mistrust of their quality, or a simple desire to promote their own handiwork over that of others.

Though there are exceptions, the new class of entrepreneurial companies that compete for our prizes have thrown "not invented here" out the window. Given that they directly compete for millions of dollars in prize money and usually wager their personal fortunes to fund their entries, one would expect them to guard their own products and ideas jealously, limiting the exchange of ideas.

Instead, though, our teams consistently advise their competitors or distribute labor when teams share common requirements. Many of the contestants in the Northrop Grumman Lunar Lander Challenge, for example, use a public e-mail list called aRocket to share test information on everything from onboard cameras or guidance systems to specific parts or propellant combinations to the complex and detailed mathematics required to, say, characterize the moment of inertia of their rockets. The "build, test, fly" strategy these teams follow generally leads to a lot of new systems being tested to the point of failure; oftentimes, a team posts test results to this public list within the hour, inviting others to share in the analysis and benefit from their results.

Similarly, most of our teams have, by necessity, vigorously pursued commercial off-the-shelf products. Lacking the time, budget, or facilities to reinvent the wheel, they scour scrap yards, commercials retailers, and even their fellow teams' shops for parts that can be slotted into their design. They also show a refreshing willingness to look outside the aerospace industry for solutions. Teams have used off-the-shelf products like irrigation tubing or automotive parts as the basis for important components of their vehicles. Parts and systems slated to go into high-performance racing cars or mass produced for consumers have gone through impeccable design and quality assurance processes and offer economies of scale never before seen in the commercial rocket industry. The massive catalog of a universal industrial parts supplier like McMaster-Carr, whose Web page is bursting with valves, piping, and other parts, practically makes these rocketeers giddy. After all, says Breed, the manufacture of rockets boils down to "just tanks and plumbing."

Size Matters

NASA and the traditional aerospace contractors generally work in teams that number in the hundreds, if not the thousands. Since the days of Kelly Johnson's Skunk Works, though, the industry has recognized the advantage of small groups of exceptionally talented engineers working with minimal oversight.

Regardless of how intelligent and innovative a manager is, it seems unlikely that any group of hundreds of contributors

Speed Up, a team in the $2 million Northrop Grumman Lunar Lander Challenge, watches the show at the 2007 X PRIZE Cup.

Photo Credit: X PRIZE Foundation

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could ever function as efficiently as a group like Armadillo Aerospace—eight close friends who have worked side by side for years and can practically finish each other's sentences. Such a group can spend most of its time on engineering or production, and little in meetings or coordinating labor.

There Is No Substitute for Passion

Working with teams seeking these prizes, I am struck by one almost overwhelming advantage they have over many traditional aerospace workers: incredible passion. For many of them, the prize entries are the fulfillment of lifelong dreams. Their vehicles are their hobbies, their keys to wealth, and their children, all wrapped into one. Team members as a rule cannot stop talking about their entries—and cannot stop working on them. They dream about their rockets. They talk to their friends and coworkers about them. They blog about them. They happily give up weekends and use up vacation days to find even more time to work. "We're standing on the threshold of a dream," says Neil Milburn, vice president of Armadillo Aerospace. There is not a 9-to-5 worker among them. Of course, NASA has its fair share of motivated employees as well. But the commitment of these entrepreneurs, with so much of their personal lives wrapped up in their projects, borders on obsession.

Some of this enthusiasm and passion comes from the lofty goals of the prize requirements; some, no doubt, comes from the thrill of competition. But I suspect their unbridled obsession comes mainly from the high degree of personal involvement and ownership each team member feels. In an era when the smaller aerospace boutiques of the 1960s have merged into a few massive corporate giants, it is too easy for engineers, especially younger engineers, to feel like a small cog in a massive machine. On teams that often number ten or fewer, the people competing for our prizes are all constantly aware of how critical they are to their teams. They are intensely and deservedly proud of this and work on their machines as though their lives depended on it. Their confidence in themselves frees them to borrow solutions from others and leads to progress at incredible speeds.

We're Entrepreneurial Space, and We're Here to Help

The creative, small, privately funded groups that find themselves called to our competitions possess, by necessity, a number of advantages that allow them to function on infinitesimal budgets, by industry standards. Many of these advantages are probably impossible to translate to efforts being undertaken by the traditional members of the aerospace community. The good news is that, despite the occasional playful bravado of some of the more colorful characters involved in these competitions, all our teams are die-hard supporters of a robust space exploration program and will gladly do their parts. As such, they can function as highly specialized components of the greater aerospace workforce. These small, innovative teams can quickly and cheaply provide services to their larger brethren. Whether it is a Northrop Grumman Lunar Lander Challenge team providing a flying platform capable of carrying experimental sensors on dozens of flights a week, or Ansari X PRIZE competitors carrying scientific payloads and their human operators into the blackness of space, or the eventual Google Lunar X PRIZE winners testing systems and returning data that will support NASA's return to the moon, the entrepreneurial community is poised to help the national space program like never before. ●

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