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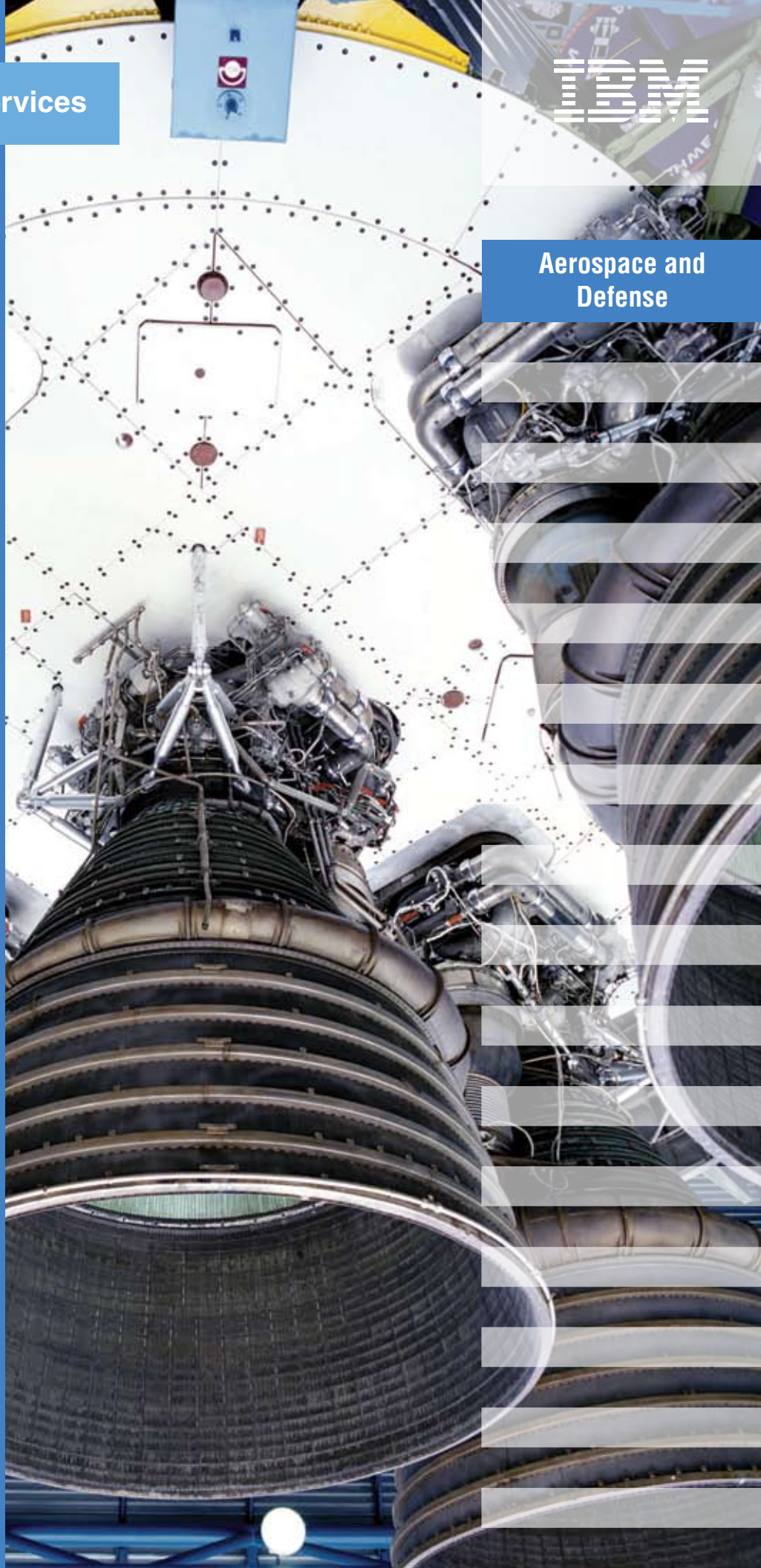
Pioneering programs

Accelerating the pace to space



Aerospace and Defense

IBM Institute for Business Value

IBM Business Consulting Services, through the IBM Institute for Business Value, develops fact-based strategic insights for senior business executives around critical industry-specific and cross-industry issues. This executive brief is based on an in-depth study by the Institute's research team. It is part of an ongoing commitment by IBM Business Consulting Services to provide analysis and viewpoints that help companies realize business value. You may contact the authors or send an e-mail to iibv@us.ibm.com for more information.

Pioneering programs

Accelerating the pace to space

Executive summary

Captivated by Neil Armstrong's dramatic moon walk, children of the 1970s often imagined piloting their own spaceship or living on another planet. For individuals who followed those visions professionally, the dreams may have lost some of their luster over time, bogged down in the everyday challenge of designing spacecraft and managing programs that have now become main stream. Governmental bureaucracy, complex technical requirements and regulatory oversight have forced many in the space industry to accept a slower pace and a narrower scope of innovation possibilities.

Yet some space pioneers are belying the complex and cumbersome characteristics that many believe are inherent in the industry. Their stories prove that innovation and speed-to-market are possible, even with a small budget. Quite simply, these pioneers are doing it – refuting prevailing "wisdom" with each successful launch.

Though they vary in size, industry segment and origin, these pioneers demonstrate tremendous similarity in four areas:

- *Safety* – They work aggressively to identify, track, monitor and mitigate risks. The prevailing attitude is "never make the same mistake twice."
- *Simplicity* – The pioneers avoid over-engineered processes, technology and systems, favoring simple solutions instead.
- *Reuse* – Leveraging proven technology already vetted in other space programs, other business units or even other industries allows the pioneers to move faster and achieve higher levels of reliability.
- *Focus* – Perhaps the most prominent trait among these pioneers is the intensity of their focus. They are passionate about success, and tenacious about achieving it.

Their strategies and practices suggest several actions for counterparts throughout the industry:

- *Develop capabilities, not RFP responses*. Build a better balance between self-funded programs and programs tied to specific RFPs.
- *Stop ignoring low-tech innovation.* Simplify design, operations and business processes wherever possible.
- *Focus on reuse.* Remember that reusable ideas may come from outside the aerospace industry.
- *Foster a startup mentality.* Find ways to encourage creativity and facilitate nimble responses.
- *Break up the monolith.* Divide the organization into smaller components that can move more quickly.
- *Strengthen the ability to share intellectual capital.* Eliminate barriers that prevent sharing across operating units – and expand external collaboration capabilities.

Despite the inherent complexities of space travel, low-cost innovation and speed-to-market are happening today. To make that the norm, established companies may need to take cues from the pioneers that are doing it.

Why study the pioneers?

Prior studies within IBM Business Consulting Services and the IBM Institute for Business Value have shown that executives are depending on new and differentiated products and services as a primary source of growth. Like their peers in other industries, aerospace and defense executives agree that innovation and speed-to-market can provide needed differentiation – but they are not so sure those differentiators are actually possible in their industry.

To find evidence to the contrary, the IBM Institute for Business Value launched a research study to identify and analyze pioneering programs in the space industry. We picked pioneers that were challenging the historically static view of what is possible in space: companies that were targeting commercial revenue opportunities in both low earth orbit (LEO) and high earth orbit (HEO). The pioneers selected also had an unwavering commitment to achieving exceptional performance. To offer useful insight, their actions and results had to prove that speed-to-market was possible, even in the safety-conscious, heavily regulated space industry, and that innovation was feasible, even on a budget. In short, they had to be credible contenders, not delusional optimists.

Filtered by these stiff criteria, we winnowed the list to four specific programs:

- Scaled Composites' SpaceShipOne
- The Space X Falcon
- China's Shenzhou space program
- ATK's boost-to-cruise program.

Although these pioneers may differ from the rest of the industry in terms of size, industry segment and history, they can provide helpful insights to companies seeking innovation and speed-to-market.

"We will never compete successfully with the giants in our industry by approaching solutions in the same manner as they do. They'll beat us every time." – *Dan Murphy, CEO, ATK*[1]

SpaceShipOne

Scaled Composites is on a journey to make space travel a more routine occurrence in the private sector. Like traditional space programs, their endeavor has been divided into several generations, which the company refers to as "tiers." The program's tier one spacecraft – SpaceShipOne – launched the first private manned space flight on June 21, 2004, opening space to commercial pioneers.

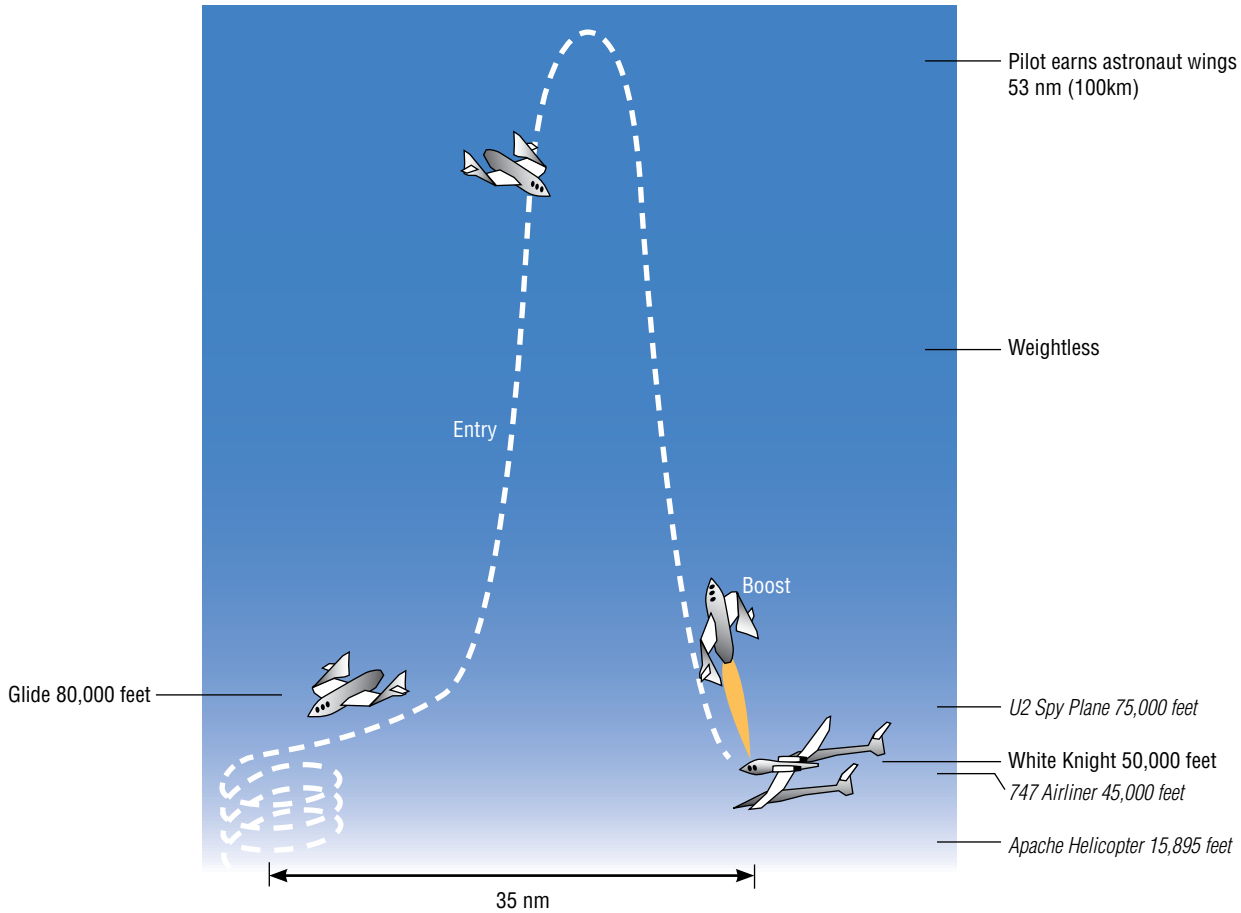
The spaceship is designed for suborbital human spaceflight using a reusable spacecraft and a launch vehicle dubbed WhiteKnight (see Figure 1). The program is focused on providing a comfortable environment that is conducive to civilian space travel, with all the complexities and sophistication that entails. Based on studies of the public's willingness to pay, analysts expect this new market to produce revenues in excess of US$700 million by 2021.[2]

Source: Scaled Composites. Used with permission.

At present, the company has 135 employees, and Hoovers estimates annual sales for this privately held company at a very conservative US$9.7 million.[3] While the first generation of the program, SpaceShipOne, was privately funded by investor Paul Allen, three companies are linking together to commercialize the next generation (called SpaceShipTwo and WhiteKnightTwo). In this venture, Scaled Composites is responsible for the design and flight testing of the new vehicles. Mojave Aerospace Ventures – a firm established by Mr. Allen – controls the intellectual property created in the initial program. And stepping in as the interface to the paying public, Sir Richard Branson has signed an agreement with Burt Rutan to form The Spaceship Company that will manufacture and market the vehicles to spaceline operators including Virgin Galactic.

"Ultimately, a passenger's ticket price for a suborbital spree will come down after several hundred people have flown… in 1990, a T-1 connection to the Internet cost $1 million a year. Now the equivalent service is $19.99 a month."[4]

Figure 1. SpaceShipOne flight profile.



Source: Scaled Composites. Used with permission.

What makes this program remarkable

Several factors make the SpaceShipOne program exceptional:

- *Phenomenal speed at nominal cost.* The SpaceShipOne program progressed from discussing the concept on Microsoft® PowerPoint slides to winning the Ansari X prize in just three and a half years. The winning flights had to include the equivalent weight of three passengers, and the program had to launch a subsequent flight within two weeks to demonstrate reusability. The team had only four powered flights before the X prize event. And the entire space program was built with a budget of US$25 million.
- *Designed for commercial – not just technological – viability.* Although the design did include technological innovations such as its signature "feather" reentry configuration, the team was equally concerned with its long-term business goal of commercial space travel. Requiring a tourist to don a bulky space suit would have tarnished the grand idea of routine civilian space travel. With commercialization top of mind, the program took great care to produce a design that would feel comfortable to its target passengers.
- *Included the full equation.* SpaceShipOne was a full-fledged program with all of the integration, scheduling, simulation and training required of a traditional counterpart; it was not built by two guys in their garage. It did, however, accomplish this full scope of effort on an intensely compressed timetable with a much smaller budget.

What made the difference

How was SpaceShipOne able to achieve such remarkable results? We believe the program's success can be traced back to a few distinguishing factors. First, the team – empowered by the entrepreneurial spirit of both its founder and investor – was willing to take risks and experiment with new approaches. For instance, in their design, the engineering team used scuba bottles for pressure actuators. Though certainly unconventional, the designers were convinced that this proven part from a totally different industry could fulfill the function and reliability requirements at a fraction of the cost.

Second, the program avoided complexity in all areas. To this team, it was not a matter of reducing or simplifying complexity, but preventing it in the first place. Among the group, they often commented that the optimum system was the one they never installed. For the sake of reliability and their finite budgets, they fought constantly against over-engineered components and processes, keeping the design and operation as simple and low weight as possible.

Finally, this program benefited from an external motivator. The competitive environment created by the X prize event helped propel the SpaceShipOne team through the inevitable slowdowns and obstacles that every program faces. With the promise of worldwide recognition (and a cash prize of US$10 million), the event created a sense of urgency that pushed the team to extraordinary levels of performance.

The Space X Falcon

Space X was created in 2002 by Elon Musk, who also founded PayPal, Inc., the leading electronic payment company, which he subsequently sold to online auctioneer eBay for US$1.5 billion in October 2002.

The Falcon program is centered on a family of launch vehicles, namely the Falcon 1, 5 and 9, that are designed to deliver various payload sizes into virtually any inclination and altitude, from low earth orbit to geosynchronous orbit to planetary missions. The program has two primary goals – which industry doubters may view as mutually exclusive:

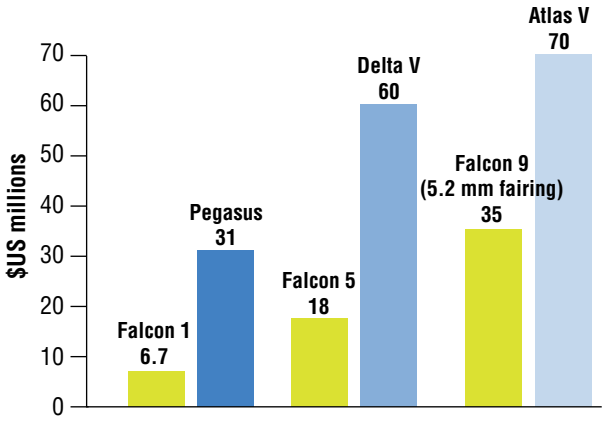
- Achieve highest level of design reliability
- Reduce cost by a factor of ten.

The maiden launch for Falcon 1 is expected to occur in the fourth quarter of 2005, carrying the FalconSat-2, a US Air Force Academy satellite that measures space plasma phenomena. The program's launch manifest for the future includes a variety of commercial and military customers – such as the US Department of Defense, the Malaysian Astronautic Technology, Sdn. Bhd. (ATSB) and Bigelow Aerospace.

Source: Space X. Used with permission.

They have kept overhead low with a flat management structure. With a clean-sheet design focused purely on reliability and cost, they have substantially reduced traditional sources of expense. For example, in the area of avionics, the designers opted to use the same kind of computer used in automated teller machines that costs US$5,000 versus the typical industry-specific computer which could total as much as US$1 million.[5] Automation has helped keep the launch crew small; attachment and fairing encapsulation can be completed in less than 24 hours.

Figure 2. Costs associated with current fleet of launch vehicles.



Source: IBM Institute for Business Value analysis.
Note: Falcon totals include some operational costs.

What makes this program remarkable

The Falcon program stands out for several interrelated reasons:

- *Drastically lower costs.* Space X is committed to reducing the structural costs associated with space travel without sacrificing innovation, reliability or safety. For instance, Falcon 5 will be a fully reusable launch vehicle with a price per launch that is less than a third of a typical competitor's cost – US$18M (see Figure 2). The idea is to be the "Honda Civic" of space – inexpensive and immensely reliable.

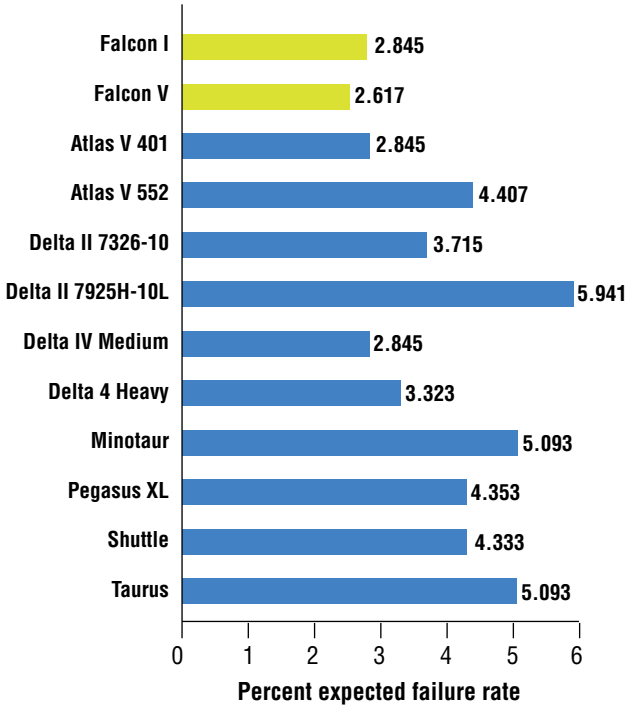
"If you look at something like a Ferrari, that's a real expensive car. But it's not reliable…But I guarantee you, if you went out and bought your basic Chevy or a Honda Civic or something like that, your odds are 1,000 to 1 that sucker doesn't break down the first year you own it. And it's not expensive."

– Elon Musk, Founder and CEO, Space X[6]

- *Increased reliability despite lower costs.* The objective of the Falcon program is to increase reliability at the design level, before testing ever begins. The spacecraft is designed to have only one stage separation event, reducing the possibility of failure. It has no strap-on boosters, and bolts are dual initiated. In the avionics area, the vehicle has triple-redundant flight computers, inertial navigation and GPS overlay capabilities. The Falcon is designed with one engine per stage, with the Falcon 5 designed to sustain one engine failure without loss of performance.

  Based on historical averages of subsystem failures, analysts expect failure rates for this family of launch vehicles to be much lower than the industry norm (see Figure 3).

Figure 3. Expected failure rates due to all causes based on historical average subsystem failures.



Source: Futron Corporation. "Design Reliability Comparison for SpaceX Falcon Vehicles." November 2004, http://www.spacex.com/FutronDesignReliability.pdf

- *Speed-to-market without higher cost.* Space X believes that bringing innovation to market quickly does not necessarily dictate a higher price tag. The Falcon 9 (5.2mm fairing), for instance, is expected to be developed in just two years and will be priced at US$35 million.

What made the difference

How is the Falcon program positioning itself for success? From founder to launch crew, Space X has an intense focus on finding low cost alternatives. For example, Falcon designers elected to use highly reliable industrial actuators which cost US$50,000 versus the standard aerospace version at five times the price. They purposely avoid costly aerospace conventions – not only in their choice of parts, but also their business and operational processes. The vehicle is run on a 21st century "Ethernet" design – run on a single cable versus the typical 1960s design of large, serial cable bundles.[7]

The company's competitive attitude also has a subtle distinction; it is in relentless pursuit of the *opportunity,* not the *competition*. Instead of wrangling market share away from the giants, Space X is attempting to expand the market, creating more opportunity for everyone, particularly itself. With the Falcon program, the firm sees revenue opportunities beyond military and government payloads and traditional commercial launches like satellites; it envisions missions like transporting supplies or performing regular maintenance and repair activities in support of inhabited space environments.

"NASA is conducting a study that examines handing off chores such as supplying the International Space Station to private industry once the space shuttle is retired in 2010."

– Michael Braukus, NASA, Public Affairs[8]

China's Shenzhou space program

In April 1992, China authorized the commencement of its manned space program. In October 2003, the Shenzhou 5 orbited the earth 14 times with Mr. Yan Liwei onboard, making China the third nation in the world to send a man into space. The program's future plans include launching a space laboratory in 2008 (see Figure 4).[9]

The program has far-reaching goals – some of which stretch well beyond typical national objectives:

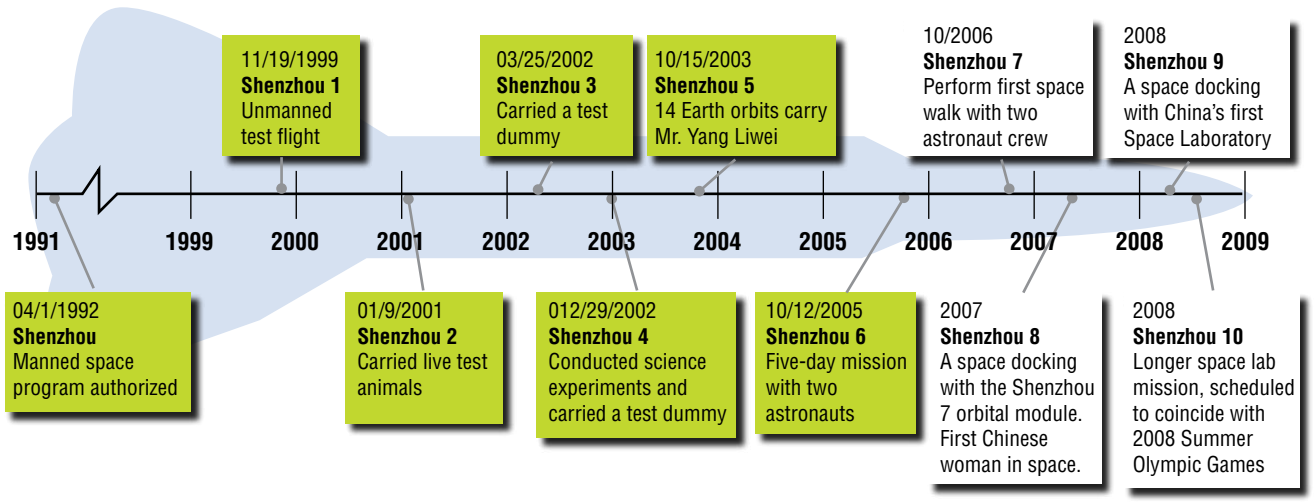
- Increase national prestige
- Improve military reconnaissance and communications
- Position China as a low-cost satellite launcher
- Lead mankind's journey to Mars.[10]

What makes this program remarkable

In every sense of the word, the Shenzhou program is pioneering for Asia, positioning China as one of the world's superpowers in space. The program has several notable distinctions:

- *Rapid replication of success.* With the Shenzhou program, China achieved manned space flight in just over a decade. Already, its rocket launch success is comparable with other programs around the world. As of 2003, the success rate of China's rocket march is up to 91 percent, compared with 94 percent for the US's Delta, 93 percent for the European Space Agency's Ariane 5 and 90 percent for Russia's Kosmos.[11] With this sort of momentum and the ability to replicate private sector advances as they emerge, China could push ahead of other national government programs.
- *Commercially competitive.* Unlike other national space programs, Shenzhou is actively seeking money-making opportunities. Similar to its reputation in the manufacturing arena, China may prove to be a very attractive, low-cost alternative for launch capability. With each successful mission, it encroaches on a competitive playing field that has historically been dominated by the private sector.
- *Mining the universe.* The Shenzhou program intends to investigate and find ways to use the resources of space – particularly Mars via the moon. While other

Figure 4. Shenzhou space program – history and future plans.



Source: IBM Institute for Business Value analysis.

programs may have ignored or dismissed these possibilities, Shenzhou is taking them seriously. Pioneering research in this area will likely open many debates about ownership and rights to resources beyond planet earth. [12]

What made the difference

How has the Shenzhou program achieved such remarkable results? For the Chinese, Shenzhou was a matter of national pride. Failure was simply not an option. They were committed to being recognized as a world leader in space exploration, just as they are in so many other areas. This tight connection with patriotism is clearly evident even in the program's name: Shenzhou means "sacred vessel" and is pronounced the same as the holy name of China.

At the launchpad of Shenzhou VI, Premier Wen Jiabao encouraged astronauts Fei and Nie to "accomplish the glorious and sacred mission" and to demonstrate that the Chinese people had "the will, confidence and capability to mount scientific peaks ceaselessly." [13]

But perhaps most critical to Shenzhou's success was the team's ability to leverage existing technology. Instead of inventing everything anew, they concentrated on starting with the current state-of-the-art and finding ways to improve it.

ATK's boost-to-cruise program

Unlike the other entrepreneurial companies studied, ATK was created in 1990 as a spin-off of Honeywell's defense business. ATK is a moderate-sized company, with revenues of US$3 billion. Through numerous acquisitions, it has grown into one of the world's most prominent providers of advanced weapons and space systems, employing approximately 14,500 people in 23 states.

In particular, we analyzed ATK's boost-to-cruise missile program, which is an internally funded effort – not part of a government or military contract. With this program, ATK intends to plug an industry capability gap – the ability to deliver a 250 pound payload 600 nautical miles in approximately ten minutes. Boost-to-cruise is focused on delivering a quick response missile system for a single operating point (Mach 5) using flight-tested technology already in production.

Source: ATK. Used with permission.

What makes this program remarkable

Both boost-to-cruise as a program and ATK as a company have distinctive accomplishments. The boost-to-cruise missile concept is expected to be demonstrated at relatively low cost.

As a company, ATK is a well-known and established enterprise that somehow manages to blend the best of both worlds – the flexibility of a startup and the experience of a legacy firm. Despite its origin as a spin-off, ATK has thrived by simplifying inherited and acquired complexity – while still leveraging its broad range of capabilities.

What made the difference

ATK's strategy has a number of distinguishing attributes that have helped produce extraordinary results with its boost-to-cruise program:

- *Fill a gap and develop a new market.* ATK has decided to proactively focus on known capability gaps in the marketplace, instead of waiting for formal requests for proposal. Developing outside the traditional procurement process has allowed a greater measure of flexibility and easier reuse of intellectual capital among programs. And boost-to-cruise is not the only one of its kind. ATK has five to eight other major projects underway where it is investing internal R&D funding to address anticipated business opportunities.
- *Focus on a single design point.* With boost-to-cruise, ATK concentrated only on the Mach 5 envelope. This singular focus allowed simpler designs that did not need to accommodate a large and diverse set of operating conditions. The simplified designs required less complex mechanics to achieve necessary performance levels.
- *Use what already works.* For boost-to-cruise and other similar internally funded projects, ATK is intent on starting with technology that has been flight-tested and already proven reliable. Integrating off-the-shelf functionality not only improves quality, but also enables faster product development.

"At ATK, we are taking what we already know to see what capability we get."

– Dr. Tony Castrogiovanni, Vice-President and General Manager ATK Missile Systems [14]

- *Weave a tight-knit fabric of capabilities.* Like its peers across the industry, ATK has a broad set of capabilities enhanced through acquisition. Unlike some of its peers, the company has not divided itself into separate parts to focus on commercial versus government programs, and it has fine-tuned its ability to collaborate and share intellectual capital among its operating units. For example, boost-to-cruise combined core competencies from several different acquisitions: ATK Thiokol provided the ability to take the vehicle to cruising speed on solid rocket fuel; ATK GASL brought hypersonic propulsion and air breathing systems; and ATK Spaces Systems and ATK Mission Research supplied high-temperature materials.

Profile of the pioneer

As we studied these four pioneering programs, we noticed several recurring patterns in how these organizations approached innovation and new product development. Despite the variety in size and mission among these programs, the pioneers had similar traits, including:

- Safety
- Simplicity
- Reuse
- Focus.

Safety

Although safety is a preeminent goal across the industry, it is absolutely crucial for a pioneering program. A major accident that involves injury or loss of life might halt a program suddenly. But even a minor incident could smother a program under an additional blanket of regulatory oversight that its budget and schedule could not bear.

These early pioneers often have fewer resources and less time to dedicate to repeated and exhaustive testing, making it absolutely critical for them to identify, track, monitor and mitigate risks aggressively. The prevailing attitude is "never make the same mistake twice." SpaceShipOne, for example, only had four powered test flights prior to its X prize event; yet, to be successful, it had to maintain the same safety standards as larger, better funded government programs.

"We made plenty of mistakes, just never the same one twice. We learned from our experience and moved on."

– Brian Binnie, SpaceShipOne Pilot [15]

Because every design review and test consumes scarce resources, these pioneers have fostered a culture where probing and questioning is treated as a positive response. Teams are anxious to surface potential problems early while they can be resolved quickly and less expensively. Even with "sensitive" topics that might impact relationships with peers or management, these pioneering teams have an innate belief that there is greater risk – to them personally and to the program itself – in choosing *not to ask* the difficult questions.

Simplicity

These pioneers have a maniacal focus on simplicity. They totally avoid over-engineered processes, technology and systems, favoring simple solutions instead. Frequently, they turn to unconventional options from other industries that provide the basic functionality with the necessary reliability. Though they were obviously breaking stride with many competitors, Falcon engineers knew that the simple industrial actuator they selected would satisfy the design requirements just as well as the more complex (and more expensive) aerospace version.

From the outset, these pioneers' design strategies and processes challenge complexity – the use of any heavily engineered, high-cost or vulnerable component requires extreme justification before it can be included. For instance, Scaled Composites routinely scrutinizes any item that might add weight to its design. This process forces an evaluation of other possible alternatives. With SpaceShipOne, they opted to make operational adjustments to avoid the extra weight of heavy avionics.

"We had a couple rules we followed: The most reliable system is the one you didn't install, and the lightest system is the one you didn't install. We avoided complexity wherever possible."

– Brian Binnie, SpaceShipOne Pilot [16]

Not only do the pioneers "punish" complexity, they also reward simplicity. These programs are quick to recognize the employees involved in their mutual success; their Web sites are plastered with biographical sketches and individual achievements. But generally, the greatest source of motivation seems to come from the intrinsic rewards their employees find in winning contracts and forging important client relationships.

Reuse

Leveraging proven technology already vetted in other space programs, other business units or even other industries allows the pioneers to move faster and achieve higher levels of reliability. Who would have thought an underwater component like a scuba bottle could fulfill a similar need in space? But the engineers designing SpaceShipOne knew it was reliable and much less expensive – and it solved the problem.

Where new components must be developed, pioneers design with future reusability in mind. And they reward creation of highly reusable and reliable components and systems. Despite the industry's historical tendency toward building disposable launch capabilities and program-specific technology, the products developed by the pioneers we studied are planned specifically for reuse.

Focus

Perhaps the most prominent trait among these pioneers is the intensity of their focus. Both the programs themselves and the people involved keep the end goal in mind at all times. They are passionate about success – and tenacious about achieving it.

To instill that sense of focus, each program had a unifying and inspiring objective that the entire team rallied behind: win the X prize, be the Honda Civic of space travel, do our patriotic duty, build with what we have.

Despite seemingly insurmountable regulatory hurdles and market entry challenges, these pioneers are not easily dissuaded. For instance, the SpaceShipOne program struggles with regulatory requirements that are not applicable to its launch approach. Boxed into the traditional ground-based launch category, the team must negotiate numerous exceptions because of its unique mid-air launch design.

These pioneers are unwilling to take "no" for an answer – frequently having to fight to be considered and sometimes having to fight to be understood. In one instance, ATK was challenged during a competitive bidding process because its proposal was too expensive. The company eventually discovered that the bid evaluators had "added on" the cost of a traditional (and very expensive) component they believed ATK had omitted from the design and the pricing. Through its persistence, ATK finally convinced the customer that the component was unnecessary with its design – and eventually won the contract. With the Falcon program, Space X CEO Elon Musk has faced a variety of market-entry battles. He must spend time fighting for the right to compete, in addition to fully managing product development.

The focus and sheer tenacity of these pioneering teams is a key determinant of their success.

Lessons for the industry at large

Within the space industry, we anticipate that the future competitive playing field will look much different than it does today. Instead of competing against a homogenous group of peers, established firms might face national programs with ready access to low-cost development and operational capabilities or collaborative consortiums of smaller, faster niche players. How firms compete may change as well. Governments may fundamentally alter how they buy products and services – eliminating program-driven initiatives or outsourcing the responsibility for supplying particular capabilities to best-in-class providers. Although governments monopolize firms' client base today, the future client set may be more diversified – catering to academic researchers, commercial scientists or even consumers.

To remain competitive amid a changing environment, companies need to find ways to reduce structural costs and act more nimbly. The primary tool for achieving these goals will be simplicity. Executives must encourage simplicity across every dimension of their business – organizationally, technically and operationally. Cues from the pioneers suggest that companies should:

- *Develop capabilities, not RFP responses.* Build a better balance between self-funded programs and programs tied to specific RFPs. Developing products outside the traditional procurement realm provides a broader range for creativity and helps build a reputation for expertise in a particular field.

- *Stop ignoring low-tech innovation.* Most of the innovation created through these programs was achieved through simplification or substitution of a less expensive or less complex part or assembly – not through the addition of new or more advanced technology. Also, low-tech innovation is not limited to the spacecraft itself – it applies to business processes as well.
- *Focus on reuse.* This is often a corollary to low-tech innovation. Remember that reusable ideas could also come from outside the aerospace industry. When invention is required, the new design should center on reusability for the future.
- *Foster a startup mentality.* Find ways to encourage creativity and facilitate nimble responses. Though inherent in entrepreneurial endeavors, agility is a steeper challenge for established firms.
- *Break up the monolith.* Divide the organization into smaller components that can move more quickly. For some, size has become an inhibitor, creating a "we can do it all ourselves" mentality that blocks external collaboration and new ideas.
- *Strengthen the ability to share intellectual capital.* Eliminate barriers that prevent sharing across operating units – and expand external collaboration capabilities. Open standards and platforms, for example, can help facilitate this exchange.

Fifteen years ago, the major US airlines probably thought they would be dominating their industry today. However, four of them are now operating in bankruptcy.[17] In major markets around the world, low-cost competitors have transformed air travel by challenging some of the most basic conventions of their industry. What will become of space travel as pioneering programs upset the status quo?

Across the industry, seemingly innocuous players are disproving long-held beliefs about what can be achieved in space and at what cost. Despite the inherent complexities of space travel, low-cost innovation and speed-to-market are happening. The question is: can they become the new norm? The answer lies in the industry's response.

To learn more about the IBM Institute for Business Value pioneering programs study, please contact us at *iibv@us.ibm.com*. You can also browse a full catalog of our research at:

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About the authors

Sandra Kearney is part of the Global Aerospace and Defense Team at the IBM Institute for Business Value. With 22 years of aviation experience, Sandy is focused on providing executives with insights they can use to build stronger, more effective companies. Sandy can be contacted at *skearney@us.ibm.com*.

Tao Jiang is a Consultant with IBM Business Consulting Services. Tao can be contacted at *taojiang@us.ibm.com*.

Linda Ban leads the Global Industrial Sector Team at the IBM Institute for Business Value. Linda can be contacted at *lban@us.ibm.com*.

Contributors

Alberto Castano-Pardo, Supply Chain Consultant

Ionel Gresescu, Product Lifecycle Management Consultant

Robert Schmitz, Supply Chain Consultant

Pitipong Veerakamolmal, Consultant

Nakia Watson, Consultant

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References

1. Crock, Stan. "The little contractor that could." *BusinessWeek Online*. July 4, 2005.
2. "Space Tourism Market Study: Orbital space travel & destinations with suborbital space travel." Futron. October 2002.
3. Hoover's, Inc. http://www.hoovers.com (accessed October 2005).
4. David, Leonard. "Space Tourism: Marketing to the Masses." *Space.com*. June 6, 2005. http://www.space.com/adastra/050606_isdc_tourism.html
5. Reingold, Jennifer. "Hondas in Space." Fast Company. February 2005. http://www.fastcompany.com/magazine/91/honda.html
6. Halvorson, Todd. "Mogul Eyes Space Coast For Rocket's Mission." *Florida Today.* January 29, 2005.
7. IBM Institute for Business Value interview.
8. Dignan, Larry. "Should NASA Open Low-Orbit Space to Business? The UPS Brown Voyager? It could happen if private companies take over low-earth space travel and free up NASA to shoot for the stars." *CIO Insight.* August 31, 2005.
9. IBM Institute for Business Value analysis.
10. China National Space Administration. "China's Space Activities." November 2000. http://www.cnsa.gov.cn/english/spacye_policy/more.asp?id=7
11. "China's space accomplishments." China National Space Administration. http://www.cnsa.gov.cn/htcj/show.asp?id=75
12. Ibid.
13. "China opens new chapter in space history." *China Daily.* October 13, 2005.
14. IBM Institute for Business Value interviews.
15. Ibid.
16. Ibid.
17. "Northwest Airlines Files for Bankruptcy." *Associated Press.* September 14, 2005.

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G510-6223-00