Spin-Out and Spin-In in the Newest Space Age

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Introduction

For the aspiring space entrepreneur, rocket science may be the biggest obstacle. This is definitely not because rocket science is impossibly difficult. Since at least the time of Robert Goddard, we have known that however difficult it is, it is not impossible.

In fact, rocket science is an obstacle as much because of the impression it gives and the aura we have erected around it, as because if its inherent complexity. For some people, rocket science and space activity are the same, and both are seen as too rigorous and unforgiving for any but the best capitalized and most technologically powerful businesses to venture forth into the markets they are creating.

Although this chapter does not hope to make any part of the space sector look easy, it does seek to open the eyes of cautious entrepreneurs and business planners to the enormous potential for a very wide range of enterprises to participate. The operative theme here is that the human experience of space, whether it be through machines of human creation or through direct human presence, has gotten so complex, its appetite for technical and procedural solutions so ravenous, and the economic resources available to it so limited in proportion to the vastness of the objectives, that there is no choice but to incorporate good ideas developed elsewhere.

For many people this concept is referred to as "spin-in:" the transfer of technology developed for uses outside of the space sector to meet needs identified inside it. Although there is by no means a standard use of this term (NASA for example often uses it to refer to a kind of partnership or co-development of technologies between internal teams and industrial partners), spin-in in the sense I have defined it above is increasingly discussed in Europe. Since it gives us a convenient short-hand for a concept that could be a profitable pathway by which to enter the space market, 'spin-in' will be used here in its European sense.

Although easily enough defined on its own, spin-in, in the context of the space sector, is best understood in relationship to its far better known and better-publicized companion concept, spin-off. Since the early days of the space era, spin-off has been invoked as one of the major benefits of large national investments in space technology. Research and development undertaken to push human horizons beyond the obviously finite limits of the Earth inevitably made discoveries that could be useful in more terrestrial pursuits. Thus, materials, medical breakthroughs, energy solutions, information technologies, industrial processes, and many more such capabilities developed for use in space applications could be re-programmed and re-deployed for other very down to Earth uses.

As we will see later, this argument has become so strong that several often cited examples of spin-off are, in fact, among the more interesting examples of spin-in. The lesson here being that spinning-in a product, idea, or technology may not only gain you a niche presence in the space market, but it might also help you gain additional market visibility and penetration in terrestrial applications. Hence, while the aura of rocket science may be an obstacle to the over-cautious entrepreneur, once you have spun something into a space project, it is likely to benefit from the public's admiration for products that are 'space proven.'

With that in mind let's begin with a quick survey of the idea and underlying business opportunities of spin-off before turning the concept around to see how business can be done by infusing outside developments into a space sector that can use them.

Spin-off

A recent search on the NASA web site (www.nasa.gov) revealed 24 hits for the term, spin-off. The European Space Agency (ESA) site (www.esa.int) yielded an astonishing 2940 hits, aided in part by its effort to bring content to its readers in the national language of all 18 member states. Digging a bit deeper however, it is clear that there is much more to the results of these searches than hits and click rates.

Both agencies have backed up their interest in spin-off as a friend-raising strategy by well documented and elaborately illustrated publications testifying to practical successes in actual business situations.[2] A few hours studying these materials would be well advised not only because applying a space developed technology to a new terrestrial use can be a good investment (there are after all still more customers on Earth than there are off it!), but it can also be a good training ground for the habits of mind necessary to see how the process could work in reverse.

An example from Europe is useful here. In June 2009 the European Space Agency's (ESA's) Technology Transfer Program Office (TTPO) posted an entry on its web site concerning the RIVOPS (Remote Intuitive Visual Operations System) implemented by the EATOPS company, a French-Dutch start-up at ESA's business incubation center in Nordwijk, The Netherlands.

See (http://www.esa.int/esaCP/SEM56L1OWUF_Improving_0.html)

The firm was reported to have adapted a technology that ESA had developed for monitoring and controlling multiple parameters affecting safe satellite operations to meet the needs of the off-shore drilling industry. This short piece contains a number of insights into the complex synergies that make spin-off ventures matters of great interest for space agencies and entrepreneurs alike.

First, although the RIVOPS system was deeply rooted in 'proven ESA technology,' Alexandre Van Damme from EATOPS is clearly listed as a co-inventor. Whether spun-off or spun-in, technologies are rarely transferred between sectors without some modifications being required by their new uses. One should expect that it is necessary to work with partners in either case. Emotionally, this may be harder for spin-in, where you must inevitably expect others to seek to transform your input in line with their perception of their needs, or their understanding of the lessons that their experience with space projects has taught. While this does not have to mean that you cede all control, it does mean that a strategy of maintaining absolute control is unlikely to make such a deal work.

Second, for the space agency, the reward of spin-off is clearly one of public benefit. Quoted in the piece, Bruno Naulais, ESA Business Incubation Manager gets right to the point. *"This is an excellent example of how space technology can benefit society."*

With spin-off, space agencies can fully expect that a short, rich example can show an attentive public that money invested in the agency's

1. European Space Agency Technology Program Office, *Down to Earth*, *How space technology improves our lives*, September 2009; and NASA Innovative Partnerships Program, *Spinoff, 2009 ed.*, Developed by Publications and Graphics Department, NASA Center for Aerospace Communication.

work does more than fund satellites and missions to far away places. The implicit payoff for the agency is public support for continued appropriation of government funds. For the time being, agencies may not see equivalent benefit in spin-in and may even see it as a 'competitor' to internally developed technologies. This means that the strategies for building a partnership bonded by perceptions of mutual benefit are often much different depending on whether the spin is 'off ' or 'in.'

Third, the 'technology' transferred in this case was already a well-honed concept involving the clustering of parameters critical to safe and effective satellite operations. A lot of the movement of value between the space sector and its economic partners takes the form of concepts or intellectual property. Although often incorporated into significant pieces of hardware, this property may involve new science, new engineering, or new ways of operating. Sometimes it involves all three, but it can often be of great value even if it involves only one. A brilliantly conceived physical tool can fail in practice because it has not yet been linked to the right way of using it. A wonderfully engineered system can fail because the technology incorporated into a single component is not equal to the demands placed upon it in critical circumstances. In the first case the shortcoming is the lack of an operating method; in the second the need for a design or manufacturing innovation. In both, the need for a solution has created a market, and this will be the case no matter what direction the technology is spinning.

Certainly, NASA shares the same understanding of the importance of spin-off. Since 1976 it has issued an annual publication devoted to the theme that should be required reading for anyone hoping to profit from meeting a market need through technology transfer with the space sector, whether spun-in or off, or a little of both. The 2009 edition is available at the following link:

http://www.sti.nasa.gov/tto/Spinoff2009/pdf/spinoff2009.pdf

In 208 short pages, it provides a yearly insight into the kinds of technologies NASA has developed and the uses to which creative business have converted them.

It does more, however. It also provides a quick insight to the huge array of subjects in which NASA is interested. Ranging from health to industrial productivity with plenty more in between, the catalogue of spin-offs generated in the past year is proof that NASA is far more than rocket science, and provides encouragement that if so many of NASA's ideas can find uses outside of aeronautics and astronautics, then there is a good chance that outside ideas could find a use inside the space sector as well. With 24 editions of Spin-off already issued, it is likely that whatever industry is closest to your heart, there is an example of previous synergy to provide inspiration and incentive to persevere. The European Space

Agency's equivalent publication, cited previously, is called *Down to Earth, How space technology improves our lives*.

Don't expect to find a companion volume on Spin-in, however. It doesn't seem to be in the culture, yet. There is a case to be made that it is equally beneficial to society and perhaps even more useful to the general economy by providing economies of scale, but it can also be interpreted either as the introduction of inexperience into missions with no room for failure, or equally sinister in the minds of some, it could be viewed as threatening competition in a world where publicly funded laboratories seek to demonstrate their usefulness or even indispensability in face of regular budget reviews.

Unfortunately, unlike spin-off, which promises to improve the chances for renewing funding for public laboratories, spin-in can seem like a threat to funding in a zero-sum game. The possibility that it might also be a chance to get more done with the relatively small budgets allocated to space agencies and procurement officers is only slowly gaining credibility with decision-makers and publicly-supported researchers.

Although we will never completely abandon the discussion of spin-off, it is time to focus on spin-in and its possibility to open the door to space commerce for small firms and large alike.

Spin-in

Years ago as a young assistant scoutmaster on a campout, I heard the scoutmaster comment that the dehydrated orange flavored drink mix we used to mix up a high vitamin C breakfast beverage was 'space-age technology.' Called Tang, this stuff had supposedly been developed for the needs of astronauts in NASA's 1960s Gemini program. This was the truth as I understood it for many years until I learned that the original patent for Tang had been issued in 1957, a good 7 years before Gemini.

The real story was that NASA wanted a good dehydrated mix that could be added to drinking water for the Gemini astronauts, and had found one that already existed on the commercial market. They did modify it a bit by adding potassium to replace astronauts' electrolytes, but the basic product was clearly spun-in rather than spun-off.

Similar stories exist for Teflon and Velcro, two widely known products. These examples should help you understand that NASA and other space customers buy good ideas when they meet their needs. Any visitor to the American module on the International Space Station soon recognizes that a lot of items that would be otherwise floating about in microgravity are firmly attached to one surface or another by the same Velcro that keeps things in their place 300 km below on earth.

The key to your ability to build business out of this reality is to keep in touch with all the needs confronted by the space sector and to review the capacity of your products or competencies to meet those needs. To add some structure to this review we will look at several categories of such products or competencies that could help forge a business relationship with the space sector.

Intellectual-property

Space activity is an insatiable consumer of ideas. Working at or beyond the limits of current knowledge or experience, the sector often needs to look beyond itself to make sense out of the environments, challenges and opportunities confronting everything from ongoing operations to unique, one-off missions.

A simple anecdote is useful to illustrate how terrestrial ideas, experience, or research results can be critical as space projects confront the new conditions imposed by the space environment. From the earliest days of space flight anything put into space is confronted by a condition that Earthly designers need rarely account for: microgravity.

Microgravity is the phenomenon that permits astronauts, and anything else that isn't tied down, to float freely in the space station. It results from the fact that the station and its contents are in free fall while in orbit, managing to not come crashing back to earth only because their forward velocity is so great that they effectively keep falling over the horizon.

The problem was that until Sputnik made it to orbit in 1957, there had been few ways to test the principle of microgravity, or its effects on materials on Earth.

As we prepared for the advent of access to orbit in the late 1950s it was possible to test some of the effects through the use of sounding rockets or drop towers. Sounding rockets rising to several kilometers of altitude could contain experiments that produced data during the time it took the expended rocket to fall back to earth. Drop towers, which were very high structures in which experiments could be subjected to free fall for a few seconds at most, provided the opportunity for greater experimental control but suffered from the fact that objects accelerate as they fall meaning that adding additional amounts of time to the free fall period required building exponentially taller towers. In both cases the costs of running the experiments were high enough that those designing the tests wanted the best understanding possible before they initiated them so as to maximize the new information they could obtain.

Fortunately, experiments and experience in microgravity preceded the space age by at least two centuries.

Two hundred ten years before Sputnik took its beep generator to orbit, William Watts had put microgravity to work in the United Kingdom. Confronting the desire of the British military to produce the most perfectly round musket balls possible, Watts erected what he called the *"Shot Tower"* in 1747. The principle was simple. Lead heated to a liquid state at the top of the tower was poured through a mesh and allowed to fall. With the temperature carefully controlled the lead would have solidified by the time it arrived at the bottom of the tower. More importantly, thanks to the behavior of liquid in microgravity, the lead arrived as perfectly shaped spheres.

With this painfully terrestrial technology having been well documented, it was available years later as space-focused engineers and scientists began to consider how to evolve their experiments and develop their equipment to function as desired in the free fall conditions of orbit.

Given the amount of time between Watts' idea and its implicit value in providing first principles to those charged with space mission planning, it is no surprise that he never received royalties. But in today's faster-moving R&D environment, there is good potential for knowledge developed to meet an Earthly need to then spin-in usefully and profitably to the space sector. This should provide an incentive to review the ability of your intellectual property to meet challenges within that sector and to participate in the space activities market.

Innovation

When searching for ways to apply what you already know to a need in the space sector, don't forget that products you have proven to work well in meeting customer needs on Earth may have a whole new range of uses beyond it as well. In this case in particular, however, the adage that innovation and adaptation go hand in hand is especially true.

Innovating from the basis of an earth-proven product requires careful attention to how the space environment differs from the conditions the product confronts on Earth. High radiation, hard vacuum, thermal stresses that can subject objects to variations of hundreds of degrees Celsius from one side (facing the sun) to the other (in shade), high vibration on launch, and highly limited energy budgets are just some of the major differences that have to be taken into account.

Innovation Example: Cisco

One recent success story in adapting terrestrial technology to the space environment involves a company that has hardly been a household name in the space business: Cisco Systems. Working under a mission statement that calls on the company to *"Shape the future of the Internet by creating unprecedented value and opportunity for our customers, employees, investors, and ecosystem partners,"* Cisco has earned a reputation in internet routing and related services in a very Earth-centered business.[3] In fact as the year 2000 ushered in the new millennium, the high volume, high value internet router part of Cisco's business was Earth-bound as well.

By 2003, however, that had begun to change. Using a production model router, a lot of innovative human capital, and less than $1,000 of modified hardware, the company launched a demonstration payload designed to show that its gear had what it took to perform in space. With results reported frequently at major space conferences over the next several years, it became clear that the router was functioning as designed, surviving frequent, intentional stops and reboots, and slowly earning the respect needed for project managers to rely on it or its derivatives when designing spacecraft architectures to support mission critical functions.

The next logical step occurred in November 2009 when Cisco's IRIS (Internet Router In Space) rocketed into orbit as a hosted payload of Intelsat's IS-14 satellite. Two months later the company announced that the router had completed its in-orbit test and had successfully become the first terrestrial-standards based Internet Protocol router to be deployed on a commercial geostationary satellite.

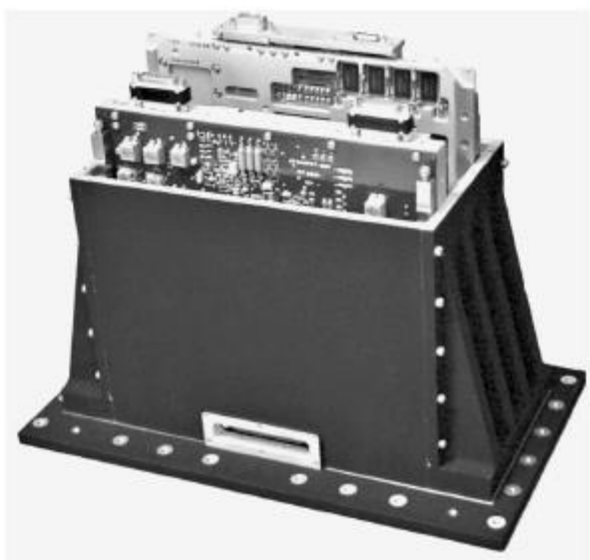

Figure 1
Cisco IRIS Router
© Cisco Systems, Inc.

In spite of the numerous space-specific adaptations needed to achieve this result, Cisco's IRIS stands as an excellent and informative example of the potential for spin-in by demonstrating several key principles.

2. "Frequently Asked Questions: What is Cisco's Mission Statement," Cisco Systems Investor Website: http://investor.cisco.com/faq.cfm?SH_No_JavaScript=yes

1. The first pre-requisite for project success was identifying a need within the space sector for which a terrestrially proven technology could promise a cost effective and reliable solution.

   a. In a news release on January 18, 2010, Cisco emphasized that the need they had identified could be addressed by an innovative use of their router and internet expertise: *"IRIS offers several enhancements over conventional satellite technology. With IRIS, users will be able to experience a true mobile network – one that helps enable them to connect and communicate how, when and where they want, and that continuously adapts to their needs without a reliance on predefined, fixed infrastructure."*[4]

   b. The same release emphasized that by placing a radiation resistant and reliable IP router in geostationary orbit they would be able to enhance mobility for their clients. They also noted that the same software upgrade capability appreciated by systems administrators on Earth had been built into their on-orbit router. This essentially meant that software associated with the router could be updated as needed, just as has been the case with ground-based systems, providing a level of flexibility and responsiveness not previously available aboard satellites.

2. The second key element was identifying the business case that supported the spin-in technologies over actual or possible competitors.

   a. IP services from space have been available up to now through the use of teleports which receive downloaded data and route it to customers. Cisco's release made it clear that they believed their technology has a decided advantage over that competitor. In fact, it promises to save bandwidth, energy, and complexity problems associated with teleport based, 'double-hop' technology.

   b. Emphasizing important government uses for their services, Cisco also made it clear that they had identified their initial market while pursuing new market opportunities with *"satellite manufacturers, system integrators, and end users"* who seek to serve markets *"outside traditional ground-based networks."* Implicit in this is that even

3. "Cisco's Space Router Successfully Operates in Orbit," Cisco Systems, Inc. news release, January 18, 2010

individual customers may be able to access IP processed content directly.

c. Perhaps even more importantly, the IRIS project was a step forward in making networks in general more robust, a long-sought goal of the company. With the added capability of in-space routing, one more truly independent element was added to network redundancy since most calamities that could put a terrestrial network element out of service would not simultaneously affect an element in orbit.

3. The Cisco release provides one more critical insight into identifying and acting on a spin-in opportunity by showing the vision to include space applications in implementing a company's strategic objectives:

a. Quoting Steven Boutelle, vice president, Cisco Global Government Solutions Group, the Cisco release makes it clear that this is exactly how the company views this initiative. *"This milestone is another step in our strategy to expand borderless networks into space and redefine how satellite communications are delivered. This technology can help transform satellite communications around the world by reducing latency and increasing the efficiency."*

b. Also quoted was Arnold Friedman, senior vice president, Sales & Marketing, Space Systems/Loral, who made it clear that Cisco's new router fell squarely in the category of innovation, saying, *"Commercial satellites offer a best value solution for quickly deploying important and innovative space-related technologies, such as IRIS.*"

c. On March 16, 2010, The Society of Satellite Professionals International (SSPI) honored Cisco with an award for innovation in technology development and applications for the IRIS project.

4. A number of other lessons need to be drawn from this example of successful spin-in.

a. Spinning-in a product is not the same as off-loading inventory. The 2009 IRIS router was not exactly off the shelf. It was built by a partner, SEAKR engineering of Centennial Colorado, space qualified, and radiation hardened to meet the rigors of space flight at the altitude necessary for geostationary orbit: about 24,000 miles.

Cisco's Internetwork Operating System (IOS) controls its multiple functions.

b. Many space applications will require your business to gain space awareness and insight before the spin-in can be successful. Cisco has been working toward this goal for nearly a decade and learning every step of the way. It is precisely for this reason that the International Institute of Space Commerce (http://www.iisc.im/) was founded on the Isle of Man in 2008 and conducts workshops and seminars at various locations including the International Symposium on Personal and Commercial Spaceflight (http://www.ispcs.com/) in Las Cruces, NM, and the International Space University in Strasbourg, France. Another useful source of space information useful to the entrepreneur is the annual Space Investment Summit (http://spaceinvestmentsummit.com/)

c. Picking space savvy partners facilitates the market entry. In bringing IRIS to the successful conclusion of its test phase, Cisco teamed up with Loral, SEAKR, and Intelsat, all space proven companies. Whether it feels entrepreneurial or not, space ventures favor partnering with others, and sharing with them some of the fruits of innovation.

(*Editor's note:* Please see the following chapter for additional information about Cisco IRIS.)

A Second Example

Another example of applying a non-space technology to a space sector need was reported in a paper presented to the International Astronautical Congress in 2003 by Raitt, v. d. Heide, Kruijff, and Hermanns.[5] By drawing its principal illustrations from the textile industry, their work shows how seemingly far afield from 'rocket science' the space sector can go in seeking the technologies it needs.

With a host of terrestrially developed technologies, the textile industry proved especially useful in providing tethers and tether management hardware. Drawing examples from the experience of a Students for the Exploration and Development of Space (SEDS) project and from the second Young Engineers Satellite (YES-2) mission, the authors demonstrate how equipment used commonly in the textile industry was used to solve engineering challenges associated with the eventual

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4. D. Raitt, E.J. v.d. Heide & M. Kruijff, F. Hermanns, "Space Spin-in from textiles: Opportunities from Tethers and Innovative Technologies," IAC-03-U.2.b.09

deployment of long tethers in support of space missions. Here the spin-in contribution took the form of machinery widely used in a non-space application. The primary innovation involved was recognizing that the equipment could meet the need, but as in the Cisco case, modifications were necessary to adapt the equipment to the space environment.

Raitt, et. al. capture the relationship between spin-in and innovation quite well in their conclusion:

> Although spin-off from the space sector to the non-space sector has hitherto been the norm, there is a growing need and demand within the space industry for innovations coming from industrial sectors outside the space field. This implies conducting a technology watch for innovations in relevant non-space sectors.[6]

What they do not make clear is that for entrepreneurs seeking to maximize the opportunity for their product to find its niche in the space sector, the technology watch that matters most is the one they conduct themselves among the technologies they or their firms control.

Industrial Processes

So far we have seen how spin-in can result from intellectual property and innovative adaptations of existing products and machinery. Now we will look at an example of how it can result from industrial processes and acquired manufacturing expertise.

By now it should be obvious that whatever product, idea or service you hope to spin-in to the space sector, it will be subjected to quality control standards and tests generally exceeding anything it would face in a terrestrial use. The inherent quality you bring to market may be sufficient to meet these tests or it may need to be space-hardened for its new application. Some earth-bound technologies, however, may already be the best that they can be given the state of the manufacturing art. In such a case it can be worth allowing your personal technology watch to explore their potential for use in or for the space sector.

If there is a poster child for this type of spin-in, it is the Magna-Steyr company of Austria. Long a major supplier of parts to the automobile industry, Magna-Steyr is particularly renowned as a supplier of automobile seats. Knowing the relationship between the seats they supplied and the safety of their occupants, Magna-Steyr placed extraordinary emphasis on the quality of its welding and the skill of its welders. With a well established business-to-business relationship with automobile

5. *Ibid.*, p. 5.

manufacturers, Magna-Steyr paid no more attention to space activity than would any outside observer interested in pushing back the frontiers of the unknown. But that turned out to be just enough.

In the normal course of looking for new business, an interesting request for proposal caught Magna-Steyr's eye. Bids were being solicited for the production of the cryogenic feed lines for the Ariane launch vehicle. This was in fact VERY close to 'rocket science' and might have been quickly passed by except for one of the critical specifications in the RFP: welding, very, very good welding. The welding standard specified was one in which relatively few firms were certified, but Magna-Steyr was one of them. Encouraged that a skill that they had mastered was on the critical path, they bid for the job and won it.

Of course an important process of learning about the demands that would be placed on the feed line system followed. The steep learning curve of understanding the world of the super cold and the effects that liquid Hydrogen and Oxygen could have on the feed lines and their joints had to be climbed. In time, it was climbed, and a company that had once been primarily a supplier to the automobile industry became a partner in the manufacturing of one of the world's most reliable launch vehicles.

It also became something more. It became an intentional developer of space related products and the holder of one of the more important patents in the production of slush hydrogen, a super cold form of hydrogen gas seen as a potential fuel for hypersonic aircraft.

There are several lessons from this example

1. If you have a state of the art quality certification, expect that some space-related RFP's are going to reference it in their specifications.
2. Once you are established as a supplier to the space market, expect to find more opportunities as you climb the learning curve.
3. Just because you enter the space sector through spin-in, don't overlook the possibility of spinning-off some of your newly acquired space-based expertise into the core businesses you started in. (In a world tired of fossil fuel and its side effects, slush hydrogen and its safe storage have some rather interesting innovative possibilities in the automotive sector.)
4. Opportunities for technology transfer and especially for spin-in are not confined to companies operating in the major space faring countries, or, for North American readers in those provinces or states most identified with the space sector. Firms operating in smaller markets may in fact have an advantage since

they have often developed expertise in managing and expanding an important niche.

Looking forward

The challenge of looking at examples of how something has been done in the past is that it can leave an impression that all the worthwhile opportunities have already been seized. Like the psychological hurdle of 'rocket science,' the feeling that you have 'missed the wave' can be a crippling, though self-imposed barrier to entry.

There are probably numerous opportunities remaining in the very same industries we have already looked at, but with the objective of showing some emerging opportunities in the space sector that we have not already covered, let's look at some places where spin-in is likely to have a big contribution to make in the decades to come.

Mining

Although Earth has been mercifully spared any cataclysmic impacts from asteroids in recent decades, we know that several past impacts have been extremely powerful. Although the likelihood of an impact is small, several countries including the United States and Italy have invested significant sums in trying to identify, classify, and count asteroids that pass close enough to Earth to present a non-zero probability of impacting us.

This effort was given a bit of a dramatic boost by the 100th anniversary of the Tunguska event, where we believe an asteroid about 40 meters in diameter exploded in the atmosphere over Siberia in 1908 causing extensive damage over a physical area larger than Los Angeles.

With several thousand such objects now identified, predictions of the total number of Tunguska sized asteroids that will ultimately be catalogued ranges as high as 500,000.[7] There may be opportunities for spin-in technologies to address the threat these objects may pose, but there is an even more interesting implication in knowing that Earth orbits in a kind of cosmic rock quarry.

Spectroscopic analysis shows that many of these objects are rich in mineral ores that on Earth are becoming scarcer by the year. Nickel and iron are commonly mentioned, but materials that are much more rare such as titanium have also been identified in extra-terrestrial rocks. Given that some of these 'rocks' are mountain-sized behemoths (although certainly not solid titanium!), the potential for eventually mining them is increasingly discussed.

6. Association of Space Explorers International Panel on Asteroid Threat Mitigation, *Asteroid Threats: A Call for Global Response, Executive Summary, 2008, p. 3.*

So where is the spin-in? Mining itself is an area of expertise that has been only marginally tapped by the space sector. Although tools like the drill bits that have served the Mars rovers, Opportunity and Spirit so well have been brought into the sector, the opportunities presented by future off-Earth mining operations promise a potential market of immeasurable size. Especially if the mining operations are driven by private capital in quest of return, there is going to be little interest in completely reinventing the mining industry in order to begin harvesting mineral-rich asteroids crossing or coming close to Earth's orbit.

There is already evidence that this possibility is attracting the attention of people with mining expertise. The Colorado School of Mines organizes an annual symposium on the subject8; AfriSpace, a new organization in South Africa is looking at applying mining technology off planet; and Korea's Hanyang University in Seoul has been working steadily on the challenges inherent in what is called In Situ Resource Utilization (ISRU) and other extreme technologies such as robotic excavation[9].

ISRU is the idea that future human communities off-Earth, whether on the moon or Mars or somewhere else, could at least partially sustain themselves by using material they could find in place. This material could range from oxygen chemically bonded into lunar regolith, to water beneath the Martian surface. In all these cases, solutions to the discovery and extraction of the desired material could be opportunities to spin-in expertise, equipment, and technology from Earth-based mining.

Interior Design

The transformation of small spaces into pleasant environments is going to be essential in any future development of space tourism. Private citizens who have made the trip so far have more nearly matched the profile of traditional adventurers or private explorers by whom the rigors and inconveniences of space travel have been accepted as part of the price of adventure. To grow appreciably, any space tourism industry will have to move beyond this hardy band.

Spacecraft heading to orbit and destinations awaiting them there will need to offer as pleasant an environment as possible under the limitations of physical volume and security. Here, of course, there is terrestrial expertise aplenty in the automobile industry, as anyone who has successfully designed the interior of a passenger car or truck cab, especially

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7. Planetary and Terrestrial Mining Sciences Symposium (PTMSS), http://www.isruinfo.com/
8. Kim Jae Won, "HYU, Touching Down on Space," *Weekly Hanyang News*, http://www.hanyang.ac.kr/controller/weeklyView.jsp?file=/top_news/2010/034/english2.html

a high-priced one, could have something to offer in the design of a spacecraft.

The potential for spin-in would not be limited to this industry of course. Designers of yachts, cruise staterooms, and pied-a-terre apartments would all have opportunities here, as would those who supply the materials. There would be plenty to learn about ensuring that techniques were space-safe and space-adapted, but the fact remains that an emerging space industry of potentially substantial proportion would greatly benefit from the expertise of a whole professional class whose work has been heretofore confined to non-space applications.

Given the 'space-proven' cachet we discussed early in this chapter, managers of luxury brands could quickly find that spinning-in their expertise serves also to give them space-themed marketing opportunities on Earth.

Telemedicine

Design will not be the only need of a space tourism industry. With more and more people going to space in good ordinary health but without the rigorous physical attributes for which we have so far selected our professional astronauts, we can expect to see a wider range of medical conditions presenting themselves in the orbiting population. Since it is unlikely that any business plan will be able to provide for a physician on every flight, telemedicine technologies developed on Earth will have spin-in possibilities.

These services are likely to range from simple consultations with passengers anxious to have new sensations or reactions explained, to more extensive assistance to crew members seeking to provide preliminary care in more serious situations. Medical services will also have opportunities prior to flight and in the period of adaptation following, where spin-in expertise may play a role. In these cases the most important expertise may be that of the passenger's own personal care physician who should be the one most familiar with the traveler's personal medical circumstances.

With medical services in remote areas of Earth increasingly augmented by remote assistance from specialists some considerable distance away, there may be increasing opportunities for institutions providing such services to contract with the emerging personal space flight industry to ensure that the needs of future passengers are addressed and that the liability of the space flight providers is managed. When the possibility of tele-surgery, robotically performed, becomes a proven reality, the technologies involved will likely have numerous opportunities to spin-in to space service, at least in low Earth orbit.

Lastly, any Earth-based surgical techniques, such as laparoscopy and arthroscopy, which reduce the amount of bleeding will be of interest to space surgeons seeking to intervene in microgravity.

Data Processing

As chip technology puts more and more data processing capability on smaller and smaller devices, the weight-sensitive space industry presents a great potential demand. To meet this sector of the demand, producers will certainly need to address the sensitivities to radiation tolerance and energy consumption as well, but even if adapted, winning technologies will have a great deal of Earth-centered legacy to rely upon. The story of Cisco's IRIS project recounted earlier demonstrates this possibility.

There is another side of the data processing opportunity however, that may hold even more promise. Amazing amounts of data are being generated daily by spacecraft already functioning in Earth orbit or beyond. Added to this is terrestrially generated data from sensors designed to improve our knowledge of the space environment generally and of the objects we have placed into it.

Today there are opportunities for spinning-in data-mining and image processing technologies because of the sheer size of the databases being generated, and the limitations on financial and human resources confronted by nearly every space project. To get a sense of the magnitude of the problem consider a couple of examples from NASA's recent history.

When the near-Earth asteroid Apophis was discovered in 2004, the limited number of observations available made the potential error in the calculation of its orbit rather large. This led to the conclusion that there was a disturbingly large probability that the space rock that was 250 meters in diameter could hit Earth on a future pass. Hoping to make their predictions more accurate, scientists poured over data sets from the Spaceguard project, which had tasked NASA with locating potentially hazardous objects much bigger than what they had just found. With clues to where they should look coming from their initial orbital calculations, they were able to narrow the search enough to find several more detections in the data. With these data they were able to refine their calculations and considerably reduce their assessment of the probability of impact in the near term. This was good news, of course, but for our purposes here the lesson is that there was useful data waiting to be found in data sets too large to have yet been fully mined for the information they contained. With data mining capability growing rapidly for Earth-based uses, the possibility of squeezing usable information out of oversized data sets in the space sector holds some tantalizing opportunities.

Another example of the 'too much data to handle problem' comes from the Mars rover program. The rovers have now generated an enormous wealth of image data alone, not to mention all the other scientific data they have sent back to Earth. The image volume is so large that NASA has made the data available in real time, recognizing that in many important cases images downloaded during the night for analytical teams in California are already processed and posted to amateur websites by the time the rover teams arrive at work in the morning.[10] This represents an enormous savings of time for the project team, and in many cases means that they have access to visual information that they would never have had the time or money to process themselves. In this case the technologies spun-in are image processing capabilities broadly available to the general market.

Although you cannot readily build a business plan around free services delivered by passionate volunteers, the possibility of more advanced image processing capabilities delivering value-added services for a fee on data that costs you nothing certainly seems worth investigating. After all, the business plans of companies currently marketing personal navigation devices are built on the solid foundation of GPS signals being made available to everyone at no cost.

So what is in it for you?

As you prepare to pursue your spin-in opportunities, plan on having plenty of work to do. Identifying your opportunities, finding a receptive ear with prospective customers, making the adjustments necessary for your product to be space worthy, and going through the process of proving it can meet the rigorous requirements of space service will all take time, investment, and perseverance. The process of identification alone will not only require investing substantial time, learning what the space industry is all about and what it needs, it will also require that you look closely at your products and core competencies to see how they stack up against what you are learning about space sector demand.

But if your interest in a profitable business is matched by a desire to be part of the industry that is most likely to be laying the foundation for the most fundamental changes in the way humans live, solve problems, and experience the future, then the work will be worth it, as it will have cleared the way for you to become part of the newest space age … the one in which you don't have to be a powerful country or a giant corporation to make big things happen.

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9. See www.unmannedspaceflight.com, a British site which does a masterful job of making rover images available on the web very shortly after their data stream arrives from the red planet.

Dr. Michael K. Simpson

Dr. Michael K. Simpson became President of the International Space University in May 2004. His academic career extends over 32 years and four continents. He has also been president of Utica College and the American University of Paris with a combined total of twenty years of experience as an academic chief executive officer. He has lectured in political science, international relations, business management, international law, leadership, and economics at Universities in the United States of America, France, China, the United Kingdom, and Australia.

Dr. Simpson received his Bachelors Degree magna cum laude from Fordham University in 1970 where he was elected to Phi Beta Kappa. He has also been elected to academic honor societies in the fields of political science and business management. After graduating from Fordham University, Dr. Simpson accepted a commission as an officer in the U.S. Navy where he served as an Oceanographic Watch Officer, Communications Officer, Leadership and Management Instructor, Repair Officer, and Political Military Action Officer. In 1993 he retired from the Naval Reserve with the rank of Commander. He holds numerous commendations including the Defense Meritorious Service Medal.

Dr. Simpson completed his Ph.D. at The Fletcher School of Law and Diplomacy of Tufts University, holds the Master of Business Administration from Syracuse University; and two Master of Arts degrees from The Fletcher School. He has also completed two prestigious one year courses in Europe: the French advanced defense institute (Institut des Hautes Études de Défense Nationale) and the General Course of the London School of Economics.

He is a board member of the Space Week International Association, a member of the Board of Governors of the National Space Society in the United States and an observer representative to the UN Committee on the Peaceful Uses of Outer Space. In 2005 he served as a participant in the workshop on *Humanity and Space the Next Thousand Years* hosted by the Foundation for the Future and from 2006-2008, he served as a panel member of the Association of Space Explorers workshop on mitigation policy for threats from near earth objects and currently serves on the commercial Spaceflight Safety Committee of the IAF. He is a co-founder of the International Institute for Space Commerce and a founding trustee of Singularity University. He is a corresponding fellow of the International Academy of Astronautics.

Seeing universities as nodes in an interconnected lattice of educational opportunities, Dr. Simpson has been responsible for concluding partnership agreements with Universities in Australia, Asia, North America, the Middle East, and Europe and has brought ISU into the Space Education Consortium in the United States as the only international partner in that body.

During his tenure as President of the International Space University, the school's already widely respected curriculum has been enhanced to include more material on satellite operations, management challenges of space projects, personal spaceflight, entrepreneurship, space policy, and prospects for commercial activity in space. An ISU Executive MBA enrolled its first students in June 2009.

The International Space University is headquartered in Illkirch-Graffenstaden in the urban community of Strasbourg, France. It offers three Masters Degrees, including the recently inaugurated Executive MBA. Each year from June through August it offers a prestigious, 9-week long session known as the Space Studies Program (SSP) that prepares high potential participants for rapid advancement in the space sector. The school also offers a number of short professional development courses tailored to the needs of space agencies and businesses.

He is also the author of Chapter 22 of this volume, *To Plan for a Century: ISU's Vision of Education in Space.*

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