



Scaling for success in space

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On this Bastille Day 2010, the executive suites of satellite operators around the world would be excused if they spent their time practicing the lyrics to la Marseillaise. Early last month, the French export-credit agency Coface, came to the assistance of mobile satellite operator Iridium, with a guarantee for a \$1.8 billion package to help finance its next-generation NEXT constellation, initiating a \$2.9 billion project for 81 satellites to be built by French/Italian manufacturer Thales Alenia Space (TAS). For Coface, this was only the latest in just over a year of almost unprecedented financings, including guarantees of \$586 million for 48 Globalstar satellites and \$465 million for as many as 24 O3b satellites, both constellations also to be built by the same TAS. For the operators, while the satellite system may be the *table d'hôte*, the financing is the *pièce de resistance*.

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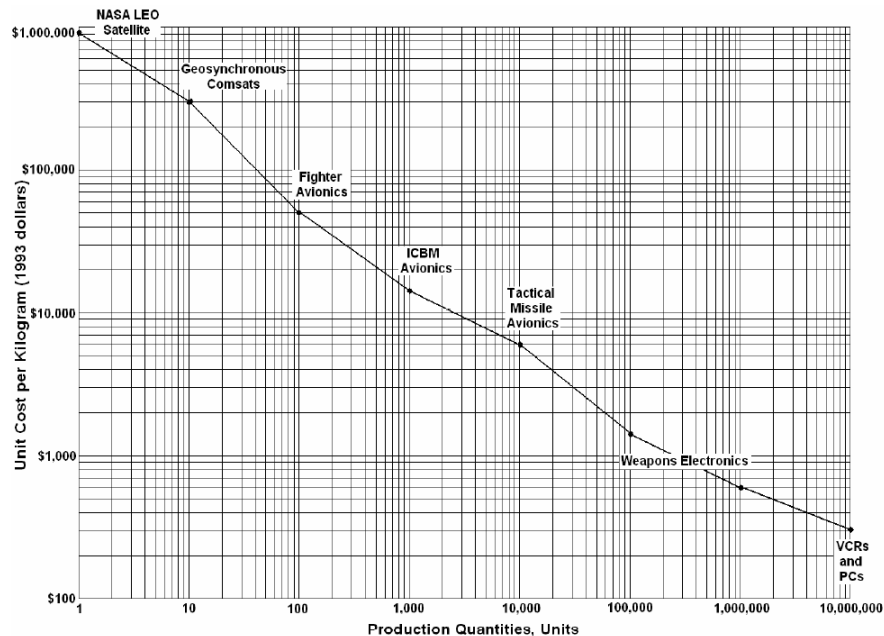
More startling than just the dollar number involved is the sheer number of satellites being built. For an industry where four or five satellites is considered a large order and eight to ten satellites a good year, those three contracts combined represent at least 153 satellites. Granted, these satellites will be smaller than the typical GEO satellite, but the aggregate kilograms to be launched into space is still very impressive and more importantly, the number of parts and components should allow for more efficient purchasing and manufacturing. Undoubtedly, TAS is intensely studying how to ramp up a line for the production of so many individual spacecraft. For others, this will have effects both up and down the supply chain as the surge will cascade across the many suppliers of components and subsystems for space systems. Even in launch systems too – witness the half a billion dollar contract Iridium signed with SpaceX to launch its system, likely to involved eight to ten launches of the Falcon 9. Assuming SpaceX hasn't yet achieved full reusability by then, that's as many as 100 identical Merlin engines in the production pipeline to add to the couple hundred already needed for pre-existing orders. Lest we think that this is limited to TAS and these three constellations, Sierra Nevada Corp, contractors of the next generation ORBCOMM constellation, is planning its own assembly line for small satellites, potentially producing batches of satellites a couple dozen at a time. All these numbers are about an order of magnitude greater than anything we've seen in the space

industry for the last decade. Has mass production in this industry arrived?

If we are seeing the beginning of a new phase in the space industry, one where there is movement from one-off projects or single-digit volumes per year to an industry producing an order of magnitude more units, then that has implications across the board. First, procurement practices on all levels of the supply chain will have to adapt to batch orders and design for manufacturability. Second, it has potentially phenomenal implications for cost, throughput and economies of scale. As much as new technology has the promise to drive down cost, far more often, as Henry Ford and others a hundred years ago showed, mass production is the real game changer.

To illustrate, the graph below, graciously provided by Ed Tuck of the Falcon Fund, was developed by Dr. James R. Stuart (of KitComm, Teledesic, Ball, Orbital and others; an expert on satellite mass-production) in 1993 to show the effects of production scale on cost, even for highly complex aerospace products. While the figures are dated to early '90s, little has fundamentally changed in that time. Almost to a tee, unit cost per kilogram is almost directly correlated (on a logarithmic scale) to the production quantity of the item produced. On an equal-sized basis, a component built in a factory intended for 10,000 units per year is an order of magnitude lower cost than built in a factory built for 1000.

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Furthermore, there is undeniable evidence that economies of scale are not limited to consumer products and simple parts, but for any product as long as the method of production is optimized for the magnitude of production. The standard modern automobile today bears tens of thousands of often complex parts and electronics, yet a plant like the NUMMI automobile plant in California (which Elon Musk's Tesla Motors recently acquired) produced at the peak of its operation about a half a million affordable vehicles per year. Similarly for seemingly more complex aircraft, the Ford Willow Run factory, the embodiment of the Arsenal of Democracy, produced 428 B-24 Liberator bomber aircraft in August of 1944, or about 14 each and every day. Although not near that production, Boeing alone still managed to deliver almost 500 commercial aircraft last year, some of which are built with millions of individual parts. As long as the market is there to justify production and the initial CAPEX, there's no telling how far we can take this, even for something as complex as a modern satellite or spacecraft. As with many things in life, the reward for success is more success.

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So, are we now moving down that line to lower costs and greater inspiration? The key phrase was, "As long as the market is there". Longtime industry observers might be feeling as though it was déjà vu all over again. In the late nineties, in the midst of the tech boom, investors were dazzled by plans for constellations comprising of hundreds of satellites driving the need for launch vehicles launching dozens of times a year. This was driven by massive optimism on the future of satellite telecommunications and further driven by spaceflight enthusiasts who hoped that the massive organic demand would help propel lower costs for their own dreams of cheap, reliable and accessible space travel. Unfortunately, most of those ventures went bankrupt with the bust, cursing investors and dreamers alike. Market risk, or the lack of the top line unfolding as forecasted was where dreams met harsh reality. Why should it be different this time?

For one, the industry is a lot stronger and more established now than it was then, with many of the new satellite constellations belonging to existing companies with real revenues and sometime profits. At the very least, the Coface guarantees will keep them from insolvency. Companies like Iridium and Globalstar are more likely to get acquired or acquire each other than to go bust. Demand for existing mobile satellite services is growing nicely, but there is little obvious room for new entrants into this already



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crowded field. Other satellite services are growing nicely, even greatly in the case of high throughput satellites, but not by an order of magnitude, not for the industry as a whole. So we ask again, where will these production rates come from?

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If we were to only see the satellite industry on its own, we would be inclined to say that this was a giant pig in a python. But luckily for the industry, Coface and the MSS operators have unwittingly chosen a perfect moment to surge their replacement satellites, just as interest in commercial cargo and commercial crew delivery to the space station has reached new heights. The International Space Station may be only one satellite, but it's a big one and consumes a lot of material that up until now was only serviced by NASA through the Shuttle and by other governmental partners. Now, that is changing. As we've discussed in prior articles, NASA has already awarded contracts for twenty cargo servicing flights to the ISS, with the number likely to rise as the Station's life is prolonged (to 2020 in the latest Congressional Bill). A move to commercial crew service may double that number again. This is not merely a transfer of activity from government to commercial, but a new market for business. With commercially operational spacecraft, any company would be free to pursue new opportunities with its R&D costs already amortized over government contracts. SpaceX is already planning for this, offering commercially available payload capacity on standalone DragonLab flights – others may follow. Moreover, Mr. Bigelow, the mega-rich space enthusiast with his own plans for commercially operated space stations has hinted (with the concurrence of the FAA) that his plans may generate as many as 150 launches through 2020. If he has the capability and the seriousness of purpose (and various news reports as well as his two prototype module already in space, bear this out), this would be a significant jump up in launch and systems demand, even at a fraction of this number. If the business bears out, again, others may follow.

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While cargo or crew carriers are not the same as comsats, they contribute to substantially the same industrial base. Truly, whether we are entering this new era of commercial space activity is directly related to the answer of whether we are expanding the demand for space and opening new markets. The current debate over commercial space, for all its sound and fury, is really a debate over the direction of the no more than the 0.1-0.2% of US GDP that Congress and the US taxpayer base has shown willing to spend on civil space projects. If the industry truly wants scale and gets



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beyond the never-ending political debates, then it must follow the path of the commercial satellite communications industry and the commercial satellite imaging industries and access the other part of the over \$14 trillion US economy.

Bigelow is targeting sovereign clients, meaning countries without an active astronaut corps, to give them the opportunity to operate a space program at lower cost and lower difficulty than current spacefaring nations. If even a few are willing to pay the just-over-\$500 million per year figure that is floating around to lease one of his space station modules, that's a market of another few billion dollars a year, to be shared amongst an array of aerospace firms along with a new breed of developers, operators and brokers that always accompany a new market. Then there's the so called tourist market, which has already launched passengers eight times to the ISS in the last decade, certainly a larger market if the \$30 million price per ticket and the 8-10 month training period come down – maybe another few hundred million per year more at least. And what of the biotech and pharmaceutical markets? There's a whole lot of rack space on the ISS that's underutilized, and we haven't even begun to explore the medical possibilities of biotech production and research in microgravity. It's been talked about for decades, but it's still yearning for truly open, affordable, turnkey access to space facilities useable by commercial researchers. If someone can achieve that, that could open the commercial space industry to a truly new and large market. Still others have suggested transport markets to access regions beyond earth orbit (such as the Moon or the Lagrange points) or even, if costs and technology advance far enough, energy and resource markets beyond our closest orbits. The market possibility: billions, maybe even trillions.

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What do you need to build an industry? For good measure, you need industrialists, engineers, designers, marketers, salesmen, investors, businessmen, educators, lawyers and even hyperactive export credit agencies. Economies of scale not only bring affordable infrastructure, but also widen and deepen pools of talent and capability, strengthening society's ability to take on markets not so easily accessed before. The essential ingredient, however, for any growing industry pushing the frontier will always be the supply of visionaries; the dreamers and the entrepreneurs that break the mold. Without them, we cannot even think of accessing new markets. The space industry has never lacked for entrepreneurs, but the stark realities of business, economics and physics have



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long trod on many plans. For those who have gotten discouraged, who have banged their head against the wall many times as the cost and immaturity of the industry have stumbled with many business plans, we say: The business of space may be getting big, and it may be here to stay, but even as it corporatizes and systematizes, it still needs the entrepreneur more than ever to enter a new commercial space age. So today, just a few days after Bastille Day, we may add, along with Coface, another *bon mot* for which we can thank the French for inventing: The entrepreneur.

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