Chapter 5 - Space Transportation

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Is the space transportation industry capable of providing the massive quantities of low-cost space transportation necessary for SSP construction?

Burt Rutan's legendary aerospace genius and Paul Allen's vision, began a new chapter in space transportation on October 4th, 2004 when Scaled Composites won the $10 million Ansari X Prize, opening the age of private, commercial space travel.

Their SpaceShipOne, the first private sector-built manned spacecraft, flew into suborbital space twice in just five days. Twenty-seven contestants from seven countries had been registered as competitors for the prize. Burt spoke about his road to victory and vision for the future "from the mountaintop" at an awards banquet:

> "The only fatal accident in the X-15 (first manned spaceship, which reached 354,200 feet) was related to flight controls during reentry, and I pledged myself to solve that problem, to make something robust for reentry in any kind of flight control failure. That initially drove me to a capsule with feathers, like a shuttlecock, to hold a specific g-level. I was going to use parachute recovery and helicopter airborne pickup.
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> "After more study it was clear that parachutes are not okay for space tourism. ... I woke up one morning and realized, "For God's sake, Burt, you've done 40 airplanes, we've got to do this with an airplane somehow. ... I had problems developing a configuration that had good subsonic flying qualities, like a light plane ... I tried all kinds of things."
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> "Finally in a middle-of-the-night inspiration, I added rotating wings that would tilt back during reentry, effectively configuring the entire aircraft as one big air brake. People, especially the pilots, came to me later and said, 'Burt, we thought you were really smoking something there for a while.'"
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> "As soon as that was shown in supersonic CFD [computational fluid dynamics] to do the trick, then I knew I had what I now call *"carefree reentry."* I knew when I made that work that it was enormous, huge, in terms of what it would mean for space tourism.[1]

In Burt Rutan's opinion, space tourism is not limited to suborbital flights – he intends to provide low-cost space tourism to the moon. Most unusually for the perennially profit challenged aviation industry, Scaled Composites has posted 88 straight profitable quarters. Even while pushing the envelope with innovations such his "carefree-reentry" that stunned his own engineers, Scaled has never suffered a fatal crash. In comparison, the best run major operating airline, Southwest Airlines, has posted 54 straight profitable quarters.

Many other companies are also planning to offer competing flights to space. Rutan says discussions are under way for similar deals with four other potential spaceline operators. Billionaire Sir Richard Branson's Virgin Galactic[1] has already purchased Burt's SpaceShipOne technology and plans to begin carrying passengers in 2007.

"We're prepared to invest another $100 million to develop this business," says Whitehorn, a director of Virgin Galactic. The first five-passenger flights are planned for 2008, and Virgin Galactic has set ticket prices at $210,000.

SpaceShipOne has made possible the business of commercial space travel. Just a month after Virgin Galactic's service was announced, more than 11,000 people, including "Star Trek" star William Shatner, "Aliens" star Sigourney Weaver and Red Hot Chili Peppers drummer Dave Navarro had registered to pay the $190,000 fare for tickets.[2, 3, 4] Rutan forecasts that 3,000 "astronauts" will fly by 2010, and by 2020, suborbital flights will become so affordable that 50,000 passengers will have entered space.[5]

> *Explaining the size of Virgin Galactic's potential market, Mr. Whitehorn said that the company has received more than 29,000 applications to fly since its announced formation last fall. "That is 29,000 people who said they are willing to pay a deposit of up to $20,000 for spaceflights within a range of prices of up to $200,000. We've also had 100 people who have actually signed 'terms and conditions' with us now to pay the full cost of $200,000 to fly on SpaceShipTwo."* [6]

Space tourism, like the "barnstormers" during the early years in aviation, appears to be an important contribution toward the low-cost space transportation market. In a 2002 study, Futron had estimated that by 2021 over 15,000 suborbital passengers with potential revenues in excess of $700 million and 60 orbital passengers with revenues $300 million; would exceed $1 Billion per year[7] Futron's numbers now appear low in our perfect hindsight.

Virgin Galactic's fleet will initially consist of five luxury SpaceShipTwo (SS2) class vehicles, each with the same diameter cabin as a Gulfstream V business jet – 6 ft (1.9m) in height and 7ft (2.2m) in width. Each will carry at least five and more likely eight passengers plus a pilot. The seats will fully recline so that even elderly passengers will be able to handle the expected force of six times Earth's gravity (6 Gs) upon descent.

Rutan expects SS2 spacecraft to soar to between 84 and 87 miles (135-140 km); a three-hour trip with about three minutes of weightlessness. Roller coaster-type restraint bars will fold out of the way so you can float around. Travelers will be able to do more than watch

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[1] http://www.virgingalactic.com/

how candy floats around in space – they can fly around themselves. A week's pre-flight training will be required.

Scaled Composites, plans to create 3,000 new astronauts a year - per departure point, Rutan adds, and per ship.[8] The first flights will leave from the Mojave Desert, but Mojave will not be the only place in the world to buy tickets and fly to space," Rutan said. Passengers may land in a different place from where they took off. A ship could launch near Las Vegas and land in Mojave," Rutan said. "Or, we could launch offshore, start out over the ocean and then... fly over the mountains and land in the desert.

Burt Rutan had estimated that "commercial suborbital flights could cost $30,000 to $50,000 initially, and as little as $7,000 to $12,000 in a 'second generation."[9] Sir Richard Branson appears to have found yet another untapped revenue stream to continue building his Virgin Inc., empire.[10] Virgin Atlantic Airlines, Virgin Records, Virgin Mobile, Virgin Cola, ... all 150 companies are profitable.

Volvo Cars of North America is giving away a seat on Branson's space craft at Volvo's www.boldlygo.com website.. In a 30-second Super-Bowl ad, Volvo unveils its Volvo XC90 V8 SUV by comparing its power to a rocket blasting into space.[11]

XCOR Aerospace has a marketing agreement with Space Adventures, Ltd to offer the first 600 flights to 62 miles (100 km) altitude aboard XCOR's Xerus suborbital vehicle. "Our experience flying the EZ-Rocket airplane has shown we can fly rocket-powered vehicles multiple times per day with a small ground crew," said XCOR CEO Jeff Greason, "We can operate at a fraction of the cost of competitive vehicles."[12]

Oracle's Space Sweepstakes' participants can win a journey to suborbital space from Space Adventures, Ltd., by demonstrating expertise with Oracle's development tools. The prize package's "total retail value is $138,000 including $35,000 cash" -- implying a discounted price of $103,000 fare for tickets on XCOR's Xerus sub-orbital flights. [13]

Nidar, a premier Norwegian confectioner; American Express' Hong Kong and United States cardmembers and 7 UP®, all offer consumers opportunities to win or earn "Free" tickets into suborbital space. [14, 15, 16]

Rocketplane Ltd., Inc. has also begun taking reservations for customers to ride their 43 foot sub-orbital Rocketplane XP to more than 330,000 feet (100 km+) above the Earth. Rocketplane intends to begin XP flights in early 2007.[17]

Orbital Race Begins

Bigelow Aerospace is now offering the $50 million 'America's Space Prize'. The winning America's Space Prize entrant will take a crew of at least five people to an altitude of 400 kilometers, dock and complete two orbits. This must be repeated within 60 days. The craft must be able to dock with Bigelow's space habitats, and be able to stay docked in orbit for six months. No more than 20% of the craft's hardware may be expendable.[18]

Robert Bigelow, owner of Budget Suites of America and other companies, has been building orbiting inflatable space habitats with NASA. These orbiting destinations could be outfitted for a thousand purposes, from casino hotels to space research and manufacturing. The deadline for 'America's Space Prize' is 10 January 2010.

The rules of competition do not allow government funding for the projects, and teams from outside the United States are excluded from entering. This may be a response to fears that ITAR regulations, designed to stop the export of military hardware, could hamper progress in commercializing civilian space flight.

Bigelow has contracted with Kosmotras to orbit a half dozen orbital habitats with Ukraine's Dnepr booster. The first launch is slated for 2006. Five more are planned at seven to eight month intervals, subject to Department of State approval[19] Dnepr's 4,500 kg payload and low launch costs have made it a popular choice for small satellite launches.

A converted SS-18 class missile, Dnepr has launched satellites for Saudi Arabia, Britain, Italy, the United States, Argentina, Germany and Malaysia.[20]. Dnepr launches are reported to cost $3 to $10 million, depending on configuration.[21]

Bigelow Aerospace, has also signed a contract to fly on the first mission of SpaceX's Falcon V, an orbital spaceship. It will carry Genesis Pathfinder, a one-third scale demonstration of Bigelow's immense inflatable habitats.

In addition to the $50 million prize, Bigelow is prepared to offer $200 million in conditional purchase agreements for six flights of a another vehicle. In addition, $800 million in options contracts for twenty-four flights will be available over a period of about 4 to 4.5 years, Bigelow said. "So we have a $1 billion dollar program between conditional contracts and options," Bigelow said.

There are two conditions attached to the agreements. One is if the U.S. government imposes legal restrictions that prevent launching privately financed orbital spacecraft. The other covers the possibility that Bigelow Aerospace might not have a full-scale module in Earth orbit. In that event a terrestrial facility can be used to demonstrate a spacecraft's docking ability,[22, 23] although the first full-scale Nautilus is scheduled to orbit in late 2008.

The America's Prize winner would also be guaranteed first rights on a contract from Bigelow for ongoing orbital servicing missions to its full size inflatable 45 X 22- ft. "Nautilus" modules, with 330 cu. meters of interior volume inflated to 10 psi – possibly docked together as a small space station. Crews can deploy water blankets on inner walls for radiation protection.

Many components have already been delivered for Bigelow's habitats. Ground tests leading to the first orbital flight test of the system on two "Guardian" inflatable – 45% scale module - flights in 2007, carrying critical life-support system demonstration hardware.[24] Hardware includes:

• Air revitalization from EADS Astrium using solid amine, instead of the molecular sieve technology used on the ISS. It uses steam to revitalize the reactants.

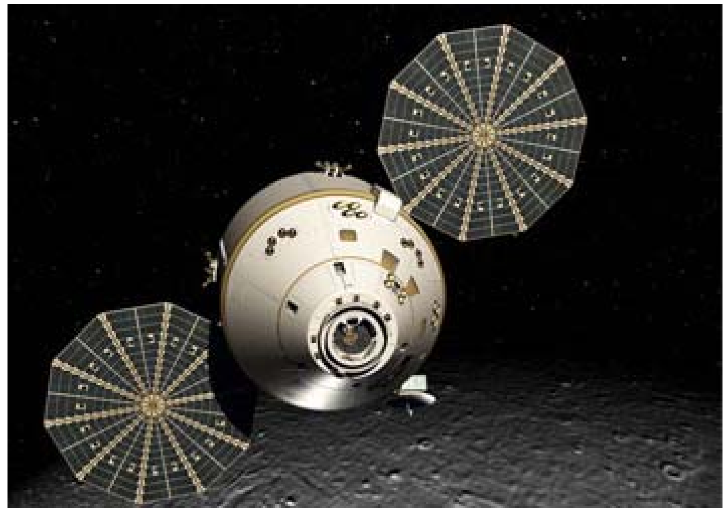
• Boeing is providing a "flight ready" water handling system.

• Gas analyzer: Two systems are being evaluated, one in Europe's Columbus ISS module, and a unit from Thermo Electron Corp., for the U.S. Environmental Protection Agency.[25]

Nautilus users could include biotech and pharmaceutical companies, university research, entertainment applications and government military and civil users, for example, the NASA-developed human tissue growth bioreactor, now in the private sector. Bigelow could earn the trust of those markets by low cost and rapid turnaround, in contrast to NASA bureaucracy. Beyond the space shuttle, four orbital habitats are under development:

New Orbital Habitats

CEV



NASA's new Crew Exploration Vehicle is envisioned as a collection of modular systems for human missions to low Earth orbit, the Moon and beyond. Initial test flights by 2008 with lunar landings around 2015-2020. They may reach a level of reliability to be used for ISS crew transport or rescue.[26] Lockheed Martin's winning concept is pictured.

Kliper

Energia, Moscow. Composed of a reusable six person re-entry main cabin with wingless glider shape, and an orbital module, one-third Soyuz' current size. Will land horizontally on most Russian airfields[27]. Russia expects to use a Zenit rocket booster (Ukraine)

Genesis / Nautilus

The watermelon-shaped Nautilus would weigh 20-25 tons and measure 45 X 22 ft., inflated in orbit. This is larger than any individual ISS module. First man-tended *commercial* module launch around 2008.

Genesis I was successfully launched on July 12, 2006 with 11.7 cubic meters of volume. Genesis II is scheduled for launch in early 2007.

www.bigelowaerospace.com

Shenzhou

China is among the nations admitted to talks exploring President Bush's moon and Mars goals. China's second crewed mission is scheduled for October 2005. Similar to Soyuz, their Shenzhou 6 will carry two people into orbit on a five- or six-day scientific mission, launched by a Long March 2F. "The possibility of a Chinese moon base is part of the reason the US administration is pushing for a lunar effort", says Charles Vick. [28, 29]

Jules Verne, Europe's first Automated Transfer Vehicle (ATV) spaceship, the most complex space vehicle ever developed in Europe, is almost ready to fly.

The 19.7-tonne ATV launches atop an Ariane 5 launcher, carrying between 1500 and 5500 kg of dry cargo to re-supply the ISS. Contained in various sized bags, the cargo will be stored in the 48 cubic meter pressurized section.[30]

Most cargo will be loaded horizontally through the aft end of the pressurized module, opposite the docking system, while not yet mated. A small fraction of the dry cargo can be loaded into the ATV just eight days before launch. The ATV will dock with the ISS's Russian Zvezda module, navigating on its own towards the ISS, combines both the autonomy of an unmanned vehicle and strict human spacecraft safety requirements.

The first ATV is expected to be launched in the summer of 2007. All the international partners have to agree upon the best date for the ATV to re-supply the International Space Station with the 7.1 tonnes of cargo.

Building Fences or Bridges?

We must transition our cis-lunar (between here and the moon) space transportation systems from historically government supported exercises, such as the current Crew Exploration Vehicle (CEV) "competition", to the private vehicles, as required by Bigelow Aerospace's America's Prize. Only private vehicles can provide the next crucial step to low cost space access.

Congress and NASA should exercise their vision and franchise by participating in a serious prize, as the Aldridge Commission recommended - by matching Robert Bigelow in his $50 million America's Prize. NASA should continue to let Bigelow administer the race, since he is now doing it alone. Elon Musk recommends "strongly supporting and actually substantially expanding upon the proposed Centennial Prizes... No dollar spent on space research will yield greater value for the American people than those prizes." Mr. Rutan is probably right again; he doesn't believe NASA is capable of doing a developmental prize:

> "NASA has a habit of trying to help sub-contractors and contractors by monitoring risks that NASA wouldn't take themselves. What NASA needs to do is to put out a very difficult goal to achieve and then not monitor it at all. Let those that go after it take their own risks. Maybe they will put someone in charge that knows the benefits of running a prize properly."[31]
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> "We're developing SpaceShipTwo, a much bigger spaceship, that could carry nine people and allow them to float around the cabin when they are weightless. It would also fly higher, and further down range. So this is going to be a craft that could do sustainable business for a long time, flying thousands of people."
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> "We will be flying within about two and a half years or so. I think it will be certified and actually in commercial operation in about four years. ... I would like to see affordable travel to the moon before I die, so I am starting relatively soon on developments for orbital-space tourism."
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> "The flying that America has done in the last 20 years is by far the most expensive way to get to space and the most dangerous. This can't be done with NASA funding. It absolutely has to be privately funded."[32]

How many billions have been spent in the last three decades building and discarding new space vehicles? We have learned a few things along the way, but most critically we should have learned that it is time to pass the baton to the private sector. Currently, besides CEV, space launch systems under development are the Air Force's Evolved Expendable Launch Vehicles[33] (EELV) – Boeing's Delta IV family and Lockheed Martin's Atlas V family – and NASA's shuttle.

National Aerospace Plane (NASP)
Dyna-Soar
DC-X
Orbital Space Plane
X-30
X-33
X-34
X-38
X-43
Spacelifter
STAS NLV
Transatmospheric Vehicle (TAV)
HLV
HLLV
Shuttle-C
Next Generation Launch Technology (NGLT)
ALS
2nd Gen
3rd Gen
... and now,
the Crew Exploration Vehicle (CEV)

Mitchell Burnside Clapp met Robert Zubrin at an AIAA technical conference in 1993 and described his idea for a new Single-Stage-To-Orbit (SSTO) rocketplane, "Black Horse". Zubrin revised the design with a new rocket engine and in 1994 mobilized sufficient R&D funds within Martin Marietta (now Lockheed Martin) to determine that his "Black Colt" was feasible and that the first prototype could be built for $90 million.

> "Further, NASA suggested that we bid Black Colt for the X-34 concept vehicle, under which NASA would pay $75 million of that $90 million. Martin Marietta management however refused to bid. This angered me a great deal. Here we had a practical concept for a near-term reusable launch vehicle and NASA would pay almost the entire bill for development, and yet – no bid.
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> I protested the decision within the company and got nowhere. Eventually a director took me aside and said, "Look Bob, it's a very clever idea, but you've got to get the picture. We build Titans. You sell one of these to the Air Force and we're out of business."[34]

Cost and schedule projections for a Two-Stage-To-Orbit (TSTO) reusable launch vehicle had historically been in the range of $30 billion to $50 billion and between 10 - 15 years to develop. The business case for private industry to build such a SSTO or TSTO could not be supported with current (2002) mission model projections.[35]

> "The truth is that I don't think any single company or NASA can truly staff or execute something this large and complex (CEV)," Boeing Vice President Chuck Allen said. "It's going to take a whole lot more capability than I think resides in any one corporate or government entity."
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> Lockheed Martin spent $1.2 billion trying to build the X-33 hypersonic plane, only to have the project canceled when cracks were found in the spacecraft's experimental fuel tanks. Similarly, Orbital Sciences' attempt to build the X-34 was shut down before any hardware was flown.[36]

Elon Musk, CEO of SpaceX, testified before the US Senate Committee on Commerce, Science, and Transportation Hearing on Space Shuttle and the Future of Space Launch Vehicles on May 5, 2004:

> "The past few decades have been a dark age for development of new human space transportation systems. One multi-billion dollar Government program after another has failed. In fact, they have failed even to reach the launch pad, let alone get to space. ...
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> "The obvious barrier to human exploration beyond low Earth orbit is the cost of access to space. This problem of affordability dwarfs all others. If we do not set ourselves on the track of solving it with a constantly improving price per pound to orbit, in effect a Moore's law of space, neither the average American nor their great-great-grandchildren will ever see another planet.

> "Dollar cost per pound to orbit dropped from $4000 to $1300 between Falcon I and Falcon V. (Musk considers four or five launches per year necessary to achieve those costs. -Ed) Ultimately, I believe $500 per pound or less is very achievable."[37]
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> "The public reaction has been to care less and less about space, an apathy not intrinsic to a nation of explorers, but born of poor progress, of being disappointed time and again. When America landed on the Moon, I believe we made a promise and gave people a dream.
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> "It seemed then that, given the normal course of technological evolution, someone who was not a billionaire, not an astronaut made of "The Right Stuff", but just a normal person, might one day see Earth from space. That dream is nothing but broken disappointment today. If we do not now take action different from the past, it will remain that way."

Congress has fully funded NASA's budget at $16.2 Billion for 2005[38]. It includes money for resuming Space Shuttle operations, continued assembly of the International Space Station, Crew Exploration Vehicle (CEV), and the Space Exploration Initiative - the Moon, Mars and beyond.

The space shuttle's listed cost per launch is $1.1 Billion, or $63,900. per kg[39] to Low Earth Orbit (LEO) – a few hundred miles up. Elon Musk's company, SpaceX, of El Segundo, California, is quoting $12 million per launch, for their Falcon V, or $2,860 per kg.[40],[41] Both Falcon and Shuttle are partially reusable space vehicles. The shuttle, however, is priced at more than 22 times the price of Musk's Falcon V!!

Of course, this is not surprising. Would you get an estimate to build or repair your spacecraft, car, truck, jet, or locomotive from NASA? No, the government should never be in commercially competitive businesses, from making trucks to raising chickens. It's time to remove cis-lunar space transportation from NASA's job description.

> "Critics might say [SpaceShipOne's suborbital flight] was less impressive because NASA did it forty years ago. That is true, but the SpaceShipOne team did it for $20 million. Today NASA could not put a man in sub orbital space for $20 million. In fact, I don't think they could do it for $200 million. The fact of the matter is that NASA is a government agency and government agencies operate under different conditions and in a different environment than the private sector." - Congressman Ken Calvert, Chair, Space and Aeronautics Subcommittee of the House Science Committee[42]

With the Ansari Prize, 2004 has presaged a new dawn in commercial space transportation. Space pioneers from Washington D.C to California's Mojave Desert; El Segundo and beyond, are working to see that the dark ages of expensive and rare access to space are over:

- In April 2004, Scaled Composites and XCOR were licensed by the FAA to provide suborbital transportation into space. Dozens of other private companies are determined to share the real conquest of space, private/commercial space, as record after record falls. Even children and hobbyists are putting rockets in space:

- On May 17, 2004, the first civilian amateur rocket carrying ham radio avionics entered space[43] (100 km altitude). Actually, ham radio amateurs have flown over fifty OSCAR[2] satellites since 1961[44]. Avionics Team Leader Eric Knight, KB1EHE, called the historic launch "a phenomenal experience. It just roared off the pad and flew into space. Everything went like clockwork ... an awesome experience." His crew included eight Amateur Radio licensees; most took part in a failed 2002 launch attempt.

- Three ninth graders from Penn Manor High School, Lancaster, PA, took first place in the world's largest and most challenging model rocketry contest, the 2004 annual Team America Rocketry Challenge. Their team achieved a perfect score when their custom rocket soared to exactly 1,250 feet and returned two raw eggs to the ground unbroken.[45] They competed successfully against 7,000 other students on 600 teams around the country and shared a $60,000 prize pool with ten other teams:

St. Johns, Shrewsbury, MA;
C. E. Jordan High School, Durham, NC;
Goshen High School, Goshen, IN;
Riverside Middle School, Greenville, SC;
Edison High School, Fresno, CA;
Penn Manor Middle, Lancaster, PA;
Holy Trinity Catholic High, Temple, TX;
Los Gatos High School, Los Gatos, CA;
Butler County High, Morgantown, KY;
Carlisle High School, Carlisle, OH

[2] (Orbiting Satellites Carrying Amateur Radio)

Space Transportation Markets

Beyond the splash created by the new wave suborbital private commercial spacecraft, new markets are being opened. The mature markets, principally communications satellites, are also changing. These new markets are inviting greater competition, revenue, further growth, newer technology, and yet larger market strategies. This new *commercial* spacecraft growth cycle can yield our SSP space freighters.

When President Bush signed the Commercial Space Launch Act in December 2004, he recognized this bold new commercial space environment's genesis. On January 6, 2005 the White House Office of Science and Technology Policy issued an all-encompassing and newly formulated "U.S. Space Transportation Policy".[46] The President's policy provides tremendous executive support for the new commercial space transportation industry. That policy section appears below:

IV. Commercial Space Transportation

1) The United States Government is committed to encouraging and facilitating a viable U.S. commercial space transportation industry that supports U.S. space transportation goals, benefits the U.S. economy, and is internationally competitive. Toward that end, United States Government departments and agencies shall:

a) Purchase commercially available U.S. space transportation products and services to the maximum extent possible, consistent with mission requirements and applicable law;

b) Provide a timely and responsive regulatory environment for licensing commercial space launch and reentry activities;

c) Maintain, subject to periodic review and the competitiveness of U.S. industry, the liability risk-sharing regime for U.S. commercial space transportation activities set forth in the Commercial Space Launch Act, as amended (49 USC, Subtitle IX, Chapter 701), including provisions for indemnification by the United States Government;

d) Refrain from conducting activities with commercial applications that preclude, deter, or compete with U.S. commercial space transportation activities, unless required by national security;

e) Involve the U.S. private sector in the design and development of space transportation capabilities to meet United States Government needs;

f) Provide stable and predictable access to the Federal space launch bases and ranges, and other government facilities and services, as appropriate, for commercial purposes on a direct-cost basis, as defined in the Commercial Space Launch Act, as amended. The United States Government reserves the right to use such facilities and services on a priority basis to meet national security and critical civil mission requirements;

g) Encourage private sector and state and local government investment and participation in the development and improvement of space infrastructure, including non-Federal launch and reentry sites; and

h) Provide for the private sector retention of technical data rights in acquiring space transportation capabilities, limited only to the extent necessary to meet United States Government needs.

2) The Secretary of Transportation shall license and have safety oversight responsibility for commercial launch and reentry operations and for operation of non-Federal launch and reentry sites, as set forth in the Commercial Space Launch Act, as amended, and Executive Order 12465. The Secretary of Transportation shall coordinate with the Secretary of Defense, the Administrator of the National Aeronautics and Space Administration, and other United States Government departments and agencies, as appropriate.

a) The Secretaries of Transportation and Defense shall establish common public safety requirements and other common standards, as appropriate, taking into account launch vehicle type and concept of operation, for launches from Federal and non-Federal launch sites. The Secretaries of Transportation and Defense shall coordinate these requirements with the Administrator of the National Aeronautics and Space Administration and other departments and agencies as appropriate.

3) The Secretaries of Commerce and Transportation shall encourage, facilitate, and promote U.S. commercial space transportation activities, including commercial human space flight.

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A senior administration official said the policy is designed to encourage entrepreneurs and to guarantee new companies a fair competition with the established aerospace companies when they are ready to play. The official said having the president make the decision on a new heavy-lift launch vehicle is more a statement that the decision is of national importance, not a slight to the Pentagon or NASA.

"The president is recognizing the fact that the best of our system is the private investment and private development of commercial capabilities of all types," the official said. "That is hopefully going to grow and bloom out here." [47]

"To exploit space to the fullest extent requires a fundamental transformation in U.S. space transportation capabilities and infrastructure. In that regard, the United States Government must capitalize on the entrepreneurial spirit of the U.S. private sector, which offers new approaches and technology innovation in U.S. space transportation, options for enhancing space exploration activities, and opportunities to open new commercial markets, including public space travel.

"Further, dramatic improvements in the reliability, responsiveness, and cost of space transportation would have a profound impact on the ability to protect the Nation, explore the solar system, improve lives, and use space for commercial purposes. While there are both technical and budgetary obstacles to achieving such capabilities in the near term, a sustained national commitment to developing the necessary technologies can enable a decision in the future to develop such capabilities."

- U.S. Space Transportation Policy

What will this policy mean to the new commercial space transportation industry? The Xprize Foundation, which created and administered the hugely successful Ansari X Prize, has now created the X Prize Cup, sponsored by the Champ Car franchise[3] and many others. . Starting in 2006, X Prize teams will bring the excitement of the racetrack to Las Cruces, NM in a ten-day spaceship-launching annual race to orbit extravaganza. "They'll compete in turnaround time, maximum passengers, cross-range, altitude, fastest flight time, and our latest category, 'coolest-looking ship.'"

"Thousands will come to watch next generation space vehicles fly, talk to the astronauts, see the vehicles up close, learn about the technology, and dream of their traveling to space. "It'll be the Oshkosh, the Grand Prix of space," Diamandis quipped.[48] A number of international teams are considering relocating to the U.S. because of the emerging regulatory environment. Diamandis said that the legislation passed is critical to building the launch base here in the United States.

What will these new spacecraft carry? Every nation and enterprise wants the benefits of increased trade. The key to building the products and services to win the new competition for space is understanding how to position themselves for the emerging and changing markets that will be served by space transportation. What are these markets? How big are they? What will it take to serve them?

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[3] http://www.xpcup.com/ More billionaires are lining up behind the X Prize Cup; Larry Page, co-founder and president of Google, Inc.; Elon Musk, founder and CEO of Space Exploration Technologies (SpaceX) and Jack Bader, CEO of NetEffects, Inc. are among the new members of the X PRIZE Foundation Board of Trustees.

Market 1: Commercial and government satellite launch

Virtually all satellites in orbit today are communications satellites — for dozens of purposes; satellite television, mobile telephony, Global Positioning Satellites (GPS), earth resources monitoring, civilian and military surveillance, digital radio, it seems endless. Based on current costs to orbit, space transportation forecasters for this oldest and original market see a continuing weakness in global commercial launch demand at current prices:

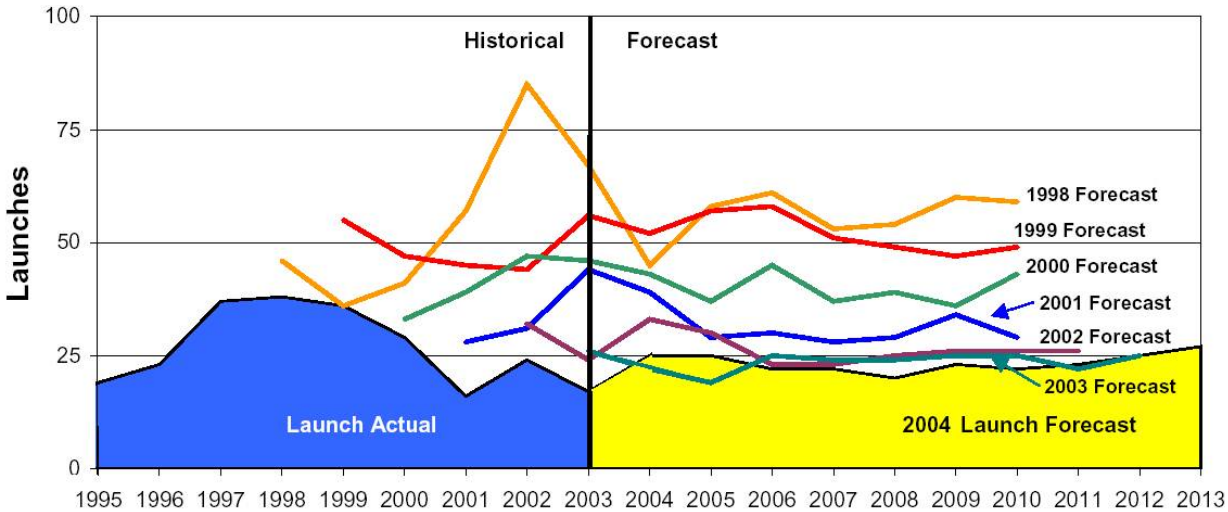


Figure 1. (FAA) Comparison of Past Global Commercial Launch Demand Forecasts(2004)[49]

During 2001-2003, 240 satellites were orbited — about 80 per year. The average number of (commercial plus government) satellites launched from 1991-2000, was about 1,250 — 125 per year. Satellite launch rates are down by 36% worldwide[50] Total worldwide orbital launches fell from 89 in 1997 to 54 in 2004. As of February 1, 2005, just three domestic commercial launches are scheduled. While global launch industry revenues have increased over the last ten years, U.S. industry revenues have declined.

A new service, the ConeXpress Orbital Life Extension Vehicle(CX OLEV), will serve as a space tug to supply propulsion, navigation and guidance to aged telecom satellites. This can greatly prolong the life of retired or aging communications satellites. These satellites are normally placed in a "graveyard orbit" as they deplete their on-board propellant near the end of a 10-15-year operational lifetime, though the satellites' communications capabilities continue.

Orbital Recovery Ltd. signed a long-term, exclusive launch contract for CX OLEV on the Ariane 5. Initial flight is 2008, followed swiftly by four more. Orbital Recovery has identified more than 70 telecommunications satellites that are candidates for life extension.[51]

Manufactured from the payload adapter used on every Ariane 5 mission, CX OLEV will be carried as a secondary payload. The Ariane's primary satellite payload mounts atop it.

After the primary payload is released, the CX OLEV begins its mission as an independent space tug. CX OLEV was developed by the Netherlands' Dutch Space, the leading investor, the DLR German Aerospace Center and Kayser-Threde, with additional funding from the European Space Agency.[52]

Fuel depletion has historically been the reason for "de-commissioning" satellites. Announced just after the FAA 2004 Launch Demand Forecast was released, global satellite launch demand could be depressed below the already low levels in FAA's annual forecast. This new service was not listed among the risk factors that affect satellite and launch demand.

One of the valuable features, which CX OLEV could provide, if realized, would be a survey of the micrometeorite type damage that may have occurred during decades of satellite service at GeoSynchronous Orbit (GSO is 35,000 km up). This data would be of great value to future spacecraft. Current direct micrometeorite damage data is largely based on the LDEF (Long Duration Exposure Facility) which occurred at low earth orbit. Current and detailed data for GSO exposure and damage would be a valuable data resource that CX OLEV could provide.

Without some surprise launch manifests from new space transportation markets as yet unknown to the official prognosticators – (think SSP) – in the years to come the launch to orbit business is going to be very cutthroat indeed. The military communications sector is increasingly using commercial bandwidth and has been increasing its use of commercially available surveillance – and by extension, launch services. About 80 percent of the communications bandwidth used by DoD during Operation Iraqi Freedom was purchased from commercially operated satellites.

> "We are getting so dependent on them (satellites) that we are creating a target," said Thomas Moorman, a retired Air force general. "We have to worry about protecting those satellites; we have to take away those tempting targets."
>
> "You can't go to war and win without (utilizing) space," said Gen. Lance Lord, the rightfully proud head of Space Command. "And if you take space away from us, people will die."[53]

An enemy planning an attack against the United States would be expected to take steps to blind the constellation of satellites that U.S. troops routinely use to monitor enemy forces on the ground and communicate between units in the field and commanders -- sometimes thousands of miles away. Satellites would likely provide the first warning that an enemy missile was about to be launched. Losing that advantage in space would result in the United States losing an advantage on the ground.

Russian President Vladimir Putin has announced that his government is developing "state-of-the-art nuclear missiles systems ... that not a single other nuclear power has, or will have, in the near future." Mr. Putin is known to have in development both a new mobile ICBM and a new solid fuel missile, among other systems.

Secretary of State Colin Powell's blockbuster allegation that Iran was also on the verge of fielding nuclear missiles was a grave warning sign that the days of the United States' military's virtual monopoly on outer space could be numbered.

Lockheed Martin's Patriot Advanced Capability-3 Missile.

The PAC-3 Missile, THAAD and the Medium Extended Air Defense System are elements of the terminal defense layer of the National Ballistic Missile Defense System. Delivery has also begun of the Standard Missile 3, a sea-based ballistic missile interceptor, "designed to intercept and destroy short to intermediate range ballistic missiles." The Navy's Aegis radar system is being upgraded to support missile detection and tracking.[54]

Unless significantly lower costs or other unforeseen events impact this oldest space transportation market, the launch demand for communications satellites is weak.

Market 2: Suborbital tourism

This newest segment has been covered in the opening pages of this chapter.

Market 3: Commercial and military package express - suborbital

Global Express Package Delivery – Just as the Interstate Highway system was originally intended to provide rapid deployment of troops in war time, it also benefited the American motorist. GEPD could provide a similar benefit, speeding critically important packages to distant locations.

A wide variety of industries and businesses would use high priority global package delivery. Fred Smith, President of Federal Express, and the Commercial Space Transportation Study Alliance in a 1994 study showed that at a price of $400/kg, the market for suborbital package delivery would be 1,000,000 kg of mail. The resulting revenue would be $400,000,000 per year.[55]

Critical repair or just-in-time" industrial parts, biological reagents, medical supplies including human organs, business documents, military materiel, and microelectronics would be among the cargo. This goal is similar to Defense Advanced Research Projects Agency's

(DARPA) RASCAL (Responsive Access, Small Cargo, and Affordable Launch) program to quickly and cheaply deliver small cargoes or packages either to distant points or to LEO.

In fact, lessons and technology from Scaled Composites' SpaceShipOne are already being applied to the RASCAL program, Jacob Lopata, chief executive officer for RASCAL prime contractor Space Launch Corp told the FAA's Commercial Space Transportation Advisory Committee (COMSTAC).[56] SpaceShipOne and RASCAL will be operating in a very similar environment with the same thermal protection system used by SpaceShipOne, he said.

After takeoff from Mojave Airport, a RASCAL aircraft will climb to 50,000 feet and perform a supersonic "zoom" maneuver until it reaches 100,000 feet altitude. At that point the four mass-injection pre-compressor cooled (MIPCC) turbojet engines will shut off and the aircraft will coast to approximately 180,000 feet, where a two stage hybrid rocket is released.

RASCAL’s stated mission is to deliver a 165 pound payload into a 310-mile sun-synchronous orbit, with a 24 hour mission turnaround time from payload arrival, and recurring launch costs of $750,000 per flight. The program is awaiting approval to start a 36-month demonstration phase culminating in two flights in 2008.

Market 4: Commercial, government, and military people express

RASCAL has been cancelled in favor of Falcon

Like RASCAL, there is also a related DARPA and Air Force project – FALCON[57] – that has significant overlap with commercial orbital passenger business, tourism, entertainment, etc.,. The somewhat artificial distinction we are making here between the cargo and passenger orbital markets is chiefly a reflection of the cost of safety at this point (2005) in space transportation. FALCON could as easily carry military cargo. Bigelow Aerospace’s America’s Prize, which moves people to LEO, is most representative of this market statement.

Clearly, orbital commercial passenger travel has not yet been demonstrated equivalent in cost and safety to airline operation. When that occurs, we will see these two markets – passenger and cargo – served by the same vehicles; as well as specialized ones. The much more mature commercial aviation market makes little distinction in the equipment serving those markets today. Hopefully, that distinction will disappear for orbital travel during the coming decade.

As has happened in the space communications market, with the military tapping the commercial market for 80% of its bandwidth needs during Operation Iraqi Freedom, the same will likely eventually happen with space transportation. This is clearly the President’s policy direction. It is an excellent goal; fully commensurate with moving the commercial space transportation market rapidly toward the low-cost structure requisite for SSP initiation.

FALCON envisions developing two vehicles – a Hypersonic Technology Vehicle and Small Launch Vehicle. SLV would place a small satellite weighing 1,000 pounds into a circular, 100 nautical mile orbit for a total launch cost under $5 million (excluding payload and payload integration costs). HTV appears to be beyond our planning horizon. DARPA and the U.S. Air Force have funded four teams for SLV second phase:

- Airlaunch LLC
- Lockheed Martin Corp., Space Systems Co.
- Microcosm Inc.
- Space Exploration Technologies Inc.

This phase culminates in 2007 with the launching of small satellites using these SLVs.[58] In addition AirLaunch and Scaled Composites are members of t/Space's collaborative proposal for NASA's CEV. We believe that the orbital transportation market will also be boosted by the booming competition in every existing commercial and defense related aerospace transportation market including the new suborbital aerospace sector:

Honda, with their partner GE, appears eager and ready to carve out a major share of the new micro-aviation business with its new small high efficiency turbofan jet engine. Weighing just 392 pounds, it packs 1600 pounds of thrust. Fitted to Honda's six seat experimental HondaJet airframe, the engine delivers 40% better fuel efficiency (nautical miles per pound of fuel) than jets currently available.[59]

This new generation of "microjets", to be delivered by 2007, have starting prices below $1 million, a third of today's entry-level business jet costs. These include the Cessna Citation Mustang, the Eclipse 500, the Diamond D-jet, the Safire Jet, the Avocet ProJet and leading the pack, the Adam A700 – air-taxi Pogo's supplier.[60]

A commercial airliner flying 500 miles or less averages 75 miles per hour, not much different than driving. So, under fuel and other cost pressures, commercial aviation is re-inventing itself; from suborbital space travel to flexible fractional-ownership aviation — such as NetJets(which invented the idea), Flight Options, Bombardier's Flexjet/Delta AirElite, CitationShares, Avantair and PlaneSense.[61]

The Teal Group forecasts business jet sales of 6,413 aircraft over the next decade, about 40% in the high-end, long-range market. Richard Aboulafia says this explosive growth is fueled by backlash to depreciating airline service, increased personal wealth, and new, lower-operating-cost jets; with unprecedented sophistication and safety on their flight decks.

Employment in the U.S. aerospace industry has been falling for fifty years, hitting 568,700 in February 2004. By September 2004, six months later, aerospace companies had added 18,900 people.[62] The hiring comes as U.S. airlines report continuing losses with several in bankruptcy and others struggling to avert it. Surging oil and jet fuel prices have troubled the aviation industry's since 9/11. The International Air Transport Association expects the global airline industry to post a loss between $3 and $4 billion in 2004.

International air traffic, however, increased a healthy 18.7% during the first eight months of 2004.[63] Jet fuel prices, the second largest expense behind labor costs, also increased 90% from $0.86 to about $1.65 a gallon between November 2003 and November 2004, as oil prices passed and retreated from $50.00 per barrel.[64]

From 2001 to 2003 the industry lost $30 billion. Of the five airlines not in bankruptcy protection, Northwest, Continental, Delta and American Airlines all reported losses again for 2004. Only Southwest Airlines, which has benefited from its aggressive fuel contract, reported another profitable year. United and US Airlines are operating under Chapter 11.

> "The Association for the Study of Peak Oil & Gas (ASPO), a group of petroleum geologists formerly with major oil companies (e.g. BP, Amoco) has recently revised their date forecast for global peak oil production forward from 2010 to 2008. ...
>
> "ExxonMobil expects 80% of additional global demand for energy up to 2020 to come from the developing countries (see ExxonMobil, A Report on Energy Trends, February 2004, p.3). In the worst-case scenario, the already emerging widening of supply/demand gap could trigger a shortage shock leading to price crisis. This would also impact world economic development."[65]

The SSPW takes no position on these date predictions. But if a price crisis from a global oil production peak were delivered to the global economy, and SSP construction had not begun, the impact would be intensified with no prospect or outlet for the vastly increased pressure for clean alternative energy baseload generation. There is no comparably clean baseload energy system on the horizon that could compete with SSP.

It is exceedingly important that SSP construction, most likely through the SunSat Act, be initiated immediately, if not sooner, to begin providing the *clean competitive baseload* energy minimally requisite for continued global development. Relief in the shape of hybrid cars, energy conservation, more efficient appliances, etc., are swiftly becoming a "day late and a dollar short", considering the increasingly massive energy demands of developing nations. The application of other key technologies is also required.

In a recent report prepared for the Department of Energy's National Energy Technology Laboratory (NETL), lead author Robert Hirsch suggests that "whatever the peak year turns out to be, 2005 is the time to get moving on energy policy. ... strong action must be taken at least 10, and preferably 20 years before we reach a world oil peak, if we are to avoid a long period of significant economic hardship worldwide."

Under normal conditions, replacing half our automobile fleet would require 10-15 years; replacing half our light trucks, 9-14 years. "Waiting until world conventional oil production peaks before implementing crash program mitigation leaves the world with a significant liquid fuel deficit for two decades or longer."[66]

With the approaching suborbital space transportation market, expanding defense work, business jet and other new aerospace segments, there **is** now a refreshing lift in the cyclical aerospace market. "Last year, we couldn't put a CNC machinist to work," said Jan Scudder, a recruiter with WorkSource in Everett, Washington, "This year, we can't find them."

Market 5: Space Solar Power – (Cargo to GSO)

World electricity consumption, increasing at 2.3 percent per year, is projected to nearly double from 2001 to 2025, from 13.3 trillion kilowatt-hours (Kwh) to 23.1 trillion Kwh.[67] The U. S. generated 3.8 trillion Kwh in 2003.

An SSP System large enough to provide 10 trillion Kwh per year, will require about 1.2 Terawatts of power to be delivered by the SSPS. This requires about 8,400,000 tonnes of payload. If we had one hundred and forty space freighters per day taking off from spaceports operating three hundred days each year that would be 42,000 flights per year. With each space freighter carrying 10 metric tonnes of payload bound for GSO, we could deliver the required cargo in twenty years.

This launch market would be over one thousand times larger than today's commercial launch market, compared to the FAA's Global Commercial Launch Demand Forecast above. Many current suborbital systems are viewed by their designers, such as Burt Rutan, as precursors of the low-cost orbital space vehicles needed for this effort. Building an SSPS is not intrinsically different than building another large economy-sized-array of communications satellites.

Developing countries aim towards the average supply capacity in developed countries of 1 kW per person.[68] A one-Megawatt generator can support about one thousand residential people. About two more kilowatts per person are used in developed countries for other supporting commercial and industrial needs.

A NASA commissioned study of SSP launch costs set the ground-rule for the researchers that only one 1.2 GW SSP satellite was to be delivered to GSO per year for thirty years – an exceedingly constrained proposal to serve the electric energy market, considering that:

(1) this imposed market restraint made it exceedingly difficult for the researchers to define a successful space transportation business model to successfully serve that market and

(2) the immense and growing energy market's unserved need for clean baseload power aggravates looming associated environmental issues.

The study forecast an aggressive price goal of $400/kg of payload to LEO, at 500 flights per year - roughly corresponding to 2.5¢/kW-hr.[69] They further forecast $800/kg of payload to GSO, assuming that boosting the payload from LEO would cost an equivalent amount.

In order to build a commercially successful solar power satellite system, a company must build many satellites. They could not, for example, build only *one* Boeing 747 and expect it to be a commercial success, because its development costs would have to be paid with a single sale. The single plane would cost billions. Even if the plane were filled on every flight, tickets would cost as much as new car. How many people would fly from New York to Chicago at $20,000 a seat? Parts and maintenance would be astronomically priced.

Realistic business models demand that hundreds or thousands of such planes or satellites be built. Like the Boeing 747, the only feasible and acceptable business plan is to build enough planes or satellites to more fully satisfy the market and enable the commensurate development costs to be spread across the fleet.

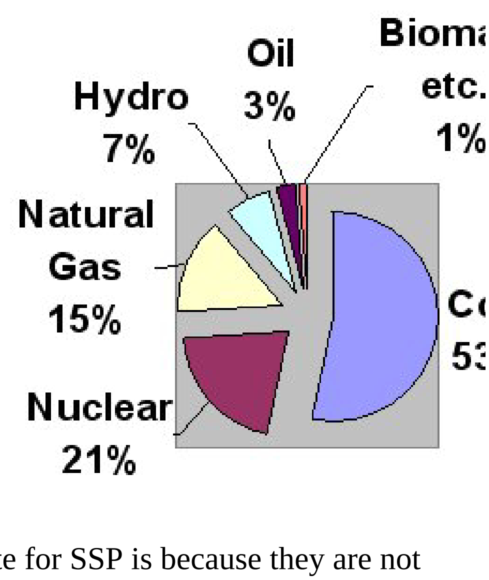
By observing the economics of airline operations most planners believe it will be more economical to build and launch these SSP satellites using many flights of vehicles with relatively small payloads. This has the major advantage of enabling economical, routine, airline-like operations. That is, the economies of large volume production and large volume operation are more important than the advantages of large unit launch size. This is only achieved with relatively smaller vehicles.[70]

The aviation industry demonstrates this clearly: for decades aircraft have been developed that are small enough for the demand for air travel to justify making and operating them in large numbers. It is only as the demand for air travel has reached its present high level of tens of millions of flights per year that very large aircraft have come to be built.

EIA's 2004 forecast projects world energy consumption to increase by 54 percent from 2001 to 2025, i.e. from 404 quads (quadrillion Btu)) in 2001 to 623 quads in 2025. Driving this are the fast developing Asian countries, forecast to increase their Gross Domestic Product by 5.1 percent per year – from refrigerators, cooking devices, telephones and lighting to innumerable industrial manufacturing processes. Not coincidentally, this yields both higher productivity and standards of living, as these are naturally linked.

Coal-fired plants accounted for 53% of US 2003 electric generation; nuclear 21%; natural gas 15%; hydroelectricity 7%; oil 3%; biomass and all "others", including geothermal, just 1%.

It is especially important to note that at EIA's forecasted growth rates, renewables such as wind power and ground-level solar cells are not projected to make a substantial contribution to U.S. or global energy supplies, even by 2025.



They reason these new renewables cannot substitute for SSP is because they are not baseload-available. Wind power and ground-level solar cells are available from 25% to 30% of a typical day and some days may be unexpectedly unavailable. They always need to backed up by reliable plants, such as coal, nuclear or other baseload spinning-demand. It is not cost effective to store **large** quantities of electric energy.

Baseload electric energy generation systems, including SSP, require many years to construct in quantity. They are the most capital intensive business extent. Between 1992 and 2002 the low cost of and increased demand for clean natural gas-fired electric generation drove a 61% increase in *new* gas-fired power generation by electric utilities - 94% of the U. S. increase in natural gas demand during that time.

Flat natural gas *production*, however, has driven natural gas prices to $6 or even $7 per MMBtu and shows no sign of returning to the $2-3 prices per MMBtu typical of the 1990s. The rationale for deregulation evaporated with this massive price increase. In 46 months this natural gas crisis cost U.S. consumers over $130 Billion, according to the Industrial Energy Consumers of America, who have watched as thousands of energy-dependent jobs have fled the U.S.[71] **If that money were instead spent on SSP, we would be well on our way to solving our global energy and CO^2 driven climate change crises.**

Market 6: Space Manufacturing

The special environments available in space could make commercial a wide variety of space manufacturing processes, many of which have already been demonstrated, but await lower cost space access. For example, the Second International Microgravity Laboratory (IML-2) showed that the manufacture of biologicals such as protein crystals could be greatly enhanced by growth in microgravity, or zero gravity -- "Small crystalline particules grew in conditions where on earth only amorphous precipitant appears."[72]

Several years ago, Andrews Space & Technology under NRA 8-27 TA 1.1 Future Space Transportation Study identified liver tissue as "the most likely early candidate for commercially viable space-based tissue engineering"

> "Tissue engineering technologies have the potential to address diseases and disorders that account for about half of the nation's total healthcare costs. Tissue culture experiments performed on the shuttle and Mir have demonstrated the positive effects of microgravity on three-dimensional tissue growth and differentiation, and thus the potential for improved products.
>
> Liver disease in the United States resulted in 25,175 deaths in 1997, while only 4,000 people received a liver transplant (in 1996). Based on 1985 data, liver and gall bladder disease cost the US health care industry US$17 billion (adjusted for inflation). Space based tissue engineering could possibly save tens of thousands of lives and has the potential of saving the US health care industry billions of dollars.[73]

Market 7: Lunar Tourism and Services

Using Russian hardware Constellation Services International, a small California space firm, recently disclosed details of their Lunar Express project to resume human flights to the moon funded by private passengers. CEO Charles Miller said, "The key is getting the cost down using existing assets." Miller's team envisions using upgraded versions of existing spacecraft, from the Russian Soyuz, (now being upgraded to Kliper, or Clipper) to the mighty Proton rocket that can carry more than 20 tons into orbit.[74]

In a Soyuz Lunar Express mission: “A logistics module with an upper-stage booster is launched into orbit from Earth and links up with a Soyuz craft from the international space station. The booster powers the Soyuz out of Earth orbit, then drops away. The Soyuz rounds the moon, then returns toward Earth. The craft's re-entry capsule separates from the logistics module and makes a parachute landing.”

Constellation Services’ estimates a lunar tourist mission will cost in excess of $100 million per ticket. Constellation Services does not minimize the engineering challenges of Lunar Express. The scheme appears remarkably doable, in the view of some space experts. The Soviet Union did once send a Soyuz-style spacecraft around the moon, though the plan was canceled after the success of Apollo.

Market 8: Commercial - asteroid defense and mining

If you discover that an asteroid has a significant chance of striking the earth ten years, for example, from now, some governments of earth may contract to alter the orbit of such an asteroid enough to avoid the earth. Many techniques for doing this have been considered.

Even if the launch costs to GSO fall to $100 / kg, just the cost of transporting materials into orbit would be $100,000 / metric ton. This is over 50 times the price of aluminum (about $1936/metric ton in the US)[75], and more than 280 times the price of structural steel (about $350/metric ton) at the Earth's surface, using existing technologies. Space transportation costs dominate make or break most space business plans.

This differential provides a wide cost margin which companies could use to profitably extract many raw materials from non-terrestrial bodies and deliver them profitably to users in Earth orbit[76]. One context for that function is with normal contractual delivery to SunSat Corp locations through a Lunar Development Authority licensee or independent asteroid miner.

Asteroid astronomy shows there are many accessible potential ore bodies among the Near-Earth Asteroids. Mining and metallurgical options exist that are simple and robust. A teleoperated miner for return of volatiles from NEAs is economically feasible, using present technology, with an initial market of about 1000 tonnes per year. Asteroid mining is close to technical and economic feasibility. Many researchers think water is the likely first target of an NEO mining mission.

"Water is easy to handle and peculiarly useful," said Mark Sonter, a mining engineer based in Sydney, Australia, who has written several papers on profitable ways to mine NEOs. "You're almost guaranteed 10-30 percent recoverable water from water-bearing asteroids," he said. "Once you've extracted it at the asteroid, you can use it directly as propellant in a steam rocket or you can split it into hydrogen and oxygen and use it in a classic chemical rocket, and using some of it, you can return the rest to Earth orbit, where it can be used as propellant, as life support, or as radiation shielding."[77]

It is also possible that if the asteroid were of proper composition, perhaps a comet core (ice) or a carbonaceous chondrite (hydrocarbons), it may well be commercially possible to capture and market the raw materials. The capabilities being developed and fielded for ABM defense clearly also encompass an initial defense capacity for defending SSP and the earth against the threat of meteorites and asteroids.

Market 9: Lunar Development Authority activities

A SunSat Corporation has no business reason to and should not be permitted to pursue off-target enterprises and endeavors, including lunar development. Its first action would be to design and build an SSP demonstration satellite. SunSat's focus should be developing SSP -- its market and associated technology, such as wireless power transfer. However, an appropriate encapsulation of that risk into forms which would work for the mutual public and private benefit of many could begin with the formation of a Lunar Development Authority (LDA).

In particular, some space analysts, notably Gerard O'Neill[78], have concluded that if some preliminary lunar development were subsidized, such as through the intent of current President Bush's "Moon, Mars and Beyond" plan, photovoltaic cells might be provided to an SSPS development at lower cost than the earth could provide these. These cells, manufactured primarily from lunar regolith[79] would be useful to moon development, as well. Lunar fiberglass production is another of the many useful products that have been investigated.[80]

Rather than lift such large masses of components, such as photovoltaic cells, the primary component by weight of SSPs, from earth to GSO, it may be shown to be more profitable to collect raw materials from the lunar surface, and even from asteroids and comets in convenient orbits.

The energy cost to transport a pound of cargo to GSO from the moon is twenty times smaller than the energy costs to transport a pound from earth. So if shipping costs from earth to GSO are $100 per kilogram; *once the infrastructure is in place on the moon,* shipping costs from the moon to GSO would be $5 per kilogram.

This is a core argument and rationale, as many millions of tonnes of photovoltaic "fabric" are required to build an SSP system. If America and other nations intend to return to the moon to stay, this purpose would seem most reasonable. Of course, first developing such an industrial capacity on the moon would first be required, probably through subsidy under an organization like a LDA.

By way of comparison, it is possible to travel from the earth to the moon in 3 days, with favorable launch windows available every day. Travel to Mars, however, requires about 270 days with launch windows available every twenty-six months, when Mars' orbit moves it closer the earth. Telesurgery or telepresence to the moon is very possible. Telesurgery or telepresence to Mars is practically impossible due to the long telecommunications delay.

In a larger sense, continuing to improve and enhance telepresence, such as telerobotic construction of SSP or the servicing of satellites, such as CX OLEV intends to do, builds critical capabilities for remote space operations. As we will examine in detail in a later chapter, telerobotics is a strong and vital field in it's owned right -- extending human reach by synthetic reality.

Telesurgery, for example, with the attending surgeon in the US and the patient in France (with surgical observers) has been accomplished; bridging the Atlantic. Doing telesurgery on the moon from earth could be accomplished as well. The military has been strongly pursuing this capability.

Telemining has been fully demonstrated on the earth in working mines. It has been done on Mars, although it is many times easier on the moon since the moon averages 237,000 miles distant, while Mars' oval orbit takes it from 35 million to 259 million miles distant from Earth. To communication with a robot on either body, it would therefore take about

2.6 **seconds** for roundtrip communications to the moon
26. **minutes** for roundtrip communications to Mars

Continuing to extend our telepresence capabilities into space activities is essential. Assembly and operation of many space systems, including SSP, would be accomplished telerobotically. For example, as we will discuss in a later chapter and the Lunar Development Authority market below, some aerospace planners have suggested that photovoltaic materials for SSP could be manufactured on the Moon and shipped more cheaply to GSO.

This may be possible, since it only requires one twentieth as much energy to read GSO from the Moon as it does earth – if an appropriate encapsulation of that risk can be done and various infrastructure can be subsidized. It is abundantly clear that Americans want to pursue and encourage development on the high frontier. So how would an LDA work?

A publicly chartered LDA would share and subsidize the cost of infrastructure needed by cis-lunar businesses to facilitate the rapid development of all. Separating this infrastructure development would reduce the risk attached to each and make a massive undertaking manageable. Candidate infrastructure areas might include:

transport,		power supply,
water,		meteorite defense,
air,		photovoltaic cell production
shelter,	...	legal other services & commodities

These infrastructure support contracts would support the nascent cis-lunar commercial manufacturing and other services. Under such special circumstances a separate lunar photovoltaic material manufacturer may very well be chartered to become a PV provider to a SunSat type corporation(s).

New industries such as tourism to the moon might be financed. An "Olympics on the Moon" in one sixth gravity would see college pole vaulters "easily" clear a hundred feet! (Imagine the thrill of aiming/looking for the landing pad from a hundred feet up!) The advertising and television rights to the first Lunar Olympics could finance the construction of a lunar hotel and sports facility, where the Olympics would be held - under LDA auspices.

The most effective and beneficial method of preventing NASA from competing with the private sector is to give the Agency a new mission, mandate and focus to turn its energies toward. To fully respond to the President's Moon, Mars and Beyond initiative we should break off a chunk of NASA, make it a public/private corporation and dedicate it lunar development - the LDA. In actuality, the LDA could be formed first. Under its charter it could select NASA's assets and budgets appropriate for lunar development and serving the common interest of subsidized Congressionally targeted commercial lunar interests.

NASA funded a Transformational Space Corp. ("t/Space") proposed lunar development architectural study of market-based competition, spurred initially by NASA incentives. In the t/Space scenario, companies would design, build and own the lunar infrastructure (vehicles, habitats, power stations, greenhouses and the like) from which NASA will buy services to support its explorers. If t/Space continues to win follow-on contracts, and Gump estimates that t/Space needs $500 million to complete its CXV by 2009, t/Space won't compete with big aerospace effort to build the next- generation CEV -- NASA's primary space-launch system; it will just quietly build a backup machine more quickly and at a fraction of the cost. "We are trying hard not to claim to be a space-shuttle replacement; we are a Soyuz replacement," Gump said, "a simple craft to ferry people up and back rather than a self-propelled space station like the shuttle."[81]

Aldridge Commission ("Moon, Mars, and beyond") recommendations:

- The private sector must be given a much larger role in the U.S. space program.

- Commercialization of space should become the primary focus of the vision, and that the creation of a space-based industry will be one of the principal benefits of this journey. If the exploration vision is implemented to encourage this -- an entirely new set of businesses can emerge that will seek profit in space."

- NASA should turn over nearly all launch activity to private firms, except for the launching of human crews. Human transport beyond LEO "will likely remain the province of the government for at least the near-term."

.

- The private sector is willing and capable of providing the initial boost into low-Earth orbit for the payloads associated with the vision," the report states. "To foster the continued development of this emerging market, the Commission believes NASA should procure all of its low-Earth orbit launch services competitively on the commercial market."

- The commission suggested that international participation should be modeled after the Joint Strike Fighter program, which permitted foreign partners to influence the direction of the effort based on the extent of their investment, while authority is retained over key decisions within the United States.[82]

Current Legislative and Regulatory Environment

The Federal Aviation Administration (FAA)'s Associate Administrator for Commercial Space Transportation (AST) has been given the mission to "ensure protection of the public, property, and the national security and foreign policy interests of the United States during a commercial launch or re-entry activity and to encourage, facilitate, and promote U.S. commercial space transportation." They intend to be recognized as the world's foremost authority on commercial space transportation safety and market assessments."[83]

The AST certified their first two suborbital spacecraft in 2004. The world's first commercial license for suborbital manned flights went to Scaled Composites. XCOR received the AST's second license for testing their current spacecraft prior to suborbital passenger travel. These were important precedents.

The Commercial Space Launch Amendments Act of 2004 placed the licensing of commercial manned spaceflight under the sole jurisdiction of AST. It provides a stable environment for commercial suborbital space tourism, in particular, so that potential investors would not face crippling lawsuits in this new high-risk business.

The temporary regulatory environment created by this landmark Act exists until 2012, balancing the need of the emerging commercial suborbital industry to come into existence with the passenger's and public's safety during this developmental period. It also makes it easier to launch new types of reusable suborbital rockets by allowing the AST to issue experimental permits that can be granted more quickly and with fewer requirements than licenses.

The agency would start regulating and certifying spacecraft to ensure crew and passenger safety only if the operation of those vehicles resulted in death, serious injury or significant operational dangers[84] (as opposed to test flight). The bill requires passengers to be informed of the risks involved, while allowing paying passengers to fly on suborbital launch vehicles at their own risk. It condenses into law the critical FAA(AST) certification process:

> "You must have certification, and it's the cheapest thing you ever buy. First of all, it only costs you between nine and sixteen percent more because the FAA is there. I asked Beechcraft when they were done certifying the structure on the Starship [aircraft], what if there was no FAA, what if you, Beechcraft, did your testing only

> for your ethics. Now your ethics mean that it's not a good thing to kill our customers. What did certification really cost you?
>
> "Beechcraft's report showed me every test, every test article, and every report that the FAA insisted that they do that they didn't think needed to be done. They took everything that was in dispute—in other words, I wouldn't have done that but the FAA made me do it—and it came out to be nine percent. Certification is not expensive because of the FAA. It's the very best thing you can buy when you have an accident and somebody gets killed.
>
> "The plaintiff's attorney's job is to convince that non-technical jury that you did a sloppy job; that you didn't do enough for his safety. The best thing you can say is there are specific government certification requirements and I met all of them. You can even bring the government in to certify to the jury that you passed all of the safety requirements. Without that you can't survive as an industry: you can't survive the first accident, and you can't get insurance. You must have that government certification that protects passengers.[85]

XCOR, the driving force behind initiating and promoting this key legislation, pushed it forward against considerable obstacles. The bill is an important step, the first of many regulatory adjustments that will to be made to facilitate and encourage the development of this evolving industry.[86]

To carry cargo more cheaply into space, it is important that the language also change: "Launch" refers to an expendable artillery shell – not a vehicle we want to ride in. A better word for a vehicle that routinely leaves the ground, reaches space, and returns to the ground is to "fly". A "spaceport" is a new place where spaceships routinely leave the ground, reach space, and return. "Flight safety" is the ability of a pilot (remote, on-board, or automatic) to recover from pilot or hardware induced problems and safely return to the ground.

A major fear of the new reusable space transportation industry, and its financial backers, has been that the government would attempt to formulate regulations in a vacuum, placing impossible obstacles in the way of people whose job is difficult enough as it is. But how, in lieu of government regulation, would the industry ensure the safety of space flyers?

> To find an answer, the most prominent industry members met in El Segundo California on 18 January 2005. They decided to establish a federally recognized Industry Consensus Standards Organization whose purpose would be primarily to establish Consensus Standards for ensuring the safety of space flyers.
>
> If such Consensus Standards exist, they take the place of federal regulation, and provide the equivalent or greater effect, just as UL approval has become an important standard for electrical devices. The same will be true of spaceships and operating procedures promulgated by this future Industry Standards Organization. When faced with the choice of flying on an approved versus non-approved spaceship, a customer is much more likely to accept the former.

> These developing Industry Standards are likely to be superior to government regulations. Since they come from industry experience, they can be accepted and implemented quickly without the review of people less experienced in the field, or who have experience only in the non-applicable field of expendable launch vehicles.[87]

Government aviation safety regulations have sometimes, historically, *reduced* aircraft safety compared to what industry would have provided. Worse, the imprimatur of government approval carries a weight that can give a false sense of security, violating the principle of informed consent.

A far from complete overview of these new lower cost, safer and reusable spaceships has been assembled here for your approval.

New Generation Space Transportation Systems

Aeronautics & Cosmonautics Romanian Assoc.(ARCA)

Ship Name: ORIZONT
President: Dumitru Popescu
Offices: Valcea, Romania
Propulsion: Liquid rocket
Launch: Vertical from ground
Landing: Ballistic reentry, parachute to water
Website:: www.arcaspace.ro

AirLaunch LLC

Ship name: QuickReach
President: Debra Lepore
Offices: Kirkland, WA
Carrier aircraft: C-17A. First stage: 172,000 lb thrust engine; liquid oxygen and propane. Second stage: Restartable 24,000 lb thrust engine, liquid oxygen and propane
Length: 66 feet, weight: 72,000 pounds
Projected first launch: 2008 from Wallops
Launch cost: 1,000 pounds to LEO $5,000,000.
Launch & Landing: Horizontal
Website: www.airlaunchllc.com

Andrews Space Inc.,

Ship Name: Alchemist
President: Jason Andrews
Offices: Seattle, WA
Propulsion: Liquid oxygen generated in sub-sonic flight using the cooling of its liquid hydrogen fuel; minimizing takeoff weight.
Launch & Landing: Horizontal from ground
Website: www.andrews-space.com/en/corporate/NGLT(200311).html

Armadillo Aerospace

Ship Name: Black Armadillo
President: John Carmack, creator of the popular video game Doom
Offices: Mesquite, Texas
Propulsion: Hydrogen Peroxide monopropellant
Launch: Vertical from ground
Landing: Parachute, crushable nose cone
Website: www.armadilloaerospace.com

Blue Origin

President: Jeff Bezos, founder, Amazon.com
Offices: Seattle, Washington
Orbital & suborbital spaceships[88] Rumored to carry seven people, liquid fueled.[89]
Link: http://www.blueorigin.com/

Bristol SpacePlanes

Spaceship Name: Ascender
Director: David Ashford
Offices: Bristol, England
Propulsion: turbofan; rocket
Link: http://www.bristolspaceplanes.com/
http://news.scotsman.com/latest.cfm?id=3740428

DaVinci Project

Ship Name: Wild Fire
Team Leader: Brian Feeney
Offices: Toronto, Ontario, Canada
Propulsion: Liquid Oxygen/Kerosene
Launch: Air launch from a hot air balloon
Landing: Guided Parachute
Website: www.davinciproject.com

European Aeronautic Defence and Space Company (EADS)

Ship Name: Hopper, prototype is Phoenix
Launch Location : Kourou, French Guyana
Launched: horizontal from four km. track.
Payload : 7.5 tonnes to an altitude of 130km.
Autonomous unmanned flight control
Landing: Hopper will return on a ballistic trajectory to Ascension. First prototype flight was May 8, 2004

Interorbital Systems

Ship Name: Neptune OLV
President: Roderick Milliron
Offices: Mohave, CA
Propulsion: White fuming Nitric Acid
and proprietary hydrocarbon
Launch: At sea vertical floating launch
Payload: 9,000 pounds manned flight control
Website: www.interorbital.com

Indian Space Research Organization

Ship Name: SLV-3
President/CEO: Gopalan Madhavan
Two stage RLV. First test flight will be in 2008-09. Cost $1,200-1,500 for a kilo of payload. The Space Capsule Recovery Experiment will launch a 600-kg satellite into an orbit 400 km from the earth. After 30 days it will return by parachute. [90]

No picture
–
airplane-shaped RLV

Kelly Space & Technology

Ship Name :Astroliner
President/CEO : Michael Gallo
Offices: San Bernardino, CA
Propulsion: Liquid oxygen and hydrocarbon
Launch: Horizontal, towed by Boeing 747
Payload : 9,000 pounds manned flight control
Website: www.kellyspace.com

Masten Space Systems

Shipname: XA-1 suborbital launch vehicle
President/CEO: David Masten
Offices: Santa Clara, CA
Website : www.masten-space.com

Pablo De Leon & Associates

Ship Name: Gauchito (The Little Cowboy)
President: Pablo DeLeon
Offices: Buenos Aires, Argentina
Propulsion: Hybrid Rocket Powered
Launch: Vertical
Landing: Parachute
Website : http://www.pablodeleon.com/

Rocketplane Kistler

** ***COTS Winner*** **
Ship Name: XP suborbital
K-1 orbital
Offices: Oklahoma City, Oklahoma
Propulsion: Kerosene/Oxygen
Launch: Vertical, conventional
Payload: 4000 kg to LEO
Landing: Parachute
Website:
www.kistleraerospace.com

Scaled Composites

*** ***Ansari X Prize Winner*** ***
FAA licensed for suborbital manned flights.

Ship Name: SpaceShipOne
President: Burt Rutan
Offices: Mojave, California, USA
Propulsion: Turbojet; Nitrous Oxide/HTPB
Launch & lands on runway:
Website: www.scaled.com

SpaceX

** ***COTS Winner*** **
Ship Name: Falcon I, V
CEO: Elon Musk
Location: El Segundo, CA
Propulsion: LOX & RP-1 kerosene
Launch: Vertical
Landing: Ocean recovery
Website: www.spacex.com

Starchaser Industries

Ship Name : Thunderstar
President/CEO: Steve Bennett
Location: Cheshire, UK & New Mexico
Propulsion: LOX-kerosene
Launch: Vertical
Landing: Parachute
Website: www.starchaser.co.uk

StarCraft Boosters Inc.

Ship Name: StarBooster
CEO: Buzz Aldrin
Location: Houston, TX
Propulsion: LOX & RP-1 kerosene
Launch: Vertical from ground
Landing: Runway landings
Website : www.starbooster.com/

Vasimr – Rocket Propulsion

Ad Astra Rocket Company

President: Franklin R. Chang Diaz, Ph. D.
Location: Houston, TX & Costa Rica
Propulsion: Variable Specific Impulse
Magnetoplasma Rocket (VASIMR)

http://www.adastrarocket.com/vasimr.html

Virgin Galactic

Ship: class SpaceShipTwo,
First vessel in class: VSS Enterprise
President: Richard Branson
Link: http://www.virgingalactic.com/

XCOR Corp

****

FAA licensed for suborbital flights

Ship Name: Xerus
CEO: Jeff Greason
Location: Mojave, CA
Propulsion: Liquid Propellant rocket engines
Launch & Landing: Horizontal on runway
Website : www.xcor.com/suborbital.html

It's not where you start. It's where you finish.

The finish line

From an SSP perspective, suborbital launch systems are only useful for delivering a second stage which can boost payloads into GSO using various "transfer" orbits. Delivery of cargo to GSO typically requires an orbital transfer stage (OTS) – another vehicle or an unmanned upper stage - to boost the payload from LEO into GSO.

Space transportation costs are an exquisitely important key to SSP. Without the vast market expansion SSP offers, however, it may be many years before the costs for space transportation can be pushed low enough to enable SSP. They are interdependent.

The current surge in aerospace development in general and the suborbital market in particular is hopeful. SpaceShipTwo's chief rival for the orbital market of interest appears to be Elon Musk. A former Internet mogul who in 2002 sold his online payment company, PayPal, to eBay for $1.5 billion in stock, Musk now runs SpaceX in El Segundo, Calif., which is developing an orbital space vehicle.

Musk notes that making it into orbit requires going eight times faster and producing 65 times more rocket energy than a suborbital vehicle like SpaceShipOne. Musk has already put more than $50 million into SpaceX and is prepared to invest $50 million more. He expects will take at least five years to get passengers into orbit. In the meantime, SpaceX is generating revenue by booking orders to launch.

"Our earned revenue will be $35 million after a little more than two years of operation," Musk says. "By comparison, the X-Prize was a one-off of $10 million, and it took Burt something like five years to do it." This leading contender for low-cost orbital transportation; Elon Musk offers two Falcon V versions:

- A $12-million Falcon V to LEO: The initial version for 2005 uses five Merlin oxygen/kerosene engines in its first stage, lofting up to 10,000-lb. into LEO.

- A $20-million Falcon V to GTO: A Pratt & Whitney RL10-equipped upper stage is planned to be operational by late 2006 able to launch 10,000-lb. payloads into geosynchronous transfer orbit (GTO) and 20,000 lb. into LEO.[91]

The first launch of Falcon I is scheduled for a first launch from our island launch complex in the Kwajalein Atoll. The customer for this mission is DARPA and the payload will be FalconSat-2, part of the Air Force Academy's satellite program that will measure space plasma phenomena, which can adversely affect space-based communications, including GPS and other civil and military communications. Nominal launch date from the Kwajalein range is late September.

Two more Falcon I launches are scheduled for 2005. The Falcon V maiden flight is targeted for late 2005. Falcon launches scheduled in 2005 for late 2006 are expected to have these capabilities:

	Falcon I	Falcon V*
200 km, 28 deg	670 kg	6,020 kg
400 km, 51 deg (Space Station)	580 kg	5,450 kg
700 km, sun-synchronous	430 kg	4,780 kg
GTO, 9 deg	-	1,920 kg
Escape velocity (no kick stage)	-	1,200 kg

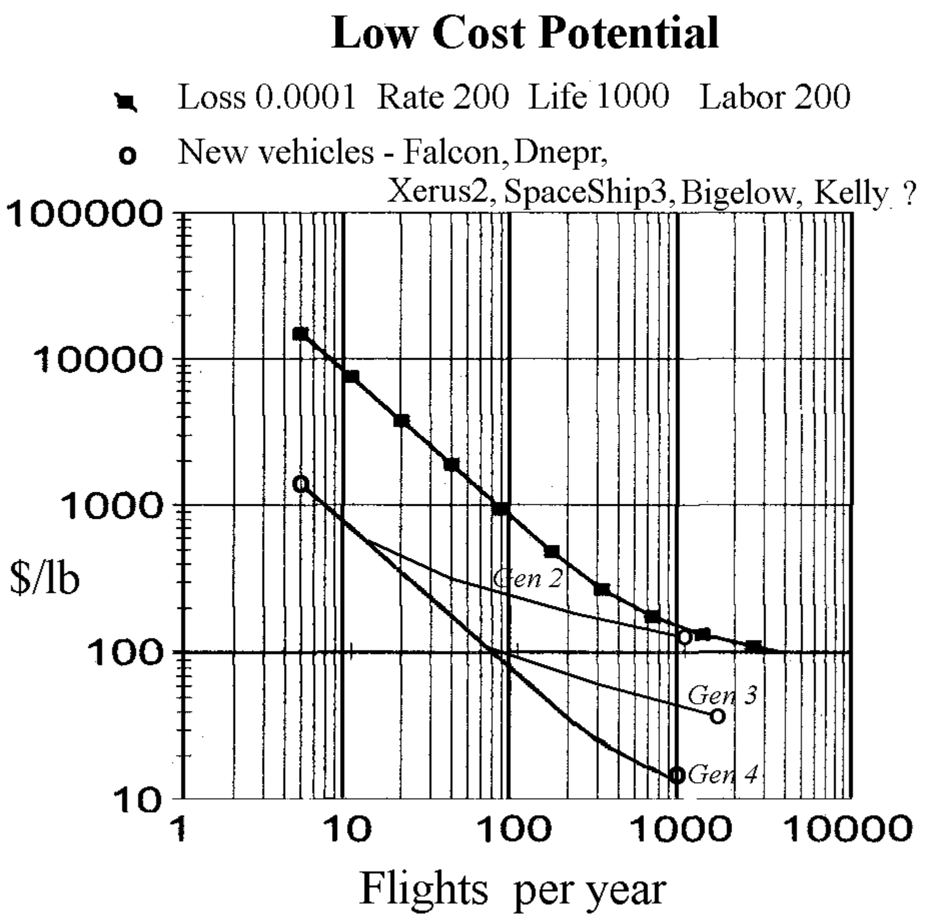
* Numbers down rated prior to completion of testing. Final performance numbers expected to be higher. Falcon I is being offered for $5.9 million and Falcon V for $15.8 million plus modest launch range fees. Updates at http://www.spacex.com/

As this is written, SpaceX and Northrop Grumman are engaged in a legal battle over Northrop's ethics and SpaceX's possible use of TRW's pintle technology. In a similar ethics lapse in August 2004, the Government Accountability Office, Congress's investigative arm, forced the Navy to nullify a Northrop contract, citing "fundamentally flawed" ethics controls at Northrop.

The GAO said Northrop's proposal to evaluate antisubmarine and antimine programs failed to recognize the potential conflicts, such as "impaired objectivity," in assessing weapons systems that Northrop itself built.[92] The larger issue is whether the military establishment, which includes Northrop, will permit SpaceX a fair opportunity to prove its hardware and skill? We trust they will. A great deal more than Mr. Musk's $2 Billion is riding on the answer.

Seven years ago, in 1998, Hu Davis, the Space Solar Power Workshop's Transportation Director, estimated that with a new RLV spacecraft flying 5,833 flights per year, the price to GSO orbit would drop to $97/kg ($44.1/lbm).[93] In our new regime, however, as the graph below shows, two companies' launch vehicles – SpaceX' Falcon and Kosmotras' Dnepr – have surged into the lead of a new generation of low cost commercial spacecraft.

We note that SpaceX has not yet launched anything (as of February 5, 2005) and Dnepr Kosmotras' rockets are not technically new, they are converted ICBMs. Regardless, both these companies are now operating on the new-improved (lower) price per flight curve. The old price per flight, the upper curve, was defined by the expendable launch vehicles you are familiar with -- Delta, Atlas, Titan, Ariane, shuttle, etc. We are eager to see other spacecraft join this race in a new low-cost to orbit space race. Will a Xerus2 or SpaceShip3 appear on this curve? Will Bigelow's America's Prize or the X Cup generate new contenders?



Costs to orbit decline at higher flight rates as demand increases
Top curve source: data from Gordon Woodcock[94] (circa January 2001).

At the new price performance curves, (Gen 2) being quoted by Mr. Musk and Kosmotras, in an admittedly thin market, we project the price would fall below $10/lbm[4] ($22/kg) at over 3,000 flights per year – once the requisite flight volume and appropriate spacecraft are realized. Further Gen 3 and 4 curves would be defined by improved launch vehicles, lower cost vehicles not yet flying. *These require higher flight volumes.* Since our SSP market is aiming for 42,000 flights per year, prices would likely fall well below these estimates once the market volume was established. *Many* other enterprises would be enabled.

[4] Lbm is pounds of *mass.* Pounds is usually a measure of weight.

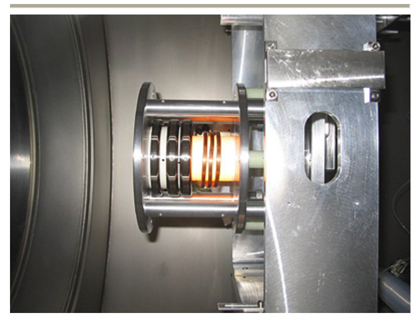
How would costs drop below $30/kg to orbit? One way would be through electromagnetic propulsion, which can send an aircraft, satellite, shuttle, bullet or train zooming through the air or along a track. Research is already underway to understand what materials, lubricants and design changes are required to reduce the damage caused by current electromagnetic devices to build new ones — including launchers for sliding maglev spacecraft.

A recent study on electromagnetic space launchers by Sandia National Laboratories for Roger Angel's space sunshade fliers projected cost down to as little as $20 a pound.[95] This would move freight to L-1. Dr. Angel proposes to combat global warming in this way. Once propelled beyond Earth's atmosphere and gravity with an electromagnetic launcher, Angel's flyer stacks would be steered to L-1 orbit by solar-powered ion propulsion, a new method proven in space by the European Space Agency's SMART-1 moon orbiter and NASA's Deep Space 1 probe. New electric or ion drives boosting freight to LEO to GEO could greatly lower costs, although they take much longer to achieve GEO:

New ion engine with a demonstrated Isp of 19200 sec !!

The European Space Agency and the Australian National University have successfully tested a new design of spacecraft ion engine that dramatically improves performance over present thrusters and marks a major step forward in space propulsion capability. Ion engines are a form of electric propulsion and work by accelerating a beam of positively charged particles (or ions) away from the spacecraft using an electric field. ESA is currently using electric propulsion on its Moon mission, SMART-1. This new engine is over ten times more fuel efficient than the one used on SMART-1. "This is an ultra-ion engine. It has exceeded the current crop by many times and opens up a whole new frontier of exploration possibilities," says Dr Walker.[96]

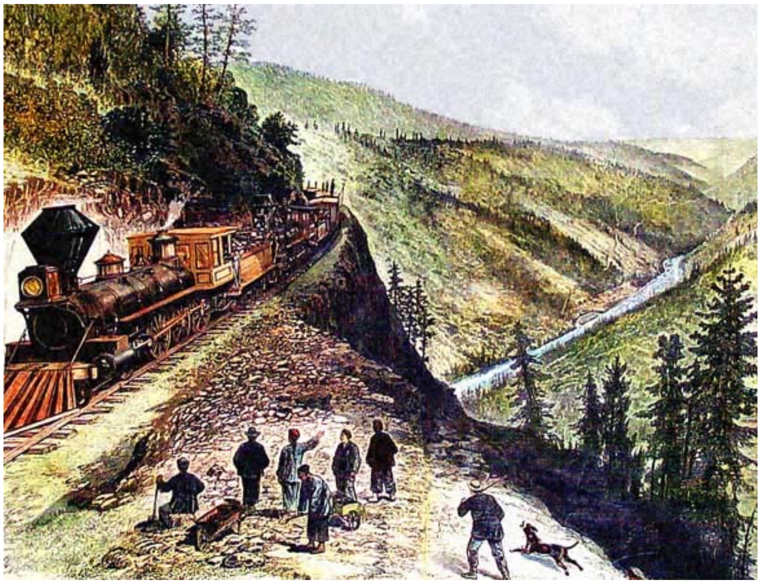
The new experimental engine, called the Dual-Stage 4-Grid (DS4G) ion thruster, was designed and built under a contract with ESA in the extremely short time of four months by a dedicated team at the Australian National University. "The success of the DS4G prototype shows what can be achieved with the passion and drive of a capable and committed team. It was an incredible experience to work with ESA to transform such an elegant idea into a record-breaking reality", says Dr. Orson Sutherland, the engine's designer and head of the development team at the ANU. During November 2005, the DS4G engine was tested for the first time in ESA's Electric Propulsion Laboratory at ESTEC in the Netherlands.



DS4G thruster firing during tests in the ESTEC Electric Propulsion facility (CORONA vacuum chamber).Credits: ESA

Electromagnetic space launchers, while low cost, usually have high G acceleration. While people cannot handle more than about 10 G without special preparations, much freight can easily be manufactured and rigged to handle 1000 G or more.

A public/private corporation like Comsat, or Sunsat would probably have to be chartered to initiate SSP construction. Would a fully private consortium have built Hoover Dam or the Transcontinental Railroad alone without subsidy? No, such a massive project as SunSat would seem to dictate a public/private corporation. The majestic and mind boggling Transcontinental Railroad is just one example of that well worn legislative path.[97] Here is a small excerpt from that colorful history:



The Excursion Train Rounding Cape Horn At The Head Of The Great American Canon, With A View Of The South Fork Of The American River, Where Gold Was First Discovered In 1848. …

From Frank Leslie's Illustrated Newspaper, April 27, 1878

"Right of way was granted through the public lands to the extent of 200 feet in width on each side of the track, and a grant of land in the amount of ten alternate section[5]s per mile on each side of the road within the limits of 20 miles on each side of the road, not previously sold or reserved, at the time ...
"Upon the completion of each 20 consecutive miles of railroad,… patents to the granted sections were to be issued.

"It also provided for at subsidy in bonds of $16,000 per mile between the Missouri River and the base of the Rocky Mountains; $48,000 per mile for the distance of 150 miles through the mountain range; ….

So the process to create such a congressionally chartered corporation, the SunSat Act,[98] is well understood. This was the same legislative tool used to create Comsat, an earlier congressionally chartered corporation (1962). The SSPW has a draft of this legislation on-line.

Michael Schwaal, an energy economist with Arlington, VA-based Energy Ventures, pointed out that "there is not much enthusiasm in the U.S. government for space based solar power", adding that NASA is not the best agency to take up the cause.[99] The energy investment community and the SSPW certainly agrees with that observation. The proper course, perhaps the only course, is a congressionally chartered corporation, such as SunSat.

[5] 1 Section = 640 acres = 1 mile long, by 1 mile wide ; 1 Acre = 0.4047 hectare

The first rule in achieving low cost space transportation is not to discard parts of the launch system after or during flight. There are today no fully reusable space launch systems to invite any comparison with commercial, or even military, jet aircraft which set the standard for reusability. The air travel industry' jets achieve an exceedingly high reusability, with typical turnarounds between flights well under an hour. They fly millions of flights per year.

Carrying people is more expensive than carrying cargo. Carrying more **cargo** to orbit will

(1) lower costs,
(2) increase flight rate, and thereby,
(3) increase safety

far faster than carrying people. The fastest and safest way to make space travel to orbit safe is to operate several thousand unpiloted freightliners. <u>Losing a cargo of SSP parts is far less costly than losing a cargo of people.</u>

Recent work aimed at developing and operating low-cost space vehicles have shown sharply reduced space transportation costs at higher flight rates. This work improves the field of space transportation bid candidates for SSP, both by improving the prospects of low launch costs, and in demonstrating to those responsible for energy security, SSP's near term feasibility under a comprehensive development policy as the President's Space Policy has committed our government to supporting.

The emerging commercial space transportation market is currently experiencing tremendous vitality. We must encourage this trend, as the President's Space Policy recognizes. We cannot permit another market bottom in the cyclical aerospace marketplace. New industries and markets will be created thereby. Our space transportation market is prepared now to support the charter of SunSat Corporation and build an SSP demonstration satellite.

The President's Space Policy has committed our government to supporting "the entrepreneurial spirit of the U.S. private sector, which offers new approaches and technology innovation in U.S. space transportation, options for enhancing space exploration activities, and opportunities to open new commercial markets, including public space travel." All that is required is for the government to share ownership with the private sector and allow the market to grow.

The many sectors of the economy that depend on and are demanding more clean low cost baseload energy would eagerly welcome the new competition SSP can provide. The space transportation capabilities SSP's immense market and promise require would be more than welcomed by the space transportation community. The innovative materials and techniques developed can build new businesses and revitalize others, as well.

~~ *** ~~

After a rocky start on May 15, 1918, the U.S. Post Office decided to expand its air mail operations with the addition of Standard aircraft (manufactured by a Japanese company) and war surplus de Haviland D.H. 4 training planes. These quickly earned the name "flying coffins," because the fuel tanks were right in front of the pilot.

The first service extension linked Washington and New York with Chicago. This required flying over the Allegheny Mountains, a treacherous flight in open-cockpit planes. Between May 1919 and the end of 1920, the "graveyard run" between New York and Chicago killed eighteen pilots — some crashing due to bad weather or mechanical failure, some blown up while flying the Junkers JL- 6, an aircraft with serious fuel leakage problems[100].

Pilots relied on ground landmarks to navigate, because there was little communication with the ground. Weather reporting and forecasting was poor. Fog and clouds often blinded pilots. Engine failures forced pilots to land suddenly, often resulting in fatal accidents.

Fearing that Warren Harding's Administration would cut the airmail service when it took power in March 1921, the Post Office staged a dramatic cross-country mail flight to impress Congress and the president. On February 22, two D. H. 4s took off from New York and two from San Francisco; hoping that at least one would make it across the country.

The entire country followed the event. Many along the route lit bonfires to point the way. The two planes that set out from New York were grounded by bad weather in Chicago. One plane flying eastward crashed in Nevada, leaving just one plane still flying. This plane landed in North Platte, Nebraska. From there its pilot, James H. "Jack" Knight was scheduled to fly to Omaha, where another pilot would complete the run to Chicago.

A broken tail skid caused a three-hour delay, so when Knight finally arrived in Omaha, all the bonfire burners had gone home, figuring the flight had failed. Worse, the pilot who was to take over for Knight had not arrived from Chicago. In one of the bravest (or most foolhardy) acts in aviation history, the exhausted Knight, who had *never flown* the Omaha-Chicago run, downed a quick cup of coffee and took off into the night for Chicago, guided only by road maps.

Flying on through the darkness for seven hours, Knight incredibly found Checkerboard Field in Chicago, arriving at 8:40 A.M. The mail was transferred to another plane and the rest of the flight went off without a hitch. The mail had crossed the continent in an astounding thirty-three hours and twenty minutes, less than half the previous record.

Jack Knight became a national hero. The flickering flame of flight glowed brightly. Airmail service was saved. Harding's Postmaster General, Will Hays, instituted many innovations -- electric light directional beacon systems, landing lights at airports, and regular broadcasts of weather conditions. Air routes were extended beyond U.S. borders.

Aviation, like space transportation could not succeed unless it was made safe and reliable. People would not buy tickets, and businesses would not ship valuables, unless their flights would arrive safely. Improving safety was and is a prerequisite to economic viability. In the nine years of its existence as a government operation, the U.S. Air Mail saw one sixth of its pilots killed.

In 1925, the Kelly Act turned airmail delivery over to private contractors, among them the biggest industrialists in America - Henry Ford, Rockefeller, Vanderbilt, Whitney, Fairchild, Charles Kettering of General Motors and powerful St. Louis business interests ...

In 1927, Charles Lindbergh further ignited this enormous interest in aviation by flying nonstop from New York to Paris. Just 5,800 passengers had flown in 1926; yet by 1930, the worst year of the Great Depression, this leaped to 417,000. NASA has continued and expanded that tradition at great cost. In 2004 the Ansari X Prize winners took us to the brink of a new frontier and a new revolution – low cost commercial space transportation.

We must move space transportation fully into the private sector, just as we did with aviation in 1925. Space has room to *grow*. Many businesses and settlements will one day thrive in space, we just have to provide a market that will incentivize low-cost space transportation. Congress should charter a space solar power corporation, just as they chartered Comsat in 1962, the first communication satellite corporation. This is the simplest and fastest way to throw open the doors to space development, while providing clean baseload power to the planet.

Many have worked and died making this country and this world a better place, to increase our freedom, our opportunity; building services, markets and wealth — that our children may dream better dreams -- and build them!! We dedicate this chapter to Jack Knight, Neil Armstrong, the crew of Apollo 13, Mike Melvill, ... and many thousands more — less famous, yet perhaps more crucial men and women — who risked their lives, their fortunes and their sacred honor in *our* service, in hopes that many, many more of us will follow in their footsteps. *Let's Roll !!*

Wright biplane, Fort Myer, Virginia, 1908 Courtesy: NASA

Space Ship One, 2004
Courtesy: Scaled Composites LLC

Outside of a dog,
a book is man's best friend.
Inside of a dog,
it's too dark to read.
– Groucho Marx

Do not be conformed to this age;
Be transformed by the renewing of
your mind, so that you may discern
what is the good, pleasing, and perfect
will of God. – Romans 12:2

Endnotes

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"Losing My Virginity", by Richard Branson.
"Richard Branson: The Authorized Biography" by Mick Brown.
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