Submission to the Aerospace Review
Part 1 of 3

Fostering Innovation, Creating New Markets: Novel Approaches to Space Policy and Programs

This submission prepared pursuant to the submissions request of the
Canadian Federal Aerospace Review 2012,
Review Head: David Emerson

Canadian Space Commerce Association
Adam Trumpour

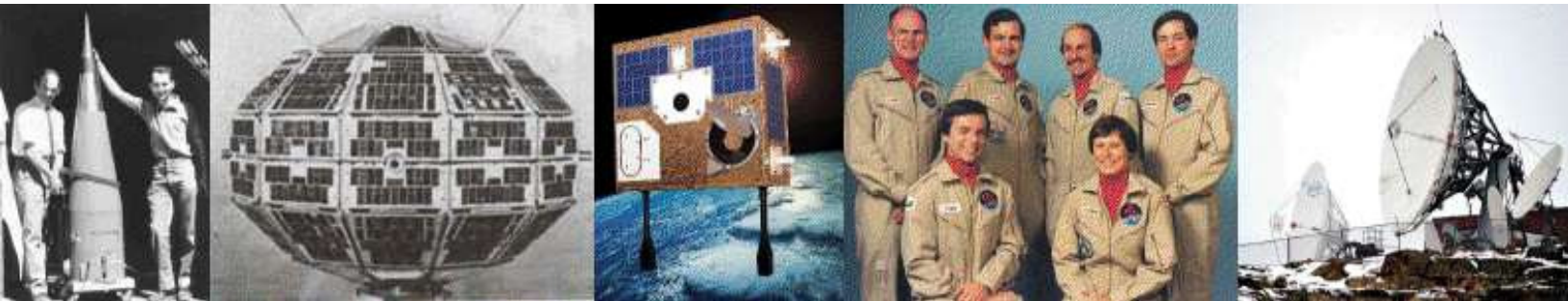
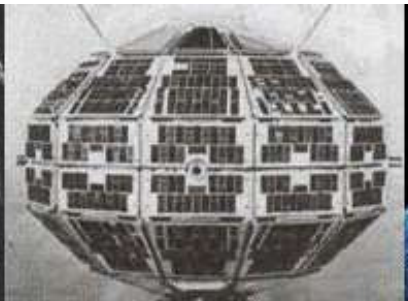


Table of Contents


1. Summary of 1st Set of CSCA Recommendations to the Aerospace Review

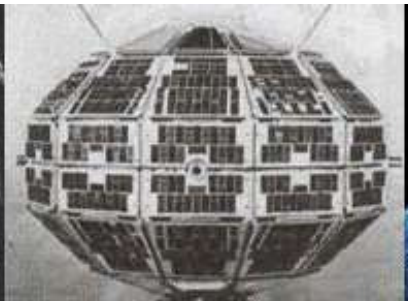
The Canadian Space Commerce Association (http://spacecommerce.ca/), a registered not-for-profit industry organization existing to advance the economic, legal and political environment for Canadian space focused companies, makes the following recommendation to the Aerospace Review (http://aerospacereview.ca/eic/site/060.nsf/eng/home):

- **We recommend that government explicitly encourage the development of entrepreneurial or "commercial space" industries and approaches.**

"*Commercial Space*" here refers to a paradigm that is gaining significant traction in both the US and internationally. Frequently also referred to as "*NewSpace*", it refers to the broadening of space-based businesses and industries beyond the traditional sphere of government space activities to develop significantly lower cost spaceflight technologies and open new markets that capitalize on the significant opportunities afforded by spaceflight. Accompanying this new trend is a rapidly growing community of relatively new, small to medium-sized aerospace companies working to minimize their overhead and streamline their business to achieve a large reduction in the cost of technologies for accessing and operating in space, and advocating progressive policies to facilitate the growth of the industry.

It should be noted that commercial space or NewSpace refers not necessarily to new technologies, but rather to new applications, new markets, and non-traditional ways of funding and conducting space activities, and to the rise of a large number of small companies seeking to competitively pursue these activities. In particular, it tends to be the opposite of the cost-plus funding method that has typically applied to large government space efforts.

It should also be noted that this broadening of space-related economic activity need not imply a significant blow to existing space companies. Indeed, many large space companies in Canada have themselves been encouraging new, entrepreneurial small companies. For example, a new Canadian company called ExactEarth was seed funded by COMDEV, and another, UrtheCast, was seed funded by MDA. A small company called Xiphos Technologies builds hardened electronics for both, and another small company called Maplesoft writes software for both.

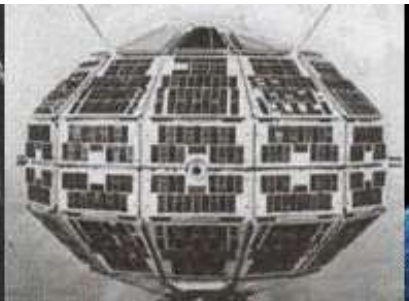

Existing approaches have tended to greatly favour large, established companies and created many barriers to entry for smaller companies wishing to compete, develop lower cost technologies and pursue new markets. New commercial space approaches should be encouraged for its demonstrated cost-effectiveness from the government's perspective and for the significant creation of sustainable, high-quality jobs and new economic opportunities that it enables. Policy and regulatory barriers that hamper the growth of this potentially large industry should be actively removed.

Government can promote commercial space in four specific ways:

i) For programs which are fully or partially sponsored by government agencies, the government should act as a *customer* rather than a *project supervisor*, and puts in place a contracting structure to facilitate this. An instructive example of this would be NASA's contracts under its Space Act Agreements, such as its COTS (Commercial Orbital Transportation Services) program. In these agreements, only very high-level end requirements are specified, and not how the supplier will meet these requirements. NASA does not own or manage the technology produced but remains a customer. These agreements can provide funding support to encourage technology or system development by a company, with funding contingent upon achieving milestones that are *mutually* agreed upon by NASA and its contract partner. A Canadian example would be exactEarth LLP (where Com Dev International is a joint owner) where the government buys AIS data but does not own or operate the satellites.

ii) The government should recognize that encouraging and participating in the rapidly growing entrepreneurial space industry is in the national interest, and should affirm its support for private space-related activities. Explicitly declaring that it is the government's policy to encourage entrepreneurial space activity in Canada would cost nothing, and would give such efforts added credibility and stronger bargaining positions.

iii) The government should provide a regulatory environment conducive to new space technology development. Where possible, it should consolidate and simplify licensing and permitting processes, reconcile jurisdictional conflicts and command existing regulatory bodies to cooperate to facilitate (rather than obstruct) this development. It should additionally allow for the licensing of airport or "spaceport" facilities that promote such activities. Instructive examples of this would be the Federal Aviation Administration (FAA)'s Commercial Space Launch Amendments Act (CSLAA) of 2004, and the


Mojave Air and Space Port, which is a local California airport that has been licensed to allow commercial rocket and spacecraft testing.

iv) The government should formulate a favourable legal liability framework to limit liability for companies participating in space activities.

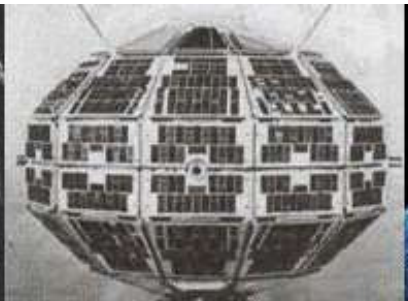
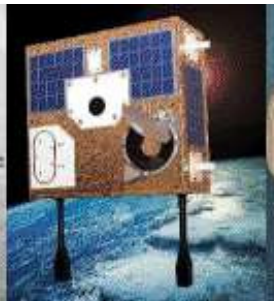
These approaches have resulted in a great expansion in space-related companies and business.

In a particular U.S. example, these approaches have resulted in the ongoing development of a number of different manned spacecraft for a cost much less than that which NASA (by its own estimates) would be able to develop a single vehicle.

SpaceX is already flying to the ISS, and even a traditional large space company, Boeing, has been able to develop its CST-100 manned spacecraft at a greatly reduced cost by not having a government agency supervise the program execution but rather only specify the end service sought.

We see no reason why the Canadian Government shouldn't similarly be purchasing space services, rather than managing space programs, allowing the private space industry to satisfy the government requirements with solutions that are more cost effective for the government while designed to have appeal to the larger commercial international space services market.

We also believe that by encouraging the private space industry with regulatory facilitation and access to some existing government facilities, private financing will develop a dynamic set of Canadian entrepreneurial space companies (and new approaches by old-line space companies) as it has in the U.S. over the past decade.

2. Supporting Documentation

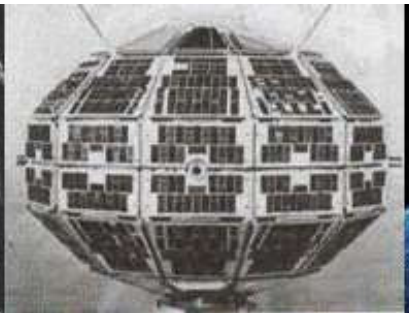
2.1. Introduction: Policies and Programs to Foster and Sustain

When on May 25, 2012 the Space Exploration Technologies (SpaceX) "*Dragon*" capsule docked with the International Space Station, a significant milestone in the development of space was reached. It was the first time a privately-developed capsule, carried by a privately-developed rocket, has accomplished this, and perhaps most significantly, it had been done for a small fraction of what such a mission traditionally costs.

In recent years, there has been a growing realization in many circles of government and industry, particularly in the US, that it is both possible and profitable to develop significant space and spaceflight technologies and systems for significantly less money than has frequently been the case in the past, by leveraging the unique capabilities and strengths of both the private and the public sectors in creative, innovation-enabling ways.

On the federal level, as budgets for national space programs have declined, it has become increasingly important to seek new ways for government to work cooperatively with industry in ways that facilitate industry's development of new and lower cost solutions to strategic national space priorities, or risk compromising essential capabilities and potentially harming an important industrial sector. At the same time, there are many within industry and government who view the potential benefits of such cooperation as going beyond simply maintaining existing capabilities for lower cost, and foresee the emergence of significant new capabilities and potentially large commercial space or "*NewSpace*" industry.

This concept of NewSpace is one that has been gaining widespread traction in the US and abroad, and refers to a rapidly growing group of small- to medium-sized companies developing technologies, products and services to take advantage of the many emerging space-related markets, including space tourism, orbital launch services, resource utilization, and many others. This movement tends to have two major characteristics. First, it is being driven substantially by relatively small, entrepreneurial companies emphasizing innovation, low cost, small teams and minimal overhead, in contrast to the more established, "*traditional*" large aerospace contractors whose business is traditionally dominated by cost-plus government contracting. And second, it seeks to develop and grow a broad, competitive and self-

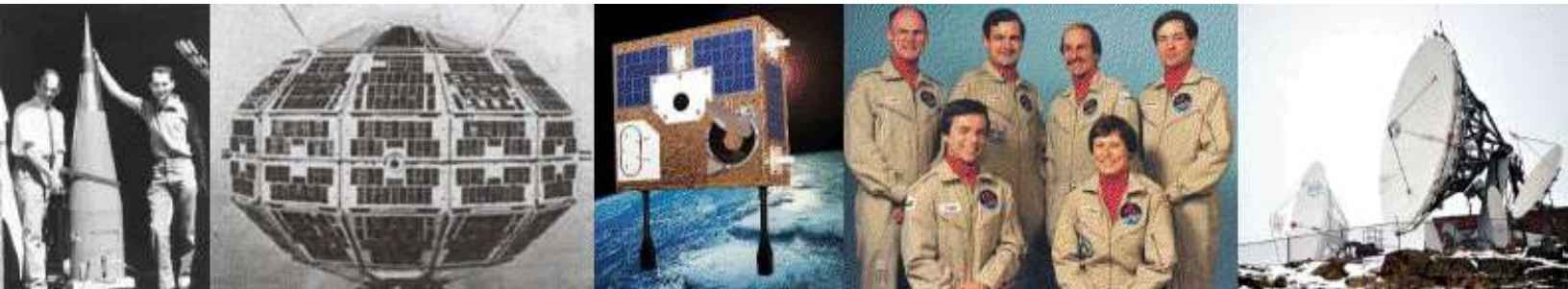

sustaining commercial market for space-related products and services, rather than being confined to the current market that tends to be dominated and propped up by large civilian and military government missions, and large communications satellites.

In the current "*government space*" model, large government-dependent companies tend to act largely as contractors developing hardware to a tight government specification, and frequently to a government-driven design. In contrast, NewSpace companies aim to develop innovative products and services of their own design for markets that frequently include government space agencies and militaries, but are not strictly limited to them. These tend to be either new markets in which many of the large, established space companies have little interest or are unable to fill, as well as existing markets in which the established space industry can be undercut. Prominent examples of these would be commercial space tourism and asteroid mining in the case of the former, and orbital space launch in the case of the latter.

Much of this transition from a market dominated and supported by massive, high-profile government missions to a potentially much larger one driven by private sector innovation in which government takes on the role of customer where possible, has been occurring in the US. The successes seen so far, of which SpaceX's recent mission to the International Space Station is only the most visible example, have been both enabled and encouraged by government policies and programs.

These policies and initiatives can be seen to fall under two categories: those that have the effect of removing barriers to entry and fostering or catalyzing the creation and growth of companies in the private sector seeking to develop space-related technologies and services, and those that are intended to help sustain that industry as it grows. Instrumental in this has been a combination of novel government contracting approaches and proactive government policy geared towards providing a regulatory environment that encourages innovation and competition. While some of these efforts involve government funding arrangements, both traditional and non-traditional, others have been able to promote the rapid development of the industry without the need to provide any government funding.

In the US, at the highest level, it has been recognized that having a vibrant, competitive space sector is both economically desirable and strategically essential, and efforts to reduce barriers to entry have all flowed down from this recognition. Significant among these efforts have been the creation of simplified, unified experimental permitting and launch licensing procedures that are designed to encourage organizations doing aerospace development work, the implementation of



safety standards that are not unnecessarily burdensome, and the limitation of liability for space tourism companies.

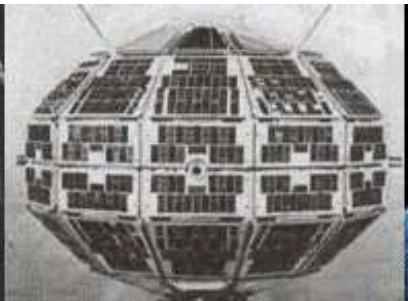
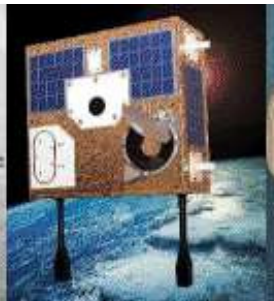
The development of the industry has also been aided by making it easy for companies to work collaboratively with government agencies, particularly NASA, giving the companies access to NASA or Department of Defence facilities and know-how.

Finally, the US government has recognized that one key way it can help promote the creation and growth of New Space companies is by acting as an anchor customer for space services. By providing an identifiable market for those services and employing a bidding process that is not biased towards large, established companies, it can help small companies to close their business case and attract investment. This was most clearly exemplified with NASA's COTS program, and the Space Act Agreement contracting structure that underpinned it.

2.2. Government Policy and Regulations

In the earliest years of the US space program, all space launch activities were funded through NASA, so no regulatory or licensing framework was necessary for commercial launches. In the early 1980's as a commercial launch industry began to form, companies were severely hampered by regulatory confusion over jurisdiction and the high cost of obtaining a license[1]. In response, the Commercial Space Launch Act of 1984 was drafted to consolidate the regulation of commercial spaceflight under the Department of Transportation's Office of Commercial Space Transportation (OCST). This served to eliminate many of the regulatory conflicts and helped encourage the growth of the commercial satellite industry in the 1980's and '90's, and in 1995 the OCST was brought under the Federal Aviation Administration (FAA) and renamed the Office of the Associate Administrator for Commercial Space Transportation (AST). In 1998 the Commercial Space Act of 1998 was passed to extend the FAA's authority to allow it full regulatory authority over commercial space launches and landings[2]. The latter provision in particular is essential in enabling companies to develop reusable launch vehicles and human spaceflight and space tourism capabilities.

Unfortunately, the AST's licensing process as of 1998 was still extremely cumbersome, and still creates jurisdictional problems, particularly relating to compliance with environmental regulations that were the responsibility of the Environmental Protection Agency (EPA)[3]. The licensing process itself could take

many months, and the complexity of complying with licensing requirements created such expense, only large companies willing to spend significant amounts of money on each launch could fulfill them[4]. This was a very large barrier to entry for any new companies seeking to develop low cost launch vehicles.

With the X-Prize competition in 1996, the prospect of sustainable commercial human spaceflight gained more attention, and in 2004, recognition of the advantages of encouraging the development of new commercial spaceflight markets led to the Commercial Space Launch Amendments Act (CSLAA). The stated goal of the Act was "to put in place a clear and balanced regulatory regime that promotes the development of the emerging commercial human space flight industry, while protecting the public health and safety"[5]. Notably, the CSLAA maintains a minimum of regulatory detail in order to stay flexible and responsive as the industry emerges.

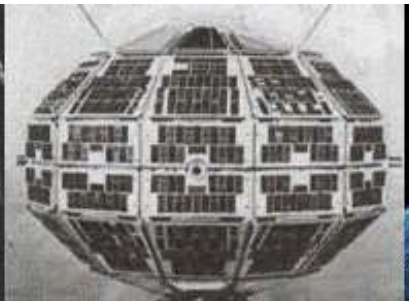
2.2.1. Experimental Permitting

The CSLAA incorporated several provisions that help encourage small space companies. One was the creation of an "*Experimental Permit*" for the testing of experimental space vehicles. This permit was patterned after the experimental permit for aircraft by the Aircraft Certification and Regulations Office (AVR)[6].

The issuance of these permits is covered in the U.S. Code, Title 49, Subtitle IX, §70105a. The company applying for the permit only needs to submit basic design information and the AST is required to provide a decision within 120 days. Once obtained, the permit allows research and development for new equipment, research pursuant to a license, and crew training, and is valid for all crewed space launches up until the first ticketed flight carrying a paying passenger, making it relatively simple for a company to undertake the development of a spacecraft.

2.2.2. Launch Licensing

The CSLAA instructs the AST "*to undertake a bottom-up review of the existing launch licensing regulations in place for the entire commercial space industry*". While the older launch licensing requirements are still in effect until this is completed, it nevertheless illustrates the government's desire to remove regulatory barriers and arrive at a process that addresses the needs of all companies seeking to participate in the space launch market.


2.2.3. Safety Standards

The CSLAA takes a very hands-off approach to safety standards, providing very broad language that allows the AST to act at its discretion. In the case of human spaceflight, the Act requires participants to receive training, satisfy medical standards, and sign an informed consent waiver, making it very similar to other risky activities such as skydiving. This helps lower costs for the industry. At the same time, the language also allows room to add detail as the industry evolves, and this provides an incentive for companies to adhere to good practices that won't prompt a tightening of the regulations.

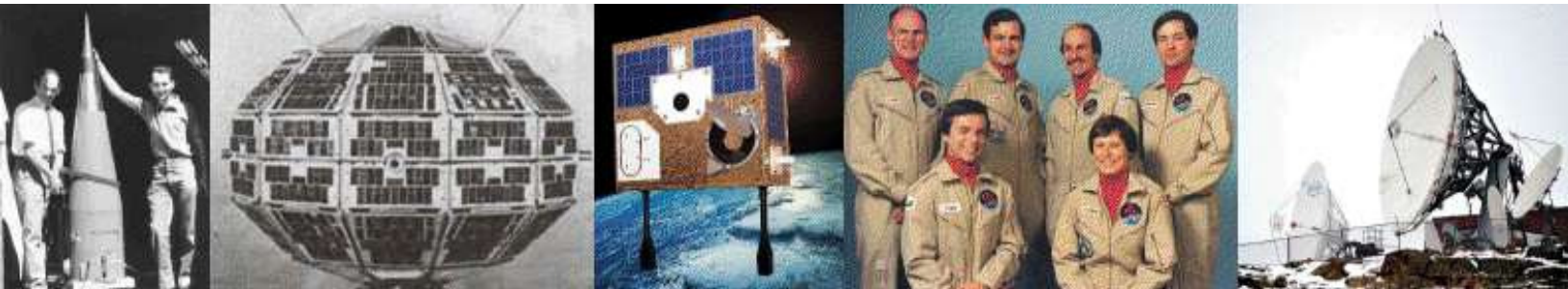
2.2.4. Liability Limitation

Until the development of a commercial space industry, there was no need for any government regulation of liability. NASA, the Air Force, and space contractors were not required to have any additional insurance to pursue their activities. In 1983, the Reagan administration's Commercial Space Launch Act of 1984 imposed insurance requirements for the commercial space industry for the first time, requiring companies be insured against damages to both third parties and government property[7]. Commercial space launch providers were given no protection and were held responsible for the maximum loss that could occur in an accident. But the commercial spaceflight industry was growing elsewhere in the world at the same time, and countries such as France began capping the insurance requirements for their own companies, causing the US commercial spaceflight industry to slow in comparison to others[8].

With the realization of the intolerable risk that unlimited liability was imposing on the American commercial space industry, several new practices were codified in 1988, amending the Act and instituting a government risk-sharing regime.

This framework is still in effect, and is comprised of three tiers:

- Tier I: Maximum Probable Loss (MPL)-Based Financial Responsibility Requirements.



Third-party liability insurance is set based on the FAA's determination of the MPL that would result from licensed spaceflight activities. The insured parties must include the licensee, its customer, the US government, the contractors, subcontractors, and insurance against third-party claims is required up to the Maximum Probable Loss (MPL) of a given space launch, to a statutory maximum of $500 million.

Insurance against government property damage is required up to a maximum of $100 million.

Additionally, launch participants enter into no-fault, no subrogation reciprocal waivers of claims, by which each participant in a launch agrees to accept its own risk of property damage or loss and agrees to be responsible for injury, damage or loss suffered by its employees.

- Tier II: Catastrophic Loss Protection (Government Payment of Excess Claims)

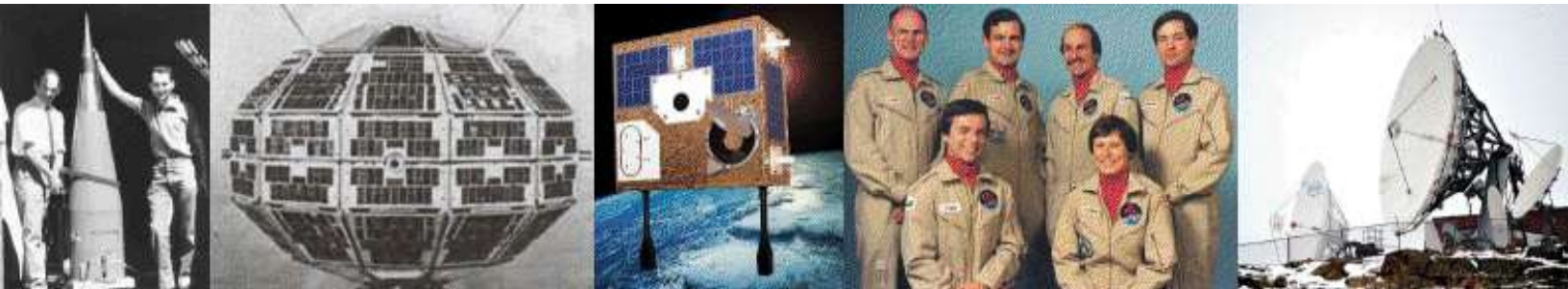
  The US government may pay successful third-party liability claims in excess of the required MPL-based insurance, up to an additional $1.5 billion (1988 US dollars), subject to approval by Congress, and assuming the company did not engage in willful misconduct.

- Tier III: Above MPL-Based Insurance Plus Indemnification

  Any claim above the combined amount of the licensee's MPL insurance and the government's indemnification is the responsibility of the licensee or legally liable party[9].

For the case of human spaceflight, the CSLAA also imposes a requirement for informed consent about all potential risks for space flight participants, requiring a waiver from the would-be participant. The space flight companies are thus released from claims of responsibility for any damages occurring as a result of space flight activity.

States have also been attempting to foster the development of the industry within that state by passing similar legislation. The State of Virginia's Spaceflight Liability and Immunity Act makes use of informed consent requirements to insulate spaceflight companies from liability for damages to passengers until 2013 (State of Virginia HB 3184).



The continuation of the federal liability indemnification regime has served to keep insurance relatively affordable for space launches. It has also served to lower the investment risk associated with new, small commercial space companies. As noted by Dr. Burton Lee, Managing Director of the Space Angels Network,

"*The most important provisions in the CSLAA [2004] are liability provisions and liability caps for private companies. No companies will invest in anything if they face the potential for unlimited liability. Insurance costs would go through the roof*"[10].

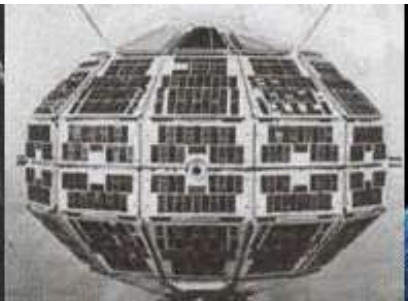
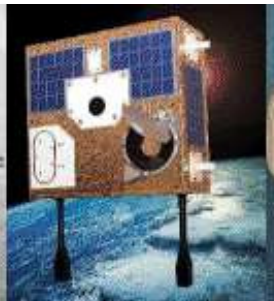
2.3. Novel Contracting Approaches

Recognizing that government space agencies and militaries currently provide the largest established market for space hardware and services, the government possesses the ability to provide a significant stimulus to the growth of space companies by implementing policies that incentivize streamlined, low cost approaches, encourage innovation within industry, and allow industry and government agencies to work together to maximum mutual benefit. In the US, several contracting vehicles have been used to achieve this, and these have been remarkably effective.

Particularly for a small company, receiving a contract provides not only seed money, but greater visibility and increased credibility with which to secure financial support from investors. A contract can also provide critical funding to allow a company to develop its technology, and can allow a company to benefit from government facilities or expertise within space agencies or the military.

Equally important, a government can use the promise of contracts for services to create a new market, or lend some stability to an uncertain market, and this can be significant in bolstering a small company's business case and helping it attract investment. In many cases, a much larger commercial market may then develop that goes far beyond the original government-supplied market, with all the attendant economic benefits that this entails.

Government contracts within the space sector can be thought of as falling into the categories of technology development and demonstration, and procurement, with the former acting to foster the initial growth of companies, and the latter helping to sustain the industry and provide a clear initial market for them.

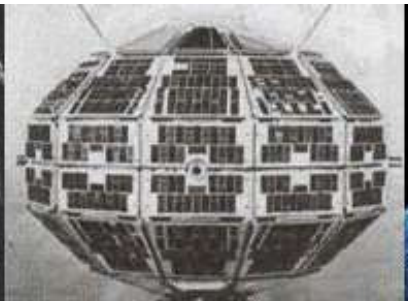
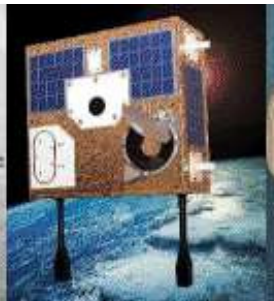
In order to maximize the effectiveness of government contracting in stimulating the industry and opening new markets, the design of the contracting mechanism that is used is of prime importance. It is possible to offer contracts that can have the effect of encouraging companies to develop low-cost, competitive technology and foster new markets, and it is equally possible to offer ones that don't have this desirable result.

In the past, a majority of space-related contracts have involved government space agencies taking the lead role in managing the design and operation of space hardware, whether that hardware involves satellites, unmanned launch vehicles, or manned spacecraft. These contracts have tended to be given on a cost-plus basis and involve large amounts of government investment. Because of the government's lead role in the design and execution of the resulting hardware, the government carries much of the risk of the program, and significant public scrutiny can result if and when problems arise.

Frequently the government's aim in tendering such contracts is not to produce or advance towards a widely marketable product or service, but only to obtain a capability that it feels it requires, and opportunities to encourage the development of technologies, products or services that can capture a wider commercial market while *also* serving the government's needs can therefore be lost.

The overhead associated with these contracts can easily become significant, and this tends to increase the cost of the program vastly. It is also easy for such contracts to impose such specific design requirements on the contractors executing them that opportunities for innovative, low-cost solutions may be lost.

A prime example of this contracting approach was the development of the US space shuttle. The shuttle was initially conceived of as a reusable launch vehicle for both humans and payloads that would lower the cost of space launch significantly, and would therefore capture the bulk of the commercial satellite launch market. But its design was driven by government and political priorities and compromises, and the resulting vehicle was highly capable but proved to be among the most expensive launchers ever developed, in spite of its reusability. The cost per flight is virtually impossible to meaningfully calculate, but is usually estimated to be much in excess of $500 million. The cost of maintaining the vast workforce necessary to operate and maintain it led to the cost of the shuttle program being largely insensitive to the number of times it is flown each year, and after 1986 no more commercial satellites were flown on it[11].

The cost overruns of the program were also significant. In 1972, NASA estimated the cost of development, procurement and 12 years of operation at $16.1 billion (1972 $US)[12]. The actual life cycle cost came in at $25 billion (1972 $US)[13].

The space shuttle did indeed provide government with a capable space transportation system, but at tremendous cost and without the ability to capture a wider market.

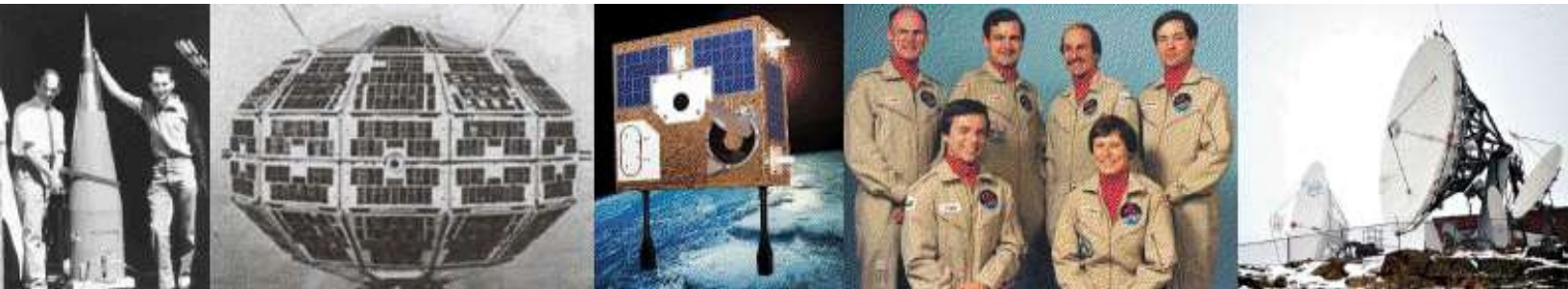
But the US government possesses other contracting mechanisms as well. These have seen some very high-profile and very successful use in recent years.

2.3.1. The Space Act Agreement

In NASA's founding document, the National Aeronautics and Space Act of 1958, Congress explicitly mandated NASA to "*seek and encourage, to the maximum extent possible, the fullest commercial use of space*" (42 U.S.C. § 2451 et seq.)
One of NASA's unique vehicles for achieving this is laid out in the Act and provides for flexible, low-overhead contracts. The Act states that NASA may:

> *…enter into and perform such contracts, leases, cooperative agreements, or other transactions as may be necessary in the conduct of its work and on such terms as it may deem appropriate, with any agency or instrumentality of the United States, or with any State, Territory, or possession, or with any political subdivision thereof, or with any person, firm, association, corporation, or educational institution. (42 U.S.C. § 2451 et seq.)*

The "*other transactions*" are legally-enforceable agreements between NASA and a partner, and are referred to as Space Act Agreements (SAA's). SAA's allow NASA to provide resources that may include personnel, services, equipment, expertise, information, facilities, and/or funding. When a SAA provides actual funding, this innovative arrangement bypasses the normal Federal Acquisition Rules, providing a more flexible framework whereby funding could be provided contingent on the recipient company achieving agreed-upon milestones. The SAA's are flexible for both parties, allowing a company the freedom to pursue whatever technical solution they feel will best meet performance and cost targets with minimal NASA oversight, so long as it achieves its intended milestones. They also provide NASA with the flexibility to cancel the agreement if the company fails to meet its requirements, or to renegotiate the terms if its own circumstances change.



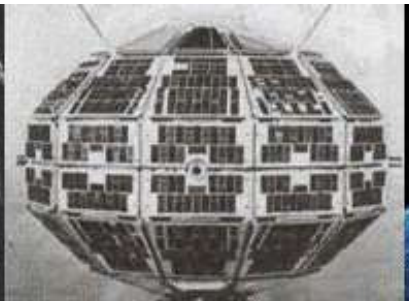
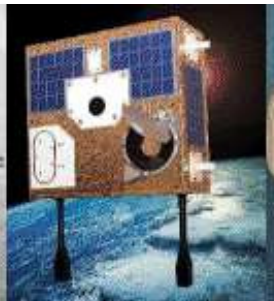
Unfunded Space Act Agreements are also available. These require no direct funding on NASA's part, but allow the recipient companies the benefit of leveraging NASA know-how and/or facilities. These may be "reimbursable", in which some percentage of NASA's costs must be reimbursed by the agreement partner, or they may be non-reimbursable. In the latter, NASA and the agreement partner are each responsible for bearing the cost of their own participation. Even these unfunded SAA's can be invaluable for NewSpace companies, as in addition to technical information or facility access they provide a measure of credibility, and the lure of a potential market.

Five non-reimbursable SAA's were signed in 2007, for example, with space companies t/Space, PlanetSpace, SpaceDev, SPACEHAB, and Constellation Services International. These were intended to aid those companies in developing transportation systems to carry cargo to the International Space Station after the retirement of the space shuttle. The agreements provide the companies with technical ISS specifications that must be incorporated in their designs, and access to additional technical assistance.

2.3.2. Commercial Orbital Transportation Services (COTS)

Perhaps the most visible use of Space Act Agreements has been the recent Commercial Orbital Transportation Services, or COTS, program. COTS was conceived out of the realization that NASA would lack the budget to implement the George W. Bush administration's Vision for Space Exploration unless it could secure much more affordable commercial launch services for routine transportation to low Earth orbit.

The traditional NASA approach has tended to maximize program overhead while severely limiting the opportunity for novel designs or concepts, leading to high program costs. The planned successor to the space shuttle, the Constellation Program, was the centerpiece of the Vision for Space Exploration, but was ultimately cancelled under the Obama administration for being economically unsustainable, after investing over $9 billion. The total cost of completing the program's Ares I rocket and Orion capsule was estimated by NASA at over $45 billion[14].
In spite of recycling much space shuttle technology, the program still had not produced a flight-capable vehicle and was years behind schedule by the time of its cancellation. With current economic and budgetary realities, the expense of the program could not be sustained. President Obama noted that the program, by its termination, was "Over budget, behind schedule, and lacking in innovation"[15].

At the same time, it was noted that the ISS does provide, for the first time, a strong, identifiable market such services that could help the business case for prospective launch providers to close. In November, 2005, NASA administrator Mike Griffin noted that:

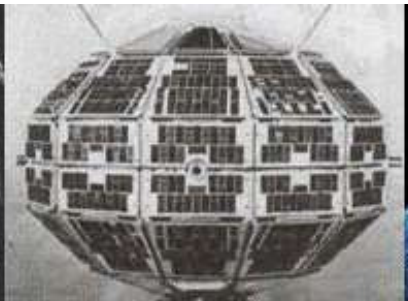
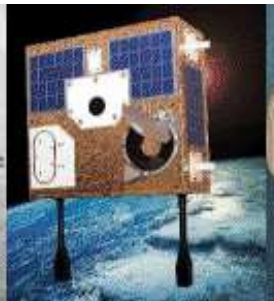
> *With the advent of the International Space Station, there will exist for the first time a strong, identifiable market for "routine" transportation service to and from LEO, and that this will be only the first step in what will be a huge opportunity for truly commercial space enterprise. We believe that when we engage the engine of competition, these services will be provided in a more cost-effective fashion than when the government has to do it*[16].

Even before Constellation's cost overruns, it was recognized by NASA that this would be necessary in order to free up enough funds to complete the program[17], and accordingly, the COTS program was launched. The stated aim of the program was to enter into agreements with private industry to develop and demonstrate the vehicles, systems and operations needed to resupply and return cargo from a human space facility.

Significantly, the COTS program was implemented using Space Act Agreements, rather than a more traditional Federal Acquisition Regulation (FAR) procurement. This allowed NASA to award contract money based on the completion of milestones that were mutually agreed upon by the companies receiving funding and by NASA, and allowed those companies to participate in the process of deciding on the milestones. The use of SAA's meant that each company had full input in writing its design requirements and setting milestones, rather than having them dictated by NASA. They simultaneously gave NASA the freedom to cancel an agreement if those milestones were not met, thereby minimizing the government's risk.

The first two phases of the program do not involve procurement of actual cargo transportation services. Rather, they focus on facilitating technology development and demonstration. Contracts for actual cargo delivery to the ISS are provided under the Commercial Resupply Services (CRS) program.

By offering a clear market for launches, in the form of the CRS program, NASA has encouraged competition between launch vehicle makers to provide a capable vehicle at the lowest possible cost. From the inception of the COTS program in 2006 through to 2010, NASA had invested a total of $500 million in the program: less than the cost of a single space shuttle flight. By the end of the first two rounds of COTS,

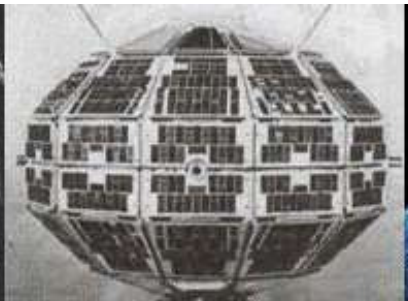
two companies had received funding: SpaceX ($278M) and Orbital Sciences ($170M). A third, Rocketplane Kistler, was initially funded but that contract was terminated due to the company's failure to raise sufficient funds as per the terms of the agreement.

Both companies had made significant progress on both spacecraft and launch vehicle, and in the case of SpaceX, their first demonstration flight had been successfully concluded. This made them the first private company to successfully launch and recover an orbital spacecraft.

SpaceX's accomplishment was all the more significant given how little it had cost them to develop their rocket and spacecraft. In 2007, NASA estimated what SpaceX's development of the Falcon 9 rocket would have cost had it been undertaken by the agency using a cost-plus contract and a traditional NASA approach. They estimated that cost at $3.977 Billion. If a more aggressive, commercial approach was used that emphasized low overhead and minimal teams, they estimated that could be reduced to $1.695 Billion. In fact, the actual cost of SpaceX's development was $300 million for the Falcon 9 rocket, plus an additional $90 million for the development of the smaller Falcon 1 rocket that served as the Falcon 9's precursor[18]. This represented more than an order of magnitude reduction compared to NASA's own estimates of the cost for a traditional procurement. This is particularly impressive given that the company was only founded in 2002.

SpaceX's work was not funded exclusively by COTS. Their development had begun prior to the launch of the COTS program, and much of the money was invested by the company. But COTS had aided the company's work significantly, with funding to aid in the development, by providing the ability to collaborate technically with NASA, and perhaps most importantly, by making it clear that the government, through NASA, intended to procure commercial launch services to the International Space Station, should SpaceX or any other companies meet their milestones and develop that capability.

The company's low costs were achieved less by novel technology than by organizational and program management innovations. It employed small teams, all working under one roof and producing most critical components in-house, enabling direct control of costs. It was able to minimize its management structure and organizational complexity, and the COTS program's flexible, hands-off structure allowed it to do this. Such minimum overhead would not have been encouraged, or even possible, under a traditional Federal Acquisition Rules procurement.


SpaceX CEO and founder Elon Musk summarized his own view of the important role NASA's support had played in their success, stating "*Without NASA, I would not have been able to create my company in the first place and would definitely not have come this far.*"[19].

2.3.3. Commercial Crew Development (CCDev)

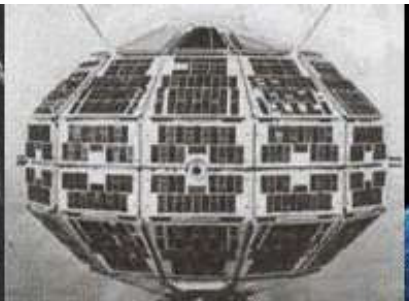
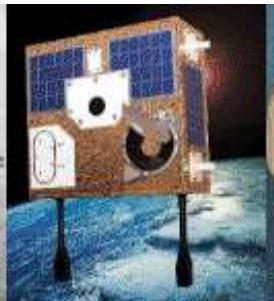
The retirement of the space shuttle not only left the US with no ability to deliver cargo to the International Space Station, it also left it with no manned launch capability. This has forced NASA to procure manned launches from Russia until such time as a US-built manned launch system becomes available. To attempt to minimize this gap, the Commercial Crew Development (CCDev) program was launched using a similar framework to COTS, and with the same Space Act Agreement contracting structure. The intention of CCDev is to encourage industry to develop safe, affordable manned launch systems in spite of NASA's severely limited budget. This program is currently underway.

While there has been debate in Congress as to how many companies should receive funding, NASA has argued strongly that at least 2 providers should be supported, and that an early down-select to a single company would strip the program of its competitive element[20].

The initial phase, CCDev 1, was funded in 2010 and provided a total of $50 million to 5 companies to foster research and development work.

This was followed up by CCDev 2 in 2011, providing a total of $270M to 4 companies for further technology development. An additional 3 companies received unfunded Space Act Agreements to partner with NASA.

CCDev 3, now renamed Commercial Crew Integrated Capability (CCiCap) is currently in progress. This phase has solicited proposals for complete end-to-end designs of spacecraft and launchers, with awards slated to be selected by mid July. CCiCap will run through 2014. NASA had originally requested $850 million for the program, but the senate currently plans on providing $525 million[21].

2.3.4. Small Business Industrial Research (SBIR) Contracts

The military offers its own counterpart to the Space Act Agreement, the Small Business Innovation Research (SBIR) contract. This program is specifically geared towards small businesses pursuing early-stage development of potentially useful technologies. They are "designed to (1) stimulate technological innovation, (2) increase private sector commercialization of federal R&D, (3) increase small business participation in federally funded R&D, and (4) foster participation by minority and disadvantaged firms in technological innovation"[22].

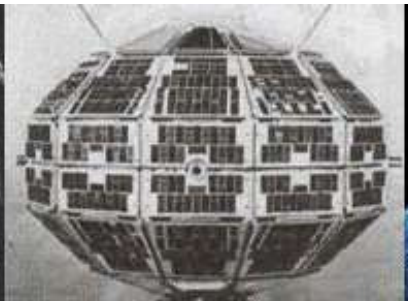
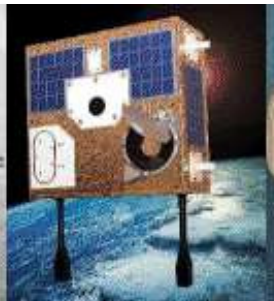
Phase I SBIR awards are up to $100 000 for approximately 6 months, to determine project feasibility. Phase II awards are up to $750 000 for up to 2 years for product development work and evaluation of commercialization potential. Phase III of the contract encompasses the final commercialization of technology using funding from the private sector[22].

Like with SAA's, SBIRs make it easier for companies to obtain investor funding, as they demonstrate a track record of receiving and performing on government contracts.

2.4. Infrastructure

The NewSpace industry benefits greatly from access to facilities and infrastructure that facilitate its experimental and development work, as well as its regular operations. Access to government or commercial laboratory and test facilities for the testing of space-related components and systems, both on the ground and in flight, can greatly reduce a company's costs. For the launch industry, the availability of spaceport facilities that are equipped to handle, process and launch spacecraft and provide the necessary supporting services and industrial base is very desirable.

In the US, many spaceports, both government and commercial, have been or are being developed, and are vying to attract NewSpace companies to set up shop there. More than just being a facility, a spaceport can act as the focal point for an entire industrial cluster, including not only space companies, but all the manufacturing, construction and logistics industry required to support it. In this way they can become powerful catalysts for economic development of an area in a similar way that an airport can.

While spaceports such as the Kennedy Space Center and Wallops Island, Virginia have been in existence since the 1960's, they are being joined by an increasing number of commercially-focused spaceports that are aligned to the needs and objectives of the NewSpace industry. They aim to facilitate the operations of NewSpace companies both in the development phase as well as in the operational phase, providing a shared infrastructure that many companies can make use of[23].

2.4.1. Commercial Access to NASA and DOD Facilities

Both the military and civilian space agencies tend to have access to multiple specialized facilities. These may include wind tunnels, test chambers and other laboratory facilities, as well as larger test ranges, proving grounds, runways, airports and spaceports, and access to these facilities can help small companies to lower their development costs. Space Act Agreements, for example, have been employed to allow companies access to NASA test facilities.

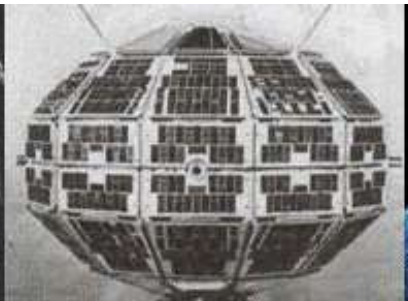
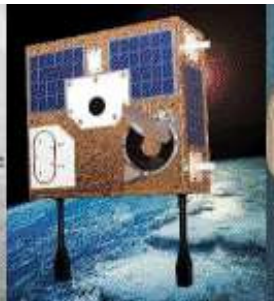
2.4.2. The Mojave Civilian Aerospace Test Center

Mojave, California is home to the Mojave Air and Space Port, a unique facility that has become an epicentre for NewSpace activity.

In the 1970s, the airport's director Dan Sabovich envisioned Mojave as the civilian counterpart to aerospace test facilities at nearby Edwards Air Force Base. By 1982, designer Burt Rutan had turned his revolutionary kit plane business at Mojave into Scaled Composites, creator of the round-the-world *Voyager* and Beechcraft's all-composite Starship[24].

Rutan would later go on to win the X-Prize competition, becoming the first private entity to launch a man into space, return him safely, and repeat the flight in the same spacecraft, and this success attracted the interest of British billionaire Sir Richard Branson. Virgin Galactic was formed, and a joint venture, The Spaceship Company, was established at Mojave between Virgin and Scaled Composites to develop and manufacture spacecraft for suborbital space tourism.

In 2004, the Mojave Air & Space Port was certified by the FAA as a spaceport, permitting space launches to occur at the site. The spaceport consciously aims to provide an environment that removes regulatory barriers and encourages innovative

companies to base themselves there. It offers several runways that companies can make use of, and a very large airspace away from urban areas.

Multiple NewSpace companies have located themselves at the facility to take advantage of its facilities, location and favourable regulatory environment. These include larger companies like Scaled Composites, but also many smaller ones including XCOR Aerospace, Masten Space Systems, and Firestar Technologies.

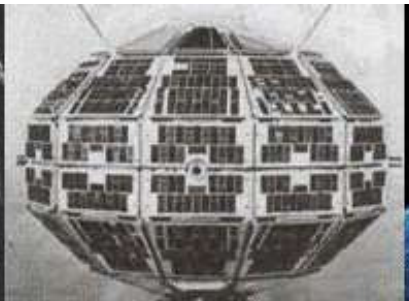
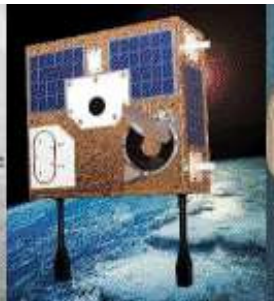
2.4.3. Spaceports

In addition to Mojave, several states have been attempting to encourage spaceports and NewSpace companies to base themselves there. New Mexico was one of the first, partnering with Sir Richard Branson's Virgin Galactic to build "Spaceport America". New Mexico was attractive due to its vast unencumbered airspace and favourable weather[25]. As an additional inducement, the state provided a 10% tax break on wages and benefits, 5% reimbursement for capital expenditures, and reimbursement for additional training necessary for local employees[26]. In exchange, New Mexico stands to profit from the operations of Virgin and other NewSpace companies, and the attendant industry that will result.

Florida in turn is attempting to transition its own established spaceport cluster to a "NewSpace" paradigm, moving away from its current dependence on NASA and the Air Force to a broader base that incorporates NewSpace companies[58].

Virginia has also been actively courting NewSpace companies, offering its own legislation to limit liability for launch providers, and enticing Orbital Sciences to launch its "Antares" COTS vehicle from the Mid Atlantic Regional Spaceport at Wallops Island, VA.

The flurry of spaceport-building activity and incentives currently taking place in multiple states illustrates those states' commitment to the emerging NewSpace industry, and their desire to attract that industry and reap the economic benefits.

3. References

1. Hudgins, E.L. & Cato Institute 2002, “Space: the free-market frontier”. Cato Institute, Washington, D.C. p.70

2. ibid, p.71

3. ibid, pp. 71-2

4. Harvard Journal of Law & Technology, 2004, "The Commercial Space Launch Amendments Act of 2004”, H.R. 3742, 108th Cong., vol. 17, no. 2, p.626.

5. Boehlert, Rep. S. 2004, “HR Report 108-429 on Commercial Space Launch Amendments Act of 2004”, U.S. House of Representatives. p.2.

6. ibid, p.10

7. Vedda, J. A., 2006, “Study of the Liability Risk-Sharing Regime in the United States for Commercial Space Transportation”, Center for Space Policy and Strategy, National Space Systems Engineering. Prepared for U.S. Department of Transportation. p.3

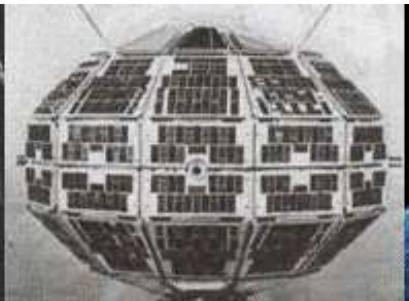
8. ibid, p.4

9. ibid, pp.1-2

10. Culver, L. et al., 2007. “Policies, Incentives, and Growth in the NewSpace Industry”. Working paper. http://commercialspace.pbworks.com/f/2007.12.12+NewSpace+Policies+Incentives+and+Growth.pdf. Retrieved June 5, 2012. p.36

11. London, Lt. Col. John R. III, 1994. “LEO On the Cheap. Methods for Achieving Drastic Reductions in Space Launch Costs”. Air University Press, Alabama. p.21.

12. Comptroller General of the United States. Cost-Benefit Analysis in Support of the Space Shuttle Program (Report). Government Accountability Office. http://archive.gao.gov/f0302/096542.pdf. Retrieved February 3, 2010.


13. Pielke, Roger Jr. "Data on and methodology for calculating space shuttle programme costs". Space Policy Volume 10, Issue 1, February 1994, Pages 78–80. http://sciencepolicy.colorado.edu/admin/publication_files/1994.01.pdf. Retrieved February 3, 2010.

14. US GAO. Constellation Program Cost and Schedule Will Remain Uncertain Until a Sound Business Case Is Established (Report). Government Accountability Office. http://www.gao.gov/new.items/d09844.pdf. Retrieved February 3, 2010.

15. Amos, Jonathan, February 1, 2010. "Obama cancels Moon return project". *BBC News*. http://news.bbc.co.uk/1/hi/sci/tech/8489097.stm. Retrieved March 7, 2010.

16. Griffin, Michael; Valin Thorn, 2007-01-11. "Commercial Crew & Cargo Program Overview" (PDF). *45th AIAA Aerospace Sciences Meeting*. Reno, Nevada: NASA. p. 2. http://www.nasa.gov/pdf/168735main_AIAA_2007_COTS.pdf. Retrieved 2007-06-06.)

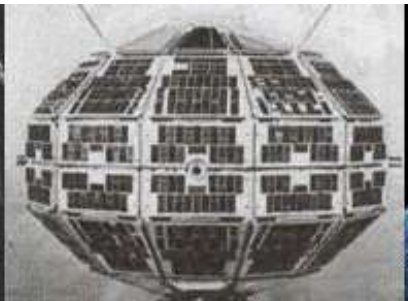
17. "X Prize Comments by Mike Griffin". NASA. 2006-10-20. http://www.comspacewatch.com/news/viewsr.html?pid=22396. Retrieved 2007-06-06.

18. August, 2011. "Falcon 9 Launch Vehicle NAFCOM Cost Estimates". Presentation, NASA Associate Deputy Administrator for Policy. http://www.nasa.gov/pdf/586023main_8-3-11_NAFCOM.pdf. Retrieved July 1, 2012

19. May 6, 2012, "SpaceX Boss Admits Sleep Elusive Before ISS Launch". Agence France Presse. http://www.france24.com/en/20120506-spacex-boss-admits-sleep-elusive-before-iss-launch. Retrieved 2012-07-06.

20. Phillips, Rich, 2011-06-30. "Private companies hold the key to space travel's future". CNN. http://www.cnn.com/2011/US/06/30/future.of.space.travel/index.html. Retrieved July 24, 2011.

21. "Garver: Funding Cut Would Only Delay Commercial Crew Effort". Space News. 2012-04-17. http://www.spacenews.com/civil/120417-garver-funding-delay-commercial.html. Retrieved 18 April 2012.


22. U.S. DoD, 2007. "United States Department of Defense, May 17, 2007-last update, DoD's SBIR and STTR Programs", [Online]. http://www.acq.osd.mil/osbp/sbir/overview/index.htm. Retrieved October 15, 2007.

23. EDWARDS, J. T., 2003. "The Road to a Spaceport". *Space Technology and Applications International Forum - STAIF 2003: Commercial/Civil Next Generation Space Transportation.* 1 ed. Albuquerque, New Mexico (USA), AIP.

24. Joiner, Stephen. "The Mojave Launch Lab" Air & Space Magazine, May 2011. http://www.airspacemag.com/space-exploration/The-Mojave-Launch-Lab.html

25. Culver, L. et al., 2007. "Policies, Incentives, and Growth in the NewSpace Industry". Working paper. http://commercialspace.pbworks.com/f/2007.12.12+NewSpace+Policies+Incentives+and+Growth.pdf. Retrieved June 5, 2012. p.55.

26. ibid, p.56.

27. ibid, p.58