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Space Launch Vehicles: Government Activities, Commercial Competition, and Satellite Exports

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SUMMARY

Launching satellites into orbit, once the exclusive domain of the U.S. and Soviet governments, today is an industry in which companies in the United States, Europe, China, Russia, Ukraine, Japan, and India compete. In the United States, the National Aeronautics and Space Administration (NASA) owns and launches its space shuttle. Private sector companies provide launch services for other NASA launches and most Department of Defense (DOD) launches. Commercial customers purchase launch services from the U.S. companies or their competitors. Since the early 1980s, Congress and successive Administrations have taken actions, including passing several laws, to facilitate the U.S. commercial space launch services business. The Federal Aviation Administration (FAA) regulates the industry.

Forecasts in the 1990s suggesting significant increases in launch demand sparked plans to develop new launch vehicles. NASA and DOD created government-industry partnerships to develop new reusable launch vehicles (RLVs) and "evolved" expendable launch vehicles (EELVs), respectively. (The space shuttle is the only RLV today. All other launch vehicles are "expendable" — they can only be used once). Several U.S. private sector companies began developing their own launch vehicles. Projections for launch services demand declined dramatically beginning in 1999, however. NASA's efforts to develop a new RLV to replace the shuttle faltered. DOD's new EELVs (Atlas V and Delta IV) began service, but, with reduced demand, the companies that build them (Lockheed Martin and Boeing) want more DOD funding to defray their costs. In 2005, the two companies announced plans to merge their EELV launch services for U.S. government customers. The joint venture, if approved by regulatory authorities, would be named the United Launch Alliance. Commercial launch services would not be affected.

Congress is debating the future of the space shuttle, which returned to flight in July 2005 after a two and one-half year hiatus following the 2003 *Columbia* tragedy. President Bush directed NASA to terminate the shuttle in 2010, but some want it to continue until a replacement is available. NASA plans to build "shuttle-derived" launch vehicles to implement the President's "Vision for Space Exploration" to return astronauts to the Moon and someday send them to Mars.

In October 2004, Burt Rutan's SpaceShipOne suborbital spacecraft won the $10 million Ansari X-prize. Some believe this heralds an era of comparatively affordable space tourism. Congress passed a law in 2004 (P.L. 108-492) that creates a regulatory environment for space tourism.

Concerns that China benefitted militarily from knowledge gained through commercial satellite launches in the 1990s led to changes in U.S. satellite export policy. The changes, especially returning control over such exports to the State Department from the Commerce Department, remain controversial because of what some claim is a negative impact on U.S. satellite manufacturing companies whose clients may choose European suppliers to avoid the U.S. export control regulations.

MOST RECENT DEVELOPMENTS

The next launch of the space shuttle is not expected before May 2006. Shuttle flights were indefinitely postponed after the STS-114 mission in July-August 2005 because of a foam-shedding event from the shuttle's External Tank that was similar to what led to the loss of the space shuttle *Columbia* in 2003. Hurricane damage to the Michoud Assembly Facility (MAF) in New Orleans, LA, where the External Tanks are manufactured, slowed the work needed to resume flights. As directed by President Bush, NASA plans to retire the shuttle in 2010. It hopes to conduct 18 or 19 more shuttle launches by then, but funding is problematic. NASA estimates that it needs $3-5 billion more for the shuttle than was included in the agency's five-year spending plan that accompanied the FY2006 budget request. The request for FY2006 was $4.5 billion. Congress provided that amount in the FY2006 appropriations act that includes NASA (P.L. 109-108), subject to a 0.28% rescission in that act, and a 1% rescission in the FY2006 DOD appropriations and hurricane recovery act (P.L. 109-148). Congress passed a FY2007-2008 NASA authorization bill (P.L. 109-155) that states that it is U.S. policy to have human access to space on a continuous basis, and directs NASA to submit several related reports to Congress. NASA's Stennis Space Center, MS, where the space shuttle's main engines are tested, also suffered hurricane damage. NASA estimates that it needs $760 million to cope with hurricane damage. The Administration requested $325 million for NASA for hurricane relief. Congress increased that to $350 million in DOD appropriations and hurricane recovery act (P.L. 109-148).

For FY2006, DOD requested $838 million for procurement of EELVs and $26 million for research and development (R&D). The $838 million includes $345 million in "assured access" costs to maintain the two launch service providers in the wake of lower than expected commercial launch demand. The FY2006 DOD authorization act (P.L. 109-163) fully funded EELV. The FY2006 DOD appropriations act (P.L. 109-148) cut $54 million from procurement.

BACKGROUND AND ANALYSIS

U.S. Launch Vehicle Policy

The National Aeronautics and Space Administration (NASA), the Department of Defense (DOD), and the private sector have developed expendable launch vehicles (ELVs) — they can only be used once — to place satellites in orbit. NASA also developed the partially reusable space shuttle. U.S. ELVs currently in use include Atlas (manufactured by Lockheed Martin), Delta (Boeing), and Pegasus and Taurus (Orbital Sciences Corporation). Delta IV and Atlas V are the most recent additions to the fleet, and were developed through DOD's Evolved Expendable Launch Vehicle (EELV) program.

From "Shuttle-Only" to "Mixed Fleet"

In 1972, President Nixon approved NASA's plan to build the first reusable launch vehicle, called the space shuttle, and directed that it become the nation's primary launch vehicle, replacing all the ELVs except Scout (later discontinued for unrelated reasons). This would have made NASA and DOD dependent on a single launch vehicle, but the resulting

high launch rate was expected to reduce the cost per flight significantly. The shuttle was first launched in 1981, and was declared operational in 1982. The phase-out of the ELVs began, but in 1984 the Air Force successfully argued that it needed a "complementary" ELV as a backup to the shuttle for "assured access to space" and initiated what is now known as the Titan IV program. Production lines for the Delta and Atlas began to close down, and it was expected that only the shuttle, Scouts, and Titan IVs would be in use by the mid-1980s.

Everything changed on January 28, 1986, however, when the space shuttle *Challenger* exploded 73 seconds after launch. Apart from the human tragedy, the *Challenger* accident deeply affected U.S. space launch policy, demonstrating the vulnerability of relying too heavily on a single system. Many military and civilian satellites had been designed to be launched on the shuttle, and could not have been transferred to ELVs even if the ELVs were not already being phased out. The remaining ELVs had their own problems in 1986. A Titan exploded in April and a Delta failed in May, which also grounded Atlas because of design similarities. Consequently, the Reagan Administration revised U.S. launch policy from primary dependence on the shuttle to a "mixed fleet" approach where a wide variety of launch vehicles are available. The shuttle is used principally for missions that require crew interaction, while ELVs are used for launching spacecraft. President Reagan also decided that commercial payloads could not be flown on the shuttle unless they were "shuttle-unique" (capable of being launched only by the shuttle or requiring crew interaction) or if there were foreign policy considerations. That action facilitated the emergence of a U.S. commercial space launch industry whose participants had long argued that they could not compete against government-subsidized shuttle launch prices. The White House and Congress had taken steps beginning in 1983 to assist in developing a commercial space launch services business, including President Reagan's 1983 designation of the Department of Transportation as the agency responsible for facilitating and regulating the commercial space launch sector. Passage of the 1984 Commercial Space Launch Act (P.L. 98-575), the Commercial Space Launch Act Amendments of 1988 (P.L. 100-657), and the Commercial Space Act of 1998 (P.L. 105-303) also have helped. But removing the shuttle as a competitor is seen as the major factor in fostering the U.S. commercial space launch business.

Clinton Administration Policy

On August 5, 1994, President Clinton released a National Space Transportation Policy that gave DOD lead responsibility for improving ELVs and NASA lead responsibility for upgrading the space shuttle and technology development of new reusable launch vehicles. The policy also set guidelines for the use of foreign launch systems, the use of excess ballistic missile assets for space launch, and encourages an expanded private sector role in space transportation R&D.

George W. Bush Administration Policy

On December 21, 2004, President Bush authorized a new U.S. Space Transportation Policy that supersedes the 1994 Clinton policy. A fact sheet on the Bush policy was released on January 6, 2005 [http://www.ostp.gov/html/SpaceTransFactSheetJan2005.pdf]. The new policy calls both for continued government support for space transportation capabilities, and for capitalizing on the U.S. private sector's "entrepreneurial spirit." DOD is directed to maintain the capability to develop, evolve, operate and purchase services for space

transportation systems, infrastructure, and support activities necessary for national security requirements. NASA is directed to maintain the same capability for the civil sector, and to engage in development activities only for those requirements that cannot be met by capabilities being used by the national security or commercial sectors. The policy also directs NASA, in cooperation with DOD, to develop options to implement the President's January 2004 Vision for Space Exploration. NASA subsequently decided to build shuttle-derived launch vehicles. The policy states that the government will continue to support both EELVs (Boeing's Delta IV and Lockheed Martin's Atlas V) until the Secretary of Defense certifies to the President that U.S. assured access to space can be maintained without both providers.

U.S. Launch Vehicle Programs and Issues

NASA's Space Shuttle Program

The Space Transportation System (STS) — the space shuttle — is a partially reusable launch vehicle and is the sole U.S. means for launching humans into orbit. It consists of an airplane-like Orbiter, with two Solid Rocket Boosters (SRBs) on each side, and a large, cylindrical External Tank (ET) that carries fuel for the Orbiter's main engines. The Orbiters and SRBs are reused; the ET is not. NASA has three remaining spaceflight-worthy Orbiters: *Discovery*, *Atlantis*, and *Endeavour*.

The *Challenger* and *Columbia* Tragedies. A total of 114 shuttle launches have taken place since April 1981. Two ended in tragedy, each killing seven astronauts. In 1986, the space shuttle *Challenger* exploded 73 seconds after launch because of the failure of a seal (an O-ring) between two segments of an SRB. In 2003, the space shuttle *Columbia* disintegrated as it returned to Earth after 16 days in orbit (see CRS Report RS21408). *Columbia* broke apart from aerodynamic forces after the left wing was deformed from the heat of gases that entered the wing through a hole caused during launch by a piece of foam insulation that detached from the ET. The *Columbia* Accident Investigation Board (CAIB) found that the tragedy was caused by technical and organizational failures, and made 29 recommendations, 15 of which it said should be completed before the shuttle returned to flight (see CRS Report RS21606 for a synopsis of the CAIB report).

Sean O'Keefe, NASA's Administrator from December 2001-February 2005, said NASA would comply with the CAIB recommendations. He established an RTF Task Group, chaired by two former astronauts, Tom Stafford and Dick Covey, to oversee NASA's implementation of the CAIB's 15 RTF recommendations. The Stafford/Covey Task Group [http://www.returntoflight.org] did not address management and culture changes, and was not tasked to determine whether the shuttle was ready to return to flight. Its assignment only was to evaluate NASA's compliance with the CAIB recommendations for RTF. The Task Group ultimately concluded that NASA met the intent of 12 of the 15 CAIB RTF recommendations, but not the other three: eliminating debris shedding from the External Tank, hardening the Orbiter so it can better survive debris impacts, and developing an on-orbit method of repairing the shuttle's thermal protection system. Dr. Michael Griffin, who became NASA Administrator in April 2005, said that NASA and contractor personnel are those responsible and accountable for determining if and when the shuttle is ready for RTF, and would not commit to meeting every CAIB recommendation.

Return to Flight (RTF). NASA launched the space shuttle *Discovery* on the first of two "Return to Flight" (RTF) missions — STS-114 — on July 26, 2005 and it successfully landed on August 9. On July 27, however, NASA announced that a piece of foam had detached from STS-114's ET during launch, similar to what happened to *Columbia*. Cameras and other sensors on *Discovery* and on the International Space Station — to which *Discovery* was docked for much of its mission — imaged the Orbiter and determined that it was not damaged, but further shuttle launches have been suspended until the problem is resolved. Meanwhile, the images revealed that two "gapfillers" — ceramic coated fabric placed between thermal protection tiles — were protruding on the belly of the Orbiter that could have affected aerodynamic heating during reentry. One of the *Discovery* astronauts removed them during a space walk. The second RTF mission — STS-121 — was scheduled for September 2005, but now is not expected until sometime in 2006.

The United Space Alliance (USA). In 1995, NASA decided to turn most shuttle operations over to a "single prime contractor" — the United Space Alliance (USA), a limited liability company owned 50-50 by Boeing and Lockheed Martin. USA was created to pull together the 86 separate contracts with 56 different companies under which the shuttle program was then operating. NASA signed a $7 billion, six-year Space Flight Operations Contract (SFOC) with USA on September 26, 1996, with the goal of reducing shuttle operational costs while ensuring safety. The SFOC contract has been extended to 2006. NASA officials assert that SFOC has saved NASA $1 billion a year compared to what the costs would have been without it. Contracts for the External Tank, Solid Rocket Boosters (SRBs), and Space Shuttle Main Engines (SSMEs) have not been incorporated into SFOC. NASA manages those contracts: with Lockheed Martin for the External Tank; ATK Thiokol for the SRBs, and Boeing Rocketdyne for the SSMEs. (Boeing is in the process of selling Rocketdyne to United Technologies.)

The Shuttle's Future. As discussed below, NASA attempted unsuccessfully for many years to develop a "2nd generation" reusable launch vehicle (RLV) to replace the shuttle (which is the 1st generation RLV). In a November 2002 amendment to its FY2003 budget request, NASA announced a new space transportation strategy that indicated the shuttle would continue flying until at least 2015, and perhaps 2020 or beyond. The *Columbia* tragedy, and President Bush's January 2004 announcement of a new "Vision for Space Exploration" — to return astronauts to the Moon by 2020 and someday send them to Mars — forced NASA to revise that plan.

The President's Vision (see CRS Report RS21720) calls for the shuttle program, which absorbs approximately 25% of NASA's annual budget, to be terminated in 2010. A primary motivation is to make that funding available to implement other aspects of the Vision, although there also is concern about shuttle safety. Congress is debating the Vision, including its impact on the shuttle and on U.S. human access to space. Some Members want to terminate the shuttle earlier than 2010 because they feel it is too risky and/or that the funds should be spent on accelerating the Vision. Others want to retain the shuttle at least until a new spacecraft, the Crew Exploration Vehicle (CEV), is available to take astronauts to and from the ISS. Under the plan announced by the President, CEV would not be ready at least until 2014, leaving a multi-year gap during which U.S. astronauts would have to rely on Russia for access to the ISS (see CRS Issue Brief IB93017). NASA Administrator Griffin hopes to accelerate CEV development and have it ready by 2012. He has made clear that he views 2010 as a firm deadline for terminating the shuttle.

At the beginning of 2005, NASA officials indicated 28 shuttle flights were needed to complete ISS construction. When he became Administrator, Dr. Griffin stated that such a number was not achievable. In the fall of 2005, NASA announced a new plan that shows 18 shuttle missions to the ISS, and possibly one more to service the Hubble Space Telescope (see CRS Report RS21767). The original versions (H.R. 3070/S. 1281) of what became the FY2007-2008 NASA authorization act (P.L. 109-155) had conflicting language about the future of the shuttle. The original Senate bill directed NASA not to terminate the shuttle until a replacement was available; the House version directed NASA not to fly the shuttle after December 31, 2010. The final law states that it is U.S. policy to have human access to space on a continuous basis, and directs NASA to submit several related reports to Congress

A related issue is what steps NASA and USA must take to make certain that the shuttle workforce retains the needed personnel and skills to ensure the shuttle flies safely through its remaining years of service. A 2005 GAO report (GAO-05-230) concluded that NASA needs to better position itself to address future shuttle workforce needs.

FY2005 and FY2006 Shuttle Budgets. The FY2005 request for the shuttle was $4.3 billion. NASA informed Congress in November 2004 that it needed an additional $762 million in FY2005. Congress appropriated the requested $4.3 billion level in P.L. 108-447 (FY2005 Consolidated Appropriations Act). NASA reprogrammed funds to make up the difference. According to NASA briefing charts accompanying its May 10, 2005 operating plan update, funding was reprogrammed as follows: $55 million from the Science Mission Directorate; $375.8 million from the Exploration Systems Mission Directorate; and $331.2 million from the Space Operations Mission Directorate.

For FY2006, NASA requested $4.5 billion for the shuttle program and received that amount in the FY2006 Science, State, Justice, Commerce appropriations bill (P.L.109-108), which includes NASA, subject to a 0.28% rescission in that law, and a 1% rescission in the DOD appropriations bill (P.L. 109-148).

"Shuttle-Derived" Launch Vehicles. On September 19, 2005, NASA announced its implementation plan for the Vision for Space Exploration. Under the plan, NASA will develop two new launch vehicles that are derived from the space shuttle system. One is for launching the new Crew Exploration Vehicle (CEV); the other for launching large amounts of cargo. The first is designated the Crew Launch Vehicle (CLV), and would use a single SRB, augmented by a new "upper stage," with the CEV on top. It is informally referred to as the "single stick" design. The cargo launch vehicle, referred to as a "heavy lift" vehicle because it will be able to launch 125 tons of cargo to Earth orbit, would use a modified ET, supplemented by SRBs (like the shuttle), with the cargo spacecraft on top. NASA Administrator Griffin and Dr. Ronald Sega, Under Secretary of the Air Force, agreed that NASA would develop these two shuttle-derived vehicles for implementing the Vision, but use DOD's Evolved Expendable Launch Vehicles (EELVs) for its other spacecraft in the 5-20 metric ton range to the maximum extent possible (although new commercially-developed launch vehicles may compete with the EELVs if they become available).

NASA's Efforts to Develop New Reusable Launch Vehicles (RLVs)

U.S. expendable and reusable launch systems remain expensive and less efficient and reliable than desired. DOD and NASA initiated several efforts in the late 1980s and early

1990s to develop new systems, but each was terminated in turn because Congress or the agencies themselves were not convinced that the required investment had sufficient priority. In response to the 1994 Clinton policy, DOD's Evolved Expendable Launch Vehicle (EELV) program, and NASA's Reusable Launch Vehicle (RLV) program, were initiated.

Proponents believe that RLV technology can dramatically lower the cost of accessing space. NASA's efforts to develop a "2nd generation" RLV to replace the shuttle have not fared well, however. Starting in 1995, NASA pursued two "X" (for "experimental") flight test programs: X-33 and X-34. X-33 was a joint program with Lockheed Martin to build a subscale prototype of a large RLV based on single-stage-to-orbit (SSTO) technology. The SSTO concept involves a rocket that can attain orbit with only one stage (instead of two or more as is common today) carrying people or cargo. X-34 was a small RLV "testbed" to demonstrate reusable two-stage-to-orbit technologies, which was being built under a traditional contract with Orbital Sciences Corporation. NASA terminated X-33 and X-34 in March 2001 because the cost to complete them was too high relative to the benefits. NASA spent $1.2 billion on X-33, and Lockheed Martin said that it spent $356 million of its own funding. NASA spent $205 million on X-34.

NASA restructured its RLV program in 2000 (as part of its FY2001 budget request) and initiated the Space Launch Initiative (SLI). It then restructured the SLI program in 2002, and terminated it following President Bush's announcement of the Vision in January 2004. The goal was to develop RLV technology that would be "10 times safer and crew survivability 100 times greater, all at one-tenth the cost of today's space launch systems." The failure of the X-33 and X-34 programs, and of the National AeroSpace Plane (NASP) program before them, made some observers skeptical about NASA's ability to develop a 2nd generation RLV. In documentation accompanying a November 2002 budget amendment, NASA conceded that a new RLV lacked economic justification. SLI was restructured into two components: building an Orbital Space Plane (OSP), a spacecraft (not a launch vehicle) to take crews to and from the space station, and developing "Next Generation Launch Technology" (NGLT). Concurrent with President Bush's announcement of the Vision, NASA terminated SLI.

DOD's Evolved Expendable Launch Vehicle (EELV) Program

DOD began what is now known as the EELV program in FY1995 (P.L. 103-335) with a $30 million appropriation. EELV was first formally identified in DOD's FY1996 budget. Two EELVs were developed in joint government-private sector programs: Boeing's Delta IV and Lockheed Martin's Atlas V. Both vehicles have successfully entered service (although the first launch of the Delta IV "heavy" — i.e., the version that can launch the greatest amount of mass — in December 2004 did not reach its intended orbit). The goal of the EELV program is to reduce launch costs by 25%.

In 1996, the Air Force selected Lockheed Martin and McDonnell Douglas (later bought by Boeing) for development contracts worth $60 million. Originally, one of those companies would have been selected in 1998 to develop the EELV. In November 1997, responding to indicators at the time that the commercial space launch market would be larger than expected, DOD announced that it would help fund development of both Atlas V and Delta IV. In October 1998, DOD awarded Boeing $1.88 billion for the Delta IV ($500 million for further development plus $1.38 billion for 19 launches), and awarded Lockheed Martin $1.15 billion for the Atlas V ($500 million for further development plus $650 million for 9

launches). The companies were expected to pay the rest of the development costs themselves. (Boeing officials state that Boeing invested $2.5 billion in design, development, and infrastructure for the Delta IV, of which the company wrote off $2 billion.)

In 2000, however, new market forecasts showed a reduction in expected commercial demand, and DOD reevaluated its EELV strategy. It renegotiated the contracts with both companies, including relieving Lockheed Martin (reportedly at the company's request) of the requirement to build a launch pad at Vandenberg AFB, CA. Each company built a launch pad for its vehicle at Cape Canaveral, FL for east coast launches. Both were expected to build them at Vandenberg for west coast launches (which launch site to use is determined by the type of orbit required by the satellite), but under this agreement, only Boeing would be able to launch from the west coast, giving it a monopoly on those EELV contracts. The companies also approached DOD to obtain additional government funding because of the downturn in the commercial market. This is called "assured access to space" in the sense of assuring that both companies remain in the EELV business so DOD has redundancy in capability should one of the launch vehicles experience difficulties. The FY2004 DOD authorization act (P.L. 108-136) codified "assured access" as U.S. policy.

Following revelations of ethics violations by Boeing in 2003, including some related to the EELV program, DOD suspended three Boeing business units from eligibility for new government contracts, shifted seven existing launch contracts from Boeing to Lockheed Martin, and disqualified Boeing from bidding for three new launch contracts. Boeing withdrew the Delta IV from competition for commercial contracts because it did not believe it could successfully compete. DOD reinstated the plan for an Atlas V launch pad at Vandenberg, so Boeing no longer would have a monopoly on west coast launches. The Boeing suspension was lifted on March 4, 2005.

The EELV program breached the "Nunn-McCurdy" limit of 25% cost growth, which requires DOD to cancel or restructure the program, or certify that it is essential to national security. In April 2004, DOD made that certification. In its report on the FY2005 DOD appropriations bill (H.Rept. 108-553), the House Appropriations Committee directed DOD to study whether both families of EELVs were really needed (H.Rept. 108-553). The December 2004 Bush space transportation policy directs DOD to continue to support both EELVs until the Secretary of Defense certifies to the President that assured access can be maintained without two EELV providers.

On May 2, 2005, Boeing and Lockheed Martin announced they planned to merge the production, engineering, test, and launch operations associated with EELV launch services for the U. S. government. If approved by U.S. and foreign regulatory bodies, both vehicles would be built at a single location (Boeing's facility in Decatur, AL), while engineering and administrative activities would be consolidated at Lockheed Martin's offices in Denver, CO. The joint venture, to be owned 50-50 by the two companies, would be called United Launch Alliance. The companies said the merger would save $100-150 million per year for the U.S. government. The merger does not affect commercial launch services.

For FY2006, DOD requested $838 million for procurement of EELVs and $26 million for research and development (R&D). The $838 million includes $345 million in "assured access" costs to maintain the two launch service providers in the wake of lower than expected commercial launch demand. The FY2006 DOD appropriations act (P.L. 109-148)

cut $58 million from procurement because of an expected delay in the launch of a particular DOD satellite. The authorization bill (P.L. 109-163) approved the requested level.

Private Sector Launch Vehicles (Including Space Tourism and the X-Prize)

Several entrepreneurial U.S. companies have been attempting to develop RLVs through private financing. Many have encountered difficulties in obtaining financing from the financial markets, and some have sought government loan guarantees or tax credits. Some have received limited direct government funding through various contracts. One company, SpaceX, headed by Elon Musk (creator of PayPal), asserts that it will dramatically reduce the cost of reaching orbit with its partially reusable Falcon launch vehicle. The first Falcon launch, of a small DOD communications satellite, was scheduled for 2004, but has been delayed by a variety of factors.

Some companies are focusing on suborbital rockets instead of those that can attain orbit, anticipating that suborbital space tourism will be a substantial market. Twenty seven teams from seven countries competed in the "Ansari X-Prize" contest [http://www.xprize.com] to win $10 million by becoming the first privately-financed company to launch a vehicle capable of carrying three people (one person actually had to be aboard) to an altitude of 100 kilometers (62.5 miles), return safely to Earth, and repeat it within two weeks using the same vehicle. On October 4, 2004, Burt Rutan's Scaled Composites Inc. won the X-prize with the SpaceShipOne vehicle, financed by Microsoft co-founder Paul Allen. Sir Richard Branson, head of the Virgin Group, is licensing the SpaceShipOne technology. He founded a company, Virgin Galactic, to offer commercial suborbital flights, and someday orbital flights. He reportedly expects to invest about $100 million in the new spaceships and associated ground infrastructure, and charge $200,000 per person per flight.

P.L. 108-492 creates a regulatory environment for commercial human space flight ("space tourism"). It sets requirements for protecting third parties, and for the crews of commercial spacecraft. There are few regulations for passengers ("spaceflight participants"), based on the philosophy that anyone who is willing to take the risk to fly on these new spacecraft should be allowed to do so as long as they are informed of the vehicle's safety record. If there are a significant number of accidents, or incidents that could have led to accidents, the FAA may set further passenger regulations. After eight years, the FAA may set any regulations it wishes. The FAA published a proposed rule in the December 29, 2005 *Federal Register* seeking public comment. Others believe that commercial human space flight should be regulated more strongly. H.R. 656 would strengthen safety requirements for passengers. A House Science subcommittee held a hearing on April 20, 2005, where Mr. Rutan sharply criticized FAA's regulatory process.

U.S. Commercial Launch Services Industry

Congressional Interest

Congress has been debating issues involving the domestic launch services industry for many years. Part of the debate has been focused on satellite export issues (discussed below). Another part concerns what the government should do to stimulate development of new

launch vehicles by the private sector. That debate focuses on whether tax incentives or loan guarantees should be created for companies attempting to develop lower cost launch vehicles. Tax incentive advocates argue that loan guarantee programs allow the government to pick winners and losers; loan guarantee advocates argue that tax incentives are insufficient to promote necessary investment in capital intensive projects. Congress created (Title IX, FY2003 DOD appropriations Act, P.L. 107-248) a loan guarantee program for companies developing commercial, reusable, in-orbit space transportation system, but such systems are not launch vehicles (they move satellites from one orbit to another) and are not discussed further here. In 2004, Congress passed a law (P.L. 108-428) extending third-party liability indemnification for the commercial space launch industry for five more years. The government indemnifies commercial space launch companies for third-party claims between $500 million and $2 billion. Other 2004 legislation relating to regulation of space tourism is discussed above. In the 109th Congress, H.R. 3643 would make spaceports, like airports, eligible for tax exempt bonds.

Foreign Launch Competition

Europe, China, Russia, Ukraine, India, and Japan offer commercial launch services in competition with U.S. companies. Most satellites are manufactured by U.S. companies or include U.S. components and hence require export licenses, giving the United States considerable influence over how other countries participate in the commercial launch services market. The United States negotiated bilateral trade agreements with China, Russia, and Ukraine on "rules of the road" for participating in the market to ensure they did not offer unfair competition because of their non-market economies. Launch quotas were set in each of the agreements. However, President Clinton terminated the quotas for Russia and Ukraine in 2000, and the agreement with China expired at the end of 2001.

Europe. The European Space Agency (ESA) developed the Ariane family of launch vehicles. The first test launch of an Ariane was in 1979; operational launches began in 1982. ESA continued to develop new variants of Ariane. Ariane 5 is the only version now in use. ESA also is developing a smaller launch vehicle, Vega, whose first launch is expected in 2005. Operational launches are conducted by the French company Arianespace. Arianespace conducts its launches from Kourou, French Guiana, on the northern coast of South America. Arianespace also markets Russia's Soyuz launch vehicle and ESA is planning to build a launch site for Soyuz at Kourou.

In 1985, a U.S. company (Transpace Carriers Inc.) filed an unfair trade practices complaint against Arianespace, asserting that European governments were unfairly subsidizing Ariane. The Office of the U.S. Trade Representative (USTR) investigated and found that Europe was not behaving differently from the United States in pricing commercial launch services (then offered primarily on the government-owned space shuttle). The incident raised questions about what "rules of the road" to follow in pricing launch services. In the fall of 1990, USTR and Europe began talks to establish such rules of the road and assess how to respond to the entry of non-market economies into the launch services business. The only formal negotiating session was held in February 1991.

Each side is concerned about how much the respective governments subsidize commercial launch operations, but another controversial topic (not formally part of the talks) was whether Arianespace should be able to bid for launches of U.S. government satellites,

which now must be launched on U.S. launch vehicles as a matter of U.S. policy. Arianespace wants that restriction lifted. France and other European governments do not have written policies requiring the use of Ariane for their government satellites. However, the member governments of ESA originally agreed to pay a surcharge of as much as 15-20% if they chose Ariane. The surcharge led some cost-conscious European governments to buy launch services from other (notably U.S.) suppliers. In the fall of 1995, ESA's member governments reached agreement with Arianespace to reduce the surcharge to encourage use of Ariane. ESA itself gives preference to using Ariane, but is not legally constrained from using other launch vehicles. Arianespace has encountered significant financial difficulties both because of the constrained market, and because of the failure of a new, more capable variant of the Ariane 5 in 2002. In May 2003, the ESA Council of Ministers adopted a European Guaranteed Access to Space (EGAS) program, providing 960 million euros for Arianespace to fix that variant of Ariane 5 (it successfully returned to flight in February 2005), and acquire Ariane 5 launch vehicles through 2009, while the commercial launch market is down.

China. The People's Republic of China offers several versions of its Long March launch vehicles commercially. China poses special issues not only because of its non-market economy, but because of technology transfer and political concerns. Launch services are offered through China Great Wall Industry Corp. (CGWIC). Because the United States currently will not issue export licenses for satellites or satellite components destined for China (see below), the Chinese commercial space launch program is sharply constrained.

U.S.-China Bilateral Trade Agreements for Launch Services. In 1989, China and the United States signed a six-year bilateral trade agreement restricting the number of Chinese commercial space launches to ensure China, with its nonmarket economy, did not unfairly compete with U.S. companies. A new seven-year agreement was reached in 1995, and amended in 1997. The agreement expired on December 31, 2001. While the agreements were in force, they established quotas on how many commercial satellites China could launch each year, and included pricing provisions to try to ensure that China did not unfairly compete with U.S. commercial launch service providers because of its non-market economy.

U.S. Satellite Exports to China: 1988-1997. In September 1988, the U.S. government agreed to grant three export licenses for satellites manufactured by Hughes to be launched by CGWIC. The Reagan Administration granted the licenses on the conditions that China sign three international treaties related to liability for satellite launches and other subjects; agree to price its launch services "on a par" with Western companies; and establish a government-to-government level regime for protecting technology from possible misuse or diversion. China met the conditions and the two countries signed a six-year agreement in January 1989. The now-defunct Coordinating Committee on Multilateral Export Controls (COCOM) approved the licenses that March.

On June 5, 1989, after the Tiananmen Square uprising, President George H. W. Bush suspended all military exports to China. At the time, exports of communications satellites were governed by the State Department's Munitions List. The satellites counted as military exports and the licenses were suspended. Then Congress passed language in the FY1990 Commerce, Justice, State and Judiciary appropriations (P.L. 101-162) and the 1990-91 Foreign Relations Authorization Act (P.L. 101-246, Section 902) prohibiting the export of

U.S.-built satellites to China unless the President reported to Congress that (1) China had achieved certain political and human rights reforms, or (2) it was in the national interest of the United States. In December 1989, President Bush notified Congress that export of the satellites was in the national interest and the licenses were reinstated. The satellites were launched by China in 1990-1992.

A different issue arose in 1990. China signed a contract to launch an Arabsat Consortium satellite for $25 million, much less than what many considered "on a par" with Western companies. The main competitor, Arianespace, turned to both the French and U.S. governments to prohibit export of the satellite. No formal action was taken by the United States. In 1991, the Arabsat Consortium terminated the contract with the Chinese and signed an agreement with Arianespace, so the case became moot, but the issue of what constituted "on a par" remained. China argued that because its costs are so low, it could offer lower prices and still adhere to international norms as to what costs are included in setting the price. Yet another issue arose in 1991 — linkage of satellite export licenses with U.S. concern over China's ballistic missile proliferation policies. On April 30, 1991, the Bush Administration approved final export licenses for two satellites and for U.S. components of another, but to emphasize its concern about Chinese missile proliferation, disapproved export of U.S. components for a communications satellite China itself was building. On June 16, 1991, the White House announced that it would not approve any further export licenses for commercial satellite launches. On July 17, the State Department identified CGWIC as one of two Chinese entities engaged in missile technology proliferation activities that require the imposition of trade sanctions under the Arms Export Control Act, including denial of license applications for export items covered by the Missile Technology Control Regime (MTCR). Although the MTCR does not cover satellites (only satellite launch vehicles, which are close cousins of ballistic missiles), the identification of CGWIC as a cause of concern complicated China's marketing plans. China agreed to adhere to the MTCR, and the sanctions were lifted on February 21, 1992. In May 1992, INTELSAT agreed to launch at least one satellite on a Chinese launch vehicle. On September 11, 1992, the State Department notified Congress that it was waiving legislative restrictions on U.S. exports for six satellite projects with China. Many observers saw the move as a conciliatory gesture in the wake of the U.S. decision to sell F-16s to Taiwan.

On August 25, 1993, however, the U.S. government again imposed sanctions against China for ballistic missile proliferation activities, and the State Department said that satellite exports would not be permitted. The State Department announced October 4, 1994, it would lift the sanctions after China pledged to abide by the MTCR. During this period, tensions were acute between those viewing the sanctions as harmful to U.S. business interests and those seeking to prevent sensitive technology from reaching China and/or to punish China for MTCR infractions. The debate centered on whether the satellites should be governed by the State Department (Munitions List) or the Commerce Department (Commerce Control List). Some responsibility for export of commercial communications satellites was transferred from the State Department to the Commerce Department in 1992; in October 1996 primary responsibility was transferred to Commerce.

In January 1995, the launch of the Hughes-built APStar-2 satellite failed in-flight. Falling debris killed 6 and injured 23 on the ground. On February 6, 1996, President Clinton approved the export of four satellites to China for launch, despite concerns about China exporting nuclear weapons-related equipment to Pakistan. On February 14, 1996, a Long

March 3B rocket carrying the INTELSAT 708 communications satellite built by Loral malfunctioned seconds after liftoff, impacting the ground and spreading debris and toxic fumes over the launch site and a nearby village. The Chinese reported 6 dead and 57 injured, but other reports suggested a higher figure. Some customers, including INTELSAT, canceled contracts.

In May 1997, USTR stated that it believed China violated the pricing provisions of the bilateral agreement for the launching of Agila 2 for the Philippines. Chinese officials disagreed. On September 10, 1997, the *Washington Times* published a story that Chinese and Russian entities (including CGWIC) were selling missile technology to Iran. China denied the allegations.

Satellite Exports to China: 1998-2000 (Including the "Loral/Hughes" Issue, the Cox Committee Report, and Lockheed Martin). On February 18, 1998, the President notified Congress that it was in the national interest to export Loral's Chinasat 8 satellite to China. On April 4, 1998, the *New York Times* reported that a 1997 classified DOD report alleged that Space Systems/Loral (part of Loral Space & Communications) and Hughes Electronics' satellite manufacturing division (then a subsidiary of General Motors; now Boeing Satellite Systems) provided technical information to China that improved the reliability of Chinese nuclear missiles. The assistance was provided in the wake of the February 1996 INTELSAT 708 launch failure (see above). The INTELSAT satellite was built by Loral, which participated in an inquiry into the accident at the request of insurance companies seeking assurances that the Chinese had correctly diagnosed and solved the cause of the failure. Loral formed a review committee that included representatives of other satellite companies, including Hughes. According to Loral, the review committee did not itself investigate the accident, but listened to Chinese officials explain their investigation and then wrote a report. Loral conceded that a copy of the report was given to the Chinese before it was provided to the State Department, in violation of Loral's internal policies. Loral says it notified the State Department when it learned that the Chinese had been given a copy. According to media sources, DOD's 1997 report says that the companies provided technical information in violation of Loral's export license. The companies insist they did not violate the licenses. The Justice Department investigated, and expanded the probe to include Hughes' response to the 1995 APStar-2 failure. A grand jury reportedly was empaneled in 1999. The government reached a civil settlement with Loral on January 9, 2002 where Loral agreed to pay a $14 million civil fine, and spend $6 million on strengthening its export compliance program. On December 26, 2002, the State Department charged Hughes Electronics and Boeing Satellite Systems with 123 export violations. The companies settled with the government on March 5, 2003, accepting a civil penalty of $20 million in cash, and $12 million in credits for money already spent ($4 million), or that will be spent ($8 million), on export program enhancements.

Many hearings on the "Loral/Hughes" issue were held by various House and Senate committees. In addition, the House established the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China, chaired by Representative Cox. The Cox committee concluded that Hughes and Loral deliberately transferred technical information and know-how to China during the course of accident investigations. The committee investigated other cases of China acquiring other U.S. technical information and made 38 recommendations.

The FY2000 DOD authorization act (P.L. 106-65) included language implementing many of the Cox committee recommendations. In brief, the Department of Justice must notify appropriate congressional committees when it is investigating alleged export violations in connection with commercial satellites or items on the munitions list if the violation is likely to cause significant harm or damage to national security with exceptions to protect national security or ongoing criminal investigations; companies must be provided with timely notice of the status of their export applications; enhanced participation by the intelligence community in export decisions is required; adequate resources must be provided for the offices at DOD and the State Department that approve export licenses; individuals providing security at overseas launch sites do not have to be DOD employees, but must report to a DOD launch monitor; and DOD must promulgate regulations concerning the qualifications and training for DOD space launch monitors and take other actions regarding those monitors and the records they maintain.

In February 1999, the Clinton Administration denied Hughes permission to export two satellites to China for launch. Export permission for those satellites (called APMTs) had been granted in 1997, but Hughes changed the spacecraft design, necessitating new export approval. That application was denied. On May 10, 2000, the White House made its first certification to Congress under the new process detailed in the FY1999 DOD authorization bill, approving the export to China of satellite fuels and separation systems for the Iridium program. On August 18, 2000, the State Department stated it would continue the suspension of a technical assistance agreement for Loral regarding launch of the Chinasat 8 satellite because the concerns that initiated the suspension in December 1998 had not been rectified. In January 2001, *Space News* reported that the Chinasat 8 export application was returned to Loral without action.

In April 2000, it became known that Lockheed Martin also was under investigation, in this case for performing a technical assessment, without an export license, of a Chinese "kick motor" used to place a satellite into its final orbit. On June 14, 2000, the State Department announced it had reached agreement with Lockheed Martin involving $13 million in penalties — $8 million that the company will pay over a four-year period and $5 million that was suspended and that the company can draw upon to fund a series of remedial compliance measures specified in the consent agreement.

Satellite Exports to China: 2001-Present. In July 2001, Senators Helms, Thompson, Shelby, and Kyl wrote to President Bush reportedly asking the President not to grant waivers for the export of satellites to China. As noted earlier, such waivers are required under the FY1990-91 Foreign Relations Authorization Act (P.L. 101-246). At the time, attention was focused on two European companies (Astrium and Alenia Spazio) that had built satellites for two multinational satellite organizations (INTELSAT and EUTELSAT, respectively) that were scheduled for launch by China. The satellites contain U.S. components. In August 2001, INTELSAT canceled its contract with Astrium for the APR-3 satellite, citing several factors, including the delay in obtaining U.S. export approval. EUTELSAT switched the launch of its satellite to Europe's Ariane. Other satellites being manufactured by U.S. companies, however, such as Chinasat 8 and another being built by Loral (Apstar-5, for APT Satellite Co.), or containing U.S. components may require waivers in the future (see CRS Report 98-485 for a list of pending satellite exports). The FY2002 Commerce, Justice, State Appropriations Act (P.L. 107-77), the FY2003, FY2004, and FY2005 Consolidated Appropriations Acts (P.L. 108-7, 108-199, and 108-447), and the

FY2006 Science, State, Justice, Commerce Appropriations Act (P.L. 109-108) require 15 days notice to Congress before processing licenses for exporting satellites to China.

Russia. U.S. policy prohibited U.S.-built satellites from being exported to the Soviet Union. Following the collapse of the Soviet Union, President George H. W. Bush said he would not oppose Russia launching an International Maritime Satellite Organization (Inmarsat) satellite and the United States would negotiate with Russia over "rules of the road" for future commercial launches. Discussions in the fall of 1992 led to agreement in principle in May 1993; the agreement was signed on September 2, 1993, after Russia agreed to abide by the terms of the MTCR (see below). On January 30, 1996, the countries amended the agreement. Prior to Russia's first launch of a U.S.-built satellite, a Technology Safeguard Agreement among the United States, Russia, and Kazakstan (where the launch site is located) was signed in January 1999. A similar agreement for launches from Russia's Plesetsk, Svobodny, and Kapustin Yar launch sites was signed in January 2000.

The 1993 agreement was signed only after Russia agreed to comply with the MTCR in a case involving a Russian company, Glavkosmos, that planned to sell rocket engine technology to the Indian Space Research Organization (ISRO). The United States declared it violated the MTCR and imposed two-year sanctions against Glavkosmos and ISRO. In June 1993, the United States threatened to impose sanctions against Russian companies that did business with Glavkosmos. The two countries finally agreed that Russia would cease transferring rocket engine technology (the engines themselves were not at issue) to India.

As noted, on September 10, 1997, the *Washington Times* published a story that Russian and Chinese entities, including the Russian Space Agency, were selling missile technology to Iran. In July 1998, Russia publicly identified nine entities that might be engaged in illegal export activities. The United States imposed sanctions against seven of them on July 28 and three more on January 12, 1999. The State Department said the United States would not increase the quota on geostationary launches that Russia could conduct under the 1996 agreement unless Russian entities ceased cooperating with Iran's ballistic missile program. The launches are conducted primarily by a U.S.-Russian joint venture composed of Lockheed Martin and Russia's Khrunichev and Energia, companies that were not among those sanctioned. Lockheed Martin was anxious to have the quota raised to 20 and eventually eliminated. On July 13, 1999, the White House raised the quota to 20, and eliminated it on December 1, 2000. (*Wall Street Journal*, December 1, 2000, p. A4).

Ukraine. Ukraine offers commercial launch services, chiefly as part of the Sea Launch joint venture among Boeing, Ukraine's Yuzhnoye, Russia's Energomash, and Norway's Kvaerner. The Sea Launch vehicle consists of a Ukranian two-stage Zenit rocket with a Russian third stage. The vehicle is launched from a mobile ocean oil rig built by Kvaerner. The rig is stationed in Long Beach, CA, where the launch vehicle and spacecraft are mated, and then towed into the ocean where the launch takes place. The United States and Ukraine signed a bilateral trade agreement in February 1996, that would have expired in 2001, but President Clinton terminated it on June 6, 2000, in recognition of "Ukraine's steadfast commitment to international nonproliferation norms." The first successful commercial launch was in October 1999. In 1998, Boeing agreed to pay $10 million for not abiding by export regulations in its dealings with Russia and Ukraine. Sea Launch announced plans in October 2003 to offer launches from Baikonur using Zenit beginning in 2005; the effort is called Land Launch.

India. India conducted its first successful orbital space launch in 1980. Its ASLV and PSLV launch vehicles can place relatively small satellites in low Earth orbit. India is developing a larger vehicle (GSLV) capable of reaching geostationary orbit. The GSLV, which uses Russian cryogenic engines that were the subject of a dispute between the United States and Russia (discussed earlier), made it first operational flight in September 2004.

Japan. Japan successfully conducted the first launch of its H-2 launch vehicle in 1994, the first all-Japanese rocket capable of putting satellites in geostationary orbit. Previous rockets used for this purpose were based on U.S. technology and a 1969 U.S.-Japan agreement prohibited Japan from launching for third parties without U.S. consent. With the H-2, Japan was freed from that constraint. H-2 was not cost effective, and encountered technical problems that led the Japanese government to abandon it in 1999. A new version, H2A, successfully completed its first launch in August 2001. In 2002, the Japanese government announced that it would privatize production of the H2A Mitsubishi Heavy Industries took over development and marketing. H-2A launches are conducted from Tanegashima, on an island south of Tokyo. In June 1997, the Japanese government reached agreement with the fishing industry to allow more launches from Tanegashima. Fishermen must evacuate the area near the launch site during launches. The agreement extends from 90 to 190 the number of days per year that launches may be conducted, and permits up to eight launches a year instead of two.

Satellite Exports: Agency Jurisdiction and Other Issues

Between 1992 and 1996, the George H. W. Bush and Clinton Administrations transferred responsibility for decisions regarding export of commercial satellites from the State Department to the Commerce Department. A January 1997 GAO report (GAO/NSIAD-97-24) examines that decision. In response to concerns about the launch of satellites by China (discussed above), Congress directed in the FY1999 DOD authorization bill (P.L. 105-261) that export control responsibility be returned to the State Department effective March 15, 1999. Which agency should control these exports remains controversial.

The 108th Congress debated, but did not clear, legislation on this topic. The House International Relations Committee (HIRC) reported H.R. 1950 (H.Rept. 108-105, Pt. 1), the FY2004 State Department Authorization Act, with language that would have left the decision on agency jurisdiction to the President if the export was to a NATO country or major non-NATO ally. Exports to China would have remained under State Department jurisdiction. The House Armed Services Committee rejected the HIRC language in its markup of the bill (H.Rept. 108-105, Pt. 3), however, and the House-passed version did not include that language. There was no further legislative action on that bill.

Some of the controversy reflects concerns of the aerospace and space insurance industries that the regulations are being implemented too broadly and vigorously. DOD officials and others have cited potential harm to the U.S. defense industrial base if U.S. exports are stifled, too. One concern is the length of time needed to obtain State Department approval. Section 309 of the FY2000 State Department authorization act (incorporated into the FY2000 Consolidated Appropriations Act, P.L. 106-113) directed the Secretary of State to establish an export regime with expedited approval for exports to NATO allies and major non-NATO allies. The rules took effect July 1, 2000. In May 2000, the State Department reportedly notified France that it would not apply strict technology export control on

satellites to be launched by Ariane (*Space News*, May 29, 2000, p. 1). The Security Assistance Act (P.L. 106-280) reduced from 30 days to15 days the time Congress has to review decisions on exporting commercial communications satellites to Russia, Ukraine, and Kazakhstan, making the time period the same as for NATO allies.

The Satellite Industry Association (SIA) released figures in May 2001 showing U.S. satellite manufacturers losing market share to foreign companies. SIA and others attributed that loss in part to the shift in jurisdiction to State, which they assert creates uncertainty for satellite customers over when and whether export licenses will be approved. The trade publication *Space News* reports on the number of new commercial satellite orders awarded world-wide each year. According to that source, U.S. companies won 19 of the 22 contracts in 2001; three of the four in 2002; nine of the 16 in 2003; and nine of the 12 in 2004.

LEGISLATION

P.L. 109-108, H.R. 2862. FY2006 Science, State, Justice, Commerce appropriations bill (includes NASA). Reported from House Appropriations Committee June 10, 2005 (H.Rept. 109-118); passed House June 16. Reported from Senate Appropriations Committee June 23 (S.Rept. 109-88); passed Senate September 15. Conference report (H.Rept. 109-272) passed House November 9, Senate November 16. Signed into law November 22, 2005.

P.L. 109-148, H.R. 2863. FY2006 DOD appropriations bill. Reported from House Appropriations Committee June 10, 2005 (H.Rept. 109-119); passed House June 20. Reported from Senate Appropriations Committee September 29 (S.Rept. 109-141); passed Senate October 7. Conference report (H.Rept. 109-359) passed House December 19, Senate December 21 (amended). Signed into law December 30, 2005.

P.L. 109-155, S. 1281. FY2007-2008 NASA authorization bill. H.R. 3070 would have authorized NASA funding for FY2006-2007; reported by the House Science Committee July 18 (H.Rept. 109-173), passed House July 22, 2005. S. 1281, as originally passed, authorized NASA funding for FY2006-2010; reported by Senate Commerce Committee July 26 (S.Rept. 109-108), passed Senate September 28, 2005. Conference report (H.Rept. 109-354), which authorizes funding for FY2007-2008, passed House December 17, Senate December 21, 2005. Signed into law December 30, 2005.

P.L. 109-163, H.R. 1815. FY2006 DOD authorization bill. Reported from House Armed Services Committee May 20, 2005, H.Rept. 109-89; passed House May 25. S. 1042 reported from Senate Armed Services Committee May 17 (S.Rept. 109-69); passed Senate November 15. Conference report (H.Rept. 109-360) passed House December 19, Senate December 21. Signed into law January 6, 2006.