FAA
Commercial Space
Transportation

Quarterly Launch Report
2nd Quarter 2008

Featuring Launch Results from the 1st Quarter and
Forecasts for the 2nd and 3rd Quarter 2008

Special Report: Human Factors Considerations for Commercial Human Spaceflight

Introduction

The *Second Quarter 2008 Quarterly Launch Report* features launch results from the first quarter of 2008 (January - March 2008) and forecasts for the second quarter of 2008 (April - June 2008) and the third quarter of 2008 (July - September 2008). This report contains information on worldwide commercial, civil, and military orbital and commercial suborbital space launch events. Projected launches have been identified from open sources, including industry contacts, company manifests, periodicals, and government sources. Projected launches are subject to change.

This report highlights commercial launch activities, classifying commercial launches as one or both of the following:

- Internationally-competed launch events (i.e., launch opportunities considered available in principle to competitors in the international launch services market);

- Any launches licensed by the Office of Commercial Space Transportation of the Federal Aviation Administration under 49 United States Code Subtitle IX, Chapter 701 (formerly the Commercial Space Launch Act).

Contents

Cover photo courtesy of Sea Launch, Copyright © 2008. A Sea Launch Zenit 3SL lifts off from the Odyssey Launch Platform in the Pacific Ocean on January 15, 2008. The launch carried Thuraya 3, a communications satellite operated by the Thuraya Satellite Communications Company, into geosynchronous (GEO) orbit.

First Quarter 2008 Highlights

Sea Launch Returns to Flight

On January 15, the Zenit 3SL vehicle returned to flight, lifting the Thuraya 3 satellite into geosynchronous (GEO) orbit. The mission was the first for Sea Launch since its failed launch of the NSS 8 satellite in late January 2007.

Scaled Composites Fined

In January, California regulators fined Scaled Composites $25,780 for the July 2007 explosion that killed three employees working on the propulsion system of the SpaceShipTwo suborbital vehicle. The California Division of Occupational Safety and Health (Cal/OSHA) levied the fines for workplace safety code violations, including lack of training in hazardous materials, such as the nitrous oxide that caused the explosion. Scaled Composites officials reported full cooperation with Cal/OSHA during the investigation and noted the company had already implemented new procedures.

Virgin Galactic and Scaled Composites Unveil SpaceShipTwo Design

On January 23, space tourism operator Virgin Galactic and vehicle developer Scaled Composites unveiled a new design for the SpaceShipTwo (SS2) suborbital spacecraft and its carrier aircraft, White Knight Two (WK2). The new design varied somewhat from the SpaceShipOne (SS1) vehicle that captured the Ansari X Prize in 2004: SS2 will feature a wing mounted on the bottom of the fuselage, rather than the top, and an elongated nose. Additionally, the WK2 carrier vehicle will feature four jet engines, rather than the two used by the original White Knight. Initial flights of the WK2 are expected to begin in the summer of 2008.

Iran Launches Suborbital Rocket

On February 4, Iran launched a suborbital rocket to inaugurate a new space center located southeast of the capital, Tehran. While the Kavoshgar-1 (Researcher-1) rocket did not reach orbit, Iran announced plans to launch its own satellite, Omid, into orbit in the "near future."

Bigelow Aerospace in Launch Service Discussions with Lockheed Martin

On February 5, Bigelow Aerospace, a company developing inflatable orbital habitats, announced it was "converging on terms" of a deal with Lockheed Martin Commercial Launch Services to purchase an unspecified number of Atlas V launches to carry crew and cargo to its planned inflatable modules. Bigelow expects it may require up to 12 launches per year when it begins operations of its full-scale facility in 2012. The spacecraft that would be used to carry the cargo and crew would be developed separately; no details about that vehicle have been announced.

Shuttle Atlantis Delivers European Laboratory Module to ISS

On February 7, Shuttle Atlantis lifted off on an 11-day mission to deliver the European laboratory module Columbus to the International Space Station (ISS). On February 12, two astronauts performed an eight-hour spacewalk to attach the Columbus lab—Europe's major contribution to the ISS—to the station. Two European astronauts were among the Shuttle's seven-person crew, and one remained aboard the station following the mission.

First Quarter 2008 Highlights

NASA Awards Orbital Sciences Corporation COTS Agreement

On February 19, the National Aeronautics and Space Administration (NASA) awarded Orbital Sciences Corporation a $170-million Space Act agreement to develop a commercial cargo system to service the ISS following the retirement of the Space Shuttle. The agreement, awarded under NASA's Commercial Orbital Transportation Services (COTS) program, is for Orbital to develop a new medium-class launch vehicle, the Taurus 2, and a maneuvering spacecraft, Cygnus, that would ferry pressurized and unpressurized cargo to the ISS. Orbital Sciences plans to perform a demonstration flight in 2010, with commercial cargo services beginning in 2011. In addition, the company is considering staging some or all of its ISS launches from the Mid-Atlantic Regional Spaceport (MARS) in Virginia, rather than Cape Canaveral, Florida.

U.S. Military Destroys Ailing U.S. Spy Satellite

On February 20, a missile launched from a U.S. Navy cruiser in the Pacific Ocean destroyed an ailing satellite operated by the U.S. National Reconnaissance Office (NRO). The satellite, USA 193, had lost all power as of January 26, and was in a decaying orbit. Citing concern that hazardous hydrazine fuel aboard the bus-sized satellite might reach the ground intact, the Department of Defense announced plans to destroy the satellite six days in advance of the operation. At 10:26 PM Eastern Standard Time, the USS Lake Erie launched a single modified SM-3 missile, which scored a direct hit wth the satellite at an altitude of 247 kilometers, disintegrating the spacecraft.

Europe Launches First ATV to ISS

On March 8, the European Space Agency (ESA) successfully launched its first Automated Transfer Vehicle (ATV) in low Earth orbit (LEO). The ATV, known as "Jules Verne," is the largest and most advanced spacecraft ever built in Europe. It is capable of transporting several tons of cargo, including food, water, propellant, and other items, to the ISS. To avoid schedule conflicts with the STS-123 Shuttle mission launched on March 11, the ATV remained in orbit, conducting tests, before successfully docking with the ISS on April 3.

Proton Launch Fails

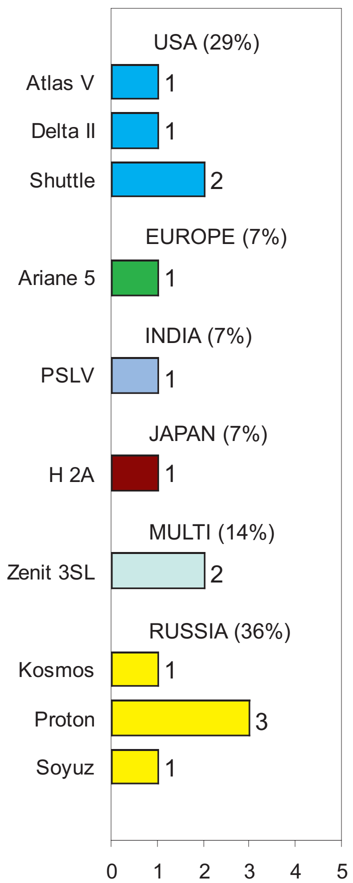
On March 15, a Proton M launch of the AMC 14 commercial communications satellite failed when the rocket's upper stage shut down prematurely, stranding the satellite in a 28,000-kilometer (17,400-mile) transfer orbit well short of GEO. The shutdown was linked to an anomaly with the Breeze M upper stage, which failed during its second burn. On April 11, satellite operator SES Americom announced that it had abandoned efforts to salvage AMC 14 from the useless orbit, declaring the spacecraft a total loss.

XCOR Aerospace Announces Suborbital Rocketplane

On March 26, XCOR Aerospace announced plans to develop the Lynx suborbital rocketplane by 2010. The Lynx vehicle would take off from a runway and use rockets to ascend to an altitude of 60 kilometers before gliding back to a runway landing. Its primary focus would be the suborbital space tourism market. The vehicle is estimated to cost $10 million to develop, with ticket prices projected to be about $100,000 per passenger.

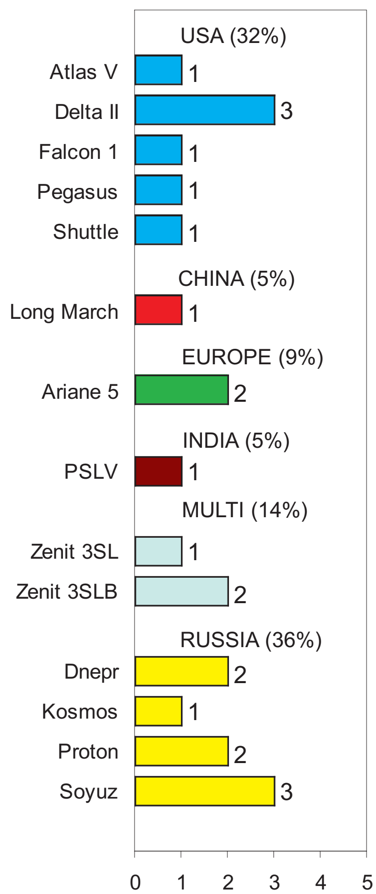
Vehicle Use
(January 2008 – September 2008)

Figure 1: First Quarter 2008 Total Launch Vehicle Use



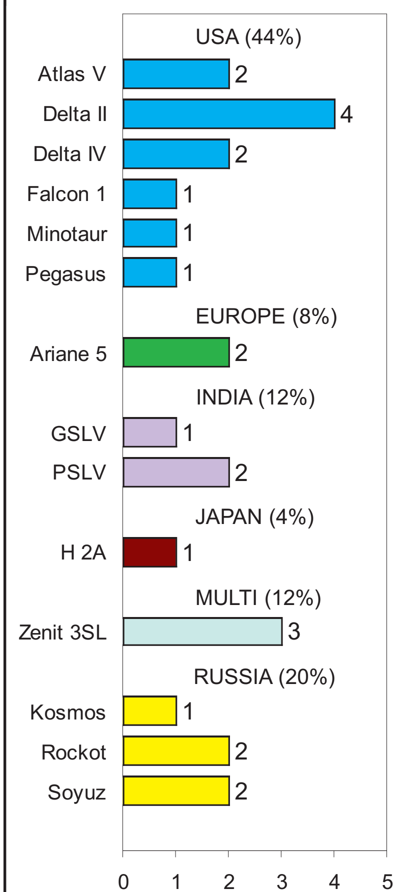
Total = 14

Figure 2: Second Quarter 2008 Total Projected Launch Vehicle Use



Total = 22

Figure 3: Third Quarter 2008 Total Projected Launch Vehicle Use



Total = 25

Figures 1-3 show the total number of orbital and commercial suborbital launches of each launch vehicle and the resulting market share that occurred in the first quarter of 2008. They also project this information for the second quarter of 2008 and third quarter of 2008. The launches are grouped by the country in which the primary vehicle manufacturer is based. Exceptions to this grouping are launches performed by Sea Launch, which are designated as multinational.

Note: Percentages for these and subsequent figures may not add up to 100 percent due to rounding of individual values.

Commercial Launch Events by Country

(January 2008 – September 2008)

Figure 4: First Quarter 2008 Commercial Launch Events by Country

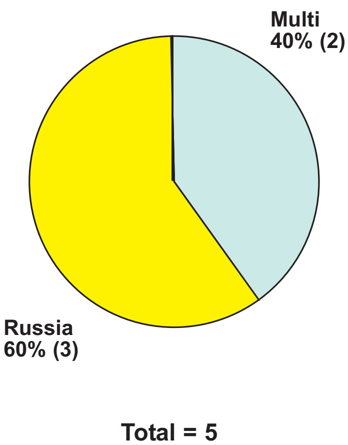


Figure 5: Second Quarter 2008 Projected Commercial Launch Events by Country

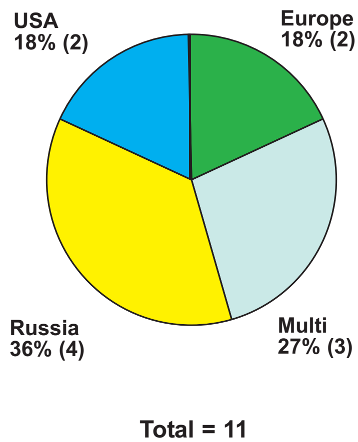
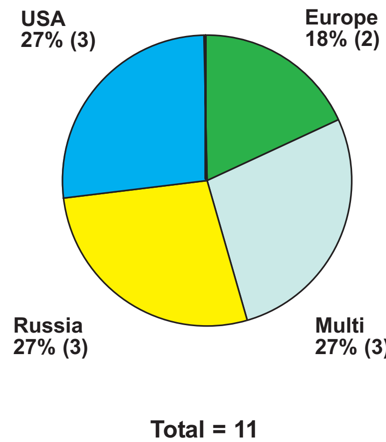


Figure 6: Third Quarter 2008 Projected Commercial Launch Events by Country



Figures 4-6 show all commercial orbital and suborbital launch events that occurred in the first quarter of 2008 and that are projected for the second quarter of 2008 and third quarter of 2008.

Commercial vs. Non-Commercial Launch Events

(January 2008 – September 2008)

Figure 7: First Quarter 2008 Commercial vs. Non-Commercial Launch Events

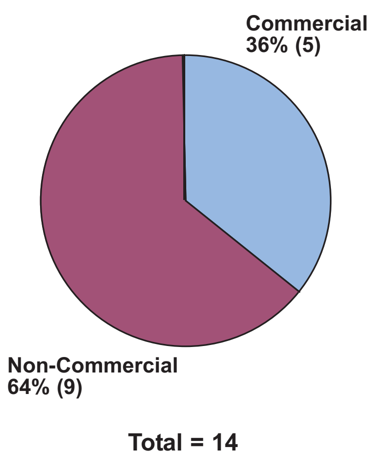


Figure 8: Second Quarter 2008 Projected Commercial vs. Non-Commercial Launch Events

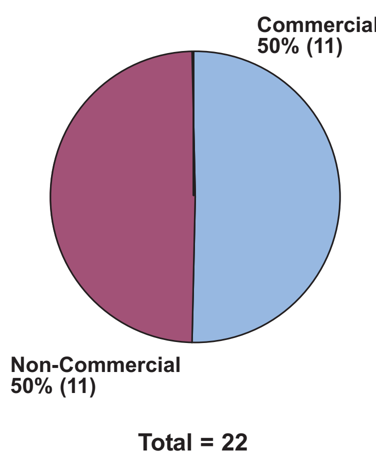
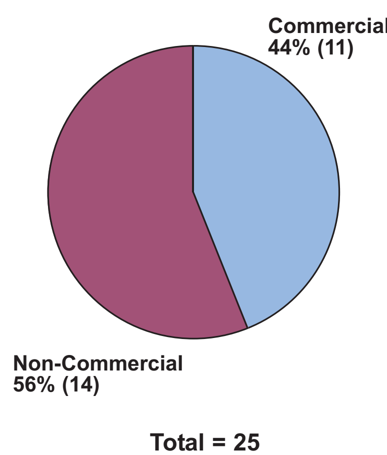


Figure 9: Third Quarter 2008 Projected Commercial vs. Non-Commercial Launch Events

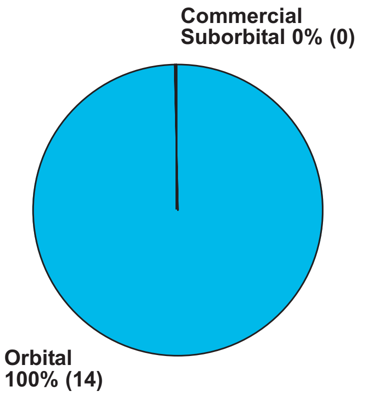


Figures 7-9 show commercial vs. non-commercial orbital and suborbital launch events that occurred in the first quarter of 2008 and that are projected for the second quarter of 2008 and third quarter of 2008.

Orbital vs. Commercial Suborbital Launch Events

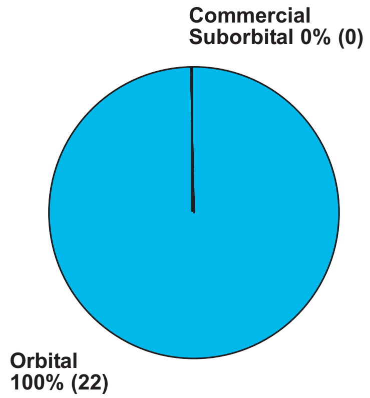
(January 2008 – September 2008)

Figure 10: First Quarter 2008 Commercial Suborbital vs. Orbital Launch Events



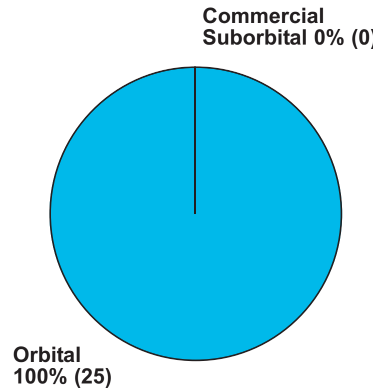
Total = 14

Figure 11: Second Quarter 2008 Projected Commercial Suborbital vs. Orbital Launch Events



Total = 22

Figure 12: Third Quarter 2008 Projected Commercial Suborbital vs. Orbital Launch Events



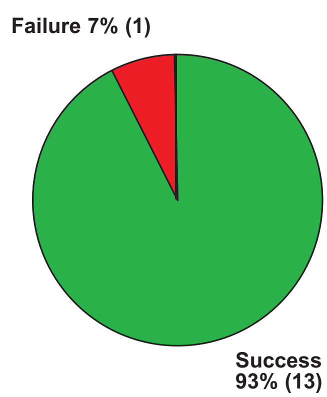
Total = 25

Figures 10-12 show orbital vs. FAA-licensed commercial suborbital launch events (or their international equivalents) that occurred in the first quarter of 2008 and that are projected for the second quarter of 2008 and third quarter of 2008.

Launch Successes vs. Failures

(January 2008 – March 2008)

Figure 13: First Quarter 2008 Launch Successes vs. Failures



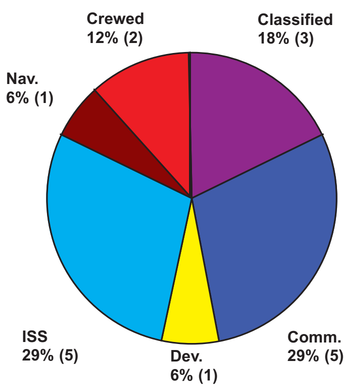
Total = 14

Figure 13 shows orbital and commercial suborbital launch successes vs. failures for the period from January 2008 to March 2008. Partially-successful orbital launch events are those where the launch vehicle fails to deploy its payload to the appropriate orbit, but the payload is able to reach a useable orbit via its own propulsion systems. Cases in which the payload does not reach a useable orbit or would use all of its fuel to do so are considered failures.

Payload Use (Orbital Launches Only)

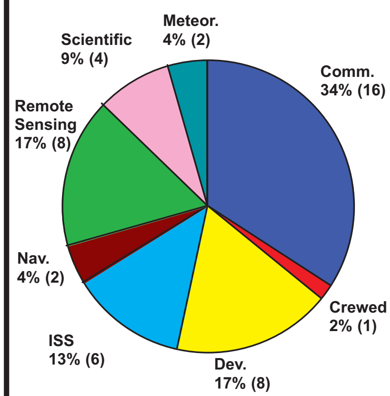
(January 2008 – September 2008)

Figure 14: First Quarter 2008 Payload Use



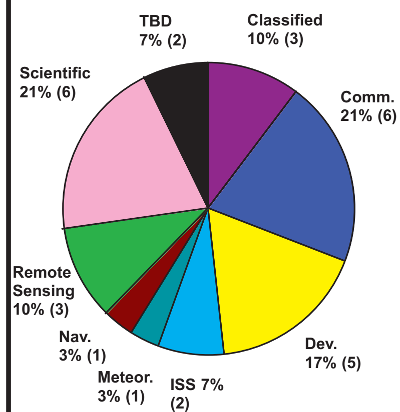
Total = 17

Figure 15: Second Quarter 2008 Projected Payload Use



Total = 47

Figure 16: Third Quarter 2008 Projected Payload Use



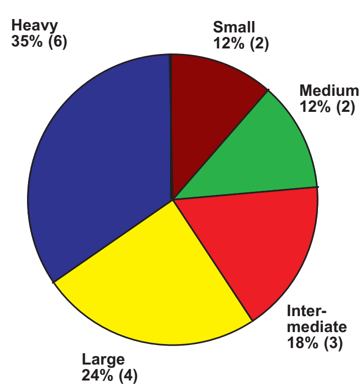
Total = 29

Figures 14-16 show total payload use (commercial and government), actual for the first quarter of 2008 and projected for the second quarter of 2008 and third quarter of 2008. The total number of payloads launched may not equal the total number of launches due to multiple manifesting, i.e., the launching of more than one payload by a single launch vehicle.

Payload Mass Class (Orbital Launches Only)

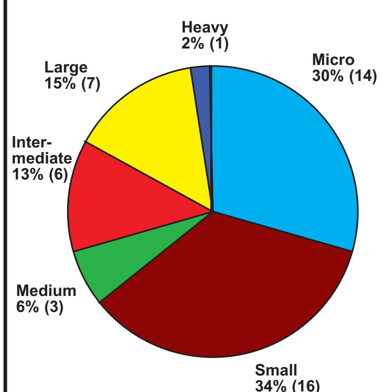
(January 2008 – September 2008)

Figure 17: First Quarter 2008 Payload Mass Class



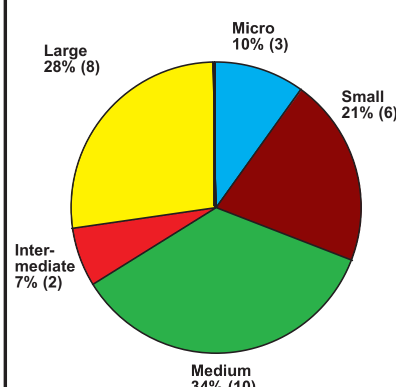
Total = 17

Figure 18: Second Quarter 2008 Projected Payload Mass Class



Total = 47

Figure 19: Third Quarter 2008 Projected Payload Mass Class



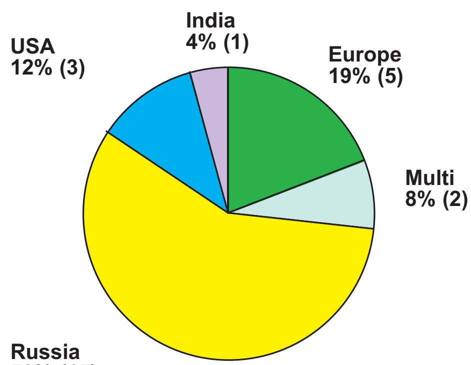
Total = 29

Figures 17-19 show total payloads by mass class (commercial and government), actual for the first quarter of 2008 and projected for the second quarter of 2008 and third quarter of 2008. The total number of payloads launched may not equal the total number of launches due to multiple manifesting, i.e., the launching of more than one payload by a single launch vehicle. Payload mass classes are defined as Micro: 0 to 91 kilograms (0 to 200 lbs.); Small: 92 to 907 kilograms (201 to 2,000 lbs.); Medium: 908 to 2,268 kilograms (2,001 to 5,000 lbs.); Intermediate: 2,269 to 4,536 kilograms (5,001 to 10,000 lbs.); Large: 4,537 to 9,072 kilograms (10,001 to 20,000 lbs.); and Heavy: over 9,072 kilograms (20,000 lbs.).

Commercial Launch Trends (Orbital Launches Only)

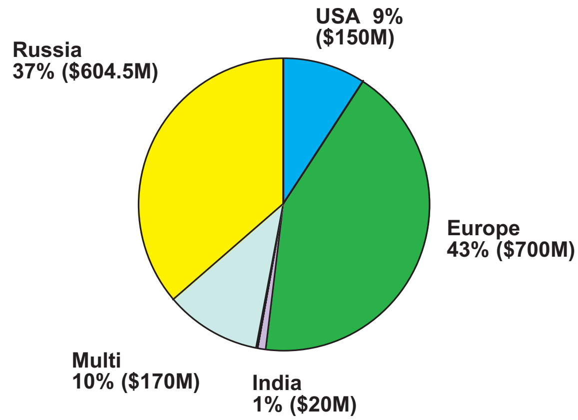
(April 2007 – March 2008)

Figure 20: Commercial Launch Events, Last 12 Months



Total = 26

Figure 21: Estimated Commercial Launch Revenue, Last 12 Months



Total = $1644.5M

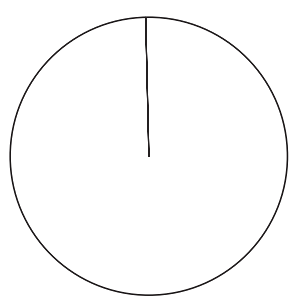
Figure 20 shows commercial orbital launch events for the period of April 2007 to March 2008 by country.

Figure 21 shows estimated commercial launch revenue for orbital launches for the period of April 2007 to March 2008 by country.

Commercial Launch Trends (Suborbital Launches and Experimental Permits)

(April 2007 – March 2008)

Figure 22: FAA-Licensed Commercial Suborbital Launch Events (or Their International Equivalents), Last 12 Months



Total = 0

Figure 23: FAA Experimental Permit Flights, Last 12 Months

Flight Date	Operator	Vehicle	Launch Site
4/19/2007	Blue Origin	Goddard	West Texas Launch Site, TX
6/2/2007	Armadillo Aerospace	Pixel	Oklahoma Spaceport, OK
6/2/2007	Armadillo Aerospace	Pixel	Oklahoma Spaceport, OK
10/20/2007	Armadillo Aerospace	MOD 1	Oklahoma Spaceport, OK
10/27/2007	Armadillo Aerospace	MOD 1	Holloman AFB, NM
10/27/2007	Armadillo Aerospace	MOD 1	Holloman AFB, NM
10/28/2007	Armadillo Aerospace	MOD 1	Holloman AFB, NM
10/28/2007	Armadillo Aerospace	MOD 1	Holloman AFB, NM

Figure 22 shows FAA-licensed commercial suborbital launch events (or their international equivalents) for the period of April 2007 to March 2008 by country.

Figure 23 shows suborbital flights conducted under FAA experimental permits for the period of April 2007 to March 2008.

Commercial Launch History

(January 2003 – December 2007)

Figure 24: Commercial Launch Events by Country, Last Five Years

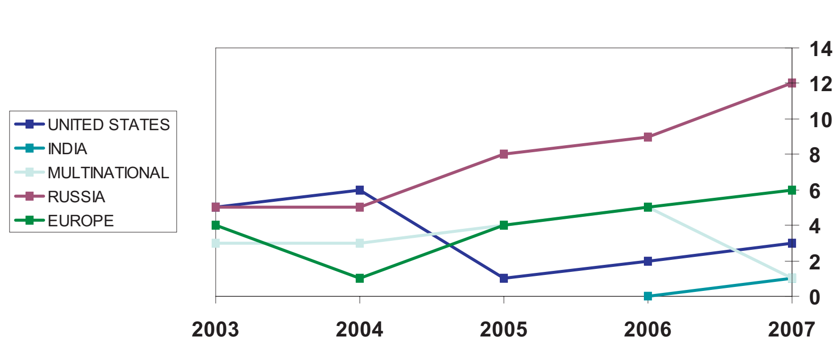


Figure 24 shows commercial launch events by country for the last five full calendar years.

Figure 25: Estimated Commercial Launch Revenue (in $ millions) by Country, Last Five Years

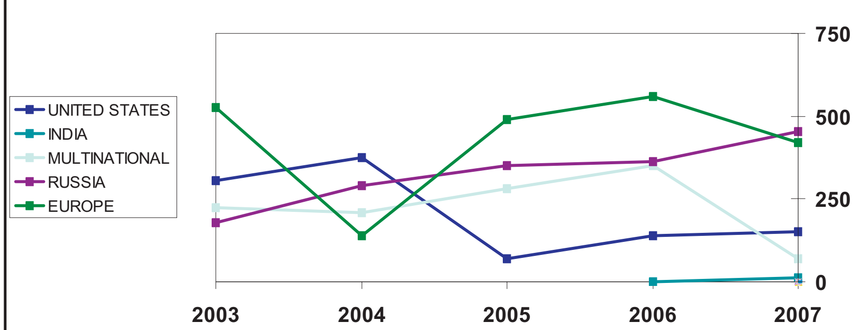


Figure 25 shows estimated commercial launch revenue by country for the last five full calendar years.

Human Factors Considerations for Commercial Human Spaceflight

Introduction

The purpose of this special report is to promote a discussion of the human factors challenges and solutions associated with commercial human spaceflight. Human factors can be defined as a discipline of study that deals with the human-machine interface. Overcoming human factors challenges requires a multidisciplinary approach that draws upon psychology, physiology, engineering, ergonomics, and medicine.

In aviation, human-related factors account for the majority of fatal aircraft accidents. The spacecraft launch and re-entry environment places even greater stress on man and machine requiring designers to spend more time considering human factors. The Federal Aviation Administration Office of Commercial Space Transportation (FAA/AST) promotes strong human factors planning because the design and layout of displays and controls and the amount of crew workload can affect the ability of the crew to perform safety-critical roles.

U.S. government federal regulations governing commercial human spaceflight requirements state:[1]

An operator must take the precautions necessary to account for human factors that can affect a crew's ability to perform safety-critical roles, including in the following safety critical areas—

(a) Design and layout of displays and controls;
(b) Mission planning, which includes analyzing tasks and allocating functions between humans and equipment;
(c) Restraint or stowage of all individuals and objects in a vehicle; and
(d) Vehicle operation, so that the vehicle will be operated in a manner that flight crew can withstand any physical stress factors, such as acceleration, vibration, and noise.

SpaceFlight Environment

To understand why human factors engineers make recommendations to place a switch in a certain position or specific design and to understand how to improve human factors designs, it is necessary to understand the unique spaceflight environment. Spaceflight vehicles and crews will be exposed to a number of unique challenges during a spaceflight. Spaceflight planners can develop ways of coping with these stresses through spacecraft design, simulation, and training. The human factors challenges associated with the spaceflight environment have also produced some interesting stories during the history of spaceflight.

Pressure and Gas Composition

As a spacecraft ascends through the atmosphere, the natural atmospheric conditions outside the vehicle cannot sustain human respiration, requiring spacecraft designers to provide flight crew with an artificial atmosphere. In addition, designers may choose to regulate a spacecraft's artificial pressure environment at non sea-level pressures or gas compositions. Emergency depressurization or harmful gas buildup can occur and are also a concern. Such a non-standard environment can have a number of negative effects on the body including hypoxia, hyperventilation, and evolved gas disorders.

Spacecraft design and crew training can be used to prepare and protect spacecraft crews from potentially deadly changes in pressure and gas composition. Such features include redundant pressure vessels and environmental sensors. Classroom training and simulation of normal and emergency cabin pressures and gas composition will help improve flight safety. Simulation tools such as hypobaric chambers can allow crews to experience the effects of non-standard pressures.

The Apollo-Soyuz Test Project in 1975 was the first human spaceflight mission managed jointly by two nations. The goal of the mission was to test compatibility of rendezvous and docking systems for American and Soviet spacecraft that would be used in future joint human flights. One of the challenges encountered by the program was mating the Apollo spacecraft containing a pure oxygen environment with the higher pressure oxygen-nitrogen atmosphere of the Soyuz.[2] A docking module had to be developed to operate as an airlock to equalize the atmospheric conditions between the two spacecraft.

Acceleration Forces

Current conventional space vehicle designs expose their crews to a variety of acceleration forces. For example, the ignition of a rocket motor creates a reactive force that may make it difficult for flight crews to interact physically with the flight controls. These forces may also create vibrations that make it difficult to read information displays. Once in a microgravity environment, maneuvering thrusters will cause the spacecraft structure to move and free-floating crew or objects could strike critical systems and crew members. Strong acceleration forces will cause blood to shift in the body leading to red-out, black-out, and even unconsciousness depending on the direction from which acceleration forces strike the crew member. Other acceleration related physiological affects include nausea, dizziness, and cardiac abnormalities.

Designers have a variety of options for dealing with the human factors challenges associated with acceleration forces. Crew member orientation during high acceleration environments, restraint systems, and automated or simplified control systems represent a few of the design options. Testing the spacecraft with simulated acceleration forces can reveal necessary design improvements. Crew members can use centrifuges or other simulation devices, such as aerobatic aircraft, to prepare for the physiological challenges of operating a spacecraft within the acceleration environment encountered during spaceflight.

On April 19, 2008, a Soyuz vehicle carrying three astronauts incorrectly re-entered the atmosphere resulting in a ballistic re-entry profile that subjected the crew to acceleration forces as high as 10-Gs.[3] The crew of the Soyuz landed 475 kilometers off target but survived. An official investigation of the accident has not yet concluded as of the writing of this report. However, automated spacecraft systems, robust spacecraft design, and preflight crew training have helped save flight crews in similar past incidents.

Microgravity

Flight crews will be exposed to microgravity during spaceflight. The physiological affects of microgravity including dizziness, nausea, and fluid shift. These effects can make it very difficult for flight crews to operate a spacecraft.

One of the simplest methods for mitigating the human factors challenges of microgravity is to simplify or automate spacecraft systems during times when the crew must adapt to microgravity. Parabolic aircraft flight profiles may help flight crew to understand the challenges of operating spacecraft while adapting to microgravity. However, the short-duration, simulated microgravity is not a perfect analog for actual sustained microgravity adaptation.

U.S. Senator John Glenn, the first American to orbit the Earth in 1962, became the oldest human at 77 years old to fly into space in 1998 onboard STS-95. One of the goals of Senator Glenn's mission was to carry out studies on the commonalities between the effects of spaceflight and aging. The results of the experiments carried out on Senator Glenn during the mission were compared with those from the other astronauts on STS-95 as well as on other space flights. In addition, studies conducted before flight and after flight were compared with findings from studies completed during the flight.[4] At the conclusion of the mission it was determined that Glenn experienced the same level of bone loss and muscle atrophy as the other six crew members of the STS-95. In addition, Glenn recovered proper muscle tone and balance about as well as his colleagues as they readapted to the Earth's gravity.[5]

Thermal

During a spaceflight, the spacecraft will be exposed to extreme heat and extreme cold. The vacuum of space causes spacecraft to lose heat. Alternatively, spacecraft exposed to sunlight can be warmed to very high temperatures. Therefore, spacecraft must be designed to insulate the flight crew from extreme temperature differentials.

Spacecraft cabins and pressure suits can be designed to regulate astronaut body temperatures in normal and emergency conditions. During training it may be possible to regulate the temperature of the training devices to simulate emergency situations with extreme temperatures.

Cosmonaut Alexei Leonov made the first spacewalk in history in March 1965. Following the 10 minute spacewalk, Leonov realized that his pressure suit had become deformed by the lack of atmospheric pressure. His suit had deformed in a way that made it impossible to reenter the airlock the way he had been trained. A quick solution was necessary because the spacecraft was headed quickly towards the night side of Earth where temperatures would plummet. Leonov also only had a limited supply of oxygen. After struggling for a time, Leonov eventually had to let the pressurized oxygen escape from the suit in order to help him squeeze head first into the spacecraft hatch. Although he risked oxygen starvation, the plan worked and Leonov made it into the spacecraft. However, his struggle caused his body to build up a great amount of heat and consequently sweat. Problems with Leonov's space capsule caused the cosmonaut to land off course. Russian ground crews could not get to the capsule for a day, leaving the cosmonaut stranded overnight. During the night temperatures dropped to -30 degrees Celsius. The combination of conditions (cold temperatures and a spacesuit so full of sweat that it sloshed) created a life threatening situation for the first human spacewalker.[6]

Noise

Conventional spacecraft are noisy. Rocket motor noise, orbital thrusters, and airflow noise can combine to make it difficult for crew members to hear one another or to hear spacecraft warning tones. A loud noise environment may cause headaches, fatigue, insomnia, and hearing loss.

Mitigating the affects of noise through design can be achieved via insulation, vibration testing, and engine-cabin positioning. Flight tests can help accurately characterize the noise environment. Flight crews can use flight training devices that recreate cabin noise.

The acoustic environment on board the International Space Station (ISS) has become one of the greatest crew habitability concerns. The ISS is filled with electronic gear and life support systems that produce a lot of noise. As a result, NASA has implemented the International Space Station Acoustic Measurement Program.[7] The program uses a large number of microphones positioned throughout the ISS, and attached to the astronauts to measure noise levels and analyze mitigation techniques.

Radiation

The atmosphere and magnetosphere protect Earth from most solar radiation and much of the galactic radiation. Operating above the atmosphere exposes machine and crew to more radiation. Operating beyond the magnetosphere dramatically increases radiation exposure. Exposure to radiation during spaceflight can cause unpredictable errors in electronic components. Random electronics failures in systems that interface with and support the flight crew can reduce mission safety.

Spacecraft designers can use radiation-hardened electronics or types of shielding to minimize the effects of radiation. Flight crews and mission operations teams can monitor the radiation environment and take measures to alter mission operations to avoid unusually high radiation environments.

Spacecraft mission planners need to be aware of the "South Atlantic Anomaly." The anomaly consists of a region of abnormally dense radiation that begins 500 Kilometers above the Atlantic Ocean off the coast of Brazil. The anomaly contain radiation in quantities so high that instruments on satellites must be shut off (or at least placed in a "safe" mode) to protect them from the radiation.[8] The South Atlantic Anomaly forms because the Earth's magnetic field is not completely symmetric and the area within the anomaly has a weak magnetic force. The weak field allows radiation particles to build up at a lower altitude than anywhere else in Earth's magnetosphere. Commercial human spaceflights that transit the anomaly risk an increased failure rate of electronics and physiological exposure to higher levels of radiation.

Crew and Duty Rest

The FAA commissioned a study in 2007 to review aviation crew rest and duty restrictions. According to the report, the goal of the effort was to improve commercial space transportation safety by ensuring that ground support personnel and flight crewmembers obtain sufficient rest to safely perform routine and emergency duties. The study made recommendations to adjust the established rest and duty time restrictions for personnel involved with operating launch vehicles. The recommendations were divided by spaceflight type (suborbital versus orbital) and by type of crew (flight versus ground).[9]

Standards and Innovation

A great deal of data has been collected since the first astronauts entered orbit. As a result, designers and flight crews have a solid foundation of knowledge to build upon. This foundation of knowledge is encapsulated in design standards that serve as a starting point for developing human machine interfaces. Some of the most relevant standards for human spaceflight include:

1. The Human Factors Design Standard (HF-STD-001, FAA)
2. DOD Design Criteria Standard--Human Engineering (MIL-STD-1472)
3. Flying Qualities of Piloted Aircraft (MIL-HDBK-1797)
4. Man-Systems Integration Standards (NASA-STD-3000)
5. Handbook of Human Factors and Ergonomics (Third Edition) (Wyle Laboratories, Inc., 2006)

Building upon these standards, engineers may create innovative methods for improving human factors. For example, NASA is currently working on an advanced caution and warning system for the Orion Crew Exploration Vehicle (CEV). The CEV will be subject to higher g-forces and interior vibration levels than the Space Shuttles. According to NASA this will necessitate a "seated" operations mode in which most crew-vehicle interactions occur via one or more handheld devices. Unlike most aircraft and spacecraft cockpits today, which use manual interfaces such as switches, these handheld devices represent a form of remote control that will handle most input into the spacecraft system.[10] This handheld interface, used in conjunction with fault isolation and recovery systems, can dramatically improve flight crew response to emergency events.

FAA Medical Monitoring

Every human's unique physiology makes it difficult to design interfaces optimal for every flight crew member. Some of these unique physiological characteristics are obvious, such as the fact that people come in all sizes and shapes. Other characteristics are less obvious such as a person's ability to handle high g-forces or adapt to microgravity.

The FAA funded a multi-year study to identify specific biomedical data, equipment, and a database that can be used to increase the knowledge and understanding of how short-duration suborbital spaceflight missions affect the human body. Although the purpose of this data will be primarily to define potential medical risk factors for spaceflight participants (passengers), the data could also help identify and ultimately mitigate physiological human factors challenges.[11] The results of this study are available to the public at the location cited in the reference.

Crew Training Survey

In 2008 the FAA funded a survey to identify human spaceflight crew training providers.[12] The survey identified commercial and non-commercial aviation and space flight instruction providers, resulting in profiles of these providers in the following disciplines:

- Physiological Training
- High Performance Jet
- High Performance Gliders
- Altitude Chamber
- Parachute Training
- Unusual Attitude Training
- High Altitude Flight
- High-G (gravity)
- Pressure Suit Training
- Flight Simulation
- Spaceflight Operations
- Microgravity Low-G Training

Many of these training providers offer access to facilities and equipment that can be used to simulate and test human factors related spacecraft design characteristics.

Looking Ahead

Industry will face many challenges developing and safely operating commercial human spaceflight vehicles. Human factors design can be overlooked in the race to bring capabilities to market. Ignoring human factors standards or failing to develop and test new methodologies could lead to accidents. The FAA is promoting an industry-wide discussion of human factors by sponsoring research and supporting government/industry discussion through the Commercial Space Transportation Advisory Committee (COMSTAC). A multidisciplinary discussion of human factors challenges and solutions will help the government and industry create a bright future for commercial human spaceflight.

Endnotes

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[12] FAA Report “Commercial Human Spaceflight Crew Training Survey.” United States Federal Aviation Administration Office of Commercial Space Transportation. February 2008. http://www.faa.gov/about/office_org/headquarters_offices/ast/media/Crew_Training_Survey_Feb_2008.pdf. Accessed 8 April 2008.

First Quarter 2008 Orbital and Suborbital Launch Events

Date			Vehicle	Site		Payload or Mission	Operator	Use	Vehicle Price	L	M
1/15/2008	√	+	Zenit 3SL	Odyssey Launch Platform, Pacific Ocean	*	Thuraya 3	Thuraya Satellite Communications Company	Communications	$85M	S	S
1/21/2008			PSLV	Satish Dhawan Space Center		TECSAR	Israeli Ministry of Defense (MoD)	Classified	$20M	S	S
1/28/2008			Proton M	Baikonur	*	Express AM33	Russian Satellite Communications Company (RSCC)	Communications	$75M	S	S
2/5/2008			Soyuz	Baikonur		Progress ISS 28P	Russian Federal Space Agency (Roscosmos)	ISS	$40M	S	S
2/7/2008			Shuttle Atlantis	Kennedy Space Center (KSC)		STS 122	National Aeronautics and Space Administration (NASA)	Crewed	N/A	S	S
						Columbus Laboratory	European Space Agency (ESA)	ISS			S
						ISS 1E	NASA	ISS			S
2/11/2008	√		Proton M	Baikonur	*	Thor 5	Telenor AS	Communications	$70M	S	S
2/23/2008			H 2A 2024	Tanegashima		WINDS	Japan Aerospace Exploration Agency (JAXA)	Development	$85M	S	S
3/9/2008			Ariane 5 ES-ATV	Kourou		ATV 1	ESA	ISS	$100M	S	S
3/11/2008			Shuttle Endeavour	KSC		STS 123	NASA	Crewed	N/A	S	S
						ISS 1J/A	JAXA	ISS			S
3/13/2008			Atlas V 411	Vandenberg Air Force Base (VAFB)		NRO L-28	U.S. National Reconnaissance Office (NRO)	Classified	$75M	S	S
3/14/2008	√		Proton M	Baikonur	*	AMC 14	SES Americom	Communications	$70M	F	F
3/15/2008			Delta II 7925-10	Cape Canaveral Air Force Station (CCAFS)		Navstar GPS 2RM-6	U.S. Air Force (USAF)	Navigation	$50M	S	S
3/19/2008	√	+	Zenit 3SL	Odyssey Launch Platform	*	DirecTV 11	DIRECTV	Communications	$85M	S	S
3/27/2008	√		Kosmos 3M	Plesetsk		SAR Lupe 4	German MoD	Classified	$12M	S	S

√ Denotes commercial launch, defined as a launch that is internationally competed or FAA-licensed. For multiple manifested launches, certain secondary payloads whose launches were commercially procured may also constitute a commercial launch. Appendix includes suborbital launches only when such launches are commercial.

+ Denotes FAA-licensed launch.

* Denotes a commercial payload, defined as a spacecraft that serves a commercial function or is operated by a commercial entity.

Notes: All prices are estimates, and vary for every commercial launch. Government mission prices may be higher than commercial prices. Ariane 5 payloads are usually multiple manifested, but the pairing of satellites scheduled for each launch is sometimes undisclosed for proprietary reasons until shortly before the launch date.

Second Quarter 2008 Projected Orbital and Suborbital Launch Events

Date			Vehicle	Site		Payload or Mission	Operator	Use	Vehicle Price
4/8/2008			Soyuz	Baikonur		Soyuz ISS 16S	Roscosmos	ISS	$40M
4/14/2008	√	+	Atlas V 421	CCAFS	*	ICO G1	ICO Global Communications	Communications	$70M
4/16/2008	√	+	Pegasus XL	Kwajalein Island		C/NOFS	USAF	Scientific	$16M
4/18/2008	√		Ariane 5 ECA	Kourou		Vinasat	Vietnamese MPT	Communications	$140M
					*	Star One C2	Star One	Communications	
4/24/2008	√		Zenit 3SLB	Baikonur	*	Amos 3	SpaceCom Limited	Communications	$50M
4/27/2008			Soyuz	Baikonur		GIOVE B	ESA	Navigation	$40M
4/28/2008			PSLV	Satish Dhawan Space Center		Cartosat 2A	Indian Space Resarch Organization (ISRO)	Remote Sensing	$20M
						AAUsat 2	Aalborg University	Development	
						CanX-2	University of Toronto	Development	
						Compass 1	Aachen University	Development	
						Cute 1.7 + APD 2	Tokyo Institute of Technology	Development	
						Delfi C3	Delft University	Development	
						SEEDS 2	Nihon University	Development	
						TWSAT	ISRO	Remote Sensing	
5/13/2008	√	+	Zenit 3SL	Odyssey Launch Platform	*	Galaxy 18	Intelsat	Communications	$85M
5/14/2008			Soyuz	Baikonur		Progress ISS 29P	Roscosmos	ISS	$40M
5/16/2008			Delta II 7920H	CCAFS		GLAST	NASA	Scientific	$50M
5/22/2008	√		Kosmos 3M	Kapustin Yar	*	Orbcomm CDS 3	ORBCOMM	Development	$12M
					*	Orbcomm Replacement 1	ORBCOMM	Communications	
					*	Orbcomm Replacement 2	ORBCOMM	Communications	
					*	Orbcomm Replacement 3	ORBCOMM	Communications	
					*	Orbcomm Replacement 4	ORBCOMM	Communications	
					*	Orbcomm Replacement 5	ORBCOMM	Communications	
						UGATUSAT	Ufa State Aviation Technical University	Scientific	
5/31/2008			Shuttle Discovery	KSC		STS 124	NASA	Crewed	N/A
						Cupola 1	NASA	ISS	
						JEM RMS	NASA	ISS	
						Port Rails 1	NASA	ISS	
						Solar Arrays SPP	NASA	ISS	
5/2008	√		Ariane 5 ECA	Kourou		Skynet 5C	Paradigm Secure Communications	Communications	$140M
					*	Turksat 3A	Turkish Telecom	Communications	
5/2008			Long March 4C	Taiyuan		Fengyun 3A	China Meteorological Administration	Meteorological	$50M

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Notes: All prices are estimates, and vary for every commercial launch. Government mission prices may be higher than commercial prices. Ariane 5 payloads are usually multiple manifested, but the pairing of satellites scheduled for each launch is sometimes undisclosed for proprietary reasons until shortly before the launch date.

Second Quarter 2008 Projected Launch Events (Continued)

Date		Vehicle	Site		Payload or Mission	Operator	Use	Vehicle Price
6/15/2008		Delta II 7320	VAFB		Jason 2	Eumetsat	Meteorological	$50M
6/30/2008		Delta II 7925	CCAFS		Navstar GPS 2RM-7	USAF	Navigation	$50M
6/2008		Falcon 1	Kwajalein Island	*	Jumpstart	U.S. Operationally Responsive Space (ORS) Office	Development	$7M
					D-sat	Astronautic Technology Malaysia	Scientific	
6/2008		Proton M	Baikonur	*	Express AM4	RSCC	Communications	$75M
				*	Express MD 2	RSCC	Communications	
2Q/2008	√	Zenit 3SLB	Baikonur	*	Telstar 11N	Loral Skynet	Communications	$50M
2Q/2008	√	Dnepr 1	Baikonur	*	RapidEye 1	RapidEye AG	Remote Sensing	$9.5M
				*	RapidEye 2	RapidEye AG	Remote Sensing	
				*	RapidEye 3	RapidEye AG	Remote Sensing	
				*	RapidEye 4	RapidEye AG	Remote Sensing	
				*	RapidEye 5	RapidEye AG	Remote Sensing	
2Q/2008	√	Proton M	Baikonur	*	Inmarsat-4 F3	Inmarsat	Communications	$70M
2Q/2008	√	Dnepr 1	Dombarovskiy		THEOS	Thai Geo-Informatics and Space Technology Development Agency (GISTDA)	Remote Sensing	$9.5M

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+ Denotes FAA-licensed launch.

* Denotes a commercial payload, defined as a spacecraft that serves a commercial function or is operated by a commercial entity.

Notes: All prices are estimates, and vary for every commercial launch. Government mission prices may be higher than commercial prices.
Ariane 5 payloads are usually multiple manifested, but the pairing of satellites scheduled for each launch is sometimes undisclosed for proprietary reasons until shortly before the launch date.

Third Quarter 2008 Projected Orbital and Suborbital Launch Events

Date			Vehicle	Site		Payload or Mission	Operator	Use	Vehicle Price
7/2/2008			Atlas V 401	VAFB		DMSP 5D-3-F18	U.S. Department of Defense (DoD)	Meteorological	$75M
7/15/2008			Pegasus XL	Kwajalein Island		Interstellar Boundary Explorer	NASA	Scientific	$16M
7/16/2008			Delta II 7920	CCAFS		STSS Demo 1 STSS Demo 2	USAF USAF	Development Development	$50M
7/25/2008			Delta IV Heavy	CCAFS		NRO L-26	NRO	Classified	$155M
7/30/2008	√		Kosmos 3M	Plesetsk		SAR Lupe 5	German MoD	Classified	$12M
7/2008	√	+	Zenit 3SL	Odyssey Launch Platform	*	XM 5	XM Radio	Communications	$85M
7/2008			PSLV	Satish Dhawan Space Center		Chandrayaan 1	ISRO	Scientific	$20M
7/2008	√	+	Delta II 7420-10	VAFB		Cosmo-Skymed 3	Agenzia Spaziale Italiana (ASI)	Remote Sensing	$50M
8/2/2008			Atlas 5 421	CCAFS		WGS 2	DoD	Communications	$75M
8/12/2008			Soyuz	Baikonur		Progress ISS 30P	Roscosmos	ISS	$40M
8/22/2008	√	+	Delta II 7420-10	VAFB	*	GeoEye 1	GeoEye	Remote Sensing	$50M
8/2008	√		Rockot	Plesetsk		GOCE	ESA	Scientific	$13.5M
9/11/2008			Soyuz	Baikonur		Progress ISS 31P	Roscosmos	ISS	$40M
9/11/2008			Delta II 7925	CCAFS		Navstar GPS 2RM-8	USAF	Navigation	$50M
9/14/2008			Minotaur	Wallops Flight Facility		TacSat 3 GeneSat 2 PharmaSat 1	USAF NASA NASA	Development Scientific Scientific	$14.5M
9/1/2008	√		Rockot	Plesetsk	*	Intersputnik 100M 1	RSCC	Communications	$13.5M
3Q/2008	√	+	Falcon 1	Kwajalein Island		RazakSAT	Malaysia National Space Agency	Development	$7M
3Q/2008			PSLV	Sriharikota		Oceansat 2	ISRO	Remote Sensing	$20M
3Q/2008			H 2A TBA	Tanegashima		GOSAT SDS-1	JAXA JAXA	Scientific Development	$85M
3Q/2008	√	+	Zenit 3SL	Odyssey Launch Platform	*	Galaxy 19	Intelsat	Communications	$85M
3Q/2008	√		Ariane 5 ECA	Kourou	*	TBD	To Be Determined (TBD)	Unknown	$140M
3Q/2008			GSLV Mark 2	Satish Dhawan Space Center		Gsat 4	ISRO	Communications	$40M
3Q/2008	√	+	Zenit 3SL	Odyssey Launch Platform	*	Echostar XI	Echostar	Communications	$85M
3Q/2008	√		Ariane 5 ECA	Kourou	*	TBD	TBD	Unknown	$140M

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