Federal Aviation Administration

Quarterly Launch Report
4th Quarter 2005

Featuring Launch results from the 3rd Quarter 2005 and Forecasts for the 4th Quarter 2005 and 1st Quarter 2006.

Quarterly Report Topic:
Risk Perception and Communication in Commercial Reusable Launch Vehicle Operations

HQ-029505.INDD

Introduction

The Fourth Quarter 2005 Quarterly Launch Report *features launch results from the third quarter of 2005 (July-September 2005) and forecasts for the fourth quarter of 2005 (October-December 2005) and the first quarter of 2006 (January-March 2006). 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 references, 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

Third Quarter 2005 Highlights 2
Vehicle Use 3
Commercial Launch Events by Country 4
Commercial vs. Non-commercial Launch Events 4
Orbital vs. Suborbital Launch Events 5
Launch Successes vs. Failures 5
Payload Use 6
Payload Mass Class 6
Commercial Launch Trends 7
Commercial Launch History 8
Special Report: *Risk Perception and Communication in Commercial Reusable Launch Vehicle Operations*, by Terry L. Hardy SR-1
Appendix A: Third Quarter 2005 Orbital and Suborbital Launch Events A-1
Appendix B: Fourth Quarter 2005 Projected Orbital and Suborbital Launch Events B-1
Appendix C: First Quarter 2006 Projected Orbital and Suborbital Launch Events C-1

Cover (photo courtesy of t/Space, copyright © 2005): A Proteus aircraft performs a drop test of a prototype of Transformational Space Corporation's Crew Transfer Vehicle (CXV), photographed here descending to Earth in half-second intervals. Transformational Space Corporation LLC (t/Space) is a private company formed in 2004 to respond to NASA's plans to implement the President's Vision for Space Exploration, which includes an emphasis on space commercialization.

Third Quarter 2005 Highlights

In July, Russia announced that the first six launches of its proposed Angara commercial booster will be conducted by the Russian Ministry of Defense. This will position the Russian military to underwrite the development costs of the new launch vehicle, whose production has been stalled for several years.

On July 26, Shuttle Discovery successfully lifted off from Kennedy Space Center carrying the crew of STS 114, signaling America's resumption of manned spaceflight more than two years after the loss of Shuttle Columbia. During the launch, the external fuel tank shed foam debris, and several small insulation tiles near the Shuttle's right landing gear door were dislodged, prompting safety concerns. However, after several extra-vehicular activities (EVAs), including spacewalks to inspect and perform minor repairs on the underside of the orbiter, STS 114 completed its nearly 14-day mission without incident, successfully touching down at Edwards Air Force Base in California early on the morning of August 9. Following the mission, NASA Administrator Mike Griffin said that the second Space Shuttle return-to-flight mission, STS 121, would not occur until the problem of foam debris shedding from the external tank was resolved. Pending investigation of the problem, the flight of STS 121 has been postponed until no earlier than May 2006.

On August 3, Transformational Space Corporation LLC (t/Space) performed a successful drop test of a prototype of its Crew Transfer Vehicle (CXV). The CXV capsule was released at an altitude of 9,400 feet (2,865 meters) and parachuted into the Pacific Ocean, impacting the water at a speed of 17 miles (27 kilometers) per hour. The private company built the CXV prototype after receiving a $6 million contract from NASA to propose a conceptual design for the next generation of NASA's crewed vehicles.

In August, Space Adventures, the private company that has sent three tourists to the International Space Station (ISS), officially unveiled a new commercial space tourism service to loop around the moon. The Deep Space Expedition (DSE) Alpha project, arranged in cooperation with the Russian Space Agency (Roscosmos) and RSC Energia, will use a Soyuz spacecraft carrying a cosmonaut commander and two space tourists, each paying $100 million. The service is not expected to be introduced until 2010.

China announced plans to deploy a third Shenzhou manned spaceflight in 2006, featuring that country's first EVA. Meanwhile, China's second manned mission successfully launched on October 12, 2005, and landed safely in Inner Mongolia on October 17, 2005.

Russia announced plans to outfit its Kliper small launch vehicle for emergency evacuation missions to the ISS if required. Kliper could be launched aboard Russia's planned Zenit 3SLB Land Launch vehicle from Baikonur. The upgraded Kliper, which could carry six passengers, is expected to be operational by 2010.

In August, The U.S. Department of State Directorate of Trade Controls approved the exchange of technical information between the American company Scaled Composites and the UK's Virgin Galactic, clearing the regulatory path for a space tourism enterprise known as The SpaceShip Company—a joint venture between Virgin Galactic and Scaled Composites.

In September, SpaceX, originator of the Falcon 1 and Falcon 5 launch vehicles, announced plans to develop a new Falcon 9 heavy-lift vehicle to compete with the Atlas V and Delta IV Evolved Expendable Launch Vehicles (EELVs) "in response to customer requirements." The Falcon 9 first stage will feature nine SpaceX Merlin engines providing total thrust on liftoff of 765,000 pounds (3.4 million newtons).

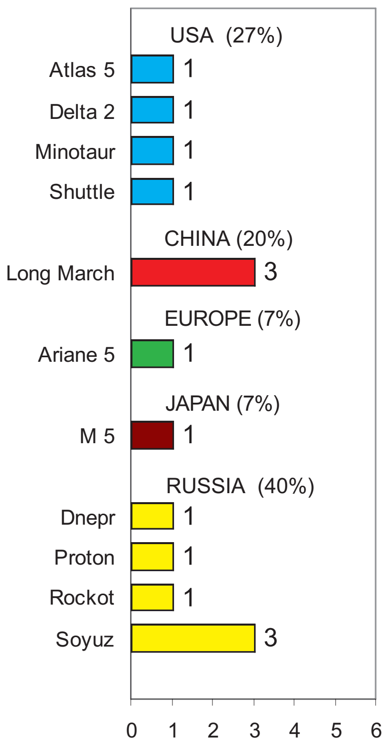
SpaceX also disclosed it was bidding on a contract from NASA to provide cargo launch services to the ISS. The company said it would charge $35 million for such launches, compared with the $100 million that would be charged by existing EELV providers.

On September 19, NASA Administrator Mike Griffin offically announced that four U.S. astronauts will return to the Moon as early as 2018. A six-passenger Crew Exploration Vehicle (CEV) mothercraft will be used to ferry crews to and from the ISS, or to fly unmanned automated supply flights to the ISS. The lunar flight will feature a four-person CEV equipped to fly 10 missions, and a lunar lander craft. The launch vehicle for the CEV will be based on existing Shuttle technology in order to reduce costs. The 13-year program to return to the Moon is expected to cost 55 percent of the budget of the eight-year Apollo program, measured in constant dollars. Following the first mission, Griffin anticipates two lunar flights per year. The goal is to gradually extend lunar missions from several days to several months in preparation for an eventual mission to Mars, expected sometime after 2030.

In late September, Shuttle Endeavour completed a major technical overhaul that began in August 2003. It is expected to launch to the ISS in late 2006 on NASA's third return-to-flight mission.

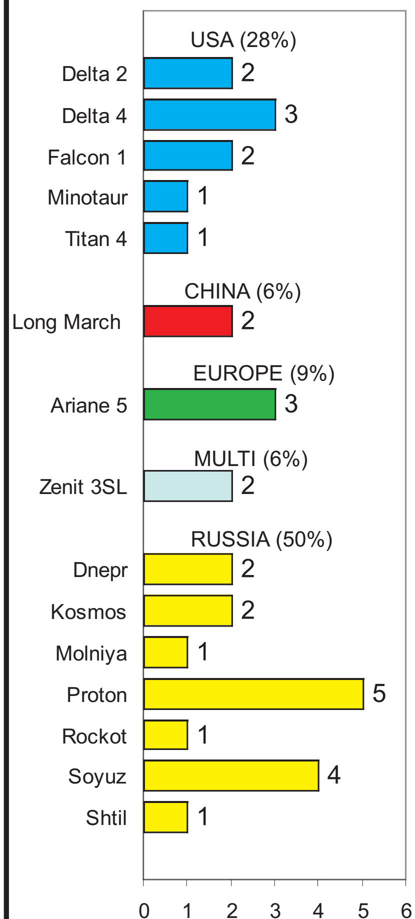
Vehicle Use
(July 2005 – March 2006)

Figure 1: Third Quarter 2005 Total Launch Vehicle Use



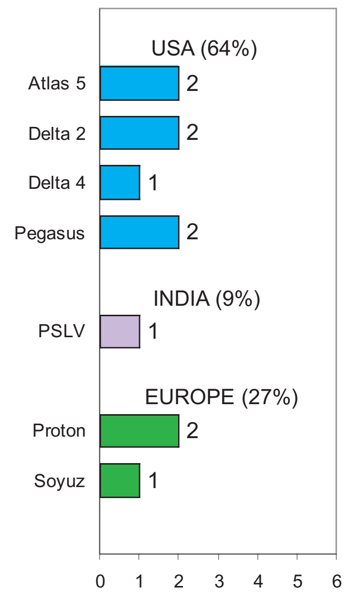
Total = 15

Figure 2: Fourth Quarter 2005 Total Projected Launch Vehicle Use



Total = 32

Figure 3: First Quarter 2006 Total Projected Launch Vehicle Use



Total = 11

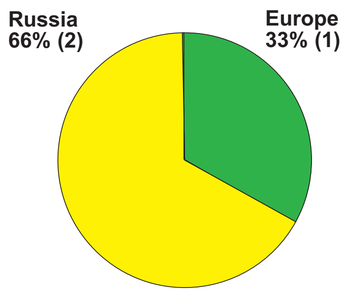
Figures 1-3 show the total number of orbital and suborbital launches (commercial and government) of each launch vehicle and the resulting market share that occurred in the third quarter of 2005, as well as projecting this information for the fourth quarter of 2005 and first quarter of 2006. The launches 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

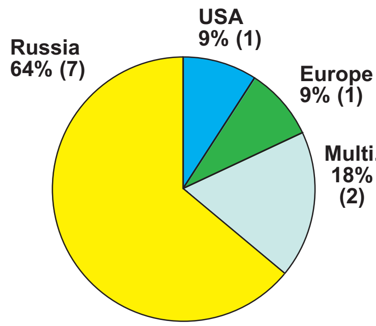
(July 2005 – March 2006)

Figure 4: Third Quarter 2005 Commercial Launch Events by Country



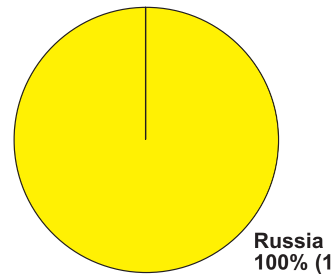
Total = 3

Figure 5: Fourth Quarter 2005 Projected Commercial Launch Events by Country



Total = 11

Figure 6: First Quarter 2006 Projected Commercial Launch Events by Country



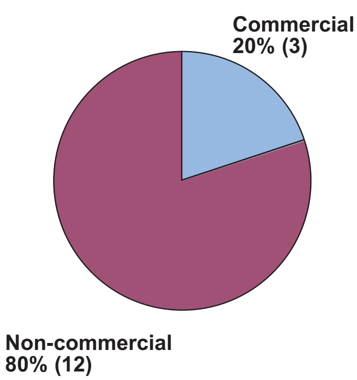
Total = 1

Figures 4-6 show all *commercial* orbital and suborbital launch events that occurred in the third quarter of 2005 and that are projected for the fourth quarter of 2005 and first quarter of 2006.

Commercial vs. Non-commercial Launch Events

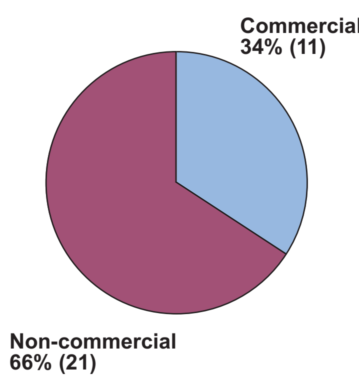
(July 2005 – March 2006)

Figure 7: Third Quarter 2005 Commercial vs. Non-commercial Launch Events



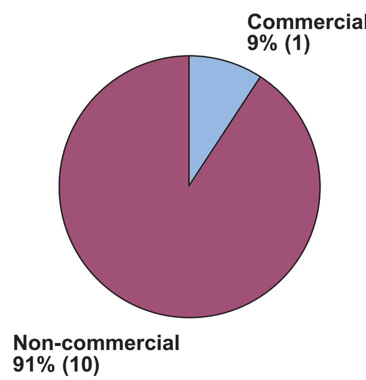
Total = 15

Figure 8: Fourth Quarter 2005 Projected Commercial vs. Non-commercial Launch Events



Total = 32

Figure 9: First Quarter 2006 Projected Commercial vs. Non-commercial Launch Events



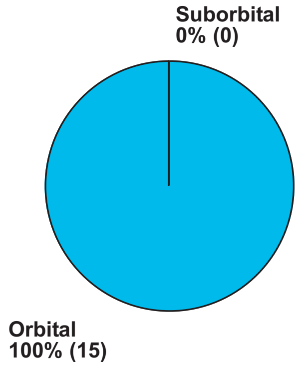
Total = 11

Figures 7-9 show commercial vs. non-commercial orbital and suborbital launch events that occurred in the third quarter of 2005 and that are projected for the fourth quarter of 2005 and first quarter of 2006.

Orbital vs. Suborbital Launch Events

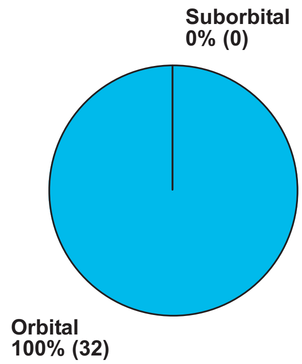
(July 2005 – March 2006)

Figure 10: Third Quarter 2005 Orbital vs. Suborbital Launch Events



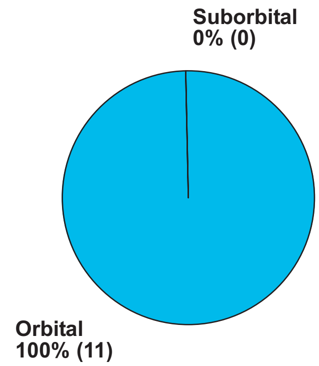
Total = 15

Figure 11: Fourth Quarter 2005 Projected Orbital vs. Suborbital Launch Events



Total = 32

Figure 12: First Quarter 2006 Projected Orbital vs. Suborbital Launch Events



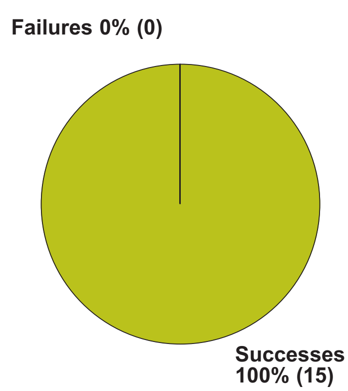
Total = 11

Figures 10-12 show orbital vs. suborbital launch events that occurred in the third quarter of 2005 and that are projected for the fourth quarter of 2005 and first quarter of 2006.

Launch Successes vs. Failures

(July 2005 – March 2006)

Figure 13: Third Quarter 2005 Launch Successes vs. Failures

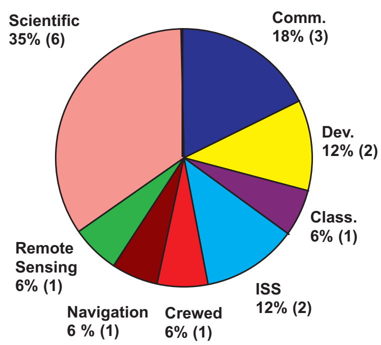


Total = 15

Figure 13 shows orbital and suborbital launch successes vs. failures for the period from July 2005 to September 2005. 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 is unable to reach a useable orbit or would use all of its fuel to do so are considered failures.

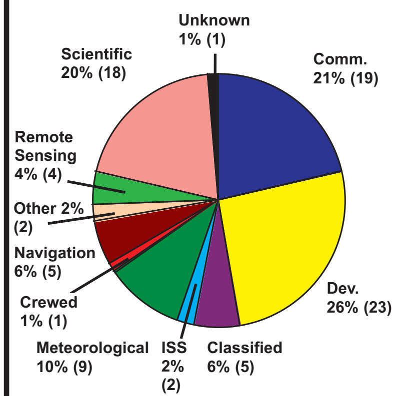
Payload Use (Orbital Launches Only)
(July 2005 – March 2006)

Figure 14: Third Quarter 2005 Payload Use



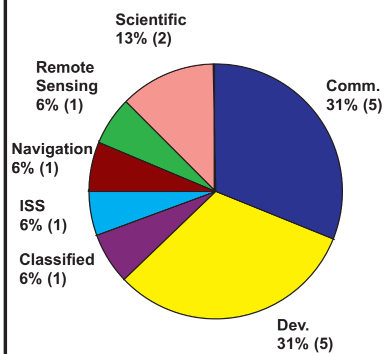
Total = 17

Figure 15: Fourth Quarter 2005 Projected Payload Use



Total = 89

Figure 16: First Quarter 2006 Projected Payload Use

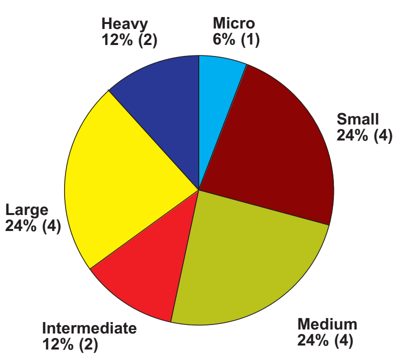


Total = 16

Figures 14-16 show total payload use (commercial and government), actual for the third quarter of 2005 and projected for the fourth quarter of 2005 and first quarter of 2006. The total number of payloads launched may not equal the total number of launches due to multi-manifesting, i.e., the launching of more than one payload by a single launch vehicle.

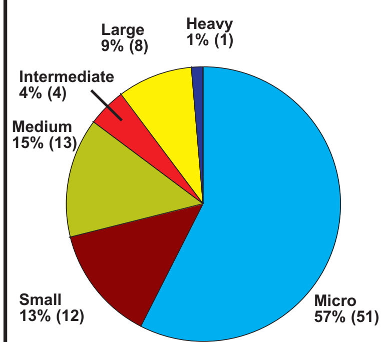
Payload Mass Class (Orbital Launches Only)
(July 2005 – March 2006)

Figure 17: Third Quarter 2005 Payload Mass Class



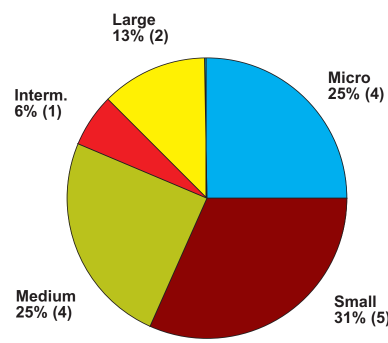
Total = 17

Figure 18: Fourth Quarter 2005 Projected Payload Mass Class



Total = 89

Figure 19: First Quarter 2006 Projected Payload Mass Class

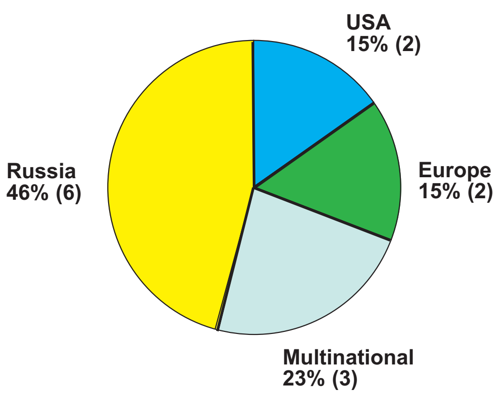


Total = 16

Figures 17-19 show total payloads by mass class (commercial and government), actual for the third quarter of 2005 and projected for the fourth quarter of 2005 and first quarter of 2006. The total number of payloads launched may not equal the total number of launches due to multi-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.).

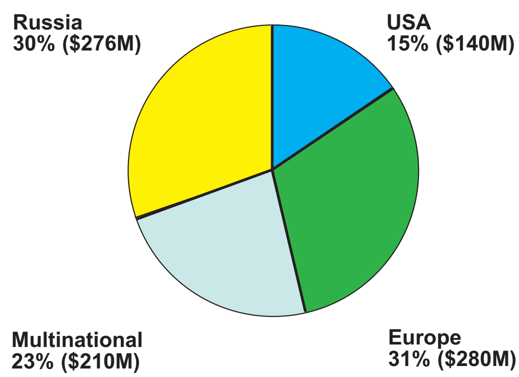
Commercial Launch Trends (Orbital Launches Only)
(October 2004 – September 2005)

Figure 20: Commercial Launch Events, Last 12 Months



Total = 13

Figure 21: Estimated Commercial Launch Revenue, Last 12 Months



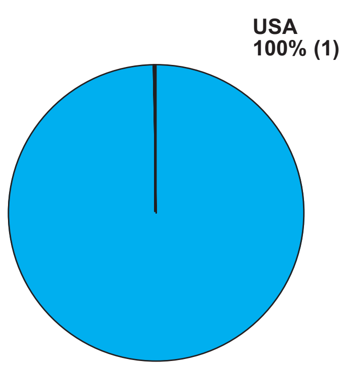
Total = $906M

Figure 20 shows commercial orbital launch events for the period of October 2004 to September 2005 by country.

Figure 21 shows estimated commercial launch revenue for orbital launches for the period of October 2004 to September 2005 by country.

Commercial Launch Trends (Suborbital Launches Only)
(October 2004 – September 2005)

Figure 22: Commercial Launch Events, Last 12 Months



Total = 1

Figure 22 shows commercial suborbital launch events for the period of October 2004 to September 2005 by country.

Commercial Launch History

(January 2000 – December 2004)

Figure 23: Commercial Launch Events by Country, Last Five Years

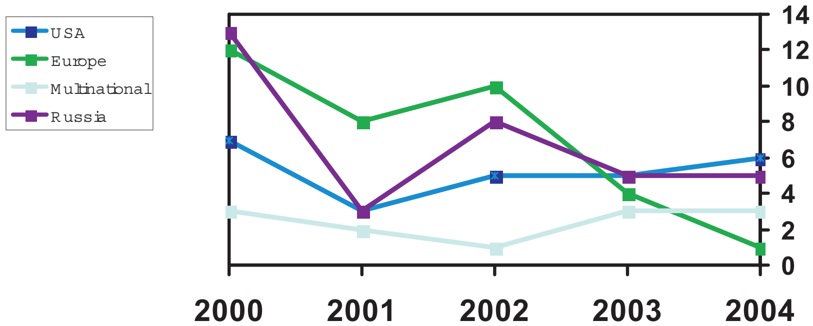


Figure 23 shows commercial launch events by country for the last five full years.

Figure 24: Estimated Commercial Launch Revenue (in $ million) by Country, Last Five Years

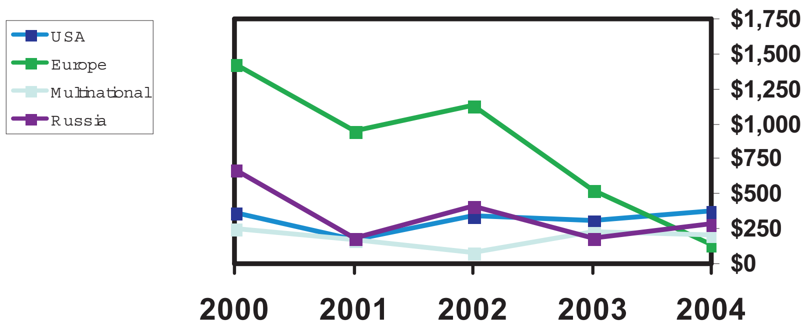


Figure 24 shows estimated commercial launch revenue by country for the last five full years.

RISK PERCEPTION AND COMMUNICATION IN COMMERCIAL REUSABLE LAUNCH VEHICLE OPERATIONS

Terry L. Hardy

Federal Aviation Administration, Office of Commercial Space Transportation, 800 Independence Avenue, S.W., Room 331, Washington, DC, 20591, USA, terry.hardy@faa.gov

1. INTRODUCTION

On December 23, 2004 the President of the United States signed into law the Commercial Space Launch Amendments Act of 2004 (CSLAA). In passing this law, the United States Congress stated that greater private investment in developing commercial space launch vehicles capable of carrying humans into space would stimulate the United States' commercial space transportation industry as a whole. However, the United States Congress also noted that space travel is inherently risky. Therefore, the CSLAA requires that space flight participants (individuals, who are not crew, carried within a launch vehicle or reentry vehicle) take personal responsibility for the risks they take traveling into space [1]. Reusable launch vehicle (RLV) operators must inform space flight participants of the risks associated with launch and reentry activities. In turn, space flight participants provide written, informed consent as a way of showing that they understand and voluntarily accept the risks associated with space launch activities. It is clear that risk communication becomes a key aspect of informed consent for RLV space flight participants. However, these participants and the uninvolved public may perceive risk differently than the FAA and the launch vehicle operators. Therefore, it is important to understand those differences in risk perception in order to effectively communicate risks.

The paper discusses informed consent agreements in other risky voluntary activities to illustrate how risk is communicated in these activities, and uses research into risk perception and communication to explain the approaches used in these agreements to communicate risk. This paper then identifies factors that can affect the perception of risk, and shows how those perceptions of risk vary depending on whether the individual is a space flight participant or whether the individual is a member of the uninvolved public. For space flight participants, the United States Federal Aviation Administration (FAA) has produced guidelines to assist in meeting the informed consent requirements in the CSLAA, and those guidelines are discussed in relation to risk perception and communication. Finally, the paper makes recommendations regarding communicating risk to both space participants and the uninvolved public.

2. INFORMED CONSENT AGREEMENTS

For this study, numerous examples of informed consent agreements were analyzed from a number of voluntary activities including rock climbing, kayaking, skiing, and boating. These agreements were examined only for their statements of risk, not to identify legal or ethical issues.

Several observations could be made from example informed consent agreements. First, the potential consequences were generally stated in plain, easy-to-understand language. For example, in one agreement, the dangers of whitewater rafting were discussed, including "drowning and shoulder dislocation." Plain language is important to assure that the risks are understood. Second, in most informed consent agreements the "risks" were stated in terms of consequences only. For example, in one informed consent agreement for rock climbing, the "risks" were listed as rope abrasions, falls, and injuries from fallen climbers, which are statements of consequence. This is contrary to the definition of risk used by most risk assessment and system safety experts, namely, that risk is a measure that takes into consideration both the consequence of a hazard and the likelihood of its occurrence. Finally, when statements of likelihood were made, the terms used were often qualitative and vague. For example, one informed consent agreement discussed "most common" and "least common" consequences. Therefore, the question becomes, if risk is defined by experts as a combination of likelihood and severity of consequences, why do most informed consent agreements focus on severity of consequences when communicating risk?

3. RISK ASSESSMENTS AND DEFINITIONS

To understand why statements of risk generally only include consequences, one must examine differences in how the public assesses and defines risk in comparison to experts in the risk assessment and system safety fields. A number of researchers in the social science field have examined how the public assesses risk, and the differences between the public and expert assessments can be summarized in Table 1.

Table 1: Characteristics of "Expert" and "Public" assessment of risk [2]

"Expert" Assessment of Risk	**"Public" Assessment of Risk**
Scientific	Intuitive
Probabilistic	Yes/No
Acceptable risk	Safety
Comparative risk	Discrete events
Changing knowledge	Is it or isn't it
Population averages	Personal consequences
A death is a death	It matters how we die

While experts see risk assessment as a scientific enterprise requiring systematic assessment, the public intuitively "knows" what is risky and what is safe. Experts describe risk in terms of probabilities, or chances of the hazard occurring, while the public sees it as "safe" or "not safe." While experts use terms like acceptable risk, with the understanding that some risk remains in any activity, the public thinks in terms of whether the harm has been removed (safety is defined as freedom from harm). Most people think in terms of discrete events (based on similar experiences where harm has occurred), and generally think that an activity that was safe will always be safe, while experts take into account comparison of risks with similar activities, and attempt to consider changing conditions such as the addition of risk mitigation strategies. Most experts also think in terms of how many people die or are injured in the general population from an activity (for example, expected casualties), while the public is more concerned about how the hazard might affect them personally. Finally, in analyzing data, scientists and engineers tend not to personalize each fatality, while the public in general does. The public cares not just about how many people die but how they die. Note that this comparison is not meant to indicate that the public is somehow incorrect in their assessment, just that they assess risks differently.

Additional psychological factors complicate discussions of likelihood with respect to risk, as discussed in [3]:

- Most people make biased judgments, or use only a small amount of data, when making decisions. For example, people tend to assign higher likelihood to events that are reported more frequently in the media, such as violent crimes.
- Many people are not interested in, or have trouble understanding, discussions of quantitative risk. For example, most people don't understand concepts such as probability.
- People can dismiss risk information because of overconfidence and unrealistic optimism. Many people feel that undesirable events, such as car accidents, only happen to other people, and not to them. This overconfidence is most prevalent when the activity is voluntary.
- People are often reluctant to change strongly held beliefs, even if quantitative evidence contradicts them. For example, if a person is afraid of flying, statistics showing low aircraft accident rates may not convince them of the safety of air travel.

Based on Table 1 and these psychological factors it becomes clearer that statements of likelihood may not be as meaningful to the public in their assessment of risk as they are to experts. In addition, statements of likelihood may be more difficult to communicate than statements of consequence.

Perhaps an even more fundamental difference in risk perception comes from differences in the definition of risk. Researchers have identified that experts and the public define risk differently, as follows [4-6]:

Experts: Risk is a combination of severity and likelihood of a hazard

Public: Risk = hazard + "outrage" [4]

A hazard is defined as an activity or condition that poses the potential for loss or harm. "Outrage" is defined as cultural perceptions or values regarding a hazard. Researchers have identified a number of outrage factors that affect how the public perceives a risk. Some of the key outrage factors are described as follows:

Voluntary versus involuntary: People are more concerned about risks that are imposed on them than risks they voluntarily take. For example, people are more concerned about pesticides on food they purchase in a grocery store than the pesticides they themselves put on vegetables in their garden. In fact, we often take voluntary risks because the risk is part of the thrill (skiing, hang gliding, etc.). Starr [7] found that the public is willing to accept voluntary risks roughly 1000 times greater than involuntary risks.

Natural versus industrial: People are more concerned about risks that are man-made than those from environmental sources. For example, people are much more concerned about uranium mine tailings than radon in their home.

Familiar versus exotic: People are much less concerned about risks from familiar sources than those from new or exotic ones. For example, people may be more concerned about unfamiliar diseases such as Severe Acute Respiratory Syndrome (SARS) than the flu. In the case of familiar hazards, it is often difficult for public health professionals to create "outrage" in order to prevent casualties, such as is the case for the U.S. Consumer Product Safety Commission in its attempts to get the public to participate in recalls of potentially dangerous household tools.

Memorable versus not memorable: Memorable events lead to higher perceptions of risk. Examples of memorable events include the dropping of the first atomic bomb, the Space Shuttle Challenger accident, and the terrorist attacks in New York City on September 11, 2001.

Not dreaded versus dreaded: Some risks are more dreaded than others. For example, cancer and birth defects are more dreaded than asthma, heart disease and in-home accidents.

Chronic versus catastrophic: People appear to be more concerned about those fatalities and injuries that are grouped in time and space, such as airplane crashes, terrorism, or outbreaks of illness, than those which are scattered or occur randomly through time and space, such as automobile accidents and deaths due to illness related to smoking.

Knowable versus unknowable: The public appears to be more concerned about those risks that only experts can know and understand, such as carcinogens, than those that are readily known, such as walking across the street.

Individually controlled versus controlled by others: People tend to be more concerned about those risks which are controlled by others, such as flying in an airplane piloted by someone else, than by those which they tend to control, such as driving their automobile or riding a bicycle.

Fair versus unfair: Hazards that are unfairly distributed can cause more outrage than those that are fairly distributed. For example, the public might be more concerned about incinerator waste coming from another country than one coming from its own country. And people often feel it is unfair to impose risks on the sick, the elderly, and the poor.

Morally relevant versus morally irrelevant: Some risks have moral implications. For example, pollution or crimes such as murder may be seen as morally unacceptable. It would therefore be unacceptable for a public safety official, such as a police officer, to talk about "acceptable numbers of murders," even when we know that we may not be able to prevent all murders and therefore implicitly accept a level of risk related to this crime.

Trustworthy sources versus untrustworthy sources: People and organizations that are perceived as benefiting from the hazard are not readily trusted. Risks described by these organizations are usually perceived to be higher than those from trusted sources. Local and federal government agencies and industries conducting hazardous operations are often not trusted, while the public trusts information from family members, consumer groups, and neutral experts such as doctors and academics.

These outrage factors are not the only ones that affect the public's perception of risk. For example, risks to children are generally more of concern than risks to adults [8]. Also, most people are more concerned about those activities that place them personally and directly at risk than those that pose no personal threat [3]. In fact, Covello [6] has identified 47 different factors that influence the perception of risk. However, the factors described above have generally been recognized as having significant influence in the perception of risk.

Based on risk perception research, the public's perception of whether a particular risk is safe or risky can often be predicted. Table 2 shows a comparison for each of the above factors and whether the activity would be seen as safer or riskier depending on the outrage factor.

It is again important to remember that these factors are legitimate expressions of risk. However, these outrage factors can lead the public to underestimate some risks and overestimate others.

Table 2: "Safer" versus "Riskier" based on outrage factors [9]

Safer	**Riskier**
Voluntary	Involuntary
Natural	Industrial
Familiar	Exotic
Not memorable	Memorable
Not dreaded	Dreaded
Chronic	Catastrophic
Knowable	Unknowable
Individually controlled	Controlled by others
Fair	Unfair
Morally irrelevant	Morally relevant
Trustworthy sources	Untrustworthy sources

4. RISK PERCEPTION AND COMMUNICATION: SPACE FLIGHT PARTICIPANTS

Using the factors outlined above, Table 3 indicates how an RLV space flight participant might perceive the risk for each of the outrage factors; the expected perception is shown as shaded and bold in the table.

Table 3: “Safer” versus “Riskier”: RLV space flight participant outrage factors

Safer	Riskier
Voluntary	Involuntary
Natural	**Industrial**
Familiar	**Exotic**
Not memorable	**Memorable**
Not dreaded	Dreaded
Chronic	Catastrophic
Knowable	Unknowable
Individually controlled	**Controlled by others**
Fair	Unfair
Morally irrelevant	Morally relevant
Trustworthy sources	Untrustworthy sources

Space flight participants voluntarily choose to ride in an RLV. In fact, as in other activities such as skydiving or hang gliding, the risk may be part of the thrill of performing the activity. The space flight participant activity would not be dreaded, would be seen as a chronic rather than catastrophic risk (catastrophic being defined as many deaths at one time), and the consequences are knowable. The risks are fairly distributed because the participants voluntarily choose to accept the risk, and there would probably be no moral concerns. On the other hand, the risk is not natural, the technology is not familiar, and memorable accidents such as Space Shuttle Challenger may make the activity seem risky. In addition, the space flight participants would not control the vehicle, increasing their perception of the risk. It is not clear whether their sources of information would be trusted or not.

The voluntary nature of the activity may be the overriding factor in the space flight participant’s perception of the risk. However, an RLV operator could reduce the space flight participant’s perception of risk by trying to increase the familiarity with the vehicle. For example, the operator could use training as a way to increase familiarity with the vehicle. In addition, the operator and the government could build trust in the operation by having honest, frank, and open discussion of the risks. The potential exists, however, that as the familiarity and trust increase, the space flight participant could perceive the risk to be less than what it actually is. This reduction of perceived risk with increased familiarity would be similar to what can occur in other situations, such as in workplace safety, where it is sometimes difficult for employees to understand the risks of equipment they work with every day.

The FAA has issued guidelines for commercial suborbital RLV operations with space flight participants [10]. The FAA Office of Commercial Space Transportation (AST) is responsible for regulating and licensing commercial space transportation to, among other things, assure that public health and safety and the safety of property would not be jeopardized by the conduct of a launch vehicle mission. These guidelines fulfill the FAA’s requirement to issue guidance on the implementation of the CSLAA prior to the issuance of regulations related to space flight participants. These guidelines also assist the FAA and potential applicants by providing guidance on what the FAA may expect to review and evaluate in an application for a license or permit that proposes to carry space flight participants. The CSLAA requires that an RLV operator (holder of a license or permit) inform a space flight participant in writing about the risks of the launch and reentry, including the safety record of the launch or reentry vehicle type. These guidelines speak to the CSLAA by recommending that a launch vehicle operator inform space flight participants of:

- Known hazards and risks to a space flight participant associated with a mission, including nominal and non-nominal launch operations (these might include death, serious injury, total or partial loss of physical and mental function),
- The safety record of the vehicles of the type being flown (including both government and private sector vehicles if information on them is applicable and available, and not simply the vehicles of a particular RLV operator), and
- The safety record of its own vehicle (including vehicle ground-test and flight-test information that includes a description of safety-related anomalies or failures that occurred and corrective actions taken).

According to the guidelines, the operator should also provide the opportunity for a participant to ask questions and obtain additional information. The guidelines also speak to training, stating that the RLV operator should provide safety training to each space flight participant prior to flight on how to respond to any credible emergency situations, which may include but are not limited to cabin depressurization, fire, smoke, and emergency egress.

These guidelines seek to provide communication of risk through a discussion of the consequences, similar to what is done in informed consent agreements in other activities. The procedures in the guidelines also serve to facilitate familiarity through training, and trust through dissemination of safety information.

A concern with RLV space flight participants, from the standpoint of communication of risk, is not that the participant will be outraged by the risk, but rather that the participant might believe that the risks are lower than they actually are. Therefore, although most informed consent agreements only focus on consequences, it is important for the space flight participant to understand the likelihood of the consequences to be fully informed of the risks. The FAA may provide a participant with a comparison of likelihood of consequences of similar voluntary activities, or with other space flight vehicles, to help clarify the risk. Such comparisons can be obtained through various sources [11].

5. RISK PERCEPTION AND COMMUNICATION: UNINVOLVED PUBLIC

Although communication of risk to the uninvolved public is not explicitly stated in the CSLAA, such communications may become increasingly important as RLV operations become more frequent. Consider Table 4, which seeks to predict how the uninvolved public might rate each of the outrage factors discussed above. The expected perception is shown as shaded and bold in the table.

Table 4: “Safe” versus “Risky”: uninvolved public outrage factors

Safer	Riskier
Voluntary	**Involuntary**
Natural	**Industrial**
Familiar	**Exotic**
Not memorable	**Memorable**
Not dreaded	Dreaded
Chronic	**Catastrophic**
Knowable	Unknowable
Individually controlled	**Controlled by others**
Fair	**Unfair**
Morally irrelevant	Morally relevant
Trustworthy sources	**Untrustworthy sources**

The uninvolved public may perceive many of the outrage factors in the same way as the RLV space flight participants. However, the uninvolved public would probably perceive the risk to be higher because they might not voluntarily choose to accept the risk. The risk might also seem unfair because the uninvolved public may not receive any of the benefits of the RLV operations. The public may not trust the sources of the information because those providing the information, specifically the RLV operators, would have something to gain from the operations. If the public relates an event such as airplanes hitting the World Trade Center on September 11, 2001 with the potential of an RLV hitting their homes, then the public may also see the operation as potentially catastrophic. The perception of risk will depend on the location of the launch vehicle operations, as well as other factors. If people in the operations area feel that they derive an economic benefit from the operations, then they might not see the risks as unfairly distributed. In addition, if operations are conducted in an area where experimental aircraft operations are common, then the risk may not be unfamiliar. However, even considering these factors, the public will probably perceive the risk to be higher than would RLV space flight participants. Therefore, the possibility exists that the uninvolved public could be truly outraged at the risk to them from RLV operations. As has been the experience in other technologies, once outrage sets in it is difficult to change public opinion, and quantitative measures of risk alone will probably not help to reduce this outrage [12]. Public outrage directed at the commercial space launches could therefore stymie the growth of the industry.

Risk communication is key to reducing the potential for outrage, and the responsibility in communicating those risks falls to both the launch vehicle operator and the FAA. A number of researchers have identified rules for effective risk communication as follows [2], [5]:

- Be honest, frank, and open in discussing risks
- Acknowledge that, although quantitative measures are important, risk is more than numbers, and people will perceive risk differently
- Acknowledge and explain quantitative and qualitative risk uncertainties, and acknowledge differences between “experts”
- Don’t compare voluntary risks (e.g., smoking) with involuntary risks (e.g., nuclear power)
- Speak clearly and with compassion in communicating risks, and express risk in several different ways
- Plan carefully and evaluate communication efforts
- Coordinate and collaborate with other credible sources

- Take concerns seriously and listen to complaints – risk communication is a two-way process
- Involve the public as a legitimate partner in risk/benefit tradeoffs

A key part of risk communication is public involvement, and some approaches include the following:

- Community meetings
- Newspaper articles and ads
- Radio and TV talk shows
- Fliers
- Films, videos, and other materials at libraries
- Direct mailings
- Surveys

The launch vehicle industry and regulatory agencies should look for ways to take advantage of lessons learned from previous efforts to improve risk communication with the public.

6. SUMMARY

The United States CSLAA requires that RLV operators inform space flight participants of the risks associated with launch and reentry activities and that space flight participants provide written, informed consent in accepting the risks associated with space launch activities. Communication therefore becomes key to assuring that participants understand these risks. Social science research has shown that the public may perceive risks differently than do experts in the field, and the perception of risk can be predicted based on a number of different factors. The commercial space launch industry should use the results of risk perception research to understand the factors which affect the perception of risk to assist in communicating risks not only to those who might fly on their vehicles but also to those not involved in the launch activities.

7. REFERENCES

1. Montgomery, L., “To Knowingly Go: Space Tourism and Informed Consent,” *The Federal Lawyer*, July 2004.

2. Powell, D., “Setting the Stage: Understanding Communication Issues with Foodborne Pathogens,” Canadian Workshop on Foodborne Pathogens, May 1998.

3. Covello, V., and Sandman, P., “Risk Communication: Evolution and Revolution,” in Wolbarst A. (ed.), Solutions to an Environment in Peril, Johns Hopkins University Press, 2001, pp. 164-178.

4. Sandman, P.M., “Risk Communication: Facing Public Outrage,” *EPA Journal* 13(9):21, 1987.

5. Sandman, P.M., “Explaining Risk to Non-Experts: A Communications Challenge,” *Emergency Preparedness Digest*, Oct-Dec 1987.

6. Covello, V., “Trust and Credibility in Risk Communication,” *Health Environ. Digest*, 6, pp.1-5, 1992.

7. Starr, C., “Societal Benefit versus Technological Risk,” *Science*, 1969.

8. Ropeik, D., and Slovic, P., “Risk Communication: A Neglected Tool in Protecting Public Health,” *Risk in Perspective*, Vol. 11, No. 2, June 2003.

9. Blake, E.R., “Understanding Outrage: How Scientists Can Help Bridge the Perception Gap,” Symposium on Preventing Child Exposures to Environmental Hazards, Washington, DC, March 1994.

10. Federal Aviation Administration, *Draft Guidelines for Commercial Suborbital Reusable Launch Vehicle Operations with Space Flight Participants*, Version 1.0, February 2005.

11. Ropeik, D, and Gray, G., *Risk: A Practical Guide for Deciding What’s Safe and What’s Really Dangerous in the World Around You*, Houghton Mifflin, 2002.

12. Vertinsky, I.B., and Wehrung, D.A., “Risk Perception and Drug Safety Evaluation,” Workshop on Risk Perception and Drug Safety Evaluation, Ottawa, March 1989.

Third Quarter 2005 Orbital and Suborbital Launch Events

Date		Vehicle	Site		Payload or Mission	Operator	Use	Vehicle Price	L	M
7/6/2005		Long March 2D	Jiuquan		SJ 7	China Academy of Space Technology (CAST)	Development	$22.5M	S	S
7/10/2005		M 5	Uchinoura		Astro-E2	Japan Aerospace Exploration Agency (JAXA)	Scientific	$50M	S	S
7/26/2005		Shuttle Discovery	Kennedy Space Center (KSC)		STS 114	National Aeronatics and Space Administration (NASA)	Crewed	N/A	S	S
					ISS LF-1	NASA	ISS		S	S
8/2/2005		Long March 2C	Jiuquan		FSW 21	China National Space Administration (CNSA)	Scientific	$22.5M	S	S
8/11/2005	\/	Ariane 5G	Kourou	*	Thaicom 4 (IPstar)	Shin Satellite Public Co.	Communications	$140M	S	S
8/12/2005		Atlas 5 401	Cape Canaveral Air Force Station (CCAFS)		Mars Reconnaissance Orbiter	NASA	Scientific	$75M	S	S
8/14/2005	\/	Soyuz	Baikonur	*	Galaxy 14	Pan American Satellite Corp. (Panamsat)	Communications	$40M	S	S
8/23/2005		Dnepr 1	Baikonur		Kirari (OICETS)	JAXA	Scientific	$9.5M	S	S
					Reimei (INDEX)	JAXA	Scientific		S	S
8/26/2005		Rockot	Plesetsk		Monitor E1	Roscosmos	Remote Sensing	$13.5M	S	S
8/29/2005		Long March 2D	Jiuquan		FSW 22	CAST	Scientific	$22.5M	S	S
9/2/2005		Soyuz	Baikonur		Kosmos 2415	Russian Ministry of Defense (MoD)	Classified	$40M	S	S
9/8/2005		Soyuz	Baikonur		Progress ISS 19P	Roscosmos	ISS	$40M	S	S
9/9/2005	\/	Proton M	Baikonur	*	Anik F1R	Telesat Canada	Communications	$70M	S	S
9/22/2005		Minotaur	Vandenberg Air Force Base (VAFB)		STP R1	U.S. Air Force (USAF)	Development	$14.5M	S	S
9/25/2005		Delta 2 7925-10	CCAFS		Navstar GPS 2RM-1	USAF	Navigation	$50M	S	S

\/ Denotes commercial launch, defined as a launch that is internationally competed or FAA-licensed.
+ 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 multi-manifested, but the pairing of satellites scheduled for each launch is sometimes undisclosed for proprietary reasons until shortly before the launch date.

Fourth Quarter 2005 Projected Orbital and Suborbital Launch Events

Date	Vehicle	Site	Payload or Mission	Operator	Use	Vehicle Price
10/1/2005	Soyuz	Baikonur	Soyuz ISS 11S	Roscosmos	ISS	$40M
10/8/2005 √	Rockot	Plesetsk	Cryosat	European Space Agency (ESA)	Remote Sensing	$13.5M
10/13/2005	Ariane 5G	Kourou	* Syracuse 3 A	Delegation Generale pour l'Armement (DGA)	Communications	$140M
			Galaxy 15	Panamsat	Communications	
10/13/2005	Long March 2F	Jiuquan	Shenzhou 6	CNSA	Crewed	$60M
10/19/2005	Titan 4B	CCAFS	NRO L-20	National Reconnaissance Office (NRO)	Classified	$400M
10/26/2005	Soyuz	Baikonur	Venus Express	ESA	Scientific	$40M
10/26/2005	Delta 2 7420	VAFB	Calipso	NASA	Scientific	$50M
			CloudSat	NASA	Scientific	
10/27/2005 √	Kosmos 3M	Plesetsk	Topsat	British Defense Ministry	Development	$12M
			China DMC+4	Beijing Landview Mapping Information Technology, Ltd.	Remote Sensing	
			UWE-1	University of Wurzburg	Scientific	
			Ncube-2	Norwegian Student Satellite Project	Development	
			XI-V	University of Tokyo ISSL	Development	
			Mesbah	Telecommunications Company of Iran	Communications	
			Sinah-1	Iran	Classified	
			Mozhayets 5	Mozhaiskiy Military Space Engineering Academy	Development	
			SSETI Express	Aalborg University	Development	
10/2005 √	Dnepr 1	Baikonur	Egyptsat	National Authority for Remote Sensing and Space Sciences	Remote Sensing	$9.5M
			ICEcube 1	Cornell University	Scientific	
			ICEcube 2	Cornell University	Scientific	
			SaudiComsat 3	Space Research Institute	Communications	
			SaudiComsat 4	Space Research Institute	Communications	
			SaudiComsat 5	Space Research Institute	Communications	
			SaudiComsat 6	Space Research Institute	Communications	
			SaudiComsat 7	Space Research Institute	Communications	
			AKS 1	Centre National d'Etudes Spatiales (CNES)	Development	
			AKS 2	CNES	Development	
			HAUSat 1	Hankuk Aviation University	Scientific	
			KUTESat	Kansas University	Scientific	
			Polysat 2	Cal Poly Aerospace Engineering	Development	
			ION	University of Illinois	Development	
			Mea Huaka'l	University of Hawaii	Scientific	
			Merope	Montana State University	Scientific	
			Ncube	Norwegian Student Satellite Project	Scientific	
			Sacred	University of Arizona	Scientific	
			Cubesat TBA	The Aerospace Corporation	Development	
			Rincon 1	University of Arizona	Scientific	
			Saudisat 3	Space Research Institute	Scientific	
			Polysat 1	Cal Poly Aerospace Engineering	Development	
			SEEDS	Nihon University	Scientific	
10/2005	Delta 4 Medium-Plus	VAFB	NRO L-22	Defense of Defense (DoD)	Classified	$70M
10/2005	Falcon 1	Kwajalein	Falconsat 2	DoD	Development	$6M
			Celestis 5	Celestis, Inc.	Other	
10/2005	Molniya	Plesetsk	Kosmos TBA 1	Russian MoD	Classified	$35M

√ Denotes commercial launch, defined as a launch that is internationally competed or FAA-licensed.
+ 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 multi-manifested, but the pairing of satellites scheduled for each launch is sometimes undisclosed for proprietary reasons until shortly before the launch date.

Fourth Quarter 2005 Projected Launch Events, Continued

Date			Vehicle	Site		Payload or Mission	Operator	Use	Vehicle Price
11/5/2005	√	+	Delta 4 Medium-Plus (4,2)	CCAFS		GOES N	National Oceanic and Atmospheric Administration (NOAA)	Meteorological	$70M
11/20/2005			Shtil	Barents Sea		Kompass 2	Russia - TBA	Scientific	$1.5M
11/2005	√	+	Zenit 3SL	Odyssey Launch Platform	*	Inmarsat-4 F2	Inmarsat	Communications	$70M
11/2005	√		Proton M	Baikonur	*	Astra 1KR	SES Astra	Communications	$70M
11/2005			Delta 2 7920	VAFB		NRO L-21	NRO	Classified	$50M
11/2005	√		Ariane 5 ECA	Kourou	*	Telkom 2	PT Telkomunikasi	Communications	$140M
					*	Spaceway 2	Hughes Network Systems	Communications	
12/1/2005			Delta 4 Medium	VAFB		DMSP 5D-3-F17	DoD	Meteorological	$70M
12/1/2005	√		Proton M	Baikonur	*	AMC 13	SES Americom	Communications	70M
12/5/2005	√		Dnepr 1	Baikonur		BelKA	National Academy of Sciences of Belarus	Remote Sensing	$9.5M
						PolySat 3	Cal Poly Aerospace Engineering	Development	
						KiwiSat	Amsat ZL	Communications	
						JAESat Master Satellite	Australian Space Research Institute	Development	
						KatySat 1	Stanford University	Development	
						UCISat 1	University of California Irvine	Development	
						Funsat	University of Florida	Development	
						AtmoCube	University of Trieste	Scientific	
						CanX-2	University of Toronto	Development	
						UniSat 4	University of Rome	Development	
						SaudiSat 4	Space Research Institute (S.A.)	Scientific	
						Baumanets	Bauman Moscow State Technical University	Development	
						CubeSat RAFT	US Naval Academy	Development	
						ALMASat 1	University of Bologna	Development	
12/6/2005			Falcon 1	Kwajalein	*	TacSat 1	USAF	Development	$6M
						Celestis 6	Celestis, Inc.	Other	
12/8/2005			Ariane 5G	Kourou	*	Insat 4A	Indian Space Research Organization (ISRO)	Communications	$140M
						MSG 2	Eumetsat	Meteorological	
12/15/2005			Kosmos 3M	Plesetsk	*	Gonets D1M 1	Smolsat	Communications	$12M
					*	Gonets D1M 2	Smolsat	Communications	
12/21/2005			Soyuz	Baikonur		Progress ISS 20P	Roscosmos	ISS	$40M
12/25/2005			Proton K	Baikonur		Glonass K R1	Russian MoD	Navigation	$72.5M
						Glonass K R2	Russian MoD	Navigation	
						Glonass K R3	Russian MoD	Navigation	
12/26/2005			Soyuz	Baikonur		Galileo System Test Bed 1	ESA	Navigation	$40M
12/29/2005			Proton M	Baikonur		KazSat 1	Kazakhstan	Communications	$75M
12/2005	√		Proton M	Baikonur	*	Measat 3	Binariang Satellite Systems Sdn Bhd	Communications	$70M
12/2005			Minotaur	VAFB		Formosat 3 A	Taiwanese National Space Program Office (NSPO)	Meteorological	$14.5M
						Formosat 3 B	NSPO	Meteorological	
						Formosat 3 C	NSPO	Meteorological	
						Formosat 3 D	NSPO	Meteorological	
						Formosat 3 E	NSPO	Meteorological	
						Formosat 3 F	NSPO	Meteorological	
4Q/2005	√	+	Zenit 3SL	Odyssey Launch Platform	*	Sea Launch Payload TBA	TBA	TBA	$70M
2005			Long March 3A	Xichang		Beidou 2A (Compass 1)	CNSA	Navigation	$50M

√ Denotes commercial launch, defined as a launch that is internationally competed or FAA-licensed.
+ 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 multi-manifested, but the pairing of satellites scheduled for each launch is sometimes undisclosed for proprietary reasons until shortly before the launch date.

First Quarter 2006 Projected Orbital and Suborbital Launch Events

Date		Vehicle	Site		Payload or Mission	Operator	Use	Vehicle Price
1/11/2006		Atlas 5 551	CCAFS		New Horizons	NASA	Scientific	$92.5M
1/31/2006		Delta 4 Heavy	CCAFS		DSP 23	USAF	Classified	$155M
1/2006		Delta 2 7925-10	CCAFS		Navstar GPS 2RM-2	USAF	Navigation	$50M
1/2006		PSLV	Satish Dhawan Space Center		Cartosat 2	ISRO	Remote Sensing	$20M
					SRE 1	ISRO	Development	
					Anusat	ISRO	Communications	
2/28/2006		Pegasus XL	VAFB		Space Technology 5A	NASA	Development	$16M
					Space Technology 5B	NASA	Development	
					Space Technology 5C	NASA	Development	
2/2006		Proton K	Baikonur	*	Yamal 203	Gazkom	Communications	$72.5M
				*	Yamal 204	Gazkom	Communications	
2/2006		Delta 2 7925H	CCAFS		MITEX	USAF	Development	$50M
3/22/2006		Soyuz	Baikonur		Soyuz ISS 12S	Roscosmos	ISS	$40M
3/2006		Atlas 5 521	CCAFS		WGS 1	DoD	Communications	$75M
3/2006	√	Proton M	Baikonur	*	Arabsat 4A	Arab Satellite Communications Organization (Arabsat)	Communications	$70M
1Q/2006		Pegasus XL	Kwajalein		C/NOFS	Spectrum Astro, Inc.	Scientific	$16M

√ Denotes commercial launch, defined as a launch that is internationally competed or FAA-licensed.
+ 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 multi-manifested, but the pairing of satellites scheduled for each launch is sometimes undisclosed for proprietary reasons until shortly before the launch date.