Federal Aviation Administration

Semi- Annual Launch Report

Second Half of 2009

Reviewing Launch Results from the 2nd and 3rd Quarters 2009 and Forecasting Projected Launches for 4th Quarter 2009 and 1st Quarter 2010

Special Report: Commercial Access to Space from Cecil Field, Florida

HQ-10998.INDD

Introduction

The *Semi-Annual Launch Report: Second Half of 2009* features launch results from April through September 2009 and forecasts for the period from October 2009 to March 2010. 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 (FAA) under 49 United States Code Subtitle IX, Chapter 701 (formerly the Commercial Space Launch Act).

The FAA has changed to a half-year schedule for publishing this report. The next Semi-Annual Launch Report will be published in May 2010.

Contents

Cover photo courtesy of Space Exploration Technologies Corporation (SpaceX) Copyright © 2009. A SpaceX Falcon 1 vehicle lifts off from Omelek Island in the Kwajalein Atoll, 2,500 miles (4,000 kilometers) southwest of Hawaii, on July 13, 2009. The commercial launch to low Earth orbit (LEO) carried RazakSAT, a Malaysian imaging satellite, along with two secondary payloads.

Highlights: April - September 2009

SpaceX and Argentina's CONAE finalize launch deal

On April 16, Space Exploration Technologies Corporation (SpaceX) and Argentina's National Commission on Space Activity (CONAE) signed an agreement to launch the SAOCOM 1A and 1B, a pair of earth-monitoring satellites equipped with L-band synthetic aperture radar (SAR) instruments. The payloads are expected to launch aboard SpaceX's Falcon 9 vehicle in 2012.

Sea Launch Zenit-3SL deploys Italian military satellite

On April 30, a Sea Launch Zenit-3SL lifted off from Odyssey Launch Platform in the Pacific Ocean. The FAA-licensed commercial launch successfully deployed Sicral 1B, a dedicated military communications operated by the Italian Ministry of Defense, in geosynchronous orbit (GEO).

Successful launch of TacSat-3

On May 19, a Minotaur 1 rocket successfully launched the U.S. Air Force Research Laboratory's TacSat-3 satellite into orbit. TacSat-3, built by Alliant Techsystems (ATK), demonstrated a hyperspectral sensor whose operations can be controlled directly by troops in the field. The launch also deployed NASA's PharmaSat, manufactured by Orbital Sciences Corporation.

U.S. division of ICO Global Communications files for bankruptcy protection

In May, the U.S. subsidiary of ICO Global Communications filed for pre-arranged bankruptcy protection under Chapter 11 of the U.S. Bankruptcy Code. The company has struggled to recover the investment costs of its ICO-G1 satellite, launched in April 2008 to serve the North American market, and retains substantial debts to its hardware suppliers. The subsidiary plans to restructure financing while continuing business operations.

Sea Launch files for bankruptcy protection

With more than $2 billion in unpaid debt, Sea Launch filed for bankruptcy protection on June 22. Sea Launch had been experiencing ongoing financial shortfalls stemming from its January 30, 2007, failed launch of the NSS 8 commercial communications satellite. Following the launch failure, Sea Launch did not resume launch operations until January 2008, and several of its launch contracts were canceled. As of October 2009, Sea Launch officials had set a goal to emerge from bankruptcy by the end of the first quarter of 2010.

ULA Delta IV launches NOAA environmental satellite

On June 27, a United Launch Alliance (ULA) Delta IV Medium-Plus vehicle lifted off from Cape Canaveral Air Force Station. The FAA-licensed launch successfully deployed GOES O, an environmental monitoring satellite operated by the National Oceanic and Atmospheric Administration (NOAA), in GEO.

Highlights: April - September 2009

Second-Generation Globalstar satellites financed for launch in 2010

In July, the satellite communications company Globalstar received a $276 million loan guaranteed by France's export credit agency, Coface—the first installment in a $586-million loan package. This financing allows Globalstar to move forward with plans for its second-generation satellite system. The system, manufactured by Alcatel Alenia Space, is expected to provide Globalstar customers with voice and data services through 2025. The satellites are slated to launch in sets of six aboard the Soyuz 2 vehicle operated by Arianespace beginning in 2010.

SpaceX Falcon 1 performs second successful commercial launch

On July 13, a SpaceX Falcon 1 lifted off from Kwajalein Atoll in the Marshall Islands. The FAA-licensed launch successfully deployed RazakSAT, a remote sensing satellite operated by the Malaysian National Space Agency, in low Earth orbit (LEO).

Final GPS-2R-series satellite launched

On August 17, a United Launch Alliance (ULA) Delta II rocket successfully deployed the last of the U.S. Air Force's GPS 2R-series positioning and navigation satellites from Cape Canaveral Air Force Station, Florida. The satellite, Navstar GPS 2RM-8, is the final of eight Lockheed Martin-built GPS 2R satellites enhanced to include additional civilian and military bandwidth capacity, higher signal power, and superior jamming resistance. The newly launched satellite joins 18 other functioning GPS 2R satellites in the Air Force's 30-satellite GPS constellation.

Maiden South Korean orbital launch fails

On August 25, the Korea Space Launch Vehicle (KSLV 1), developed jointly by South Korea and Russia, failed in its first orbital launch attempt. The vehicle veered off course following liftoff from the Naro Space Center in Goheung, South Korea, due to a second-stage malfunction that prevented payload fairing separation from the launch vehicle. As a result, the demonstration satellite STSAT-2 was lost. South Korea plans to stage a second launch attempt in May 2010.

Japan's HTV-1 successfully reaches the ISS

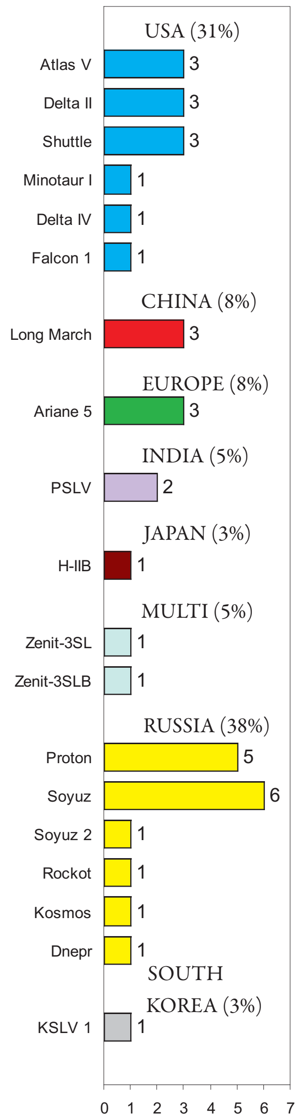
Japan's H-II transfer vehicle (HTV-1), a spacecraft designed to ferry cargo to the International Space Station (ISS), was launched on September 10 from Tanegashima Space Center. The $680-million HTV-1 spacecraft, in development since 1997, was deployed aboard a H-II B rocket. It carried food, experiments, mission hardware, and general cargo to the ISS, where it was scheduled to dock for 55 days.

India deploys ocean-monitoring satellites

On September 23, Oceansat-2 and six European nanosatellites were successfully launched aboard an Indian Polar Satellite Launch Vehicle (PSLV) that lifted off from the Satish Dhawan Space Centre. The 960-kilogram (2,100-pound) Oceansat-2 continues India's decade-long program of regular ocean monitoring, maintaining data collection operations initiated by Oceansat-1 in 1999.

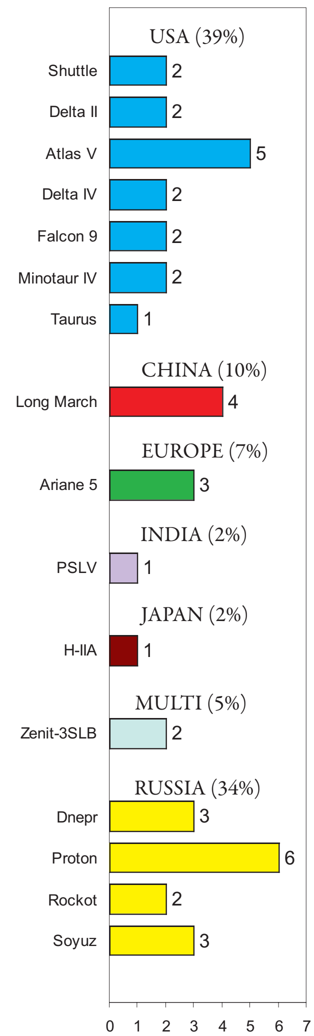
Vehicle Use
(April 2009 – March 2010)

Figure 1: Total Launch Vehicle Use: April - September 2009



Total = 39

Figure 2: Total Projected Launch Vehicle Use: October 2009 - March 2010



Total = 41

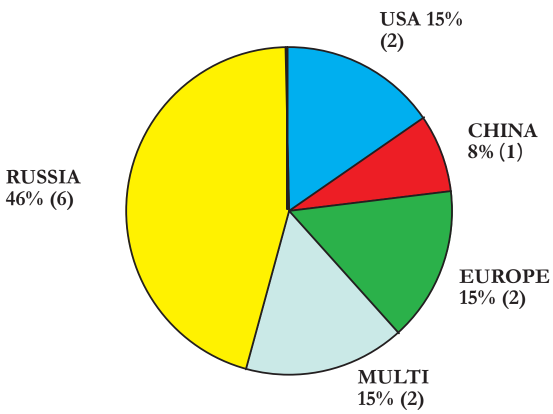
Figure 1 shows the total number of orbital and commercial suborbital launches of each launch vehicle and the resulting market share that occurred from April through September 2009. **Figure 2** projects this information for the period from October 2009 through March 2010. The launches are grouped by 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

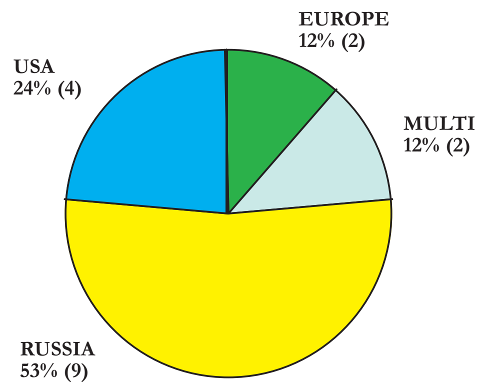
(April 2009 – March 2010)

Figure 3: Commercial Launch Events by Country: April - September 2009



Total = 13

Figure 4: Projected Commercial Launch Events by Country: October 2009 - March 2010



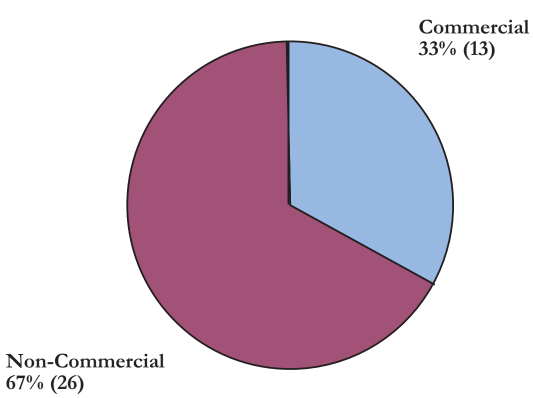
Total = 17

Figure 3 shows all commercial orbital and suborbital launch events that occurred from April through September 2009. **Figure 4** projects this information for the period from October 2009 through March 2010.

Commercial vs. Non-Commercial Launch Events

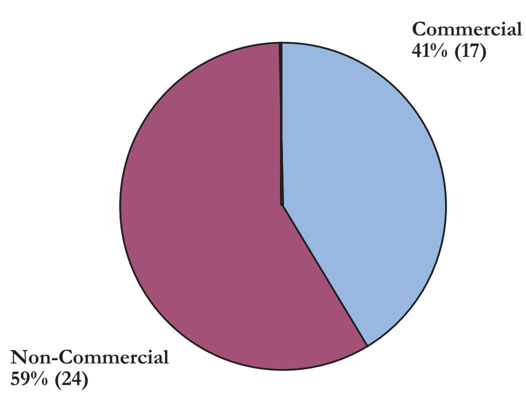
(April 2009 – March 2010)

Figure 5: Commercial vs. Non-Commercial Launch Events: April - September 2009



Total = 39

Figure 6: Projected Commercial vs. Non-Commercial Launch Events: October 2009 - March 2010

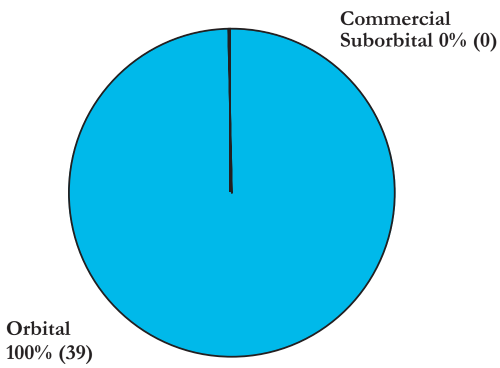


Total = 41

Figure 5 shows commercial vs. non-commercial orbital and suborbital launch events that occurred from April through September 2009. **Figure 4** projects this information for the period from October 2009 through March 2010.

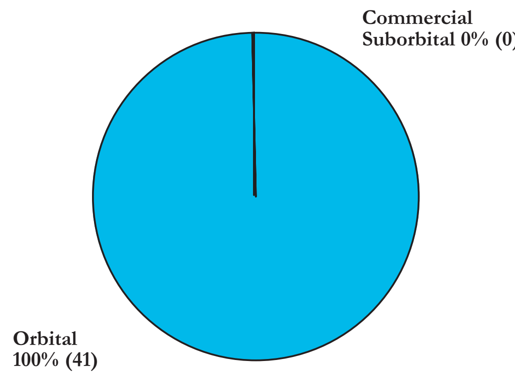
Orbital vs. Commercial Suborbital Launch Events
(April 2009 – March 2010)

Figure 7: Orbital vs. Suborbital Launch Events: April - September 2009



Total = 39

Figure 8: Projected Commercial Suborbital vs. Orbital Launch Events: October 2009 - March 2010

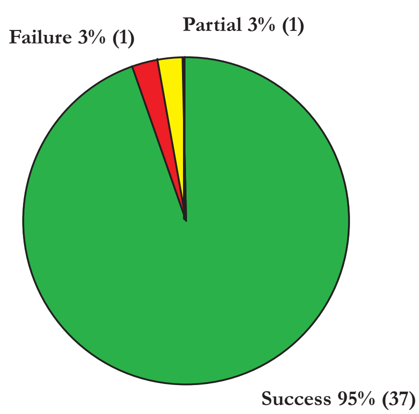


Total = 41

Figure 7 shows orbital vs. FAA-licensed commercial suborbital launch events (or their international equivalents) that occurred from April through September 2009. **Figure 8** projects this information for the period from October 2009 through March 2010.

Launch Successes vs. Failures
(April 2009 – September 2009)

Figure 9: Launch Successes vs. Failures: April - September 2009

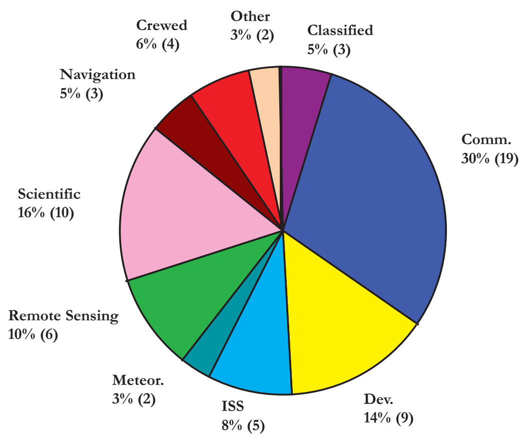


Total = 39

Figure 9 shows orbital and commercial suborbital launch successes vs. failures for the period from April through September 2009. 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.

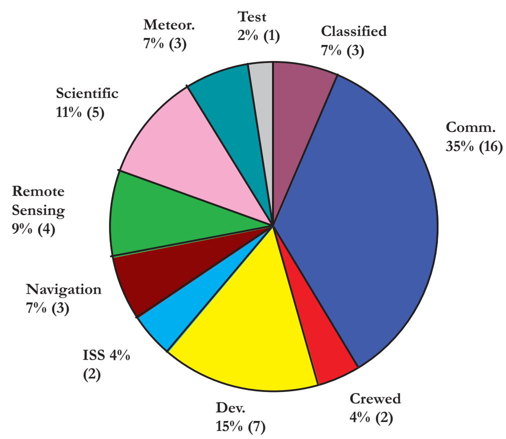
Payload Use (Orbital Launches Only)
(April 2009 – March 2010)

Figure 10: Payload Use: April - September 2009



Total = 46

Figure 11: Projected Payload Use: October 2009 - March 2010

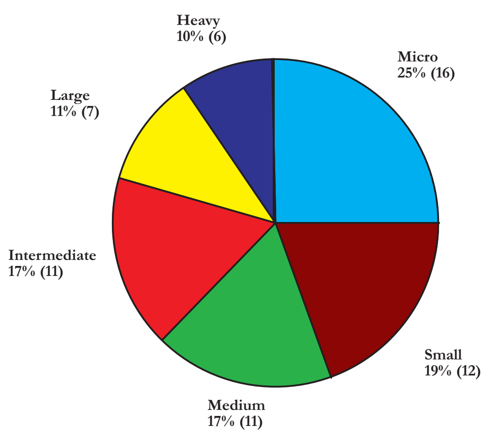


Total = 63

Figure 10 shows total payload use (commercial and government), actual for the period from April through September of 2009. **Figure 11** projects this information for the period from October 2009 through March 2010. 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.

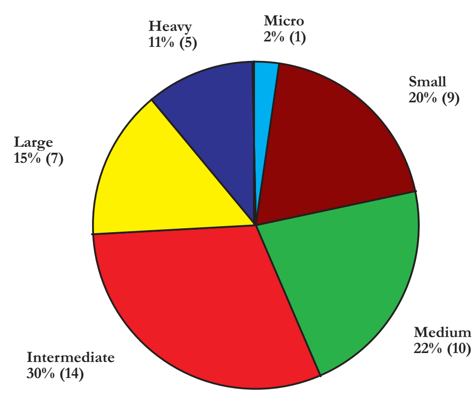
Payload Mass Class (Orbital Launches Only)
(April 2009 – March 2010)

Figure 12: Payload Mass Class: April - September 2009



Total = 46

Figure 13: Projected Payload Mass Class: October 2009 - March 2010

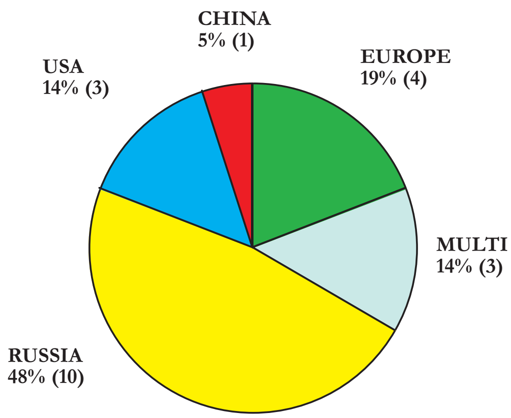


Total = 63

Figure 12 shows total payloads by mass class (commercial and government), actual for the period from April through September 2009. **Figure 13** projects this information for the period from October 2009 through March 2010. 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.).

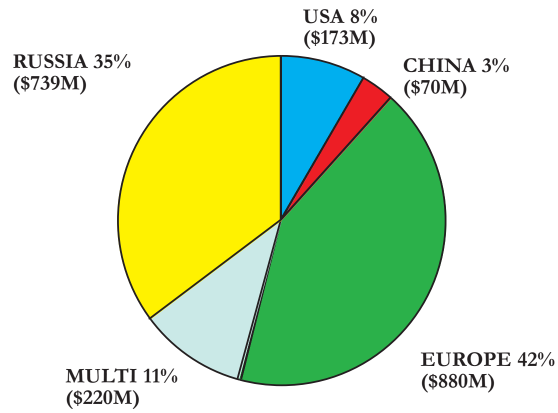
Commercial Launch Trends (Orbital Launches Only)
(October 2008 – September 2009)

Figure 14: Commercial Launch Events, Last 12 Months



Total = 21

Figure 15: Estimated Commercial Launch Revenue, Last 12 Months (US$ millions)



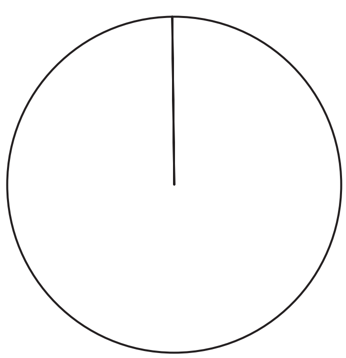
Total = $2,082M

Figure 14 shows commercial orbital launch events for the period from October 2008 through September 2009 by country.

Figure 15 shows estimated commercial launch revenue for orbital launches for the period from October 2008 through September 2009 by country.

Commercial Launch Trends (Suborbital Launches and Experimental Permits)
(October 2008 – September 2009)

Figure 16: FAA-Licensed Commercial Suborbital Launch Events (or Their International Equivalents), Last 12 Months



Total = 0

Figure 17: FAA Experimental Permit Flights, Last 12 Months

Flight Date	Operator	Vehicle	Launch Site
10/26/2008	Armadillo Aerospace	Pixel	Las Cruces International Airport, NM
10/25/2008	Armadillo Aerospace	MOD-1	Las Cruces International Airport, NM
10/25/2008	Armadillo Aerospace	MOD-1	Las Cruces International Airport, NM
10/25/2008	Armadillo Aerospace	MOD-1	Las Cruces International Airport, NM
10/25/2008	TrueZer0	Ignignokt	Las Cruces International Airport, NM

Figure 16 shows FAA-licensed commercial suborbital launch events (or their international equivalents) for the period from October 2008 through September 2009 by country.

Figure 17 shows suborbital flights conducted under FAA experimental permits for the period from October 2008 through September 2009 by country.

Commercial Launch History
(January 2004 – December 2008)

Figure 18: Commercial Launch Events by Country, Last Five Years

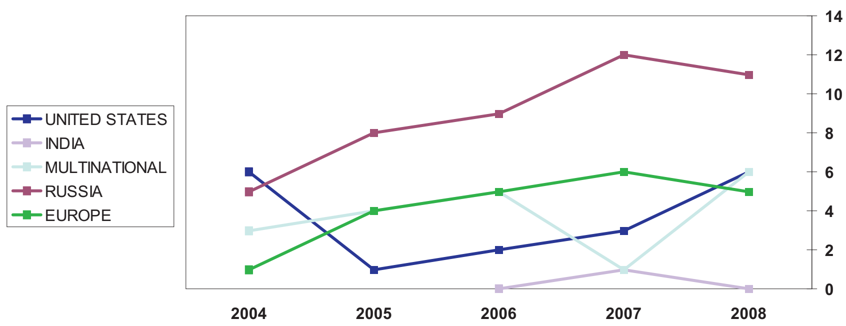


Figure 18 shows commercial launch events by country for the last five full calendar years.

Figure 19: Estimated Commercial Launch Revenue (US$ millions) by Country, Last Five Years

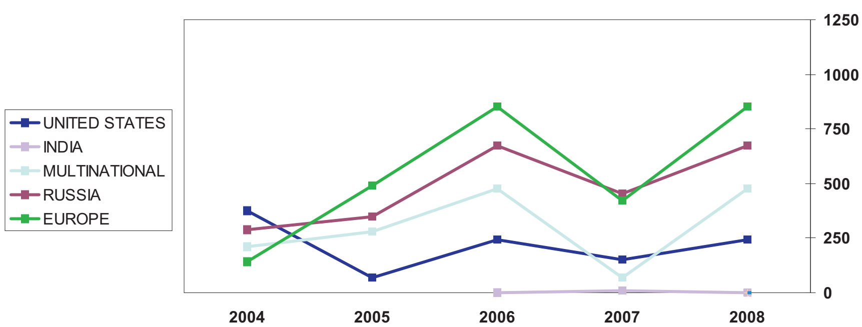


Figure 19 shows estimated commercial launch revenue by country for the last five full calendar years.

Commercial Access to Space from Cecil Field, Florida

Introduction

The FAA has conducted a brief study to identify National Airspace System (NAS) integration requirements associated with proposed twice weekly commercial space transportation operations at Cecil Field, Florida.

The operations studied and included in this report are limited to those based on the Scaled Composites WhiteKnightOne (WK1) / SpaceShipOne (SS1) operations out of Mojave, California. This combination is the only one that has actually flown at this time and was used as a model for the newer Virgin Galactic commercial WhiteKnightTwo (WK2) / SpaceShipTwo (SS2) vehicles. There are several other mission concepts under development including vertical launch/parachute recovery, horizontal air breathing launch with rocket-powered Kármán Line penetration and air breathing powered return and landing. In addition, for the purpose of this study all operations are assumed to be from the former Cecil Field Naval Air Station south west of Jacksonville Florida.

The case study was developed to depict typical operations in the 2025 timeframe and an assumed flight rate of two flights a week. The goal of the study was to uncover any unique requirements that must be considered in the development of the Next Generation Air Transportation System (NextGen) to allow for this type of commercial space tourism with minimal impact on the NAS as it develops.

Several issues that were believed to be critical prior to this study were found to present minimal impact to the NAS. The first of these was the impact of high altitude flight through commercial airways. After careful study of the flight paths of this type of operation, it was found the actual footprint of the flight was fairly small and very little airspace was needed. Once the spacecraft is released, it climbs from above 40,000 feet to over 350,000 feet returning to the same small area over the ground. On return to between 40,000 and 70,000 feet altitude, the spacecraft converts to a glider that proceeds on an almost straight line to approximately 8,500 feet directly over Cecil Field for landing. Because of the inability of the space craft to hold or perform a missed approach, the most important critical issue for airspace controllers is the requirement to have a window for the spacecraft to land after release from the carrier aircraft. The window for this clearance appears to open about 20 minutes after release from the carrier aircraft. Actual release of the spacecraft can also be significantly delayed to provide spacing for other aircraft approaching Cecil Field giving JAX TRACON controllers' significant operational flexibility. The window for landing would normally be a period less than 5 minutes in duration. After landing, the spacecraft is normally clear of the runway within 30 minutes and the parallel runway is able to support normal operations throughout the removal of the spacecraft.

Carrier aircraft (WK2) operation will have almost no impact on controllers as it is able to fly under a normal Flight Plan and its operation is relatively predictable and does not normally present any issues to NAS controllers. The carrier aircraft with SS2 departs from and returns to Cecil Field like any other aircraft.

All other support aircraft operations are conducted in visual flight rules (VFR) conditions under normal local flight plans, and operations are virtually transparent when compared to other normal aircraft operations in the area.

It is the top level conclusion of this study that the flights described in this report will not have a significant impact on NAS operations. Furthermore, export of this type of operation to other geographic areas can be easily integrated into the NAS in other areas, especially those with lower traffic density than the northern Florida area west of Jacksonville used in this study. Because of the unique nature of these kinds of flights, individual evaluation of other proposed sites would be necessary, but there were no systematic issues that would prevent exporting this type of operation to other locations.

Although the study was not to consider emergency procedures, a spacecraft abort was found to have some minor impacts that will be reviewed briefly in the conclusions. A more detailed study of each operational abort scenario is recommended to uncover any NAS impacts that would not necessarily have been uncovered in the cursory abort research done in this study.

Approach

The first step in the evaluation process was to develop information on all vehicles (and sites) used in past developmental efforts and extrapolate that data for proposed operations.

In the second step, the flight profiles were reverse engineered for the vehicles based on publicly available information and published performance capabilities where available. Where performance capabilities were not published or available, expert judgment was used to extrapolate probable capabilities based on available information. This notional flight profile was compared to information on previous flights to validate the model used. In this step, significant differences were found in published performance capabilities for different carriers and spacecraft. These differences had minimal impact on the final conclusions. Flight profiles (for WK2 / SS2) can be found in Figures 1 and 2, respectively.

The third step was to use the notional profiles to develop "distance from base of operations" and altitude tracks for all vehicles used in the operation. Performance differences for vehicles from different sources were accounted for in this section by using the "worst case" (and interpolation of "worst case") information. This had the effect of slightly increasing the footprint for operations.

Using surface maps and standard airspace charts for areas around Cecil Field, nearby population centers and areas at high risk from over-flight incidents were located. These areas were further defined using logical assumptions about over-flight restricted areas and typical vehicle performance. In actual operation, it is expected that the areas shown in this report may be slightly smaller than shown, reducing the impact on the NAS.

Timelines for each vehicle were over-laid to develop a full mission time profile. The timeline was limited to the actual flight period for the mission. Because of potential impact on other traffic at Cecil Field, the mission was defined as extending from man-up of the first vehicle through clearing of the runway by towing SpaceShipTwo from the active runway. The last vehicle to land would be one of the chase aircraft, but that was not considered since those aircraft, as well as the WhiteKnightTwo aircraft, have considerable loiter capability and would be operating within normal flight rules like any other aircraft entering Cecil Field airspace.

(WK2 - virgingalactic.com)

The fourth step was to integrate the operation profiles and timelines for all vehicles used into a normal NAS operation to determine potential impacts to normal operations and evaluate what actions would or would not be needed by regulators and controlling authorities. The team has had no liaison with Jacksonville Center/TRACON to evaluate actual traffic flow.

Assumptions

All analysis was based on historic flights of the WK1 and SS1 in the Mojave operating area along with available data acquired on the capabilities and operation of the proposed WK2 and SS2 vehicles.

All support aircraft used in the Cecil Field area were assumed to be the same as those used in Mojave. Although there is a high probability that support aircraft will not be the same for Virgin Galactic operations as for Scaled Composites, the Mojave aircraft are representative of those needed for Florida operations.

No emergency/abnormal procedures were to be addressed. As the analysis progressed, it was discovered that some "off nominal" events—such as several mission aborts (including carry-back, drop, and no ignition with and without oxidizer dump)—might require contingency procedures to avoid becoming emergencies. It is strongly recommended that additional analysis be performed to determine the impact on the NAS of non-emergency, contingency operations. Whenever normal flight operations can be accomplished under existing regulations and procedures it was assumed they would be used.

Methods

Baseline and specific data from the FAA, Virgin Galactic public information, internet research, technical knowledge of NAS and operations as well as technical expertise in spacecraft/aircraft operations and limitations were used to support all derivations and conclusions. Although the conclusions from this report concern the operation of WK2/SS2, the bulk of raw data available was related to WK1/SS1. Therefore, every effort has been made to identify all data applications as to which vehicles and operations are used.

Aircraft/ Spacecraft Data

As a first step towards developing this report, basic data was gathered on the configurations and performance of all vehicles used in past similar operations. This real world data was limited to the WK1/SS1 operations out of Mojave, California—the only non-government operation to reach space at this time. The following table contains basic data gathered for each aircraft and vehicle involved and is primarily based on publicly available data. Because much of the information was contradictory concerning statistics for WK1, SS1, WK2, SS2, and SS3, all data used was selected from the source that provided the "most conservative" input (i.e., the longest gliding range to determine radius of operation from the highest altitude listed). This provided a total "most conservative" size in footprint and altitudes of operation. As long as the space vehicles analyzed remained within this conservative footprint, those vehicles should be able to reach a safe landing at the home airfield.

Vehicles:

- WhiteKnightOne (WK1)

- WhiteKnightTwo (WK2)
- SpaceShipOne (SS1)
- SpaceShipTwo (SS2)
- Support/chase aircraft
  - (current for SS1 and potential for SS2)

Parameters	WK1	WK2	SS1	SS2	SS3	Chase 1	Chase 2	Chase 3	Chase 4
Type	**NA**	**NA**	**NA**	**NA**	**NA**	**Starship**	**Duchess**	**Alpha Jet**	**Extra 300**
Crew	2	2	1	2	Unk	2	1	2	1
Passengers	2	14	2	6	Unk	6 or 8	3 or 5	0	1
Payload	8,000lb	35,000 lb	Unk	Unk	Unk	4,513 lb	854 lb	11,000 lb	595 lb
Fuel	Jet A	Jet A	N2O/ HTPV	N2O/ Rubber	Unk	Jet A	100 LL	Jet A	100 LL
Engines	2 GE J85-GE5 AB	4 PW 308A	1 N20/HTPV Space Development	Scaled Composites Proprietary	Unk	Two 895kW (1200shp) PT6A67A	2 O-360 Lycoming	2 SNECMA Turbomeca Larzac 04-C6 turbofans	1 AEIO-540-L1B5 300HP
Thrust	5,000 lb (each)	6,900 lb (each)	14,000 to 16,530 lb (Sig variance in data)	Unk	Unk	NA	NA	NA	NA
Empty Wt	Unk	Unk	2,640 lb	Unk	Unk	9,887 lb	2,446 lb	7,750 lb	1,500 lb
Gross Wt	~17,000 lb	60,000 lb	6,828 lb	Unk	Unk	14,400 lb	3,900 lb	18,000 lb	2,095 lb
Span	82 ft	141 ft	16 ft, 5 in	27 ft	Unk	54 ft, 5 in	38 ft	30 ft	24.25 ft
Length	Unk	Unk	16 ft, 5 ft	60 ft	Unk	46 ft, 1 in	29 ft	43 ft, 5 in	22' 9.5"
Service Ceiling	53,000 ft	70,000 ft	367,360 ft	>360,000 ft	NA (Orbital)	41,000 ft	19,400 ft	50,000 ft	16,000 ft
Release Alt	40,000 to 47,000 ft	40,000 ft (planned)	40,000 to 47,000 ft	40,000 ft (planned)	NA	NA	NA	NA	NA
Rate of Climb	Unk	Unk	82,000 ft/min	Unk	Unk	3,225 ft/min	1,248 ft/min	Unk	3,200 ft/min
I_{sp}	NA	NA	250 sec	Unk	Unk	NA	NA	NA	NA
Burn Time	NA	NA	84 sec	Unk	Unk	NA	NA	NA	NA
V Max	Unk	207 mph	2,170 mph	2,600 mph	Unk	285 mph	197 mph	621 mph	253 mph
Max Mach	NA	M .65 (VNE)	M 3.09	Unk	M 25	NA	NA	NA	NA
Range	Unk	Unk	30 NM	Unk	Unk	1,634 NM	923 NM	1,500 NM	510 NM
Apogee	NA	NA	Unk	360,000 ft	240 miles (Orbit)	NA	NA	NA	NA
Launch Alt	NA	NA	45-46K ft	50,000 ft	TBD	NA	NA	NA	NA
Status	Retired	in test	Retired	in test	design	operational	operational	operational	operational

Table of Vehicle Data

Flight Concept of Operations and Diagrams

Flight Scenarios

SS1 and SS2's objective is to cross the Kármán line (328,000 feet). There are future plans for a SS3 that would be capable of orbital flight and International Space Station (ISS) docking. However, SS3 will not be addressed in this report.

Flight frequency: Flights per week

Initially one flight per week was proposed as an initial study parameter. Given the projected rise in suborbital space tourism, future flights expectations could exceed three per week. Considering these two scenarios, the FAA study considered a baseline of two flights per week. This baseline, while reasonable for the short term, will likely need to be reconsidered in future years. Two flights per week will likely be exceeded later in the 2010 to 2025 timeframe, considering the number of paid flights already transacted by the suborbital space tourism firm Virgin Galactic.

Duration

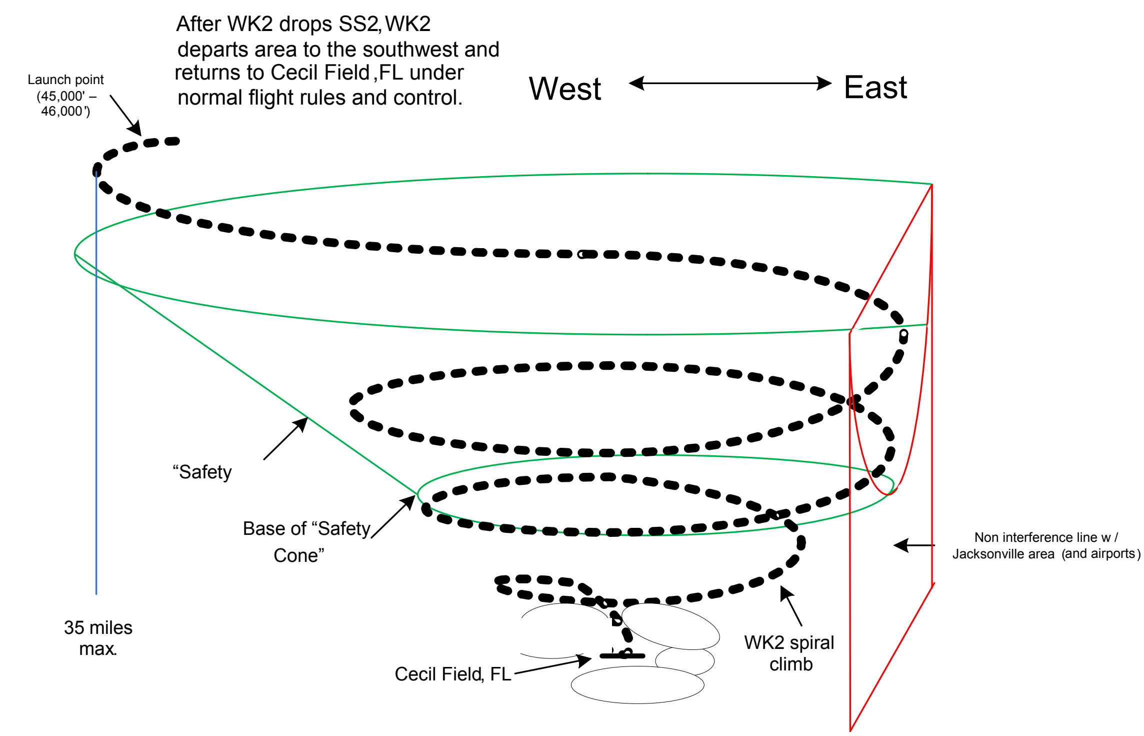
Total mission evolution is estimated to be 1.5 hours (from take off of WK2 until recovery of SS2 (on a normal flight profile). The WK2 carrier aircraft and all support aircraft will have the same impact on the NAS as any other normal aircraft flying in the area and will land after recovery of the SS2. If the launch of SS2 is aborted and it is carried back to Cecil Field by WK2, the SS2 flight plan would be canceled and SS2 would return with WK2 with no impact on NAS operations.

Flight Profile for WK2 and SS2:

WK2 will take off from Cecil Field, FL, climb to approximately 50,000 feet, where it will release SS2, and return to Cecil Field under normal FAA control and flight rules. SS2 releases from WK2 at approximately 50,000 feet and accelerates to M 4 in a steep (almost vertical) climb. At approximately 205,000 feet, the rocket propellant is expended and the engine shuts down. SS2 continues to "coast" up to an altitude of approximately 360,000 feet, crossing the Kármán line (328,000 feet). At 360,000 feet the spacecraft reaches apogee and starts to fall. SS2's wings are shifted to the feather mode at 350,000 feet (wings deflected causing a "deep stall, free fall" near vertical descent). SS2 continues descending to between 70,000 and 40,000 feet. where the wings are unfeathered, rotating the fuselage into the normal glide attitude, from nose up to nose down. In that configuration, SS2 continues a normal glide back to Cecil Field.

The following flight profile was derived from WhiteKnightOne/SpaceShipOne profiles and performance. The basic flight paths were adapted for WK2/SS2 using the new vehicle performance and applied for operations in the Cecil Field operating area. All altitudes and dimensions are estimated for WK2/SS2 and Cecil Field.

White Knight (WK2) Climb Flight Profile for Operations at Cecil Field, FL



- Not to Scale -

Figure 1

Determination of Safety Cone:

The **safety cone** is a three-dimensional zone that combines geographic surface area with altitude and airspace. It is referred to as a cone because the airspace from which a spiral descent is possible is wider at the highest altitude, and narrows as the vehicle approaches the ground (see Figure 1).

This safety cone of aviation activity represents an "outer operation boundary" that would allow SS2 to reach Cecil Field via a controlled glide after release from its WK2 carrier aircraft under almost all conditions. The cone takes into account failure of the SS II engines to ignite and mission abort scenarios with early SS2 release, fully loaded with fuel and oxidizer and with oxidizer dumped (SS2 fuel cannot be dumped).

During ascent (emergency procedure)

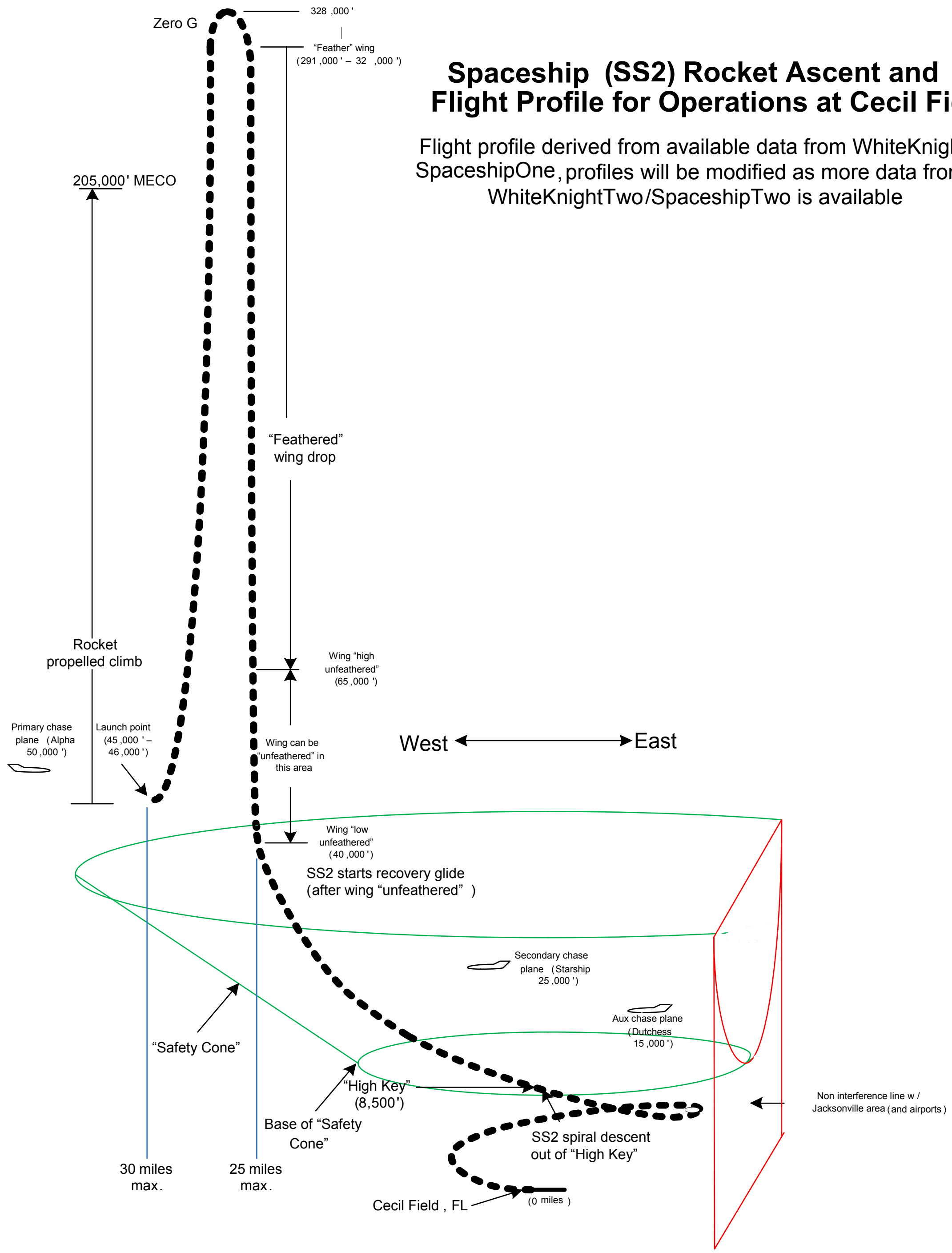
The base of the safety cone was determined based on the following:

1) Altitude required to separate from WK2 and accelerate from optimum climb speed of WK2 to optimum glide speed of SS2.
2) Rate of descent with full load of fuel.
3) Altitude required to reach modified high key (fuel load) on the proper heading.

Note that if oxidizer is dumped the base altitude could be lowered—but this was not assumed in the analysis.

Spaceship (SS2) Rocket Ascent and Flight Profile for Operations at Cecil Field

Flight profile derived from available data from WhiteKnightOne / SpaceshipOne, profiles will be modified as more data from WhiteKnightTwo/SpaceshipTwo is available



- Not to Scale - Figure 2

Ground Track

Parent aircraft – After takeoff from Cecil Field, WK2 will fly a climbing spiral to the release altitude and point. This spiral will remain within the safety cone to enable the spacecraft to return safely to Cecil Field after emergency release. WK2 is capable of flying under normal control throughout its entire mission.

Spacecraft – After drop from WK2 (at the designated altitude, position, and heading), the spacecraft will ignite its rocket engine and start a near vertical climb. After the rocket engine has shut down, the spacecraft will continue to climb, arc over, and start a near vertical descent. After the wing feather/unfeather evolution, it will start its glide (relatively straight line) to the intended "high key" (an aviation term indicating the maximum altitude from which a glide descent may safely be conducted). It is possible because of unpredicted factors such as high altitude winds that the flight profile will require modification in flight to arrive at a point that would enable a safe approach to Cecil Field. This may not be the established high key altitude glide path position. Ideally, the spacecraft would reach the appropriate high key altitude and perform a 360-degree turn to arrive at the final glide path for landing. The spacecraft should always remain within the safety cone to ensure the capability of gliding to Cecil Field for a safe landing.

Support Aircraft – There may be as many as four aircraft involved with the mission. All are capable of normal flight control. Their takeoff, flight, and landing at Cecil Field will be under normal control.

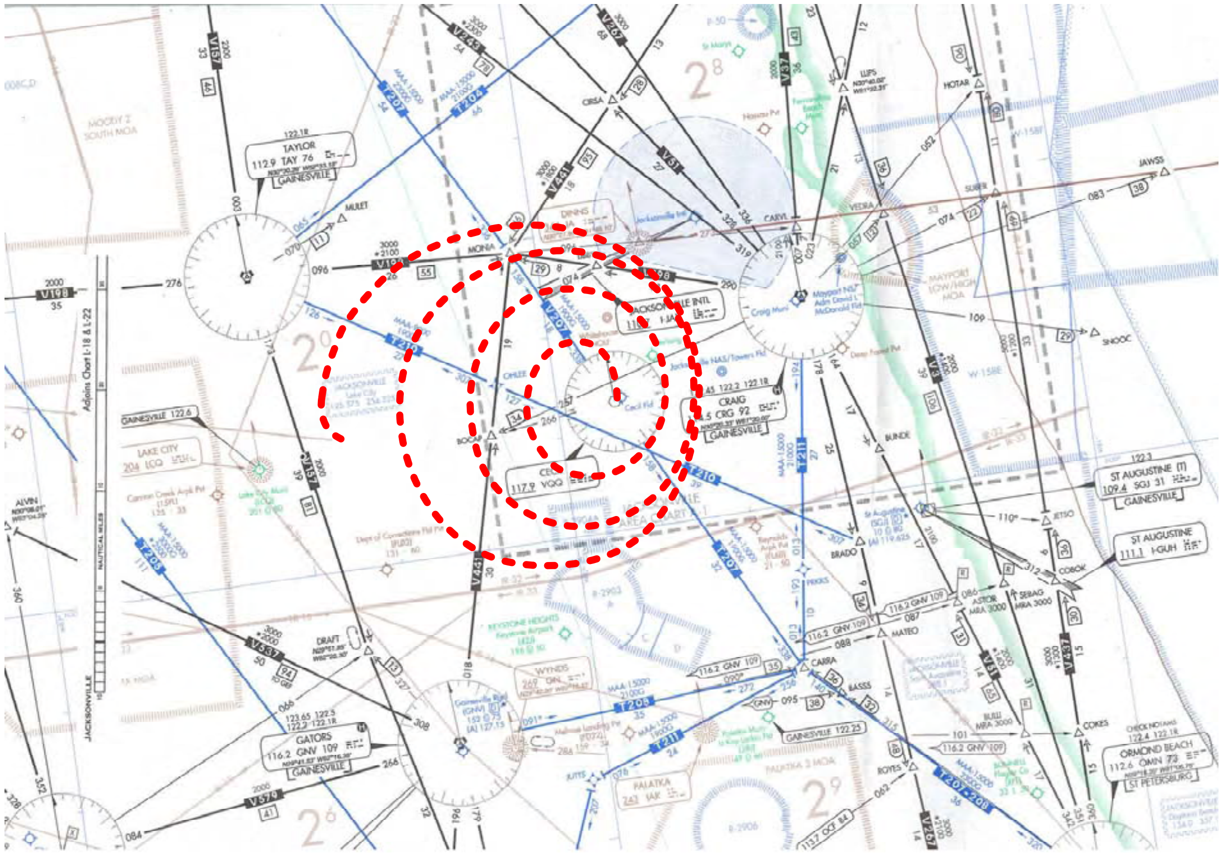


Figure 3 - WK2 Ascent Depicted on Low Altitude Airway Chart

In Figure 3 above, the flight path is overlaid on a low altitude chart (surface to 18,000 feet). The center of the spiral is the takeoff point at Cecil Field. The left outer end of the spiral represents the planned release point for SS2 at 45,000 feet. In an abort, WK2 could release SS2 anywhere above the safety cone base as long as it was within the cone and SS2 could still make a safe approach and landing at Cecil Field. This would be a declared emergency and could be treated by controllers like any loss of power emergency approach and landing for a high performance aircraft.

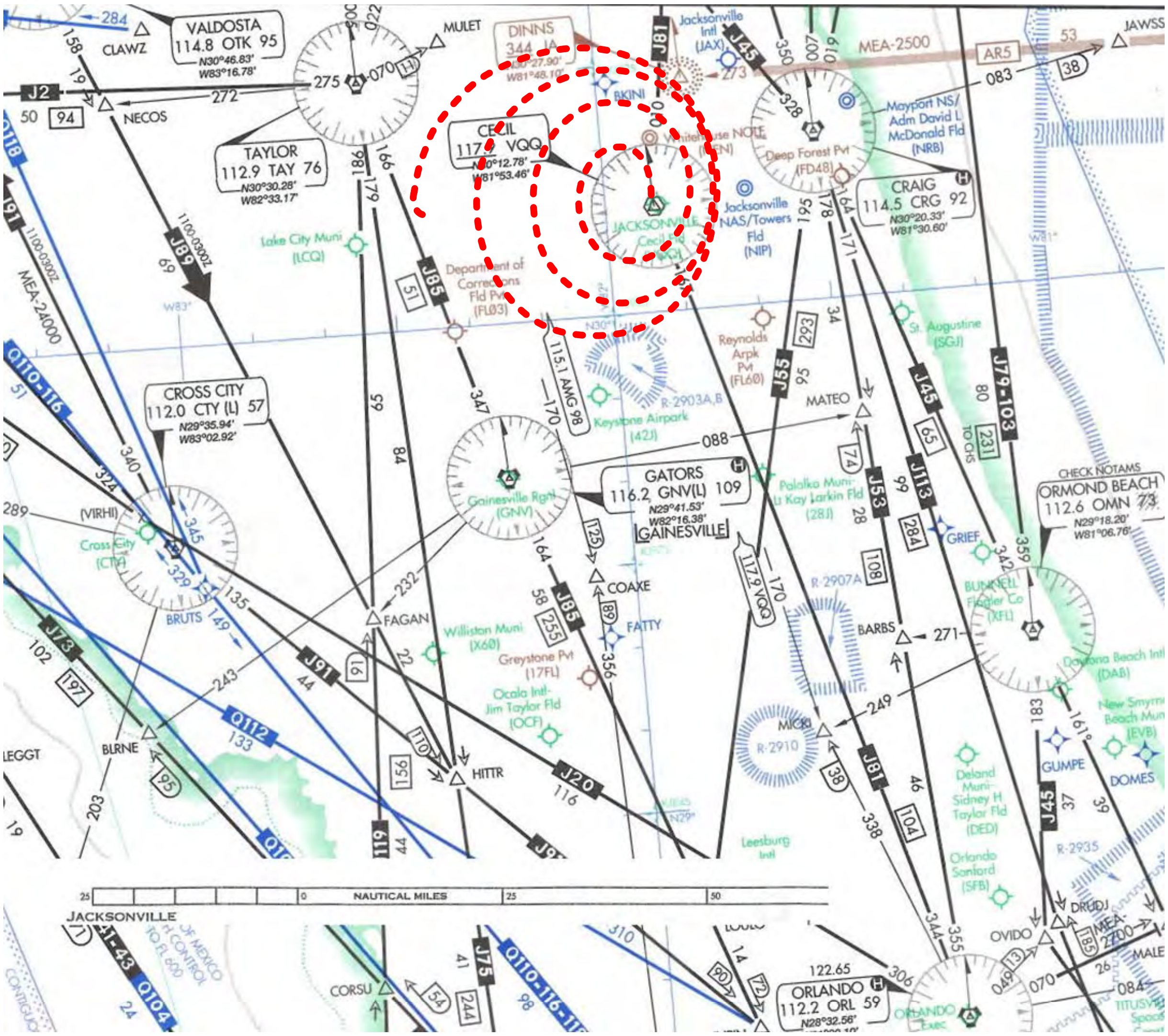


Figure 4 - WK2 Ascent Depicted on High Altitude Airway Chart

In Figure 4 above, the flight path is overlaid on a high altitude chart (180 feet and above). As on the low altitude chart, the center of the spiral is the takeoff point at Cecil Field and the left outer end of the spiral represents the planned release point for SS2 at 45,000 feet. In a high altitude abort, WK2 would most likely have time to advise controllers and delay release long enough to allow clearing of the airspace for landing of both vehicles (together or with SS2 released as long as WK2 was within the safety cone). If an emergency was declared, controllers could respond in an established manner, like any other aircraft. SS2 would be high enough for oxidizer jettison and could either land attached to WK2 or independently like a normal release, but with higher landing weight from the carried, non-jettisonable fuel.

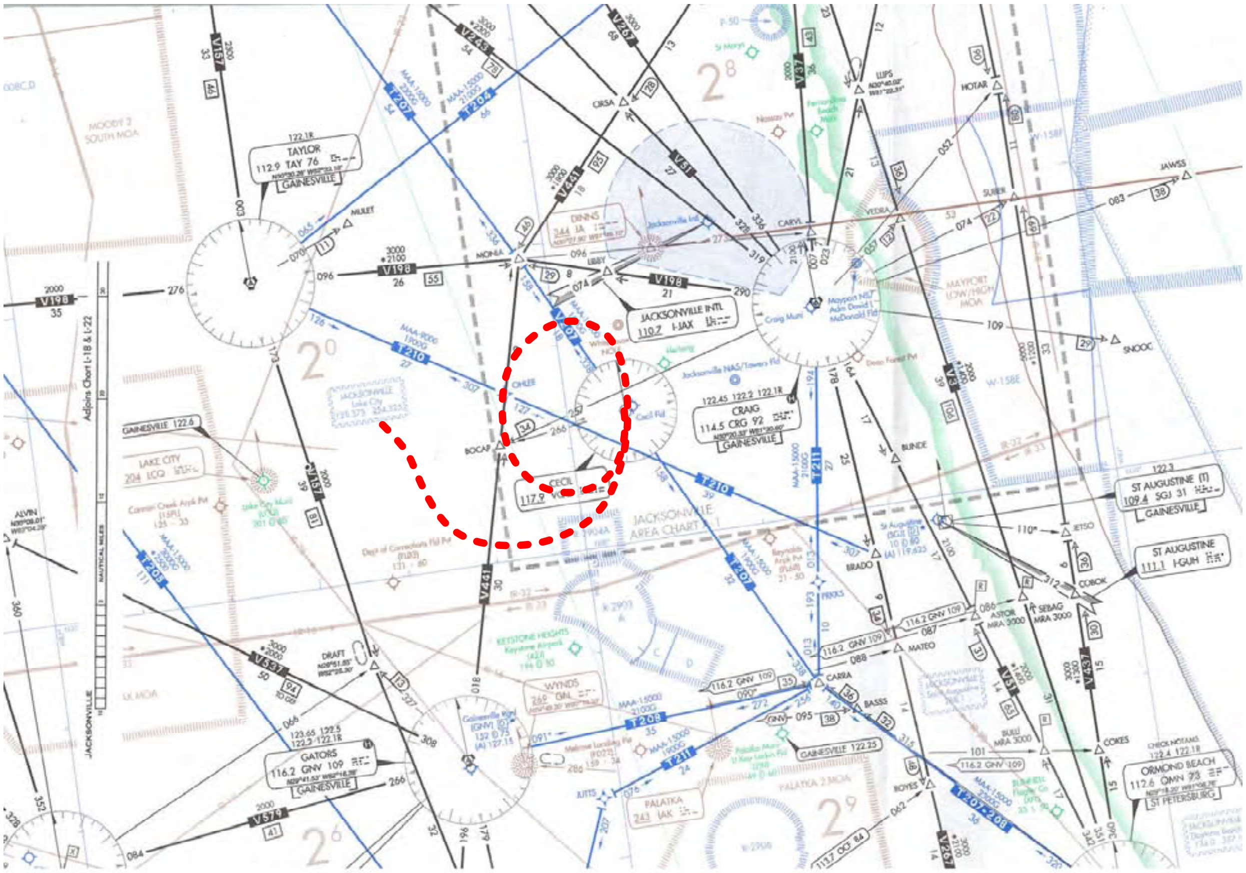


Figure 5 – SS2 Descent and Approach Depicted on Low Altitude Airway Chart

In Figure 5 above for the low altitude chart and Figure 6 below for high altitude, a normal SS2 return to Cecil Field is depicted. WK2 releases SS2 at around 45,000 feet near the left end of the depicted flight path. SS2 would ignite the rocket engine and perform a near vertical climb and descent, returning to the same area as release. SS2 would follow a smooth flight path to the high key point, increasing or decreasing the arc and descent rate to arrive at the appropriate high key altitude, direction, and speed.

If the rocket engine does not ignite, oxidizer would be dumped during the descent and the SS2 vehicle would fly nearly the same flight path at a slightly higher speed due to the additional weight of the un-jettisoned fuel. From the appropriate high key altitude, SS2 would perform a single 360 degree approach and landing. Arrival time from release would be accurately predictable based on release time and WK2 position.

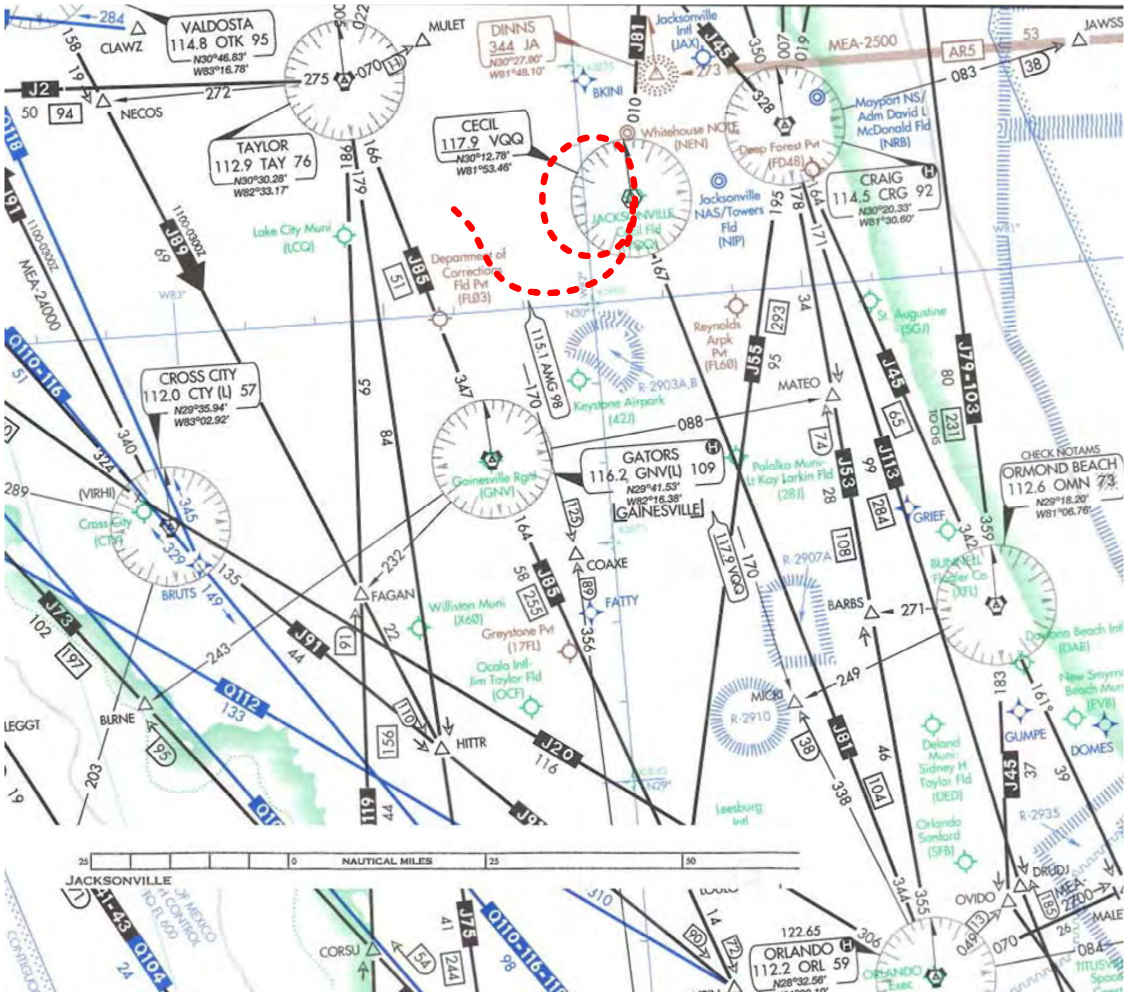


Figure 6 – SS2 Descent and Approach Depicted on High Altitude Airway Chart

NAS Interface

All aircraft participating in SS2's mission (other than SS2 itself), are capable of, and will be operating within the NAS under normal Federal Aviation Regulations (FARs).

SS2, due to its unique flight profile, will require clearance to land prior to release from WK2. Though this will take special consideration, the evolution (release from WK2 to landing) is very short in duration and highly predictable. In addition, there is flexibility in releasing SS2 from WK2 to allow for "realtime" contingencies to address non-mission related (other aircraft emergencies). Once SS2 is released, it is committed to land without interference.

Note that WhiteKnightTwo is *not* equipped with either an autopilot or a certified altimeter and therefore in NOT qualified for Reduced Vertical Separation Minimums (RVSM) operation for FL 290 – 410 (Certificate of Waver from Administrator in accordance with the relevant FARs).

FAA Approvals for Operations

The following issues should be resolved and implemented before commencing flight operations:

- Letter of Agreement/Memorandum of Understanding (LOA /MOU) between the Cecil Field facility and the vehicle operators in accordance with FARs.
- "Stereo Route"(that is, standardized and pre-planned) flight plan development
- Vehicle Certification
- Propulsion system certification

Conclusions

Normal operations for all aircraft (except SS2) are transparent to the FAA/NAS (present no special operational burdens or requirements) and operate under current FARs and flight plans/"stereo routes" defined by LOA between the facility and vehicle operators. All aircraft operating in coordination with the SS2 flight will fly within normal operating limitations.

The SS2 vehicle will require special consideration from takeoff from Cecil Field through clearing the runway after landing. These considerations can be broken into the following phases:

1. Any non emergency mission abort where WK2 does *not* release SS2 will result in a normal return to the runway under normal air traffic control procedures. This may involve an approach delay to jettison the onboard oxidizer.
2. If SS2 is released before reaching the minimum fully loaded abort altitude it will *not* be able to return to Cecil field safely and will initiate a forced landing with fuel and oxidizer onboard. Therefore, this phase must be carried out over a safe impact zone. Release of SS2 in this area would be considered extremely unlikely and would almost certainly result in serious damage (such as vehicle destruction and/or loss of life). This statement is

conjecture since we do not have any data from Virgin Galactic regarding off nominal events.

3. Minimum safe abort return altitude to (altitude providing sufficient time to dump all oxidizer). Abort in this zone would allow the SS2 to reach the runway threshold and land, but the vehicle would be carrying at least a partial load of oxidizer and a full solid fuel load that would create a risk.
4. "Fuel dump minimum altitude" to normal mission release altitude. Abort in this zone would allow for release of all oxidizer and a normal abort approach and landing. This phase abort would be flown like a normal mission from an airspace control perspective with the exception of the SS II being "n" minutes ahead of schedule and landing over normal landing weight from the mass of the solid fuel which could not be dumped.
5. Normal mission, handled in accordance with the LOA/ MOU.

Aside from SS2, this report does not analyze abnormal situations that could arise with other aircraft, since they will comply with the resepective FARs and their established procedures in their Pilot Operating Handbook.

Recommendations

Follow-on analysis with regards to SS2 is recommended:

For Associated Risks (not addressed by this report):

- National Transportation Safety Board (NTSB) – Fuel and oxidizer hazards
- Crash/explosion (public liability)
- Vehicle service life – long range airworthiness certification issues

For Public relations issues:

- Public safety
- Environmental impact
- Noise
- Oxidizer dumping
- Oxidizer and fuel ground shipping/handling

Future Concepts

Additionally, there are future concepts and technologies under development that will require further study to determine their impact on operational safety and their interface requirements on the NAS. Technologies with potential impact to safety include side effects from using and transporting cryogenic materials such as liquefied hydrogen and oxygen and highly toxic materials that will be proposed for flight use in attitude control systems, such as hydrazine. Storage, transfer, and fueling of vehicles at public facilities could create severe hazards that should be evaluated and mitigated before their use.

Although it does not apply to the Virgin Galactic proposed vehicles, several concepts may use vertical launch and high drag (parachute) or retro rocket recovery. This represents a whole new set of problems for operation in the NAS. These problems are not within the scope of this report.

While gathering data and developing scenarios for this report several different concepts of operation were discovered that are being developed by companies that can be expected to follow Virgin Galactic in seeking FAA support for operations with private access to space. These fall into the two main categories of vertical ballistic flight (non orbital) and orbital flight. None of the concepts for private orbital flight for hire is nearing maturity. The leaders seem to be SpaceX with the Falcon 9 launch vehicle and Dragon spacecraft (which would probably fly from established launch facilities such as Kennedy Space Center or the launch facilities at Kwajalein Atoll), Planet Space's Silver Dart orbital space plane, Scaled Composites/Virgin Galactic with the SpaceShipThree concept.

Virgin Galactic

The development of SS3 (as referenced above).

Rocketplane Inc.

Rocketplane is based out of Oklahoma City and their vehicle is based on stretching the Learjet 25 fuselages to make room for the kerosene and liquid oxygen tanks that will power a 36,000-pound thrust rocket engine. The stabilizers are removed and replaced with a V-tail to raise the nose when loaded with fuel. The standard, straight Lear wing is replaced with a delta wing, increasing surface area and adding sweep for reduction of drag divergence at supersonic speeds. Flight cost was estimated at $225,000 to $300,000.

In operation, twin GE CJ610 jet engines will provide power to a launch altitude of 25,000 feet where they will be shut down and the rocket engine will fire for a 70-sec, 4-g boost into space at a maximum speed of Mach 3.5 to Mach 4. After rocket engine shut down, passengers will experience four minutes of weightlessness.

Critical to safe Rocketplane operation is the computerized flight control system that will navigate the dynamic pressure and supersonic speeds of reentry. A Reaction Control System (RCS) must interact with the vehicles aerodynamic control surfaces throughout flight in the rarified atmosphere for reentry to prevent loss of control and exceeding the maximum safe dynamic pressure on the vehicle. The pilot will only take control in emergencies and for landings. The twin jet engines will be restarted at 20,000 feet. for a powered landing. Total flight time is estimated at about one hour.

The Rocketplane vehicle is planned to weigh 19,500 pounds at takeoff compared with the Learjet 25's 15,000 pounds. Operations are planned for the former Strategic Air Command base in Burns Flat, OK (now Oklahoma Spaceport). Rocketplane hopes to fly its first passengers beginning in 2010.

Numerous issues face the FAA with this concept, both in the safety and NAS integration areas.

XCOR Aerospace

The XCOR vehicle is also proposed to launch from a runway but unlike the Rocketplane concept does not use jet engines. A developmental vehicle has already been flown. (EZ-Rocket was a modified Rutan Long-EZ home-built airplane and is now retired.) EZ-Rocket was a manned technology demonstrator and flew 26 developmental missions using twin XR-4A3 (XCOR developed 400-pound thrust LOX/alcohol) engines. These engines are multiple air start capable and have made over 700 runs for a total of more than 165 minutes.

Although there is little verifiable information on the final passenger vehicle available yet, XCOR has stated preliminary design is underway. The suborbital vehicle has been named Xerus and is a single-stage suborbital vehicle designed for research, space tourism, and transporting microsatellites to low Earth orbit via a small secondary stage.

Numerous technical challenges must be addressed by XCOR before a final design and evaluation of their concept for NAS is feasible. Since these challenges are not yet resolved, such an evaluation is not within the scope of this study.

Additional Conceptual Vehicles (Less Mature Development):

In addition, the following vehicles were found that are at lower technology readiness levels and could be further developed into viable space access platforms.

- AERA Corporation Altairis
- ARCASPACE Orizont
- Da Vinci Project Wildfire
- Interorbital Systems Neutrino
- Masten Space Systems
- XA Series
- Space Adventures Explorer
- SpaceDev Dream Chaser
- Starchaser Industries Nova 2 and Thunderstar
- Truax Engineering, Inc. Volksrocket X-3
- XCOR Aerospace Lynx Rocketplane

Proposed orbital projects include:

- Interorbital Neptune
- Masten Space Systems O Series
- Rocketplane Kistler K-1
- T/Space Crew Transfer Vehicle

There are numerous other design concepts that may or may not warrant in-depth consideration. The vehicles and projects listed above have been evaluated and have some chance of being able to be developed into test vehicles, which in turn could affect future NAS operations at some level.

April - September 2009 Orbital and Suborbital Launch Events

Date			Vehicle	Site		Payload or Mission	Operator	Use	Vehicle Price	L	M
4/3/2009	√		Proton M	Baikonur	*	Eutelsat W2A	Eutelsat	Communications	$100M	S	S
4/3/2009			Atlas V 421	CCAFS		WGS 2	DoD	Communications	$125M	S	S
4/15/2009			Long March 3C	Xichang		Compass G2	CNSA	Navigation	$70M	S	S
4/20/2009			PSLV	Sriharikota		Risat 2	ISRO	Remote Sensing	$25M	S	S
						Anusat	ISRO	Communications			S
4/20/2009	√	+	Zenit 3SL	Odyssey Launch Platform		Sicral 1B	Italian MoD	Communications	$100M	S	S
4/22/2009			Long March 2C	Taiyuan		Yaogan 6	China - TBA	Remote Sensing	$25M	S	S
4/29/2009			Soyuz	Plesetsk		Kosmos 2450	Russian Space Forces	Classified	$60M	S	S
5/5/2009			Delta II 7920	VAFB		STSS-ATRR	Missile Defense Agency	Classified	$65M	S	S
5/7/2009			Soyuz	Baikonur		Progress ISS 33P	Roscosmos	ISS	$60M	S	S
5/11/2009			Shuttle Atlantis	KSC		STS 125	NASA	Crewed	N/A	S	S
						Hubble Servicing Mission 4	NASA	Other			S
5/14/2009			Ariane 5 ECA	Kourou		Herschel Space Observatory	ESA	Scientific	$220M	S	S
						Planck Surveyor	ESA	Scientific			S
5/16/2009	√		Proton M	Baikonur	*	Protostar II	Protostar Ltd.	Communications	$100M	S	S
5/19/2009			Minotaur	Wallops Flight Facility		TacSat 3	USAF	Development	$15M	S	S
						GeneSat 2	NASA	Scientific			S
						PharmaSat 1	NASA	Scientific			S
5/22/2009			Soyuz 2 1A	Plesetsk		Meridian 2	Russian MoD	Communications	$65M	S	S
5/27/2009			Soyuz	Baikonur		ISS 19S	Roscosmos	ISS	$60M	S	S
6/18/2009			Atlas V 401	CCAFS		Lunar Reconnaissance Orbiter	NASA	Scientific	$125M	S	S
						LCROSS	NASA	Scientific			S
6/21/2009	√		Zenit 3SLB	Baikonur	*	Measat 3A	MEASAT	Communications	$60M	S	S
6/27/2009	√	+	Delta IV Medium-Plus (4,2)	CCAFS		GOES O	NOAA	Meteorological	$100M	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.

April - September 2009 Launch Events (Continued)

Date			Vehicle	Site		Payload or Mission	Operator	Use	Vehicle Price	L	M
7/1/2009	√		Ariane 5 ECA	Kourou	*	TerreStar 1	TerreStar Networks	Communications	$220M	S	S
7/1/2009	√		Proton M	Baikonur	*	Sirius FM-5	Sirius Satellite Radio	Communications	$100M	S	S
7/6/2009			Rockot	Plesetsk		Kosmos 2452	Russian MoD	Communications	$15M	S	S
						Kosmos 2453	Russian MoD	Communications			S
7/13/2009	√	+	Falcon 1	Kwajalein Island		RazakSAT	Malaysia National Space Agency	Development	$8M	S	S
7/15/2009			Shuttle Endeavour	KSC		STS 127	NASA	Crewed	N/A	S	S
						AggieSat-2	Texas A&M University	Development			S
						BEVO 1	University of Texas - Austin	Development			S
7/21/2009			Kosmos 3M	Plesetsk		Kosmos 2454	Russian MoD	Navigation	$15M	S	S
						Sterkh 1	Russia - TBA	Other			S
7/24/2009			Soyuz	Baikonur		Progress ISS 34P	Roscosmos	ISS	$60M	S	S
7/29/2009	√		Dnepr 1	Baikonur		DubaiSat-1	Emirates Institution for Advanced Science and Technology	Remote Sensing	$12M	S	S
					*	AprizeStar 3	Aprize Satellite	Communications			S
					*	AprizeStar 4	Aprize Satellite	Communications			S
					*	DEIMOS	Deimos Imaging	Remote Sensing			S
						Nanosat 1B	INTA	Communications			S
						UK DMC 2	British National Space Centre	Remote Sensing			S
8/11/2009	√		Proton M	Baikonur	*	Asiasat 5	Asiasat	Communications	$100M	S	S
8/17/2009			Delta II 7925	CCAFS		Navstar GPS 2RM-8	USAF	Navigation	$65M	S	S
8/21/2009	√		Ariane 5 ECA	Kourou	*	JCSAT 12	JSAT	Communications	$220M	S	S
					*	Optus D3	Singtel/Optus	Communications			S
8/25/2009			KSLV 1	Naro Space Center		STSAT 2A	KARI	ISS	TBD	F	F
8/28/2009			Shuttle Discovery	KSC		STS 128	NASA	Crewed	N/A	S	S
8/31/2009	√		Long March 3B	Xichang	*	Palapa D	PT Indosat Tbk	Communications	$70M	P	P
9/8/2009			Atlas V 401	CCAFS		PAN	USA - TBA	Classified	$125M	S	S
9/10/2009			H-II B	Tanegashima		HTV	JAXA	ISS	$100M	S	S
9/17/2009			Soyuz	Baikonur		Meteor M1	Russian Meteorological Service	Meteorological	$60M	S	S
						Sumbandila	University of Stellenbosch	Development			S
9/18/2009	√		Proton M	Baikonur	*	Nimiq 5	Telesat Canada	Communications	$100M	S	S
9/23/2009			PSLV	Satish Dhawan Space Center		Oceansat 2	ISRO	Remote Sensing	$25M	S	S
						BeeSat	Technical University of Berlin	Development			S
						ITU-pSat	Istanbul Technical University Turkey	Scientific			S
						Rubin 9.1	OHB System	Scientific			S
						Rubin 9.2	OHB System	Development			S
						SwissCube-1	Ecole Polytechnique Federale De Lausanne	Scientific			S
						UWE-2	University of Wurzburg	Scientific			S
9/25/2009			Delta II 7920	CCAFS		STSS Demo 1	USAF	Development	$65M	S	S
						STSS Demo 2	USAF	Development			S
9/30/2009			Soyuz	Baikonur		ISS 20S	Roscosmos	Crewed	$60M	S	S

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October 2009 - March 2010 Projected Orbital and Suborbital Launches

Date			Vehicle	Site		Payload or Mission	Operator	Use	Vehicle Price
10/1/2009	√		Ariane 5 ECA	Kourou	*	Amazonas 2	Hispasat	Communications	$220M
						COMSATBw 1	EADS Astrium	Communications	
10/8/2009	√	+	Delta II 7920	VAFB	*	WorldView 2	DigitalGlobe	Remote Sensing	$65M
10/15/2009			Soyuz	Baikonur		Progress ISS 35P	Roscosmos	ISS	$60M
10/18/2009			Atlas V 401	VAFB		DMSP 5D-3-F18	DoD	Meteorological	$125M
10/29/2009	√		Ariane 5 ECA	Kourou	*	NSS 12	SES New Skies	Communications	$220M
					*	Thor 6	Telenor AS	Communications	
10/29/2009			Proton M	Baikonur		Glonass TBA	Russian MoD	Navigation	$90M
11/2/2009	√		Rockot	Plesetsk		SMOS	ESA	Remote Sensing	$15M
						Proba 2	ESA	Development	
11/10/2009			Soyuz	Baikonur		Mini Research Module 2	Roscosmos	Scientific	$60M
11/12/2009			Shuttle Discovery	KSC		STS 129	NASA	Crewed	N/A
11/14/2009	√	+	Atlas V 431	CCAFS	*	Intelsat 14	Intelsat	Communications	$125M
11/18/2009			Delta IV Medium-Plus (5,4)	CCAFS		WGS 3	DoD	Communications	$170M
11/28/2009			H-II A 2024	Tanegashima		IGS 4A	Japanese Defense Agency	Classified	$100M
11/29/2009	√	+	Falcon 9	CCAFS	*	Falcon 9 Demo Flight	SpaceX	Test	$40M
11/2009	√		Zenit-3SLB	Baikonur	*	Intelsat 15	Intelsat	Communications	$60M
11/2009			Dnepr 1	Baikonur		Prisma Main	Swedish Space Corporation	Development	$12M
						Prisma Target	Swedish Space Corporation	Development	
11/2009	√	+	Proton M	Baikonur	*	Eutelsat W7	Eutelsat	Communications	$100M
12/7/2009			Delta II 7320	VAFB		WISE	JPL	Scientific	$65M
12/10/2009			Ariane 5 GS	Kourou		Helios 2B	DGA	Classified	$220M
12/21/2009			Soyuz	Baikonur		ISS 21S	Roscosmos	ISS	$60M
12/2009	√		Dnepr 1	Baikonur	*	TanDEM X	Infoterra	Remote Sensing	$12M
4Q/2009	√		Proton M	Baikonur	*	MSV 1	Mobile Satellite Ventures	Communications	$100M
4Q/2009			Minotaur IV	VAFB		SBSS 1	USAF	Classified	$20M
4Q/2009	√		Proton M	Baikonur	*	Intelsat 16	Intelsat	Communications	$100M
4Q/2009			Long March 3A	Xichang		Beidou 4	CAST	Navigation	$60M
4Q/2009			Long March 4B	Taiyuan		Fengyun 3C	China Meteorological Administration	Meteorological	$60M
4Q/2009			Long March 3A	Xichang	*	DFH 4A	Chinese MPT	Communications	$60M
4Q/2009	√		Rockot	Plesetsk	*	SERVIS 2	USEF	Development	$15M
4Q/2009			Long March 4B	Taiyuan		Fengyun 3B	China Meteorological Administration	Meteorological	$60M

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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.

October 2009 - March 2010 Projected Launches (Continued)

Date			Vehicle	Site		Payload or Mission	Operator	Use	Vehicle Price
1/23/2010			Taurus XL	VAFB		GLORY	NASA GSFC	Scientific	$35M
2/3/2010			Atlas V 401	CCAFS		Solar Dynamics Observatory	NASA GSFC	Scientific	$125M
2/4/2010			Shuttle Endeavour	KSC		STS 130	NASA	Crewed	N/A
2/28/2010	√		Dnepr M	Baikonur		Cryosat 2	ESA	Remote Sensing	$12M
2/2010			Delta IV Medium	CCAFS		Navstar GPS 2F-01	USAF	Navigation	$170M
1Q/2010	√		Proton M	Baikonur	*	BADR-5	Arabsat	Communications	$100M
1Q/2010			Atlas V 541	CCAFS		MUOS 1	DoD	Communications	$125M
1Q/2010			Atlas V 501	CCAFS		X-37B OTV	USAF	Development	$125M
1Q/2010			Minotaur 4	VAFB		TacSat 4	USAF	Development	$20M
1Q/2010	√		Zenit 3SLB	Baikonur	*	AMC 1R	SES Americom	Communications	$60M
1Q/2010	√	+	Falcon 9	CCAFS		Dragon COTS Demo 2	SpaceX	Development	$40M
1Q/2010			PSLV	Sriharikota		Megha Tropiques	ISRO	Scientific	$25M
1Q/2010	√		Proton M	Baikonur	*	DirecTV 12	DIRECTV	Communications	$100M
					*	Arabsat 5A	Arabsat	Communications	

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