SPACE EXPLORATION 2007

Brian Harvey

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Front cover illustration: The first ever landing by a spacecraft on the moon of another planet! An artist's impression depicting the parachute descent of the European Space Agency's Huygens lander through the cloudy atmosphere of Saturn's largest moon Titan to its eventual historic touchdown on the surface. Image courtesy C. Carreau and the European Space Agency.

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Preface

WELCOME TO SPACE EXPLORATION, 2007

WELCOME TO *Space Exploration 2007*, the first of a series of annuals bringing readers the latest news, views, information and comment on space exploration. This book is the first in an annual series published by Praxis/Springer and aims to provide a balanced content of news and articles covering all the countries involved in space exploration, from the huge programme run by the United States to relative newcomers like India. The annual will look back to the great events in past space exploration, to future planned missions, such as the Bush plan to return to the moon and fly onward to Mars. The book will report on both manned, piloted missions and the pioneering voyages of unmanned space probes. The annual will cover the unspectacular but nonetheless important area of the application of space technology and how this can improve the quality of life on Earth.

For the first *Space Exploration* annual, a team of writers has presented a series of chapters on the cutting edge of manned and unmanned ventures into space today. First, many readers will have seen the International Space Station cross the night sky and Neville Kidger describes the progress in building the space station so far, with the promise of what's still to come. Second, we turn to the solar system and the remarkable progress made in its exploration over the past number of years. In chapter 3, David Harland writes of the results from the recent explorers of Mars. Chapter 4 is called *Solar system log* and Sean Solomon and Ralph McNutt, who are both leaders of the MESSENGER project, describe the United States' first probe to the Mercury in over thirty years. David Harland brings us results of exploration from two different ends of the solar system: Venus and Saturn. Rosaly Lopes writes about results from Titan while John Mason describes the extraordinary missions made to comets and asteroids over the past two years. Rick Greenberg focuses on the exploration of Jupiter's icy moons.

Chapter 5 looks forward to future space missions and especially the Vision for Space Exploration. John Catchpole describes how the American space agency, NASA, plans to return to the moon and fly astronauts to Mars, while Jim Oberg, in a thought-provoking article, looks at another, possibly better way of developing manned space exploration outside Earth orbit. The next chapters also look at future developments. Laurent de Angelis describes the new Soyuz launchpad in the south American jungle while Paolo Ulivi previews the forthcoming moon missions by China and India. Finally, it is easy to forget that Russia remains, in terms of launches made every year, the leading spacefaring nation in the world. Here, in chapter 8, Bart Hendricx examines Russia's plans for a new space shuttle, the Kliper.

Thanks are due to the writers who contributed, as well as the space agencies and individuals who provided illlustrations, such as NASA, ESA (www.esa.int), JAXA and Nicolas Pillet.

But first, in chapter 1 a review of important developments in 2005.


BUNNY
IN SPACE
ASTRO KAT
ROCKET MANUAL
CAT FOOD

PUBLISHER'S NOTE

IN MY youth I was an avid collector of 'annuals' which, in the UK, consisted of a large-format book containing strip cartoons, short stories and other items and puzzles designed to stimulate the imagination and therefore the learning process.

In developing the range of books in the Praxis imprint *Space Exploration* it occurred to me there was a real need for a book for enthusiasts of all ages on space exploration. I found a kindred spirit for this idea in Brian Harvey who is also a lover of annuals.

This provided the ideal opportunity to fulfill a longstanding ambition of mine to produce a book - an annual - containing various reviews of latest developments of discoveries in our Solar System. And let's illustrate the chapters with a series of one-page cartoons on the various topics, to lighten the learning curve and make the reader smile.

The cartoons show how the latest space missions, anniversaries and the people behind the missions could be seen through the eyes of a cat! This allowed me to have some 'publishing fun' with our cover designer and illustrator, Jim Wilkie, in developing this idea and thus immortalising my wife Jo's incredible 20-year old Russian Blue cat, Bunny, as AstroKat!

Sincere thanks go to Jim's wife, Rachael, for helping to shape and focus the cartoon ideas with Jim and to Arthur Foulser of BookEns, who surpassed the design challenge I set him for the layout of the text. To our intrepid *Space Exploration* Advisory Editor, John Mason, a big thank you for his work on the final selection of images and other essential detail.

I've always believed learning should be fun, so for the first time since I started the Praxis imprint over a decade ago, I decided to write a publisher's note to explain the thinking behind this book. To all readers, please enjoy this annual and other volumes in future years. This is the start of a classic series and the very first volume usually becomes a prime collector's item, so you should keep your copy as a treasure after reading it.

Finally, a big thank you to Harry Blom of Springer New York for his enthusiastic support for this project.

Clive J Horwood

■ *The Space Shuttle Discovery and its seven-member crew launched at 10:39 a.m. (EDT) on 26 July 2005 to begin the two-day journey to the International Space Station on the historic Return to Flight STS-114 mission.*
Image courtesy NASA.

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THE EPIC JOURNEY BEGINS...

The space age began in October 1957, and every year brings its own crop of exciting developments, new records, trends, launches and anniversaries.

Here *Brian Harvey* sets the scene with a review of the major events during 2005.

The Annual REVIEW

One of the dates that separate the old world from the new is 1957. On 4 October 1957, fifty years ago, the Soviet Union launched the first spacecraft, Sputnik. Early visionaries, going back to Herman Oberth and science fiction writers such as Jules Verne had dreamt of how people might one day fly in space. The first modern rocket, Wernher von Braun's A-4, known and feared as the V-2, was flown over the Baltic on 3 October 1942. Once the war was over, European, American and Russian engineers and scientists realized that the A-4 had brought technology to a level which could contemplate the putting into orbit of a small satellite. The early 1950s saw leading American companies, designers and think tanks put forward proposals for a small satellite that could orbit the Earth. In the Soviet Union, a satellite team was assembled by one of Russia's greatest designers, Mikhail Tikhonravov. They tried to interest their respective governments. But the cold war dominated the thinking of the two superpowers and their rulers were principally interested in missiles, not scientific satellites of questionable value.

The International Geophysical Year (IGY) provided a practical opportunity and political environment that would make the first satellite possible. Setting aside political differences, governments of the world declared 1958 a year for exploring the Earth's geophysical environment and the participant countries announced a series of experiments and observations based on land, sea and polar ice, using different kinds of equipment for observations and even using small sounding rockets. The promoters of scientific satellites eventually persuaded their governments that a small set of instruments placed in Earth orbit would be the perfect way to mark the geophysical year. An announcement by the United States government that it would launch a satellite during the year led to a similar announcement in Moscow and what became a race got under way.

The United States were the obvious winners of this race. The United States were much wealthier and had suffered none of the appalling damage to their homelands as had the Soviet Union during 1941-5. The American economy expanded throughout the 1950s, funding a boom in home-building, road construction and consumer spending.

Above: *The team that built the first Sputnik 50 years ago.*

America's scientific dominance was self-evident. The ranks of American scientists had not been decimated by purges. The Americans had taken the most knowledgeable of Germany's scientists westward, with their formidable experience not just in rocket engines but the associated disciplines of guidance, control and precision engineering. When the federal government eventually approved the satellite project, it opted for a civilian satellite put up by new rocket developed by the United States Navy, Vanguard, in preference to a development of the A-4 offered by von Braun. The decision was a complex one, shaped by inter-service rivalry, military vs civilian satellites and personal preferences.

A series of announcements by the Soviet Union of its plans to launch a satellite to mark the geophysical year attracted little attention - either in the west or the USSR itself. Western nations probably doubted that the Soviet Union had the capacity to do such a thing, neglecting recent demonstrations of scientific prowess such as its mastery of atomic power and the Tupolev 104 jetliner. Within the USSR, people had been brought up for years on the ideas of scientists and theorists. There had been science fiction films, space exhibitions and clubs for space travel since the 1920s.

Originally, the USSR planned to put up a large scientific satellite which the designers called 'object D'. It weighed 1.5 tonnes, marking a dramatic contrast to Vanguard's 1.5kg. The design of object D proved so difficult that chief designer Sergei Korolev substituted a much smaller, simpler satellite, the PS or Preliminary Satellite. He asked the builders to equip it with aerials so that its transmitter could be picked up by simple receivers over long distances. 'Object D' was not the only cause of difficulty on the Soviet side, for the rocket to launch it, the R-7, blew up several times during tests, not eventually flying until August 1957, its nosecone successfully impacting in the Pacific ocean.

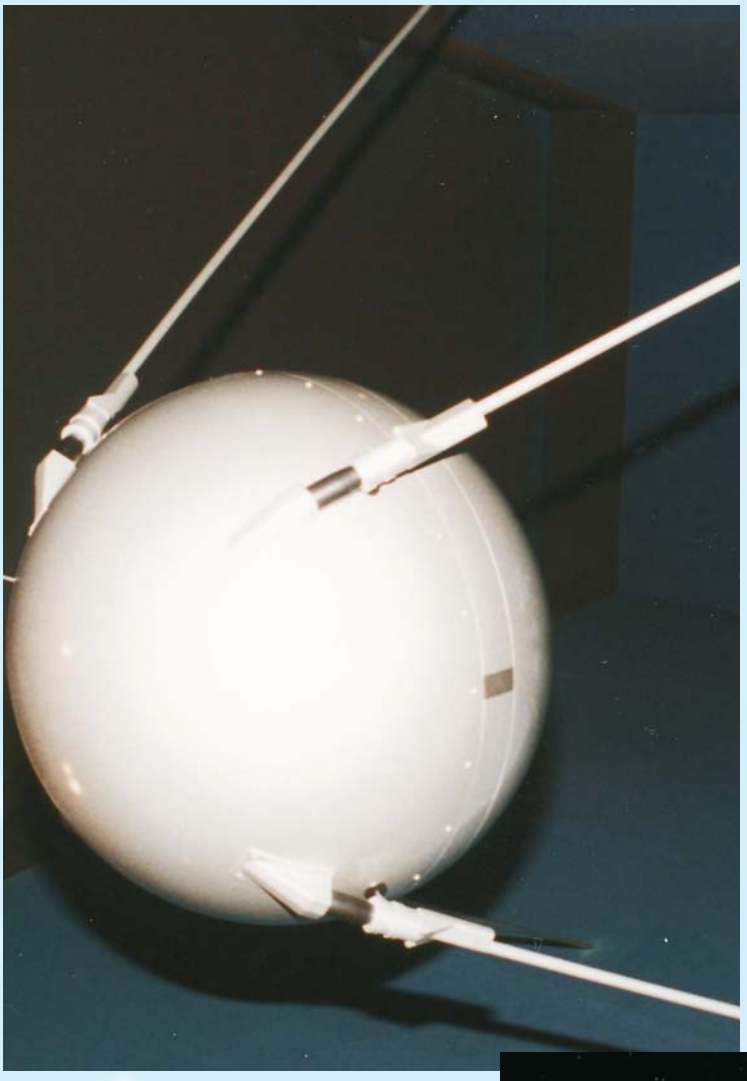
Sergei Korolev and his colleagues left us their memories of what happened on that never-to-be-forgotten day. They tell us of how Sputnik was placed on the top of its R-7 rocket, lying flat on its railcar in the steel hangar in Baikonour cosmodrome, Tyuratam. For the last time on Earth, the plug was taken out of the Sputnik to test its transmitter and the *beep! beep! beep!* could be heard, on amplifier, echoing around the hangar. The plug was reconnected and it fell silent. The next time the plug would be disconnected was to be in orbit and set the transmitter beeping again.

The first Earth satellite took off into a cold night sky. It was nearly midnight and Korolev and his colleagues watched the R-7's flames disappear into the high distance over the Kazakhstan desert to the east. There was nothing they could do now but wait for the 90mins that it took for Sputnik to circle the Earth and return over the launch site. After what must have been a lifetime, they gathered in the hangar to listen.

And eventually, they came, the tiny *beep! beep! beep*! sounds through the dark distance. Their joy knew no bounds and Korolev climbed a step ladder to make a short speech to his ecstatic colleagues. For many of them, getting the Sputnik into orbit was the culmination of their life's work. What Korolev told them was probably not what they expected, for he told them that this was just the beginning of a new life's work that would send cosmonauts into orbit and on to Mars.

Was this the excited reaction of the Kremlin? Not a bit of it. Korolev told Khruschev who told a party meeting of the accomplishment and then went to bed. The following morning's *Pravda* put the launching well down the front page, with the

Right: *Chief designer Sergei Korolev.*



bland heading of *Tass communiqué*, followed by three paragraphs. The British Broadcasting Corporation announced the launching at the end of the midnight news, but the tone of the announcer was uncertain, as if not knowing what to make of the event or its significance. Korolev and his colleagues prepared to take the long train journey back to Moscow.

It was only once they were on their way that the significance of the launching began to hit home. As the train chugged across the Kazakh steppe and the lowlands of the Volga, crowds surged forward to congratulate the designers on their achievement, their numbers and enthusiasm growing all the time. It took the leaders of the Kremlin less than a day to sense the pride which ordinary Soviet people took in the Sputnik. On 6 October 1957, the satellite was the only story on the *Pravda* front page. Across the world, the transmitter's little beep could be picked up by amateurs with little difficulty. With unintentional but exquisite timing, the launching came just as the world's space scientists were assembling for their annual conference in Barcelona, Spain. In the United States, phone calls rang during all day and all night as politicians, administrators and generals called one another to relay the stunning news. The political panic quickly set in. Children and adults went out into their back yards to watch the Sputnik (or more likely, its larger rocket stage) a pinpoint of light silently cross the dark autumn skies of the northern hemisphere.

There were only three Sputniks, a Russian word that means 'companion'. Sputnik 2, a similar design but with an animal cabin, carried the dog Laika into orbit a month later, the first living creature to fly (and sadly, to die) in space. Object D was the scientific laboratory planned as the original Sputnik and flew in May 1958 as Sputnik 3. But nothing was ever the same again after the first Sputnik on the night of 4 October 1957.

Top: *Sputnik 1.*

Above: *Japan's OICETS experimental communications satellite. Image courtesy JAXA.*

LAUNCH LOG 2005

12 Jan	**Deep Impact**	Cape Canaveral	**Delta II**	***United States***
20 Jan	**Cosmos 2414 Tatania**	Plesetsk	**Cosmos 3M**	***Russia***
3 Feb	**AMC-12**	Baikonour	**Proton M**	***Russia***
3 Feb	**USA 181**	Cape Canaveral	**Atlas IIIB**	***United States***
12 Feb	**XTAR Maqsat B2 Sloshsat**	Kourou	**Ariane 5**	***Europe***
26 Feb	**MTS-1**	Tanegashima	**H-IIA**	***Japan***
28 Feb	**Progress M-52**	Baikonour	**Soyuz U**	***Russia***
1 Mar	**XM-3 Rhythm**	Odyssey Platform	**Zenit 3SL**	***Russia/Ukraine***
11 Mar	**Inmarsat 4**	Cape Canaveral	**Atlas V**	***United States***
28 Mar	**TEKh 42**	ISS		***Russia***
30 Mar	**Express AM-2**	Baikonour	**Proton K**	***Russia***
11 Apr	**XSS**	Vandenberg AFB	**Minotaur**	***United States***
12 Apr	**APstar 6**	Xi Chang	**Long March 3B**	***China***
15 Apr	**DART**	Vandenberg AFB	**Pegasus**	***United States***
15 Apr	**Soyuz TMA-6**	Baikonour	**Soyuz FG**	***Russia***
26 Apr	**Spaceway F-1**	Odyssey Platform	**Zenit 3SL**	***Russia/Ukraine***
29 Apr	**Lacrosse/Onyx**	Cape Canaveral	**Delta IV**	***United States***
30 Apr	**USA 182**	Cape Canaveral	**Titan IVB**	***United States***
5 May	**Cartosat Hamsat**	Sriharikota	**PSLV**	***India***
20 May	**NOAA-18**	Vandenberg	**Delta II**	***United States***
22 May	**DirectTV-8**	Baikonour	**Proton M**	***Russia***
31 May	**Foton M-2**	Baikonour	**Soyuz U**	***Russia***
16 June	**Progress M-53**	Baikonour	**Soyuz U**	***Russia***
24 June	**Intelsat Americas/Telstar 8**	Odyssey Platform	**Zenit 3SL**	***Russia/Ukraine***
24 June	**Express AM3**	Baikonour	**Proton K**	***Russia***
6 July	**Shi Jian 7**	Jiuquan	**Long March 2D2**	***China***
10 July	**Astro E-2**	Kagoshima	**M-V**	***Japan***
26 Jul	**Discovery**	Cape Canaveral	**Shuttle STS-114**	***United States***

2 Aug	**FSW 21**	Jiuquan	**CZ - 2C**	***China***
11 Aug	**Thaicom4**	Kourou	**Ariane 5**	***Europe***
12 Aug	**MRO**	Cape Canaveral	**Atlas V**	***United States***
13 Aug	**Galaxy 14**	Baikonour	**Soyuz FG**	***Russia***
24 Aug	**OICETS** **INDEX**	Baikonour	**Dnepr**	***Russia***
26 Aug	**Monitor E**	Plesetsk	**Rockot**	***Russia***
29 Aug	**FSW 22**	Jiuquan	**CZ - 2D2**	***China***
2 Sep	**Cosmos 2415**	Baikonour	**Soyuz U**	***Russia***
8 Sep	**Progress M-54**	Baikonour	**Soyuz U**	***Russia***
9 Sep	**F-1R**	Baikonour	**Proton M**	***Russia***
22 Sep	**Streak/USA 185**	Vandenberg	**Minotaur**	***United States***
26 Sep	**GPS-IIIR**	Cape Canaveral	**Delta II**	***United States***
30 Sep	**Soyuz TMA-7**	Baikonour	**Soyuz FG**	***Russia***
12 Oct	**Shenzhou 6**	Jiuquan	**CZ-2F**	***China***
13 Oct	**Syracuse 3a** **Galaxy 15**	Kourou	**Ariane 5**	***Europe***
19 Oct	**USA 183**	Vandenberg	**Titan IVB**	***United States***
27 Oct	**Mozhayets 5** **Sina 1** **China DMC 4** **SSET Express: XIV1,** **UWE, NCube 2** **Topsat**	Plesetsk	**Cosmos 3M**	***Russia***
8 Nov	**Inmarsat**	Odyssey Platform	**Zenit 3SL**	***Russia/Ukraine***
9 Nov	**Venus Express**	Baikonour	**Soyuz FG Fregat**	***Russia***
16 Nov	**Spaceway 2** **Telkom 2**	Kourou	**Ariane 5**	***Europe***
21 Dec	**INSAT 4A** **MSG-2**	Kourou	**Ariane 5**	***Europe***
21 Dec	**Progress M-55**	Baikonour	**Soyuz U**	***Russia***
21 Dec	**Gonetz D1M** **Cosmos 2416**	Plesetsk	**Cosmos 3M**	***Russia***
25 Dec	**Cosmos 2417-9**	Baikonour	**Proton K**	***Russia***
28 Dec	**Giove 1**	Baikonour	**Soyuz FG Fregat**	***Russia***
29 Dec	**AMC-23**	Baikonour	**Proton M**	***Russia***

Here are some details. Starting with the first launch of the year, Cosmos 2414 was a military navigation satellite in the *Parus* series. Tatiana was a 23kg microsatellite to celebrate 250 years of the Moscow Lomonosov State University and designed to study magnetic fields (the satellite is also called Universiteski).

USA 181 was a classified American satellite operated by the National Reconnaissance Office and used for maritime surveillance. A subsatellite may have been deployed early in the mission. This was the last launch of the Atlas IIIB.

MTS-1 was Multifunctional Transport Satellite and marked the return to flight of Japan's H-IIA rocket. The H-IIA is Japan's main large launcher and had been grounded after a failure in November 2003. A vigorous programme of quality control had been put in place since, with an evidently successful outcome. MTS-1 is a satellite that combines functions of weather forecasting and air traffic control.

DART, or Demonstration of Automated Rendezvous Technology was a small 140kg experimental satellite intended to spend 18 months intercepting satellites and rocket stages at altitudes of up to 850km. There is nothing new about rendezvous in space: Vostok 3 and 4 passed close to one another in 1962. The Americans achieved the first rendezvous in 1965 (Gemini 6 and 7) while Russia's Cosmos 186 and 188 rendezvoused and docked together in 1967. The principal purpose of DART was to test out the capabilities of autonomous computer systems. All did not go well though, for although **DART** closed to within 100m of an old satellite launched in 1999, it soon became clear that it had used up nearly all of its fuel in doing so. NASA termed the mission a partial success - and a good learning experience for when such manoeuvres must be practised in Martian orbit in the future. Sent up only four days before DART, XSS was a small military satellite to test out rendezvous, autonomous and inspection technology.

USA-182 was a Lacrosse Onyx classified American radar imaging satellite.

Cartosat was a 1.5 tonne Earth resources and mapping satellite while Hamsat is a small, 42.5kg amateur radio satellite.

NOAA-18 was a weather satellite for the National Oceanic and Atmospheric Administration (NOAA) after which it is named and will collect data on the Earth's atmosphere, seasonal development and climate change.

Astro E-2 was Japan's fifth astronomical observatory in this series, replacing the earlier

Above: *Giove-1, the first satellite in Europe's new satellite navigation system was launched by a Soyuz Fregat launcher in December 2005. Image courtesy ESA*

Astro E-1 which failed at launch in February 2000. In line with the Japanese tradition of renaming satellites once they reach orbit, Astro E-2 was renamed Suzaki after a bird god. Suzaki is a 1,700kg observatory circling at 550km carrying an x-ray spectrometer, x-ray imaging spectrometer, hard-x-ray detector and five x-ray telescopes.

MRO was Mars Reconnaissance Orbiter (see David Harland: *Arrival at the red planet*, Chapter 3). It was the first of two interplanetary missions, the other being Venus Express, launched by Russia in November.

OICETS (Optical Inter Orbit Communications Engineering Test Satellite) was a Japanese satellite used to test laser communications systems in orbit. Originally intended for the cancelled Japanese J-1 launcher, OICETS was eventually transferred to a Russian Dnepr. Once in orbit it acquired the name Kirari. Accompanying OICETS was INDEX, the Innovative Technology Demonstration Experimental Satellite, which was given the name Rimei.

Cosmos 2415 was a recoverable military observation satellite in the *Kometa* series introduced in 1981 and used to compile high-accuracy military topographical maps. It was the first *Kometa* for five years.

Monitor was a new type of Earth observation satellite. Traditionally, Russian observation satellites were large and with Monitor, Russia follows Europe and other countries in flying smaller, high-quality observation systems on less expensive rockets.

Streak was a technology demonstrator with instruments to measure atomic hydrogen and atmospheric density.

GPS IIIR was a modernized version of the American Global Positioning System navigation satellite.

Syracuse 3a was a French military communications satellite.

The October Cosmos 3M launch from Plestsk had a complex set of payloads. The prime payload, the 80kg Mozhayets 5 was a training satellite built by the students of St Petersburg military academy, but it failed to detach from the rocket carrier and no signals were ever received. Topsat was a 120kg demonstrator imaging satellite of 2.5m resolution built by SSTL in Surrey, England, for the British Ministry of Defence. DMC-4 was a 150kg small satellite built by SSTL as China's part of the Disaster Monitoring Constellation and carries two cameras. SSETI Express was a European technology demonstrator built by students from 23 universities, but it suffered an electrical failure after a day in orbit. This carried three picosatellites, each weighing in at 1kg! NCube was built by Norwegian students while UWE was built by the University of Wurzberg to test telemetry, sensors and guidance. Cubesat XI-V was built by the University of Tokyo's Intelligent Space Systems Laboratory. The precise nature of the Sina-1 payload is uncertain. It was built by the OKB Polyot company in Omsk for Earth observations, but it has also been identified as an Iranian satellite.

USA 183 was a 19-tonne polar orbiting KH-11 digital photo-reconnaissance satellite, the fourteenth in the series begun in 1976 and which looks like the Hubble Space Telescope in appearance. The KH-11 series replaced the KH-9 series, which sent down recoverable film capsules in pods. USA 183 was expected to go into an orbit of 264 - 1,050km, 98°. This was the last launch of a Titan IVB rocket.

The following satellites were commercial launches by Russia: Galaxy 14, Anik F1R (for Canada) and AMC-23. The Zenit 3SL is used entirely for commercial satellite launches: *Rhythm* digital radio (following predecessors XM-1, *Rock* and XM-2, *Roll)*, Spaceway F1 high-definition TV and Inmarsat 4. The United States launched Inmarsat 4. The European Space Agency launched Thaicom 4, Galaxy 15, Spaceway 2, Telkom 2.

The following were domestic communications satellite launches: APstar 6 (China) and Express AM2 (Russia).

The last European launching of 2005 put two applications satellites into orbit: INSAT 4A, which will supply direct television throughout India and the second Meteosat Second Generation, a European weather satellite.

Gonetz D-1M was a Russian military communications satellite. Cosmos 2416 was a small military satellite. Cosmos 2417-9 were three satellites in the Russian navigation satellite system, GLONASS. These launches brought the strength of the GLONASS constellation to 17, two thirds of its intended strength of 24 satellites.

Giove 1 was the first satellite in Europe's new navigation satellite system called Galileo. Giove 1 was a test satellite built by SSTL in Surrey, England.

In addition, the TEKh nanosatellite, weighing only 4.5kg, was launched by the crew of the International Space Station from orbit in the course of a spacewalk on 28 March.