

The world's space systems

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It is difficult to find a single country in the world today that does not depend, in one way or another, on services provided by space systems. In our daily lives we rely increasingly on satellites for such matters as television and radio reception, telephone communications and the Internet, military and civilian security, weather forecasting, air traffic control and ensuring the security of bank transactions.

Hence even if there are still only a small number of space powers—understood as countries capable of building and launching a spacecraft—the entire international community has a stake in the smooth operation of space systems. This is a practical reflection of the 1967 Outer Space Treaty, Article 1 of which provides that the exploitation and use of outer space shall be the province of all mankind.

This article describes the various craft currently deployed in space, as well as the countries that have a significant space programme and industrial base.

Types of space systems

Many spacecraft are launched into orbit each year. They are all carried by rockets, with the exception of the United States Space Shuttle, which takes off and lands like an aircraft.

In 1945 the United States and the USSR took on the members of the German teams which had been working on the V-2 rocket at the Peenemunde site. As the technologies needed to manufacture a space launcher are broadly similar to those used for ballistic missiles, they pursued their initial ballistic missile and satellite launcher programmes in parallel. In both cases vertical thrust is followed by a curved trajectory; the payload is released by remote control at a precise moment. But the trajectory followed by the payload is different. In the case of ballistic missiles, the payload is guided to a target on the ground. For launchers, positioning engines are used to put the satellites into their final orbit.

Launchers come in various sizes, suited to carrying one or several satellites of different weights. The most common type of launcher is still a rocket launched from the ground that breaks up in orbit after launch. Research programmes are underway to develop reusable launcher systems (such as the manned United States Space Shuttle which has been operational since the 1980s) and systems involving rockets launched from aircraft.

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Currently, possession of launcher technologies is a sign of a credible and advanced space programme. It offers the only possibility of independent access to space and is of major political significance. While the development of such rockets is generally undertaken by national armed forces or space agencies, commercial firms often take over and offer launch programmes on a commercial basis.

Probes are generally sent on space exploration missions, while the United States Space Shuttle, certain versions of Russian rockets and the International Space Station transport or accommodate teams in orbit for both short and long periods, for purposes normally involving scientific research.

Since 1976, the Convention on Registration of Objects Launched into Outer Space has required states or organizations responsible for launches to place them on a 'register of objects launched into outer space'.¹ The purpose of this register is to facilitate efforts to hold launching states liable in the event of problems. States declaring launches are not required to reveal the precise nature of the payload carried by the rocket. Still, the figures provided in the register remain useful tools for evaluating the level of space activity in the world.

Among space systems, applications satellites are by far the most numerous. At the beginning of 2001, more than 2,600 civilian and military satellites were in orbit.² A wide variety of functions are listed for these satellites: navigation, observation, telecommunications, technical or scientific experiments.

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They have a number of different types of users: the scientific community, intelligence officers and other military officials, but above all the public, which purchases the services they provide on commercial markets.

The service life of satellites varies and there is a growing problem caused by the presence of inactive satellites and rocket fragments in space around the Earth. This debris presents a hazard for other satellites, since it can cause damage through collisions. It eventually burns up and disappears when it re-enters the atmosphere, but this does not occur at a sufficiently rapid rate to solve the problem. International discussions are underway in an attempt to curb or reduce the amount of debris circulating in space.

The space powers

Some commercial satellites belong to countries that have no independent capability in space technology. Egypt, for example, has two Nilesat direct television satellites; Thailand has three Thaicom telecommunication satellites; and Indonesia has a fleet of seven satellites covering all areas of telecommunications. Local operators have purchased these satellites from firms in Europe, the United States or elsewhere, and their services cover extensive geographical areas.

In this way, even if they do not possess the technologies required to be regarded as fully fledged space powers, many states have interests in space. Of course, individuals who make use of the services provided by satellites are found in every country.

If a narrower definition is used, the number of space powers diminishes. Some countries are fairly well advanced in satellite manufacture, for example Pakistan, which launched the Badr-B meteorological observation satellite in 2001. But the countries described below are those that have both satellite programmes and relatively advanced launcher programmes. Not surprisingly, there are major differences in the resources they possess and in their achievements to date.

UNITED STATES

The United States, which together with the USSR, was a pioneer in the conquest of space from the 1950s onwards, remains the world's number one space power. The civilian and military space budget in the United States was estimated at US\$27 billion in 2001. Thanks to its experience and resources, it is a clear leader in all space-related areas.

The United States has a powerful industrial base. Following the concentration of companies in this sector during the 1990s, there are two firms with main contractor status for satellite launchers: Boeing, with the Delta family of rockets, and Lockheed Martin, with the Atlas family of rockets. There is also a substantial industrial fabric in the shape of subcontractors. Space industries in the United States have major market shares in sales of launchers and satellites.

For some years, these firms have been facing serious economic difficulties, partially due to the fact that since 1998 American regulations governing the export of sensitive equipment have been tightened, hampering the sale of satellites overseas. The crisis in the telecommunications sector has also cut demand for satellites and launchers at the very time when supply has grown in various countries. Yet these companies receive substantial aid from the public sector. The civilian and scientific programmes supervised by NASA are substantial, for example, the Space Shuttle. The Shuttle services the International Space Station. But NASA's ambitions are turning towards other goals, in particular the proposed Mars exploration programme.

The United States military space programme is certainly the most advanced programme in the world today. Space has been used to obtain strategic intelligence since the 1960s, when observation satellites were used to map Soviet military bases. In the 1990s, tactical support systems for ground forces began to be available for large-scale regional operations such as the Gulf War. Satellites for meteorology, navigation, targeting and, of course, telecommunications provide near real-time services to the troops deployed on the ground.

The arrival of Donald Rumsfeld in the Pentagon has given a boost to research on a third and new category of military space facilities. The official view is that the fleets of satellites in orbit, on which the defence of the United States is now so dependent, must be protected at any cost. This protection is understood in both the 'passive' and the 'active' senses.³ Teams of researchers are working to upgrade satellites to cope with the threat of jamming, for example, but also on systems to attack enemy satellites.

The various laboratories run by the United States armed forces are engaged in research and development programmes on anti-satellite (ASAT) weapons that make use of a variety of highly innovative technologies. The Department of Defense considers chemical and kinetic interceptors and low-energy lasers to be the easiest to produce. Nuclear weapons and radio-frequency weapons are more complex, while high-energy lasers and particle rays are further from reach. The Air Force is studying a space-based laser system and a ground-based system for jamming satellites (space control technology); the Army is developing a ground-based satellite interceptor (kinetic energy anti-satellite weapon or KE-ASAT); and a ground-based laser known as MIRACL (mid-infrared advanced chemical laser) was tested in 1997.⁴ However, the development of ASAT weapons is contentious in the United States.⁵

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Lastly, there is rising concern that the space facilities of the major powers are vulnerable to certain attacks. The necessity to protect space assets is sometimes used as the justification for the militarization of outer space. Yet it should be recalled that even with simple conventional terrestrial capabilities it is

possible to interfere with the smooth operation of military or civilian space systems. An explosive charge set off in a ground station could temporarily deny access to a satellite application.

RUSSIAN FEDERATION

Starting in the 1950s, the USSR vied with the United States for primacy in the conquest of space. The Soviet Union recorded many high-profile 'firsts': from the first satellite, Sputnik, launched in 1957, and Yuri Gagarin, the first man in space in 1961, to the first permanent orbiting station, Mir, deployed in 1986. Above and beyond prestige, the USSR was also in pursuit of certain military applications. Following the START disarmament agreements, in 1993 and 1994, the former Soviet SS-12M and SS-25 missiles were converted into commercial rockets (Rokot and Start respectively). Soviet missile technologies retained many similarities with those developed for satellite launches. In the same way, the Proton rocket, initially a missile, has become a launcher in the process of its development. The Kosmos series of satellites carried out all the missions demanded by the Soviet authorities, civilian and military.

The collapse of the USSR in 1991 led to a number of problems for its space programmes. The first stemmed from the fact that the former Soviet launch sites were dispersed among various republics. The Russian Federation retained the Plesetsk launch site and constructed a new site at Svobodny, but the Baikonur site is now in Kazakhstan. Ukraine, which still has a major industrial base in the space field, has no launch site within its borders. It has contributed to the construction of a launch site on the ocean as part of the international joint venture Sea Launch.

The second consequence was that the Russian space budget shrunk from US\$6 billion in 1992 to an estimated US\$1 billion in 2001. Consequently, the programmes suffered a marked slowdown. The United States devised the International Space Station programme partly in order to prevent ex-Soviet engineers from exporting their missile-related know-how to countries considered to be dangerous. The programme provides work and funding that keep the Russian teams in their present posts.

Russian rocket engine technologies have also caught the interest of Western companies, as they are often cheaper and offer different features than others on the market. Western companies have initiated cooperation with firms in the former Soviet Union. International Launch Services, an American-Russian joint venture, handles the launching of Atlas satellites constructed by Lockheed Martin and Proton rockets built by Khrunichev in the Russian Federation. The other American-Russian joint venture is the previously mentioned Sea Launch, which also has Ukrainian and Anglo-Norwegian partners. The European Arianespace has set up Starsem, a company that sells space on Soyuz rocket launches.

The beginning of this cooperation dates from the mid-1990s, when industrialists expected strong demand for telecommunications satellites and launches. This market has since collapsed, and the fact that Western industries have taken over some functions in respect of ex-Soviet launchers is now adding to the problem of over-capacity on the launcher market.

EUROPE

The European countries embarked on space programmes at the beginning of the 1960s. In contrast to the United States and the Soviet Union, their main motivation was not the development of military applications, nor space exploration, but the development of commercial civilian systems. Europe's space budget stood at US\$6 billion in 2001.

It is a complex matter to evaluate European influence in the space field because of the large number of stakeholders and programmes. Most states have a national programme. France's budget is usually the most significant, with a notable portion attributed to military space developments. There are also a number of programmes being pursued jointly by two or three states. But most of Europe's achievements in space take place under the auspices of the European Space Agency, made up of fifteen European countries.

Europe now administers large telecommunication and meteorology systems and is involved in many scientific research programmes. The Ariane launcher has the largest share of the world market for the launching of commercial satellites in geostationary orbit.

Europe's space industries have been hard hit by the current crisis in demand for telecommunications satellites. They receive less assistance from public funds than their partners in the United States. Yet a promising recent development is related to the fact that the European Union has been assigned functions in the space field. The proposed Galileo navigation programme and the Earth observation programme known as GMES (Global Monitoring for Environment and Security) reflect new space ambitions for Europe, which have been entrusted to the European Commission.

CHINA

While it is hard to ascertain the scale of China's military programme, the progress made in Chinese technology may be assessed through its commercial programmes. In 2001, China had thirty-one satellites in orbit, including eleven telecommunications satellites. The commercial aspects of its range of Long March launchers have been in the hands of the China Great Wall Industry Corporation since the end of the 1980s.

Chinese rockets were used to launch many American satellites up to 1998, when Lockheed Martin and Hughes were accused of having transferred too much technological information to their Chinese partners. These scandals led to tighter controls in the United States on the export of sensitive equipment, and the American government banned American companies launching their satellites from China.

China's space budget was estimated at US\$1 billion in 2001. The Chinese government announced its ambitious new space programme in 2001, which will continue the manned flight programme initiated in 1999. A 'taikonaut'⁶ is due to fly on the Chinese shuttle Shenzhou by 2005.⁷

JAPAN

Japan was relatively late in developing its space capabilities. The total space budget, equivalent to US\$2.5 billion, is small in relation to Japan's GDP. The restrictions on the country's military ambitions, together with the lack of large-scale market opportunities for space programmes, have discouraged efforts by Japanese industry. Progress in these programmes cannot be compared with that in the motor vehicle or computer sectors, which have been market leaders since the 1970s.

Yet the importance of the National Space Development Agency and the enthusiasm of political leaders for space programmes seems to be rising. Work is well advanced on the ALOS, ADEOS-II and EOS-Aqua Earth observation satellites, the successors to already operational satellites. Japan is also an active participant in cooperative scientific research and in the International Space Station programme.

Following a series of failures, Japan's H-IIA rocket placed four satellites into orbit on 14 December 2002. The Agency plans to launch a further ten H-IIA rockets between now and 2005, when the launcher is due to be privatized. Mitsubishi Heavy Industries has expressed interest.⁸ The entry of this new participant into the market is causing concern among commercial enterprises in other countries, which are already suffering from a drop in orders.

Japan's constitution places strong constraints on acquiring very extensive military capabilities, and consequently the Japanese rocket programme has not led to a parallel programme to produce ballistic missiles.

INDIA

India's space programme enjoys high political priority. Although the national space budget stood at only US\$300 million in 2001, it is large in relation to the country's GDP. Moreover, production and labour costs are lower than in the West, and as a result much can be done with this sum.

India's achievements in space matters are fairly substantial. The family of IRS observation satellites may be found on commercial markets, and compete with the European system Spot.

India's position within the Non-Aligned Movement means that the country did not develop strong ties with either the West or the Soviet bloc during the Cold War. This has had repercussions for the national space programme. The heads of the Indian Space Research Organisation, India's space agency, and the military personnel handling space issues have become accustomed to operating independently. India plays only a small role in international space cooperation programmes.

India already possesses a rocket capable of launching satellites into polar orbit—the Polar Satellite Launch Vehicle. In April 2001, India launched its first satellite into geostationary orbit, using the Geostationary Satellite Launch Vehicle (GSLV). This programme, which started in the 1980s, was held up for at least six years during the 1990s for political reasons. As part of its missile non-proliferation policy, the United States imposed sanctions on India in 1992 in order to obstruct a 1988 agreement for the delivery of equipment and technologies from the Russian Federation. Negotiations among the three states were completed only in 1998, with a delivery of Russian equipment on terms acceptable to the United States.⁹ With this new launcher, India, which hitherto had been a good customer of the European company Arianespace, has become self-sufficient for its launches.

Given that India has developed short-range and medium-range missile systems—Prithvi (with a range of 150–250km) and Agni (up to 2,500km)—fears that a space launcher may be converted into an intercontinental missile must be taken into account.

ISRAEL

Israel's space budget stands at only about US\$50 million a year.¹⁰ In the context of the current crisis there is a risk that it will be cut further.

However, Israel's achievements, the fruit of cooperation with the United States, European, Russian and Ukrainian space agencies, are notable. A score of space enterprises and a few university and military research laboratories are active in the country.

Israel's space agency was set up in 1983. Since then, Israel has developed a number of satellite applications. The fifth Offek military observation satellite was launched in May 2002; a commercial

Earth Resources Observation Satellite has been operational since 2000, with a second scheduled for 2004. The first Amos telecommunication satellite was launched in 1996, and more will be launched from 2003 onwards.

Israel is trying to position itself in certain niches such as satellite miniaturization, electric boosters for satellite trajectory modification, and seismic applications of navigation.

Lastly, Israel has developed a launcher system, Shavit, which was used to launch the first Offek satellite in 1988. The company Israel Aircraft Industries, which is in charge of its development, is counting on a growing demand for the launching of small satellites. The current LK-A model is designed to launch 250kg satellites into low elliptical polar orbit (240–600km); the LK-1 system currently under development will launch 350kg satellites into a circular polar orbit (700km).

Israel has a number of operational missile systems. The currently deployed Jericho 2 missile, which may correspond to the first two stages of the Shavit rocket, achieved ranges of 850–1,300km during tests in 1987 and 1989. According to analysts at the Lawrence Livermore National Laboratory, the Shavit rocket could achieve a range of 5,000km if converted into a ballistic missile.

BRAZIL

Brazil carried out a launcher development programme during the 1970s and 1980s, but its enthusiasm for the programme has waned since the programme for the development of nuclear weapons and ballistic vectors was officially abandoned in 1990. Two of its small VLS rockets were tested, in 1997 and 1999, and Brazil has two launch sites (Barreira do Inferno and Alcantara).

The country nevertheless has a relatively well-developed industrial base for space activities. Companies that merit mention are Elebra (data processing, radar and telecommunications), Embraer (participates in manufacturing the SCD-1 satellite and in the VLS launcher project), Avibras (rocket probes), Cenic (composites for the VLS launcher), Mectron (satellite control software and data-gathering systems), Digicon (components for satellites, assembly of solar panels in cooperation with the German company MBB) and Akros (dynamic and static testing for satellites, structural analysis, technical documentation). These companies enjoy solid institutional support, within the framework of a national space agency and several research institutes.

Brazil has placed a number of data-gathering satellites in orbit: SCD-1 in 1993 and SCD-2 in 1998. It is also participating in several international projects: the CBERS observation satellite programme with China, a scientific micro-satellite project with the Centre national d'études spatiales (CNES, the French national space studies centre), and has a small role in the International Space Station.

Conclusion

The interest of states in acquiring space capabilities seems to have changed over the past ten years.

Some countries, such as Brazil and South Africa, have abandoned their ambitions in the nuclear and missile fields and consequently seem to be less committed to the pursuit of a space programme. Others, in contrast, such as Pakistan, Iraq and North Korea, are maintaining their missile programmes and for the time being are not seeking to develop civilian applications for these rockets.

Considerations of international prestige and the expansion of trade underlie many innovative space programmes. The development of advanced space capabilities remains a major element of technological and political credibility for rising regional powers, as it was for the United States and the USSR during the 1960s. More recently, prestige might have been a motivating factor for India embarking on its space programme.

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The development of space systems for commercial purposes was another important aim during the 1990s. The strong demand expected in space-related markets held out the hope of substantial profits in the sector covering launchers as well as telecommunication and observation satellites. The current slowdown in demand is dampening competition among the potential space powers. The economic crisis in Asia has also deterred possible candidates. In this context, Japan's enthusiasm seems to run against the tide.

Where the established space powers are concerned, the present situation is an interesting one. Commercial competition is increasing in an already tight market. The drop in demand is accentuating the downward pressure on launcher and satellite prices, and space-sector companies have reached a critical point. Until now, they have reacted to these difficulties by calling for ever-larger state subsidies. Space powers such as Europe cannot go on responding to these demands. In the medium term it seems inevitable that to some extent, without going as far as to establish cartels, markets will be divided up among companies, to curb the fall in prices and lessen the appetite for public funding.

Notes

1. Text available at < <http://www.oosa.unvienna.org/SORegister/registxt.htm> > .
2. Unless otherwise stated, all figures are from Isabelle Sourbès-Verger, 2001, *L'espace dans le monde, Géoeconomie*, no. 20 (winter), pp. 49–61.
3. *Report of the Commission to Assess United States National Security Space Management and Organization*, Washington DC (Public Law 106-65), 11 January 2001, available at < <http://www.space.gov/docs/fullreport.pdf> > , known as the 2001 Space Commission.
4. See article in this issue of *Disarmament Forum* by Theresa Hitchens, page 15.
5. Marcia Smith, U.S. Space Programs: Civilian, Military and Commercial, *CRS Issue Brief IB92011*, 2 May 2001.
6. Each language has coined its own word for the persons sent into space, including astronauts in English, cosmonauts in Russian, spationautes in French and taikonauts in Chinese.
7. Marc Boucher, 2000, *Shenzhou 2 Launch Imminent, Chinese Manned Space Program Targets the Moon*, 30 October 2000, available at < <http://www.spaceref.com/news/viewnews.html?id=239> > .
8. Space and Tech, 2002, *Japan's H2A launches experimental DRTS and USERS spacecraft*, 10 September, available at < <http://www.spaceandtech.com/digest/flash2002/flash2002-076.shtml> > .
9. Philip Clark, 2001, *India's GSLV reaches orbit, but can it be a contender?*, *Jane's.com*, 20 April, available at < http://www.janes.com/aerospace/civil/news/misc/jsd010420_1_n.shtml > .
10. *Israel Space Agency Aims High Despite Low Budget*, AFP, 18 July 2002.