This principle encouraged the development of the Italian space industry. Italy's major space companies have been Thales Alenia Spazio (previously Alenia Space) (living structures, scientific satellites, and telecommunications) and Avio (space propulsion), both of Gruppo Finmeccanica, and Gavazzi Space (small scientific satellites). Between 1964 and 2007, Italy contracted with NASA, Arianespace, Kosmotras, Indian Space Research Organisation (ISRO), and Cosmos International to launch 19 satellites into orbit. Among these were three types of microsatellite: *Itamsat 1* for radio amateurs, two Unisat experimental satellites for the University of Rome, and three communications satellites owned by private companies.

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See also: Alcatel Alenia Space, European Space Agency, European Space Research Organisation, European Space Vehicle Launcher Development Organisation, *International Space Station*, *Spacelab*

Bibliography

Giovanni Caprara, *The Complete Encyclopedia of Space Satellites* (1986).
———, *L'Italia nello spazio* (1992).
———, *Living in Space* (2000).
M. De Maria, L. Orlando, and F. Pigliacelli, *Italy in Space*, ESA HSR-30 (2003).

Japan

Japan has developed an incremental, risk-averse, but relatively consistent space program that has included launch vehicles and a variety of spacecraft. Post–World War II constitutional limitations on military development, early twenty-first-century economic stagnation and consequent funding limitations, a primarily bottom-up policy making process, and the conservative nature of Japanese culture have limited the scale of program initiatives.

In 1955, in preparation for the International Geophysical Year (IGY), University of Tokyo Professor Hideo Itokawa, working with several colleagues, launched the tiny "Pencil Rocket." Within three years, they had developed the K (Kappa) sounding rocket as part of Japan's contribution to IGY. Many of the scientists working on these programs, and eventually their students, became members of the Institute of Space and Astronautical Science (ISAS), created in 1964–65 as part of the University of Tokyo.

After 1969 Japan's space program took shape and considered more ambitious plans beyond the academic realm. The National Space Development Agency (NASDA) was created in 1969 from the Space Development Promotion Section of the Science and Technology Agency (STA) with responsibility for the applications aspects of space development and a commensurately large budget. It received primary funding from the STA. NASDA reported to the Space Activities Commission, housed in Japan's Prime Minister's Office.

Japanese astronaut Soichi Noguchi waves from the Shuttle payload bay during STS-114. (Courtesy NASA)

While NASDA focused on space applications, science remained the responsibility of academics. ISAS deemed it critical to launch one satellite per year, even if it meant sacrificing scale for frequency, to ensure that graduate students, usually in a five-year education cycle, would have the opportunity to be involved with a flight experiment. It was increasingly clear to government officials that the University of Tokyo was too small to manage this growing enterprise. Consequently, in 1981 ISAS was reborn as a joint research organization among Japanese universities, under the purview of the Ministry of Education.

Another Japanese space participant, the National Aerospace Laboratory (NAL), was founded in 1955 as a national research laboratory, under the authority of STA, with its areas of focus expanded in 1969. NAL's mandate included conducting basic, advanced, and applied research. Together NASDA, ISAS, and NAL formed the nucleus of Japan's space program for several decades, occasionally joined by other organizations, such as the Ministry of Posts and Telecommunications and the Ministry of International Trade and Industry, according to a given program's functional nature. In 2003 NASDA, ISAS, and NAL merged to form the Japanese Aerospace Exploration Agency (JAXA). ISAS became one of JAXA's four departments, which also included Strategic Planning and Management Department, Office of Space Flight and Operations, and Office of Space Applications.

At the time of the merger, ISAS had 301 employees and a budget of $162 million. Programs undertaken by ISAS included development of the L (Lambda) and M (Mu) series launch vehicles; *Ohsumi*, Japan's first satellite, launched in 1970; interplanetary missions such as *Lunar A*; programs undertaken with international cooperation (*Suisei* and *Sakigake* as part of the Halley's Comet mission in 1985–86 and *Geotail* with NASA as part of the ISAS solar terrestrial science program); the *Hayabusa* sample return probe; and a variety of other projects, including research on scientific ballooning. ISAS and its predecessor organization successfully launched 25 scientific satellites and probes.

NASDA, with a 2003 budget of approximately $1.7 billion and 1,090 employees, focused on launch vehicles, participation in the International Space Station (ISS) program, satellites and applications, and general research and development. Initial programs undertaken by NASDA to develop launch technology, specifically the N series, were licensed U.S. technology. With the later H series, Japan began indigenous technology development. As of 2010 Japan had launch sites on Kagoshima, on Kyushu Island (originally called Kagoshima Launch Center but renamed Uchinoura Space Center in 2003), and on Tanegashima Island south of Kyushu. Both could only operate at certain times each year because of pressure from Japan's fishing lobby. These restrictions hampered Japan's launch program and contributed to its difficulties with marketing the H-I and entirely indigenous H-II rockets as commercial launch vehicles. Programs undertaken by NASDA included participation in the ISS program with the *Japanese Experimental Module* (*JEM*) *Kibo*, with the first piece delivered to the *ISS* in March 2008. Although Japan had not independently pursued a human spaceflight program, it participated in those of the United States and the former Soviet Union. Journalist Toyohiro Akiyama flew on the Soviet *Soyuz TM* (Transport Modification) *11* mission in December 1990. NASDA astronaut Mamoru Mohri flew on the Space Shuttle Space Transportation System (STS)-47 mission in 1992. By 2010 an additional six astronauts (Chiaki Mukai, Kouichi Wakata, Takao Doi, Soichi Noguchi, Naoko Yamazaki, and Akihiko Hoshide) had completed space missions.

NAL, with a 2003 budget of approximately $28 million and 424 employees, focused on space technology and aeronautical technology, especially spaceplanes and airplanes. NAL often supported NASDA programs. For example it developed the LE-5 engine for the second stage of the H-I and H-II rockets.

In the early 1990s ISAS, NASDA, and NAL experienced incremental budget growth, with NASDA generally receiving about 75 percent of Japan's space budget. Japan had also traditionally benefited from a strong interest, and subsequent investment, in space activities by industry. The major launch vehicle manufacturers for NASDA and ISAS were, respectively, Mitsubishi Heavy Industries and Nissan Motor Company. Mitsubishi Electric Corporation, Nippon Electric Corporation, and Toshiba Corporation were the main satellite prime contractors—Fuji Heavy Industries, Ltd., and IHI Company, Ltd., supported development of reusable space transportation systems and *JEM* for the *ISS*. Sumitomo Heavy Industries, experienced in launch vehicle support facilities, and construction giants Shimizu and Obayashi were active in the design of long-range facilities, including outposts on the Moon and Mars. The late 1990s economic downturn in Japan negatively impacted public and private space budgets.

In addition to the work done under the auspices of ISAS, NASDA, and NAL, Japan embarked on the development of Information Gathering Satellites (IGS) in 1998. The first two IGS satellites were launched in 2003; as of 2010 four—two optical, two radar—were operational. This program differed from other Japanese space programs in several ways. The IGS system was a dual-use system of satellites to provide information for diplomatic and defense policy decision making and to support crisis management and disaster relief operations. Undertaken soon after North Korea's launch of a Taepo-Dong missile over Japan in 1998, IGS was politically driven and funded through the prime minister's office. That program was considered indicative of the increased importance ascribed to space assets in Japan's security sector and perhaps signaled a change from the past. As a matter of national policy, Japan initially rejected direct engagement regarding military activities in outer space. In May 1969 the Japanese Diet, in compliance with Article 9 of the Constitution, adopted a resolution pledging that the country's space projects would be limited to peaceful (defined as nonmilitary) uses. This was slowly reinterpreted through the years in recognition of the realities of information technology. A strict interpretation of the resolution, for example, could have barred Japanese Self Defense Forces from using communications or navigation satellites.

Following a decade of technical difficulties amid national economic stagnation, on 1 October 2003 a major reorganization of Japanese space activities occurred with the merger of ISAS, NASDA, and NAL to form JAXA. The merger combined the resources, development experience, and technology of these organizations to promote cooperation with industries and the more efficient development of Japan's space program. Despite occasional failures, a variety of missions furthered scientific, technology, and national security objectives. Japan's first attempted Mars mission, *Nozomi*, failed to achieve proper orbit around Mars in December 2003. Following a 2003 launch failure, JAXA successfully orbited *Himawari 6* on 26 February 2005. Between September and December 2005, *Hayabusa* rendezvoused with and analyzed the asteroid Itokawa. During July–August 2005 astronaut Souichi Noguchi flew on the STS-114 mission of the Space Shuttle *Discovery*. On 24 August 2005 the *Kirari* was launched from the Baikonur Cosmodrome. In December 2005 *Kirari* successfully established the first successful optical intersatellite communications with the European Space Agency *Advanced Relay and Technology Mission Satellite*. On 4 October 2007 the *Kaguya* satellite was placed into lunar orbit.

Announced in February 2005, the JAXA Vision/JAXA 2025 Project called for using aerospace technology to address natural disasters and global environmental issues; exploring space, asteroids, and the Moon; establishing competitive, reliable space transportation systems; and developing advanced supersonic aircraft while demonstrating technologies for hypersonic aircraft. Future plans included launching the improved H-IIB rocket and developing improved rockets.

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See also: Halley's Comet Exploration, International Geophysical Year, *International Space Station*

Bibliography

Steven Berner, *Japan's Space Program: A Fork in the Road?* (2005).

Brian Harvey, *The Japanese and Indian Space Programmes: Two Roads into Space* (2000).

Joan Johnson-Freese, *Over the Pacific: Japanese Space Policy into the Twenty-First Century* (1993).

Russia (Formerly the Soviet Union)

Russia (formerly the Soviet Union) has maintained one of the two largest space programs in the world since the 1950s, during which time it has launched more spacecraft into orbit than any other nation, beginning with the launch of the world's first artificial satellite, *Sputnik*, in 1957 by the Soviet Union.

The Soviet space program grew out of the desire to build long-range ballistic missiles after World War II. In 1953–54 the Soviet government assigned OKB-1 (Special Design Bureau-1 of Scientific Research Institute (NII) 88, which became Experimental Design Bureau-1 (also OKB) in 1956), the leading missile development organization, to develop an intercontinental ballistic missile (ICBM) to strike targets in the continental United States. Simultaneously, Mikhail Tikhonravov, a senior scientist who worked at the NII-4 (Scientific Research Institute) military institute, was directing studies to evaluate the possible uses of an artificial Earth satellite. OKB-1 Chief Designer Sergei Korolev, who had worked with Tikhonravov in the 1930s, assembled a powerful coalition of forces, which included scientists from the Soviet Academy of Sciences, to propose a satellite that could be launched by the R-7 ICBM. In January 1956 the Soviet government formally approved the development of such a scientific satellite, which would be equipped with an array of instruments to study Earth during the International Geophysical Year (IGY). Fearful that the United States would upstage this project, Korolev proposed a "simple satellite" that could be launched on quick notice in 1957. After two relatively successful launches of the R-7 ICBM in August and September 1957, Korolev's team launched the simple satellite (*PS 1*), popularly known as *Sputnik*, into orbit on 4 October 1957. *Sputnik 2*, launched a month later, carried a dog named Laika into orbit. A larger scientific satellite, *Sputnik 3*, was launched in 1958, ending the first stage of the Soviet space program.

Despite the successes of Sputnik, it took a while for the Soviet government to establish long-range goals in spaceflight. In this vacuum, the early years of the program were essentially driven by the whims of leading Chief Designers, such as Korolev, or the short-term needs of the military. Korolev played a key role in proposing the first human spaceflight project, Vostok, which he offered to the government for dual use as a robotic spy satellite platform known as Zenit. Using the 3KA version of the Vostok, the Soviet Union took a qualitative step forward with the launch into orbit of Yuri Gagarin, the first human in space, in 1961. A number of important achievements in the human spaceflight program followed, including the first group flight (*Vostok 3* and *4* in 1962) and the first woman in space (Valentina Tereshkova on *Vostok 6* in 1963). Responding to political imperatives to upstage the U.S. space program, OKB-1