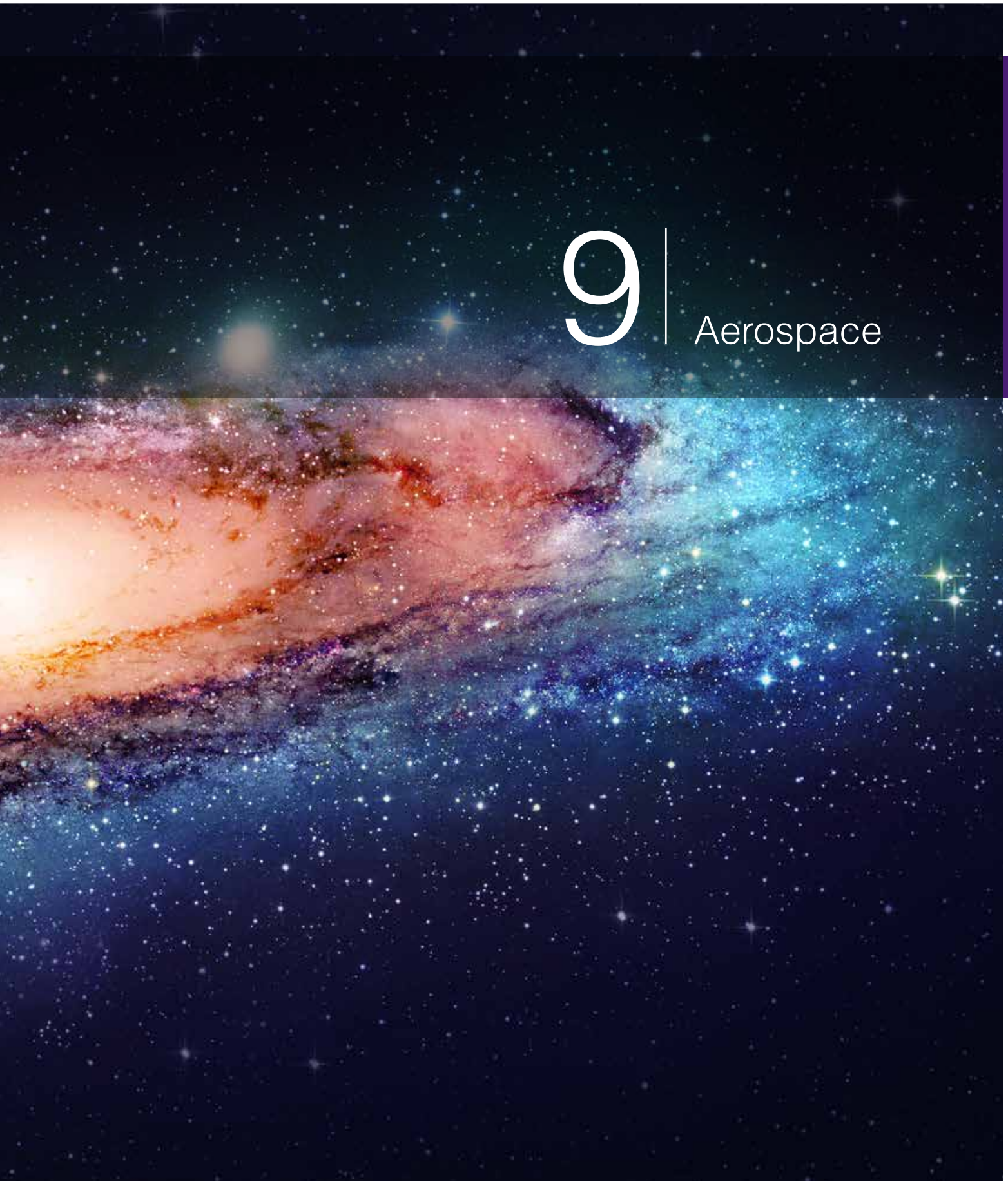


9 Aerospace

Aerospace

I. History and Background

Aerospace technology has had an ever-present and progressive position in the Islamic Republic of Iran. The aerospace research in I.R. Iran was initiated in the eighth century. The eighth and ninth centuries witnessed the attempts of Abu Abdullah Muhammad ibn Musa al-Khwarizmi`s Zij al-Sindhind, which is a seminal work consisting of approximately 37 chapters on calendrical and astronomical calculations and 116 tables with calendrical, astronomical and astrological data, as well as a table of sine values. Iran's space exploration efforts were continued till the 16th and 17th centuries when Baha al-Din Muhammad ibn Husayn al-Amili has probably written 17 tracts and books on astronomy and the related subjects.

The modern era has also witnessed a lot of aerospace advancements in Iran. In 1869 Iran joined the International Telecommunication Union (ITU). In 1951 the National Geographic Organization of Iran was founded. Iranian Space Agency (ISA) was established in 2003 and in 2005 Iran's 10-year space program plan was released which led to launching Sina-1 satellite to space as the result of cooperation between Iran and Russia in 2005. Since then, many satellites were built, among them, there are Safir Satellite launch vehicle (SLV); the first and the second sub-orbital sounding rockets named Kavoshgar-1 and Kavoshgar-2; Safir1-A SLV which placed the first domestically made satellite, named "Omid", into orbit; Kavoshgar-4 and Rasad-1; Navid, etc. 2013 was a fruitful year for Iran's space exploration programs as it witnessed launching Kavoshgar-6 that was partially successful in recording and receiving images and biological data. In 2013 "Pishgam", the first monkey reaching a height of 120 km by Kavoshgar Pishgam was sent to space and at the same year the second monkey, named "Fargam", was also sent to space by Kavoshgar Pajuhesh. "Fajr" the latest Iranian satellite which was an imaging satellite carrying a locally made experimental navigation system was launched in 2015. At the same year, Iran exhibited the mock-up of new manned spacecraft made by the Aerospace Research Institute (ARI) and founded Iran National Space Administration (INSA).

II. Objectives and Strategies

Major objectives and strategies for this industry inspired by the comprehensive aerospace development document are as follows:

A. Macro Level Objectives

- Understanding the magnitude and order of the universe and the heavens and discovering

the wisdom and power of the Creator of the world by spreading science and technology and space exploration;

- Achieving the first place in conquering and dominating space in the region through the related science and technologies and using capabilities of universities and scientific and research centers of the country;
- Conducting manned space missions and sending man to the earth orbit with an emphasis on indigenous science, technology, and industry through participation of the Muslim world and international cooperation;
- Designing, manufacturing, launching, and utilizing satellites in Geosynchronous orbit and other orbits with such applications as communication and remote sensing with priority given to local technology and industry through participation of the Muslim world and international cooperation;
- Developing access to space-based communication services and infrastructure in order to meet national, regional, international, public, and commercial requirements compatible with land-based communications platforms;
- Achieving the necessary technology to meet service requirements of remote sensing and earth observation with less than 10 meter precision;
- Contributing to positioning, navigating, and timing at national and regional levels of competitive quality compatible with international standards;
- Becoming a regional hub and achieving the leading global position by means of science and technology capabilities of the universities and scientific-industrial centers.

B. Macro Level Strategies

- Consolidating all the measures related to policymaking, governance, coordination, and accumulation of knowledge and implementation of macro aerospace programs through exploiting maximum capability of the governmental and non-governmental institutions and entities;
- Supporting privatization and providing the required platform to create knowledge-based industries in the aerospace domain;
- Providing purposeful support for educational-research activities and scientific hubs in aerospace domain;
- Intelligently and actively developing international cooperation and interactions in order to advance space programs while protecting and preserving space assets of the country;

- Using space achievements in understanding the universe, developing astrophysics and astronomy, reviewing the Islamic resources in this domain, and analyzing their congruence with modern science;
- Supporting basic researches relying on Islamic knowledge foundation in an attempt to produce, develop, and strengthen basic sciences in aerospace;
- Designing, manufacturing, and operating launching vehicles for the required satellites including satellites equipped with a biological capsule and geosynchronous satellites;
- Promoting space science, technologies, and achievements in different social classes, particularly young people and the elites.

III. Capacities and Capabilities

A. Scientific Productivity

Experienced human resources and advanced scientific capabilities have allowed Iran's aerospace industries to achieve a rapid progress. The growing trend of research papers on aerospace indicates great achievements of the young aerospace experts in recent years.
The following table shows the country's rank in terms of citable documents in the world. With a 24-step progress, Iran has successfully improved its rank from 35th to 11th.

Table 1

Iran's Global Rank in terms of Citable Documents in Aerospace (2005-2015)

Year	Global Rank	Documents	Citations
2005	35	46	216
2006	33	54	307
2007	22	97	1088
2008	21	126	1029
2009	19	127	676
2010	19	146	962
2011	17	171	882
2012	17	203	965
2013	14	275	408
2014	12	360	127
2015	11	341	101

B. Some Achievements

Launch Vehicles, Satellites and Other Products

• Safir SLV

The first Satellite Launch Vehicle (SLV) developed by Aerospace Industries Organization (AIO) was Safir-1A. It was used to place Omid, the domestically developed satellite, into orbit. Launching Omid placed Iran among the eight countries enjoying independent satellite launching infrastructures.
The achievement of SLV technology for Safir-1A included system engineering, conceptual design, preliminary design, simulation, integration and testing, and quality assurance.

• Simorgh SLV

In 2010, AIO began to develop a more powerful satellite launch vehicle, named Simorgh, with a mission to carry heavier satellites up to 350kg to Low Earth Orbit (LEO). Its first stage has four main engines, plus an engine for attitude control. Its first stage engines enjoy a reinforced thrust which is around four times more than that of Safir launchers. Toloo and Autsat satellites are expected to be launched by Simorgh launch vehicle.

• Sounding Rockets

As the first biological payload was launched by Iran, it was ranked as the sixth country to send animals into space.

Kavoshgar (the explorer) is the name of a series of Iran's suborbital space launchers whose objective is to enable Iran to send human into space. Eight missions have been performed using these launchers- as the stepping stones towards this goal- from 2006 to 2013 as follows:

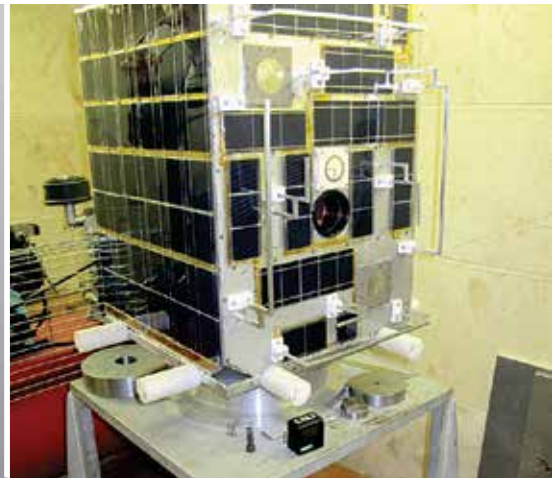
Table 2

Iran Space Missions and Achievements (2006-2013)

Launcher	Launcher class	Date	Height	Main Achievements
Kavoshgar-1	A	2006	10 km	Iran's first step to engage in space exploration
Kavoshgar-2	B	2008	40 km	Complete success, payload was recovered safely
Kavoshgar-3	B	2010	55 km	Iran engaged in Biospace research
Kavoshgar-4	C	2011	135 km	Complete success, payload was recovered safely
Kavoshgar-5	C	2011	120 km	First monkey in space, receiving images and biological data
Kavoshgar-6	C	2012	120 km	Partially successful, recording and receiving images and biological data
Kavoshgar- Pishgam	C	2013	120 km	Completely successful, Safe return of Iran's first space monkey
Kavoshgar- Pajuhesh	D	2013	120 km	Completely successful, Safe return of Iran's second space monkey

• SharifSat Communication Satellite

SharifSat was built by a group of students at Sharif University of Technology and delivered to ISA on December 2013. It is a 50 Kg imaging, storing and forwarding communication satellite. It has successfully passed all the operational and environmental tests, and is planned to be launched into LEO orbit. Most of its subsystems are indigenously developed including magnetic sensors and actuators, a fault tolerant OBC, communication transmitters and receivers, antennas, solar panels, a camera and an image compression engine, heat pipes and the isogrid structure.



• Mesbah Telecommunication Satellite

Mesbah (meaning 'Lantern'), a low earth orbit (LEO) telecommunication satellite, was jointly built by Iranian Research Organization for Science and Technology (IROST) and Iran Telecommunication Research Center (ITRC). It was the first project to build and launch a satellite in Iran after the Islamic revolution. To run the project, three ground stations were also developed; one at IROST, one at ITRC and a backup station. Mesbah-1 was scheduled to be launched in late 2006 onboard a Kosmos-3M launch vehicle from the Plesetsk cosmodrome. However, launching this satellite was deferred due to some unavoidable circumstances.

• Sina Remote Sensing Satellite

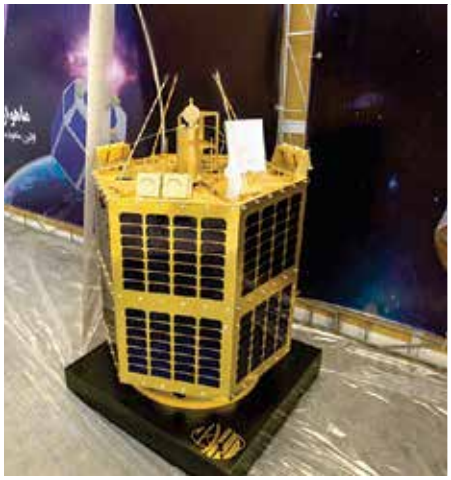
The first Iranian satellite, Sina-1, was launched by a Russian Kosmos-3M rocket from Plesetsk in the Murmansk Province of the Russian Federation on Oct. 27, 2005. Sina-1 made Iran the 43rd member of the world satellite owner club. The satellite is on a mission to gather information concerning agricultural issues, natural disasters, and natural resources. It operates on VHF and UHF frequencies and has also provided Iran with valuable experiences in ground control tracking and telemetry handling.

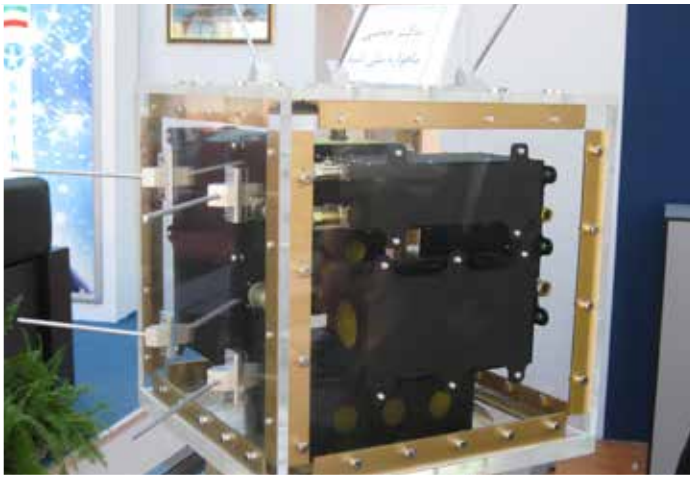
• Omid Telecommunication Satellite

On Feb. 2, 2009, Iran successfully launched its first domestic SLV carrying Iran's first domestic telecommunication satellite called Omid. Omid (means 'Hope' in the Persian language) was developed at the Iran Electronics Industries (IEI) and its launching placed Iran in the club of nine countries enjoying independent satellite launching and manufacturing capacities. The main achievements of Omid project were manufacturing the first domestic space system, acquiring the space technology to drive other industries, persuading academia to cooperate with and contribute to development of space technologies, and capacity building in satellite manufacturing, integration and tests. In fact, Iran was the first country to reach outer space using its own independent satellite launching and manufacturing capacities in the new millennium.

• Rasad Remote Sensing Satellite

In line with research and development plans in space science and technology, a Safir Satellite Launch Vehicle placed the Iranian satellite Rasad-1 into the LEO on June 15, 2011. Rasad was equipped with body-mounted solar panels to generate power for the batteries, with no limitation in the power source. Stabilization is provided by an extendable gravity gradient boom. As the country's first imaging satellite, it was developed by Malek Ashtar Technical University. This sat-





ellite performed its mission successfully, beaming images with 150 m resolution to its receiving station and reentering the atmosphere on July 6, 2011. It was the third Iranian satellite on the earth's orbit and the second one launched by an indigenous launcher.

• Navid Remote Sensing Satellite

The 50 kg Navid microsatellite launched on Feb. 3, 2012 was the first satellite constructed by Iran University of Science and Technology in conjunction with ISA. Navid was a 50 cm cube designed to test a camera taking image of the earth and collecting weather data, and the associated telecommunications link. Navid was the third satellite launched indigenously by Iran and was placed into orbit by a new configuration of Safir-1B satellite launch vehicle, whose second stage was larger with a 20% greater thrust.

• Fajr Remote Sensing Satellite

Fajr is the 2nd satellite built and launched by IEI after Omid

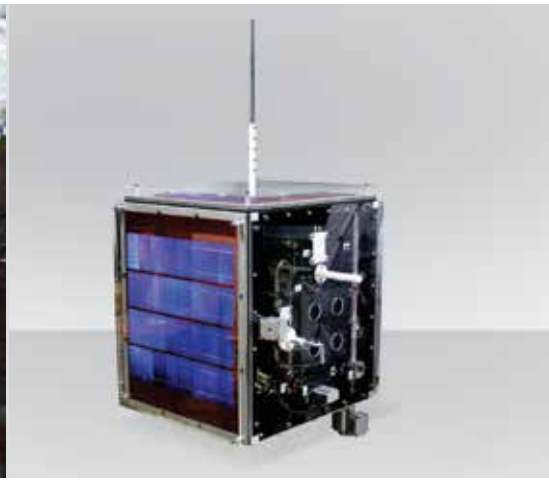
Fajr was an imaging satellite, which also carried an experimental locally made GPS system built by IEI. As the first Iranian satellite, it was equipped with solar panels for power generation and cold gas thrusters for attitude control. Fajr was launched by a Safir-1B rocket from the Iranian Space Agency's launch site in Semnan Province. The launch took place on Feb. 2, 2015, Iran's national day of space and the sixth anniversary of the country's first successful orbital launch. It was deployed into a low earth orbit and reentered earth's atmosphere on Feb. 26, 2015.

• AUTSAT Earth Observation Satellite

AUTSAT is a microsatellite with a remote sensing mission and a secondary mission of storing and forwarding communications data. This satellite is at the stage of design and construction by Amirkabir University of Technology, a leading technical university in Iran, in conjunction with ISA. It is also capable of monitoring growth of agricultural products in its coverage area.

• Toloo Earth Observation Satellite, the Heaviest Iranian Satellite

It is the first of a new generation of reconnaissance satellites being built by IEI with SIGINT capabilities. Its imagery products will be used for synoptic land mapping, monitoring water bodies and environmental disasters, agricultural areas and forests, urban distribution, and cloud coverage. Toloo is the first domestic remote sensing microsatellite planned to acquire images of the earth with a resolution of 50 m.



• Nasir-1 Star Tracker

This celestial navigation tool was manufactured for the first time in Iran in the faculty of Aerospace and Electrical Engineering, K. N. Toosi University of Technology and was successfully tested. Subsystems used to design and manufacture Nasir-1 Star Tracker include optical hardware, electronic hardware, image processing software, star model identification, and attitude determination software. The precision of the sensor has been reported lower than 20 accurate seconds with a 768x512 Pixel CCD.

IV. Authorities

A. Iran National Space Administration

Iran National Space Administration (INSA), established in 2014, is a subsidiary of Iran's Vice-Presidency for Science and Technology. Its mission is coordinating, policymaking, planning and supervising Iran's space sector. It is an independent entity consisting of highly ranked specialists from scientific centers and knowledge-based companies.

B. Other Authorities

• Space Supreme Council

Being active since July 20, 2005, the Space Supreme Council (SSC) has presented its main goals as follows:

- Manufacturing, launching, and using space technologies in national research satellites;
- Approving the status of space-related programs of the private sector;
- Promoting partnerships in private and cooperative sectors for the efficient use of space;
- Identifying guidelines for regional and international cooperation in space activities.

• Aerospace Industries Organization

The Aerospace Industries Organization (AIO) is a leading high-tech industry which is affiliated to the Defense Industries Organization of the Ministry of Defense and Armed Forces Logistics (MODAFL). Its products include launchers, rocket and booster propellants and components. AIO is the leading Iranian organization in development and production of the space assets such as space propulsion systems and space launch and operations centers and ground control stations. It is also the main developer of Iranian launch vehicles called Safir and Simorgh and their successive versions.

- **Iranian Space Agency**

The Iranian Space Agency (ISA), established in 2003, is involved in conducting engineering and research in different fields of aerospace such as satellite development, communications and remote sensing. Some of the key tasks assigned to ISA by the Space Supreme Council were to undertake studies, research, and design and engineering in space services, perform remote sensing, strengthen domestic and international space networks, and conduct studies and research in designing, manufacturing and launching satellites.

- **Iran Aviation and Space Industries Association**

The Iran Aviation and Space Industries Association (IASIA), established in 2007, is a non-governmental entity which started its activities with 27 participating companies active in the aerospace industry. Now IASIA includes more than 170 active companies with formal membership in the aerospace engineering field. Supporting members to develop their activities and services and also providing the basis of general development of aerospace engineering field in Iran are the main objectives of IASIA. It is also the primary holder of the National Exhibition of Iranian Aviation and Space Industries which is held annually. The exhibition provides an opportunity for the Iranian state-owned and private companies, airlines, knowledge-based aerospace companies, academic centers, aviation publications and producers of aeronautical parts to showcase their capabilities.

V. International Cooperation

Iran is capable of exporting and providing the following services to the developing countries:

- Remote sensing satellites with high spatial resolution;
- Lightweight telecommunications satellites;
- Sounding Rockets;
- Design and development of Spaceports;
- Design and development of lightweight launch vehicles;
- Lightweight satellite launch services;
- Design and development of ground stations to receive images.

Iran is ready to cooperate with the countries enjoying space-related technologies in the following areas:

- Launch technology development;
- Space-based navigation and positioning systems;
- Communications satellite and services;
- Launch services;
- Remote sensing satellite services;
- Ground stations;
- Space science and exploration;
- Promoting space science and technology;
- Remote sensing cameras;
- Remote sensing satellites.