



PRESENTATION

Today, all of the world's countries are engaged in an unprecedented race for the construction of impressive astronomical facilities, as well as for the development of increasingly-ambitious space missions to explore the Universe. It is becoming clearer that modern astronomy has a strategic role for the future of humanity: it not only pushes our knowledge to the edges of the Universe, but also creates assets that are crucial for innovation and our planet's safety.

In modern astronomy, ground and space observations are two inseparable, complementary aspects of the study of the Universe. The National Institute for Astrophysics (INAF), founded in 1999 and composed today of about 1,400 staff members spread out over twelve cities, possesses all of the intellectual and instrumental power needed for the exploration of the Universe; it operates at all wavelengths, from the ground and from space.

INAF is a "young" institution: it will be 20 years old in 2019. It is therefore a next-generation institution: it drives innovation and produces great industrial returns for our country. It has a significant presence on the national territory, with a strong impact in terms of training, higher education, public outreach, technology transfer, and historical heritage preservation.

INAF has been ranked second in the world for international collaborations by the authoritative, international scientific journal Nature

(see Il Sole 24 Ore, 16 November 2016, "Technology" section)

Modern astronomy: a strategic engine for socio-economic development

"Astronomy has the power to bring about development where it is needed. Establishing groups of professional astronomers, technicians, engineers and other highly trained staff can provide ongoing economic and educational stimulus to a region. Moreover, the construction of new observing facilities injects much-needed money, employment and infrastructure".

Nature Publishing Group (Focus of Nature Astronomy, 3 July 2018)



INAF

ISTITUTO NAZIONALE
DI ASTROFISICA
NATIONAL INSTITUTE
FOR ASTROPHYSICS

**INAF on board the most ambitious
space missions in the world**



THE ROLE OF INAF IN ESA'S SCIENTIFIC PROGRAM

Italy is one of the founding countries of ESA, the European Space Agency, and ranks in third place in terms of annual contribution. ESA regulations stipulate a compulsory scientific program. INAF, in close collaboration with the Italian Space Agency (ASI), is the main stakeholder of the high-profile astrophysical community that guarantees returns for Italy, both in the industrial and scientific sectors. INAF nominates an Italian representative who works as an Advisor with the ASI delegates in ESA's Science Program Committee (SPC).

As of today, INAF is involved in:

- 5 space missions under study
- 10 space missions under construction
- 16 space missions in the operational phase
- 5 missions in the post-operational phase

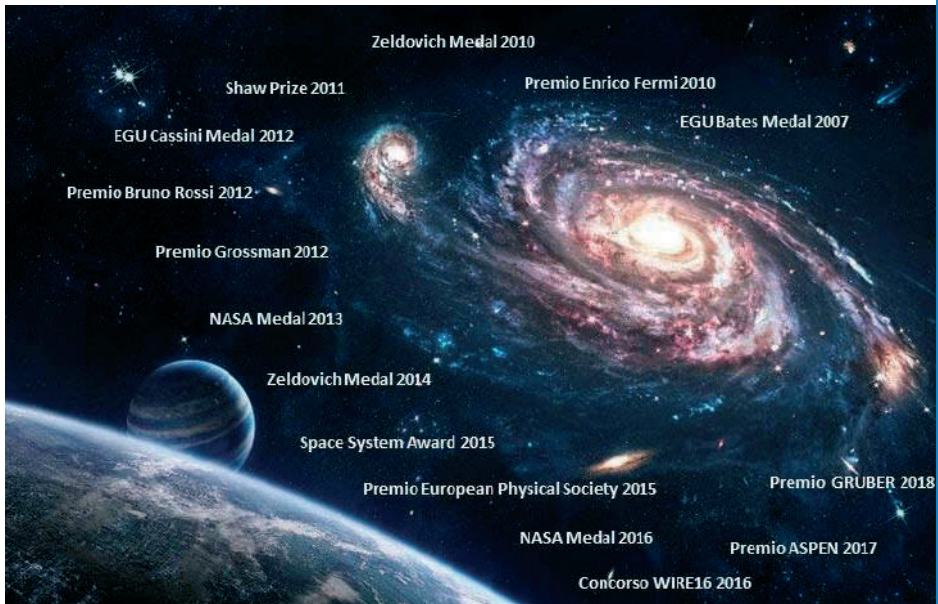


The process for selecting scientific missions. ESA involves scientific institutions on a competitive basis. The institutions propose the scientific instrumentation to be housed on board the missions, build and test the prototypes, and finally analyze and publish the data collected during the missions. As of today, INAF holds a remarkable record of participation in ESA scientific missions, in which the national industry is systematically involved. INAF is also involved, often as a leader, in various NASA missions and collaborates with space missions from other

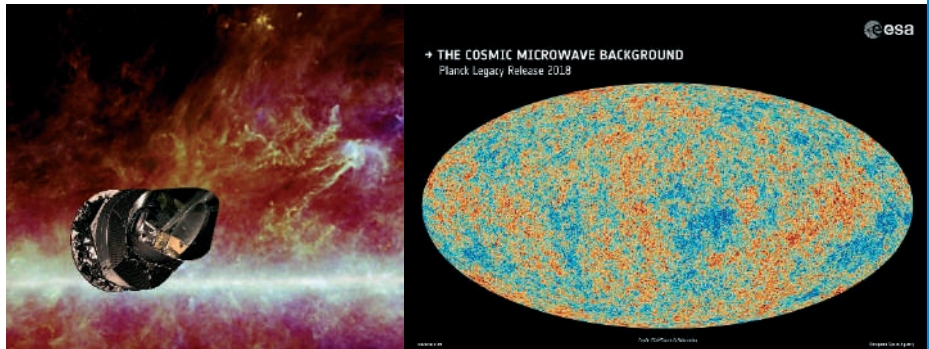




INAF: AWARDS IN THE FIELD OF SPACE SCIENCES



INAF scientists hold important positions in COSPAR
(COMMITTEE ON SPACE RESEARCH)





INAF MAKES HEADLINES IN THE MAIN NATIONAL AND INTERNATIONAL PRESS: THE DISCOVERY OF AN UNDERGROUND LAKE ON MARS

In July 2018, the results of the discovery of an underground lake of brackish water located about 1.5 km deep at the south pole of Mars, were presented in the journal Science. The exceptional, all-Italian discovery led by INAF researchers, in collaboration with ASI, the Roma Tre University, the D'Annunzio Chieti-Pescara University, the National Research Council (CNR), and the Sapienza University of Rome, was achieved using data acquired from the Italian radar MARSIS on board the Mars Express European space mission. The discovery opens up new scenarios in the exploration of Mars and the search for life beyond the Earth. Today Mars is cold, arid and inhospitable, but on its surface, there are clear signs of a very different past in which oceans, rivers and lakes abounded: this suggests potentially favorable conditions for the development of life. INAF's discovery of a liquid basin constitutes a fundamental step forward in the search for life on the red planet.

INAF CAPTURES THE HEADLINES ALL OVER THE WORLD FOR THE DISCOVERY OF WATER ON MARS

- 30 articles** in the main national newspapers
- Over 400 reports** on Italian websites, blogs and news aggregators
- 30 articles** in the main international newspapers
- Over 50 reports** on Italian and foreign TV
- 212,803** visits on the INAF website
- 364,585** pages visited

Numerous interviews including CNN, BBC and Guardian News, with INAF researcher Roberto Orosei





INAF'S LABORATORIES DEVELOP THE INSTRUMENTATION FOR THE MISSIONS OF THE WORLD'S MAIN SPACE AGENCIES

INAF actively participates in the development of instrumentation (for which it involves the national industry), and in the management and data analysis of large national and international space projects. The large space projects often last more than twenty years after the publication of each *Announcement of Opportunity* (AO) by the agencies, and include: the launch into orbit, the operational phases, the scientific use of the mission and its post-operational phase.



INAF's contributions in the field of space astrophysics, which were achieved with the support and remarkable synergy with ASI, have allowed it to reach levels of excellence in many sectors of space research, as well as a highly competitive presence at the international level. INAF's presence can be seen through its collaborations with major institutions, research institutes and space agencies around the world.

INAF's research facilities, distributed throughout the national territory, operate advanced laboratories for the development and construction of scientific instrumentation that is subsequently installed on board space missions. The industry is constantly and significantly involved in the construction phase.



INAF IN THE EUROPEAN MISSIONS FOR SOLAR SYSTEM EXPLORATION

Solar system exploration is one of ESA's major scientific programs. In close synergy with ASI, INAF is involved in most of these missions, with a scientific contribution in the design phase, the development and testing of the sophisticated onboard scientific instrumentation, and the analysis and interpretation of the collected data.

Missioni spaziali con sostanziale partecipazione INAF



INAF/Ufficio Spazio: Adapted from ESA

soho
Fading the Sun

venus express
Studying Venus' atmosphere

bepicolombo
Exploring Mercury

proba-2
Observing coronal dynamics and solar eruptions

juice
Characterising the conditions of ocean-bearing moons around Jupiter

mars express
Investigating the Red Planet

cassini-huygens
Studying the Saturnian System and landing on Titan

cluster
Measuring Earth's magnetic shield

rosetta
Chasing a comet

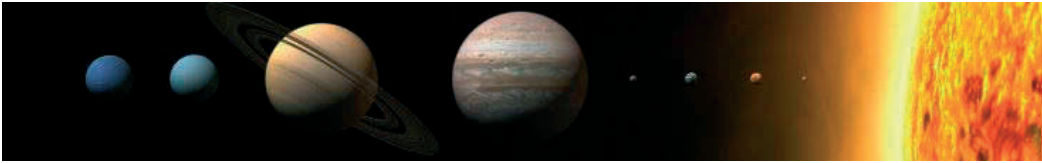
solar orbiter
The Sun up Close

ESA'S FLEET IN THE SOLAR SYSTEM

The Solar System is a natural laboratory that allows scientists to explore the nature of the Sun, the planets and their moons, as well as comets and asteroids. ESA's fleet of spacecraft is designed to study the Solar System in detail, and to provide new insights into how the Sun interacts with Earth and its neighbours. The Solar System is the result of 4.6 billion years of formation and evolution. Studying how it appears now allows us to unlock the mysteries of its past and to predict how the various bodies will change in the future.

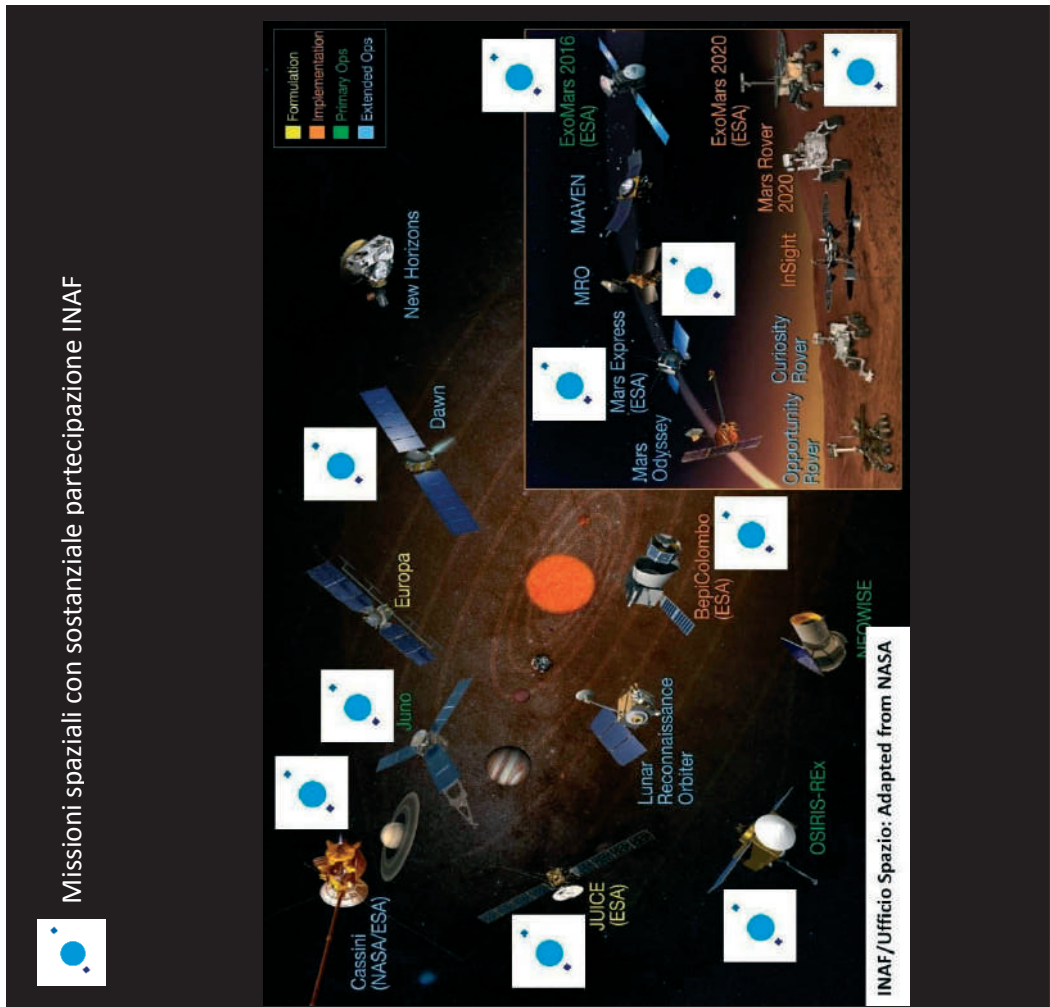
www.esa.int

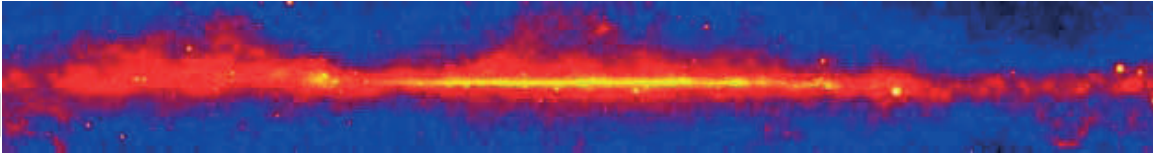
European Space Agency



INAF IN THE U.S. MISSIONS FOR SOLAR SYSTEM EXPLORATION

Solar system exploration is also one of the major scientific programs for NASA, with which Italy has been collaborating for several decades. In addition, NASA participates in various ways in a few ESA missions. Here as well, INAF is involved in most of these missions. Of particular interest is the exploration of the planet Mars. From 2020, INAF will also be on the surface of the red planet with its own instrumentation onboard both the rover and the lander of the joint ExoMars mission.





INAF IN THE EUROPEAN MISSIONS FOR OBSERVING THE UNIVERSE AT ALL WAVELENGTHS

ESA has been dedicating several space missions to the observations of the Universe at all wavelengths. The observations of the Universe that are carried out outside the atmosphere are indeed complementary to those that are carried out from the ground; in many cases, they make it possible to do measurements that would be impossible from the ground. Thanks to its close synergy with ASI, INAF is involved in many of the missions in this field, with the development and testing of sophisticated scientific instrumentation, which strongly involves the national industry, as well as with the analysis and interpretation of the data.

Missioni spaziali con sostanziale partecipazione INAF



→ ESA'S FLEET ACROSS THE SPECTRUM

It is as a cutting edge technology laboratory's unveiling a fully new world of space, we can explore the full spectrum of light and probe the fundamental physics that defines our universe. From our deep sea, terrestrial reaches only at limited wavelengths, to the cold dark energy of the universe, ESA's missions are building our knowledge and even helping us to discover more about our place in space.

gala
Surveying a billion stars

herchel
Unveiling the cold and dusty universe

just
Designing the first light

euclid
Probing dark matter, dark energy and the expanding universe

hst
Exploring the frontiers of the visible universe

xmm-newton
Sifting deeply into the hot and vibrant universe

isa pathfinder
Testing the technology for gravitational wave detection

planck
Looking back at the dawn of time

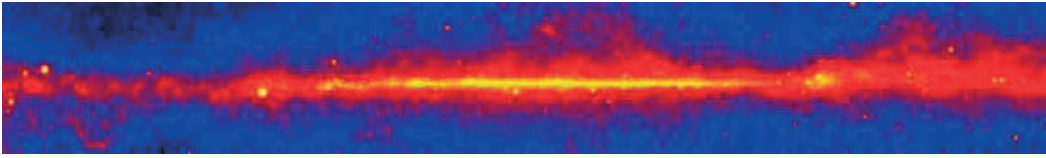
infogera
Sifting the secrets of the universe

ESA

INAF/ULIBO Sponsor. Adapted From ESA

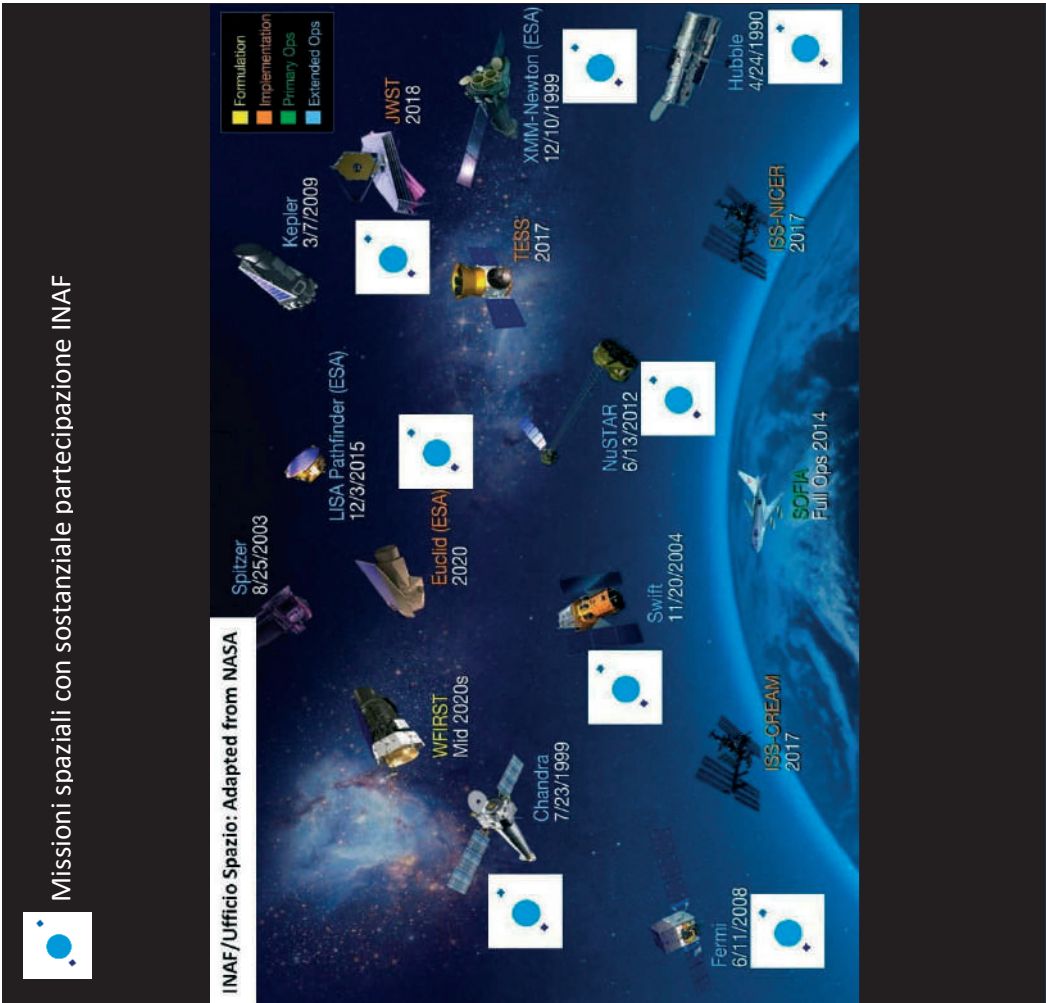
European Space Agency

The infographic features a central rainbow spectrum arc with labels: microwaves, sub-millimetre, infrared, visible, X-ray, and gamma rays. To the right, a spiral galaxy is shown. Various satellite icons are placed along the spectrum, each with a small INAF logo and a brief description of its mission.



INAF IN THE U.S. MISSIONS FOR OBSERVING THE UNIVERSE AT ALL WAVELENGTHS

NASA dedicates a large number of space missions to the observations of the Universe at all wavelengths; the Hubble Space Telescope is famous for its scientific results and for its evocative images. In this case as well, thanks to its close synergy with ASI, INAF is involved in most of these missions. In particular, the IXPE mission dedicated to measuring the polarization of cosmic X-rays will allow us to investigate the physical processes that take place near objects such as black holes and neutron stars.



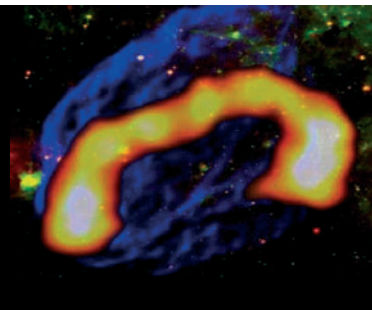
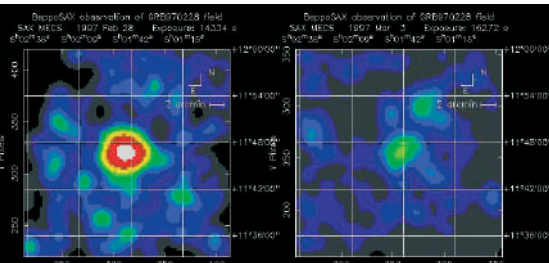


INAF AND THE TWO ALL-ITALIAN PRESTIGIOUS SCIENTIFIC SPACE MISSIONS

THE ITALIAN SATELLITE: "BeppoSAX". Italy was among the first great nations to develop space observing techniques, and was driven in particular by the exceptional school of Giuseppe "Beppo" Occhialini and Bruno Rossi, who were the first in the world to push and observe the universe in X-rays and gamma rays. One of the tangible results of this school was the Beppo-SAX Italian mission (with a Dutch collaboration) for X-ray astronomy. Beppo-SAX made fundamental contributions in the study of gamma-ray bursts. Made with an important contribution from the national industry, this mission has had an operational life of six years.

The fundamental results obtained with the Italian satellites BeppoSAX and AGILE led to the awarding of prestigious prizes to INAF researchers: the "Shaw Prize", a million-dollar prize, was awarded to Enrico Costa; the "Enrico Fermi" prize was awarded to Enrico Costa and Filippo Frontera for the results obtained with Beppo-SAX; the Bruno Rossi prize was awarded to Marco Tavani and to the AGILE team

THE ITALIAN SATELLITE: "AGILE". An acronym for "Astrorivelatore Gamma a Immagini LEggero", the AGILE Italian satellite explores the universe at X-ray and gamma-ray wavelengths. Launched in 2007 from the Sriharikota base in India, and still in operation, AGILE is an ASI scientific "Small Mission". INAF plays a fundamental role in AGILE's scientific management and coordination. INFN and the Interuniversity Consortium for Space Physics (CIFS) have also been involved in this mission; the national space industry was significantly involved in its construction.





INAF INVOLVED IN THE NEW INNOVATIVE INITIATIVES OF THE SPACE ECONOMY

Nano satellites: the "HERMES" project. Nano satellites started as university initiatives to allow the launching of scientific instruments designed by researchers and students. In recent years, nano satellites have received great attention not only from a growing number of research institutes, but also from companies in this sector and from National Agencies that have foreseen their possible applications: telecommunications, Earth monitoring, applications of fundamental physics and astrophysics. The HERMES project, conceived by INAF in close collaboration with ASI, is a technological prototype of a high-energy astrophysics modular experiment that uses nano satellites.

With the HERMES and DORA projects, INAF is involved in the development of sectors of the Space Economy, which, according to recent market assessments, should lead to a turnover of over 7 billion euros by 2022

Deployable Optics in space: the DORA project. The so-called field of “deployable optics” is emerging today. It is one of the scientific-technological areas that can generate transformation processes of the production system and create new market sectors in the space economy. Deployable optics are already used in the space telecommunication satellites of the TDRS constellation, and constitute an area of experimentation of growing interest for space agencies all over the world. As part of the PON “Research and Innovation” projects, a project called DORA (Deployable Optics for Remote sensing Applications) was recently approved. INAF is involved in this project, together with the Politecnico di Milano, the Parthenope University, the Sitael Company and other Apulian SMEs



MINISTERO DELL'ISTRUZIONE DELL'UNIVERSITÀ E DELLA RICERCA



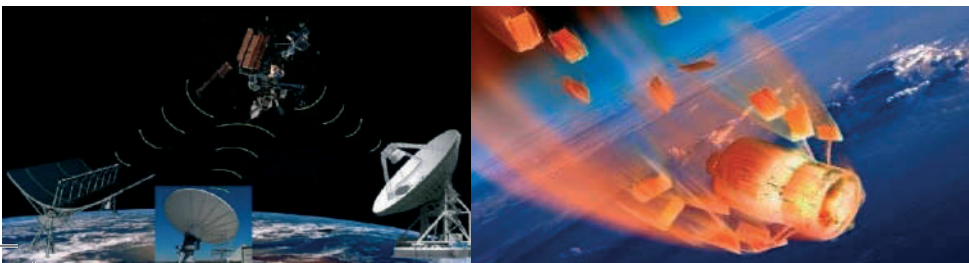
INAF'S LARGE GROUND FACILITIES USED TO SUPPORT SPACE ACTIVITIES

INAF's large radio telescope in Sardinia. The Sardinia Radio Telescope (SRT) is one of INAF's most important national facilities; it was ordered by the MIUR in the National Program for Research Infrastructures (PNIR). The use of SRT for space applications, in particular for NASA's Deep Space Network, is the subject of a Program Agreement between INAF and ASI. In September 2017 for example, SRT was involved in the tracking of the Cassini probe in its dive final into Saturn.

INAF facilities for "Space Weather". The SVIRCO Observatory is unique in Italy in that, since 1954, it continuously measures the intensity of cosmic rays. In addition, INAF is successfully equipping its radio telescopes for the so-called Space Meteorology. Space Meteorology studies the perturbations of interplanetary Space caused by the phenomena occurring on the Sun, in the solar wind, in the magnetosphere, as well as in the terrestrial ionosphere. These perturbations then propagate up to the Earth and affect life and its activities.

INAF and BIG DATA in the space sector. INAF operates a space data center, called Space Science Data Center (SSDC), with ASI and INFN. This center provides services and support to the users of space mission data.

An Agreement between INAF, ASI and the Ministry of Defense, allows the use of INAF facilities for monitoring the so-called "space debris". The monitoring of the re-entry of the Chinese space station Tiangong-1 into the atmosphere was of particular interest. INAF was involved in these activities, which were coordinated by the Civil Protection.



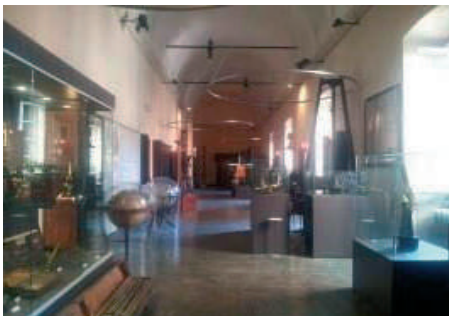


INAF TRANSFERS ITS INTERNATIONAL EXCELLENCE ONTO THE NATIONAL TERRITORY



INAF is spread out over 12 cities, and has a strong impact on the territory in terms of training, higher education, public outreach, technology transfer, historical heritage preservation, and operates its own online newspaper.

With its territorial institutes, INAF participates in most regional aerospace districts, thereby attracting funding and investments, contributing to regional development, and involving industry and SMEs





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the Scientific Directorate and the INAF Communication Department

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