Università di Roma Tor Vergata

esa

→ ESRIN'S VALUE TO ITALY

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1) ESRIN, ESA Centre for Earth Observation

ESRIN, located in Frascati, Italy, is the ESA Centre for Earth Observation and the reference centre for other space-related activities (VEGA, the European Small Launcher Programme, Space Rider, the Near Earth Objects Coordination Centre) as well as corporate functions (Information Technology, Communication and Security). Being ESRIN's role in the field of Earth Observation, the centre manages the payload operations and hosts the managers for all the relevant missions. ESRIN also coordinates the infrastructure of acquisition stations and ground segment operations for the Copernicus Sentinel missions, and for the Earth Explorer missions.

In addition, ESRIN manages scientific projects in collaboration with the European and worldwide community and the applications related to the use of Earth Observation data. ESRIN coordinates also the ESA contribution to major international initiatives (e.g. CEOS, GEO) and hosts the Secretariat of the International Charter Space and Major Disasters.

The Earth Observation Directorate was recently reorganised adopting an approach to better meet the new challenges of the EO sector. A new department was created to implement new initiatives in the field of innovation (InCubed, the Φ-lab, Science for Society).

ESRIN hosts the VEGA integrated project team. VEGA's maiden flight has successfully taken place in 2012, and the demonstration activities associated to the programme (VERTA Programme) was successfully completed in 2015 leading to the successive start of the exploitation phase. Arianespace is now fully responsible for VEGA commercial exploitation, while VEGA Launcher Exploitation and Accompaniment Programme (LEAP) ensures that VEGA remains operational and optimizes launch service costs. Currently the Space Rider Development Programme and the VEGA-C programme are managed at ESRIN, developing the VEGA-E family, and its key technologies.

Since May 2013, ESRIN hosts the ESA Space Situational Awareness Near Earth Object Coordination Centre (SSA-NEOCC).

Concerning ESA corporate functions, over the last five years the IT Department played a major role, especially in providing valuable support to the Agency, by improving ESA's IT infrastructure, by introducing Esacloud in 2013 and Esaconnect in 2014, and by substantially updating ESA-p. In 2015, the IT Department renegotiated its contracts with several suppliers thus providing better and more efficient services.

Since 2007, the ESA Security Office is located in ESRIN and provides a policy and measures for the implementation of the security of ESA sites. It prepared security instructions for the Agency and has signed cooperation agreements with the European Defence Agency (EDA) and the European Global Navigation Satellite Systems Agency (GSA).

ESRIN site is managed using environmentally friendly innovation technologies (e.g. water consumption, earthquakes regulations and renewable energy). The new ESRIN Host Agreement was signed in 2010, and its implementation, still ongoing, offers a number of new possibilities for its development.

2) ESRIN's economic value to Italy

The study presented in this report highlights the economic benefits of the Centre for Italy and the Italian Space Industry, as well as for many non-space-related companies. The analysis shows that in the last five years, ESA has signed a consistent share of industrial commitments with Italian contractors through ESRIN, generating business opportunities with a positive impact both at national and regional level. Moreover, ESRIN offers proximity advantages to the Italian enterprises dealing with ESA, facilitating their internationalization and fostering their competitiveness at national and international level.

The Italian space industry obtains considerable economic benefits in terms of direct industrial commitments with ESA. Since the discontinuation of the time series in 2014, Italy has been in over-return (ESA level coefficient 1.10 at December 2017). Measured in euros, the Italian surplus with respect to the ideal share of the weighted value of contracts signed between ESA and the Italian companies, amounts to about 158 million euros.

The Italian participation in ESA Earth Observation programme shows a consistent contribution over the years. In the period 2007-2016, eleven Italian EOP space contractors signed contracts valued at more than 10 million euros, for an overall amount of 713.4 million euros, with most of the EOP Italian space contractors located in the Lazio Region.

With regard to the industrial procurement of Copernicus Ground Segment Development, it is worth noting the economic relevance of the Italian industrial commitments in the activities related to Sentinel 1 (142 million euros, almost 45 of them already paid at the end of 2016) and Sentinel 3 (37 million euros, almost 8 already paid at the end of 2016).

The in-depth analysis of the Italian participation in VEGA shows that all the industrial organizations have an Italian Prime in each project, namely: ELV for the Launch Vehicle, Avio who delegates to Europropulsion (Italy and France) for the P80, and VITROCISET for the Ground Segment. Italy's involvement in VEGA's development and exploitation programmes is exemplified by the consistent national long-term investments in almost all programmes related to the launcher (on average, more than

50% of the overall cost). The total value of the Italian industrial commitments with ESA in the VEGA programmes since 2001 is well above 1 billion euros.

As our study illustrates, ESRIN can be safely considered an asset to Italy providing direct, indirect and induced additional benefits to the Italian contribution to ESA. Proximity advantages for the Italian space industry apart, most of the benefits achieved through ESRIN extend to the local and regional economy in terms of additional demand of goods and services and touristic impact, to non-space-related companies in terms of procurement and to the Italian government itself in terms of taxes.

We have about 700 people in total working at ESRIN, out of which 200 are ESA staff. Furthermore, even if tourism is outside the core business of ESRIN, it is still worth noting the positive effect on the local economy. Overall, our estimates indicate a net direct impact on domestic travel-related and touristic activities of almost 6 million euros with about 4.5 million euros to the local economy.

The industrial contracts signed by ESRIN with Italian Prime Contractors amount to almost 500 million euros in the period 2013-2016. The VEGA IPT is responsible for more than 50% of the total invoiced by ESRIN, the IT Department for an additional 30% share, and the EOP (for the part attributable to ESRIN) for a 14% share. The remaining 6% is attributed to ESRIN facility management services (3%) and to ESRIN local offices (among them, the Communication office and the Legal Affairs office are the most relevant). It is worth noting how the Italian contractors sign contracts with ESA mostly through ESRIN and ESTEC and how ESRIN's procurement with Italian contractors has a consistent non-space component (the scientifically negligible value of the total invoiced amount), that amounts to almost 40% of the overall amount invoiced.

By extending the benefit analysis to the whole economy we obtain a rough estimate of the added value generated by the Italian government when investing in ESA for all economic sectors of activities and consumers.

We estimate that Italy obtains an added value ranging from 2.6 to 4.3 over a five years horizon for each euro of Italian contribution to ESA. Furthermore, if we consider the value of 2.7 as the ratio between the value added multiplier and the sales multiplier adopted by ESA for the launchers sector in 2016, we obtain a sales multiplier for the Italian contribution to ESA in the whole economy ranging from 7.0 to 11.6 euros.

In brief, the calibration model illustrates how investing in ESA guarantees considerable economic benefits to the Italian industry and to the Italian government itself: a win-win game. Moreover, ESRIN allows to maximize proximity advantages and provides additional economic benefits to the Italian public sector (in terms of estimated yields over a five-years horizon) and to the local and regional economy (in terms of exogenous additional stimulus).

This confirms that by involving ESA partners in space activities of national interest, Italy raises the financial resilience of its investments by catalysing additional financial resources to cover costs, and gains the opportunity to participate in a wide range of other initiatives that might prove profitable for the Italian Space economy and more in general for the country itself in terms of innovative spin-offs.

3) ESRIN's scientific and networking benefits to Italy

By investing in ESA and by hosting ESRIN, Italy obtains consistent benefits in terms of scientific achievements and technological spillovers. Indeed, Italy is one of the world leading countries in land monitoring and hazards application fields. The main users of ESA EO data at national level are mostly public institutions (the consistent involvement of the Italian public sector as a user of EO data constitutes an Italian primacy worldwide), therefore it is reasonable to expect that the Italian Government will obtain consistent benefits from the implementation of Copernicus, as the latter is a game changer in most Earth Observation activities due to the exponential growth of the volumes of data produced. Furthermore, Italy obtains real benefits in terms of research and educational activities related to the launcher sector, due to the active involvement of local universities. The VEGA IPT generates also innovative spin-offs to the Italian industry in terms of new technological achievements that can be used in other sectors of economic activity.

Lastly, the study illustrates how ESRIN is deeply rooted both in the national space system and in the regional scientific and technological district. At national level ESRIN's activities are well interconnected with those of all the Italian Space Agency's major establishments and of the other international research centres hosted by Italy. ESRIN collaborates with the local research district, having signed numerous agreements with the neighbouring research institutions (ASI, INAF, INFN, ENEA, Tor Vergata University and Polyclinic, Frascati Scienza...). Indeed, most of the agreements signed by ESRIN with local partners in the previous decade have been rearranged to face the current paradigm shifts, and beside the consistent heritage of connections and shared infrastructures, new initiatives are taking place to tackle future challenges.

1 A historical overview of ESRIN

1. The foundation of ESRIN (1964 – 1974)

More than 50 years ago, during the negotiations for the foundation of the European Space Research Organisation (ESRO), the Italian delegation asked to establish a laboratory in Italy. The ESRO Council accepted the request and the European Space Research Institute (ESRIN) came into being. Initially, ESRIN was designed as a centre dedicated to undertake laboratory and theoretical research in basic physics and chemistry.

1964

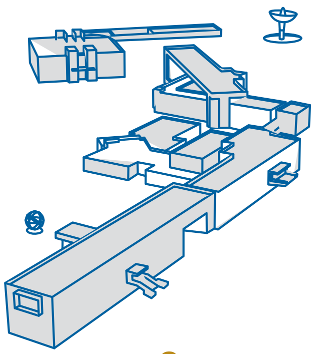
ESRIN's foundation as research point for plasma and basic physics

H.L. Jordan was appointed in 1964 as the first director of ESRIN and he placed the new research centre in Frascati because it would be close to a growing concentration of establishments with similar interests. Nine months later, a small team rapidly organised the first conference on plasma physics. It was held in May 1966 but due to several difficulties, the cornerstone for ESRIN's new building was not laid until September 1968.

More difficulties lay ahead. In 1971, although it was agreed that the work done by ESRIN was of high scientific calibre, the Council ruled that ESRIN's activities were not directly related to ESRO's operational programme, therefore decided to terminate ESRIN's scientific activities and close the research centre by September 1973. ESRO's Italian delegation refused to accept the end of ESRIN. Quite apart from the technological and scientific reasons, Italy wanted an ESA establishment. At the end of the negotiation, ESRIN was repurposed. Research activities were stopped and the Space Documentation Service (SDS) was opened late in 1972 or early in 1973.

2. The first steps of ESRIN within the European Space Agency (1975 – 1985)

In 1975 ESA was born out of the merging of the European Launcher Development Organisation (ELDO) and ESRO. The SDS on-line database became one of the world's largest, with all data acquisition and data entry centralised at the Frascati establishment. In 1976, considerable progress was made on the Earthnet Programme, which provided European users with imagery generated by NASA's remote-sensing satellites, and promoted the use of such data for research and application purposes.



1981

ESRIN's activities had significantly expanded

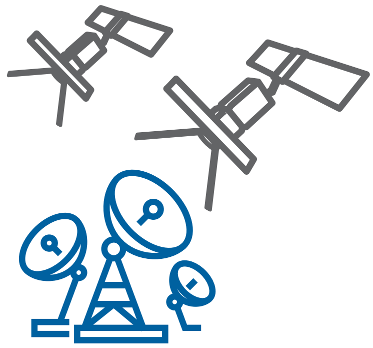
By 1981, ESRIN's activities had significantly expanded since the days of space documentation and information retrieval for external customers. The establishment now also encompassed a major service to internal clients. Therefore the possibility of treating ESRIN as a support establishment rather than a basic activity was considered. This change of perspective enabled the costs to be 'recharged' to internal users and projects. Hence, it provided ESRIN with a fixed minimum level of financing, independent of fluctuating programme requirements.

In 1982, the ESA Director General set up a review group to examine the possibilities of introducing further on-site activities at ESRIN. As a result, the Information Retrieval Service (IRS, which was formerly known as SDS) had its interfaces revised to cope with national public packet switching networks, now interconnected among them and with Euronet, the public telecommunication network devised by the EEC (European Economic Community). By 1986, it became clear that ESRIN's future would be to play an important role in payload data handling, using the expertise acquired in its many years of data processing activities.

3. The development of ESRIN and the consolidation of its role (1986 – 1995)

At the beginning of the 90s, the IRS was involved in the implementation of an expansion plan. The Information Systems Division (ISD) completed the design phase for most of its projects during 1991, and in 1992 began the implementation. 1991 was an important year for telecommunications, with capacity having to be maintained on a 24-hour basis. An ESA Home Page was created for the world wide web, carrying institutional details on the Agency and its establishments, and with pointers to topical information services on site. In December 1995, the ESA Director General announced his decision to transfer the management of all the Agency's information systems dealing with non-operational data to ESRIN. This resulted in the need for an internal reorganisation of the establishment.

Core innovations were experienced mostly in the field of Earth Observation. Indeed, at the beginning of the 90s ESRIN consolidated its position as "The gateway to Earth observation from space". **With the launch of ERS-1 (the first ESA Earth Observation satellite) in 1991, for the first time ESRIN provided support to the ground facilities during operations.** In 1992, two new departments were created in ESRIN, one covering Exploitation and one involved in Projects & Engineering. In 1993 came the operational success of the Processing and Archiving Facilities (PAF). In the same year, a number of new stations on all continents underwent station validation tests. With the successful launch of ERS-2 in April 1995, the continuation of the Agency's Earth Observation Programme and ESRIN's supporting activities were assured. During 1996, the use of ERS-based information in pre-operational applications increased sharply, therefore most of the facilities of the ERS Ground Segment were upgraded to manage the more consistent data and service requirements. Where applicable, they were also modified to handle data from the new sensors. Finally, commercial exploitation via the ERS industrial data consortium showed steady growth, and ESRIN became very active in raising the awareness of Earth observation data to existing and potential users.



1991
for the first time ESRIN participates to the operational phase of a satellite

4. ESA corporate functions, EO international cooperation and new programmes (1996 – 2005)

During 1996, ESA's corporate website was extended and updated; and in 2000, it became the ESA Communication Portal. In 1997, the Informatics Department at ESRIN became part of the Agency's Directorate of Administration, and begun to provide informatics support to all of the Agency's Establishments and Directorates.

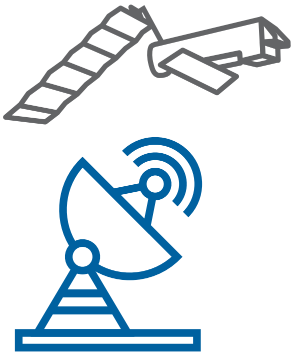
2000
ESA Communication Portal is made operational

As regards Earth Observation, in 1996 ESA set up a Data User Programme (DUP). This tackled all issues related to the extraction of information from remote-sensing data to meet user requirements. It also paved the way for future ESA Earth-observation missions, data exploitation, and commercialization. During the same year, the first release of the Multi-mission User Information Services (MUIS) infrastructure became operational. In 1997, the MUIS were fully embedded as a Multimission Remote Sensing Product Catalogue into the Earthnet On-line Internet user service.

During 1997, the Earth Observation Department at ESRIN became part of the Directorate of Applications. In 2000, the Mission Management Office for the Earth Observation Programmes was installed at ESRIN. During the same year, contributions to established international Earth observation activities were expanded. Important products were the European Digital Data Archive (EDDA), the Catalogue Interoperability Protocol (CIP) and the Committee on Earth Observation Satellites (CEOS) Dossier database on space-system capabilities and user requirements.

In 1998, considerable effort was devoted to the provision of educational activities through a cooperation with the European Association for the International Space Year (EURISY), with the European Project for the use of Space Technologies for Risk Management (EUROPA-STRIM Programme) and, at national level, with the Italian Space Agency (ASI) and the Italian Public Education Ministry (now, Ministry of Instruction, University and Research, MIUR). During the same year, various international exhibitions and workshops related to Earth Observation applications were developed. The emphasis was on user services for remote sensing applications that had been generated by Small and Medium-Sized Enterprises (SMEs).

Following a re-organisation of the Directorate of Earth Observation Programmes, in 2001 two Earth Observation Departments were established at ESRIN: the Science and Applications Department and the Ground Segment Department. In addition to operation and exploitation of the ERS and third-party missions data, these departments were now also responsible for ENVISAT mission operations and services. The ESA ground segments were extended to include new missions such as CryoSat, Gravity field and steady-state Ocean Circulation Explorer (GOCE) and Japan's ALOS Earth Observation satellite.



2005
ESRIN is ESA's leading center for Earth Observation

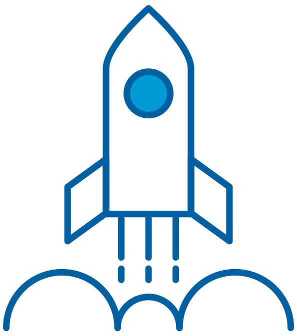
The International Charter Space and Major Disasters and the programme for Global Monitoring for Environment and Security (GMES) complemented the Earth Observation programmes. **In 2004, a new Director of Earth Observation Programme and Head of ESRIN brought a new impetus to the establishment and, at the beginning of 2005, ESRIN became ESA's leading centre for Earth Observation.**

Concerning other programmes, in 1999 ESRIN had acquired the Integrated Project Team (IPT) managing the VEGA Small Launcher Development Programme. This aggregated staff from ESA, ASI and CNES and its presence introduced a completely new set of activities, including project reviews and regular progress meetings with European industry. In October 2004, the VEGA IPT initiated the activities associated with the VEGA ground segment in Kourou.

Finally, in 2004, the ESRIN Satellite Multimedia Infrastructure responded to a number of requests for support from external users, such as the French and Italian Civil Protection Authorities. A laboratory area was set up with appropriate uplink facilities to ensure good connections to the Internet and academic networks, to provide access to satellites and to serve as a showcase for ESA's telecommunications activities in the fields of telemedicine, tele-education, secure communications and other applications.

5. ESRIN's recent history (2006 – present)

In 2009, ESRIN's core role as payload operations centre for ESA's Earth Observation missions was consolidated by the start of the operational exploitation phases of the first three Earth Explorers (GOCE, SMOS and CryoSat-2). In the GMES Programme, work continued on preparing ground segment operations for several satellites in the upcoming Sentinel suite, and on further Earth Explorer missions (Swarm was planned for 2012 and ADM-Aeolus for 2014). Science and applications development was pursued further on site, as was management of the International Charter Space and Major Disasters. Procurement activities for the Sentinel-1, -2 and -3 ground segment, processing and archiving facilities, and networks were completed in 2013.



2011
VEGA maiden flight successfully takes place

In the launchers sector VEGA's maiden flight successfully took place in 2011, and soon the VEGA Research and Technology Accompaniment Programme (VERTA) developed new launches. The first of the VERTA flexibility demonstration flights carried the ESA mission Proba-V. It successfully left Earth on 7 May 2013. This flight qualified a fundamental customer service improvement, namely the development of the multiple-payload launch capability for VEGA. At the end of the year, a contract was signed between Arianespace and ELV for the procurement of a batch of 10 launchers to be flown between 2015 and 2018.

Furthermore, the ESA Space Situational Awareness Near Earth Object Coordination

Centre (SSA-NEOCC) was opened on 22 May 2013 at ESRIN. This centre is currently the central access point to a network of European NEO data sources and information providers, and supports the scientific research needed to improve NEO warning services globally.

Turning to ESA corporate functions within the IT Department, Operational IT played a major role, providing valuable support to the Sentinel ground segment development. Operational IT was also instrumental in supporting many crucial events for ESA in 2014 and 2015 (the Rosetta landing, Sentinel-1A and Galileo launches, LISA Pathfinder, MSG-4, Sentinel-2A, the Intermediate eXperimental Vehicle (IXV) etc.).

During the last few years, the IT Department has also improved ESA's IT infrastructure. **In 2013, a new private cloud computing infrastructure, called Esacloud, was introduced and in 2014 Esaconnect was made operational.** In 2014, the IT Department worked to substantially update ESA-p, the corporate IT unified financial and procurement system. In 2015, the IT Department renegotiated its contracts with several suppliers for telecommunications, software and services, to provide better services for ESA under more efficient contracts, and in October the new communications service provider consortium became operational.

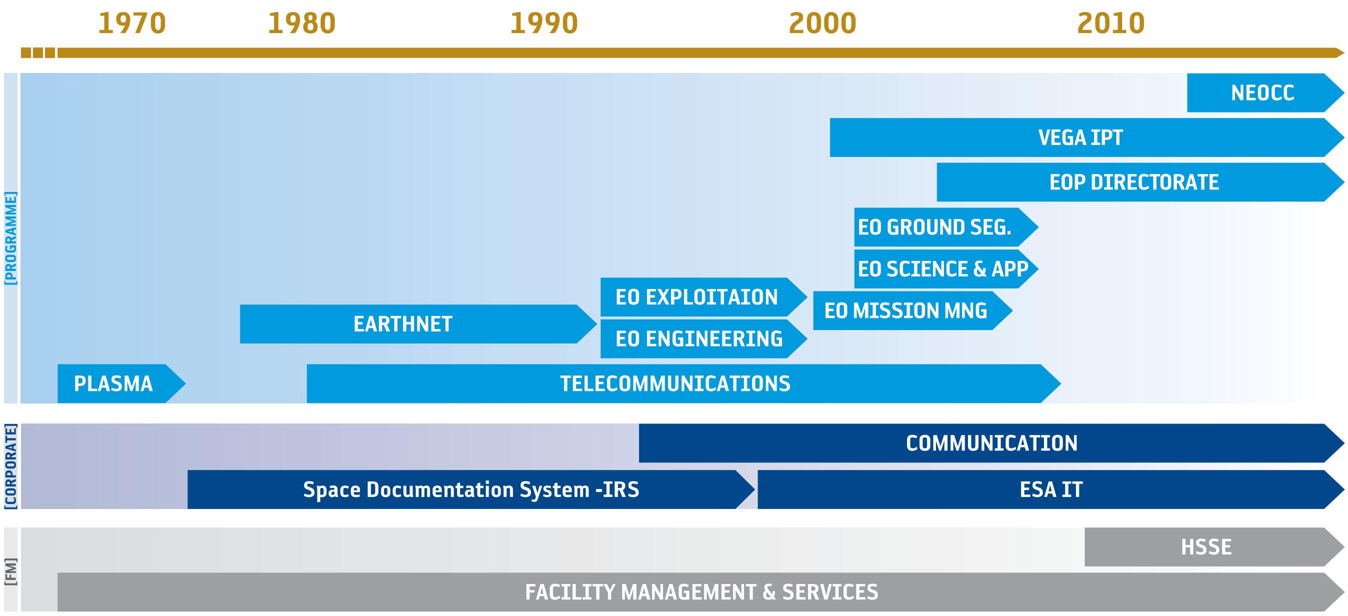
Finally, progress was achieved in the security assessment of ESA's programme-specific IT systems, specifically at ESRIN. The Security Office, established in 2007, prepared and approved the ESA COMSEC instructions for the security of electronic communications, and signed security arrangements with the European Defence Agency (EDA) and the European Global Navigation Satellite Systems Agency (GSA). In accordance with the new ESA security regulations on the evolution of security threats, the Security Office also carried out a revision of the ESA Security Directives.

Turning to facility management, 2010 saw the negotiation for the new ESRIN Host Agreement, and the approval process continued into 2011. Since the turn of the new millennium, the aim of making ESRIN more environmentally friendly has become a major issue, as the principles of sustainable development have directly or indirectly inspired numerous scientific conferences, high-level scientific workshops, industrial meetings and reviews, as well as VIP visits and events for the general public.

2013

ESA IT infrastructure is consistently upgraded

A snapshot on ESRIN's evolution



~350M€ year
2007-2016

2007-2016
TAS (IT), Leonardo, SERCO, ACS, CGS, Telespazio, E-Geos

Copernicus, EOEP-5, Φ-Lab, Science for Society

Earth Observation Programme

1976 — 1. At ESRIN a computerised catalogue of available imagery is established within the existing Recon system connected to the SDS

1977 — 2. Earthnet is incorporated as an optional programme by eight Member States (including Italy)

1985 — 3. Council approves the Earthnet Medium-Term Plan 1985-1990, as well as the start of two elements: the "ERS-1 off-line Phase-B" and the "Access to Third-Party Missions."

4. The Earth Observation Preparatory Programme (EOPP) is elaborated and proposed.

1991 — 5. With the launch of ERS-1, ESRIN has to support ground facilities during the operational phase of a satellite for the first time.

1992 — 6. Two new departments are created at ESRIN, one covering Exploitation, and the other involved in Projects & Engineering.

1993 — 7. The Processing and Archiving Facilities (PAF) proves an operational success and ESRIN consolidates its position as "The gateway to Earth observation from space."

1994 — 8. Intense activity to educate users about ERS-1 data applications takes place in many parts of the world and in ESRIN itself.

9. The ground segment and network facilities are technically upgraded to be ready for ERS-2, and the agreement with the ERS Consortium for worldwide data distribution is extended to ERS-2.

1995 — 10. ERS-2 is successfully launched in April and the Global Ozone Monitoring Experiment (GOME) opens a new field of research in atmospheric chemistry.

1996 — 11. ESA sets up a Data User Programme to tackle all issues related to the extraction of information from remote-sensing data.

1997 — 12. The Earth Observation Department at ESRIN becomes part of the Directorate of Applications.

13. ESRIN improves cooperation in educational activities (EURISY, EUROPA-STRIM, ASI and MIUR).

1998 — 14. The first release of the Multi-mission User Information Services (MUIS) infrastructure becomes operational.

15. ENVISAT site is ready for Payload Data System deployment.

2000 — 16. The Department's Mission Management Office for the Earth Observation Programmes is installed at ESRIN.

2001 — 17. Two EO Departments are established at ESRIN: the Science and Applications Department and the Ground Segment Department.

18. The ESA ground segments are extended to include new missions such as ALOS, CryoSat, and GOCE.

19. The International Charter Space and Major Disasters is included in the EOP.

20. The programme for Global Monitoring for Environment and Security (GMES) is included in the EOP.

2002 — 21. ENVISAT is successfully launched.

2004 — 22. Arrival of the new Director of Earth Observation Programme and Head of ESRIN. ESRIN becomes ESA's leading centre for Earth Observation.

2009 — 23. Operational exploitation phases of the first three Earth Explorers (GOCE, SMOS and CryoSat-2) begins.

2013 — 24. Sentinel-1, -2 and -3 procurement activities in the area of Ground Segment, Processing and Archiving Facilities, and Network are completed.

2014 — 25. Copernicus Sentinel 1A and 2A are launched.

2016 — 26. Copernicus Sentinels 3A and 1B are successfully launched.

2017 — 27. Copernicus Sentinel 2B is successfully launched.

28. Copernicus Sentinel 5P is successfully launched.

VEGA IPT

1. The integrated Project Team managing the VEGA Small Launcher Development Programme is located at ESRIN.	1999
2. VEGA IPT consolidates with the recruitment of ESA (internal and external), ASI and CNES staff. This leads to a team of 12 at ESRIN by year's end.	2001
3. The VEGA IPT begins activities associated with the VEGA ground segment in Kourou.	2004
4. VEGA's maiden flight successfully takes place, and the VERTA programme develops new launches.	2012
5. VV02 is successfully launched.	2013
6. VV03 is successfully launched.	2014
7. VV04 (IXV), VV05 (Sentinel 1A) and VV06 (LISA Pathfinder) are successfully launched.	2015
8. VERTA ends in December and VEGA commercial exploitation begins.	
9. Two new launches are successfully accomplished.	2016

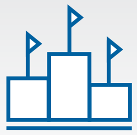
~120M€
year
2007-2016

programme & project mngmt; propulsion, mechanical, avionics & system engr; product assurance. ESRIN Data Center, Security & Corporate apps infrastructure

Information Technology Department

1. SDS moves at ESRIN and a new IBM 360/50 is installed.	1973
2. The SDS online database becomes one of the world's largest. All data acquisition and entry is centralized in ESRIN.	1974
3. IRS interfaces are revised to cope with Euronet and with increasing Earthnet data storage.	1979
4. IRS interfaces are revised to cope with newly established national public packet switching networks.	1982
5. ESA-IRS begins the implementation of an expansion plan.	1990
6. ESA's Director General announces his decision to transfer the management of all the Agency's information systems dealing with non-operational data to ESRIN.	1995
7. The Informatics Department at ESRIN becomes part of the Agency's Directorate of Administration, and begins to provide informatics support to all of the Agency's Establishments and Directorates.	1997
8. A Computer Emergency Reaction Team (CERT) is created to defend any ESA systems that come under cyberattack.	2001
9. An important success is achieved with the establishment of the ESA Intranet.	
10. The Information Systems Department achieves successful certification to ISO 9001:2000 of its Quality Management System (QMS).	2002
11. ESRIN IT provides support to the Sentinel ground segment development.	2011
12. IT infrastructure is prepared for Security Office accreditation (SDIP phase 2)	
13. The IT Department brings Esacloud into operation.	2013
14. The IT Department provides the design and implementation for the new NEO data centre as well as the IT infrastructure for the SSA programme.	
15. Virtualisation technology allows consolidation and rationalisation of computing needs.	2014
16. Esaconnect is introduced	

ESRIN Data Center, Security infrastructure, Corporate application infrastructure



ESA Web Portal, ESA Web TV, Big Hall

Web, Distribution & ESRIN Outreach Unit

1993 1. ESRIN establishes a number of services reachable from the world wide web. An ESA Home Page is created, carrying institutional details on the Agency and its Establishments, with pointers to topical information services on site.

1995 2. ESRIN provides substantial support in the form of visual exhibits to a number of thematic Earth Observation conferences and workshops, to in-house events at ESRIN, and for the ESA Pavilion at the Le Bourget Air Show.

1998 3. Various international exhibitions and workshops related to Earth Observation applications are prepared at ESRIN. The emphasis is on user services for remote sensing applications being developed by Small and Medium-Sized Enterprises (SMEs).

1999 4. Contacts with Italian institutions (Italian Civil Protection Agency, Environment Ministry and Defense Ministry) and ASI are maintained throughout the year. Meetings are also arranged with the Italian Parliamentary Committee on Space, the European Commission, and the European Union.

2000 

5. The new ESA Web Portal is launched on the web and a staff dedicated to its management is formed. For the first time, ESA's web site gains a multilingual dimension.

2002 6. A number of new features are added to the ESA Web Portal, including the Multi-media Gallery, Focus On, and Space Live.

7. ESRIN hosts the CEOS (Committee on Earth Observation Satellites) 16th Plenary Meeting in November, and the CEOS high-level open session on Earth Observation related follow-up actions from the World Summit on Sustainable Development.

8. EDUSPACE is an immediate success, with more than 200 schools registered.

2004 9. The ESA Web Portal experiences a considerable increase in visitor numbers and implements new measures targeting improved security and wide broadband access.

10. The 100th meeting of the ESA Earth Observation Programme Board is held at ESRIN on 27 May.

2005 11. A new ESRIN web site is launched in 2005, including a virtual tour of the site and facilities.

2009 

12. The Vice-President of the European Commission and European Commissioner for Industry and Entrepreneurship, Antonio Tajani, visits ESRIN in September.

13. ESRIN hosts delegation visits and bilateral meetings with partner agencies, such as NASA and the Canadian Space Agency.

2011 14. VEGA launch communication campaign at the Auditorium Parco della Musica in Rome.

15. A permanent installation of a mock-up Galileo satellite atomic clock is installed.

2014 16. Annual visitors to ESRIN reach 45,000, making ESRIN the most visited ESA establishment after ESTEC.

2015 17. Visitors to ESRIN reach 60,000 visitors.

ESRIN Estates and Facilities Management Service

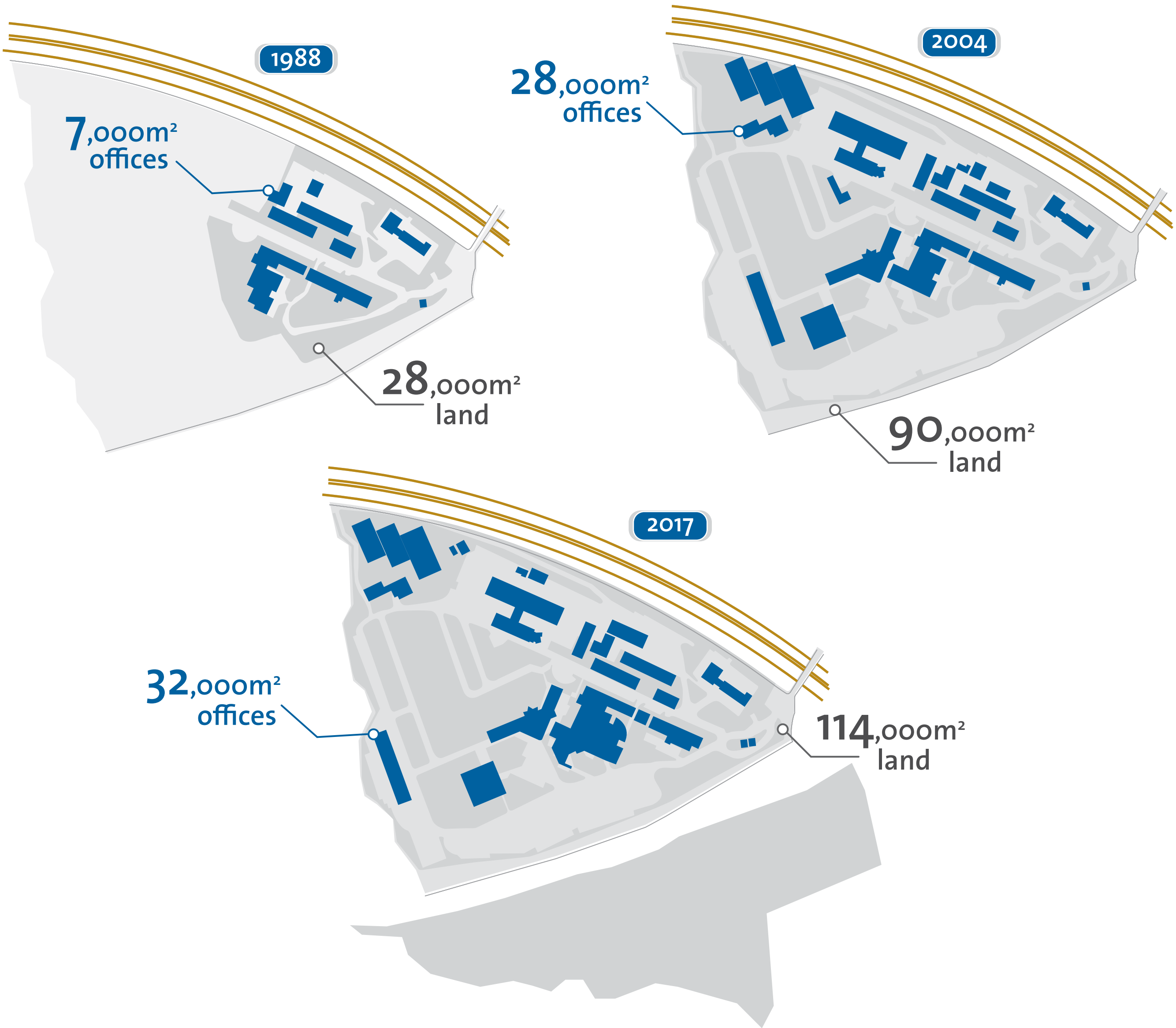
~6,2m€ year

1. ESRIN is established in Frascati.	1965
2. ESRIN's cornerstone is placed.	1968
3. The sale to the CNR of some ESRIN buildings and technical installations dismissed during the downsizing of 1973 allows the building of new facilities for ESRIN that ensure the smooth running of the IRS.	1979
4. Computer and related facilities dismissed during the downsizing of 1973 are re-housed in custom facilities, and the ESRIN Conference facilities are reinstated.	
5. A new building is inaugurated, increasing office and other space by some 2000 m^2.	1986
6. A new extension is built to provide even more offices, a fully equipped training/seminar room, and some archiving space.	1988
7. A prefabricated two-story building and a new computer area dedicated to Earth Observation Data Network services are founded.	1993
8. ESRIN is granted an additional 4-5 hectares of land by the Italian authorities, which allows the construction of a new office building.	1994
9. A new office building dedicated to Edoardo Amaldi is officially inaugurated.	1996
10. The construction of a new building to house the ENVISAT ground segment activities begins.	
11. The installation of the Envisat Ku-band antenna begins.	
12. The logistics for VEGA IPT are prepared.	1998
13. The new European Centre for Space Records (ECSR) becomes operational in October.	2002
14. A Virtual Reality Theatre is installed.	2004
15. A new social centre with childcare facilities is inaugurated.	
16. ESRIN employs its own Health, Safety and Security officer responsible for procedure maintenance and site security.	2009
17. ESRIN's workplace canteen is the first in Italy with a Zero Impact certification, which equates to a net zero carbon footprint.	
18. ESRIN receives full certification from the British Standards Institute for Occupational Health and Safety Management, and Environmental Management.	2010
19. ESRIN is recertified for the ISO 14001 environmental management system and OHSAS 18001 health and safety management system by the British Standards Institution.	2012
20. Frascati experiences a light earthquake and it emerges that some (older) buildings need reinforcement.	
21. Work begins on ESRIN's new canteen seating area, refurbished kitchen and self-service sector.	
22. ESRIN's Energy Management System is compliant with the ISO 50001:2011 standard.	2013
23. Construction works for a new bridge start as part of the new ESRIN Host agreement.	
24. The canteen refurbishment work is completed and the new lunch room is opened.	
25. ESRIN's Energy Management System is certified according to ISO 50001:2011.	2014
26. ESRIN reduces its overall energy use by 7% from the baseline year of 2007, and by 25% from 2010.	
27. ESRIN CO^2 emissions are reduced by 28% from the baseline year.	
28. The anti-seismic consolidation project is completed for buildings 3, 6, 7 and 10.	2015

ESA History

1961	1. The Groupe d'Etudes Européen pour la Recherche Spatiale (GEERS) institutes the Commission Préparatoire Européenne de Recherches Spatiales (COPERS).
1962	2. The European Launch Development Organisation (ELDO) and the European Space Research Organisation (ESRO) are founded.
1974	3. ELDO is disbanded.
1975	4. ESA is founded by merging ELDO and ESRO through an agreement signed by ten European States.
2004	5. The legal basis for the EU-ESA cooperation is provided by a Framework Agreement.
2007	6. The approval of the European Space Policy unifies the approach of ESA with those of the European Union and their Member States.
2009	7. The Lisbon Treaty provides the European Union with an explicit competence in space.
2016	8. The Europe's Space Strategy is approved.
	9. ESA launches the Space 4.0 strategy.

ESRIN's evolution



Agreements

1. H.L. Jordan is appointed first Director of ESRIN.	1964
2. First Conference, on plasma physics, takes place.	1966
3. A Host Agreement is signed with the Italian Government.	1970
4. Scientific activities are terminated and ESRIN is downsized.	1973
5. ESRIN evolves from a basic activity to a support establishment.	1981
6. ESRIN is included on the map of "important international establishments" in Italy.	1986
7. The Italian Government and ESA sign a new Host Agreement.	1993
8. In January, the ASI Science Data Centre is inaugurated at ESRIN.	2001
9. The Host agreement for the Spaceguard Foundation is signed.	2002
10. A bilateral agreement with the University of Rome Tor Vergata is signed.	2003
11. ESA BIC Lazio agreement becomes operational and five incubators for SMEs are hosted at ESRIN.	2005
12. An agreement with the CNR is signed in June to cover cooperation in the field of broadband connectivity.	
13. ESRIN signs an agreement with the European Commission Joint Research Centre (JRC) concerning the development of space-based information services and the access to and provision of Earth Observation data.	
14. The new Host Agreement for ESRIN is signed.	2012

2 ESRIN's programmes and activities

1. An in-depth analysis of the Earth Observation at ESRIN

ESRIN, ESA's Centre for Earth Observation, hosts the Directorate of the Earth Observation Programmes (D/EOP). The EOP Director is also the Head of ESRIN. Since July 2017, the EOP Directorate has been supported by the Earth Observation Business Unit Controlling Office and the Strategy, Programme and Coordinating Service and by four Departments:

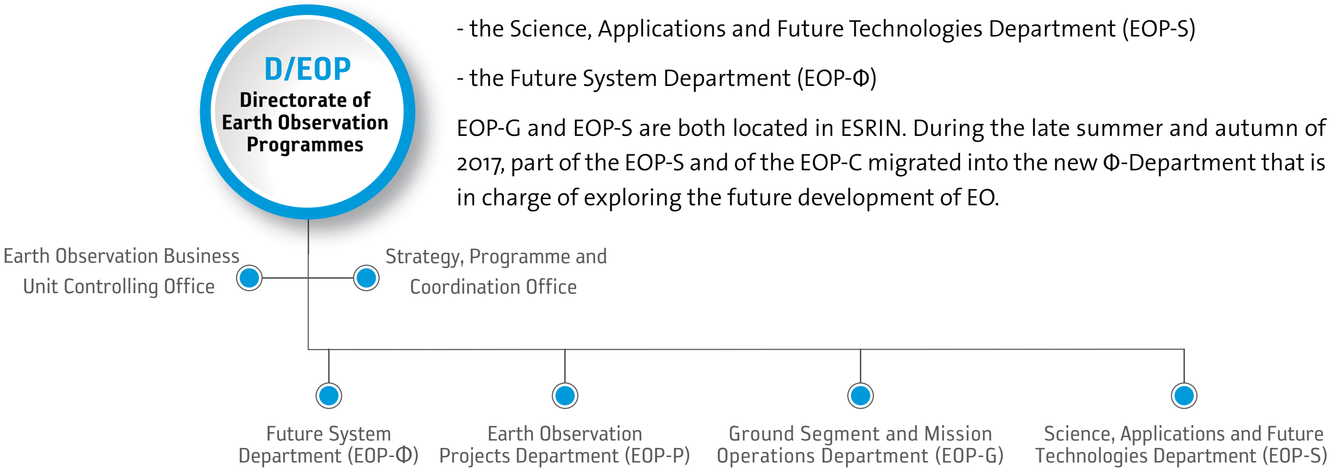
- the Ground Segment and Mission Operations Department (EOP-G);

- the Earth Observation Projects Department (EOP-P);

- the Science, Applications and Future Technologies Department (EOP-S)

- the Future System Department (EOP-Φ)

EOP-G and EOP-S are both located in ESRIN. During the late summer and autumn of 2017, part of the EOP-S and of the EOP-C migrated into the new Φ-Department that is in charge of exploring the future development of EO.



1.1. Ground segment and Mission operations

ESRIN manages a complex, worldwide distributed ground segment that uses national and industrial facilities.

ESRIN must ensure the ground segment is ready to acquire and process data once a satellite is in orbit and operating, both for new ESA missions and third party missions. To achieve this goal, it is necessary to identify the ground stations and to decide where to process data according to several legal, economic and technical parameters. Some ground stations are in the ESA network, others are situated within ESA Member States or belong to non-ESA Member States. The ground stations selected may or may not be operated by ESA, depending on the requirements and the capacity of stations.

The Network of ESA Ground Stations

COOPERATIVE NETWORK	CORE ESA NETWORK	AUGMENTED NETWORK
1 Poker Flat	1 Kourou	1 South Point
2 Goldstone	2 Kiruna	2 Santiago
3 Madrid	3 Redu	3 Troll
4 Weilheim	4 Cebreros	4 Svalbard
5 Esrange	5 Villafranca	5 Dengara
6 Hatebeesthook	6 Maspalomas	
7 Malindi	7 New Norcia	
8 Kerguelen	8 Santa Maria	
9 Usuda	9 Malargüe	
10 Masuda		
11 Canberra		

EO Mission Management

ESRIN is responsible for managing the operations of ESA-EO satellites once they are in orbit. Each ESA-EO satellite has a Mission Manager that ensures mission objectives are met and addresses users' requirements. To achieve their goals, ESRIN's Mission Managers work in close contact with the offices that are responsible for planning and supervising data acquisition and archiving, and with the offices that are responsible for product generation and dissemination. Mission Managers also cooperate with several offices at ESTEC and ESOC to resolve unexpected technical problems and to request potential adjustments to the spacecraft and/or its instruments to meet requests for specific data. Once a mission is completed and the satellite is no longer transmitting data, Mission Managers must ensure data accessibility for long-term exploitation. Finally, Mission Managers must provide an ex-post assessment of the mission, in order to facilitate and promote the definition of new mission scenarios for the future.

Past and future ESA Earth Observation Missions

As of May 2017, ESA EO activities include 12 satellites in operation and 28 satellites in development. It is related to **four classes of EO Missions**:

- Scientific Missions;
- Copernicus;
- Meteorological Missions;
- Third Party Missions.

The currently active **Scientific Missions** include the **Earth Explorers 7 and 8** (GOCE, ADM-Aeolus, EarthCARE, Biomass, SMOS, Cryosat, Swarm and Flex). At the time of writing, two missions have been selected for phase A studies for **Earth Explorer 9**. **Copernicus Missions**, the so-called Sentinels, are each based on a constellation of two satellites and carry state-of-the-art technology to deliver a stream of complementary imagery and data tailored to the needs of the programme. **Meteorological Missions** include Meteosat Second Generation (MSG) missions and the Meteorological Operational satellite programme (MetOp). Finally, ESA uses its multi-mission ground systems to acquire, process, archive and distribute data from other satellites, the so-called **Third Party Missions.** ESA is producing 14 terabytes of data per day, which is approaching comparability with the 500 terabytes per day of Facebook. The data from these missions are distributed under specific agreements with the owners or operators of the missions, following the ESA Data Policy.

1.2. Ground segment

ESRIN is responsible for acquiring raw data from a worldwide set of receiving stations, and for arranging for these data to be processed and archived so that they are available for use. ESRIN is continuously adding to its archive of Earth Observation data, the largest collection of its kind in Europe. This information is a unique source of environmental information that serves as the basis for a steadily widening range of applications, and provides vital feedback for future programmes.

Researchers can apply to receive Earth Observation data through the ESRIN-hosted **Earth Observation Principal Investigator (EOPI)** Portal. ESRIN's researchers work with external scientific partners to calibrate and validate the outputs of ESA's many orbiting EO sensors, and refine the processing algorithms that turn raw data into useful geophysical values. This activity is essential to ensure the reliability of satellite data at level 1 and 2, sometimes at level 3. ESRIN also regularly hosts major scientific conferences and workshops concerning topics related to Earth Observation.

Another part of ESRIN's role is to increase the wider take-up of satellite data by supporting development of innovative EO-derived information products and services. ESRIN achieves this goal through a series of programmes that foster partnerships among research institutions, service companies and user organisations:

- the **Support to Science Element (STSE)**, launched in 2008;
- the **Data User Element (DUE)**, a continuation of the Data User Programme;
- the **Value Adding Element (VAE)**, also known as Earth Observation Market Development (EOMD) Programme;
- the Global Monitoring for Environment and Security **Services Element (GMES-GSE), now Copernicus GSE**.

Finally, international cooperation is a significant way of leveraging the returns from ESA EO activities. ESRIN liaises with several international bodies including the Committee on Earth Observing Satellites (CEOS) that coordinates space agencies' mission planning, data products and policies in the field of planetary monitoring. In addition, ESRIN is the centre overseeing ESA's participation in the **International Charter Space and Major Disaster**s, which puts EO resources of its member space agencies at the disposal of civil protection authorities in the event of a natural or man-made disaster. The centre also provides support to various international ESA initiatives including the **Tiger Initiative**, which supplies satellite data to African users in support of sustainable water management, and the **Dragon Programme,** an initiative between China and ESA to encourage joint research across a number of thematic areas, concentrating on Chinese territory.

1.3. Future EO and the inauguration of the Φ-Lab

The recently established Φ-Lab includes the InCubed Initiative and is one of the three offices of the Φ-Department. The Φ-Lab is a novelty that will be located in a new building at ESRIN, while the future mission office will be located in ESTEC. The third office of the Φ-Department is dedicated to Copernicus, and will remain part of ESRIN.

The Φ-Lab aims to identify, support and scale innovative EO-based solutions and business models harnessing the power of transformative digital technologies. The Φ-Lab team:

1) provides know-how, guidance, and an experimentation open space at ESRIN;

2) fosters partnerships with industry, academia, innovation leaders and startups

to better understand, explore and scale new technologies in the field of Earth Observation.

By adhering to ESA's Space 4.0i policy, the EOP is opening up to new actors and paradigms (academia, industries, agencies...) without abandoning previous successes (Meteo, Copernicus, Earth Explorers, users communities, partnerships...) and this will enhance the **EOP role as EO System Architect**.

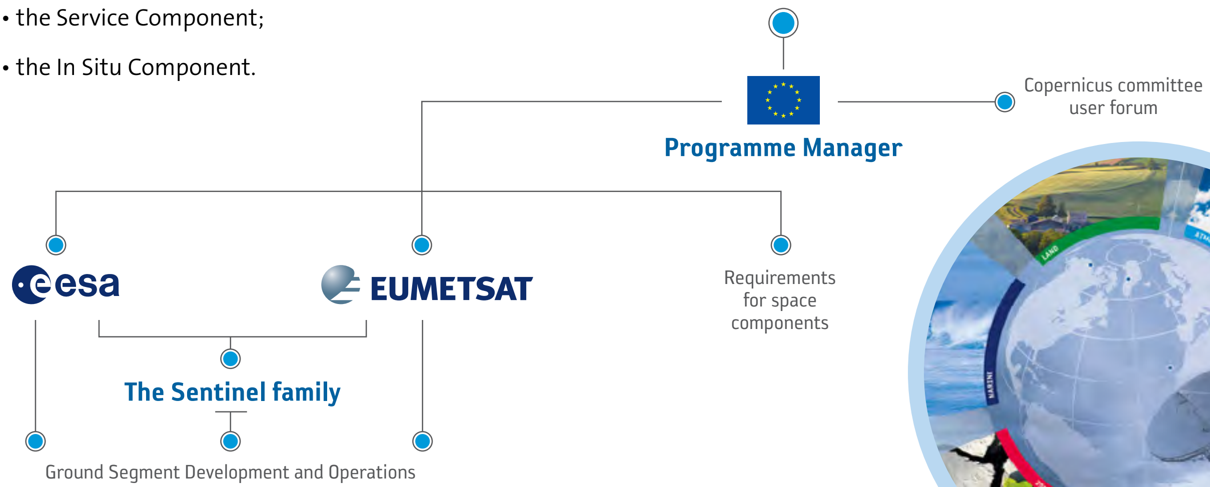
Copernicus

Copernicus is **the third largest data provider in the world**. It guarantees **free, full and open access to data and services** to its users. Copernicus data and services support the development of many applications that create added value in several non-space domains, for several different user segments.

Copernicus is headed by the European Commission (EC) in partnership with ESA and with the European Environment Agency (EEA). The EC, acting on behalf of the European Union, is responsible for the overall initiative, setting requirements and managing the services. On the other hand, **ESA manages the Space Component**, and coordinates satellite data delivery.

Copernicus is made of three components:

- the Space Component;
- the Service Component;
- the In Situ Component.



The Space Component serves users with remote sensing data from the Sentinels and the Copernicus Contributing Missions, which are independent missions developed at national, European and international level. The ground segment, which facilitates access to Sentinel and Contributing Mission data completes the Copernicus Space Component. The Space Component forms the European contribution to the worldwide Global Earth Observation System of Systems (GEOSS).

The Service Component provides a unified system through which vast amounts of data are fed into a range of thematic information services, which are designed to benefit the environment, living standards, humanitarian needs and to support effective policy-making for a more sustainable future. Copernicus services fall into six main categories: **land management, marine environment, atmosphere, emergency response, security and climate change**.

Some of them were already declared operational several years ago (such as the Land Monitoring Service and the Emergency Management Service – Mapping in 2012, and the Atmosphere Monitoring Service and the Marine Environment Monitoring Service in 2015). Others were declared operational more recently (such as the Border

Surveillance and the Maritime Surveillance components of the Security service in 2016 and the Support to External Action component in May 2017). Yet more are still in their development phase (Climate Change Service).

National governments own and operate the In Situ component that includes contributions of the Member States to the Copernicus Programme, as a significant part of the data and monitoring infrastructure. The Copernicus In Situ Component also benefits from international efforts to collect and share data, in many cases from research infrastructures. The Copernicus In Situ Component's main goal, therefore, is to map the in situ data landscape, comparing what is available against requirements to identify gaps, support the provision of cross-cutting data and manage partnerships with data providers to improve access and usage.

Copernicus Data access

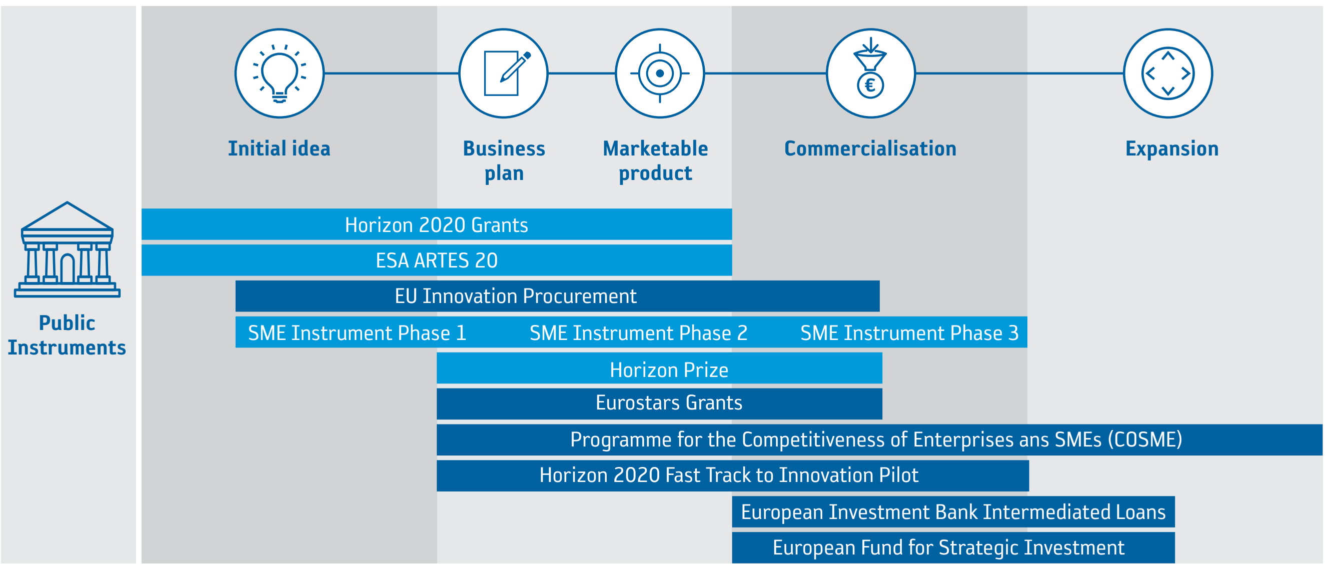
	Access point	Data policy	Providers
Satellite Data	Sentinel Scientific Data Hub (SCI-Hub)	Free, full and open data policy	ESA
	Copernicus Space Component Data Access (CSCDA)	Access limitation apply	ESA
	EUMETCAST	Access requires specific equipment	EUMETSAT
	CODA	Free, full and open data policy	EUMETSAT
Services Data and Information	Copernicus Atmosphere Monitoring Service (CAMS)	Free, full and open data policy	ECMWF
	Copernicus Marine Monitoring Service (CMEMS)	Free, full and open data policy	Mercator
	Copernicus Climate Change Service (C3S)	Free, full and open data policy	ECMWF
	Copernicus Land Monitoring Service (CLMS)	Free, full and open data policy	EEA and EC
	Emergency Management Service (EMS)	Activation by authorised users	EC
	Security	Access restricted	FRONTEX, EMSA, EU SatCEN

source: www.copernicus.eu

As already mentioned, **Copernicus space infrastructure and Copernicus services data and information are free and open both for people and institutions**. Specifically, they are accessible through a series of access points, whose characteristics are summarized in the table above.

Secondly, the Copernicus Programme intends to boost innovation and economic growth. In this, the commercial downstream sector plays a key role in maximising the achievable benefits. To facilitate this task, the EU and several public and private institutions have designed a set of **financial instruments and platforms to support SMEs and start-ups in developing Copernicus-related businesses**. The graph below provides an overview of the instruments activated by the public sector.

Public financial instruments (in dark blue those one specifically relevant for Copernicus downstream)



source: www.copernicus.eu

Thirdly, **Copernicus follows a user uptake strategy**. Copernicus data, like most space data, cannot be used directly by end users. The key objective of the strategy is therefore to support an ecosystem of service providers (public or private) that transform space data into accessible and usable information.

The strategy focuses on three actions:

• increase awareness about Copernicus;

• facilitate access to Copernicus data and services;

• support downstream sectors.

For the first action, two networks (**Copernicus Relays and Academy**) have been set up, with more than 140 members acting as multipliers in all European Regions[1]. For the second action, a new industry-led platform will be available by the end of 2017, with a **Data and Information Access Service (DIAS)** and the **Copernicus Support Office**. Finally, the following initiatives are part of the third action: **Copernicus Masters and Accelerator, Copernicus Incubation Programme, Copernicus Hackaton Programme, and Copernicus Skills Programme.**

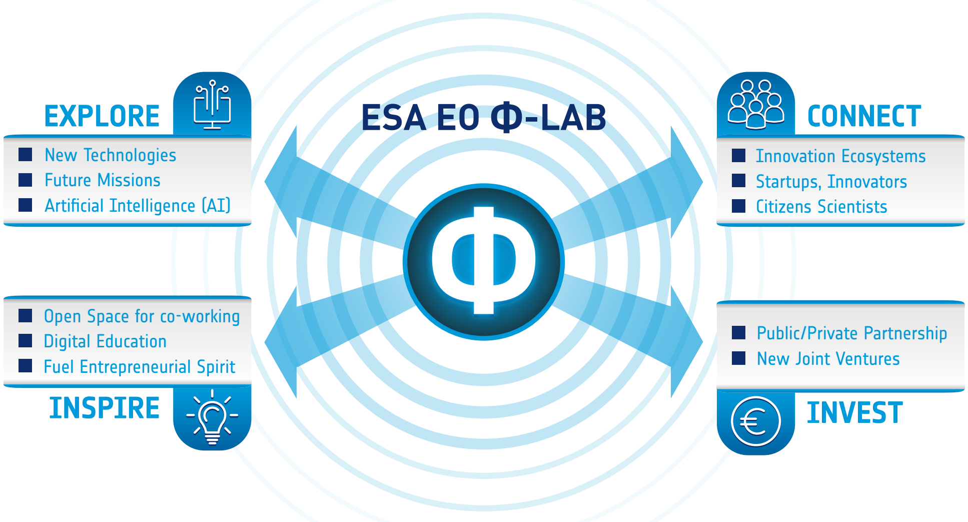
[1] *As of 2 November 2017, nine members are located in Italy. A full list of Copernicus Academy Members can be downloaded at:* http://copernicus.eu/sites/default/files/documents/News/Network_of_Copernicus_Academies-List_of_Members_23Oct2017.pdf.

As of August 2017, four Relays are located in Italy. A complete list of Copernicus Relays can be downloaded at: http://copernicus.eu/sites/default/files/documents/News/NetworkOfCopernicusRelays_ListOfMembers_04Aug2017.pdf

The Φ-Lab

EO technologies are constantly evolving, as are the ways of processing and exploiting satellite data. The scientific, societal and economic benefits of the latter are virtually endless – and realising their full potential in these three areas is key. The Φ-Lab pursues this overarching goal by addressing four areas of activity in a way that is coherent with the ESA Space 4.0i approach.

Based on the Space 4.0i philosophy, the Φ-Lab will:



1.4. Earth Observation and the UN 2030 Agenda: a long value chain

The overall effort of observing the Earth with the use of satellites has resulted in significant progress in several scientific areas, laying the basis for the development of new applications. In the remainder of the paragraph, the major achievements, applications and benefits generated by the ESA EOP and more in general by the EO activities conducted worldwide are illustrated. Being the ESA Centre for Earth Observation and hosting the EOP Directorate, ESRIN is at the heart of this valuable process

The climate change initiative, International treaties and heritage sites

Datasets provided by Earth Observation satellites are crucial for measuring the key parameters of climate change, the so called "**Essential Climate Variables**". These data are

required by the Global Climate Observing System (GCOS) to support the United Nations Framework Convention on Climate Change (UNFCCC) and the International Panel on Climate Change (IPCC).

As a first step to explore how current and future Earth observation systems may help the implementation of international environmental treaties, in 2001 ESA set up the **Treaty Enforcement Services using Earth Observation (TESEO)** initiative. This worked with various treaty secretariats to develop satellite-based services and bring them into operation. TESEO has paved the way for the **Global Monitoring for Environment and Security (GMES)** Programme, now renamed **Copernicus**.

Furthermore, in 2003 ESA launched an Open Initiative with UNESCO to use Earth Observation to help developing countries to more effectively **protect their World Heritage sites.** The Initiative now involves other space agencies, universities, research institutes and entities from the private sector. The idea is that data from space can be used to monitor heritage sites, alerting authorities to land use changes and human activities (such as wars, the deliberate destruction of cultural symbols, pillage, pollution, poaching and poorly managed tourism...) that could damage the sites.

Securing the environment

The supply of a consistent set of continuously updated global satellite data can be turned into actionable information for decision making on various environmental issues, **strengthening public safety**. Specifically, satellite-based rapid mapping services can support civil defence and humanitarian aid activities during crises as well as supporting risk assessment and prevention efforts in the long term. Within this context, as already mentioned ESA co-founded in 1999 t**he International Charter Space and Major Disasters**, an agreement between space agencies to make near-real time satellite data available to worldwide civil protection agencies. Following the Charter's activation, space-acquired data products and associated resources are made directly available to the civil protection agencies concerned. Services are not limited to supplying data but include processing and interpretation as well.

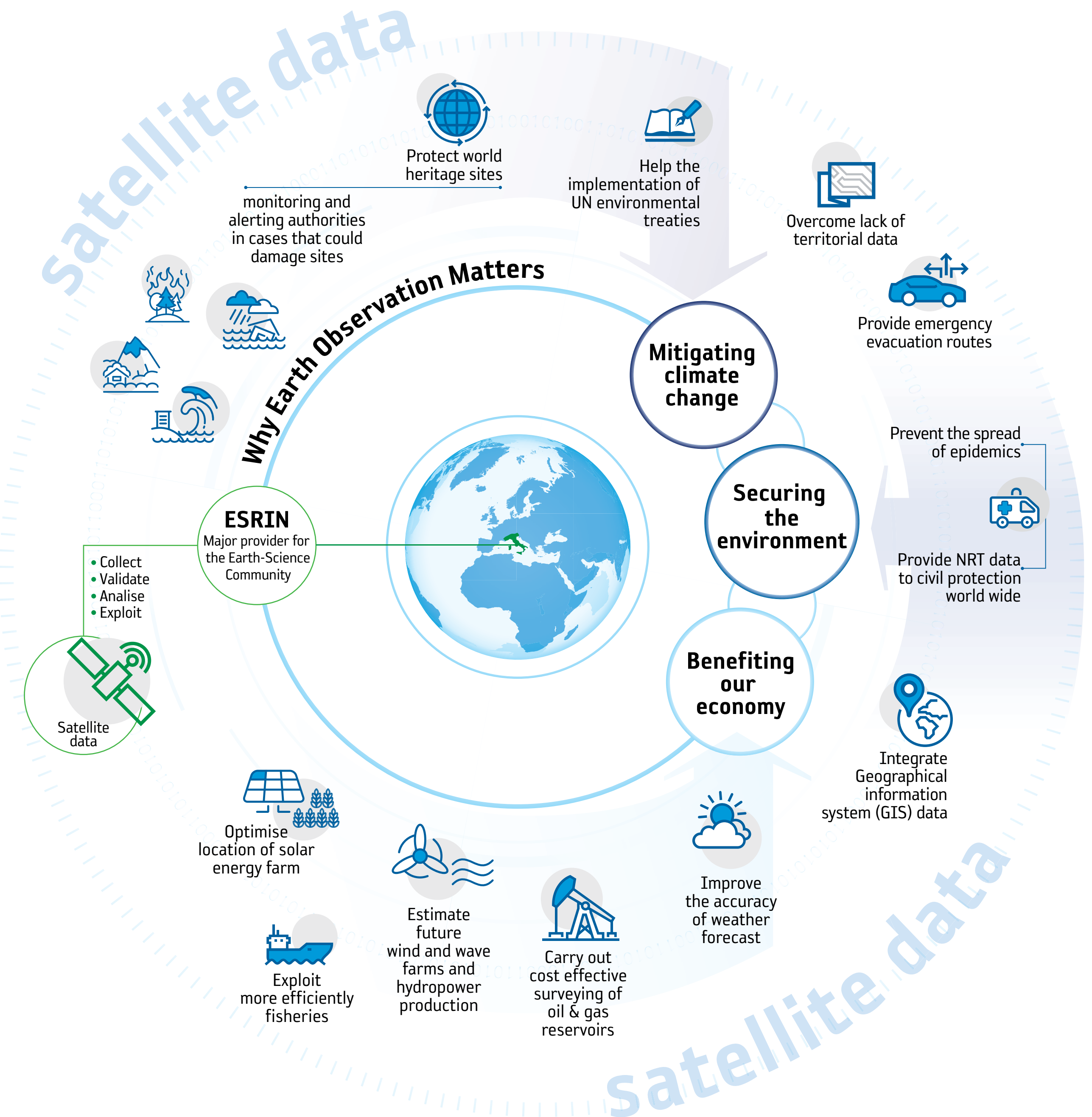
Furthermore, Earth Observation has the potential to **overcome a lack of territorial data**, yielding satellite imagery with high levels of both spatial and temporal resolution. In poor and remote areas, these images can serve as a source of reliable baseline geographical products suitable for operational planning, such as the speedy distribution of emergency food and medicine or deciding emergency evacuation routes for personnel. Satellite imagery can also be integrated within standardised **geographical information systems (GIS)** software, to be supplemented with local knowledge gathered on the ground – such as road conditions, warehouse stocks or the current battlefronts within war zones.

Finally, satellite data are a valuable support for the aid of authorities working **to prevent the spread of epidemics**, as they have the potential to help forecast disease outbreaks. As an example, as a part of a project called **Epidemio**, ESA provided products to the World Health Organisation (WHO) who was leading a global partnership called **Roll Back Malaria.** This was aimed at halving malaria cases by 2010 by distributing countermeasures such as bed nets. The ESA products included satellite-derived maps of water bodies, digital elevation models, and weekly land surface temperature maps.

Benefiting our economy

Space-derived information provides a whole new dimension of knowledge and services which can benefit human daily life. As an example, satellite data have radically improved the accuracy of weather forecasts, generating practical benefits in many sectors of economic activity.

Furthermore, **the Earth offers a wide array of resources with the potential to create wealth, and satellite data reveal these resources**. As an example, by returning data on hilltop snow cover or precipitation amount, satellite images capturing an entire river basin within a single acquisition enable accurate, advanced **estimates of future reservoir depth and hydropower production**. Space-based instruments also make possible the creation of wide-ranging "**sunshine indexes**" for the **optimal location of solar energy farms**, and by recording the incoming solar energy amount they provide an objective yardstick for testing if existing farms are functioning efficiently. Thirdly, orbital sensors recording wind and wave parameters can provide the equivalent service for wind and wave farms. The latter are especially useful for **positioning offshore facilities where meteorological statistics are not usually gathered**. Fourthly, **fisheries can be exploited more efficiently** with ocean current and sea temperature data returned from satellites serving as a basis for guiding fishing fleets to areas where the catch is likely to be the highest. Fifthly, as oil and gas reserves dwindle, offshore frontier areas such as the Arctic and south-east Asia have come under an increased focus of interest for energy companies. Exploration managers are making



increasing use of satellite data as a cost-effective mean of carrying out large-scale surveying of unexplored areas. Finally, wide-area satellite images have the potential to identify the **distinctive geological structures associated with oil and gas reservoirs and also mineral deposits**.

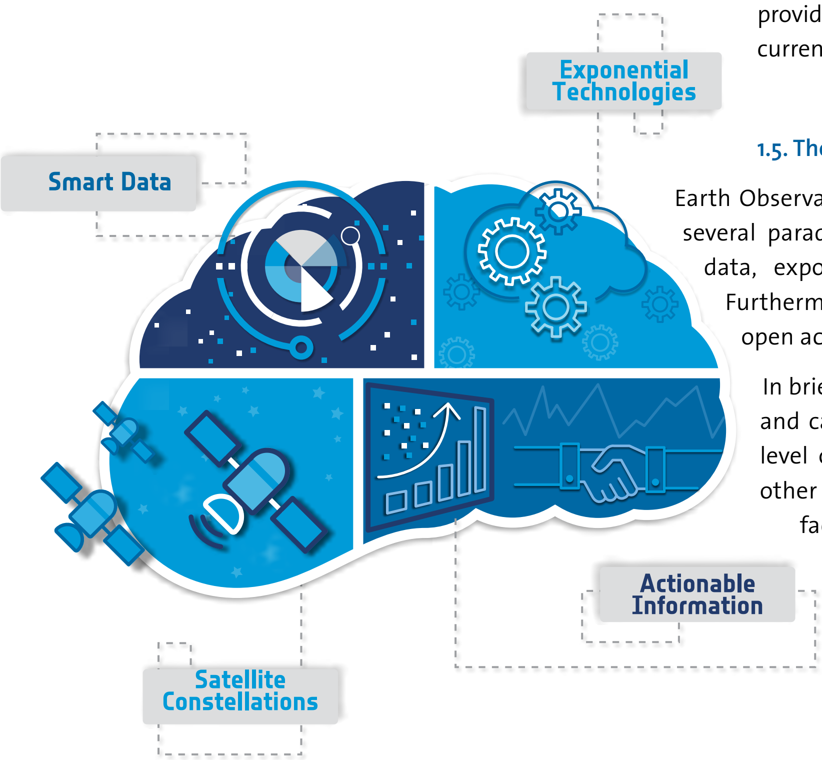
EO and the 2030 UN agenda

As an international organisation ESA has a responsibility to use its technology for the further development of humankind according to a sustainable development pattern. Indeed, ESA has developed a wide range of programmes that will help achieve the **Sustainable Development Goals (SDGs)**. The table on page 25 represents some of ESA's programmes and their connection to the post-2015 SDGs identified in the **2030 UN agenda**.

Indeed, Earth Observation satellites supply data that, once turned into actionable information, can be used to ensure that economic development does not take place at the expense of the environment's irreplaceable resources.

Furthermore, with the potential to frame an entire city in a single image, and trace growth as it occurs, satellites are becoming a useful tool for town planners attempting to manage the growth of urban settlements. In the developing world in particular, the pace of change soon makes printed maps outdated, but Earth Observation provides constant updates, allowing to flag regions that are susceptible to floods, landslides or subsidence as unsuitable for building, **channeling urban development toward more suitable zones, and defending rich agricultural lands from urban encroachment.**

Within cities, satellites can help identify **overdeveloped "hotspots"** in danger of overcrowding, congestion and other factors that reduce the quality of life of their residents. They can also monitor air quality and trace pollution sources. Finally, as already pointed out, Earth Observation is a particularly useful means of studying cities within the context of the wider landscape, checking on the continued **sustainability of natural resources** essential for urban living such as dependable energy sources and clean water. Long-term monitoring of Earth from space helps to assess the **environmental effects of human activities** on a systematic basis, and provides an extensive time series of data for the projection of current environmental trends into the future.



1.5. The EO four paradigm shifts and Open Science

Earth Observation and space research in general must encompass several paradigm shifts, involving satellite constellations, smart data, exponential technologies and actionable information. Furthermore, an issue that must be tackled is the one regarding open access and Open Science.

In brief, while miniaturization allows for new opportunities and capabilities, it is also necessary to mature the higher level of efficiency needed to face the competitiveness of other emerging technologies. Another challenge to be faced is the inevitable increase in space debris. If this were to rise exponentially, it could seriously affect space accessibility and reduce the reliability of new satellites. To deal with these new challenges, technological advances need to be complemented with new rules and more complex algorithms.

UN's Sustainable Development Goals (SDGs), EO services and ESA programmes

SDG	EO services	ESA Programme
1 NO POVERTY	Supporting banking systems International development Sustainable production of food Supporting development banks	Support to development banks Earth Observation for international development Herding from space Satellites for remote banking
2 ZERO HUNGER	Sustainable agriculture Monitoring food production and security	Agriculture and food security Global monitoring for food security Health of livestock
3 GOOD HEALTH AND WELL-BEING	Telemedicine Space for Health ISS research	Telemedicine using Satcoms Space aids Ebola patients Mapping deadly mosquitos Satellites helping to assess the risk of epidemics Space for Health
4 QUALITY EDUCATION	Tele-learning Tools for educators	Satcoms linking rural schools in South-Africa and Italy ESA kids e-Learning in rural areas ESA educational projects
5 GENDER EQUALITY	Attracting more women to science and technology careers	Space Girls-Space Women Women choosing STEM careers
6 CLEAN WATER AND SANITATION	Recycling water Closed-loop systems Monitoring water quality	TIGER project GEO-Aquifer project Worldwide water quality app MELiSSA
7 AFFORDABLE AND CLEAN ENERGY	Solar energy Energy research	Energy research at ESA Electric propulsion innovation and competitiveness
8 DECENT WORK AND ECONOMIC GROWTH	Regional development Job creation	Copernicus opportunities for economic growth and regional development First ESA facility in UK, catalyst for growth Job creation and growth within space Copernicus benefiting society and the environment
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	GPS Telecom satellites	Broadband for all Technology transfer and business incubation Protecting our infrastructure from space weather Tracking trains Satellites for remote banking Galileo-based solutions for transport and infrastructure
10 REDUCED INEQUALITIES	Supporting developing countries Providing applications and services	Providing energy, clean water, food, education, ...

SDG	EO services	ESA Programme
11 SUSTAINABLE CITIES AND COMMUNITIES	Living on the ISS/Concordia Urban areas Air quality Transport systems Cultural heritage	The international Space Station (ISS) Concordia, antarctic research station Mapping urban areas Monitoring air quality Mapping global air pollution Integrated applications projects - Transport Satellites in support of world heritage
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Recycling Closed-loop systems	The ISS as a closed-loop system Concordia, antarctic research station MELiSSA, closed-loop ecological system
13 CLIMATE ACTION	Research in Arctic/Antarctic Monitoring ice sheets Climate change initiative Desertification	Looking out for landslides Supporting the healthcare in emergency areas Desert watch SMOS: Monitoring the oceans and surface moisture ESA's climate change initiative Monitoring the atmospheric composition and climate Cryosat: monitoring the arctic/antarctic Sentinel 1A-radar monitoring of oceans and ice ESA and the arctic ESA and the antarctic
14 LIFE BELOW WATER	SAT-AIS Sustainable fishing Soil moisture and ocean salinity (SMOS) satellite	Tracking marine animals with satellites Vessel tracking from space SMOS Maritime security ESA and oceans Copernicus - Marine projects
15 LIFE ON LAND	Forestry/deforestation Biodiversity Land use detection	Trees tell their own story Smart logging Tracking biodiversity Burned area land use change detection Monitoring forest degradation and deforestation Forest fires Land cover maps
16 PEACE, JUSTICE AND STRONG INSTITUTIONS	Support to identify illegal actions Support of election processes	Detection of ship movements Maritime surveillance e-Training via satellite in support of African electoral cycles
17 PARTNERSHIPS FOR THE GOALS	Partnering with other space agencies Partnering with other companies Partnering with institutions	ESA partners

Satellite constellations

Small **satellite constellations** in LEO to test new technologies and new concepts in space can be a faster and cheaper alternative than larger GEO spacecrafts. Part of the attraction of non-GEO orbits is that the rights to some spectrum bands that may already be used in GEO are more accessible for new players in other orbits. Therefore a key issue for future success in EO is to compete in terms of efficiency, cost and time to market, keeping in mind that what really matters is the nature and quality of service delivered to the end users.

Secondly, space research is exploring the field of **formation flying of multiple satellites (FFS)**, because under certain conditions FFS can operate like a single virtual instrument. To make the FFS work, precise measurement systems, as well as autonomous on-board algorithms, are needed to let the satellites know where the others are. Verifying these "metrologies" and algorithms in practical terms is extremely costly.

Thirdly, **convoys** are additional cost-effective missions that can be flown together with operational missions to increase the possibilities for achieving new science and application objectives. Currently, several convoy missions are being studied to complement the Sentinel Missions and the gap that remains in the production of data on the Earth's systems.

Finally, **high-altitude platform stations (HAPS)** are proving attractive alternatives to satellites, especially in EO and telecommunications. Indeed, operating a satellite requires significant time and monetary resources, in terms of development and launch. HAPS, on the other hand, are comparatively less expensive and can be easily launched. Another major difference is that a satellite, once launched, cannot be landed for maintenance, while HAPS can.

Smart data, exponential technologies and actionable information

There are many sources that predict exponential data growth toward 2020 and beyond, and they all agree that the size of the digital universe will double every two years at least, resulting in a 50-fold growth from 2010 to 2020. The acquisition and analysis of data and its subsequent transformation into actionable insight is becoming a complex workflow that extends beyond data centres.

Enterprises now have access to cheap and powerful computing platforms, and modern software enable real-time analytics for a wide range of uses. In addition, implementing storage capacities and capabilities that enhances data flow, in-place analytics, and storage efficiency such as object storage and high-performance distributed file systems, is critical for effective scaling. The cloud provides scalability, and the Internet of Things (IoT) forms the foundation for investments in big data and cognitive computing. Smart data, artificial intelligence and analytics are the key to the global shift towards making research findings available free of charge for readers, so-called "open access".

Open access and Open Science

Open access policies aim to provide users with access to peer-reviewed scientific publications and research data free of charge as early as possible in the dissemination process, and enable the use and re-use of scientific research results. Open access to scientific research data enhances data quality, speeds up scientific progress and helps to combat scientific fraud. Open access requires reliable e-infrastructures underpinning the scientific information systems to foster access to scientific information and the long-term preservation of it. Finally, society is now moving decisively from "open access" into the broader picture of "Open Science".

FUTURE EO IN A NUTSHELL

1. Small satellite constellations in LEO can be a faster and cheaper way than larger GEO spacecrafts to rapidly test new technologies and new concepts in space.

2. Formation flying satellites is not a difficult principle, but the new challenge is flying autonomously in precise formation.

3. Smart data are big data turned into actionable information available in real-time for a variety of business outcomes

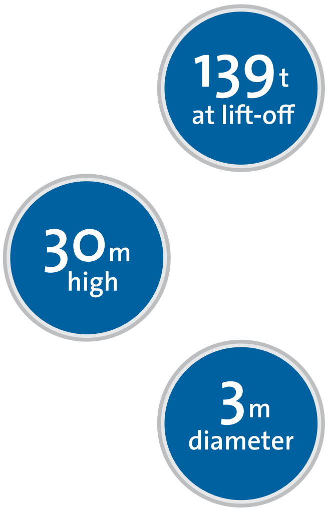
4. The use of edge devices, in situ-computation and analysis, centralized storage and analysis, and deep learning methodologies which accelerate data processing on the large scale requires a new technological approach.

5. Smart data, artificial intelligence and analytics are the key to the global shift toward making research findings available free of charge for readers, the so-called "open access".

6. Society is now moving decisively from "open access" into the broader picture of "Open Science", but science has always been open, unlike the processes for producing research and diffusing its results.

2. An in-depth analysis of the VEGA Programme

2.1. VEGA launch vehicle



VEGA is an expendable launch system commercialised by Arianespace and developed jointly by ASI and ESA. Italy is the leading contributor to ESA's VEGA Programme. VEGA preparatory studies were performed in several European countries as a co-operative project with other Member States within the ESA framework. Capitalizing on previous experience, however, ASI and the Italian space industry not only developed concepts, but also began pre-development work based on their established know-how in solid propulsion.

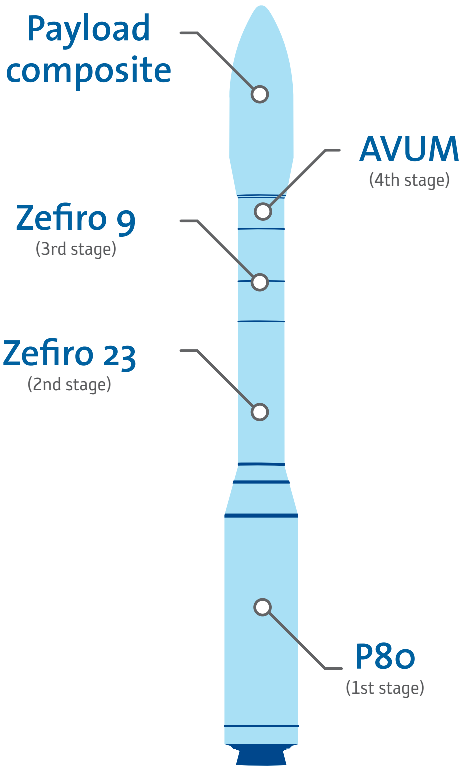
Indeed, VEGA introduces great innovation among launcher technologies particularly in the solid-propulsion, materials and avionics fields. Furthermore, VEGA offers and improves launch flexibility by providing launch services for a wide range of institutional and commercial missions especially for small payloads. Specifically, the launcher can deliver a reference payload mass of up to 1,500kg into a circular sun-synchronous orbit of 700km altitude. In operation, VEGA has a perfect record with ten successful launches plus the IXV re-entry system test.

2.2. The VEGA launcher in brief

VEGA is a single-body launcher approximately 30 meters high, with a maximum diameter of 3 meters, and a weight of 139 tonnes at lift-off. It has three main sections, namely the Lower Composite, the Restartable Upper Module and the Payload Composite.

The Lower Composite consists of three solid-propellant stages or solid rocket motors (SRM): the P80, the Z23 (Zefiro23), and Z9 (Zefiro9) plus the four stage-interfacing structures.

The Restartable Upper Module or 4th stage is known as AVUM (Altitude and Vernier Upper Module). The AVUM provides attitude control and axial thrust during the final phases of VEGA's flight to allow the correct orientation and orbit injection of multiple payloads.



The **Payload Composite** that accommodates the satellite(s) is composed of the fairing and the payload/launcher interface structure. It is worth mentioning that VEGA can deliver multiple payloads into different orbits. The **VEGA Secondary Payload Adapter (VESPA)**, housed in the fairing at the top of the rocket, can carry a 1000kg main satellite on top, and either a secondary payload of 600kg in the internal cone, or several auxiliary payloads totalling 600kg distributed on a platform.

VEGA benefits from the existing launch infrastructure of the European Spaceport at Kourou in French Guiana, where VEGA's dedicated ground infrastructure comprises the **Launch Zone** (ZLV: Zone de Lancement VEGA) and the Operational Control Centre.

The **maiden flight of VEGA**, designated as VV01 (VEGA Vehicle 01), took place on 13 February 2012 from Kourou in French Guiana. The primary scientific payload was LARES (LAser RElativity Satellite) from ASI. The secondary payload consisted of 7 CubeSats and 1 microsatellite, AlmaSat, of the University of Bologna, Italy.

To allow a smooth transition between development and exploitation (after the maiden flight), the **VERTA (VEGA Research and Technology Accompaniment)** programme undertook five flexibility demonstrations flights primarily for ESA missions (ADM-Aeolus, Swarm, LISA Pathfinder, PROBA-3, and the IXV reentry demonstrator). The VERTA programme had three main components:

- Procurement of five launches (VERTA demonstration flights)
- Customer Service Improvement activities
- Production accompaniment and technological activities.

The VERTA Programme was completed on 3 December 2015 with the launch of LISA Pathfinder on VEGA's sixth flight. **Arianespace is now fully responsible for the commercial operation** of VEGA. The five VERTA flights are illustrated in the table on the right of this page.

To support VEGA's full commercial exploitation, ESA refined and improved the launch system configuration and operations. This lowered costs mainly by speeding up the launch campaign. The VEGA launches in 2015 (VV04, VV05 and VV06) displayed the capacity of the system to reach three missions per year. ESA's **Launchers Exploitation Accompaniment Programme (LEAP)** ensures that VEGA remains operational and that further improvements will reduce launch service costs. At the ESA Ministerial meeting in December 2014, Member States agreed to develop the more powerful VEGA-C, now expected to debut in mid-2019.

2.3. VEGA and Space Rider Development

The **VEGA and Space Rider Development Programme** is strengthening the VEGA competitiveness for widening the capture of the available worldwide markets, by introducing the VEGA-C, developing the VEGA-E family of launchers, and a series of spin-off products under definition.

VEGA-C

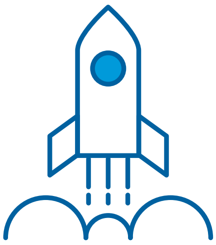
The new configuration of the VEGA launcher is called the **VEGA-C** (Consolidation). VEGA-C will increase the performance from VEGA's current 1,500kg to about 2,200kg in a reference 700km polar orbit, covering identified European institutional users' mission needs, with no increase in launch service and operating costs. The total length of VEGA-C is about 35m with a mass at liftoff of 210 tonnes. Additional modifications are being studied to enable VEGA to carry **micro- and nanosatellites** to be cost-effective in this emerging market.

VEGA-C is based on the existing VEGA launcher and comprises four stages. The first stage is based on the P120C, the largest monolithic carbon fibre solid-propellant rocket motor ever built. Its development relies on new technologies derived from those of P80 VEGA's current first stage motor (see A focus on the P120 C booster on page 30). The second stage is the new **Zefiro-40 (Z40)** motor. The third stage is the **Zefiro-9** currently used on VEGA. Finally, the **AVUM+** upper stage is derived from the current VEGA AVUM but has a lighter structure, carries more propellant inside larger tanks and features several new European-developed components.

Demostration	Payload
	MAIDEN FLIGHT
	VV01 (13/02/2012)
• New technologies for large solid-propellant motors demonstrated under flight conditions by the P80FW first stage	• LARES (ASI) • 7 CubeSats • Almasat (Bologna)
	VERTA FLIGHTS
	VV02
• First VERTA flight • Upper module capability to change both the inclinations and the orbital altitudes to deploy multiple satellites in different orbital planes using the VESPA dispenser • Sun-synchronous polar orbit • New flight software • New ground station	• ESA's Proba-V • VNREDSat 1A (Vietnamese Earth observation satellite) • ESTCube-1 (Estonian picosatellite)
	VV03
• Exploitation flight	• KazEOSat 1DZZ-HR (Kazakh Earth Observation satellite)
	VV04
• Suborbital equatorial trajectory with the payload nearing VEGA's maximum capacity	• ESA's IXV spaceplane
	VV05
• Exploitation flight	• ESA's Copernicus Sentinel-2A
	VV06
• Release into an elliptical low Earth transfer orbit	• ESA's Lisa Pathfinder scientific satellite

A larger fairing with an increased payload envelope to accommodate larger satellites is also being developed to host Earth Observation satellites of more than two tonnes, and the Space Rider re-entry vehicle.

ESA is overseeing procurement and the architecture of the overall launch system, while industry is building the rocket with ELV SpA as prime contractor. An industrial cooperation agreement has been signed between Airbus Safrane Launchers (ASL) and AVIO for the P120C solid motor. The **Launch System Critical Design Review** is planned for the end of 2018, and the **Ground Qualification Review** in the first quarter of 2019.



100%
successful launches

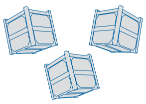
A focus on the P120 C booster

The P120 C solid propellant motor derives from the first stage of the VEGA Launcher P80. Capitalising on the major investments required for building solid-propellant engines, the P120 C (Common) is an engine that can serve both as the first stage of the VEGA-C and as the booster of the future Ariane 6.

The new launcher for GTO payloads will have the maiden flight in 2020 and will replace the Ariane 5 in 2023. The launcher will be equipped with two or four solid rocket motors respectively for Ariane 62 and Ariane 64 configurations. This evolution provides high economies of scale in the field of launcher production, thus growing the competitiveness of European launchers.

Light satellite, Low-cost Launch opportunity (LLL or L3) and the Small Spacecraft Mission Service (SSMS)

26
microsatellites



The Small Spacecraft Mission Service (SSMS) initiative aims at providing VEGA with a comprehensive ability to deploy multiple small spacecraft during a single launch. A VEGA launcher will be set to demonstrate its extended capability to deploy multiple light satellites using the new dispenser in the second half of 2018. This demonstration provides the first of the launch opportunities under the new **Light satellite, Low-cost Launch opportunity Initiative (LLL or L3)**. L3 aims to provide low-cost and regular launch services for European Institutional light satellites through full exploitation of the Ariane 6 and VEGA C launch systems' capabilities. The SSMS dispenser with its modular design enables VEGA to provide launch opportunities for light satellites with masses ranging from 1kg up to 400kg, with different configurations and relevant combinations under a "rideshare" concept. The following figure shows the number of universities and research centres interested in the announcement of opportunity for the launch of multiple light satellites on a VEGA flight.

1kg = €30,000

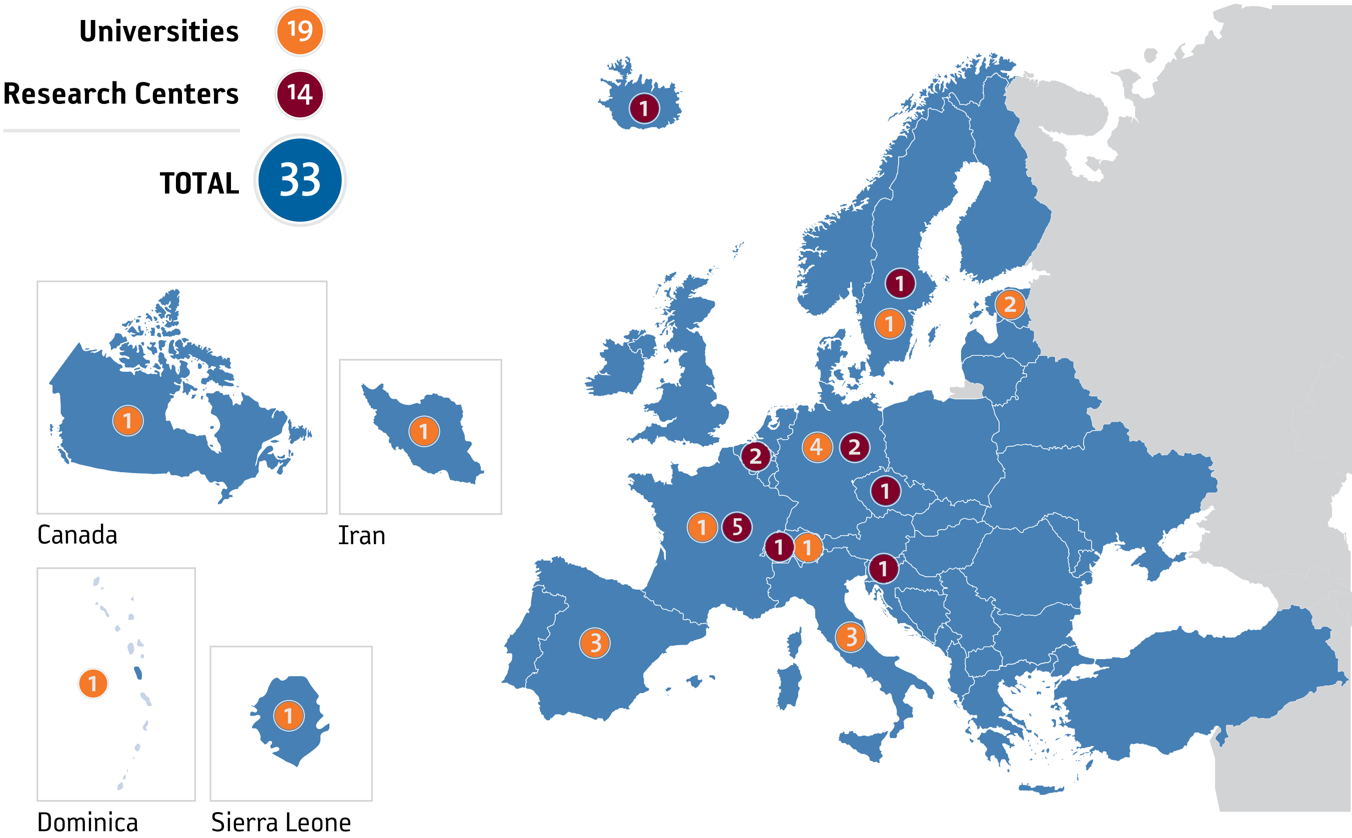
Space Rider

The aim of **Space Rider** is to provide Europe with an affordable, independent, reusable end-to-end integrated space transportation system for routine access and return from low orbit. Specifically, Space Rider has the potential to allow:

- experiments in microgravity;
- technologies in-orbit validation (IOV);
- educational missions;
- a higher level of competitiveness of the European space industry.

The operational missions for Space Rider include a wide spectrum of orbital altitudes and inclinations in low orbit, compatible with the performance of the VEGA-C launch system and its future evolutions.

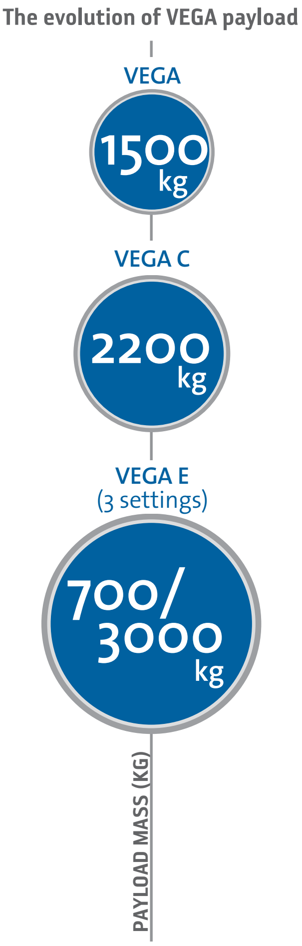
The spacecraft will stay in orbit as required by its payloads, and then it will perform a ground landing. Afterwards, it will be refurbished and equipped with new payloads for the next flight. A ground segment will support the in-orbit operations, the reentry and landing, and the early processing of the payloads after landing. By 2025, Space Rider could be operating commercially.



VEGA-E

Preparatory activities are under way for VEGA's evolution into a family of configurations beyond 2025. A European cryogenic upper stage powered by a 10t-class liquid oxygen and methane expander cycle engine will replace the current Zefiro-9 and AVUM. The other elements will be based on existing and still developing building blocks (P120C, P80, Z23, Z40, Z9, AVUM, VUS). New technologies such as 3D printing will be evaluated and tested as possible ways to reduce the cost of the engine and other subsystems. To reduce the environmental impact, improve the safety of the ground processes and reduce costs, a new "green" roll and altitude control system using hydrogen peroxide will be developed, with potential earlier applications on VEGA-C and Space Rider.

The VEGA-E family will improve the system's competitiveness for the normal VEGA-C payload class in the small–satellite market. In addition, efforts are being aimed at widening the VEGA market. These include creating opportunities for small spacecraft mission services and for reaching geostationary orbit and beyond with the use of the flexible VENUS (VEGA New Upper Stage) electric propulsion module, while keeping the cost competitive on the world market.



2.4. Future applications of VEGA

Together with the use of electrical propulsion modules, VEGA will enable economically accessible solar system exploration projects to NEOs (Near-Earth Objects), the Moon, Mars and its satellites, Venus, and the moons of Jupiter.

AVIO has also carried out feasibility studies and simulations for In-Orbit Servicing missions. For example, VEGA could transport new materials and bring used materials and modules from the International Space Station. It could also be used for SDM (Space Debris Mitigation) activities for the recovery of defunct satellites.

VEGA is also an ideal environment for conducting low cost experiments for educational and scientific purposes, and for the qualification of technological systems and components in orbital conditions. In short, the VEGA-E family will be even more flexible and versatile, and will further broaden the horizon of potential applications.

3. A need for security

The higher level of capability, accessibility and openness that now characterizes Earth Observation and Earth Sciences in general must be complemented by a higher level of security. Indeed, ESRIN is actively working to balance the necessary and economically valuable exposure to disruptive innovation and the need to protect more than fifty years of effort and success in pushing forward the technological frontier in space research, and more specifically in the field of Earth Observation.

The Security Office, inaugurated at ESRIN in 2007, is responsible for the security of ESA. ESRIN cooperates also with a wide array of stakeholders to guarantee the security of European citizens and of global society by providing the data distributed through the Copernicus Security Service. Finally, the recently inaugurated NEO Coordination Centre (NEOCC) participates in the Space Situational Awareness Programme by monitoring the Near Earth Objects (NEOs).

3.1. The Security Office and other security assets hosted in ESRIN

The Security Office is an entity with a regulatory and judicial function that serves corporate functions and in special cases provides services to enterprises. In the field of Earth Observation, security is a crucial activity because of the constant threat of cyberattacks due to the open nature of the data providing service. The Security Office is in continuous contact with the National Security Authority, and the Security Committee is located in ESRIN.

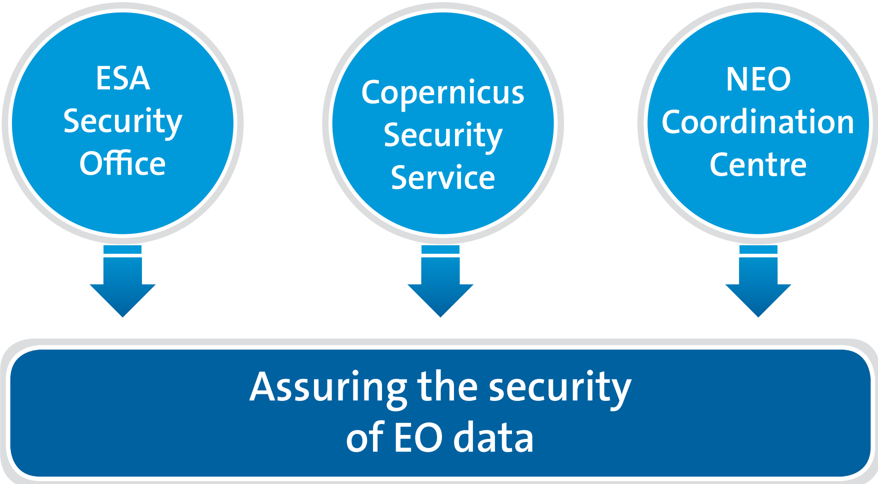
The Security Office manages several lines of activities regarding:

- physical security;
- information protection;
- personnel security;
- CIS security;
- security in invitation to tenders (ITT).

ESRIN also hosts several facilities dedicated to security, as for example the Central Registry, and the **IT security infrastructure**.

The latter rests on three pillars:

- the Security Information Event Management Infrastructure (ESA SIEM), that allows us to identify security breaches and compromised systems from internal and external cyber-attacks;
- the ESACERT Security Management Infrastructure that implements:
  - all ESACERT security workflows to assure a correct life-cycle during times of a security request;
  - the regular security assessment of ESA's system against vulnerability;
  - tailored security early warnings and security alerts for ESA systems;
- the ESACERT Specialized Infrastructure supports the Security Incident Management.



3.2. Copernicus service for Security

Earth Observation can contribute to support several security areas at European level:

- border surveillance;
- maritime surveillance;
- support to EU External Action.

In the area of **border surveillance**, the main goals are to reduce the number of illegal immigrants entering the EU undetected, to reduce the death toll of illegal immigrants by rescuing more lives at sea and to increase internal security of the European Union as a whole by contributing to the prevention of cross-border crime.

In the area of **maritime surveillance**, the EU aims to support Europe's maritime security objectives and related activities. The corresponding challenges mainly relate to safety of navigation, support to fisheries control, combating marine pollution, and law enforcement.

Finally, a main objective of the EU is to **assist third-party countries in a situation of crisis or emerging crisis and to prevent global and trans-regional threats** having a destabilising effect. The Support to External Action (SEA) component of the Copernicus Security Service will assist the EU in its operations outside EU territory, providing decision makers with geo-information on remote, difficult to access areas, where security issues are at stake.

3.2. ESA NEO Coordination Centre (NEOCC)

The **NEOCC** is the operational centre of the SSA-NEO segment located in ESRIN. It aims at coordinating and contributing to the observation of small Solar System bodies to evaluate and monitor the NEO hazard. The services provided by the **NEOCC** are demanded by scientists and journalists.

The reason why NEO monitoring programmes are needed is that **our knowledge of the NEO population is still incomplete**. To date more than 90% of objects with diameters larger than 1km have been discovered, but this figure drops to only 10% when considering 100m-sized objects.

source: NEOCC (2017)

Impact hazard, frequency of occurrence and selected consequences

Diameter of impactor	Event type	Effect	energy (Megatons TNT)	Timescale (years)	Examples	Notes
› 1 km	Impact	Global (climate change)	› 1,000,000 mt	› 1,000,000	Chicxulub	Chicxulub is a 170km crater whose formation is thought to be responsible of the Cretaceous / Tertiary mass extinction (K/T boundary)
150 m	Impact	Local (earthquakes, tsunamis)	100 mt	~10,000	Iso Naakkima Zhamanshin	Craters of the order of 10 km can be considered as limiting cases between local and global consequences.
50 m	Impact	Local (earthquakes, storms)	1 mt	~1,000	Tunguska Meteor Crater	Outcome depends on the impactor composition and dynamics. Tunguska was a large airburst producing no crater, the Meteor Crater was formed by a metallic impactor.
10 m	Impact/ Superbolide	Local (craters, blast waves)	› 1	~10	Kamil Carancas Chelyabinsk	Carancas was a slow high altitude event producing a 12 m crater. Kamil crater (40 m) was originated by a 1 m iron impactor. In the Chelyabinsk event, the meteorid exploded before reaching the ground.
1 m	Bolide	Local (local flash, meteorites)	10 kt	~1	Revelstoke 2008 TC3	The Revelstoke fireball led to the recovery of meteorite grains, 2008 TC3 was the first meteorite fall observed prior to atmospheric entry.
1 cm ‹	Bolide	upper atmosphere / near earth environment (shooting stars, spacecraft damages)	Negligible	hourly rates	Perseids, Leonids, Geminids etc.	Sporadic meteors and meteor showers (shooting stars) can be of cometary or asteroidal origin. Since these bodies completely burn in the upper atmosphere, damage is limited to orbiting infrastructures.

3 ESRIN's economic benefits to Italy

There is plenty of anecdotal evidence that the space industry generates ample returns for nations that invest in it. Italy is obviously not excluded from this trend: the Italian Government's investments in ESA via ASI are a driving force of this mechanism. Through its close and coordinated link with ESA, ASI allows the latter to flourish. This generates returns for both ESA Member States at large and Italy itself. Indeed ESA's action cross-fertilizes all countries involved in its governance, and one of ESA's key institutional engines is its italian-based ESRIN.

In this chapter we try to define ESRIN's value to Italy according to several methods of analysis. In section 1 we illustrate ESRIN's economic and strategic value to Italy. By "economic" and "strategic" we mean the economic value related to the ESA programmes in which Italy participates.

ESRIN generates a consistent impact on the local and regional economy in terms of value added

Specifically, in the first part of the section we illustrate the Italian return coefficients computed by the Industrial Policy Committee (IPC) by comparing the Italian investment in ESA with the industrial commitments signed by ESA with Italian companies. In the second part of the section, we analyse the Italian industrial returns related to the programmes hosted in ESRIN, i.e. the Earth Observation Programme, the VEGA and Space Rider Development Programme (and related exploitation activities), and the Near Earth Object Coordination Centre (NEOCC).

In section 2 we provide an overview of ESRIN's economic impact on the Italian economy, and we separate this impact at sectorial level into its direct, indirect and induced components. In the first part of the section we illustrate ESRIN's economic impact on a local level in terms of employment and tourism. Specifically, we illustrate how ESRIN generates a consistent impact on the local and regional economy in terms of value added, i.e. additional demand of final goods and services, most of them produced locally. In the second part of the section we illustrate the main figures related to ESA and ESRIN's procurement, focusing on the Italian contractors. We show how ESA's industrial commitments with Italian companies exceed the Italian contribution to ESA. We also show how ESRIN attracts additional economic benefits to Italy of the same magnitude as ESA's internal costs, which are crucial to guaranteeing the financial sustainability of the Italian investment in ESA. Finally, in the third part of the section we present the results of a scenario analysis aimed at disentangling the direct, indirect and induced benefits for Italy generated by each euro invested in ESA. We show how benefits overcome costs for a wide array of private stakeholders and for the public sector.

ESA's industrial commitments with Italian companies exceed the Italian contribution to ESA

In section 3 we illustrate ESRIN's relational and scientific value and the innovative spin offs related to Earth Observation and the VEGA Development Programme. Where feasible, we single out the Italian participation, both in terms of companies involved and users. In the second part of the section we briefly illustrate ESRIN's national context. We focus on the other national and international space research centres located in Italy, provide an overview of the Italian space industry, and finally we discuss the terms of the Memorandum of Understanding (MoU) signed between ESA and the Italian Government in 2008 on the future development of ESRIN. In the third part of the chapter we illustrate the local context in which ESRIN is placed and we briefly summarize the most important agreements signed by ESA and the neighbouring institutions. It emerges that ESRIN is part of a local research district that is at the heart of a technological revolution that is shifting the major stakeholders in the Science 2.0 paradigm, making ESRIN an important agent of change.

1. The economic and strategic value of ESRIN to Italy

At the beginning of joint European space research collaboration, the European Space Research Organisation (ESRO), there was no specific provision to distribute industrial commitments on a geographical basis. It was the Austrians who suggested that some attempt should be made to ensure that all Member States had a guaranteed return from the effort. The principle was accepted within ESRO in 1962, but several years of discussion were necessary to clarify its interpretation. Finally, the principle adopted was that the distribution of contracts by value should be proportional to the Member States' contribution to the overall budget (the so-called principle of just return). By the end of 1966, weighting factors distinguishing technically interesting contracts (WF=1) from contracts for lands and buildings as well as administration and transport equipment (WF=0.25) were introduced in ESRO's industrial policy. No limit to the excess of expenditure over contribution was fixed, in order to retain flexibility in the award of contracts, though it was agreed that as soon as possible no Member State should be more than 100% above its ideal share. In 1967, ESRO's industrial policy was reoriented to ensure that by 1971 each Member State would have achieved a return coefficient of at least 0.7, using the weighting factors for the value of contracts agreed. Whereas until this time the idea had always been to penalise Member States which were performing 'too well', now the aim was to encourage those who were performing badly. Even now, far from having achieved a stable equilibrium, the long running economic debate over the geographical distribution of contracts is of strategic importance for most ESA Member States.

far from having achieved a stable equilibrium, the long run economic debate over the geographical distribution of contracts is of strategic importance for most ESA Member States

1.1 The analysis of the Italian return coefficients

Nowadays, the ESA Industrial Policy Committee (IPC) calculates quarterly the ESA Members State's return coefficients. The return coefficient is a measure that compares the economic benefits obtained by each Member State in terms of Industrial commitments with the share of its contribution to ESA programmes. The ESA Members return coefficients are analysed cumulatively, i.e. with respect to the overall industrial commitments and national contribution accounted since the last date in which the time series was "discontinued" (restarted). The last update runs to the end of June 2017 and refers to the 3rd cumulative geographical return statistics, which began in 2015. The next formal review of the geographical distribution of contracts is set for the end of 2019, with an interim review by the end of 2017. The return coefficients are calculated only for the contribution of ESA Member States in Mandatory and Optional Programmes.

The formal reviews verify that the measures used to target a return coefficient of one[1] and achieve the lower limits[2] for the overall return coefficient, are adequate and effective. For the 3rd statistical period[3], from 2015 to 2024, Council decided to adopt the following lower limits for the cumulative return coefficient for all Member States, except for those still benefitting from transitional measures under their Accession Agreements: 0.91 at end-2019; 0.93 at end-2022; 0.95 at end-2024.

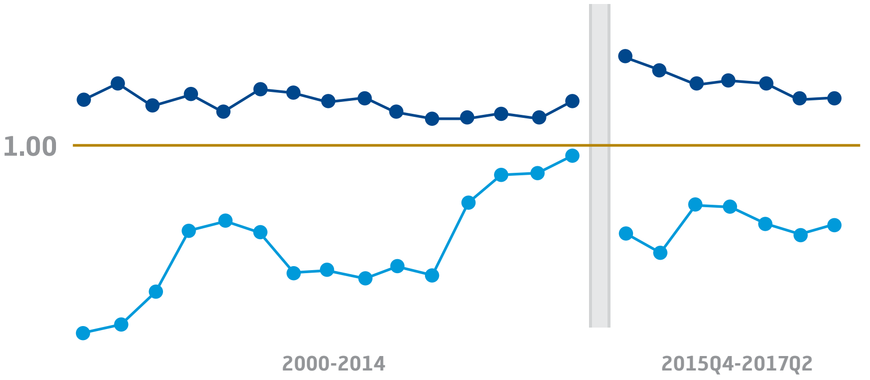
Graph 1 illustrates the evolution of minimum and maximum return coefficients over a 15-year period following the discontinuation of statistics at the end of 1999, and the move to the current statistical period. The data show how the spread was narrower in the beginning of the current statistical period with respect to the 1999 discontinuation. A further converging trend of the deviations is expected in the upcoming formal reviews. Therefore, even if a Member State is currently benefiting from a return coefficient greater than one, the cumulative value will eventually converge to one by 2024.

[1] For a Participating State, it means that the industrial commitments are equal to the ideal share of contracts that it should receive according to its contribution in ESA.

[2] The minimum amount of industrial commitments with respect to the ideal share of contracts that the Participating State should receive according to its contribution.

[3] The discontinuation of the return coefficient means the interruption of the time series. Specifically, the new return coefficients are computed on the overall value of contracts measured after the discontinuation date.

Graph 1.
Evolution of minimum and maximum overall return coefficients for ESA Member States

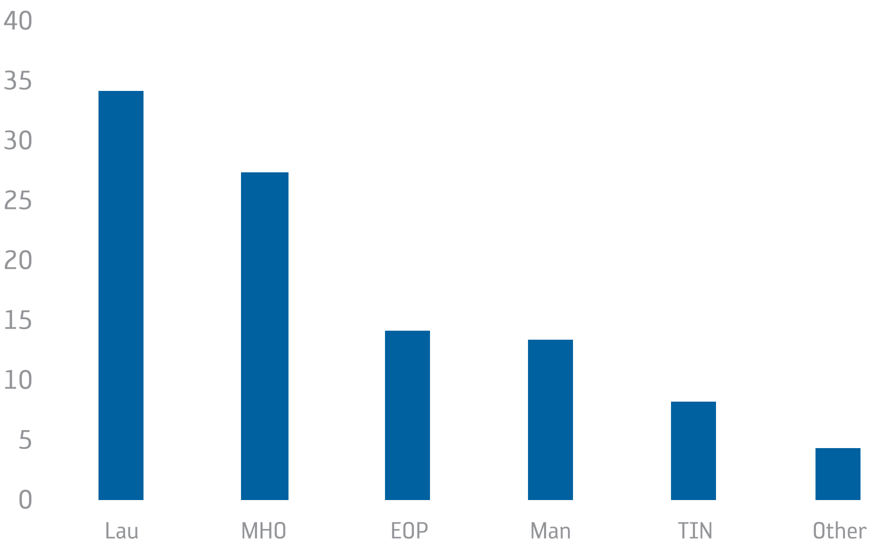


Source: ESA/IPC(2017)13, rev.1

NW: data before discontinuation refer to annual intervals. Data after discontinuation are quarterly and begin with 2015Q4.

Graph 2 provides an overview of the weighted value of contracts per domain computed at the end of June 2017. The overall weighted value of contracts amounted to 11.48 billion euro. It was mostly associated with the Launchers sector (Lau), followed by "Microgravity, Human Spaceflight and Operations" (MHO) and Earth Observation Programme (EOP).

Graph 2.
Weighted value of contracts (M€) disaggregated by ESA programmes (Y2015-2017)

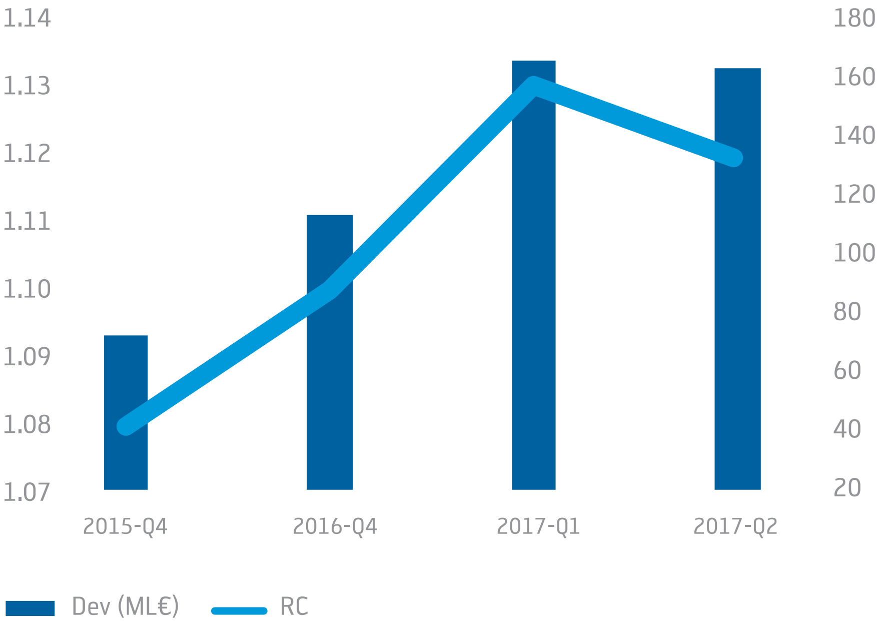


Source: our elaboration on ESA/IPC(2017)13, rev.1.
NW: "Lau" = Launchers, "MHO" = Microgravity, Human spaceflight and Operations, "EOP" = Earth Observation Programme, "Man" = Mandatory programmes and activities, "TIN" = Telecommunications, Integrated applications and Navigation, "Other" = Not yet associated to a domain.

By taking into account the boundaries within which return coefficients are calculated and their implications, it is possible to illustrate in more detail the economic value of the Italian returns.

The value of the overall Italian return coefficient is illustrated in Graph 3. Since the discontinuation of the time series in 2014, Italy has been in over-return, and only recently has the Italian return coefficient begun to converge to one. Measured in euros, the deviation, i.e. the Italian over-return with respect to the ideal share of the weighted value of contracts signed between ESA and Italian contractors, is worth cumulatively 162.2 million euros.

Graph 3. Italian deviation (Dev) from the ideal share and return coefficient (RC) after 2014 discontinuation (M€)



Source: our elaboration on ESA/IPC(2017)13, rev.1 data

As in the case of Italy, if the return coefficient is significantly greater than one, there are two alternatives to make it converge to one:

- increase the denominator: the Participating Country invests more, therefore the scale of contribution raises and the ideal share increase accordingly;
- reduce the numerator: the value of ESA industrial commitments with contractors of the Participating country in severe over-return decreases.

While an in-depth analysis on the process by which an over-returned Participating State achieves convergence goes beyond the scope of this document, the topic has been considered to indicate just how Italy's positive deviation will probably decrease in the years leading to 2024.

A share of value that does not need to decrease is the scientifically negligible value of contracts signed by Italian companies (DW), as this figure is by construction excluded by the computation of the return coefficients. DW can be considered as a non-space co-production of the technologically relevant industrial commitments. As of 2017, the cumulative DW is worth almost 386 million euros for Italy, therefore more than 20% of the unweighted value of the Italian industrial commitments.

Clearly, economic imbalances might be more than compensated by technological and scientific achievements, but in this case a policy maker would face a trade-off between pursuing either scientific goals or economically sound investments. Instead, by obtaining an appropriate share of the non-scientific contracts (DW), scientific and economic goals might be encompassed.

Table 1 briefly summarizes the relevant figures needed to assess the unweighted (i.e. the total) Italian over-return. Italy benefits from a consistent over-return in Mandatory Programmes. Within the Optional Programmes of interest for ESRIN, Italy has a return coefficient close to 1.0 in Earth Observation and 1.12 in Launchers. The overall return coefficient is 1.12. It is worth noticing how the value of the non-scientific contracts compared to the overall amount of the Italian industrial commitments is lower both in the Mandatory Programmes (18%) and in the Optional Programmes hosted at ESRIN (respectively 8% and 15%).

Table 1. The Italian over-return in brief

	UW(k€)	W(k€)	Deviation(k€)	RC	DW(% of W)
Overall	1,889,262	1,503,415	162,121	1.12	20
Mandatory	248,163	202,791	44,152	1.28	18
EO	173,133	159,848	-684	1.00	8
Launchers	493,830	417,850	44,702	1.12	15

Source: our elaboration on ESA/IPC(2017)13, rev.1 data. NW: "UW" = unweighted value of contracts, "W" = weighted value of contracts

While the EOP Directorate is at ESRIN and consequently the aggregate return coefficient fits the purpose of this research, the aggregate "Launchers" refers to several programmes that include VEGA, Ariane, FLPP and others, therefore we have analysed the Italian returns for VEGA programmes accounted in the period 2014-2017. Furthermore, we have added an analysis of Italian returns for the Space Situational Awareness (SSA) Programmes 1, 2 and 3, as they should include the industrial commitments for NEOCC. Table 2 illustrates the results.

The data show heterogeneous over-returns from 0.67 to 1.29 in the Launchers programmes, and consistently higher in the SSA programmes (the latter however generate an unweighted amount of industrial commitments equal to almost 5 million euros, against an overall figure for VEGA of more than 341 million euros). Also the share of the non-scientific contracts exhibits a high degree of heterogeneity among programmes, but high percentage values are associated with the low value of contracts.

To conclude, Graph 4 provides a measure of the Italian over-return generated by its

Table 2. An in-depth analysis of the Italian over return in Launchers and SSA programmes

Source: our elaboration on ESA/IPC(2017)13, rev.1 data. NW: "UW" = unweighted value of contracts, "W" = weighted value of contracts.

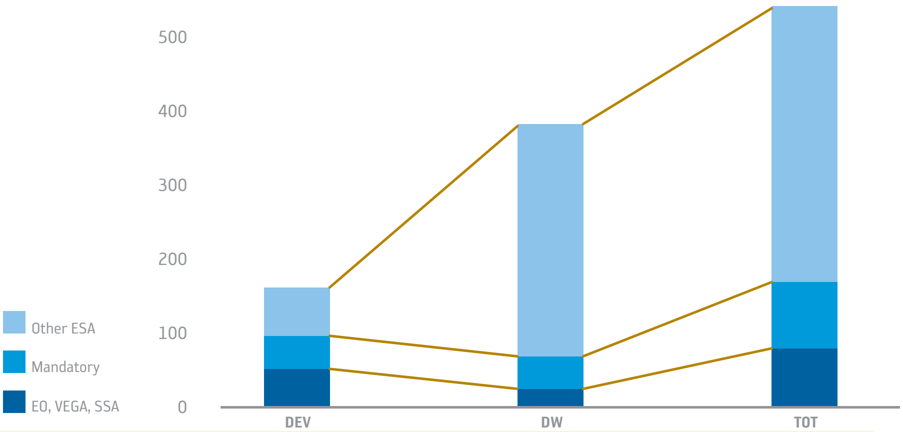
	Programme	UW(k€)	W(k€)	RC	DW(%)
VEGA	LEAP (2013-2014) VEGA Classical & MCO	29,349	27,359	1.00	6.8%
	LEAP (2015-2016) VEGA Classical & MCO	29,699	24,783	1.00	16.6%
	LEAP (2015-2016) VEGA Supplementary	26	6	1.00	76.9%
	Reusable In-Orbit Demonstrator for Europe	1,779	1,510	0.67	15.1%
	Ariane and VEGA Development (VEGA Element)	82,311	80,444	1.18	2.3%
	Ariane and VEGA Development (P120C element)	155,709	155,419	1.29	0.2%
	Ariane and VEGA Development (Launchers Evolution Element)	54	13	n.a.	75.9%
	VEGA Consolidation and Evolution Preparation Programme	39,726	38,965	1.23	1.9%
	VEGA Research and Technology Accompaniment Programme	2,777	-302	1.00	110.9%
	Small Launcher Development Programme	87	22	1.00	74.7%
SSA	Space Situational Awareness Period 3	1,311	1,086	2.12	17.2%
	Space Situational Awareness Period 1,2	3,520	2,911	1.85	17.3%

industrial commitments with ESA with respect to several aggregates of interest:

- Optional Programmes hosted in ESRIN (VEGA, EO and NEOCC, approximated to SSA),
- Mandatory Programmes,
- ESA's overall Italian over-return.

The incidence of the positive deviation from the ideal share of Italy's industrial commitments (left column) compared to the total over-return (right column) is more relevant when accounting for ESRIN programmes, and becomes less relevant when referring to wider aggregates. Clearly, the opposite is true when considering the unweighted residual (DW) of the Italian industrial commitments.

Graph 4.
Italian deviation (Dev) and value of non-scientific contracts (DW) (M€)



Source: our elaboration on ESA/IPC(2017)13, rev.1 data

1.2 An in-depth analysis of the Italian industrial returns for EOP and VEGA

An in-depth analysis of the EOP

The Italian contribution to EOP's past and present programmes

As illustrated in Table 3, the Italian contribution to the EOP is consistent yet varies according to the selected programme. However, in comparative terms it is lower than the French or German contribution and in most programmes also the UK contribution, as contributions to the Programme tend to converge to the GNP level.

Before providing more details about the measures approved in the Ministerial Council of 2016, we give a brief overview of the other EOP programmes discussed in table 3.

Table 3. The Italian contribution in EO – comparison with France, Germany and UK

Programme	Total subscr. env. (M€)	Economic Conditions	Italy (%)	France (%)	Germany (%)	UK (%)
EOEP 1, 2, 3	2,619	1997	12.4	19.7	24.1	17.8
EOEP 4	1,034	2012	10.8	15.5	29.4	20.1
EOEP 5	1,158	2016	11.3	15.5	22.1	22.1
MTG	943	2008	11.9	31.0	31.0	-
MetOp-SG	809	2012	11.5	26.0	26.0	12.5
CCI	164	2009	3.8	11.9	21.3	25.4
GSC 1, 2	1,553	2006	19.6	19.4	31.9	6.1
GSC 3	405	2012	5.6	22.0	37.0	8.0
EW – GSE	135	c.e.c.	11.2	12.6	21.8	8.6
ALTIUS	95	2016	-	-	-	-
InCubed	35	2016	3.4		-	28.3

Source: our elaboration on EOP-B data.
c.e.c. = "current economic conditions".

The Earth Observation Envelope Programmes (EOEPs) are the backbone of ESA-funded EO activities. They design and test innovative instruments and missions. Each one targets specific scientific goals and monitors challenges to the Earth's systems. The EOEPs are run as optional ESA programmes over five-year periods.

Meteosat Third Generation (MTG) takes over from Meteosat 11 in 2018, the last of four Meteosat Second Generation (MSG) satellites. Like its precursors it is a joint project between ESA and EUMETSAT. MetOp is a series of three satellites to monitor climate and improve weather forecasting, and makes up the space segment of EUMETSAT's Polar System (EPS).

The Earth Watch programme element 'Global Monitoring of Essential Climate Variables' (GMECV) is also known internationally as the 'ESA Climate Change Initiative' (CCI). It responds directly to the United Nations Framework Convention on Climate Change/Global Climate Observing System (UNFCCC/GCOS) requirements, within the internationally coordinated context of Group on Earth Observation/Committee on Earth Observation Satellites (GEO/CEOS). Its objective is to establish the long-term global Earth Observation archives that ESA and its Member States have maintained over the last thirty years, as a significant and timely contribution to the 'Essential Climate Variable' databases, which are required by the UNFCCC. This programme element ensures that full capital is derived from the on-going and planned ESA missions for climate purposes.

The joint ESA/European Commission initiative GMES (now Copernicus) is the response to Europe's need for geo-spatial information services. It provides autonomous and independent access to information for policy makers, particularly for environment and security issues. As already mentioned, ESA is implementing the GMES Space Component (GSC), developing the Sentinel satellite series, its ground segment and coordinating data access.

The GMES Service Element (GSE) was the first initiative fully dedicated to GMES and is still running the third and final phase related to Earth Watch (EW – GSE). GSE has enabled GMES end-users to become involved in "closing the loop" between operational results obtained from the present generation of EO satellites and the definition of future systems.

The Ministerial Council of 2016 and the ESA funded EOP programmes

The Ministerial Council of 2016 approved a budget of 1.55 billion euros for the EOP, to be spent across six programmes: EOEP-5, GMECV+3, InCubed, ALTIUS, SEOSAT, Earthnet and Long Term Data Preservation (LTDP). As part of the mandatory level of resources, LTDP and Earthnet will receive another 26 million euros per year.

EOEP-5 will develop new scientific Earth Observation satellite missions and data exploitation schemes to advance the Earth Sciences. Specifically, it will produce the following major outcomes:

- preparation of next-generation EO missions and instruments (including an evolution of the Copernicus Space Component);
- preparation of the following Earth Explorers: Biomass (launch/operation), FLEX (development/launch), Earth Explorer-9 (selection/development), Earth Explorer-10 (selection) plus a feasibility study for a "mission of opportunity";
- development of Saocom-CS (with Argentina) and preparation of Polaris missions (Arctic monitoring);
- support applications on Sustainable Development in UN 2030 Agenda.

The Earth Watch Programme "**Global Monitoring of Essential Climate Variables +3**

element” (GMECV+3) will improve the global records of the Essential Climate Variables (ECV) to support climate science and policy making. It will produce the following major outcomes:

- new long-term climate records from European Earth Observation;
- increased European impact in the Intergovernmental Panel on Climate Change assessments (IPCC);
- key inputs for climate models and climate services;
- major advances in climate science;
- better informed policy implementation post-COP21 (The United Nations Climate Change Conference where the Paris Agreements were signed).

The Earth Watch new element “**InCubed**” begun its activities on 6 September 2017. The goal of InCubed is to support industry-led initiatives that will open new market opportunities, bring innovative systems and products faster to market, and compete in the global marketplace. InCubed will, in most cases, co-fund up to 50% of a proposed venture, and will provide access to ESA expertise and technical support. Proposals must be of sufficient technical readiness and market viability, meaning that the project would eventually be sustained by the market rather than further public funding. InCubed is now open for proposals from businesses in 13 participating states (Austria, Czech Republic, Denmark, Finland, Ireland, Italy, Luxembourg, Netherlands, Norway, Romania, Spain, Sweden and the United Kingdom).

The Earth Watch element “**ALTIUS**” aims to develop a limb sounder mission based on a small satellite. ALTIUS is a mission based on an innovative instrument concept and on features offered by the PROBA bus, ensuring a small autonomous multi-mode mission, that allows for atmospheric observations in multiple sounding geometries. Development and operations costs are optimized by the re-use of facilities and experience gained in the development and operation of previous PROBA missions.

SEOSAT/Ingenio (Spanish Earth Observation SATellite) is a high-spatial-resolution optical mission developed together with PAZ (a synthetic aperture radar satellite), under the Spanish Earth Observation National Programme for Satellites (PNOTS). The overall mission objective is to provide information for applications in cartography; land use and mapping; urban, costal, water and risk management; agriculture and environmental monitoring; precision agriculture; security. ESA is entrusted with the technical and contractual management of the industrial activities.

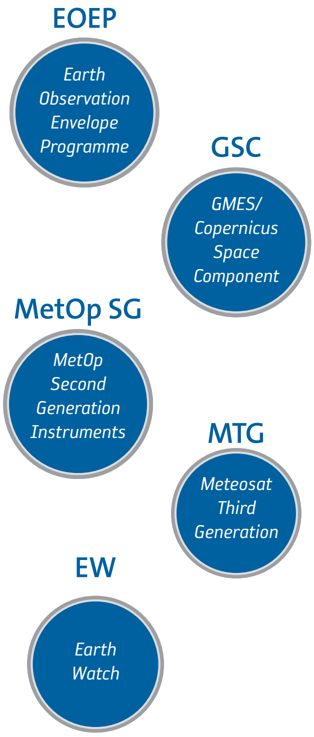
Finally, Earthnet has been a cornerstone in Earth Observation activities in Europe for more than 30 years. ESA’s **Long-Term Data Preservation** (LTDP) activities are targeted on the preservation of scientific and environmental data from space missions, and will capitalise on previous investments and infrastructure, which will offer long-term benefits for downstream data exploitation.

The Italian major Prime Contractors in EOP

As in most ESA programmes, several EO activities are contracted out to public institutions and private companies in order to maximize the returns of Member States’ investments in ESA. The major Italian Prime Contractors are indicated in table 4. Other entities (81 public and private institutions) have a relevant presence in the EOEP, and a low presence in all other EOP sectors. Finally, there is a low presence of Italian space sub-contractors in EOEP, GSC, and MetOp. Most of the EOP Italian space contractors have their headquarters in the Lazio Region.

Table 4. EOP-ESA Italian major prime contractors in the period 2007-2016 (M€)

	EOEP	GSC	MetOp-SG	MTG	EW	Total (M€)
THALES ALENIA SPACE ITALY	•	•	•	•	-	
LEONARDO	•	•	•	•	-	
SERCO	•	•	-	-	•	
ACS Advanced Computer Sys.	•	•	-	-	-	
CGS	•	-	•	•	-	
TELESPAZIO (Finmeccanica)	•	•	-	-	•	
E-GEOS	•	•	-	-	•	
SELEX ES	•	•	-	-	-	
ELSAG DATAMAT	•	•	-	-	-	
SPACE ENGINEERING	•	•	•	•	-	
VITROCISET	•	•	-	-	-	
INTECS	•	•	-	-	-	
ARESYS	•	•	-	-	-	
ASI	•	-	-	-	-	
CNR	•	•	-	•	•	
ELITAL	-	-	•	•	-	
ANTARES	-	-	-	•	-	
TERRADUE	•	•	-	-	-	
TAITUS SOFTWARE ITALIA	•	•	-	-	-	
PLANETEK ITALIA	•	-	-	-	•	
TOTAL	174.9	381.4	85.4	99.1	3	743.8



Source: our elaboration on EOP-B data.

Economic, human and infrastructural resources

The EOP budget of the approved programmes increased from roughly 400 million euros in 2007 to 900 million euros in 2014[4]. Since 2014, the EOP budget has increased sharply to a peak of almost 1.544 billion euros[5] in 2017, making EOP the most important ESA programme in terms of economic relevance. Until 2027, the expected EOP budget (sum of Approved Programmes and Future Programmes) should fall slightly, remaining within 1.2 and 1.5 billion euros[6], and 2021 is a milestone for the beginning of new activities.

The share of ESRIN's EOP budget increased from roughly 100 million euros in 2007 to 200 million euros in 2013. Since 2013, ESRIN's EOP budget increased sharply, reaching a peak of 350-400 million euros in 2016, then fell to almost 300 million euros in 2017. In the future, ESRIN's estimated EOP budget (sum of Approved Programmes and Future Programmes) should remain close to 350 million euros until 2020, then, after a dip to around 250 million euros in 2021, it should increase sharply reaching a peak of almost 500 million euros in 2024[7]. Finally, it should decrease again, reaching 450 million euros in 2027.

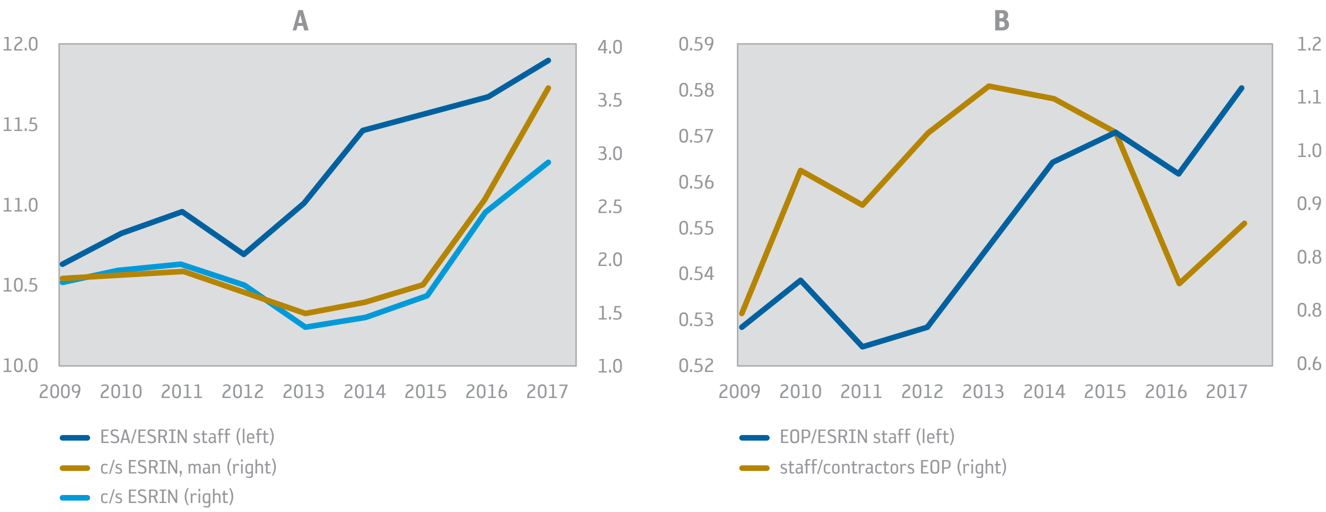
Since 2007, the percentage of ESRIN staff engaged in the EOP grew from 49% to almost 60% in 2017, but a correct assessment should take into account that ESRIN also hosts a significant number of EOP contractors. The overall picture is that since 2007, the number of EOP employees at ESRIN (staff plus contractors) decreased by 7 units (-2.8%), following a "U" trend between peaks observed in 2009 (265 units) and 2016 (255 units).

[4] *EOP-B data as of 4/07/2017.*
[5] *ESA Corporate Presentation IT*
[6] *EOP-B estimated data as of 4/07/2017.*
[7] *EOP-B estimated data as of 4/07/2017.*

Specifically, the EOP staff grew 20 units (+10.4%) following a rapidly increasing trend until 2010 and then remained almost stationary to the level of 112 units. The number of contractors, however, has decreased since 2007 by 27 units (-17.3%), following a "U" trend between peaks observed in 2009 (156 units) and 2016 (145 units). This number does not include almost 50 ESRIN contractors moved into the Frascati area as a consequence of recent ESA policies aimed at regulating the number of contractors on site.

Graph 5 illustrates how ESRIN staff has decreased in proportion to the overall ESA staff (the latter grew from 10.5 times to almost 12 times ESRIN's staff numbers), however, the average number of contractors for each ESRIN staff member grew from more than 1.5 to 3-3.5. Yet, the EOP staff located in ESRIN grew from more than 50% to almost 60% of the overall ESRIN staff, and from almost 70% to almost 90% of the EOP contractors. It means that the EOP offices located in ESRIN now have a higher weight in terms of ESA staff, but proportionally employ less contractors than in 2009.

Graph 5.
a) The relevance of ESRIN within ESA and the ratio of contractors to staff in ESRIN
b) The relevance of EOP within ESRIN and the ratio of staff to contractors within the EOP (Full time equivalent)



Source: our elaboration on EOP-B data (2017). NW: all figures are measured in full time equivalent, except "c/s ESRIN, man" that is measured in number of employees. "c/s ESRIN, man" has been added to graph a) as "c/s ESRIN" is based on our estimates of contractors number in FTE (we have only the number of employees).

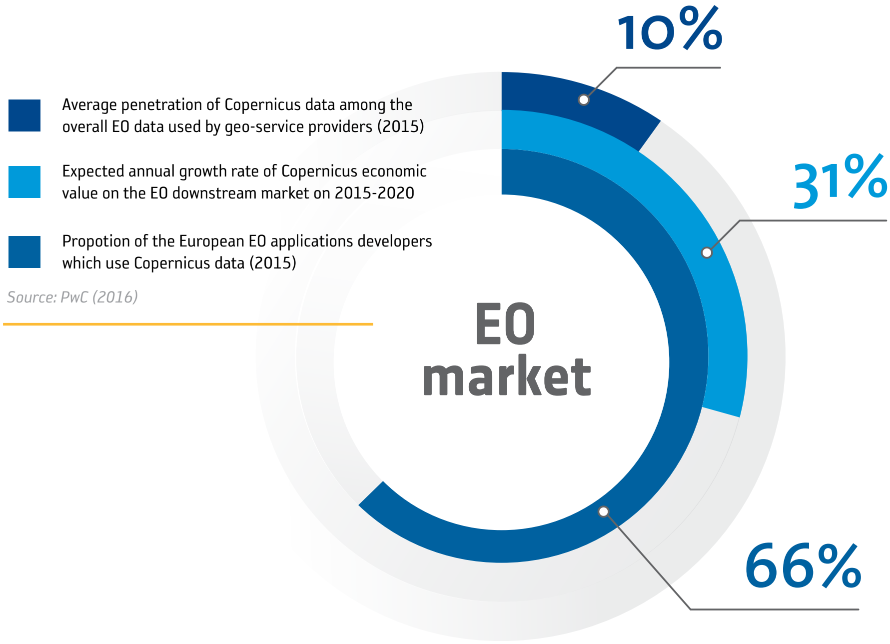
A focus on Copernicus

Copernicus is the most ambitious Earth Observation programme to date. It is noteworthy because it marks the transition from scientific to operational Earth Observation for the environment and civil security. Copernicus is a model for the future evolution of the EU-ESA relationship because on the one hand the R&D and space infrastructure management expertise of ESA can help fulfil EU policy requirements, while on the other the EU can integrate space and its applications into relevant sectorial policies and deliver the necessary funding.

Furthermore, Copernicus generates business opportunities across the whole spectrum of the value-added chain (upstream and downstream), and provides platforms and infrastructure for information exchange and informed decision-making. Finally, space activities create benefits that are not always quantifiable with financial indicators, but are tangible in providing better global information about the Earth's state, the threats to its environment and people, which can enhance citizens' safety and quality of life (Aschbacher, 2017).

Since the beginning of its operational phase, Copernicus data have shown consistent diffusion across the EO market, as illustrated in Graph 6, and now are used by the majority of the EO application developers in the EU. The widespread diffusion of Copernicus data will increase the economic value of the programme at an annual rate of more than 30%.

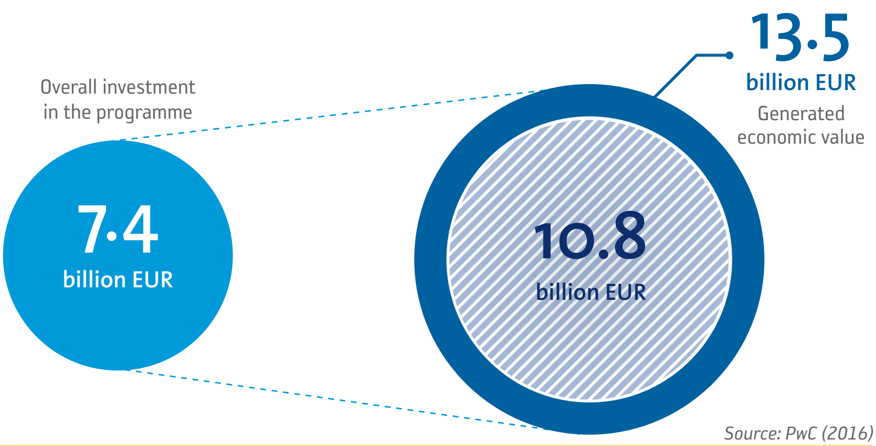
Graph 6.
Copernicus data widespread diffusion in the EO market



Source: PwC (2016)

As illustrated in Graph 7, from an overall investment of 7.4 billion euros between 2008 and 2020, the overall value generated by the programme is estimated at 10.8-13.5 billion euros.

Graph 7.
Copernicus overall investment and economic value generated (2008-2020 BN euro)



Source: PwC (2016)

From 2014 to 2020, the EU is committing 4.3 billion euros to Copernicus, and most of the budget will be spent on industrial activities. Specifically, industrial commitments are worth almost 2.8 billion euros, mostly related to the Space Segment Development, while ESA remuneration is worth almost 0.4 billion euros (less than 15% of the industrial commitments and less than 10% of the overall cost of the Programme). Table 5 focuses on the industrial procurement of the Copernicus Ground Segment Development, and lists the major Prime Contractors, the overall value of the contracts signed with ESA and the advance in payments at the end of 2016. It is worth noting the economic relevance of the contracts signed by Thales Alenia Space Italy in procurement activities related to Sentinel 1 and Sentinel 3.

NON-ECONOMIC REASONS FOR THE COPERNICUS FREE AND OPEN DATA POLICY

Beyond economic considerations, there are a number of other reasons why Copernicus adopted a free and open data policy.

1. The EU itself advocates free and open access models to foster innovation, as demonstrated in its 2020 strategy for smart, sustainable, and inclusive growth, or in the PSI and Infrastructure for Spatial Information in the European Community (INSPIRE) directives.

2. The US, China, and Russia grant free and open access to satellite data. Since the provision of data to users takes place within an open world market, protection of European data would not have stopped others offering and sharing their data.

3. There are market segments of space-based Earth Observation where commercial models apply, for example in the data range of a resolution better than two meters (e.g., TerraSAR-X, COSMO-SkyMed, or Pleiades), but the Sentinels do not cover this market segment. If in the future a Sentinel (e.g., for security purposes) will address such a market segment, the free and open data policy will have to be reviewed.

Source: our elaboration on Aschbacher (2017).

Table 5. Space segment development: main contractors, expenditure and advance payments (€)

Copernicus GS Dev.	Major Prime Contractors
Sentinel 1	ArianeSpace
	Thales Alenia Space Italy
	Thales Alenia Space Italy
	Tesat-Spacecom GMBH&Co.
	ASTRIUM GMBH - Satellites
	Airbus Defence and Space
Sentinel 2	ASTRIUM GMBH - Satellites
	Tesat-Spacecom GMBH&Co.
	ArianeSpace
	Airbus Defence and Space
Sentinel 3	Thales Alenia Space France
	Thales Alenia Space Italy
	Selex ES S.p.a.
	Airbus Defence and Space
	Jena-Optronik GMBH
Sentinel 5	Airbus Defence and Space GMBH SAT
Sentinel 5P	Eurockot Launch Services GMBH
Contract Value	**912,946,986**
Adv. Pay. (end 2016)	**327,915,352**

Source: our elaboration on EOP-CO/QIR1/17 data.

An in-depth analysis of VEGA

VEGA is the first launch system development programme where ESA has full technical and managerial responsibility. In 2000, the management of the VEGA Small Launcher Development Programme was established in ESRIN. It is supported by an Integrated Project Team (IPT) including, besides ESA staff, staff from ASI and CNES and by several contractors. The VEGA IPT has consistently improved ESA competences and knowledge in ESRIN in the areas of system engineering, solid propulsion, guidance navigation and control, safety and, in general, launch system development and exploitation engineering.

Decisions made at the Ministerial Council in December 2016, confirmed the responsibility of the VEGA IPT for the development of VEGA-C and the VEGA exploitation accompaniment programmes. In addition, the responsibility of managing the VEGA-E preparation activities and Space Rider development has been integrated into the VEGA IPT in ESRIN. This decision allows to:

- reduce ESA management costs
- increase the efficiency thanks to the synergies generated by the VEGA C – Space Rider integrated transportation system
- avoid duplication of competences and of ESA expertise and resources dispersion
- enlarge ESRIN technical competences on space transportation to re-entry, thermal protection, etc.

The ESA funded VEGA programmes

VEGA's industrial organization is a forerunner of the future organization for European launchers development. It is based on having a Prime Contractor for each project: ELV (Italy) for the Launch Vehicle, Avio (Italy) who delegates to Europropulsion (Italy and France) for the P80, and Vitrociset (Italy) for the Ground Segment. Italy's involvement in VEGA's development and exploitation programmes is exemplified by the consistent national long-term investments in almost all programmes related to the launchers. It has fostered the participation of several Italian industries and universities in various design and implementation activities.

Table 6 illustrates the overall investment for each VEGA programme since 1997, the Italian contribution in percentage points, the Italian industrial return (in millions of euros) and the Italian return coefficient (RC), according to both current and 2017 economic conditions.

Table 6.
Italy's participation and returns in Vega Development and Exploitation programmes according to current and 2017 economic conditions

Source: our elaboration on VEGA IPT data (2017).

	Programme	Economic conditions	Overall Investment (M€)	Italian Investment (%)	Italian return (M€)	Note	Italian RC
DEVELOPMENT	Small Launcher	1997	376.3	0.64	283	Final figure	**1.18**
		2017	572.2	0.64			0.78
	P80 Development	2000	55.5	0.10	4.4	Final figure	**0.79**
		2017	83.7	0.10			0.52
	Vega Add. Development	2007	35.0	1.00	36.1	Final figure	**1.03**
		2017	41.0	1.00			0.88
	Vecep	2012	84.1	0.59	39.7	Provisional figure against an ideal Italian return of 42.5	**0.79**
		2017	89.7	0.60			0.74
	Vega C Sub-element	2014	260.6	0.49	100	Provisional figure against an ideal Italian return of 110.2	**0.78**
		2017	264.4	0.49			0.77
	Vega E Sub-element	2016	76.6	0.65	5	Provisional figure against an ideal Italian return of 44.4	**0.10**
		2017	76.7	0.65			0.10
	Space Rider	2016	26.6	0.65	6	Provisional figure against an ideal Italian return of 15.0	**0.35**
		2017	26.6	0.65			0.35
EXPLOITATION	VERTA 1,2	2006	362.9	0.58	187.4	semi-final figure	**0.88**
		2017	435.3	0.58			0.74
	VEGA LEAP '13-'14	2012	54.8	0.64	28.4	semi-final figure	**0.81**
		2017	58.4	0.64			0.76
	VEGA LEAP '15-'16	2014	65.0	0.47	32.3	semi-final figure	**1.06**
		2017	65.9	0.47			1.04
	VEGA LEAP '17-'19	2016	84.7	0.59	0	no contracts signed yet with Italian companies	**0.00**
		2017	84.8	0.59			0.00
	VEGA LEAP Suppl.	2014	19.9	0.41	8.4	semi-final figure	**1.04**
		2017	18.6	0.44			1.02
	VERTA 3	2016	7.7	0.65	0	no contracts signed yet with Italian companies	**0.00**
		2017	7.7	0.65			0.00

A significant heterogeneity emerges across the programmes for almost any variable considered. The most relevant programmes in terms of overall investment are the Small Launcher Development Programme with 376.3 million euros of investment at 1997 economic conditions (an estimated 572.2 at 2017 economic conditions), the VERTA 1,2 Exploitation Programmes with 362.9 million euros invested at 2006 economic conditions (estimated 435.3 at 2017 economic conditions), and VEGA-C Sub-element Development Programme with 260.6 million euros at 2014 economic conditions (estimated 264.4 million euros at 2017 economic conditions).

In most VEGA Development and Exploitation Programmes Italy contributed to more than 50% of the total investment. Significative exceptions are the P80 Development, to which Italy contributed 10%, and, at the other end of the scale, the VEGA Additional Development Programme, to which Italy contributed the entire investment amount.

According to the available data, it is too early to assess Italy's overall return from the VEGA programmes, as most procurement activities are still far from finished. Furthermore, the Italian return coefficients estimated at 2017 economic conditions severely underestimate the final figures indicated in ESA reports, while the Italian return coefficients estimated at current economic conditions probably slightly overestimate them. We consider the return coefficients estimated at current economic conditions to be the more reliable. For programmes initiated after 2012, the spread among the values is usually equal or lower than 5 percentage points, while for programmes initiated before 2012 final or semi-final figures are already available.

The Italian Prime Contractors of VEGA

For all VEGA and Space Rider programmes there has been strong engagement of the private industrial sector in providing the know-how and the technical capabilities required to achieve the major goals. Table 7 briefly summarizes the main contracts signed with ESA by three large Italian enterprises, Avio, ELV, VITROCISET, for a selection of VEGA programmes. The overall value of the contracts signed since 2001 is greater than 1 billion euros in value. The most consistent share of it has gone to ELV, the VEGA consortium's Prime Contractor. At least one of the three companies participated in each VEGA programme, except "Support to VEGA launcher and ground segment development".

Table 7. Main contracts signed by Italian Prime Contractors for VEGA (M€, c.e.c.)

Italian Prime Contractor			AVIO, ELV, VITROCISET
VEGA	P80 Motor Development	2001	84
	VEGA Launcher Development	2003	410
	VEGA Ground Segment Development	2005	155
	Support to Vega Launcher and GS Dev.	2006	-
VEGA C	VEGA C Launcher and GPM Development	2013	288
	VEGA C Launcher (P120C part)	2015	230
	VEGA C Ground Segment Development	2016	12
	VEGA C Launcher (SSMS part)	2017	8
Overall value of contracts			1,187

Source: our elaboration on VEGA IPT data (2017).
NW: VEGA C Launcher and GPM Development does not include P120C and SSMS part.

More generally, many companies that were not Italian were also involved in VEGA activities, as illustrated in table 8. The non-Italian companies are from France (Europropulsion and SNECMA Propulsion Solid), the Netherlands (Dutch Space and Stork Product Engineering), Belgium (SABCA), Spain (EADS CASA) and Switzerland (Contraves Space).

Table 8. A selection of companies involved in the VEGA Programme by country and component

COMPANY	COUNTRY	COMPONENT
Contraves Space	Switzerland	Fairing
EADS CASA	Spain	Adapter
Thales, Zodiac, Galileo Avionica, CRISA, SAAB, SAFT	Various	AVUM Avionics
Avio	Italy	AVUM (stage integration and test)
EADS CASA	Spain	AVUM Structure and AVUMT3 Skirt
Avio	Italy	AVUM Propulsion System
Avio	Italy	3rd Stage (production, integration and test)
SABCA	Belgium	3rd Stage TVC
Oerlikon Contraves Italia (OCI)	Italy	2/3 Interstage
Avio	Italy	2nd Stage (production, integration and test)
SABCA	Belgium	2nd Stage TVC
Dutch Space	The Netherlands	1/2 Interstage
Stork Product Engineering	The Netherlands	Igniters of Stages 1-2
Avio	Italy	1st Stage (integration and test)
Europropulsion	France	P80FW Motor
SABCA	Belgium	2CT: Interstage Skirt
SABCA	Belgium	1st Stage TVC
SNECMA Propulsion Solid	France	Nozzle

Source: ESA Web Portal and VEGA IPT (2017).

ESRIN's corporate activities and local offices

The IT Department

The strategic objectives of the Open Science and Space 4.0 initiatives respond to recent advances in ICT and new digital technologies, combined with a growing demand for science in society. On the opposite side, the rapid obsolescence of digital technologies, combined with the fragmentation of resources and proliferation of standards are major threats to several informatics-related fields (e.g. data, information and knowledge asset preservation; discovery, access, interoperability and exploitation). Finally, Informatics has a key role in boosting innovation in support to the 2030 Agenda for Sustainable Development Goals, and to the success of ESA, EU and Member States' Digital Agendas and National Space Plans.

In this context, the role of ESRIN as a centre for ICT and related aspects is of the utmost importance for ESA, ASI and the local research district of Frascati-Tor Vergata. Indeed, the added value of cooperation among directorate domains, external and IT infrastructure specialists has reinforced the connective tissue, and led to the emergence of new roles for technical IT and domain specific data managers.

The IT Department provides support for Agency-wide IT related infrastructure and services in accordance with ESA's IT Strategy and ESA's Digital Agenda for Space (EDAS) implementation plan. Particularly, this aims at enabling the Digitisation of Space (known as Space 4.0), which will foster ESA's cooperation with the Science 2.0 world by allowing ESA to work, cooperate and communicate more effectively both within the ESA Executive and with Member States.

Within Space 4.0, data and information shall be disseminated to broader general purpose communities for crowd science applications, innovative research and co-funded operational services. Emerging needs and the on-going implementation of directorate specific and inter-directorate technical information management systems, knowledge laboratories, operational and scientific data lakes bring with them the need to exploit ICT technologies with a common approach that overcomes the limitations of the traditional silos architectures. Doing this will pave the way to new staff roles with terms of reference such as data scientist, data curator, IT data manager with skills in data science foundations and analytics.

ESRIN Communication office

ESRIN hosts an ESA Communications Office, whose main purpose is to give the widest and clearest message as to why Europe must invest in space activities. The Office also serves as the country desk for Italy and for other countries in the vicinity (Greece, Romania and Hungary). The country desk is responsible for the translation of corporate productions into national realities, local relations, promotions and partnerships.

ESRIN Communication Office manages the Esa Web Portal, the Esa TV, and it is involved in the organisation of several events on site

One of the major ESA Communication assets managed in ESRIN is the ESA Web Portal. Space in Images was among the most-visited pages in 2014, with 10 million page views in 12 months. Furthermore, Space in Videos attracted 2 million page views in 2014, with visitors spending an average of 3:44 minutes watching each video. Finally, the ESA Web Portal also runs a dedicated video site for professionals, that has more than 1,000 registered users and receives 20 to 30 requests a month.

The ESRIN Communications Office also features ESA TV, a television broadcasting service that provides high-quality productions on a wide range of space issues. ESA TV has two main outputs: live events coverage, and video news releases. The ESRIN Communications Office is fostering the development of the Big Hall for further studio and production capacity as well as live, web-streaming content.

The Communications Office is also present and active on a range of the most popular social media platforms (YouTube, Flickr, Google+, Facebook, Twitter...). Sixteen active ESA's Blogs provide in-depth views and behind-the-scenes information. Furthermore, the Office contributes to #SocialSpace and supports the SpaceUp conferences, manages ESA wide intranet contents and produces a wide array of scientific and informative material that is distributed off-line.

The ESRIN Communication Office is involved in the organization of the European Researchers' Night, that includes presentations and round tables with scientists and researchers. Finally, every year ESRIN Open Days give children the chance to discover space. Several universities visit ESRIN's facilities, and many official events are organized during the year to inspire top decision-makers, key industry figures, the leaders of official organizations and media representatives.

ESRIN Estates and Facility Management Services (FM)

The ESRIN Estates and Facility Management Services (FM) provide a wide array of services to the establishment and to its employees. Specifically, the office manages:

- ESRIN's real estates, such as buildings and grounds, all associated technical facilities and accommodation;
- all services related to the facilities, such as cleaning, transport, the canteen, conferences and travel;
- health, safety, security and environmental services;
- personal services to workers and employees such as reception, switchboard, transport (customs, shipments), travel, bank and reproduction services, meeting and mail room facilities, privileges and immunities to ESRIN staff.

ESRIN's FM offers also a range of services that contribute to the general wellbeing of users.

A dedicated building hosts ESRIN's childcare and sports facilities (a gym, two fitness rooms, changing rooms, two mini-football pitches, a tennis court and a multi-purpose court). A room for anti-computer syndrome massages is also available. To use the facilities ESRIN employees must refer to the corresponding club (Football club, Gym Club, Tennis club), and all clubs are part of the ESRIN Social Committee (ESC), except the childcare facilities, which are managed by the Human Resources office. Finally, the FM has negotiated special agreements with several suppliers, giving staff access to various discounts (most of the agreements apply only to ESA staff).

ESRIN other local offices

Communication and Facility management apart, ESRIN also hosts several other local offices. Their main functions are facilitating the management and supporting the activities on site, contributing to raise employees' wellbeing and productivity, and improving ESRIN's attractiveness as a location of existing and new ESA programmes. The main local offices hosted at ESRIN are the IPL Operations and Ground Segment Procurement office, the Financial Operations and Accounting office and the Human Resources office.

ESA WEB PORTAL IN NUMBERS

The ESA web site has 20 country desks and according to Google indexing contains 357,000 pages. It supplies more than 3,500 videos and animations, 13,000 photos, live streaming capacity and more. In recent years, visitors to the ESA Web Portal have soared in number, increasing by 9 million between 2013 and 2014 to reach 15 million visitors. Since the launch of the new portal in 2012, there has been a 305% increase in visitors.

Source: ESA(2016)

ESRIN'S SPACE RELATED EVENTS IN NUMBERS

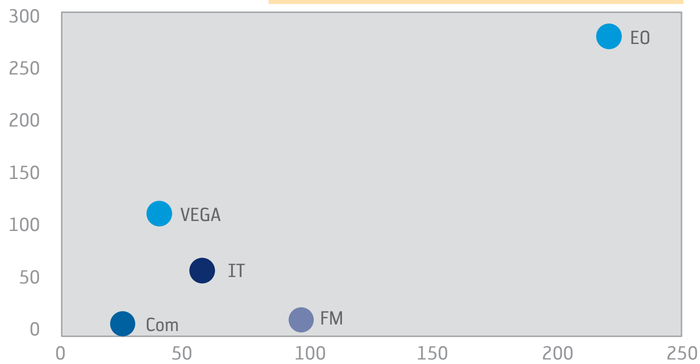
ESRIN accommodated 46,161 visitors in 2016, averaging 3,847/month. Within the same year, ESRIN hosted 8,818 meetings and videoconferences (average of 735/ month), and 141 events that attracted 7,755 visitors (average of 646/month). ESRIN has one dedicated conference hall (Magellan) for 150 persons, 16 small to medium-sized meetings rooms, and 6 videoconference rooms. A large, multi-use open space in Building 14, the Big Hall, can host up to 400 persons for larger conferences (however, the Big Hall is a temporary solution, and is not properly equipped for conference use).

Source: ESRIN data, 2017

ESRIN's other programmes and activities: an overview

Graph 8 briefly summarizes the weight of a selection of ESRIN's programmes and offices in terms of average staff and budget figures related to the last five years of activity. Due to the fact that most ESRIN offices also support activities located in other ESA establishments, and that ESA's accountability is centralized, the numbers presented mostly reflect ESRIN's self-assessment of the local relevance of the figures considered.

Graph 8. A snapshot on VEGA IPT, ESRIN corporate functions and main local offices in terms of employees (horizontal axis) and budget (vertical axis, M€).



Source: our elaboration on data surveyed through the interview plan (2017).
NW: data refer to 2012-2016 average values.

2. The direct, indirect and induced economic impact of ESRIN on Italy.

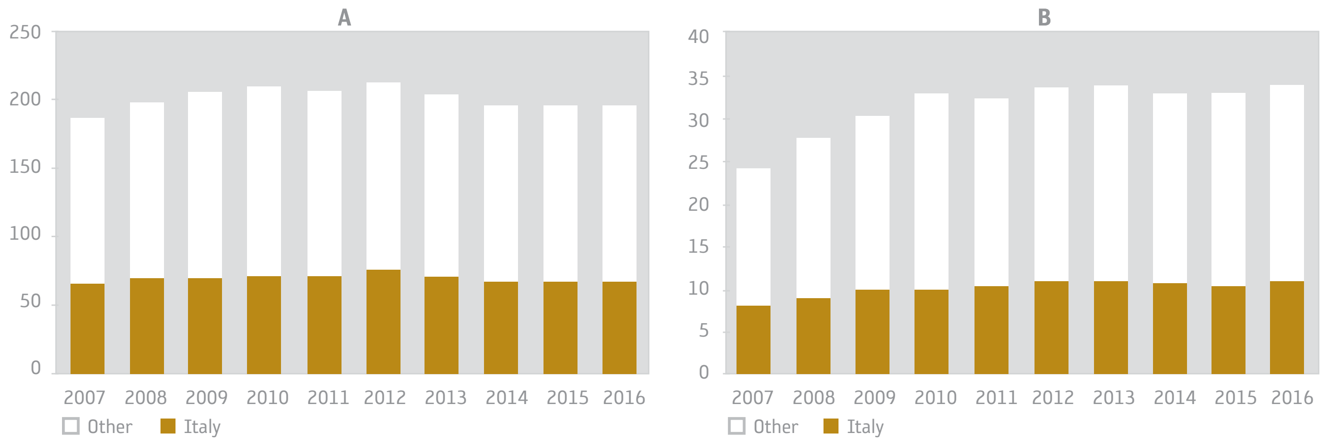
2.1 ESRIN's direct impact in terms of employment and tourism

Employment and salaries

As illustrated in Graph 9, ESRIN's workforce of 775 people is composed of 200 ESA employees and 575 contractors. Between 65-70 of them are Italian. The salary cost of ESRIN's ESA staff increased in the last decade, reaching a peak of almost 34 million euros in 2016. Of this slightly more than 11 million euros was earned by Italian employees. On average every ESA staff member earns an annual salary of around 85,000 euros. Compared to the average wage in Italy, this value might seem high but ESRIN ESA staff are mostly high skilled and, compared to other ESA establishments, ESRIN's location demands a high cost of living for international staff. This is due to the absence of services such as international schools, the need to buy a car, inflated house prices and rents…[9]). This average wage amount has obvious benefits for the local economy since it translates into money being spent on goods and services from the nearby locality.

[9] This consideration emerged in several interviews with ESRIN managers.

Graph 9. The Italian share on a) ESRIN staff (FTE) and b) ESRIN salary cost (M€)*

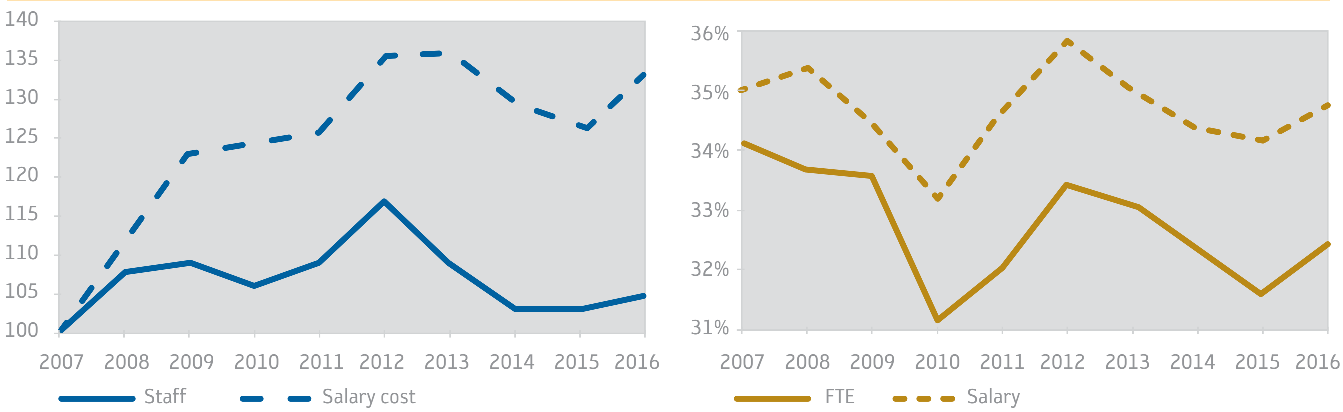


Source: HIF-HR data (2017)
** Including ESA contribution to pensions.*

Graph 10 shows that while staff numbers at ESRIN remained almost constant in the last decade (after registering a peak in 2012, the final increment is less than 5%), the overall salary cost increased sharply, generating a cumulative increment of more than 30% with respect to the value observed in 2007. In the last decade, the percentage of Italians on staff at ESRIN has oscillated around 35%, while their share of the salary cost decreased from 34% to 32% of the total. It is worth noting that the salary cost is computed in nominal terms, and therefore this change might be almost entirely explained in terms of inflation adjustment (around 22% by considering a constant 2% inflation rate) and growth of ESA staff (about 5%).

Source: HIF-HR data (2017)

Graph 10. a) Growth of ESRIN staff and salary cost (2007 = 100) and b) share of Italian employment and salary cost over ESRIN total (%).



Visitors and impact on the local economy

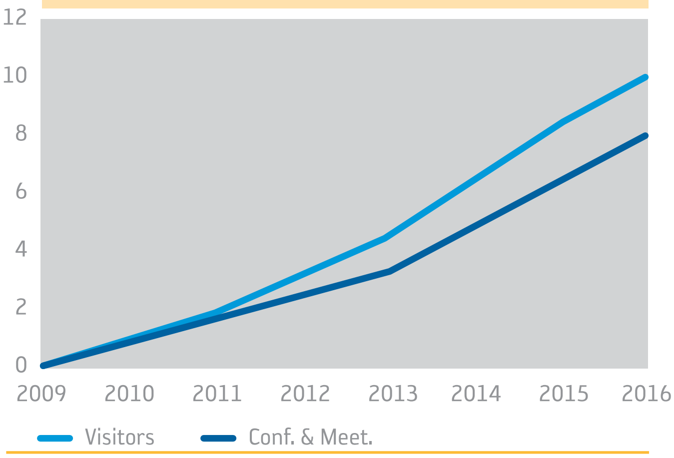
ESRIN hosts numerous scientific conferences, meetings with industry and events during the year that attract thousands of visitors. Some of them spend one or more days in the neighbourhood, generating a consistent demand for touristic activities, local goods and services.

Even if business tourism is clearly outside the core business of ESRIN, it is still worth noting this positive pecuniary side effect of the establishment being in Italy. As illustrated in Graph 11, the number of visitors to ESRIN grew exponentially from 2009 to 2016. Similarly, the number of conferences and meetings grew also. Such figures confirm ESRIN's primary position among ESA establishments in terms of visitors' numbers.

In qualitative terms, ESRIN attracts a heterogeneous visiting public. It is made of decision makers, VIPs, ESA personnel working in other ESA establishments, businessmen participating in industrial meetings, researchers and scientists, students, etc., but each group has a different budget to cover the expenses related to the journey and to the accommodation.

The assessment of ESRIN's impact on local tourism deserves an accurate analysis, which is beyond the scope of this report. In the following box we "guestimate" its order of magnitude by referring to publicly available data and some (debatable) assumptions.

Graph 11. Cumulative growth of visitors and conference meetings held in ESRIN since 2009.



Source: HIF-ER data (2017). NW: cumulative growth is measured in multiples of 2009's value.

Box 1. A "guestimate" of ESRIN's annual impact on local tourism on 2016/2017 available data

The assessment is based on ESRIN facility management data, and it refers to an overall annual number of 50,000 visits on site.

Family, friends and local business/research

A consistent number of visits involve ESRIN employees' family members and friends, but also business and research related activities with the neighbouring institutions (ASI, INAF, INFN, ENEA, the Universities of Rome, the Tor Vergata Polyclinic, the Tiburtino High tech district, Avio...). We estimate 6,000 personal visits (12% of the total) and 10,000 local visits (20% of the total), and we assign a budget of 10 euros for each visitor (one meal at the ESRIN canteen plus two train tickets from Rome), obtaining a total expenditure of 160,000 euros in the local economy.

Educational visits

As of the end of September 2017, almost 6,800 educational visits on site (including those on Open Days and Researchers night's) were registered, therefore we cautiously estimate a number of 9,000 educational visits (18% of the total) during the whole year.

According to the available data for 2017, almost 11% of educational visits involve local residents, almost 45% involve students living in Italy beyond the Lazio Region, and the remainder involve students from abroad. We estimate a daily expenditure (excluding travel) of 7 euros for local residents for a meal at ESRIN's canteen, and of 90 euros for Italian and foreign residents (it includes dinner and accommodation). We obtain a weighted average expenditure of 81.5 euros for each educational visit, and therefore an overall expenditure of 1,105,730 euros, of which 837,107 euros in the local economy.

Business and research visitors

We assume that the remaining 50% of the visits registered during the year are either for business (25%) or for research purposes (75%), and we distinguish three groups of visitors according to their provenance (40% Italy, 36% UE, 24% extra-UE). As every visitor can stay one or more days in ESRIN, the number of visits exceeds the number of visitors, and we briefly summarize our guestimates in the following table, where it is indicated an overall expenditure of 2,835,625 euros in the local economy.

Table B1. Business and research visitors T&T expenditure

	Visits	Visitors	DE (av., €)	TD (av, €)	TLT (av., €)	TTnL (av., €)*
Italy	10,000	7,500	85	850,000	243,750	1,406,250
UE	9,000	6,750	85	765,000	219,375	3,206,250
Extra-UE	6,000	3,000	110	660,000	97,500	3,750,000
Overall	25,000	17,250	91	2,275,000	560,625	8,362,500

** DE" = daily allowance (average, euro), "TD" = total allowance (average, euro), "TLT" = total local transport expenditure (average euro), "TTnL" = Total travel non local expenditure (average euro). The expenditure in the local economy includes TD and TLT for all visitors, plus TTnL only for Italian visitors.*

ESA missions

Finally, ESRIN is the destination of numerous ESA missions. We estimate the current ESA inbound missions to number approximately 3,000, and we do not consider the ESA outbound missions.

We break down the ESA missions by the number of nights spent in the local region (50%: 0 nights, 25%: 1 night, 25%: 2 nights) and we estimate a business allowance for travel (about 1,000 euros within the EU) and daily expenditure (about 100 euros for accommodation and 100 euros for meals and local transports), obtaining an average expenditure of 1,250 euros for each mission.

Therefore, we obtain a total annual economic impact of 3,750,000 euros, of which only 750,000 euros in the local economy.

An overall picture of ESRIN impact on the Travel & Tourism sector

Graph B1 illustrates our estimate of ESRIN's annual impact on local tourism and on the travel industry. It compares the national contribution to the ROW (rest of the world) contribution.

Due to the underlying assumptions almost one-third of visits (family and friends, business and research relations with local institutions) provide a quasi-null economic impact on the travel and tourism sector. Also, it seems that educational visits do not generate relevant economic impacts overall, and their contribution to the local economy is of the same magnitude as ESA's inbound missions, which do generate a consistent economic impact in terms of travels for the rest of the world. Most of the economic impact therefore depends on visits for business and research purposes but excluding those from local institutions. Overall, we estimate a gross economic impact in 2016 of slightly more than 16.2 million euros, that generates a net direct impact on domestic travel-related and touristic activities of almost 6 million euros (4.5 million euros in the local economy). The other 10.2 million euros go to the rest of the world for travel expenses.

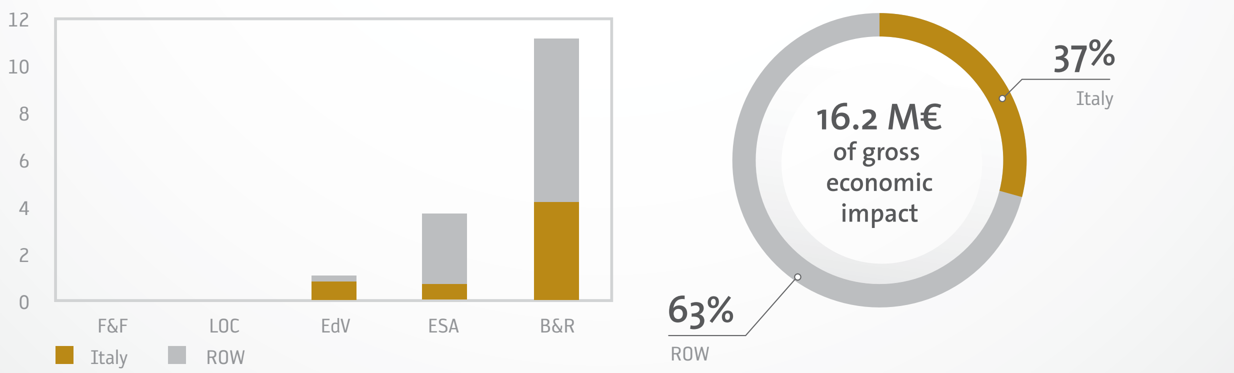
We did not consider in our analysis the contribution that ESA outbound missions from ESRIN might provide to the national travel industry, as anyway it has no impact on the local economy.

An alternative measure of ESRIN's economic impact on local tourism

In order to test the magnitude of ESRIN's annual estimated impact on the local economy, we analyse the value added to Rome's tourist economy. In 2014, this amounted to almost, 5.6 billion euros according to the National Institute for Statistics (ISTAT). By considering that Frascati's population (22,331) over Rome's (4,353,738) is equal to almost 0.51%, if spending on tourism were distributed uniformly across both populations then Frascati should contribute almost 28.3 million euros to the overall value. However, a recent survey suggests that ESRIN, ENEA, INFN and ERICSSON generate almost 70% of the local touristic demand. By equally weighting the four institutions, ESRIN should generate almost 5 million euros of tourism spending.

It's worth noting how the annual value of almost 4.5 million euros, that we estimated in the previous section, is close to the value roughly computed on ISTAT data, and it is downward skewed as it might reflect Frascati's lower average prices. Therefore, we consider our estimate reliable to the order of magnitude.

Graph B1. ESRIN's annual estimated economic impact on tourism (ML€ at c.e.c.) by group of visits for Italy and rest of the world



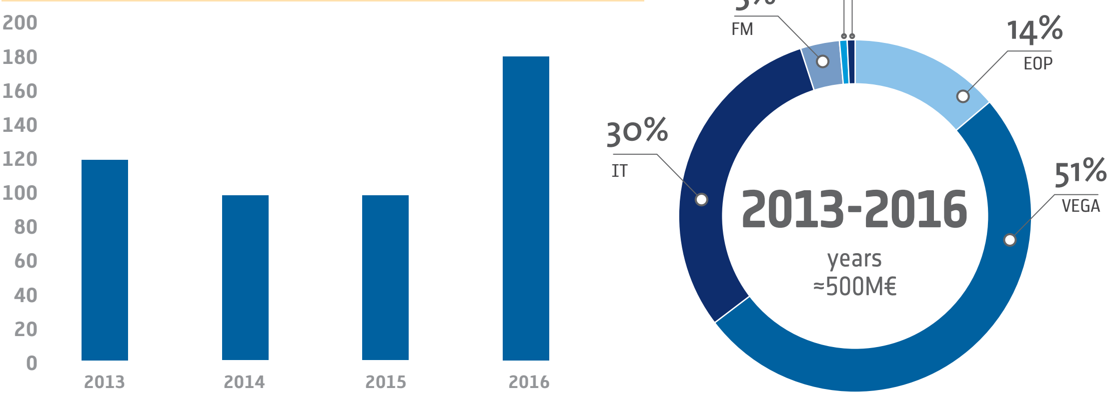
Source: our estimate (2017). NW: "ROW" = Rest of the world. "F&F" = Family & Friends, "LOC" =Local Institutions, "EdV" = Educational Visits, "ESA" = ESA Missions, "B&R" = Business & Research.

2.2 ESRIN's procurement: a focus on the Italian Industrial Prime Contractors

During the last four years, ESA signed numerous contracts with Italian industry through ESRIN. This generated consistent benefits in terms of industrial commitments for several Italian companies. Graph 12 illustrates how, after a decreasing trend, the industrial commitments signed at ESRIN with Italian Prime Contractors rose in 2016 to more than 181 million euros, and in the period 2013-2016 amounted to almost 500 million euros.

Sorting the data by initiating service (i.e., the programme to which the cost is assigned), shows how VEGA is responsible for more than 50% of the total invoiced by ESRIN, the IT Department for an additional 30% share, and the EOP (for the part attributable to ESRIN) for an additional 14% share. The remaining 5% is attributed to ESRIN facility management services (3%) and to ESRIN local offices (among them, the Communication office and the Legal Affairs office are the most relevant).

Graph 12. ESRIN Italian Primes:
Total invoiced by year (M€) and initiating service (2013-16)



Source: our elaboration on IPL and ESA-p data (2017). NW: Annual attributions refer to the payment date. "EOP" = Earth Observation Programme, "VEGA" = VEGA IPT, "IT" = IT Department, "FM" = Facility Management, "Comm" = ESRIN Communication Office.

Table 9 lists the Italian Prime Contractors that received more than 1 million euros from ESA through ESRIN and briefly summarizes the main aspects of their activity. It can be noticed how 15 out of 21 are non-space contractors (mostly involved in informatics). In terms of total invoice amount, more than half remains related to the space economy, especially due to the agreements with ELV. As already illustrated in Graph 12, ESRIN's Italian Primes mostly provide goods and services to the VEGA IPT (STS), but also to the Earth Observation Programme (EOP), the IT Department and Facility management services (HIF), ESRIN Communication Office (DG) and Procurement and Legal Affairs office (IPL).

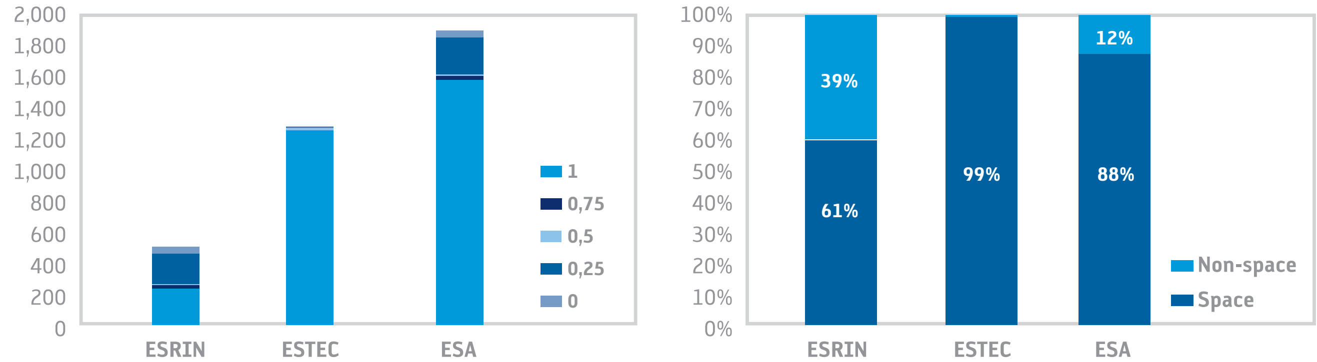
Table 9. ESRIN's Major Italian Prime Contractors (Y2013-2016)

Italian Prime Contractor	SE/NS	Initiating service
ELV SPA	SE	STS
CAP GEMINI ITALIA SPA	NS	EOP, HIF
HP ENTERPRISE SERVICES ITALIA SRL	NS	HIF
SERCO SPA	NS	EOP, HIF
TELESPAZIO S.P.A.	SE	EOP, HIF
VITROCISET SPA.	SE	EOP, STS
E-GEOS	SE	EOP, TEC
RANDSTAD ITALIA SPA	NS	HFC, DG, EOP, HIF, IPL, OPS
ORANGE BUSINESS ITALY SPA	NS	HIF
NIKAL FM SRL	NS	HIF
KELLY SERVICES	NS	DG, EOP, HIF, IPL, STS
NATUNA S.P.A.	NS	HIF
ACS ADVANCED COMPUTER SYSTEMS	SE	EOP
PEDEVILLA SPA	NS	HIF
RINA CONSULTING SPA	NS	STS
ATOS ITALIA SPA	NS	HIF
AVIO SPA	SE	STS
DigitasLBI S.R.L.	NS	DG
IMPRESA COSTRUZIONI E. PASQUALUCCI	NS	HIF
REMEDIA ITALIA SRL	NS	DG, EOP
IFAC-CNR IST FISICA APPLICATA	NS	EOP
Other	na	na
Tot. Inv. Am. (M€)	**8,308,841**	

Source: our elaboration on HIF and IPL data (2017). NW: "SE" = Space Economy, "NS" = non speace economy.

Graph 13 illustrates the results of a comparative analysis of the total amount invoiced by the Italian Prime Contractors with ESRIN, ESTEC and all ESA. It is worth noting how the Italian Primes mostly have signed contracts with ESRIN and ESTEC and how the total amount invoiced by ESRIN is lower than the amount invoiced by ESTEC. Furthermore, ESRIN's procurement with Italian Primes has a consistent non-space component (the non-scientific share of the total amount), that amounts to almost 40% of the overall amount invoiced. As stated, ESTEC procurement is more consistent (more than 1,278 million euros) and almost totally space-related (the non-scientific share amounts to less than 1%). However, by considering that ESTEC is the largest ESA establishment (it employs five times more ESA staff than ESRIN), ESRIN's level of procurement with the Italian Primes is consistently higher if calculated over some index of economic activity. This evidence might be considered as a measure of proximity benefits, and mostly involves the non-space dimension. By considering only space-related procurement, the results are of the same magnitude.

Graph 13. ESRIN, ESTEC, ESA procurement with the Italian Primes (2013-16):
a) unweighted value by weighting factor (Total invoiced amount, M€) **b) weighted value and residual (DW, %).**



Source: our elaboration on ESA-p data for 2013-2016.
NW: labels in graph a) refer to Weighting Factors.

Finally, Graph 14 illustrates how the Italian contribution to ESA during 2013-2016 and ESA's industrial commitments with the Italian Prime Contractors have almost the same overall value and the same composition. This shows how ESRIN adds economic value to the overall Italian investment.

Specifically, ESA procurement is worth almost 14.5 million euros more than the Italian contribution to ESA net of the Agency's internal costs, i.e. 0.77% more. By considering that roughly 15% of the Italian contribution covers ESA's internal costs[10], we estimate an outflow of almost 283 million euros. This corresponds to a net inflow of greater value. Indeed, ESA's space-relevant industrial commitments with Italian companies are worth 63 million euros more than the estimated net Italian contribution to ESA (gross contribution minus estimated contribution to ESA's internal costs). ESA non-space industrial commitments with Italian companies are worth roughly an additional 235 million euros, and most of them are signed through ESRIN. Furthermore, ESRIN staff allows Italy to benefit from an exogenous expenditure on domestic goods and services equal to ESRIN's staff wages of 134 million euro in the period 2013-2016, plus an additional 24 million euros spent on tourism and local transport services[11].

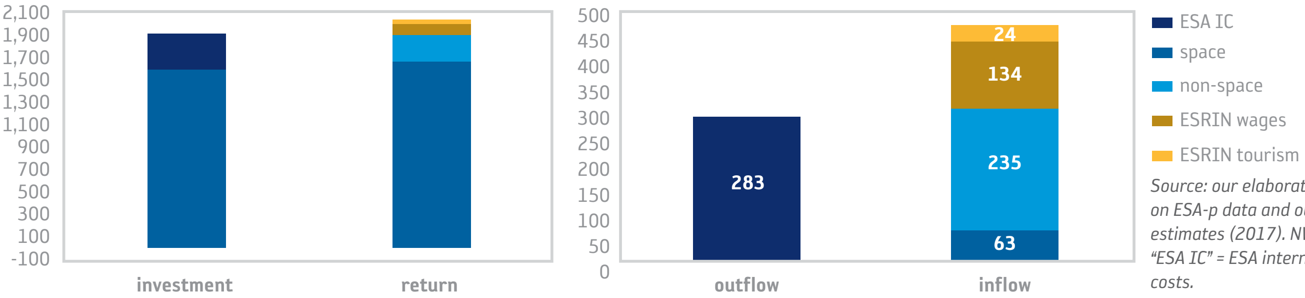
Considering these figures, we estimate that in the period 2013-2016 compared to the overall Italian contribution to ESA, Italy obtained an estimated 8.4% return on each euro invested, apart from the benefits of proximity in non-space procurement (already included in the assessment). The Italian return is even more consistent in percentage terms if compared to other values. As an example, compared to the national contribution to ESA's internal costs, the Italian return is more than 60%. Furthermore, considering that most of ESA's non-space procurement with Italian companies depends on ESRIN, ESRIN's economic value to Italy in the period 2013-2016 ranges between 158 and 393 million euros (a reasonable point estimate is 356 million euros).

[10] This percentage value was considered reliable in several interviews conducted at ESRIN and ASI.

[11] This value has been obtained by reparametrizing the annual results illustrated in Box 1 to the cumulative number of visitors registered in the period 2013-2016, and by multiplying the number of ESA missions by four, missing any term of comparison to estimate more accurately the number.

It is worth noting also how, even if by directly investing in the national space economy the Italian Space Agency (ASI) were to maximise the space-related procurement, indeed the ESA non-space procurement is mostly related to Information technology, therefore is anyway scientifically relevant.

Graph 14. Italian investment and returns from ESA (Y2013-16): a focus on net flows (M€)



Source: our elaboration on ESA-p data and our estimates (2017). NW: "ESA IC" = ESA internal costs.

2.3 The direct, indirect and the induced benefits of ESRIN to Italy

In this section we present a simple model of calibration with the aim of providing an estimate of ESRIN's overall (direct, indirect and induced) economic benefits to Italy. This attempt mostly reflects a widely used approach that should provide relatively unbiased estimates with respect to the actual values, due to the narrow interval of years selected to estimate the most relevant parameters (the last four years of economic activity).

An overview of Italian investments and returns in ESA is provided in table 11. The process has been separated into several steps.

Step 1. The Italian Government endows ASI with an amount of funds equal to (1 + a) euros (call this amount "D").

Step 2. ASI spends 1 euro in ESA.

Step 3. ESA collects 1 euro from ASI and spends part of its overall budget which includes contributions from all Member States, to buy goods and services from both the Italian Space and non-space economic sector. Benefits to Italy are at least threefold[12]:

A. Italian contractors obtain on average contracts for a weighted value greater than one with respect to the ideal share of the Italian investment in the optional programmes (Italian return coefficient > 1), and ESRIN guarantees proximity advantages to the Italian companies. Furthermore, the weighted value of contracts signed by the Italian contractors is complemented by an average 30% share of the unweighted value;

B. due to proximity advantages several Italian non-space contractors obtain unweighted contracts for a consistent value;

C. the local economy benefits from an exogenous demand of goods and services approximately equal to the amount of wages of ESRIN employees, and also from a consistent demand for local touristic services, as ESRIN attracts business and non-business visitors.

BOX 2.
DIRECT, INDIRECT AND INDUCED EFFECTS

1) Direct effects: the exogenous expenditure in the space economy generates an additional production within the space economy itself, and in all those non-space sectors that produce intermediate products and services used as inputs in the production process.

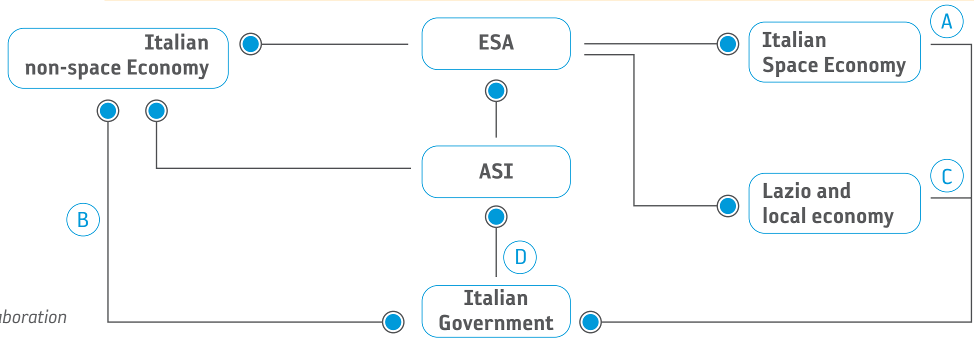
2) Indirect effects: the exogenous expenditure in the space economy also activates indirectly other non-space economic sectors, following a chain of actions and reactions that propagates the initial stimulus in all the economic sectors of activity.

3) Induced effects: the direct and indirect chains activated by the exogenous expenditure in the space economy remunerate households with labour income, generating an additional expenditure in final consumption goods, that activates an induced chain of actions and reactions, providing an additional stimulus in all sectors of economic activity.

The total added value generated in the national economy by an exogenous expenditure in the space economy can be estimated by summing the direct, indirect and induced effects, measured in terms of added value.

[12] Even if A, B and C have the same nature of the direct, indirect and induced benefits, they reflect the expected multivariate "impulses" in terms in terms of exogenous expenditure, rather than the "response" in terms of direct, indirect and induced effects. The latter can be roughly estimated by multiplying the former using "fair" multipliers derived from other researches. Results might be biased, but at least the order of magnitude of the cumulative effect should be correct. An ad hoc estimate of a multiplier for the Italian space economy in 2017 might provide unbiased estimates, but this analysis goes far beyond the scope of this research, and presents several theoretical challenges that to the best of our knowledge are still unsolved.

Table 11. A flow chart of Italian investments and returns in ESA



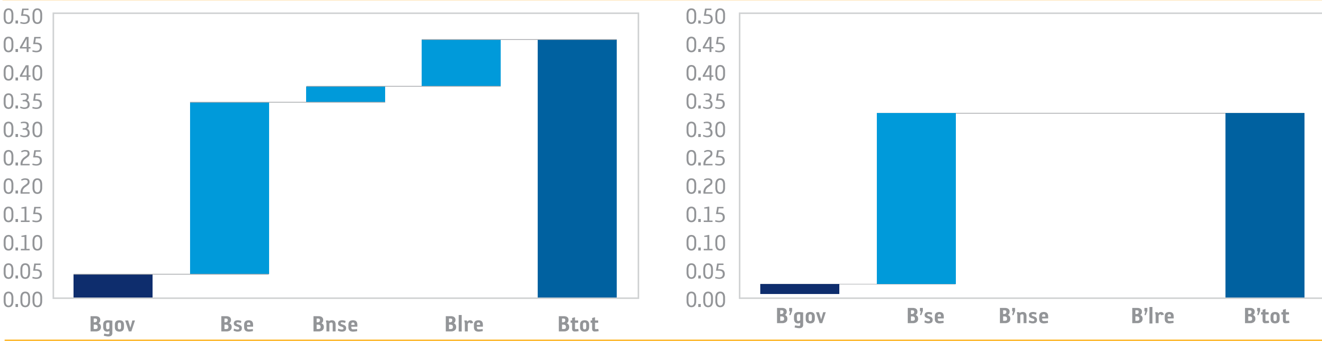
Source: our elaboration

The two figures in Graph 15 illustrate a heterogenous array of benefits, reflecting a multistakeholdership analysis rather than a macroeconomic perspective. Indeed, on the one hand the light blue bars reflect the additional "Impulse", i.e. the additional exogenous expenditure generated by investing in ESA with respect to a direct contribution to the national space economy (it is worth noting how these values are not multiplied, as they reflect the initial additional stimulus to the national economy). On the other hand, the initial dark blue bar indicates how the Italian contribution to ESA produces additional revenues also for the public sector in terms of fiscal drag over a five years horizon: it can therefore be considered as an investment rather than as a subsidy.[13]

[13] *It is worth noting how this value is obtained by multiplying the exogenous expenditure in the national economy by a spending multiplier. We have considered the level of taxation collected over the direct, indirect and induced effects of the exogenous expenditure in the space economy.*

Graph 15a therefore illustrates the net benefits that one euro of the Italian contribution to ESA generates for a heterogeneous set of stakeholders (overall, almost 0.46 euros for each euro invested). Graph 15b illustrates the same benefits in a counterfactual scenario that does not account for ESRIN-related benefits (overall, almost 0.33 euros for each euro invested).

Graph 15. Benefits to the Italian economy for one euro invested in ESA by the Italian Government:
a) current scenario **b) without ESRIN**



Source: our elaboration on ESA-p data and IPC (2017). "Bgov" = benefits for the Italian Government; "Bse" = benefits for the Italian Space economy; "Bnse" = benefits for the Italian non-space economy; "Blre" = benefits for the local and regional economy; "Btot" = Overall value to Italy. Labels with the apostrophe refer to the same in the counterfactual scenario without ESRIN.

By considering a fiscal multiplier for the Italian economy close to three (which includes direct, indirect and induced benefits), the Italian contribution to ESA provides (net) positive returns (estimated yield over a five years horizon) for the Italian government itself.[14] Furthermore, it provides a positive return (exogenous additional stimulus) for a wide array of stakeholders: the Italian space industry (0.31 euros), the Italian non-space industry (0.03 euros), the local and regional economy (0.08 euros). Under the same assumptions, in a counterfactual scenario that excludes ESRIN's value to Italy, an Italian contribution of one euro to ESA generates a return (estimated yield over a five years horizon) of almost 0.02 euros for the Italian public sector (government) and 0.31 euros of return (exogenous additional stimulus) for the Italian space industry.

[14] *We consider a cautious annual value of 0.04 euros for each euro spent. Without discounting uncertainty, this value is instead close to 0.20 euros for each euro invested.*

If we extend our benefit analysis to the whole economy, i.e. if we consider the "response" (the sum of the direct, indirect and induced effects) rather than the "additional impulse" (the additional multivariate exogenous stimulus) we are finally able to obtain a rough estimate of the added value generated by the Italian Government when investing in ESA for all economic sectors of activities and consumers. Specifically, by considering:

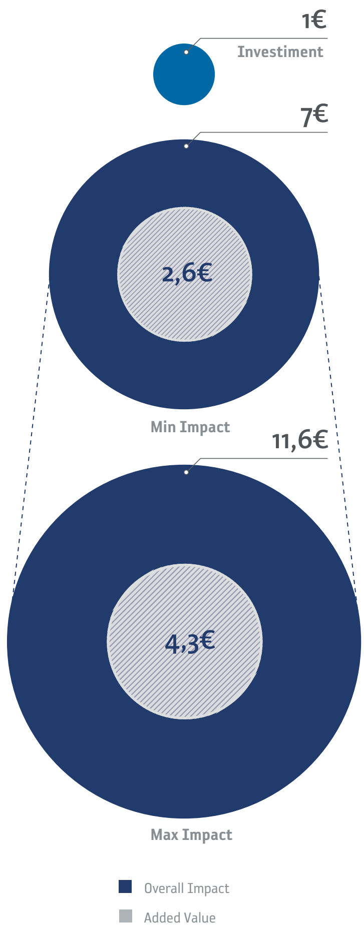
- a gross benefit of 1.42 euros (the euro invested plus the additional 0.42 euros of exogenous expenditure collected, i.e. the sum of the light blue bars second in graph 15a) over each euro invested by the Italian Government in ESA and
- a fiscal multiplier ranging from 1.8 (direct plus indirect benefits) to 3.0 (direct, indirect plus an average estimate of the induced benefits) euros (a recent research by ANCE has estimated similar values for the manufacturing sector and for the Italian economy using 2011 data)

we can safely assume that Italy obtains an added value ranging from 2.6 to 4.3 over a five years horizon for each euro of Italian contribution to ESA. Furthermore, if we consider the value of 2.7 as the ratio between the value added multiplier and the sales multiplier adopted by ESA for the launchers sector in 2016, we obtain a sales multiplier for the Italian contribution to ESA in the whole economy ranging from 7.0 to 11.6 euros. Finally consider that, as shown in the third section, there is an added contribution given by the wide array of non-monetary societal benefits.

over a five year horizon, for each euro of Italian contribution to ESA we estimate an overall impact on the whole Italian economy ranging from 7.0 to 11.6 euros

In brief, this calibration model illustrates how investing in ESA guarantees considerable economic benefits to Italian industry and to the Italian government itself: a win-win game. Moreover, allows Italy to maximize proximity advantages and guarantees additional economic benefits to the Italian public sector (in terms of estimated yields over a five-year period) and to the local and regional economy (in terms of an exogenous additional stimulus).

This confirms that by involving ESA partners in space activities of national interest, Italy raises the financial resilience of its investments by catalysing additional financial resources to cover costs, and gains the opportunity to participate in a wide range of other initiatives that might prove profitable for the Italian Space economy and more in general for the country itself in terms of innovative spin-offs.



3. The relational and scientific value of ESRIN to Italy

In the previous section we have illustrated how ESRIN generates consistent additional benefits to Italy with respect to the national contribution to ESA. This makes it clear that ESA provides a profitable way of investing in space to the Italian Government, which generates consistent benefits for the national space economy and for the regional and local economy in which ESRIN is located (the Lazio Region and the Municipality of Frascati).

It is now important to complete the assessment of ESRIN's value to Italy with more qualitative issues. This will illustrate better 'why' Italy should invest in ESA in terms of the scientific and relational spin-offs achieved, and the additional scientific value obtained by hosting ESRIN.

In the first first sub-section below it emerges how the Italian endeavours in Earth Sciences and Earth Observation are consistent, especially in land management and hazard monitoring applications, where Italy is one of the leading countries worldwide. The main users of ESA EO data at the national level are mostly public institutions, and the consistent involvement of the Italian public sector as a user of EO data constitutes an Italian primacy worldwide. Therefore, it is reasonable to expect that the Italian Government will obtain consistent benefits from the implementation of Copernicus, as the latter is a game changer in most Earth Observation activities due to the exponential growth of the data it produced. Italy obtains consistent benefits in terms of research and educational activities related to the launcher sector, and the consistent involvement of local universities in the programme is not a mere coincidence. The VEGA IPT generates innovative spin-offs to the Italian industry in terms of new technological achievements that can be used in other sectors of economic activity.

ESRIN is deeply rooted in the local context, and is currently involved in a technological and institutional revolution that is shifting most local research institutions toward the new Science 2.0 paradigm

In the second sub-section below we provide a brief description of the wide array of public and private institutions that obtain benefits from the Italian contribution to ESA, in terms of procurement, technological transfer, research achievements, etc. Indeed, several Italian institutions benefit from the ESA free and open data policy in EO and are involved in the operations of the most important ESA and EU programmes. The same is true for the many Italian companies (both large enterprises and SMEs) involved in the programmes hosted in ESRIN (EO and launchers) and in several other ESA programmes in terms of industrial commitments. The Italian participation in ESA is of the utmost importance at industrial level because it connects Italian space endeavours with those of the other ESA Member States, generating mutual benefits and fostering the competitiveness of Italian industry in an international environment without losing the proximity advantages achieved by hosting an ESA establishment.

Specifically, the Memorandum of Understanding signed in 2008 between ESA and the Italian Government (the so-called "Mussi Agreement") attests to the will of both partners to maximize the economic incentives of the Italian participation in ESA by deepening the existing collaborations and by tying ESRIN's future development to the Italian contribution to ESA.

Finally, in the third sub-section we provide a brief overview of the actors that are involved at local and regional level in space-related activities, and that are involved in the nexus of agreements signed by ESRIN with local partners. We show how ESRIN is deeply rooted in the local context, and how it is currently involved in a technological and institutional revolution that is shifting most local research institutions toward the new Science 2.0 paradigm. As happened in the first decade of the new millennium, ESRIN can again play a leading role in this process, facilitating the transition and confirming it as a major driver of change and of internationalization for the locality.

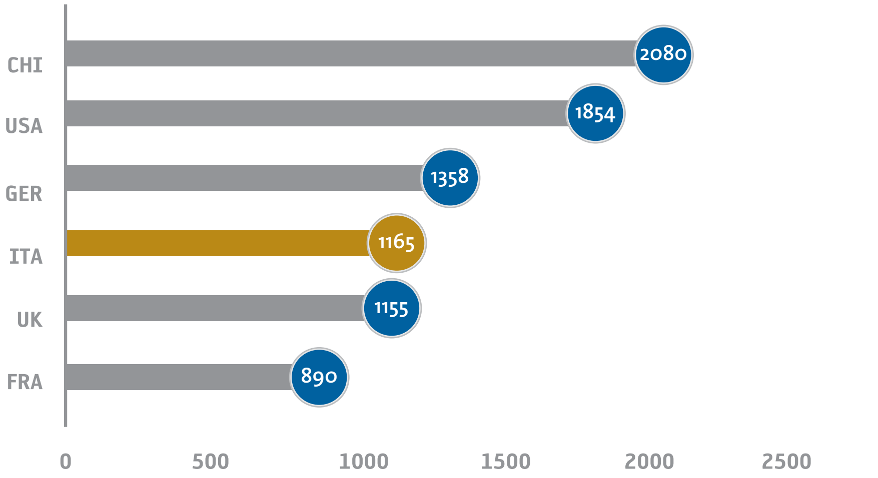
3.1 ESRIN in its global context: scientific achievements in EO and launchers

An overview of ESRIN's value to Italy must consider the relevant impact in terms of scientific and technological achievements obtained by the Italian public and private research institutions due to their cooperation with ESA, at least in part due to ESRIN's proximity. Being very to disentangle the technological and scientific benefits that Italy might have achieved by participating in ESA independently from the existence of ESRIN from those obtained due to ESRIN's proximity, we restrict our focus to the ESA programmes hosted in ESRIN (EOP and VEGA) and we try to identify those topics in which data indicate a more consistent Italian presence or contribution.

Scientific and technological achievements in EO

Since the beginning of ESA's activities, almost 16,900 Principal Investigators (PIs) were involved in research using ESA-EO data. Graph 16 shows how Italy, with 1,165 projects activated as of November 2017, is the fourth country worldwide by number of PIs registered in the EOPI Portal.

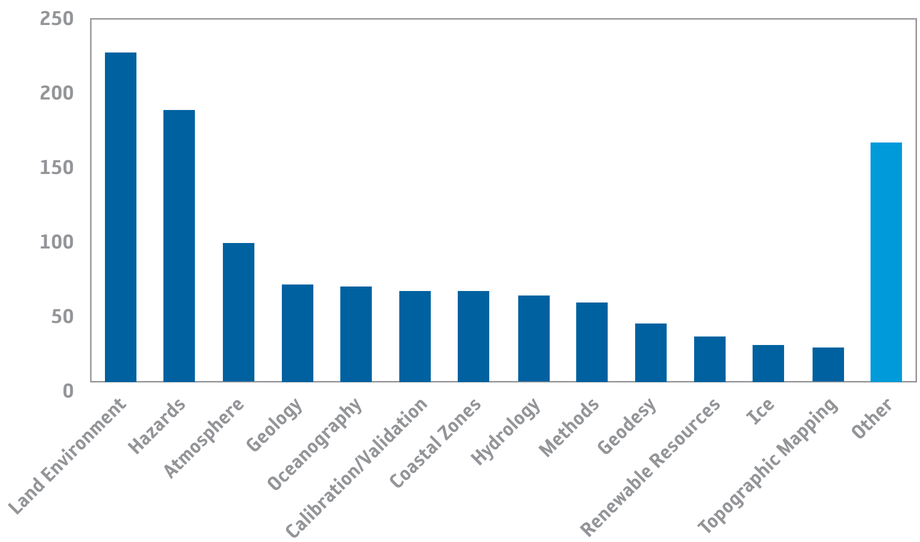
Graph 16. Number of PIs for selected countries registered in the EOPI Portal



Source: our elaboration on EOPI Portal data (2017).

As illustrated in Graph 17, the 1,165 Italian EO research projects registered in the EOPI Portal mostly concern land environment (227) and hazards (187), but the Italian involvement in the research on the Earth's Systems is consistent also in several other fields of applications, as atmosphere (95), geology (67), oceanography (65), calibration and validation activities (63), coastal zones (62), hydrology (60), methods of analysis (55), geodesy (40), renewable resources (32), ice (25), topographic mapping (23).

Graph 17. Number of Italian PIs by application domain



Source: our elaboration on EOPI Portal data (2017).

In terms of PIs, the Italian research effort in land environment and hazards is comparable to other major countries' international Earth's Systems research (see table 11). Furthermore, the Italian research activities dedicated to Earth Systems exhibit a high degree of variety. It is worth mentioning how, even if in most fields the countries with the highest number of PIs are China and USA, by aggregating Germany, Italy, UK and France, the EU is the most active in Earth Systems research. Indeed, the number of EU PIs exceeds those of China and the USA combined.

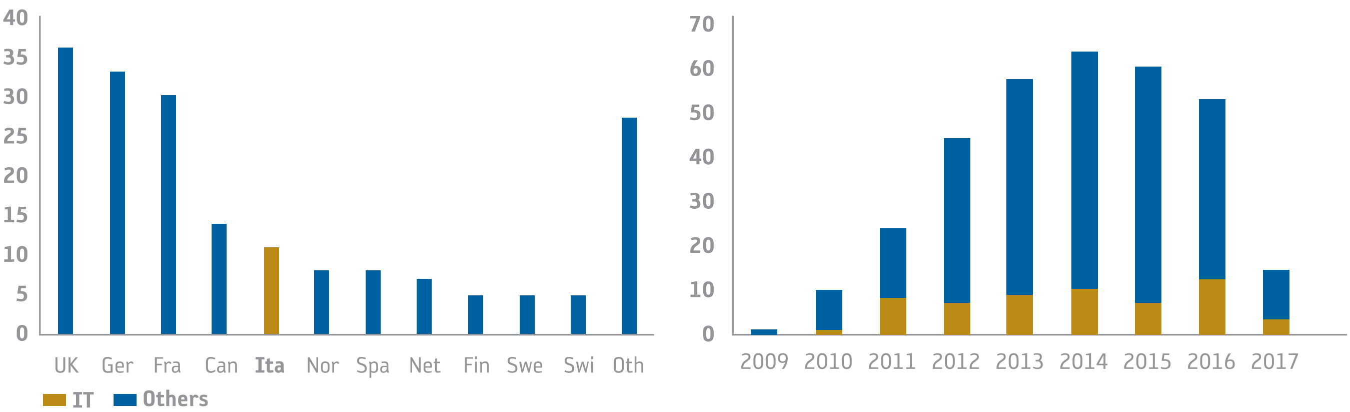
Table 11. An overview of PI's activities for Application and country (number of PIs)

Application/ Country	CHI	USA	GER	ITA	UK	FRA	TOT
Atmosphere	209	182	147	95	84	58	775
Calibration/ Validation	42	117	87	63	85	88	482
Coastal Zones	77	96	61	62	57	49	402
Geodesy	202	97	109	40	53	28	529
Geology	142	132	55	67	74	62	532
Hazards	218	157	92	187	90	91	835
Hydrology	153	205	109	60	59	62	648
Ice	65	109	60	25	96	26	381
Land Environment	376	244	263	227	221	125	1,456
Methods	106	48	74	55	30	54	367
Oceanography	246	216	71	65	95	106	799
Renewable Resources	23	31	43	32	45	22	196
Sea-Ice	41	58	39	14	41	8	201
Topographic Mapping	55	34	36	23	28	23	199
Other	125	128	112	150	97	87	699
Total	**2,080**	**1,854**	**1,358**	**1,165**	**1,155**	**889**	**8,501**

Source: Our elaboration on EOPI portal data (2017).

Graph 18 illustrates the number of project partners involved in the Support to Science Element (STSE). Even if the most active countries are UK (36), Germany (34) and France (30), Italy ranks fifth with 11 project partners. It means that ESRIN's value to Italy in terms of scientific support in EO researches has always been relevant, and Italian researchers authored almost 21% of more than 300 STSE publications.

Graph 18. STSE: project partners by country (number) and publications by Year (number)

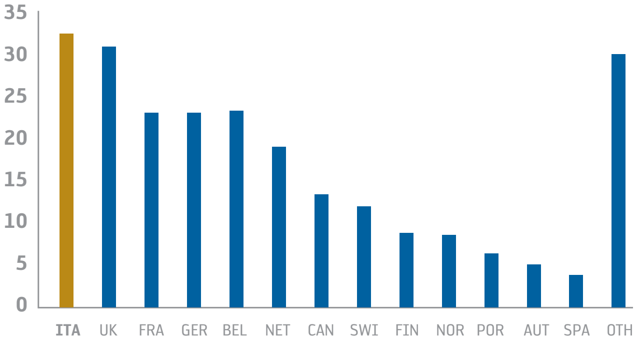


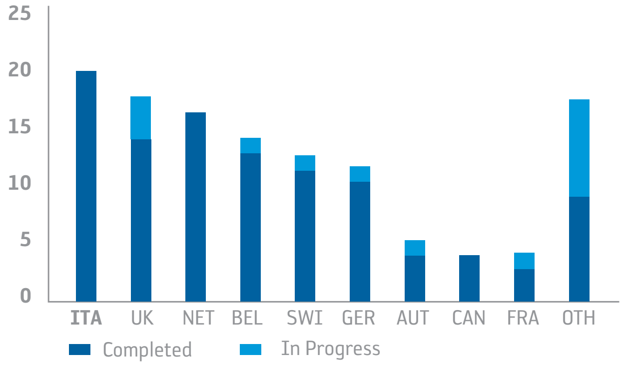
Source: our elaboration on STSE data (2017).

Graph 19 illustrates how in the Data User Element (DUE)[15] Italy ranks first both in the number of involved companies (32) and in the number of projects (20). Only the UK exhibits similar results in terms of involved companies (31), while a group of five countries has achieved similar results in terms of projects.

[15] The DUE is a programmatic component of the Earth Observation Envelope Programme and its mission is to favour the establishment of a long-term relationship between the User communities and Earth Observation

Graph 19. Data User Element: Number of companies and projects (concluded and in progress) by country

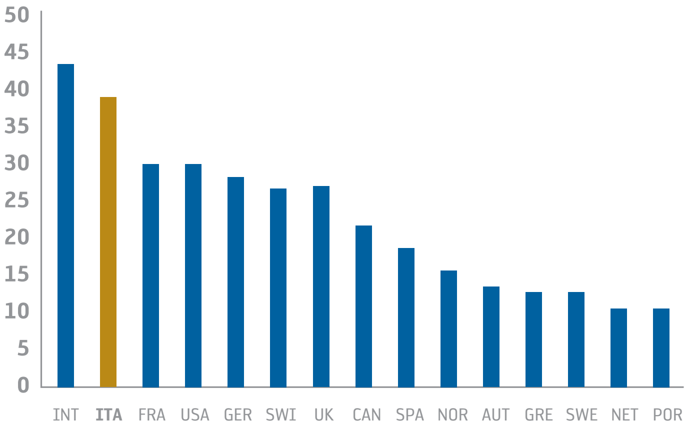


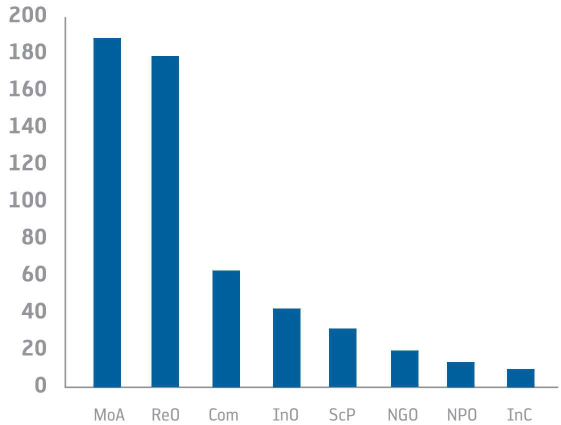


Source: our elaboration on DUE data (2017).

Graph 20 illustrates how, in terms of users registered in the DUE, Italy ranks second (39 users) immediately after the international organizations (43 users), and before a group of five countries. The DUE users (522 organizations) are mostly ministries and agencies (185) and research organizations (174). Italy is the country that hosts the highest number of ministries and agencies registered in the DUE (26 out of 185).

Graph 20. Number of Users by country and Type of organization





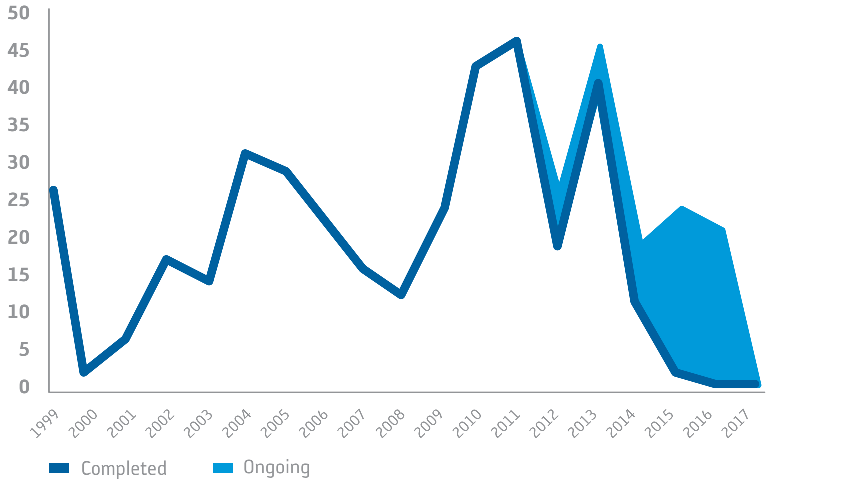
Source: our elaborations on DUE data (2017). NW: "MoA" Ministries and Agencies, "ReO" Research Organization, "Com" = Companies, "InO" = International Organization, "ScP" = Scientific Programmes, "NGO" = Non Governmental Organizations, "NPO" = Non-profit Organizations, "InC" = International Conventions.

Finally, within the Value Adding Element (VAE, also known as Earth Observation Market Development, EOMD) 117 projects have been activated since the beginning of the activities, most of them in 2009, 2011 and 2014. The Italian companies participating in the VAE are Carlo Gavazzi Space, FlyBy s.r.l., Geo-K s.r.l., Planetek s.r.l. and e-Geos.

A focus on Copernicus' applications and users

Copernicus provides a unified system through which vast amounts of data are fed into a range of information services designed to benefit the environment, satisfy humanitarian needs and support effective policy-making for a more sustainable future. As illustrated in Graph 21, since 1999 more than 425 applications have used Copernicus (and previously GMES) data, and 56 out of them are still ongoing. Copernicus applications span several fields of activity: land, marine environment, atmosphere, emergency management, climate change, pirated ships tracked by satellite, Earth topography and economic growth. Since 2005 (i.e. over 326 applications), the Italian public agencies, research institutions, universities and companies have been involved in 52% of projects. Furthermore, they are involved in 54% of the ongoing applications.

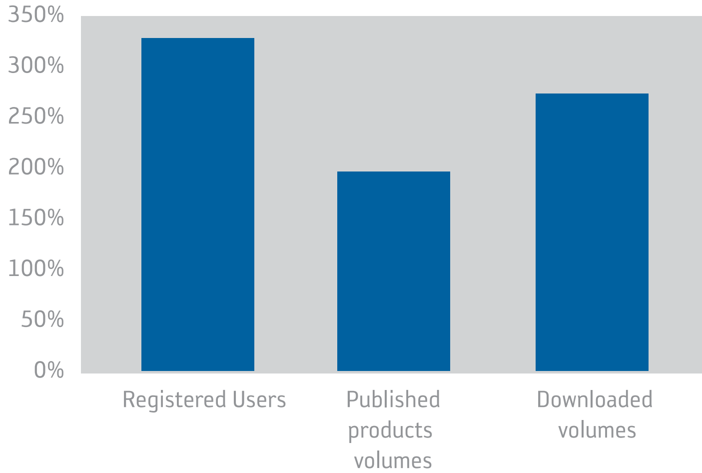
Graph 21. Number of Copernicus Applications by starting date



Source: our elaboration on STSE data (2017).

Graph 22 illustrates how, between 2015 and 2016, Copernicus statistics highlighted several important records: +320% registered users, +192% Published Product volumes, +268% downloaded volumes.

Graph 22. Copernicus users, publications and downloads (% growth rate 2015/2016)

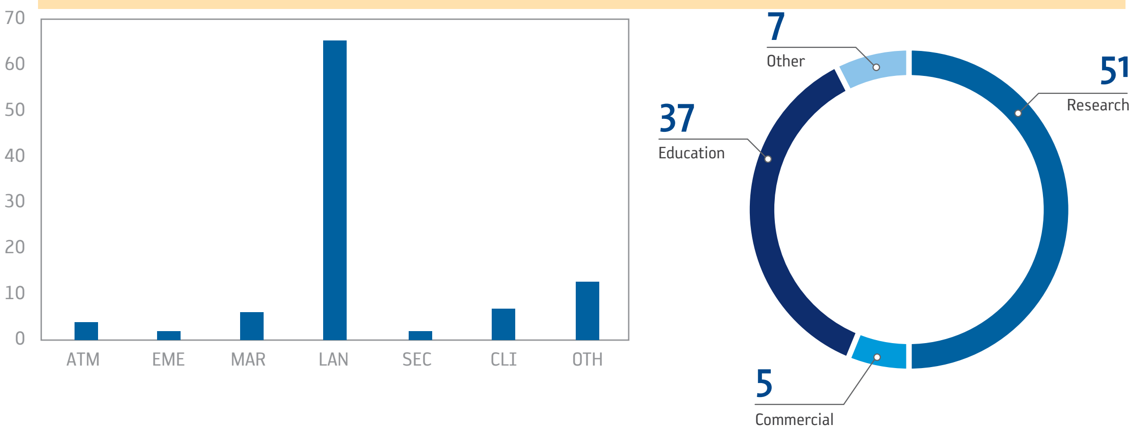


Source: SERCO, 2017, v.1.2

Graph 23 provides an overview of Copernicus Open Access Hub users. Almost two-thirds of them are interested in Copernicus Land Management (CLMS) products, especially for research (51%) and education (37%) purposes.

Graph 23. Copernicus Open Access Hub: users by

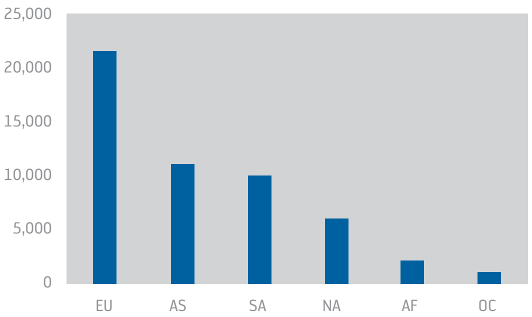
a) declared thematic domain **b) usage type (%, Y2016)**

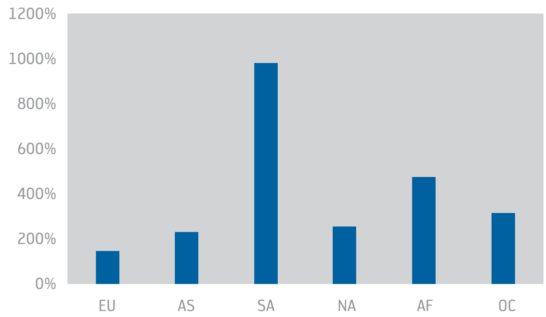


Source: SERCO, 2017, v.1.2. NW: "ATM" = Atmosphere, "EME" = Emergency, "MAR" = Marine, "LAN" = Land, "SEC" = Security, "CLI" = Climate Change, "OTH" = Other.

Graph 24 shows that in terms of geographical distribution, Copernicus users are mostly concentrated in Europe (21,476), Asia (10,948) and South America (10,021), especially in Brazil. Since 2015, the number of users grew mostly in South America (almost 10 times) and Africa (almost 5 times).

Graph 24. Registered users: Frequency and growth rate (%) 2015/16 by continent.

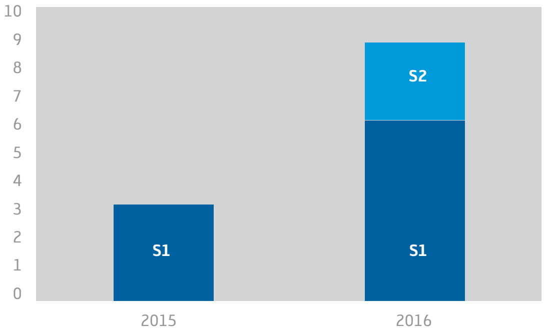


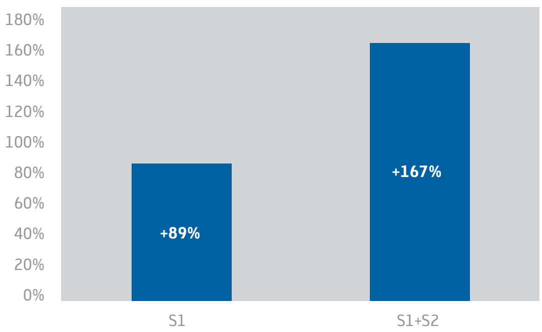


Source: SERCO, 2017, v.1.2. NW: "EU" = European Union, "AS" = Asia, "SA" = South America, "NA" = North America, "AF" = Africa, "OC" = Oceania.

Graph 25 illustrates how the volume of products downloaded since the start of the operations grew between 2015 and 2016 both due to the increase in the Sentinel 1 (S1) downloaded products and to the additional download of Sentinel 2 (S2) products. Indeed, S1 products download grew by almost 90%, while the overall growth in products download was of 167%.

Graph 25. Volume (PiB) and annual growth (%) of products downloaded by year and mission





Source: SERCO, 2017, v.1.2. NW: PiB = Pebibytes, i.e. 1 Pebibite = 250 bytes, almost 1.13 Petabytes (PB).

Finally, Copernicus has four access hubs: the Open access, the Collaborative, the International and Copernicus Services. The Open access hub is by far the most used Copernicus Hub and serves as intermediary for more than two-thirds of Copernicus products. Since the beginning of operations, Copernicus has served more than 100,000 registered users, with more than 36 petabytes of data downloaded.

Table 12 provides an overview of Copernicus users and downloads. These figures cover the period 1 July 2016 - 1 June 2017, and apply only to use of the Copernicus Open Access Hub. They show how the total number of Italian registered users during the period 1 July 2016 - 1 June 2017 has been 1,581. However, the number of 'active users', i.e. users who made one or more download during the same period for either Sentinel 1 or Sentinel 2, is significantly lower (737 for S1 and 821 for S2).

Table 12. Copernicus users (registered and active) and download (TiB) for Italy (July 2016/2017)

		number	volume	Europe (rank for) number	Europe (rank for) volume	World (rank for) number	World (rank for) volume
Registered Users		1,581		3		7	
Active Users	S1	737		3		5	
	S2	821		2		3	
Downloads	S1	404,059	669,03	6	6	8	7
	S2	639,047	438,02	6	6	8	8

Source: our elaboration on CSC- QIR (2017).

Table 13 illustrates the top five EU countries for registrations and user downloads per Sentinel in Q1 2017. Bold text means that the country occupies a new place in the ranking. It is worth noting how Italy in Q4 2016 was the 2nd European country for S1 downloads.

Table 13. Top 5 European Countries for registrations and user downloads per Sentinel in Q1 2017

Registrations since start			Downloads S1		Downloads S2		Downloads S3	
Country	n.	2016Q4 Change	Country	TiB	Country	TiB	Country	TiB
DE	5,666	33%	NE	134,86	SL	372,85	UK	32
UK	4,184	29%	**UK**	110,64	FR	327,41	FR	27
ITA	2,966	17%	FR	109,52	**UK**	162,60	AU	23
FR	2,266	29%	**IT**	78,37	**DE**	131,67	IT	23
ES	2,182	32%	**DE**	58,71	**AU**	94,50	DE	20

Source: our elaboration on CSC-QIR data (2017).

Finally, Table 14 indicates the total number of active users per Sentinel 1 and Sentinel 2 in 2016. As of 30 November 2016, Italy was the 2nd highest ranking country worldwide for both Sentinel 1 and Sentinel 2 active users during the year.

Table 14. Number of Active Users (AU) per Sentinel 1 and 2 in 2016 compared to registered users (%)

Sentinel 1			Sentinel 2		
Country	AU	%	Country	AU	%
DEU	834	21%	DEU	770	19%
ITA	**642**	**26%**	**ITA**	**455**	**18%**
UK	621	20%	USA	411	12%
USA	621	19%	UK	387	12%
CHI	533	18%	ESP	341	22%
BRA	427	9%	FRA	267	15%
FRA	393	23%	BRA	260	5%
ESP	301	19%	NET	206	20%
CAN	293	26%	POL	186	16%
RUS	283	32%	MEX	155	12%

Source: our elaboration on CSC-QIR data (2017).

Technological achievements in the launchers sector

The VEGA IPT has activated important connections with universities and research institutions. As illustrated in table 15, this includes a now long-standing collaboration with the University of Rome La Sapienza that involved also the Italian National Research Centre (CNR) during the period 2014-2015. Another Italian research institution involved in VEGA IPT activities has been the Italian Consortium of Aerospace Research (CIRA). This collaboration lasted from 2010 to 2012 and from 2016 to now. Furthermore, the VEGA IPT activated a collaboration with the Office National d'Etudes et de Recherches Aérospatiales (ONERA) from 2006 to 2011, with the Netherland Organization for Applied Scientific Research (TNO) from 2006 to 2010, with the Industrieanlagen-Betriebsgesellschaft mbH (IABG) in the same period, and with the Spanish National Institute for Aerospace Technology (INTA) from 2015 to 2016.

Table 15. Main collaborations of VEGA Programme with universities and research centres

Y/Country	IT	IT	FR	DE	NE	ES
2005	University of Rome La Sapienza					
2006	University of Rome La Sapienza		ONERA	IABG	TNO	
2007	University of Rome La Sapienza		ONERA	IABG	TNO	
2008	University of Rome La Sapienza		ONERA	IABG	TNO	
2009	University of Rome La Sapienza		ONERA	IABG	TNO	
2010	University of Rome La Sapienza	CIRA	ONERA	IABG	TNO	
2011	University of Rome La Sapienza	CIRA				
2012		CIRA				
2013						
2014	La Sapienza CNR					
2015	La Sapienza CNR					INTA
2016		CIRA				INTA
2017	La Sapienza	CIRA				

Source: VEGA IPT (2017).

Table 16 illustrates the most innovative industrial spinoffs of the VEGA Programme. The carbon material for throat insert is currently used in the construction of nuclear power plant, aircraft and road vehicles. Secondly, the adhesives for high-performance boarding are currently used in the automotive sector, while the pre-impregnated carbon fiber reinforced polymer (prepreg CFRP) is currently used in the production of tennis rackets, golf-clubs and fishing roads.

Table 16. Main industrial spinoffs of the VEGA Programme

Technology	Sector	Spin off
Carbon/Carbon materials for throat insert	Nuclear power plant	Reactor material for neutron moderator
	Aircraft	Discs for high performance brake systems
	Automotive	Discs for high performance brake systems
Adhesives for high performance bonding	Automotive	Secondary structures and interiors
Prepreg CFRP	Sports and goods	Tennis rackets, golf-clubs, fishing roads

Source: VEGA IPT (2017).

3.2 ESRIN and the Italian Space Economy

The public Space centres in Italy

Italy has an excellent record in space research: it was the third country after the USSR and the USA to launch and operate a satellite (San Marco 1 in 1964), it is one of the ESA Founding Members and currently is the third major ESA contributor. As a consequence, Italy currently owns a consistent heritage made of several institutes and infrastructures, most of them already active.

The **'Piero Fanti' Space Centre** is located at Fucino (Abruzzo). Established in 1963, it is actively involved in satellite operations, in the provision of telecommunications, television and multimedia services. Specifically, it hosts the **Galileo Control Centre (GCC)**, an infrastructure that manages satellite navigation and the quality of services supplied to the end users.

The **ASI Centre of Space Geodesy** is located in Matera. It was inaugurated in 1983 as a joint effort between CNR, the Basilicata Region and NASA. Currently, it is one of the main research and technological transfer institutions in Southern Italy. Matera hosts the **ASI Space Centre for Earth Observation**, which has been active since 1994 in the field of acquisition, elaboration, archiving, and dissemination of EO data. Specifically, the centre is involved in the acquisition and processing for civil purposes of Cosmo SkyMed data, and it is part of the Copernicus Core Ground Segment.

The **Italian Aerospace Research Centre (CIRA)**, with headquarters and operational structures in Capua (Campania), was created in 1984 for the purpose of performing research in the fields of space and aeronautics. Thirty years since its set up, CIRA now has the biggest research facilities in the field of aerospace in Italy, testing facilities that are unique in the world, and state-of-the-art laboratories that are all used by industries around the world.

The **'Luigi Broglio' ASI Space Centre** is located at Malindi (Kenya). It has a fundamental role in Italian space history, and is now active in satellite tracking for several agencies (ASI, NASA, ESA and the Chinese Space Agency). The Centre is managed by the University of Rome 'La Sapienza' through the **Research Centre of the San Marco Project (CRSPM)**.

Beside the national centres, Italy also hosts the European Commission **Joint Research Centre (JRC)** at Ispra (Varese), which has been historically active in the development of environmental monitoring applications based on satellite data.

Finally, Italy hosts several activities related to the most important research institutions in Environmental Sciences (European Facility and Airborne Research, Euro-Argo, Eurofleets, Joint European Research Infrastructure Network for Coastal Observatories, Integrated Carbon Observation System, Lifewatch, the Long Term Ecological Research Network, Svalbard Integrated Arctic Earth Observing System) and coordinates three of them (European Research Infrastructure for the observation of Aerosol, Clouds and Trace gases, European Plate Observing System, European Multidisciplinary Seafloor and water column Observatory).

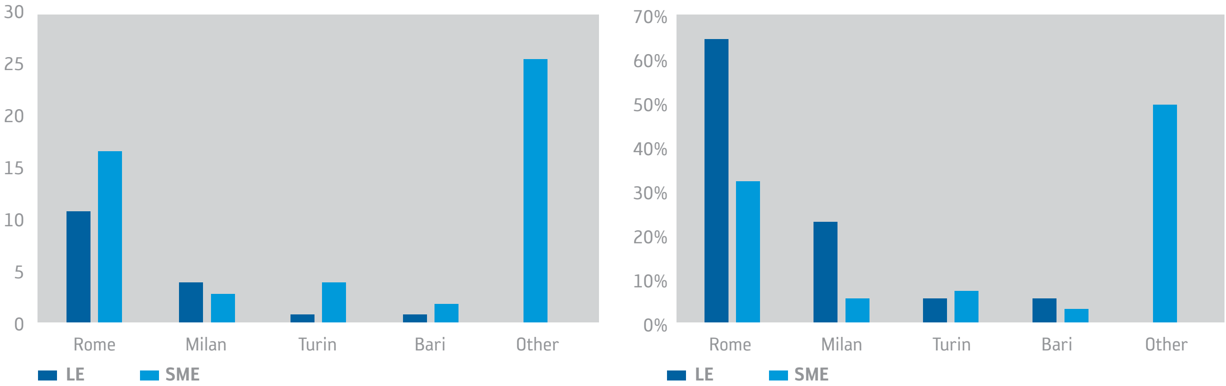
Italian Space Industry

In terms of scientific design, Italy is one of the few countries worldwide to have a complete space supply chain, made of several applications for civil and defence purposes, an important international presence both at technical and scientific level (i.e. in remote sensing), and a successful interaction among theoretical research, applied research and commercialization.

Concerning the private sector, the National Catalogue of the Italian Space Industry (ASI-ICE, 2017) lists 17 large enterprises and 59 SMEs involved in the national Space Economy. The Province of Rome hosts the headquarters of 37% of the Italian companies operating in the space sector (11 large enterprises and 17 SMEs). Moreover, more than 60% of space companies are located in four provinces: Rome, Milan, Turin and and Bari. Although there is no way of evaluating proximity advantages, there is evidence that the enterprises are concentrated near ASI headquarters, major centres and other Italian space centres. We interpret this as proof of proximity advantages, both for the Large Enterprises (LE), and for the Small and Medium Enterprises (SME) for which proximity represents an enabling factor for internationalization in the space sector.

Source: ASI-ICE, 2017, "National catalogue of the Italian space industry".

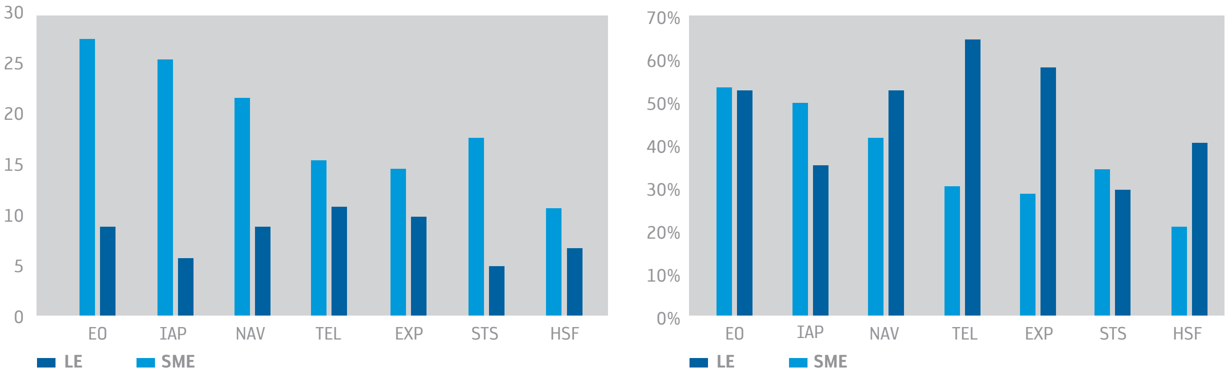
Graph 26. Absolute (left) and percentage (right) frequency distribution of the Italian space enterprises by province (2017)



Concerning applications, Graph 27 illustrates how, while large companies are more focused on telecommunication systems, space science and robotic exploration, satellite navigation systems and Earth Observation, SMEs are more focused on Earth Observation, Integrated applications and services, security and satellite navigation systems. Furthermore, large enterprises are on average involved in more application domains than SMEs.

Source: our elaboration on ICE-ASI Industry Catalogue (2017). NW: "EO" = Earth Observation; "IAP" = Integrated applications and services, security; "NAV" = satellite navigation systems, "TEL" = Telecommunication systems, "EXP" = space science and robotic exploration, "STS" = Space Transportation, Launch and Re-entry Systems, "HSF" = Human exploration, space station capsule manned.

Graph 27. Italian Space economy: share of Large Enterprises and SMEs involved in EO and launchers.



The ESA-Italian Government MoU of 2008

In 2008, ESA signed with the Italian Government, represented by The Ministry of Education, Universities and Research (MIUR), a Memorandum of Understanding (MoU) for the reinforcement of the role of ESRIN. The two Parties shared the common understanding that the role of ESRIN had to be reinforced so as to be commensurate with the Italian investment in ESA. A joint ESA-Italy working group was set up to elaborate a plan for this reinforcement.

Taking into account the results of this implementation plan, ESA and the Italian Government confirmed their willingness to assign ESRIN new additional activities, and to establish new roles and reinforce the present ones in the fields of Earth Observation, Integrated Applications (IAP and SSA), Launchers, Exploration and other areas (Information Technology, ESA Financial Reform, ESA incubators).

It was foreseen that the outcomes identified in the Implementation Plan had to be achieved gradually and according to Italy's participation in the already mentioned ESA programmes. Table 17 briefly summarizes the major ESRIN achievements in terms of site extension and their cost of implementation and maintenance.

Table 17. ESRIN MoU agreement on site extension

Activity	Description	Cost (M€)	Funding	Mant. (k€)
New land	Procurement of approximately 30.000 m^2 of additional land adjacent to ESRIN.	1.0	ASI	90
New entrance, Canteen	Redesign of the main entrance (Building 9). Expansion of canteen to reach 800 meals/day	4.8	ESA	120
Power plant upgrade	Increase of 500 KW, including generation, distribution and emergency	1.1	ESA	100
New building	New 2500 m^2 of covered office space/computer rooms	7.0	ASI	500
Conference Centre	Refurbishment of two big halls near Building 14 for a total of 1700 m^2	3.5	ASI	200
Social facilities	New building of 200 m^2 to separate Childcare from current social facilities	0.7	ESA	50
Exploration Institute	Construction of 2500 m^2 of laboratories and offices.	7.0	ASI	300
Total cost		**25.1**		**1,360**

Source: our elaboration on Annexes to MoU 2008.

ESA and the Italian Government also recognized that the reinforcement of ESRIN had to include bringing the existing Human Resources Service up to the same level as other ESA sites. It would also need the secondment of personnel from ASI (or other Italian research institutions) to ESRIN.

3.3 ESRIN and the regional context: towards a scientific and technological district

Far from being 'only' a scientific centre of national and international relevance, ESRIN is also deeply rooted in the local and regional context, where it has a leading role in terms of technological transfer and innovation.

As a follow-up of the Memorandum of Understanding (MoU) signed in 2008 with the Italian Government, ESRIN has signed several agreements with local institutions of national scientific and economic relevance, developing a consistent portfolio of relations in support of local development.

Firstly, ESRIN cooperates with ASI in the implementation of the ASI Space Data Centre, now Space Science Data Centre. Secondly, ESA has signed an agreement with BIC Lazio to found an ESA BIC Incubator (EBI) to provide business start-up support as well as technical expertise to space-related economic initiatives. Thirdly, ESRIN has signed an agreement with the Lazio Region and MIUR to implement the MEGALAB Project for high-speed interconnectivity between several neighbouring research centres (ESA-ESRIN, CNR, ENEA, INFN), the University of Tor Vergata, the Tiburtino Space Technology District and the Lazio Region itself. In particular, ESRIN cooperates with several Italian National Research Institutes CNR, INFN and ENEA, in sharing networks and computing GRID infrastructure on several projects of scientific interest. Fourthly, as regards research, education and training, ESRIN has a framework agreement with Tor Vergata University and has a close cooperation with other Italian universities on training and projects (Sapienza University of Rome, Politecnico of Milan, Venice University, etc.). Fifthly, ESRIN has signed two agreements with the Municipality of Frascati to participate in Bacchus, an experiment related to emerging technologies for wine management, and Frascati Living Lab. Both initiatives are now merging to become Lazio Pulse, a Frascati Scienza initiative.

ESRIN's local agreements during the first years of the new millennium

The ESA-ASI Agreement for the Science Data Centre

The ASI Science Data Centre (ASDC) was a multi-mission, multi-disciplinary, science operation centre, data processing and data archiving facility, built on the experience acquired within ASI with the management of the BeppoSAX Science Data Centre. It is located at ESRIN, and it has been in constant evolution since its establishment in November 2000. The ASDC has major responsibilities for three operational high-energy astronomy satellites (Swift, AGILE and Fermi) and supported a number of Italian experiments aboard solar system exploration satellites (e.g. SHARAD, MARSIS, etc.).

In more than 15 years of activity, the ASDC has contributed to i) the long-term preservation of valuable scientific space data, ii) the re-utilization of past experience and infrastructure and therefore the achievement of consistent cost savings, iii) the provision of support to the scientific community, and iv) the integration of data from different experiments.

The Multi Mission Interactive Archive

The ASDC's MMIA is a web-based high-energy astrophysics archive and advanced database system that provides access to extensive multi-wavelength information. Through the MMIA System, archival data from the missions AGILE, Swift, BeppoSAX, Chandra, ROSAT, ASCA, Einstein and EXOSAT can be easily retrieved. The data can be analyzed on-line in a preliminary way via various exploitation platforms developed by ASDC.

The Multi-frequency Data Explorer

The ASDC's Multi-frequency Data Explorer is a web-based tool designed to visualize and analyse the data stored in the Multi-Mission Interactive Archive. It allows fast visualization of a portion of sky centred on a specific source in all energy bands, and the cross-matching between archival catalogues. It also points to external services for more extended searches and to internal tools to perform a more detailed analysis.

High-energy astrophysics missions data

In addition to the archives of the Swift, Fermi and AGILE missions, the ASDC hosts data from other high energy astrophysics missions. At ASDC there is the official archive of the BeppoSAX satellite and data from several other international missions obtained by the ASDC under a data exchange agreement between ASI and other institutions. Moreover, the ASDC hosts an official mirror of the Chandra archive.

ASDC Information and Communication Technology (ICT)

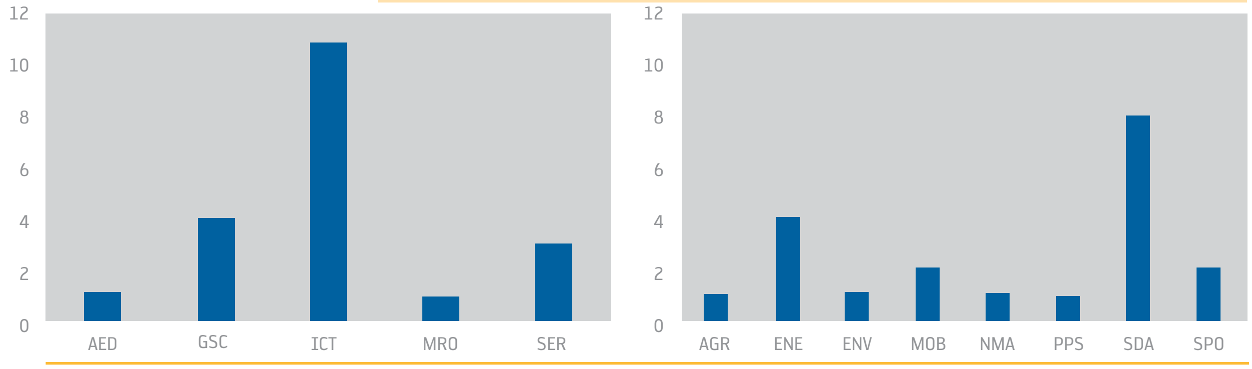
All the informatics needs of the ASDC are achieved through a modern Information Communication Technology (ICT) system specifically developed for a dynamical environment where rapidly changing scientific requirements must be met by stable engineering solutions.

The Technology Transfer Programme Office (TTPO) and ESA BIC Lazio

The Italian ESA Business Incubation Centre was founded in 2005 and is managed by the Italian company BIC Lazio SpA. ESA BIC Lazio is located at the business incubator ITech in Rome, and offers business start-up support. It also offers technical expertise, particularly in the areas of systems and software infrastructures for data handling, and integrated Earth Observation, satellite navigation and communication applications. It also provides the 'incubates' with a chance to take advantage of the expertise located in ESRIN in the field of EO, launchers, IT and Telecommunications.

Currently, ESA BIC Lazio is managing 20 incubates, operating in several economic sectors and exploiting different technologies. Specifically, eleven of them are active in the 'ICT' sector, four in the 'green economy and smart cities', three in 'services', one in 'aerospace and defence', and one in 'mechanics and robotics'. Concerning technologies, most of projects are focused on 'satellite data exploitation' (eight) and 'energy efficiency' (four).

Graph 28. Number of ESA BIC Lazio spin offs by sector and technology



Source: our elaboration on ESA BIC Lazio data (2017). NW: "AED" = Aerospace and Defence, "GSC" = Green Economy and Smart Cities, "ICT" = Information and Communication Technologies, "MRO" = Mechanics and Robotics, "SER" = Services. "AGR" = Agrifood, "ENE" = Energetic Efficiency, "ENV" = Environment, "MOB" = Mobility, "NMA" = New Materials, "PPS" = Private & Public Sector, "SDA" = Satellite Data Using, "SPO" = Sport.

The ESA-CNR agreement and the ESRIN GRID Infrastructure

In 2004, ESRIN and CNR signed an agreement to interconnect their respective GRID dedicated infrastructures and data in a wide-area-network and to grant shared access to identified research users. They also agreed to joint demonstration applications and to joint GRID technology developments. The ESRIN-CNR agreement fostered the development of a wider GRID infrastructure using high-connectivity bandwidth in the geographical area of Rome, to enlarge the utilisation of GRID to a wider scientific user community and for new applications of common interest to promote the use of GRID technology in their area of scientific influence. Furthermore, the agreement reinforced ESA/ESRIN and CNR co-operation in the field of outreach activities such as joint conferences, symposiums, exhibitions, and open days.

ESA had two GRID hardware infrastructures already, one located in ESTEC and one in ESRIN, and had developed several initiatives in the field (SpaceGrid, Concurrent Design Facility, Astrovirtel, GRID-aware End-to-end system Analysis and Service Environment...). It had also participated in several external activities (Astrophysical Virtual Observatory, DataGrid and DataTAG). Among the latter, the project DataGrid was funded by the EC and led by CERN with the participation of ESRIN. It aimed to develop a large-scale multidiscipline (mainly dedicated to High Energy Physics but also Earth Observation and bioengineering) GRID infrastructure and the necessary 'middleware'.

Following ESRIN's participation in DataGrid, the first large European Commission funded GRID project, the EOP Directorate at ESRIN developed a dedicated Earth Science GRID infrastructure under the name Earth Observation GRID-Processing-on-Demand, that is still active. This generic GRID-based environment (G-POD) ensures that specific EO data handling and processing applications can be seamlessly plugged into the system.

The ESRIN-Lazio Region agreement for MEGALAB

MEGALAB is a project launched with the Lazio Region and supported by the Frascati Living Lab. It is focused on GRID computing and provides high speed connection (HSC>10Gbps) across major local scientific institutions (ESRIN, INFN, CNR, Tor Vergata University) in order to promote cooperation between industrial and research centres and to develop innovative services for various sectors including e-government, aerospace, urban living, environment, e-health, education, tourism, culture, multimedia and audiovisual. Tecnopolo Tiburtino has been identified as one of the main points of reference in the network.

ESA-Tor Vergata agreement

In 2012, ESA and Tor Vergata University renewed a 5-year agreement that allows for closer cooperation and increased collaboration in the field of space related research, education and innovation. Since the original agreement, signed in September 2000, ESRIN's EOP Directorate has hosted more than 50 Tor Vergata students studying telecommunications, electronics and environmental engineering. As part of the agreement, ESA will continue to offer PhD scholarships as well as host PhD and Masters-level students at ESRIN in order to conduct research and complete their education.

ESRIN also works in close cooperation with other Italian universities on trainings and projects (Sapienza University, Polytechnic of Milan, Venice University, etc.). More generally, ESRIN itself is a centre of EO education with training courses, summer schools and international educational activities.

Toward a new model of aggregation?

The new Space Science Data Centre

The ASDC and Earth Observation data are now going to be merged in the new Space Science Data Centre (SSDC), which is still under construction. The SSDC is a multi-mission science operations, data processing and data archiving centre that provides support to several scientific space missions. The three departments of the SSDS will be devoted to Universe Observation, ICT and EO, and active participation of scientists and engineers from other institutes is foreseen within specific agreements and MoUs. Following the ASDC's previous network, the SSDC Universe Observation segment involves other National Research Institutes like INAF and INFN, and industries like

Telespazio and SERCO for ICT support. The SSDC, located in ASI, will follow the lines defined by the Open Universe Initiative in cooperation with the United Nations Office for Outer Space Affairs (UNOOSA). The national research institutions involved in the project are INAF and INFN.

The new ESA BIC Lazio agreement

In 2016, the ESA BIC Lazio agreement was renewed, extending the activity for another two years, showing the commitment of the Lazio Region and the Italian Space Agency (that joined in 2011) to support space spin-off. The new MoU signed between ASI, ESA and Lazio Region has the objective of jointly fostering space technology transfer and the applications of space systems in the Lazio Region, particularly in the framework of the implementation of Lazio's Smart Specialisation Strategy within the EU Horizon 2020 Programme.

The Fab Space 2.0.

FabSpace 2.0 is an network for geodata-driven innovation that aims at making universities open-innovation centres for their regions. This is designed to improve their contribution to the socio-economic and environmental performance of society. To achieve this goal, the FabSpace 2.0 project focuses on data-driven innovation, with a particular attention to Earth Observation data.

In the six European regions covered by the consortium, partner universities work together with co-located ESA's Business Incubation Centres (ESA BICs) to turn space-connected business ideas into commercial companies, and provide technical expertise and business-development support.

LazioPulse: an innovative integrating environment?

The Rapid transition of Research towards the Science 2.0 paradigm shows the on-going systematic changes in research and scientific activities. These are driven by rapid advances in ICT and Digital Technologies, combined with a growing demand to do Science for Society (actionable research) and in Society (co-design of knowledge). In this context, Lazio Pulse propose the development of a regional Public Private Partnership of stakeholders interested in sharing data, know-how and infrastructures. This ecosystem will be supported by the already existing infrastructures of the Research Centres mainly based in the Frascati area, which can share a huge amount of data through open software and gain by the existing ESA BICs infrastructures (Business Incubation Centres).

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