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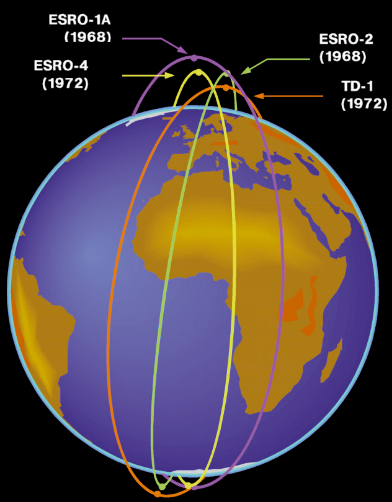

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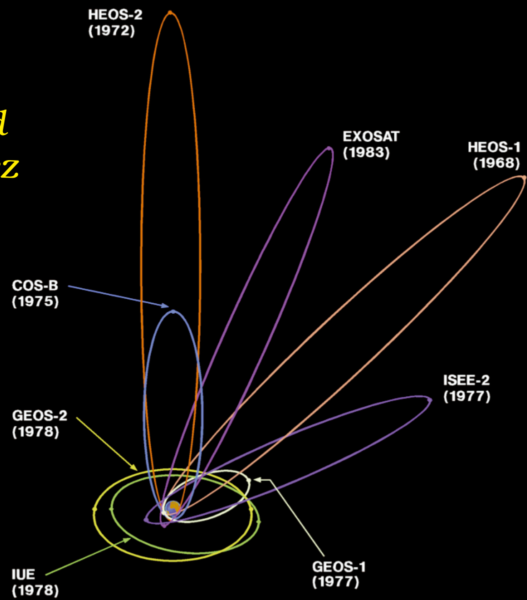

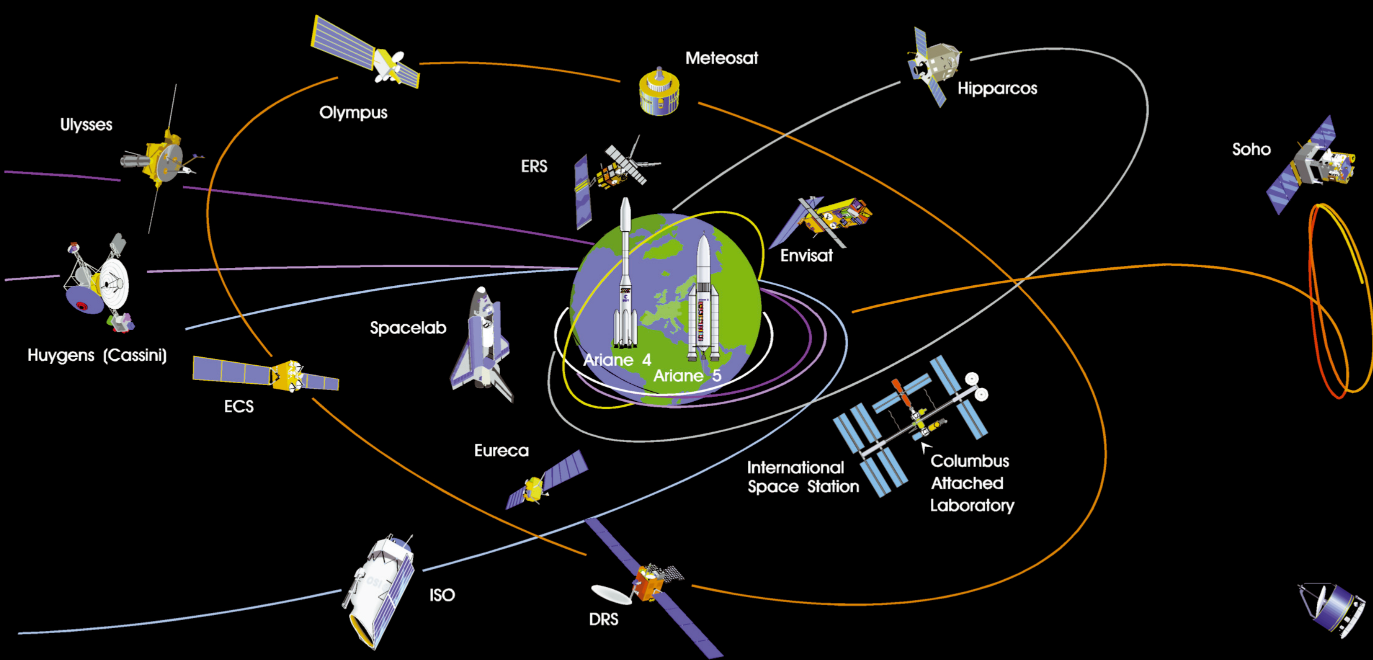

European Space Agency
Agence spatiale européenne

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Contents

1 Introduction

This short account of Spain's space activities describes Spanish efforts and achievements since the beginning of the space era that, as everyone knows, opened in 1957 when Sputnik 1, the first man-made satellite, was placed in Earth orbit.

1.1 Origins, Development and Future

A study of the origin of Spanish space activities shows that Spain joined the European space effort right at the beginning and that this imposed demands that were beyond the country's financial and technical resources at the time, making for a difficult start and almost destroying the dream behind that initiative. An analysis of this early period suggests that the initiative was largely attributable to an external source and that Professor Theodore von Karman's high esteem for Spain and his frequent contacts with the Spanish aeronautical authorities and investigators during those years may have been instrumental. He was the driving force behind many achievements in the USA and elsewhere and may also have provided the initial impulse that was taken up by the Spanish aeronautical authorities. Not all the political authorities were equally enthusiastic however – there were efforts to abort the new activity as soon as it made even the least demand on the small resources available in those years.

The initiative was finally authorised, albeit with an insufficient allocation of resources. Its approval was due mainly to the political value to the Spanish regime of admission to a prestigious European organisation and to the beginning of Spanish collaboration with NASA – another activity carrying high political kudos – which obviously favoured parallel collaboration with the rest of Europe. NASA is therefore the second external player whose influence must be acknowledged.

The development of space activity in Spain was marked by substantial and sustained efforts by those involved during the early years and also by those sections of industry and institutions that decided of their own free will to participate and invest. Substantial financial support and an understanding of the development potential of this activity are relatively recent, dating from around 1988, according to the investment figures. Since then, support has been maintained at a level unprecedented in Spain for an R&D activity. This has been due very largely to ESA, which is thus the third external player to be acknowledged, and it should also be remembered that ESRO was highly supportive in 1967, when there was considerable pressure in Spain to leave that organisation.

This external support shows that space activity is essentially multinational and is widely understood to be so.

This sustained effort has had remarkable results: the industrial training of several thousand professionals to the most advanced technical level; a parallel improvement in the technological resources available to industry and in the experimental capabilities of institutions; the creation of products and services that contribute to the nation's wealth in areas unheard of only ten years ago; and pioneering integration in Europe of an important section of Spain's administration, industry and universities. In the scientific field, many groups are already familiar with subjects that were not within the reach of the scientific community a few years ago and some are today leading European experiments. Also, as another consequence of this activity, Spain is a member of many new and important organisations, both European (Eurospace, Eumetsat, Eutelsat, Arianespace) and international (Intelsat, Cospas, Cospar, Inmarsat).

The upshot is that there is now a critical mass in the space sector, ensuring a promising future for this activity in Spain. None of this would have come about, had Spain not been a member of ESA.

The scenario is changing however. The ongoing consolidation of the aerospace industry has had a major impact on the European space sector and it is important to understand that decisions must be taken now – decisions on whether future policy should be confined entirely to financing proposals presented by these new transnational companies, or whether there is a willingness to establish and support a single competitive policy, common to all European countries. This is the question to be answered, with the confidence born of the achievements of forty years of common effort and with due regard to the strategic nature of space activity.

2 Collaboration with NASA

Spain's first contact with the space sector was through NASA. Its relations with the USA in this field have been developed mainly through INTA[1]. This institute's contacts with NACA to exchange information on aeronautical matters go back to 1951, when they were initiated through Professor Theodore von Karman, a good friend of Spain and a regular visitor to the country. In 1958, when NACA became NASA, the relationship between INTA and the new organisation continued without a break.

The main areas covered by this relationship are described below.

2.1 The Seminar on Space Science and Technology (1960)

INTA began preparations for this seminar in 1959, with the direct support of Professor von Karman, and it took place in the spring of 1960. It was the first significant Spanish activity in the space sector.

The seminar was important for the exceptional scientific level of the 15 foreign speakers[2] led by Professor von Karman, their contributions reflecting the state of the art in the various subjects at that time. The seminar was also remarkable for its range, comprising 32 sessions covering practically every area connected with space exploration. Collected and printed by INTA, the proceedings were to form the first basic book about space published in Spain[3]. But above all, the seminar was important for the early date when it took place, just one year after the USA had placed its first satellite in orbit.

2.2 The Maspalomas Station (1960 – 1975)

In the same year, on 18 March 1960, the Spanish and US Governments signed a Memorandum of Understanding agreeing to establish the first NASA satellite tracking station in Spain and work started immediately on building the station close to the Maspalomas lighthouse in the southern part of Grand Canaria. The choice of location was determined by the fact that Cape Canaveral and Maspalomas are at the same latitude, with an ocean between them, and by the objective of the station.

Initially, the station was intended to support the first American manned space flights, which took place within the Mercury programme (1962 – 63).

Figure 1: The Maspalomas Tracking Station

The Maspalomas station was part of the NASA Mercury network, comprising 14 stations distributed arround the world. The station became operative on 13 September 1961, to support mission MA-4 (an unmanned capsule which orbited the Earth once). It also took part in subsequent missions under this programme, including, of course, John H. Glenn's flight on 20 February 1962.

INTA was involved in operating the station from the beginning, initially with an almost token staff, which gradually grew to over 60.

1 Instituto Nacional de Técnica Aeroespacial.

2 Including contributions from well-known figures such as Luigi Broglio, Lucien Malavard, Eugen Sanger, Jean Kovalevsky and Eberhardt Rechtin.

3 Ciencia y Tecnología del Espacio, INTA 1961

When the Mercury programme came to an end in 1963, the station was substantially enlarged and ready to take part in the subsequent manned flight programme, Gemini, in which the capsules were larger and could carry a crew of two. The station took part in the ten manned flights under this programme carried out in 1965 and 1966.

The next stage of the Maspalomas station was its contribution to the Apollo programme (1968 – 1972) but, before that, it had to face the problem of the unstoppable tourist expansion in the southern part of Grand Canaria, which threatened to interfere with its operations. This threat was felt to be so serious that, after the necessary technical and political negotiations with INTA and the Spanish Government, it was decided to close the station down and build a completely new one, much larger and better equipped, several kilometres away from the original site.

The new station, which continued to bear the name of Maspalomas, had a supporting role in all the manned flights of the Apollo programme, the manned space station Skylab (1973 – 74) and the joint Soviet-American mission, the Apollo-Soyuz Test Project (ASTP), in 1975.

At the end of this last mission, NASA estimated it would no longer need this station and proceeded to deactivate it and transfer it to the institute, together with part of the equipment installed in it. The station remained closed from 1975 to 1979, when it was again activated by CONIE[4] and INTA as an entirely Spanish station. Since then, it has worked for ESA and NASDA Earth observation programmes and also for Spanish programmes such as Minisat, Hispasat, Helios and Cospas/SARsat.

2.3 The Robledo de Chavela Station (1964 – 2001 and later)

On 29 January 1964, another Memorandum of Understanding was signed between the Spanish and American Governments for “the construction and functioning of a tracking and data acquisition station of space vehicles located 47 km West of Madrid”. INTA was designated in that Memorandum as the Spanish representative and the organisation in charge of its development.

That is how the Robledo de Chavela station was officially founded. However, the preliminary work had started a year earlier. During January and February 1963, representatives of NASA and INTA had searched large areas in the provinces of Seville, Malaga, Toledo, Avila and Madrid looking for an appropriate location for the station. Once the intergovernmental Memorandum of Understanding was signed, construction work began immediately and the station started operating in July 1965, just in time to receive images of Mars transmitted by Mariner 4, the first close imagery mankind had ever obtained from another planet.

The original station, equipped with only one parabolic antenna of 26 m diameter was to undergo great changes and enlargements:

Figure 2: The Robledo de Chavela Station

- in 1973, a second and much larger antenna of 64 m diameter became operational;
- in 1979, the original 26 m antenna was enlarged to 34 m;
- in 1986, the second antenna was enlarged to 70 m;
- in 1984, a third 26 m antenna from the deactivated Fresnedillas station was added;
- in 1987, a fourth 34 m antenna started working; and in 1997, another 34 m antenna, the fifth, was installed.

These enlargements made this station the most important in Europe.

[4] Comisión Nacional de Investigación del Espacio.

The original Robledo station, transformed into the Robledo station complex with the enlargements mentioned above, has always been an integral part of NASA's Deep Space Network. It has participated in all the NASA missions to explore the Solar System (the Moon, the planets and their satellites, the Sun, asteroids, comets and interplanetary space), including some of historic importance such as the aforementioned reception of the first photographs of another planet (Mars), man's arrival on the Moon, and the "Grand Tour" encompassing Jupiter (1979), Saturn (1981), Uranus (1986), Neptune (1989) and many other bodies of the solar system.

Spanish participation in the complex has been very important from the beginning. On 3 March 1970, NASA transferred the responsibility for its operation to INTA and in 1972 Spanish staff replaced the last American technicians working at the station. In July 1992, INTA created INSA[5], the company which has been in charge of the station ever since.

High-profile activities of the Robledo complex include participation in NASA missions carried out in cooperation with ESA (Ulysses, SOHO, Cassini-Huygens, etc.) and Germany (Helios 1 and 2); in the injection into geostationary orbit of many European satellites (for Germany, France, Eutelsat); and in critical phases of some ESA missions such as the Giotto Probe encounter with Halley's comet.

2.4 The Arenosillo Launch Range (from 1966)

The Arenosillo range started operating on 14 October 1966, with the launch of a Judi-Dart sounding rocket followed by the launch of a Skua rocket.

The building of El Arenosillo was the result of a Memorandum of Understanding signed by NASA and CONIE, for the study of the upper atmosphere using sounding rockets. At the end of 1965, INTA received an assignment from CONIE to create, organise, operate and maintain a rocket launch range that would, among other things, enable the commitments of the said MoU to be met. INTA's first task was to find a location for the range and Arenosillo was selected as being the most suitable (see Chapter 4).

In the spring of 1966, a group of eight people went to the NASA station at Wallops Island, Virginia, USA, where they underwent three months' training in order to acquire experience in handling, assembling and operating rockets and their payloads, and in the operation of radar, telemetry and other range equipment. At the same time another group was building the range in Spain.

The Arenosillo range, located by the sea in the province of Huelva, has a vast impact area in the Atlantic Ocean and enjoys excellent weather conditions. Approximately 600 rockets have been launched from this range, most of them in the context of international cooperative programmes. Apart from its connection with NASA, El Arenosillo has been a factor in collaboration agreements with research centres in Germany, France, Belgium, Italy and other European countries. It has also been used as a test range for the development of national rocket vehicle programmes.

2.5 The Cebreros Station (1966 – 1983)

On 11 October 1965, an Exchange of Notes was signed between the Spanish and US Governments concerning the enlargement of the Robledo station, as a result of which the Cebreros and Fresnedillas stations were built.

The Cebreros station, located in the municipality of the same name in the province of Avila, started operating on 27 December 1966. It too was equipped with a 26 m parabolic antenna and was in a sense a duplicate of the original Robledo station, although they were located some 12 km apart. Both stations always worked in close collaboration and the Cebreros station played an active part in the NASA programmes for the exploration of the Solar System.

INTA contributed to the operation of this station from the very beginning. By 14 June 1969, when NASA transferred the operational responsibility for the station to INTA, its staff of about 60 was entirely Spanish.

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[5] Ingeniería y Servicios Aeroespaciales S. A.

On 19 April 1983, the station was completely transferred to INTA and it continued taking part in some NASA programmes until it was finally deactivated in May 1986.

2.6 The Fresnedillas Station (1967 – 1985)

This station, located in the municipalities of Fresnedillas de la Oliva and Navalagamella, both in the province of Madrid, was built for a very specific purpose, namely to assist the manned flights of the Apollo programme. This station and two other identical ones, located at Canberra in Australia, and Goldstone, California (USA), were the key elements for communicating with astronauts at lunar distances.

The station became operational on 4 July 1967. It had a 26 m parabolic antenna and was later enlarged with the addition of a 9 m antenna. Although it was built specifically for the Apollo programme, it played a part in other manned missions such as Skylab, ASTP (Apollo-Soyuz) and the first Space Shuttle flights. It also provided support for a large number of NASA scientific satellites in Earth orbit.

As at the Robledo de Chavela and Cebreros stations, INTA staff participated from the beginning. At the end of 1972, the staff of 145 was mainly Spanish and, on 18 December 1972, NASA transferred the responsibility for its operation and maintenance to INTA. With this transfer, INTA was now responsible for operating all three stations (Robledo, Cebreros and Fresnedillas) forming the Robledo complex.

The Fresnedillas station continued working until it was deactivated in 1985, as part of a NASA plan to concentrate all its activities in the Robledo station. The 26 m antenna was moved there, with its associated equipment, and the Fresnedillas station was officially transferred to the Spanish Government on 12 June 1987. It was initially taken over by INTA and later transferred to the Ministry of Defence.

2.7 Intasat (1974 – 1976)

Figure 3: The Intasat Launch

INTA and NASA have always been on excellent terms and NASA played an important part in the Intasat project for the first Spanish satellite. Its most important economic contribution to the project was the free launch on 15 November 1974 of Intasat as a secondary payload on board the Delta vehicle used to launch the ITOS-G weather satellite

Other NASA contributions to the project included collaboration in the definition of the payload, review of the satellite's design and manufacture, access to its facilities at Greenbelt (GSFC) for climatic and solar simulation tests, and the support of its network of tracking stations for calculating orbits and receiving telemetry data.

Intasat ceased transmitting two years later on 5 October 1976, according to plan, after completing a successful mission.

2.8 The Space Shuttle Emergency landing (from 1983)

After signing the corresponding Memorandum of Understanding with the Spanish Government, the Spanish Air Force base at Saragossa was designated as an emergency landing runway for the Space Shuttle, to be used if the propulsion system did not work properly during launch and the spaceship failed to achieve enough speed to reach orbit. This designation entailed providing the Air Force base with the necessary staff and equipment to enable the Shuttle to complete its delicate approach and landing procedures safely and to provide any further attention the crew, the spaceship and its payload might need.

The year after, in 1984, the Air Force base at Morón (Seville) was also designated as a base for emergency landings of the Shuttle fleet and equipped accordingly. The Saragossa base is activated for launches into high inclination orbits and the Morón base for any kind of orbit. Fortunately, despite the number of launches that have taken place, it has never been necessary to use either of these bases.

3 Collaboration with ESA

3.1 Participation in COPERS

The history of Spain's connection with the European Space Agency began on 15 November 1960. On that date, the Minister Plenipotentiary at Spain's Permanent Delegation to the International Organisations in Geneva informed his Minister of Foreign Affairs that an intergovernmental meeting was to be held on the 28th of that month "… to constitute a preparatory commission to study the creation of a European centre for scientific space research, similar to CERN". Anticipating possible instructions from Madrid, the Delegation had been trying to find out from CERN whether Spain might attend the meeting as an observer. It was told that it would be sufficient "to send a *note verbale*, through the Spanish Embassy in Bern, to the Federal Political Department asking for Spain to be granted that status". This was done and, on 17 November, the Political Department of the Swiss Government's General Directorate of International Organisations sent the Spanish Ambassador at Bern an invitation to participate in the meeting, adding on 25 November that the invitation was to attend as an observer and that it would be for those present to decide whether it was appropriate for other states, such as Spain, to be admitted.

That is how Spain came to participate in what was to be known as the Commission Préparatoire Européenne de Recherche Spatiale (COPERS). It was a unique opportunity for Spain, which was virtually unrepresented in Western European fora at the time and was taking energetic political steps to remedy this situation, its ultimate aim being to pave the way for Spain to join the European Common Market. It should be remembered that in the previous year (1959), after more than 20 years of political isolation, Spain had succeeded with US support in joining the International Monetary Fund and then the World Bank, GATT (now WTO) and OEEC (now OECD). In this context, admission to a European space organisation in whatever capacity was a highly attractive political proposition.

Following the Ministry of Foreign Affairs initiative, with the agreement of the Industry and Air Ministries and the Presidency of the Government[6], a delegation was authorised to attend as observers. Once at the meeting, the Spanish Delegation had a very clear objective, namely to be accepted as a full member of COPERS, and it worked tirelessly and brought very intense diplomatic pressure to bear to achieve it. Some countries raised objections of a legal nature "primarily because it could set a precedent, which could be used by other countries whose presence is not desired". As a result of the Delegation's good work, Spain was finally accepted as a member and signed the agreement, known as the Meyrin Agreement after the place where the meeting took place.

Notwithstanding the political success acceptance in COPERS represented, there was some discussion in Spain as to the wisdom of participating in space activity. It was argued at the time that the high cost of space development and the purely scientific nature of the investigations "appear to exclude nations with a weak economy and limited scientific and technical resources, as the economic sacrifice involved does not appear to be offset by the results that may be expected". Proponents of these pessimistic views even cited Spain's longstanding backwardness in scientific matters to justify non-participation in COPERS: "The benefits that might accrue from European collaboration would have little effect on our progress". The President of CONIE, on his side, justified Spanish membership on practical grounds: "… if its purposes are purely scientific, the means required will bring revolutionary progress in many other techniques" and he also returned to a recurring theme of Spanish scientific politics, the vital need not to be left behind "… in the scientific revolution that is taking place in the present world, where progress is so rapid that no-one can afford to remain on the side-lines as a passive spectator. A choice must be made, either to share in this progress or be condemned irrevocably to underdevelopment."

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[6] Acting through the Comisión Asesora de Investigación Científica y Técnica.

3.2 Participation in ESRO

In June 1962, Spain signed the protocol of ESRO, an organisation established for a period of eight years, with a budget to which Spain was to contribute 2.54%. The President of CONIE commented: “Spain has obtained favourable terms, thanks to the good work of our delegates. Thus, although charges are normally allocated in proportion to national income – an approach that would have resulted in Spain paying double the contribution finally negotiated – an exception was made for countries with per capita income below US$ 300, as is the case with Spain and Austria”. This reduction from the initial 4.34% to 2.54%, ultimately increased to 2.66% when Austria and Norway failed to sign the Convention, meant that the Spanish contribution was ninth out of the ten nations signing.

Another of the Spanish Government's objectives was to secure one of the future European space facilities. Spain had a wide range of suitable sites to offer[7]: the Canary Islands (Lanzarote) or Fernando Po (a Spanish colony at that time) for a satellite launch range; the Canary Islands, Madrid or Monegros for ground stations; the Spanish Sahara, Canary Islands, southern Spain or Monegros for a sounding rocket range. It would also have liked to see ESTEC installed at Madrid close to INTA. It was not to be and the failure of these attempts is clearly linked to the low level of Spain's contribution, because a few years later, on 25 November 1965, an Agreement was signed between the Spanish Government and ESRO, with the prior approval of CNES, authorising the organisation to use the CONIE-CNES station at Sardina del Sur in the Canary Islands and many European institutions were also using the Arenosillo range by that time (see Chapter 4).

3.3 Non – participation in ELDO

ELDO, the organisation for the development of the European heavy launcher, was founded at the same time as ESRO but Spain decided not to participate. As the President of CONIE said: “It is difficult to decide whether or not it is of interest for Spain to participate in this organisation. On the one hand, it would place a heavy burden on our resources, about 50 MPta a year; on the other, although the capability and validity of the Blue Streak vehicle have not been clearly demonstrated … its technology is very advanced for us and could represent a very important learning experience for our industry”. In the end, economic considerations prevailed.

3.4 The 1967 crisis

The total Spanish contribution to ESRO from 26 February 1962 to the end of 1967 was FF 16,254,456, or 2.93% of the total ESRO budget, and the contracts signed by ESRO with Spain amounted to only 29.4% of the due return. This meant that Spain had the lowest return of all ESRO members. On the other hand, at the end of 1967 the Spanish debt with ESRO accounted for almost 67% of the total accumulated during those years[8].

The contradictions in the position of the Spanish Government, which wanted to spend as little as possible but was also keen to participate in the European space project, landed Spain in an impossible situation. There were very few Spanish personnel in ESRO. Spanish research centres and firms were ill-versed in space matters, no ESRO facility had been allocated to Spain and the country was in debt to the organisation. As a result, its industrial returns were almost nil and Spain did not figure in Europe's plans.

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[7] COPERS STWG Blue Book.

[8] The industrial return was 2% in 1964 and 2.25% in 1966, that is to say almost nothing in three years. In 1967 the return was 24.9%, all these figures being in relation to the return due to Spain in accordance with its contribution.

By 1967, the devaluation of the Spanish peseta and the associated reduction of public spending made it difficult to get foreign currency in Spain and this aggravated the payment situation. In December 1967, the Spanish debt to ESRO amounted to FF 10,861,517[9].

At the same time, CONIE was trying to launch a national space plan and the Finance Ministry considered that the effort required to finance two programmes, European (ESRO's) and national (CONIE's), in a hazy area such as space research, was not justified. Its opposition forced a rethink of Spain's position in ESRO.

ESRO was concerned about a member country leaving the organisation and on 30 November 1967 it suggested that Spain should either revert to observer status, make a special arrangement under which it would pay only a token contribution, or enter into a Technical Cooperation Agreement.

Figure 4: The Skylark Launch Tower at ESRANGE

Spain, however, preferred to take a stand-by position for the time being and to suspend all payments.

After several negotiating sessions, Spain announced on 21 December 1967 that it intended to withdraw from ESRO with effect from 1 January 1968 but that it did not propose to denounce the Convention. In that same announcement, Spain expressed its gratitude for the goodwill shown by ESRO, affirmed its clear commitment to Europe, and emphasised that it was withdrawing for purely internal economic, technical and financial reasons. The ESRO Council did not accept this decision and looked for some way to reach a short-term compromise with Spain, to pay FF1 during the first half of 1968, although it had no solution to suggest for the future. Noting one of the reasons for the Spanish decision, the ESRO Council also stated its firm intention to obtain a minimum return of 70% for each and every Member State and to reduce the growing differences between them.

Further talks were held over Christmas 1967 and the first few weeks of 1968, in an attempt to solve the problem. On 16 February, a delegation from the ESRO Secretariat met Spanish delegates in the Ministry of Foreign Affairs, under the auspices of the General Director of International Organisations. It was a fruitful meeting and as a result the Spanish Government reconsidered its position. In short, Spain agreed to pay 10% of its contribution and to review it in 1969, 1970 and 1971 with a view to normalisation. It also agreed to present a proposal regarding permanent membership at the end of 1968, with an increased contribution. At the ESRO Council meeting on 27 November 1968, the Spanish Delegation offered to pay 10% in that year as agreed, 18% in 1969, 25% in 1970 and 36% in 1971. In addition, it agreed to pay 80% of its theoretical contribution to the TD1 satellite project, the largest and most expensive of the European satellite projects at that time.

The crisis had been weathered. Two factors had been instrumental in bringing about this happy ending. Spain did not want to increase its isolation and did want to be part of the European scenario. Europe did not want to fall behind in the space race with the two great powers and it was essential that all Western European countries unite to ensure that did not happen. It would set a bad example if one country left the organisation.

Since then, the Spanish contribution has been in line with the agreement reached. By 1973, the return coefficient was 97% and in 1975, Spain was one of the members to approve the establishment of ESA, an organisation in which Spain has maintained its membership within mutually satisfactory limits.

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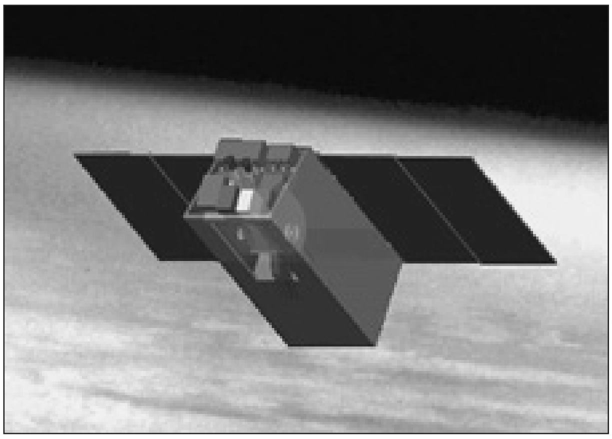
[9] The Spanish debt included all 1967 contributions at 3.29% and half the 1966 contributions at 2.66%, percentages of the total ESRO budget already reduced because the theoretical rates should have been 4.34% in 1966 and 4.46% in 1967.

3.5 Stability in ESA and the integration of the industry

The need to ensure competence and at the same time to comply with the rules on national returns imposed by Council led, at the end of the 1960s, to the creation of three European industrial consortia, each consisting of companies from almost all the member countries gathered round a nucleus of one or two European lead companies. For each major contract, ESRO announced a competition open to the various consortia and they responded with proposals including a complete industrial structure, with a main contractor and subcontractors, that took care of the national return situation. Some kind of rotation among the consortia kept their respective workloads within acceptable limits. This system worked well and was instrumental in establishing across Western Europe a broad base of industries with experience in the space sector and common work procedures.

Spain was represented in the three main consortia and this required the presence of INTA to complete the Spanish group of companies, with CASA and SENER. In 1967 INTA joined the MESH consortium, increasing its ongoing connection with HSD in the Spanish national programme, and in 1969 SENER became a member of STAR, and CASA[10] joined the COSMOS consortium, maintaining its early links with Sud Aviation in the ESRO sounding rocket programme.

The consortium structure began to break up in the 1980s for two reasons. On the one hand, rising costs meant that there were fewer major ESA contracts and it was sometimes politically unacceptable to allocate them to a single consortium (e.g. the Columbus programme). On the other hand, moves towards the consolidation of the European aerospace industry made it impossible to maintain the necessary competence as the barriers between the consortia came down and some companies joined more than one consortium. This gradually reduced the need for INTA to be involved in this industrial sector.



Spanish companies have done well in this new consortium-free scenario. Thus, SENER held subsystem and even system responsibilities in the highly important Columbus programme and CASA has supplied large on-board antennas for satellites and large structural components for Ariane and other launch vehicles. As a final example of this satisfactory development, ESA has recently included a Spanish mission in its Earth Watch programme, the Fuego mini-satellite constellation proposed by the Spanish company INSA.

Figure 5: A Fuego Satellite

3.6 Spanish industry and ESA

CASA and SENER as well as INTA (for the above-mentioned reason) have maintained a continuous and remarkable Spanish presence in the European space effort for almost forty years.

INTA's first development work was in the areas of electrical and mechanical ground support equipment for various satellite projects and later in the Spacelab programme. Its first development of flight hardware was the vibration amplifier for the Blue Streak project and this was followed by flight equipment for other projects, including VHF communications antennas for several satellites. With that experience, after completing the development of a new S-band antenna in 1983 within the framework of the ESA ASTP programme, INTA specialised in this type of antenna, its first commercial customer being the French Telecom 1 satellite. INTA is now one of the main European suppliers of this type of equipment.

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[10] Construcciones Aeronáuticas S.A.

CASA has concentrated on a number of areas. The first was sounding rocket payloads, where it started working for ESRO in 1964 and became one of its main contractors, delivering more than forty payloads for rockets. This was followed by work on structures, electrical harnesses and thermal control for programmes such as Heos, COS B and Exosat. With this last project, CASA began to move from space structures in light alloys to structures in composite materials, such as glass and carbon fibres, becoming a leading company in this field and contractor for important elements such as the primary structures of ESA's large Envisat and Artemis satellites. During this transitional period, CASA turned its attention to a third field of activity, reflecting antennas, developing a 1.8 m prototype antenna in carbon fibre under an ESA ASTP contract. This made a highly competitive entry into the market and, in collaboration with the Institute of Electronics under the aegis of CSIC and INTA, it went on to demonstrate its competence in large microwave antenna technology with the development of the ERS 1 and 2 wind scatterometer antennas. CASA has since extended its competence in this field, providing carbon fibre reflecting antennas for various communications payloads. At present, it works mainly for Arianespace, producing large carbon fibre and light alloy components for Ariane launchers, using the most advanced installations in Europe for the automatic placement of fibres.

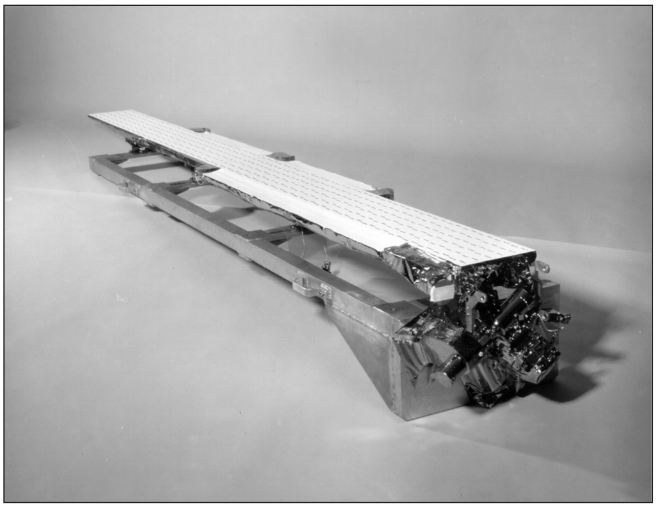

Figure 6: Antenna for ERS

SENER too has developed important activities in three areas. First, in projects for large facilities, such as the Kiruna launch tower for Skylark rockets, the umbilical tower of the ELA1 assembly at Kourou for the launch of Ariane-1 rockets, part of the ESA station at Villafranca del Castillo, and the integration and transport system for the first European Space laboratory, Spacelab, installed at ERNO (Bremen) and NASA (KSC, Cape Canaveral). A second and major area of interest is the development of flight mechanisms and deployable elements, an area in which it has developed its own technology with products such as CTM masts and LTS truss structures. Examples of its achievements are the masts on board ISEE B, ISPM and Cluster satellites and the FOC mechanisms on board the Hubble Space Telescope, including in all cases the associated control and pyrotechnics electronics. Its third area of interest is system engineering, in which it has carried out important studies for the Columbus, Hermes and Space Station programmes (Hermes-Columbus compatibility study, Hermes space plane landing site, utilisation study of European payloads externally attached to the International Space Station) and software development.

With the end of the rigidity that was an essential feature of the consortium environment, the increase of space activity in Spain and the establishment of CDTI, which plays a very important promotional role, new companies have joined the Spanish space sector.

Figure 7: ELA 1 Umbilical Tower at CSG, Kourou

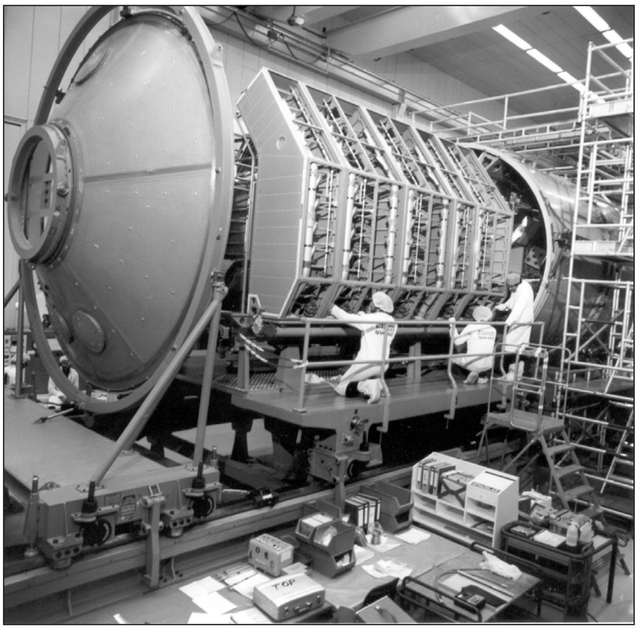

Figure 8: Spacelab Assembly Cradle (Bremen)

They include: CRISA, with on-board power and control equipment and ground electronics; Alcatel Espacio, with on-board digital electronic equipment and active and passive RF equipment; Tecnologica, a company specialising in the processing of space components; GMV, a company designated by ESA as a centre of excellence in orbital mechanics, which provides a variety of services for ESOC and other satellite ground systems; RYMSA, specialising in antennas; MIER Comunicaciones, specialising in solid state amplifiers, MMIC and other RF equipment; INDRA Espacio, which provides ground systems and equipment for satellite communications; GTD, specialising in software for control centres; Iberespacio, with expertise in analysing the behaviour of propulsion stages, in modelling and simulation of fluid systems in propulsive stages and in thermo structural and rams analyses; and NTE, which supplies sensors and control electronics, etc.

There has been a marked qualitative improvement in the Spanish industrial sector recently. The launch of a new and very important European programme, the Galileo navigation system, has led CDTI to promote the establishment of a Spanish industrial consortium, Galileo Sistemas y Servicios, led by AENA[11], to protect the interests of Spanish industry in this European programme.

3.7 Spanish science and ESA

Although participation in the ESA science programme is mandatory for member countries, the industrial return policy does not apply to scientific experiments, which are generally financed and made available for missions free of charge by the member countries proposing them. The lack of Spanish input in this area has meant that Spain has not been represented on the decision-making committees defining the programmes. There are two interrelated reasons for this: one, minimal funding was provided for this kind of activity under the national plan and, two, the scientific community involved in this type of investigation in Spain was very small. This community was confined to meteorology and the ionosphere in the 1960s and 1970s, fields that were well served with sounding rocket capabilities.

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[11] Institution in charge of airports and air navigation in Spain.

ESA decided to be more flexible in this matter and in some cases agreed to finance certain instruments. This at least opened the field to Spanish industry, as in the case of SENER with the FOC mechanisms for the Hubble Space Telescope. Before that Spain had only developed the experiments on board Intasat.

When Spain passed a new Science Act in 1986 (see Chapter 4), there was a significant improvement in the support for scientific research. More resources were allocated to R&D under the national plan, facilitating the development of instruments and scientific participation in major ESA missions. The other problem, the small number of scientific groups able to conduct flight experiments, has also gradually been solved in the past ten years.

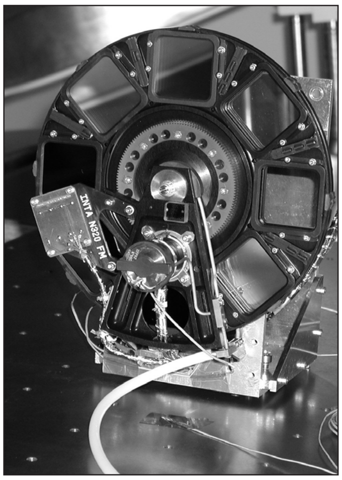
In this new environment, Spain started to participate actively in the scientific aspects of ESA missions. The first important instrument developed by Spain was the Isophot–S, a photopolarimeter for the infrared space telescope ISO, which CASA delivered in 1990, a project under the leadership of the IAC[12] with the participation of the IAA[13]. This activity was continued with two other instruments, GOLF (filter mechanisms) and Virgo, on the SOHO satellite, with Spanish participation under the leadership, this time, of the IAC and with industrial support provided by CRISA and CASA.

Following this lead, other universities and research institutions joined in the effort in the astrophysical and planetary fields: the University of Valencia took responsibility for the IBYS, SPI and JEM-X instruments on the Integral satellite, with industrial support from INTA and SENER; the IAA participated in the instruments measuring atmospheric parameters on the European Huygens probe, with industrial support from SENER; INTA provided the filter wheels and the electrical supply equipment for Osiris optical cameras on the Rosetta mission, with industrial support from SENER. There was also substantial Spanish participation in the instruments on the First (Herschel) and Planck satellites, involving five Spanish institutions (IAC, OAN, IFC, UPC and UC), and in the AMS, an experiment to detect the presence of antimatter in space, installed on board the ISS[14], in which CIEMAT is responsible for the Cerenkhov detector in an experiment led by Nobel Prize winner, Professor S.C.Ting.

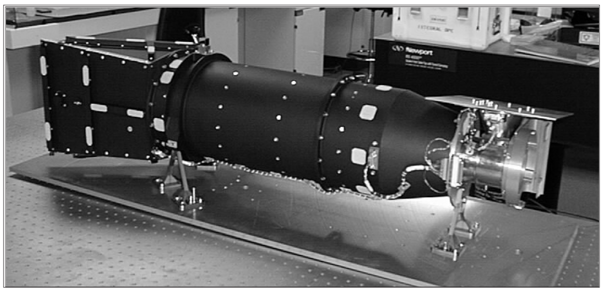
There is also considerable activity in the field of microgravity, a discipline in which there are many good Spanish investigators, witness the combustion experiments on board sounding rockets, the biological experiments on board Shuttle flights and the leadership in Tribolab, an experiment Spain is to deliver to the ISS.

Figure 9: Integral Mask

Figure 10: Filter Wheel Rosetta Osiris Camera



[12] Canary Islands Astrophysics Institute.
[13] Andalucía Astrophysics Institute.
[14] International Space Station.



Very considerable progress has thus been made on the scientific side during the past decade. Another example is the recent acceptance of a Spanish scientist as principal investigator in a major ESA instrument, the OMC[15], supplied by INTA, with Belgian optics, for the Integral satellite.

Figure 11: Integral Optical Monitoring Camera

3.8 ESA facilities in Spain

ESA maintains one ground station in Spain operated by Spanish personnel. On 2 August 1974, Spain and ESA signed the agreement to establish and operate a ground station in Spain that was to start its operational life with the International Ultraviolet Explorer (IUE) satellite. This station is located at Villafranca del Castillo, close to Madrid and was inaugurated on 12 May 1978 by the King of Spain. In this first mission, the station hosted centres for spacecraft control, science operations and data distribution, sharing these tasks with NASA´s GSF centre and Wallops Island station. This satellite remained in operation for more than 18 years, well beyond the intended 3-year life-span, thanks to the interest attaching to its operation and the expertise shown by the ground crews. Another major mission supported in a similar manner by this station was the Infrared Space Observatory (ISO). The additional responsibility of acting as a scientific control centre makes this station a real observatory and focal point for astronomical operations, giving it an added value in the scientific field that increases its interest for the Spanish scientific community. Thus, CSIC and INTA have installed an astrophysics and fundamental physics laboratory, LAEFF, nearby, which works closely with the station archives and has helped to increase Spanish scientific activity in the space sector. The station has also played a major part in other projects, Exosat (an X ray observatory), the OTS2 telecommunication satellites, the ECS series and Marecs.

ESA also supports other facilities in Spain, such as the INTA solar cells laboratory, Spasolab[16], which was designated as an official ESA facility in 1989 and is used to study, determine and certify the characteristics of solar cells used in satellites; and Crepad[17], another INTA facility working in close contact with the reception capabilities of the Maspalomas ground station, which houses E-PAC**,** the Spanish Envisat centre.

Figure 12: The Villafranca del Castillo Earth station

3.9 Spanish institutions and ESA

The working relation between Spain and ESA has been fostered over time by three institutions, in addition to the Ministry of Foreign Affairs which has taken care of the political aspects.

The first was INTA, which acted as the technical focal point in the period 1960 to 1964, when Spain was a founding member of ESRO. The second was CONIE, which took over this responsibility from INTA and was active for 25 years, from 1964 to 1986 during the period when ESRO became ESA.

[15] Optical Monitoring Camera.
[16] **Spa**ce **So**lar Test **Lab**oratory.
[17] **C**entro de **Re**cepción **P**roceso, **A**rchivo y **D**istribución de imágenes de Observación Terrestre.

These two institutions did a good job, given the resources available, solving some critical problems with ESRO's help and achieving full integration for Spain in ESRO and later in ESA.

In 1986, the Science Act was passed in Spain and the responsibility was handed on to a third and new institution, CDTI[18], under the Ministry of Industry and Energy (now the Ministry of Science and Technology). During this third period, Spanish support for space activities increased sharply in 1989 and 1990[19] and has since been maintained at a level unusual in Spain for an R&D activity.

This has enabled CDTI to increase the number of Spanish firms involved in ESA programmes and, with the collaboration of CICYT, to pay serious attention to the scientific aspects, culminating in the integration of Spanish scientific groups in ESA's scientific activities and thus in the full integration of Spain into ESA. At the same time, harmonisation of national technology development work with ESA projects has produced good results, providing Spanish industry with competitive technologies and products endorsed by acceptance by ESA. CDTI has also provided training for about 200 Spanish students in various ESA establishments and enabled Spanish students to participate in microgravity campaigns on board the ESA plane dedicated to this kind of experiment.

In this third period, the Spanish contribution to ESA has increased by a factor of four to a level (4%) that is more consistent with the wealth of the country (see Annex 2). Spain now participates in the ESA basic budget at almost 7% and is represented in all the optional programmes, in some cases with a high contribution (e.g. 8% in the Telecommunications programme and 11% in the Galileo programme). Under an agreement with CDTI, AENA also supports this last programme, which is designed to provide Europe with an independent infrastructure for high precision radio navigation.

During these years, CDTI and ESA have maintained a Spanish industrial return that is satisfactory in both quantity and quality. Also, Spain's direct representation in ESA, that is to say the number of Spaniards holding positions at various levels in the organisation, has reached an appropriate level with 102 Spaniards working for ESA (6%) and one (proposed after a very important national selection process led by CDTI) in ESA´s corps of 15 astronauts. He flew for the first time in 1998 as a member of the crew on the STS 95 Space Shuttle mission.

The brief review contained in this chapter confirms that CDTI has finally achieved the initial objective set in 1963, namely full and satisfactory Spanish participation in ESA. As a result of these events and the volume of resources CDTI manages, this organisation is today the centre of reference for space activity, with all the synergy accruing from integrated management of most of the institutional and industrial space activity in Spain.

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[18] Technological and Industrial Development Centre.

[19] See Annex 2, Financial Matters.

4 National Plans

Official government interest in space research and development activities dates from 8 July 1963, when the National Commission for Space Research (CONIE) was established by Act 47/1963. That is when the national space plans were first defined and developed. One of the Commission's responsibilities was to establish the technical basis of the relationship with ESRO and maintain direct contact with the Delegation to that organisation. The Spanish delegates to ESRO were therefore members of the Commission. Under the same Act, INTA was closely attached to CONIE as its Technology Centre.

4.1 The Preparatory Programme (1964 – 1967)

While the first national space plan was being defined and approved, a plan that did not really start until 1968, some activities were conducted between 1964 and 1967 as part of a preliminary programme, with a total approved annual investment of 156 MPta. These activities were of two types, technological and scientific.

4.1.1 Technological activities

CONIE adopted four main lines for future development:

- to set up and operate a sounding rocket launch range;
- to design and develop rocket vehicles;
- to design and develop space platforms; and
- to improve existing ground facilities.

The foundations for these four types of activity were laid during the preparatory programme.

4.1.1.1 Sounding Rocket Launch Range

The first moves to achieve this objective were made in 1965, when INTA and the French Navy considered the possibility of collaboration, with the French partner providing trajectography and telemetry/command equipment and the Spanish partner completing the facility as a range that would operate for its own purposes and also provide the services required by the French Navy, namely to track the flight and locate the impact points of long-range missiles launched for test from Les Landes. These missiles flew on a course parallel to the north coast of Spain and landed in the ocean in an area located NW of Cape Ortegal. This obviously required the range to be located on that cape. INTA, after studying this option, discarded it because of the very negative orographical and meteorological characteristics of the site.

NASA-CONIE had already signed an Agreement in 1964 for a cooperative meteorological programme and, on the termination of the above-mentioned study discarding collaboration with France, INTA renewed contact with NASA with a view to obtaining its support for the installation of a launch range. At the same time, it continued its search for a suitable location for the range. Several sites on the south coast of Spain were examined and one was finally chosen, close to Arenosillo and about 7 km from Mazagón (Huelva).

In January 1966, two CONIE-NASA Memoranda of Understanding were signed, one concerning the launch range, with NASA providing radar and meteorological equipment as well as a launch ramp for Judi Dart rockets; the other concerning the performance of scientific experiments from that range. In addition, under a contract with British Aerojet (BAJ), INTA was also to supply the equipment needed to launch Skua rockets.

To operate the facility, INTA sent personnel to be trained at NASA (Wallops Island) and at BAJ and while it prepared the chosen location to receive all the equipment and install the necessary facilities. NASA and BAJ delivered the equipment and INTA completed the installation of the range in 1966.

The first launch took place on 14 October 1966 and 14 more rockets were launched during that year in accordance with the Agreement with NASA. Financial difficulties at CONIE prevented any more launches in 1967 but, with the start of the first national space plan in 1968, activities continued apace, with a total of 557 sounding rocket launches to date.

4.1.1.2 Sounding Rocket Development

To start development, training was needed in the techniques and technologies required for this type of vehicle and, to this end, it was decided to construct a real sounding rocket vehicle with the collaboration of the British company, BAJ, using rocket components developed earlier. The project was carried out from September 1966 by a team of INTA and CASA engineers, working in close collaboration with British engineers, in England and Spain.

The result was a trained team of people and a vehicle (INTA 255) 6 m long, 255 mm in diameter and weighting 340 kg, that reached an apogee of 150 km with a payload of 30 kg. Three prototype vehicles were successfully launched in June and December 1969 and in December 1970.

4.1.1.3 Satellite Development

Preparatory activities for this development, such as staff training and preliminary concept studies, were started in 1964. After considering the possibility of copying the ESRO I or ESRO II platforms, it was decided to develop a small piggy-back satellite that could be launched free of charge. This approach enabled all the platform subsystems to be developed without incurring unduly high costs. The British firm HSD (Stevenage, Herts) was chosen as consultant for this development.

4.1.1.4 Ground Facilities

To develop the above vehicle and platform developments, it was necessary not only to train people in the related techniques but also to acquire a number of technologies and improve the available measurement, manufacturing and simulation capabilities. During this period, with financial backing from CONIE, laboratories were installed at INTA for electrical measurement, electrical calibration, electrical standards and storage batteries, as well as workshops for the manufacture of transformers and printed circuit boards and for the encapsulation and assembly of electronic equipment. Qualification of the technicians, work procedures and facilities was performed in Spain after initial training at HSD. Also, an agreement was signed with CNES to install a telemetry and tracking station at Llanos de Sardina del Sur on Grand Canaria, to support French programmes.

4.1.2 Scientific Activities

The main scientific activities sponsored by CONIE in this preparatory period were three programmes with sounding rockets, one programme with balloons and the upgrading of a number of scientific observatories.

Two of the programmes using rockets were devoted to atmospheric investigation, one in 1964 involving INTA, NASA and INM[20] and the other in 1966 involving CONIE and NASA. In the course of these two programmes, 18 rockets were launched from Arenosillo. The third, a joint INTA-IAL[21] programme, was dedicated to ionospheric investigation using ESRO Skylark rockets launched from Sardinia.

The programme using balloons was a campaign carried out in collaboration with CNES. It began in 1966 and was completed in 1969, having launched a total of 26 stratospheric balloons from Leon (Spain).

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[20] Instituto Nacional de Meteorología.
[21] Astrophysics Institute, Liège.

Finally, CONIE supplied an ionospheric sounder to the Ebro observatory[22] to support ionospheric studies; several photographic cameras to Complutense University to support experiments on the Earth's gravitational and magnetic fields; and a spectrophotometer to the Teide observatory to perform nocturnal luminescence experiments.

4.2 *The First National Space Plan (1968 – 1974)*

During the preparatory period, CONIE tried very hard to obtain government approval for a five-year space plan but it was held up because the Government was unwilling to take a position on a long-term investment such as space research, when other pressing short-term national needs required urgent attention. It was very pessimistic about the cost of ESRO membership and the country's future in that organisation, so much so that Spain almost cancelled its membership. That might also have spelled the end of the national space plan and the abandonment *sine die* of all space activity.

Thanks to CONIE's efforts and the understanding shown by the other members of the organisation, it was possible to arrange for payments to be rescheduled and negotiate a reduction in the Spanish contribution[23] to ESRO. In this new situation, the Government was able to agree to Spain becoming a permanent member of ESRO and authorise the national space plan.

The plan had been submitted to the Government for the first time in November 1966, with a total budget of 600 MPta and a duration of five years (1967 – 1971). It was finally approved at the end of 1968, with the same budget and a duration of six years. In the end, it ran for seven years (1968 – 1974), with heavy emphasis on technology[24] and less on scientific activities.

4.2.1 Technology activities

The four main lines of activity laid down in the preparatory period were maintained.

4.2.1.1 Launch Range

The Arenosillo range was completed under this first plan. It was provided with a third radar set, trajectography equipment, launchers for other rockets, improvements in the meteorological station, a 30 m high anemometric mast, IRIG telemetry equipment and important improvements in other services and installations. All this permitted a normal rate of activity, with the impressive record of 307 launches between 1966 and 1974, which marked the end of this period.

4.2.1.2 Development of Sounding Rockets

The national plan included development of a sounding rocket. The first objective was to obtain a commercially competitive vehicle and the second to transfer the relevant technologies to Spain, propulsion being the most important. Explosivos Rio Tinto (ERT) joined the project for this reason. The CONIE budget for this project – INTA 300 – was 55 MPta, not including the cost of INTA labour estimated at around 20 MPta. The British company BAJ was again selected as consultant for the technology development and was required, as in the former agreement, to collaborate in the development of the vehicle and also to serve as a link, to facilitate the transfer of procedures and patents of a family of propellants to be delivered by the British centre for development of rocket motors[25] and by the factory filling these motors.

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[22] It was founded by the Jesuit Society in 1904 and since then it has been devoted to studies in Solar-Terrestrial Physics. Today it is integrated in the Ramon Llull University.

[23] It was agreed that the national contribution would be proportional to per capita income instead of national income when the former was below US$ 300. A new set of dates for the Spanish payments was also agreed.

[24] By decision of the Government, a ratio of 1:3:8 was applied to basic research, applied research and industrial development. This ratio was modified in favour of industrial development before the Plan was approved, with the result that scientific activities represented only 5% of the budget.

[25] Royal Propulsion Establishment (RPE).

As regards the first objective, the design produced a two-stage vehicle – INTA 300 – with an apogee of 300 km and an internal payload of 30 kg. Its main physical characteristics were a total weight of 500 kg, a diameter of 255 mm and a length of 7 m. The first launch took place at Arenosillo in October 1974 and this was followed by three more launches in October 1975, June 1978 and February 1981. Three of these four prototype vehicles were equipped with technology payloads to record flight parameters and one of them, the third, carried an ionospheric experiment produced by INTA in collaboration with the Universities of Sussex and Southampton.

This vehicle was also manufactured in the UK under the name of Fulmar and six British units were manufactured and launched from the Andøya range (Norway), carrying several experiments developed by British universities.

As regards the second objective, the design techniques were learned during the execution of the project, the propellant technology was acquired with the installation and commissioning of the above-mentioned laboratories, and the rocket motor technology was obtained through the design and manufacture of two types of motor, both using a composite solid propellant.

Figure 13: INTA 300

4.2.1.3 Satellite Development

The first Spanish satellite was developed by INTA between 1968 and 1974, when it was launched into orbit. INTA's principal collaborators were CASA and SESA[26], technical consultancy was provided by HSD, and NASA gave important assistance free of charge.

The satellite, Intasat, had a dodecagonal right prism configuration, 445 mm face to face and was 450 mm in height, with a weight of 25 kg at launch. Electrical supply was provided by solar cells and stabilisation by a magnetic system. All typical satellite subsystems were developed within the project, even some subsystems that did not fly but were kept on for learning purposes, with a view to future projects.

The payload included two experiments coordinated with NASA and developed by INTA. One was a scientific experiment, an ionospheric beacon, and the other was a technology experiment designed to measure the effect of space radiation on the behaviour of some new CMOS components.

This first Spanish satellite was launched as secondary payload on board a Delta launcher on 15 November 1974 and worked perfectly until 6 October 1976, when transmissions were automatically terminated as planned. The satellite signals were received in Spain at three stations installed at the Ebro observatory, INTA and the Arenosillo range. More than forty stations in other countries received the signals.

Figure 14: The Intasat Satellite

[26] Standard Eléctrica S.A.

The project cost to CONIE was 123 MPta and the total real cost, including the contributions of the three major Spanish participants, was about 185 MPta.

Another important activity in the first year of this plan was the definition of a thin film satellite telemetry system, a state-of-the-art project at the time. This study was carried out at Filton (UK) in collaboration between INTA and British Aircraft Co. Despite the satisfactory results of the definition study, this advanced project was discontinued for lack of funds.

4.2.1.4 Ground Facilities

Following the effort of the preparatory plan, additional laboratories were completed at INTA. They were dedicated to environmental testing, photography and illumination, solid propellants, static tests of rocket motors, mechanical integration of vehicles and payloads and pilot plants to produce propellants (installed at ERT) and to fill rocket motors.

The propellant technology, supplied through BAJ (Banwell), came from British establishments[27]. It was a propellant composed mainly of polyisobutylene as fuel and ammonium perchlorate as oxidiser. This technology was used in many INTA motors from 1970 until the early 1990s, when it was replaced by the more advanced HTPB propellant.

Other facilities installed at that time included one PCM telemetry station at INTA and three receivers for the Intasat Ionospheric beacon, one at Arenosillo, another at the Ebro observatory and a third at INTA.

4.2.2 Scientific Activities

Various experiments were performed under the first plan, using rocket vehicles, balloons or ground equipment.

All the activities using rocket vehicles were conducted from Arenosillo. Four main programmes were carried out. The first was an atmospheric study up to an altitude of 60 km conducted jointly by INTA, NASA and the INM, under an agreement renewed every two years covering the period 1966 to 1974, involving about 150 launches of different types of rocket. This programme continued until 1980. The second was a study of winds up to an altitude of 100 km, conducted by INTA and INM involving the launch of 32 rockets. The third programme, designed to measure the evolution of atomic oxygen at night between 80 and 100 km, was the outcome of collaboration between INTA and the Space Aeronomy Institute of Belgium (IASBG), launching five rockets. Finally, a fourth cooperative programme was conducted by CONIE, NASA and CNES, launching a total of 17 rockets to study the characteristics of the E layer. Other centres participating in this programme were CNRS (France), the University of Bern (Switzerland) and several Spanish Institutions (the Ebro observatory, CIF Torres Quevedo, JEN[28] and INTA).

The most important of the activities using balloons were two cooperative programmes. The first, conducted by INTA and the Autonomous University of Barcelona, was designed to study cosmic radiation with balloons flying up to an altitude of 36 km, launched by CNES from Tellard and Aire sur l´Adour (France). The second, developed jointly by OAM, the Astrophysics Institute of the University of Liège, NOAA (USA) and CONIE, was designed to perform solar studies with balloons launched from Palestine (USA) and equipped with stabilised platforms.

Many other experiments were performed using ground equipment, two of the most remarkable being the CONIE-JEN-CALTECH study of meteorites and lunar samples by mass spectrography, and the CONIE-JEN collaborative project to analyse lunar dust provided by NASA through its Apollo XI and Apollo XII missions.

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[27] RPE (Westcott) and the factory at Bridgewater.

[28] Junta de Energía Nuclear.

4.3 National Space Activities Since 1975

Two phases can be distinguished since 1975. The first covering the period 1975 to 1986, when a new Science Act was approved by the Spanish Government, and the second from 1986 to the present day.

4.3.1 1975 – 1986 (CONIE)

In 1975, when the first space plan was completed, there was no approved follow-on plan. Also, under a government reorganisation in 1977, the Air Ministry's responsibilities, including responsibility for INTA and CONIE, were transferred to a new Defence Ministry. In this new situation, CONIE's annual budgets decreased steadily, reaching bare subsistence level (70 MPta) by 1982. Development of new Intasat satellites was abandoned, and development of sounding rockets and performance of scientific experiments were reduced. The staff of CONIE, which had numbered 98 in 1975[29], was cut to only 12, incorporated in INTA in 1986 and transferred later to LAEFF[30], a laboratory jointly sponsored by INTA and CSIC[31].

In the first few years of this period, CONIE maintained the ongoing rocket programmes and started the other programmes described below. New ramps for rockets were installed but the number of scientific experiments on board sounding rockets was drastically reduced after 1979. Between 1975 and 1994, 236 sounding rockets were launched, an average of 15 launches a year, much lower than the average of 44 a year between 1968 and 1974. The last sounding rocket, an INTA 300 B, was launched from Arenosillo in 1994.

Rocket development continued. The INTA 100 sounding rocket project was initiated in 1980 and the first launch took place in June 1984. By 1986, six prototypes had been launched. INTA's other activities included improvements to several rocket motors and the study and development of a hybrid inertial/infrared guidance system.

The ongoing scientific experiments initiated under the first plan were completed, i.e. reception of Intasat ionospheric beacon signals and performance of experiments in sounding rocket campaigns. As regards new experiments, five additional scientific programmes were conducted using rockets. Two were CONIE programmes to study the dynamics of the atmosphere (40 rockets launched from Arenosillo) and the D layer (one rocket launched from Kiruna) and three were cooperative programmes to carry out astronomy studies (two rockets with the collaboration of DFVLR), to investigate electromagnetic phenomena in the ionosphere (in collaboration with Sussex University in the UK and IROE in Italy) and to study the stratosphere and the mesosphere (22 rockets launched in collaboration with seven other countries).

Two programmes using balloons were also initiated. The first, under a CNES/CNR/INTA Agreement signed in 1977 and still in force between INTA and ASI, covered various kinds of study (astronomy, biology, stratosphere, cosmic radiation, etc.) using trans-Mediterranean balloons launched from Trapani (Sicily) and recovered in Spain after 20 to 30 flight hours. By the year 2000, 63 balloons had been launched. The second programme was a collaborative project conducted with the University of Valencia and the Autonomous University of Barcelona, using balloons launched from Gap and Aire sur l´Adour (France).

Figure 15: INTA 100

[29] 35 at the Arenosillo range.
[30] Laboratorio de Astrofísica Experimental y Física Fundamental.
[31] Consejo Superior de Investigaciones Científicas.

Finally, several remote-sensing campaigns were conducted, using a C-212 aircraft equipped with Hasselblad cameras, line scan and M 25 multispectral sensors.

4.3.2 1986 onwards (CDTI)

In 1986, with the passing of the Science Act, CONIE was closed and new institutions took its place. Representation in ESA and responsibility for managing the industrial and scientific returns were assigned to CDTI. The task of defining and financing national space activities (PNIE) was allocated first to CAICYT and later to its successor CICYT, responsible for the national R&D plan.

The situation of space activity improved after 1988, when the national space research programme (PNIE) was incorporated in the Spanish national R&D programme. The PNIE is managed by CDTI, its objectives being to harmonise PNIE projects with the ESA Technology Research Programme, to obtain ESA technical support for Spanish industry, to train Spanish personnel at ESA establishments and to promote new areas of technology. The budget for national activities increased during these years and at the same time the scientific community lost interest in using sounding rockets for satellites. These two changes, combined with the weak position of Spanish scientists in ESA, led to calls for a change in the content of the national plan, to enable scientists to use ESA satellites. The successful results of this move and the increased support accorded to space science have already been described in Chapter 3.

Other results worth recording here are the flights of UPM and Minisat satellites and the commissioning of Crepad and Spasolab installations.

UPM[32] developed a satellite which was launched as a secondary payload by an Ariane-4 launcher in 1995. It was a 40 kg magnetically stabilised satellite with a payload comprising technology experiments on the behaviour of certain types of batteries and solar cells, and a microgravity experiment. By now, the plan was also supporting the Minisat satellite, an INTA development programme described below, which was successfully completed.

Recently, the national plan has contributed to the establishment of two new installations: Crepad in the Canary Islands, a facility designed to disseminate data from Earth observation satellites, developed with participation by INTA and ESA; and ESA´s Spasolab, a laboratory installed at INTA and consecrated to the study and qualification of solar cells.

4.4 Developments Sponsored by the MoD

In addition to conducting its own programmes, INTA has traditionally supported the national space plans. Since 1988, the MoD has increased INTA's budgets to levels that have allowed the development of important space systems, with additional funding from CDTI in some cases. An account of these programmes is given below.

4.4.1 Guided Vehicle INTA 300 G

Once the INTA 300 first prototype was successfully launched in 1976, INTA planned, with the collaboration of British Aerospace, to use this experimental vehicle as a test bed for guidance and control developments. This vehicle was guided by a high-precision inertial system, controlled inside the atmosphere by aerodynamic means and outside by cold gas jets. Lack of funds in those difficult years prevented completion of this project.

[32] University Schools of Aeronautical and Telecommunications Engineers, Madrid.

4.4.2 The INTA 100 Sounding Rocket

As a result of the closure of CONIE in 1986, the INTA 100 project remained without financial support for four years. Activities resumed in 1990 under the INTA budget, with the launch of six rockets, and were completed in 1992. This vehicle was a small 2-stage meteorological sounding rocket with an apogee of 115 km, a 6 kg payload, a total mass of 70 kg, a diameter of 10 cm and a length of 4 m. The rocket was produced entirely in Spain and was used by the INM.

4.4.3 The Capricornio Launcher

This was a satellite launch vehicle with capacity to place microsats (50 to 100 kg) in low Earth orbit (600 km). Different configurations were studied and finally a three-stage vehicle was chosen, 11 m long, 1.15 m in diameter and with a mass of 14,000 kg. Studies started in 1990 and development was suspended in 1998.

In association with this programme, INTA in collaboration with INSA and the US firm Lockheed Martin, studied the requirements for a launch range for this type of small satellite launcher on the island of El Hierro (Canary Islands), an idea INTA had had in mind since 1961. The cancellation of Capricornio also meant the cancellation of these studies.

Figure 16: Capricornio

4.4.4 Minisat and Nanosat Satellites

The Minisat programme was designed to develop a family of small satellites for various scientific uses, Earth observation applications and communications platforms.

The feasibility study was proposed by SENER to INTA in 1989 and it was planned that INTA, SENER and the Italian company Augusta should conduct the programme.

Augusta dropped out when Italy decided to develop its own small satellite, leaving the project in Spanish hands.

The first Minisat satellite was developed by INTA, with CASA as prime, in collaboration with INDRA, SENER and Ball Aerospace (USA). It was launched using a Pegasus vehicle, the carrier plane transporting the launcher having taken off from INTA. Its operation was completely successful.

Two missions are currently being developed on Minisat platforms. The first is an optical Earth observation mission, Isthar, and the second is the Fuego programme, which plans to place a 12-satellite constellation in orbit.

Also under development is the Nanosat programme, in which INTA, in collaboration with the National Centre for Microelectronics and UPM, is developing a small satellite (15 kg) with the support of CDTI under the national plan.

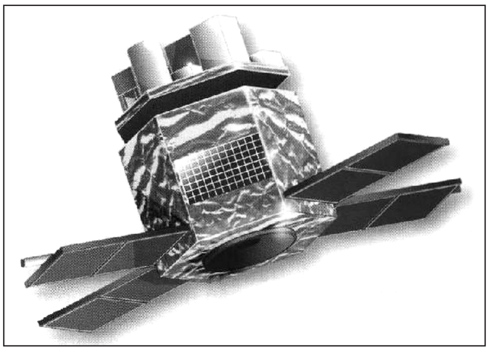

Figure 17: Minisat

Recently INTA has decreased its support for some of these programmes and put its resources into other defence space programmes described below (see Chapters 5 and 6).

This decision has affected the development of new Minisat-based satellites and has led to the cancellation of the Capricornio launcher programme.

4.4.5 The Arenosillo Launch Range

INTA has greatly increased this range's capacity to track rockets and receive data by installing new optronic equipment for trajectography. These improvements are a natural corollary of other programmes – military vehicles – carried out on this range since 1990.

5 Commercial Programmes

These programmes, which clearly focus on applications, fall into three groups: transport vehicles, communications platforms and observation platforms. Some of these activities are conducted under Agreements signed by CDTI with other institutions (INM, MoD, Hispasat, etc.) to obtain industrial returns (offsets) for major orders placed by these institutions in foreign aerospace companies. In other cases, they are connected with internal industrial developments also supported by CDTI.

5.1 Transport Vehicles

This group covers activities carried out by Spanish companies for the supply of components and services for Ariane vehicles or their operations. Spanish companies have a combined share of 2.47 % in Arianespace.

Most of this work is done by the EADS-CASA space division, which has developed and manufactured structural components for all Ariane vehicles since 1985. EADS-CASA manufactures payload adapters and the structure of the upper-stage equipment bay for Ariane-5 and it supplied the structure of the equipment bay, the cylindrical structure of the first stage, most of the payloads adapters, the safety and switching electronics and the anti-POGO valves for Ariane-4. Other companies working in this area are CRISA, which produces the sequential electronics for Ariane-5, and GTD and INSA, which have developed specific services software and provide operational support at CSG-Kourou.

In the US market, EADS-CASA has won two contracts with Lockheed Martin to supply structural elements for the Atlas-5 launch vehicle.

5.2 Communications Platforms

The most important activity in this group is associated with the Hispasat company. The Hispasat programme resulted from an INTA initiative in 1989, when it called for a basic specification and proposal for a communications satellite. The specification was based on a highly innovative concept, contrary to normal practice at the time, combining communications services – civil and military – with direct broadcasting of TV signals. Also – another world first – to avoid a problem encountered then as now, the design allowed reception of these TV signals at home with a very small antenna, which could be located inside any window facing in the right direction, with no visual impact on the local environment. The proposed concept made use of the capabilities of the most advanced European platforms, thus providing a highly competitive commercial design and an excellent opportunity for Spanish and European industry.

Once the design had been approved by the General Secretary of Communications at the MTTC[33], INTA issued a call for tenders and an inter-ministerial board was formed, involving the MoD (INTA), MTTC and MINER[34] (CDTI) to evaluate the bids, negotiate industrial returns and make the contract recommendation to the MTTC. The MTTC, after approving the recommendation, established a company, Hispasat, which signed a contract with the French company MATRA to deliver two units.

Hispasat has gone from strength to strength and today has three units in orbit (1A, 1B, 1C) and another in production (1D), the last two under contract to the French company Alcatel. It has set up a subsidiary in Brazil, Hispamar, which is working on the Amazonas unit oriented (61º W) towards American regions where the coverage of Hispasat units is marginal or non-existent. As a result of the

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[33] Ministry of Transport, Tourism and Communications.
[34] Ministry of Industry and Energy.

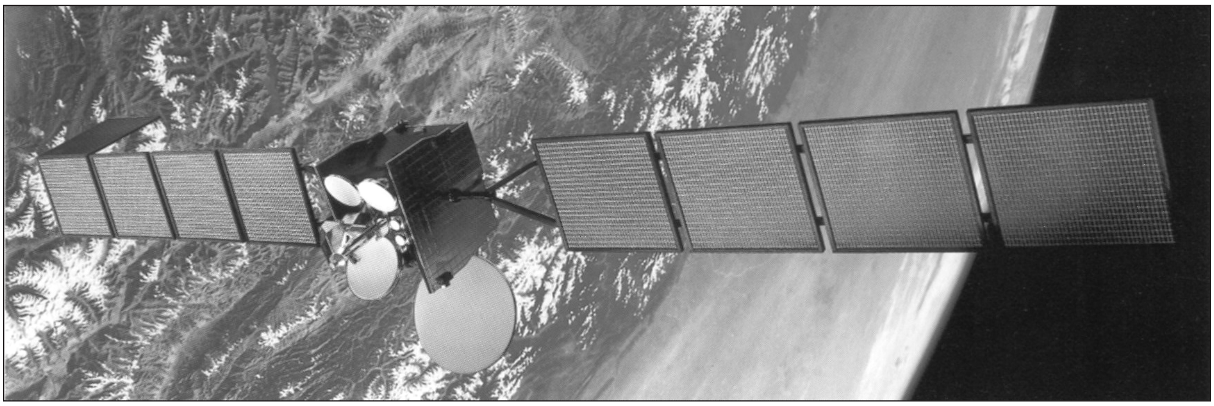

Figure 18: Hispasat 1

preliminary negotiations led by CDTI, all Hispasat platforms contain a high percentage (not less than 30 %) of components produced in Spain. In the case of ground stations, the percentage is even higher.

The first two platforms are nearing the end of their operational life and will have to be replaced, together with the military payloads on board. This led to the establishment in 2001 of a new company, Hisdesat, owned by Hispasat and some other aerospace companies, to commercialise two new satellites for military use. The first, Spainsat, will be directly managed by Hisdesat and fully dedicated to the Spanish MoD. The second, XTAR-EUR, will be managed by another company, XTAR, in which Hisdesat owns 49% of the stock and Space Systems Loral the remaining 51%. This second satellite is intended to provide additional accommodation for the first unit, any remaining capacity being rented out to other military users. Both satellites are being manufactured by Space Systems Loral, with substantial Spanish participation.

The Hispasat and Defence satellites have been of great benefit to Spanish industry, since in every case CDTI has negotiated offset programmes representing important business opportunities for Spanish companies, after signing agreements with the procuring agency or company**.** As a result, Spain has produced many items of equipment and components for foreign commercial satellite programmes. Thus, INTA has supplied S band flight antennas, CRISA digital and power flight electronics, RYMSA antennas, Alcatel Espacio digital and RF flight equipment, INDRA ground stations and CASA on board reflecting antennas.

In the field of satellite communications, mention should also be made of the services provided by Hispasat, with its own platforms, and by INSA, with VSat systems using Loral platforms and with global store and forward communication satellites using Orbcomm platforms.

5.3 Observation Platforms

The main activities in this group are the reception at the Maspalomas ground station (Canary Islands) of data from several Earth observation satellites for ESA-ESRIN and NASDA, the development of Fuego, a forest fire detection and monitoring satellite constellation promoted by INSA, and the delivery of equipment for observation satellites.

The Fuego project was initiated as a possible and feasible commercial application of the Minisat platforms. It is dedicated to detecting incipient forest fires and monitoring their evolution. Its ground segment processes the data and supplies value-added information to fire-fighting teams in real time and on the spot. The future of this programme is protected by the direct participation of national and international potential users, many of which are already involved in the development work, and by the interest shown not only by these users but also by CDTI, the EU and finally ESA, which has included the project in its Earth Watch programme. Other European companies, including Officine Galileo, the Sema Group, and Alcatel Space, have also joined the programme.

The Fuego system consists of four sets of three satellites placed in four different orbital planes, forming a total constellation of 12 satellites providing continuous coverage 24 hours a day. They are equipped with four visible and infrared sensors and are controlled from a central station, accessible through small regional or portable stations based on a small antenna and a PC.

Flight equipment for various Eumetsat and SPOT platforms is produced under contracts obtained as a result of agreements negotiated by CDTI with MMA[35] and INM on appropriate offsets for Spanish firms.

[35] Ministry of the Environment.

6 Defence Programmes

6.1 Earth Observation

The tasks of detection, reconnaissance, identification and description of objectives of military interest is currently performed in Spain mainly by Helios 1 satellites. The development of the Helios system was initiated by France in 1986. Italy joined in the following year with a 14 % participation and, on 9 November 1988, Spain too joined with a 6 % participation. The first satellite, Helios 1A, was placed in orbit in July 1995 and began operating at the end of that year. The second, Helios 1B, was launched in December 1999. The Government has recently approved Spanish participation in the Helios 2 programme.

Spanish utilisation of Helios satellites is based on two centres:

- the Spanish centre for image reception (CRIE) located at the Maspalomas ground station (Canary Islands), which receives some of the images taken and transmitted by the satellites; and
- the Spanish main Helios centre (CPHE) located at the Torrejón AFB, close to Madrid, which participates in the day-to-day programming of the satellites' activity, and processes and exploits the images.

These centres are operated by the Defence High Command and administered by the Air Force.

Helios is the first Earth observation programme of the Spanish Armed Forces. Military personnel have had to be trained and specialised military units set up to ensure correct use of the system and the images. The images obtained have been used to plan and develop military operations in places such as Bosnia, Yugoslavia, Albania, Africa, Kurdistan, Central America, for treaty verification purposes, etc. They have also enabled a database to be compiled, containing several thousand images of zones of military interest to Spain.

Another activity in this field is the development of the Isthar, an optical observation spacecraft based on the experience gained in the development and satisfactory operation of the first Minisat satellite.

6.2 The WEU Satellite Centre

The decision to establish this centre, which can be regarded as an important milestone in European Defence Policy, was taken by the WEU Council of Ministers in 1991, when the Spanish proposal to have the centre installed in Torrejón AFB was accepted.

It was inaugurated on 28 April 1993, with the following missions: to develop methods for interpreting the satellite images, to train technicians in the analysis of images, to set up a European database, to help in the verification of compliance with disarmament treaties, and to evaluate any environmental disaster.

The centre[36] does not control any satellites but uses commercial images taken by civil satellites, such as the French SPOT, the US Landsat and the European ERS. It also sometimes buys images of higher quality and resolution taken by the Helios satellites, by prior agreement with the owners of the system (France, Italy and Spain).

6.3 Space Communications

The space system of military communications by satellite, Secomsat, is part of the Spanish Ministry of Defence's integrated system of military transmissions (SCTM).

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[36] EU Satellite Centre since 1 January 2002

Its space segment is the government payload on-board the Hispasat 1A and 1B satellites placed in geostationary orbit at 30º W. This payload was defined with coverage of all areas of strategic interest to Spain and consists of two transponders in the X-band (7-8 GHz). The MoD has recently approved the procurement of two new satellites Spainsat and XTAR-EUR to replace the first group of government payloads (see Chapter 5, Commercial Programmes). An agreement has been reached between CDTI and MoD to obtain appropriate offsets for this procurement.

When it became clear in October 1992 that the planned ground segment would not be available on time, the MoD accepted an INTA proposal to set up a reduced system within three months. This system (CICSAT) inaugurated the service to the Spanish military mission in Bosnia and to the Fleet Combat Group. In 1993, the delivery of the ground segment was finally started with substantial participation by Spanish firms. It comprises a control and resources allocation centre, located at Bermeja (Madrid), which administers the use of the government payload on the satellites, a link with the Hispasat satellite control centre at Arganda (Madrid), and user terminals.

Annex 1. Chronology

Year	Europe	Spain
1955	Blue Streak Project	
1956		
1957	**Sputnik 1**	
1958	COSPAR	
1959		
1960	COPERS	COPERS membership MoU INTA- NASA. Canary Station
1961	EUROSPACE	Courses on Space Technologies Course on Servo systems Course on Guidance NASA Station in the Canary Islands
1962	1st satellite UK (Ariel 1)	
1963		
1964	ESRO ELDO 1st satellite Italy (S. Marco 1) Intelsat (provisional)	CONIE ESRO membership MoU CONIE-NASA. Meteorological programme MoU INTA-NASA. Madrid Stations
1965	1st satellite France (Astérix) 1st launcher France Diamant	New laboratories INTA 255 Project NASA Station at Robledo Mars images received at Robledo
1966		Arenosillo Range MoU CASA-Sud Aviation. Sounding rocket payloads Contract ESRO-SENER for Kiruna NASA Station at Cebreros COSPAR membership
1967		NASA Station at Fresnedillas
1968	1st satellite ESRO (ESRO II) 2nd satellite ESRO (ESRO I) 3rd satellite ESRO (HEOS A)	1st Space Plan Delivery of Kiruna Tower Delivery first rocket payloads
1969	1st European comsat (Skynet I. UK) 1st sounding rocket Spain	Intasat Project INTA 255 rocket launch INTA 300 Project 1st man on the Moon
1970	1st satellite BDR(Dial I)	
1971	Intelsat final agreement	
1972		MoU CONIE-NASA. Intasat launch INTA takes full responsibility for operating all NASA stations
1973		Large 63 m antenna at Robledo
1974	1st satellite Netherlands (ANS) 1st satellite Spain	INTA 300 rocket launch 1st satellite (Intasat)launch

1975	**ESA**	
1976		Villafranca Station INTA 300G Project
1977	Eutelsat Meteosat 1	Eutelsat membership
1978	OTS 2 - ISEE 2 - IUE	
1979	Inmarsat - Ariane-1 Cospas SARsat	Umbilical Tower Ariane-1
1980	Arianespace Marecs A	Arianespace membership
1981		
1982		Integration system for Spacelab
1983	Spacelab - ECS 1	
1984	Telecom 1A	
1985		
1986	Eumetsat SPOT 1	New Science Act. CONIE closure CDTI Delegation to ESA Eumetsat membership Large 70 m antenna at Robledo
1987		4th 34 m antenna at Robledo
1988	Ariane-4 - TDF 1	Helios 1 Membership
1989	Hipparcos - Mop 1 Olympus DFS Kopernikus	Hispasat
1990	Ulysses - Hubble Eutelsat 2 - SPOT 2 Inmarsat 2	Capricornio Project
1991	Italsat 1 - ERS 1	Spanish astronaut selection
1992	Eureca 1	Hispasat 1A – Cicsat launch
1993	SPOT 3	Hispasat 1B – Secomsat launch WEU Satellite Centre at Torrejón
1994		
1995	Giotto - SOHO ISO - ERS2 - Helios 1A	UPM SAT launch
1996	Ariane-5 - Inmarsat 3 IUE switched off	1st Spanish principal investigator in Integral
1997	Huygens	5th 34 m antenna at Robledo Helios 1A launch Minisat launch MoU CDTI-Hispasat. Offsets H1C MoU CDTI-MMA. Offsets METOP/MSG
1998	Spacelab last flight SPOT 4	NASA STS 95. 1st Spanish astronaut
1999	XMM-Newton	Helios 1B launch MoU CDTI-AENA. EGNOS. Galileo
2000	Cluster MSG	Hispasat 1C launch Hisdesat programme MoU CDTI-Hispasat. Offsets H1D MoU CDTI-INM. Offsets Eumetsat

Annex 2. Financial Data

YEAR	ESRO/ESA	NATIONALPLAN	NASA	INTA	DEFENCE	COMMERCIAL OPERATIONS	TOTAL MPta	Exchange Pta/AU	TOTAL M
1960	0	0	0	*4*	0	0	4		
1961	0	0	0	*4*	0	0	4		
1962	0	0	0	*4*	0	0	4		
1963	0	0	0	*4*	0	0	4		
INTA TO CONIE TRANSITION									
1964	33	5	0	*1*	0	0	39		
1965	58	21	0	*5*	0	0	84		
1966	44	26	+	*5*	0	0	75		
1967	90	25	82+	*5*	0	0	202+		
1968	15	82	93+	*16*	0	0	206+		
1969	36	100	127+	*20*	0	0	283+		
1970	55	100	155+	*20*	0	0	330+		
1971	104	100	196+	*20*	0	0	420+		
1972	101	94	236+	*18*	0	0	449+	72,203	6,2+
1973	273	172	252+	*35*	0	0	732+	71,812	10,2+
1974	268	159	332+	*32*	0	0	791+	68,823	11,5+
1975	370	164	415+	*32*	0	0	981+	71,159	13,8+
ESRO TO ESA TRANSITION									
1976	748	153	495	*30*	0	0	1.426	72,602	19,6
1977	1,066	75	535	*15*	0	0	1.691	74,539	22,7
1978	1,677	78	618	*16*	0	0	2.389	78,357	30,5
1979	343	78	747	*16*	0	0	1.184	97,885	12,1
1980	2,362	79	876	*16*	0	0	3.333	98,400	33.9
1981	1.504	80	963	*16*	0	0	2.563	99,632	25,7
1982	1.511	71	1.027	*14*	0	0	2.623	100,728	26,0
1983	2.340	96	984	*20*	0	0	3.440	106,786	33,2
1984	2.571	217	1.083	*43*	0	0	3.914	127,837	30,6
1985	4.538	190	1.077	38	0	483	6.326	126,303	50,1
CONIE TO CDTI TRANSITION. SPANISH NEW ACT OF SCIENCE									
1986	3.938	256	1.255	*52*	0	782	6.283	128,021	49,1
1987	6.678	275	1.214	*55*	0	1.192	9.414	137,410	68,5
1988	7.064	1.915	1.307	*150*	0	1.588	12.024	144,062	83,5
1989	7.945	1.923	1.307	*160*	1.000	7.453	19.488	137,350	141,9
1990	9.450	2.060	1.362	288	2.200	14.812	30.172	137,350	219,7
1991	12.998	1.230	1.425	171	2.300	14.754	32.878	131,957	249,2
1992	14.489	810	1.564	731	3.109	5.558	26.261	128,157	204,9
1993	11.914	756	1.630	983	3.254	2.531	21.068	129,018	163,3
1994	14.843	662	1.509	2.961	665	3.118	23.758	150,332	158,0
1995	15.584	805	1.486	2.443	1.369	3.797	25.484	159,017	160,3
1996	18.164	889	1.617	1.731	1.444	5..006	28.851	161,907	178,2
1997	13.712	1.547	1.702	2.211	1.672	15.938	36.782	160,328	229,4
1998	12.275	752	1.647	2.682	1.543	19.183	38.082	163,542	232,9
1999	16.998	1.431	1.594	2.602	1.138	21.422	45.185	166,383	271,6
2000	14.492	858	2.007	1.484	1.719	18.313	38.873	166,386	233,6

Origin of data: Eurospace, CASA, INTA, CRISA, INSA, ESA, INDRA, CDTI and M. Bautista
The area in grey shows years for which data from Maspalomas Station is not yet available
Figures in italic are best guesses in the absence of proper accounting per application (about 20% of National Plan column)