History of Rocketry and Astronautics

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Front Cover Illustration:

Professor Luigi Broglio (left) in discussion with U.S. Vice President Lyndon B. Johnson during a visit to the Centro Ricerche Aerospaziali (CRA) at the Urbe airport near Rome, Italy. The photo was taken in September 1962 on the occasion of the signature of the Intergovernmental Agreement for Space Cooperation between the United States and Italy leading to the San Marco project.
Source: Prof. Carlo Ulivieri, University of Rome.

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Chapter 9

Luigi Broglio: The First Italian Space Dreamer*

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Abstract

Italians generally believe that their country has nothing to do with space. Everyone is aware of the achievements of great scientists such as Guglielmo Marconi or Enrico Fermi, but only a few people know anything about the figure of Luigi Broglio. Aerospace engineer Theodore von Kármán tagged him "the space man" and he represents, beyond any doubt, the father of the Italian space program. His professional activity spans a great part of the 20th century, and it represents an ideal bridge between the first successes achieved by Italian aviation and the first steps moved in the space field. Broglio embodied better than anyone else the spirit of this congress "from imagination to reality": the perfect mix of the Ulysses spirit with a brilliant mind. His biography recounts a life of service, honor, and traditional values. Broglio has always been known for his integrity, common sense, courage, and leadership. Under the lead of this strong and lone man, Italy reached incredible goals, such as the first European supersonic wind tunnel and space simulator and the first worldwide equatorial launch site, the San Marco platform, from which it is possible to inject a satellite into a direct equatorial orbit. Italy was the third country to launch a satellite after the Soviet Union and the United States. In 1971 NASA officially recognized the San Marco team

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as the best launch team of the year. Luigi Broglio wished to create a school, a culture, a tradition for his country and he is, still today, a powerful source of inspiration in an age that needs, more than ever before, the values that Luigi Broglio personified. The aim of this chapter is to give a simple behind-the-scenes account of the life of a man who held in his hands the first and, at the same time, the greatest Italian space enterprise, as a posthumous thank you.

Story of a Spaceman

U.S. President Dwight Eisenhower said: "Neither a wise man nor a brave man lies down on the tracks of history to wait for the train of the future to run over him." This is the story of a wise and brave man who wholly dedicated himself to the aeronautical and astronautical sciences. Born in 1911, Luigi Broglio's life spans a great part of the 20th century, a time of cultural earthquakes. The Wright Brothers made their first flight only eight years before his birth, and the airplane was still a handmade toy.

After graduating in 1934 in civil engineering and in 1938 in aeronautical engineering at the School of Aeronautic Engineering in Rome, Broglio enrolled as a lieutenant in the Italian Air Force. Later on, in 1940, he graduated also in mathematics and physics. During World War II, he dealt with war fighter designs: in particular he worked on the RE-2005, a jet plane. This plane had been the first jet plane built in Europe.

In 1946 he became a professor. In 1949 Broglio was invited to be a visiting professor in the United States at Purdue University in the city of West Lafayette, Indiana. The U.S. government offered him the chance to become a citizen, but he refused and eventually returned to Italy. Not long afterward, the U.S. Air Force offered him the opportunity of collaboration, and Broglio proposed a research on blow-down wind tunnels. In 1952 he was elected dean of the School of Aeronautical Engineering. Here he built, with his best students, the first European Mach 4 wind tunnel using some old compressors and tanks refurbished from dismissed submarines. All was done in a very pioneering way, and accidents did happen; for instance, the first test caused the crumbling of a wall. Some years later, thanks to the foresight of the Aeronautical Secretary General, Broglio and his team were able to pursue their research in an old airport in Rome. But they still needed funding, so Broglio had the nerve to ask for money from the government, the Italian Air Force, and even to Theodore von Kármán, then president of the Advisory Group for Aeronautical Research and Development (AGARD). So thanks to his own audacity, Broglio realized the first European Mach 6 (blow-down) wind tunnel.

Higher and Higher

In 1956 the Italian Air Force called him to direct the Arms and Ammunitions Research Department, which was involved, among other things, in missile research. At that time no one in Italy knew anything about space technology. Even within the university there were only sporadic mentions to missile technology. This opportunity and his innate thirst for knowledge turned him from a world-class expert in aeronautics to a resolute seeker of real possibilities to fly into space. This was not a painless choice, because the U.S. Air Force axed funds to his researches. Also Theodore von Kármán mocked him with the name-calling of "space-man." Broglio was seen in America as a traitor to the aeronautical cause, because he was considered the best aeronautical structurist.

Figure 9–1: Luigi Broglio.

Professor Broglio's generation was traumatized by two world wars, and many of them identified themselves as survivors and dedicated themselves to creating the structures for a different world. Their vision was often illogically optimistic and generous. Many of them had the courage to change careers, to re-educate themselves in new fields, and to work toward a better future.

Broglio's first move as "space-man" was the institution of a two-year course on missile technology at the University of Rome. At the same time he tried to introduce a degree in aerospace engineering: he convinced the Italian Air Force to attempt this new challenge, and he tried to create new cooperation. He

talked to them about the economic benefits that space activities might bring to society. Some benefits take the form of public goods, other of services. Some are delivered through government space efforts, others result from profitable commercialization of space activities by private industries.

History changed when in October 1957 the Soviet Union successfully launched *Sputnik 1*. While the *Sputnik* launch was a single event, it marked the start of the space age. Immediately after, the U.S. Department of Defense responded to the political furor by approving funding for another U.S. satellite project. Wernher von Braun and his Army Redstone Arsenal team began work on the Explorer project. Broglio's foresight turned out to be right. His activities in the early 1950s marked the beginning and the earliest substantial development of Italian space activities and would eventually bring Italy to be the third country in the world, after the Soviet Union and United States, to send a satellite to orbit (*San Marco A*, 1964).

Broglio's Intuition: The Equatorial Launch Facility

Broglio's greatest insight was the need for Italy to have its own launch site. After many considerations, an equatorial platform seemed to be the best choice, because the Italian launch site would have been the first equatorial one. This was highly desirable for the following reasons. First, when launching a satellite, the lowest inclination of the orbit plane achievable equals the latitude of the launch site. This means that if the launch occurs in an eastward direction from a site that is located at 28° of latitude (as is the case for Cape Canaveral), the orbit plane will be inclined at 28° with respect to the equatorial plane. Thus, the only way to launch directly into an equatorial orbit is to have an equatorial launch site; this also means that it's the only site from which all orbit inclinations can be achieved directly. Second, for nearly equatorial satellites, an access to the station occurs on every orbit; it's likely then that only one station is needed for uplink and downlink.

Third, the weather meets launch conditions for most parts of the year. The choice of using a sea platform instead of a terrestrial launch site was driven mainly by the need to avoid transporting the rocket by road as much as possible. Otherwise, huge funding would have been needed to adapt the local road system to the launch site needs. Three countries were selected to host the Italian platform: Somalia, Kenya, and Brazil. Kenya was the final choice because of the weather and the proximity to Italy.

The Birth of the Italian Space Centre

The Italian Space Centre is made up of two segments: the marine segment represented by the launch oceanic platform and the Earth segment represented by the data receipt center. The sea segment consists of two platforms: San Marco (named after the patron saint of navigators) platform was a former oil rig, located to the north of Cape Ras Ngomeni on the coastal sublittoral of Kenya, close to the equator. It was a U.S. military asset, which the National Aeronautics and Space Administration (NASA) donated to Broglio. The second platform, named the Santa Rita (after the patron saint of things impossible), was given at a very low price from the then president of the Italian Energy Department (ENI), Enrico Mattei. She too was a former oil rig, and was positioned southeast of San Marco.

Figure 9–2: The San Marco platform.

The San Marco acted as the actual launch pad, while the launch control room was located on the Santa Rita. The Centre (longitude: 40.19° E, latitude: 2.99° S) covers an area of about 3.5 hectares on the coast of the Indian Ocean 32 kilometers away from Malindi and may be reached through the littoral zone of Kenya. While the soil is a property of the Republic of Kenya, the management was entrusted to the San Marco Project Research Centre (CRPSM)* until 31 De-

* Italian acronym for Centro di Ricerca Progetto San Marco – University of Rome "La Sapienza," Italy.

cember 2003 and to the Italian Space Agency (ASI)* starting 1 January 2004, in accordance with the intergovernmental agreements between Italy and Kenya currently in force.

The presence of the Centre within the territory of Kenya, which dates back to 1966, is today ruled by an intergovernmental 15-year renewable agreement signed in 1995. This agreement involves the possibility to carry out launch activities, data acquisition from satellites, and remote sensing and training activities, both in Kenya and in Italy. Italy defines the programs, supplies the necessary equipments, and trains and takes on local employees. Kenya grants the soil under the payment of a rent by Italy, and also trains and takes on local workers. The local government must be informed about activities taking place at the Centre and asks, for commercial programs, a royalty depending on the terms of the commercial agreement. After 15 years, equipment becomes the property of Kenya. The Earth segment involves many buildings (made of masonry and wood, used as accommodations and services); a small seaport (for docking the ships serving as a link with the platforms): and three Earth stations (antenna systems for the in-orbit control and telemetry download from satellites and launch vectors). The three stations are the following:

- S-Band station, equipped with a 10-meter parabolic antenna used for the agency programs;
- S/X/L Band station, equipped with a 10-meter parabolic antenna used for the control of launch vehicles (Arianespace, Titan) and to give support to the first phases of commercial satellites flight (LEOP);† and
- X-Band station, equipped with a 6-meter parabolic antenna used to receive remote sensing data (ERS-2, Spot, Landsat).

The Centre is linked to Italy through Intelsat in the context of an ASI network. In 2001, after Professor Broglio's death, ASI renamed the launch site Luigi Broglio Space Centre in his honor. Beginning in 2004, and the name changed from the previous San Marco Equatorial Range to Broglio Space Centre (BSC). While the ground station is still in use for satellite communications, the BSC is not currently used as a launch site.

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* Italian acronym for Agenzia Spaziale Italiana.

† Acronym for Launch and Early Orbit Phase.

Figure 9–3: Luigi Broglio Space Centre in Malindi.

San Marco Project: A Fruitful Cooperation with the United States

In 1959 the collaboration in the space field between the United States and Italy was renewed. NASA and Broglio's team worked together in high-altitude dynamics. The objective of the experiment was to perform the same measurements in Sardinia and in the United States and make a comparison between the results. To this end a little launch site was also realized in Sardinia, Perdas Is Furonis, to launch a liquid propelled rocket probe. The experiment was successfully performed in 1961, and this guaranteed a better relationship with NASA.

The "San Marco" Project conceived and directed by Professor Broglio was born in 1962. Representatives of NASA and the Italian Space Commission of the Italian Research Council signed the Memorandum of Understanding. Such agreement regarded cooperation in a scientific experiment, which had the objective to perform measurements of atmospheric and ionospheric characteristics and make the resulting scientific data freely available to the world scientific community.

The experiment consisted of launching into a Low Earth Orbit two Italian-built satellites. The first (*San Marco A*) was to be launched from the NASA Wallops Station launching facility, while the launch of the second satellite (*San Marco B*) had to take place from the Italian complex in Kenya using a Scout

rocket provided by NASA. Launch operations were conducted by a completely Italian team trained by NASA technicians.

San Marco A successfully took off from Wallops on 16 December 1964. The satellite was built as follows: an external spherical shell, which was connected by means of a spring-light device to an internal shell carrying all the hardware and instruments. Therefore the satellite was very sensitive to surface forces, such as aerodynamic drag. It provided in fact, for the first time, very precise measurements of the upper atmosphere density. *San Marco B* successfully launched from the Malindi range on 26 April 1967.

The last satellite in the series, *San Marco D/L*, was placed in an orbit that ranged in altitude from about 118 to 279 miles, circling Earth every 93 minutes. The roughly spherical device carried five scientific instruments: Italy's contribution was a Neutral Atmosphere Density or "drag balance" experiment, known as "Broglio's balance," designed to measure drag forces on the satellite. From West Germany came an Airglow Solar Spectrometer, a multipurpose device to measure solar radiation reflected from Earth's surface and clouds; radiation of solar, interplanetary, and intergalactic origin that reaches the satellite directly; and the equatorial day and night airglow (observable light that originates in the high atmosphere and is associated with photochemical reactions of gases).

Three U.S. instruments completed the package: a wind and temperature spectrometer measured the electromagnetically neutral winds and neutral particle temperatures around the satellite, and also concentrations of selected gases. Another device monitored the electric fields through which it passed. A third sensor reported on bulk ion velocities and ambient plasma concentrations, which bear on such fundamental matters as the nature of plasma turbulence and of the coupling between ionized and neutral-gas motions.

The San Marco launch platform was in use from March 1964 to March 1988, with a total of 27 launches, primarily sounding rockets including the Nike Apache, Nike Tomahawk, Arcas, and Black Brant launchers. Low payload weight orbital launches were also made, using the solid-propellant Scout rocket (in its B, D, and G subvariants). The first satellite specifically for X-ray astronomy, *Uhuru*, was launched from San Marco on a Scout B rocket on 12 December 1970. In 1971 NASA awarded the San Marco team, after the 15 November SSS-1 satellite launch, as best launch team of the year.

Figure 9–4: Scout launches the last San Marco satellite.

First Signs of Decay

Since 1961 Broglio's team could have built an Italian rocket in cooperation with the United States thanks to the United Technology know-how. It would have been a solid propelled rocket, built by Fiat. In the end, political reasons prevented Italy from having its own launch vehicle. This was only the first in a long series of opportunities that Italy lost. In 1961 a European agreement with the aim to build a European rocket was born: European Launcher Development Organisation (ELDO). This initiative represented a burden to the possibility to have an Italian rocket. This event signed the beginning of the decay in the Italian aerospace researches.

In 1968 after the failure of the European project for the vector ELDO Perigee-Apogee System (ELDO-PAS), the story of the first Italian communications satellite, *Satellite Italiano Ricerca Industriale Orientata* (*SIRIO*), started. The story up to the launch in 1977 involved the encumbering legacy of the San Marco satellite's success in the 1960s, political uncertainty in Italy, international economic crises of the 1970s, an overtly complex management system, and an inexperienced aerospace industry. Despite these handicaps, *SIRIO* won the race with its nearest competitor, the European *Orbital Test Satellite* (*OTS*), which had a similar research aim in the super-high-frequency band. In addition to collecting a large amount of useful data, *SIRIO* catalyzed the process for developing an improved organizational structure for Italian space research.

Unfortunately, in this period, European partnership was not fruitful. In particular the cooperation with France was not as good as the one with the United States. Americans gave experience, facilities, and rockets; Broglio's team gave them ideas and designs to realize. Unfortunately after the Apollo program, everything changed: in a paradoxical way the greatest event of the 20th century, the conquest of the Moon, represented the end of the space race.

The period between 1967 and 1970 was characterized by a complete lack of funding and by a meaningless thwarting of San Marco team plans between scientific engagement and managerial inexperience. The importance of space activities was poorly understood by citizens and politicians alike. Still today, space and space technologies are not in their minds when they make use of these services as final consumers, forgetting that without the satellite network surrounding Earth most of these facilities would not be available.

Notwithstanding the ever-increasing potential of space technology to provide cost-effective solutions to many of humanity's pressing needs, the financial and political realities today, and also in Broglio's time, mean that there are other priorities competing for limited resources. The major challenge for the space community is to convince policy makers and industry leaders that the development and application of space technology warrants continued investment. The national space agencies play in support of national commercial space industries and big international partnership. This is not wrong but support for the non-commercial sector of space, such as space science, by national agencies is often a less contentious issue than the support provided to the commercial sector, such as the satellite communications industry. Nothing is worse than the active ignorance of our politicians.

The Professor's Heritage

Broglio represents, beyond a shadow of a doubt, the father of Italian and European astronautics, thanks to his internationally recognized scientific charisma and to his foresight. Broglio's foresight and perseverance allowed Italy to be, in the early 1960s, in the frontline of aerospace research, following the United States and the Soviet Union. During this time Italy had a significant advance in space technologies and astounding scientific discoveries. Experiences, both positive and negative, that have been encountered in Broglio's professional life should represent, today, lessons learned.

Younger people will be responsible for developing and enhancing current space activities, education, and awareness; they can play a significant role as the workforce of tomorrow, making space appealing to younger students and pushing

the boundaries of space exploration. Broglio's professional life should inspire vigor and energy in the new generation of space leaders, who dare to dream big and work powerfully to overcome their limits.

The School of Aerospace Engineering in Rome

Professor Broglio's heritage is still present in the School of Aerospace Engineering in Rome: everything, in the daily work talks about him. There are some professors who worked on San Marco's team; others are still today part of San Marco Project Research Centre (CRPSM), a research center of the University of Rome, "La Sapienza," that represents the continuation of the San Marco Project (SMP). From the very beginning, SMP, and later CRPSM, developed and actively pursued fruitful and mutually rewarding cooperative programs, mainly with NASA and, over time, with several Italian and foreign organizations, such as the European Space Agency (ESA), Italian Air Force (AMI), National Council of Research (CNR), Italian Space Agency (ASI), U.S. and European universities (Texas, Michigan, New Hampshire, Max Planck Institute, et cetera).

Moreover following in the pioneer footsteps, a University Satellite (UNISAT) program was established in late 1990s at the School of Aerospace Engineering in Rome. It is an educational project with the aim to involve students, researchers, and professors in designing, manufacturing, and operating in orbit small microsatellites. Most of the UNISAT satellites components are based on commercial off-the-shelf (COTS) technology. This keeps program costs low and affordable for the university. The main goal of the UNISAT program is educational, with the aim of student participation in all the phases of a real space program, from the initial mission concept design to in-orbit operations. There is a strict time constraint on the mission development, which must fit in the two year's didactical plan of the students. In the framework of this project four microsatellites have already been launched from the Baikonour Cosmodrome using the Dnepr launch vehicle. The program has now achieved an experience of several years, in which the methods of hands-on education have been employed, along with traditional class teaching, to improve the students' skills. All the UNISAT program purposes reflect the life philosophy of Professor Broglio: economic saving, hands-on method, and international cooperation.

Every year Giorgio Di Bernardo Nicolai, a scientific reporter involved in the astronautic field, holds a seminar about astronautical history in which he narrates with passion to new students about Professor Broglio and his deeds. Di Bernardo also wrote Broglio's biography and this enlightening book is given to the students during the graduation ceremony as a good wish, to never forget the

pioneering spirit that should guide them. Yesterday's dreams are a reality today. Today's dreams might be a reality tomorrow, if people keep that spirit alive.

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