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CARLOS BETTENCOURT FARIA'S DREAM: THE MULEMBA ASTRONOMICAL OBSERVATORY AT LUANDA IN ANGOLA

Maria Almeida
Physics Department, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal.
E-mail: mariaga@ua.pt

and

Vitor Bonifácio
Physics Department, Research Centre on Didactics and Technology in the Education of Trainers (CIDTFF), University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
E-mail: vitor.bonifacio@ua.pt
(Corresponding Author)

Abstract: Mulemba Astronomical Observatory, later known as the Mulemba Space Centre was founded in 1958 on Luanda's outskirts in Angola, then an African Portuguese colony, by the polymath Carlos Mar Bettencourt Faria. Being, from all accounts, a charming and knowledgeable individual who was mainly self taught, he managed to build several radio telescopes, a solar observing station, a state-of-the-art electronics laboratory and a satellite tracking facility. Financial support was obtained from a variety of individuals, commercial companies, public institutions and from 1971 onwards Angola's national government. Faria's ambitious plans were nevertheless always thwarted or delayed by lack of funds. In 1973 data started to be collected at the solar station but the whirlwind of 1970s politics had a decisive impact in Angola. Faria's beautiful dream effectively ended when he was assassinated at the Observatory in 1976. In this paper we recall Carlos Bettencourt Faria's life and his battle against all odds to establish a professional-level astronomical observatory in Angola.

Keywords: Mulemba Astronomical Observatory, Carlos Bettencourt Faria, radio astronomy, satellite tracking, solar observations

1 INTRODUCTION

As is well known, radio astronomy is an offshoot of radar technology developed during World War II. After the war, physicists and radio engineers involved in radar research used available equipment for their research and became the first generation of professional radio astronomers (Sullivan, 2009; Verschuur, 2007). For example, in Australia, Joseph Lade Pawsey (1908–1962), head of the Radio Astronomy group at the Commonwealth Scientific and Industrial Research Organisation's Division of Radiophysics, devoted himself to the study of the Sun (Goss et al., 2023).

Following the pioneering steps taken in the USA in the 1930s by Karl Jansky (1905–1950) and Grote Reber (1912–2002), radio astronomy blossomed in Australia, Canada, England, France, Japan, the Netherlands, New Zealand and the USA in the immediate post-war years, and a series of discoveries followed (e.g., see Nakamura and Orchiston, 2017; Orchiston, et al., 2021; Sullivan, 1984). In 1946 it was found that solar radio emission was associated with sunspots and that the emitting regions had a temperature of one million degrees Kelvin. In 1947 the first solar radio bursts produced by solar flares were documented. In 1948 the Taurus A radio source was identified with an optical object, the Crab Nebula, and Centaurus A and Virgo A with faint anomalous extragalactic objects (Sullivan, 2009). Still, by the end of the 1950s the accumulated knowledge about radio astronomy was limited to a few optical sources; an emission mechanism (synchrotron radiation); an increasing recognition that most radio sources must be extragalactic; and approximately 100 catalogued objects, some of which were still subject to confirmation (Verschuur, 2007).[1]

At that time (1958) Angola's Carlos Mar Bettencourt Faria (1964) began the construction of the first Portuguese radio telescopes. Although there were astronomical observatories in Lisbon, Coimbra and Porto, none had radio astronomy capabilities. At Coimbra the solar spectroheliograph daily observations that started in 1925 were still carried out, notwithstanding the fact that no major original research was done following the unfortunate appointment of a new Director, Manuel dos Reis (1900–1992), following the mandatory retirement in 1934 of Francisco Miranda da Costa Lobo (1864–1945) and the untimely death of his son Gumersindo (1896–1952).

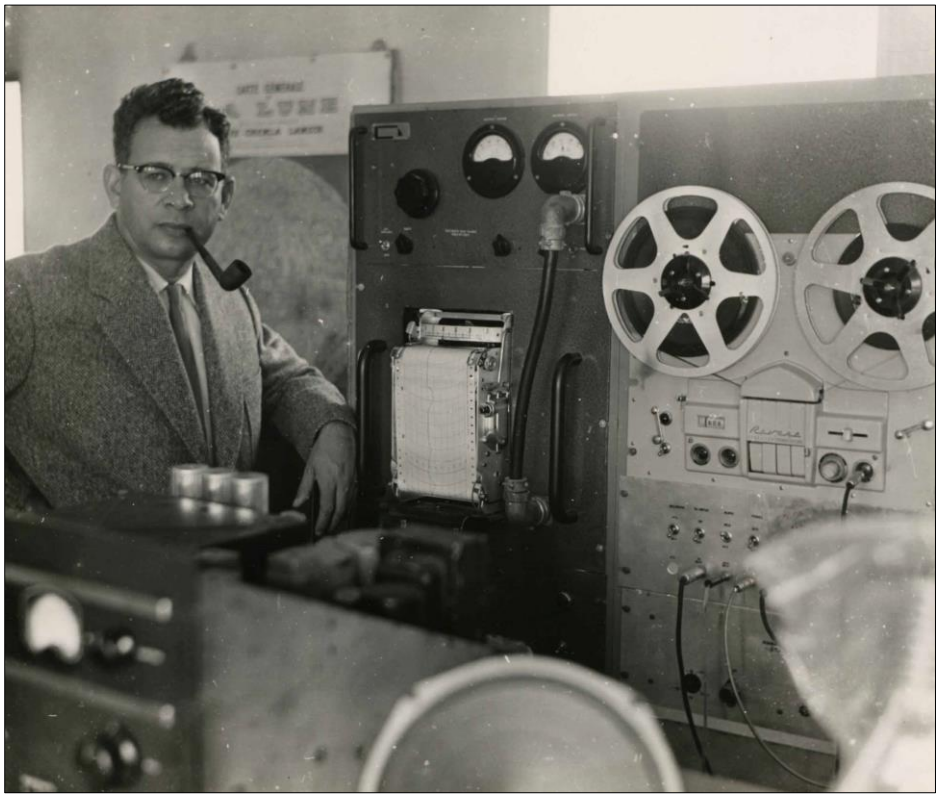


Figure 1: Carlos Mar Bettencourt Faria, owner of the Mulemba Astronomical Observatory photographed, most likely, in the early 1960s (courtesy: Calouste Gulbenkian Foundation, PT FCG FCG:SU- S002-FOTO01039, F04-16518).

2 CARLOS MAR BETTENCOURT FARIA'S LIFE

Carlos Mar Bettencourt Faria (Figure 1) was born in Anjos parish, Lisbon, on 13 February 1924. In 1930, due to his father's poor health and financial problems he moved with his mother and siblings to São Miguel Island in the Azores, where his maternal grandfather was a physician (Bettencourt, 2002b). There, the sight of the star-filled skies over the Azores generated his interest in space and astronomy (Payne, 1969). From a young age Faria showed a determined and inventive spirit. Aged 10 or 11 he repaired a broken physiotherapy device needed by his grandfather (Vida e morte, 1976). His formal education was acquired at Ponta Delgada, Azores, in the now-named Antero de Quental Secondary School and at the Funchal Industrial School on Madeira Island (Anonymous, 1976). After his father's death, he moved to Madeira where he lived with a great-uncle who was a priest and a radio, astronomy and marine biology enthusiast. These were interests that Faria would acquire (Bettencourt, 2002b; Vida e morte, 1976).

In 1944 he returned to Lisbon to do his military service and for two years was stationed at the Navy Administrative Services at Alfeite Arsenal. There he met commander Eugénio Correia da Conceição e Silva (1903–1969), a well-known amateur astronomer and astrophotographer (Bettencourt, 2002b; Ingalls, 1952). Later, he moved to the Azores as an employee of the Portuguese aviation company Transportes Aéreos Portugueses (Bettencourt, 2002b). Simultaneously he fuelled his passion for amateur radio, having stations CT1UX in Lisbon and CT2AB in the Azores (Barbosa, 1966).

In 1949, he married a cousin, Stela Maria Faria Patrício with whom he had two children, Maria do Mar (1951–) and Carlos Mar (1953–) (Bettencourt, 2002b).

In 1951, Faria moved to Angola to work for the local diamond company, Diamang, as a sound recording technician, designer and inquirer of local populations (Minga et al., 2019). At the same time, he continued to pursue his interest in radio, astronomy and marine biology (Barbosa, 1966; Vida e morte, 1976). It was in Angola that he passed the amateur radio operator exam and obtained the CR6CH code for his Mulemba station (Figure 2) (Barbosa, 1966). He also became very competent in electronics (Vida e morte, 1976) and at an undetermined date he graduated as a Radio Corporation of America (RCA) Electronic Engin-

eer (Anonymous, 1976).

In the 1950s he became convinced that it was "… indispensable for someone to make a sacrifice for the benefit of the community …" (Faria, 1964: 17) and to develop for Portugal the scientific fields of radio astronomy and astrophotography. So, with great financial effort, he bought a plot of land at Mulemba, on the outskirts of the city of Luanda, and in October 1958 founded the Mulemba Astronomical Observatory ('Observatório Astronómico da Mulemba') (Associação Astronómica de Angola, 1971; Faria, 1964; Vida e morte, 1976).

In 1962 Faria worked at Petrofina's oil refinery as head of the Mechanics and Electronics Departments, being responsible for a group of engineers in each (Biblioteca de Arte e Arquivos da Fundação Calouste Gulbenkian, 2021; Rodrigues, 1962; Vida e morte, 1976). Faria (1962b) said that he worked at the refinery "… every day from morning to night except Wednesdays and Saturdays in the afternoon and Sundays …", and in the Observatory in his spare time (Barbosa, 1966). Later, at an unknown date, he started working full-time at the Observatory.

The early difficulties were many as described in a 1961 letter to José Ribeiro dos Santos, Director of the Calouste Gulbenkian Foundation ('Fundação Calouste Gulbenkian', or henceforth FCG)[2] Science Service:

> When we started the construction of our observatory, we only counted on ourselves … [and] knowing my persistence I shouldered the task, considered by many to be impossible, or crazy. Alone I dug foundations, carried bricks and cement, raised walls, built tools, appliances and everything else that is here.
>
> Right from the start, we were faced with a systematic negative reaction not only by Institutes, Centres, Boards, commercial firms, companies, etc., but also by graduated people who eventually could have helped us a lot. (Faria, 1961).

Santos was in favour of granting the subsidy but was concerned that the endeavour was of an entirely private nature (Biblioteca de Arte e Arquivos da Fundação Calouste Gulbenkian, 2021). So, in order to create the necessary legal and financial status for the Observatory, in 1964 Faria founded the Astronomical Association of Angola (AAA) (Associação Astronómica de Angola, 1971). He continued to invest his time and money in the Observatory, and with support from numerous individuals and public and private entities over the next two decades he managed to develop the Observatory in various ways. Thus, it functioned as a solar monitoring station, a satellite tracking facility, an electronics laboratory, a technical library, a natural science and history museum and a science and technology museum (Barbosa, 1966; Bettencourt, 2002a; 2002b; Costa, 1975; Faria,1964).

Being essentially self-taught, Faria attended specialised courses at Bochum, Bonn and Munich in Germany; at Jodrell Bank and Greenwich in England; at Milan in Italy (digital electronics); and in South Africa and at Houston in the United States (communication electronics and antennas)(Anonymous, 1976).

In 1969 Faria accompanied by Luís Pereira Venâncio broadcast live from Houston the historic Moon landing on the Radio Ecclesia program 'Luanda 69'. He also had the privilege of speaking with Neil Armstrong (1930–2012) (Al-

Figure 2: CR6CH Amateur radio station card (courtesy: Tom Roscoe K8CX Collection).

meida, 2016; Faria, 1975; Luanda 69, 1969; Os Astronautas Americanos, 1969; Ribeiro, 2006). In the previous year he had already transmitted from Mulemba Observatory on the official Angola radio the various phases of the Apollo 8 spacecraft lunar orbit entry and translated the dialogue between the three astronauts and Houston service operators (Anonymous, 1969: 273). The 1969 Houston trip was sponsored by small local Angola businesses, and each broadcaster received $1,000 in expenses. On the second day in Houston and with no money left, Faria gave swimming and diving lessons to children in the hotel pool in order to continue their trip, and Luís Pereira Venâncio carried guests' bags (Almeida, 2016). We believe that this simple anecdote reveals Faria's approach to life's difficulties.

Throughout his life, Faria was a committed science populariser. Helder Manuel Ferreira Coelho, a Professor in the Department of Electrical Engineering at the University of Lu-

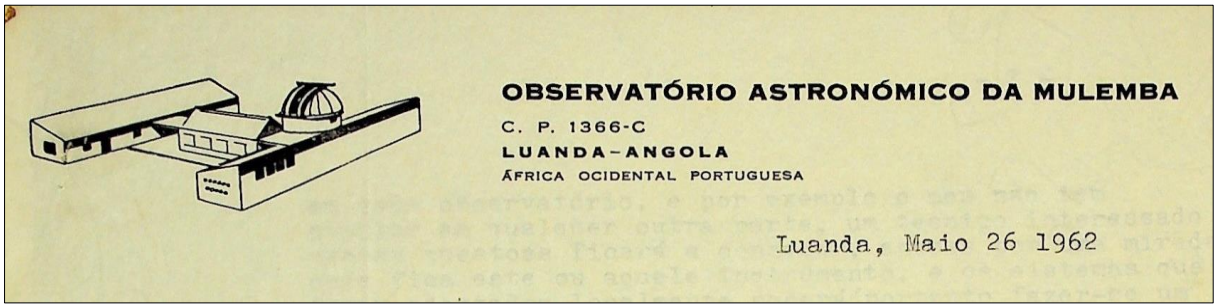


Figure 3: The Mulemba's Observatory letterhead paper, with a schematic diagram showing the layout of the buildings (after Faria, 1962b).

anda between 1971 and 1973 and a regular Mulemba Observatory visitor, remembers that Faria

> … was a man of good will who shared his knowledge and information in an open manner. He communicated by telephone with Luanda radio stations providing information about satellite passages (he followed their trajectories manually) and other scientific news … he carried out authentic reporting of cases and phenomena to the media in Angola … I loved Faria, who took the opportunity to play the piano while I was soldering wires and components for a digital clock that I was commissioned to make by the National Laboratory of Nuclear Engineering. Thus, I spent my Saturdays sometimes talking and discussing with Faria, sometimes working in his Laboratory (Coelho, pers. com., 2021).

Bettencourt (2002b) reports that during the Observatory's existence

> … more than three thousand five hundred interviews, reports and articles were sent to international institutions, magazines, newspapers, television station ... [and] radio programs …

Faria was enthusiastic and had a friendly nature, and he dedicated his life to science. Sadly, on 4 July 1976 he was assassinated at the Observatory he had given so much to, during political instability associated with Angola's struggle for independence (Almeida, 2016).

3 FOUNDING OF THE MULEMBA ASTRONOMICAL OBSERVATORY

In 1958, Faria, working alone, began "… constructing the observatory masonry, machines in the workshop, and over three quarters of the instruments." (Rodrigues, 1962). Luanda, in his opinion, was conveniently located because

(1) the nearby sea had a moderating effect upon the climate;
(2) it had a high annual percentage of cloudless days; and
(3) its latitude was close to the Equator (Faria, 1962a: 64).

At equatorial latitudes the Sun is always high in the sky and is for many "… hours of the day under generally optimal conditions for examination …" (*ibid.*).

Initially the Observatory faced several difficulties. There was no piped water, network electricity or telephone. Construction and equipment acquisitions proceeded in a slow and irregular manner, depending on the financial support from various sponsors, including the Municipality of Luanda, the Bank of Angola and several private companies (Faria, 1964).

The location of the Observatory could also be a problem, as he simultaneously publicised the Observatory locally and actively looked for information from abroad. For example, in a letter dated 26 May 1962 he wrote:

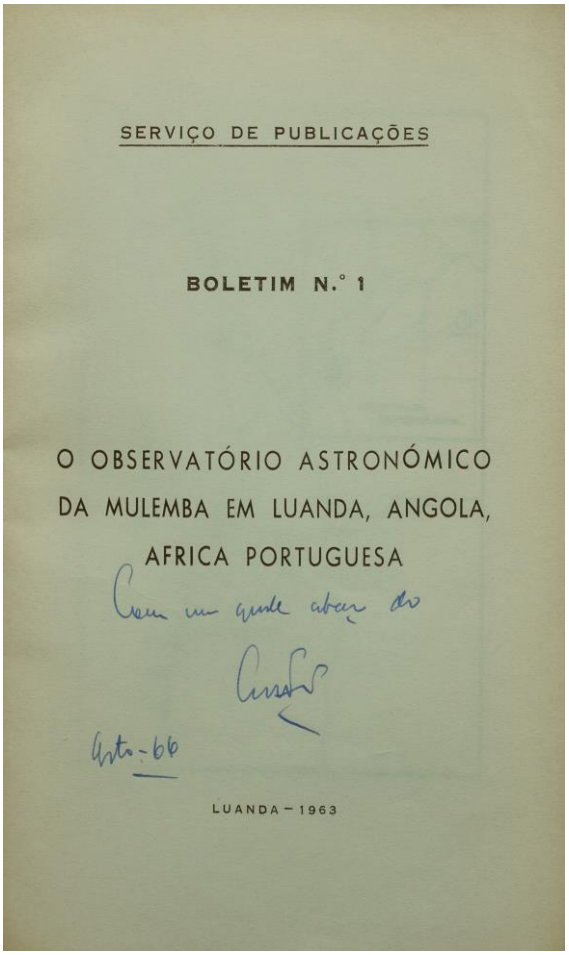
> I enclose for you an example of the two hundred circulars that I sent (calculate the expense ...) to all astronomy observatories in the world, including those in USSR, Japan, etc … Even for a technical study it is always interesting to know what has been done, and mechanical and electrical solutions for problems (Faria, 1962b; our English translation).

This letter is on Mulemba Observatory letterhead paper, which shows the layout of the Observatory buildings (see Figure 3).

Farias' astronomical research goals are described in the Observatory's first and only *Bulletin*: regular solar photography; spectroheliograph observations; and the direct and indirect radio detection of solar storms. The publication of this *Bulletin* (Figure 4) was paid for with an FCG subsidy (Faria, 1964).

In 1963 three radio telescopes were under construction. The transit radio telescope would have a fixed parabolic reflecting surface 20-m in diameter and a focal length of 13.33 metres

(Figure 5). At the prime focus there would be electronic instrumentation on a circular platform that was supported by iron tripod legs. The receiver was located in a cabin on the ground, and the radio telescope would have automatic operation. When completed it would be one of the largest transit telescopes of this kind in the world, and Faria (1964) planned to observe the Galactic Centre, and monitor the Sun for about 4 hours daily.


SERVIÇO DE PUBLICAÇÕES

BOLETIM N.° 1

O OBSERVATÓRIO ASTRONÓMICO
DA MULEMBA EM LUANDA, ANGOLA,
AFRICA PORTUGUESA

LUANDA – 1963

Figure 4: Mulemba Astronomical Observatory's *Bulletin* title page signed by Faria (after Faria, 1964).

The 12-metre diameter alt–azimuth radio telescope had a focal length of 5 metres and weighed about 30 tons (see Figure 6). The diameter of the antenna was selected after Faria had reviewed the dimensions of antennas at satellite-tracking stations, while the focal length would allow observations from 100 MHz to 10 GHz. The antenna had a cabin intended for electronic and electrical control instrumentation mounted on the rotating platform. In a separate building there were receivers, and recording and transmitting equipment. This antenna would be used for tracking artificial satellites and for radio astronomical research (Faria, 1964).

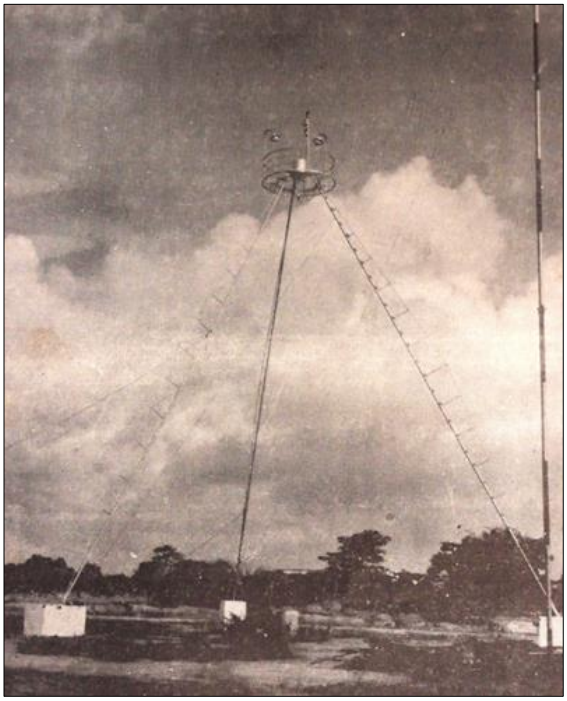


Figure 5: The transit radio telescope in 1963 (after Faria, 1964).

This radio telescope was entirely built on-site (Faria, 1967). A newspaper reported that

> The vertical pipes holding the dish of the radio antenna are petroleum drilling pipes. The main horizontal supports are dismantled metal strips from a railroad wagon ... All the metal parts of this radio telescope ... were given free as scrap. The telescope design, like the instrument itself, was home-made to fit the parts available. (Payne, 1969: 17).

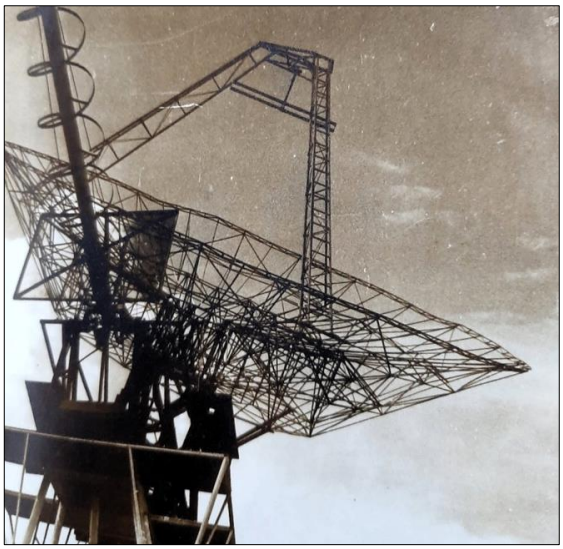


Figure 6: In the background is the alt–azimuth radio telescope and in the foreground part of the equatorial radio telescope (after Associação Astronómica de Angola, 1970).

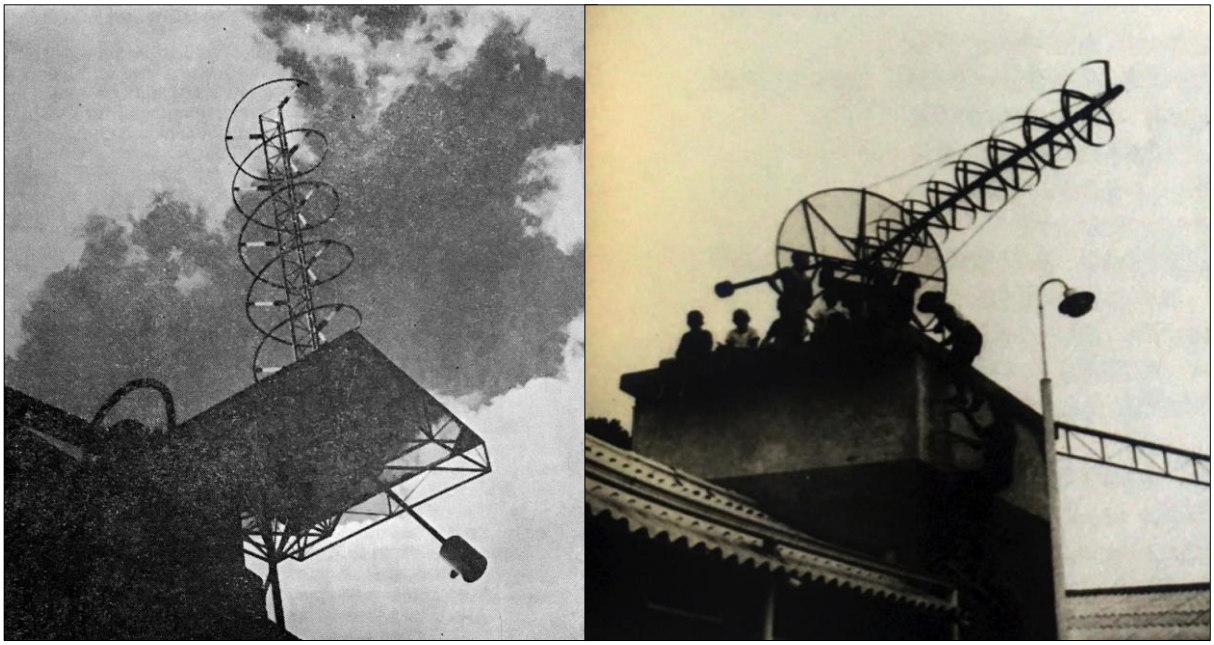


Figure 7: The equatorial radio telescopes. The first one built is on the left (after Faria, 1964; Associação Astronómica de Angola, 1971).

Finally, the 'equatorial radio telescope' had a German equatorial mounting and a helical antenna set for observations of the Sun at 108 MHz (see Figure 7). In 1963 it was nearing completion, and only lacked the drive (Faria, 1964).

There also was a plan to build a 7.5-metre diameter radio telescope that could observe the Sun over the frequency range from 100 MHz to 10 GHz (Faria, 1964).

In the meantime, from June 1962 indirect reception of solar storms at 27 kHz took place at the Observatory with an inverted L antenna (Marconi-type) and a transistorised receiver powered by batteries (since the Observatory had yet to access the public electricity distribution network), and an Esterline–Angus chart recorder (Faria, 1964). Solar flares cause a sudden increase in the ionization of the ionospheric D layer,[3] creating a phenomenon known as 'Sudden Enhancement of Atmospherics' (see Barocas, 1973). Faria (1964) planned to observe these events and contribute to solar research.

In 1962, Mulemba Observatory also had four equatorially mounted optical telescopes. The largest of these was a 100-mm *f*/15 refractor, which was used for astrophotography (Rodrigues, 1962). Eclipses, transits and occultations were photographed with this telescope and timed with two precision chronometers made by Ulisses Nardin and A. Johannsen (Faria, 1964: 28–29). There was also a two-meter focal length refractor that was fitted with "… photoelectric cells for infrared observations of the sun." (Rodrigues, 1962). José António Madeira (1896–1976) former Chief Observer at the Coimbra University Astronomical Observatory and Astronomer at the Lisbon Tapada da Ajuda Astronomical Observatory stated that Mulemba Observatory had

> … surpassed, in some aspects, our Portuguese observatories, especially in terms of integral astronomical photography by means of optical reflector systems …

and mainly in the area of radio astronomy, a field where the other Portuguese observatories even lacked projects planned for the future (Madeira, 1964: 12).

In order to carry out what can only be described as an ambitious research programme financial assistance was needed. In 1963, Faria was still waiting for a subsidy of 500 contos (about US$17,500) that was anticipated in 1960 from the FCG in Portugal, but which was delayed pending the creation of an organisation that, legally and financially, would ensure the Observatory's viability and continuity (Biblioteca de Arte e Arquivos da Fundação Calouste Gulbenkian, 2021; Faria, 1964). At that time, the FCG subsidy amounted to ~75% of Lisbon Astronomical Observatory's annual budget (Portugal: Governo de Portugal, 1960: 537), and in 2020 it would equate to somewhere between $120,000.00 and $674,000.00 depending on how one looked at the Observatory's finances (Measuring Worth, n.d.).

4 THE MULEMBA SPACE CENTRE AND SOLAR STATION

In 1964 the Angola Astronomical Association was founded to provide a legal basis for the Mulemba Observatory and in this manner "… guarantee its continuity with an annual subsidy." (Associação Astronómica de Angola, 1971: 8). The statutes of the Association explicitly state its objectives:

> a) Carry out solar studies, namely: daily integral photographs, sunspot counts, heliography, spectroheliography and reception of electromagnetic waves; b) Conduct any kind of astro-photography; c) Carry out radio-astronomical studies and tracking of artificial satellites; d) Cooperate with the Education Services in order to develop an interest in astronomy, providing observation and study visits to teachers and students of educational establishments; e) Disseminate, through periodical publications, the work carried out by the Association or by others related to astronomy, scientific, technical or general cultural interest. (Direção dos Serviços de Educação, 1964: 2039).

As we have seen, these correspond precisely to what Faria wanted to achieve.

In 1965, the AAA was statutorily obliged to send to the Institute of Scientific Research of Angola (Instituto de Investigação Cientifica de Angola, or IICA) and the Province General Government a report detailing the previous year's activities and a work plan for the following one (Associação Astronómica de Angola, 1972: 6). In 1966, the Association began to receive financial support and, from then on

> … people were hired to build the equipment, as well as to assist with operations and maintenance. (Associação Astronómica de Angola, 1972: 7).

Despite what was claimed when the FCG subsidy finally materialized, in early 1968, it took the form of loaned equipment with the contract clearly stating that

> The Calouste Gulbenkian Foundation lends [the equipment] free of charge to the second contractor [Carlos Mar de Bettencourt Faria], at his request … (Fundação Calouste Gulbenkian e Carlos Mar Bettencourt Faria, 1967)

and not to the AAA. Bettencourt Faria is also identified as the "… owner and director of the Mulemba Astronomical Observatory." (Fundação Calouste Gulbenkian e Carlos Mar Bettencourt Faria, 1967).

Between 1966 and 1972 the AAA received financial support from:

- 1966 – the IICA;
- 1967 – Luanda District Government;
- 1968 – the IICA;
- 1969 – the IICA;
- 1970 – the IICA;
- 1971 – General Budget of the Province of Angola
- 1972 – General Budget of the Province of Angola

In our opinion this shows Mulemba Observatory's growing institutionalisation.

In the meantime, the Observatory's workload shifted, at least in the radio band, from astronomy to satellite tracking. Although this was one of Faria's goals from at least 1962, in the late 1960s satellite tracking would become the Observatory's main activity (Faria, 1962a).

4.1 Satellite Tracking

The first meteorological satellite, TIROS I (Television Infrared Observation Satellite I) was launched in 1960. Signal recordings were made on magnetic tape and, on command, sent to pre-established stations. This system for recording and transmitting photographs was used until the TIROS VII satellite, launched in 1963, when it was replaced by the Automatic Picture Transmission (APT) protocol. This allowed stations to receive local images when a satellite was above the horizon (Faria, 1968: 272). TIROS VIII (1963) and Nimbus-A (1964) were the first satellites using this system.

At Mulemba Observatory the European Space Agency's series 2, 4, 6 and 8, and U.S. Nimbus series 3 and 4 satellites were tracked. The equatorial radio telescope with the helical antenna was modified to receive satellite signals at 136 MHz (Barbosa, 1966). Since this antenna sometimes lacked a free line of sight, a second one of the same design was built (Figure 7). Because of the interest paid to these two antennas there was no time, or resources, to make the transit and alta–azimuth radio telescopes fully operational. Between 1966 and 1971, 49,473 artificial satellite orbits were calculated at Mulemba Observatory, of which 15,960 were for the ESA-8 satellite. In the same period, 7,830 photographs were taken. Requests for photographs came from Bochum Observatory and the Tropical Atlantic Laboratory (Faria, 1974). According to NASA engineer Redford P. Brown Mulemba's Observatory got "Very fine, superior photographs, of better quality than those photos obtained in the United States (from US Satellites) …" (Associação Astronómica de Angola, 1971: 65).

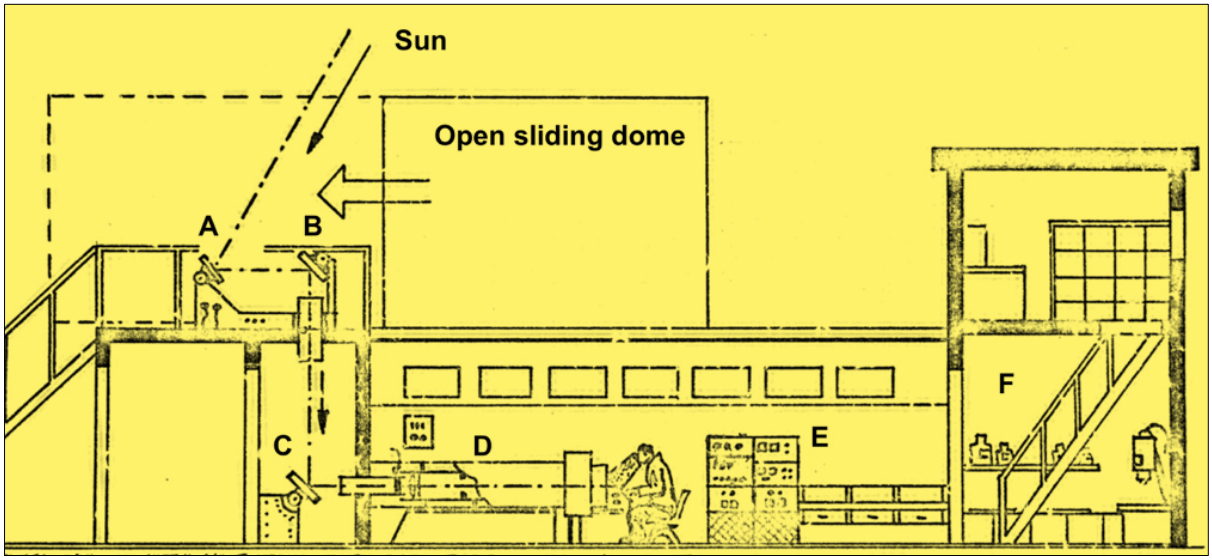


Figure 8: A cut-away section showing the Solar Station. The capital letters in the diagram are defined in the text (after Associação Astronómica de Angola, 1971: 57).

It was probably in order to reflect this line of work that the Mulemba Astronomical Observatory was formally renamed the Mulemba Space Centre (Centro Espacial da Mulemba) in 1972 (Associação Astronómica de Angola, 1972).

4.2 The Solar Station

Nevertheless, Faria never lost interest in astronomy. Although we were unable to find further information concerning solar storms, Sudden Enhancement of Atmospheric events observed, or other astronomical observations made in the 1960s, we realised that over the years experiments were carried out to set up a solar observing facility. Experiments made in 1970 showed that the solar camera could not be directly exposed to solar radiation because of moisture condensation on the optical elements (lenses, prisms, filters). To solve this problem a building with a roll-off roof was constructed to protect a three-mirror solar telescope (Associação Astronómica de Angola, 1970). The optical, mechanical, and electrical equipment cost 5,000 contos (at the time about $177,000) (Associação Astronómica de Angola, 1971: 60–61). The FCG was asked to support the cost of the optical system, but this request was declined in 1971. Nevertheless, in 1972 Faria was awaiting the arrival of the three special mirrors ordered from the USA, after having consulted several authorities (Associação Astronómica de Angola, 1971; 1972).

Finally, on 16 September 1973 the Solar Station was operational, thus accomplishing a goal that Faria had first identified in 1962, more than a decade earlier (Faria, 1962a; Mafalda, 1973).

The Solar Station building had two floors (see Figure 8). On the ground floor there was a dark room (F) and a work room, where the solar camera (D) and the electrical and electronic control systems (E) were located. The brightness and temperature of the rooms were controlled to keep all optical, mechanical and electronic components in optimal operating conditions. On the first floor two mirrors were protected by a sliding roof (Associação Astronómica de Angola, 1971). The three-mirror system (A, B, C) projected the image of the Sun into the work room, where the sunspots and their groups were counted (Associação Astronómica de Angola, 1970).

Observations of sunspot positions, areas, classifications and sunspot numbers (that is the A01 and A02 solar–terrestrial physics data categories) were made. Thus,

> Special purpose data available after 1 month. Data are on photographic paper when the size of sunspots justifies this, also drawings of the same and graphs of Wolf numbers, as well as lists of sunspot relative numbers from which are derived the graphs (monthly). (Coffey and Shea, 1977: Mulemba).

In 1975 the future installation of an Hα filter was planned at the Solar Station, which would have made Mulemba the only facility with this capability on the African continent (Figure 9). Although no data were sent to Solar–Terrestrial Physics World Data Centres A, B and C, they were available to researchers upon request (Coffey and Shea, 1977).

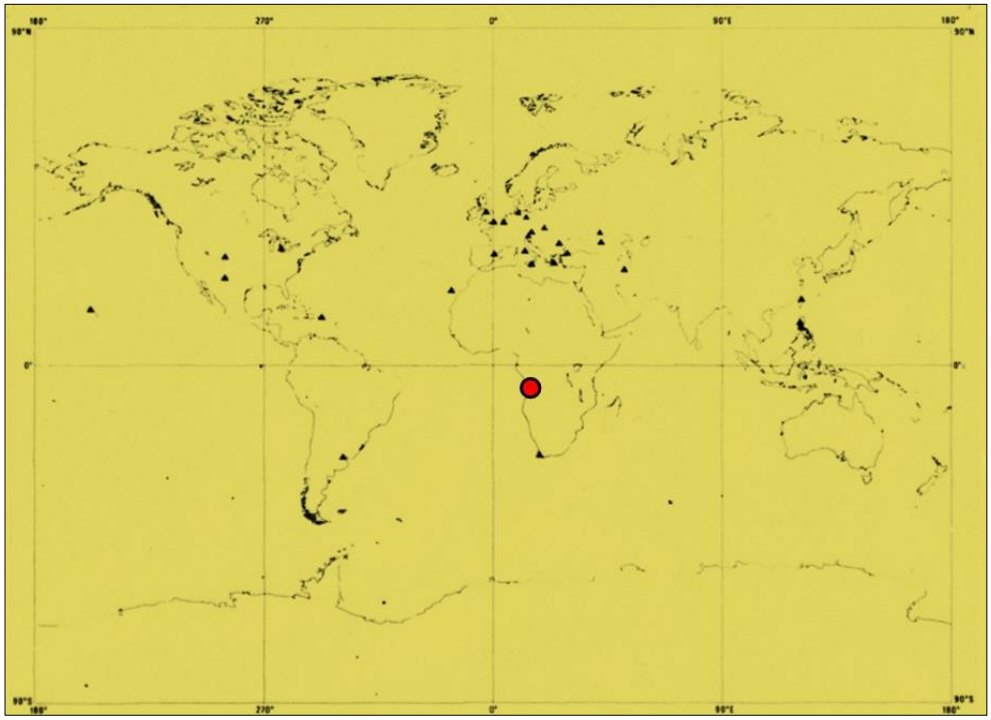


Figure 9: A map showing the distribution of observatories collecting A01 and A02 data. Note that there were only three observatories on the African continent. The red circle marks the Mulemba Space Centre (after Coffey and Shea, 1977; map modification: Wayne Orchiston).

5 EPILOGUE

In the early 1970s Mulemba's future seemed more secure than ever before (Figure 10). A contact network was established, and the Observatory was recognised as an important local asset. According to Helder Coelho (1971: 2), the Observatory was "… the only place where you may work in depth on electronics and where it is possible to make any project come true." It also had an up-to-date library where it was "… possible to find documentation on any problem in the electronics domain." (*ibid*.). From October 1971 to October 1972 approximately 4000 satellite photographs were taken, destined for Lobito's bio-oceanological fishery mission. The Observatory received 2602 visitors, and 237 science popularization radio programmes were broadcast. From 1973 there also were plans to modify the 12-metre radio telescope and, as previously mentioned, the collection of optical solar data was well underway (Associação Astronómica de Angola, 1972; Coffey and Shea, 1977).

Simultaneously, from 1961 war was raging between Portugal, the colonial power, and locals fighting for independence (Pinto, 2018). Following the 25 April 1974 coup d'état in Portugal, the so-called Carnation Revolution, which overthrew the ruling dictatorial regime, the colonial war ended and decolonization was promoted.

These events seriously impacted upon the Mulemba Space Centre, especially after July 1975. Armed conflict in the Mulemba industrial area led to the abandonment of the area by most of the inhabitants, including the Centre's employees. Support for the Centre from local companies disappeared, while the price of necessary materials increased. Consequently, the Centre's two main projects, the collection of daily satellite photographs and solar observations had to be suspended, and

> … due to the fact that both services were performed using equipment, part of which was installed in high structures – too exposed to the frequent shots that reached the Centre, breaking glass, drilling into walls, roofs, etc. … [the] director, at the risk of his own life at times, had to dismantle the most susceptible units, in order to protect them, for future use, from the consequences of those armed actions (Anonymous, n.d.: 2).

Faria decided to remain at the Centre, in order to tend to equipment and carry out necessary maintenance, and to prevent its closure. During this period, the Brazilian Government invited him to visit local scientific establishments, with the aim of establishing future collaborations. He was also invited to guide university students in the creation of a similar fa-

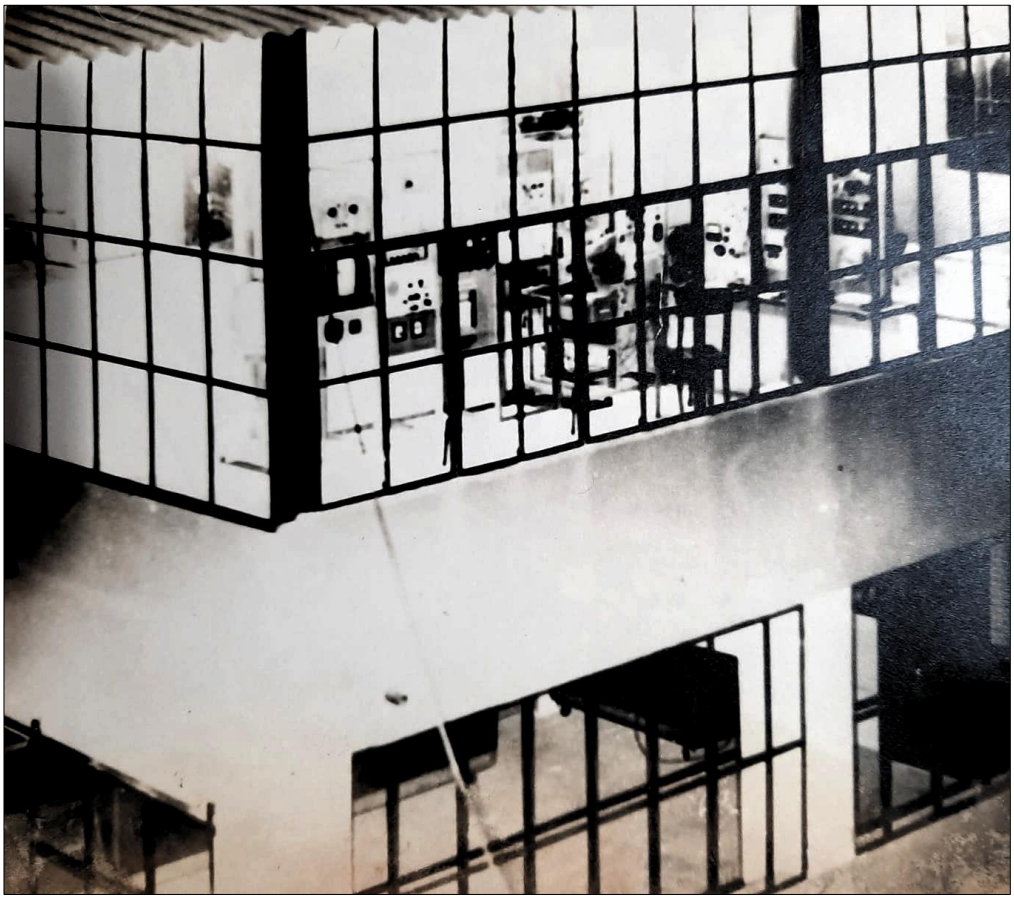


Figure 10: A night view of one of the Mulemba Space Centre buildings where the electronic equipment that received satellite photographs and solar data at 400 MHz was stored (after Associação Astronómica de Angola, 1970).

cility in Brazil. Faria decided to make the trip despite, he claimed, the adverse conditions experienced and great personal sacrifice

> … with the clear aim of giving Angola and its people an establishment of cultural dissemination, in constant technological evolution, with benefits for students and future technicians. (Anonymous, n.d.).

In May 1976, after Angola's independence, Faria was informed by Henrique Abranches, Superior Inspector of the Popular Armed Forces for the Liberation of Angola (Forças Armadas Populares de Libertação de Angola, FAPLA) that the Mulemba Space Centre would be nationalised and reorganised. A new Director would be appointed, and Faria would become a simple employee earning a FAPLA stipulated salary. Although he would be able to continue to reside at Mulemba, FAPLA personnel would be trained to operate the Centre. The documents from the Technical Library would be transferred to the Municipal Library of Angola, with copies remaining at the Centre. In addition, the Natural Sciences and History Museum would be integrated into the Museum of Angola and the Science and Technology Museum would be transferred to new facilities. The aeronautical materials would be transferred to the Military Academy Museum (Bettencourt, 2002b).

As can be imagined, this was a particularly stressful period for Faria. In addition to the nationalisation of the Centre he faced accusations of spying and keeping a weapons arsenal at his home. His amateur radio station CR6 CH was closed, and his correspondence and telephone were placed under surveillance (Bet-tencourt, 2002b). In a letter to his mother, he remarked:

> I have always fought for culture, freedom of movement, creating new things, loved free and open spaces, I came to Africa to materialize a dream – the Mulemba Space Centre, but the work environment is getting adverse, and a dark sadness surrounds me. (Bettencourt, 2002b).

On 4 July 1976 Faria, then 52 years old, was murdered at the Mulemba Space Centre, the largest private scientific establishment in Angola, valued at an estimated 130,000 con-

tos (or approximately 5 million US dollars in 1975).

6 CONCLUDING REMARKS

The one and only Mulemba Observatory *Bulletin* published in 1964 is still the best insight into Faria's plans: a state-of-the-art observatory focused mainly on solar work—from classical sunspot counts, to spectroheliograph and radio observations; a satellite-tracking facility; a scientific library—at a location where information was not easy to come by—a science centre and an electronics laboratory.

In the early 1960s several radio telescopes were being built, with another one planned, and indirect evidence of solar storms was observed at 27 kHz. In the following years Faria continued to invest time and money in the Observatory, while supported by several public and private entities. In 1968 instruments were loaned by the Calouste Gulbenkian Foundation and from 1971 Mulemba Astronomical Observatory entered on an institutionalisation path when an annual stipend was included in the Angolan general budget. The creation of the Angola Astronomical Association was another stepping stone in this process of circumventing the 'it's just an individual' stigma.

Available testimonies show that Faria's friends and acquaintances were enthralled by his personality and his knowledge: "I honestly think that nothing seems 'impossible' to him." wrote Barbosa (1966: 128). But there were others who had very different attitudes. For example, António Silva de Sousa, Director of Campos Rodrigues Observatory in Lourenço Marques (today's Maputo) in Mozambique, not only refused to attend Faria's 1965 lecture about Mulemba Observatory activities but effectively managed to block his membership of the Society of Studies of Mozambique (Sociedade de Estudos de Moçambique) on the grounds that he did not have a university degree. One of Faria's friends presented a very different explanation: it was "All out of envy." (Castel-Branco, 1967).

Despite Faria's fund-raising creativity, lack of money appears to have been the main factor that limited the Observatory's development. The multiple avenues pursued at Mulemba Observatory (astronomical research, science popularization and creation of a museum) were due to his personality and his personal interests,[4] but in our opinion these were also fundamental in raising public awareness of the institution and consequently strengthening the case for its official support. In the late 1960's the radio telescopes either were diverted to other observational goals or else never became fully operational, while satellite tracking, initially considered a subsidiary part of the Observatory's activities, had become its main activity by the end of the decade. This certainly helped the Observatory's survival since it provided a useful outcome (daily photographs of the African continent), and we suspect that Faria tried to transform this into a commercial operation. In the early 1970s Mulemba's electronic laboratory had technical conditions and instruments that were nonexistent at either the Army Transmissions or at the University of Luanda (Coelho, 2021), and it was supported by a technical library with more than six thousand books and reports on various topics (Bettencourt, 2002b).

The fact that a new solar station was in operation by September 1973 seemed to indicate a new astronomical life for the Observatory. Monochromatic Hα solar observations were planned, to make it the only facility in Africa with this capability. Unfortunately, in the aftermath of Angola's war of independence Faria lost his life and his dream was destroyed. No remains of the observatory are visible on recent satellite images, and we were unable to find the whereabouts of its 1970s contents. Sadly, our attempt to learn more about the Observatory's day-to-day activities were limited by the scarcity of primary sources available to us.

In our opinion, Faria's life story provides a cautionary tale for those individuals who aspire to take on the rightful role of governments or well-endowed research institutions, but simultaneously, it is a source of inspiration when we take into account all that he managed to achieve.

7 NOTES

1. For further information concerning the development of Radio Astronomy the IAU–URSI Historical Radio Astronomy Working Group website (https://rahist.nrao.edu) is an invaluable resource.
2. Aiming to improve the quality of life through art, charity, science and education the Calouste Gulbenkian Foundation (FCG) was created in 1956 by Calouste Sarkis Gulbenkian's will (Calouste Gulbenkian Foundation, 2021).
3. The lowest region of the Earth's ionosphere located between 80 km and 90 km altitude.
4. "They claim dispersion is my biggest defect. They don't understand that my greatest strength lies in it." (Faria, 1961).

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Maria Almeida was born in Guarda (Portugal) in 2000 and is finishing her Master's degree in physics engineering at the University of Aveiro (Portugal), with the thesis "Effects of ionizing radiation on fiber optic sensors".

Her interest in astronomy led her to become a member of the Physics Association of the University of Aveiro (FISUA) for 3 years, where she had the opportunity to organize physics and astronomy outreach events.

Furthermore, she started to investigate the history of amateur astronomy in Portugal in the final year of her Bachelor's degree. Consequently, a paper co-authored by Vitor Bonifácio titled "Against All Odds: Bettencourt Faria's Astronomical Observatory" was presented at the 10th Conference of the European Society for the History of Science in Brussels in 2022.

Professor Vitor Bonifácio was born in Lisbon (Portugal) in 1967. He has a degree in Physics/Applied Mathematics from the University of Porto, a Master's degree in Astrophysics from Queen Mary and Westfield College, University of London, and a PhD in Physics from the University of Aveiro where he is invited Assistant Professor. In the IAU he is a member of Division C (Education, Outreach and Heritage) and Commission C3 (History of Astronomy).

Vitor mainly published papers on the history of astronomical cinema and photography, historic transits of Venus; historic solar eclipses; the development of astrophysics; historic astronomical and navigation instruments, amateur astronomy and nineteenth century science popularization publications.

With wide-ranging interests Vitor is currently researching the history of Portuguese astrophysics in the nineteenth and early twentieth centuries via its main protagonists and he continues to study the development of astronomical societies in the nineteenth century.