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Chapter 3

Aldo Zeoli, Chief of Argentine Rocketeers[*]

Pablo de León[†]

Abstract

Aldo Zeoli was an Argentine Air Force officer who oversaw and directed the development of a family of solid rockets in Argentina. Interestingly, in Argentina, it was the Air Force that was tasked with the development of scientific rockets for peaceful purposes, since at that time, the military had a near monopoly in development and manufacturing of aerospace systems in their Instituto Aerotécnico, located near the city of Cordoba. Zeoli, an aeronautical engineer and avid reader of technical papers and books in English, took the task of the development of not only bi-basic and composite solid propellants but also the design of rockets, recovery systems, and even the planning of launching facilities, like the launch bases of Chamical and CELPA Atlántico in the Argentine South Atlantic Coast. Zeoli, who was born in 1916 and received his professional engineer diploma in 1943, started to work as a project engineer, but the director of the Instituto Aerotécnico saw his potential and encouraged him to enter the Air Force as an officer. He traveled to the UK to specialize in engines at the Power Jets Company in Lutterworth. This company at that time organized courses for military officers of other countries. After his return in 1960, he was put in charge of the Departamento de Vehículos Espaciales y Armamento (Department of Space

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Vehicles and Weapons). There, Zeoli oversaw the development of a family of solid rockets propellants and was a major proponent of the development of an indigenous satellite launch vehicle.

I. Introduction

Argentina was the first country in Latin America to have a space program, a space agency, and a family of high-altitude research rockets.

Modest first steps, done in 1932, with the creation of a first astronautical club [1] continued with the creation of the Argentine Interplanetary Society (Sociedad Argentina Interplanetaria, 1949), an IAF founding member [2], and early development of liquid rocket engines [3].

By 1959, everything was in motion for the development of an indigenous rocket program.

At that time, the Argentine Air Force, believing (as did many air forces around the world) that space, being an extension of atmospheric flight, was in their realm, started to research the possibilities of producing rocket propellants in the country.

The research and development laboratory of the Air Force, the Aerotechnical Institute (Instituto Aerotécnico), based in the city of Córdoba, was put in charge to investigate the complexities of producing either bi-basic or composite solid propellants locally.

Here the figure of Aldo Zeoli was of the maximum importance to develop and organize the rocket development effort in the Argentine Air Force and with modest resources, educate a group of propulsion experts, develop propellants and facilities, and create a family of Argentine research rockets.

II. Beginnings

Aldo Zeoli was born on June 3, 1916, in the city of Rosario, a cultured and elegant city, which also holds one of the largest ports in the country, by the Parana River, which mixes with the Rio de La Plata ending in the South Atlantic Ocean. In Rosario, Zeoli did his first years and completed elementary school. For his high school, as customary with technically inclined young men of the time, he went to a “technical high school” (Escuela Industrial de la Nación in Rosario). There, students pursued not only their regular classes, but also graduated as technicians. Zeoli graduated as a Mechanical Technician.

The English language also fascinated him and, while attending to high school, he studied at the Academia Nacional de Lenguas Vivas to become an English instructor and translator. This knowledge was going to be very useful for him later on.

While Zeoli, who cultivated model airplanes as a child (Figure 3–1), was initially interested in becoming a pilot for the Naval Aviation, his physical test failed because he used glasses. So, he decided, instead, to become an aeronautical engineer.

Figure 3–1: A teenager Zeoli with one of his model airplanes. Courtesy of the Zeoli Family.

In 1939, he started his studies in engineering at the National University of Córdoba (Universidad Nacional de Córdoba) graduating in 1943 as an Aeronautical Engineer. His thesis was called "Turbo Compressor for Aircraft Engine and Wing Structure Reinforcements" (Turbo compressor para motor de aviación y estructura metálica de alas).

During those years he built a pulsojet engine from a kit (Figure 3–2). He would test the engine in his house, but the noise was so loud that every time he tested it, the police was called in the neighborhood [4].

Figure 3–2: Pulsojet engine assembled by Aldo Zeoli. Courtesy of the Zeoli Family.

Zeoli started working in the Instituto Aerotécnico, while teaching aeronautical electrical systems courses at night at the technical school of the Air Force.

During his first years at the Instituto Aerotécnico, Zeoli worked as a "calculator" and a designer. These were some of the most active years in the development of new planes in Argentina, and there were a number of military planes being designed in the nearby Military Aircraft Factory (Fábrica Militar de Aviones), among them, the Pulqui II reaction jet designed by Kurt Tank, and the flying wings developed by Reimar Horten.

The aeronautical engineers and technicians were in desperate need of knowledge of the new technologies that were taking place in Europe and the United States, so there were plenty of opportunities for young professionals who wanted to study overseas. All expenses were paid by the Argentine government.

The son of Aldo Zeoli, Adrián, remembers

> "My father was working with some calculations late at night at the Institute, and the Brigadier San Martín (director of the Institute and the Military Airplane Factory) showed up and asks him 'Zeoli, do you speak English, right?' My father answered affirmatively, and San Martín asked him to meet him the next day in his office. He was offered travel to be trained in jet engines at the Power Jets Laboratory in Lutterworth, UK" [5].

Frank Whittle, the inventor of the first jet engine in that country, created power jets. The company provided training to foreign engineers working for friendly countries. Since at that time, the United Kingdom had a very good relationship with Argentina, its engineers could enroll in the propulsion courses designed for the engineers and military officers of their own country.

It is possible that here, Zeoli was exposed to the productive environment of a European company and learned not only the specifics of this field but also about manufacturing techniques and quality control. Here he developed a practi-

cal point of view that he was going to put at a good use in the development of Argentine rockets.

After spending three years in the United Kingdom, Zeoli returned to Argentina, where he is asked once again by Brigadier San Martín to join the Air Force, as a First Lieutenant (due to his engineering degree). Zeoli accepted and started his military career at a moment where the young Argentine Air Force was searching for qualified officers.

His first military deployment was an operational one, as chief of the Aviation Technical Group in the Second Aerial Brigade (Segunda Brigada Aérea) in Paraná province of Santa Fe.

By the end of 1959, a French engineer from Matra, Marcel Invernizzi, was hired by the Argentine Air Force to present a two-month course on rocketry. Zeoli, as well as other military officers and engineers attended to this course.

Some other engineers and officers were also sent to other countries, such as the United States and France, to enroll in different rocket propulsion courses in order to create a basic core group of educated professionals.

By 1960, Zeoli, then a Commodore, was transferred once again to Córdoba, the center of aeronautical development of the country, and is named as chief of the Department of Space Vehicles and Weapons (Departamento Vehículos Espaciales y Armamento).

Aldo Zeoli recounted in an interview

> … in 1960 I attended to a Space Research Conference held in Buenos Aires. Dr. Hugh Dryden, the first NASA Deputy Director, was one of the speakers. We started talking, since there weren't many people there who could speak English and I invited him to visit Córdoba, so I could show him our facilities. At that time, we were interested in rocketry, and wanted to see if an expert like Dr. Dryden could assess if our machinery and equipment was adequate to make high altitude sounding rockets. Since Dr. Dryden accepted, we chartered one of our military planes, an Argentine-designed Guarani, and flew there. After he visited the factory, while having lunch I asked him about some advice he can give us, and he said, Zeoli, start to launch things to the sky, because doing so you will learn things that are not in the books (Figure 3–3). His words impressed me greatly, and this is how we started the practical development of our rockets [6].

Figure 3–3: Aldo Zeoli, talking during the visit of Dr. Dryden to Córdoba. Courtesy of the Zeoli Family.

III. Alfa and Beta Centauro

After Dr. Dryden's visit, Zeoli convinced the aeronautical authorities that it was important to develop a first sounding rocket for the Air Force. The National Commission for Space Research (Comisión Nacional de Investigaciones Espaciales, CNIE), created in 1960 by a decree of President Arturo Frondizi and chaired by Teófilo Tabanera was in need of sounding rockets to start their research, but lacked the facilities to do so. The Air Force, with its research and manufacturing capabilities was an ideal partner [7].

Initially, the CNIE was favoring the import of US-made Nike rockets for high altitude research, but the Air Force authorities convinced Tabanera that the indigenous development was a better option.

Zeoli, pressured by the circumstances, and trying to demonstrate to CNIE that they were capable of developing a sounding rocket in a short time, decided to see what was already available.

In the Factory of Villa María (Fábrica Militar de Villa María, a joint armed forces powder and explosives factory, also located in Córdoba) there were double-base powder (nitrocellulose-nitroglycerine) grains used for artillery rockets. With a 94-millimeter grain, Zeoli decided to create a rocket based on this already available propellant.

Zeoli and his group of engineers decided to use a seamless steel tube of 2.7 meters in length, with a simple nozzle without thermal protection. Four aluminum fins at 90 degrees each were going to provide stabilization, and the nose cone was equipped by a static and dynamic pressure probe, a simple accelerometer, and a temperature probe. It was named Alfa-Centauro.

A simple tubular launch tower rail was also developed, as well as an electrical panel for the ignition. The calculated apogee was 20 km, and the rocket and payload containing the nosecone were supposed to separate at apogee and fall on a parachute. Since there was no transmission of data, it was vital to recover the nose cone. An airplane was supposed to locate the payload using an electronic beacon and send the coordinates to a ground party to locate it (Figure 3–4).

Since at that time there were not any launch ranges for horizontal launches, Zeoli spoke with the owner of a large ranch in Pampa de Achala, in the province of Córdoba. Located in a desolated region the ranch, called Santo Tomé, was equipped with temporary tents and Air Force vehicles to support the launch.

On February 2, 1961, with the presence of about thirty military officers, engineers, technicians, and one journalist, the Alfa Centauro APEX-A1-02, first Argentine research rocket was launched.

Figure 3–4: Argentine Air Force personnel installing the Alfa-Centauro launch tower. Author's Archives.

Aldo Zeoli was the project director, with Captain Luis Cueto as the chief of launch operations.

It reached approximately 20 kilometers in altitude, but the beacon system did not work, so the airplanes were not able to locate the payload. A party on foot located pieces of the rocket motor at less than one kilometer of the launch site. Since the payload was not attached, the separation occurred, but the payload was never found [8].

In any case, the launch was considered successful, and the journalist who covered the launch did not mention any issue.

President Frondizi sent a letter of congratulations to all the team and they were received later in the government house (Figure 3–5).

Figure 3–5: Aldo Zeoli being congratulated by President Arturo Frondizi. Courtesy of the Zeoli Family.

The launch tower used in this launch, with a model of an Alfa Centauro, are in display at the Museo Universitario de Tecnología Aeroespacial, MUTA in Córdoba, located at the same place where most of the Argentine rockets were built.

After this first attempt, Zeoli decided to make a new development with a two-stage rocket, i.e., the Beta-Centauro.

IV. Chamical and von Braun

Meanwhile, it was clear that the "Base Santo Tomé," i.e., the private ranch that was converted into a modest space center, was not going to be enough to support higher altitude launches. There were a number of small towns and villages nearby and the initial calculations made clear than 25 kilometers were the maximum allowed altitude for this site.

Because Zeoli's plans were to develop a family of high-altitude rockets, it was clear than the country needed a full-fledged rocket launch site.

A military-owned artillery site, located about 300 kilometers north of Córdoba, in Chamical, province of La Rioja, and adjacent to the Salinas Grandes desert, was selected by Zeoli and his team to become the first government launch site for Argentina. It was officially created on July 27, 1961. The site was named Centro de Experimentación de Proyectiles Autopropulsados, CELPA (Center for experimentation on self-propelled projectiles), but was more familiarly known as Chamical.

The construction work started in 1962 to adapt the site to its new use. It included a concrete pad, an exhaust shaft, and an underground blockhouse at one block from the launch pad.

By November of the same year, all facilities were completed, including an unpaved 2,000-meter runway for medium-size military planes carrying equipment.

Later, multiple buildings were added, including water tanks, several workshops with tools and equipment, its own phone service, and radio and radar systems, plus simple accommodations for up to 100 people. Chamical was the first launch center in the Latin America region.

In October 1961, Captain Cueto was in charge of the launch of the first Argentine instrumented two-stage rocket, the Beta-Centauro (APEX-A1-S2-015). Zeoli was not present, because he was taking part in Air Force training at the NASA Wallops Flight Facility and at the Arnold Air Force Base.

For the Beta-Centauro, the electronics was more sophisticated, and it included a telemetry system, to prevent losing the data in the event that the payload was not recovered. It reached 25 kilometers at apogee.

The need for higher altitude rockets for atmospheric research was formalized with a formal request from CNIE to the Air Force authorities. This request called for the development of a family of rockets, which, in a first stage, could

reach altitudes of between 40 and 80 kilometers and a more ambitious goal, or rockets of an apogee of between 100 and 150 kilometers. By that time, the Instituto Aerotécnico had changed its name to a new one, more in accordance with the new times. It was renamed "Instituto de Investigación Aeronáutica y Espacial, IIAE" (Aeronautical and Space Research Institute).

At his return from the United States, Zeoli started to work with his group in a much more aspiring program, i.e., to reach altitudes in the order of 300 kilometers.

During this time, another visit from the United States was going to spark the interest of the Argentine rocketeers. In August 1962, Dr. Fridtjof Speer from NASA's Marshall Spaceflight Center presented a talk about the Apollo program. Teófilo Tabanera subsequently invited Dr. Wernher von Braun, who he knew from the International Astronautical Congresses.

Despite his extraordinarily busy schedule, von Braun decided to pay a visit to the country, and in October 1963, traveled with his wife to Buenos Aires first, and then to Córdoba. He visited with then President Arturo Illia and gave some conferences about the beginnings of project Apollo.

Figure 3–6: Aldo Zeoli and Wernher von Braun during his visit to Córdoba. Courtesy of the Zeoli Family.

In Córdoba, von Braun was shown what was taking place regarding sounding rockets and propulsion, visited the wind tunnel facilities, and he gave some interesting advice to the still inexperienced rocketeers (Figures 3–6 and 3–7). One of his observations was that he had learned a lot during his years in the VfR (Verein für Raumschiffahrt), the German Society for Space Travel, and that practical experience was of paramount importance in rocket research. Zeoli, who accompanied von Braun during his visit, took note of the rocket expert's comments.

Figure 3–7: Von Braun receiving an IIAE Pad Leader helmet from Aldo Zeoli. Courtesy of the Zeoli Family.

V. Propellants and New Rockets

After the modest success of the Beta-Centauro, a number of new developments started to take place.

Because the double-base powders used so far in the Argentine rockets were of limited use, the Argentine engineers started to look for composite propellants in other countries. The first possible provider was the United States, but in this case, the providers wanted to sell the entire sounding rocket. However, the intention in Argentina was to purchase only the propellant grain, and build the rocket indigenously, and later, develop the formulation to produce composite propellants nationally.

At that time, Argentina had some previous experience with the French Centaur rockets. Consequently, the IIAE authorities decided to send a number of engineers and officers to France to study their sounding rockets.

Considering the openness of the French to sell their propellants, as well as to transfer the technology for nozzle thermal protection, igniters, stage separation, timer systems and pyrotechnics, the IIAE decided to sign a contract with the Société Nationale de Poudres et d'Explosifs (SNPE).

Two composite propellant grain diameters were selected in this first stage, 200 millimeters and 260 millimeters. These were Ammonium Perchlorate, PVC aluminum powder, with a specific impulse (IsP) in the order of 220 seconds,

which was considered a top formulation at that time. At that time, Argentina paid only $35 per kilogram of propellant [9].

Despite the low cost of the propellant, the intention of Zeoli's group was to one day develop propellants in-house, as was the case for all IIAE elements that were considered strategic.

Zeoli sent Captain Juan Beverina to Japan to research the purchase of modified food mixing machines, which were adequate to be adapted for composite propellant manufacturing. They were also able to procure Ammonium Perchlorate in Japan.

With that development, a new rocket was envisioned, i.e., the Orión, a 100 kilometer apogee sounding rocket able to use either the French propellant or a future Argentine one.

The preliminary calculations gave an apogee of just 80 kilometers with 5 kilograms of payload. Consequently, a new design, the Orión II, was developed and the first one was discarded.

Orion II became a 3.7-meter rocket, with a total weight of 140 kilograms, 15 of them destined for the payload. Its first flight took place in August 1966 and reaching 112 kilometers. Once again, Zeoli was in charge of the launch operation and he pressed the ignition switch. For the first time, Argentina reached what was considered "space" (Figure 3–8).

A few months later, in November, Argentina tested for the first time the Orion II on foreign soil. Under an agreement with NASA, two Orion II were launched from Wallops Island and become the first and only Latin-American rockets to be tested in the United States.

Figure 3–8: Aldo Zeoli in the Chamical underground launch control, with the launch team. Courtesy of the Zeoli Family.

VI. The BIO Experiments

With the concentration on propulsion and rockets, there was also a growing interest in instrumentation. Several universities started collaborating with IIAE and with funds either from the Air Force or from CNIE, developed a series of small electronic payloads for the growing family of rockets.

Some of these sensors were biomedical, since there was a need in the Air Force to develop cardiovascular and respiration sensors. It led to the first biological payload in an Argentine rocket, i.e., the so-called BIO or Biociencias (Biosciences) project.

It consisted in launching a mouse inside a detachable capsule with an array of sensors, including cardiovascular, respiration and temperature.

The National Institute for Aerospace Medicine, (Instituto Nacional de Medicina Aeronáutica y Espacial, INMAE) helped to create the sensors and test them. Meanwhile, the IIAE developed a small conical capsule, resembling an Apollo spacecraft which was going to carry the small mouse into the atmosphere.

The selected mouse, Belisario, was a small male mouse, weighting 120 grams, and was protected by a harness that kept him immobile during the flight.

Belisario was launched on April 11, 1967 (Figures 3–9 and 3–10). The mouse was recovered shaken, but alive [10].

Several other mice were launched in later experiences, with some failures, and some successes. During these later launches, the sensors, restraints, and recovery systems were upgraded.

Two years later, a caí monkey, named Juan, was launched from a Canopus II rocket in Chamical, reaching 82 kilometers (Figures 3–11 and 3–12).

Figure 3–9: Aldo Zeoli, with two unidentified Air Force medical officers, while they install Belisario in his couch. Courtesy of the Zeoli Family.

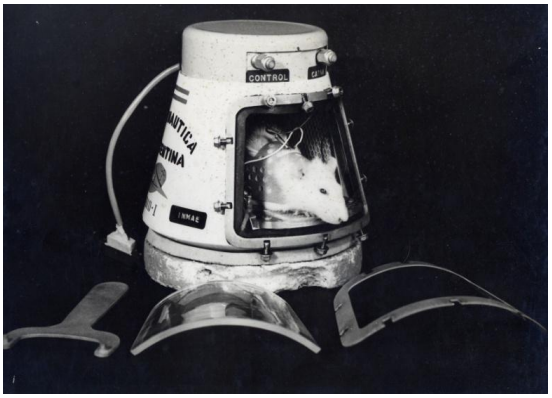

Figure 3–10: Belisario, in his capsule, after the flight. Courtesy of the Zeoli Family.

Figure 3–11: IIAE technicians and medical personnel securing Juan in his couch. Courtesy of the Zeoli Family.

Figure 3–12: Aldo Zeoli (middle) with all the launch team after the recovery of the monkey Juan. Courtesy of the Zeoli Family.

VII. Later Years

By 1969, Argentina had developed an impressive family of sounding rockets, including to the two-stage, 1.2-ton, 8-meter Castor. A solid propellant rocket able to reach 500 kilometers of apogee, with a 75 kilograms payload (Figure 3–13).

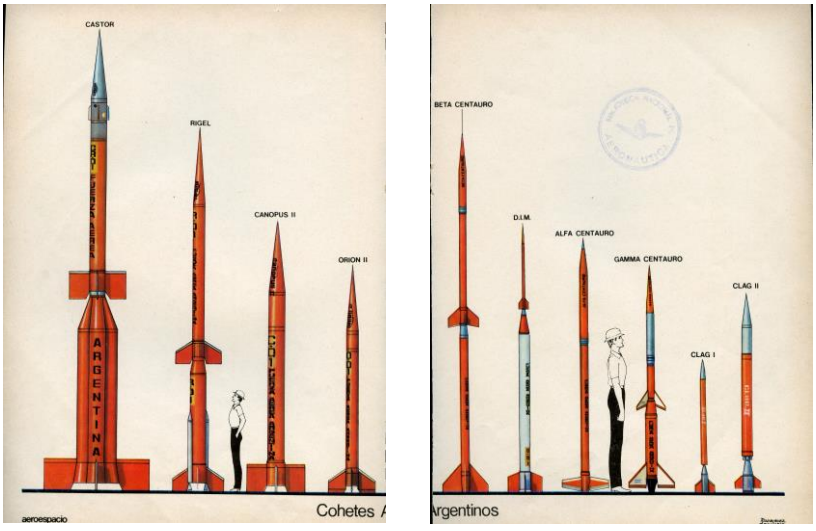

Figure 3–13: Family of Argentine sounding rockets 1961–1970. Aeroespacio Magazine. Author's Archives.

A propellants plant, also devised by Aldo Zeoli, was completed in 1971, which allowed to the country to formulate and manufacture its own rocket fuel. There were also plans to develop an Ammonium Perchlorate production plant, but those could not be finished due to budgetary issues (Figure 3–14).

Figure 3–14: Zeoli with other Air Force officers and engineers at the rocket motor static test bench. Courtesy of the Zeoli Family.

In 1968, Aldo Zeoli was named director of the IIAE and from there he commanded the entire aeronautical and space industrial complex of Argentina until his retirement in 1979.

Then, the restless Zeoli became Academic Secretary at the National Technological University, Córdoba until 1983.

Aldo Zeoli passed away in Córdoba on August 19, 2003, after a life dedicated to the aerospace development of his country. His unfinished dream was to see a satellite launch vehicle developed in Argentina (Figure 3–15).

Figure 3–15: Aldo Zeoli, Argentine pioneer of rocketry. Courtesy of the Zeoli Family.

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