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Chapter 4

The True Beginnings of French Astronautics 1938-1959 (Part 1)*

Philippe Jung†

Introduction

There is an old tradition of rocketry in France that dates back to the black powder rockets of the famous family of pyrotechnists, the Ruggieri brothers of the 18th century, and was further amplified by the development of very powerful war rockets for their day by Commander [Louis Auguste Victor Vincent—ED.] Susane at the École de Pyrotechnie de Metz during the second half of the 19th century.[1] France's leading position in rocketry was confirmed during World War I with the appearance of the world's first air-to-air missiles, the rockets of French Navy Lieutenant de Vaisseau [Yves P.G.—ED.] Le Prieur, as used against the German Zeppelins and drachens ["dragons," or German World War I observation balloons—Ed.];[2] then there were the multi-stage rockets of Louis Damblanc in 1935.

One of these men, Esnault-Pelterie (also known as REP), was initially an aviation pioneer known for his REP monoplanes and, for the first time, planes equipped with a stick [or "joy stick"—Ed.] for their control. REP gave a conference in Paris on June 8, 1927 about interplanetary travel, just as Lindbergh had crossed the Atlantic to Paris Le Bourget, that had profound consequences in

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France. It affected the careers of Artillery Lieutenant Jean-Jacques Barré[3] and the Russian emigré Alexandre Ananoff, both of whom had been in the audience.

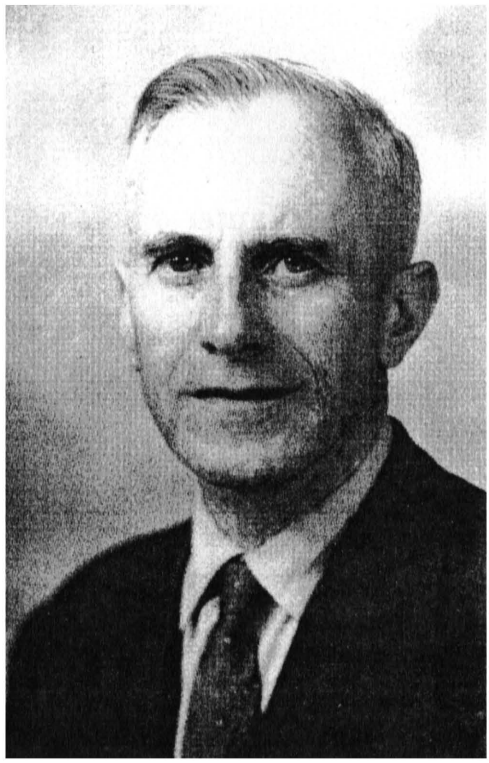

Figure 1: Jean Jacques Barré (1901-1978) – French rocket pioneer (From F. I. Ordway Collection, U.S. Space and Rocket Center).

The necessary next step, guiding a missile and not having it passively stabilized, had its origins in the improvement of air-launched bombs. It was the famed pilot-engineer Maurice Hurel of CAMS (Chantiers Adro Maritimes de la Seine), a seaplane manufacturer, who made the initial steps in this development in France. He thought about a gliding bomb for which he eventually found in 1938 a specialist in guidance, named Jean Turck, with the Bougault Company. The latter proposed a frequency modulated tele-command system. Towards the end of 1938, a reduced scale model of the 160 kg BHT 38 (Bombe Hurel Turck) was built by CAMS in Sartrouville and was to be tested in Vincennes. A joint French Air Force-French Navy contract was let in 1939. In March-April 1940, ten BHT 38s, manufactured by Atelier des Torpilles, were lined up at CEPA (Commission d'Études Pratiques d'Aviation, the French Navy's test center) at St. Raphael. An operator, located on a mountain 20 km away, was able to successfully command the bomb

controls thanks to a mini stick and a Turck emitter. However, the defeat of France in June 1940 led the team to blow up their hardware in the bay of Toulon.

Hurel became the technical director of the National Design Office of Cannes, collecting there most of the French aviation engineers who started building the first aircraft prototypes.

On August 16, 1943, Hurel took one of the planes, the unfinished SO 90 No. 01, and accomplished a most extraordinary first flight in aviation history—taking off from the airfield of Cannes-Mandelieu under the nose of the Italian sentinels, flying a three hour low level straight line flight with the landing gear down, in the absence of hydraulics, and making the aircraft's first ever turn to land in Philippeville in Algeria! On board were eight passengers, including Turck. The two friends then rejoined in Algeria where, with the agreement of Vice-Admiral Lemonnier and Commander Nomy, they created the Groupe Engins Télécommands and accordingly pursued the development of the BHT. Hurel was in charge of aerodynamics and Turck's responsibility was the radio-electric system. Offices and a laboratory were established in the Palais Brus, the seat of the Marine headquarters. Manufacturing was carried on the first floor, in the garage. The means of Caudron, the builder of famous racing aircraft holding many world records, were put to good use. There was also an annex in the Société Française Radio Electrique. Two Martin 167s, based in Boufarik, were used for trials. One time, the missile stuck itself into the tail and the pilot had to shake the aircraft over the sea to dislodge it.

Turck then went to Southern England where he created a company in Clapham Common, London, with a laboratory and a workshop. Offices and a laboratory were also located in London, with Admiral Thierry d'Argenlieu. He built half a dozen jamming devices to be used against the German Henschel Hs 293 missile. Mounted on boats, they succeeded in their task that led to some interesting explanations after the war when French and German engineers collaborated on many missile programs. One month after the Allied landing in Provence, on August 15, 1944, the DCCAN (Direction Centrale des Constructions et Armes Navales) took over the BHT development and hired Turck. All active BHT members were transferred to Cuers, near Toulon. A Lior St. Olivier Leo 451 E8 bomber, F-BDJE No. 493, was based there for testing, together with a photographic Avenger. In December 1945, Hurel was back in Cannes to put his baby in a wind tunnel for testing, proving that control with stick and rudder worked. However, as Michel Decker from the Service Technique Aéronautique STAe put it, this formula was not viable as it lacked any attitude reference for guidance and control. Turck confirms that the BHT was rather unstable. Thus, the program was canceled in August 1946.

It should be noted that in the summer of 1939, the SNCAM (Société Nationale de Constructions Aéronautiques du Midi) studied the addition of removable

wings on a 50 kg bomb. It no doubt was an answer to the five-year plan of August 1936 that included a highly secret armament section calling for gliding bombs. Heading was kept by a gyroscopic device with barometric drive initiation. Several tests were performed in the wind tunnel of the IMF (Institut de Mécanique des Fluides) in Toulouse Banléve, from October 17 to 19, 1939 and continued in the following months of November and December. After satisfactory trials in Cazaux around March 1940, a pre-series batch was ordered by Amide de l'Air on April 30, a few being delivered from the Bagnbres-de-Bigorre prototype plant South of Toulouse, just before the armistice of June 1940 but too late to be used operationally. Modified 100 and 200 kg bombs were also studied as possible guided bombs but they were not built.

EA 1941, The First French Liquid Fuel Rocket

The French Army had not stayed inactive in regards to rocket development. Following the conference of Esnault-Pelterie, Barré switched his career. He started corresponding with the great pioneer, exchanging more than 300 letters on the subject of rocket propulsion that led, on September 25, 1931, to his being assigned to REP's laboratory in Boulogne-sur-Seine. There, he started to work on an aeronomy (meteorological) rocket of 100 km ceiling. But the Army took him back the following September as an officer was not supposed to have activities linked to rocketry. However, (the now) Captain Barré was allowed to work in his spare time on a 16 kg anti-aircraft rocket shell, using nitrogen peroxide and benzotoluene. The planned altitude was a respectable 12.5 km and speed at burnout, 1,428 m/s. A 700 kg thrust motor was tested in Versailles from February 9, 1937. However, after a fifth test on April 6, 1938 that resulted in an explosion all activities on this project were terminated on May 24, 1940.

Following the defeat of France in the war, the STA (Section Technique de l'Artillerie), under the aegis of Colonel Dubouloz, was moved to Croix Rousse, near Lyon, under the cover name of Service Central des Marchés et de Surveillance des Approvisionnements. Transferred there on November 16, 1940, Barré continued his rocket shell studies, also looking into the new ramjet motor.

In March 1941, he started the study of the motor for a sounding rocket. This became the EA 1941, the first modern liquid-propelled French rocket. To hide his activities from the Germans, he called it a "gazogdndrateur." Of 720 kg thrust and using liquid oxygen and gasoline ether, it was first tested successfully in the Camp du Larcac in Massif Central on November 15th. However, when the slightly modified EA 1941B engine was tested on March 17 and 18, 1942, a nearly instantane-

ous explosion occurred each time. This was apparently due to overheating induced by the confined configuration of the test installations. The team thus went to Fort de Vancia near Lyon, where four good runs were performed from July 6 to September 24 and a maximum thrust of 860 kg was recorded. It was decided to test fly the rocket in the Algerian Sahara, south of Oran, in Beni Ounif. But just when the second consignment, with the last two thirds of the hardware, was about to depart from Marseille, the Allied landing in North Africa took place and the ship's captain was obliged to unload the vessel and hide everything in a nearby castle. Half of this material was later transferred to Lyon, in an estate belonging to the Barré family.

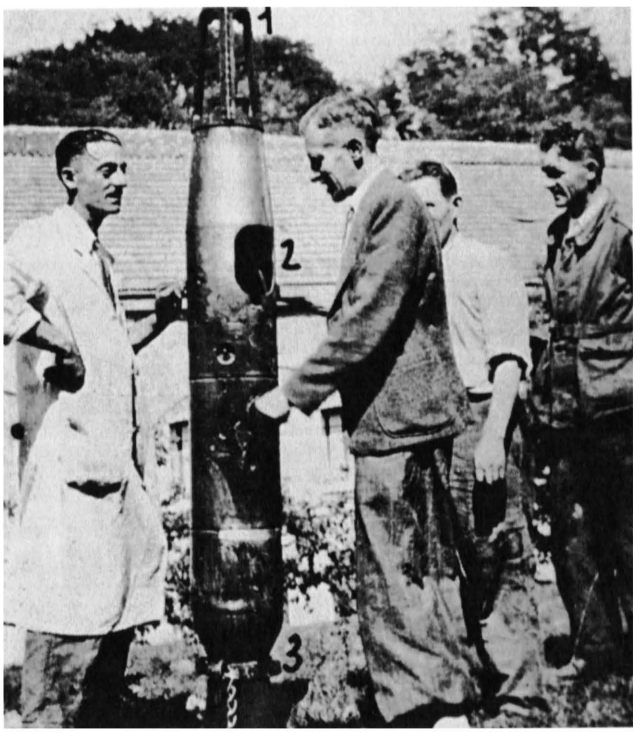

Figure 2: The EA 1941, the first French liquid fuel rocket, at Vancia, before its first test of July 1942 (Courtesy of Philippe Jung).

But the demarcation line disappeared on November 11 and Lyon was occupied. Barré entered the Résistance in the Dubouloz-Gallia network, still working on the EA 1941. He worked on nuclear and ionic propulsion as well. In October 1943, he began microfilming the EA 1941 drawings for sending them to officials in London.

These activities were hard to conceal and Dubouloz was interned in the summer of 1944 in the infamous Fresnes jail. However, he managed to convince

the Gestapo that the work of Barré was frivolous! It was the team member, Colonel Gentil, who was deported to the Dora camp, where he died a few months later.

Even before Victory by the Liberation of France in mid-1944, all the EA 1941 rocket hardware from Marseille, Lyon, and Oran, was reunited and the decision was made to test the rocket from the La Renardiére range in St. Mandrier, in the bay of Toulon.

Thus, on March 15, 1945, the 100 kg rocket rose from its inclined ramp. However, it was immediately unstable and exploded. The following day, the second one burst on its ramp, leading to the cancellation of the third launch. Manufacturing of the rockets then was contracted to industry. SAGEM in Argenteuil, was selected. Three more launches were performed on July 6, the last one being an important success with an estimated range of 60 km reached over the Mediterranean, even if the rocket motor only burned for 7.5 seconds instead of the planned 13 seconds. With a burnout speed of 5,000 km/hr, the EA 1941 thus became the first French supersonic vehicle.

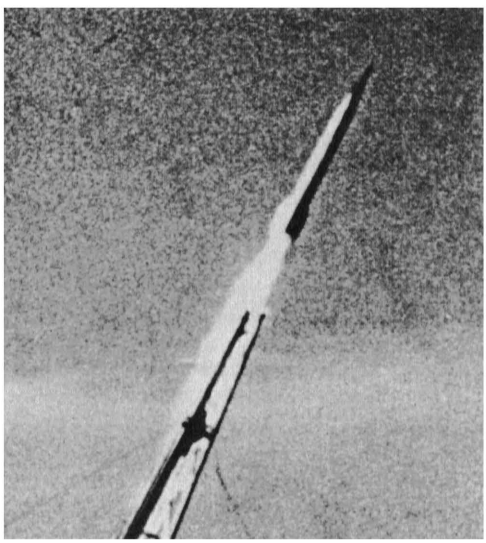

Figure 3: Launch of the EA 1941, No. 3, on 6 July 1945, that flew 10 km down range, the first French liquid fuel rocket to fly (Courtesy of Philippe Jung).

Two new attempts on July 18 failed when the rockets burnt out on the ramp. They had been equipped with a Mesny radio localization beacon made by Professor Yves Rocard, the father of the future French Prime Minister [Michel Rocard—ED.]. The seventh model was therefore not launched and was instead, statically tested at Mont Valirien in Paris, with success. Later, it was found out

that bits were coming off the interior of the nitrogen pressurant bottles, thus impeding the propellant flow. At last, France had rejoined, albeit quite modestly, the trio of the U.S. (Goddard launched the first liquid rocket in March 1926), the USSR, and Germany [in the development of liquid propellant rockets—ED.].

French Missions in Germany

It is not well known that without waiting for the Armistice of May 8, France sent (similar to its American and Soviet allies), numerous missions in Germany to try to recover whatever was available. The new categories of "secret weapons" created a lot of excitement, and the three French arms created specific structures or nominated persons dedicated to what became known as "special devices."

Whereas the French Navy and Army sent personal missions as early as September 1944, the Air Ministry created a specific organization, the SCIT (Service Central d'Information Technique), with a dozen people, under the head of Guy du Merle, the former official responsible for aircraft in the STAd. He took Michel Decker with him to cover the missiles. The latter's first job was to investigate the fall of a V-2 on October 4th, in Deuil-la-Barre, where his family resided. In the Fall of 1944, he began the first of about fifteen trips of one week, some of them very complicated. He visited the following locations: Stuttgart, Friedrichshafen, Bregenz, Lindau and Lowenthal in Southern Germany, in the Kochel wind tunnel south of Munich, in the Soviet zone in Vienna; and he also went with other Frenchmen to Peenemünde. In Germany, support, was provided by a mission in Kressbronn-Lindau with Delbèue, responsible for that area. Decker only found bits and pieces, the essential things already having been taken away by the Americans. He was once even turned away at gun point from a mine in Longwy, near Metz, where V-1s had been built, although he had an authorization from the Minister himself! He recorded 138 studies of missiles, but he mainly saw only subcontractors. However, he was able to recover some documents on ground-to-air missiles, as well as a little hardware; several German missiles were turned over as priorities to the Arsenal de l'Aéronautique in Châtillon. These included Rheintochter controls, some V-1s, and a Henschel Hs 293. The latter was turned over to the Marines. A few German engineers were also later sent to France.

The Army naturally used the services of Barré, but they also obtained the services of Professor Henri Moureu, code-named "Charles" in the Resistance.[4] The latter, director of the Laboratoire Municipal de la Ville de Paris (that included a Service des Explosifs and a Service de Recherches Scientifiques), already had en-

quired on the mysterious explosion of September 8, 1944 in Charentonneau, near Châtillon. On that day, at about 11 a.m., for the first time in history a ballistic missile had been launched in anger, killing or injuring about twenty people.[5]

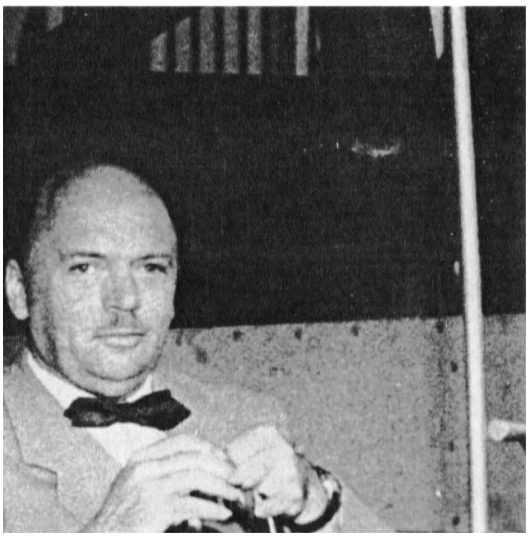

Figure 4: Michel Decker (b. 1913), French missile pioneer (Courtesy of Philippe Jung).

A Summary of V-2 Launches

Contrary to a tenacious legend, the first V-2 was indeed launched against Paris, and not London, from Bochholz in Belgium, by the German Army's 444th Training and Testing Battalion. This weapon was again used against the French capital between October 2 and 5. Those 23 firings allowed Moureu to recover many elements and to transmit several reports to the État-Major Général de l'Armée (the French Army headquarters). The latter created, on January 1, 1945, the BSA (Bureau Scientifique de l'Armée), with among others, Moureu on its staff. A structure for information and prospective actions, the existence of which was to be rather short, the BSA allowed liaison with the scientists. It should be noted that 55 other V-2s were launched, beginning in October until the 5th, in the North of France (25 landed on Lille, 19 on Tourcoing, six on Arras, four on Cambrai and one on St. Quentin). The Army's DEFA (Direction des Études et Fabrications d'Armement) sent two missions under the head of d'Alauzin, including Barré and the BSA (Moureu); on May 9 to the 17, 1945 to the "Porzellan" plant for V-2 ac-

ceptance in Oberraderach near Friedrichshafen, and on June 7 to 29 to the "Basalt" factory of Lehesten (V-2 nozzles) and "Mittelwerk"/Dora. The second mission, in the American zone around Nordhausen, allowed the recovery of four V-1s, although the promised ten V-2s never were delivered. The Navy created, in October 1944, a Commission des Armes Secrètes Allemandes, on Boulevard Victor in Paris, headed by Chief Engineer Brard. The principal engineer Pierre Contensou of DCCAN, based in Constance, was also part of the team that went to Peenemünde. The latter recovered some interesting German engineers, as well as a few air-to-ground Ruhrstahl X-1 "Fritz X" (or SD 1400X) and the Hs 293. He was later to become the director of ONERA and was elected to the French Academy.

Different Strategies

The three French armed forces adopted differing strategies to cover the new field of rocket weapons. In October 1945, the Marines created GANES (the Groupe Aéronautique Navale Engins Spéciaux) in Eutingen, near Constance, with Lieutenant Decaix, to test recovered rockets. Their goal was to continue and develop the German studies, in order to provide the Marines with new weapons, essentially flying torpedoes and anti-aircraft systems. On July 17, 1946, the decision was made to come back to France to Cuers, near Toulon. GANES was dissolved on November 23, to be replaced by the EST (Engins Spéciaux et Torpilles) section within CEPA, still with Decaix. A special barracks was erected in St. Raphael for the German engineers on March 15th, 1947. A special devices ES group was created in STCAN in Paris, with another ES technical team in Brest, later shifted to Ruelle in ECAN (Etablissement des Constructions et Armes Navales). The use of Le Luc airfield with its runway of adequate length was negotiated with the Air Ministry; this airfield is presently the base for the Army's ALAT helicopter school.

On the Army side, Moureu proposed to create the Institut Français de la Fusée [French Institute of Rocketry—ED.] in May 1945, supported by Chief Engineer Jacques Lafargue, head of the technical services of DEFA. Already having its own special devices section in St. Cloud near Paris, DEFA proposed on August 13, the creation of Centre d'Études de la Fusée [Study Center of Rocketry—ED.], under the responsibility of Moureu, nominated as their technical advisor. In mid-August, Moureu instituted the GOPA (Groupe Opérationnel des Projectiles Autopropulsés) with DEFA, No. 2 Bureau and the CNRS (Conseil National de la Recherche Scientifique), under the aegis of the État-Major des Armées. Around September, DEFA hired 28 German aerodynamicists from Kochel, south of Munich, who had moved there from Peenemünde after the air raids. They were sent to Em-

mendingen, in the French zone of occupation in Southwestern Germany, where a design bureau was created to develop a wind tunnel that was eventually built in Vernon. On November 14, yet another change saw GOPA becoming CEPA (the Centre d'Études des Projectiles Autopropulsés) in Puteaux, with Lafargue as the technical director. It included about ten scientists split into two groups, a military Technical Department attached to DEFA, and a Scientific Department with both military and civil personnel, as had happened at CNET (Centre National d'Étude des Télécommunications). No less than 133 reports were published in less than two years, but without any follow-up. There was more talk than action.

Then DEFA created on May 17, 1946 the LRBA (Laboratoire de Recherches Balistiques et Aérodynamiques), under the head of Libessart. It was eventually decided to locate it to Vernon, after the arrival there of Karl Maybach on September 1, 1946. The so-called Maybach Group was a team of German engineers belonging to the company that had developed engines for armored vehicles. This led to the decline of CEPA, which became double-headed in 1947 with Lafargue and Moureu. The latter proposed to build 30 V-2 in Puteaux, a costly suggestion without a future that was refused by the État-Major des Armées in October 1947, although Moureu had already started collecting the V-2 elements given to Lafargue. Obviously, a civilian could not handle matters related to defense. So, CEPA stayed as a forum for discussion, never having any permanent activities; rather, its goal was to give the appearance of a central direction to the service of Moureu.

On May 5, DEFA had already started signing its first contracts, hiring German engineers, initially grouped in the area of Emmendingen, 35 specialists in the EAP (Engins Autopropulsés – Propulsion) group in Riegel with Jauernick, and 25 others in the EAG (Engins Autopropulsés – Guidage) group in Denzlingen with Otto Müller.[6] A total of about one hundred was employed, some of them previously employed by the British, but most of the Germans had been recovered by the Americans and the Soviets. They were tasked with reconstituting the A-4 and Wasserfall files. Heinz Bringer, the future father of the Viking engine for the Ariane launch vehicle, belonged to EAR DEFA. He used the services of several of its branches—the EET (Etablissement d'Expériences Techniques) in Satory near Versailles for studies on the use of solid propellant; the EET in Bourges for launch tests, the Service des Études of the Manufacture de Levallois near Paris for studies of boresight computers; and APX (Ateliers de Puteaux, a manufacturing plant in the suburbs of Paris), for studies of V-2 gyroscopes and of rocket propulsion. In October 1946, a dozen German engineers were sent to APX, where a design bureau was created to finish the V-2 drawings.

As can be seen, there was some lack of order at the time and each arm obviously tended to be only interested by its own needs (e.g. the Army was not

concerned with air-to-air missiles). Some also did not realize that missiles used aeronautical techniques. Furthermore, even in the Armée de l'Air, pilots did not look favorably upon these automatic machines, potential competitors for themselves. On May 2, 1946, however, the engineer named Norguet, from the Génie Maritime, asked the État-Major for a better coordination, but without proposing criteria for a split of the work. This resulted in a decision by the État-Major in August 1946 to begin working on tactical missiles, to be followed later by strategic ones, i.e. having a range greater than 300 km. Priority was given to liquid propulsion for several programs: the 4209 tactical "long range" missile of more than 100 km range, the ONM for the Office National Météorologique (an improved EA 1941 studied in 1947 by APX), the anti-aircraft PARCA (Projectile Autopropulsé Radioguidé Contre Avions), and the already ordered Barré EA 4211 EOLE. The first two were, however, cancelled in May 1947; work on the PARCA only started later.

In these conditions, it is the third arm which eventually took the lead. In October 1945, the Ministère de l'Air created within STAé, a section called the Engines Spéciaux (STA/ES), with a dozen persons, headed from January 1947 by Decker. It included among others, Bastien-Thiry, later to be executed for having made an attempt on De Gaulle's life. The other arms representatives there were: Bigeon for the Army and Salmon for the Navy. At the same time, Operation Backfire was taking place in Cuxhaven, Germany; one thousand German people had rebuilt eight V-2s for the British, three of which flew satisfactorily between October 2 and 14, 1945, in the presence of Theodore von Kármán, William Pickering, Henri Moureu, and the yet unknown, Sergei P. Korolev and Valentin P. Glushko. Decker adopted what turned out to be the best strategy. He decided, first to work on all subjects for all arms (because what flys belongs to aeronautics), then to start from scratch with a methodic progression, German hardware only being used if necessary. Incidentally, only a few German engineers were employed in the Ministere de l'Air's activities. There were initially two in Cannes—Czerwenka who quickly went back home, and Thorn, who only made a modest contribution in the analysis department, under ex-LeO Paul Gross.

He thus wrote a seminal program, but many know it without realizing its origins! To sort out the various missiles, he split them into several basic types, referenced AA (air-air), AS (air-sol or air-to-surface), SA (sol-air), SS (sol-sol) and CT (Cible télécommandée, or remotely-controlled target). He sent this program to the whole French aeronautical industry, another important decision, instead of trying to have it made in-house, such as with Arsenal de l'Aéronautique. In June 1946, he released the final version, only slightly amended. Today, this

has become a standard in France, as exemplified by the famous laser guided AS 30L missile.

The completeness of the Decker program undoubtedly makes him one of the fathers of French space activities, as it allowed the development of all the corresponding basic techniques.

The SE 1500

The clarity and the wide scope of the STA specification naturally aroused the interest of nearly the complete French aeronautical industry, if only in the hope of compensating the massive cancellations in the wake of the newly-won peace. Many proposals were submitted, often brilliant, sometimes weird, by the Societie Nationales de Constructions Aéronautiques SNCASE (Sud Est), SNCAC (Centre), SNCAN (Nord), and by private organizations, the BTEguet, ECA, and MATRA. A special place, however, was reserved by STA to Arsenal; it appeared natural to rely upon it in this virgin domain, full of unknowns and risks, all the more as a thorny reconversion problem was looming.

The quickest was Louis Marnay, the dynamic chief of land aircraft in Marignane. He knew Decker well since having graduated in 1934 from the premier French aeronautical engineering school, two years before his future customer; he became responsible for the Lioré & Olivier Leo LeO 45 medium bomber, managed on the Air Ministry side by Decker. In the wake of the terror bombings of Coventry and Dresden, there was a lot of interest in the world for the anti-aircraft ground-to-air missile. By using the new operational research method, Decker had shown in this respect the superiority of the guided missile over canon and aircraft. Marnay did not even wait for the final document to propose (for the AS 10 program?) the SE 1500,[7] a stabilized glider to be released from a LeO 45. The aim was to evaluate the damage created by the explosive charge of a missile, as well as to serve as a gliding bomb. The idea was to lower the explosives at variable distances from the belly of the vehicle, which thus simulated a bomber. The aircraft-like configuration, something SNCASE knew very well, allowed the engineer in charge, Marcellin Laurent, to progress quickly. This was so much so that already on November 7, 1946, the first test of the 43 m span glider took place.

At this moment, a reorganization of SNCASE took place and it was decided in March 1947 that all so-called "re-conversion" non aeronautical activities would be shifted to the Cannes plant that already depended upon Marnay and was surviving by building metallic chairs. An added bonus was to be able to pur-

sue these top secret activities in a small plant located in a most unlikely place, known more for doing nothing of importance than for technology! On a more personal note, this also allowed Marnay to detach himself definitely from the tutelage of the many chief engineers at Marignane.

The SE 1500 quickly aroused much interest, starting with Marines that saw it as a very good target for its anti-aircraft cannons, all the more as the parallel Arsenal 5501 (for the CT 10 program) had a protracted development. That was to be the start for what became the first series-produced missile in France, as well as the first to be recoverable, with a parachute (plus, later, skids for a land version for the Armée de l'Air); 118 were built in Cannes, making 173 flights from such diverse aircraft as the SE 161 Languedoc, the Handley-Page Halifax, and the English Electric Canberra. On October 28, 1948, the SE 1500 No. 9 was the first vehicle launched from the new CEES (Centre d'Essais d'Engins Spéciaux, created on April 24, 1947) in Colomb-Béchar, which became in 1948, the CIEES Interarmdes. The location for this range had already been selected in November 1946, just as the first SE 1500 was making its first flight. From the same range, France became, in 1965, the third space power with the Diamant launch vehicle [launching the A-1 test satellite on November 26th of that year—Ed.]. Other launches took place from Toulon, Istres, and Biscarosse. The SE 1500 was built in 13 versions, some of them propelled, with Turboméca jet engines or a SEPR 401 rocket motor of 1.25 t thrust. The latter used the nitric acid/tonka (a 50/50 mixture of xylidine and triethylamine) combination of the war-time German BMW 109-448 rocket engine. The SEPR 4 also was used as the booster for the SE 4100.

Meanwhile, the Department of the Marines was still interested in Turck's work. They accordingly proposed to free him, not without promising that he would be given study contracts for telecommand and telemetry systems—a promise not fulfilled. Thus, the Etablissements' Jean Turck became, in 1946, one of the very first French equipment manufacturers of the nascent rocket industry. Two initial contracts were won from STAG, one for the SE 1500, and one for ECA (Études de Constructions Aéronautiques in Meudon, near Paris) for the S.20 target. So, on March 19, 1948, SE 15 10 No. 1 became the first French guided missile in Brétigny, near Paris. Guidance was by a tele-pilot located on the Leo 45 carrier. Both radio and non-jammable infra-red links were tested. Thus, the SE 1500, under the appearance of a classical glider, actually became the initial test bed for the French equipment industry. Stabilization was ensured by a loop built by ECA, that had been created by Gianoli, a former Couzinet aircraft engineer (this company had built the "Arc-en-Ciel" transatlantic aircraft for [French aviation pioneer Jean—ED.] Mermoz.). Parachutes were provided by

EFA or Aerazur. Another company acquired precious experience on the SE 1500: SFIM, that built the remarkable recorders invented by Hussenot and quickly exported them to Great Britain.

Arsenal's SS 10 and CT 10

In Arsenal, there was a need to find work for the team of Emile Stauff, a Polytechnique graduate, with the winding down of aircraft and engine activities. It also looked appropriate to give Arsenal whatever work the companies could not, or did not want to or should not do. Stauff thus created, in October 1946, with the blessing of the DTIA (Direction Technique Industrielle de l'Aéronautique), a new design bureau called E5 for "Engins Spéciaux," with 43 persons under the leadership of Emile Stauff. It incorporated about half a dozen German engineers. The famous Sänger-Bredt couple [Drs. Eugen Sänger and Irene Bredt; see Chapter 1—ED.] who had planned a space plane to bomb New York, and who already had arrived in July, was not part of E5. They actually isolated themselves in their rooms. After a brief spell of two weeks, Max Kramer, the father of the X-series of German wartime missiles, quickly left. It would appear that some personnel left over from the closure of ACC (Atelier de Construction de Châtillon, ex-Brandt, and under the aegis of DEFA) on January 1, 1947 were taken by Stauff. He also recovered an air-to-air Ruhrstahl X-4, an anti-tank X-7, a V-1 and a Messerschmitt E-4 Enzian. Full of new ideas, Stauff was, however, persuaded by STA to initially use the wealth of German experience he had under his hands. He thus responded to the start-up programs AA 10, SS-10, and CT 10.

In December 1946, he launched the first of two or three Arsenal 5 101 in Suippes, near Reims. Copies of the X-4 built in the frame of the AA 10 program, they had the 0.2 t thrust SEPR 16 and improved SEPR 21 rocket motors (themselves copies of the [Helmut—ED.] von Zborowski BMW 109-448 engine). It was a failure, as the handling of this complex vehicle, from a Junkers Ju 88, was abominable. There were even helicoidal tanks to try to handle the sloshing problem! In February 1950, Le Luc airfield was used for launches near the now famous beach of Pampelonne, near St. Tropez.

However, from it evolved the now well-known wire guidance system, as used on the X-4 and X-7. The experimental two-fin anti-tank Arsenal 5201 was conceived in December 1947, but its flights were marred by an unwanted helicoidal movement. A four-fin Arsenal 5202 version was quickly evolved. It was used operationally for the first time in the world as the Arsenal 5202 and 5203 of the SS-10 program. Propelled by a solid block of SNPE, one of the world's first

anti-tank missiles was built in the remarkable amount of 29,849 examples, 60% of which were exported to the U.S. Army included (as the MGM-21A).

For the CT 10, Stauff elected to use the V-1 configuration. It also used a pulse jet, tested in January 1947 on the back of a Leo 451 in Marignane. Development of the Arsenal 5501 proved laborious, from an August 1946 design to an April 2, 1949 first flight. Roger Chevalier, the future Diamant chief, was brought into the picture to improve matters. He succeeded and the Arsenal 5501, of simpler use than the SE 1500, took over as it was ground launched with boosters, thus obviating the need to use carrier aircraft. No less than 413 examples were built, some exported to Great Britain and the U.S.

One of the unfortunate competitors for the CT 10 program was ECA, with its T 40 project. This company built several little-known small vehicles. The S.20 of 1947 was a crude glider for testing stabilization and telecommand systems, followed by the targets [drones—ED.] designated as the ECA 21, ECA 27, ECA 30, and ECA 57 for the Navy, the towed ECA 58 also for the Navy, and towed XC-13. It then concentrated on the development of homing devices and equipment for stabilization. It notably subcontracted to SNCASE at Cannes for the manufacture of twenty T 50's.

The Marines and the German Missiles

The French Marines were initially interested in aircraft-launched torpedoes. To learn more, it continued the development of the German gliding bombs, either recovered or rebuilt. No less than eight Junkers aircraft were used for the experiments; four Ju 188s for the X-1 and Hs 293s, and four Ju 88s. Lieutenant Salzedo was involved on behalf of CEPA. He was an easy-going person, once appearing in CERES completely naked, except for his cap on the head! The Ju 188s of the IOS Flotilla in St. Raphael were used from August 20, 1947 to launch near Pampelonne, the X-1's, renamed Pluvier. Starting on December 2, 1948, at least two X-8, supersonic follow-on to the X-1 built by Arsenal, were flown. More streamlined, without the braking ring, they were stabilized by slow roll. This is the first time that the existence of this weapon was confirmed as it previously was thought to have been the result of confusion with the X-71.

Towards 1949, there were 74 Palombe missiles, in fact the Hs 293 that were built in the Brest and Ruelle Arsenals. They used the Walter 109-507 German rocket engine of 0.7 t thrust, with hydrogen peroxide and calcium permanganate. Two TV guided Hs 293Ds also having been recovered, guidance tests were made by mounting one in a Ju 188, the latter then playing the role of a flying bomb.

A first attempt at new hardware was the L.50, a German F5 torpedo suspended under a delta wing built in the Atelier ties Torpilles in St. Tropez and La Londe (this would be one of the very first applications of the delta wing in missiles). Development was given to the German team with many subcontractors located in the area of Constance. Guidance was performed with V-1 hardware. About 60 were launched from 1947. There were no less than 22 consecutive failures until one engineer had the idea to replace the flexible rubber tubes used for anemometry for rigid copper ones! There also was a weird project for an autogyro torpedo, with a two or three-bladed rotor; the three examples launched from a Ju 88 all failed, the first one when the rotor collided at deployment with the torpedo body.

By this time, it was felt that there was a need to turn to industry in order to progress. Latecouère, a long-time supplier of seaplanes for the French Navy, and now severely lacking orders, was a natural choice.

The Birth of SEPR

On May 30, 1944, Fernand Florio had already created SCEPR (Société Civile pour l'Étude de la Propulsion par Réaction), at Rue St. Lazare in Paris. It became SEPR in 1945 and was transferred at the end of that year to the nearby village of Villejuif, where some space was available for testing. It first studied recovered German hardware, before testing in July 1947 its first in-house motor, the SEPR 3 of 0.75 thrust, based upon the Walter 109-509 of the Messerschmitt Me 163 rocket interceptor. It used a combination of C-Stoff (hydrazine hydrate, methyl alcohol and water) and T-Stoff (hydrazine peroxide and 20% water).

LRBA Studies

On the Army side, about 60 German engineers were transferred from Emmendingen to Vernon between the end of March and August 1947, bringing the team size to 87 with the French people. The Germans already had proposed on September 21, 1946 to study larger derivatives of the V-2, later called the R-1 and the R-2.[8] This EA 4212 study, with Wolfgang Pilz and Heinz Bringer, dealt with a 900 km range missile of 40 t thrust. It was the biggest rocket under study in the world at the time. Too ambitious, it was abandoned in 1949, not without the first test in December 1947 of a gas generator of 4 t thrust, using nitric acid and kerosene. Few Germans really integrated themselves in the French program, many stay-

ing with their theoretical studies, some coming back to their home country. The Army studies experienced a slow progress and, like the Navy, no use was made of the services of aircraft prime contractors. The Army thought they could acquire the necessary technologies by hiring German engineers, but they were not in a position to check the real competencies of the latter.

Interestingly, Lafargue and Decker, also contacted Contraves in Switzerland around 1948, as they were developing in Emmen the ground-to-air RSC-50 (which was later tested in 1950 in France), as a follow-on to studies initiated during the war, perhaps for Germany.

Ananoff and Space

Ananoff had been making a lot of effort promoting space activities, with conferences and exhibits, notably on the occasion of the Universal Exposition of 1937. In June 1945, he created the Groupement Astronautique Français within the Aéro-Club Universitaire de France, and publishing a monthly review, *l'Astronef*. During the Congress National de l'Aviation Française, on April 16, 1946, an astronautical sub-section was created. But a high level of secrecy surrounded any rocket activity; when he proposed building a postal rocket, the Minister of Posts, Telegraph and Telephone answered that the decree of Prairial 27, year IX (according to the Revolutionary calendar of the 18th century) forbade it!

So, by the end of 1949, everything was in place in France for rocket activities, with three military customers, several primes and their equipment manufacturers, as well as launch bases. The first true French rocket, built by SNCAC in Boulogne-Billancourt, was then ready to depart for the Army Mailly Camp, near Reims.

The SE 4100, First French Rocket Program

At SNCAC, Louis Besson had decided to reply to the simpler missiles of the STA program, itself a progressive one, with e.g. an experimental SA 10 preceding an operational SA 20. So was conceived the NC 3500 missile,[9] with solid or liquid (nitric acid and tonka) boosters mounted on the sides or at the base of the vehicle itself that was beam guided by a ground radar. The nose could be recovered to analyze the on-board equipment, recorders included.

A fortuitous event then took place. With difficulties in its aircraft programs, plus the necessary rationalization of the many SNCA's, it was decided to close SNCAC on June 30, 1949. But Besson's team was doing an excellent job, and Decker immediately stepped in, proposing to Marnay to recover it in Cannes. The occasion was too good to be missed for everybody, the Cannes plant even regaining its independence from Marignane, with Marnay as its director—he now was free at last! The plant was officially specialized by the STA on March 15, 1950 in the field of "engins spéciaux," becoming the GTC, Groupe Technique de Cannes. About fifty engineers were transferred from Marignane. Thus was constituted, in the greatest secrecy, a formidable team of 250 persons, about to go from world record to record, the best rocket team of the 1950s in Europe. With hindsight, it now appears that this decision of 1950 was the starting point for a process which led to the remarkable success of Ariane 1 at its very first launch in December 1979.

Besson, after having been housed by SEPR in Villejuif, went to Mailly, on his way to Cannes, to launch the first NC 3500, now called SE 4100 in the SNCASE Cannes series. On September 29, 1949, under the 2.5 t thrust of its two lateral SEPR 4 boosters half-filled (to stay within range limits), the M02 left its vertical ramp in the Champagne sky. A remarkable progression saw this SA 10 test bed equipped with its liquid propellant SEPR 2 sustainer of 1.25 t thrust, similar to the SEPR 4, and then by the new French solid boosters, made by STRIM (Société Technique de Recherches Industrielles et Mécaniques) in Paris. Mounted on the SE 4110 version, they developed a total thrust of 7.5 tons for six seconds, the first flight taking place on January 10, 1951 at CIEES. Besson had been waiting for them eagerly, as their simplicity of use and quick reaction time made them mandatory for any ground-to-air missile.

Guidance testing, with an on-board CNET receiver called Pénélope, started with a recovered German Würzburg ground radar creating a fixed beam, to be followed by the missile. Then the beam was directed to the target. Experiments were made with several stabilization loops or autopilots. After ECA, the Standard 2 introduced yet another company. SFENA, which later realized the complete Standard four loop (gyro meters, servo-controls, and jacks). SFENA is today the provider of the Ariane inertial platforms. The origins of this company lie in the creation of a laboratory in Wasserberg, near Constance, at the end of 1945, with 35 specialists of guidance and navigation from Siemens, Patin and Askania. In February 1947, 25 of them were sent to GERIA (Groupe d'Études et de Recherches Industrielles Aéronautiques) in Bagntres-de-Bigorre. The following September, the group moved to a new company, SNERA (Société Nationale d'Études et de Recherches Aéronautiques) in Neuilly, near Paris. When the name

changed to SFENA (Société de Française d'Equipements pour la Navigation Aérienne) in 1948, only about seven Germans were still present. The first equipment built there was a reference platform with three gyroscopes.

Figure 5: NC 3500 missile (Courtesy of Philippe Jung).

Various instruments were tested (vertical speed and speed indicators), as well as several control devices (Wagner or Kramer spoilers). The SE 4140 tried a three-fin configuration instead of the normal four-fin model. But it was the SE 4116 version that became the testing workhorse, notably for the last phase of the program with on-board homing devices, allowing the missile, after having been brought close to the target by the radar, to complete the interception itself. Several devices were tested: optical (Ingebert) and radioelectric (SFENA).

With the launch of 78 examples in 16 versions, the SE 4100 not only was the first French rocket program, but it allowed a wide-ranging sweep of all the basic techniques of astronautics—staging, propulsion, aerodynamics, guidance and control, and recovery up to 1,000 km/hr and 11,200 m altitude. The French equipment industry thus acquired a precious experience.

Only a few days after the first SE 4100, an interesting rocket was launched in October 1949, the SEPR 35 for weather related measurements. It was not common that a motorist built himself a complete rocket; furthermore, the latter became the first modern French three-stage solid vehicle, a first stage of 45 t with SD propellant, and two upper stages of 0.05 t thrust with APK propellant.[10]

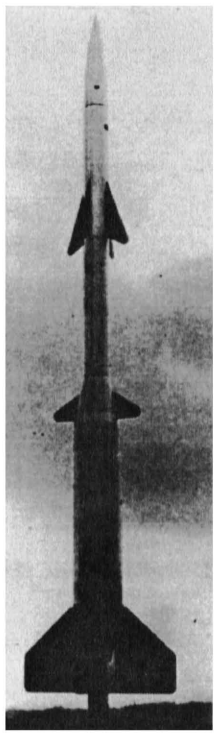

Figure 6: The SEPR sounding (meteorological) rocket, ca. 1949, France's first modern three-stage rocket (Courtesy of Philippe Jung).

The First Operational Ramjet System in the World: the SE 4200

In Billancourt, Besson had also started working on the SS 40 program for an Army ground-to-ground missile.[11] To keep the price of the NC 3510 as low as possible (the cost of a Citroen "Traction Avant" automobile!), he retained a flying wing configuration and the new revolutionary ramjet invented earlier by Frenchmen René Lorin and René Leduc, the so-called simple flying stove, without any mobile parts inside. In 1947, he tried several types of ramjet intakes, circular or

flat, with an American GMC riding at 90 km/hr on the Monthldry racetrack, near Paris. The flat version (NC 3511) allowed a perfect integration of the intake within the wing.

Now the SE 4200 in Cannes, the program's first hops were made on the Pampelonne beach on February 8, 1950, under the power of two lateral STRIM 3100 motors of 4.5 t total thrust. The ramjet was activated on October 3, with SE 4204 No. 1, a European first. The Marines, feeling they had a need for a range closer to metropolitan France, created during that October 1950, an annex to CEPA in the Ile du Levant, that was named CERES (Centre d'Essais et de Recherches d'Engins Spéciaux) in 1951; already, on January 23, 1951, SE 4205 Nos. 3 and 4 were launched here.

Many tests were made, essentially in CIEES, notably of the new PD radar of CSF, used to define the vertical plane inside which the missile had to stay until reaching its target, 130 km away. SFENA provided the auto-pilot. Several homing devices were experimented on, starting with SE 4208 No. 19 on April 27, 1954; optical ECA 402 and 422, radio-electric Spale or CSF CR1 (meaning Contre Radar). For the ramjet, cooperation was inaugurated with ONERA, which by the way, had taken over on November 1, 1946 the Cannes wind tunnel. In 1955 already, the SE 4242 inaugurated glass fiber wings (perhaps a world first for a missile), that incorporated additional tanks; other versions replaced the original wooden wings with aluminum ones. In 1960, the Thomson Tatou equipment was tested.

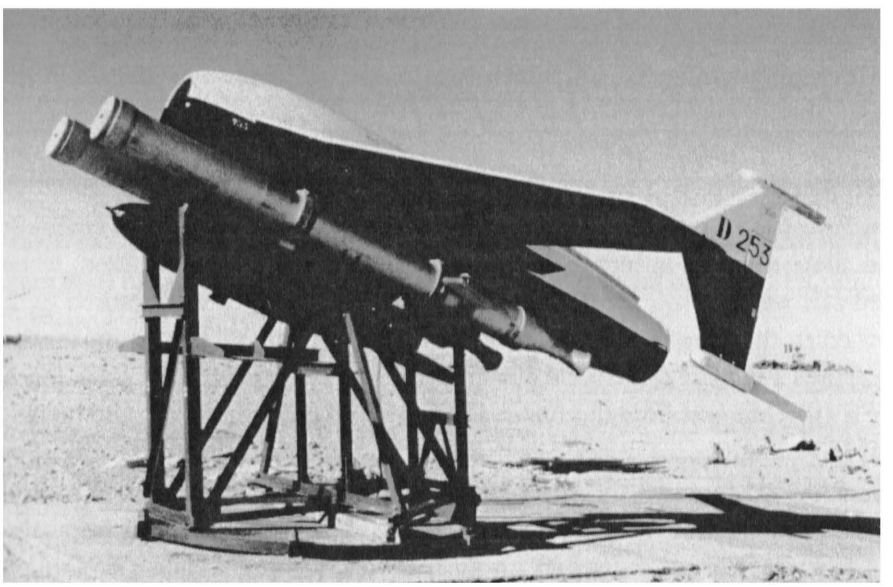

Figure 7: The SE 4242, No. 51 missile with fibreglass wings, at Colomb-Bechar, Algeria, 22 January 1958 (Courtesy of Philippe Jung).

But on June 8, 1955, the launch by the 701 GAG (Groupement d'Artillerie Guidée) of SE 4263 No. 1 in Colomb-Béchar marked the world's first operational use of a ranger weapon system. GTC actually was responsible for providing the Army with a complete mobile turnkey system, missiles, radars, transportation vehicles and all field hardware. No less than four missiles could be guided simultaneously to their target, after launches spaced by 15 seconds. The 701ê GAG and 7026 GAG in Epernay, put a total of six versions (SE 4245, 4246, 4247, 4262, 4263 and 4280) into service and differed from each other by their equipment and boosters (STRIM 3100, 3340 or 3370 of 3.2 t unit thrust).

In 1958, discussions to sell the SE 4200 to Sweden (plus license manufacturing) and Switzerland were nearly concluded. Interestingly, these two countries later introduced the ramjet propelled ground-to-air Bloodhound missiles.

The technical success of the SE 4200 system was such, notably its accuracy, that incentives of up to 840% were given to Cannes, immediately reinvested in expanding the plant, thus ensuring its presence to this day.

Interestingly, it should be noted that, from the EA 1941 to the SE 4200, virtually all the French post-war rocket realizations had been orchestrated on the Mediterranean sea.

Véronique, The First French Sounding Rocket

With the Army interest in the ground-to-air missile, LRBA decided to structure itself into two groups into which the EAG and EAP groups were integrated in 1948.[12] The first one with Collet-Billon and Otto Muller, was to concentrate on the corresponding guided missile, the PARCA. But to learn about propulsion techniques, a second group with Jean Corbeau and Heinz Bringer, was tasked to develop a less ambitious vehicle that was unguided and only aerodynamically stabilized. Some German influence could be traced to the initial stabilization; when the speed still was too low for the fins to be effective, stability was ensured by wires attached to the base of the rocket, and unreeling symmetrically from the launch pad. It was a passive system, no electrical orders being transmitted as on the Arsenal SS 10. Thus was born the Étude 4213, decided in March 1949, and quickly renamed Véronique.

Powered by a 4 t thrust motor using nitric acid and terebenthine gasoline, plus furfuryl alcohol as a hypergolic additive, Véronique also had been planned right from the start to be used as a sounding rocket able to reach a 65 km height. The first one was launched from the Suippes military range on August 2, 1950, as a Véronique R version (R like Réduit) with reduced propellant for a 6.5 seconds burn

time, so as to stay within range limits. On May 22, 1952, Véronique N (Normale) No. 3 was launched from Hammaguir and went supersonic and reached 70 km, a French record. It was lengthened several times to increase its altitude performance up to 220 km, with Véronique NA (Normale Allongde) and Véronique 61 (year of 1961). Besides being the highest altitude rocket for France, Véronique also allowed our first scientific experiments to be made in aeronomy and astronomy, as well as our first biological flights (rats, and later cats).

Development of the PARCA began in 1948. The first one would appear to have been launched at the same time as Véronique, in August 1950 in Suippes, although this seems dubious for a much more elaborated vehicle. Propelled at Mach 1.7 by a SEPR motor using nitric acid and furaline, it was boosted by four SEPR solids. A pre-series of 100 examples was put into service with the 7016 GAG in 1958. It never actually could be made to work because of stability problems stemming from liquid propellant sloshing during high-g maneuvering.

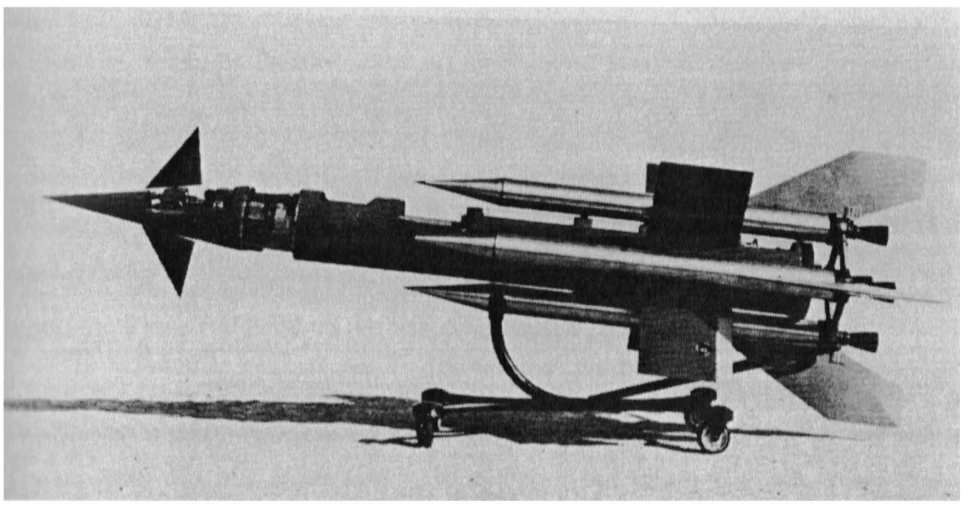

Figure 8: A mockup of a PARCA ground-to-air missile, boosted by four SEPR solid fuel motors, ca. 1958 (Courtesy of Philippe Jung).

As previously seen, DEFA already had ordered, on August 22, 1945, from SAGEM, a more powerful derivative of Barré's rocket, the EA 1946 of 3.4 t weight, also called Étude 4211. It was renamed EOLE, for Engin fonctionnant avec l'Oxygéne Liquide et l'Ether de pétrole [Engine Functioning with Liquid Oxygen and Petroleum Ether—ED.], but difficulties with such an explosive combination during two static tests in 1949 and 1950, as the EOLE 1946-A, led to a change to propellants of liquid oxygen/ethylic alcohol. The basic name, however, was kept, as EOLE 1951 (Engin utilisant Oxygéne Liquide et Alcool Ethylique) [Engine

Utilizing Liquid Oxygen and Ethyl Alcohol—ED.]. In the course of ten static tests, seven with the engine and three with the complete rocket, a maximum thrust of 9.5 t was recorded. The first launch only took place on November 22 from Hammaguir. Like the second one two days later, it quickly ended with in-flight rupture when the fins broke away at Mach 1, a common problem at the time.

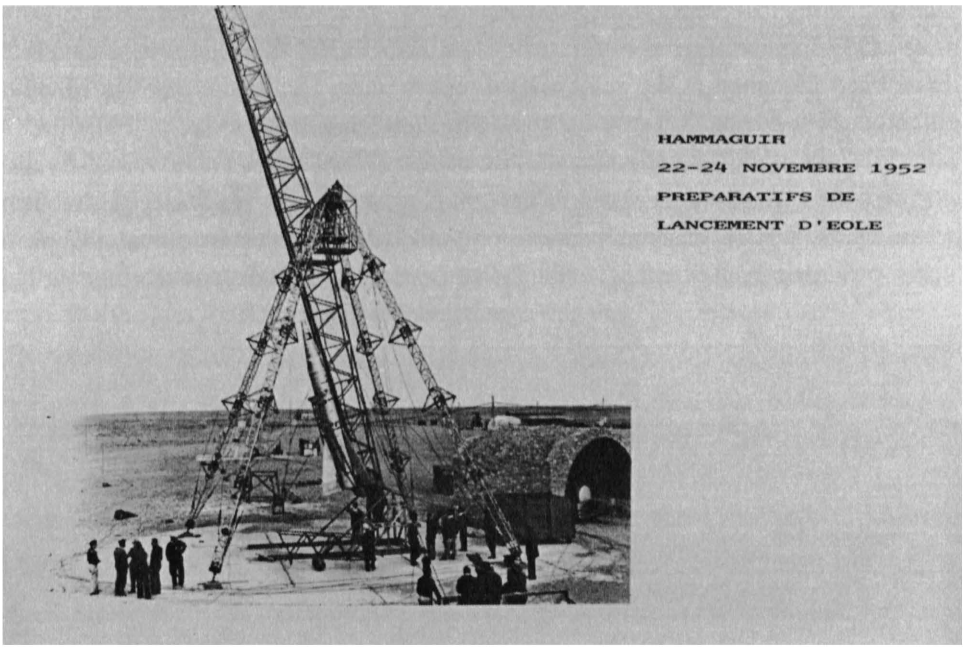

Figure 9: Preparation for launch of the Eole missile at Hammaguir, Algeria, 22-24 November 1952 (Courtesy of Philippe Jung).

The Birth of the IAF

The year 1950 was also an important one, since after many discussions and efforts by Ananoff, the first Congress International d'Astronautique took place in La Sorbonne in Paris from September 30 to October 2. There were only eight countries that participated—modest beginnings for what has now become the biggest yearly world space meeting: Argentina, Austria, Denmark, France, Germany, Great Britain, Spain and Sweden were represented at the first Congress. Although invited, the U.S. and USSR declined to come because of the Cold War and the distances involved. An important conclusion was the decision to create a Federation, which saw the light on September 4, 1951 during the second Congress in London, under the name of IAF, International Astronautical Federation.

On a lighter note, Ananoff also gave permission to the Belgian Hergé, to allow him publish his 1950 cartoon, "Objectif Lune" ["Objective Moon"—ED.], with Tintin.

MATRA Steps In

The young MATRA (Mécanique Aviation TRAction) also had chosen to compete for the STA program in the much sought ground-to-air category, but also in the air-to-air one. In line with an in-house forward-looking policy, Roger Robert, the former chief of the Bernard Design Bureau, which had held the world speed record for aircraft decided in particular to go straight to the supersonic guided missile. He started with M04 mock ups released at altitude by a Handley-Page Halifax ("0" is used in France for prototypes). After inert launches in May 1950, the SEPR 12 rocket engine of 1.25 t thrust using nitric acid and tonka made the achievement possible in the spring of 1952 at Colomb-Béchar as the first controlled supersonic flight in France, occurring for a few seconds. The stabilization equipment employed ECA and SFENA hardware, was later replaced by MATRA products.

An explanation of the MATRA codes should be given here. The "R" stood for Robert, while the first digit indicated the category (4 for SA missiles, 5 for AA, 6 for AS, 1 being reserved for aircraft, 2 and 3 being unidentified). The second digit was given chronologically. The last one showed variants. For prototypes, the 0 was followed by the first two digits of the operational version.

In September 1952, two R04 prototypes of more compact configuration were launched from Hammaguir, but without success. They had a SEPR 44 motor of 1.5 t thrust and 4 SEPR boosters of 1.25 t thrust each, all using nitric acid and tonka. The program was then reoriented by switching to the solid propellant. M042 mock ups launched in 1953, perhaps still with a liquid SEPR 441 sustainer of 2 t thrust. R042 prototypes with three SEPR 50 boosters of 10 t unit thrust then followed in May 1954. The definite R422 with three SEPR 5051 boosters of 10 t unit thrust and a SEPR 703 of 1.45 t thrust appeared in November 1954, using a SFENA homing device. A R422B version, probably with a SEPR 732 booster of 20 t thrust (or SEPR 734 of 23.2 t and a SEPR 705 sustainer of 1.45 t thrust), was tested in October 1956. To increase range, a final version R431 with SEPR 732 and Nord Aviation ramjet, preceded in November 1954 by M043 mock ups and eventually reached a maximum Mach of 3.3. But, following the mission of General Crépin to the U.S., the disastrous decision was made to stop the French anti-aircraft missiles. The total number of these MATRA missiles is still today unclear (there are also

references to an R045 with a 10 t thrust SEPR 5044 booster, and an R435 with a 20 t thrust SEPR 73 booster), the numbers varying between one and two hundred.

Even though air-to-air missiles are small in dimensions, they follow the same aerodynamic laws as any rocket experiences in its initial trajectories and thus accumulated experiences can directly be used if necessary. Incidentally, MATRA is today in charge of the equipment bay of Ariane. It is thus appropriate to recap here the beginnings of the air-to-air missile in France.

After the failure of the X-4 in the frame of the AA 10 program, Stauff developed in, November 1951, the all-new Arsenal 5102, with diamond-shaped fins. It quickly evolved in February 1952 into the swept-wing supersonic 5103 (Mach 1.7) with solid propellant, radio guidance and control by jet vanes. The same year, on July 1, Arsenal was taken over by SNCAN. Fighting to keep some measure of independence, it became SFECMAS (Société Française d'Études et de Construction de Matériels Aéronautiques Spéciaux) on December 31, still within SNCAN. The renamed Nord 5103 became, in May 1956, the first pre-operational air-to-air missile in France, used on the Dassault Mystère IV (and later on the Super Mystère B2 and the Navy de Havilland Aquilon), in the frame of the AA 20 program. But with the decision around 1958 to specialize with Nord Aviation on surface-launched missiles and MATRA on air-launched ones, an AS 20 version was proposed, the Nord 5110. It was a big success, with 8,000 sold to France, Germany, Italy, South Africa and another country. But when Stauff proposed the bigger 5104 for the AA 25 and AA 26 programs for the Dassault Mirage III, a hot competition with the MATRA R530 saw the latter retained, ending the air-to-air activities of Nord Aviation.

The 1958 decision stemmed from the Air Ministry's request to Stauff to switch to a more automatic device: for the pilot to have two sticks, one for the aircraft and one for the missile were a bit too much! Curiously, Stauff stubbornly refused. MATRA immediately sensed a good opportunity and proposed such an improved system. Arsenal later switched to the 5103, but it already was too late. As is well-known, MATRA is now the European leader in the air-to-air business.

MATRA initially realized the R051 with two-axis control, preceding the three-axis R052. The first tests took place in Mailly in 1951, with old Republic P-47 Thunderbolt fighters. The SFENA control loop was then tested in Istres during the spring of 1952 with a Meteor jet fighter. The following year, the STRIM solid was replaced by a Brandt one and the first live tests against targets involved various homing devices, optical (Drivomatic H01 to H03, Turck) or radio-electric (Thomson FC) systems. At the end of September 1953, the first French auto-guided flight took place in Colomb Béchar with an R051 locked on the Sun thanks to an H01. Later targets were special parachutes and Gérin flares. A pre-

series of 100 R510 was ordered, launches starting in 1957. Eventually, the 900 series R511, with the FD homing device, were the first truly operational air-to-air missiles in France and equipped SO 4050 Vautour, Mirage III, and Aquilon fighters, and light bomber. They opened the way to the widely exported R530 and Mica. It should be noted that MATRA made some foray into the air-to-ground business with the R062 prototype for the Vautour. But only a few were tested (e.g., in October 1953 at CERES).

At the same time, DEFA also tried to enter the anti-tank field, with the Entac, first launched in 1952. Only after help from Nord Aviation—the experts—did it succeed, but not without financial losses. It was put into service in ten countries, including by the U.S. Army (as the MGM-32A), the series manufacturing of nearly 120,000 being subcontracted to Nord Aviation.

Bréguet, the inventor in 1907 of the helicopter, and which had made initially good proposals to STAIES, progressed very slowly. Proposed for the AS 10 program, the Br 910 flying bomb, of 1.36 t mass, only appeared in 1952. Optically guided, it had the very peculiar characteristic of having pre-stressed concrete wings! The goal was to have a simple and cheap design. Six Br 910s were built, six wings of which were tested in France, and the six other wings delivered to the British. An order for 1,400 examples never was confirmed.

The Marines began to test their own first missiles. Some 200 Maruca of the Ruelle Arsenal, with nitric acid and a mixture of aniline and furfurylic alcohol as propellants, were launched from 1950. Several dozen models of the Mabranca, made by the Brandt company, were also launched from May 26, 1951. To improve the visibility of its targets, the Navy ordered from SNCAC a simple but "big" glider, to be towed behind an aircraft. However, the development of this NC 1110 of 9.6 m span was very long and only a few examples were built by DCCAN in Toulon after the SNCAC folded. The future Admiral Mauban flew the Bloch 175 light bomber, used to tow them in Istres, from June 13, 1952. The Curtiss SB2C Helldiver was later used but no stable flight was ever achieved.

In this period, the newly created ONERA (Office National d'Études et de Recherches Aéronautiques) [National Office of Studies and Aeronautical Researches—ED.] on May 5, 1946, was given a wide charter for research. Based in Châtillon, it also began experimenting with ramjets, about ten crude VD1 test vehicles being flown up to Mach 1.8 in 1951 from Mailly.

World Speed Record for the SE 1910 Sled

Even if it was not a flying machine, the contribution that the SE 1910 brought to French experience, including GTC and SEPR, was significant. Initially conceived by Laurent to provide an initial flying speed to military or postal vehicles, the SE 1900 truly was a ground aircraft with a negative-lift wing to keep the contraption on the ground.[13] It was propelled by four SEPR 9 engines using calcium permanganate and hydrogen peroxide, of 1 t thrust each. This combination was the same as the one used to propel the Hs 293 missile as well as the launching shoe of the V-1 on its ramp. It was to track a black line painted in the middle of airport runways. However, stability of such an automatic vehicle obviously was going to be a critical aspect of the program, so quite early it was decided to start with a tracked version, the SE 1910.

Braking was provided by two front SEPR 9, or with disk brakes on the wheels. Later, U-shaped skids lowered on the rails were added. One of the world's first tracks with welded rails and concrete beams was specially built in Istres; there, on March 28, 1952, the SE 1910 No. 1 broke the world's speed record on tracks with an astonishing 328 km/hr, 30 years before the TGV. Four sleds were built, but No. 1 was enough to exhibit in 50 tests an excellent reliability, including with an operating V-1, pulsejet. But just as jettisoning of this V-1 was to be performed, the program was cancelled, in favor of carrier aircraft even though, as Decker puts it, the latter were often unserviceable.[14] Recently, a scale mock up of the SE 1910N-1 assembly was built by the Istres Base Commander.

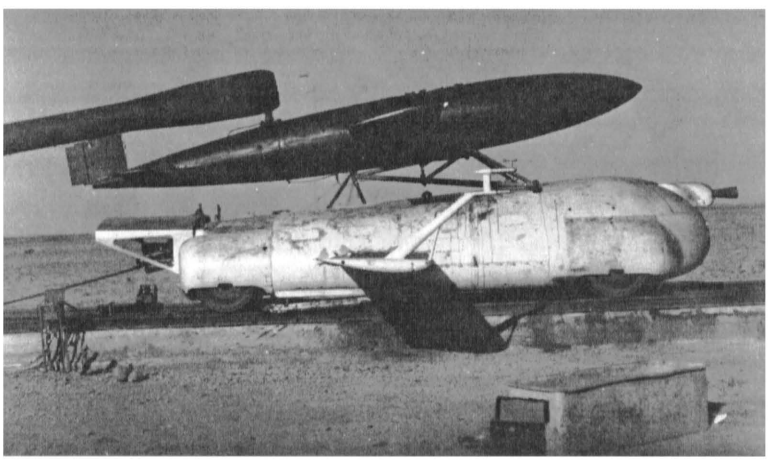

Figure 10: The SE 1910 with V-1, on sled, at Istres, France, that achieved a world land speed record of 328 km/hr on 28 March 1952
(Courtesy of Philippe Jung).

La Furia Francese

There were not many new missile programs in France in 1953, but this was just a lull before the great success in the field of ramjets. The latter form of propulsion almost appeared magical at the time, with its apparent simplicity and performance increasing with speed.

Towards the end of the year, Latécoère flew its first vehicle in the ramjet category, the MS 10 Masalaca (Marine SALmon Contre Avions), developed by Salmon. An experimental supersonic ground-to-air missile, it was launched in many examples as the MS 10 and MS 15 versions, although the ramjet never could work satisfactorily.

Stauff also initiated the hugely successful Arsenal 5210 for the SS II and AS11 programs, first flown in December 1953. Some 170,000 examples of this anti-tank weapon were built for 34 countries, including the AGM-22A and B for the U.S. Army.

By 1953, it thus can be seen, that missile activity in France was indeed incredibly hectic. But this was not known at all outside the small circle of the actors themselves. Abroad, the two super powers were on the verge of taking off with the Viking sounding rocket that had already reached an altitude of 1,173 km in 1951, and Korolev's R-5 rocket of 29 t, twice the weight of the V-2, and had flown on March 15, 1953. The R-11 Scud followed in April, the Redstone in August, while the Nike-Ajax became operational in December (the WAC Corporal probably also in 1953). A host of missiles of all categories also were being tested, some ready to be fielded, like the air-to-air Hughes Falcon.

The era of the rocket was thus dawning in the world. In France, all the actors were in place with the corresponding technologies ready to be perfected. Only inertial guidance was then missing.

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The 44 French Missile Programs that Flew, 1939-1953

First flight	Manufac-turer	Name	Mission	Thrust, tons	Speed, maximum	Altitude, maximum	Range	Built	Laun-ched	Notes
End, 1939	SNCAM	Flying bomb	AS					Few		
1943?	Hurel/Rurck	BHT38	AS					10		
15.3.45	Barré	EA 1941	SS	1 t	5,000 km/h		60 km		7	
7.11.46	SNCASE	SE 1500	AS 10		450 km/h	13 km		118	173	
12.46?	Arsenal	Ars 5101 Ars 5102	AA 10		Mach 0.9			20		X-4
20.8.47	DCCAN	Pluvier	AS						>36	Fritz X
47?	ECA	S.20	Experim.		500 km/h			53		
<1.48	DCCAN	L.50 Macreuse	AS			2 km	15+ km		60	
Early, 1948	Arsenal	Ars 5201 to Ars 5203	SS 10		300 km/h		1.6 km	29,849		
<10.48	DCCAN	CN	Target							
2.12.48	DCCAN	X-8	AS		>Mach 1			>4	>2	
<13.1A9	DCCAN	Palombe	AS					74		Hs 293
>1.49	DCCAN	Autogyro Torpedo	AS					5	3	

2.4.49	Arsenal	Ars 5501	CT 10	180 kg	540 km/h	5 km		413		
29.9.49	SNCASE	SE 4100	SA 10	2.5 t	1,000 km/h	11.2 km		81	78	
10.49	SEPR	SEPR 35	Weather	0.55 t						
8.2.50	SNCASE	SE 4200	SS 40	4.5 t	Mach 0.8	2.5 km	127 km	608	567	
5.50	MATRA	M04	Experim.	1.25 t	> Mach 1	4.5 km	35 km	12		
2.8.50	IDEFA LRBA	P A R C A Véronique	Sounding	4 t	1.9 km/s Mach 1.7	220 km 25 km	321 m	112	96	
26.5.51	Brandt	Mabranca	SA						No.33	
<29.6.51	Ruelle	Maruca	SA		Mach 0.85				200	
1951	ONERA	VD-1			Mach 1.8	5 km			10	
1951	Arsenal	Ars 5102 Ars 5103	AA 10? AA 20		Mach 1.7		4 km	2,000?		
1951	MATRA	R05 R510/51 I	AA 20	1.8 t	Mach 1.8	18 km	4.5 km	1,600		
<12.2.52	ECA	ECA 30	Target							
15.2.52	SNCASE	SE 1910	Sled	6 t	328 km/h		3 km	4	50	
13.6.52?	SNCAC	NC 1110	Target		580 km/h			3?		Towed
9.52	MATRA	R04/042/422 R043/431	SA	30 t	Mach 2.5	20 km			192?	

22.11.52	Barré	EA 1951 SOLE	Experim.	10 t	1,130 km/h	3 km	4 km	5	2	
1952	DEFA	Entac	SS		300 km/h		2 km	119,417		
1952	Bre	Br 910	AS 10		800 km/h	5 km	50 km	6		
<26.3.53	DCCAN?	Gertrude	AS							
<21.4.53	DCCAN?	Hirondelle	S-to-?						No. 25	
<22.4.53	DCCAN?	Toréador	S-to-?						No. 67	
<6.53	ECA	ECA 27							No. 8	
?	ECA	ECA T50	Target							
?	ECA	ECA 57	Target		720 km/h	6 km	40 km			
?	ECA	ECA 58	Target		290 km/h					Towed
?	ECA	XC 13	Target							Towed
<9.53	EC!	ECA 21								
15.10.53?	MATRA	R062	AA?							
12.53	SFECMAS	Airs 5210	SS 11 AS 11		500 km/h		3 km	170,123 +		
17.12.53	Laté	MS 10115 Masalca	SA		Mach 2.5			138	131	