# VEGA: the Italian Proud

by **Paolo D'Angelo**

On 13th of February the Italian-European VEGA rocket was launched for the first time from the European Spaceport in Kourou, French Guiana.

VEGA, an acronym for Vettore Europeo di Generazione Avanzata (Next-Generation European Launcher), is a brand new small solid-propellant launch vehicle conceived, designed and produced in Italy. Its history dates back from the Sixties, when Italy launched its satellites from the equatorial San Marco offshore launch site in Malindi, Kenya, using the American Scout rocket. After the bankruptcy of LTV, Scout-s developer, the team led by Professor Luigi Broglio started to design the San Marco-Scout launch vehicle, an improved version of the American rocket. The project didn't succeed, but the studies were resumed few years later – also with the contribution of Professor Carlo Buongiorno, who recently passed away – and led to the current VEGA.

As the base of the Malindi platform was in a state of advanced disrepair, Italy became involved in the ESA project, which enlarged the participation to half a dozen of European countries, Italy being the main contractor.

Vega, with a height of 30 m, is a launch vehicle for payload masses ranging from 300 to 1500 Kg, in low orbit. Vega has three solid-propellant stages and a liquid-propellant upper module, called AVUM (Attitude and Vernier Upper Module).

Produced by Avio in its facilities in Colleferro, near Rome, Italy, Vega features new technologies like the carbon-epoxy filament-wound motor casing: the largest in the world for a monolithic motor. This initiative is a world first and so is attracting the interest of other competitors in the space industry.

Vega's second and third stages are based on Zefiro solid-propellant motors developed by Avio, respectively called P80FW (first stage), Zefiro-Z23 ($2^{nd}$) and Zefiro-Z9A ($3^{rd}$).

In its first qualification launch VEGA carried a passive satellite called LARES (Laser Relativity Satellite), put in orbit on behalf of ASI (Italian Space Agency). The satellite, built by Carlo Gavazzi Space, is a 376 mm-diameter sphere made of tungsten alloy, weighing about 400 Kg, and it is nowadays the heaviest artificial body in the entire solar system. Its operational orbital life is expected in the range of 25.000 years.

VEGA's multi-payload also included ALMASat-1 (Alma Mater Satellite) – a small 12,5 Kg satellite for technology demonstration, developed and built by the University of Bologna, Italy – and seven CubeSat picosatellites: 1 kg, 1 W, 10 cm cubic structures, provided by European universities.

After this technical data, let me spend few words on the emotional aspects of a launch yours truly had the chance of watching live. In the early morning, on a small square called Agami – 7 Km far from the launch pad –half a dozen buses arrived, full of Italian workers and technicians who had been involved in the VEGA-s development, all of them in their dress blues with the Italian flag on the shoulder. On a muggy morning, surrounded by mosquitos, as usual in the French Guiana, we observed the launch, driven – it almost seemed !! - by the incitements of people, even more than by its engines.

A crackling and after few moments, also thanks to its solid propellant, it disappeared from our sight.


All of us could follow the launcher through the large monitors showing the images broadcasted by the Control Centre. All was nominal. At every ignition of the engines of a new stage you might hear enthusiastic ovations and see waving flags. When LARES was released, people got emotional and, with the hand on the heart, struck up the national anthem. And you could catch what the launch of VEGA was meaning for most of them: years of hard work, in adverse conditions, not only because of the tropical climate but also for the disbelief of those who has not been involved in the development of this launcher and had rather enjoyed the schadenfreude of its earlier failures. Not only the Italian rocket – launched in another country, on another continent – was now flying in the sky, but also the heart of each of them. For all of us, an indelible memory, full of emotion for a proud all-Italian.

## VEGA at first launch

by **Luigi Bussolino**

With the first successful launch of the "VEGA" missile was concluded a period of design and development that allowed ESA to have a launcher for small satellites and then offer on the market a complete family from the small "VEGA " to the powerful ARIANE 5, passing through the Vostok ex R7.

Italy through ASI is the main sponsor of the Italian programme that became all-European; looking at the movie of the launch in Kourou, it has been a satisfaction for me to see many faces of young engineers and technicians showing happiness for the successful launch (but how much do all those missions cost today?).

I recalled the BPD engineers (former Bombrini Parodi Delfino with whom I had the chance to collaborate for many years such as Messrs. Scolastico, Solfanelli, Baldi, Borsò and many others, who for longtime worked seriously to consolidate the various technological experiences (starting from the solid propellant Flexadyne production, the utilization of carbon fibres for the nozzle and the "filament winding" for the case). All those improvements allowed them to design the solid propellant apogee kick motor of the SIRIO 1 satellite, the motor of IRIS launcher and a series of other solid propellant motors for the P80 and then the P23 of the current "VEGA", notwithstanding the various events connected to the property and organization changes of the former BPD, passed under Snia Viscosa and then to FIAT becoming BPD Defense and Space, later incorporated in 2004 in Fiat Avio, that now includes all the aerospace activities of the large expanded FIAT group.

VEGA has been saluted in the media as the "symbol of Italian genius". We look forward to VEGA launching other payload in space and renew the success of today.

## The Vega Story

It was called “the launcher of discords” because from the beginning it was creating discords among the various parts involved in national space programmes. In the 70’s Prof. Broglio, who found the American launcher “Scout“ perfect for his projects, when LTV-LORAL decided to retire the launcher from the market for obsolescence and proposed to the LTV the development of a more powerful version called “San Marco-Scout“. He believed the Italian industries unable to undertake a research and development programme for a launcher already defined by CRA and also be sufficiently economical to involve an American company knowing very well the product. From the other side ASI was delaying the founding and the strategic decision concerning an Italian launcher and the support to the San Marco range in Kenya at Malindi for improving the structures and so extend its life.

ASI in the frame of the National Space Plan (PSN) 1990-94 decided to support the development of an Italian launcher for small satellites and then many people wondered (see an interview of Prof. Carlo Buongiorno to Spazio Italia) if for Italy, even if with big ambitions in space activities both from science as well as technological/industrial standpoint, it was strategic to have a launcher for small satellites, connected to the availability of a range, in which in any case for at least twenty years people were trained to launch and track, but had required investments for the needed improvements.

ASI seemed to support this approach when a specific recommendation to the Italian Parliament in this sense was issued. “The objective was not only to import components and materials from USA - said Prof. Buongiorno - but also to allow the San Marco-Scout to become progressively an Italian product with the chance of further development”. PSN at that moment was supporting two programmes: the first managed from the Rome University for a new launcher design and a second for industrial development and further evolutionary studies.

The second programme was given to BPD for an amount of 120 billion liras. In the meantime the discord between ASI and Rome University was growing because the judge forced ASI to complete the payment of 90 billion liras to the University for past activities and then the agreement between ASI and the University “La Sapienza“, regularly signed with a initial disburse of 30 billion liras was cancelled, saying that the San Marco Programme as initially proposed was no longer feasible.

The launcher issue did not go to court but rested in a limbo of hope because from one side Rome University was proposing its twenty years of Scout management without any failure, while from the other side BPD, with the money obtained, had already started on the development of a solid propellant booster, able in any case to support both the LTV solution as well as the national version, and to study what became for long time the nightmare of BPD, i.e. the guidance system and its main elements (the launcher’s brain).

ASI later, having LTV difficulty in providing Scout elements, no longer required by NASA, started to study another launcher configuration, replacing the second and third stage of the original Scout and introducing the solid propellant motor of IRIS launcher as the fourth stage. At this time it was still possible to integrate the system know-how of LTV-LORAL with the technologies currently available in Italy, such as the solid propellant Flexadyne, for which BPD had a license, the carbon fibre structure made by “*Filament winding*“ derived from the MAN experience, the carbon-carbon nozzle and throat with thermal shields of Aeritalia, derived from ELDO.

Prof. Broglio was thinking foolish the Italian engagement in the development of a complete launcher, well understanding the difference between the development of a single engine and the project of a complete launcher, surely requiring many years of activities and large funding… And he was not that wrong…

The BPD undertaking was important: they had experience but not enough to approach the guidance and navigation system development as well as the thrust control, the vibrations and the noise at launch with the direct effect on the missile structures (and this even if they were supported by the rich FIAT of the ‘90s). The development of the launcher with P80 engine was going slow till ESA,

and mainly France, around 2000 understood the importance of including in the launcher family a small one specially dedicated to small satellites.
In 1995 BPD organized a congress, and I was invited to participate, to discuss the future of the small launcher, showing a dozen possible payloads, demonstrating that there might be possible clients and then convince ESA about the return of their investment; I well recall the happy face of Mr. Procacci of ASI, dreaming future assembly lines for many launchers (forgetting that this was neither the vocation nor the responsibility of the Italian Space Agency).
I believe that industry managers as well as politicians moved and then ASI, even if very generously funding the programme, passed to ESA a hot programme. For sure ESA it has been highlighted from the Ariane 5 development nearing conclusion, a powerful launcher able to deliver together into space three telecom satellites, that there was not an intermediate launcher for single satellite and then started talks with Russia for having available at Kourou range the old but reliable Vostok, that in 1961 launched Gagarin into space and has been operating with a success percentage near to 99% as measured on one thousand launches. The small launcher was then integrating the family for the clients of ARIANESPACE and here began the final part of the VEGA story, with the P80 first stage based on solid propellant, a second and third also solid propellant stages, and finally a fourth based on liquid propulsion for launch and manoeuvre in orbit.


If I remember correctly, between the first launch of a P80 in Sardinia at Perdasdefogu, in the Salto di Quirra range in 1992 – that step by step was further developed for launching into orbit an initial 700 kg payload that progressively became 1500, and the development of the intermediate stages and of the liquid fourth stage (called AVUM for Attitude & Vernier Upper Module) – a long period of time passed for giving to the launcher the orbit injection performance necessary for competing on the international market. Many years of studies, development and tests that culminated today with the first successful launch of VEGA.

## The destiny of the small launcher

It is my personal opinion that, beyond this actual success, the amount of money spent by ASI was excessive for the following reasons.
Let's say that the small satellites that everybody is anxiously waiting for, would be the technological descendants of the present satellites weighing some tons: when in the future advanced technologies will be available, surely the electronic apparatuses will have better performance and reduced size, as in past, and then the structure required to support the various subsystems will be smaller and so a satellite of two or three tons will reach two or three hundred kg or better twenty or thirty kg. An example is provided by the Space Telescope "HUBBLE", whose on board computational capacity was based on a 286 computer technology; after ten years the Shuttle astronauts in EVA activities substituted that with a 386 space qualified computer (when on the ground the technology based on 586 was used) increasing the overall telescope performances of many times……
When we speak about "small satellites" we mean small size satellite but with performances of the bigger one and this today is not yet possible. Perhaps in the next ten years… I was also a sponsor of "small satellites" and in 1994, in occasion of a congress in Tremezzo, I organized a research project, trying to test the opinion of industries but mainly of the scientists; in fact the satellite

several times deployed in orbit scientific experiments created by professors in support to specific researches.
The result of this research was discouraging and resulted in critical comments such as “small satellite = small science “ and similar. The scientists did not appreciate the possibility of flying with lower costs, shorter development periods of time and then many advantages in respect to the current situation where a scientific satellite ,from the proposal stage, the selection , the funding to the construction, launch and operations in orbit requires fifteen to twenty years, Many times for containing cost the Agencies integrated on board the same satellite more than one experiment, having the same bus, but this means satellite became bigger and heavier, exactly the opposite of what was planned.
What is required is a quantum shift in microelectronics and in the “nanotechnologies “ in order to concentrate the performances of a current satellite of some tons into a probe of tenth or hundred Kg; for this reason I would said that they are still in the mind of the God of Space.
Till now some small satellites have been used for the development of new technologies applicable to lunar missions and to Galileo navigation system such as Proba and they have been successful ; in addition to that there are the scientific satellites of SSTL ( Space Satellite Technology Limited founded by English Sussex University) and those designed and manufactured by students of aerospace university such as TUB in Berlin and Rome University of Prof. Graziani that weigh 20 kg.


These enterprises are usually not supported by big funding, but have to take advantage of the occasional launch as partners of other larger satellites whose sponsors pay the major part of the launch price or of the first qualification launch of a launcher in development for which no insurance company will accept the risk (as happened to ESA when decided to fly four CLUSTER satellites on the first launch of ARIANE 5 … they were lost together with the launcher).
The VEGA payload for the first launch was formed from seven cube TUB satellites , two Italian satellites (ALMAsat of Bologna University and that of Prof. Graziani) and then the LARES satellite of Prof. Ciufolini in Rome (a satellite called for long time LAGEOS 3 because it had to work in conjunction with LAGEOS 2 launched by Italian IRIS in 1992 and with LAGEOS 1 launched in 1976 (Prof. Ciufolini had to wait for a fifteen years or more before seeing it in orbit).
Another issue unfavourable for VEGA is the cost that in 2010, when I was interested in it for launching a small satellite, was around €30M (perhaps 32…); this price will make hard its life against private American launchers such as SpaceX Falcon 1 to 9 (costing less than one third) and Russian missiles Rockot SS19 type , available in large quantity and to be destroyed at certain dates due to SALT 1 and 2 treaties.

## References

SPAZIO Italia - Marzo 1993
G.Caprara “L’Italia nello spazio“ Ed. Levi, 1992
My specific experience in space activities 1975 - 2004