Vega: a European small launcher

Marco Caporicci

ESA Directorate of Launchers, Paris

The substantial pre-design work on small launcher configurations, mainly carried out in Italy and France in the last few years, provides a good basis for a European small launcher development programme. At the same time the evolution of a series of factors indicates that there is now the potential for the development of such launcher.

The small launcher market

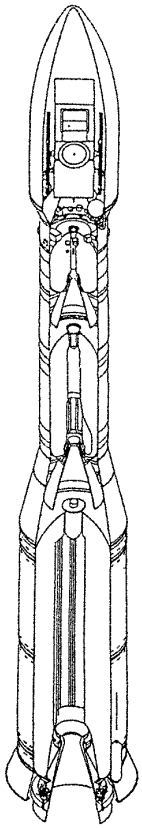
The pressure applied on the governmental budgets has led the space agencies worldwide to give preference to smaller satellite missions requiring lower investments and shorter development time. Recently new standardised satellite platforms have been proposed or are being developed in Europe, with mass, cost and manufacturing time considerably reduced. In particular for satellites in the 300-1200 kg range, several buses are being developed (Proteus, MITA, PRIMA, Minisat), which will require a launch capability in the light payload class. Such platforms will represent the basis for several space agency missions in the fields of science, earth observation and telecommunications.

In Europe, the development and operation of such launcher will certainly take advantage of technologies, facilities and hardware developed in the Ariane programmes and other national programmes.

In parallel to the Ariane launcher family, a small launcher will increase the system flexibility, allow to accommodate unforeseen payloads on demand and satisfy the needs of unconventional customers. Moreover the launch price reduction of a small launcher will make it attractive for new categories of users.

Therefore the development of a European small launcher, named Vega, is an important contribution to make access to space easier, timely available and more affordable.

On this basis, the ESA Council has approved on 23-24 June 1998 the first step of the Vega Small Launcher Development Programme.



Two important aspects have to be taken into account for the successful realisation of Vega:

- the necessity of reducing the development cost of the launcher and its ground infrastructure;
- the need of limiting the overall launch service recurrent cost.

Launch service target price and potential market

At the time of entry into service of the Vega launcher (end 2002), two main families of small launchers will be available: the Russian launch vehicles, generally derived from existing ballistic missiles, available at a relatively low price, and the American launch vehicles, developed by the US industry for commercial purposes, with some support by NASA or the Air Force.

The future of the first family is unclear due to questionable availability in the long term of the vehicles and to the uncertain evolution of their launch price with the change of economic conditions in Russia. In any case their present production price cannot be matched by any Western development.

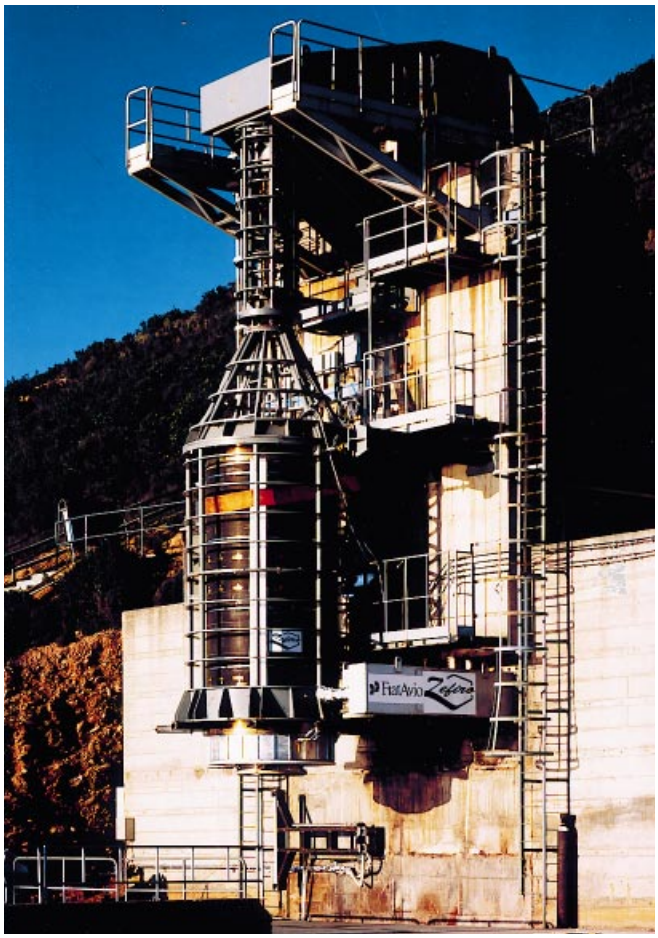
The US launch vehicles are less numerous, but their reliability is increasing and new vehicles are proposed.

The European small launcher target price has been set about 15% below the present US prices in order to get a competitive launch service for Western standard; on this basis a target launch price of 20 M$ for a 1000 kg payload has been identified.

The projected market for a European small launcher may consist of three to four launches per year in the initial years starting from 2002. The total number of launches is expected to grow up to five or six launches per year, once the launch service is well established.

Description of the Vega launcher

On the basis of the identified European needs and the open market requirements, the minimum required in-orbit capability for the small launcher has been set at 700 kg satellite mass in a 1200 km circular orbit with 100° inclination for a launch from the CSG in Kourou.



Vega is designed as a single-body satellite launch vehicle, composed of three solid propulsion stages with an additional liquid propulsion upper module (AVUM) for attitude and orbit control, satellite release and de-orbiting, and a fairing for satellite protection.

Vega first stage

The Vega launch vehicle first stage is based on the use of a solid rocket motor derived from the Ariane-5 solid booster (P230), with a reduced propellant mass, named P85. This motor will require redesign of the propellant grain, sizing of the thermal protections, a new nozzle, a new igniter and some re-design of the metallic case.

The P85 motor employs a metallic case directly derived from the Ariane-5 booster by assembling the forward dome, the aft dome and two cylindrical sections. All connections are made by factory joints. The case is insulated by bonding an EPDM rubber to its interior surface.

The P85 motor uses the same solid propellant as the Ariane-5 boosters, having a 86 % of solids and an HTPB type polymer. The propellant grain, consists of a conventional centre perforate design, combined with a star section in the aft region (nozzle side), usually called finocyl.

The nozzle, based on the Ariane-5 booster technology, is movable and uses a flexible joint.

Vega second stage

The Zefiro solid motor, whose development has been initiated by FiatAvio under contract by the Italian Space Agency and company funding, is the Vega second stage.

Zefiro is a 16 tons solid propellant motor, having a length of four meters, and a diameter of 1.9 meters. It employs a low-mass carbon-epoxy case, an EPDM-based thermal insulation, HTPB propellant, and a moving nozzle, based on the flexible joint technology.

The case pressure vessel is built by composite filament winding technology, using a high strength pre-impregnated carbon fibre.

The material used for the motor internal thermal insulation is an EPDM based elastomer, filled by aramid fibres.

A HTPB 1614 composite propellant, using a binder in Hydroxy-Terminated-Polybutadiene and 16% of aluminium has been adopted. To achieve the required performance curve, a finocyl grain has been selected, with the star section located in the aft zone of the motor near to the maximum polar opening.

The nozzle, made of carbon phenolic with a 3D carbon-carbon throat insert, is submerged and movable in pitch and yaw by using a flexible joint with an aft pivot point architecture.

The first motor case for Zefiro has been built and pressure tested with satisfactory results. The second case,

loaded with solid propellant, has been successfully fired on 18 June 1998. The test results are currently being evaluated.

Vega third stage
After a number of trade-offs, the propulsive solution retained for the third stage is based on the use of a 7 tons solid rocket motor, presently named P7, having the same diameter as the Zefiro motor (about 1.9 m) which equips the second stage. This results as the most suitable configuration for the Vega launcher requirements, both in terms of cost and performance.

The P7 motor will take advantage of the on-going development of Zefiro and of previous French developments for a motor of similar size.

It will include many design features, technologies and materials already proven on the above mentioned motors, as:

- a graphite epoxy filament-wound case;
- a finocyl, centre-perforated propellant grain, obtained by casting tooling and final machining, that uses an HTPB composite propellant;
- a partially submerged nozzle, made of carbon phenolic and 3D carbon-carbon .

The Attitude and Vernier Upper Module
The Vega launch vehicle is equipped with a liquid propulsion module (AVUM), which provides roll control and pitch, yaw, and axial thrust during the final phase of flight. It shall perform the following functions:
- roll control;
- attitude control during coasting flight and in orbit phase;
- correction of axial velocity error due to solid rocket motor performance scatter;
- generation of the required velocity change for orbit circularisation (as required);
- satellite pointing;
- satellite release manoeuvres;
- empty stage de-orbiting.

The current technical baseline includes the adoption of a liquid bipropellant system for the AVUM, utilising Nitrogen Tetroxide (NTO) as oxidiser and Unsymmetrical Monomethil-Hydrazine (UDMH) as fuel, both fed by gaseous helium under pressure.

Payload fairing
Two fairing configurations are presently compared:
- a single piece fairing that will be axially extracted by the action of springs during a dedicated coasting phase, which is expected to be advantageous in terms of recurring cost.
- a conventional fairing made up of two shells with a clamp attachment and pyrotechnic longitudinal separation, which would probably be lighter.

Avionics
In order to reduce as much as possible the development and recurring costs, the Vega avionics will be largely based on the adaptation of existing hardware and/or components under development.

Two alternatives are presently considered for the guidance, telemetry and power subsystems:

- a distributed architecture with more electronic boxes, but simpler in terms of hardware, which takes advantage of a modular design;
- a centralised architecture (of the type used on-board of missiles), which minimises the number of electronic boxes.

As far as the launcher destruction system is concerned, the use of an architecture similar to that of the Ariane launchers and of similar components is preferred in order to fulfil the CSG Range Safety Rules.

Launch Base
The European CSG Range in Kourou shall be the launch base for Vega. This site offers a variety of launch azimuth capabilities (equatorial, polar and intermediate inclinations), already existing infrastructures, services and logistic support, which make it the natural choice for the new European small launcher.

A preliminary evaluation of the range compatibility with Vega has been initiated. Two suitable launch sites have been identified (ELA-1 or ELA-3). A detailed definition of the new installations or upgrades required on each candidate site will be performed during the first step of the programme.

The ELA-1 launch pad is presently preferred to avoid any interference with the Ariane-5 operations.

Programme management structure
ESA will have the overall responsibility for the programme and will exercise the technical and financial control.

A dedicated Vega Executive Board, composed of representatives of ESA, of Agenzia Spaziale Italiana (ASI) and of Centre National d'Etudes Spatiales (CNES), will be responsible of supervising the implementation of the programme.

The day-to-day programme management will be executed by an Integrated Programme Team (IPT), made up of a co-located staff coming from the ESA, ASI and CNES and located at the ESA's European Space Research Centre (ESRIN) in Frascati (Italy).

Industrial organisation
FiatAvio and Aerospatiale, who have originated together the present concept of the Vega launcher, will establish a Joint Venture, which will act as Prime Contractor for the Vega development programme, with the support of other specialised European companies from the European Member States participating to the programme.

A financial participation by industry to the development programme and to possible cost overruns is envisaged and it will be negotiated during the first step of the programme.

During the operational phase of the launcher, Arianespace will be in charge of marketing Vega and running its operations.