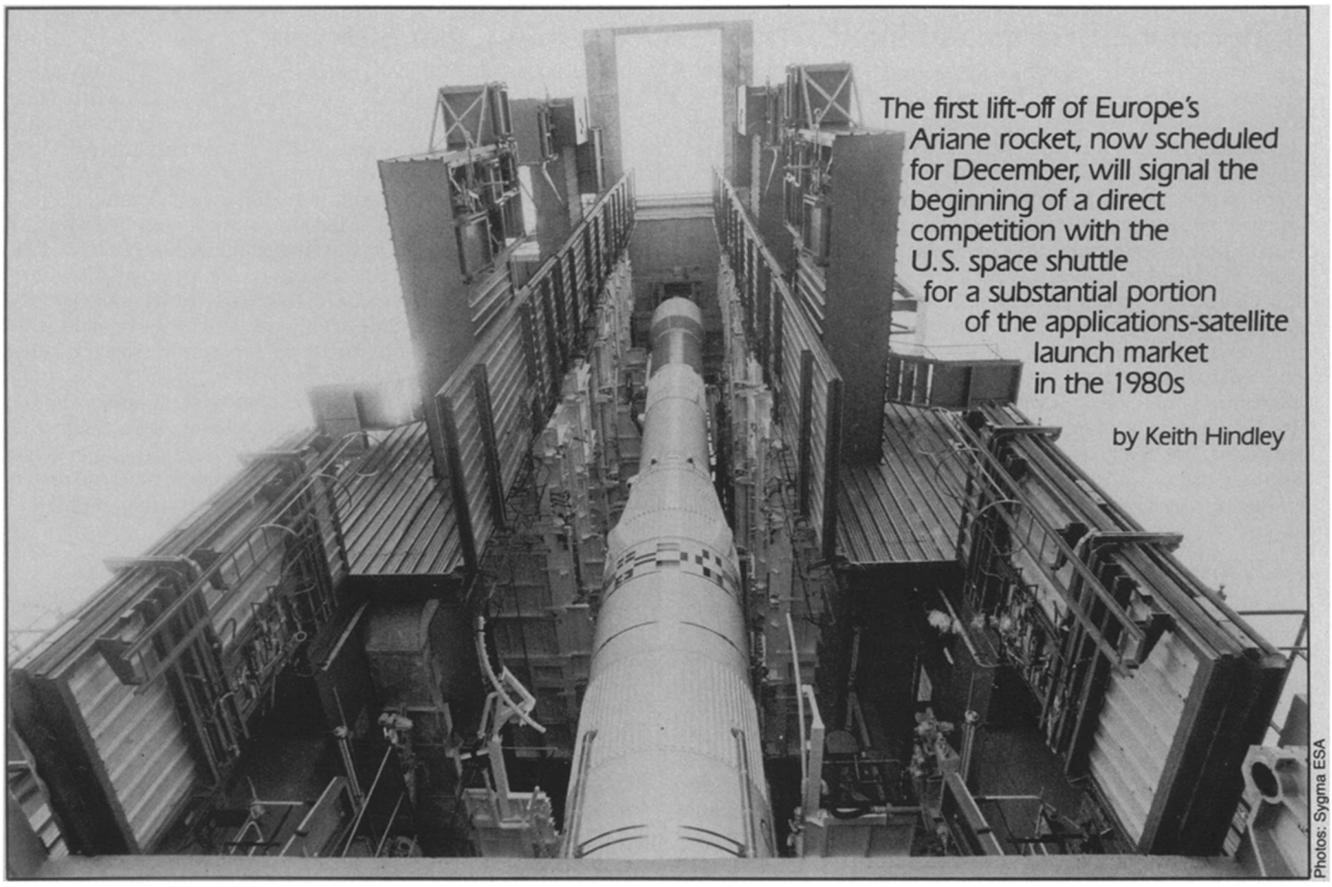
Ariane: Europe's Independent Launcher



The first lift-off of Europe's Ariane rocket, now scheduled for December, will signal the beginning of a direct competition with the U.S. space shuttle for a substantial portion of the applications-satellite launch market in the 1980s

by Keith Hindley

Photos: Sygma ESA

The prototype of the European Space Agency's (ESA's) Ariane launcher now stands on its launch pad amidst the swaying palm trees of France's Guiana Space Center in South America. This highly conventional rocket (in contrast to a reusable shuttle design) was born out of a strong political will in France (and to a lesser degree in West Germany) to be free of dependence on U.S. launchers. It is intended to meet the launch needs of the European states in commercial and scientific satellites, and at the same time corner a slice of the lucrative and expanding market for orbiting geostationary satellites.

At first sight, Ariane hardly looks like competition for NASA's space shuttle. The shuttle will be able to launch nearly ten times the payload that Ariane can lift into earth orbit. Indeed, the shuttle will launch Spacelab 1, the joint ESA/NASA manned scientific station, in 1981.

The bulk of the bread-and-butter launch business in the next decade will be to lift at least 200 geostationary satellites into orbit at 35,800 km. There, a satellite's orbital motion exactly counterbalances the earth's rotation and it hangs apparently motionless over a point on the earth's equator. This is the place for communications satellites, and signs are that more and more nations want their own piece of hardware up there.

To carry out this kind of mission, the shuttle requires an additional powered stage, and ESA claims that its payload advantage over Ariane then falls to about a factor of two. (Carrying a large manned cabin around is a heavy penalty for any launcher.) Although the shuttle was intended to cope with orbiting any type of satellite, it was designed principally for carrying large masses into low earth orbit cheaply.

Ariane can place 1.75 tons into geostationary orbit, including a one-ton satellite, and ESA claims it is also suited for sun-synchronous satellites at 840 km in polar orbits. A big bonus is the rocket's launch site in South America within 5½ degrees of the equator. Launches there get the full benefit of the earth's rotational velocity, making the site ideal for geostationary missions. ESA rockets get a 17 percent payload advantage compared with a similar launch from NASA's Kennedy Space Center in Florida.

How the cost of Ariane breaks down

Country	Contribution (percent)
France	63.9
West Germany	20.1
Belgium	5.0
United Kingdom	2.5
Netherlands	2.0
Spain	2.0
Italy	1.7
Switzerland	1.2
Sweden	1.1
Denmark	0.5

European cooperation in space projects has had its ups and downs. A decade ago cooperative projects among the member countries of the European Launcher Development Organization (ELDO) and the European Space Research Organization (ESRO) became hung up in administrative wrangles. In the end, the planned Europa launcher project was shelved.

In contrast, ESA's Ariane project has progressed relatively smoothly since its inception in 1973. Although much is

Keith Hindley is a science writer living in York, England.

stated in public about the cooperation of 60 companies in 10 European countries, Ariane owes its success so far to firm French control. As the budget breakdown shows, it is France that has footed the major portion of the bill and French industry that has gained the lion's share of the development contracts.

The rocket's total development cost is likely to be about $660 million, a price that is over the nominal budget, but by barely 50 percent of the contingency fund set aside to cover unexpected costs. For this price, ESA gets all the facilities needed to launch the vehicle and an initial five Ariane rockets, four of which will actually be launched.

The project is managed for ESA by the French National Center for Space Studies (CNES), (which handled the successful Diamant rocket) with a small ESA team overseeing each stage. Ariane is a deliberately conservative design based on European rocket experience and its lack of major technological innovation has reduced development risk and cost. In addition, the project was designed to make the best use of facilities that already existed in the ESA member states.

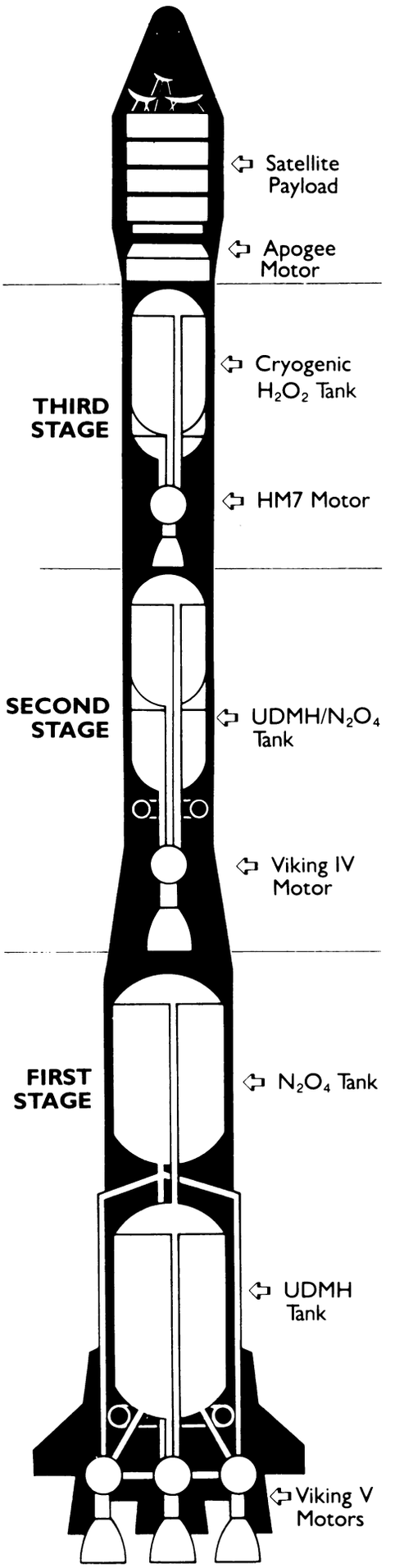
Ariane is a conventional three-stage rocket standing 47.5 meters high. It has a dead weight of only 17.5 tons, which rises to 207 tons when fully fueled for liftoff. The first two stages are powered by variants of the Viking motor, a power plant that was already in an advanced state of development when Ariane was planned. A cluster of four is used in the first stage and a single motor in the second. Viking uses unsymmetrical dimethyl hydrazine (UDMH) fuel with nitrogen tetroxide oxidizer. In contrast, the third stage is a cryogenic one, using liquid hydrogen and oxygen.

In a typical launch, a first-stage burn of 45 seconds will accelerate the vehicle to a speed of 1.87 kilometers per second and separate at 52 km altitude. The second stage will fire for 138 seconds, carrying the payload to 4.78 km/sec and fall away at 138 km altitude. The third stage will then burn for 570 seconds, pushing the velocity to 9.76 km/sec and fall away at 213 km, just over 14 minutes after liftoff. The payload will then be en route to geostationary orbit.

The rocket components are manufactured in plants all over Europe but the main stages are made in Fance (first and third) and Germany (second). All the components are assembled at Aerospatiale's integration site at Les Mureaux near Paris. After testing, the launchers are shipped off to Kourou in French Guiana for launch.

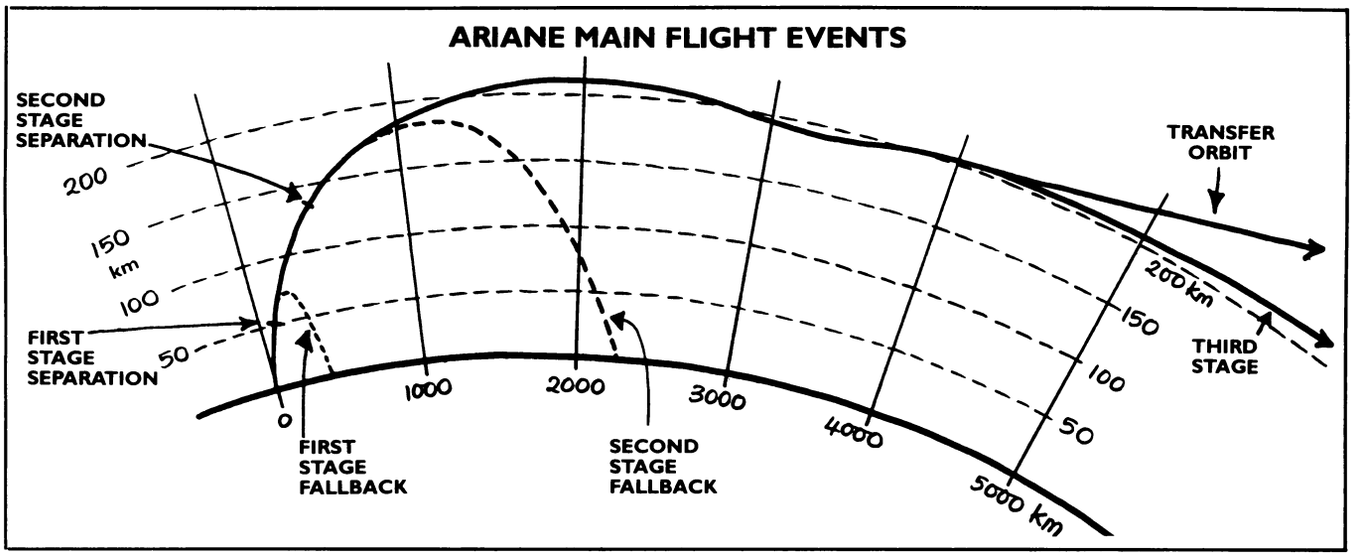
The testing program has suffered only a few major problems. For example, early

Underground launch control center during countdown trials earlier this year.



Comparison of Space Launchers

Launcher	Country	Mass raised to circular earth orbit (tons)	Mass raised into transfer orbit (tons)	Satellite mass raised to geostationary orbit (tons)
Cosmos C-I	USSR	0.07	0.35	0.15
Delta 3914	USA	2.50	0.90	0.44
Atlas-Centaur	USA	6.50	1.85	0.91
ARIANE I 1979	Europe	4.50	1.70	0.93
ARIANE 2 1983	Europe	6.00	2.30	1.26
Soyuz A-2	USSR	7.50	2.40	1.10
Titan III-C	USA	15.00	4.50	1.50
Zond D-le	USSR	22.00	5.00	1.60
Space Shuttle	USA	30.00	—	1.80



Main flight events during Ariane launch of a satellite package into geostationary orbit.

firings of the four clustered first-stage Viking engines cracked the graphite liner of the combustion-chamber throat. The noise generated during firing (it reached 180 dB at a frequency of 135 Hz) was sufficient to degrade the material, so a silica/phenolic resin replacement was developed.

Some development work has also been necessary on the second stage, which, unlike the first, operates in a near-vacuum. The Viking motor has been modified by extending and thickening its nozzle. In addition, fuel pipes have been relocated to prevent the motor from ingesting pressurized gas when the fuel tanks have almost emptied. Another problem occurred during test-firing of the third-stage motor, when a safety device intended to safely ignite any leaking hydrogen gas failed to operate, and the hydrogen exploded. This did little damage to the third stage but damaged the testing bay.

In general, though, tests have proceeded smoothly and successfully, and the first launch date has crept forward by only a few months during development. The initial motor trials started nearly two years ago, and all stages have now fired successfully under launch conditions. The launch and tracking facilities in French Guiana are now complete, and the first rocket (destined never to be launched) underwent launch pad checks from February to May of this year. This program culminated with full fueling of the rocket and a complete countdown that was terminated just five seconds before engine ignition.

ESA now has a fully ground-tested launcher with a good reliability record, and the rocket due to make the first qualification launch is now on the pad. ESA is not slow to compare this record with the series of minor problems and budget overruns that has beset the development of the U.S space shuttle.

NASA administrator Robert Frosch announced recently that there is now a 50/50 chance that the first shuttle flight will take place by June 1980, and even that date could slip by several months for technical and/or financial reasons.

Certainly some potential users of either Ariane or the shuttle are delaying before signing a launch contract. NASA enjoys an unrivaled reputation for reliability, but potential users are worried about the technological innovations in the craft's design; each new spacecraft has suffered early problems that have always taken time to put right. ESA's declared aim is to complete four test launches by the end of 1980, commencing commercial launches by early 1981.

The shuttle schedule is certainly tighter. A failure with one or more of the early Ariane launches would not significantly affect the commercial schedule. Yet one shuttle vehicle (102 Columbia) may be used for NASA's four qualifying flights and up to the first six operational flights. Any problems in flight, even if minor, could further delay the start of commercial shuttle operations.

All these factors have led to a steadily filling launch-book for Ariane. One major coup was the signing this spring of a contract to launch a satellite for the Washington-based Intelsat organization in the face of an offered shuttle launch. The first five Intelsat V's are being lifted by NASA Atlas-Centaur rockets. The Ariane price for the sixth is $25.29 million with an option for launch of the seventh Intelsat in 1982 at a fixed price of $27.46 million. These prices are a little cheaper than for a shuttle launch, and the difference could grow. Shuttle launches quoted up to 1983 are being pegged on the cheap side by NASA. From the start of 1984 prices will be adjusted to cover the true flight costs over the first decade. But for the first time a NASA project is under external commercial pressure to keep its costs down.

The first four development Ariane rockets either will carry ballast or will launch satellites free of charge on an "owner's risk" basis. In addition, five commercial launches are now firm:

Launch		Name & Satellite type
L01	November 1979	Data capsule & ballast
L02	March 1980	Amsat (radio amateurs) Firewheel (German scientific)
L03	June 1980	Meteosat F2 (European meteorological) Apple (Indian communications)
L04	October 1980	Marecs A (European maritime communications)
	April 1981	Exosat (European scientific)
	June 1981	Marecs B (European maritime communications) Sirio 2 (Italian scientific)
	August 1981	Intelsat 6 (international communications)
	December 1981	ECS 1 (European communications)
	December 1983	Spot (French earth-resources)

In addition, ESA expects business from further Marec, ECS, Intelsat and Telecom satellites as well as earth-resources, meteorology or communications satellites (such as Arabast) launched for countries who would prefer not to be dependent on

Continued on page 254

...Ariane

either the United States or USSR for launch facilities. The Guiana Space Center can handle about four launches a year, and ESA is looking for between 40 and 50 launches during the 1980s.

Such is the volume of satellites likely to be orbited that both Ariane and the shuttle should keep a full launch schedule. Most European countries will probably opt for Ariane, and most U.S. satellites will still go to NASA. But the two launch systems operating side by side will give added flexibility, and some organizations will probably choose whichever program can launch to suit a particular date.

ESA is already looking at various economies that could be applied to production rockets. One study has shown that the recovery of the spent first stage from the south Atlantic Ocean for servicing and reuse would save about 15 percent of the cost of a launcher. They are also looking beyond the simple initial version of the vehicle. An improved Ariane 2 — with the first-stage thrust increased ten percent, with two solid propellant boosters and with the third-stage fuel increased by two tons — is already going ahead, scheduled to be ready by 1983. This will add only a few percent to the development cost so far. Ariane 2 will be able to launch 2.3 tons into geostationary orbit (including two of the larger satellites) and will be able to use the existing launch pad in Guiana. Plans for even larger Ariane variants, including one that could launch a manned spacecraft, would require a larger launch pad and a further massive investment of funds.

European economic and political unity is slowly gaining momentum through the European Economic Community, but a formal United States of Europe is still a long way off. Yet the European states do have a larger combined economic base than either the United States or the USSR and could certainly finance further space ventures. A major independent European space program is still in the future, but Ariane does mark the first firm steps along that road. ☐