given the lead role in technical design and construction, a consortium was established by companies from Britain, West Germany, Italy, and Spain—but excluding France.

French Prime Minister Jacques Chirac has subsequently given the go-ahead for substantial government support for Dassault to develop unilaterally its own fighter aircraft, Rafale. But Defense Minister Giraud has made known publicly his reservations about the cost-effectiveness of the deal. "The European Fighter Aircraft is a good example of both the potential and the problems of European collaboration in military technology," says Dennis Brennan of the International Institute for Strategic Studies in London.

In the long term, a full-blooded commitment to collaborate on military research is only likely to result from a political consensus on the need for a common defense policy; or, as one observer puts it, on "the political harmonization of the concept of European defense."

The U.S. invitation to European nations to participate in the Strategic Defense Initiative research program has been one stimulus at the technical level, encouraging discussion of Europe's possible role in the development of those technologies which could contribute to its own space-based defense. Politically, a comparable result was achieved by the agreement on the "zero-option" principle at Reykjavik last fall, which many European leaders felt left them standing powerless on the sidelines.

Within this broader context, groups such as IEPG are already taking steps to encourage greater cooperation in research as a move toward closer European integration in defense policy more generally. A major step in this direction was taken by IEPG last year with the organization of the first meeting of the directors of all Western European military research laboratories.

Many now argue that closer European cooperation is needed to enable Europe to participate in a dialogue with the United States over defense technologies. "It is very important to coordinate European efforts in order to enable Europe to become an equal partner to the United States," says a French defense official.

The United States, while supportive of the logistical advantages of closer cooperation among its European allies, remains wary of such arguments. For example, one of the main reasons Congress decided last year to allocate $200 million to collaborative R&D projects between U.S. and European companies—the so-called Nunn-Warner-Roth amendment—was the fear that a strong and united European voice might weaken U.S. influence over NATO decision-making. ■ **DAVID DICKSON**

Space: It Is Expensive in the Major Leagues

A meeting this fall will determine whether Europe believes playing a leading role in space is worth $30 billion

Paris

EUROPE'S space program is facing a crisis. Space officials and aerospace companies claim that a package of collaborative programs carrying a price tag of at least $30 billion over the next 15 years is essential if Europe is to sustain a major role in space activities into the next century. But European governments are far from united over whether they are prepared to pick up the bill.

A symptom of the crisis is the fact that the ministers responsible for space in the 13 member states of the European Space Agency (ESA) have postponed from June to November a top-level meeting designed to approve a strategy for the agency up to the year 2000. A recent decision by British Prime Minister Margaret Thatcher not to increase the United Kingdom's space budget in the near future (*Science*, 7 August, p. 597, and 14 August, p. 719) has only made the negotiations over the agency's long-term plans more difficult.

But although the immediate cause of the crisis is money, this has merely triggered deeper tensions. As with most major European technological ventures, the space program requires a delicate equilibrium between the political, technical, and economic interests of the various partners. Furthermore a desire for Europe to develop its own independent (and expensive) space capabilities must be balanced against pressures—both internal and external—to participate more fully in the U.S. program.

All was relatively harmonious at the ministers' last meeting in Rome 2 years ago. Complimenting themselves on the success of the package agreed on a decade previously—which included the Ariane rocket and the shuttle-launched Spacelab—they agreed to preliminary design studies of an ambitious set of new projects.

These included a new, more powerful version of Ariane, known as Ariane V, and—as a successor to Spacelab—various hardware contributions to the U.S. space station, known collectively as Columbus. The hardware will include a laboratory module permanently attached to the space station, a polar orbiting platform and, later, a separate free-flying platform that would be tended periodically by astronauts.

Since the Rome meeting, however, the estimated costs of each element in the proposed package have grown significantly, some say almost doubled. And the likely overall costs have been further inflated by the insistence of France's space engineers that a third element be added, the spaceplane Hermes (whose own cost estimates have themselves been escalating rapidly over the past 2 years).

At the same time, the governments of Britain, West Germany, and even France—three of the four largest contributors to the European space budget—have each been increasingly reluctant to provide public funds for large-scale technology projects in a time of economic constraint, arguing that a greater share of such commitments should come from the private sector.

The November meeting could therefore be a key test for the future viability of ESA itself. The agency was set up in 1975 as an amalgam of the (successful) European Space Research Organization and the (less successful) European Launcher Development Organization. It currently has a budget of about $1.1 billion a year and a staff of 1400 scientists, engineers, and technicians.

ESA director general Reimar Lüst points proudly to a string of ESA achievements. These include, in addition to Ariane and Spacelab, last summer's encounter of the spacecraft Giotto with Halley's Comet. "We have shown that we can work together in Europe, not only in basic science, but also in fields of advanced technology where we have a high level of industrial competence," he says.

The problem now is whether this achievement can be repeated in the new political climate of the late 1980s. Or rather, whether European governments, which together spend on space less than one-sixth the amount spent by the United States and an even smaller proportion of that spent by Soviet Union, can be persuaded that this difference in funding is a major weakness requiring a significantly increased injection of public funds.

As far as the technology is concerned,

Europe's space engineers, buoyed by their recent successes, are confident of meeting the challenges of the various programs currently under discussion. Innovations under development include a new cryogenic engine for Ariane V (known as HM60), the heat-resistant materials (and crew-escape mechanisms) required by Hermes, and a "revolutionary"—and still secret—engine design for a one-stage reusable launcher (HOTOL) designed by British Aerospace.

Such technical confidence has given rise to a certain impatience with the apparent procrastination of politicians. "Preparations [for Ariane, Columbus, and Hermes], both in industry and in ESA, are at such a stage that we feel the necessary political decisions to proceed to the development phase must be taken this year," says Lüst. "European industry cannot wait much longer, since further delays will create serious problems in keeping teams together."

Part of the difficulty, however, lies in the way ESA operates. The agency's programs fall into two categories: the space science program, which (together with general administration) is paid for out of membership subscriptions; and a set of optional projects that ESA members are free to join voluntarily, with no fixed rules about levels of participation.

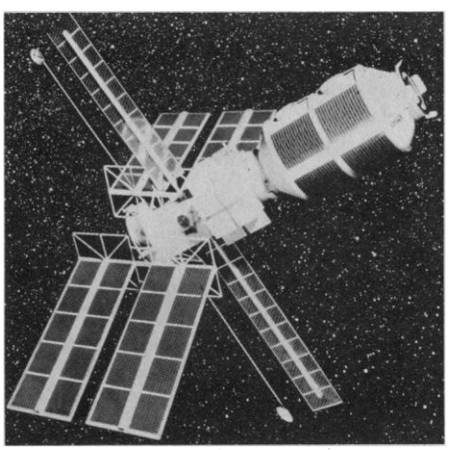
In principle, this application of what is described as "variable geometry" offers a highly flexible way of financing collaborative projects, not least because one country's desire to achieve independence from the United States—the philosophy behind the launcher Ariane—can be balanced against another's desire to collaborate directly on a particular project, such as Spacelab.

As Frédéric d'Allest, the director of France's National Center for Space Studies (CNES) puts it: "The key point is that we are committed to achieving both coherence and balance in the European space program. And from the French point of view, it is very important for us to have a balance between cooperation in the [U.S.] space station, and the development of European technology for use in our own autonomous programs."

In practice, negotiating an overall package of optional projects requires considerable trade-offs between member states. And the consensus achieved can be fragile, since the need to achieve an overall balance can lead one country to support another's project in order to obtain complementary support for its own goals, without necessarily being convinced of the project's merits.

France, for example, has expressed little enthusiasm for direct European participation in the U.S. space station; but France is widely seen as having been prepared to back Columbus in return for the support of other countries (in particular West Germany and Italy) for her own preferred projects, namely Ariane V and Hermes, both of which have generated skepticism in other countries.

The principle of simultaneously achieving both technical and political equilibrium has already been successful in building up ESA's space science activities. Under the title of Horizon 2000, a 15- to 20- year program was approved at the Rome meeting based on a joint commitment to four so-called "cornerstones": solar and terrestrial physics, planetary missions, x-ray spectroscopy, and high-throughput heterodyne spectroscopy in the millimeter range.



Platform or springboard? *One of Europe's projects for the U.S. Space Station.*

Each of these cornerstones is identified with a particular set of ESA experiments or missions. For example, the solar and plasma physics area includes two missions already approved, named SOHO and Cluster; candidate projects are currently under consideration for each of the other three.

"It is a balanced, minimal program which is widely recognized as being scientifically very strong," says Roger Bonnet, ESA's director of scientific programs. "If you take one element out, you could lose the unanimous support. For example, if you dropped the x-ray missions, then Britain, West Germany, and the Netherlands would probably not support the overall package."

The arguments were convincing in Rome, where the ESA member governments agreed to increase the science programs by 5% a year up to 1989—the first time a real increase had been accepted since the early 1970s, according to Bonnet.

ESA is hoping to receive a commitment at the November ministerial meeting that this rate of increase will be extended for a further 3 years (the space science budget is approved every 3 years for the following 5 years). What space scientists fear is a European version of what has been happening in the United States: that science will be squeezed to find more money for the technology projects. This, says Bonnet, would be counterproductive.

"Today the costs of scientific users is less than 40% of the program costs," he says. "If you go below that, how can you justify the development of these big hardware pieces?" Furthermore, a scientific committee of the European Science Foundation has pointed out that, as in the United States, the proposed space station is not what Europe's space scientists would have chosen on the basis of their own priorities.

Purely scientific arguments, however, tend to be swamped in space policy decisions by two larger factors. The first is the debate over the longer term importance of space-based technologies for both commercial and military applications. The second is the argument that Europe needs a viable presence in space in order to retain its political independence from the two superpowers. (This second factor is particularly important in France, which spends five times as much per capita on space as Britain, and almost twice as much as West Germany.)

Supporters of an expanded collaborative space program argue that joint projects such as Hermes, if successful, could fulfill both functions, acting as an important symbol of Europe's technical skills and political independence, at the same time that they provide a direct stimulus to its high-technology industries.

"We need two or three major technological projects in Europe to prove that we are still able to achieve something" says former French research minister and CNES president Hubert Curien, who headed his country's delegation at the Rome meeting.

The British government is not alone, however, in expressing its reservations about this argument. West Germany's finance minister Gerhard Stoltenberg—himself a former minister responsible for space—has indicated that he, too, is opposed to a significant increase in his government's space budget. And France's industry minister Alain Madelin is said, despite his country's Gaullist traditions, to have his own reservations as a free-marketeer.

The November meeting will demonstrate whether European governments believe playing a leading role in space in the 21st century is worth the $30-billion price tag they are being asked to pay. ■

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