military projects will certainly continue to be limited to getting them up. The chief fear of supporters of the civilian space programme is that with the increased emphasis on these military uses of space, NASA may end up doing little more than running a bus service, and may, as suggested in *Space World* recently, become in effect a "vassal" of the Air Force. The announcement of an 85 per cent rise in the rates charged to civilian users of the shuttle for flights after October 1985 and a scheduled tripling of charges for LANDSAT data this October — not to mention uncertainty over the government's continued support for LANDSAT — have added doubts about the Administration's commitment to the civilian space programme.

Stephen Budiansky

Franco-Japanese collaboration

Plumbing depths

France is flirting with Japan. Tsukuba, the Japanese "science city" outside Tokyo, is to be named as a twin with Orsay, the complex of scientific institutions and industry south of Paris. At the end of this month, officials from the French ministry of research and technology will be visiting Japan to study Japanese management of science and technology.

M. Jean-Pierre Chevènement, the minister of research and industry has already visited Tokyo twice in his year as a minister. Will he try to model the new ministry of research and industry on its Japanese counterparts?

Philosophical uncertainties apart, one concrete new Franco-Japanese project has been set up — JASP, an oceanographic study of the Japan trench. The objective is scientific, but since the trench involves the subduction zone that causes Japan's frequent earthquakes, there is practical interest in the outcome.

Japan also stands to gain a knowledge of French submersible technology in the form of "SM 97". This new exploration submersible capable of reaching a depth of 6,000 metres is being built at the French oceanographic research institute at Brest, and may be ready by 1985.

The research will take place in two stages, the first in 1984, when the surface research vessel *Jean Charcot* will use a narrow-beam echo sounder (called Sea Beam) to draw a profile of the trench on a scale 1/10,000 to 1/20,000, while Japanese groups make gravimetric, magnetic and seismic measurements. Special study will be made at points where sea-mounts are being subducted and at the point of intersection of the Pacific, Philippine and Eurasian plates.

In the second stage, in 1985 SM97 will be sent down to points reckoned from the first survey to be of particular interest. Three transmitting seismographs and an inclinometer will be left behind.

Robert Walgate

India to expand space technology

Lucknow

India's determination to achieve self-reliance in space technology is evident from the government's recent approval of a space programme for the rest of the decade to build one satellite and two launch vehicles at a cost of 3,963 million rupees (£240 million). An 800-kilogramme remote sensing satellite will be used from 1985 to provide resource information in agriculture, water management, forestry, hydrology, geology and coastal oceanography.

The launch vehicle projects comprise an Augmented Satellite Launch Vehicle (ASLV) and a Polar Satellite Launch Vehicle (PSLV) whose development will rely on the know-how and the subsystems already developed for the Indian launch vehicle SLV-3, which during its first developmental flight in May 1981 put a 38-kilogramme satellite in near-Earth orbit. It is hoped that ASLV will launch a 150-kilogramme satellite in a similar near-Earth orbit by 1983.

The second launch vehicle, PSLV, would be able to launch a 1,000-kilogramme satellite in polar Sun-synchronous orbit by 1987.

The Indian space programme has been quite successful. The first Indian experimental communications satellite, Apple, although one of the solar panels did not function, could be used for about 14 hours a day and will be used for conducting a course for teachers in institutes of technology on the use of satellite networks in university education. This project, like those based on communications satellites still to be launched will draw on the experience of earlier experiments in broadcasting to Indian villages direct.

The first functional telecommunication multi-purpose satellite, INSAT-1A, launched on 10 April 1982, is now ready for use in telecommunications, television broadcasting and weather monitoring although non-deployment of the C-band antenna and the continued malfunctioning of solar sails may curtail its useful life. But this may not matter if INSAT-1B, to be launched in July 1983 by the American space shuttle, functions well. The two satellites, INSAT-1A and INSAT-1B, have a total operational lifetime of 10 years with an overlapping period of two years.

By 1990, the Department of Space may have launched and tested INSAT-2, an improvement on the present INSAT satellite. It may then be necessary to have one satellite for telecommunications and television and one for meteorology.

Zaka Imam

Permanent space station

Europe cautious

The European Space Agency (ESA) is cautiously considering an invitation from the US National Aeronautics and Space Administration (NASA) to collaborate in building a permanent manned space station. NASA believes that international collaboration will improve the chance that Congress will approve the \$3,000–\$5,000 million project. But the agency, wary of collaboration since NASA withdrew most of its promised participation in the joint international solar polar mission, will be seeking strict assurances that NASA will not renege on the new project.

NASA has been for some time considering two proposals for a manned space station. The Johnson Space Center favours an immediate start on a large manned facility, built piecemeal from components transported by the shuttle, that would serve as an operating base in low Earth orbit. The Marshall Space Flight Center has an initially modest plan for a series of small unmanned platforms that could be built up later into a large manned station.

NASA has invited US industry to submit by the end of this month proposals to define the space station more closely. One eight-month study will define user needs and six smaller studies will draw up specific aspects of space station design. NASA plans more detailed studies in 1983 and 1984, and will next month be putting a request for \$16 million to finance them to the Office of Management and Budget for fiscal year 1984.

Meanwhile, NASA has invited other countries, including Canada and Japan as well as those in Europe, to consider what use they might make of a space station. Last week, ESA decided to support a study of European needs and to call on European industry to participate with US counterparts on the six detailed design studies. European industry will be looking for ways in which it can contribute expertise gained through building Spacelab, the modular laboratory to be carried on the shuttle. So far, ESA has set aside \$6 million for these preliminary studies.

It will not be easy for ESA to decide whether to accept NASA's invitation. Acceptance would almost certainly mean abandoning ESA's independent idea for an advanced transportation system on which those member states that value independence are keen. Largely stimulated by French proposals, ESA is now considering a partly reusable launcher that would build on experience gained during development of Ariane. Several companies, including Aerospatiale, Erno and Marconi, are conducting feasibility studies for a launch system that would be capable of carrying manned payloads. Next year, the agency also plans to place contracts for studies on

an "in-orbit infrastructure" that might even rival NASA's plans for a space station, although the scale of the project has yet to be defined. In parallel with ESA's efforts, the Centre National d'Etudes Spatiales (CNES), the French national space agency, is also studying space transportation systems using robots rather than men in space.

ESA plans to assess the results of its own studies and those of CNES in 1984 in time for an operational launch system by the mid-1990s. But NASA's invitation introduces a new dimension. Clearly, the agency must choose between the independent route and collaboration. That will be a difficult political decision that could make the much discussed, although as yet unscheduled, conference of European space ministers particularly opportune.

The NASA invitation will also sharpen the division between those in Europe who advocate almost total independence in space and those who would rather spend their money on hardware for launch systems developed largely with US money. Much will depend on the price of European space independence, certain to be tempered by what assurances the United States can give that the space station project will not be abandoned when funds have been committed. ESA will be looking for an intergovernmental agreement that provides greater security than the memorandum of understanding in force when NASA decided to abandon the spacecraft it was due to launch as part of the international solar polar mission.

Judy Redfearn

US nuclear power

Risk underestimated?

Washington

A Nuclear Regulatory Commission (NRC) study of actual nuclear power plant operations from 1969 to 1979 has concluded that the likelihood of a major accident — one that could lead to severe damage of the reactor core — has been seriously underestimated.

According to the new findings, a major accident could have been expected every 200 to 600 reactor-years during the period under study. The United States has at present 74 commercial reactors, so that translates to one major accident every three to nine years. NRC's 1975 Reactor Safety Study (also known as WASH-1400, or the Rasmussen report), which has been frequently criticized for underestimating the risks of nuclear power, put the frequency of major accidents at one every 20,000 reactor-years. NRC recently set a safety

goal of one every 10,000 reactor-years.

The new study, *Precursors to Potential Severe Core Damage Accidents*, was prepared for NRC by Oak Ridge National Laboratory's Nuclear Operations Center. It sifted through nearly 20,000 "event reports" that plant operators are required to file with the commission, and identified 169 of these as possible "precursors" to a major accident. In only one of these cases — the March 1979 accident at Three Mile Island Reactor 2 — did severe core damage, as defined by the study, actually occur.

In 52 cases, however, the events were considered to hold a significant risk of leading to severe core damage under the right conditions — particularly if emergency back-up systems subsequently failed. The operator reports include reports on all emergency system failures, including those discovered during routine tests; thus it was possible to calculate the frequency of such failures. This information, combined with the frequency of the "precursors", was used to calculate the overall frequency prediction for a major accident.

The director of NRC's Division of Risk Analysis, Robert Bernero, stresses, however, that the uncertainty in this estimate is large. For one thing, the single accident at Three Mile Island is responsible for about half of the frequency estimate. The study also notes that the estimate is on the conservative side; it "could be too low by a factor of two to three or too large by one or two orders of magnitude", according to William Cottrell, director of the Oak Ridge analysis centre.

Nor does the report take into account the equipment modifications and procedural modifications ordered after the Three Mile Island accident. A second report, now in preparation, will analyse 1980–81 event reports, and should provide a clue to how effective these modifications have in fact been.

The discrepancy between this study and the earlier Rasmussen report seems to hinge on two factors. According to Bernero, the most important is that the earlier study had little actual operating data to go on. Its approach was to think up possible accident scenarios and to use known failure rates of components such as pumps and valves. Inevitably, this approach is incomplete. A striking example of the sort of accident that cannot be anticipated was the bizarre sequence of events at Rancho Seco in March 1978 that began with a dropped light bulb and ended with a loss of main feed water to the reactor.

The second factor is that the Rasmussen report seems to have made some mistakes even in the scenarios it did consider.

Bernero says that although there is "general agreement" between the two reports on failure probabilities, the new data show that the Rasmussen report made a "poor fire analysis" and a poor analysis of certain minor loss-of-coolant accidents that result from pump-seal leaks.

It is significant that the new findings did not reveal any pattern of accidents among plants of any particular vendor, architect-engineer, power rating or age. Thirty-eight per cent of the precursor events involved human error.

NRC hurriedly released the study last week after the Critical Mass Energy Project, a Ralph Nader anti-nuclear group, made public a draft of the study.

Stephan Budiansky

Soviet research careers

Pay impediments

Low pay scales are hampering recruitment into Soviet science, according to a Moscow specialist in economics, Dr G. Lakhtin, writing in *Pravda*. The average salary of a scientist, he said, is less than that of a worker in transport or industry. A major overhaul of the pay structure, he says, is necessary if science is to be productive.

The need to implement the results of "scientific and technical progress" in the economy is a frequent theme in the Soviet press. Recently Vadim Trapeznikov, a former deputy chairman of the state committee for science and technology, published in *Pravda* a blistering account of delays and bungling in diffusing the results of research and development to the shop-floor level. Hitherto, however the problem has been treated as one of organization and planning — in particular, of drawing scientists into closer links with industry. Lakhtin, however, pinpoints another basic problem — how should scientists be rewarded?

Not everybody is badly paid. Lakhtin quotes the example of a worker holding the degree of Candidate of Sciences, head of laboratory in a "First Category" institute and with a service record of more than 10 years, who receives 400 rubles a month, "neither more nor less", compared with the national average monthly salary of about 170 rubles.

Soviet salaries are rigidly defined by academic qualification and job. Past attempts to set a salary range for each grade came to nothing, for individual salaries in each range soon drifted back to the mean. As Lakhtin explains, administrators raised the salaries of younger at the expense of the older workers, thus blunting the incentive to improve qualifications and job status.

Academic qualifications play a major part in fixing salaries, and the degree of Doctor of Science can be worth as much as an extra 100 rubles a month. Doctors of Science are, however, relatively rare, owing to what now appears to many Soviet

Accident	Date	The most significant "precursors"
Three Mile Island 2	28 March 1979	Loss of feedwater; open pilot-operated relief valve. Human error involved.
Browns Ferry 1	22 March 1979	Cable tray fire. Human error involved.
Rancho Seco	20 March 1978	Failure of non-nuclear instrumentation; steam generator dryout. Human error involved.