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 is 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 uncertaintly 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

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.

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 montly 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

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academics as a historical anomaly. During the industrialization of the 1930s, young graduates were recruited into industry without having had time to complete their PhD studies, and the degree of Candidate of Sciences was introduced as a half-way house.

Now, the degree of Doctor of Sciences is rarely awarded before the age of 40, and often only shortly before retirement at 60. Recently there has been some pressure by academics to abolish the Candidate's degree, which would almost certainly result in a cut in pay for Doctors of Science.

Some opponents of the present structure have suggested that pay should be job-related only. This, says Lakhtin, would simply mean that certain jobs would become associated with certain qualifications, so stifling the incentive for self-improvement. Moreover, a Candidate might be an excellent researcher but have little talent for administration. If the doctorate were linked to the post of laboratory head, and such a Candidate went on to take a Doctor's degree, he would have to be promoted to a post for which he had no aptitude.

Work in science, says Lakhtin, is a "complex social phenomenon" and its remuneration is a "knot where economic, social and psychological factors are entwined". Accordingly he refrains from proposing a solution. Lakhtin's article is precisely of the type used to present to the public a proposed change of policy. One of the general principles for discussion floated by Lakhtin must nevertheless have struck an apprehensive chord in the Soviet Union's almost one million strong research force. Science, said Lakhtin, must enjoy priority in pay, even if this means cutting back the total of those employed in science. A scientist who proves unable to pull his weight should not have his pay cut but should be moved to another sphere of activity. **Vera Rich**

French university research

Whose strings?

The powerful research and industry minister, M. Jean-Pierre Chevènement, does not control the whole of science in France, it seems. During a recent meeting with French university staff, the ministry of education's director of research, M. Bernard Descomps, let slip that his ministry was considering setting up elected committees that would review university research proposals. Other indications from the ministry suggest that even a national university research council is possible; and none of these bodies would be under M. Chevènement's political control.

A revolution? Not exactly. The committees and the council would assess applications from the universities for research money controlled by the ministry of education, a relatively paltry sum compared with the flood pouring — or promised — from the ministry of research and industry. But for a typical university, support from the ministry of education can still account for a fifth of the research budget (aside from salaries) and this can be turned to unfashionable subjects out of favour at the research and industry ministry.

The structure of the elected assessment committees, however, and the nature of the elections, have yet to be determined. Ministry staff say the committees should be multidisciplinary and regional, each assessing the science policy of a number of universities; and that they should judge the distribution of ministry cash — and jobs — in areas "orthogonal" to the interest of the big government research institutions such as the Centre National de la Recherche Scientifique. (These institutions have most of their laboratories in universities, but are controlled by Chevènement's ministry.)

So far so good, but it is clear that there will be problems with the committees. For one thing, multidisciplinary committees are likely to be large and unwieldy, and the regional political battles very fierce; and it will not always be easy to separate the politics of the ministry of education from that of the research and industry ministry.

Meanwhile, French biologists have not been slow to exploit another source of research money, also emanating from the ministry of education, and which may or may not be controlled by the elected committees. These are sizeable funds devoted to a particular research theme, changed each year. This year's flavour covers some of the less fashionable sides of biology, from taxonomy to ethology, which the ministry would like to see profit from advances in techniques in the faster-moving biological sciences. To this end, the ministry earlier this year announced grants totalling some FF 2–3 million (the sum is not yet fixed). So far it has received around 400 applications, each representing a group of some 3–10 French biologists.

How will these applications be assessed? As usual, says the ministry of education, in close liaison with CNRS and others of Chevènement's institutions.

In the past this would not have seemed so like sleeping with the lion as it does now. Many of the best French experts are associated with these institutions, and — after all — before President Mitterrand came to power CNRS belonged to the ministry of education itself. At that time, liaison between university policy and CNRS policy was close. Even now, many in the ministry of education would like it to remain so (after all, M. Chevènement has most of the money!). But certain university researchers, worried about the effects of the Chevènement technological wave, might take comfort from a different possibility: that the separation of CNRS from the ministry of education should encourage the establishment of an independent science politics at the ministry, and so work ultimately in the universities' favour. **Robert Walgate**

British biotechnology

Public concern

The Porton Laboratory of the Public Health Laboratory Service, once the British government's microbiological defence research establishment, is probably still the most successful publicly supported biotechnology organization in Britain, at least by the criterion of the value of its products sold. Last year, the laboratory sold products worth more than £900,000, and confidently expects to sell more than £1 million worth in the present financial year.

The Porton laboratory seems now to be well through the metamorphosis from sword to ploughshare. Although the British government has traditionally forsworn the use of biological weapons, until five years ago the Porton laboratory was kept occupied on what was described as a

programme of defensive research. By the skin of its teeth, the laboratory survived a period during which closure seemed imminent. Now, people at the laboratory daydream about the possibility that if that crisis had been a little delayed, the laboratory might have become the channel for public investment in biotechnology, now represented principally by the company Celltech, in which the British government has a 40 per cent stake. On the whole, they conclude, they are better off as they are.

Part of the explanation may be that the laboratory is earning something like £2 million towards its total annual cost of £5.2 million, half of that by means of "in–out" contracts with other public organizations. Of the products being sold, the enzyme asparaginase (used with other drugs in the chemotheraphy of leukaemia) is the biggest seller, at about £500,000 a year. Earlier attempts to make Porton a major source of restriction enzymes for recombinant-DNA research have, however, been abandoned. The laboratory's strength is in the large-scale production of bacteria and not, it appears, in marketing products in competitive fields.

The laboratory is also the only source in Britain of human growth hormone from

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