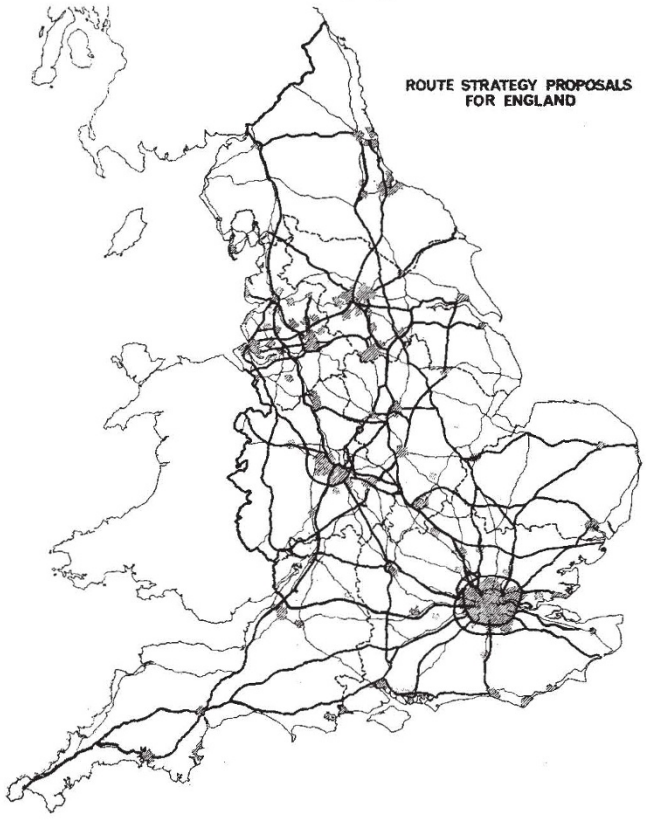
priorities among the proposals which are now up for debate. But before the end of 1969, when the plan has been fully appraised and the comments and suggestions of Regional Economic Planning Councils and local authorities have been mulled over, the minister intends to announce a definitive plan.

Apart from the scale and long-term planning, the new programme is distinguished from its predecessors in being backed by a new mathematical model developed by the ministry for assessing the cost effectiveness of the investment in roads. The economic benefits arising from individual road schemes, the savings in vehicle operating costs, the proportion of time wasted



by vehicle occupants and the cost of accidents have, of course, been part and parcel of road planning for years. But calculations have not previously included estimates of all the other consequential benefits of road improvement, still less combined their interactions in a network.

The mathematical model which the ministry has devised is in essence based on estimates of the traffic on every section of the network, and on the changes which would result if any part of the system were improved or replaced. The calculation of traffic depends on relationships between all the factors which generate traffic—population, vehicle ownership, distances between population centres and actual traffic on existing roads.

In the model, England is divided into about 1,400 zones of known population. All the links in the network of trunk and principal roads, as well as the characteristics of each link, the width of the road, the number of side roads, the average speed and so on, can be measured. From this information, a computer can calculate the traffic and its characteristics as populations move from one zone to another. The traffic flows predicted by the model can then be checked against actual traffic flows and adjustments made until the model matches reality. With the model the ministry claims it can now calculate the redistribution of traffic and the consequent direct economic benefits that would arise from any change in population or improvement or extension of the road network considered either as a whole or in part. This can then be set against the capital cost of any particular road work to give an indication of which scheme gives best value for money. The model has already been used in drawing up the network announced in the green paper, but it will really start earning its keep when it comes to choosing between the proposed network and any other which may emerge during discussions and then deciding on the priorities within the network.

EUROPEAN SPACE

Esro Euphoric

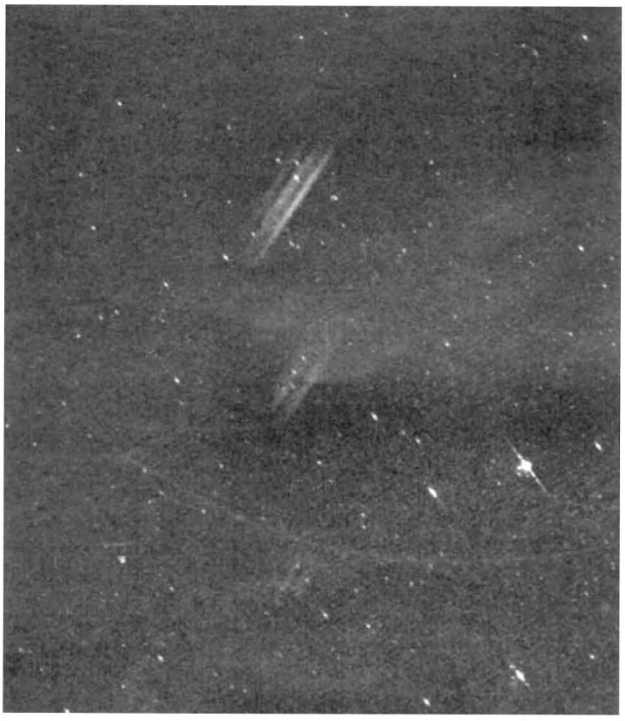
from our Astronomy Correspondent

LAST week's two-day council meeting of the European Space Research Organization approved three new satellites for launching between now and 1972, including one launching for September or October this year which nicely fills what was previously an awkward gap in satellite launches before the next HEOS satellite in 1971. The meeting of the council in Paris was celebrated by Esro's most spectacular space experiment yet—the release of a cloud of barium ions 70,000 km over the Atlantic to plot electric and magnetic fields. This was visible with the naked eye from North and South America. As well as the sprinkling of small satellites which are now assured for the early 1970s, there is every possibility that by July Esro will be in a position to choose two major projects in the $20–50 million class. One of these could be a planetary probe to Mercury, as a joint venture with the United States. It is hardly surprising that Professor Hermann Bondi, Director-General of Esro, is saying that there has never been a council meeting like this before.

Counting the next HEOS scheduled for September 1971 and TD 1 in March 1972, the council decision means that Esro now has five satellites on the stocks. The cheapest of the projects for which approval has been given is the launching of the spare flight model of Esro 1, the satellite now called Aurorae since its successful firing last year. Launching of the second flight model can be as early as September or October, a year after the launch of its predecessor. The satellite is designed to study the northern aurorae, and will be in orbit in time for the northern auroral season. The second new project, HEOS A2, is very similar to the HEOS satellite launched last December and will carry seven experiments, five of them entirely new. Its name is an acronym for the highly eccentric orbits in which this series of satellites travels outside the magnetosphere. The novelty of HEOS A2 is that its polar orbit will take it over the poles, thus mapping the polar magnetosphere and in particular the postulated neutral points between the terrestrial and interplanetary fields. The polar magnetosphere has been neglected in recent years, so that there should be rich pickings for Esro. Again, Junkers is to be the prime contractor, and the launching will be in December 1971. The third satellite is the TD2 rescue project,

containing five of the eleven experiments scheduled for the cancelled TD 2 solar physics satellite. Called ESRO 4, the launch is due for the autumn of 1972. The chief contractors are Hawker Siddeley.

Six ventures are also under consideration as the major projects which justify Esro's existence as an organization to do what no European state can tackle on its own. It may be financially possible to choose two major projects this summer, so long as they are phased so that the peak expenditure comes at different times. A third may be chosen next year. The six candidate satellites are designed for (1) ultraviolet astronomy; (2) gamma ray astronomy using a spark chamber; (3) the Mercury probe; (4) studies of the magnetosphere with a geostationary satellite; (5) large-scale exploration of the ionosphere; and (6) studies of the upper atmosphere. The first four projects are



Three successive exposures of the barium cloud taken with a 48-inch Schmidt telescope at Mount Palomar Observatory, California. The cloud has formed striations along the line of force.

looked on more favourably than the less ambitious ionosphere and upper atmosphere satellites. The hope is that three out of the four will eventually be adopted. If the Mercury probe is picked this year, then the second project will presumably be correspondingly less ambitious. It seems clear, however, that the geostationary satellite, which for the first time will make it possible to disentangle time variations from space variations of magnetospheric phenomena, will fit in nicely with Esro's other activities. The plan is for the satellite to be on the same magnetic line of force as the Esro rocket range at Kiruna (Sweden), so that satellite measurements could be correlated with sounding rocket experiments and with observations by ground-based equipment also established at Kiruna.

Like almost every other organization, Esro is also going in for studies of applications satellites, but the organization is sensibly keeping off the rather dubious bandwagon of earth resources satellites, for the time being at least. Instead, it has its eye on applications where there are likely to be more financial benefits. This spring, Esro will place contracts for serious studies of weather satellites and communications satellites for air traffic control. The feeling is that Earth resources should come third in the list of priorities.

The sounding rocket programme which has been the backbone of the organization since its inception is to go on at more or less the same financial level as before. The trend is to increase the sophistication of the experiments, however, with more pointing rockets, for example, so that the number of launches will decrease.

The spectacular success of the barium cloud experiment last month is being taken in Esro circles almost as an omen that last year's nadir in the affairs of the organization is at last over. The aim of the experiment, planned by the Max Planck Institute for Extraterrestrial Physics, is to measure electric and magnetic fields high in the magnetosphere by observing the motion of a cloud of barium ions released from the HEOS satellite (*Nature*, **220**, 1171; 1968). Release took place over the Atlantic at a height of more than 70,000 km, and the cloud spread to a distance of 3,000 km. Photographic observing stations were at Kitt Peak in Arizona and at La Serena in Chile, and the cloud was visible by eye for as long as 22 minutes. It was also seen from as far away as Alaska.

MECHANICAL ENGINEERING

Lubricating Tribology

TRIBOLOGY is the science of lubrication; it is also fashionable. According to the report of the Committee on Tribology for 1967–68 (HMSO, 5*s* 6*d*), the Ministry of Technology has now even produced a speaker's kit which includes briefing material, slides and films for the evangelists of tribology to use at "industrial gatherings".

Why is tribology so fashionable? The answer is that engineers and the ministry have suddenly discovered that it is cheaper to design suitable lubricants than to put up with a high rate of wear and tear and a high replacement rate. There is no mistaking the Ministry of Technology's determination to see that Britain is well provided with tribologists. The committee's report tells of the three new centres set up in the past year, at the Universities of Leeds and Swansea and at the Atomic Energy Authority's laboratories at Risley. These centres train people and also function on a commercial basis as part of a national network to offer consultancy services to industry.

The Leeds group has so far received contracts worth £10,000, including work on bearings for turbines and wear in machine tools. In one case, the centre has been able to suggest a change costing £50 a year which will mean a saving of several thousand pounds.

The report says that the atmosphere of commercial realism may account for the rapid rise in applicants for the MSc course which Leeds offers. In 1968, ninety people applied and eighteen were accepted compared with twelve, eight and five successful applicants in the previous three years. Risley has had equal success.