man of the Appropriations subcommittee on transportation, a post he has now yielded. Boland's recorded pronouncements on space or science are few; in a speech made in 1958 in the aftermath of the launching of Sputnik, Boland declared that "in the present race for survival [the US] cannot afford to lose its vast reservoir of brainpower in the fields of engineering, science and the humanities merely because these young Americans cannot be given a college education".

But these are small crumbs of comfort for those seeking a commitment to science, since every Congressman was saying the same thing at the time. The indications from Boland's remarks at the CASW seminar last week are that he is well informed about science policy, favours a strong basic research effort by mission oriented agencies, and that if he has to wield the knife on NASA or NSF budgets will at least do so conscientiously.

NASA

A Leader Found

by our Washington Correspondent

WHEN a Dalai Lama dies the Tibetan priests search high and low for the newborn child whose features proclaim it to be the true successor to the Lama's throne. The Nixon Administration has been combing the land with equal care to find a successor to Dr Thomas O. Paine, who resigned as head of the National Aeronautics and Space Administration on September 15 to return to General Electric. The new head of the agency was announced this week after long delay and much vacillation in high councils as Dr James C. Fletcher, a 51-year-old Mormon who is president of the University of Utah.

The search for a successor seems to have been inhibited by the lack of appeal of presiding over NASA's contracting budget. At least eight people seem to have been considered with varying degrees of seriousness, including George M. Low, the deputy administrator; Howard W. Johnson, president of the Massachusetts Institute of Technology; Colonel Frank Borman; Congressman Richard L. Roudebush of Indiana; Roger Lewis, president of the General Dynamics Corporation; James M. Beggs, Undersecretary of Transportation; Congressman George Bush of Texas; and Frank Jameson, president of Teledyne Ryan Aeronautical.

Within the last few weeks the choice was narrowed down to Beggs, Jameson and Fletcher, and an article in *Business Week* for February 13 stated categorically that the job had gone to Jameson, described as a "real charger" of a man who would turn NASA to solving the national problems of education, ecology and the environment as well as keeping the flag flying in space. Unfortunately Jameson fell out of favour with the Lama-hunters in the White House before his appointment could be announced officially and after a few weeks of silence it emerged that the chosen one was not Jameson after all, but Fletcher.

Dr James C. Fletcher

Fletcher is a physicist with industrial experience in several aerospace companies. He served with the Aerojet-General Corporation prior to 1960, as president of the Space Electronics Corporation from 1960 to 1962, and as chairman of the Space General Corporation until 1964, when he became president of the University of Utah. Fletcher has also been a consultant to the President's Science Advisory Committee, the Office of the Secretary of Defense and the Arms Control and Disarmanent Agency.

Other recent changes in NASA's personnel include the dismissal at a month's notice of Julian Scheer, assistant administrator for public affairs, who has been with NASA since its earliest days. Architect of the extensive coverage whereby NASA's doings were made known to the world, Scheer is said to have fallen foul of certain congressional interests in his methods of presenting NASA.

ARMS RACE

Accuracy of ICBMs

by our Washington Correspondent

AN order of magnitude improvement in missile guidance is within the grasp of present-day technology, according to Dr David Hoag, director of the Apollo Guidance and Navigation Program. Quite feasible advances in missile guidance techniques could reduce the average error with which an ICBM hits its target, now 1,000 metres at most, to about 30 metres, the chief residual source of inaccuracy being imperfect knowledge of the Earth's gravitational field.

Improvement of missile accuracies to this degree has alarmed many arms control experts because of the possibility it offers of a successful first-strike attack that would destroy the enemy's missiles in their silos. Hoag, however, in a paper delivered to a Pugwash symposium held at Racine, Wisconsin, last June and now published in book form* argues that the development of high accuracy missiles would encourage the exchange of weapon against weapon instead of weapon against city.

Hoag lists seven major sources of inaccuracy in missile guidance and the approximate errors they cause in the range and track of the missile. One class of error resides in the inertial sensing caused by errors in the accelerometers and gyroscopes. Another may be inaccuracy in specifying to the missile's computers initial conditions such as the location and attitude of the missile on its launcher. A third kind of error may arise from the computations used to track and control the missile's flight. By and large, the trajectory calculations can be made as precise as desired by increasing the number of terms in the power series describing the trajectory, which is limited only by the capability of the on-board computer. Hoag believes that the state of technology in compact digital computers should be able to reduce target-miss contributions from this source to negligible proportions.

Thrust termination errors arise if all the components of the missile velocity fail to attain the exact value required at the moment the rocket thrust is cut off. For example, a 0.1 metre/sec difference between actual and predicted values causes a 650-metre miss at the target. This difficulty can be eased by using an additional low-thrust rocket, called a vernier stage, which adds the last small part of the required velocity. In fact, for a MIRV missile the final vernier-like correction can be made as the individual warheads are released from their "bus".

Fifth, there are the gravity anomalies in the Earth's gravitational field which are too slight to affect missiles at full height but may exert a small influence during the initial and terminal phases of flight. A gravity anomaly altering a missile's velocity by 0.02 metre/sec during the first 100 seconds of launch could cause a 50-metre miss at target.

Uncertainties in the geographical coordinates of the target are a sixth source of error, and finally the missile may be deflected by aerodynamic forces as it re-enters the atmosphere.

* *Impact of New Technologies on the Arms Race*. Ed. B. T. Feld and others. MIT Press, 1971; $2.95.