sity of Wisconsin at Madison.

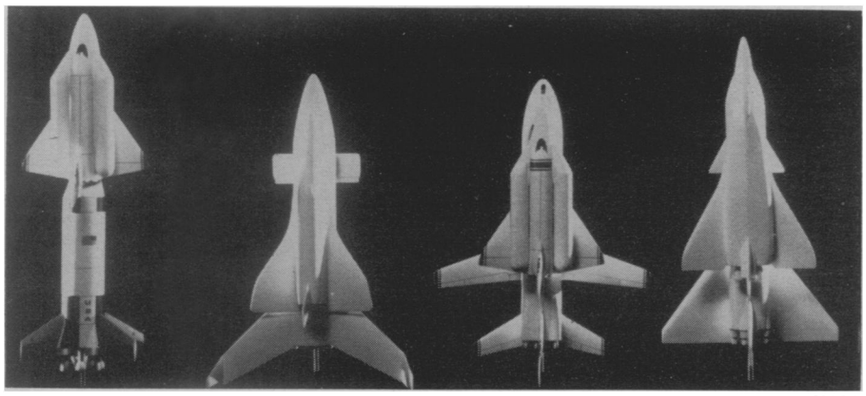
They studied interactions in which positive pi mesons, positive K mesons, negative pi mesons and protons were struck against proton targets. The results in each case contained negative pi mesons plus anything else. The data show that all the experiments agree with each other except those where negative pi mesons are the impinging particle. The experimenters say this disagreement may support a prediction by Dr. Chan Hong-Mo and others of Stony Brook that particular combinations of properties of the colliding particles can influence the result at low energies.

All in all the recent results enhance the hope that simple principles underlie the complexities of particle physics. The strong nuclear interaction, which dominates the proceedings in all these collisions, has been one of the most intractable topics in the history of physics. These experiments yield the hope that at high energies, at least, it follows behavior patterns susceptible to description by simple models.

In the minds of physicists the results also underscore the need for higher and higher energy experiments, whether with storage rings or with stationary targets to find out what that putative simple model is. Since the strong interaction is the force that holds atomic nuclei together, an understanding of it is fundamental to understanding the structure of matter. □

SPACE-PROGRAM OPTIONS

Shuttle is weathering the storm



NASA

Choice lies ahead: Four different proposed configurations for the shuttle.

The dropping of $200 million Saturn boosters into the Atlantic Ocean every time the United States launches men into space is not generally regarded as the most frugal sort of action. In the space program, "reusable" has become a magic word.

The National Aeronautics and Space Administration wants to build, for economic reasons, a reusable booster to take men and reusable hardware into earth's orbit. But the space shuttle, as this transportation system is called (SN: 8/29/70, p. 178), has been the object of criticism from a small group of Senators who believe it will be not an object of thrift but a multibillion-dollar program designed to perpetuate the manned space program. NASA's budget of $3 billion, even though it is about one twenty-fifth the Defense Department's, is still an enticing target for proponents of "new priorities"; NASA has found it has had to scrutinize every dollar.

The Senate amendment this year to delete the shuttle's $80 million from the NASA budget was defeated again, however, by an even greater margin than last year. In the Senate vote to authorize funds for NASA, the anti-shuttle amendment lost 62 to 22. This week, the Senate voted to actually appropriate NASA funds, but the sponsors of the amendment—Senators Walter F. Mondale (D-Minn.), William Proxmire (D-Wis.), Clifford P. Case (R-N.J.) and Jacob K. Javits (R-N.Y.)—decided not to try to introduce it into the appropriations bill because of the size of the earlier defeat.

Muddying the already murky waters of the political debate were two vaguely contradicting cost-analysis studies of the shuttle. One study, released in May by Mondale, was written in 1970 by four Rand Corp. analysts under contract to the Air Force. The study was based on the 1969 Space Task Group (STG) report and 1969 shuttle statistics (the STG report is no longer considered feasible by NASA and has been largely dropped). The other study, done by Mathematica, Inc., was completed this May for NASA and was based on current data. Mathematica is now doing another cost study of the "phased approach" announced by NASA last month of developing the orbiter first and delaying the development of the booster until 1981 (SN: 7/17/71, p. 41).

Comparison of the two studies is difficult because they are based on different assumptions about the space program for the next 20 years. The STG report used by Rand included the cost not only for the shuttle and the tug (the tug would be used to take payloads from the shuttle orbit to synchronous orbit), but also for a space station and base, a lunar station and base, and a lunar tug. The Rand authors conclude that all of this would cost NASA $94 billion to $97 billion between now and 1990, and cost the military $41 billion to $44 billion. If NASA does only the space station, base and shuttle, the cost would be less for NASA ($77 billion to $81 billion) but more for the military ($42 billion to $46 billion).

The Rand authors used a two-stage (booster and orbiter), reusable shuttle that could carry 50,000 pounds to orbit, have a 100-flight lifetime and a two-week turn-around period. Most of their conclusions were based on the predicted amount of shuttle traffic, the total of which was slightly higher than in the Mathematica report. It is also significant to note that the Rand report did not evaluate precise payload savings. The authors concluded that the shuttle would cost $9 billion and show a net undiscounted transportation cost saving of only $2.8 billion by 1990. The civilian space budget would peak to $7 billion in 1975 under the Rand plan. Significantly Rand also concluded that heavy traffic favors the shuttle and that a large shuttle was more economical than a small one (50,000 pounds or 25,000 pounds payload). The Rand study did not consider payload effects. It concluded that the shuttle was hard to justify.

Mondale described the Rand report as "devastating" to the shuttle. Pro-shuttle Senators said the Rand report was based on two-year-old data and pointed out that the Mathematica study was the result of 12 to 16 man-years and a $600,000 contract and the Rand report only 2 or 3 man-years and a $40,000 contract.

The Mathematica study considered only shuttle and tug developments. Mathematica used a 10 percent discount rate for the next 20 years—a rate assigned by the Government to low priority items; the higher the discount rate the more a project has to do before the private sector sees a return on its tax investment. (For example, most Government projects have a zero percent to five percent discount rate.) Yet even with this high discount rate Mathematica concluded that to develop a shuttle and tug and buy the fleet (3 or 4 orbiters and 4 or 5 boosters) would cost only $12.8

billion in nonrecurring costs. Based on a flight schedule for 13 years—1978 to 1990—and considering payload effects (the fact that with the shuttle satellites could be built cheaper and could be repaired for reuse) the study concluded that the shuttle would pay for itself or break even with a total of only 40 flights a year for both NASA and the Air Force. In 1970 NASA and the Air Force launched 36 payloads.

Mathematica considered many variations and produced 26 scenarios of plans for the space program. For their traffic model the analysts used 736 missions identified by DOD and NASA. The continued use of current expendable booster rockets or new expendable rockets instead of the reusable shuttle resulted in a modest investment, but the recurring cost of operation remained high. For example, with the shuttle, the initial cost would be $12.8 billion and the cost per launch only $4.6 million; with the expendable boosters, the initial cost would be only $1.5 billion but the cost per launch would be $13.1 million. Mathematica also concluded that use of the shuttle would save $14 billion on the cost of satellites and other hardware put into orbit. (They would not have to be nearly so miniaturized and automated.)

All this may be confusing to the layman but it appears to be necessary to forecast approximately the effects of a new system. The shuttle is still in the study phase. So far $94.5 million has been spent on shuttle studies. This year, however, the first moneys will be placed into hardware—$58 million for initial development of the shuttle engines and $42 million for the vehicles. Shuttle defenders point out that nothing NASA has spent so far commits the agency to immediate development of the two-stage vehicle. In fact, some NASA supporters are now favoring the phased approach, which has two noticeable advantages: it would eliminate the need for a peak $6 billion or $7 billion space budget and would allow engineers to use the orbiters to test the flight regime of the booster.

Included in the options of the phased approach are solid- or liquid-fuel expendable boosters. Although NASA is not too enthusiastic about it, Lockheed's stage-and-a-half shuttle is still in the running (only the orbiter with drop tanks). The stage and a half would probably cost as much to operate but would possibly save $3 billion to $5 billion in development cost.

This year's debate on the shuttle is only the beginning. But several things seem in the shuttle's favor. Space theorists had been advocating reusable systems since the late 1950's but the Apollo program allowed neither the time nor state-of-the-art development. The Air Force's need for an already developed shuttle is also a vote-getter in Congress. For example, the Air Force has testified that 50 percent of its space requirements are to reach synchronous orbit. Here they could place not only monitoring devices and missile detectors but perhaps also devices such as lasers to destroy missiles. On the negative side, current antimilitary sentiment in the country does not bode well for NASA's developing a shuttle that would also be used by the military. NASA responds that the cheaper route is to build a shuttle everyone can use. □

SCIENTIFIC FREEDOM

Protecting the scientist

NBS

Austin: Head of AAAS committee.

Last year Sen. Edmund S. Muskie (D-Me.) called on the American Association for the Advancement of Science to make a judgment in an alleged case of denial of scientific freedom. Drs. John W. Gofman and Arthur R. Tamplin, outspoken critics of national radiation standards, had their staffs cut by the Atomic Energy Commission. This, they claimed was in retaliation for their criticism and therefore a denial of scientific freedom.

In answer to Muskie's request, the AAAS last December decided to set up a committee to study and report on specific instances of alleged abridgment of scientific freedom. This committee has now been formed, although not quite along the original lines. Dr. Athelstan Spilhaus, chairman of the AAAS board of directors, has announced a five-member, national policy-making committee "to develop policies for safeguarding independent scientific inquiry and to develop procedures to ensure responsible scientific conduct." The committee will not look at individual cases but will set up "guidelines and procedures that will enable the association to develop machinery for handling individual cases."

Dr. Allen V. Astin, former director of the National Bureau of Standards, and now Home Secretary of the National Academy of Sciences, will be chairman. The other members, like Dr. Astin, have been involved in or concerned about issues of scientific freedom and public responsibility; Dr. Mary Catherine Bateson, associate professor of sociology and anthropology at Northeastern University in Boston; Walter J. Hickel, former Secretary of the Interior; Dr. John H. Knowles, director of Massachusetts General Hospital in Boston, and the Hon. Earl Warren, former Chief Justice of the United States.

Their specific charge is to study and report on the general conditions required for scientific freedom and responsibility, develop criteria and procedures for the impartial study of these problems, and to recommend mechanisms to enable the association to review specific instances in which scientific freedom is alleged to have been abridged or otherwise endangered or in which responsible scientific conduct is alleged to have been violated.

This will not be a completely novel role for the AAAS. William Bevin, AAAS executive officer, says the association has in the past even sent its lawyer to court (for moral support) with scientists involved in civil liberty cases. And whenever scientists asked for help they were given as much information and advice as was available. Now, says Bevin, the AAAS will have the official means, machinery, resources and policy guidelines to stand up for "civil liberties in the context of the scientific community." The only problem he foresees is funds. Once this machinery starts into motion Bevin expects to be deluged with requests from distressed scientists. And it will take quite a lot of money to implement whatever mechanisms the group comes up with.

As to what these mechanisms will be, no one is prepared to say. But Bevin promises that the committee will have complete freedom and will be more autonomous than any other AAAS committee. As a result he will not predict what it might come up with.

The same is true for the members themselves. Drs. Astin and Knowles both say that they have some ideas, but they will not discuss them until after the committee has had time to meet. Just when this first meeting will be is still a question, but the AAAS board of directors and the committee members are excited about the prospect and hope to get things going as soon as possible. Dr. Astin says that this will happen as soon as all of the members can get together at the same time. He hopes it will be in September or October. □