Missiles and Spaceflight . . .

This kind of interim activity would give us much-needed launch experience, more knowledge in depth about manned inputs into these kinds of systems, and in particular could give us answers to questions about manned operations in space during rendezvous, midcourse trajectory changes and similar operational experiences.

This kind of activity would and should be undertaken concurrent with and in support of our work on Project Apollo. It would be a highly productive undertaking which would take maximum advantage of our Mercury experience and know-how and provide new experience and capabilities for application to Apollo.

The mission of Apollo is threefold. First, we will undertake extended-duration Earth-orbital flights; then we will proceed to circumlunar exploratory flights; and finally, we will go on to lunar landing and return.

The detailed configuration of the Apollo spacecraft has not as yet been completely defined. The spacecraft design will be determined partially by the industry design competition now underway and more completely by subsequent NASA/contractor detail design efforts. Basically, it will consist of a three-man command module attached to advanced propulsion modules for lunar landing and take-off. The launch vehicle will be a large multi-stage chemical rocket of the Nova class.

Project Apollo began almost two years ago when a small team within the Space Task Group was set up to define the mission and to develop working guidelines for the effort. All of the NASA research and spaceflight centres and resources were brought into the programme to ensure that sound basic research would get underway in order to assure the availability of a solid technological basis for the programme. . .

The primary propulsion systems for launching Apollo are under study. Saturn, the predecessor of the Nova-class rockets, is now about to enter the flight-test phase with the first test vehicle now on the pad [since successfully launched] at Cape Canaveral . . .

Major Apollo Problems

As is the case in any major advance in technology, there are a multitude of complex problems involved in the Apollo flight mission. I would like to outline some of the major problems.

Re-entry dynamics. First, there is the problem of protection of the spacecraft and its crew from the searing heat of re-entry at velocities of 36,000ft/sec. Here we must dissipate a kinetic energy per pound weight that is far greater than the chemical energy of any known compound. . .

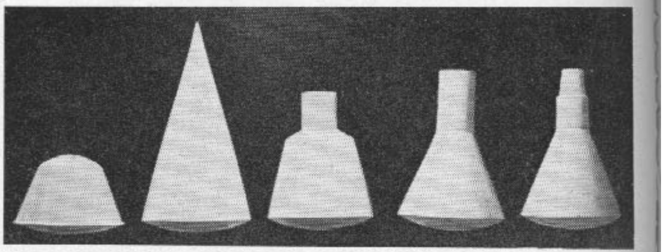
Earth landing capability. The problem of Earth landing capability includes the ability to avoid local hazards and to control the final touchdown point. Some degree of lift ability in the vehicle itself plus adaptation of either steerable parachutes or the Rogallo kite (paraglider) may provide the solution to this problem.

Lunar landing. In the manned lunar landing we must achieve a genuinely "soft" controlled landing in a vacuum and on a surface about which we know almost nothing. The lunar sciences programme should provide us with many of the answers we need here. However, a large engineering undertaking will be required.

Performance. The performance problem facing us is basically related to the size of the step to be taken. Project Mercury requires a launch vehicle capable of putting about 1½ tons in low Earth orbit. For the lunar landing and return, Apollo will require a basic launch vehicle capable of putting one hundred times that weight in low Earth orbit. For flights to the Moon and the planets, the ratio of take-off thrust to spacecraft weight will approach 1,000 for chemical rockets. Because of the extremely large vehicles which might result, it may well be that rendezvous techniques will provide the only means of accomplishing the mission with launch vehicles of considerably smaller proportions. It also seems clear that we shall soon have to progress to the more exotic forms of propulsion such as nuclear or nuclear-electric if we are to engage in planetary exploration with relatively reasonable thrust-to-weight ratios.

Reliability. Many factors tend to mitigate against high reliability in large space-vehicle design. But one factor—Man—requires that the reliability must be high. We must achieve an order-of-magnitude reduction in failure rates in our launch vehicle to approach the required values of stage reliability necessary for manned flight. Possibly the desired order-of-magnitude reduction is launch-vehicle failure rates can be achieved by order-of-magnitude increases in previously used measures of simplicity, redundancy, quality control, and the human input to control the system. This will not be an easy task, but it is one worthy of our most intense efforts [Mr Gilruth concluded].

Although the subject of this article is the NASA programme of "civilian" space exploration, it is relevant to record the views of the Commander of the USAF Systems Command, Gen B. A. Schriever, who has said "As a military commander who shares the responsibility for the defence and security of the nation, I am convinced that we must be prepared to operate in space in order to preserve the peace."



Stages in the design of the Mercury spacecraft: (from the left) (1) simple shape was unstable, (2) more stable shape was too weak and heavy, (3) shape planned for interior requirements, (4) as specified for space and structure, (5) final shape to take antenna and escape tower

In the past, Gen Schriever claims, US space efforts have been carried out under an "unnecessary, self-imposed restriction"—i.e., the artificial division between space for peaceful purposes and space for military uses. There is very little technical distinction between the two, in the general's opinion: the same hardware and techniques used to launch an orbiting scientific capsule can also be used to orbit an early-warning satellite. The same techniques that can send a man into space as a scientific observer may also send him there in a military role.

Gen Schriever added at a press conference in New York that he was not claiming a military function on the Moon at the present time, although there might be one in the future.

Application Spacecraft In the field of "application" spacecraft, the outstanding examples are meteorological and communications satellites, both of which not only have been shown to be feasible but have been put to work with directly useful results.

Thanks largely to rocket and satellite developments, the Chief of the US Weather Bureau, Dr F. W. Reichelderfer, has said, "We are now approaching a new era where meteorology will become an increasingly quantitative science." Each day now, he remarked, two weather maps were computed "without contamination by human hands," and as a further example he quoted September 11, 1961, on which day Tiros 3 revealed no fewer than seven tropical storms—one over Africa, hurricanes Debbie and Esther in the Atlantic, Carla crossing the Texas coast, Nancy and Pamela near Japan and an embryo tropical cyclone in the Pacific.

Data obtained from meteorological satellites includes stratospheric, tropospheric, cloud-top and surface temperatures; information on atmospheric constituents such as water vapour, ozone and carbon dioxide; the motion, type and ground-cover of clouds; and heat-budget items such as solar radiation, reflected solar radiation, and radiation from the Earth and the atmosphere. In addition to improving and extending weather predictions, Dr Reichelderfer has said that the US operational satellite programme [described in last week's issue] "may afford the opportunity to establish initial 'causes' from which might develop a truly scientific weather-modification effort."

Even more impressive in immediate-use implications is the massive and varied effort which both NASA and the US Defense Department are putting into the development of a family of communication satellites. It may not be generally realized in this country that six separate communication-satellite programmes are underway in the USA at present—at least four of which will involve satellite launches next year. The British GPO may find this of interest.

NASA is involved in five of the six projects. Another orbital launch of an Echo passive communication satellite will be made next year, and this will be followed by Rebound, in which three passive satellites will be placed in a 1,500-1,700 mile orbit. Active repeater satellites comprise Relay (low-altitude orbit at 1,000-3,000 miles), Telstar (in co-operation with American Telephone and Telegraph, similar orbit to Relay) and Syncom (24hr synchronous satellite at 22,300 miles), all of which will be launched during 1962.

The Defense Department's main communication-satellite programme is the active-repeater Advent, to be launched into synchronous orbit initially by Atlas-Agena B and later by Centaur. The Department also has an interest in passive systems, to which the recent West Ford launch was intended to be relevant.

As indicated, both passive and active systems, and both high and low orbits, are being investigated prior to any thoughts of "freezing" a particular design or system. Dr John R. Pierce, director of research of Bell Telephone Laboratories (an A.T. and T. company) has suggested that satellite and component reliability is the most important single problem to be tackled. Communications satellites will be useful and will make good commercially, he emphasizes, only if they "keep going for years." To obtain reliability one should use well-tested components, few in number, and use actual flight testing to discover whether the anticipated life could be achieved.

(*to be continued*)