could also eliminate some "lower probability" planned landing areas. The recovery of the spacecraft could be accomplished by surface vehicles at a more leisurely pace after the flight crew had been recovered. Flotation gear would be attached to the spacecraft to insure its flotation if the landing should occur on water and location buoys would be attached as a location aid.

There has been little recovery planning for a space-station project, but concepts developed for the other programs discussed here are directly applicable. Major recovery-force requirements will be associated with logistic-vehicle operations, particularly if launch-vehicle stages are recovered. In a space-station program, contingency recovery forces would be required nearly full-time to support logistic vehicles. Other manned space programs, however, will likely be operational during the same period, and these could engage the same recovery forces.

OPERATIONS

Flight crew requirements

BY RICHARD E. DAY

The Manned Spacecraft Center selects and prepares the flight crews for present and future NASA manned space programs. What are their requirements and how are they prepared for space missions?

"The NASA Astronaut Program" by Walter C. Williams and Warren J. North (*Aerospace Engineering*, Vol. 21, No. 1, Jan. 1962, pp. 13–15) describes the selecting of astronauts in detail. Briefly, the men are selected for obvious physical endowments, a certain age range, and education and professional background that will minimize their training.

Nine new men joined the first seven astronauts in October 1962, early enough to gain full indoctrination and general participation in the engineering and development of the Gemini and Apollo programs. These 16 men, now in various stages of intensive training, will provide the primary and alternate crews for missions in overlapping programs. Additional men will be picked as hardware and program developments demand them.

The general training program for Gemini and Apollo includes science lectures, field trips to government and contractor facilities, systems briefings, engineering development participation, and environmental and operational training.

Astronomy, flight mechanics, computer theory and operation, rocket propulsion, communications, aerodynamics, guidance and navigation, atmospheric and space physics, selenology, meteorology, and medical aspects of spaceflight—these subjects form the science lectures, which are space-mission oriented. For example, the navigational tasks of the complete Apollo mission—from lunar insertion to earth-re-entry energy management—require knowledge of the first seven topics.

System briefings are presented and constantly updated as hardware develops. Systems trainers (see page 82) help develop systems knowledge and reduce training time.

As in the Mercury program, the flight crew will both follow and participate in engineering developments, and educate each other in specific areas.

Centrifuge programs will familiarize the pilots with launch and re-entry acceleration profiles under normal and emergency conditions and allow them to evaluate spacecraft systems, such as controls displays and restraints. They will be familiarized with pressure-suit characteristics and mobility. Each man will be trained to recognize his own symptoms caused by high concentration of carbon dioxide. Their survival training will cover landings in water, desert, or tropics.

The astronauts will gain operational training through a variety of fixed-base and free-flight simulators (see page 78), many simulating Gemini and Apollo missions from launch to near-landing. Instructors will be able to insert malfunctions, and the crew in turn will be able to perform in-flight tests and maintenance operations. Many early flights, moreover, will involve training. For example, lunar-excursion-module docking will be tried in earth orbit before a lunar mission. Throughout the program, the astronauts must maintain their flight proficiency in high-performance aircraft.

Specific flight-crew preparation requires practically full-time participation of the primary and alternate crews at the launch site. This preparation may begin three or more months before the scheduled flight, depending on the complexity of the mission. At that time, all spacecraft-engineering and flight-plan changes should be held to minimum, and so permit adequate checking of spacecraft systems, and allow the crew time to acquaint themselves thoroughly with the systems and planned operations.

During this period, the large number of operational checks in the white room, vacuum chamber, and vertical assembly tower, or on the launch complex, require part or all of the crew for participation or observation.

The crew will utilize the mission trainer to practice normal and emergency procedures, guidance and navigation, control-mode switching and tasks, and test monitoring and maintenance. In the final stages of preparation, integrated network simulations will be conducted with all ground and flight crews participating.

From this regimen the flight crew will emerge ready for its mission. ••

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