SPACEFLIGHT

Apollo 13: accident in space

THE HOPES AND PRAYERS of an anxious world were well satisfied by the sight of the command module gently sinking beneath its three supporting parachutes bringing astronauts Lovell, Haise and Swigert safely home on April 17 after their four days of ordeal in outer space. Thanks to television and its worldwide satellite hook-up a vast audience around the globe was able to see in close detail the quickest recovery operation yet achieved. Nobody could have had anything but admiration for the way NASA was able to cope with a difficult situation and salvage craft and personnel after such a major failure of primary systems.

The schedule for landing the third American crew on the Moon was suddenly and decisively lost in the early hours of April 14 when a near-catastrophic failure in the service module occurred. At 4.17 a.m. BST that Tuesday, the Apollo 13 commander James Lovell reported: "Hey, we've got a problem." At that moment, though it was not immediately recognised as such, the prime object of Apollo 13, a landing on the Moon's highlands, was replaced by the urgent need for getting the three astronauts safely back to Earth.

Up to that time the flight had gone with characteristic Apollo smoothness. There had been a snag with the second (S-II) stage of the Saturn V vehicle, in which the centre engine of the cluster of five shut down 26sec prematurely. In order to maintain the desired flight path, the other four were kept burning for an extra 26sec and, after the stage had been discarded, an extra 10sec burn time on the S-IVb third stage was necessary. So far no explanation has been given for this rather worrying fault, which occurred previously on one of the 16 unmanned Apollo tests.

On board the spacecraft a new command-module pilot, Jack Swigert, had replaced Ken Mattingly at only two days' notice. Mattingly had become exposed to infection from German measles, and medical checks revealed that his resistance to the disease was so low that there was a risk that he might succumb to it. The new pilot, already taken on board with some misgivings (although he was a member of the Apollo 13 back-up crew), was immediately put to work rehearsing procedures, and finally Lovell expressed himself satisfied. Actually there was a slight hitch; on waking up after his first sleep in orbit, the new man discovered that he had left behind Part 1 of his flight plan, dealing with photography and candidate sites for the next lunar landings. To make up for this, skilful handling during the insertion burn resulted in a 20lb, 9kg saving of fuel, for which Swigert was congratulated.

The main burn, using the S-IVb engine to get out of Earth orbit, took place at 10.48 p.m. on Saturday night, 4hr 25min after launch. Again there was a technical shortfall, the single J-2 engine of the S-IVb stage terminating 3.5sec early.

The transposition and docking manœuvre was smoothly and successfully executed and the crew settled down to the expected uneventful flight to the Moon. The first mid-course correction burn was not made, owing to the accuracy of the track. A colour television broadcast from the spacecraft was widely ignored by the American networks; it wasn't a novelty any more.

But then, at 4.15 a.m. on Tuesday, April 14 (only 5min after the spurned TV tour of the spacecraft), Lovell exclaimed: "Hey, we've got a problem." Asked by the Mission Control Centre in Houston to repeat the message, Lovell replied, "Houston, we've had a problem. We've had a main bus internal" (verbal shorthand for a fault in the d.c. busbars, the main electrical supply lines). A bang had been heard, transmitted through the structure of the service module. Ten minutes later Lovell reported that gas was venting from the spacecraft into space, causing the craft to roll.

The crew then reported that the oxygen pressure was dropping and it was clear that the three fuel cells in the service module (which, in direct contrast to a lead-acid battery consume oxygen and hydrogen in order to generate electricity) had been damaged. The oxygen supply to the cells was cut off to conserve the now-precious gas. It quickly became clear that an evacuation to the lunar module was necessary to conserve the remaining electrical power (supplied by three silver-zinc storage batteries) for the re-entry, and to make use of the oxygen and life-support system in the lunar-landing craft. Accordingly, Lovell and Haise made their way through the connecting tunnel to the lunar module, Swigert staying behind to carry out a power-down procedure.

Shortly afterwards the electrical system on the lunar module was switched on, and conversations with Houston were commenced using the landing craft radio. The connecting tunnel was left open so that oxygen from the LM could enter the command module.

When the accident occurred, the spacecraft was more than half-way to the Moon. Celestial dynamics, however useful they may be at times, do not allow instant turn-rounds. Apollo 13, whatever else happened, was bound to go round the Moon.

Houston rapidly got down to analysing the flight and to seeing how best to recover the situation. The service-propulsion engine obviously could not be used; even had any oxygen remained, there were grave dangers associated with using an operationally suspect engine. The LM descent engine, of considerably less thrust than the SPS engine, would have to be used for all the main trajectory changes. The first thing to do was to place the spacecraft on a free-return trajectory, in which it could swing behind the Moon and back on to an Earth-return path.

There were, of course, housekeeping problems; the water situation in particular was giving rise to anxiety. Water is needed not only for drinking, but also for cooling and other purposes.

In fact it turned out that there was enough water, sufficient for about 12hr more than was likely to be needed. Contamination of the atmosphere within the craft threatened, and steps were taken to avoid, excessive build-up of carbon dioxide. It was calculated that the three astronauts would be using some 6lb to 8lb, 2.7kg to 3.6kg of oxygen per day and that there was a likely margin of some 50hr. Had the crisis arisen after the LM had left for the Moon or during the return journey to Earth there is no doubt that it would have proved fatal as there was only a few hours of emergency oxygen and battery power available in the command module. In order to conserve