Spaceflight

LUNAR EXPERIMENTS FOR APOLLO

The scientific experiments which will be left on the Moon's surface during the initial Apollo expeditions have been selected by Dr Holmer E. Newell, NASA Associate Administrator for Space Science and Applications, following recommendations by NASA's space science steering committee. Seven geophysical instruments were chosen as primary and back-up experiments to be included in three flight packages and one back-up on the early lunar landings.

A 150lb package of experiments, known as the Apollo lunar surface experiments package (ALSEP) will be carried in the lunar excursion module. The package will be left on the Moon's surface, and will transmit data back to Earth for periods of between six months and one year.

The seven experiments chosen are:—

(1) Passive lunar seismic experiment. This is a three-axis seismometer which will measure lunar tremors or Moonquakes in order to study the Moon's interior and so determine whether it has a crust and core, or is layered in structure.

(2) Three-axis magnetometer. The magnetometer is similar to ones already flown on unmanned flights and will measure the Moon's magnetic field together with the interaction of the solar wind with this field.

(3) Medium-energy solar wind experiment. The plasma spectrometer will measure the velocity and direction of protons, electrons and alpha particles in the solar wind as they arrive at the Moon, and the interaction of these particles with the lunar surface.

(4) Suprathermal ion detector, to measure the Moon's ionosphere by sampling ions over a wide range of energies to determine how strongly it is affected by the solar wind.

(5) Lunar heat-flow measurement. This experiment is designed to measure the outflow of heat from the Moon's interior through the surface to provide information on the distribution of radioactive elements and the thermal and volcanic history of the Moon.

(6) Low-energy solar wind. This is similar to the medium-energy solar wind experiment, but covers a lower energy range.

(7) Active lunar seismic experiment, to obtain information on the physical properties of the lunar surface down to a depth of about 500ft. An astronaut-operated surface "thumper" will provide the necessary surface excitation at distances close to the experiment, while at great distances this will be provided by a small mortar firing projectiles to land on the surface.

FOR LUNAR EXCURSIONS

Fifteen flight versions of the Apollo lunar excursion module, ten test versions and two mission simulators are to be supplied to NASA by Grumman Aircraft Engineering Corporation under a revised contract based on a cost-plus-incentive agreement. This four-year contract will provide "profit incentive for outstanding performance, cost control and timely delivery as well as potential profit reductions if performance, cost and schedule requirements are not met" and will be worth approximately $1,019 million. Grumman was selected by NASA in November 1962 to develop the LEM; the cost of the work, added to the new agreement, totals $1,420,000.

Grumman's revised contract is the second major Apollo contract conversion by NASA this year. On January 21 a similar agreement was signed with North American Aviation for development of the Apollo command and service modules, covering a one-year period and amounting to $671.3 million. Total cost of the NAA contract, is approximately $2,200 million.

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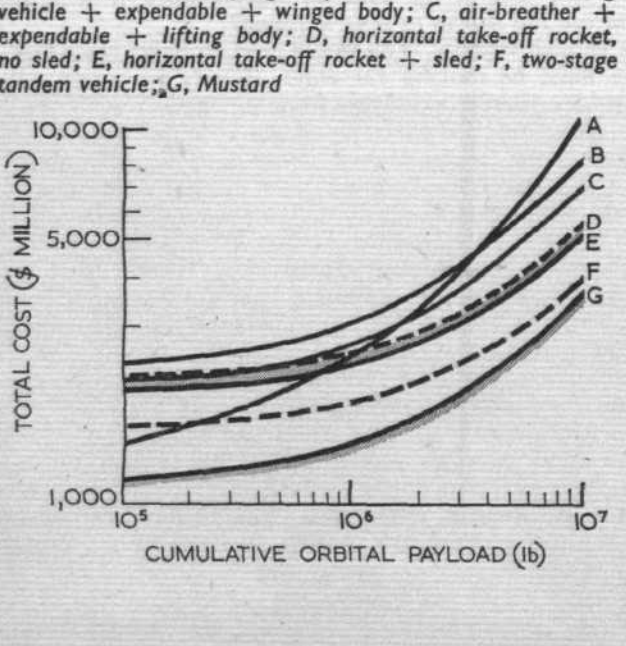
Our studies on such systems are by no means at the stage where we could be dogmatic. Nevertheless, we feel justified in using the values we have obtained to make comparisons, if only to illustrate the kind of comparison that should be made in choosing a joint European space transporter.

In Fig 5 we have plotted our estimates of total cost against the cumulative orbital payload for these same systems carrying the same 5,000lb unit disposable payload. It should be noted that the US and USSR have each orbited the order of 0.5 x 10^6lb equivalent in low Earth orbit, and each will have reached 10^6lb by 1967.

Fig 5 Cost of operating a 5,000lb payload vehicle, including landing and return engines, over a ten-year period. A, expendable vehicle + lifting body; B, Mach 4 air-breathing vehicle + expendable + winged body; C, air-breather + expendable + lifting body; D, horizontal take-off rocket, no sled; E, horizontal take-off rocket + sled; F, two-stage tandem vehicle; G, Mustard



Research Programme In order to try to build up a better picture of the R&D situation our studies have paid particular attention to the detail programmes necessary to determining both costs and time-scales.

There seems no reason to expect a change in the pattern that we have experienced on high-performance aircraft, that is, major changes to a basic configuration occur largely due to problems encountered in low-speed handling, landing and take-off. For this reason we have put forward ground-simulator testing which, we feel, must be backed up by some flight vehicle to establish a datum sufficiently near the likely final configuration, and we are proposing a glider very much on the pattern of the Edwards M2 vehicle and launched by the first stage of the proposed Black Arrow. This programme, backed up by both low- and high-speed tunnel testing, should give us the necessary confidence in the aerodynamic configuration, and would also tell us whether landing engines are necessary—particularly for the spacecraft, which suffers most from their inclusion.

Conclusions We believe that all concepts for space transportation must be judged by the criterion of minimum total cost. Recognising that existing costing methods are inadequate, we see an urgent need to improve them.

We have studied the use of a multi-module lifting-body vehicle as a way of reducing R&D costs; and, having satisfied ourselves that it is feasible, we believe that it should be considered a serious proposition for the space transporter.

Comparison with other systems on a manufactured-weight basis shows VTO rocket-propelled systems with modular or tandem-stages to be the best. This conclusion is equally true when total costs are compared insofar as we can truly estimate them by existing methods.