SPACE FLIGHT-LAUNCH VEHICLES

The last decade has seen a tremendous progress in space flight. Beginning with small grapefruit-sized payloads launched into low Earth-orbits, the technology has advanced to deep-space probes, to large 50 ton payloads, three-men space capsules circling not only the Earth but venturing out toward the Moon, and capable of maneuvering in space, rendezvous, docking, etc.

Examples are the recent Apollo flights of the U.S. Space Program. During the historic Apollo 8 space flight, human eyes have seen for the first time in history, the surface of the Moon, from close distance, unaided by optical instruments.

Indeed, advancements beyond prior expectations for this short period of time!

In the United States, the launch cost per pound payload in low Earth-orbit has been reduced from $3000 for vehicles as the Thor, to $800 for vehicles as the Atlas, and to $400 and $500 for the Saturn-5, as shown in Figure 1. As impressive as these cost reductions are, their significance has been somewhat obscured by the associated increases of the launcher size.

Figure 2 shows while an Atlas launch vehicle would cost approximately $8 million, the cost of a Saturn-5 vehicle is in excess of $120 million. Adding to the launch vehicle the cost of the payload and the operational cost for launch,

reentry and recovery, a single launch in the Saturn-5 class will require funds of between $400 million and $500 million. With such a high cost per launch, even most generous space budgets are not expected to support more than limited space programs, that is only a few launches of boosters in the Saturn-5 class per year. Such number of vehicles will be too small to achieve appreciable cost reductions from mass production or systems maturity.

Enthusiastic public support for adequate space budgets can in the long run, be counted on only if utilization of space assumes a strong place beside exploration of space. If this situation is not achieved, funding for the space program can scarcely be expected to increase greatly or even to maintain its current high level, but must count on being reduced, for instance, to the considerably more modest level of research in astronomy.

Looking into the future, it may be firmly assumed that a considerable portion of future space activities will be directed toward applications of space technology and commercial utilization of space, that is, to areas affecting directly the everyday life of each human being and the entire economy on Earth, such as communication satellites, navigation satellites, etc., are doing already today.

In a vigorous space program, with emphasis on "space-utilization", the cost of the launchers must be drastically reduced. This need becomes particularly pressing when in the near future large space stations are assembled and

manned for long-time operation in Earth-orbit. Their operation, and hence their usefulness, may be severely curtailed by the high cost of the first generation type space launch vehicles, as the only vehicles available to provide their continuous logistic support.

It can no longer be afforded to dump the launch vehicle into the ocean, after only one-time-use of costly $100 million hardware.

Also, cost reductions by means of component recovery with parachutes or similar devices, will be no more than a short-time expediency. Economical fully re-useable ferry-type vehicles are needed, having airline like reliability and operational capabilities similar to our aircraft, that is, capable of taking off and landing from space-ports, similar to our regular airports, depositing the payload, men as well as goods, at low-orbit space stations and returning safely to Earth.

Only with such multi-purpose ferry vehicles, the era of "space utilization" instead of mere "space exploration" can in earnest begin.

Current technology is advanced to such an extent that systems of the re-useable ferry-type are technologically feasible. With appropriate support for research, prototype design, prototype and final configuration testing, the available scientific and technological base can be systematically extended to provide the required detail design data.

The launch cost of such vehicles is estimated to go