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DISCUSSION OF INTEGRAL LAUNCH VEHICLE/ SPACECRAFT STUDIES AT MCDONNELL DOUGLAS, ST. LOUIS

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Bellcomm, Incorporated
Washington, D. C.

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955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

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SUBJECT: Trip Report - Discussion of Integral Launch Vehicle/Spacecraft Studies at McDonnell Douglas, St. Louis - Case 103

DATE: November 25, 1968

FROM: D. E. Cassidy

ABSTRACT

A trip was made to McDonnell Douglas Astronautics Division (St. Louis) to discuss the work they are doing on reusable spacecraft and integral launch vehicle systems. The areas of discussion were mostly related to the stage and one half launch vehicle concept and included launch and mission operations, on-board checkout, reusability and expendable tip tanks.

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MEMORANDUM FOR FILE

On November 12, 1968, H. S. London, D. Macchia, A. S. Kiersarsky, and D. E. Cassidy had personal discussions with representatives of the McDonnell Douglas Astronautics Division (St. Louis). McDonnell representatives were R. Quest, S. L. Hislop and D. Sturgess. The subject was low cost round trip transportation to earth orbit and the work they are doing on the stage and one-half concept (SOH).

Introduction

McDonnell has been performing design and system studies of stage and one-half to orbit vehicles (SOH).* The SOH concept is directed toward low cost round trip transportation to earth orbit, where cost reduction is achieved through maximizing the system reusables and minimizing expendables. The concept is to use an integrated reusable core vehicle and low cost expendable strap-on tip tanks. The core vehicle would contain all the expensive subsystems including; electronics, G & N, control, ECS, power and engines. The tip tanks would contain most of the ascent propellant and a minimum number of non-tank elements; for example, the pressurization and fuel transfer plumbing, and attachment fittings.

Cost Elements

Systems cost, particularly on a recurring/reuse basis, was the major topic of discussion with the McDonnell people. In order to reduce the cost of placing payloads into earth orbit the cost of operating the launch system must be reduced. With the SOH concept in mind, some of the elements of cost that must be attacked in order to accomplish this are:

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*Lockheed, based on previous studies with the USAF Flight Dynamics Laboratory (FDL) is also pursuing this concept. RFP's from both the NASA headquarters and the FDL include this concept as one of the potential integral launch and reentry vehicle systems (ILRV).

1. the launch and mission operations;

2. the core vehicle turn-around cost, from landing to relaunch including labor and spare parts;

3. the number of times the core vehicle can be reused;

4. the number of people required to provide sufficient engineering support for the mission life; and

5. the expendable tip-tank cost.

Launch and Mission Operations

The cost of launching space vehicles and the cost of providing ground support for systems checkout, mission control, failure detection and diagnosis is to a large extent the cost of the supporting personnel. Reducing costs will require new approaches such as providing most, if not all, of these capabilities on-board the launch vehicle under crew control. Simplifying and increasing systems reliability through test and reuse also goes hand in hand with reducing these costs. The number of functions performed, particularly at the launch site including multi-discipline systems monitoring, can be reduced through high confidence in systems performance.

Just to what extent the vehicle and crew can be made autonomous will require detailed systematic evaluations of what is required to launch, conduct mission operations in orbit and return to earth. McDonnell is going to include on-board checkout of a "Big Gemini" logistics spacecraft as a company funded addition to their current NASA funded study of "Logistics Spacecraft System Evolving from Gemini". Checkout in this case will be primarily directed toward making the in-orbit spacecraft autonomous for the deorbit maneuver. In addition, they also plan to look at integrated spacecraft/launch vehicle guidance, in cooperation with Martin Marietta Corp. On board launch vehicle checkout would then be a logical extension of an avionics system that could perform the previous two functions; Martin may also look at this if time permits.

Reusability

The major cost of a manned launch system is the cost of the spacecraft which returns the man to earth. Turn-around cost of the SOH core vehicle will have very significant effects on how cheaply the logistics mission can be conducted. There are wide

differences of opinion, however, as to just what these costs might be. They vary from a concept of aircraft type operations to a concept of tear-in and tear-out where complete systems analyses are conducted, similar to present acceptance testing, and the heat protection system is replaced.

The extent of systems checkout (particularly the electronics) after landing will be very closely tied to the methods of systems checkout prior to launch, while in-orbit, and during de-orbit. One might postulate an on-board checkout system which would provide all the information necessary to identify system problems (coupled with crew observations and judgements) and permit the ground crew to run-up and repair, as necessary, only the malfunctioning components.

The airframe (heat protection system and structure) is also a major cost item. The ideal airframe would require no post landing analysis or repair except for visual inspection and occasional panel or rivit replacements.

The heat protection system for this kind of operation would probably have to be reradiative utilizing graphite on the leading edges, coated refractory metals on the underside areas receiving the highest heating rates, and super alloys on lower temperature regions. The upper body could get away with titanium shingles. McDonnell believes such an airframe could be used 20 times; however, there is uncertainty as to what the cost of inspection and refurbishment would be. They are presently using a figure of about 10% of initial airframe cost, per flight.

An ablative system would be less sensitive to the entry environment (for example, atmospheric variations, and the necessity at times of obtaining additional lateral range). Ablative systems would, however, require replacement of the ablator after each flight.

Expendable Tip Tanks

The cost of expending the tip tanks can represent a significant percent of the overall operational cost particularly as the cost of launch operations and core vehicle turn-around is reduced. One of the major questions is whether large LOX-LH_2 tanks can be fabricated at substantially lower cost than at the present time. They emphasized that the primary factors in tank costs are the production rate and the complexity of fabrication. McDonnell thinks (based on statistical data influenced by SIVB fabrication) that $50/pound (dry weight) could be achieved on a long production run

basis. This is in some contrast with the $22/pound Lockheed believes is possible. We also discussed the cost of the F4 aircraft tip tanks with McDonnell, which might or might not have application in costing analogy. At any rate, the initial units cost was on the order of $150/# which, after about 8000 tanks, are now bought for less than $10/#. On the other hand, the Thor launch vehicle tanks are bought for $40/# and the SIVB tanks which initially cost $400/# are now about 150 to 200 $/#.

To what extent cryogenic tanks are different and expensive will require more detailed analysis to identify possible reductions in fabrication, testing and inspection costs.

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