REQUIREMENTS FOR SPACE SHUTTLE SYSTEMS

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This paper, "Requirements for Space Shuttle Systems," is the introductory paper for the session on Space Shuttle Cryogenic Technology Review. The purpose of this session is three-fold: (1) to identify the technology disciplines required in the area of Shuttle cryogen systems, (2) to identify deficiencies which exist and to discuss current programs and identify new programs which eliminate the deficiencies. In addition to providing management with a rapid and thorough technology assessment, the session will hopefully acoomplish significant data exchange between the various research and development government and contractor organizations. Although the time for preparation has been short, the papers to follow attempt to assess technology on a national basis contrasted to technology existing within a specific government installation or contractor facility. Participating in this review are Marshall Space Flight Center, Lewis Research Center and three contractors involved in the Phase B Shuttle definition studies: (1) General Dynamics, Convair Division, (2) North American Rockwell/Space Division, and (3) McDonnell Douglas Corporation. Each participant has many years experience in cryogenics as related to space vehicles.

This introductory paper attempts to accomplish three factors: (1) to identify for the Space Shuttle vehicle the systems utilizing cryogens, (2) to identify the technology disciplines which must be addressed by the designer and which will be addressed to this technology session, and (3) to identify the specific Shuttle requirements which appear to most adversely affect the design of cryogen systems.

CRYOGEN APPLICATIONS

Cryogens are required on the Space Shuttle for propulsion and power purposes, for environmental control and for logistics. Requirements are for both H_2 and O_2 for propulsion and power, O_2 and N_2 for environmental control and H_2 and perhaps others, for logistics. Neither the individual cryogen quantities nor the total quantities are well defined, however, the total quantity is very large, comparable to the Saturn V quantity.

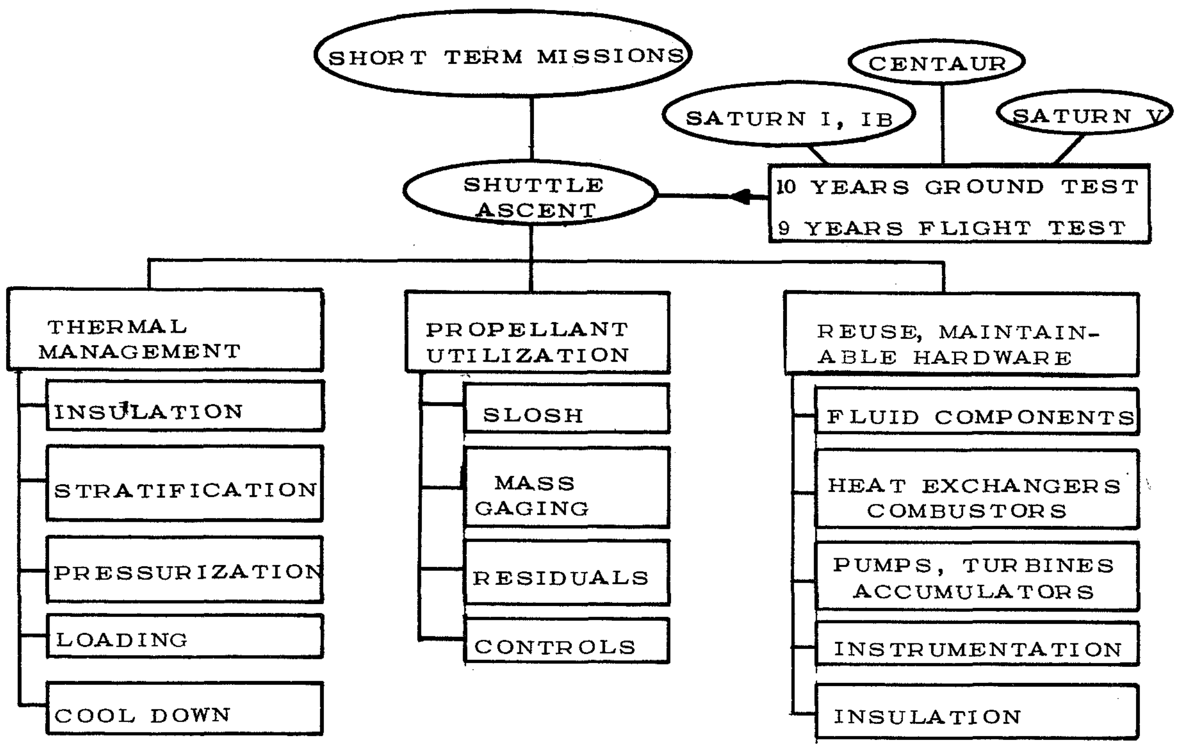
SUBSYSTEM	BOOSTER	ORBITER
* ASCENT PROPULSION	X	X
ATTITUDE PROPULSION	X	X
* ON-ORBIT PROPULSION		X
AUXILIARY POWER UNIT	X	X
JET ENGINES	X	X
* ENVIRONMENTAL CONTROL	X	X
LOGISTICS		PAYLOAD

* PRE SHUTTLE PROGRAMS

CRYOGEN TECHNOLOGY DISCIPLINES

Mission duration is a significant "driver" relative to the cryogen technology discipline to be encountered. The mission duration and mission profile selected for the Space Shuttle allow for grouping of technology according to short term missions, representative of the booster and orbiter ascent phase of flight (FIG 3), and medium term missions, representative of the orbiter during orbit flight (FIG 4). The technology disciplines identified with the two distinctive flight phases are shown on the respective figures. On both figures the technologies are grouped according to system definition, performance type task (thermal management and propellant utilization) and the mechanical design and supply aspects of specific hardware items (reuse maintainable hardware). For simplicity of presentation, the wording on the two figures is concise and each task implies a multitude of related or closely associated tasks. For example, the identified technology discipline "Fluid Components" includes such items as valving, seals, ducting, expansion joints, regulators, etc., while the term "pressurization" implies a multitude of technical information associated with establishing gas requirements, control dynamics, heat exchanger sizing and selection, etc. The broadness of the cryogen technology area becomes immediately obvious with the realization that each technology discipline depicted can exist for each of the cryogen applications shown on Figure 2. In spite of this broad area, the most important aspects in cryogen technology related to the Shuttle will be addressed in the subsequent papers.

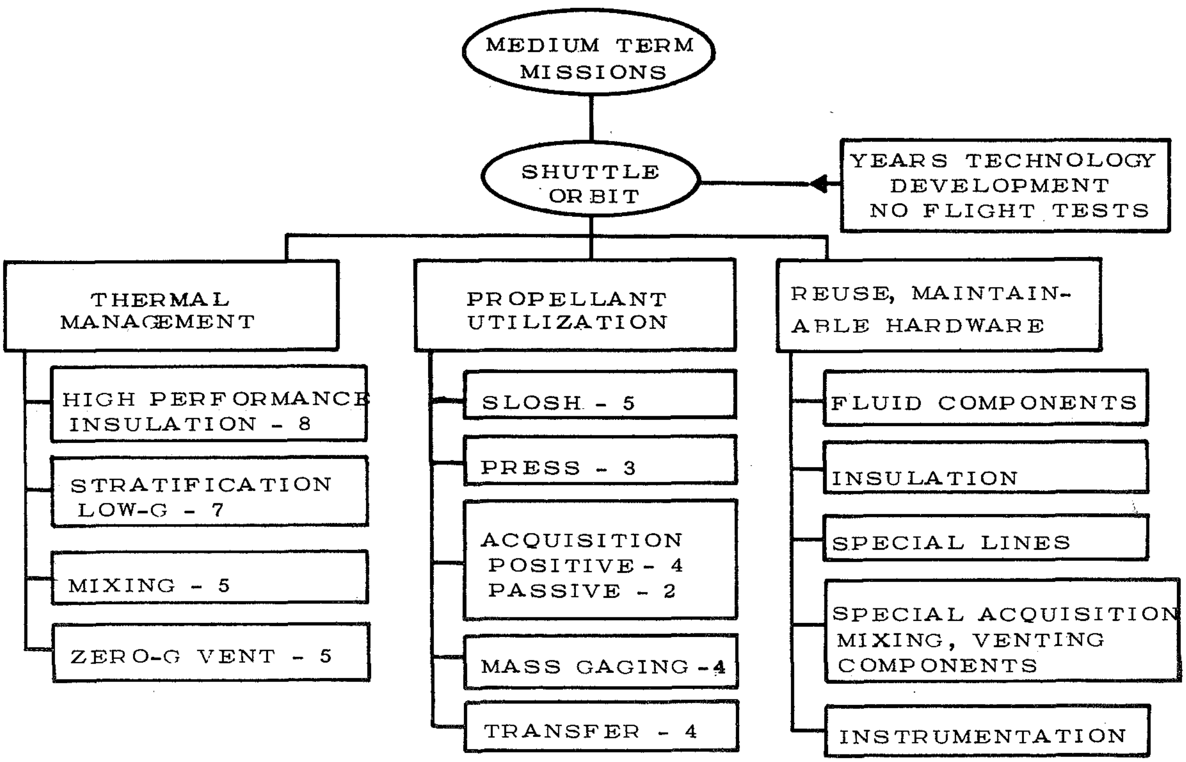
For the so-called short term missions on the Shuttle, a tremendous amount of technology has been accumulated during the Saturn program. The appropriateness and applicability of this technology and complementary technology from research programs conducted over a number of years for application to Shuttle will be reviewed from a systems design aspect in the second paper of this session, and from the hardware aspect in the fifth paper. The more critical technology availability areas will be identified and addressed separately.



CRYOGEN TECHNOLOGY DISCIPLINES

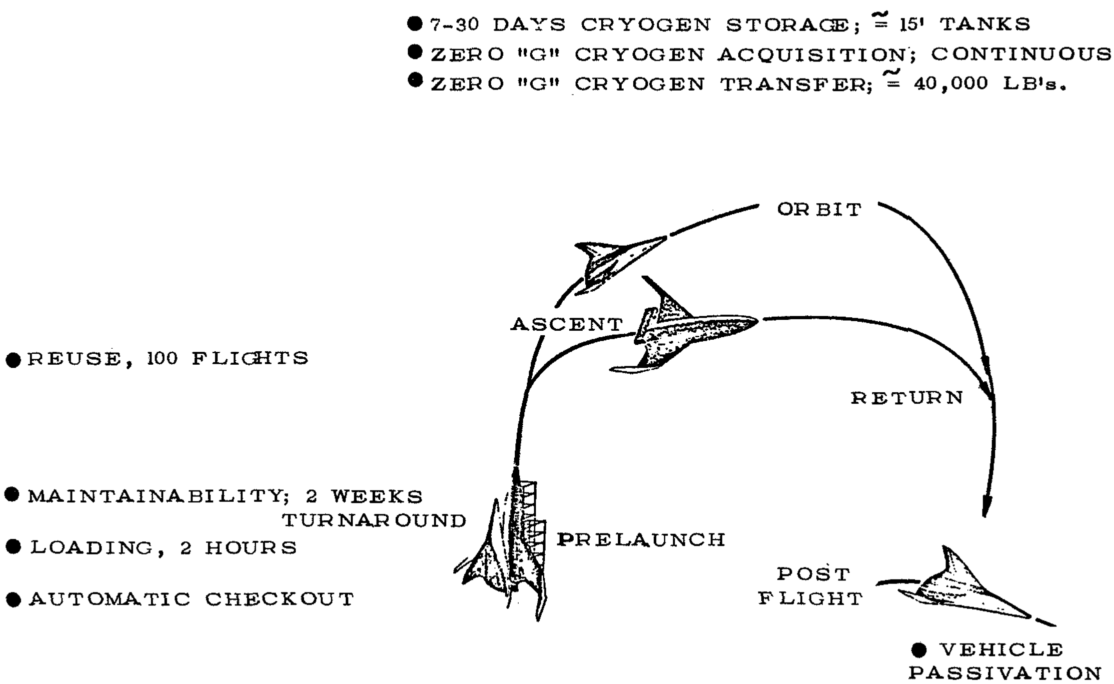
Technology disciplines peculiar to the orbital flight phase of the Shuttle are shown on Figure 4. These are in addition to or are special cases of those specified for ascent, Figure 3. For example, stratification, appearing under the category of thermal management occurs during ascent flight as well as during orbital flight, however, the technology needs are distinctly different. Also, the additional orbital requirement on "Fluid Components," relative to Figure 3, includes factors such as lower allowable thermal and fluid leakage, disconnects for propellant transfer in orbit, more rigid thermal environment, etc. Similar factors account for other terms which are used on both Figures 3 and 4.

Technology programs have been in progress for a number of years in many of the required areas and the approximate number of years devoted to each area is shown in each technology block.



SPECIFIC SHUTTLE REQUIREMENTS

The Shuttle requirements having a major impact on Shuttle cryogen systems are depicted here. The impacts on cryogen systems attributed to each indicated requirement are by no means equal. The most severe requirement appears at this time to be reuse, cryogen acquisition in a zero "g" environment, and cryogen transfer associated with the Shuttle logistics role.



SHUTTLE FLIGHTS FOR PROPELLANT MAKEUP VERSUS TRANSFER EFFICIENCY

The cryogen technology discipline will be a "major driver" to vehicle configuration, vehicle design and mission planning. One simple illustration as to the importance of the technology disciplines is the requirement for 20 extra flights per year if as a H_2 logistics vehicle the propellant transfer efficiency is 75 percent contrasted to 90 percent and the quantity of propellant to be delivered each year is 3 million pounds.