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DEFINITION OF SPACE SHUTTLE PROGRAM PLAN, STUDY

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STUDY PLAN

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STUDY PLAN

DEFINITION OF SPACE SHUTTLE PROGRAM

1.0 INTRODUCTION - As the result of the Space Shuttle Phase B definition studies of a reusable Space Shuttle System, several promising concepts have been identified for further study. This Study Plan defines an extension of contract effort to define the Mark I/Mark II Orbiter, the pressure fed series burn Ballistic Recoverable Booster, the parallel burn Ballistic Recoverable Booster modules, the backup parallel burn solid rocket motors, and the LOX/RP Flyback Booster.

1.1 OBJECTIVES - The primary objective of this study extension is to develop the preliminary definition of an economical Space Shuttle Program in which the evolution to full operational capability is achieved through phased subsystem development. To achieve this objective, the study extension activities will emphasize the following:

a. Definition of system and subsystem configurations including facilities requirements and operational approaches.

b. Definition of a phased evolution from a Mark I to a Mark II Orbiter configuration.

c. Achievement of a further understanding of the design, test, cost, and schedule requirements of the candidate systems.

d. Definition of candidate Booster designs and programs to facilitate selection.

e. Definition of the program, system, and vehicle requirements to support the next phase of the Program.

1.2 GUIDELINES - The Study Control Document Draft dated October 20, 1971, provided by NASA will be used for this study effort. Any additions to the Mark I system exceptions delineated in Paragraph 1.2.14, that are identified as a result of this study effort, will be recommended to the NASA.

The Statement of Work Draft entitled, "Definition of Space Shuttle Program", dated October 20, 1971, provided by the NASA will be used as a general guide for this study effort. However, as indicated in this Study Plan, the first two months of the study effort will place emphasis on the issues related to selection of a single Orbiter/Booster baseline configuration. Thereafter, the study effort will place emphasis on the in-depth definition of the single Orbiter/Booster configuration selected by the NASA. Therefore, the study effort will adhere more closely to the Contractor Tasks in the Draft Statement of Work after NASA selection of the single Orbiter/Booster configuration.

1.3 STUDY APPROACH

1.3.1 Study Logic - The study logic is depicted on Page 1-5 "Definition of the Space Shuttle Program - Study Logic". During the first two months Mark I/Mark II Orbiter Definition (including trade-off of those issues directly influenced by booster selection) is studied in parallel with the major booster options defined below. It is expected that these parallel paths will converge at the end of the first two months as a result of NASA selecting a single space shuttle system to permit the remaining effort to be concentrated on in-depth definition of the selected system.

Systems Integration trade studies and requirements analysis as well as costing and scheduling activities will continue throughout the study to ensure adequate integration of all parallel activities.

Key meeting and documentation milestones are indicated on this logic chart enabling it to also serve as a master schedule for the study.

1.3.2 Structure of the Study - Grumman/Boeing will with NASA guidance and direction, perform a design study of the selected shuttle system concepts. This effort will be a continuation and further refinement of the systems concepts resulting from the previous Alternate Space Shuttle Concepts (ASSC) extension study.

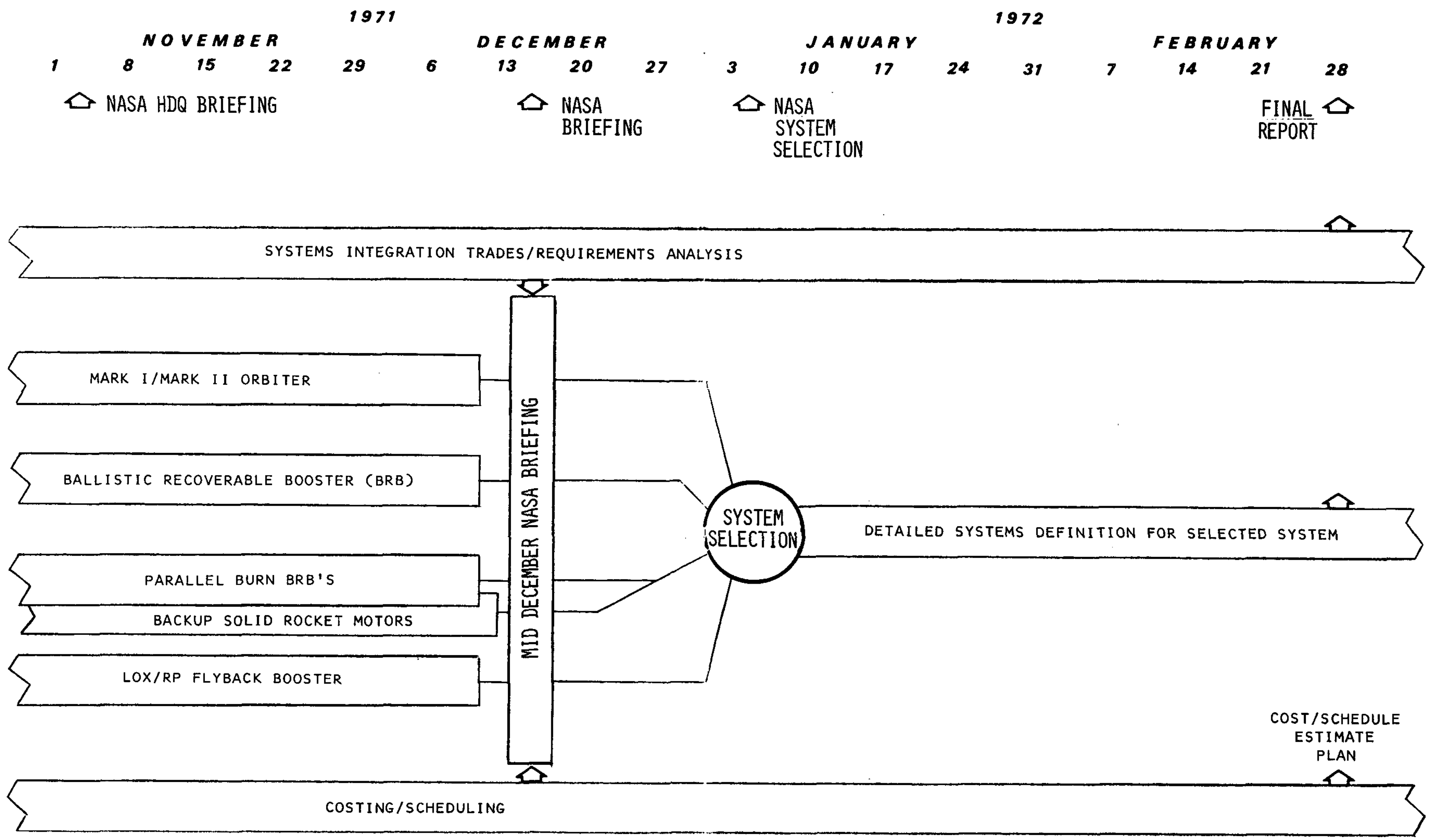
The major study activity will be to define the shuttle systems consisting of the Mark I/Mark II Orbiter with either of the two boosters (including parallel BRB) on a parallel basis. Upon system selection by the NASA, work will be discontinued on all but a single system design to enable concentration of the remaining effort on the preferred design.

The study program will be accomplished through the following activities:

a. Mark I/Mark II Orbiter - Conduct a preliminary design definition study, including development of costs and schedules for an external Hydrogen/Oxygen tank orbiter. The MSC 040A concept will be used as a starting point for orbiter definition. The following orbiter/main engine combinations will be included in the definition study:

   - o Mark I/Mark II J2S
   - o Mark I/Mark II J2S-HiPc
   - o Mark I/Mark II HiPc

   Major discriminators which influence booster selection will be identified. The Mark I orbiter will, where possible, use existing technology and sub-systems and will evolve to Mark II through introduction of new technology and subsystems.



DEFINITION OF
SPACE SHUTTLE PROGRAM

STUDY LOGIC

b. Pressure fed series burn Ballistic Recoverable Booster - Continue preliminary definition, including development of costs and schedules for the series burn BRB including consideration of descent, water entry survival and re-furbishment for re-use.

c. Parallel burn Ballistic Recoverable Booster Modules - Continue preliminary definition and trade studies of the parallel burn (from launch) Ballistic Recoverable Booster Modules with particular emphasis on the launch, ascent and separation phases of the mission.

d. Backup Solid Rocket Motors - Conduct preliminary definition and trade studies of 156" and/or 120" Solid Rocket Motors as a backup to the parallel burn Ballistic Recoverable/ Booster module program. Because this is, by definition, a backup to the parallel BRB the orbiter/booster inter-face will remain as close as possible to that required for the parallel BRB.

e. LOX/RP Flyback Booster - Continue preliminary definition study including re-assessment of costs and schedules.

The above activities shall include:

a. Requirements definition - to consolidate and verify requirements and desired system and subsystem characteristics.

b. Implementation definition - to accomplish preliminary definition of the selected shuttle system and associated costs and schedules.

1.3.3 Boeing-Lockheed Interface - Grumman/Boeing will assemble booster system informal data packages on the LOX/RP and Ballistic Recoverable Boosters for use in the LMSC Space Shuttle Program definition study. These data packages, assembled in detail as practicable within the limitations of budget assigned to this task, will contain information pertinent to system integration/orbiter synthesis and analysis such as the following:

a. Data prepared in accordance with S.O.W. paragraph 4.2.1 which are needed for needed for compliance with S.O.W. paragraph 4.1.1.

b. Preliminary design drawings and mass properties to describe the baseline booster configurations, interfaces with the orbiter, and interfaces with launch facilities, and major GSE.

1.3.3 (continued)

c. Mission profile, trajectory, aerodynamic heating (in relation to affects on the orbiter), performance, abort, and staging condition constraints (altitude, velocity, and GAMMA) as influenced by booster entry loads and temperatures.

d. Interface structure design loads, flight control characteristics, separation characteristics, and acoustic and vibration environments.

e. Booster avionics requirements, interfaces.

f. Baseline booster data in the areas of flight and ground operations, logistics, turnaround, safety, reliability, costs, funding rate, and schedule data.

g. Booster weight and cost scaling relationships as influenced by propellant load, staging velocity, flow, thrust, dynamic pressure, and launch azimuth.

The data packages, updated to the latest designs, will be transmitted to LMSC in a timely manner for appropriate use in implementing their studies and preparation of their data deliveries to NASA.

2.0 ORGANIZATION

2.1 OVERALL SCOPE - Grumman, as prime contractor with full responsibility for management of the study effort, will integrate the activities of our major associate, The Boeing Company, and the other sub-contractors. The Grumman Program Director's Office performs the following functions:

- o Serves as the focal point for NASA contacts
- o Directs progress toward achieving the study objectives
- o Provides complete control of all program aspects - technical and business
- o Provides direction of all Grumman shuttle activities and sub-contracts to ensure compatibility and consistency with the study objectives

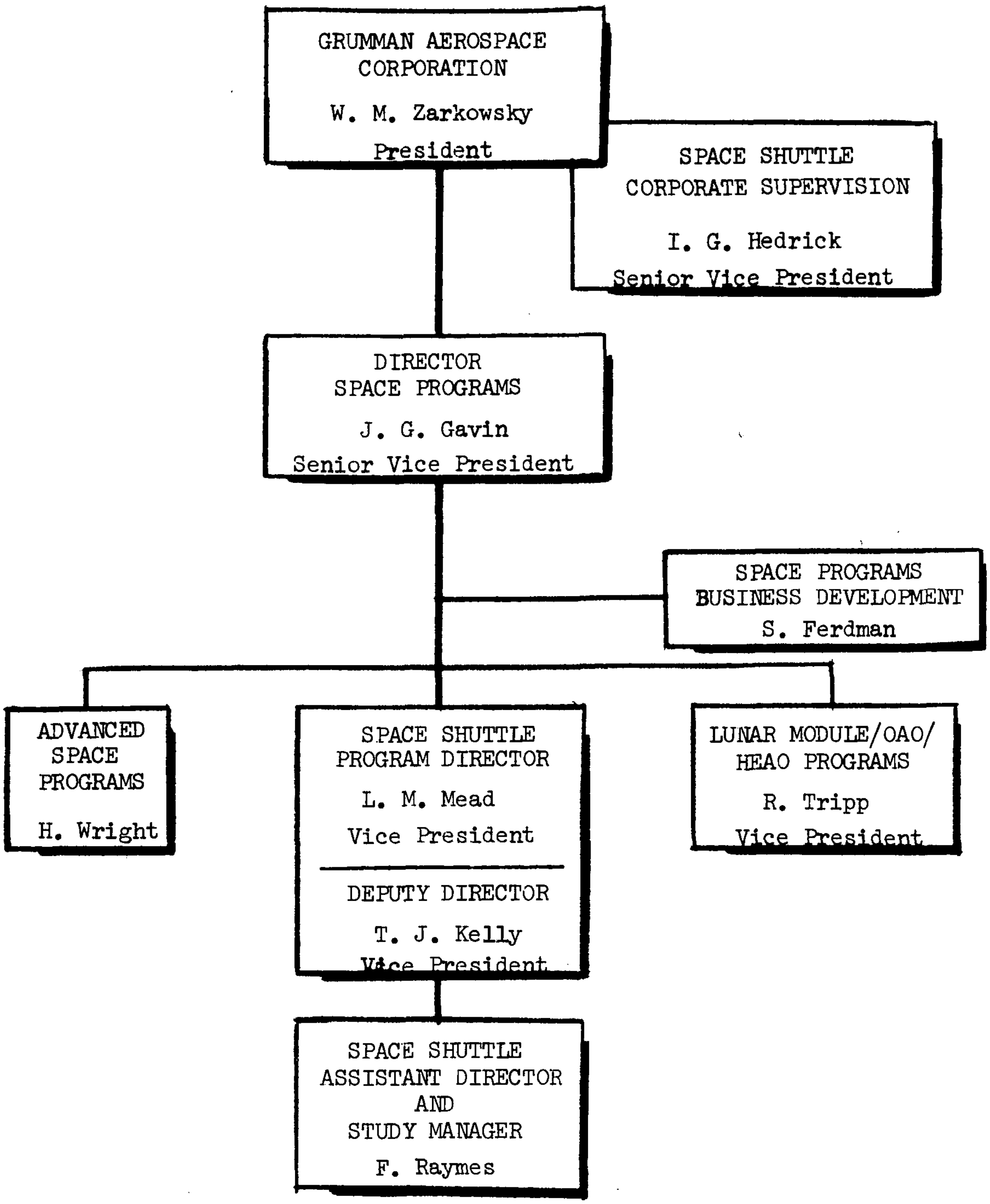
Grumman's Space Shuttle activities report to the President, W. M. Zarkowsky through Senior Vice President J. G. Gavin, Director of Space Programs. Grant Hedrick, Senior Vice President, has been appointed to assist the President on Shuttle technical policy. Mr. Hedrick is Director of Technical Operations and as such commands the entire technical resources of the Company. These relationships are described on page 2-3.

Boeing, as associate to Grumman, provides pertinent past experience, resources and exceptional technical capability. This effort will be conducted within the Boeing Aerospace Group. O. C. Boileau, Vice President, has assigned responsibility for Boeing's Shuttle Program activities as described on page 2-4.

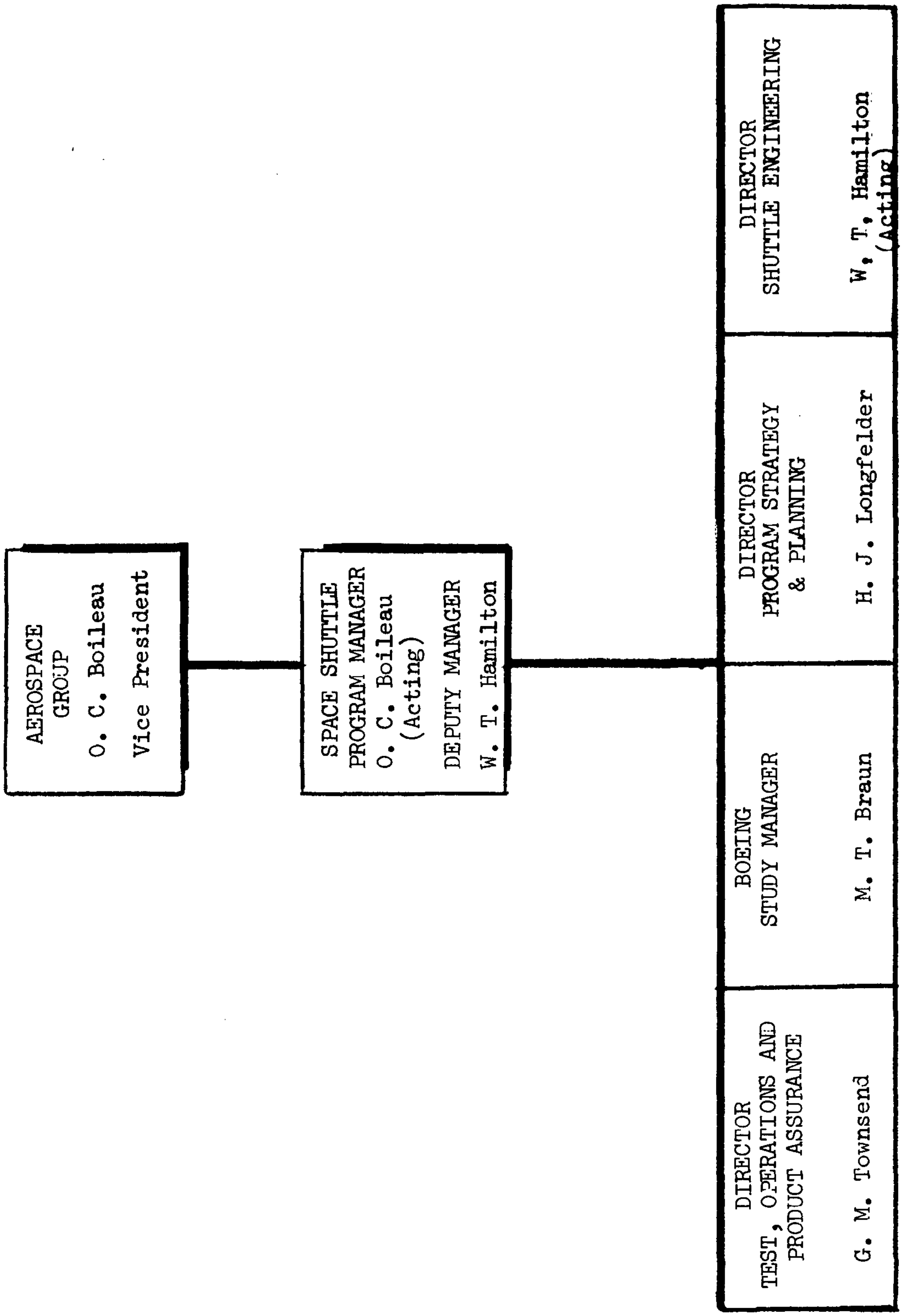
2.2 SHUTTLE PROGRAM ORGANIZATION - Providing complete continuity with our ASSC study, Vice President Larry Mead is Program Director and Vice President Tom Kelly is Deputy Director. This corporate commitment to the Space Shuttle Study is further reflected in a high degree of management and technical expertise assigned throughout the program. Fred Raymes is the Assistant Director assigned as the full time Study Manager and Max Braun of Boeing continues as full time Deputy Study Manager (Page 2-5). Systems Integration is under the leadership of Arnold Whitaker and Project Managers R. Carbee, H. Sherman, G. Smith and R. Waldt report to the Study Manager.

The Functional Disciplines provide the resources to conduct the various technical elements of the study effort. The conceptual designs, performance analyses, technical tradeoffs, etc. are done by Engineering. The Manufacturing, Operations and Test functions are performed for all baseline and alternate program concepts. All parametric and detailed costing, and technical and cost comparisons are performed by Program Analysis. These functions are headed by Grumman and Boeing managers as shown, to provide the balance required for optimum system definition.

Key technical and business staff support to the Study Manager is provided as shown on page 2-5.

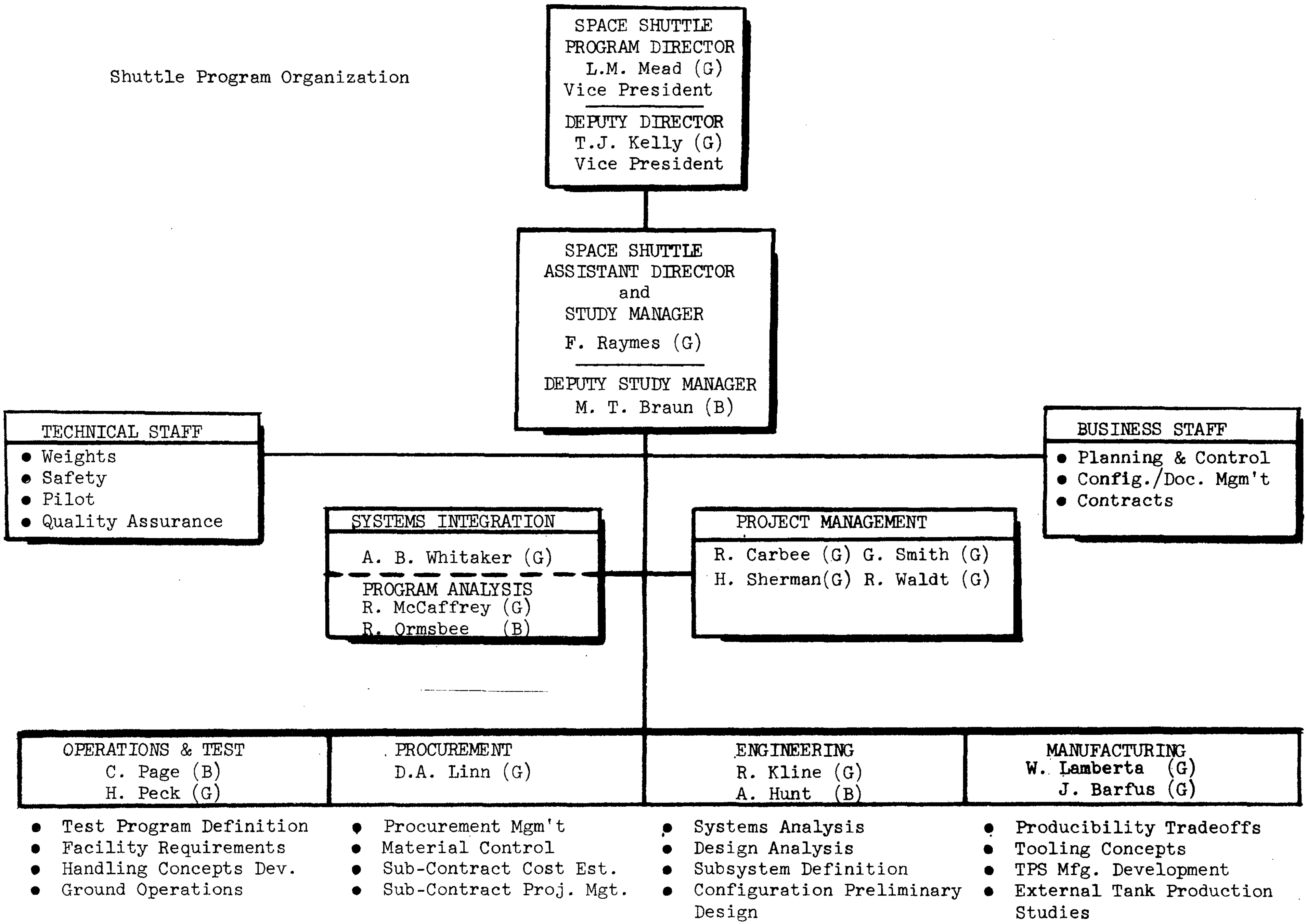


Grumman Space Shuttle Program/Corporate Relationship



Boeing Space Shuttle Program/Corporate Relationship

Shuttle Program Organization



(G) Grumman (B) Boeing

3.0 WORK BREAKDOWN STRUCTURE (WBS) - The Work Breakdown Structure provides a baseline for planning and control for the Definition of the Space Shuttle Program. It is the common framework required for integrated planning and control of costs and schedules. Through subdivisions of the total program effort, the WBS provides a basis for establishing budgets and schedules, for evaluating performance, and for identifying responsibilities.

As shown on page 3-2 the total program (Level 1) is divided into six study areas at Level 2:

- Integration
- Mark I/Mark II Orbiter Definition
- Booster Definition
- Operations and Test
- Program Management
- LMSC Interface

DEFINITION OF SPACE SHUTTLE PROGRAM

WORK BREAKDOWN STRUCTURE

LEVEL 1	LEVEL 2	LEVEL 3
Space Shuttle	Integration	Systems Requirements Systems Analysis Systems Test Commonality Product Assurance Resources and Cost Analysis
	Mark I/Mark II Orbiter Definition	Orbiter HO Tank Subsytems
	Booster Definition	Ballistic Recoverable (Series) Ballistic Recoverable (parallel) and SRM backup LOX/RP Flyback Test Program
	Operations & Test	Ground Operations Analysis Maintainability Test
	Program Management	Program Management
	LMSC Interface	LMSC Interface

4.0 TASK DESCRIPTIONS - The ongoing study activities described in Section 1.3 require the continued support of all disciplines to achieve the desired level of Space Shuttle system definition.

Additionally, in accordance with NASA's request, those tasks which require special emphasis during this study extension to aid in system selection and definition are described in this section.

The table, titled KEY TASK INDEX, on the following page is a condensed summary of those special emphasis tasks which are described further in the pages following the table.

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I. SYSTEM INTEGRATION

System Integration covers those total system-level and inter-element activities which are needed to assure that the Space Shuttle System meets program and system (including mission) requirements. Within this context, Grumman plans to support NASA/MSC in coordinating and integrating the Orbiter, Booster, Main Engine and Operations elements of the system. General tasks that will be conducted for the subject contract include:

A. SYSTEM REQUIREMENTS - Additional definition of system requirements and their allocation among the elements.

B. SYSTEM ANALYSIS -

- Flight system analyses for the ascent (mated configurations), during separation and for abort conditions.
- Trade studies to optimize system performance for the candidate Orbiter/Booster configurations.

C. SYSTEM TEST - Evaluation of system test requirements for consistency and completeness.

D. COMMONALITY - Definition of common usage for the Orbiter/Booster flight hardware, software and the ground system.

E. PRODUCT ASSURANCE - Identify and track critical product assurance problems in the reliability, safety and quality assurance disciplines.

Specific tasks follow:

A. SYSTEM REQUIREMENTS

1. Establish mission profiles and perform functional analysis to further define system requirements and their allocation among the baseline Orbiter/Booster configuration(s) and the main engine.

2. Perform ascent (mated configuration) and separation trajectory analysis to further define system requirements.

3. Perform re-entry trajectory analysis for minimum Mark II structural/TPS weight.

4. Establish control requirements during ascent (mated configuration) and separation.

5. Abort requirements shall be investigated for abort modes of the Space Shuttle System. The abort regimes will be derived and applicable abort techniques will be established. Limitations or constraints on mission abort capability will be clearly identified. The regimes will include: return to launch site and downrange (CONUS) sites and aborts due to partial loss of Booster power where Orbiter separation occurs at Booster propellant depletion.

6. Recommend updates of the NASA-furnished Study Control Document (draft dated 20 October 1971) to maintain consistency with the selected system configuration (such as dynamic pressure, and acceleration limits, etc.)

B. SYSTEM ANALYSIS

1. Perform Orbiter/Booster performance trade study to establish a single orbiter configuration that is suitable for all booster configurations. If this is not feasible, identify the major orbiter design characteristics that are unique to the BRB, parallel BRB, SRM backup and LOX/RP flyback booster options.

2. Conduct trajectory and control system analyses to verify that selected Orbiter/Booster configuration meets program and system (including mission) requirements.

3. Evaluate candidate Orbiter/Booster separation techniques. Consider both nominal mission and abort staging. Include use of TVC, RCS or aero surface control systems, or some blended combination. Include the effect of separation device operation on resulting Orbiter/Booster staging performance.

4. Booster/Orbiter Separation

   a) The NPSH requirements for the J2S engine turbopump will be established dependent upn LOX tank location (orbiter) and vehicle attitude at separation.

   b) The effect of late J2-S start up (Low NPSH) on performance will be analyzed.

C. SYSTEM TEST

1. Define the mated configuration modal vibration survey requirements and approach.

2. Define the integrated (system-level) test program and facility requirements and approach.

D. COMMONALITY

1. Establish potential Orbiter/Booster commonality candidates.

2. Prepare a list of potential common-usage GSE for Orbiter and Booster.

E. PRODUCT ASSURANCE

1. Establish system reliability models including reliability apportionment between Orbiter and Booster.

2. Evaluate each Orbiter/Booster configuration concept for impact on operational safety requirements and constraints.

3. Identify safety-critical Orbiter/Booster interfaces for candidate system configurations.

II. MARK I/MARK II ORBITER

A. ORBITER

1. Structural Dynamics

a. Parallel BRB Acoustical Environment Due to Parallel Burn

b. Vehicle Tank and Interstage Stiffness

(1) Development of dynamic stick models and influence coefficients.

(2) Evaluate structural impact of tank separation dynamics.

(3) Perform Orbiter point design loads analyses.

2. Aerodynamics/Flight Dynamics

a. Support aerodynamic configuration development of Orbiter, including vehicle balance determination.

b. Establish Orbiter control requirements during entry and on-orbit flight phases.

c. Evaluate entry flight trajectories.

d. Determine heating and contamination protection required for crew compartment windshields.

e. Determine ascent structural modes and frequencies.

3. Thermo

a. Perform system thermodynamic analyses to establish plume heating effects and tank insulation requirements.

b. Perform aeroheating analyses of Orbiter and HO tank.

4. Structural and Weight Definition (Lift-Off/landed)

a. Prepare a point design structural arrangement, perform a stress analysis and size the structure for Orbiter.

b. Assess the structural design implication of the Orbiter landing gear.

c. Establish structural designs for payload handling and docking requirements.

d. Assess the impact of hydraulic systems, ABPS deployment, door mechanisms and explosive devices on structural system design.

e. Determine total configuration mass properties and publish monthly Mass Properties Reports.

f. Perform a trade study of internal versus external vehicle LO_2 lines.

g. Perform trade studies of SS versus aluminum lines, liquid versus SRM de-orbit system and ball joint versus flex joint designs.

h. Finalize tankage selection.

i. Continue tradeoff of existing versus new design hardware.

j. Perform payload integration analyses.

k. Develop loads for non air load conditions.

l. Continue Mark I/Mark II orbiter configuration development and structural optimization.

5. <u>TPS Design & Mark I/Mark II Phasing</u>

a. Perform aeroheating analyses of orbiter and HO tank to establish TPS requirements.

b. Perform system thermodynamics analyses of base heating, payload environment, and to support subsystem design.

c. Define thermal environment and establish requirements for thermal protection or control of OMS modules.

d. Define thermal environment and establish requirements for thermal protection or control of RCS modules.

e. Conduct applications studies to assess the operation impact of removing and replacing bonded-on ablators.

f. Evaluate alternative non-destructive evaluation (NDE) methods to determine the integrity of the bond lines between (a) ablative TPS materials and the aluminum substrate in Mark I and (b) non-metallic E.I. material and the aluminum substrate in Mark II.

g. Continue Mark I/Mark II ablative TPS materials identification including unit weights, temperature gradients, thermal stresses, and substructure trades.

6. Aborts (Orbiter)

a. Provide inputs to the Systems Integration abort analyses to aid in abort mode definition.

b. Determine penalty/requirement due to orbiter gimbal angle constraints.

c. Evaluate effects due to retro burn on orbiter heating, stability, and gimbal angle requirements.

d. Define drop tank separation environment and ground impact as a function of launch azimuth, launch site, and time of abort.

e. Update orbiter thermal model consistent with abort re-entry modes.

7. Main Engine Selection and Substitution

a. Evaluate the implications of selecting J2S/SSME vs. J2S vs. SSME for Mark I/Mark II Orbiter.

b. Define the orbiter modifications, weight scars and delta qualifications associated with substitution of Mark II for Mark I main engine configuration.

8. Wind Tunnel Tests

a. Mated Configuration

See Appendix (1)

b. Orbiter Configuration

See Appendix (I)

B. ORBITER HO TANK DEFINITION

1. HO Tank Design and Size

a. Optimize tank pressures and line sizes for selected tank configurations and Orbiter/Booster line separation sequence.

b. Determine propellant allotment, required tank sizes, and pressurization system requirements for selected tank configurations.

c. Determine effects of staging velocity variations on HO tanks, core vehicle T/W, main engine selection, and structural sizing.

d. Perform aeroheating analyses of orbiter and HO tank to establish TPS requirements.

e. Evaluate structural implication of tank separation dynamics.

f. Perform HO tank interstage design.

g. Establish HO tank sizing and design studies including effects of O/F, I_{sp}, dome configurations, interference aerodynamics, POGO, and line routing.

h. Establish proof pressure test logic and evaluate the implications of tank proof acceptance testing on tank safety margins, weight, vehicle performance and program cost.

i. Evaluate the applicability of SATURN tooling, equipment and facilities to the manufacture of the HO tank.

C. SUBSYSTEM DEFINITION

1. Task Summary

a. Establish Mark I/Mark II subsystem performance requirements for the alternate configurations.

b. Generate preliminary Mark I/Mark II subsystem definition including description, performance, weights, volumes, safety, major interface, installation and logistic support requirements for the selected configuration.

2. Task Approach

The subsystem definition effort will utilize existing Phase B and ASSC subsystem definitions and results of existing trade studies as starting points. The subsystem definition effort will identify the necessary modifications to the basic ASSCS subsystems and the incremental changes necessitated by the special requirements of phased Mark I/ Mark II development. Key issues peculiar to both the Mark I and Mark II system will be identified and evaluated. The final output of these extended studies will be descriptions, performance, weights, volume, costs, safety,

C. 2. (continued)

major interface, installation and logistic support requirements for the selected configuration. Subsystem definition will be provided for:

a. Structure

b. Thermal Protection System

c. Main Propulsion System

d. Reaction Control System (RCS)

e. Orbit Maneuvering System (OMS)

f. External (H-O) tankage system

g. Air Breathing Propulsion System

h. Electro-Mechanical

i. Landing System

j. Docking and Payload Deployment System

k. Crew and Passenger Accommodations

l. Launch System Interfaces

m. Flight Control Systems

n. Avionics

o. Environmental Control/Life Support System

p. Power

q. Separation System

r. Abort System

During the first two months of the study, subsystem definition will be limited to the level of detail required to support evaluation of the various alternate configurations. The key subsystem differences between configurations will be identified and evaluated.

For the second two months of the study, a more detailed subsystem definition will be undertaken for the selected shuttle configuration with emphasis on characteristics peculiar to the Mark I/Mark II approach as follows:

C. 2. (continued)

- o Define the extent to which aluminum will be used as vehicle structure and design the aluminum substrate to accept ablative TPS in Mark I and reusable surface insulation as TPS in Mark II.
- o Design Mark I TPS panels to achieve low refurbishment costs.
- o Design the Main Engine installation to minimize scars in phasing of J2S engines in Mark I and SSME in Mark II.
- o Perform main propulsion mixture ratio, thrust and expansion ratio studies.
- o Define recirculation schemes for J2S and SSME engines and size the required components.
- o Analyze engine start-up and shutdown transients.
- o Design feed system, pressurization and recirculation systems.
- o Design RCS and OMS modules to achieve safe handling and minimum refurbishment and maintenance costs.
- o Design H-O tank to accommodate Mark I/Mark II engine (mixture ratio) phasing with minimum scar and lowest cost.
- o Define orbiter avionics subsystem requirements and determine equipment configuration (interface and on-board equipment) for series and parallel BRB's and SRM's, including checkout and communications interfaces to the ground support systems.
- o Design avionics to use GSE and ground updates for vehicle checkout in Mark I, and evaluate use of on-board instrumentation, displays and computational (or data management) equipment for checkout in Mark II.
- o Evaluate use of multifunction display sets, electronic attitude display indicators and multipurpose keyboards.
- o Establish computer sizing and software requirements determined by system design for phased development.
- o Establish functional requirements for control electronics.

C. 2. (continued)

- o Define FCS failure detection.
- o Define RCS jet logic.
- o Trade-off naviation landing aids (microwave scanning beam, precision ranging, ILS, Radar).
- o Define vehicle antenna locations, avionics equipment packaging and vehicle locations.
- o Establish impact of low cost avionics on measurement list, telemetry and collection formats, functional and electrical interfaces, displays and controls and antennas.
- o Establish instrumentation and control and display interfaces to non-avionics subsystems.
- o Establish Development Flight Instrumentation (DFI) measurement requirements and design a DFI system to meet those requirements, following a series of integrated vs. dedicated DFI system weight/cost trades.
- o Analyze subsystem requirements to determine electrical power requirements for the fuel cell system and the hydraulic power system.
- o Optimize the power distribution system including solid-stage management.
- o Perform a trade study of a hydrazine versus a H_2/O_2 auxiliary power unit.
- o Design a cooling system compatible with the baseline low cost avionics equipment (air cooled).

The output of this two month period will be subsystem definition including description, performance, weights, volumes, safety, major interfaces, installation and logistic support requirements. The subsystem definition will include costing and growth provisions.

D. GSE REQUIREMENTS DEFINITION

1. Prepare requirements for GSE needed for handling transporting refurbishing and maintaining the orbiter and its subsystems.

III. BOOSTER DEFINITION

The Contractor tasks during this program definition study will be conducted to provide the technical and program information necessary for NASA to make a booster system selection for the Space Shuttle. Ballistic Recoverable Booster, the parallel burn BRB with backup SRM's, and the LOX/RP flyback booster systems will be studied.

The study will give special attention to the issues that are critical to the feasibility and effective implementation of the Space Shuttle system.

The booster configuration will be aerodynamically defined and verified through analysis and wind tunnel testing.

To the configuration will be added the necessary subsystems including:

Structures
Pressurization
Propulsion
RCS
Recovery

Throughout the definition of the required subsystems consideration will be given to:

Low cost operations and minimized program cost
Developmental risk

The results of the foregoing tasks will be the substantiated recommendation of a Space Shuttle booster system.

A. REUSABLE LOX/RP FLYBACK BOOSTER DEFINITION

This booster definition task has been segmented into trade studies and key design issues which must be addressed in time for the December 15 review. The new baseline design release (979-061) will be based on the results of the previous study period (November 3 review). This will provide the basis for design, system and trade studies described below.

1. Configuration Design

   a. Integrate vehicle general arrangement and inboard profile designs. Perform delta wing, airbreather engine location, and vertical tail trade studies.

   b. Provide preliminary booster structural design.

   c. Provide input data to aero, weight and cost tasks.

   d. Assure compatibility of subsystem and structure installations.

2. Configuration Structural Analysis

   a. Determine loads for major airframe components (body, wing, etc.) for use in structural sizing.

   b. Calculate integrated launch vehicle bending frequencies and define stiffness requirements.

   c. Provide preliminary stress analysis.

   d. Develop and maintain vehicle weight statements and mass properties.

3. Thermal Analysis & Material Selection

   a. Structural temperatures and gages will be established using current analytical methods. The influence of booster plume heating and the impact of plume impingement on the nose of the booster for early J2S startup will be included.

   b. Structural materials will be selected based on reliability, temperature use tolerance, cost, performance impact, etc.

   c. Material structural characteristics developed on the X-20, SST and other programs will be used along with an assessment of manufacturing processes, tooling and shop capability to develop manufacturing cost estimates.

4. Assess Impact of Early Shutdown on F-1 Engine Reuse

   a. Conduct analyses to determine heat loads and temperature profiles on an inoperative F-1 engine vs. engine position based on S-1C base heating analytical methods and flight data.

   b. Conduct trade studies to determine insulation and/or propellant bleed requirements to maintain acceptable engine temperature limits.

   c. Coordinate with engine manufacturer to determine maintenance/refurbishment/reusability.

5. Re-entry Controllability

   Based on available wind tunnel test data static trim analysis and simulator studies will performed to: a) determine required trim and control capability as well as associated hinge moments and b) to define alternate means of longitudinal trim.

6. Directional Stability

   a. Computer analysis and simulator studies will be used to determine directional stability criteria.

   b. Analysis of available wind tunnel data will be used to determine vehicle tail arrangements that fulfill the above mentioned criteria.

   c. Drag and weight will be determined for the different concepts, the influence on performance assessed and a baseline configuration chosen.

7. Flight Control System Simulation

   a. The LOX/RP flyback booster linearized aerodynamics (979-049) and a preliminary flight control system are currently simulated. These will be updated as appropriate. Evaluations of the Apollo three-axis side arm controller and three-axis altitude indicator will be made.

   b. Handling qualities will be evaluated for the nominal flight reentry and flyback profile. The evaluations will include controllability with all SAS inoperative.

   c. The 6 DOF simulation of the booster reentry will be used to refine RCS requirements and the transition from reaction control to aero dynamic control. Updated aerodynamic data for the 979-061 booster are required.

8. LOX-RP Flyback Booster Subsystem Definition

a. The preliminary subsystem definition effort will cover the following subsystems:

1) Avionics

2) EC/LS

3) Hydraulic Power

4) Electrical Power

5) Flight Control Actuation

6) Landing Gear Actuation

7) Airbreathing Engine System

8) Main Propulsion

9) RCS and APU Subsystems

b. In addition to the general subsystem development tasks outlined above, special emphasis will be placed on the following:

1) Define RCS thruster size, performance, and location.

2) APU size and performance.

3) Propellant storage and delivery system component weight and size.

B. BALLISTIC RECOVERABLE BOOSTER DEFINITION

This definition task includes the series burn BRB and the parallel burn modules. It is planned to provide maximum visibility of high-leverage trades and design decisions in time for the Mid-December review. Second order trades are deferred as appropriate. A new baseline release based on results of the previous study period (reported to NASA on November 3), will provide the basis for the design, system studies, and trade studies which are described below under the following primary headings:

- o Design Development
- o Design Analysis
- o Design Trade Studies
- o System Analyses
- o Subsystem Design

1. Design Development

a. Initial Baseline Definition - This task will establish an updated baseline against which the trade options can be compared. The 979-144 booster configuration will be updated using the latest parametric optimization trade data pertaining to 1) engine chamber pressure, 2) propellant mixture ratio, 3) nozzle ratio, 4) latest stage weight data, and 5) OLOW characteristics.

b. Configuration Development - This task will update the configuration of both series and parallel BRB's for costing. The results of the various trade studies will be incorporated in the final recommendation ballistic reusable booster configuration. An inboard profile of each configuration will be provided.

c. Structures Design - This task will provide definition of each major structural component in support of 1) the baseline update and 2) trades made against the baseline. The major components to be addressed will be:

- o Nose Cone
- o Separation System
- o Destruct Ordnance
- o Tank
- o Thrust Structure
- o Heat Shield

B. 1. c. (continued)

- o Fins
- o Raceways
- o Pressurant Tanks
- o Pressurant Tank Supports

2. Design Analysis

a. Aerodynamic Analysis - This task will entail analysis of the aerodynamic characteristics of the mated vehicle configuration for launch control requirements and vehicle dynamics. Aerodynamic characteristics of the booster configuration for entry dynamic analyses, and control requirements including RCS propellant consumption will be estimated.

Aerodynamic trade studies will be accomplished to establish booster body length/diameter ratio, nose shape, fin size and dihedral for acceptable launch and entry aerodynamic compatibility.

Aerodynamic analyses will be conducted on selected recovery systems for performance and trajectory determination.

For the parallel BRB modules, aerodynamic characteristics will be estimated for the mated vehicle configuration to support launch performance analysis, and for the booster configuration to support entry trajectory analyses.

b. Loads and Dynamics - This task will include determination of loads for prelaunch, launch ascent (including POGO analysis), descent, and impact conditions. The first bending mode frequency for the orbiter-booster combination will be calculated for boost flight. Loads on the booster during the deployment of the recovery system and water impact will also be determined.

c. Allowables and Stress - This task will support design studies by continuing materials trade studies and investigations. Design allowables data and materials characteristics will be provided. Fracture toughness data for tank proof test definition and weld sizing substantiation will also be furnished, as well as structural sizing in support of the baseline configuration and major structures trades.

B. 2. d. Weights - This task will entail generation of mass property inputs to booster configuration trade studies. Parametric weight prediction equations will be updated and input for configuration sizing. A detailed weight analysis will be made on the baseline configuration and trade options using drawings, layouts, parts lists and system descriptions. Mass properties for the final vehicle, with characteristics defined by optimization trades, will also be provided.

e. Thermal Analysis - This task will include definition of time-temperature histories of selected structural elements, and heat-sink requirements for external surfaces. The selected structural elements will include:

- o Tank Walls
- o Nose Cone
- o Base Skirt
- o Fins

f. Subsystems Analyses - This task entails performance of detailed subsystem functional analyses for the series BRB propulsion and recovery systems to support the subsystem design activity (Section 5). Results will be extrapolated to the parallel BRB configuration. The propulsion analysis task will provide definition of the BRB propulsion system operation state point at significant times during the operational mission.

The recovery analysis task will provide definition of the sequencing and operating charateristics of the recovery system, from stage separation to water impact. Simplified rigid body analyses will be made of dynamics and loads during parachute deployment and de-reefing. Proper sequencing will be established by trajectory simulations of recovery system operations.

Functional flow analysis will be performed to establish sequencing functions and operational requirements.

3. <u>Design Trade Studies</u>

a. Recovery concept trade - This task will entail definition of a retro-rocket alternative deceleration system in sufficient depth to permit cost, risk, and weight comparison with the baseline parachute system. Deceleration requirements will be translated into retro-rocket size, weight, and configuration.

B. 3. a. (continued)

The retro-rocket system will be analyzed to establish the need and requirements for attitude control during transonic and subsonic descent and retro-rocket operation. Impact on the vehicle structure and weights will be determined. The preferred alternative will be selected for the baseline update.

b. Engine/thrust structure arrangement - This task entails investigation of the effect of a varying number of engines on booster performance control, cost, and arrangement of the thrust structure. Manufacturing feasibility analyses, controllability analyses, weight predictions and cost estimates will be generated to make the proper comparison and selection.

c. Single tank w/common bulkhead vs. two tanks - This task will trade the weight penalty to avoid pressure reversal on the common bulkhead against the weight required to use two separate tanks. The cost will also be evaluated since the segregated tank arrangement allows the material in the RP-1 tank to be changed to something more cost effective.

d. Tank material selection - The tank material trade is a carryover from the previous contract effort. An aluminum tank with fiberglass overwrap is being compared with an Inconel 718 tank in the areas of cost, weight, and technical risk. The study is in its final stages.

e. Propellant selection (RP-1 vs. Propane) - This task will provide a recommendation as to whether RP-1 or propane (C_3H_8) should be selected for the pressure-fed booster. A comparative evaluation of RP-1 and propane will be made on the basis of booster performance and cost.

f. Pressurization system - This task will entail generation of a preliminary design for the candidate systems for the series BRB booster system. Weight, development cost, fabrication cost, operation cost and effects on interfacing systems will be analyzed and a design will be selected.

4. System Analysis

a. Flight performance - This task is comprised of three subtasks: Design Reference Trajectories, Trajectory Optimization, and System Sensitivities.

4. a. 1. Definition of design reference trajectories - support will be provided to systems integration in the definition of an ascent reference trajectory. In addition, descent trajectories will be determined. These trajectories are required for heating/loads analysis and determination of subsytem requirements.

2. Ascent and booster descent trajectory optimization - support will be provided in the definition of optimal ascent trajectories. Optimal descent trajectories will also be determined. The end objective is the definition of trajectories resulting in minimum GLOW and/or system and operation cost.

3. System sensitivities - Point mass and system sizing computer programs will be used to relate system sensitivity (GLOW) to booster engine characteristics, tank pressures, ', and material allowables.

b. Flight dynamics and control - Detailed flight dynamics analyses will be conducted for ascent (supporting task) and entry of the BRB system. Entry results will be extrapolated to the parallel BRB configuration. Specific booster tasks are:

1. Perform a fin size trade to reduce TVC deflection requirements in design winds. (Include quasi-aeroelastic fin effects).

2. Evaluate engine-out capability and control requirements for unequal thrust of the parallel BRB modules.

3. Preliminary analysis of flight control requirements for booster re-entry using computer simulation.

4. Refinement of flight control studies to determine RCS control authority, fuel consumption, and control law design requirements.

5. Support study of the separation trajectories and dynamics of the booster and orbiter vehicles. A baseline trajectory will be defined and studies will be conducted to determine the effects of the booster shutdown and orbiter ignition sequence. Additional parametric studies will include the effects of vehicle attitude and staging dynamic pressure.

4. c. Reliability and number of reuses - Classical methods will be employed to establish BRB reliability through ascent, re-entry, descent and recovery. The rules for establishing the reliability goals will be defined. The sensitivity of water entry survival probability to varying the cost and weight of water entry provisions will be studied.

Operational stress levels and proof test stress levels will be defined that insure varying numbers of highly reliable reuse flights for the main fuel tanks and the pressurization tanks.

System life cycle costs will be determined as a function of design number of reuses to find the optimum.

Using all available material test data, fracture mechanics technology will be used in the selection of acceptable operating and proof stress levels for various number of pressure cycles. The data used in the analysis will be updated with test data as it is obtained.

Parametric sizing analyses will be used to determine booster size and weight as a function of number of reuses, based on the stress/fracture toughness results.

Monte Carlo analyses will be used to determine number of vehicles required in the operational program based on reliability and wearout (number of reuses).

Parametric cost analyses will be used to integrate the above results to obtain life cycle cost.

d. Manufacturability, tooling and facilities - This task will entail the following:

1. Support the design effort with recommendation to reduce the fabrication cost of high cost items.

2. Provide manpower estimates and determine the tooling required for each "make" item.

3. Determine facility requirements in the areas of manufacturing, test, and operations.

e. Interface definition - This task will entail definition of the principal system interfaces. Functional analyses will be used as required. Technical descriptions and data will be obtained from design, design analysis, and operations analysis tasks, and formatted as required.

B. 5. Subsystem Design - BRB/Parallel Burn BRB

a. Task Summary - Primary emphasis will be placed on propulsion and recovery systems, since they have a primary influence on the BRB system design and costs. Detailed design data developed for the BRB system will be applied to the parallel burn BRB modules where possible.

b. Task Approach - Subsystem definition will be carried out as follows:

1. Propulsion system design definition will include pressurization, propellant management, engines, and thrust vector control. Design optimization studies will be conducted on the subsystems. A detailed propulsion system design definition will be prepared to support additional weight, cost, operations, and interface studies.

2. Recovery system definition will be carried out for both the BRB and parallel BRB modules - The definition will be concerned with identification of the concepts to solve the problems of re-entry, stabilization, deceleration, orientation, water impact, vehicle righting and floatation, and location and retrieval. The definition will identify and specify the hardware required to implement the concepts selected. NASA will define and implement as GFE the system for booster retrieval and return to the launch site. However, the contractor will define the requirements for safing and protecting the vehicle during retrieval and return operations.

3. Subsystem design definition will also be carried out for:

o Avionics

1. Establish requirements, configuration and redundancy.
2. Determine cost and weight

o Electrical Power

1. Determine electrical loads and power sources.
2. Configure power distribution system.
3. Establish weight and cost

B. 5. b. 3. (continued)

- o Environmental Control System
  1. Resolve requirements for equipment cooling and purge systems.
  2. Establish a system concept and determine weight and cost.

C. SOLID ROCKET BACKUP BOOSTER DEFINITION

As a backup to the pressure fed parallel burn booster a solid rocket booster system will be defined and costed.

The solid rockets will so far as possible, be interchangeable with the pressure fed modules. Necessary modifications to the orbiter to accomodate the backup SRM's will be identified.

Booster definition will be limited in scope to 120" and 156" motor diameters. Various propellants will be evaluated. Control requirements for unequal thrust of the SRM's will be evaluated.

Configuration development will concentrate on minimizing booster costs through use of orbiter avionics, minimizing booster thrust vector control requirements and minimizing differences in structural attachments.

IV. TEST & OPERATIONS

A. DEVELOPMENT TEST PROGRAM

1. Define the overall Orbiter and Booster subsystem test program and facility requirements.

2. Define Booster and Orbiter main tankage development and qualification test programs.

   a. Identify differences between HO tank test programs with particular emphasis on larger parallel BRB

3. Define Booster and Orbiter MPS feed system development, qualification and Propulsion Test Article test programs.

   a. Identify differences betwwen BRB, parallel BRB, SRM backup and LOX/RP flyback Booster configurations.

4. Define the Booster and Orbiter structural test program.

   a. Resolve the question of static testing by parts versus a complete Structural Test Article.

5. Define the Booster/Orbiter/HO tank vibration survey test program (both mated and orbiter/tank alone configurations). Identify differences between BRB, parallel BRB, SRM backup and LOX/RP flyback Booster configurations.

6. Establish factory test and checkout requirements for Orbiter/Booster subsystem and combined systems testing.

   a. Insure configuration design is compatible with check-out capability.

   b. Evaluate the impact of test requirements/configuration design on GSE, facilities, flow logic, cost and schedules.

7. Establish flight test requirements for Orbiter and Booster systems including aero/thermodynamics, avionics, fluid and mechanical subsystems. Assess cost and schedule impact to meet those requirements.

   a. Identify Orbiter and Booster FHF vehicle flight test objectives and configurations.

   b. Identify Orbiter and Booster FMOF vehicle flight test objectives and configuration.

8. Identify the differences in Orbiter and Booster flight test planning and schedules dependent on booster configurations.

9. Incremental Flight Test Study - Investigate potential techniques for incrementally expanding the booster and orbiter flight envelope beyond the limits of the air breathing propulsion system performance capability. An analysis of several candidate methods including, but not limited to, single element suborbital vertical launches, and augmented thrust through use of the main propulsion system, will be evaluated in sufficient detail to permit intial screening in terms of,

   a. technical feasibility

   b. cost

   c. applicability to test issues

   d. program schedule effects

   e. safety

B. OPERATIONS

1. HO/Ballistic/Parallel BRB/Backup SRM

   a. Define operations concept and GSE definition in concert with the following assumption: Recovery operations, pickup and transportation back to the launch site are assumed to be provided as GFE. Special requirements to be considered for GFE implementation will be identified by the contractor.

   b. Define Spares, Maintenance and Support Systems (Booster only).

   c. Provide preliminary analyses of operations support requirements.

2. HO/Flyback

   a. Provide further definition of launch complex systems with emphasis on mobile launcher including umbilical locations.

   b. Verify recurring operations costs and timeliness.

C. REFURBISHMENT ANALYSES

Provide preliminary technical and cost analyses of the refurbishment required to permit re-use of the recoverable elements for each of the orbiter/booster systems being studied.

V. COSTING AND SCHEDULING

This activity encompasses the basic cost/schedule tasks that are necessary for evaluating alternate shuttle system concepts and defining the detailed planning requirements for the selected configuration. In addition, several special emphasis tasks, focused on refining the data base used in the overall cost/schedule activity, are included.

A. BASIC TASKS

1. Program Resource Analysis - Define comparative cost/schedule requirements for the specified alternate shuttle system concepts and detailed cost/schedule requirements on the selected configuration in accordance with DRD MA-26IT.

2. Design/cost trades - Update parametric cost model and support technical trade studies as required, including definition of subsystem cost/weight factors and evaluation of vehicle manufacturing costs and schedules.

3. Cost/Schedule sensitivity analysis - Analyze effects major milestones have on program schedule and cost.

B. SPECIAL EMPHASIS TASKS

1. Cost estimating data base - Provide analysis and comparison of major WBS items with historical cost data on other corporate programs to substantiate the estimate as appropriate.

2. Analysis of major program assumptions - Analyze cost/schedule impact of major assumptions to determine validity of the estimate.

3. Effect of Mark I/II S/S approach on program costs - Evaluate cost/schedule relationship of selected approach for reduced peak funding with its impact on program cost/schedule. This task includes defining the implications of production stretchout due to Mark II phasing.

4. Basis for Mark I/II Master Program Schedules - Provide comparison of Mark I/II development activities with similar activities on other programs.

5. Analysis of cost complexity factors - Provide analysis and comparison of related vehicle complexity factors with historical data to determine the validity of the estimates.

6. Operations cost analysis - Provide analysis of operational spares, related support, expendable tanks and TPS refurbishment and main engine overhaul site to justify vehicle operational cost estimate.

B. 7. Analysis of non-hardware WBS items - Provide analysis and comparison of factors applied to vehicle hardware to estimate non-hardware items with historical data to provide substantiating data for their use.

5.0 MANPOWER ALLOCATION

Total program direct manpower requirements are presented in the following tables, expressed in man-months:

- o Table 5.1 depicts the combined Grumman/Boeing manpower requirements for each level 2 WBS area (Integration, Orbiter Definition, Booster Definition, Operations & Test and Program Management).
- o Tables 5.2 and 5.3 break the above total combined manpower requirements into Grumman and Boeing manpower respectively.

GRUMMAN/BOEING DIRECT MANPOWER DISTRIBUTION

TABLE 5.1

		1971		1972	
		NOV	DEC	JAN	FEB
I	INTEGRATION	34	34	31	31
II	ORBITER DEFINITION	53	53	46	46
III	BOOSTER DEFINITION	166	166	140.5	140.5
IV	OPERATIONS & TEST	33	33	30	30
V	PROGRAM MANAGEMENT*	7	7	7	7
VI	LMSC INTERFACE	7	7	7	7
TOTAL GRUMMAN/BOEING MANPOWER		300	300	261.5	261.5

* FUNCTION IS INDIRECT AT BOEING

GRUMMAN DIRECT MANPOWER DISTRIBUTION

TABLE 5.2

	1971		1972	
	NOV	DEC	JAN	FEB
I INTEGRATION	24	24	21	21
II ORBITER DEFINITION	53	53	46	46
III BOOSTER DEFINITION	-	-	-	-
IV OPERATIONS & TEST	15	15	12	12
V PROGRAM MANAGEMENT	7	7	7	7
TOTAL GRUMMAN MANPOWER	99	99	86	86

BOEING DIRECT MANPOWER DISTRIBUTION

TABLE 5.3

			1971		1972	
			NOV.	DEC.	JAN.	FEB.
I	INTEGRATION		10	10	10	10
III	BOOSTER DEFINITION	BRB (Series)	49	49	122 (BRB (Series), PARALLEL BRB & BACKUP SRM's, LOX/RP FLYBACK combined)	122 (BRB (Series), PARALLEL BRB & BACKUP SRM's, LOX/RP FLYBACK combined)
		PARALLEL BRB & BACKUP SRM's	48	48		
		LOX/RP FLYBACK	25	25		
		TEST PROGRAM	44	44	18.5	18.5
IV	OPERATIONS AND TEST		18	18	18	18
V	PROGRAM MANAGEMENT*		-	-	-	-
VI	LMSC INTERFACE		7	7	7	7
	TOTAL BOEING MANPOWER		201	201	175.5	175.5

* FUNCTION IS INDIRECT

6.0 SUBCONTRACT PLAN

6.1 During the Study Extension, Grumman plans to compliment its technical input with Associate Contractors who will provide support in key areas as follows:

6.2 The Boeing Company - During the study extension, Boeing will provide design and technology data to assist Grumman in definition studies of the Space Shuttle program. Boeing will have responsibility for the design and technologies associated with Boosters, ballistic recoverable, parallel BRB, backup SRM's and LOX/RP flyback. Boeing will be responsible for ground turnaround/ maintenance and ground and launch operations analysis. Boeing will also support Grumman in vehicle conceptual design, low cost avionics subsystem definition, program integration, test requirements analysis, safety, reliability and quality assurance.

Boeing's Booster and Operations analyses will include flight and launch trajectory, sizing, loads and cost.

6.3 Aerojet-General - Aerojet will continue to assist Grumman in the areas of design, analysis, and associated cost trade-off studies on selected orbiter tankage. These will include but not limited to the OMS and RCS hypergolic propellant tanks. Aerojet will continue to provide consultation for these tanks (excluding dewar type) as needed.

6.4 Eastern Airlines - During the study extension Eastern will provide consultant services in the following areas:

6.4 Continued:

- o Maintenance and logistics including definition of low cost procedures, personnel skill requirements and computerized maintenance, logistics and base system controls.
- o Review from a commercial airline viewpoint of the practicality of proposed methods of Shuttle System Operation.
- o Definition of low cost ground and flight requirements in such areas as base operations, payload handling, turnaround time, and vehicle checkout.

6.5 AVCO - AVCO will continue to assist Grumman with ablative Material definition including attachment, refurbishment and inspection.

6.6 Dornier* - Dornier will continue to support the Grumman Shuttle effort with analysis and testing. They also plan to investigate interfaces between Shuttle and Tug.

6.7 Dassault* - Dassault will continue the Long Life TPS technology program.

6.8 Avionics - Continuation of subcontractor support in avionics requirements and implementation definition is planned.

6.9 Thermal Protection System - Continue subcontractor support in aerothermal analysis and overall thermal protection system design.

* Not charged against contract.

APPENDIX I

WIND TUNNEL TEST PROGRAM

A wind tunnel program will be conducted on the orbiter, booster and launch configurations. The test objectives are to:

1. Resolve critical issues and potential problem areas of the configurations not possible or practical through analysis.
2. Provide substantiating data for selection of baseline configuration.
3. Continue support of the 040A orbiter development program as defined in MSC letter EX 24/7109-279B dated Sept. 16, 1971 and subsequent memoranda.

The schedules for the planned wind tunnel test program are presented in Figures 1 and 2. Booster and launch vehicle schedules have been shown for the duration of the study contract, however, it is assumed that a NASA system selection will be made in early January at which point it is assumed that the remaining wind tunnel testing will be devoted to the selected system. No cost to the contractor has been assumed for testing in government facilities.

Brief descriptions of the proposed wind tunnel test program are included to illustrate the test objectives, facility requirements and type of data to be obtained. In the case of the 040A orbiter development program, only the Grumman portion is described.

040A ORBITER WIND TUNNEL PROGRAM

The Grumman portion of the orbiter wind tunnel program for the 040A configuration is described below.

The 040A wind tunnel schedule including the HO tank is shown in Figure 1. It is basically the NASA MSC defined 040A Orbiter wind tunnel schedule, contractor supported, as defined in the MSC memo EX 24/7109-228C dated September 15, 1971 with certain additions.

The original program to which Grumman is committed and is carrying over is identified by test numbers S-055 and S-056 in Figure 1. This contract extension will also be used to conduct the follow on first pass orbiter tests numbered S-063 and S-064 and the second pass orbiter tests S-071 and S-072. These follow on tests are defined below.

Test Descriptions:

Test Numbers: S-063 and S-064

Purpose: First pass configuration testing of the refined basic 040A configuration to determine the longitudinal and lateral-directional stability and control characteristics in the supersonic and hypersonic Mach range, respectively.

Test Numbers: S-071 and S-072

Purpose: Second pass configuration testing of the 040A configuration to determine the longitudinal and lateral-directional stability and control characteristics in the supersonic and hypersonic Mach range, respectively.

BOOSTER AND LAUNCH VEHICLE WIND TUNNEL PROGRAM

The wind tunnel program to develop the LOX/RP Flyback and Ballistic Recoverable Booster and launch configurations is shown in Figure 2.

The individual tests identified by numbers 1 and 2 for the LOX/RP Flyback, 3 through 5 for the Ballistic Recoverable booster and 6 through 8 for the selected configuration are described below.

LOX/RP FLYBACK BOOSTER

Test: Number 1 - LOX/RP Flyback Booster Configuration Development (Subsonic, Transonic, Supersonic)

Purpose: Determine best means of obtaining a satisfactory level of directional stability at subsonic, transonic and supersonic speeds. Determine the effects of increased wing area and change in plan form.

Model: Approximately 0.003 scale

Facility: MSFC Trisonic

Date & Duration: November 29, 1971; 100 hours

Test: Number 2 - LOX/RP Flyback Booster Configuration Development (Hypersonic)

Purpose: To determine the stability and control characteristics of the 979-061 configuration at M = 6.

Model: Approximately 0.003 scale
Model will be of simple construction with a minimum of parts. A body of revolution having two, interchangeable noses. An untwisted, uncambered wing with three elevon angles (one side only).
Removable ABES pad. Top Strut mount.

Facility: LA. R.C. 20" W.T. (M = 6)

Date & Duration: December 13, 1971, 40 hours

BALLISTIC RECOVERABLE BOOSTER

Test: Number 3 - Ballistic Recoverable Booster Aerodynamic Development, supersonic

Purpose: Verify supersonic stability and trim at high angles of attack.

Model: .015 Scale of the Ballistic Recoverable Booster

Facility: Boeing Supersonic Wind Tunnel

Date & Duration: November 22, 1971; 16 hours

Ballistic Recoverable Booster (continued)

Test: Number 4 - Ballistic Recoverable Booster Aerodynamic Development, Transonic

Purpose: Verify transonic stability and trim at high angles of attack.

Model: .015 Scale of the Ballistic Recoverable Booster

Facility: Boeing Transonic Wind Tunnel

Date & Duration: November 29, 1971; 16 hours

Test: Number 5 - Ballistic Recoverable Booster Aerodynamic Development, Hypersonic

Purpose: To determine the elevator hypersonic trim and stability requirements at high angle of attack.

Model: Approximately 0.003 scale

Facility: LaRC 20" Hypersonic Tunnel (Mach 6)

Date & Duration: December 20, 1971; 40 hours

Selected Configuration

Test: Number 6 - Selected Booster Configuration Development (Low Speed)

Purpose: To obtain performance, stability and control data at low speeds. To determine ground proximity effects. To find the effects of configuration variable changes. To find the effect of airbreathing engine exhaust plume on booster aerodynamic characteristics.

Model: Scale 0.029
Body strut mounted, external balance model. Model to have pitch, yaw and roll controls and to permit variations in vertical tail, wing and body geometry.

Facility: University of Washington or equivalent.

Date & Duration: February 7, 1972; 100 hours.

Selected Configuration (continued)

Test: Number 7 -	Selected Booster - Launch Configuration Development (Subsonic, Transonic, Supersonic)
Purpose:	Verify stability and control characteristics in pitch and yaw of LOX/RP booster and launch configuration.
Model:	Approximately 0.003 scale.
Facility:	MSFC Trisonic
Date & Duration:	January 24, 1972; 160 hours
Test: Number 8 -	Selected Aerodynamic Development, Hypersonic
Purpose:	Elevator hypersonic trim and stability requirements at high angles of attack.
Model:	Approximately 0.003 scale.
Facility:	LRC 20" Hypersonic Tunnel (Mach 6)
Date & Duration:	February 21, 1972; 60 hours

040A ORBITER WIND TUNNEL TEST PROGRAM

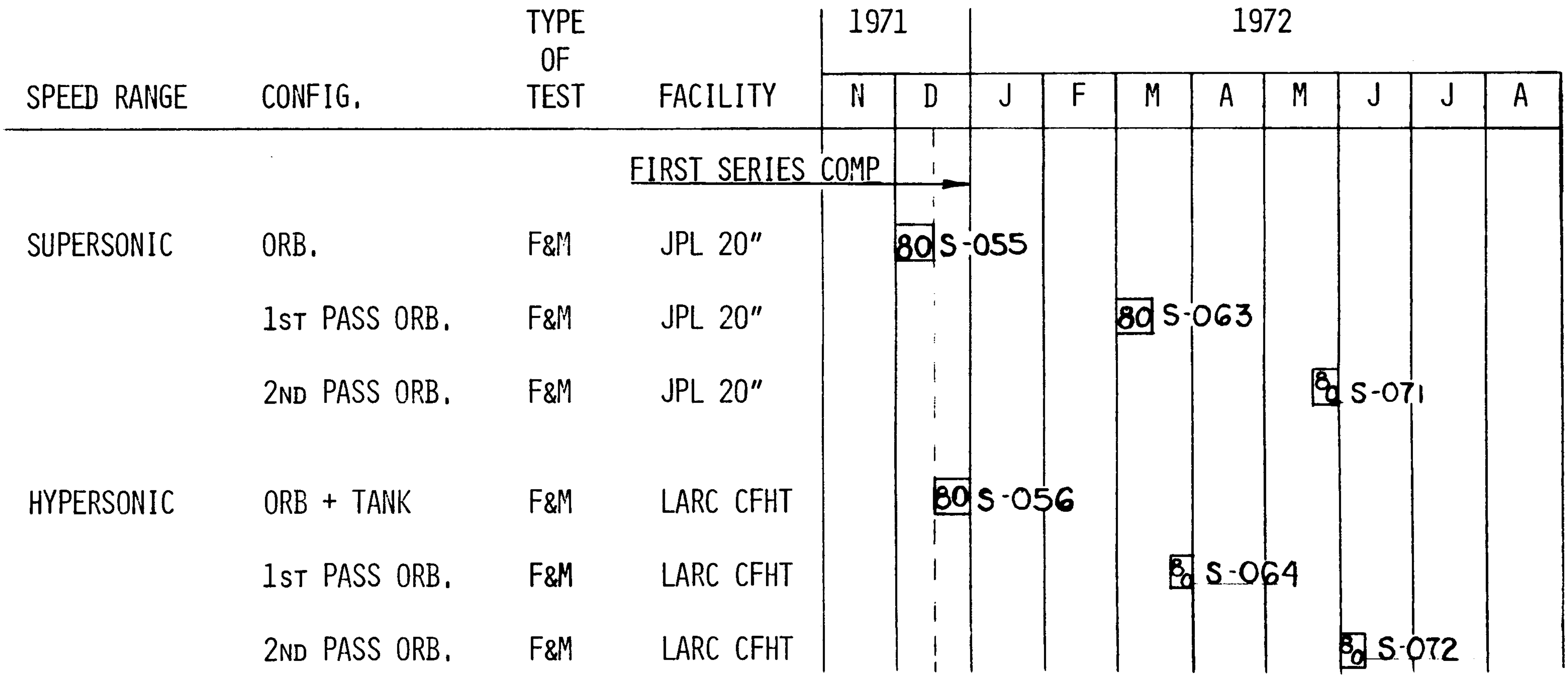
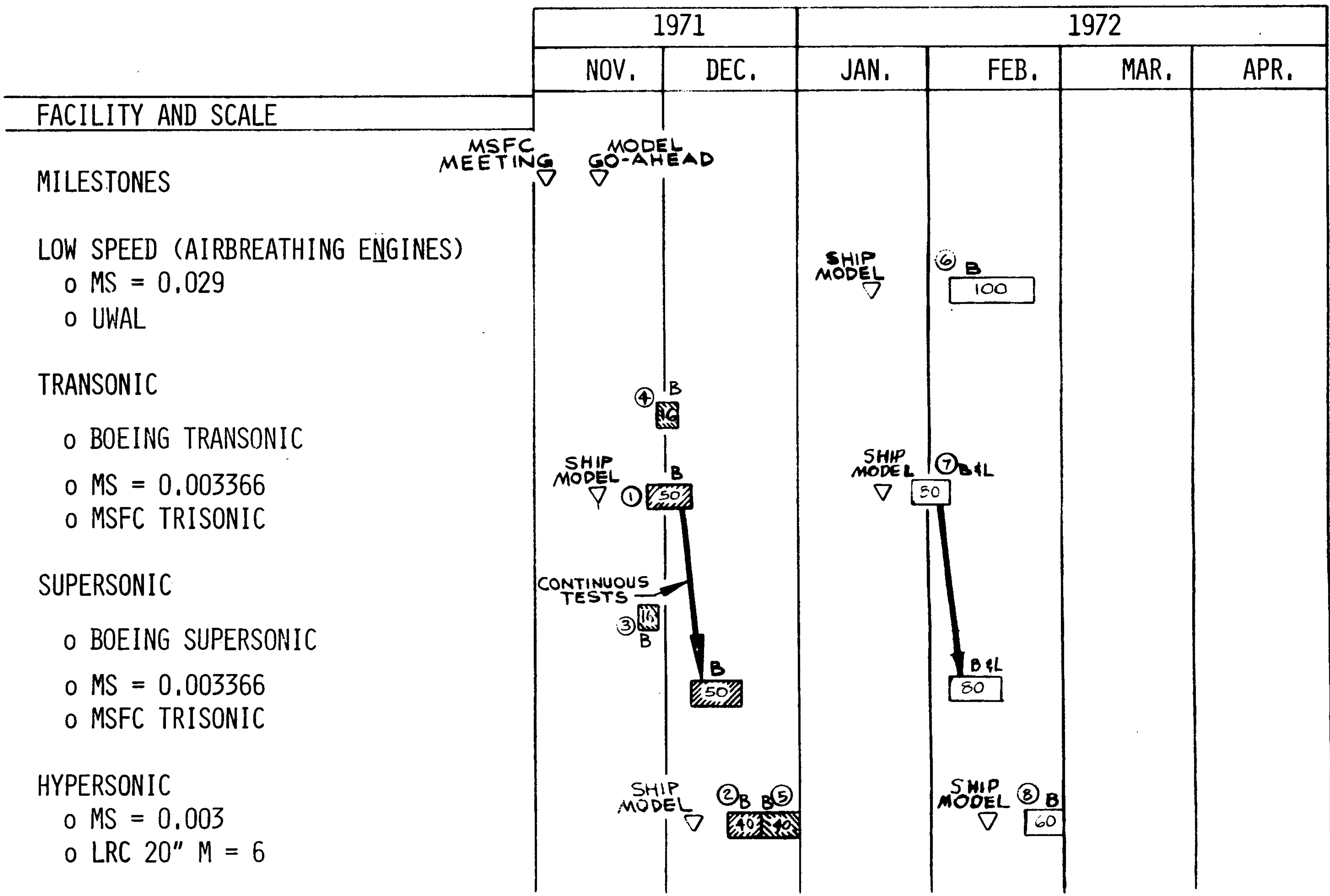


FIGURE 1

BOOSTER-LAUNCH CONFIGURATION DEVELOPMENT

WIND-TUNNEL TEST SCHEDULE



FLYBACK LOX/RP RECOVERABLE PRESSURE FED SELECTED CONFIG.

FIGURE 2

APPENDIX II

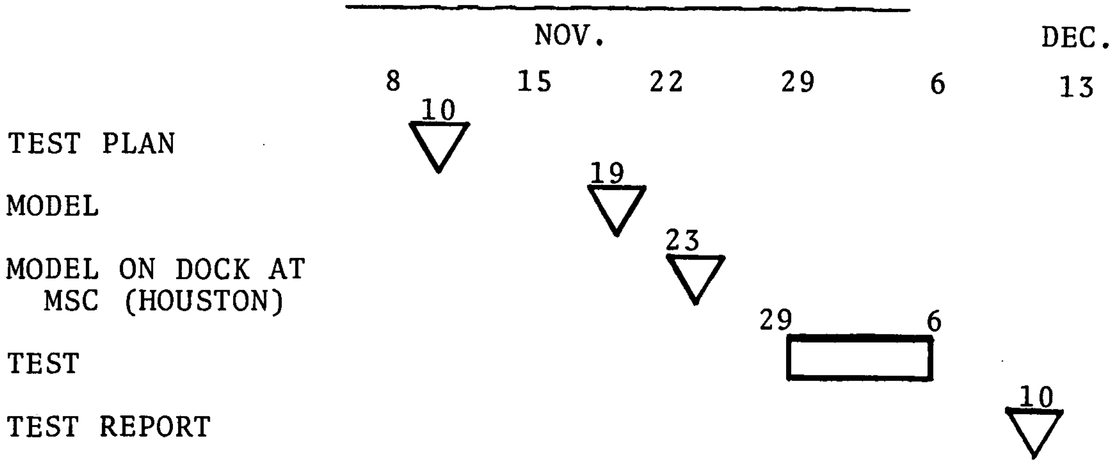
BALLISTIC RECOVERABLE BOOSTER WATER IMPACT TEST PLAN

The purpose of this test is three-fold:

1. Determine the vehicle accelerations and resulting loads due to water impact, both the initial impact on the vehicle nose and the subsequent broadside impact.
2. Investigate method of reducing those loads, i.e. modified nose shapes, entry angles, etc.
3. Generate data base to aid in checking out analytical water impact models.

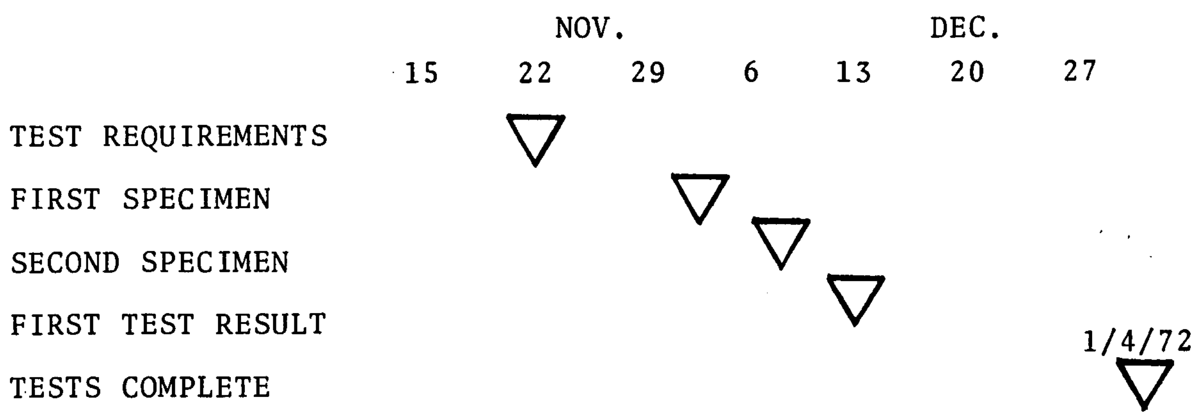
A 1/60 scale model is to be dropped to impact the water surface at various velocities (50 to 200 ft/sec. full scale), altitudes and vertical velocities (75 drops are planned). The model has several interchangeable nose shapes and its length and weight can be varied. The longitudinal, lateral and angular accelerations will be recorded on magnetic tape and oscillograph and the motions will be recorded by high speed movie cameras.

BRB WATER IMPACT TEST SCHEDULE



SALT WATER DAMAGE ELIMINATION TEST - LOX SYSTEM

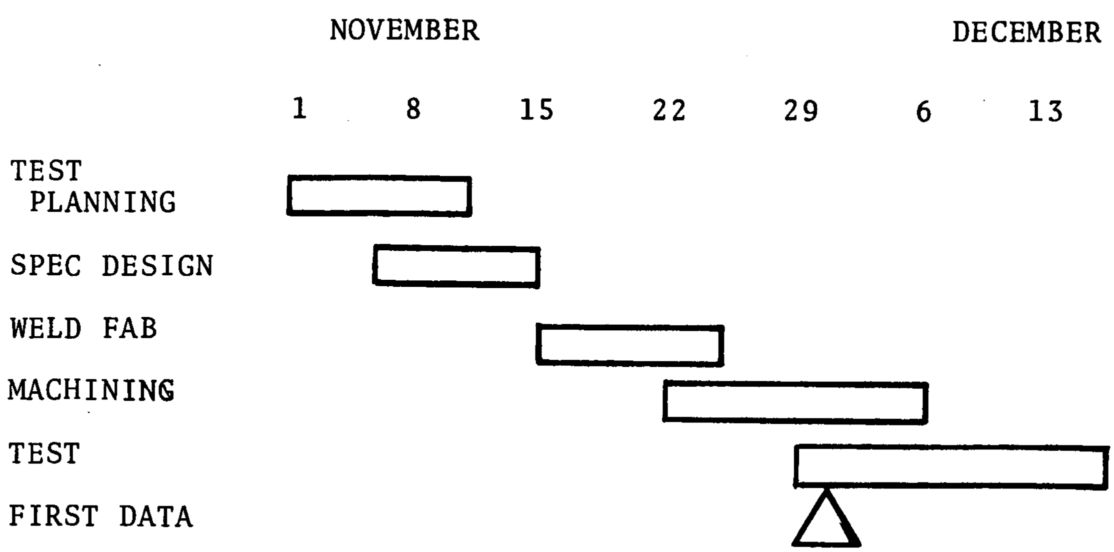
Determine design and servicing requirements to insure reusability of ocean recoverable booster LOX system components exposed to marine environments. Prevention of corrosion and/or loss of LOX compatibility during the period between sea water immersion and land based LOX cleaning will be studied. Materials selections, design configuration constraints and sea based cleanup procedures will be selected and demonstrated by tests on typical subsystem configurations.



INCONEL 718 FRACTURE TEST PROGRAM

PURPOSE: Investigate the fracture toughness and low cycle fatigue characteristics of plasma arc and TIG welds (1/2" to 3/4" thick) INCONEL 718. Fracture toughness tests will be conducted at room temperature and at -320°F both in the weld and in the heat affected zone.

SCHEDULE:



INCO 718 WELD TESTING REQUIREMENTS
REVISED (Nov. 15, 1971)

TEST	WELD TYPE	WELD CONDITION	FLAW LOCATION	TEST TEMP	QUANT.	MACHINE AND TEST AT:
KIC	GTA	AS-WELD	CL	RT	1	MSC
KIC	GTA	AS-WELD	HAZ	RT	1	(5 TESTS)
KIC	GTA	AGED	CL	RT	2	
KIC	GTA	AGED	HAZ	RT	1	
KIC	PAW	AS-WELD	HAZ	RT	1	BOEING
KIC	PAW	AS-WELD	TBD	-320	1	(6 TESTS)
KIC	PAW	AS-WELD	CL	RT	1	
KIC	PAW	AGED	TBD	-320	1	
KIC	PAW	AGED	HAZ	RT	1	
KIC	PAW	AGED	CL	RT	1	
KIC	EB	TBD	TBD	TBD	6	MSC (6 TESTS)
TENSILE	GTA	AS-WELD	-	RT	1	BOEING
TENSILE	GTA	AGED	-	RT	1	(8 TESTS)
TENSILE	PAW	AS-WELD	-	RT	1	
TENSILE	PAW	AS-WELD	-	-320	1	
TENSILE	PAW	AGED	-	RT	1	
TENSILE	EB	AS-WELD	-	RT	1	
TENSILE	EB	AGED	-	RT	1	
TENSILE	EB	AGED	-	-320	1	

All material and weld wire furnished by Boeing. Upon completion of above testing, fabricate blanks for 100 additional specimens welded by 2 of the three above processes to be machined and tested by MSC. MSC will furnish the material, Boeing will furnish weld wire.

APPENDIX III

DOCUMENTATION REQUIREMENTS

1.0 INTRODUCTION. This appendix specifies the documentation requirements for the Space Shuttle contract extension. Data are scheduled for submittal to NASA in conjunction with and in response to applicable task requirements contained in the Statement of Work. The contractor may suggest additions, deletions, or changes to the documentation requirements during performance of the contract. Upon contract award, the negotiated DRL shall be the governing document for the submittal of documentation to NASA.

2.0 TYPES OF DOCUMENTATION. For the purpose of this procurement, the following documentation types are applicable:

a. Type 1. These documents require NASA approval

b. Type 2. These documents are required to be submitted to the NASA but NASA approval is not required

c. Type 3. These documents are prepared by the Contractor in the accomplishment of the requirements of the contract but are only submitted to the NASA upon written request

3.0 DATA IDENTIFICATION. All data delivered shall be clearly marked with the following information:

a. Contractor identification

b. Title of document

c. Date

d. Contract number

e. DRL number and line item number

f. DRD number and revision letter

g. MSC identification number (numbers to be provided)

4.0 REFERENCE TO OTHER DOCUMENTS WITHIN DATA SUBMITTALS. Data submittals which make reference to other documentation are permissible, providing the references are adequate and include such identification elements as title and number. When a document to be referenced would only be applicable to a minor or limited extent, the Contractor shall include the applicable information and avoid using the reference. All referenced documentation should be readily available to document users.

5.0 DATA DISTRIBUTION INSTRUCTION. The NASA will provide distribution requirements for each deliverable document prior to its scheduled delivery. The quantity to be delivered shall be as specified in the DRL and distributed in accordance with the NASA Distribution Instructions.

6.0 DOCUMENTATION REQUIREMENTS. NASA documentation requirements are listed on the following NASA Form 1106, DRL No. T-752 (GAC) which identifies data line item requirements and their specific delivery schedules. The NASA Form 9, which describes in detail the data to be submitted, follows directly after the DRL.

DATA REQUIREMENTS LIST

ATTACHMENT NUMBER:	
EXHIBIT NUMBER:	
CONTRACT/RFP NUMBER:	
DRL NUMBER:	T-752 (GAC)
PROJECT/SYSTEM:	
CONTRACTOR:	GRUMMAN AEROSPACE CORPORATION
PREPARATION DATE:	11-1-71
PAGE 1 OF 3 PAGES	
REVISION:	Basic

1 LINE ITEM NO.	2 DRD NUMBER	3 TITLE	4 OPR	5 TYPE	6 INSPECT/ACCEPT	7 FREQ OF SUBM	8 INITIAL SUBMITTAL	10 AS OF DATE	11 COPIES A TYPE	11 COPIES B NO.
1	SE-417T	Plan, Study	NASA	1	2	AR	11-8-71	11-1-71	PRINT	110
2	SE-418T	Report, Progress and Status	NASA	2	6	WK	11-15-71	11-12-71	PRINT	70
3	MA-260T	Presentation Materials	NASA	2	6	AR	AR		PRINT	150
4	SE-419T	Data, Wind Tunnel	NASA	2	6	AR	AR		*	

9 REMARKS

Item 1:
Initial submittal requires NASA approval.
Subsequent updating will be accomplished by the contractor as required.
Copies of all changes will be submitted to the NASA for information only.

Item 2:
Report shall be submitted on Monday of each week with data as of the previous Friday.

Item 4:
* All data is prepared and forwarded for input to SADSAC. The NASA SADSAC system, using contractor provided wind tunnel test results, compiles and publishes the formal reports and distributes them to participating contractors and NASA centers.

DATA REQUIREMENTS LIST

ATTACHMENT NUMBER:

EXHIBIT NUMBER:

CONTRACT/RFP NUMBER:

DRL NUMBER: T-752 (GAC

PROJECT/SYSTEM:

CONTRACTOR: GRUMMAN AEROSPACE CORPORATION

PREPARATION DATE: 11-1-71

PAGE 2 OF 3 PAGES

REVISION: Basic

1 LINE ITEM NO.	2 DRD NUMBER	3 TITLE	4 OPR	5 TYPE	6 INSPECT/ACCEPT	7 FREQ OF SUBM	8 INITIAL SUBMITTAL	10 AS OF DATE	11 COPIES A TYPE	11 COPIES B NO.
5	MA-022-1M	Report, Independent Research & Development	NASA	2	6	QU	2-15-72	2-1-72	PRINT	50
6	SE-420T	Report, Technical Summary	NASA	2	6	OT	2-29-72		PRINT	250
7	SE-421T	Drawings	NASA	2	6	OT	2-29-72		REPRO PRINT	2 5
8	SE-422T	Report, Mass Properties	NASA	2	6	*	*		*	

9 REMARKS (item 6): (PART OF FINAL REPORT)

9 REMARKS (item 7): (PART OF FINAL REPORT)

9 REMARKS (item 8):

* 50 copies of monthly status report shall be provided to NASA by the 15th of each month beginning December 15, 1971.

100 copies of the Detailed Mass Properties Report shall be provided on Feb. 29, 1972.

(PART OF FINAL REPORT)

NASA FORM 1106 (REV. 11-65) PREVIOUS EDITIONS OBSOLETE

DATA REQUIREMENTS LIST

ATTACHMENT NUMBER:

EXHIBIT NUMBER:

CONTRACT/RFP NUMBER:

DRL NUMBER: T-752 (GAC)

PROJECT/SYSTEM:

CONTRACTOR: GRUMMAN AEROSPACE CORPORATION

PREPARATION DATE: 11-1-71

PAGE 3 OF 3 PAGES

REVISION: Basic

1 LINE ITEM NO.	2 DRD NUMBER	3 TITLE	4 OPR	5 TYPE	6 INSPECT/ACCEPT	7 FREQ OF SUBM	8 INITIAL SUBMITTAL	11 COPIES A TYPE	B NO.
9	MA-261T	Report, Cost and Schedule	NASA	2	6		2-29-72	PRINT	250
10	SE-425T	Data, Booster Interface	*	N/A	N/A		**	PRINT	1

9 REMARKS (item 9): (PART OF FINAL REPORT)

9 REMARKS (item 10):

* Data shall be shipped directly to Lockheed Missiles & Space Company. A copy of the transmittal letter shall be forwarded to the cognizant NASA office.

** Initial submittal shall be accomplished on a priority basis dependent on requirements and availability. Updates shall be on a real time basis.

NASA FORM 1106 (REV. 11-65) PREVIOUS EDITIONS OBSOLETE

Reproduced from best available copy.

ATTACHMENT NUMBER a	DATA REQUIREMENTS LIST (DRL)	RESPONDENT f	RESPONDENT PREPARATION
EXHIBIT NUMBER b		PREPARATION DATE g	12 RESPDT USE % / 11 EST/ACT / 14 TOTAL COST
CONTRACT RFP NUMBER c	PROJECT SYSTEM e	PAGE h	15 EST NO SUBM/ PGS PER SUBM / 18 PREP C (ADMIN)
DRL NUMBER d		REVISION i	16 EST NO REV/ PGS PER REV / 19 PREP C (TECH)

1 LINE ITEM NO	2 DRD NUMBER	3 TITLE	4 OPR	5 TYPE	6 INSPECT ACCEPT	7 FREQ OF SUBM	8 INITIAL SUBMITTAL	17 REPRO AND DELIV COST	20 DEVELOP COST
9 REMARKS							10 AS OF DATE / 11 COPIES / A TYPE / B NO.	21 REMARKS	

For more explicit instructions in completing this form, see MSF DRL Preparation Standard, DM018-016-1.

SHORT FORM INSTRUCTIONS FOR COMPLETING NASA FORM 1106

GENERAL

NASA Forms 1106 and 1106-1 contain two separate sections plus heading information common to entire DRL. The first section contains acquisition information, the second section contains cost information. When more than one page is required to complete DRL, continuation page (NASA Form 1106-1) shall be used. The numbers and letters below correspond to numbers and letters on sample form above.

HEADING INFORMATION

a. ATTACHMENT NUMBER—When form is an attachment to a Contract RFP, enter attachment number.

b. EXHIBIT NUMBER—Enter exhibit identification (numbers or letters) when form is an exhibit to a Contract RFP.

c. CONTRACT RFP NUMBER—Enter contract number or RFP number, if applicable. For inter NASA use, enter authority reference for DRL.

d. DRL NUMBER—Enter assigned DRL number. (Four alphanumeric character limit.)

e. PROJECT SYSTEM—Enter nomenclature descriptive of equipment activity to which DRL pertains.

f. RESPONDENT—Enter respondent name. For use within NASA, enter NASA respondent organization.

g. PREPARATION DATE—Enter actual preparation date as follows: MONTH DAY YEAR.

h. PAGE—Enter page number.

i. REVISION—Enter DRL revision code and the revision date (MONTH DAY YEAR). The revision code may be the DRL revision letter or number as applicable or contract modification number. (Two-character limit.)

j. RESPONDENT PREPARATION DATE—Enter MONTH DAY YEAR respondent completes items 12 through 21.

ACQUISITION INFORMATION
(ITEMS NO. 1 THROUGH 11)

1. LINE ITEM NO.—Number line items sequentially 1 through 999 maximum.

2. DRD NUMBER—Enter identification number of DRD that is being used, including source code letter and revision letter as applicable.

3. TITLE—Enter DRD title to be assigned to responding data item or an acceptable alternate.

4. OPR (OFFICE OF PRIMARY RESPONSIBILITY)—Enter office code of NASA organization levying data requirement and designated to exercise technical and or administrative control.

5. TYPE—Enter type of data code as follows:

CODE	DESCRIPTION
1	Applicable to All MSF Organizations. Data requiring written approval by procuring activity prior to implementation into procurement or development program.
2	Data submitted to procuring activity for coordination, surveillance, information, review and or management control.
3	Applicable to All MSF Organizations [struck out]. Data submitted to procuring activity for coordination, surveillance or information. [struck out] Data retained by respondent to be made available to procuring activity upon request.
4	Applicable to All MSF Organizations Except MSC. Data retained by respondent to be made available to procuring activity upon request. The respondent shall furnish a list to procuring activity upon request.
5	Applicable to All MSF Organizations Except MSC. Data to be retained by respondent and reviewed by NASA on request.

6. INSPECT ACCEPT—Enter inspection. Acceptance code as follows.

CODE	INSPECTION	ACCEPTANCE
1	Source	Source
2	Destination (OPR)	Destination (OPR)
3	Source	Destination (OPR)
4	Certificate of Conformance (Mandatory)	Not Applicable
5	Certificate of Conformance (Optional)	Not Applicable
6	No Inspection Required	No Acceptance Required

7. FREQ OF SUBM—Enter frequency of submittal code as follows:

CODE	DESCRIPTION	CODE	DESCRIPTION
AD	As Directed	BW	Biweekly (Every other week)
AN	Annually	DA	Daily
AR	As Required	DD	Deferred Delivery
BE	Biennially (Every other year)	MO	Monthly
BM	Bimonthly (Every other month)	OT	One Time

7. FREQ. OF SUBM.—(Continued)

CODE	DESCRIPTION	CODE	DESCRIPTION
PC	Per Contract	PV	Per Vehicle
PD	Per Failure	QU	Quarterly
PE	Per Event	RD	As Released
PF	Per Facility	RT	One Time and Revisions
PI	Per Equipment End Item	SA	Semiannually (Once every six months)
PJ	Per Project		
PL	Per Launch	TY	Three Per Year
PS	Per System	UR	Upon Request
PT	Per Test	WK	Weekly

8. INITIAL SUBMITTAL—Enter MONTH DAY YEAR of initial submittal. If calendar date is not scheduled, enter number of days preceding or following event to which data requirement is related (e.g., 90 days prior to launch). Amplify in Remarks, Item 9, if necessary.

9. REMARKS—Enter in this space
   a. When DRD provides options, limitations may be specified in this block. Other minor exceptions may also be specified.
   b. Reference to specific work statement paragraph as applicable to provide relationship of data line item to task.
   c. Additional submittal information, if necessary.
   d. Comments which explain an entry made in any block of the DRL.

10. AS OF DATE—If data is of a recurring nature, give as of date (cutoff date) and due date, e.g., 15 1 indicates input cutoff date on 15th and due date on 1st. Amplify in Remarks, Item 9, if necessary.

11. COPIES—General heading defining copy submittal requirements as follows:

A. TYPE—Enter code as follows:

CODE	DEFINITION	CODE	DEFINITION
PRINT	Printed Copies	MICRO	Microfilm Aperture Cards
REPRO	Reproducible Copy	OTHER	Explain in Remarks, Item 9

B. NO.—Enter number of copies required opposite each type of copy furnished.

COST INFORMATION
(ITEMS NO. 12 THROUGH 21)

ALL DATA IN THIS SECTION INCLUDING HEADING ... TO BE FILLED IN BY THE RESPONDENT. ALL COST DATA WHETHER ESTIMATED OR ACTUAL SHOULD REPRESENT TOTAL COST.

NOTE: The Data Item Cost Estimate (DICE) form or equivalent may be used in lieu of completing items 12 through 20. Consult MSF Data Cost Estimating and Analysis Standard, DM018-015-1 for DICE preparation instructions. Copies may be obtained from: OFFICE OF MANNED SPACE FLIGHT, MSD, NASA, Washington, D.C. 20546

THE SECTION ON COSTS IS NOT TO APPEAR ON COPY OF DRL PLACED ON CONTRACT.

12. RESPDT USE %—Enter percentage of data usage by respondent. If respondent does not use data whatsoever, enter 00 percent. If he makes total use of data, enter 100 percent. If DRL is being used for inter-NASA data acquisition, substitute "NASA Respondent" for Contractor.

13. EST ACT—Enter (EST or ACT) to indicate that total cost is estimated or actual.

14. TOTAL COST—Enter sum of Preparation Cost (Administrative), Preparation Cost (Technical), Reproduction and Delivery Cost, and Development Cost (items 17, 18, 19 and 20).

15. EST. NO. SUBM (PGS PER SUBM.—Enter estimated number of times the data will be submitted during the period of performance. Following the slash ( ) enter the estimated average number of pages per submittal.

16. EST. NO. REV (PGS PER REV.—Enter the estimated number of times data will be revised during period of performance. Following the slash ( ) enter estimated average number of pages per revision.

17. REPRO. AND DELIV. COST—Enter only cost of data reproduction, packaging, storage, and delivery.

18. PREP. COST (ADMIN)—Enter only those costs associated with typing, charting, proofing, layout, and purely administrative functions.

19. PREP. COST (TECH)—Enter only those costs associated with following technical functions: Writing, drafting, illustrating, coordinating, reviewing, editing and other related functions, including layout. Although some engineering time could be involved in above functions, cost of engineering manhours should be included in Development Cost (item 20).

20. DEVELOP COST—This estimate shall include any engineering manhour costs that the respondent believes are properly chargeable to data. If a data processing system is used, the primary purpose being the production of data, include this cost. Entries in this field must be specifically identified by the respondent in Remarks, Item 21.

21. REMARKS—Enter any comments pertinent to the cost of the data requirements. If the DICE form or equivalent is used, state "see cost form attached."

Figure 1. DRL Form Instructions

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE	2. NUMBER
PLAN, STUDY	SE-417T
3. USE	4. DATE 11-15-71
To define the contractor's planned method of accomplishing the tasks set forth in the Statement of Work. The approved plan will be the primary technical guideline as well as NASA's program control document for study task definition.	5. ORGANIZATION Grumman
7. INTERRELATIONSHIP	6. REFERENCES

8. PREPARATION INFORMATION

The plan shall include the following information as a minimum:

a. A description of the tasks to be accomplished and the key issues to be addressed in accomplishing these tasks.

b. Planned time-phased manpower requirements in accordance with the Work Breakdown Structure for the performance of the contract.

c. A study program milestone schedule.

NASA technical directives will amend the study plan.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE Report, Progress and Status	2. NUMBER SE-418T
3. USE To provide customer visibility of significant events occuring during the reporting period and status of milestone schedule.	4. DATE 11-15-71 5. ORGANIZATION Grumman
7. INTERRELATIONSHIP	6. REFERENCES

8. PREPARATION INFORMATION

This report shall include the following information:

a. Progress against the milestone schedule.

b. Actual or potential problems that may cause a deviation to accomplishment of the study plan objectives or the planned milestone schedule. Show cause and corrective action planned.

c. List all NASA technical directives received during the reporting period (or other technical instructions) and indicate the impact of such communications on the study plan and milestone schedule.

This report may be prepared in letter format and should consit of the minimum number of pages consistent with a summary presentation of the above information and some details in areas of importance as required to provide adequate NASA visibility.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE	2. NUMBER
Presentation Materials	MA-260T
3. USE To provide the NASA with a hard copy of all significant presentations made by the contractor during the period of this study effort	4. DATE 10-19-71 5. ORGANIZATION NASA
7. INTERRELATIONSHIP	6. REFERENCES

8. PREPARATION INFORMATION

In the preparation of presentation materials in support of significant NASA reviews, briefings and/or presentations, the contractor shall also prepare hard copy documentation of the presentation materials for submittal to the NASA.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE	2. NUMBER
Data, Wind Tunnel	SE-419T

3. USE	4. DATE
Provides a centralized aerothermodynamic data bank for NASA/DOD	10-19-71
	5. ORGANIZATION NASA

7. INTERRELATIONSHIP	6. REFERENCES

8. PREPARATION INFORMATION

These data shall encompass all wind tunnel aerothermal studies on the Space Shuttle candidate vehicles (Orbiter, Booster, and combination) including force and moment heating, pressure distribution, oil flow, and other flow visualization studies.

Immediately upon acquisition and reduction of the data to co-efficient form it shall be submitted to NASA as follows:

a. All force and moment, pressure distribution and heating data obtained at discrete points (such as by use of thermocouples) shall be submitted on magnetic tape along with necessary associated information to NASA for inclusion into the SADSAC Data Management System.

b. Reproducible copies of all other aerothermal data (e.g., oil flow, schlieron, phase change paint heating, etc.).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE Report, Independent Research and Development	2. NUMBER MA-022-1M
3. USE To provide the NASA with information applicable to the contractor's independent research and development activities.	4. DATE 10-19-71 5. ORGANIZATION NASA
7. INTERRELATIONSHIP	6. REFERENCES

8. PREPARATION INFORMATION

The contractor shall prepare a quarterly letter describing his independent research and development activities which are related to the contract work.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE Report, Technical Summary	2. NUMBER SE-420T
3. USE To provide a comprehensive report of the complete study effort accomplished during the period of this contract.	4. DATE 11-1-71 5. ORGANIZATION GRUMMAN
7. INTERRELATIONSHIP	6. REFERENCES

8. PREPARATION INFORMATION

The Technical Summary shall be prepared in two (2) parts as follows:

a. Part I - Executive Summary. Provide a summary description of the results of studies performed and a description of the selected design. Also provide overall schedules and costs for the development and operational phases of the program.

b. Part II - Technical Summary, Provide the following:

(1) Design and functional descriptions of selected configuration.

(2) Trade-off study conclusions.

(3) All technical considerations pertinent to configuration selection.

(4) A comprehensive summary of facilities required, manufacturing and test approaches, and other significant factors relating to the selected configuration.

Part I should be limited to approximately 30 pages. Part II should be in sufficient detail to adequately portray the significant elements of the study.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE Drawings	2. NUMBER SE-421T
3. USE To document engineering data developed during the period of this study effort.	4. DATE 10-19-71 5. ORGANIZATION NASA
7. INTERRELATIONSHIP	6. REFERENCES

8. PREPARATION INFORMATION

All drawings developed by the contractor during this study period in support of his selected configuration shall be provided to the NASA with the final report.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE Report, Mass Properties	2. NUMBER SE-422T
3. USE Provides visibility of mass properties for the selected configuration	4. DATE 11-15-71 5. ORGANIZATION Grumman
7. INTERRELATIONSHIP	6. REFERENCES

8. PREPARATION INFORMATION

The contractor shall supply a monthly Status Report that will include a Group Weight Statement in accordance with paragraph 3.5 of MSC-04419 "Shuttle Mass Properties Report" for the baseline configuration. Other configurations of interest will be reported on a one page Weight Summary (similar to the MSC-04419 Mission Weight Summary form).

The final report will include a detailed Weight Statement for the baseline configuration and a Group Weight Statement and Design Data Summary for any other configuration of interest at the time.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE	2. NUMBER
Cost and Schedule Data Requirements	MA-261T
3. USE	4. DATE 22 October 1971
	5. ORGANIZATION NASA
7. INTERRELATIONSHIP	6. REFERENCES

8. PREPARATION INFORMATION

1. GENERAL. Cost and Schedule Data will be presented for the reusable orbiter, and for each booster (flyback, pressure-fed, other), according to the specifications of DRD MF003M (May 1971 revisions). These requirements are the same as those given during Phase B, with the following amplifications.

2. AMPLIFICATIONS TO DRD MF003M. A format will be furnished by the NASA for standardizing a summary of the data presented. In addition, the contractor is now formally required to furnish data describing his costing methodology and assumptions. All CER's employed, along with supporting data, will be described, i.e., the effects of design complexity and other vehicle and program complexities will be described in detail. Cost assembly methods and logic will also be clearly shown. All items estimated as cost-from-cost factors will be shown, along with data to support the choice of each factor.

   All assumptions employed, including those for learning, commonality, ground test hardware, and spares will be specified, and reasons for their choice will be justified. If the contractor has reason to choose an assumption different from one given by the NASA, the choice should be well justified; such choices are encouraged where good justifications exist.

   If hardware is converted from ground test to flight test use, or from flight test to operational use, the quantities and costs involved will be clearly shown.

3. SCHEDULE DATA REQUIREMENTS. A comprehensive schedule document shall be provided by the contractor for use in properly evaluating and managing tasks at various management levels. This document shall contain, as a minimum, a Master Phasing Plan, a Program Logic Network, and System/Subsystem Activity Schedules.

DATA REQUIREMENT DESCRIPTION October 22, 1971 MA-261T

Cost and Schedule Data Requirements

8. Preparation Information (Cont'd)

(a) The Master Phasing Plan is to provide a top-level time phasing of the overall Shuttle Program by displaying the major program activities and key milestones through the operational phase.

(b) The Program Logic Network shall give graphic illustration of the contractor's integration plan for accomplishing the program through the operational phase. This network should be constructed in a manner to display specific System/Subsystem integration logic as it may pertain to the total program at any point in time. This network shall be activity-oriented with activity times expressed in weeks.

(c) The System/Subsystem Activity Schedules shall be prepared to display the significant activities and events for each hardware oriented System/Subsystem. These schedules are to be in a bar chart format and keyed from the Program Logic Network. The intra-schedule relationships between the design, fabrication, test, checkout and integration of each applicable system/subsystem should be displayed with constraints between consecutive activities shown. These schedules should be constructed in a manner that will facilitate schedule/cost correlation for each System/Subsystem when used in conjunction with complementary funding curves.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE Data, Booster Interface	2. NUMBER SE-425T
3. USE Support Lockheed Missile & Space Company (LMSC) contractual obligations to NASA.	4. DATE 11-1-71 5. ORGANIZATION Grumman
7. INTERRELATIONSHIP	6. REFERENCES

8. PREPARATION INFORMATION

The contractor shall supply to LMSC booster interface data consisting of:

(a) Physical and functional interface requirements.

(b) Booster performance as it affects an orbiter.

(c) Ground support requirements.

(d) Timelines and operational support requirements.

(e) Costing information to complete Lockheed total program costs.

The above information shall be limited to the following booster concepts:

(1) The Flyback LOX/RP Booster.

(2) The Ballistic Recoverable Booster.