FINAL REPORT

SCHEDULING TECHNIQUE IMPROVEMENT STUDY

for

ADVANCED PROGRAMS

VOLUME IV

GROUND SUPPORT, TEST, TRAINING, INVESTMENT, OPERATIONS ADVANCED SPACE TRANSPORT PROGRAM

25 July 1971

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VOUGHT MISSILES AND SPACE COMPANY
DALLAS, TEXAS

FOREWORD

The Scheduling Technique Improvement Study for Advanced Programs was conducted by the Vought Missiles & Space Company, LTV Aerospace Corporation, Dallas, Texas, under Contract No. NAS9-11659. This study was conducted for the Operations Analysis Branch of the Manned Spaceflight Center, National Aeronautics and Space Administration, Houston, Texas. The period of this contract covered twenty (20) weeks, including a two-week final reporting period. Contract dates were from 7 March 1971 through 25 July 1971.

This document is submitted in compliance with NAS9-11659, Paragraph V (Deliverable Items) of Exhibit A to the Statement of Work.

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7/29/71
Date

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ABSTRACT

This report, in four volumes, is the final report of a twenty-week study conducted by Vought Missiles & Space Company for the Operations Analysis Branch, Manned Spacecraft Center (MSC), NASA, to generate improved techniques for scheduling major advanced programs. Study results directly support on-going and future programs within the National Aeronautics and Space Administration (NASA) as well as having application to any program, new or existing, under cognizance of the U. S. Government and its agencies where the techniques described herein may be utilized to estimate program milestone schedules. The basic technique is termed Time Estimating Relationships (TERs), where relationships are derived from statistical data to relate time to those technical parameters judged to be drivers in subsystem, system or total program scheduled development and delivery.

In addition to TER development, this study also addressed, and has reported herein, a comparative baseline for the scheduling improvement effort. Included are: (1) a master schedule for developing an Advanced Space Transport Program, (2) the Work Breakdown Structure and Dictionary (work statement) for the Program, (3) the detail schedules developed by standard techniques for estimating design and development, and (4) the logic diagrams which identify principle tasks and their sequence. All efforts reported herein are keyed to the Work Breakdown Structure (WBS) developed for an Advanced Space Transport Program in accordance with NASA level designations. This Program is used as the baseline for the study effort and is representative of programs being considered by NASA for operations in earth-to-near earth space environments.

The four volumes which contain the Final Report, under title of "Final Report, Scheduling Technique Improvement Study for Advanced Programs", are subtitled as follows:

Vol. I - Summary

Contains the final oral report presented to MSC covering the results of the entire study, including the TERs developed during the study. Contains, in addition, the objectives, approach and ground rules for generating the TERs, WBS Dictionary, Logic Charts, and Master and Detailed Schedules. The Work Breakdown Structure and Dictionary for the Total Program, for the Air Vehicle, for Integration and Assembly of Air Vehicle Stages and Payload, and for the Payload conclude this volume. A glossary of abbreviations, symbols and terms are included in the preamble to the text.

Vol. II - Stage II, Advanced Space Transport Program

Contains Stage II Work Breakdown Structure Dictionary, Detail Schedules and Logic Diagrams. Stage II (a manned, reusable orbiting transport vehicle) is defined consistently to the 6th (Assembly) Level and to the 7th (Component) Level for certain subsystems.

Vol. III - Stage I, Advanced Space Transport Program

Contains Stage I Work Breakdown Structure Dictionary, Detail Schedules and Logic Diagrams. Stage I (a manned, reusable boost vehicle) is defined consistently to the 5th (Subsystem) Level and to the 6th (Assembly) and 7th (Component) Levels for certain subsystems.

Vol. IV - Ground Support, Test, Training, Investment, Management; Advanced Space Transport Program

Contains the Work Breakdown Structure Dictionary, Detail Schedules and Logic Diagrams for the major program elements for the life-cycle program other than Air Vehicle. These elements are consistently defined at the 3rd (Project) Level and partially defined at the 4th (System), 5th (Subsystem) and 6th (Assembly) Levels.

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INTRODUCTION TO VOLUME IV

SECTION 1

INTRODUCTION TO VOLUME IV

This Volume contains the Work Breakdown Structure (WBS) Dictionary, Detail Schedules and Logic Diagrams for Blocks 2.0 thru 12.0 of the Advanced Space Transport Program, introduced in Section 8 of Volume I to the Final Report.

The Master Schedule for this Program, also introduced in Section 8 of Volume I, is included here (Figure 0.0-W-1) for both reference purposes and for correlation with Detail Schedules shown on Page 1 of each WBS Dictionary writeup, or to callouts to the Master Schedule where Detail Schedules are not provided.

Blocks 2.0 thru 12.0 are 3rd Level Program elements shown on the 'top' WBS for the Program (Figure 0.0-W-2), repeated here for reference purposes.

For introductory data on the Work Breakdown Structure used for this study, for the top WBS Dictionary (WBS ID 0.0), for Master and Detail Schedules, and for Logic Diagrams, the reader is referred to Volume I.

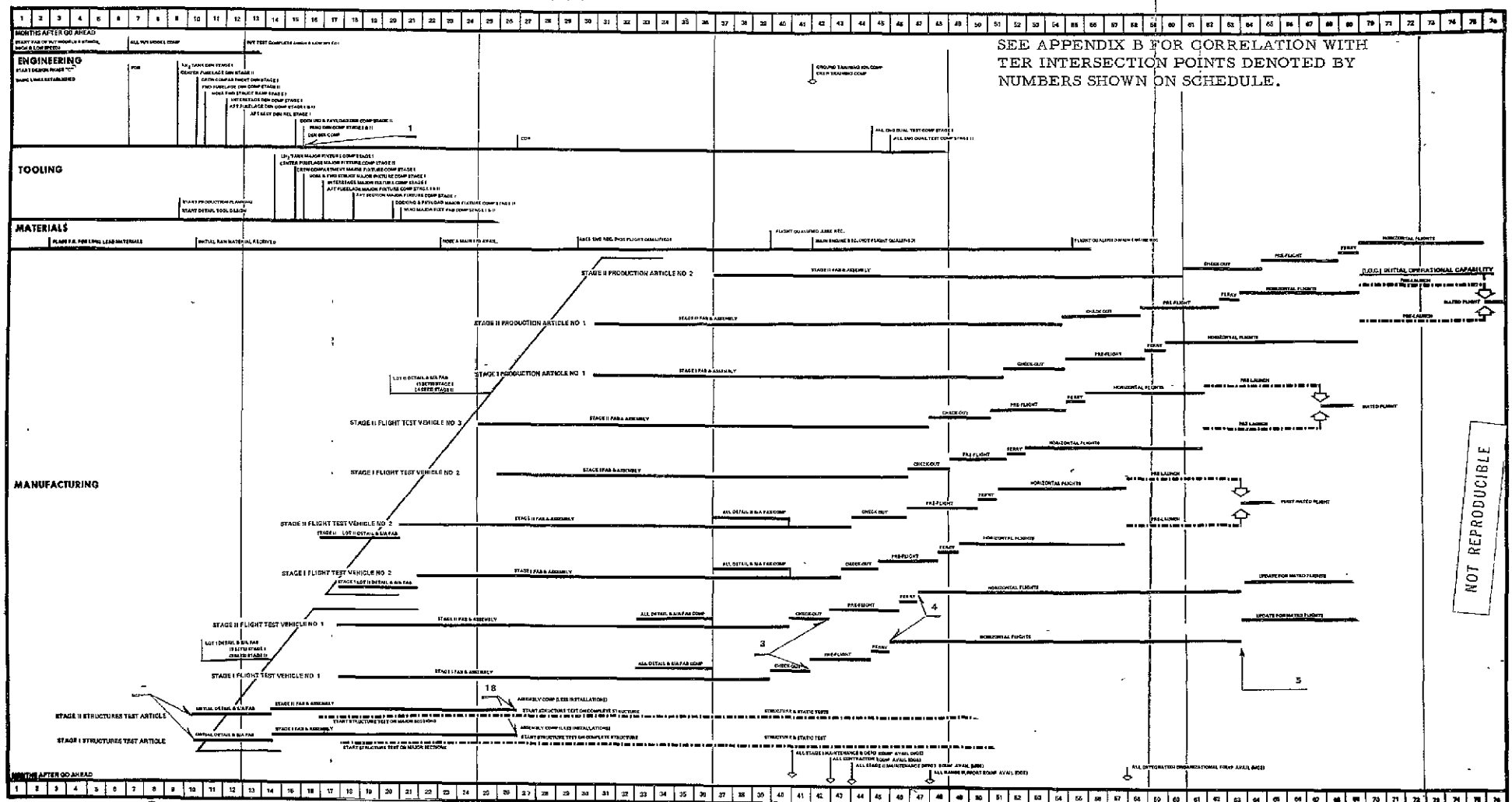
Stage II data of a similar nature to that reported herein is contained in Volume II. Stage I data is contained in Volume III.

Appendix A provides an Index to the Logic Diagram 'connectors'. Appendix B compares the Time Estimating Relationships (TERs) results contained in Volume I with certain Detail Schedule and Logic Diagram results contained in this Volume. The Glossary (List of Abbreviations, Symbols and Terms), introduced in Volume I, is repeated in this Volume as Appendix C.

FOLDOUT FRAME 1

FOLDOUT FRAME 2

MASTER SCHEDULE - ADVANCED SPACE TRANSPORT PROGRAM



VOUGHT MISSILES AND SPACE COMPANY

FIGURE 0.0-W-1 MASTER SCHEDULE

FOLDOUT FRAME 1

FOLDOUT FRAME 2

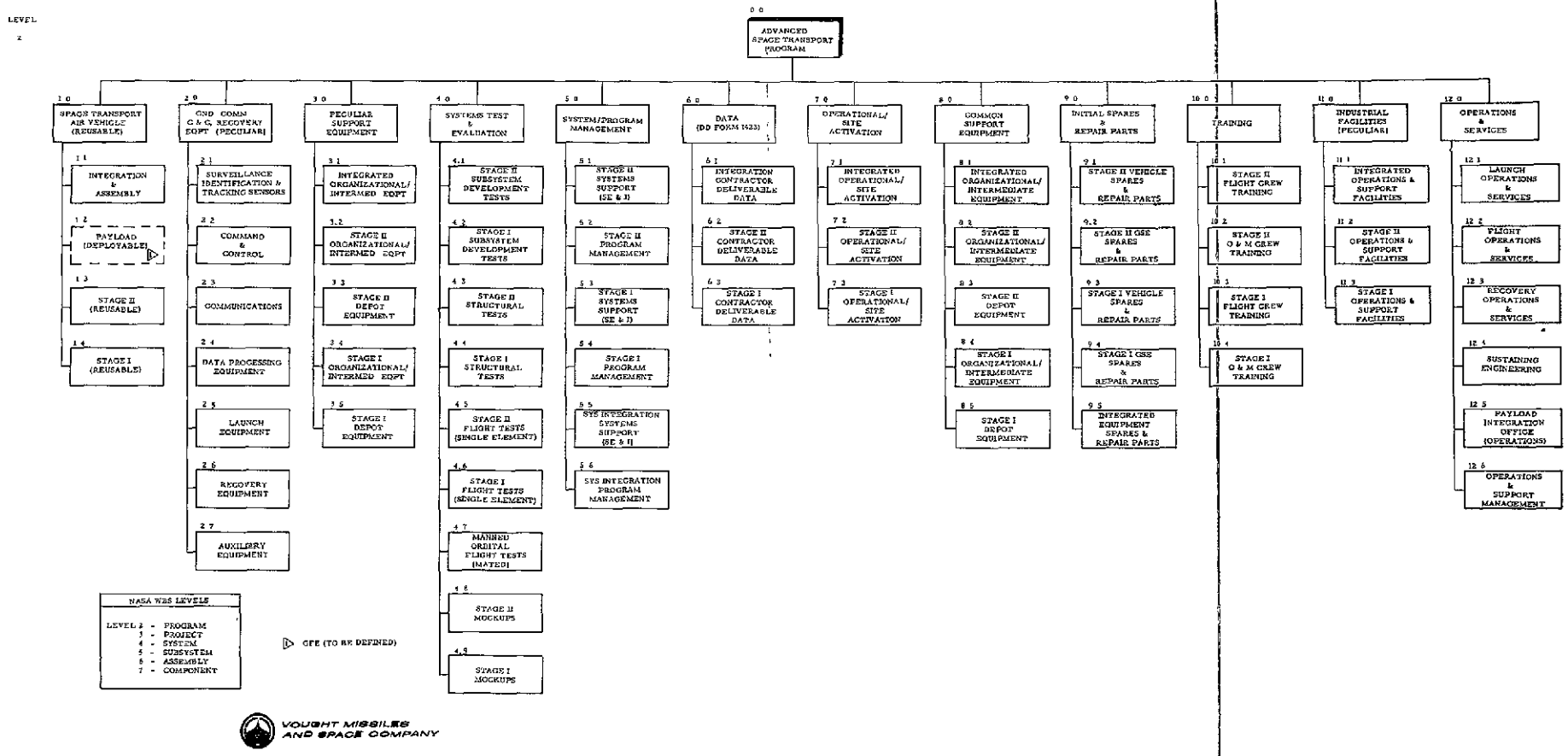


FIGURE 0.0-W-2

WORK BREAKDOWN STRUCTURE,
ADVANCED SPACE TRANSPORT PROGRAM
(WBS ID 0.0)

SECTION 2

WBS DICTIONARY, SCHEDULES & LOGIC DIAGRAMS (WBS ID 2.0 THRU 12.0)

GSE
(2 0/3.0)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 2.0

TASK TITLE GND. COMM, C&C, RECOVERY EQUIP. (PECULIAR)

LEVEL 3, Project Level

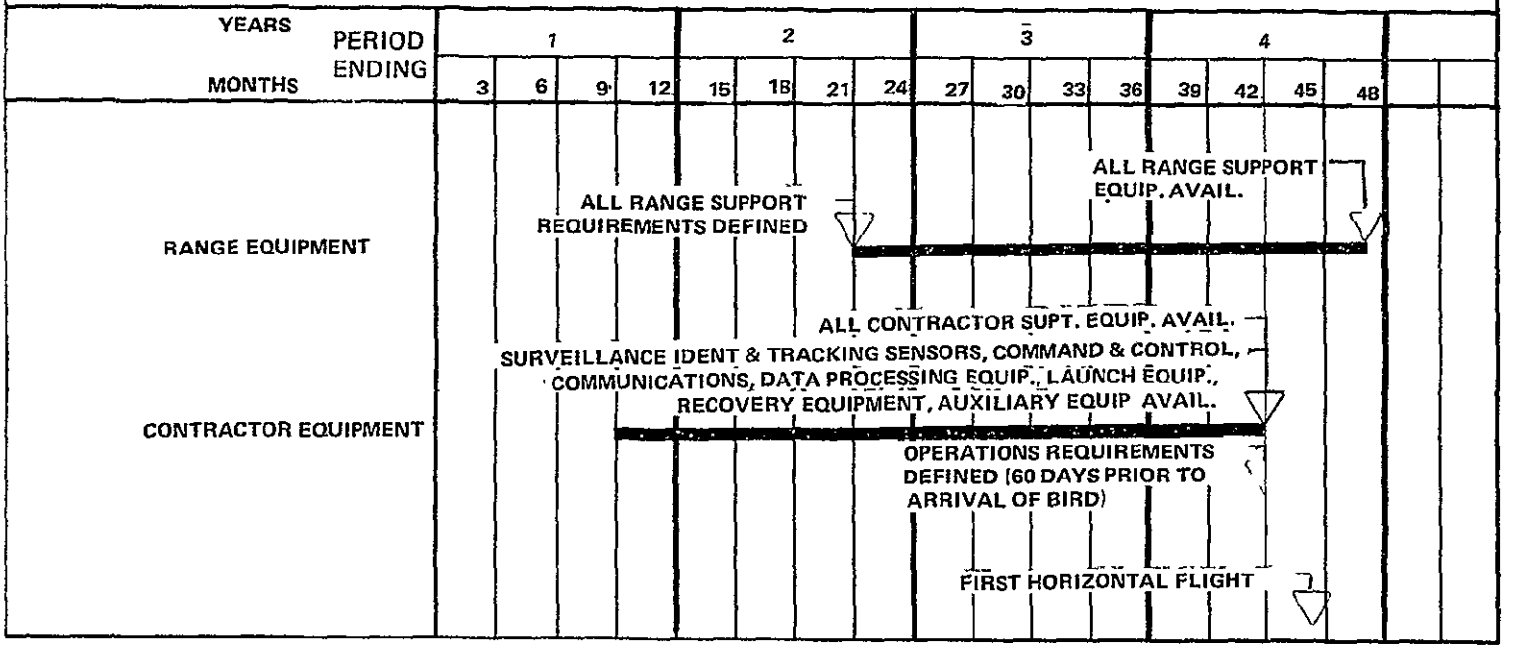
WBS DICTIONARY

I. REQUIREMENTS

Means are required to provide operating support to the two-stage reusable Space Transport Air Vehicle during launch, flight and recovery operations which are part of NASA's Advanced Space Transport Program. The design missions for the Space Transport's second stage (WBS ID 1.0, 1.3) are to deploy GFE payloads into baseline 100 nm due east circular orbits, or into reference 100 nm south polar circular orbits and reference 270 nm at 55 degree inclination orbits, and to retrieve GFE payloads from these orbits and return them safely to earth (WBS Dictionary Element 0.0, Para. IV).

The operating ground equipment which satisfies the above requirements shall provide the following capability to the operational Space Transport Program and, in addition, shall provide the same support as required

TASK SCHEDULE MILESTONES



during RDT & E: (1) surveillance, identification and tracking of all Space Transport flights in order to provide real time data on the location, altitude, heading and status of each Stage from liftoff to recovery, including ferry flights back to the turnaround facility; (2) command and control over all launches, flights and recovery operations, including ferry flights; (3) communications with the Air Vehicle (Stage I and Stage II) and between operating support elements, including up-down voice and data links and the ground-to-ground transmission thereof including communications between interlinked ground systems needed to support operations; (4) data processing of all operational mission data, (checkout, launch, flight, recovery and post-flight data) in both real time and delayed processing as well as providing data storage and retrieval capability for use on future missions; (5) launch equipment required to provide status and monitor on launch operations as well as provide automatic portions of the launch countdown; (6) recovery equipment for normal, aborted and emergency landings including recovery forces, logistics support and recovery equipment; and, (7) auxiliary equipment required to support the various operating capabilities of the command, launch and recovery equipments.

II. SYSTEM-LEVEL DEFINITION

Seven major elements define the peculiar Operating Ground Equipment (OGE) required to support the Space Transport Air Vehicle. These elements, denoted on Figure 2.0-W-3, cover design, development, manufacture and/or modification of new or existing components, modules, assemblies, subsystems and systems into prototype and operational configurations needed to satisfy the Advanced Sapce Transport Program's RDT & E, Investment and Operations phases.

The WBS identification of Ground Communications, Command and Control, and Recovery Equipment (Peculiar) systems needed to support

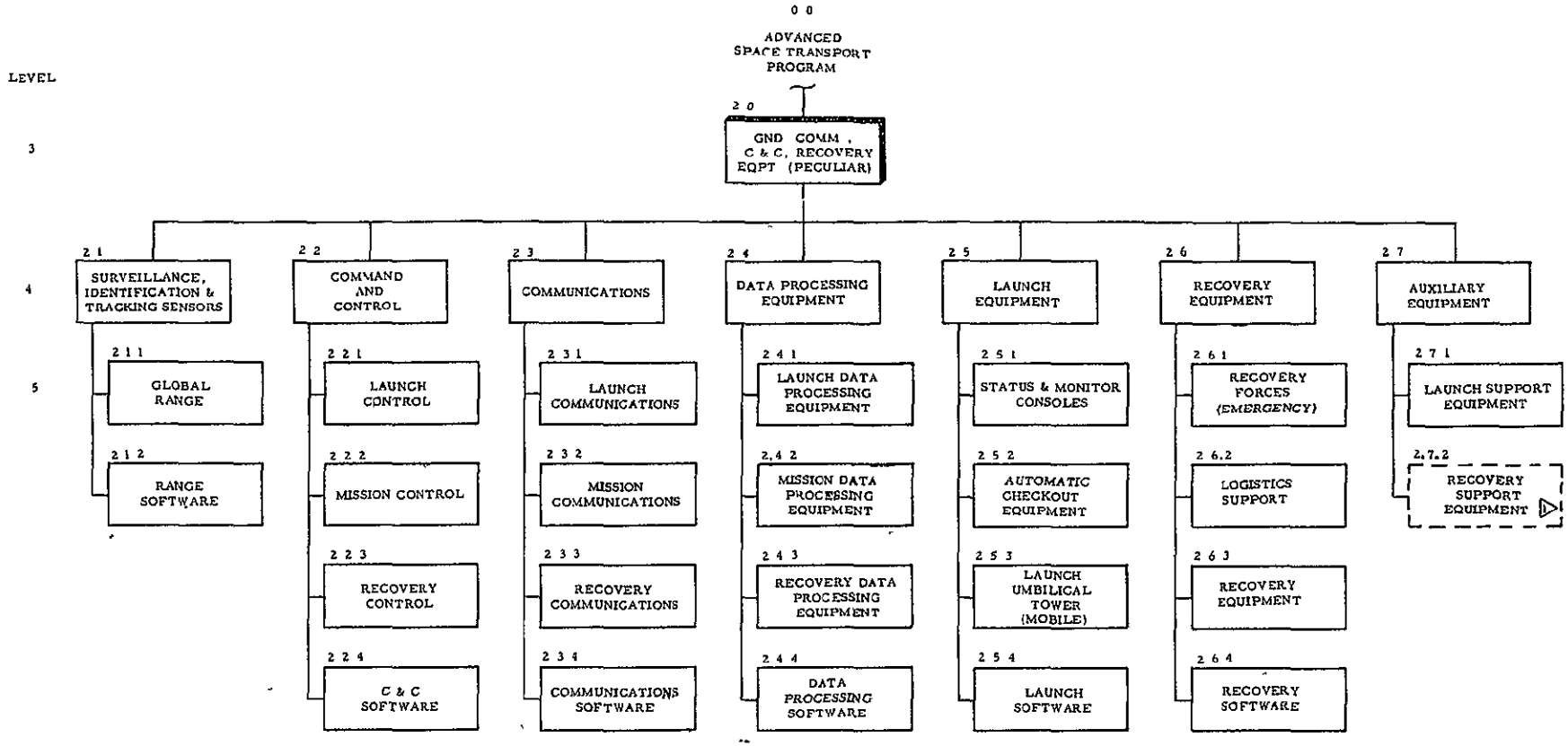


FIGURE 2.0-W-3 WBS, GROUND COMMUNICATIONS, COMMAND & CONTROL, RECOVERY EQUIPMENT (Peculiar) (WBS ID 2.0)

the Advanced Space Transport Program is as follows:

2.1	Surveillance, Identification and Tracking Sensors
2.2	Command and Control
2.3	Communications
2.4	Data Processing Equipment
2.5	Launch Equipment
2.6	Recovery Equipment
2.7	Auxiliary Equipment

Details on these systems are provided at lower levels of the WBS Dictionary.

III. FUNCTIONAL DESCRIPTION

At Phase C go-ahead, final design of the Air Vehicle and support elements will be initiated. Preliminary design is assumed to be completed (Phase B). Air Vehicle PDRs (WBS ID 5.0) will be held to review Part I specifications of the Contract End Items (CEI's) which each major air vehicle contractor, together with NASA, have defined. These will establish the air vehicle design which must be satisfied with CEIs Part II (WBS ID 1.0).

Following Air Vehicle PDRs, the system requirements analysis (WBS ID 5.0) can be completed to identify the Operating Ground Equipment (OGE) required to support launch, flight and recovery of the Air Vehicle and its elements. At an appropriate point, PDRs can be held to review Part I specifications of the CEI's which each major ground support contractor, together with NASA, have defined. These will establish the OGE designs which must be satisfied with CEIs Part II (WBS ID 2.0). Development tests, as required, will be conducted on single systems, or elements thereof, under WBS ID 2.0. Integrated tests will be conducted under appropriate elements of WBS ID 4.0, including acceptance thereof. Both prototype, modified, and production equipments will be fabricated or procured under WBS ID 2.0 and installed and tested under WBS ID 4.0 (test programs) or WBS ID 7.0 (site activation, new). Spares will be provisioned under WBS ID 4.0 for test programs or under WBS ID 9.0 for Operations. Maintenance equipment required to maintain both the Air Vehicle and OGE are designated under WBS ID 3.0 and 8.0.

IV. DESIGN REQUIREMENTS

The Advanced Space Transport Program Operating Ground Equipment (OGE) shall be designed to support Program requirements specified in WBS Dictionary Element 0.0 and Air Vehicle requirements identified in WBS Dictionary Element 1.0 and in lower levels thereto. Specific design requirements will be developed in Phase C and delineated on CEIs Part I. Preliminary design requirements for OGE are specified in lower levels of WBS ID 2.0.

V. TEST REQUIREMENTS

Test requirements for OGE are specified under lower levels of WBS ID 2.0. Generally, development tests of single components, modules, assemblies, subsystems and systems are conducted under the appropriate level of WBS ID 2.0. Combined system tests needed to demonstrate adequacy of design and integration are conducted under WBS ID 4.0. For new operational sites, installation and checkout tests are conducted under WBS ID 7.0.

VI. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 2.1

TASK TITLE SURVEILLANCE, TRACKING & IDENTIFICATION SENSORS

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

Means are required to maintain surveillance, tracking and identification of the Space Transport Air Vehicle during operational flights, from liftoff to stage separation and from separation through end of each stage's independent mission, including reentry and landing. The means shall support the Advanced Space Transport Program objectives (WBS Dictionary Element 0.0) during development flight test - ferry flights, horizontal flights, and vertical flights - as well as flights in support of Space Transport operational missions.

II. SUBSYSTEM LEVEL IDENTIFICATION

The elements which are required to satisfy the surveillance, identification and tracking sensor requirements consist of the following sub-system level

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

elements, as noted on Figure 2.0-W-3:

2.1.1	Global Range
2.1.2	Range Software

III. FUNCTIONAL DESCRIPTION

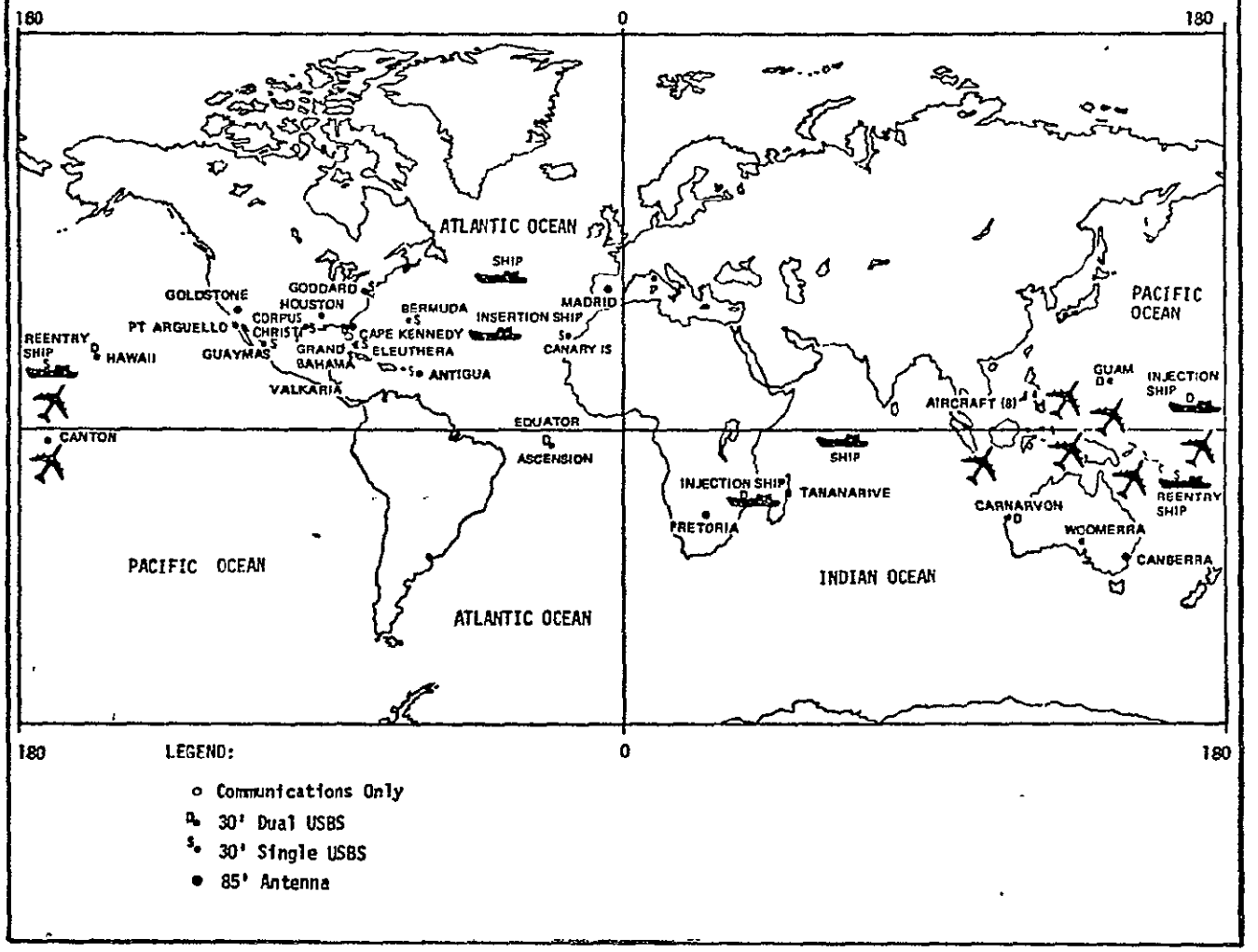
The Space Transport Air Vehicle is defined to consist of manned, reusable stages as described in WBS Dictionary Elements 0.0, 1.0, 1.3 and 1.4. A GFE payload is to be carried aboard Stage II (Orbital Vehicle) and deployed/retrieved in space in accordance with mission requirements. During the test phase of the Program (WBS ID 4.0), development flight tests will be independently conducted on each stage to verify ferry compability, horizontal cruise, and single element vertical launch capability.[1] Culmination of flight test will include mated flights to verify operational mission capability. At an appropriate point, IOC will occur and enable 10-year operations to begin (see WBS Dictionary Element 12.0).

To support both flight test and operations, the Global Range which supported Mercury, Gemini, Apollo and other NASA and DoD launches, will be required. Modifications will need to be made to support the operational phase of the Advanced Space Transport Program. The illustration shown below (Ref. A) is indicative of the type of sensor support which will be required during early mated flights of the once-around or longer test missions to demonstrate capability to launch, orbit and reach a specified landing site in the CONUS.

Differences between Apollo flights and Space Transport flights should result in a simpler requirement on the Global Range, since the Space Transport utilizes self-recoverable stages which land on conventional runways. The requirement for air transport type landings in the CONUS (or, in an emergency, outside the CONUS) will require,in addition to global range sensors, landing aids of the air traffic control nature (VOR, VORTAC, ILS, etc.). These latter ground sensors are defined under WBS ID 2.3, Communications.

[1] Current NASA planning calls for tie-down Static Firings, only, for Single Element Vertical Flight Test. This is subject to review during Phase C/D.

MANNED SPACE FLIGHT NETWORK APOLLO STATIONS



Basically, four types of ground sensors will be required. Augmentation of these by other sensors (navsats and ground-based military defense sensors, for example) may be initially required. The four basic types include:

- Range Safety Sensors
- Tracking Radars
- Optical Sensors
- Radio Frequency Sensors

The following on-board navigation sensors are defined in the baseline concepts of Stage II and Stage I which require ground interfaces for portions of each stage's independent mission. Communications sensors, listed in WBS Dictionary Element 2.3, also provide a means for surveillance, tracking and identification.

On-Board Sensor	Affected Stage II	Affected Stage I	Airborne Sensor Function	Ground Sensor Function
Unified S-Band (USB) (WBS ID 1.3.9.2)	X		Tracking, Data, Command, Voice Link	Identification and Tracking Vehicle in Orbit
(DME, VOR, ILS, UHF Voice)*	X		▷1	▷2
(Crash Recorder & Beacon)**	X	X	▷3	▷2
Air Traffic Control Transponder (WBS ID 1.4.9.2)		X	FAA & ATC Identification	Monitor Vehicle Airborne Flights, Approach, Landing
(Precision Ranging System Interrogator, UHF Voice)*		X	▷1	▷2

* Communications & Navaids equipment (See WBS Dictionary Element 2.3)

** Emergency Communications, Crash Location (See WBS Dictionary Element 2.3)

▷1 See WBS Dictionary Element 1.3.9

▷2 See WBS Dictionary Element 2.3

▷3 See WBS Dictionary Element 1.3.9, 1.3.10, 1.4.10.4

Software required for ground sensors used in tracking and identifying Space Transport stages will need to be defined and provided, both from a basis of predicted flight paths as well as for statistical data as flights build up.

IV. DESIGN REQUIREMENTS

Based on the analysis which defines the specific requirements for ground (and space, if applicable) sensors to support both test flights and operational flights of the Space Transport Air Vehicle (WBS ID 5.0), sensors must be provided which effectively maintain surveillance of, provide tracking of, and provide positive identification of each stage of the Air Vehicle. In some cases, present positioning of these sensors may not prove to be effective, requiring either repositioning or new positioning (new sensors). Examples may include polar missions where current sensors of the CONUS defense nature are not completely compatible and either require modification or augmentation to satisfy mission requirements. Design data is thus dependent on vehicle profile, location, mission frequency, etc. to establish specific requirements for the ground-based surveillance, tracking and identification sensors. During development of the airborne vehicles, analysis of the interface will establish support requirements which, through PDR and CDR, will permit sensor requirements to be implemented in equipments (hardware and software) which can be tested during vehicle development and test to enable IOC to be achieved.

V. INTERFACES

Surveillance, tracking and identification sensors basically interface with the Air Vehicle (WBS ID 1.0) and its stages (Stage II, WBS ID 1.3; Stage I, WBS ID 1.4). An interface will also exist with certain Air Vehicle payloads (WBS ID 1.2). Ground-to-ground interfaces will exist with other sensors within WBS ID 2.1, with Command and Control (WBS ID 2.2), with support Communications (WBS ID 2.3), with Data Processing (WBS ID 2.4), with Launch Equipment (basically Range Safety, WBS ID 2.5), and with Recovery (WBS ID 2.5). Program peculiar sensor equipment which requires maintenance support from Advanced Space Transport Program GSE will interface with WBS ID 3.0/8.0. Other Program interfaces will include WBS ID 5.0,

System/Program Management; WBS ID 4.0, Systems Test and Evaluation; WBS ID 6.0, deliverable Data; WBS ID 7.0, Operational/Site Activation (new sites installed only for Operations; others required for test and operations are installed under WBS ID 4.5, 4.6 and 4.7); WBS ID 10.0, Training; WBS ID 11.0, Logistics Support Industrial Facilities; and WBS ID 12.0, Operations and Services.

VI. REFERENCES

A. MSFC-MAN-506, Saturn V Flight Manual, SA 506, NASA, 25 February 1969

(Others to be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO 2.2

TASK TITLE COMMAND AND CONTROL

LEVEL 4. System Level

WBS DICTIONARY

I. REQUIREMENTS

Means are required to implement and conduct command and control over test and operational flights of the manned, reusable, two-stage Space Transport Vehicle. These flights will occur during Phase C/D of the Advanced Space Transport Program in accordance with the requirements established in WBS Dictionary Elements 0.0, 1.3, 12.0 (Levels I, II and III requirements and the Space Transport Traffic Model). The means will be required for launch control, mission control and recovery control and shall provide needed software for both automatic and manual phases of each mission as applicable.

II. SUBSYSTEM-LEVEL DEFINITION

The elements which comprise Command and Control support to the test and

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

operational missions of the Space Transport Air Vehicle and required support elements are basically profile sensitve. These elements include (see Figure 2.0-W-3):

2.2.1	Launch Control
2.2.2	Mission Control
2.2.3	Recovery Control
2.2.4	Command and Control Software

III. FUNCTIONAL DESCRIPTION

During flight test of the Space Transport Air Vehicle stages (Stage II, WBS ID 1.3; Stage I, WBS ID 1.4), command and control will be required to verify readiness for ferry flight tests, horizontal cruise flight tests, single element vertical flight tests, and mated flight tests (WBS ID 4.0). Inasmuch as Program objectives call for manned stages with both on-board checkout and automatic/manual flight mode capability, Command and Control (C & C) will be needed basically to ensure takeoff (or liftoff) readiness (ground complex, crew readiness, range readiness, etc.) and preparedness for and conduct of mission and recovery support. For operational flights, C & C responsibility will be similar to that of flight test but will be expanded for Stage II because of the Payload interface (WBS ID 1.2) and the interface with the space mission (space base, space station, free space payload deployment/retrieval).

Accordingly, the following types of C & C are required as a function of a typical operational mission. Hardware and software requirements will be defined in Phase C/D as a function of these functional requirements (see WBS Dictionary Element 5.0):

OPERATIONAL MISSION PHASE	C & C CONTROL REQUIRED	C & C FUNCTIONS
. Launch	. Range Safety*	. Verify vehicle status . Verify range safety readiness . Acquire data

OPERATIONAL MISSION PHASE	C & C CONTROL REQUIRED	C & C FUNCTIONS
. Launch (Continued)	. Launch Control	. Handle countdown and launch (ground functions)** . Maintain ground control . Interface with crew for on-board launch functions . Verify Mission Control & Recovery readiness . Acquire data
	. Statistical Launch Data Utilization	. Software inputs to all C & C functions on previous missions to assist in Launching current vehicle
	. Pad Safety	. Monitor vehicle and ground functions during countdown to ensure safe launch . Handle pad aborts . Acquire data
. Mission	. Mission Control	. Maintain ground-to-air and ground-to-ground data links with stages of Air Vehicle, target vehicle (if applicable), ground sensors, launch control, recovery control

OPERATIONAL MISSION PHASE	C & C CONTROL REQUIRED	C & C FUNCTIONS
. Mission (Continued)	. Mission Control (Continued)	. Support normal missions as required . Control emergency conditions . Acquire data
	. Statistical Mission Data	. Software inputs to C & C functions on previous missions to assist current mission
. Recovery	. Recovery Control (Normal Missions, Emergency Landings)	. Meteorological Data at landing site and approach corridor . Landing Site and support status . Voice data on status for crew . Landings *** . Acquire Data
	. Statistical Recovery Data	. Software inputs to C & C functions on previous recoveries to assist current mission

* Both stages are manned for this Program.

** Portions of countdown are conducted on board. Ground functions include pre-conditioning tanks, loading expendables on board, handling automatic launch sequencing. See WBS ID 2.5 for Launch Equipment.

*** Normal landings on conventional airports will be under FAA and Air Traffic Control direction. Landings at military bases will be under FAA and military base control. Emergency landings control is emergency dependent. See WBS ID 2.6 for Recovery Equipment.

Flight test modifications to the above C & C functions will be required because of the need to acquire telemetry data and to monitor and control emergencies which may arise.

IV. DESIGN REQUIREMENTS

Equipments required to meet the command and control functions will be identified in Phase C/D analysis, PDRs and CDRs and will consist of either existing equipment (such as for Apollo missions), modified existing equipment, or new equipment. In addition to the analysis which defines the hardware and software requirement, site locations of the needed equipments and software also requires definition. Part I specifications of CEIs will be developed and reviewed during the design and development phase of the Advanced Space Transport Program. Solutions thereto will determine whether the requirements are satisfied by GFE and/or CFE hardware. Software is expected to be basically new.

V. INTERFACES

Command and Control interfaces with all other elements of the ground support system (WBS ID 2.0), with the Air Vehicle (WBS ID 1.0), with peculiar and common GSE (WBS ID 3.0/8.0), with Systems Test and Evaluation (WBS ID 4.0), with System/Program Management (WBS ID 5.0), with deliverable Data (WBS ID 6.0), with Operational/Site Activation for new operational sites (WBS ID 7.0), with Initial Spares and Repair Parts (WBS ID 9.0), with Training (WBS ID 10.0), with Industrial Facilities for any production, inventory or logistics support requirements of an industrial facility nature (WBS ID 11.0), and with Operations and Services (WBS ID 12.0).

VI. REFERENCES

(To be added)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 2.3

TASK TITLE COMMUNICATIONS

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

Means are required to communicate with the manned, reusable two-stage Space Transport Air Vehicle during test and operational missions and to communicate between ground support elements in support of test flights and operational missions. The ground-to-air and air-to-ground ground links shall be compatible with the airborne sensors. Program requirements are specified in WBS Dictionary Element 0.0. Stage II and Stage I requirements are specified in WBS Dictionary Elements 1.3.9 (Stage II Communications and Navaids) and 1.4.9 (Stage I Communications and Navaids). GFE Payload requirements are to be determined (see WBS Dictionary Element 1.2).

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

II. SUBSYSTEM-LEVEL DEFINITION

Elements of support Communications are basically profile dependent and are subject to specific requirements established for both test and operational missions. These elements include (see Figure 2.0-W-3):

2.3.1	Launch Communications
2.3.2	Mission Communications
2.3.3	Recovery Communications
2.3.4	Communications Software

III. FUNCTIONAL DESCRIPTION

Ground-to-vehicle communications are established while the stages are on the ground (airport apron, launch pad) via intercom connectors located at accessible points on the stages. This will enable voice and data communications between ground personnel/equipments and the vehicle if power is on the vehicle and if the flight crew or on-board ground personnel are controlling vehicle function (see WBS Dictionary Elements 1.3.9 and 1.3.11 for Stage II and 1.4.9 and 1.4.11 for Stage I, these being the communications, navaids and controls and displays elements of each vehicle). In addition to hardwire communications capability, antennas on board each stage enable checkout to be conducted on the ground with RF, Ranging and Voice/Data on-board communications and navaid links using ground antenna couplers and hardwire/RF links.

The following tabulates, by Stage, the on-board communications and navaids which will require support Communications for launch verification, missions and recovery, including any post-flight requirements such as readiness for crew/passenger exiting, ground power and cooling connected, etc. (See WBS Dictionary Element 2.1 for Tracking/Identification sensors carried on board).

ON-BOARD SENSOR	AFFECTED STAGE II	I	AIRBORNE SENSOR FUNCTION	GROUND SENSOR FUNCTION
Unified S-Band (USB) Transponders, Antennas (WBS ID 1.3.9.2)	X		Tracking, Data, Command, Voice Link	Tracking, Data, Command, Voice Link
UHF Transceivers, Antennas (WBS ID 1.3.9.2, 1.4.9.4)	X	X	2-way voice with airport for landing	2-way voice with vehicle for landing
Crew Headsets, Microphone, Intercom (WBS ID 1.3.9.2, 1.3.11.5, 1.4.9.4, 1.4.11.4)	X	X	2-way voice with ground crew (pre-, post-flight)	2-way voice with flight crew or onboard service personnel
DME Sets, Antennas (WBS ID 1.3.9.5)	X		LOS Range to VORTAC stations for approach	LOS Range response to vehicle(VORTAC stations)
ILS Receivers, Antennas (WBS ID 1.3.9.5)	X		Localizer Beam and Glide Slope for approach & landing	Transmit ILS signals to vehicle .
VOR Receivers, Antennas (WBS IS 1.3.9.5)	X		Determine bearing to fixed ground points for approach	Transmit VOR signals for vehicle approach
Ranging Sets (WBS ID 1.3.9.3)	X		Precision ranging (S-band) with target for rendezvous and docking	▷1
Precision Ranging System (PRS) Interrogator, Antennas (WBS ID 1.4.9.3)		X	Obtain precision range for approach and landing	Transmit PRS signals (S-Band)

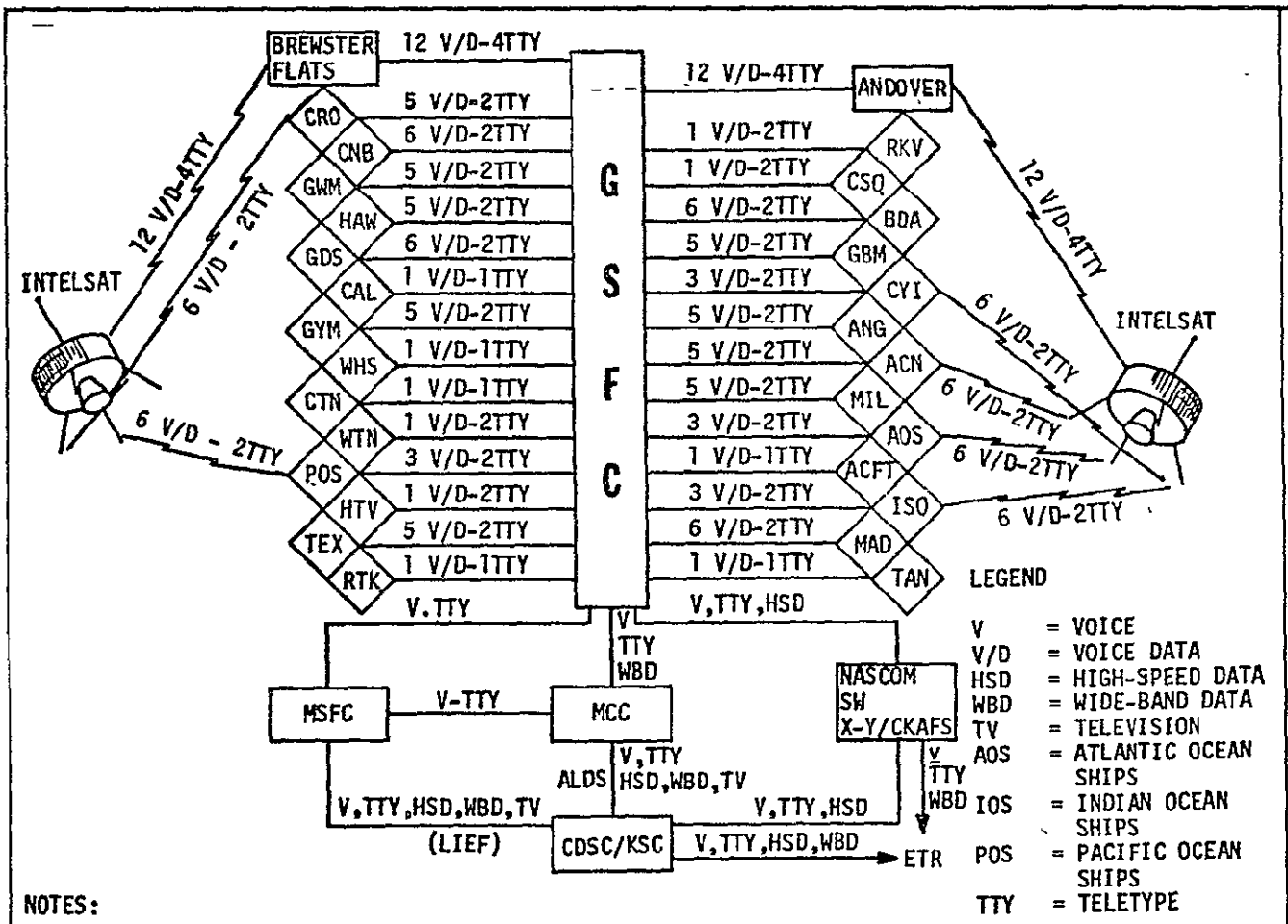
ON-BOARD SENSOR	AFFECTED STAGE II	AFFECTED STAGE I	AIRBORNE SENSOR FUNCTION	GROUND SENSOR FUNCTION
Crash Recorder & VHF Transmitter	X	X	Emergency, vehicle location/data	Home on beacon for rescue/recovery function (emergency)
Telemetry, S-Band (Flight Test Only)	(2)	X	Transmit T/M data	Receive T/M data

(1) Passive, target vehicle (2) To be identified

The ground to vehicle and ground-to-ground links required for launch will be dependent on launch site configuration. If KSC is used for launch, existing capability should exist, with modifications required to suit the Space Transport Program needs. The same will apply to Global Range Communications illustrated by the figure shown on the next page (Typical Apollo Communications Network Configuration, Reference A).

IV. DESIGN REQUIREMENTS

Specific design requirements for the Space Transport support Communications will be defined from the requirements analysis, Part I Specification, PDRs, Part II Specifications and CDRs which are part of the final design and development phases of the Advanced Space Transport Program (Phase C/D). If existing equipment, or modifications thereto will suffice, then the design task will be one of definition supplying mod kits, and providing integration to meet test flight schedules. If new requirements must be satisfied resulting in new design (such as new launch sites, new mission sites and/or new recovery sites) considerable design effort may be required. The resultant, in either case, must provide compatibility with the vehicle, with supporting ground elements and with Program objectives.



NOTES:

1. NASCOM interface points for ships and aircraft are mission dependent.
2. Additional V/D and TTY circuits between GSFC and centers are augmented as required.
3. Communications circuits as shown exist at this time or will be available for missions as required.
4. Circuit routing is not necessarily as indicated.
5. Voice Data Network to and from the Apollo USB stations will be configured with usage as indicated
   a. Net #1 Mission Conference
   b. Net #2 Biomed Data
   c. Net #3 Network M & O
   d. Net #4 Telemetry Data/Command Data (USB)
   e. Net #5 Tracking Data (USB)
6. One additional voice data circuit will be available to each Apollo station equipped with an 85' antenna and to Bermuda for high-speed tracking data.
7. Apollo stations and ships connected to GSFC via Intelsat can receive at all times, regardless of number of stations or ships. Only two stations or ships can transmit at a given time via each Intelsat.
8. Apollo ship may be assigned to any of these areas.

V. INTERFACES

Support Communications interfaces with all other ground elements (WBS ID 2.0, 3.0/8.0) as well as with the Air Vehicle and its elements (WBS ID 1.0). Other Program interfaces include Systems Test and Evaluation (WBS ID 4.0), System/Program Management (WBS ID 5.0), deliverable Data (WBS ID 6.0), new Operational/Site Activation (WBS ID 7.0), Initial Spares and Repair Parts (WBS ID 9.0), Training (WBS ID 10.0), Production, Inventory and Logistics Support Facilities (WBS ID 11.0), and Operations and Services (WBS ID 12.0).

VI. REFERENCES

A. MSFC-MAN-506, Saturn V Flight Manual, SA 506, NASA, 25 February 1969

(Others to be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 2.4

TASK TITLE DATA PROCESSING EQUIPMENT

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

Means are required to condition and display real time and delayed processing data received from the launch, missions and recovery of the manned, re-usable, two-stage Space Transport Air Vehicle and its support equipment during the Operations phase of the Advanced Space Transport Program. In addition, similar functions are also required during flight test.

The means shall consist of data processing equipment such as computers, peripheral equipment and software and shall include or interface with data links needed to receive data from remote sources and the means to process and transmit such data to the user in both real time and in delayed reporting. In addition, the means shall also provide a statistical data library of previous tests, test flights and operational missions for use in current and future mission. The contents of this library, reporting format, and dissemination needed are to be determined.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

II. SUBSYSTEM-LEVEL DEFINITION

Elements which form the Data Processing Equipment are mission profile sensitive and account for both vehicle data and ground support data and necessary processing software. The equipments and software noted below are applicable to both test and operations. See Figure 2.0-W-3 for WBS.

2.4.1	Launch Data Processing Equipment
2.4.2	Mission Data Processing Equipment
2.4.3	Recovery Data Processing Equipment
2.4.4	Data Processing Software

III. FUNCTIONAL DESCRIPTION

Both Stage II (Orbiting Vehicle) and Stage I (Boost Vehicle) are defined to have on-board data management subsystems capable of conducting pre-launch checkout and automatically conducting the Space Transport missions from liftoff to touchdown. Stage II carries the GFE payloads which form the Space Transport's missions as noted in WBS Dictionary Elements 0.0, 1.2, 1.3 and 12.0. Accordingly, the majority of data generated during a typical mission will be recorded on-board and will require processing following stage landings (each stage lands similar to a conventional transport aircraft).

In addition to on-board data processing and storage, a capability will also exist in each stage for transmitting voice and flight data via the communication links noted in WBS Dictionary Element 2.3. Such data and two-way voice must be ground-processed for use by Command and Control during the mission and recorded on the ground for analysis and evaluation following a mission.

Launch data will result from pre-launch checkouts, countdowns and launches. Recovery data will result from both normal and emergency landings and will include data resulting from the landing itself (both Stage II and Stage I) such as that provided in support of landings (ground transponders, air traffic control, purge and safing, ferry flights, post-flight maintenance).

Typical types of data gathered in support of missions which will require conditioning, processing, storage, handling and dissemination include:

- Voice messages (air-to-ground, ground-to-air, ground-to-ground)
- Data transmission (air-to-ground, ground-to-air, ground-to-ground)
- Photographic data (basically launch and recovery, although photographic data gathered in-flight will also require processing and dissemination, especially that gathered for test and for emergency)
- Tracking data
- Logistics support data (consumables utilization, spares, refurbishment, support aircraft utilization, etc. which establishes statistics required for future needs)
- Failure data/repair data (to support reliability, maintainability and safety program needs)
- Vehicle subsystem performance data
- Crew data (human factors statistics)
- Payload support data (interfaces with the Space Transport Program)

Data processing software needed to support data processing will include real time software, delayed transmission and reporting software, and data retrieval software for statistical data collected from past tests and missions to support current mission requirements (see WBS Dictionary Element 2.1 and 2.2).

IV. DESIGN REQUIREMENTS

The Data Processing Equipment required to support the Advanced Space Transport Program will be existing, modified or new as determined in the system requirements analysis which generates Program needs (WBS ID 5.0). If modified or new equipment and software are required, they will be specified and developed per Part I CEI specifications during Phase C/D, resulting in PDRs, Part II specifications, CDRs and procurement in time to meet flight test program requirements. WBS ID 4.0 specifies areas where data processing is required for test purposes. Following completion of test and qualification acceptance of the vehicle and all support elements, IOC will occur enabling 10-year operations to begin. Specific requirements on Data Processing will thus be specified in Phase C/D and in the Operations Plans which form the basis for operations.

V. INTERFACES

Support Data Processing Equipment will interface with the stages of the Space Transport Air Vehicle through the on-board Data Management Subsystems (WBS ID 1.3.10 and 1.4.10) for pre-flight and post-flight data processing. For in-flight air-to-ground and ground-to-air voice and data resulting from launch, missions, and recovery, the vehicle interfaces are WBS ID 1.3.9 and 1.4.9 (Communications and Navaids Subsystems), the ground interfaces are WBS ID 2.1 (Surveillance, Tracking and Identification), 2.2 (Command and Control) and 2.3 (Communications). Interfaces will also exist with WBS ID 2.5 (Launch Equipment) and 2.6 (Recovery Equipment). Interfaces with maintenance will exist through WBS ID 3.0/8.0. Interfaces with test phases of the Program will exist through WBS ID 4.0. Other Program element interfaces include WBS ID 5.0 (System/Program Management), WBS ID 6.0 (deliverable Program Data, not test and mission data), WBS ID 7.0 (new Operational/Site Activation), WBS ID 9.0 (Initial Spares and Repair Parts), WBS ID 10.0 (Training), WBS ID 11.0 (Inventory and Logistics Support Industrial Facilities), and WBS ID 12.0 (Operations and Services).

VI. REFERENCES

(To be added)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 2.5

TASK TITLE LAUNCH EQUIPMENT

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

Means are required to launch the Space Transport Air Vehicle for both operational and test missions in support of the Advanced Space Transport Program objectives (WBS Dictionary Elements 0.0, 4.0 and 12.0). The means shall consist of ground equipments, launch tower, automatic sequencer and necessary software. Auxiliary equipment of a general purpose, multi-usage nature is provided under WBS ID 2.7. The means shall be compatible with the less-than-two-week turnaround objectives specified in WBS Dictionary Element 0.0. The location of the equipment will be either Kennedy Spacecraft Center (KSC), Western Test Range (WTR), or an inland site.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

II. SUBSYSTEM-LEVEL DEFINITION

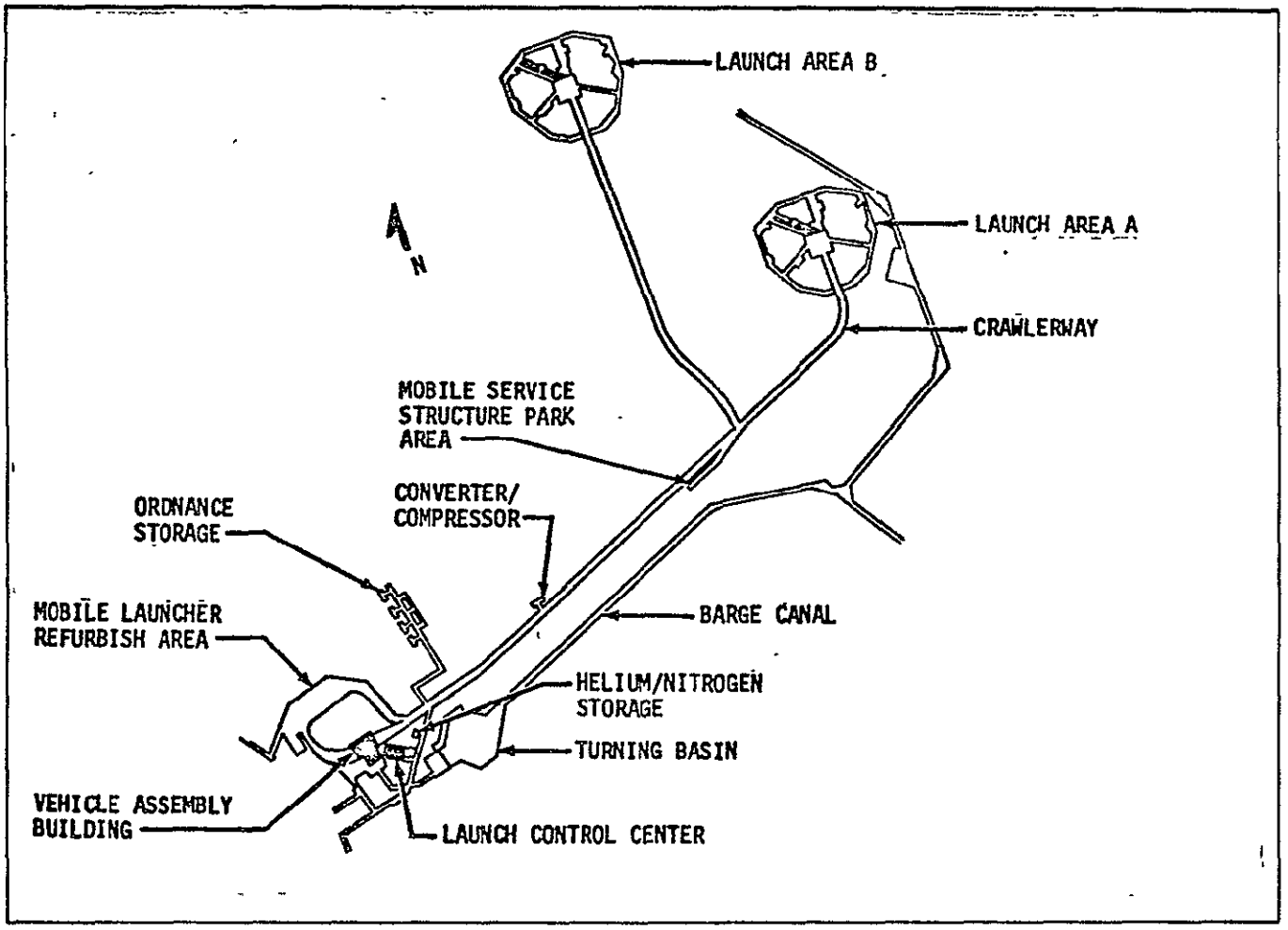
As specified in the baseline concept for the Advanced Space Transport Program, the Launch Equipment will be minimal under the concept of maximizing on-board capability for vehicle (Stage II, Stage I) checkout prior to a launch and conduct of the launch, itself. The stages are manned (see WBS Dictionary Elements 1.0, 1.3, 1.4) and provide on-board data management subsystems for pre-launch interrogation and display/transmission of vehicle status. Accordingly, the launch equipment, noted below, provides the ground elements needed for countdown and launch as support to on-board capability (see Figure 2.0-W-3).

2.5.1	Status and Monitor Consoles
2.5.2	Automatic Checkout Equipment
2.5.3	Launch Umbilical Tower (Mobile)
2.5.4	Launch Software

III. FUNCTIONAL DESCRIPTION

The baseline concept for launching the Space Transport Air Vehicle includes use of a mobile launch umbilical tower similar to that used to launch Saturn V. Mating of the stages, with the payload aboard Stage II, is performed in a vertical assembly building with the Vehicle resting on, and constrained to, the launch umbilical tower. Movement to the launch pad considers use of a crawler/transporter (WBS ID 2.7). A launch control center will provide necessary status and monitor consoles to handle countdown requirements including automatic sequencer functions, final countdown being handled on board. Command and control will be under the Launch Director (WBS ID 2.2.1).

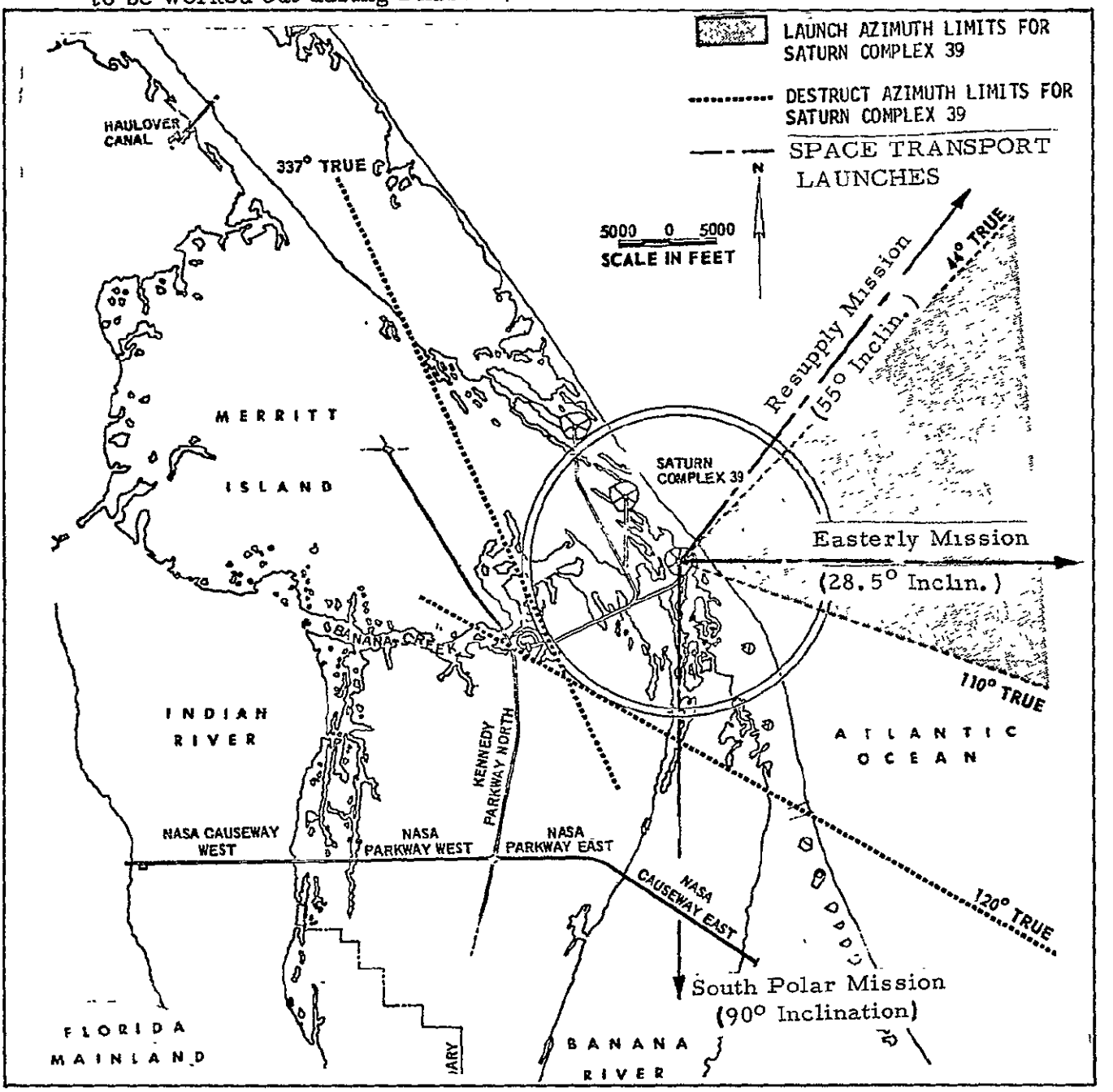
The illustration on the following page (Ref. VI.A) shows Launch Complex 39 at KSC, considered to be typical for launching the Space Transport Air Vehicle.



Typical equipments required in the launch control center (LCC) will include ground power control, status and monitor; LO_2 loading control, status and monitor; LH_2 loading control, status and monitor; nitrogen purge control, status and monitor; GH_2 control, status and monitor; helium control, status and monitor; and automatic sequencer. (Command and control consoles in the LCC are covered under WBS ID 2.2.1 (launch control, range safety, pad safety); Data Processing equipment is covered under WBS ID 2.4; Communications equipment is covered under WBS ID 2.3.)

The mobile launch umbilical tower will provide the tower structure and mobility, launcher base, launcher pedestal, and swing arms. Equipments needed on the tower or in the pad area to support the launch are defined under WBS ID 2.7.

The launch corridors for the Space Transport Air Vehicle are superimposed on the Saturn azimuth limits shown on the following sketch and are indicative of launch corridors for the Space Transport Air Vehicle. This sketch, for Saturn, notes Range Safety limits which are not specifically applicable to the Space Transport Program, the stages each being manned, although Range Safety constraints must still be observed. This interface will need to be worked out during Phase C/D.



Activation of the launch site will be conducted under WBS ID 4.7, if an existing or new site is used for test, or under WBS ID 7.0 if a new site is required for operations. During Phase C/D, the specific launch equipment will be finalized, including launch site definition for both test and operations.

IV. DESIGN REQUIREMENTS

Launch equipment required to launch the Space Transport Air Vehicle will be either existing, modified or new based on the system requirements analysis completed under Phase C/D (WBS ID 5.0). These requirements will result in Part I specifications for peculiar launch equipment. Based upon PDR reviews, Part II specifications will resolve whether equipments (consoles, automatic checkout, mobile launch umbilical tower and software) are to be existing, modified or new. CDR's will review these decisions to enable procurement to proceed, including installation and checkout for test launches (WBS ID 4.7). Specific design requirements will be stated on Part I specifications when generated.

V. INTERFACES

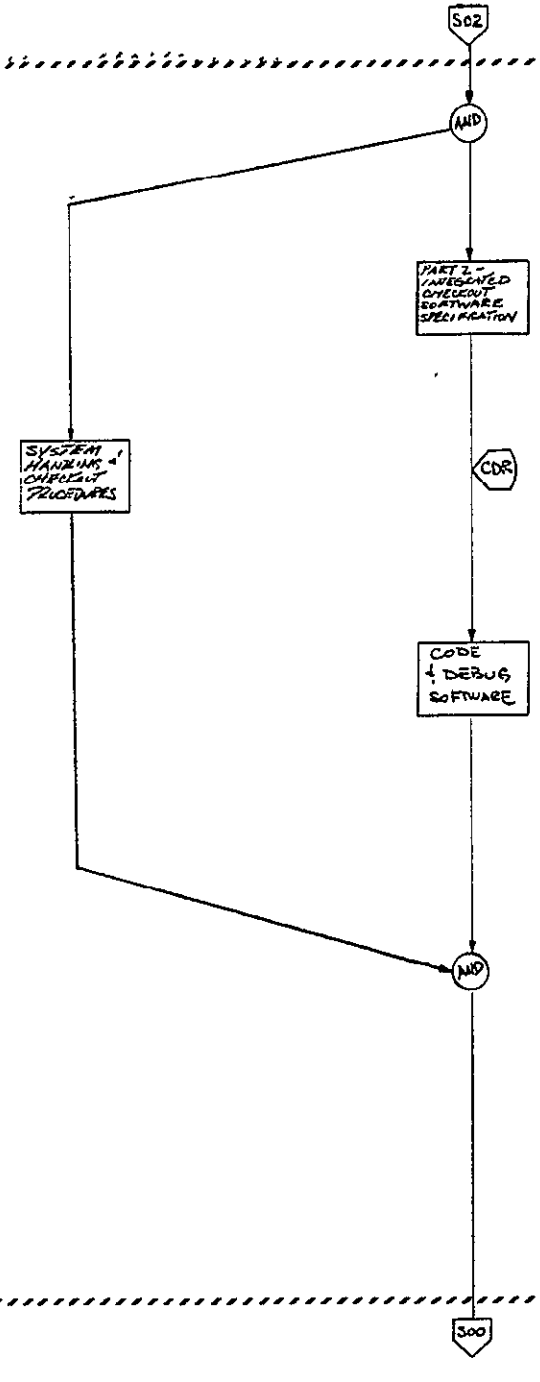
Launch equipment and launch software interface primarily with the Air Vehicle (WBS ID 1.0) through hardlines, physical interfaces, and through Auxiliary Equipment (WBS ID 2.7). Interfaces with other operating ground equipment (OGE) include Command and Control (WBS ID 2.2), Communications (WBS ID 2.3), Data Processing (WBS ID 2.4), and Surveillance, Tracking and Identification (i.e., Global Range) Sensors (WBS ID 2.1). Other Program interfaces include WBS ID 3.0/8.0 (maintenance of OGE), WBS ID 4.0 (Systems Test and Evaluation), WBS ID 5.0(System/Program Management), WBS ID 6.0 (deliverable Data), WBS ID 7.0 (Operational/Site Activation, new sites), WBS ID 9.0 (Initial Spares and Repair Parts), WBS ID 10.0 (Training), WBS ID 11.0 (affected Industrial Facilities), and WBS ID 12.0 (Operations and Services).

VI. REFERENCES

A. MSFC-MAN-506, Saturn V Flight Manual, SA 506, NASA, 25 February 1969

(Others to be added.)

INPUTS



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	254.00
TITLE	INTEGRATED LAUNCH/CHECK-OUT SOFTWARE
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	26 MAY 71

ENGINEERING

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 2.6

TASK TITLE RECOVERY EQUIPMENT

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

Means are required to support normal and emergency recovery of both Stage II and Stage I following an operational mission, following a mated flight test and following single element flight tests. The means are required in support of the Advanced Space Transport Program objectives (WBS Dictionary Element 0.0). To satisfy this requirement, the means shall consist of emergency recovery forces, logistics support, recovery equipment and recovery software. Additional recovery support of a maintenance nature will be provided by WBS ID 3.0/8.0 equipment as specified in WBS Dictionary Elements 3.0 and 8.0.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

II. SUBSYSTEM-LEVEL DEFINITION

The subsystem-level elements which form the Recovery Equipment system are based on the major functions required for support of Stage recovery, both stages possessing on-board capability for automatic and manual landings. These elements are (see Figure 2.0-W-3):

2.6.1	Recovery Forces (Emergency)
2.6.2	Logistics Support
2.6.3	Recovery Equipment
2.6.4	Recovery Software

III. FUNCTIONAL DESCRIPTION

Each stage of the baseline Space Transport Air Vehicle (WBS ID 1.0) is a manned, reusable vehicle capable of either automatic or manual landings on conventional airport runways similar to landings by conventional military and commercial transport type aircraft. Accordingly, normal landings will require minimal Operating Ground Equipment (OGE) support. In the event emergencies occur, there will be a requirement for recovery forces such as air-sea rescue provided by USAF or provided by CAA. For safe and purge operations, crew needs, payload needs, and data handling needs following either a normal or emergency landing, equipments defined under WBS ID 3.0/8.0 will be required. Logistics support for recovery is concept dependent. Stage II, under baseline requirements, may or may not have air-breathing engines and sufficient fuel tank capability aboard to enable ferry flight to the turnaround facility. In this event, logistics support will be required to deliver necessary GSE, ferry kits, possibly jet fuel, necessary back-up crews, necessary spares and refurbishment items, etc.

For emergency recoveries in addition to or in lieu of the above, certain emergency equipments may also be required.

Accordingly, recovery equipment (and software required to define needed equipments, procedures and support) is defined to include Emergency Recovery Forces (such as Air-Sea Rescue), Logistics Support (aircraft,

jet fuel, gaseous nitrogen for purge requirements, data handling and storage, and spares and refurbishment items), and Recovery Equipment (Emergency equipment, ferry kits, etc.). Recovery software will include any software needed to support the Recovery operations as determined by Command and Control (WBS ID 2.2).

IV. DESIGN REQUIREMENTS

Specific design requirements for Recovery Equipment will be defined in CEI Part I's for the equipments and software needed to support Recovery, both in the flight test and operational phases of the Advanced Space Transport Program. The equipment will be existing, modified or new. Following PDRs on Operating Ground Equipment (OGE), design will determine the Part II specifications (existing, modified or new), review these in CDRs and procure the necessary capability so that Recovery Equipment will be available to support the flight test program when required (see WBS ID 4.0). Operational needs will be based on the Operations Plan (WBS ID 5.0), modified as required by actual flight test experience.

V. INTERFACES

Recovery Equipment basically interfaces with each stage of the Space Transport Air Vehicle according to each stage's unique support requirements (Stage II, WBS ID 1.3; Stage I, WBS ID 1.4). Payload recovery support is to be determined (WBS ID 1.2), but may be treated as part of Stage II for both normal and emergency recoveries. An interface also exists with WBS ID 3.0/8.0 for transport of purge and safing equipment to alternate or emergency landing sites as well as maintenance of the Recovery Equipment, itself. An interface will also exist with transport of backup crews needed for ferry flights. Other program interfaces include WBS ID 4.0 (Systems Test and Evaluation), WBS ID 5.0 (System/Program Management), WBS ID 6.0 (deliverable Data), WBS ID 7.0 (new Operational/Site Activation), WBS ID 9.0 (Initial Spares and Repair Parts, both for transporting these for Recovery as well as spares needed for the Recovery Equipment, itself),

WBS ID 10.0 (Training), WBS ID 11.0 (Inventory and Logistics Support Industrial Facilities), and WBS ID 12.0 (Operations and Services).

VI. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 2.7

TASK TITLE AUXILIARY EQUIPMENT

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

Means are required to support the various operational capabilities of the command and launch equipments needed for the test and operational phases of the Advanced Space Transport Program. The means shall consist of general purpose/multi-usage ground equipment as defined herein.

II. SUBSYSTEM-LEVEL DEFINITION

The Space Transport Air Vehicle will be launched in a vertical mode and land in a horizontal mode similar to landings by conventional military or commercial transport type aircraft. Accordingly, the major requirement for auxiliary equipment is for equipment required to support launches of the Air Vehicle at launch sites to be located at Kennedy Space Center (KSC), at Western Test Range (WTR), or at an inland site. The subsystem level

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

definition for Auxiliary Equipment is, therefore, as follows:

2.7.1 Launch Support Equipment

It is assumed that similar equipment at the recovery site is not peculiar, i.e., is existing and does not require specific definition other than in service manuals already existing. If this assumption is incorrect, then a second element will require definition and subsequent configuration specification during Program Phase C/D, i.e.

2.7.2 Recovery Support Equipment

III. FUNCTIONAL DESCRIPTION

The auxiliary equipment needed to support the launch of the Space Transport Air Vehicle is basically that equipment located on or in the vicinity of the launch umbilical tower (see WBS Dictionary Element 2.5). The Air Vehicle consists of two stages, each manned, which are mated in a vertical assembly building, then checked and delivered to the launch pad on the mobile launch umbilical tower using a crawler/transporter, similar to the concept used to launch Saturn V. The unique shapes of the stages requires an umbilical tower which allows freedom for the aerodynamic surfaces to clear the tower during launch, allows ingress and egress of flight crew and passengers, allows access to the payload bay of Stage II, and provides count-down support such as cryogen loading, ground power (hydraulic, electrical), ground communications, tank purging, venting, pressurization gas loading, etc. (see WBS Dictionary for Air Vehicle (WBS ID 1.0), for Payload (WBS ID 1.2), for Stage II (WBS ID 1.3) and for Stage I (WBS ID 1.4)).

A baseline list of typical auxiliary equipment is tabulated below to identify the interface which requires the equipment. This list is tentative and will be firmed up in Phase C/D.

LAUNCH SUPPORT EQUIPMENT	INTERFACE SUPPORTED
. Pivot and Support Adapter (Stg II)	. Stage II: lift for mating
. Pivot and Support Adapter (Stg I)	. Stage I: lift for vertical positioning

LAUNCH SUPPORT EQUIPMENT	INTERFACE SUPPORTED
. Vehicle Lift Sling	. Both stages: lift for mating and vertical positioning
. Riseoff Disconnect Panels (Launcher)	. Launch Umbilical Tower: enable disconnect at launch
. Launcher Hold Down and Release System	. Launch Umbilical Tower/Stage I: vehicle hold down and release
. Crawler/Transporter	. Launch Umbilical Tower: move Tower & Vehicle to Launch Pad; move away for launch
. Crane, Umbilical Tower	. Launch Umbilical Tower/Air Vehicle: raise vehicle stages to vertical position and for mating
. Emergency Egress System	. Launch Umbilical Tower/Crew/Passengers: enable rapid egress for pad/vehicle emergencies
. Hydraulic Ground Power Unit	. Launch Umbilical Tower/Stages: supply ground hydraulic power prior to APU startup
. Gaseous Helium Service Unit	. Launch Umbilical Tower/Stages: pressurization and purge
. Water-Glycol Unit	. Launch Umbilical Tower/Stage II: supply for ECLSS prior to activation
. ECS Unit (Launcher)	. Launch Umbilical Tower/Stage I: supply conditioned air to crew/equipment compartment prior to launch
. Pneumatic Control Unit (Launcher)	. Launch Umbilical Tower/Stage I: GN_2 distribution for anti-icing and purge prior to launch
. Flex Connections LO_2, LH_2 Residual Drain	. Launch Umbilical Tower/Stages: topping drainage during fill

LAUNCH SUPPORT EQUIPMENT	INTERFACE SUPPORTED
. Flex Connections, Tank Pressurization	. Launch Umbilical Tower/Stages: fill and drain, pressurant liquids/gases
. GN_2 Storage	. Launch Pad/Tower/Stages
. Gaseous Helium Storage	. Launch Pad/Tower/Stages
. Umbilical Disconnects	. Tower/Stages
. Defueling Pit and Connections	. Tower/Stages
. GH_2 Service Units	. Tower/Stages: pre-condition LH_2 vehicle storage tanks
. Electrical Power Cart	. Tower/Stages: supply ground electrical power prior to APU startup
. LH_2 Storage	. Launch Pad/Tower/Stages
. LH_2 Supply Lines	. Launch Pad/Tower/Stages
. LO_2 Storage	. Launch Pad/Tower/Stages
. LO_2 Supply Lines	. Launch Pad/Tower/Stages
. Ground Communications Hard Lines (Voice/Data)	. LCC/Pad/Tower/Stages
. On-Board Software Transport Kit	. Tower/Stages: transport software for pre-launch loading into Data Management mass memory
. Protective Covers	. Stages: protect vehicle critical areas prior to launch. Remove during countdown. Store for re-use
. Lighting	. Tower: provide both tower and Vehicle illumination as required for launch operations
. Optical Reference	. Optical Tracker & IMU (Stage II): azimuth alignment and optics calibration

LAUNCH SUPPORT EQUIPMENT	INTERFACE SUPPORTED
. Closed Circuit TV	. Tower: remote viewing during actual launch; monitoring of critical areas
. Potable Water Transport	. Tower/Stages: transport for crew/passenger use
. Food Transport	. Tower/Stage II: transport for crew/passenger use

IV. DESIGN REQUIREMENTS

The equipment, of the type listed in the foregoing, will be defined in Part I specifications during Phase C/D and reviewed during OGE PDR's. Part II specifications will note whether the required equipment is existing, modified or new. CDR's will verify approval to proceed with procurement and installation required for flight test (see WBS ID 4.7). Specific design requirements must therefore await completion of the system requirements analysis and Part I CEI effort.

V. INTERFACES

The required Launch Support Equipment of the type noted in the preceding table will interface with the launch pad, with the launch control center, with the mobile launch umbilical tower (WBS ID 2.5) and with the stages of the Space Transport Air Vehicle (WBS ID 1.0). Other Program interfaces will include the following: WBS ID 3.0/8.0 (maintenance equipment which both handles Air Vehicle assembly in the vertical assembly building and in the turnaround facility, as well as maintains OGE) WBS ID 4.0 (Systems Test and Evaluation); WBS ID 5.0 (System/Program Management); WBS ID 6.0 (deliverable Data); WBS ID 7.0 (new Operational/Site Activation; WBS ID 4.7 handles site activation for Test); WBS ID 9.0 (Initial Spares and Repair Parts);

2

WBS ID 10.0 (Training); WBS ID 11.0 (Industrial Facilities for Fabrication, Inventory, Logistics Support, Turnaround Facility interfaces); and WBS ID 12.0 (Operations and Services).

VI. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.0

TASK TITLE PECULIAR SUPPORT EQUIPMENT

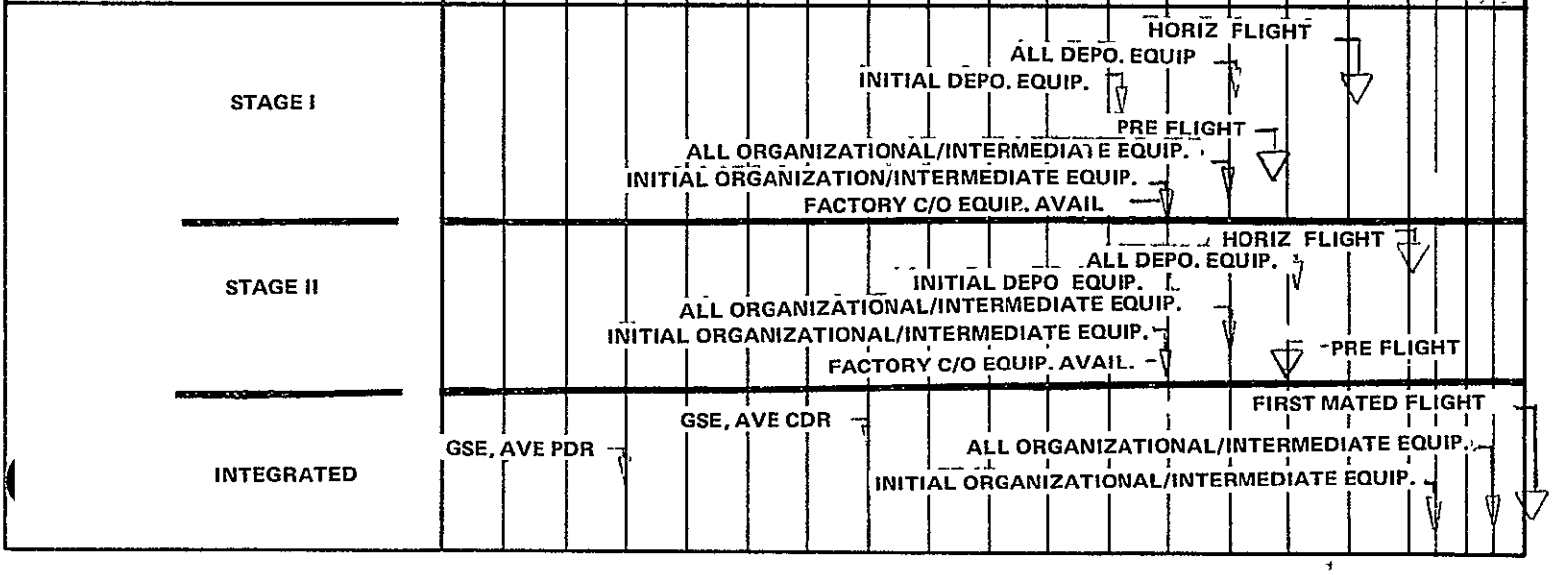
LEVEL 3, Project Level

WBS DICTIONARY

I. REQUIREMENTS

Means are required to maintain the two-stage reusable Space Transport Air Vehicle; to maintain the peculiar Operating Ground Equipment needed to support Vehicle launch, missions and recovery; and to maintain the peculiar maintenance equipment needed to ensure operational capability of the Air Vehicle and its peculiar ground equipment. To satisfy these requirements, which are a part of NASA's Advanced Space Transport Program (WBS ID 0.0), peculiar support equipment is required which provides the following capability to the operational program, as well as to the RDT & E and Investment phases which precede Operations: (1) provide integrated organizational and intermediate level equipment needed to transport, handle, checkout and service the Air Vehicle and its support equipment, including software associated therewith; (2) provide organizational, intermediate and depot level equipment needed

TASK SCHEDULE MILESTONES



to transport, handle, calibrate, test and checkout, service, and repair Stage II and its support equipment, including software associated therewith; and, (3) provide organizational, intermediate and depot level equipment needed to transport, handle, calibrate, test and checkout, service and repair Stage I and its support equipment, including software associated therewith.

II. SYSTEM-LEVEL DEFINITION

Five major elements define the peculiar Maintenance Ground Equipment (MGE) and Depot Maintenance Ground Equipment (DMGE) which comprise the peculiar support equipment for the Advanced Space Transport Program. This equipment is defined in accordance with the three major end items which are a part of this Program (integration, i.e. Air Vehicle peculiar; Stage II peculiar; and Stage I peculiar) and in accordance with the maintenance levels associated with this Program (organizational level, e.g. maintenance associated with the installed on-board vehicle equipment, such as test, fault isolate, remove and replace, checkout; intermediate level, e.g. maintenance associated with the removed air vehicle module or assembly to determine the fault, then remove and replace faulty component or module; and, depot level, e.g. maintenance associated with the faulty component or module to determine the fault, then remove and replace and conduct repair thereon, including post repair checkout). Maintenance associated with the Payload (WBS ID 1.2) is not included, except that transportation and handling (T & H) equipment needed for Integration and Stage II shall, to the extent feasible, be available to support installation/removal of Payload into/from Stage II.

Accordingly, the elements which comprise WBS ID 3.0 (see Figure 3.0-W-4) include the following systems:

3.1	Integrated Organizational/Intermediate Equipment
3.2	Stage II Organizational/Intermediate Equipment
3.3	Stage II Depot Equipment
3.4	Stage I Organizational/Intermediate Equipment
3.5	Stage I Depot Equipment

Details on these systems are provided at lower levels of the WBS Dictionary.

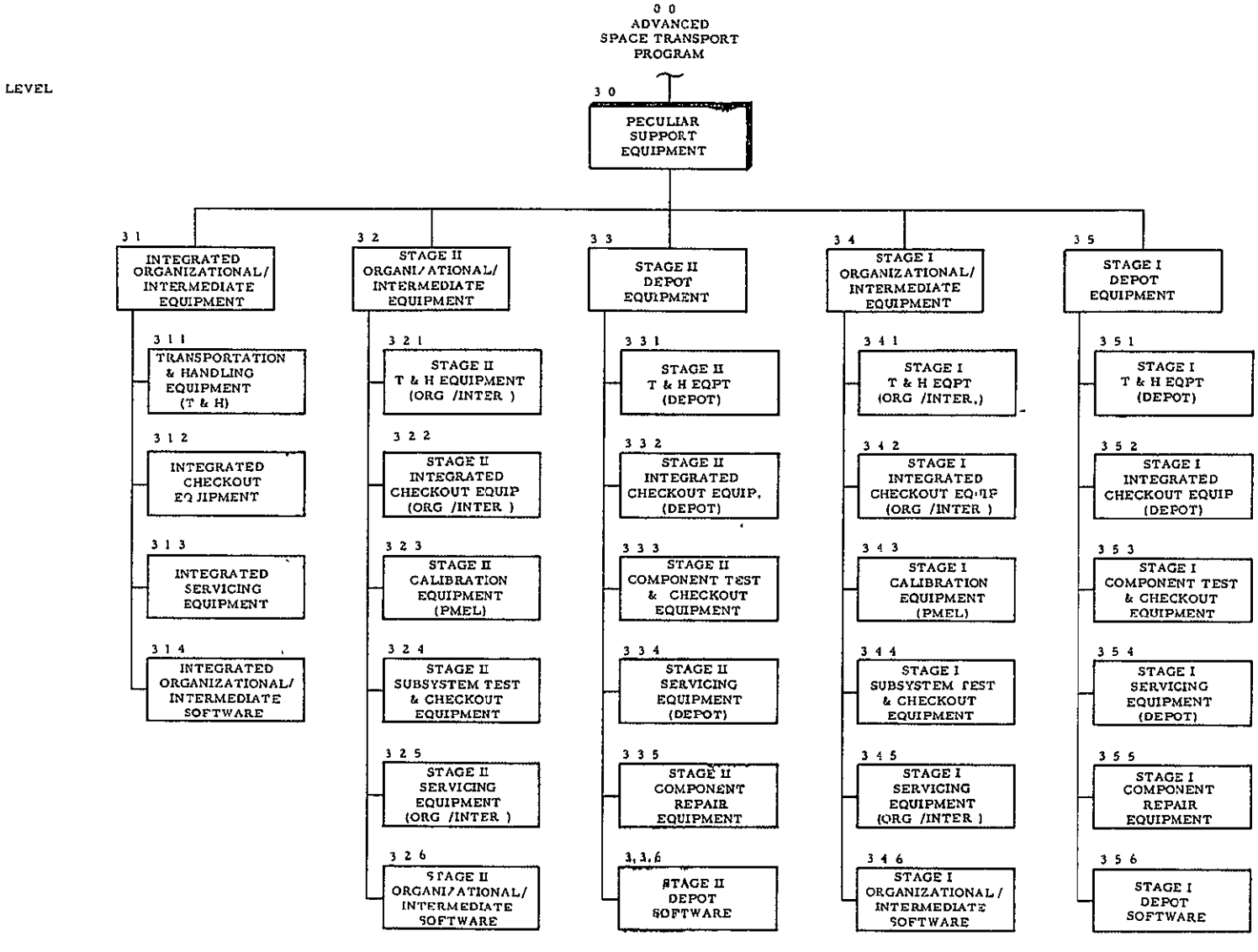


FIGURE 3.0-W-4 WBS, PECULIAR SUPPORT EQUIPMENT
(WBS ID 3.0)

III. FUNCTIONAL DESCRIPTION

At Phase C go-ahead, final design of the Air Vehicle (WBS ID 1.0) and support elements will be initiated. Preliminary design is assumed to be completed (Phase B). Air Vehicle PDRs (WBS ID 5.0) will be held to review Part I specifications of the Contract End Items (CEIs) which each major air vehicle contractor, together with NASA, have defined. These will establish the air vehicle design which must be satisfied with CEIs Part II (WBS ID 1.0).

Following Air Vehicle PDRs, the system requirements analysis (WBS ID 5.0) can be completed to define the Operating Ground Equipment (OGE) required to support launch, flight and recovery of the Air Vehicle and its elements. OGE PDRs will be held to review Part I specifications of the CEI's which each major ground support contractor, together with NASA, have defined. These will establish the OGE designs which must be satisfied with CEIs Part II (WBS ID 2.0).

Following the Air Vehicle PDR, the maintenance analysis, begun in Phase B, can be completed to define the requirements and solutions to these requirements needed to maintain the Air Vehicle (Integration, Stage II, Stage I) at the organizational, intermediate and depot levels. The equipment needed to satisfy the Air Vehicle maintenance analysis is termed MGE (Maintenance Ground Equipment) and DMGE (depot Maintenance Ground Equipment) and will consist of both peculiar (CFE) and common (GFE) equipment needed to transport, handle, test, check-out, calibrate, service and repair the Air Vehicle in accordance with Program objectives and requirements. Peculiar MGE for the Air Vehicle and its Stages will be designed, developed and tested under WBS ID 3.0 as single end items and installed and tested at the using site under WBS ID 4.0 for the systems test program and under WBS ID 7.0 for any new sites which are required. Common MGE, that is equipment which is identified to already by available by Federal Stock Number (FSN) through government stores, will be procured under WBS ID 8.0 and "loaded" according to site need (WBS ID 4.0, 7.0).

Similarly, following OGE PDRs, the maintenance analysis, begun in Phase B, can be completed to define the requirements and solutions to these requirements needed to maintain the peculiar Operating Ground Equipment (OGE) at the organizational, intermediate and depot levels. This equipment is also termed MGE and DMGE in accordance with where, in the maintenance cycle, it is required. Again, design and development is a function as to whether the equipment is peculiar (CFE) or common (GFE), common being procured as FSN equipment under WBS ID 8.0.

Following the maintenance analysis on air vehicle and OGE, maintenance analysis on MGE and DMGE can be completed to identify any new equipments, peculiar and common, needed to maintain this equipment.

At appropriate points, PDRs can be held on CEIs Part I for Air Vehicle MGE/DMGE; OGE MGE/DMGE and MGE and DMGE MGE/DMGE. These PDRs will provide approved requirements for equipment which can be satisfied by either design, development or modified designs or by FSN designation. Thus, CDRs on MGE and DMGE can be held when Part II's or their equivalence demonstrate to NASA that an acceptable end item either exists or can be fabricated or modified to meet the requirement.

IV. DESIGN REQUIREMENTS

The peculiar support equipment (MGE and DMGE) shall be designed to support Program requirements specified in WBS Dictionary Element 0.0, Air Vehicle requirements identified in WBS Dictionary Element 1.0 and lower levels thereof, and Operating Ground Equipment requirements identified in WBS Dictionary Element 2.0 and lower levels thereof. Specific design requirements will be developed in Phase C and delineated on CEIs Part I. Preliminary design requirements for Integrated, Stage II and Stage I vehicle and OGE peculiar support equipment are specified in lower levels of WBS ID 3.0.

V. TEST REQUIREMENTS

Test requirements for peculiar support equipment are specified under lower levels of WBS ID 3.0. Generally, development tests of end item components, assemblies and the end item, itself, are conducted under WBS ID 3.0 at the appropriate level. Installed equipment tests will be conducted under WBS ID 4.0 for test program needs and under WBS ID 7.0 for new operational site needs, if required.

VI. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.1

TASK TITLE INTEGRATED ORGANIZ./ INTERMED. EQUIPMENT

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

Means are required to provide maintenance support to the Air Vehicle while it is on the launch pad or while it is in the vertical assembly building at the launch site. In addition, means are required to assemble Stage I, Stage II, and the GFE payload to form the Air Vehicle. A means is also required to maintain the integrated maintenance equipment. Integration of payload with Stage II prior to and following a mission is tentatively covered under WBS ID 3.2.1, subject to review during Phase C/D. The means shall consist of Integrated Organizational/Intermediate (O/I) Equipment.

II. SUBSYSTEM-LEVEL DEFINITION

Four major elements define the Integrated O/I Equipment. These elements

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

are based on the maintenance philosophy of Organizational Level and Intermediate Level maintenance, i.e. maintenance performed directly on the pre-flight/post-flight vehicle (Organizational Level) and maintenance performed in the support facility (Intermediate Level). Accordingly, the subsystem-level elements include (see Figure 3.0-W-4):

3.1.1	Transportation and Handling Equipment (T & H)
3.1.2	Integrated Checkout Equipment
3.1.3	Integrated Servicing Equipment
3.1.4	Integrated Organizational/Intermediate (O/I) Software

III. FUNCTIONAL DESCRIPTION

For the baseline Space Transport Air Vehicle concept, peculiar support equipment (see WBS Dictionary Element 8.0 for Common Support Equipment) is required for maintenance functions associated with:

- Air Vehicle Assembly/Disassembly
- Integrated Air Vehicle Servicing
- Integrated Air Vehicle Checkout
- Maintenance of Peculiar Integrated O/I Equipment

Three basic operational locations require Integrated O/I Equipment: (1) the Vertical Assembly Building, (2) the Intermediate Level support shop of the Turnaround Facility, and (3) the Stage Landing Sites (Primary, Alternate or Emergency).

During Phase B, an initial maintenance analysis effort has been undertaken to identify the peculiar support, i.e. maintenance, equipment, required for the Air Vehicle and the elements thereof (Payload, Stage II, Stage I). Following Phase C go-ahead, the analysis will be completed in order to specify the required equipment and software and to generate CEI Part I's, hold GSE PDRs, generate CEI Part IIs, hold GSE CDRs and procure the needed equipments. Until the maintenance analysis is completed, a firm definition of needed MGE, its orientation (Integrated, Payload, Stage II, and Stage I), and its origin (peculiar or common) and source (CFE or GFE) must be considered as preliminary.

Lower levels of WBS Dictionary Element 3.1 will identify the Integrated O/I Equipment for the Air Vehicle as presently conceived. Firmer definition must await Phase C/D effort.

IV. DESIGN REQUIREMENTS

Integrated O/I Equipment design requirements will be specified in accordance with the maintenance analysis (WBS ID 5.0) completed in Phase C/D. Basic design requirements shall include performing the needed function (transportation, handling, checkout, servicing) and meeting the environmental, safety, reliability, and maintainability requirements imposed by Systems Engineering. Equipment which must be air transportable will require special design for light weight, ruggedness, reduced packaging size, etc. Specific requirements are dependent on the end usage of each required item, including software.

V. INTERFACES

Integrated O/I Equipment basically interfaces with the end item which it supports (Air Vehicle, Payload, Stage II, Stage I, i.e. WBS ID 1.0). In addition, interfaces will exists with other MGE (WBS ID 3.0/8.0), with the launch facility (WBS ID 4.7, 7.0, 11.0) and with Launch and Recovery OGE (WBS ID 2.0). Other Program interfaces will include WBS ID 5.0 (System/Program Management), WBS ID 6.0 (deliverable Data), WBS ID 9.0 (Initial Spares and Repair Parts), WBS ID 10.0 (Training), and WBS ID 12.0 (Operations and Services).

VI. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.1.1

TASK TITLE TRANSPORT. & HNDLNG. EQUIPT. (T&H) (INTEG.)

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

Integrated Transportation and Handling Equipment (T & H) is required at the launch facility and at Stage landing sites to handle crew egress following a landing and to handle the mating of Stage II to Stage I in the vertical assembly building at the launch site. In addition, Integrated T & H equipment is required in the Intermediate Level maintenance area of the Turnaround Facility to handle maintenance functions which are common to both Stage I and Stage II. These requirements will exist for both flight test and operations.

II. ASSEMBLY LEVEL DEFINITION

The following Integrated T & H Equipments are preliminarily identified for the baseline concept requirements. They are subject to modification during

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

Phase C/D as the maintenance analysis is firmed up. These equipments are vehicle peculiar and do not include any equipment for maintaining OGE or MGE.

WBS ID	NOMENCLATURE	SITE LOCATION	
		LAUNCH SITE*	LANDING SITES**
3.1.1.1	Crew Egress Vehicle		X
3.1.1.2	Tow Tractor	X	X
3.1.1.3	Tow Bar, Nose Gear	X	X
3.1.1.4	Tie-down Cables & Wheel Chocks	X	X
3.1.1.5	Ground Crew Access		X
3.1.1.6	Rocket Engine Sling	X	
3.1.1.7	Air-breathing Engine Sling	X	[1]
3.1.1.8	Engine Removal/Install Fixture (ABES)	X	[1]
3.1.1.9	Wing Handling Load Beam & Sling	X	
3.1.1.10	Rudder Removal/Install Load Beam & Sling	X	
3.1.1.11	Wing "Movable Surface" Handling Fixtures	X	
3.1.1.12	APU Removal/Install Fixture	X	[1]
3.1.1.13	Engine Cowling Cradle (ABES)	X	
3.1.1.14	Rocket Engine Transport Dolly	X	

* Vertical Assembly Building or Turnaround Facility, as appropriate

** Primary, Alternate and Emergency Landing Sites (permanent or air-transportable as appropriate)

[1] Non-scheduled maintenance, only. Requirements to be determined.

WBS ID	NOMENCLATURE	SITE LOCATION LAUNCH SITE	SITE LOCATION LANDING SITES
3.1.1.15	Air-breathing Engine Transport Dolly	X	1
3.1.1.16	Wing Transport Dolly	X	
3.1.1.17	Rudder Transport Dolly	X	
3.1.1.18	ACPS Engine Remove/ Install Fixtures and Sling	X	
3.1.1.19	Generator Sling	X	
3.1.1.20	Brake Handling Fixture	X	
3.1.1.21	Tripod Jacks, Vehicle (Wing Pickup)	X	
3.1.1.22	Tripod Jacks, Vehicle (Fuselage Pickup)	X	
3.1.1.23	Tripod Jacks, Vehicle (Axle Pickup)	X	
3.1.1.24	Air Vehicle Lift and Rotation Sling	X	
3.1.1.25	Erection Tag Line & Winch	X	
3.1.1.26	Vertical Lift, Mobile Load Beam (VAB)	X	
3.1.1.27	LH_2 Tank Truck	X	X

1 See Previous Page

III. FUNCTIONAL DESCRIPTION

The Integrated T & H Equipment supports assembly/disassembly of the Air Vehicle as required by the launch or maintenance operation. In addition, certain equipments are required at the landing sites to support common

Stage recovery requirements. For turnaround maintenance, Integrated T & H Equipment enables disassembly/assembly of assemblies or components common to each Stage in order to perform fault isolation and to return the maintained assembly or component to its original location following repair.

IV. DESIGN REQUIREMENTS

(To be determined. See WBS Dictionary Element 3.1)

V. INTERFACES

Integrated T & H Equipment interfaces with the Air Vehicle and its major elements (WBS ID 1.0, 1.2, 1.3, 1.4). Assembly of the Stages and Payload, and interfaces thereto, are defined in WBS ID 1.1. Other interfaces are as noted in Para. V of WBS Dictionary Element 3.1.

VI. TEST REQUIREMENTS

Integrated T & H Equipment will be tested as specified in CEI Part I/II specifications generated in Phase C/D. Basic end items will be tested under WBS ID 3.1.1. Integrated testing will be performed under WBS ID 4.7 as appropriate.

VII. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.1.2

TASK TITLE INTEGRATED CHECKOUT EQUIPMENT

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

Integrated Checkout Equipment is required at the launch site and landing sites to verify Air Vehicle or Stage readiness to perform flight. Stage-unique checkout and test equipment is covered under WBS ID 3.2 and 3.4. The Equipment shall be automated to the extent consistent with the requirement to ensure all subsystems are essentially flight ready.

II. ASSEMBLY LEVEL DEFINITION

The maintenance analysis which defines the specific equipment needed for Integrated Checkout is incomplete. Accordingly, the following assembly-level definition is preliminary.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

WBS ID	NOMENCLATURE	SITE LOCATION LAUNCH SITE *	SITE LOCATION LANDING SITES **
3.1.2.1	Universal Test Equipment	X	TBD
3.1.2.2	Control Surface Protractors	X	
3.1.2.3	Fuel & Propellant Tank Pressure Tester	X	

* Vertical Assembly Building, Turnaround Facility, Launch Umbilical Tower

** Primary, Alternate and Emergency Landing Sites (permanent or air-transportable, as appropriate)

III. FUNCTIONAL DESCRIPTION

The analysis of required Integrated Checkout, i.e. Air Vehicle unique or common to each Stage, Equipment is incomplete. Universal test equipment implies sets of test and checkout equipment capable of testing each subsystem of the Air Vehicle in order to verify flight readiness, including readiness following maintenance. Until the Vehicle is firmly designed, the specific description of needed test and checkout equipment can only be estimated.

IV. DESIGN REQUIREMENTS

(To be determined. See WBS Dictionary Element 3.1)

V. INTERFACES

Integrated Checkout Equipment interfaces with the subsystems of the Air Vehicle (WBS ID 1.3 and 1.4). Software needed for automatic checkout is provided by WBS ID 3.1.4. Other interfaces are defined in WBS Dictionary Element 3.1, Para. V.

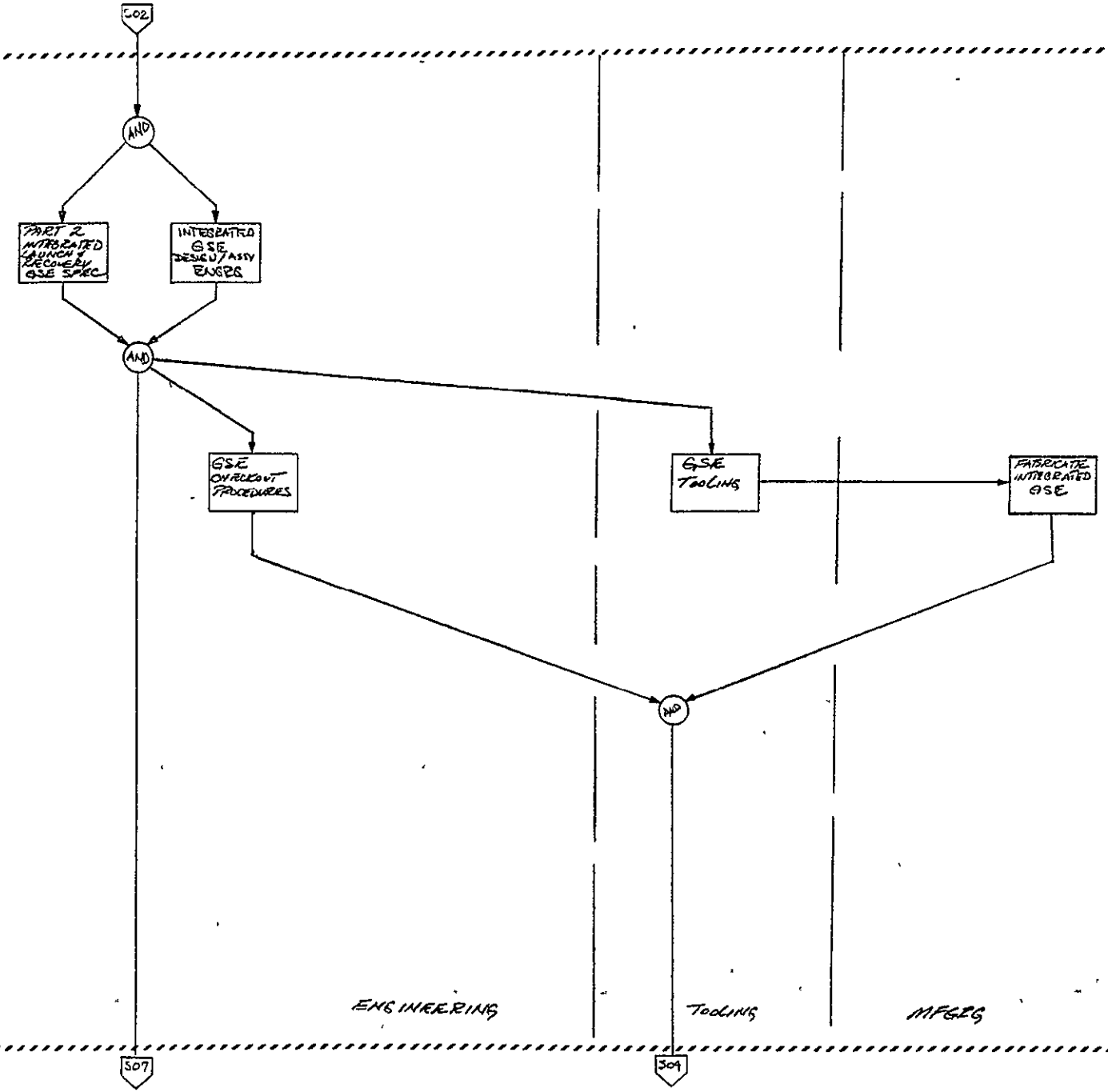
VI. TEST REQUIREMENTS

Integrated Checkout Equipment will be tested as specified in CEI Part I/ Part II specifications generated in Phase C/D. Basic end items will be tested under WBS ID 3.1.2. Integrated testing will be performed under WBS ID 4.7 as appropriate.

VII. REFERENCES

(To be added.)

INPUTS

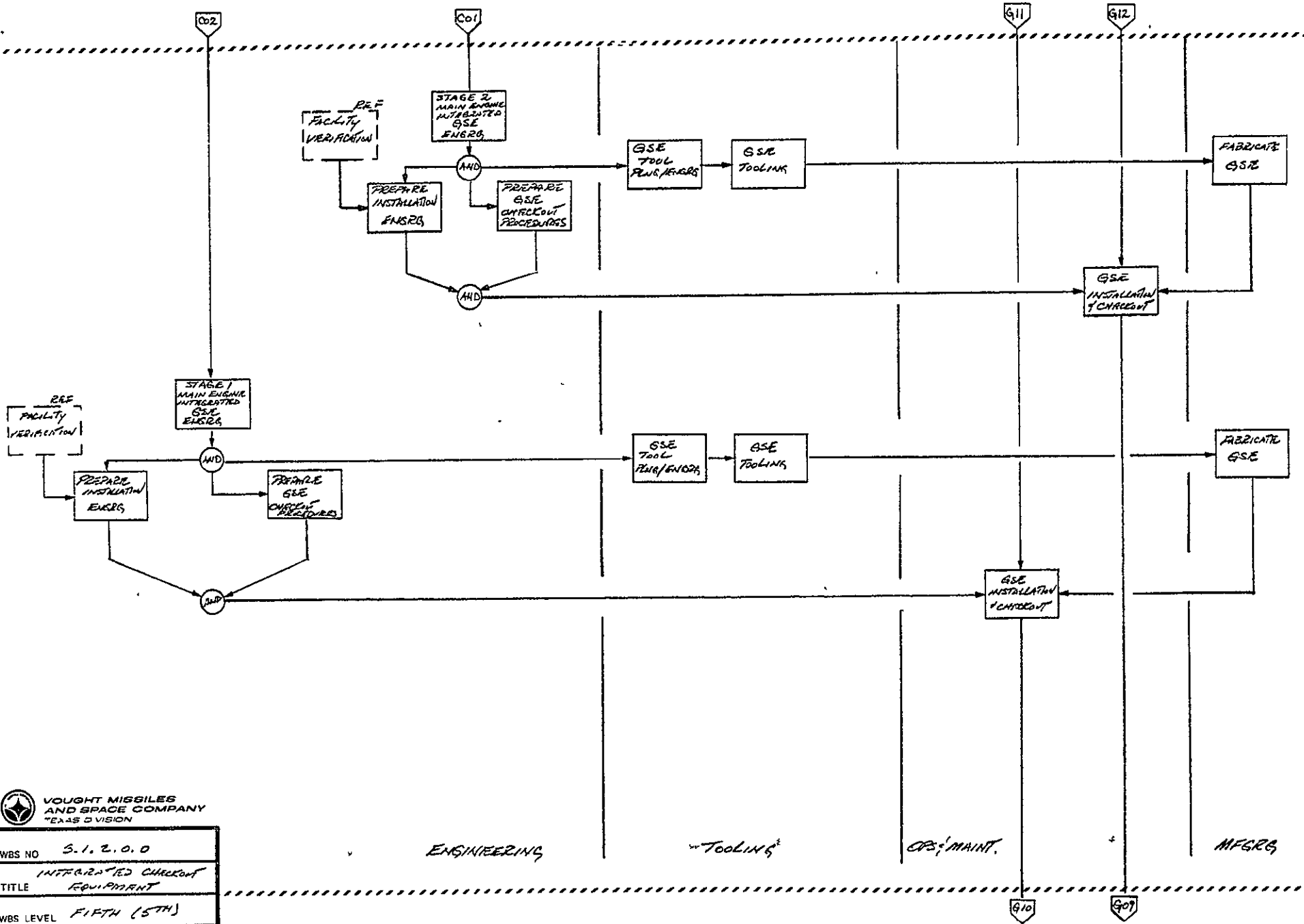


VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	31000
TITLE	INTEGRATED CHECK-OUT EQUIPMENT
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 3
DATE	JUN 71

OUTPUTS

INPUTS

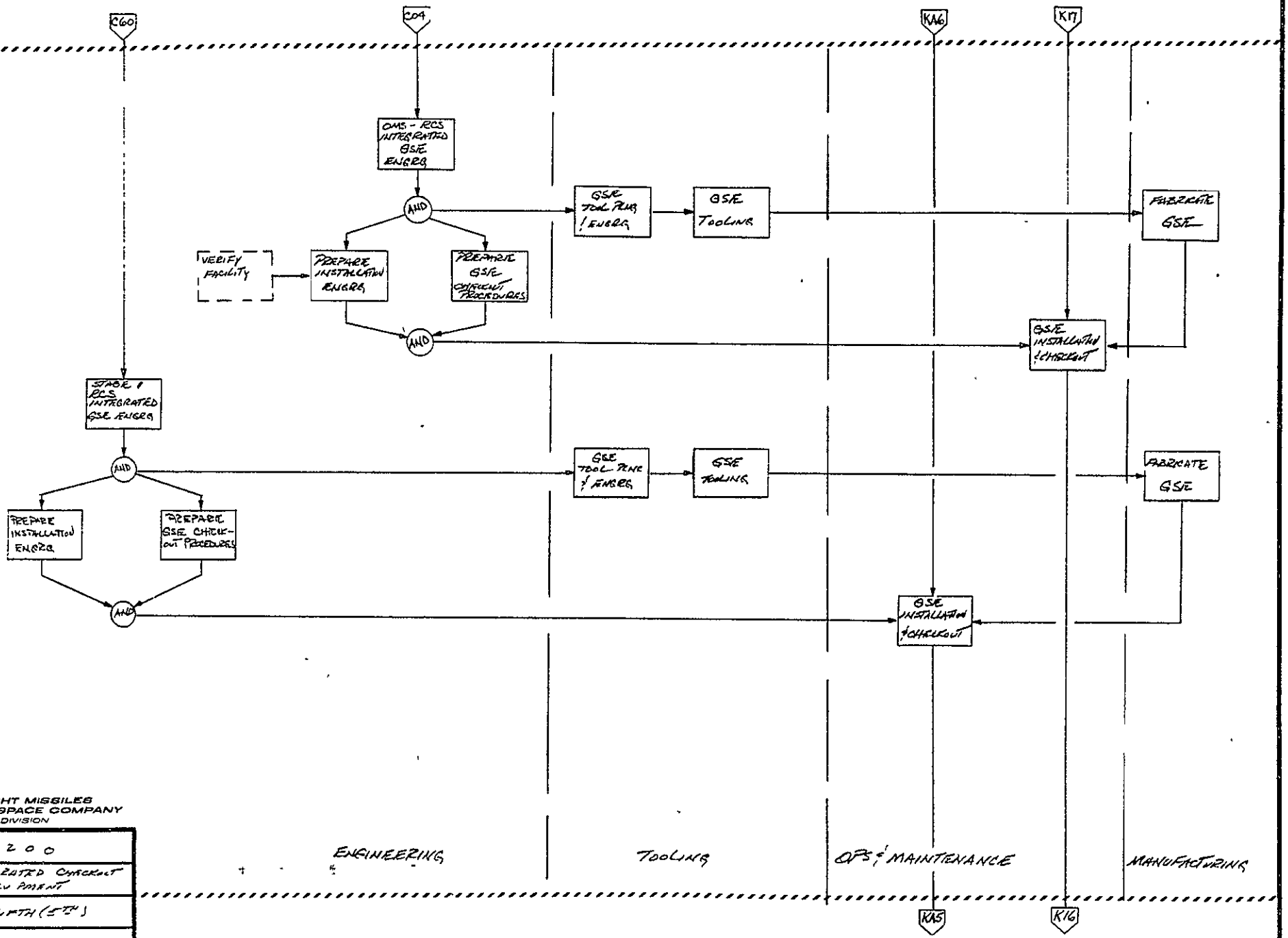


VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	5.1.2.0.0
TITLE	INTEGRATED CHECKOUT EQUIPMENT
WBS LEVEL	FIFTH (5TH)
PAGE	2 OF 3
DATE	7 JUN 71

OUTPUTS

INPUTS



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	3.1 2 0 0
TITLE	INTEGRATED CHECKOUT EQUIPMENT
WBS LEVEL	FIFTH (5TH)
PAGE	3 OF 3
DATE	7 JUN 71

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.1.3

TASK TITLE INTEGRATED SERVICING EQUIPMENT

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

Integrated Servicing Equipment is required at the launch site and Stage landing sites in order to perform servicing and maintenance on the Air Vehicle prior to launch and on the Stages following a mission. Stage-peculiar servicing equipments are covered under WBS ID 3.2 and 3.4 for Organizational/Intermediate Level maintenance and under WBS ID 3.3 and 3.5 for Depot Level maintenance.

II. ASSEMBLY LEVEL DEFINITION

The maintenance analysis which defines the specific equipment needed for Integrated Servicing is incomplete. Accordingly, the following assembly-level definition is preliminary.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

WBS ID	NOMENCLATURE	SITE LOCATION LAUNCH SITE*	SITE LOCATION LANDING SITES**
3.1.3.1	Control Surface Stands	X	X
3.1.3.2	Engine Access Stands (ABES, Main)	X	X
3.1.3.3	Platforms, Data Removal		X
3.1.3.4	Cleaning Units, Vacuum	X	
3.1.3.5	Vehicle External Cleaning Stands	X	
3.1.3.6	Access Panel Removal, Wing (Work Stand)	X	
3.1.3.7	Access Panel Removal, Fuselage (Work Stand)	X	
3.1.3.8	Fuselage Side Work Stand, LH, RH	X	
3.1.3.9	Vertical Mate Access Platform	X	
3.1.3.10	Wheelwell Access, Main Landing Gear (Work Stand)	X	
3.1.3.11	Nose Stand (Work Stand)	X	
3.1.3.12	Nose Gear Area Access Stand	X	
3.1.3.13	Wing Access (Various) (Work Stand)	X	
3.1.3.14	Cockpit Access Stand	X	
3.1.3.15	Mating Area Access Stand (Horizontal) (Work Stand)	X	
3.1.3.16	Vertical Stabilizer Access Stand (Work Stand)	X	

* Vertical Assembly Building or Turnaround Facility O/I area as appropriate

** Primary, Alternate and Emergency Landing Sites (permanent or air-transportable as appropriate)

III. FUNCTIONAL DESCRIPTION

The Integrated Servicing Equipment provides servicing support for the Air Vehicle and to the Stages as common equipment during pre-launch checkout, post-landing operations, and turnaround maintenance. Specific subsystem servicing equipment which is Stage-unique is defined under WBS ID 3.2 through 3.5 as appropriate.

IV. DESIGN REQUIREMENTS

(To be determined. See WBS Dictionary Element 3.1)

V. INTERFACES

Integrated Servicing Equipment interfaces basically with the Air Vehicle and its Stages (WBS ID 1.0, 1.3, 1.4). Other interfaces are defined in WBS Dictionary Element 3.1, Para. V.

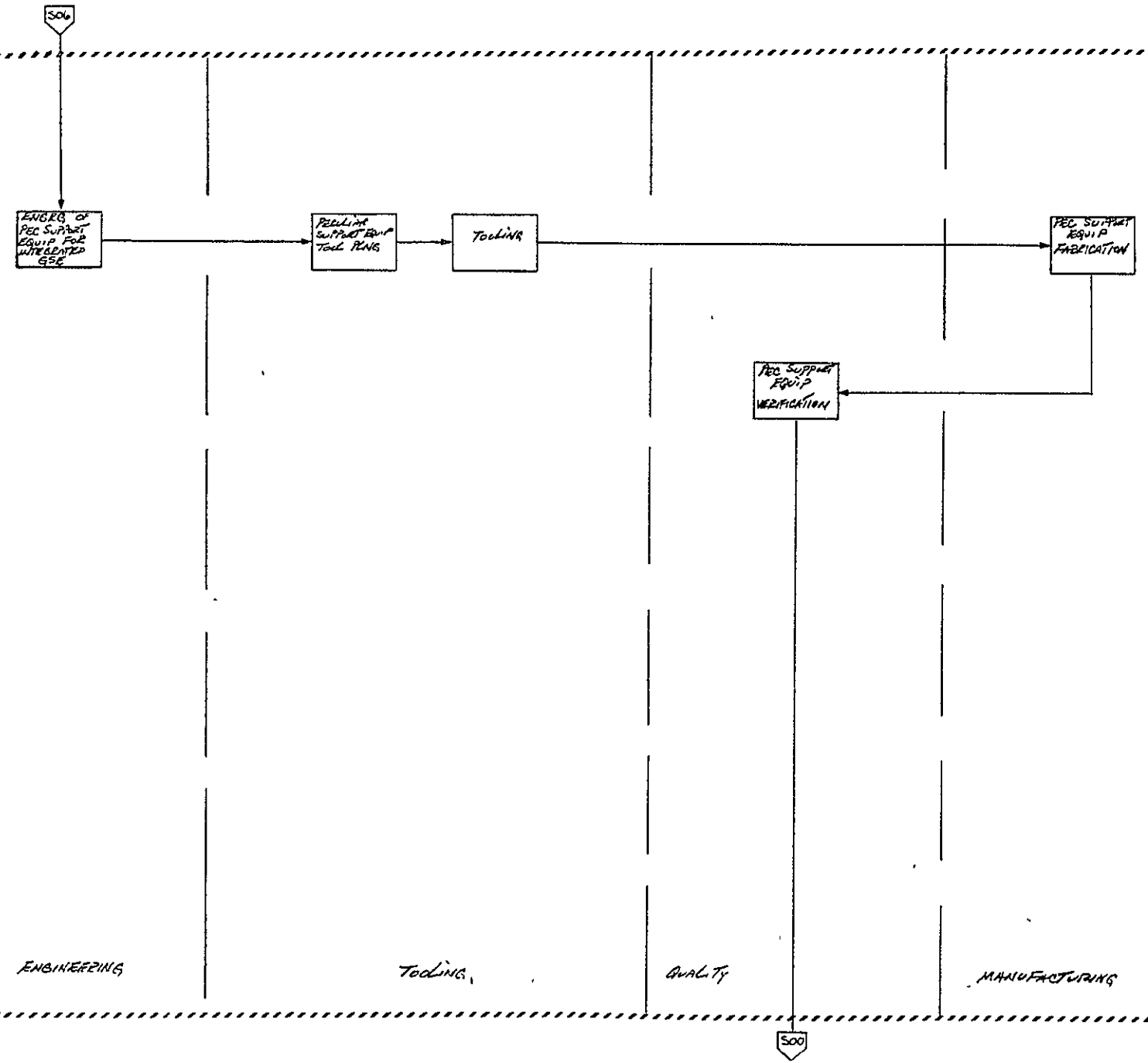
VI. TEST REQUIREMENTS

Integrated Servicing Equipment will be tested as specified in CEI Part I/II Specifications generated in Phase C/D. Basic end items will be tested under WBS ID 3.1.3. Integrated testing will be performed under WBS ID 4.7 as appropriate.

VII. REFERENCES

(To be added.)

INPUTS



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	3.1.9 0.0
TITLE	INTEGRATED SERVICING EQUIPMENT
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	1 JUN 71

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO 3.1.4

TASK TITLE INTEGRATED ORG./ INTERMED. SOFTWARE

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

Integrated Organizational/Intermediate (O/I) Software is required to enable checkout of the Air Vehicle prior to transport to the launch pad. Inasmuch as each individual Stage of the Air Vehicle will have its own software for Stage checks, the required Integrated O/I Software will essentially provide end-to-end checks to be used with Integrated Checkout Equipment (WBS ID 3.1.2) after Vehicle assembly but prior to pad countdown.

II. ASSEMBLY LEVEL DEFINITION

Definition of the specific executive program, sub-programs and subroutines required for Air Vehicle checkout has not been defined at this time.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

III. FUNCTIONAL DESCRIPTION

The baseline concept for the launch site operations is as follows (assume an initial launch):

- Individual Stage receival at turnaround facility
- Perform premate checkout (individual Stages)*
- Perform Vehicle erection and assembly**
- Transfer and install at pad
- Perform launch operations***

* Software for this function is Stage-unique. See WBS 3.2.6 and 3.4.6

** WBS 3.1.4 software, i.e. end-to-end verification of flight readiness. During this event, flight programs (WBS ID 1.3.10.7 and 1.4.10.5) are loaded aboard each Stage prior to mating (mission & targeting data, subsystem management, configuration management, checkout and fault isolation, displays and controls data, and the executive program)

*** Software for this function is included in WBS ID 2.5.4, i.e. checkout prior to launch, including software to control launch operations

From the above, it is noted that Integrated O/I Software is basically that software which enables end-to-end verification of Vehicle continuity following mating in the vertical assembly building, but prior to pad operations. Inasmuch as detailed checkout of each Stage is performed both in the final assembly area and at the pad, the integration check is basically one of continuity (electrical, mechanical, voice, data, separation integrity).

Details on how this check will be performed and what specific software is required will be firmed up following Phase C go-ahead. Advantage will be taken of the inherent self-check capability each Stage possesses using on-board avionics and software for this purpose (see WBS Dictionary Element 1.3.10 and 1.4.10).

IV. DESIGN REQUIREMENTS

(To be determined)

V. INTERFACES

Integrated O/I Software interfaces with Integrated Checkout Equipment (WBS ID 3.1.2) and with the Air Vehicle (WBS ID 1.0). Other interfaces are specified in WBS Dictionary Element 3.1, Para. V.

VI. REFERENCES

(To be added)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.2

TASK TITLE STAGE II ORG. / INTERMEI EQUIPMENT

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

Means are required to provide maintenance support to Stage II at the Organizational/Intermediate (O/I) Level maintenance facilities. Operationally, this will include the turnaround facility, the mating facility, the launch pad and the recovery sites. During test phases of the Program, the above maintenance is also required as well as maintenance performed at the horizontal test site. Where applicable, the equipments and software required for on-site maintenance of Stage II should also be utilized for factory test and checkout including pre-flight and ferry tests.

II. SUBSYSTEM-LEVEL DEFINITION

Six major elements define Stage II O/I Equipment. These include (see Figure 3.0-W-4):

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

3.2.1	Stage II Transportation and Handling (T & H) Equipment (Organizational/Intermediate)
3.2.2	Stage II Integrated Checkout Equipment (Org. /Inter.)
3.2.3	Stage II Calibration Equipment (PMEL)
3.2.4	Stage II Subsystem Test and Checkout Equipment
3.2.5	Stage II Servicing Equipment (Org. /Inter.)
3.2.6	Stage II Organizational/Intermediate Software

III. FUNCTIONAL DESCRIPTION

For the baseline Stage II concept, peculiar support equipment (see WBS Dictionary Element 8.0 for Common Support Equipment) is required for maintenance functions associated with:

- Payload installation/removal and handling interfaces with Stage II
- Stage II integrated checkout
- Stage II subsystem test and checkout
- Stage II component calibration
- Stage II servicing
- Transporting and handling Stage II, its subsystems, assemblies and components
- Crew and passenger transportation
- Data handling and storage

Maintenance equipment to meet these functions will be required at the launch site, landing sites and flight test sites. If applicable, specific equipment will also be required at the factory (see WBS Dictionary Elements 1.3.1 and 1.4.1).

During Phase B, an initial maintenance analysis effort has been undertaken to identify the peculiar, i.e. maintenance, equipment required for the Air Vehicle, for Stage II and for Stage I, including Payload interfaces with Stage II. Following Phase C go-ahead, the analysis will be completed in order to specify the required equipment and software and to generate CEI Part I's, hold GSE PDRs, generate CEI Part II's, hold GSE CDRs and procure the needed equipments. Until the maintenance analysis is completed,

a firm definition of needed MGE, its orientation (Integrated, Payload, Stage II and Stage I), and its origin (peculiar or common) and source (CFE or GFE) must be considered as preliminary.

Lower levels of WBS Dictionary Element 3.2 will identify the Stage II O/I Equipment as presently conceived. Firmer definition must await Phase C/D effort.

IV. DESIGN REQUIREMENTS

Stage II O/I Equipment design requirements will be specified in accordance with the maintenance analysis (WBS ID 5.0) completed in Phase C/D. Basic design requirements shall include performing the needed functions (transportation, handling, checkout, calibration, test and checkout, servicing) and meeting the environmental, safety, reliability, and maintainability requirements imposed by Systems Engineering. Equipment which must be air-transportable will require special design for light weight, ruggedness, reduced packaging size, etc. Specific requirements are dependent on the end usage of each required item, including software.

I. INTERFACES

Stage II O/I Equipment basically interfaces with the end item which it supports (Payload, Stage II, i.e. WBS ID 1.2 and 1.3, respectively). In addition, interfaces will exist with other MGE (WBS ID 3.0/8.0), with the launch facility (WBS ID 4.7, 7.0, 11.0), with launch and recovery equipment (WBS ID 2.0), and with the horizontal flight test operation (WBS ID 4.5). If this GSE is required in the factory to support final assembly and checkout, an interface will exist with WBS ID 11.0. Other Program interfaces will include WBS ID 5.0 (System/Program Management), WBS ID 6.0 (deliverable Data), WBS ID 9.0 (Initial Spares and Repair Parts), WBS ID 10.0 (Training) and WBS ID 12.0 (Operations and Services).

VI. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.2.1

TASK TITLE STAGE II T & H EQPT. (ORG./INTER.)

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

Stage II Transportation and Handling (T & H) Equipment (Organizational/ Intermediate) is required operationally at the launch site and at Stage II landing sites to handle the installation of payload into or removal from Stage II, to handle passenger egress following a landing and to handle Stage II - peculiar assemblies and components. Stage II T & H equipment which is common with Stage I T & H equipment is covered under WBS ID 3.1.1, Integrated T & H equipment. A requirement also exists for this equipment during test phases of the Program and may exist for factory final assembly operations as applicable.

II. ASSEMBLY LEVEL DEFINITION

The following Stage II T & H Equipments are preliminarily identified for

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

the baseline concept requirements. They are subject to modification during Phase C/D as the maintenance analysis is firmed up. These equipments are vehicle peculiar and do not include any equipment for maintaining OGE or MGE.

WBS ID	NOMENCLATURE	SITE LOCATION LAUNCH SITE*	LANDING SITES**
3.2.1.1	Passenger Egress Vehicle		X
3.2.1.2	Protective Passenger Transport (Bus)		X
3.2.1.3	Nose Landing Gear Removal Dollies	X	
3.2.1.4	Main Landing Gear Removal Dollies	X	
3.2.1.5	Thrust Ring Removal and Handling Sling	X	
3.2.1.6	Payload Install/Remove GSE Slings	X	X
3.2.1.7	Payload Guide-Rails Install/Remove	X	X
3.2.1.8	Payload Handling Load Beam-Vertical & Horizontal	X	X
3.2.1.9	Payload Transport Cart	X	X
3.2.1.10	Payload Door Removal/Install Sling	X	X
3.2.1.11	Payload Door Transport Cart	X	X
3.2.1.12	Payload Door Storage Cart	X	X

* Turnaround Facility (Operations)

** Primary, Alternate, Emergency Landing Sites (Operations)

III. FUNCTIONAL DESCRIPTION

Stage II T & H Equipment (Org. /Inter.) is required to support Stage II - peculiar transportation and handling needs. The preceding list of equipment is preliminary. As noted, T & H equipment supports payload, passengers, and certain vehicle assembly needs required for maintenace functions. This equipment list is preliminary at this time and will be firmed up during Phase C/D as the maintenance analysis is completed. T & H equipment common to both Stage II and to Stage I is covered under WBS Dictionary Element 3.1.1.

IV. DESIGN REQUIREMENTS

(To be determined. See WBS Dictionary Element 3.2.)

V. INTERFACES

Stage II T & H Equipment (O/I) interfaces with Stage II (WBS ID 1.3), with the Payload (WBS ID 1.2), and with the Passengers. Other interfaces are as noted in Para. V of WBS Dictionary Element 3.2.

VI. TEST REQUIREMENTS

Stage II T & H Equipment (O/I) will be tested as specified in CEI Part I/II specifications generated in Phase C/D. Basic end items will be tested under WBS ID 3.2.1. Integrated testing will be performed under WBS ID 4.5 and 4.7.

VII. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.2.2

TASK TITLE STAGE II INTEGRATED CHECKOUT EQPT. (O/I)

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

Stage II Integrated Checkout Equipment (Organizational/Intermediate) is required for checking the Stage prior to a flight to verify readiness for the mission. This requirement exists prior to mating Stage II to Stage I for operational missions and following maintenance performed in the turnaround facility after mission return. A similar requirement exists during the test program for both horizontal and vertical flight test. As applicable, this equipment may be used for factory final assembly checkout.

II. ASSEMBLY LEVEL DEFINITION

The Phase B maintenance analysis is incomplete and will be firmed up in Phase C/D. Accordingly, the following assembly-level equipments are preliminary.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

WBS ID	NOMENCLATURE	SITE LOCATION LAUNCH SITE*	LANDING SITES**
3.2.2.1	Payload Weighing and Balancing Fixture	X	
3.2.2.2	Master Tooling GSE - Interface Control (Payload/ Stage II/Docking Module)	X	
3.2.2.3	Universal Test Equipment	X	X

* Turnaround Facility (Pre-Flight area)(Operations)
** Primary, Alternate and Emergency Landing Sites (Operations)

III. FUNCTIONAL DESCRIPTION

The Stage II Integrated Checkout Equipment (O/I) is required to verify that Stage II and its payload are flight ready, Inasmuch as on-board avionics provides the capability for this checkout, once the vehicle is energized, the amount of ground support equipment can be minimized. A ground-test software program (WBS ID 3.2.6), similar to the on-board checkout software used to verify launch pad readiness, will be required, together with the ground support equipment required to program the on-board computer. In addition to vehicle checkout, the payload weighing and balancing fixture and master tooling will enable payload interfaces to be determined. Servicing equipment (WBS ID 3.2.5) will be needed to support the checkout function.

As required, certain test equipment will be required at the landing site to verify ferry flight readiness.

Similar use of this equipment will be required to support flight test.

IV. DESIGN REQUIREMENTS

(To be determined. See WBS Dictionary Element 3.2.)

V. INTERFACES

Stage II Integrated Checkout Equipment (Org. /Inter.) interfaces with Stage II and its payload (WBS ID 1.3 and 1.2, respectively). Other interfaces are as noted in Para. V of WBS Dictionary Element 3.2.

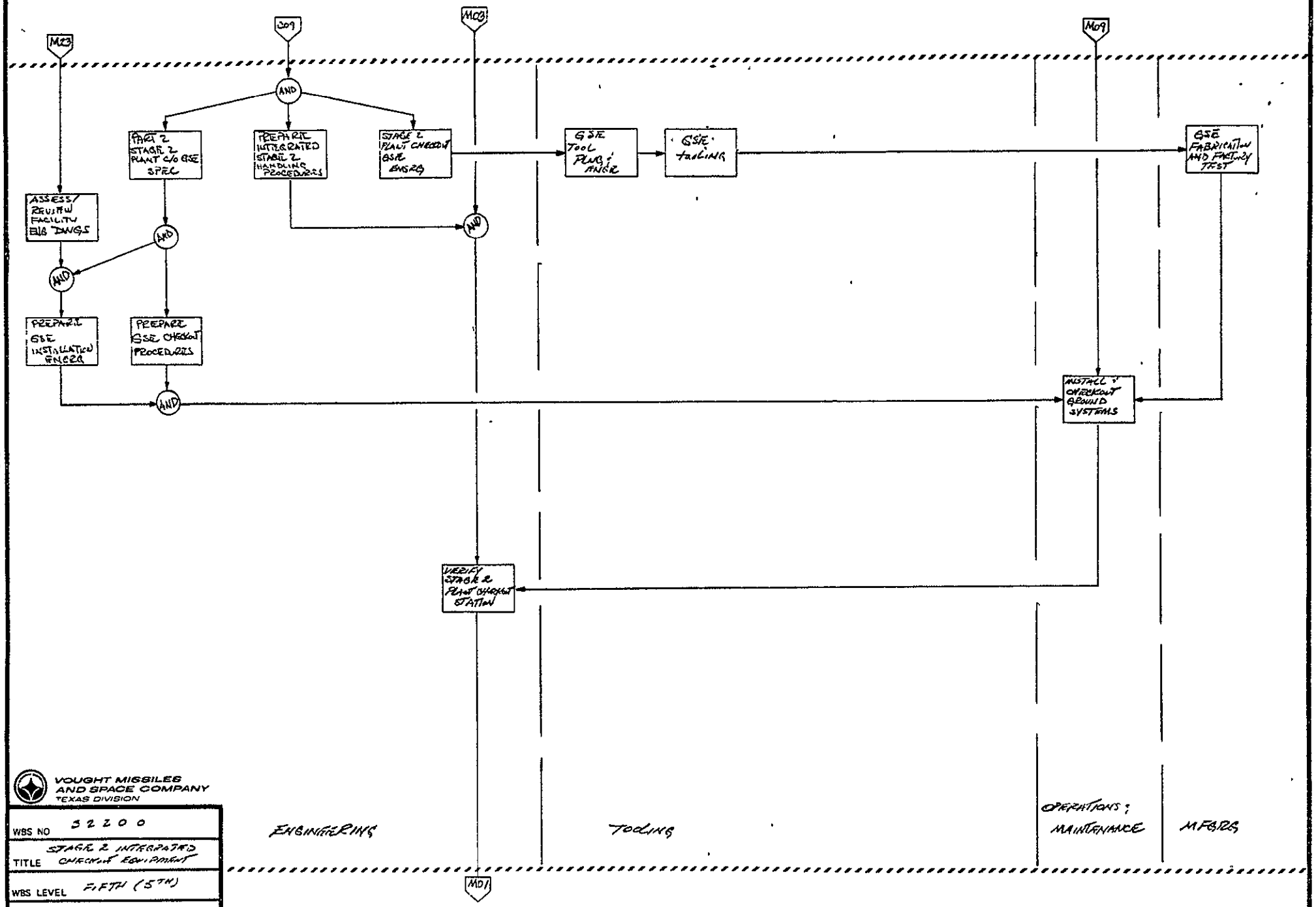
VI. TEST REQUIREMENTS

Stage II Integrated Checkout Equipment (Org. /Inter.) will be tested as specified in CEI Part I/II specifications generated in Phase C/D. Basic end items will be tested under WBS ID 3.2.2. Integrated testing will be performed under WBS ID 4.5 and 4.7.

VII. REFERENCES

(To be added.)

INPUTS



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	52200
TITLE	STAGE 2 INTEGRATED CHECKOUT EQUIPMENT
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	7 JUN 71

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.2.3

TASK TITLE STAGE II CALIBRATION EQUIPMENT (PMEL)

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

Stage II Calibration Equipment (Precision Measuring Equipment Laboratory, PMEL) is required to calibrate instruments and instrumentation which are part of Stage II. This requirement also extends to ground support equipment used to test and checkout Stage II and its subsystems during operations and maintenance, including test programs preceding IOC.

II. ASSEMBLY LEVEL DEFINITION

Specific equipments needed to satisfy the requirements are not identified at this time. These equipments will be defined during Phase C/D.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

III. FUNCTIONAL DESCRIPTION

As noted in the WBS Dictionary descriptions of Stage II (WBS ID 1.3 and lower levels thereto), a considerable variety of controls, displays, and instrumentation exist, all of which require precise calibration to ensure accurate indications of the affected parameter measured, operated on, and/or displayed to the crew. To maintain this equipment in an accurate read-out state, it will be necessary to provide a laboratory and equipment which can handle the calibration requirements.

In addition to vehicle equipment calibration needs certain OGE, MGE and DMGE which supports Stage II will also require calibration.

To the extent feasible, common calibration requirements which exist between Stage II and Stage I should be identified so as to consolidate the Advanced Space Transport Program calibration equipment needs. Subcontracting to responsible non-Program agencies should also be evaluated.

IV. DESIGN REQUIREMENTS

(To be determined. See WBS Dictionary Element 3.2.)

V. INTERFACES

StageII Calibration Equipment (PMEL) interfaces basically with Stage II (WBS ID 1.3). Other interfaces are to be determined (OGE, MGE, DMGE). See Para. V of WBS Dictionary Element 3.2 for other Program interfaces.

VI. TEST REQUIREMENTS

(To be determined.)

VII. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.2.4

TASK TITLE STAGE II SUBSYSTEM TEST & C. O. EQUIPMENT

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

Stage II Subsystem Test and Checkout Equipment is required to fault isolate malfunctioning subsystems both on-board the Stage (Organizational Level) and in the Intermediate Level maintenance area of the turnaround facility and to checkout repaired or replaced modules to verify fault removal and satisfactory subsystem operation following repair. This same requirement will exist during test programs which precede IOC. For faulty Stages returning from a mission, certain test and checkout capability will be required at the landing site.

II. ASSEMBLY LEVEL DEFINITION

During Phase B, an initial maintenance analysis has been performed to preliminarily identify the equipments needed for subsystem test and checkout.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

The analysis is incomplete and will be firmed up in Phase C/D. Therefore, the following assembly-level definition is to be considered as preliminary.

WBS ID	NOMENCLATURE	SITE LOCATION	
		LAUNCH SITE*	LANDING SITES**
3.2.4.1	Servo Valve Test Stand	X	
3.2.4.2	APU Test Stand	X	
3.2.4.3	Generator Test Stand	X	
3.2.4.4	Jet Engine Starting Cart	X	X
3.2.4.5	Hydraulic Valve Test Stand	X	
3.2.4.6	Air-breathing Engine Test Stand with Silencer	X	
3.2.4.7	Payload Air-lock Test Device	X	
3.2.4.8	Hydraulic Pump and Motor Test Stand	X	
3.2.4.9	Ordnance Test Set	X	

* Turnaround Facility (Operations)
** Primary, Alternate, Emergency (Operations)

III. FUNCTIONAL DESCRIPTION

Prior to flight, on-board avionics and software are available in the baseline Stage II concept to interrogate each subsystem to determine flight readiness. If a fault exists, it will be displayed. Certain test equipment will be required to verify that an on-board fault exists to enable remove and replace and checkout to verify that the fault is removed. Following a mission, capability will exist to similarly denote an on-board failure. If the landing is at a remote site, means will be required to similarly verify the on-board failure for remove and replace and checkout. For subsystem elements removed from the vehicle, a need will exist in the Intermediate Level maintenance area of the turnaround facility for test and checkout equipment, and for support equipment, to perform fault isolation and to remove and replace and checkout

the faulty module or component for delivery to the depot. This maintenance concept is standard with all major DoD agencies employing major systems similar to the Space Transport. For jet engine maintenance, a tradeoff exists as to what level of maintenance should the Advanced Space Transport Program provide direct support as opposed to utilizing existing commercial facilities. Similarly, sensitive avionics items (IMUs, communications equipment, computers, etc.) may best be maintained in existing laboratories established for these purposes. This decision must be firmed up early in Phase C/D to ensure a capability exists when required for flight test.

IV. DESIGN REQUIREMENTS

(To be determined. See WBS Dictionary Element 3.2.)

V. INTERFACES

Stage II Subsystem Test and Checkout Equipment basically interfaces with Stage II (WBS ID 1.3). Where common equipment exists with Stage I, this may reduce the amount of equipment required to support Air Vehicle maintenance. Inasmuch as certain OGE, MGE and DMGE must also be maintained there is an interface with that equipment also. See WBS Dictionary Element 3.2, Para. V, for other Program interfaces.

VI. TEST REQUIREMENTS

Stage II Subsystem Test and Checkout Equipment (O/I) will be tested as specified in CEI Part I/II specifications generated in Phase C/D. Basic end items will be tested under WBS ID 3.2.4. Integrated testing will be performed under WBS ID 4.5 and 4.7.

VII. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.2.5

TASK TITLE STAGE II SERVICING EQPT. (ORG./INTER.)

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENT

Stage II Servicing Equipment (Organizational/Intermediate) is required in order to support maintenance operations on Stage II at the turnaround facility and at the landing site. Similar requirements for this equipment exist during test phases of the Advanced Space Transport Program

II. ASSEMBLY LEVEL DEFINITION

Phase B maintenance analysis has disclosed a preliminary list of servicing equipment required to support Organizational and Intermediate Level maintenance of Stage II. This list will be modified and upgraded in Phase C/D.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

WBS ID	NOMENCLATURE	SITE LOCATION LAUNCH SITE*	LANDING SITES**
3.2.5.1	GN_2 Purge Hose Kit		X
3.2.5.2	Ground Crew Access		X
3.2.5.3	Rigging Pins & Safety Locks		X
3.2.5.4	Nose Landing Gear Trunnion Shaft Puller	X	
3.2.5.5	Main Landing Gear Trunnion Shaft Puller	X	
3.2.5.6	Hydraulic Ground Power Unit	X	X
3.2.5.7	Air Conditioning Unit	X	X
3.2.5.8	Coolant Unit	X	X
3.2.5.9	Electrical Power Cart	X	X
3.2.5.10	Pneumatic Control Cart	X	
3.2.5.11	GH_2 Burn Stack		X
3.2.5.12	Blast Deflectors (Fuselage Protection, Engine Runup)	X	
3.2.5.13	Air-breathing Engine Maintenance Stand	X	
3.2.5.14	Hand Tools, Special Design (Set)	X	
3.2.5.15	Payload Area Access Stand (with Crane)	X	X
3.2.5.16	Payload Area Access Stands, LH/RH	X	X
3.2.5.17	Payload Area Access Stand Load Bar & Sling	X	X
3.2.5.18	Payload Storage Stand	X	X
3.2.5.19	Payload Work Stands	X	X
3.2.5.20	Gaseous Helium Service Units	X	
3.2.5.21	GN_2 Storage		X

* Turnaround Facility (Operations)
** Primary, Alternate, Emergency (Operations)

III. FUNCTIONAL DESCRIPTION

The Stage II Servicing Equipment (O/I) provides maintenance support capability for Stage II at both the turnaround facility, the launch pad (as required) and at the landing sites. Following a landing, a need will exist for safing and purging the Stage, removing the payload, applying ground power for any checkout needed, burning off any remaining GH_2, etc. In the turnaround facility, maintenance and refurbishment will require ground power, access to the payload bay, and possibly engine runup. Air-breathing engines must be checked and serviced.

During Phase C/D, the maintenance analysis for servicing equipment requirements (including test requirements) will be completed enabling a complete list of equipment to be defined, reviewed and procured in time for test program needs. Integration of Stage II and Stage I Servicing Equipment will be needed to define common requirements/solutions.

IV. DESIGN REQUIREMENTS

(To be defined. See WBS Dictionary Element 3.2.)

V. INTERFACES

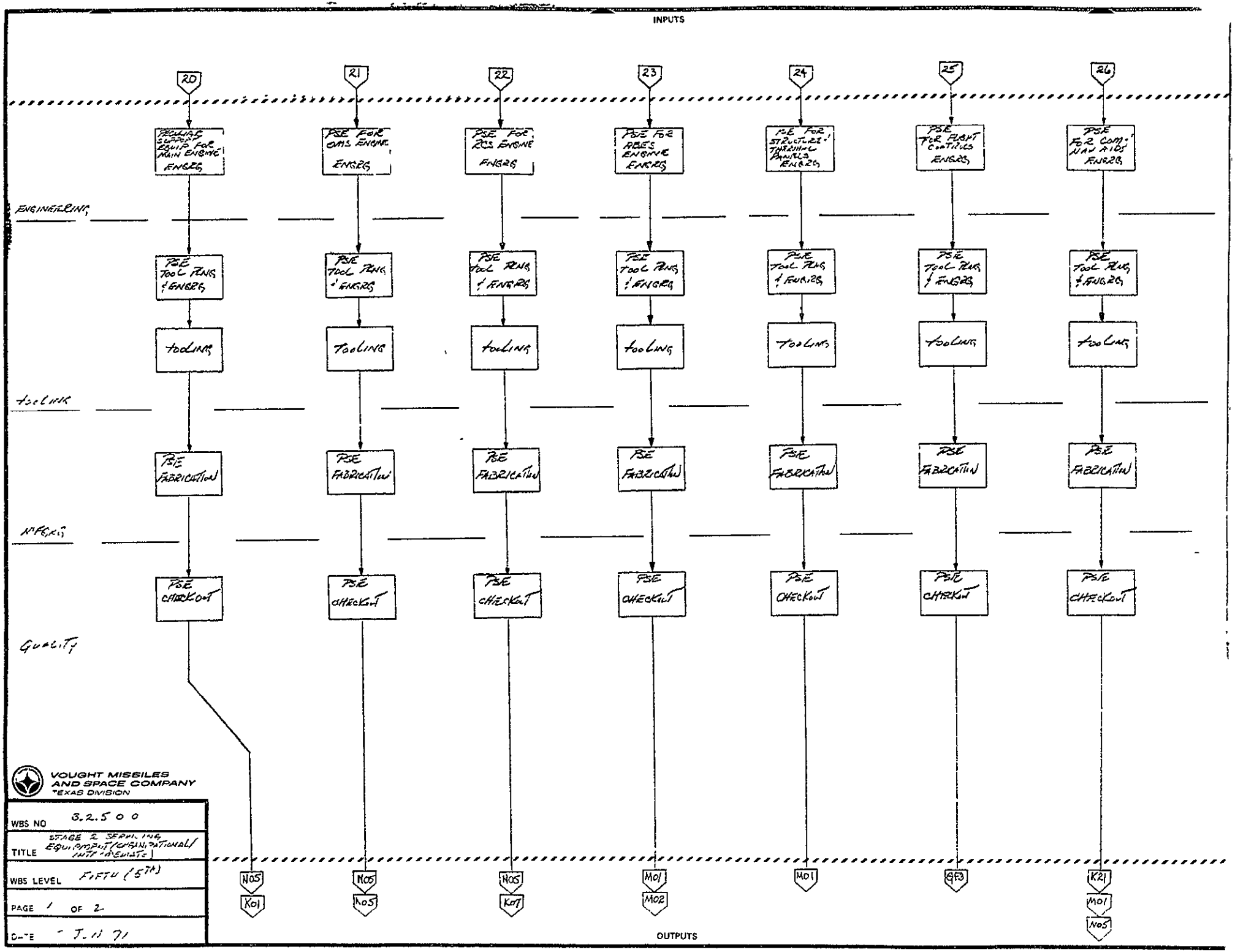
Stage II Servicing Equipment (O/I) basically interfaces with Stage II and its Payload (WBS ID 1.3 and 1.2, respectively). Other interfaces are specified in WBS Dictionary Element 3.2, Para. V.

VI. TEST REQUIREMENTS

Stage II Servicing Equipment (O/I) will be tested as specified in CEI Part I/II specifications generated in Phase C/D. Basic end items will be tested under WBS ID 3.2.5. Integrated testing will be performed under WBS ID 4.5 and 4.7.

VII. REFERENCES

(To be added.)


INPUTS
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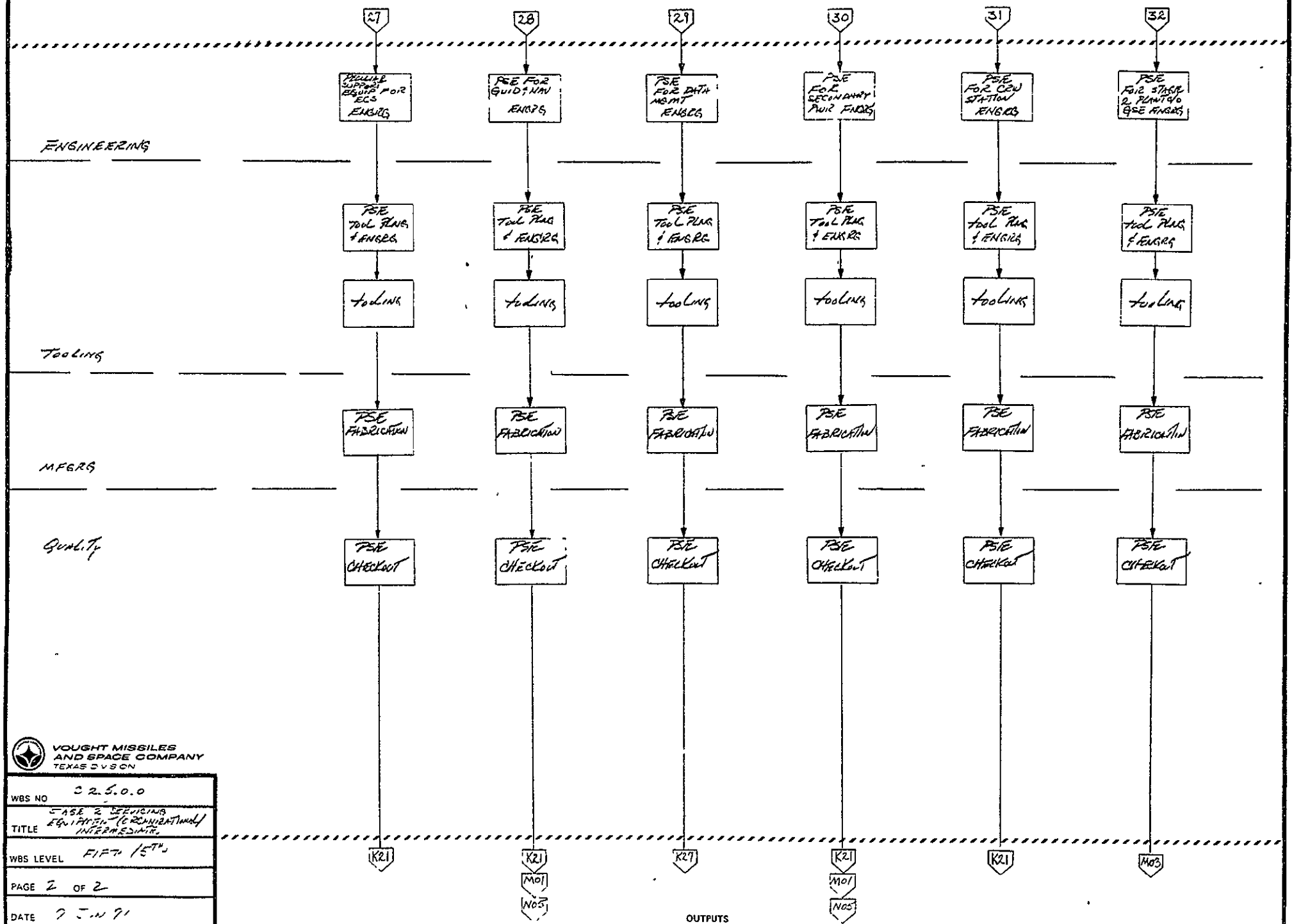
PSE FOR MAIN ENGINE ENGRG
PSE FOR OMS ENGINE ENGRG
PSE FOR RCS ENGINE ENGRG
PSE FOR ABES ENGINE ENGRG
PSE FOR STRUCTURE/THERMAL PANELS ENGRG
PSE FOR FLIGHT CONTROLS ENGRG
PSE FOR COMM/NAV AIDS ENGRG
ENGINEERING
PSE TOOL PLNG & ENGRG
TOOLING
TOOLING
MFG
PSE FABRICATION
QUALITY
PSE CHECKOUT
N05
K01
N05
N05
K01
M01
M02
M01
GF3
K21
M01
N05
OUTPUTS
VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION
WBS NO 8.2.5 0 0
TITLE STAGE 2 SERVICING EQUIPMENT (GROUND/OPERATIONAL/INTERFACE)
WBS LEVEL FIFTH (5TH)
PAGE 1 OF 2
DATE 7 JUL 71

INPUTS



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	2.5.0.0
TITLE	PHASE 2 SERVICING EQUIPMENT (ORBITAL/INTERMEDIATE)
WBS LEVEL	FIFTH (5TH)
PAGE	2 OF 2
DATE	9 JAN 71

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.2.6

TASK TITLE STAGE II ORG./INTER. SOFTWARE

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENT

A requirement exists for ground support software needed for integrated check-out and for subsystem test of Stage II in the Organizational/Intermediate maintenance facility at the launch site. A similar requirement will exist for test phases of the Advanced Space Transport Program.

II. ASSEMBLY LEVEL DEFINITION

Specific software requirements have not been defined for operational ground support software. Accordingly, assembly-level definition must await Phase C/D analysis before specific software can be defined.

III. FUNCTIONAL DESCRIPTION

Prior to mating Stage I to the launch umbilical tower, then mating Stage II

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

and its payload to Stage I for Air Vehicle Assembly (WBS ID 1.1) and subsequent transfer to the launch pad, an integrated checkout of each Stage is required in order to verify launch/flight integrity. An on-board avionics capability will exist for subsystem test, provided that software is available. WBS ID 3.2.2 provides the necessary integrated checkout ground equipment. WBS ID 3.2.6 must provide the needed software.

In addition to integrated checkout software, certain software will be required for Intermediate Level subsystem test and checkout (WBS ID 3.2.4). This software will enable automatic fault isolation in equipment requiring such capability in order to permit remove and replace, then checkout, to verify fault removal.

Similar requirements will exist during flight test (WBS ID 4.0).

IV. DESIGN REQUIREMENTS

(To be determined. See WBS Dictionary Element 3.2).

V. INTERFACES

Stage II O/I Software will interface with Stage II Integrated Checkout Equipment (O/I) (WBS ID 3.2.2), with Stage II Subsystem Test and Checkout Equipment (WBS ID 3.2.4), and with Stage II (WBS ID 1.3). Other interfaces are specified in WBS Dictionary Element 3.2, Para. V).

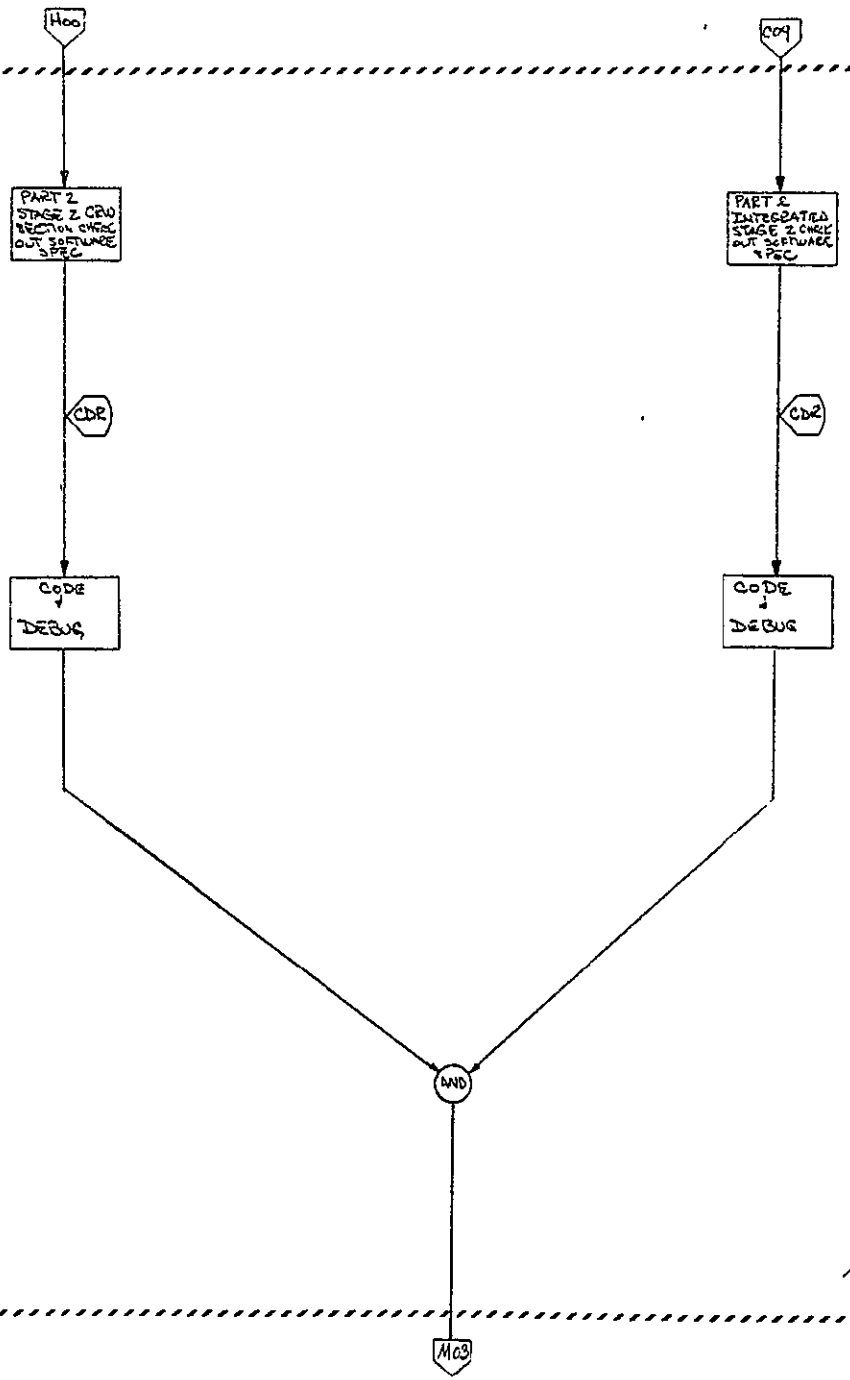
VI. TEST REQUIREMENTS

(To be determined in Phase C/D.)

VII. REFERENCES

(To be added.)

INPUTS



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	3.2 6 0.0
TITLE	STAGE 2 OPERATIONAL - INTERMEDIATE SOFTWARE
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	7 3 [illegible] 21

ENGINEERING

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.3

TASK TITLE STAGE II DEPOT EQUIPMENT (PECULIAR)

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

Means are required to maintain Stage II modules and components and Stage II peculiar support equipment at the depot level during both operational and test phases of the Advanced Space Transport Program. The means shall consist of Stage II Depot Equipment (Peculiar).

II. SUBSYSTEM-LEVEL DEFINITION

Six major elements define the Stage II Depot Equipment (Peculiar) as noted on Figure 3.0-W-3. These elements are based upon the maintenance philosophy that on-board maintenance (Organizational Level) will be performed to fault isolate an assembly, remove and replace, then checkout with the replaced assembly. At the Intermediate Level (turnaround facility O/I shop), the removed assembly will be tested to fault isolate to the failed module or component, then removed, replaced and checked out. The faulty module

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

or component will then be sent to the depot (turnaround facility depot repair area or off-site facility) for test, remove, repair and/or throw-away, and replace, then checkout for cycling the repaired module or component back into the assembly or into storage for continued operational capability.

Accordingly, the subsystem-level elements are as follows (see Figure 3.0-W-4):

3.3.1	Stage II Transportation and Handling (T & H) Equipment (Depot)
3.3.2	Stage II Integrated Checkout Equipment (Depot)
3.3.3	Stage II Component Test and Checkout Equipment
3.3.4	Stage II Servicing Equipment (Depot)
3.3.5	Stage II Component Repair Equipment
3.3.6	Stage II Depot Software

III. FUNCTIONAL DESCRIPTION

Depot maintenance will be required for failed modules and components of Stage II as well as for failed assemblies, modules and components of Stage II support equipment. Depot level maintenance will be required for both test and operational phases of the Advanced Space Transport Program. During Phase C/D, the maintenance analysis of the Air Vehicle (WBS 1.0) will determine needed maintenance and at what level that maintenance is to be performed (Organizational, Intermediate, Depot) in accordance with reliability predictions. Maintenance Ground Equipment (MGE) and Depot Maintenance Ground Equipment (DMGE) will be defined which satisfies the maintenance analysis.

As the analysis is extended to maintenance of peculiar Operating Ground Equipment (OGE) and Maintenance Ground Equipment (MGE and DMGE), the entire set of MGE/DMGE will have been identified. Part I specifications will be written for both MGE and DMGE end items (CEIs) which, together with the analysis, will enable PDRs to be held on MGE and DMGE to establish the requirements to be satisfied by Part II specifications (solutions to be peculiar, or common, depending on requirements). Peculiar DMGE will be developed

and/or procured following CDRs as part of WBS ID 3.3. Common Stage II depot equipment (FSN-identified) will be procured under WBS ID 8.3.

Inasmuch as the present (Phase B) analysis is incomplete, only the following equipments have been identified at this time as depot-peculiar. This list will expand as Phase C/D requirements/solutions are developed.

ASSEMBLY LEVEL WBS ID	NOMENCLATURE	TYPE OF DEPOT EQUIPMENT
3.3.1.-	(Analysis Incomplete)	Stage II T & H
3.3.2.-	(Analysis Incomplete)	Stage II Integ. C.O.
3.3.3.-	(Analysis Incomplete)	Stage II Component Test & Checkout
3.3.4.1	Hydraulic Valve Test Stand	Stage II Servicing Equipment
3.3.4.2	Hydraulic Pump & Motor Test Stand	Stage II Servicing Equipment
3.3.4.3	Servo Valve Test Stand	Stage II Servicing Equipment
3.3.5.-	(Analysis Incomplete)	Stage II Component Repair Equipment
3.3.6.-	(Analysis Incomplete)	Stage II Depot Software

IV. DESIGN REQUIREMENTS

Peculiar Stage II Depot Equipment design requirements will be specified in accordance with the maintenance analysis (WBS ID 5.0) completed in Phase C/D. Basic design requirements shall include performing the needed function (transportation, handling, checkout, repair, test and checkout, servicing, storage) and meeting the environmental, safety,

reliability and maintainability requirements imposed by Systems Engineering. Inasmuch as experience shows that much of the Factory Support Equipment (FSE) designed for use in fabricating the Air Vehicle subsystem also has field application, monitoring of this equipment needed for in-plant use may find a ready solution for field use. Accordingly, properly coordinated effort between Systems Engineering (maintenance analysts) and Systems Design (maintenance designers) early in the Program may have high payoff in Depot areas needed to support both test and operations. Usually, FSE does not have to be maintained except through the production phase. However, if FSE is to become deliverable as GSE, i.e. WBS ID 3.0, then extra care in FSE design will enable this equipment to become GSE by adding nameplate and serial number identification and by providing backup engineering data (specifications, drawings, part lists) to support the equipment for field use (test programs and operations). The same applies to development software cycled into test and operational software.

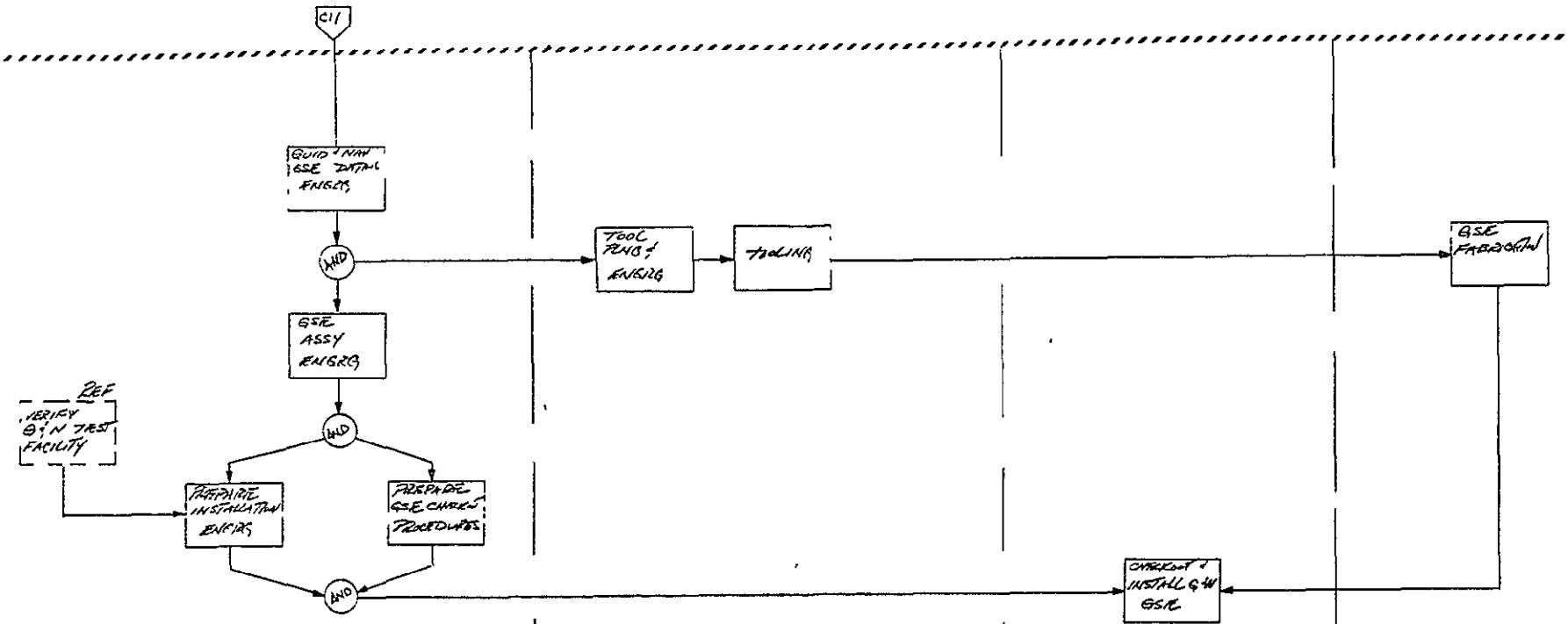
V. INTERFACES

Peculiar Stage II Depot Equipment basically interfaces with Stage II, its subsystems, assemblies and components (WBS ID 1.3). This equipment will also interface with Stage II peculiar support equipment (WBS ID 2.0, 3.0). Other Program interfaces will include WBS ID 4.0 (Systems Test and Evaluation), WBS ID 5.0 (System/Program Management), WBS ID 6.0 (deliverable Data), WBS ID 7.0 (new Operational/Site Activation; WBS ID 4.5 and 4.7 providing Test Site Activation), WBS ID 9.0 (Initial Spares and Repair Parts), WBS ID 10.0 (Training), WBS ID 11.0 (Industrial Facilities), and WBS ID 12.0 (Operations and Services).

VI. REFERENCES

(To be added.)

INPUTS



QUALITY | TOOLING | OPS & MAINT | MFGRS

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	33300
TITLE	STAGE 2 COMPONENT TEST & CHECKOUT EQUIPMENT
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	11 MAY 71

100

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.4

TASK TITLE STAGE I ORG./INTERMED. EQUIPMENT

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

Means are required to provide maintenance support to Stage I at the Organizational/Intermediate (O/I) Level maintenance facilities. Operationally, this will include the turnaround facility, the mating facility, the launch pad and the recovery sites. During test phases of the Program, the above maintenance is also required as well as maintenance performed at the horizontal test site. Where applicable, the equipments and software required for on-site maintenance of Stage I should also be utilized for factory test and checkout including pre-flight and ferry tests.

II. SUBSYSTEM-LEVEL DEFINITION

Six major elements define Stage I O/I Equipment. These include (see Figure 3.0-W-4):

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

3.4.1	Stage I Transportation and Handling (T & H) Equipment (Organizational/Intermediate)
3.4.2	Stage I Integrated Checkout Equipment (Org. /Inter.)
3.4.3	Stage I Calibration Equipment (PMEL)
3.4.4	Stage I Subsystem Test and Checkout Equipment
3.4.5	Stage I Servicing Equipment (Org. /Inter.)
3.4.6	Stage I Organizational/Intermediate Software

III. FUNCTIONAL DESCRIPTION

For the baseline Stage I concept, peculiar support equipment (see WBS Dictionary Element 8.0 for Common Support Equipment) is required for maintenance functions associated with:

- Stage I integrated checkout
- Stage I subsystem test and checkout
- Stage I component calibration
- Stage I servicing
- Transporting and handling Stage I, its subsystems, assemblies and components
- Crew transportation
- Data handling and storage

Maintenance equipment to meet these functions will be required at the launch site, landing sites and flight test sites. If applicable, specific equipment will also be required at the factory (see WBS Dictionary Elements 1.3.1 and 1.4.1).

During Phase B, an initial maintenance analysis effort has been undertaken to identify the peculiar, i.e. maintenance, equipment required for the Air Vehicle, for Stage II and for Stage I, including Payload interfaces with Stage II. Following Phase C go-ahead, the analysis will be completed in order to specify the required equipment and software and to generate CEI Part I's, hold GSE PDRs, generate CEI Part II's, hold GSE CDRs and procure the needed equipments. Until the maintenance analysis is completed,

a firm definition of needed MGE, its orientation (Integrated, Payload, Stage II and Stage I), and its origin (peculiar or common) and source (CFE or GFE) must be considered as preliminary.

Lower levels of WBS Dictionary Element 3.4 will identify the Stage I O/I Equipment as presently conceived. Firmer definition must await Phase C/D effort.

IV. DESIGN REQUIREMENTS

Stage I O/I Equipment design requirements will be specified in accordance with the maintenance analysis (WBS ID 5.0) completed in Phase C/D. Basic design requirements shall include performing the needed functions (transportation, handling, checkout, calibration, test and checkout, servicing) and meeting the environmental, safety, reliability, and maintainability requirements imposed by Systems Engineering. Equipment which must be air-transportable will require special design for light weight, ruggedness, reduced packaging size, etc. Specific requirements are dependent on the end usage of each required item, including software.

V. INTERFACES

Stage I O/I Equipment basically interfaces with the end item which it supports (Stage I, i.e. WBS ID 1.4). In addition, interfaces will exist with other MGE (WBS ID 3.0/8.0), with the launch facility (WBS ID 4.7, 7.0, 11.0), with launch and recovery equipment (WBS ID 2.0), and with the horizontal flight test operation (WBS ID 4.6). If this GSE is required in the factory to support final assembly and checkout, an interface will exist with WBS ID 11.0. Other Program interfaces will include WBS ID 5.0 (System/Program Management), WBS ID 6.0 (deliverable Data), WBS ID 9.0 (Initial Spares and Repair Parts), WBS ID 10.0 (Training) and WBS ID 12.0 (Operations and Services).

VI. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.4.1

TASK TITLE STAGE I T & H EQUIPMENT (ORG./INTER.)

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

Stage I Transportation and Handling (T & H) Equipment (Organizational/Intermediate) is required operationally at the launch site and at Stage I landing sites to handle Stage I - peculiar assemblies and components. Stage I T & H equipment which is common with Stage II T & H equipment is covered under WBS ID 3.1.1, Integrated T & H equipment. A requirement also exists for this equipment during test phases of the Program and may exist for factory final assembly operations as applicable.

II. ASSEMBLY LEVEL DEFINITION

The following Stage I T & H Equipments are preliminarily identified for the baseline concept requirements. They are subject to modification during Phase C/D as the maintenance analysis is firmed up. These

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

equipments are vehicle peculiar and do not include any equipment for maintaining OGE or MGE.

WBS ID	NOMENCLATURE	SITE LOCATION LAUNCH SITE*	SITE LOCATION LANDING SITES**
3.4.1.1	Canard Transport Dolly	X	None Identified To Date
3.4.1.2	Canard Remove/Install Load Beam	X	
3.4.1.3	Nose Landing Gear Removal Dollies	X	
3.4.1.4	Main Landing Gear Removal Dollies	X	
3.4.1.5	Thrust Ring Removal and Handling Sling	X	
3.4.1.6	Battery Handling, Remove/ Install	X	

* Turnaround Facility (Operations)
** Primary, Alternate, Emergency Landing Sites (Operations)

III. FUNCTIONAL DESCRIPTION

Stage I T & H Equipment (Org. /Inter.) is required to support Stage I - peculiar transportation and handling needs. The preceding list of equipment is preliminary. As noted, T & H equipment supports certain vehicle assembly needs required for maintenance functions. This equipment list is preliminary at this time and will be firmed up during Phase C/D as the maintenance analysis is completed. T & H equipment common to both Stage II and to Stage I is covered under WBS Dictionary Element 3.1.1.

IV. DESIGN REQUIREMENTS

(To be determined. See WBS Dictionary Element 3.4.)

V. INTERFACES

Stage I T & H Equipment (O/I) basically interfaces with Stage I (WBS ID 1.4). Other interfaces are as noted in Para. V of WBS Dictionary Element 3.4.

VI. TEST REQUIREMENTS

Stage I T & H Equipment (O/I) will be tested as specified in CEI Part I/II specifications generated in Phase C/D. Basic end items will be tested under WBS ID 3.4.1. Integrated testing will be performed under WBS ID 4.6 and 4.7.

VII. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO 3.4.2

TASK TITLE STAGE I INTEGRATED CHECKOUT EQPT. (O/I)

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

Stage I Integrated Checkout Equipment (Organizational/Intermediate) is required for checking the Stage prior to a flight to verify readiness for the mission. This requirement exists prior to mating Stage II to Stage I for operational missions and following maintenance performed in the turnaround facility after mission return. A similar requirement exists during the test program for both horizontal and vertical flight test. As applicable, this equipment may be used for factory final assembly checkout.

II. ASSEMBLY LEVEL DEFINITION

The Phase B maintenance analysis is incomplete and will be firmed up in Phase C/D. Accordingly, the following assembly-level equipments are preliminary.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

WBS ID	NOMENCLATURE	SITE LOCATION LAUNCH SITE*	SITE LOCATION LANDING SITES**
3.4.2.1	Universal Test Equipment	X	X

* Turnaround Facility (Pre-Flight area) (Operations)
** Primary, Alternate and Emergency Landing Sites (Operations)

III. FUNCTIONAL DESCRIPTION

The Stage I Integrated Checkout Equipment (O/I) is required to verify that Stage I is flight ready. Inasmuch as on-board avionics provides the capability for this checkout, once the vehicle is energized, the amount of ground support equipment can be minimized. A ground-test software program (WBS ID 3.4.6), similar to the on-board checkout software used to verify launch pad readiness, will be required, together with the ground support equipment to program the on-board computer. Servicing equipment (WBS ID 3.4.5) will be needed to support the checkout function.

As required, certain test equipment will be required at the landing site to verify ferry flight readiness.

Similar use of this equipment will be required to support flight test.

IV. DESIGN REQUIREMENTS

(To be determined. See WBS Dictionary Element 3.4.)

V. INTERFACES

Stage I Integrated Checkout Equipment (Org./Inter.) basically interfaces with Stage I (WBS ID 1.4). Other interfaces are as noted in Para. V of WBS Dictionary 3.2.

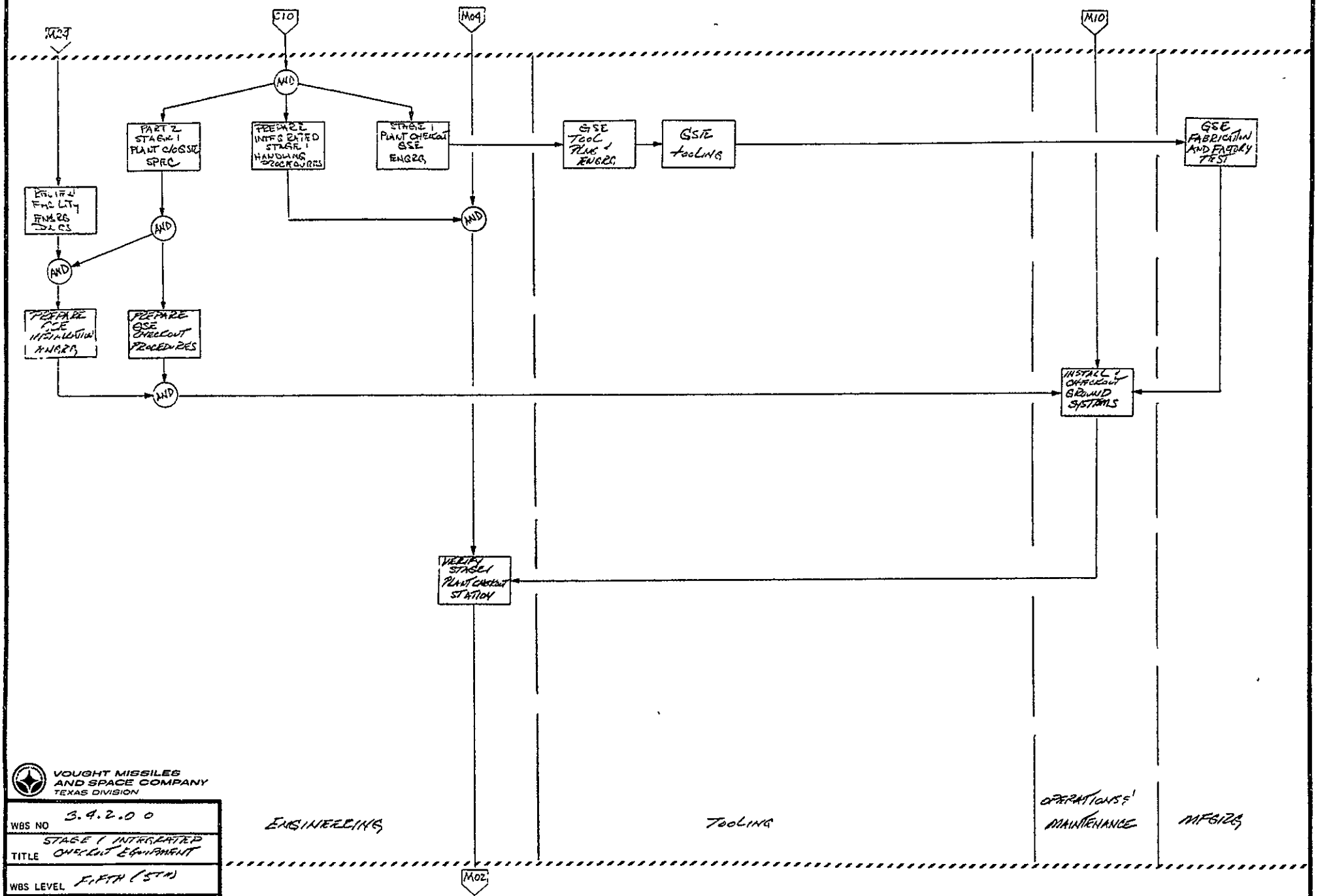
VI. TEST REQUIREMENTS

Stage I Integrated Checkout Equipment (Org./Inter.) will be tested as specified in CEI Part I/II specifications generated in Phase C/D. Basic end items will be tested under WBS ID 3.4.2. Integrated testing will be performed under WBS ID 4.6 and 4.7.

VII. REFERENCES

(To be added.)

INPUTS



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	3.9.2.0 0
TITLE	STAGE 1 INTEGRATED CHECKOUT EQUIPMENT
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	7 JUN 71

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO: 3.4.3

TASK TITLE STAGE I CALIBRATION EQUIPMENT (PMEL)

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

Stage I Calibration Equipment (Precision Measuring Equipment Laboratory, PMEL) is required to calibrate instruments and instrumentation which are part of Stage I. This requirement also extends to ground support equipment used to test and checkout Stage I and its subsystems during operations and maintenance, including test programs preceding IOC.

II. ASSEMBLY LEVEL DEFINITION

Specific equipments needed to satisfy the requirements are not identified at this time. These equipments will be defined during Phase C/D.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

III. FUNCTIONAL DESCRIPTION

As noted in the WBS Dictionary descriptions of Stage I (WBS ID 1.4 and lower levels thereto), a considerable variety of controls, displays, and instrumentation exist, all of which require precise calibration to ensure accurate indications of the affected parameter measured, operated on, and/or displayed to the crew. To maintain this equipment in an accurate read-out state, it will be necessary to provide a laboratory and equipment which can handle the calibration requirements.

In addition to vehicle equipment calibration needs certain OGE, MGE and DMGE which supports Stage I will also require calibration.

To the extent feasible, common calibration requirements which exist between Stage II and Stage I should be identified so as to consolidate the Advanced Space Transport Program calibration equipment needs. Subcontracting to responsible non-Program agencies should also be evaluated.

IV. DESIGN REQUIREMENTS

(To be determined. See WBS Dictionary Element 3.4.)

V. INTERFACES

Stage I Calibration Equipment (PMEL) interfaces basically with Stage I (WBS ID 1.4). Other interfaces are to be determined (OGE, MGE, DMGE). See Para. V of WBS Dictionary Element 3.4 for other Program interfaces.

VI. TEST REQUIREMENTS

(To be determined.)

VII. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.4.4

TASK TITLE STAGE I SUBSYSTEM TEST & C.O. EQUIPMENT

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

Stage I Subsystem Test and Checkout Equipment is required to fault isolate malfunctioning subsystems both on-board the Stage (Organizational Level) and in the Intermediate Level maintenance area of the turnaround facility and to checkout repaired or replaced modules to verify fault removal and satisfactory subsystem operation following repair. This same requirement will exist during test programs which precede IOC. For faulty Stages returning from a mission, certain test and checkout capability will be required at the landing site.

II. ASSEMBLY LEVEL DEFINITION

During Phase B, an initial maintenance analysis has been performed to preliminarily identify the equipments needed for subsystem test and checkout.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

The analysis is incomplete and will be firmed up in Phase C/D. Therefore, the following assembly-level definition is to be considered as preliminary.

WBS ID	NOMENCLATURE	SITE LOCATION LAUNCH SITE*	LANDING SITES**
3.4.4.1	Servo Valve Test Stand	X	
3.4.4.2	APU Test Stand	X	
3.4.4.3	Generator Test Stand	X	
3.4.4.4	Jet Engine Starting Cart	X	X
3.4.4.5	Hydraulic Valve Test Stand	X	
3.4.4.6	Air-breathing Engine Test Stand with Silencer	X	
3.4.4.7	Hydraulic Pump and Motor	X	
3.4.4.8	Ordnance Test Set	X	

* Turnaround Facility (Operations)
** Primary, Alternate, Emergency (Operations)

III. FUNCTIONAL DESCRIPTION

Prior to flight, on-board avionics and software are available in the baseline Stage I concept to interrogate each subsystem to determine flight readiness. If a fault exists, it will be displayed. Certain test equipment will be required to verify that an on-board fault exists to enable remove and replace and checkout to verify that the fault is removed. Following a mission, capability will exist to similarly denote an on-board failure. If the landing is at a remote site, means will be required to similarly verify the on-board failure for remove and replace and checkout. For subsystem elements removed from the vehicle, a need will exist in the Intermediate Level maintenance area of the turnaround facility for test and checkout equipment, and for support equipment, to perform fault isolation and to remove and replace and checkout

the faulty module or component for delivery to the depot. This maintenance concept is standard with all major DoD agencies employing major systems similar to the Space Transport. For jet engine maintenance, a tradeoff exists as to what level of maintenance should the Advanced Space Transport Program provide direct support as opposed to utilizing existing commercial facilities. Similarly, sensitive avionics items (IMUs, communications equipment, computers, etc.) may best be maintained in existing laboratories established for these purposes. This decision must be firmed up early in Phase C/D to ensure a capability exists when required for flight test.

IV. DESIGN REQUIREMENTS

(To be determined. See WBS Dictionary Element 3.4.)

V. INTERFACES

Stage I Subsystem Test and Checkout Equipment basically interfaces with Stage I (WBS ID 1.4). Where common equipment exists with Stage II, this may reduce the amount of equipment required to support Air Vehicle maintenance. Inasmuch as certain OGE, MGE and DMGE must also be maintained there is an interface with that equipment also. See WBS Dictionary Element 3.4, Para. V, for other Program interfaces.

VI. TEST REQUIREMENTS

Stage I Subsystem Test and Checkout Equipment (O/I) will be tested as specified in CEI Part I/II specifications generated in Phase C/D. Basic end items will be tested under WBS ID 3.4.4. Integrated testing will be performed under WBS ID 4.6 and 4.7.

VII. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.4.5

TASK TITLE STAGE I SERVICING EQPT. (ORG./INTER.)

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENT

Stage I Servicing Equipment (Organizational/Intermediate) is required in order to support maintenance operations on Stage I at the turnaround facility and at the landing site. Similar requirements for this equipment exist during test phases of the Advanced Space Transport Program.

II. ASSEMBLY LEVEL DEFINITION

Phase B maintenance analysis has disclosed a preliminary list of servicing equipment required to support Organizational and Intermediate Level maintenance of Stage I. This list will be modified and upgraded in Phase C/D.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

WBS ID	NOMENCLATURE	SITE LOCATION	
		LAUNCH SITE*	LANDING SITES**
3.4.5.1	GN_2 Purge Hose Kit		X
3.4.5.2	Ground Crew Access		X
3.4.5.3	Rigging Pins & Safety Locks		X
3.4.5.4	Nose Landing Gear Trunnion Shaft Puller	X	
3.4.5.5	Main Landing Gear Trunnion Shaft Puller	X	
3.4.5.6	Hydraulic Ground Power Unit	X	X
3.4.5.7	Air Conditioning Unit	X	X
3.4.5.8	Chilled Water-Glycol Unit	X	
3.4.5.9	Electrical Power Cart	X	X
3.4.5.10	Pneumatic Control Cart	X	
3.4.5.11	Chilled Water & Glycol Serving	X	
3.4.5.12	Blast Deflectors (Fuselage Protection, Engine Runup)	X	
3.4.5.13	Air-breathing Engine Maintenance Stand	X	
3.4.5.14	Hand Tools, Special Design (Set)	X	
3.4.5.15	Canard Work Stand, LH/RH	X	
3.4.5.16	Gaseous Helium Service Units	X	
3.4.5.17	GN_2 Storage		X

* Turnaround Facility (Operations)
** Primary, Alternate, Emergency (Operations)

III. FUNCTIONAL DESCRIPTION

The Stage I Servicing Equipment (O/I) provides maintenance support capability for Stage I at both the turnaround facility, the launch pad (as required) and at the landing sites. Following a landing, a need will exist for safing and purging the Stage, removing the payload, applying ground power for any checkout needed, etc. In the turnaround facility, maintenance and refurbishment will require ground power, and possibly engine runup. Air-breathing engines must be checked and serviced.

During Phase C/D, the maintenance analysis for servicing equipment requirements (including test requirements) will be completed enabling a complete list of equipment to be defined, reviewed and procured in time for test program needs. Integration of Stage I and Stage II Servicing Equipment will be needed to define common requirements/solutions.

IV. DESIGN REQUIREMENTS

(To be defined. See WBS Dictionary Element 3.4.)

V. INTERFACES

Stage I Servicing Equipment (O/I) basically interfaces with Stage I (WBS ID 1.4). Other interfaces are specified in WBS Dictionary Element 3.4, Para. V.

VI. TEST REQUIREMENTS

Stage I Servicing Equipment (O/I) will be tested as specified in CEI Part I/II specifications generated in Phase C/D. Basic end items will be tested under WBS ID 3.4.5. Integrated testing will be performed under WBS ID 4.6 and 4.7.

VII. REFERENCES

(To be added.)

INPUTS

33 34 35 36 37 38

ENGINEERING

PECULIAR SUPPORT EQUIPMENT FOR MAIN ENGRG | PSE FOR RCS ENGRG | PSE FOR STRUCT & THERMAL PANEL ENGRG | PSE FOR FLIGHT CONTROLS ENGRG | PSE FOR GUID & NAV ENGRG | PSE FOR COMM & NAV AIDS ENGRG

TOOLING

TOOL PLNG & ENGRG | TOOL PLNG & ENGRG | TOOL PLNG & ENGRG | TOOL PLNG & ENGRG | TOOL PLNG & ENGRG | TOOL PLNG & ENGRG

TOOLING | TOOLING | TOOLING | TOOLING | TOOLING | TOOLING

MANUFACTURING

PSE FABRICATION | PSE FABRICATION | PSE FABRICATION | PSE FABRICATION | PSE FABRICATION | PSE FABRICATION

QUALITY

PSE CHECKOUT | PSE CHECKOUT | PSE CHECKOUT | PSE CHECKOUT | PSE CHECKOUT | PSE CHECKOUT

N06 K02 | N06 K02 | M02 | GF2 | K22 M02 N06 | K22 M02 N06

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	3.4.5.0.0
TITLE	STAGE I SERVICING EQUIPMENT (ORGANIZATIONAL / INTERMEDIATE)
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 2
DATE	7 JUN 71

INPUTS

39 40 41 42 43

ENGINEERING

PSE FOR DATA INSTMT ENGRG | PSE FOR TOOLS ENGRG | PSE FOR SECONDARY PWR ENGRG | PSE FOR GRD STATION ENGRG | PSE FOR PLANT CHECK-OUT EQPT ENGRG

TOOL PLNG & ENGRG | TOOL PLNG & ENGRG | TOOL PLNG & ENGRG | TOOL PLNG & ENGRG | TOOL PLNG & ENGRG

TOOLING

TOOLING | TOOLING | TOOLING | TOOLING | TOOLING

MANUFACTURING

PSE FABRICATION | PSE FABRICATION | PSE FABRICATION | PSE FABRICATION | PSE FABRICATION

QUALITY

PSE CHECKOUT | PSE CHECKOUT | PSE CHECKOUT | PSE CHECKOUT | PSE CHECKOUT

K28 | K22 | K22 | K22 | M10f

M02

N06

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	2 4 5.0 0
TITLE	STAGE I SERVICING EQUIPMENT (ORGANIZATIONAL / INTERMEDIATE)
WBS LEVEL	FIFTH (5TH)
PAGE	2 OF 2
DATE	7 JUN 71

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO 3.4.6

TASK TITLE STAGE I ORG./INTER. SOFTWARE

LEVEL 5, Subsystem Level.

WBS DICTIONARY

I. REQUIREMENT

A requirement exists for ground support software needed for integrated check-out and for subsystem test of Stage I in the Organizational/Intermediate maintenance facility at the launch site. A similar requirement will exist for test phases of the Advanced Space Transport Program.

II. ASSEMBLY LEVEL DEFINITION

Specific software requirements have not been defined for operational ground support software. Accordingly, assembly-level definition must await Phase C/D analysis before specific software can be defined.

III. FUNCTIONAL DESCRIPTION

Prior to mating Stage I to the launch umbilical tower, then mating Stage II

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

and its payload to Stage I for Air Vehicle Assembly (WBS ID 1.1) and subsequent transfer to the launch pad, an integrated checkout of each Stage is required in order to verify launch/flight integrity. An on-board avionics capability will exist for subsystem test, provided that software is available. WBS ID 3.4.3 provides the necessary integrated checkout ground equipment. WBS ID 3.4.6 must provide the needed software.

In addition to integrated checkout software, certain software will be required for Intermediate Level subsystem test and checkout (WBS ID 3.4.4). This software will enable automatic fault isolation in equipment requiring such capability in order to permit remove and replace, then checkout, to verify fault removal.

Similar requirements will exist during flight test (WBS ID 4.0).

IV. DESIGN REQUIREMENTS

(To be determined. See WBS Dictionary Element 3.4.)

V. INTERFACES

Stage I O/I Software will interface with Stage I Integrated Checkout Equipment (O/I) (WBS ID 3.4.2), with Stage I Subsystem Test and Checkout Equipment (WBS ID 3.4.4), and with Stage I (WBS ID 1.4). Other interfaces are specified in WBS Dictionary Element 3.4, Para. V.

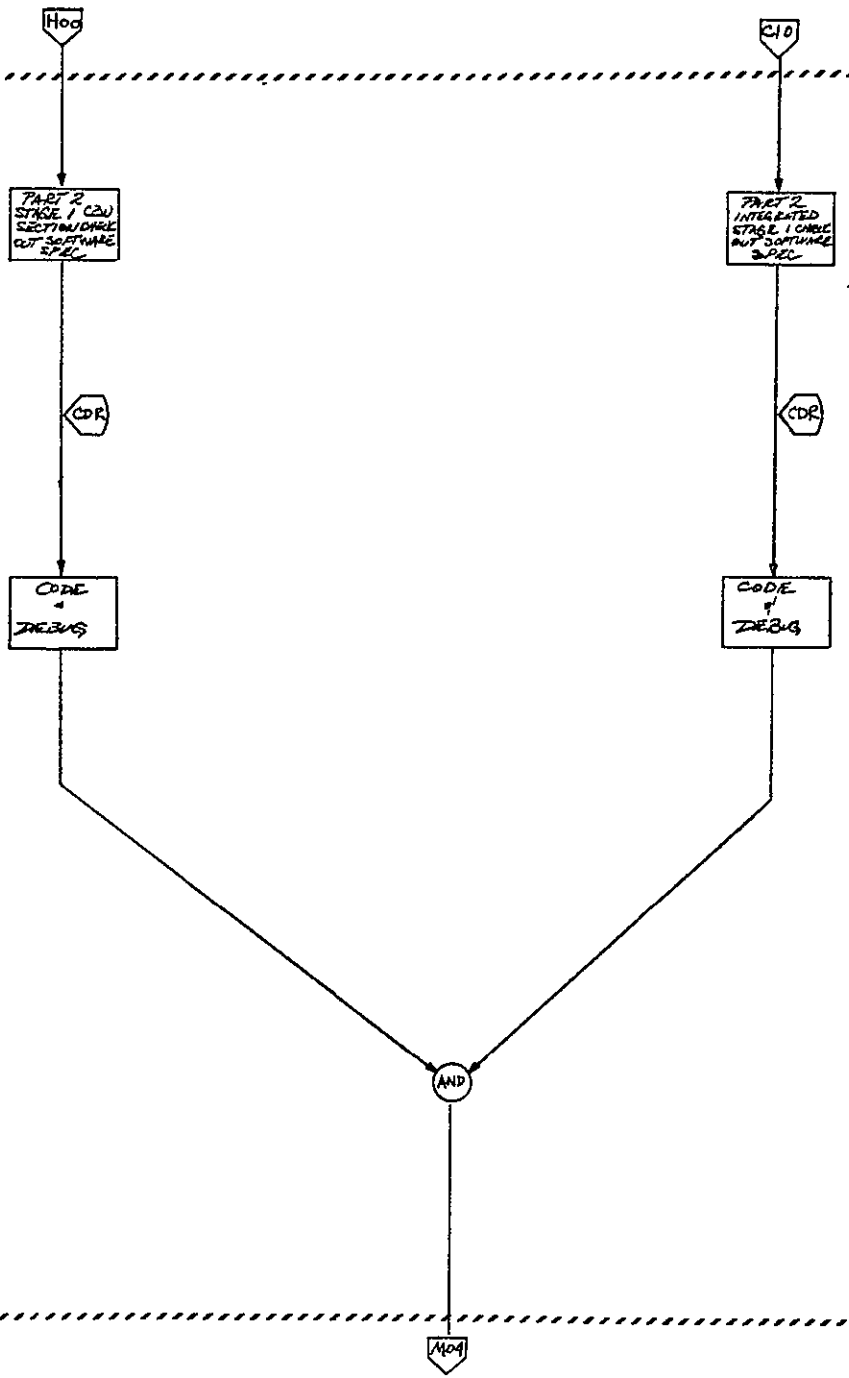
VI. TEST REQUIREMENTS

(To be determined in Phase C/D.)

VII. REFERENCES

(To be added.)

INPUTS



ENGINEERING

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	3460.0
TITLE	STAGE I ORGANIZATIONAL - INTERMEDIATE SOFTWARE
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	8 JUN 71

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 3.5

TASK TITLE STAGE I DEPOT EQUIPMENT (PECULIAR)

LEVEL 4. System Level

WBS DICTIONARY

I. REQUIREMENTS

Means are required to maintain Stage I modules and components and Stage I peculiar support equipment at the depot level during both operational and test phases of the Advanced Space Transport Program. The means shall consist of Stage I Depot Equipment (Peculiar).

II. SUBSYSTEM-LEVEL DEFINITION

Six major elements define the Stage I Depot Equipment (Peculiar) as noted on Figure 3.0-W-4. These elements are based upon the maintenance philosophy that on-board maintenance (Organizational Level) will be performed to fault isolate an assembly, remove and replace, then checkout with the replaced assembly. At the Intermediate Level (turnaround facility O/I shop), the removed assembly will be tested to fault isolate to the failed module or component, then removed, replaced and checked out. The faulty module

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

or component will then be sent to the depot (turnaround facility depot repair area or off-site facility) for test, remove, repair and/or throw-away, and replace, then checkout for cycling the repaired module or component back into the assembly or into storage for continued operational capability.

Accordingly, the subsystem-level elements are as follows:

3.5.1	Stage I Transportation and Handling (T & H) Equipment (Depot)
3.5.2	Stage I Integrated Checkout Equipment (Depot)
3.5.3	Stage I Component Test and Checkout Equipment
3.5.4	Stage I Servicing Equipment (Depot)
3.5.5	Stage I Component Repair Equipment
3.5.6	Stage I Depot Software

III. FUNCTIONAL DESCRIPTION

Depot maintenance will be required for failed modules and components of Stage I as well as for failed assemblies, modules and components of Stage I support equipment. Depot level maintenance will be required for both test and operational phases of the Advanced Space Transport Program. During Phase C/D, the maintenance analysis of the Air Vehicle (WBS 1.0) will determine needed maintenance and at what level that maintenance is to be performed (Organizational, Intermediate, Depot) in accordance with reliability predictions. Maintenance Ground Equipment (MGE) and Depot Maintenance Ground Equipment (DMGE) will be defined which satisfies the maintenance analysis.

As the analysis is extended to maintenance of peculiar operating ground equipment (OGE) and maintenance ground equipment (MGE and DMGE), the entire set of MGE/DMGE will have been identified. Part I specifications will be written for both MGE and DMGE end items (CEIs) which, together with the analysis, will enable PDRs to be held on MGE and DMGE to establish the requirements to be satisfied by Part II specifications (solutions to be peculiar, or common, depending on requirements). Peculiar DMGE will be developed and/or procured following CDRs as part of WBS ID 3.5. Common Stage I depot equipment (FSN-identified) will be procured under WBS ID 8.5.

Inasmuch as the present (Phase B) analysis is incomplete, only the following equipments have been identified at this time as depot-peculiar. This list will expand as Phase C/D requirements/solutions are developed.

ASSEMBLY LEVEL WBS ID	NOMENCLATURE	TYPE OF EQUIPMENT
3.5.1.-	(Analysis Incomplete)	Stage I T & H
3.5.2.-	(Analysis Incomplete)	Stage I Integ. C.O.
3.5.3.-	(Analysis Incomplete)	Stage I Component Test & Checkout
3.5.4.1	Hydraulic Valve Test Stand	Stage I Servicing Equipment
3.5.4.2	Hydraulic Pump & Motor Test Stand	Stage I Servicing Equipment
3.5.4.3	Servo Valve Test Stand	Stage I Servicing Equipment
3.5.5.-	(Analysis Incomplete)	Stage I Component Repair Equipment
3.5.6.-	(Analysis Incomplete)	Stage I Depot Software

IV. DESIGN REQUIREMENTS

Peculiar Stage I Depot Equipment design requirements will be specified in accordance with the maintenance analysis (WBS ID 5.0) completed in Phase C/D. Basic design requirements shall include performing the needed function (transportation, handling, checkout, repair, test and checkout, servicing, storage) and meeting the environmental, safety, reliability and maintainability requirements imposed by Systems Engineering. Inasmuch as experience shows that much of the Factory Support Equipment (FSE) designed for use in fabricating the Air Vehicle subsystem also has field application, monitoring of this equipment needed for in-plant use may

find a ready solution for field use. Accordingly, properly coordinated effort between Systems Engineering (maintenance analysts) and Systems Design (maintenance designers) early in the Program may have high payoff in Depot areas needed to support both test and operations. Usually, FSE does not have to be maintained except through the production phase. However, if FSE is to become deliverable as GSE, i.e. WBS ID 3.0, then extra care in FSE design will enable this equipment to become GSE by adding nameplate and serial number identification and by providing backup engineering data (specifications, drawings, part lists) to support the equipment for field use (test programs and operations). The same applies to development software cycled into test and operational software.

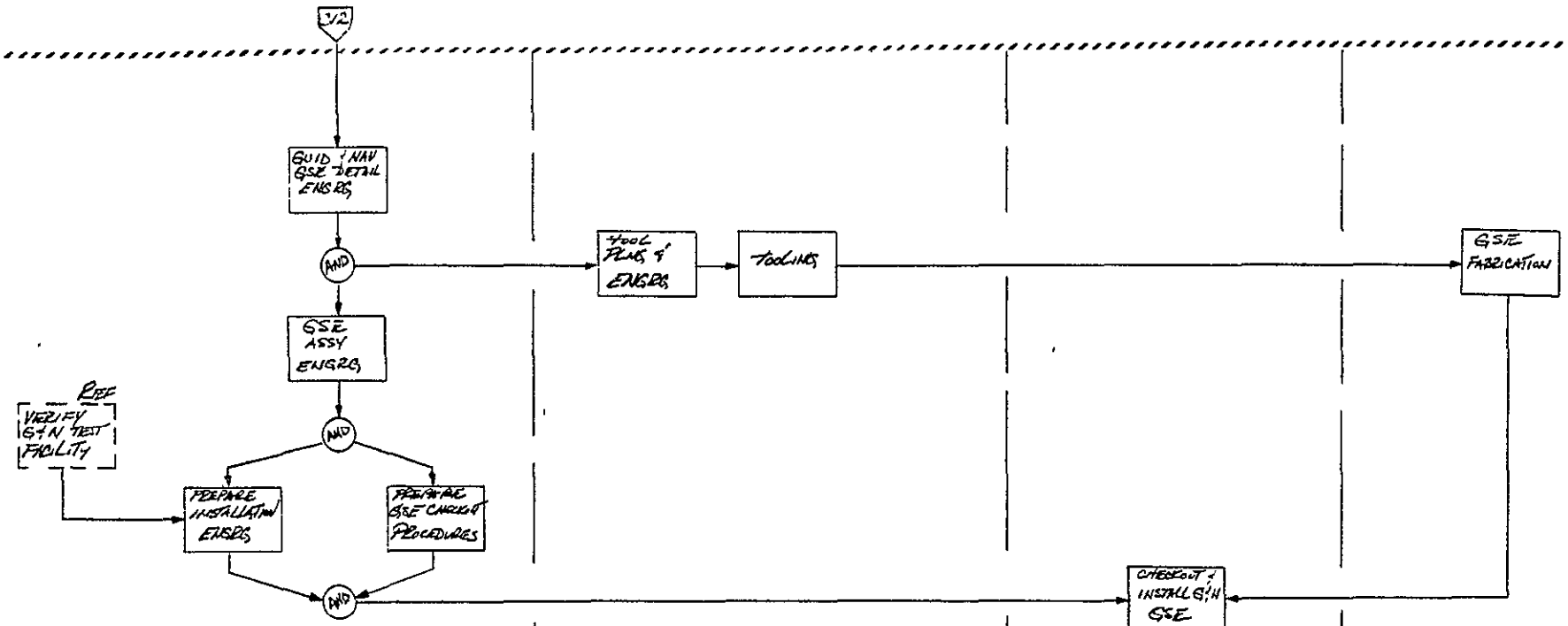
V. INTERFACES

Peculiar Stage I Depot Equipment basically interfaces with Stage I, its subsystems, assemblies and components (WBS ID 1.4). This equipment will also interface with Stage I peculiar support equipment (WBS ID 2.0, 3.0). Other Program interfaces will include WBS ID 4.0 (Systems Test and Evaluation), WBS ID 5.0 (System/Program Management), WBS ID 6.0 (deliverable Data), WBS ID 7.0 (new Operational/Site Activation; WBS ID 4.5 and 4.7 providing Test Site Activation), WBS ID 9.0 (Initial Spares and Repair Parts), WBS ID 10.0 (Training), WBS ID 11.0 (Industrial Facilities), and WBS ID 12.0 (Operations and Services).

VI. REFERENCES

(To be added.)

INPUTS



Quality | Tooling | OPS/MAINT | MFG'RG

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	35.300
TITLE	STAGE / COMPONENT TEST-CHECKOUT EQUIPMENT
WBS LEVEL	FIFTH (5TH)
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SYSTEMS TEST
& EVALUATION (4.0)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.0

TASK TITLE SYSTEMS TEST AND EVALUATION

LEVEL 3, Project Level

WBS DICTIONARY

I. REQUIREMENTS

A need exists for a series of tests to be conducted which will obtain and validate engineering data on the performance of the Space Transport Air Vehicle and its associated support equipment prior to committing these elements to an operational status as called for by WBS Dictionary Element 0.0, Advanced Space Transport Program. To meet this need, an integrated test plan (WBS ID 5.0) will be developed and approved which establishes the effort required; defines the tests to be conducted; defines the number and types of prototypes and flight test vehicles to be produced and delivered; defines the number and type of operating ground equipment articles to be built and delivered and/or made available; defines the number and types of peculiar and common support equipments to be built and delivered and/or procured; defines the location of and test facilities to be made available; defines the software requirements; defines the

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE LOWER LEVELS FOR DETAIL SCHEDULES

consumables required; specifies the instrumentation required; denotes the types and skills of personnel needed; delineates the non-Program element support required; and defines the Program controls documentation, procedures, spares, etc. which will be employed to obtain, evaluate and validate test data.

Based on this test plan, WBS ID 4.0 will conduct Stage I and Stage II combined subsystem development tests, conduct Stage I and Stage II structural tests, conduct Stage I and Stage II single element flight tests, and conduct mated manned orbital flight tests. In addition, Stage I and Stage II mockups will be designed, developed, fabricated and maintained throughout the RDT & E phase as design, integration and training tools as called for by contract. At the completion of RDT & E, mockups will be either dissambeled and disposed of or delivered to NASA as specified in the contracts of affected end item suppliers.

Effectively, WBS ID 4.0 provides Category I and II testing, or their equivalent, to validate capability of the Air Vehicle and its support equipment to provide an initial operational capability (IOC). With this capability approved, the Investment phase can be accomplished, resulting in IOC for the Advanced Space Transport Program.

II. SYSTEM-LEVEL DEFINITION

Nine major elements are required to form the Systems Test and Evaluation element of the Advanced Space Transport Program. Each element is defined in accordance with the three major end items of the Program (Integration, Stage II, Stage I) and with the steps which each end item must take to validate its performance and effectiveness prior to receiving full qualification and acceptance for entering IOC. Accordingly, WBS ID 4.0 (see Figure 4.0-W-5) is defined to consist of the following system-level elements:

4.1	Stage II Subsystem Development Tests
4.2	Stage I Subsystem Development Tests
4.3	Stage II Structural Tests
4.4	Stage I Structural Tests
4.5	Stage II Flight Tests (Single Element)

FOLDOUT FRAME 1

FOLDOUT FRAME 2

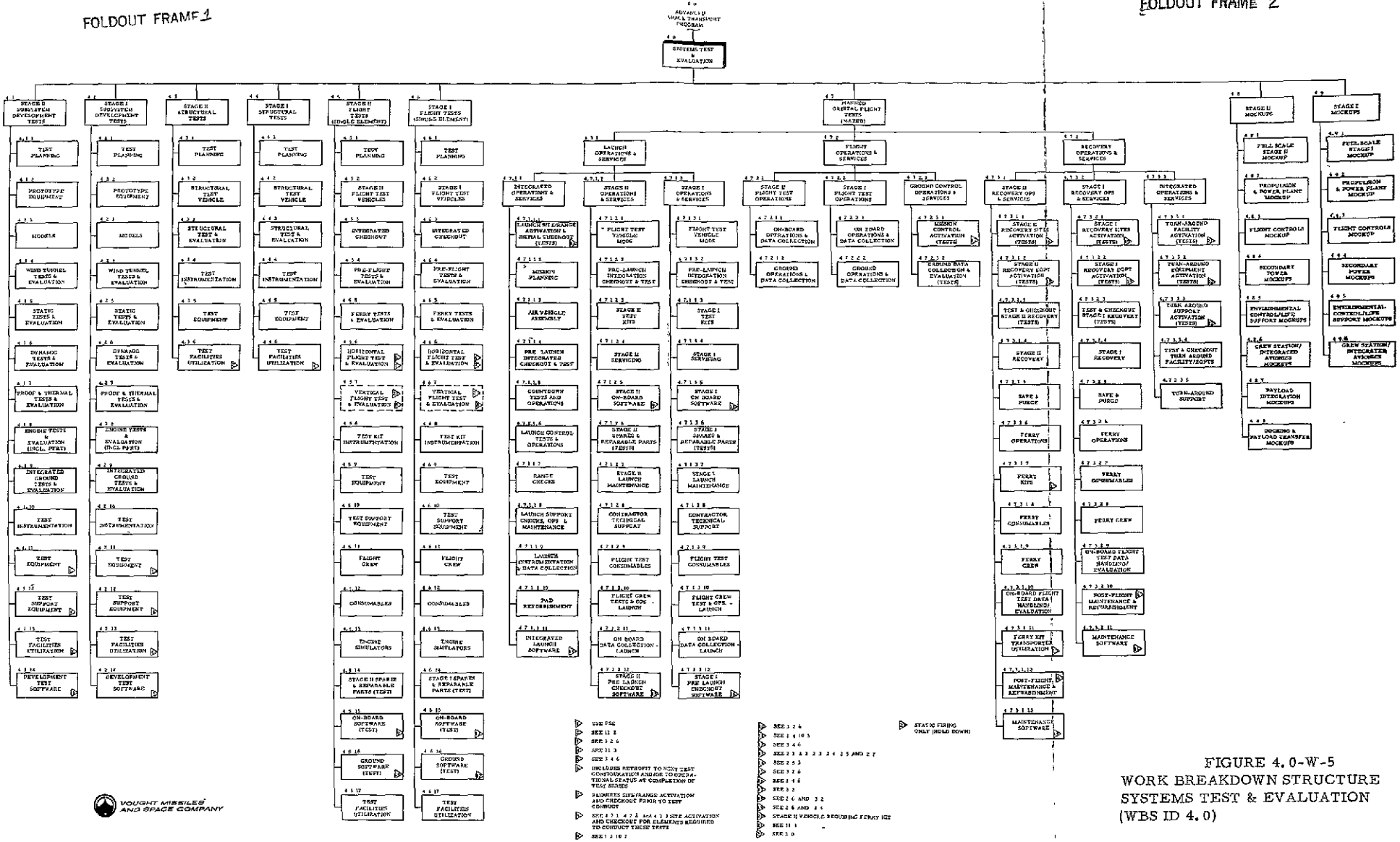

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FIGURE 4.0-W-5
WORK BREAKDOWN STRUCTURE
SYSTEMS TEST & EVALUATION
(WBS ID 4.0)

4.6	Stage I Flight Tests (Single Element)
4.7	Manned Orbital Flight Tests (Mated)
4.8	Stage II Mockups
4.9	Stage I Mockups

The Air Vehicle is defined to include a GFE Payload (WBS ID 1.2), Stage II (WBS ID 1.3) and Stage I (WBS ID 1.4) as stated in WBS Dictionary Element 1.0. Operating ground equipment required to support flight test as well as operations is specified in WBS Dictionary Element 2.0. Peculiar and common support equipment needed to maintain the airborne elements and operating ground equipment are specified in WBS Dictionary Elements 3.0 and 8.0. Lower level WBS Dictionary elements further define WBS ID 4.1 through 4.9.

II. FUNCTIONAL DESCRIPTION

At Phase C go-ahead, final design of the Air Vehicle, Operating Ground Equipment (OGE) and Maintenance Ground Equipment and Depot Maintenance Ground Equipment (MGE/DMGE) will proceed through generation of Part I specifications on end items (CEI's), conduct of PDRs (Air Vehicle, OGE, MGE/DMGE), and subsystem development needed to generate CEI Part II specifications, the approval of which in CDRs will permit hardware procurement and flight test article fabrication.

In parallel with the above, preliminary test plans generated during Phase B can be finalized in Phase C and approved at an appropriate point to establish a Transport System Test and Operations Plan for conducting single and combined subsystem development tests, structural tests single element flight tests and mated flight tests. In addition, mockups generated in Phase B can be upgraded as the design progresses, or fabricated in Phase C/D as specified by contract. Part I specifications, and PDRs thereon, may be required on mockups as determined by NASA.

Component, module, assembly and subsystem tests peculiar to only one subsystem are, in general, conducted under the affected subsystem (see WBS ID 1.0, Volumes I & II). Exceptions to this occur in the need for wind tunnel testing and engine testing, and certain structural testing which are included under WBS ID 4.1 and 4.2 for Stage II and Stage I, respectively.

WBS ID 4.0, as noted in lower Dictionary elements, then provides the requirement for and conduct of subsystem development tests, structural test vehicle tests, single element flight tests, and mated flight tests, as well as mockups of the complete stages and major subsystems thereof. Test support is also included in WBS ID 4.0 including the design, development and fabrication of test instrumentation; special test equipment provisioning; test support equipment provisioning; test facilities activation, provisioning and utilization; and test software design, development, procurement, provisioning and utilization. Systems engineering required to define and support WBS ID 4.0 test and evaluation is defined under WBS ID 5.0. Design and manufacturing engineering needed to support WBS ID 4.0 test and evaluation is defined under WBS ID 1.0. Ground support equipment (OGE, MGE, DMGE) design and manufacturing/materiel engineering needed to support WBS ID 4.0 test and evaluation are defined under WBS ID 2.0, 3.0 and 8.0.

IV. DESIGN REQUIREMENTS

The elements under WBS ID 4.0 which require design include test instrumentation, special test equipment, test software, test facility modification, and mockups. As appropriate, design requirements on these elements will be specified at lower levels under WBS ID 4.0.

V. REFERENCES

(To be added.)

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PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.1

TASK TITLE STAGE II SUBSYSTEM DEVELOPMENT TESTS

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

Development tests are required of Stage II subsystems (see Figure 1.3-W-3, Vol. II) which effectively complete Category I tests and enable flight test to proceed. A complementary set of Category I tests on Stage II includes major Structural Tests, WBS ID 4.3.

Stage II Development Tests will be contractor-conducted, NASA controlled, and will demonstrate performance, reliability, maintainability, safety and integrity of Stage II subsystems, including components, modules and assemblies thereof. In addition, preliminary performance, operating characteristics and qualitative adequacy of the system, subsystem and end items will be developed.

Other objectives which will be met by these tests include: (a) preliminary

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE LOWER LEVELS FOR DETAIL SCHEDULES

compatibility checks of interfacing components, modules, assemblies and subsystems; (b) preliminary supportability requirements evaluation; (c) preliminary training requirements evaluation; (d) preliminary software requirements evaluation; (e) preliminary reliability, maintainability and safety criteria evaluation; (f) adequacy of design and modifications to design resulting from design deficiencies and/or design improvements; (g) procedures development for both normal and emergency utilization of vehicle and ground support hardware/software; and (h) data needed to generate statistical histories as a basis for on-board and ground software for pre-flight, in-flight and post-flight operations and maintenance.

II. SUBSYSTEM-LEVEL DEFINITION

As noted on Figure 4.0-W-5, fourteen elements comprise the subsystem-level definition of Stage II Subsystem Development Tests. These elements form the end items of Category I tests resulting from single subsystem development tests which are part of each subsystem as noted in WBS Dictionary Element 1.3, Para. VI. Whereas WBS ID 1.3.2, 1.3.3, ... 1.3.13 tests are unique to components and sub-assemblies of each subsystem, WBS ID 4.1 tests are generally unique to one or more subsystems, with the exception of Airframe and Structure where, due to the complex interactions of this subsystem with other subsystems, it is essential that complete air-worthiness and design integrity be verified in both WBS ID 4.1 and 4.3 prior to fabricating flight test vehicles. To a similar extent, propulsion and power plant also require full development testing prior to commiting these elements to flight test.

The fourteen subsystem level elements are as follows:

4.1.1	Test Planning
4.1.2	Prototype Equipment
4.1.3	Models
4.1.4	Wind Tunnel Tests and Evaluation
4.1.5	Static Tests and Evaluation
4.1.6	Dynamic Tests and Evaluation
4.1.7	Proof and Thermal Tests and Evaluation
4.1.8	Engine Tests and Evaluation (Including PFRT)

4.1.9	Integrated Ground Tests and Evaluation
4.1.10	Test Instrumentation
4.1.11	Test Equipment
4.1.12	Test Support Equipment
4.1.13	Test Facilities Utilization
4.1.14	Development Test Software

III. FUNCTIONAL DESCRIPTION

WBS ID 4.1 is a composite of hardware, software, procedures, test facilities, logistics support and test personnel which together comprise the development test program for Stage II subsystems (WBS ID 1.3.2 through 1.3.13). Inasmuch as the Advanced Space Transport Program objectives (WBS Dictionary Element 0.0) are to provide 10-year operations using manned, reusable two-stage Air Vehicles to transport GFE payloads from earth to near-earth space, to retrieve certain payloads from space, and to successfully return therefrom to earth for recycle to the next mission, it is necessary that development tests be performed which both demonstrate maximum design capability as well as demonstrate life cycle capability.

The Level I and II requirements specified in WBS Dictionary Element 0.0, Para. IV. A and B, and in WBS Dictionary Element 1.3, Para. IV, effectively establish the general requirements which WBS ID 4.1 shall verify for Stage II subsystems prior to committing these subsystems to system tests (Category II tests).

The following table summarizes the tests which need to be conducted under WBS ID 4.1. Details of these tests will be specified after Phase C go-ahead.

STAGE II SUBSYSTEM		TYPE DEVELOPMENT TESTS REQUIRED (WBS ID)					
WBS ID	Nomenclature	Wind Tunnel (4 1 4)	Static Tests (4 1 5)	Dynamic Tests (4 1 6)	Proof & Thermal Tests (4 1 7)	Engine Tests (4 1 8)	Integrated Ground Tests (4 1 9)
1.3 2	Airframe & Structure	.Aero .Heat Transfer .Struct. Dyn. .Mission Profile	Fatigue .Struct Integrity .Human Factors Eval, Hdw Integ	Separation Drop (Model) .Ditching (Model) Life Cycle Payload	.Pressure Leak Heat Transfer .Drop Tests (Gear)	---	.Cabin/ ECLSS Cluster Firings Ground Purge .Thermal Control
1 3 3	Primary Cryogenic Storage	---	Fatigue .Integ of Hardware	Life Cycle	Hydro-static Penumo-static .Leakage	---	OMS Propul ACPS Propul .Ground Purge
1 3.4	Propulsion & Power Plant	.Design Rqts	.Integ. of Hardware	Acoustics Vibration .Life Cycle Flow Rates	Pressure .Leak .Heat Transfer .Fire Ex-tinguish	.Main OMS ACPS ABES	Cluster Firings Thermal Condition-ing
1.3 5	Flight Control	.Design Rqts	Integ of Hardware	Life Cycle On/Off Rates, Gains	Pressure Leak .Heat Transfer	---	Integ Avionics/ Non-Avionics Cluster Firings
1.3 6	Secondary Power	---	Integ of Hardware	Flow Dyn Expulsion Rates .Start/Stop .Loads/ Transients .Life Cycle	Leak Checks Pressure .Heat Transfer	---	Integ Avionics/ Non-Avionics Cluster Firings Cabin/ ECLSS Ground Purge
1.3 7	ECLSS	Design Rqts	In eg of hdw	Simulations Rates Pressures Leakage	.Fire Protection	---	.Cabin/ ECLSS Ground Cooling
1 3 8	Guidance & Navigation	---	Pre-launch Alignment Technique Integ of Hardware	Drift Rate .Switching Simulations	Heat Transfer	---	Integ Avionics/ Non-Avionics Cabin/ ECLSS
1.3 9	Communications & Navaids	---	Integ of hdw.	RF Tests .Voice Tests Navaids Tests	Heat Transfer	---	Integ Avionics/ Non-Avionics Cabin/ ECLSS
1.3 10	Data Management	Design Rqts	Integ of Hdw/ Software	.Simulations Instrumen-tation Checks	Heat Transfer	---	Integ Avionics/ Non-Avionics .Cluster Firings Cabin/ ECLSS Thermal Control
1.3 11	Displays & Controls	---	Human Factors Eval. Integ of Hardware	.Simulations	---	---	.Integ Avionics/ Non-Avionics Cabin/ ECLSS
1 3.12	Crew Subsystems	.Design Rqts	Human Factors Eval .Integ of Hardware	Visibility Mobility Ingress/ Egress Zero G	.Fire Pre-vention	---	(See Mock-ups, WBS ID 4 8) .Cabin/ ECLSS
1 3 13	Safety Subsystem	Design Rqts.	Human Factors Eval Integ of Hardware	Sled Tests Escape Tests	---	---	(See Mock-ups, WBS ID 4 8) Cabin/ ECLSS

IV. TEST SUPPORT

The preceding tests will be conducted at Government and Contractor test facilities in accordance with the adopted Test Plan (WBS ID 5.0). Test support will include the need for test instrumentation calibrated to measure the desired parameter within the specified accuracy required, test equipment including necessary software, and test support equipment including environmental simulation required. Test requirements and test procedures will be based on CEI Part I/II specifications as applicable. Test articles will, in most cases, be prototype hardware. If test results are to qualify the hardware/software for flight, necessary procedures shall be adhered to and tests witnessed so as to ensure results are officially recognized as representing flight hardware and simulated flight environment.

V. REFERENCES

(To be added.)

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PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.1.2

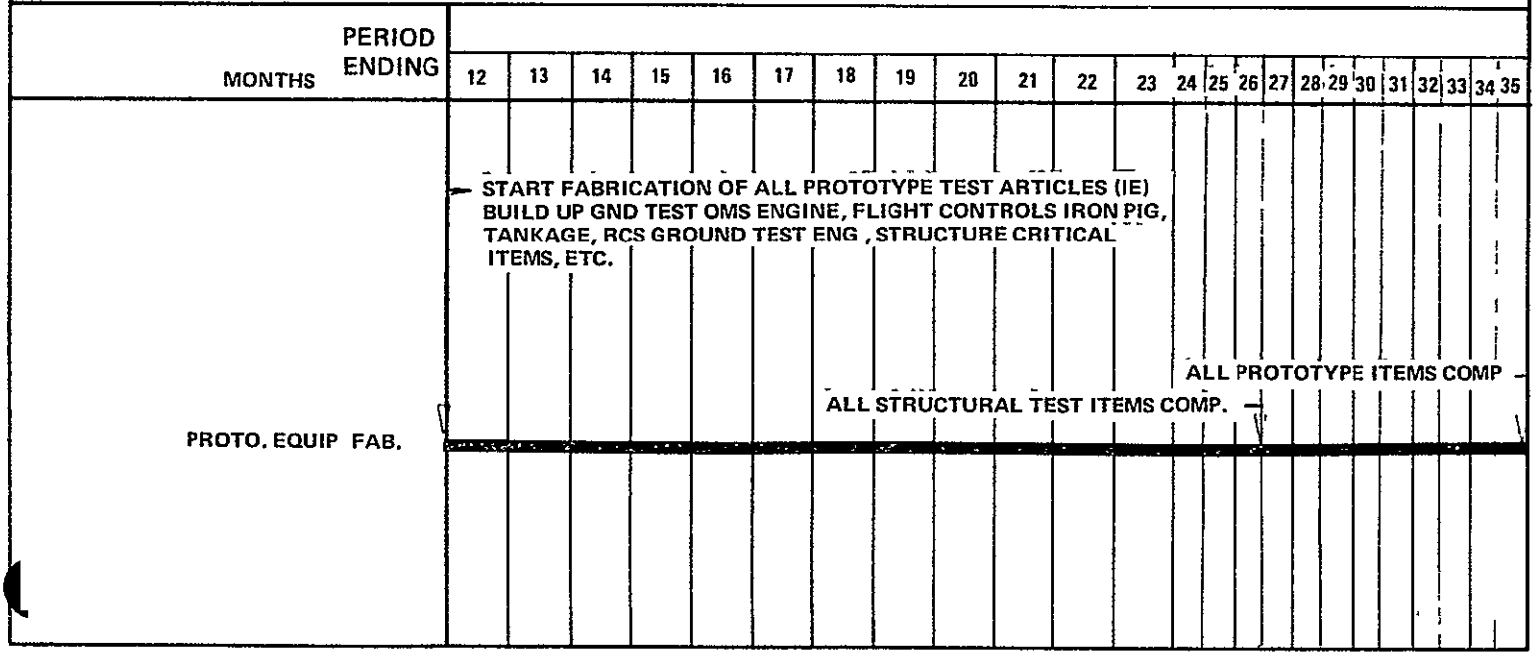
TASK TITLE PROTOTYPE EQUIPMENT (STAGE II) (TEST)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.1.)

TASK SCHEDULE MILESTONES



VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.1.3

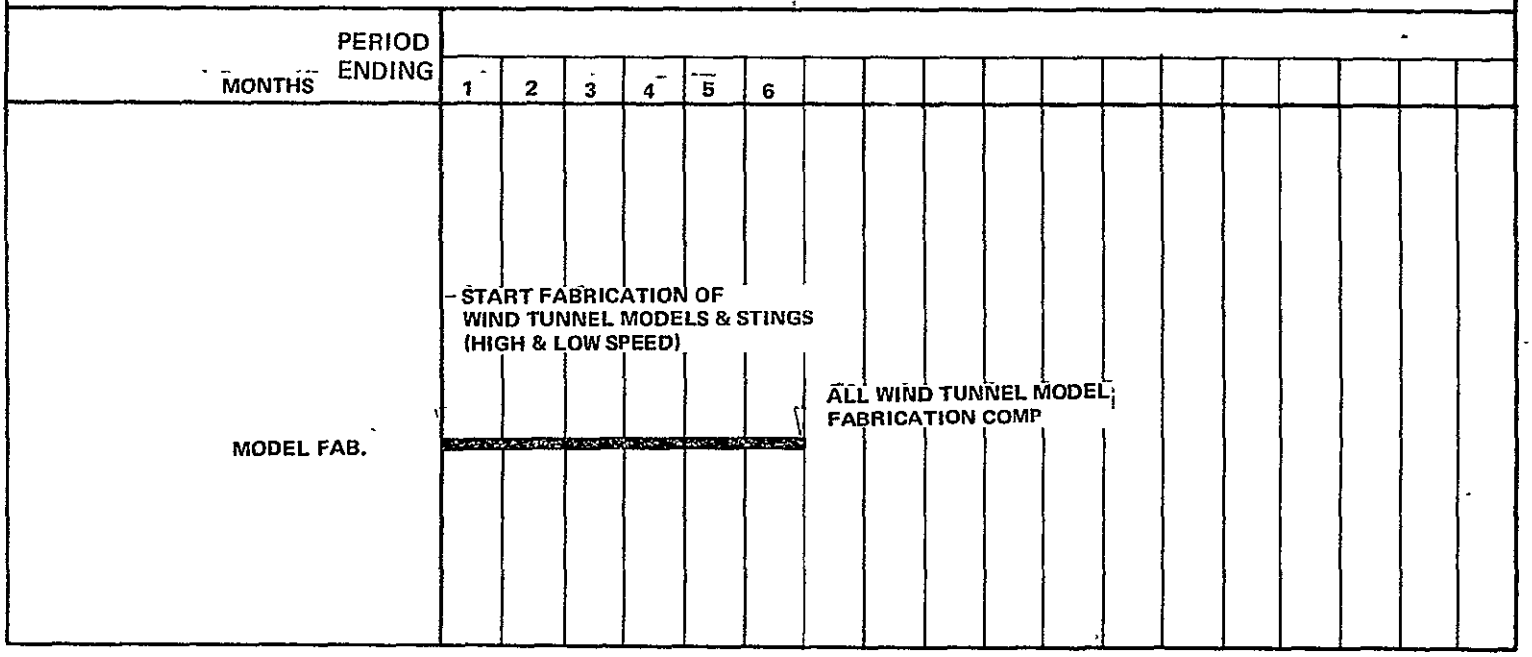
TASK TITLE MODELS (STAGE II) (TEST)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.1.)

TASK SCHEDULE MILESTONES



VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.1.4

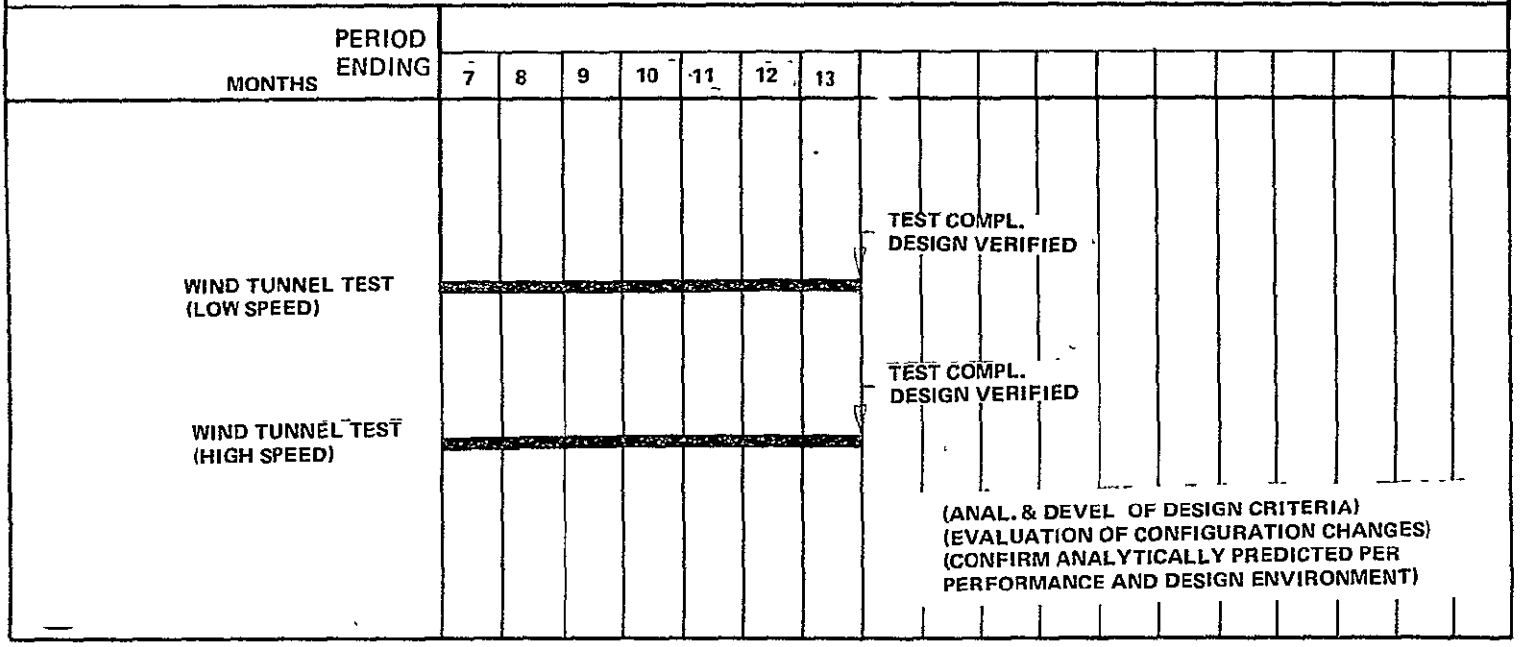
TASK TITLE WIND TUNNEL TESTS & EVALUATION (STAGE II)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.1.)

TASK SCHEDULE MILESTONES



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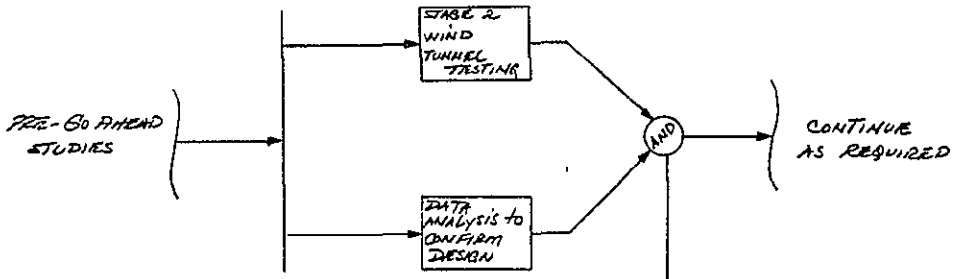

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TEXAS DIVISION

WBS NO	4.1.4 0 0
TITLE	STAGE R WIND TUNNEL TESTS + EVALUATION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
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ENGINEERING

B01

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.1.5

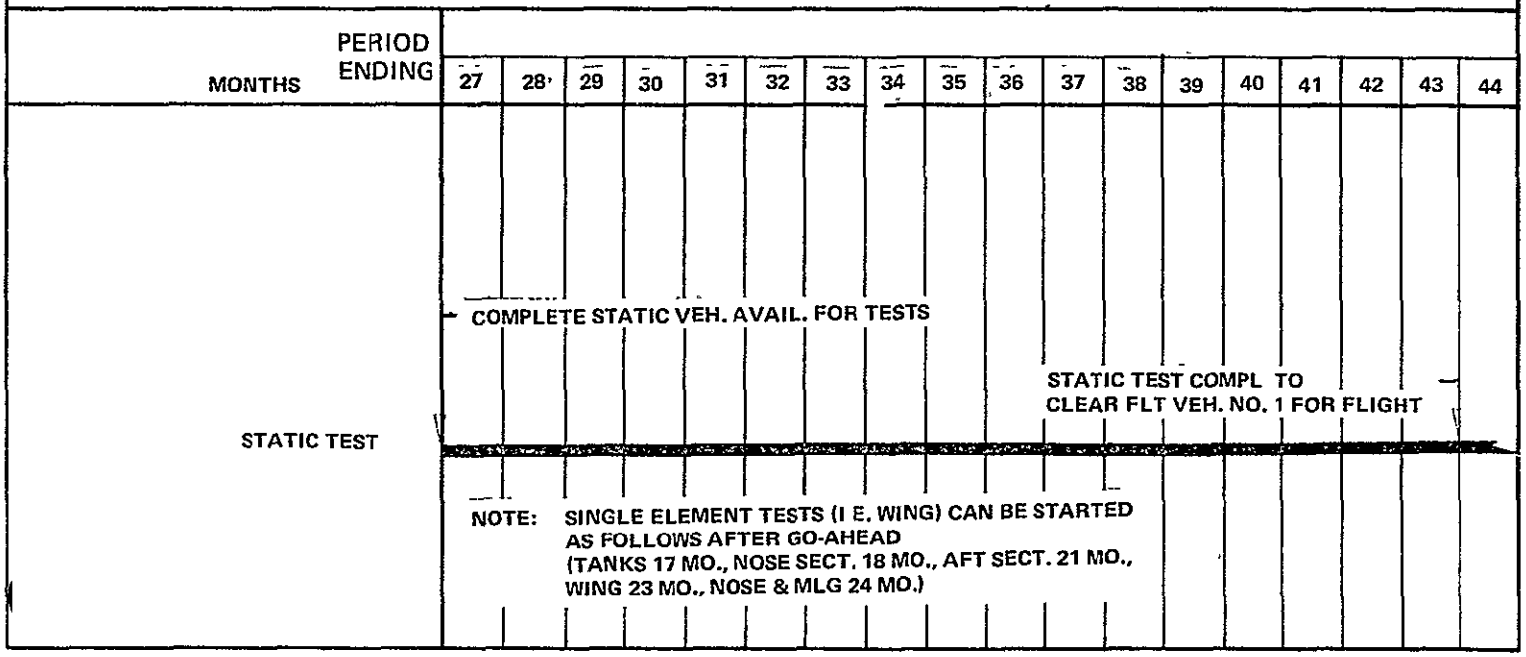
TASK TITLE STATIC TESTS & EVALUATION (STAGE II)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.1.)

TASK SCHEDULE MILESTONES



VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.1.6

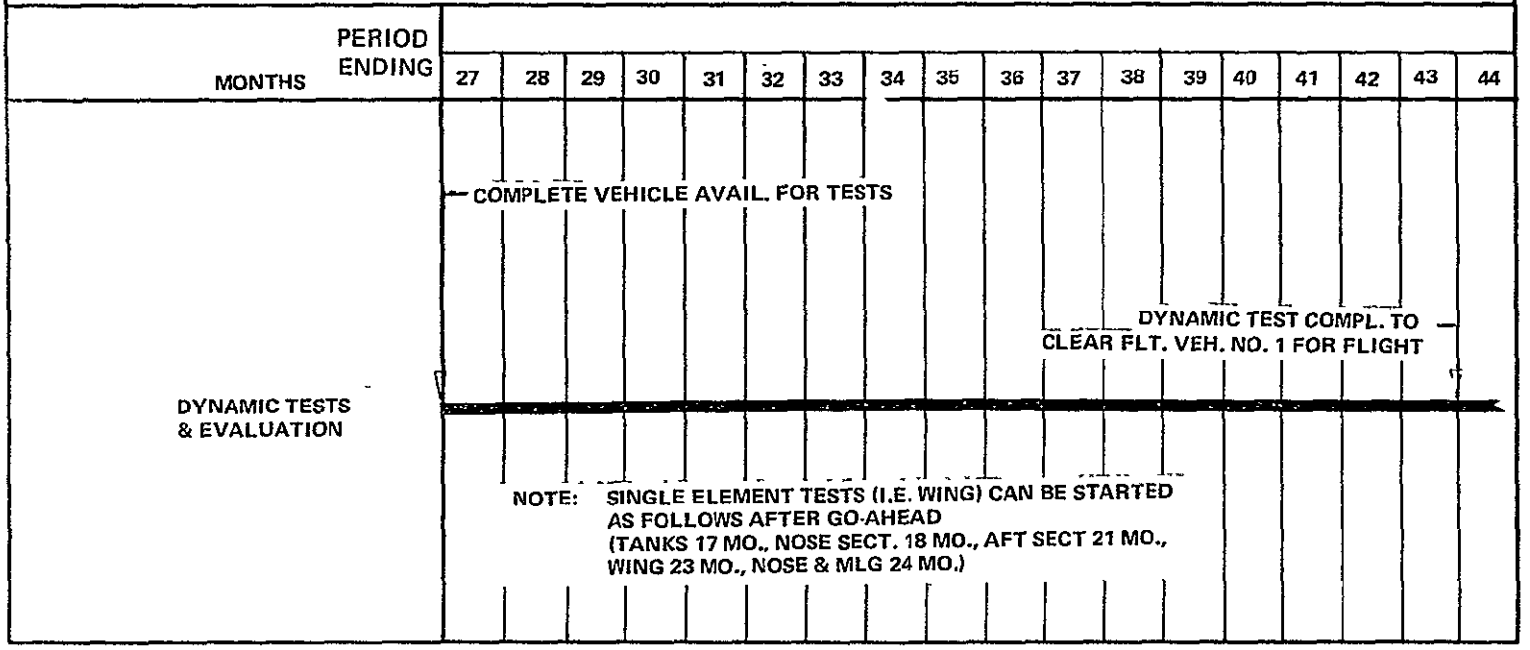
TASK TITLE DYNAMIC TESTS & EVALUATION (STAGE II)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.1.)

TASK SCHEDULE MILESTONES



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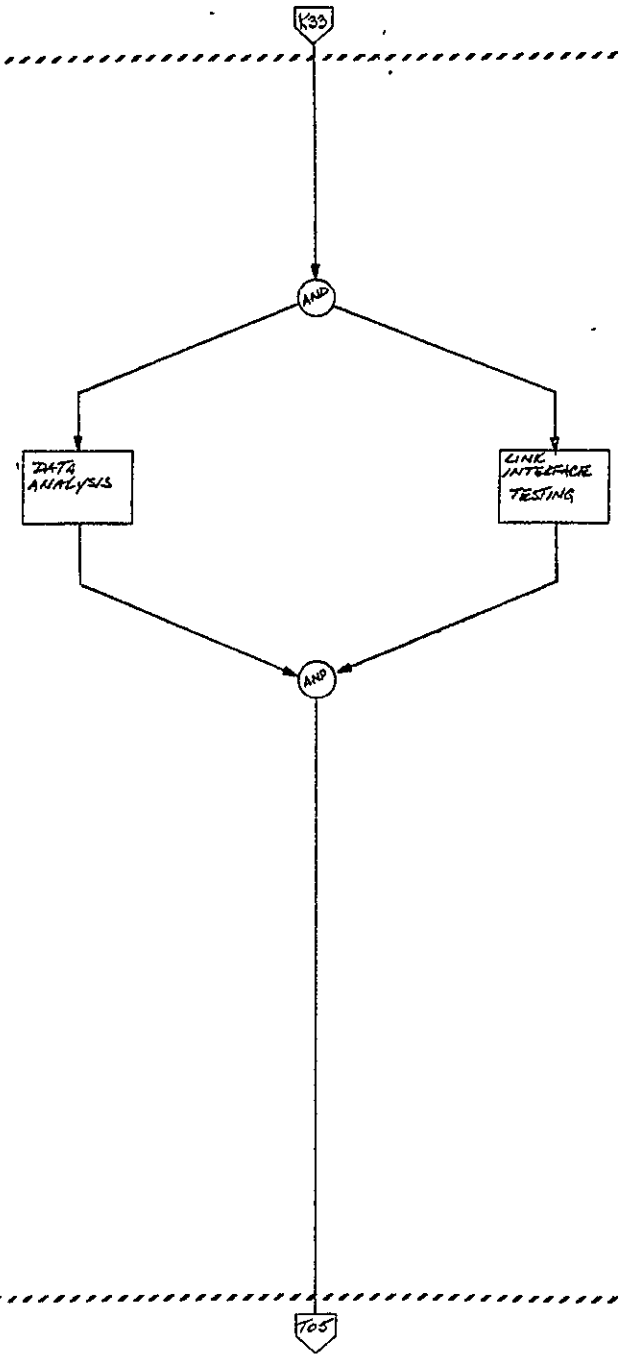

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4.1600
TITLE	STAGE 2 DYNAMIC TESTS & EVALUATION
WBS LEVEL	FIFTH (5TH)
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OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.1.7

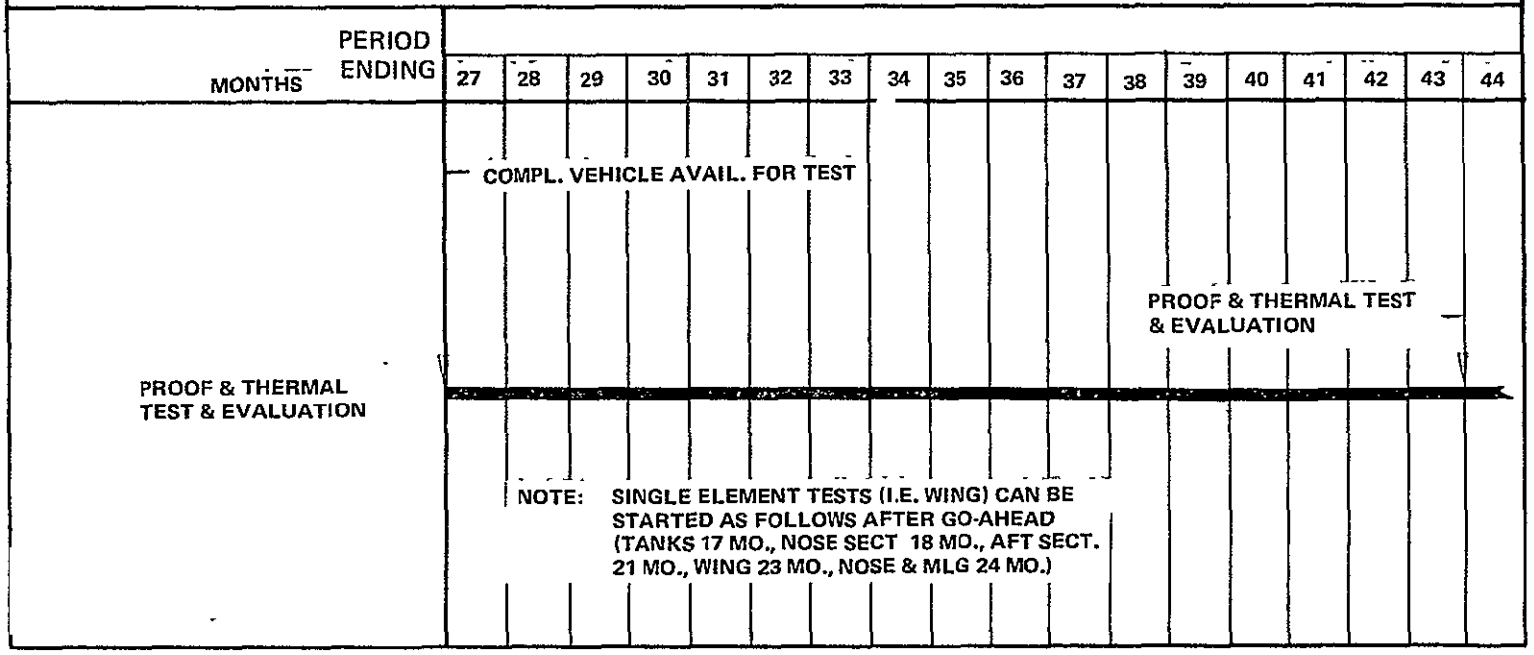
TASK TITLE PROOF & THERMAL TESTS & EVALUATION (STAGE II)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Description not provided. See WBS Dictionary Element 4.1.)

TASK SCHEDULE MILESTONES



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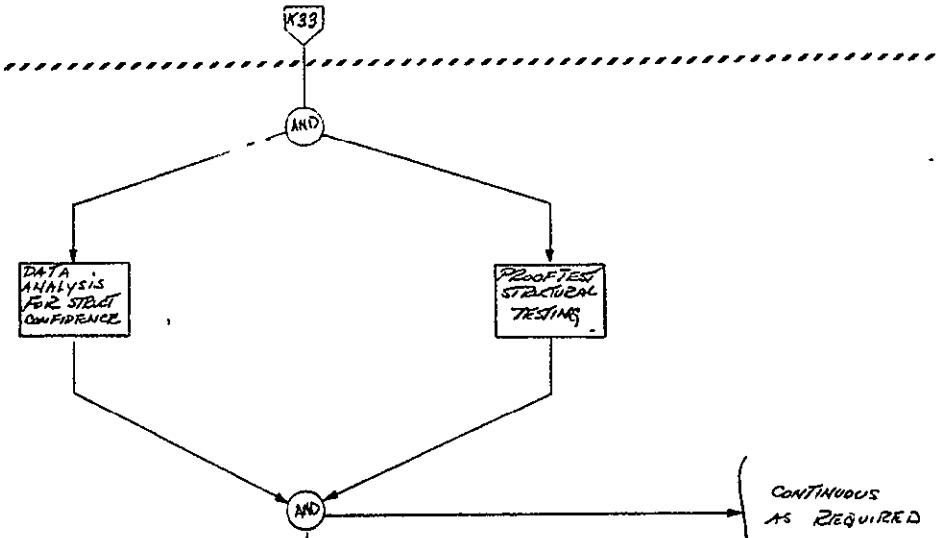

ENGINEERING

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4.1.7.00
TITLE	STAGE 2 PROOF AND THERMAL TESTS/EVALUATION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	8 JUN 71

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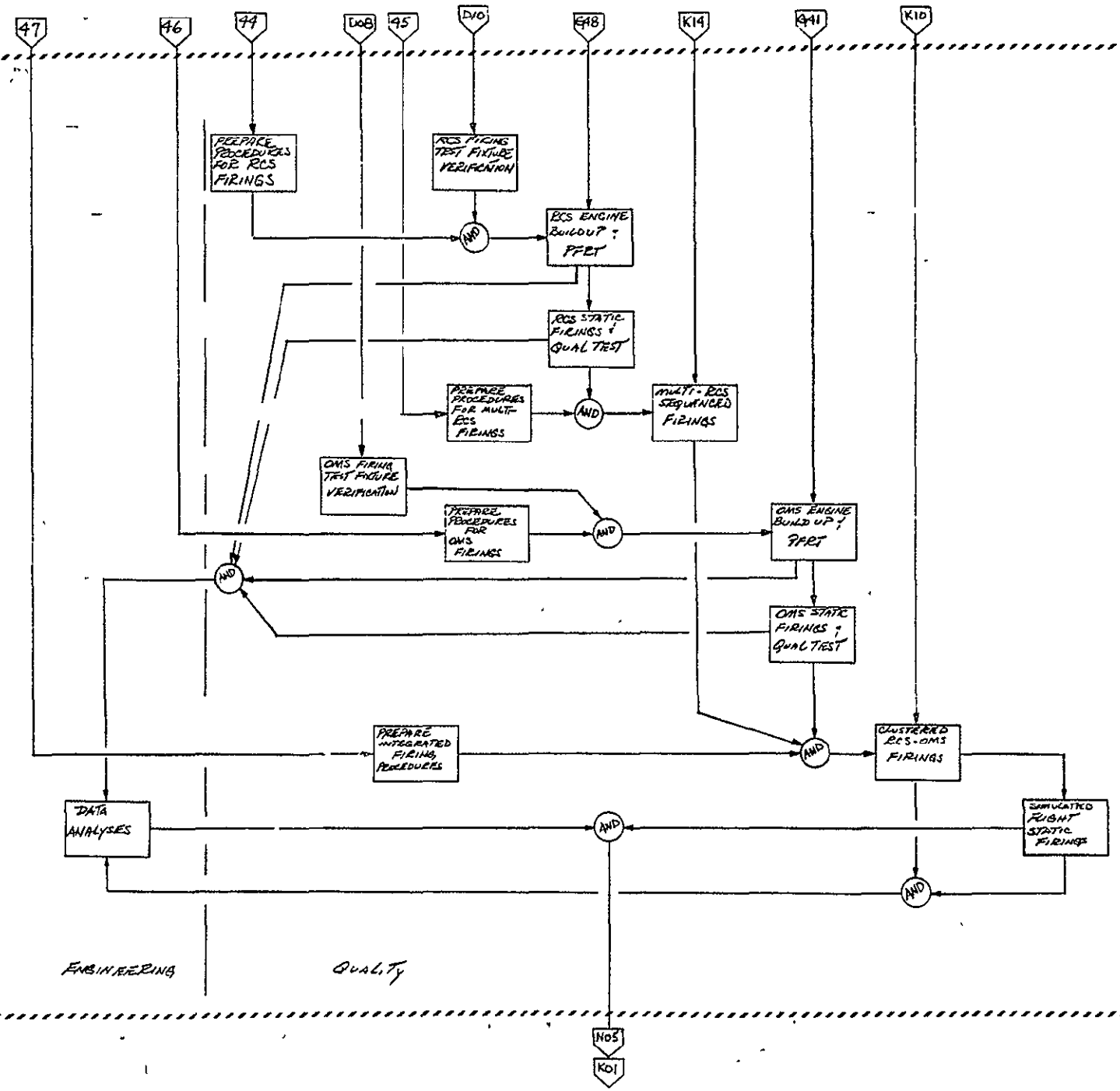

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

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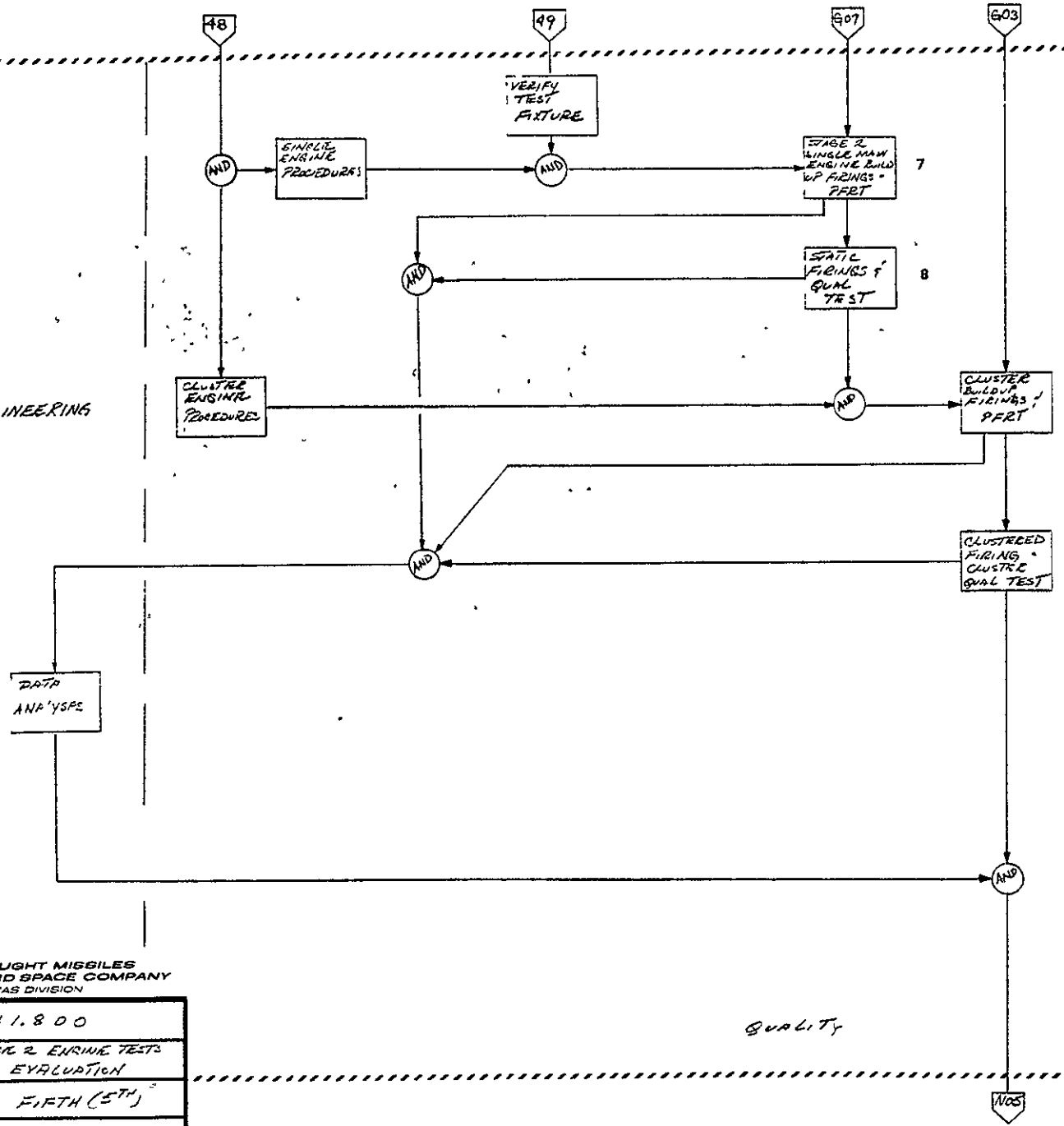
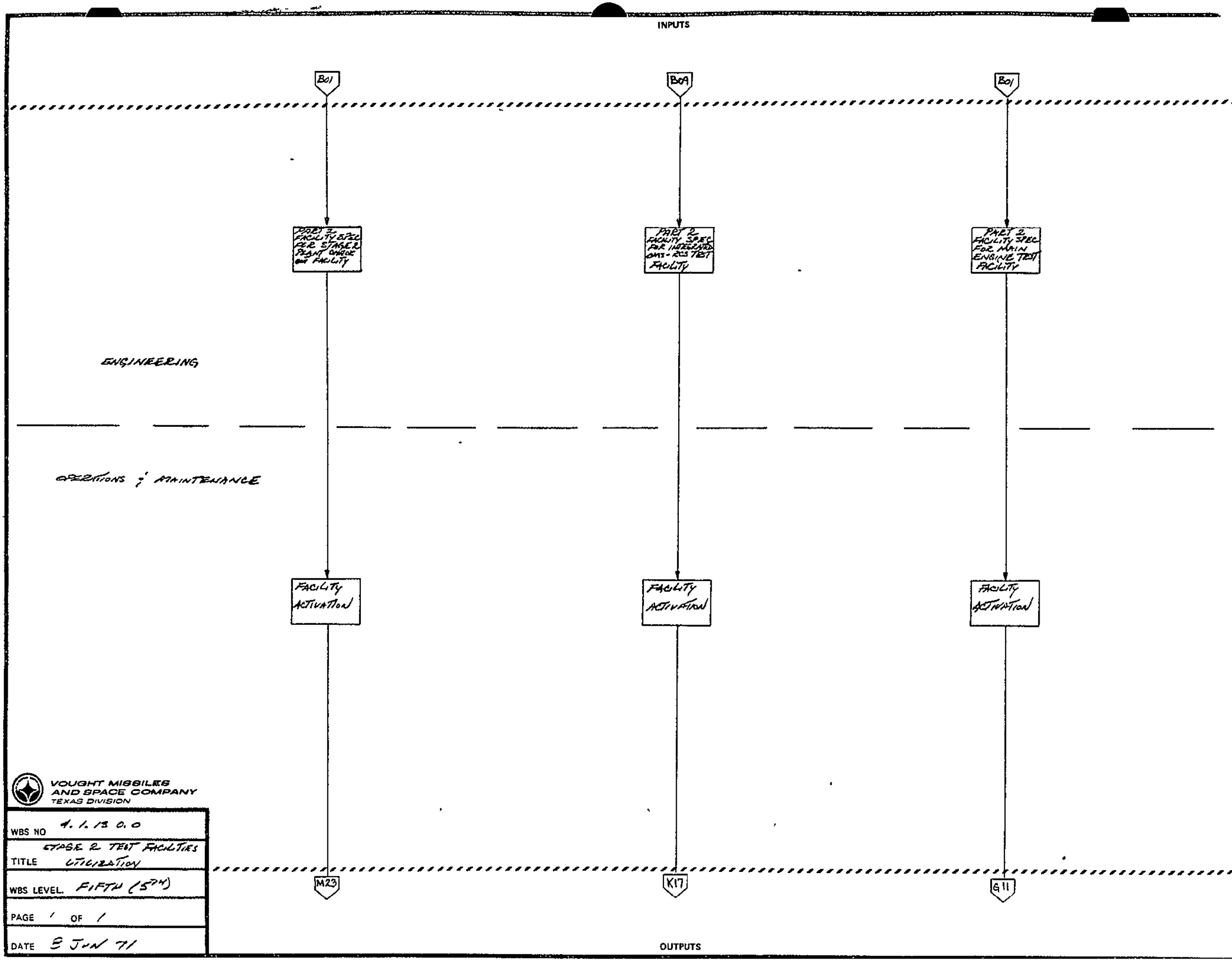
TITLE	STAGE 2 ENGINE TESTS AND EVALUATION
WBS LEVEL	FIFTH
PAGE	1 OF 2
DATE	7 JUN 71



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	41.800
TITLE	STAGE 2 ENGINE TESTS AND EVALUATION
WBS LEVEL	FIFTH (5TH)
PAGE	2 OF 2
DATE	9 JUN 71



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4.1.13 0.0
TITLE	STAGE 2 TEST FACILITIES UTILIZATION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	3 JUN 71

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.2

TASK TITLE STAGE I SUBSYSTEM DEVELOPMENT TESTS

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

Development tests are required of Stage I subsystems (see Figure 1.4-W-3, Vol. III) which effectively complete Category I tests and enable flight test to proceed. A complementary set of Category I tests on Stage I includes major Structural Tests, WBS ID 4.4.

Stage I Development Tests will be contractor-conducted, NASA controlled, and will demonstrate performance, reliability, maintainability, safety and integrity of Stage I subsystems, including components, modules and assemblies thereof. In addition, preliminary performance, operating characteristics and qualitative adequacy of the system, subsystem and end items will be developed.

Other objectives which will be met by these tests include: (a) preliminary

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE LOWER LEVELS FOR DETAIL SCHEDULES

compatibility checks of interfacing components, modules, assemblies and subsystems; (b) preliminary supportability requirements evaluation; (c) preliminary training requirements evaluation; (d) preliminary software requirements evaluation; (e) preliminary reliability, maintainability and safety criteria evaluation; (f) adequacy of design and modifications to design resulting from design deficiencies and/or design improvements; (g) procedures development for both normal and emergency utilization of vehicle and ground support hardware/software; and (h) data needed to generate statistical histories as a basis for on-board and ground software for pre-flight, in-flight and post-flight operations and maintenance.

II. SUBSYSTEM-LEVEL DEFINITION

As noted on Figure 4.0-W-5, fourteen elements comprise the subsystem-level definition of Stage I Subsystem Development Tests. These elements form the end items of Category I tests resulting from single subsystem development tests which are part of each subsystem as noted in WBS Dictionary Element 1.4, Para. VI. Whereas WBS ID 1.4.2, 1.4.3, ... 1.4.13 tests are unique to components and sub-assemblies of each subsystem, WBS ID 4.2 tests are generally unique to one or more subsystems, with the exception of Airframe and Structure where, due to the complex interactions of this subsystem with other subsystems, it is essential that complete air-worthiness and design integrity be verified in both WBS ID 4.2 and 4.4 prior to fabricating flight test vehicles. To a similar extent, propulsion and power plant also require full development testing prior to commiting these elements to flight test.

The fourteen subsystem level elements are as follows:

4.2.1	Test Planning
4.2.2	Prototype Equipment
4.2.3	Models
4.2.4	Wind Tunnel Tests and Evaluation
4.2.5	Static Tests and Evaluation
4.2.6	Dynamic Tests and Evaluation
4.2.7	Proof and Thermal Tests and Evaluation
4.2.8	Engine Tests and Evaluation (Including PFRT)

4.2.9	Integrated Ground Tests and Evaluation
4.2.10	Test Instrumentation
4.2.11	Test Equipment
4.2.12	Test Support Equipment
4.2.13	Test Facilities Utilization
4.2.14	Development Test Software

III. FUNCTIONAL DESCRIPTION

WBS ID 4.2 is a composite of hardware, software, procedures, test facilities, logistics support and test personnel which together comprise the development test program for Stage I subsystems (WBS ID 1.4.2 through 1.4.13). Inasmuch as the Advanced Space Transport Program objectives (WBS Dictionary Element 0.0) are to provide 10-year operations using manned, reusable two-stage Air Vehicles to transport GFE payloads from earth to near-earth space, to retrieve certain payloads from space, and to successfully return therefrom to earth for recycle to the next mission, it is necessary that development tests be performed which both demonstrate maximum design capability as well as demonstrate life cycle capability. Stage I's mission is defined in WBS Dictionary Element 1.4 (Vol. III).

The Level I and II requirements specified in WBS Dictionary Element 0.0 Para. IV. A and B effectively establish the general requirements which WBS ID 4.2 shall verify for Stage I subsystems prior to committing these subsystems to system tests (Category II tests).

The following table summarizes the tests which need to be conducted under WBS ID 4.2. Details of these tests will be specified after Phase C go-ahead.

STAGE I SUBSYSTEM		TYPE DEVELOPMENT TESTS REQUIRED (WBS ID)					
WBS ID	Nomenclature	Wind Tunnel (4.2 4)	Static Tests (4.2 5)	Dynamic Tests (4.2 6)	Proof & Thermal Tests (4.2 7)	Engine Tests (4.2 8)	Integrated Ground Tests (4 2 9)
1.4.2	Airframe & Structure	.Aero Heat Transfer Struct Dyn Mission Profile	.Fatigue .Struct Integrity Human Factors Eval Hdw Integ	Separation Drop (Model) Ditching (Model) Life Cycle	Pressure Leak Heat Transfer Drop Tests (Gear)	---	Cabin/ ECLSS .Cluster Firings Ground Purge Thermal Control
1 4 3	Primary Cryogenic Storage	---	Fatigue Integ of Hardware	Life Cycle	Hydro-static Penumo-static Leakage	---	APS Propul .Ground Purge
1 4 4	Propulsion & Power Plant	Design Rqts	Integ of Hardware	Acoustics Vibration Life Cycle Flow Rates	Pressure Leak Heat Transfer Fire Extinguish	Main ACPS ABES	Cluster Firings Thermal Conditioning
1 4 5	Flight Control	Design Rqts	Integ of Hardware	Life Cycle On/Off Rates, Gains	Pressure Leak Heat Transfer	---	Integ Avionics/ Non-Avionics Cluster Firings
1 4 6	Secondary Power	---	Integ of Hardware	Flow Dyn Expulsion Rates Start/Stop Loads/ Transients Life Cycle	Leak Checks Pressure Heat Transfer	---	Integ Avionics/ Non-Avionics Cluster Firings Cabin/ ECLSS Ground Purge
1 4 7	ECLSS	Design Rqts	Integ of hdw	Simulations Rates Pressures Leakage	Fire Protection	---	Cabin/EC Gnd Cool .Ground Purge
1 4 8	Guidance & Navigation	---	Pre-launch Alignment Technique Integ of Hardware	Drift Rate Switching Simulations	Heat Transfer	---	Integ Avionics/ Non-Avionics Cabin/ ECLSS
1 4 9	Communications & Navaids	---	Integ of hdw	RF Tests Voice Tests Navaids Tests	Heat Transfer	---	Integ Avionics/ Non-Avionics Cabin/ ECLSS
1 4 10	Data Management	Design Rqts	Integ of Hdw/ Software	Simulations Instrumentation Checks	Heat Transfer	---	.Integ Avionics/ Non-Avionics .Cluster Firings .Cabin/ ECLSS Thermal Control
1 4 11	Displays & Controls	---	Human Factors Eval Integ of Hardware	Simulations	---	---	.Integ Avionics/ Non-Avionics .Cabin/ ECLSS
1 4 1.	Crew Subsystems	Design Rqts	Human Factors Eval Integ of Hardware	Visibility .Mobility Ingress/ Egress Zero G	Fire Prevention	---	(See Mock-ups, WBS ID 4 9) Cabin/ ECLSS
1 4.13	Safety Subsystem	Design Rqts	Human Factors Eval Integ of Hardware	.Sled Tests Escape Tests	---	---	(See Mock-ups, WBS ID 4 9) Cabin/ ECLSS

IV. TEST SUPPORT

The preceding tests will be conducted at Government and Contractor test facilities in accordance with the adopted Test Plan (WBS ID 5.0). Test support will include the need for test instrumentation calibrated to measure the desired parameter within the specified accuracy required, test equipment including necessary software, and test support equipment including environmental simulation required. Test requirements and test procedures will be based on CEI Part I/II specifications as applicable. Test articles will, in most cases, be prototype hardware. If test results are to qualify the hardware/software for flight, necessary procedures shall be adhered to and tests witnessed so as to ensure results are officially recognized as representing flight hardware and simulated flight environment.

V. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.2.2

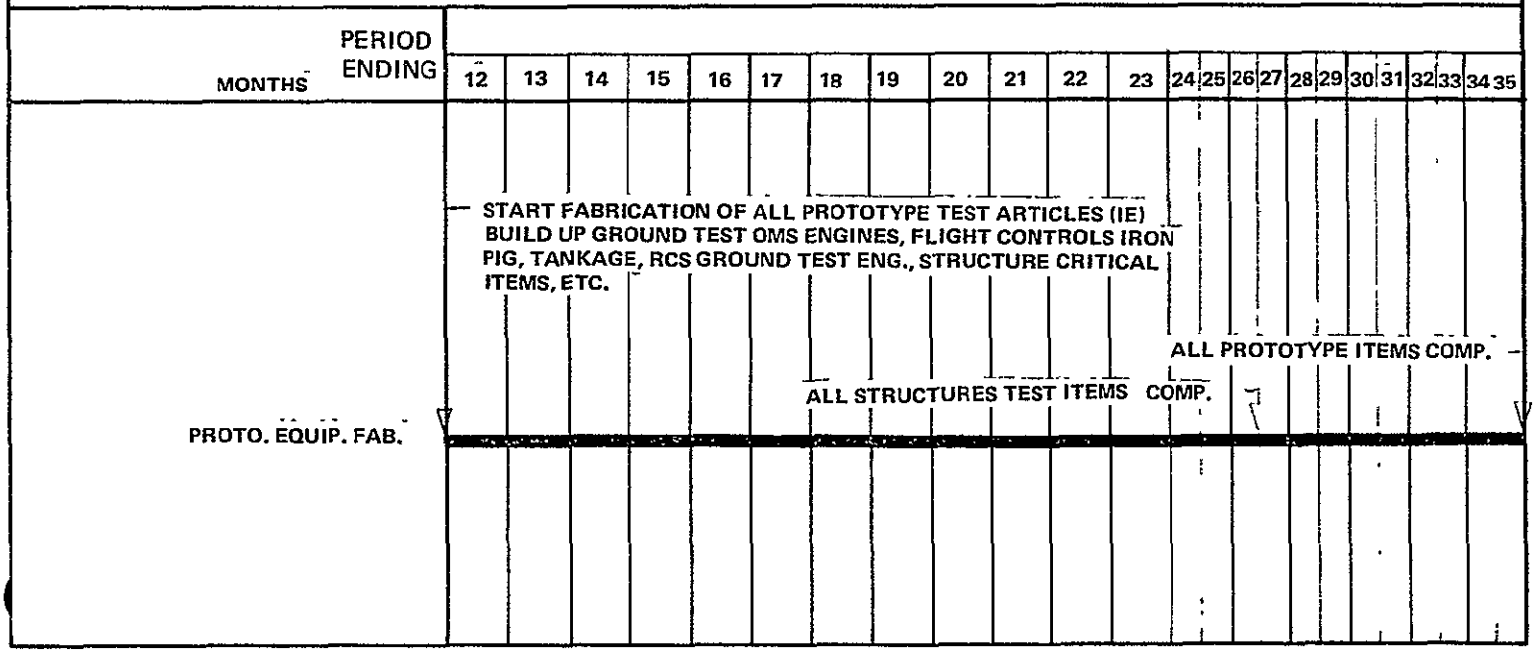
TASK TITLE PROTOTYPE EQUIPMENT (STAGE I) (TEST)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.2.)

TASK SCHEDULE MILESTONES



VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.2.3

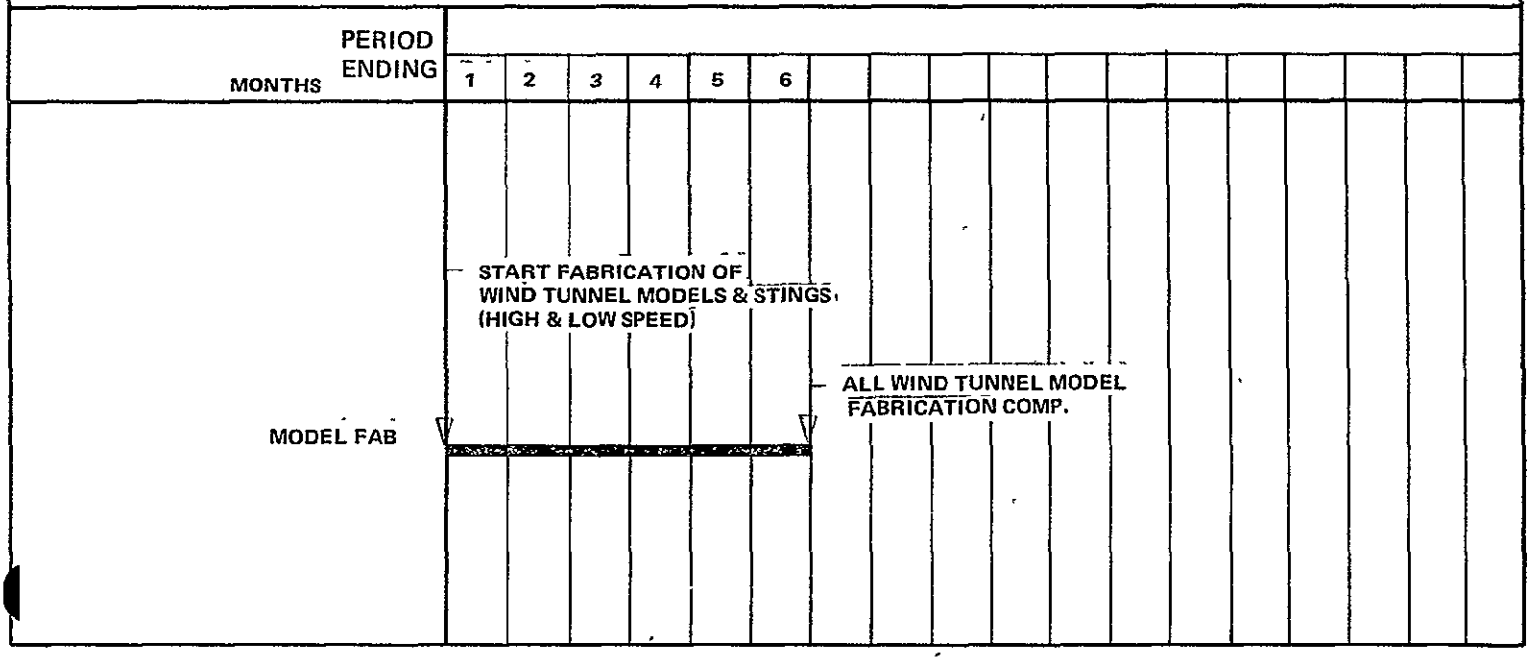
TASK TITLE MODELS (STAGE I) (TEST)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.2.)

TASK SCHEDULE MILESTONES



VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.2.4

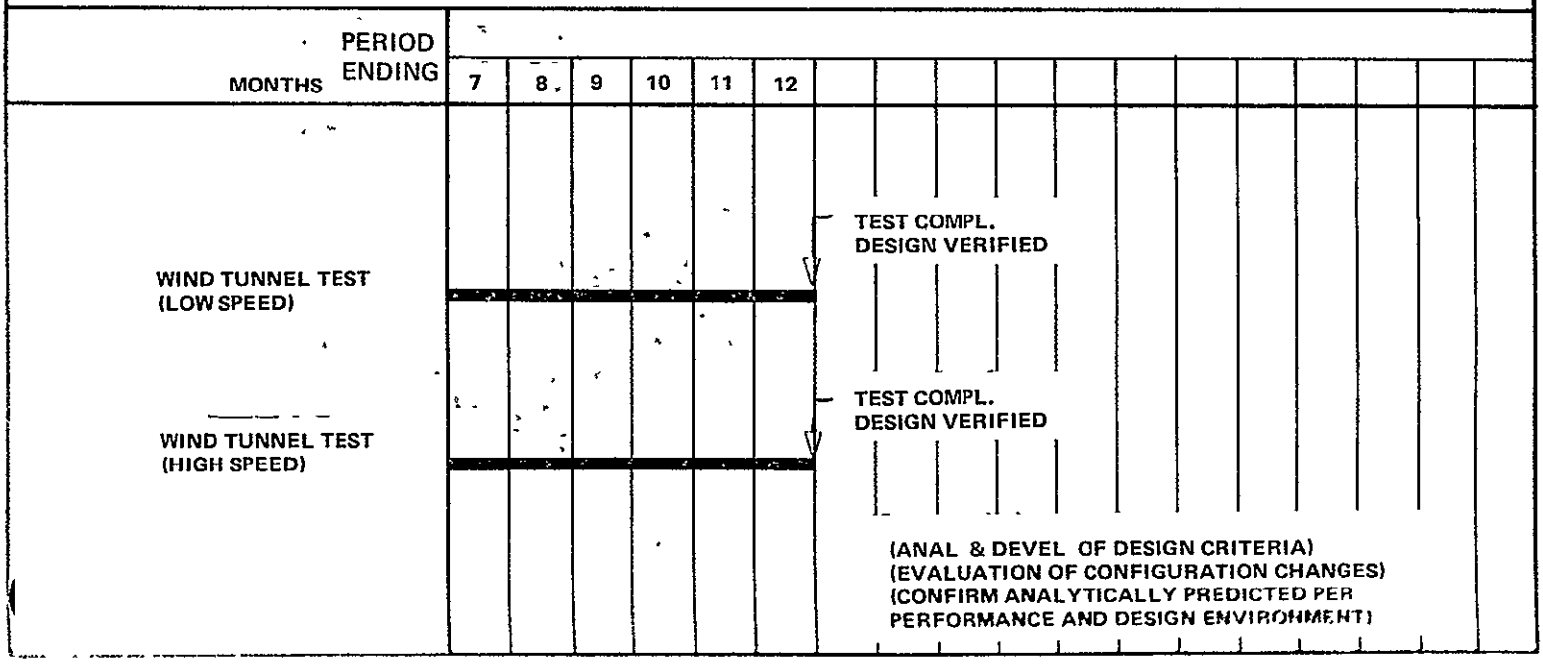
TASK TITLE WIND TUNNEL TESTS & EVALUATION (STAGE I)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.2.)

TASK SCHEDULE MILESTONES



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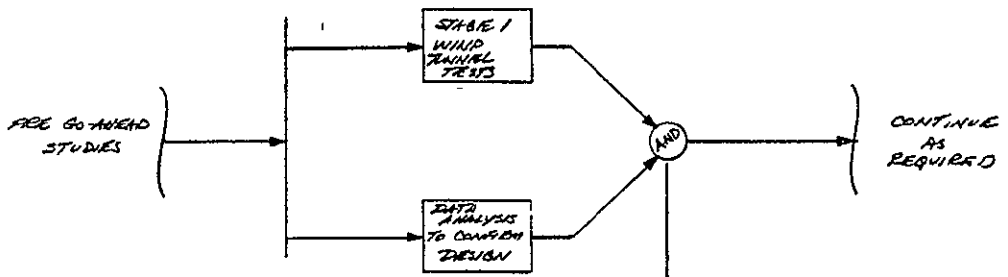


ENGINEERING

801

OUTPUTS

159

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	42400
TITLE	STAGE I WIND TUNNEL TESTS & EVALUATION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	9 Jun 71

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.2.5

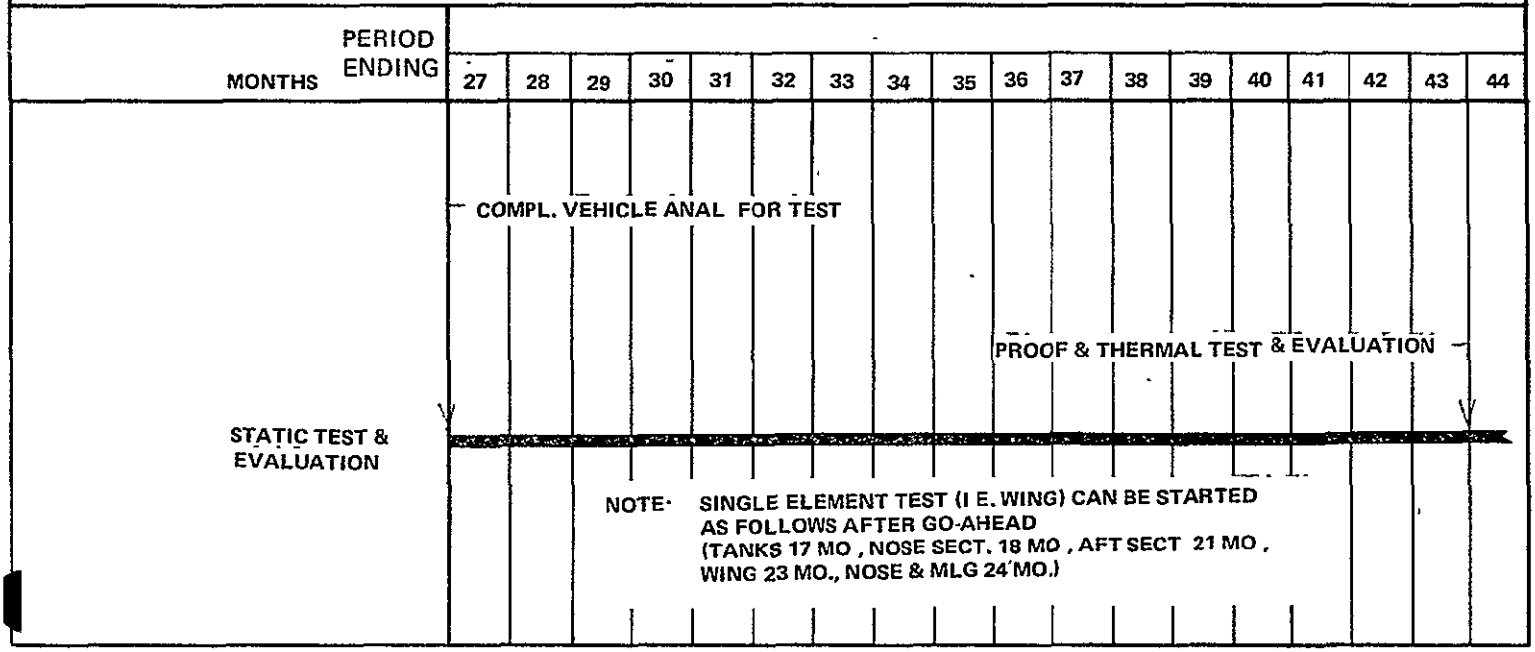
TASK TITLE STATIC TESTS & EVALUATION (STAGE I)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.2.)

TASK SCHEDULE MILESTONES



VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.2.6

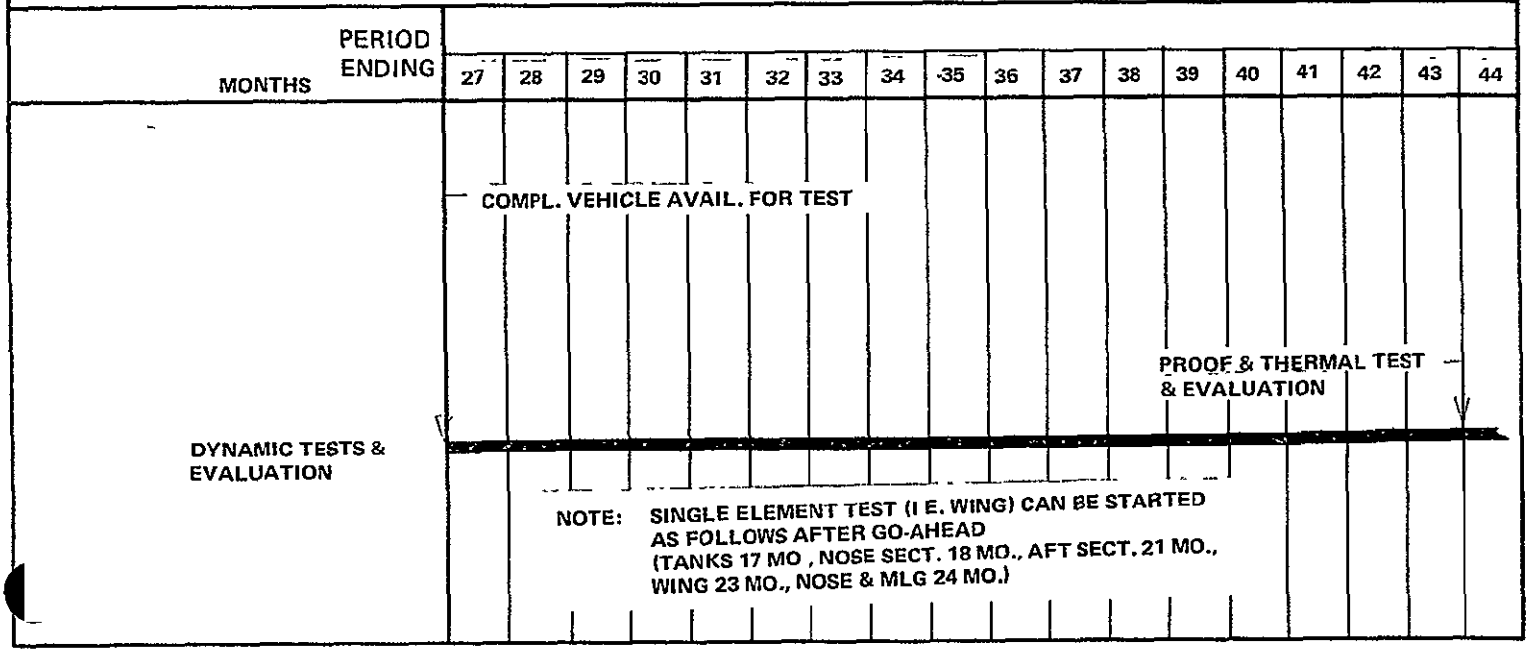
TASK TITLE DYNAMIC TESTS & EVALUATION (STAGE I)

LEVEL

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.2.)

TASK SCHEDULE MILESTONES



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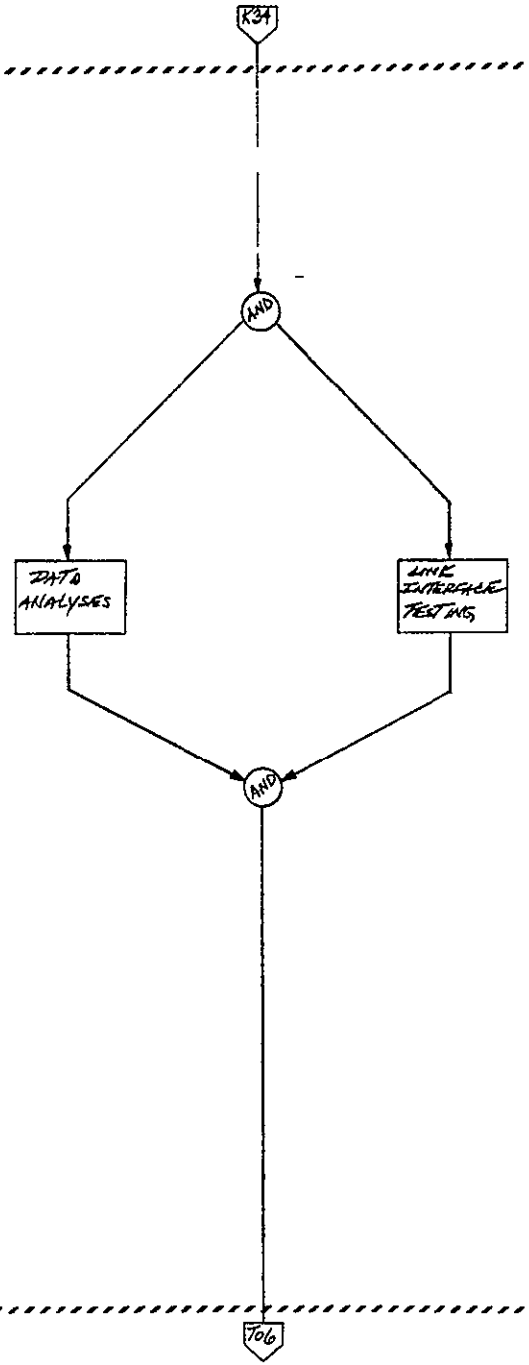


ENGINEERING

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4260.0
TITLE	STAGE I DYNAMIC TEST & EVALUATION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	9 JUN 71

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.2.7

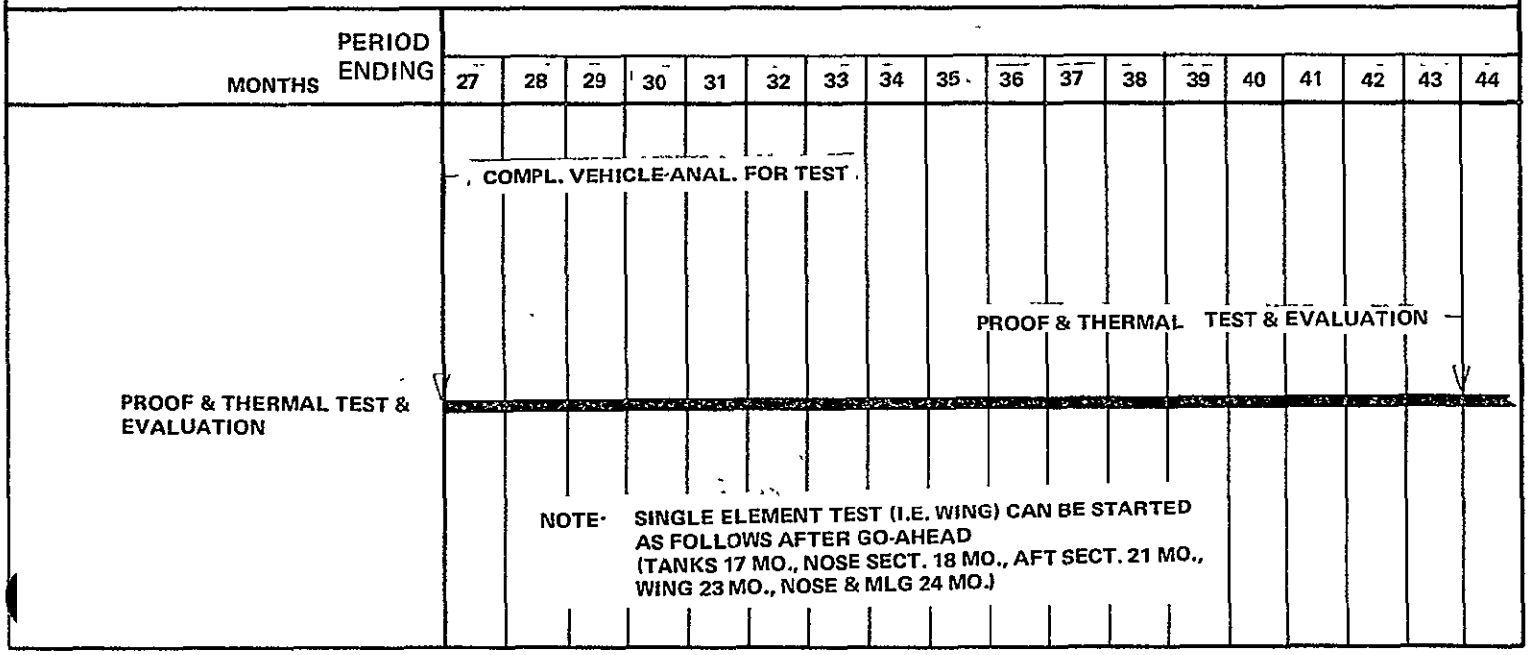
TASK TITLE PROOF & THERMAL TESTS & EVALUATION (STAGE I)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.2.)

TASK SCHEDULE MILESTONES



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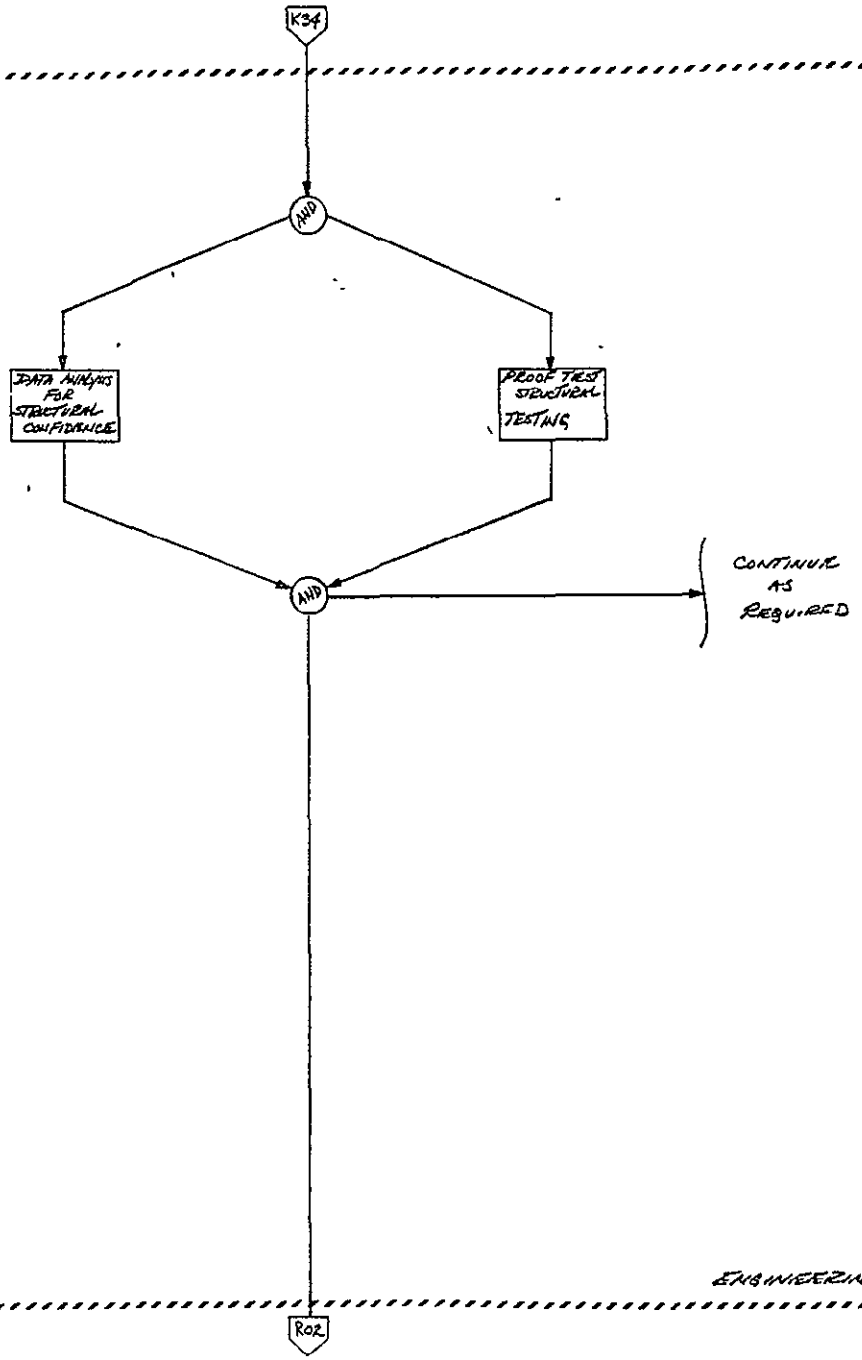


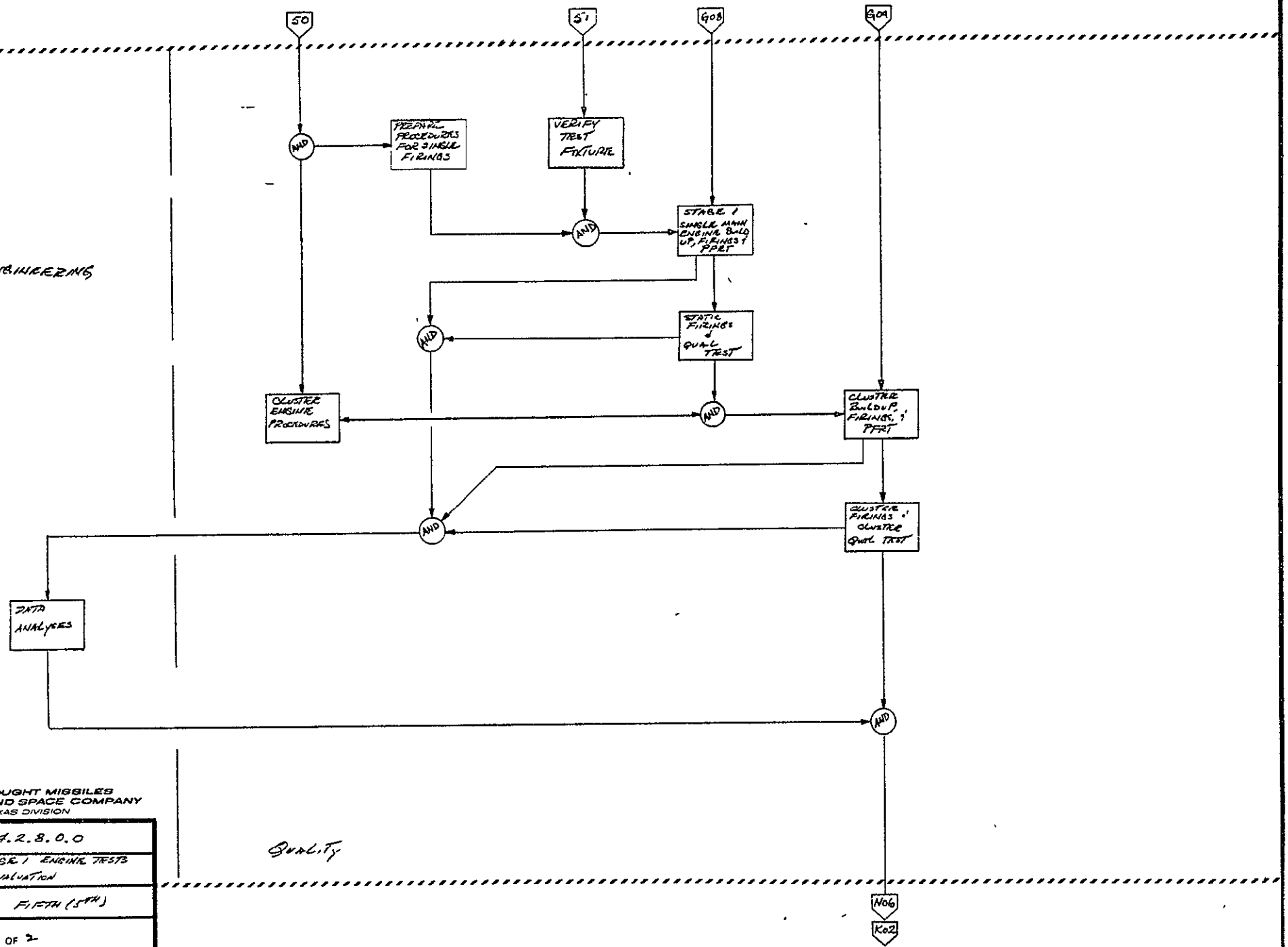
ENGINEERING

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	42700
TITLE	STAGE 1 PROOF & THERMAL TESTS & EVALUATION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	7 JUN 71

INPUTS

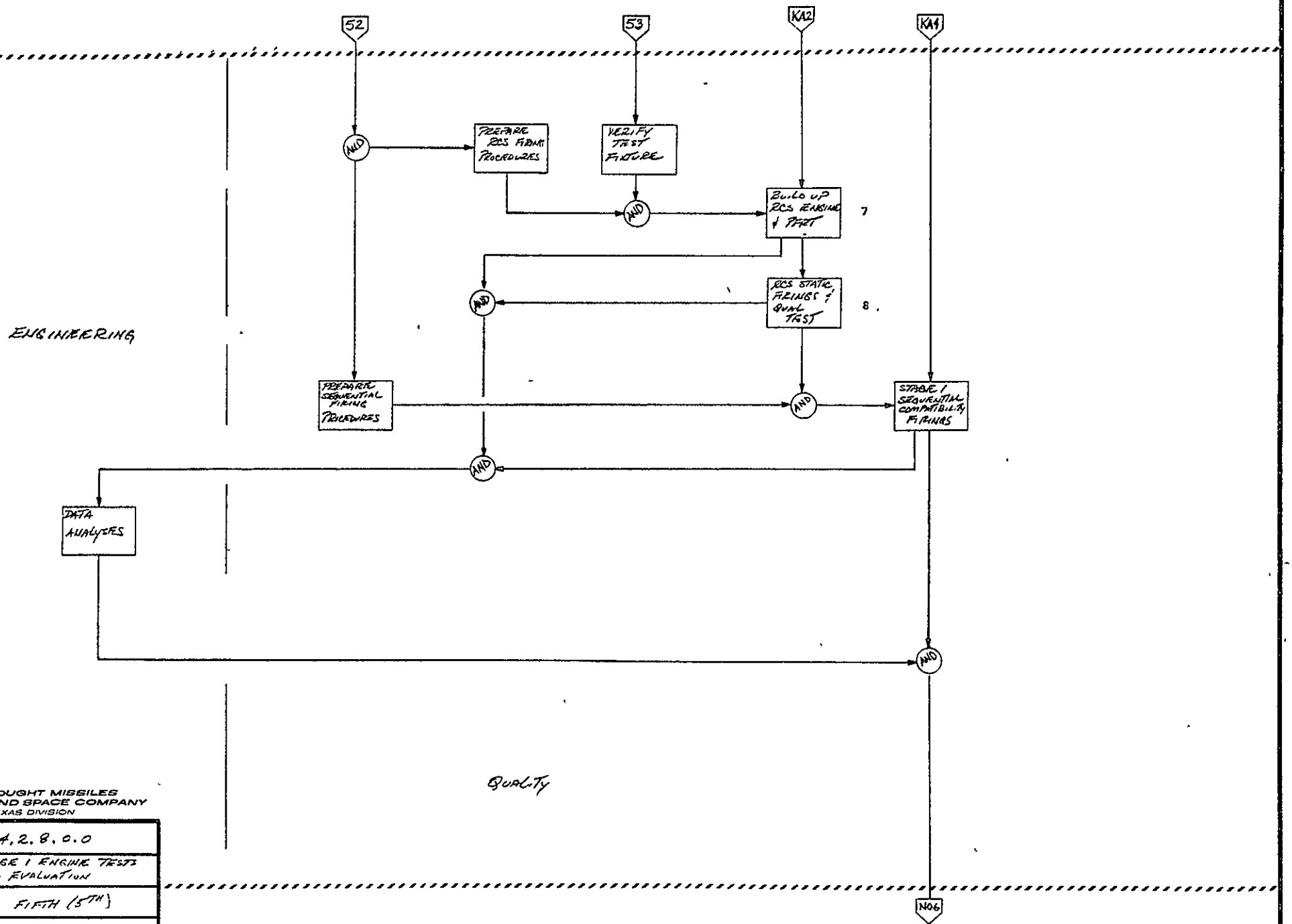


OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4.2.8.0.0
TITLE	STAGE 1 ENGINE TESTS & EVALUATION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 2
DATE	10 JUN 71

INPUTS



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4.2.8.0.0
TITLE	STAGE I ENGINE TESTS & EVALUATION
WBS LEVEL	FIFTH (5TH)
PAGE	2 OF 2
DATE	10 JUN 71

OUTPUTS

INPUTS

B01 | B15 | B01

ENGINEERING

PART 2 FACILITY SPEC FOR STAGE I PLANT OMEGA FACILITY

PART 2 FACILITY SPEC FOR RCS TEST FACILITY

PART 2 FACILITY SPEC FOR MAIN ENGINE TEST FACILITY

OPERATIONS & MAINTENANCE

FACILITY ACTIVATION

FACILITY ACTIVATION

FACILITY ACTIVATION

M24 | K16 | G12

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4.2.13.0.0
TITLE	STAGE I TEST FACILITIES UTILIZATION
WBS LEVEL	FIFTH
PAGE	1 OF 1
DATE	10 JUN 71

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.3

TASK TITLE STAGE II STRUCTURAL TESTS

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

In addition to Subsystem Development Tests, major structural tests are required of Stage II to complete Category I testing on Stage II prior to producing Flight Test Vehicles to be used for Category II (System) tests. Certain structural tests (tankage, partial structure) are defined under WBS ID 4.1. Remaining structural development tests are included herein.

The Stage II Structural Tests shall, to the extent deemed necessary, demonstrate the structural integrity of full scale primary and secondary structure of this stage of the Air Vehicle under simulated maximum design loads with safety margins as well as demonstrate capability to meet the life cycle loads encountered throughout flight test plus 10-year operations (WBS Dictionary Element 0.0).

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE LOWER LEVELS FOR DETAIL SCHEDULES

II. SUBSYSTEM-LEVEL DEFINITION

Six major elements are required (see Figure 4.0-W-5) at the subsystem level to define Stage II Structural Tests. These elements are:

4.3.1	Test Planning
4.3.2	Structural Test Vehicle
4.3.3	Structural Test and Evaluation
4.3.4	Test Instrumentation
4.3.5	Test Equipment
4.3.6	Test Facilities Utilization

III. FUNCTIONAL DESCRIPTION

The objectives of Stage II Structural Tests are to demonstrate, on a full scale structural test article (or articles), the capability of primary and secondary structure to withstand both ground-induced (transportation and handling, principally) and flight induced loads and pressures which reflect pre-launch, launch, ascent, separation, injection, translation, rendezvous and docking, deorbit, reentry, transition, cruise, approach, landing and ferry flights on a recyclable basis.

These tests will consist of fatigue and cyclic load tests which, with safety margins, will ensure expected loads and pressures (internal as well as external) can be dissipated throughout the load carrying members without failure, undue stress, unwanted strain or creep, and with return to the original shape once the loads or pressures are removed.

The structural test article shall consist of the fuselage and aerodynamic surfaces (wing and vertical stabilizer) less thermal protection system, unless same is considered primary or secondary structure. Main tankage, if it integral structure, shall be included. The pressure vessel crew/equipment compartment need not be included as part of the test article. Landing gear are not required for this test. If the two major positions (vertical and horizontal) of the test vehicle can not both be handled effectively, one or the other may be selected by NASA to demonstrate structural integrity so long as the test employs anticipated loads along all affected axes.

IV. TEST SUPPORT

The objectives for these tests will be developed in Phase C/D under WBS ID 5.0. Specific test plans and objectives will be covered under WBS ID 4.3 to cover day-to-day requirements. The test hardware will be prototype full scale airframe and structure produced under WBS ID 1.3.2.1, Integration and Assembly, Airframe and Structure, Stage II. Test instrumentation will consist of contractor-furnished load application devices (torsion, tension, compression). Test equipment will consist of contractor-furnished load and strain measuring and recording systems, data acquisition systems and capability for computer-controlled test and data acquisition. Test support will include contractor-furnished fatigue loading systems. Test facilities will include a structural test facility, power, and a support laboratory. Software, if required, will be that necessary to control static, fatigue and creep load tests as well as that for implementing data acquisiton, processing, recording and evaluation.

V. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO 4.3.2

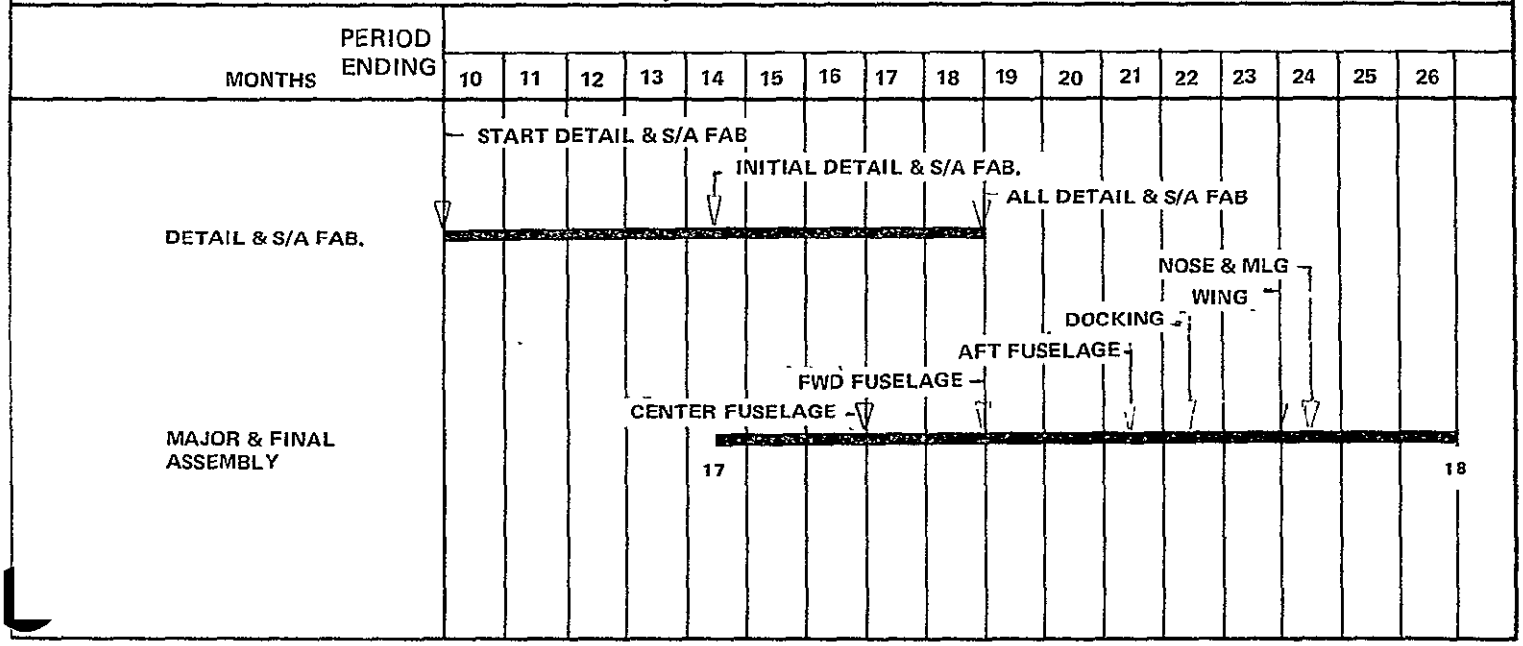
TASK TITLE STRUCTURAL TEST VEHICLE (STAGE II)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.3.)

TASK SCHEDULE MILESTONES



INPUTS

GHI

17

ASSEMBLE STRUCTURAL TEST ARTICLE

18

MANUFACTURING

K33

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	432.0.0
TITLE	STAGE 2 STRUCTURAL TEST VEHICLE
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	10 JUN 71

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.3.3

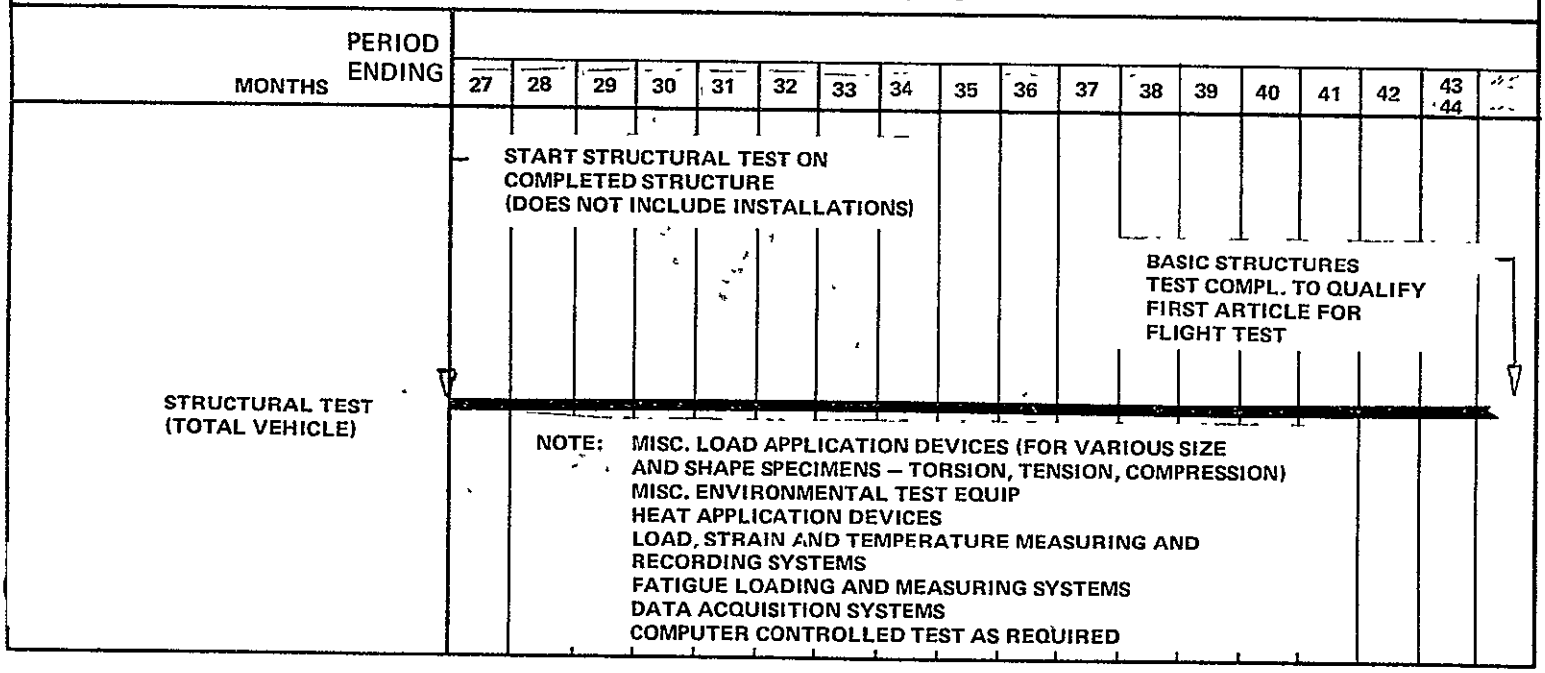
TASK TITLE STRUCTURAL TEST & EVALUATION (STAGE II)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.3.)

TASK SCHEDULE MILESTONES



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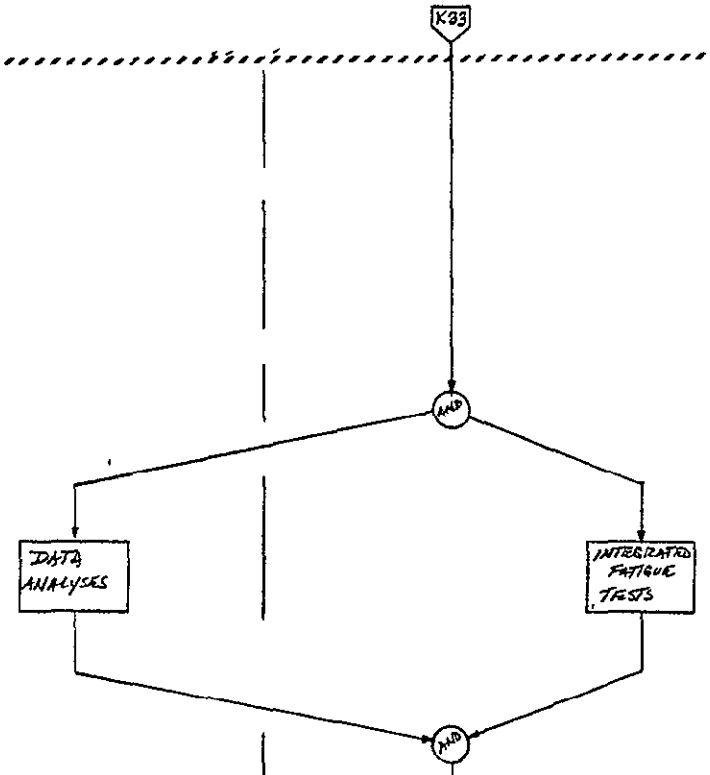


ENGINEERING

AS REQUIRED FOR STRUCTURAL CONFIDENCE

QUALITY

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4.3 3.0.0
TITLE	STAGE 2 STRUCTURAL TEST & EVALUATION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	18 JUN 71

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO 4.4

TASK TITLE STAGE I STRUCTURAL TESTS

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

In addition to Subsystem Development Tests, major structural tests are required of Stage I to complete Category I testing on Stage I prior to producing Flight Test Vehicles to be used for Category II (System) tests. Certain structural tests (tankage, partial structure) are defined under WBS ID 4.2. Remaining structural development tests are included herein.

The Stage I Structural Tests shall, to the extent deemed necessary, demonstrate the structural integrity of full scale primary and secondary structure of this stage of the Air Vehicle under simulated maximum design loads with safety margins as well as demonstrate capability to meet the life cycle loads encountered throughout flight test plus 10-year operations (WBS Dictionary Element 0.0).

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE LOWER LEVELS FOR DETAIL SCHEDULES

II. SUBSYSTEM-LEVEL DEFINITION

Six major elements are required (see Figure 4.0-W-5) at the subsystem level to define Stage I Structural Tests. These elements are:

4.4.1	Test Planning
4.4.2	Structural Test Vehicle
4.4.3	Structural Test and Evaluation
4.4.4	Test Instrumentation
4.4.5	Test Equipment
4.4.6	Test Facilities Utilization

III. FUNCTIONAL DESCRIPTION

The objectives of Stage I Structural Tests are to demonstrate, on a full scale structural test article (or articles), the capability of primary and secondary structure to withstand both ground-induced loads and pressures which reflect pre-launch, launch, ascent, separation, coast and maneuver to reentry point, reentry, transition, cruise, approach, landing and ferry flights on a recyclable basis.

These tests will consist of fatigue and cyclic load tests which, with safety margins, will ensure expected loads and pressures (internal as well as external) can be dissipated throughout the load carrying members without failure, undue stress, unwanted strain or creep, and with return to the original shape once the loads or pressures are removed.

The structural test article shall consist of the fuselage and aerodynamic surfaces (wing, canard, and vertical stabilizer) less thermal protection system, unless same is considered primary or secondary structure. Main tankage, if it integral structure, shall be included. The pressure vessel crew/equipment compartment need not be included as part of the test article. Landing gear are not required for this test. If the two major positions (vertical and horizontal) of the test vehicle can not both be handled effectively, one or the other may be selected by NASA to demonstrate structural integrity so long as the test employs anticipated loads along all affected axes. A need to simulate Stage II plus zero-to-maximum payload will be required to simulate Air Vehicle assembly (VAB), movement on the Launch Umbilical Tower to the pad, pre-launch standby, countdown operations and fuel loading, launch firing, ascent and staging.

IV. TEST SUPPORT

The objectives for these tests will be developed in Phase C/D under WBS ID 5.0. Specific test plans and objectives will be covered under WBS ID 4.4 to cover day-to-day requirements. The test hardware will be prototype full scale airframe and structure produced under WBS ID 1.4.2.1, Integration and Assembly, Airframe and Structure, Stage I. Test instrumentation will consist of contractor-furnished load application devices (torsion, tension, compression). Test equipment will consist of contractor-furnished load and strain measuring and recording systems, data acquisition systems and capability for computer-controlled test and data acquisition. Test support will include contractor-furnished fatigue loading systems. Test facilities will include a structural test facility, power, and a support laboratory. Software, if required, will be that necessary to control static, fatigue and creep load tests as well as that for implementing data acquisition, processing, recording and evaluation.

V. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.4.2

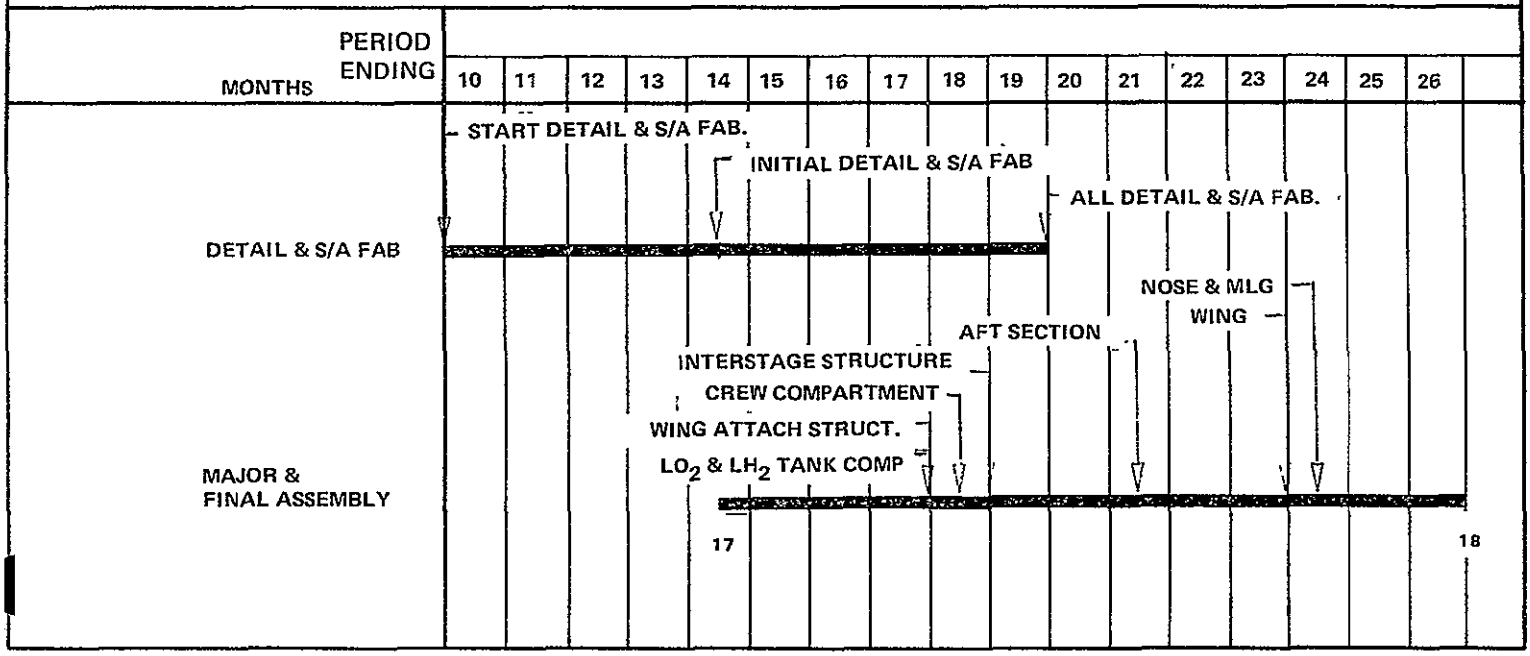
TASK TITLE STRUCTURAL TEST VEHICLE (STAGE I)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.4.)

TASK SCHEDULE MILESTONES



INPUTS

GH2

17

ASSEMBLE STRUCTURAL TEST ARTICLE

18

K34

MANUFACTURING

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	44200
TITLE	STAGE 1 STRUCTURAL TEST VEHICLE
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	10 JUN 71

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.4.3

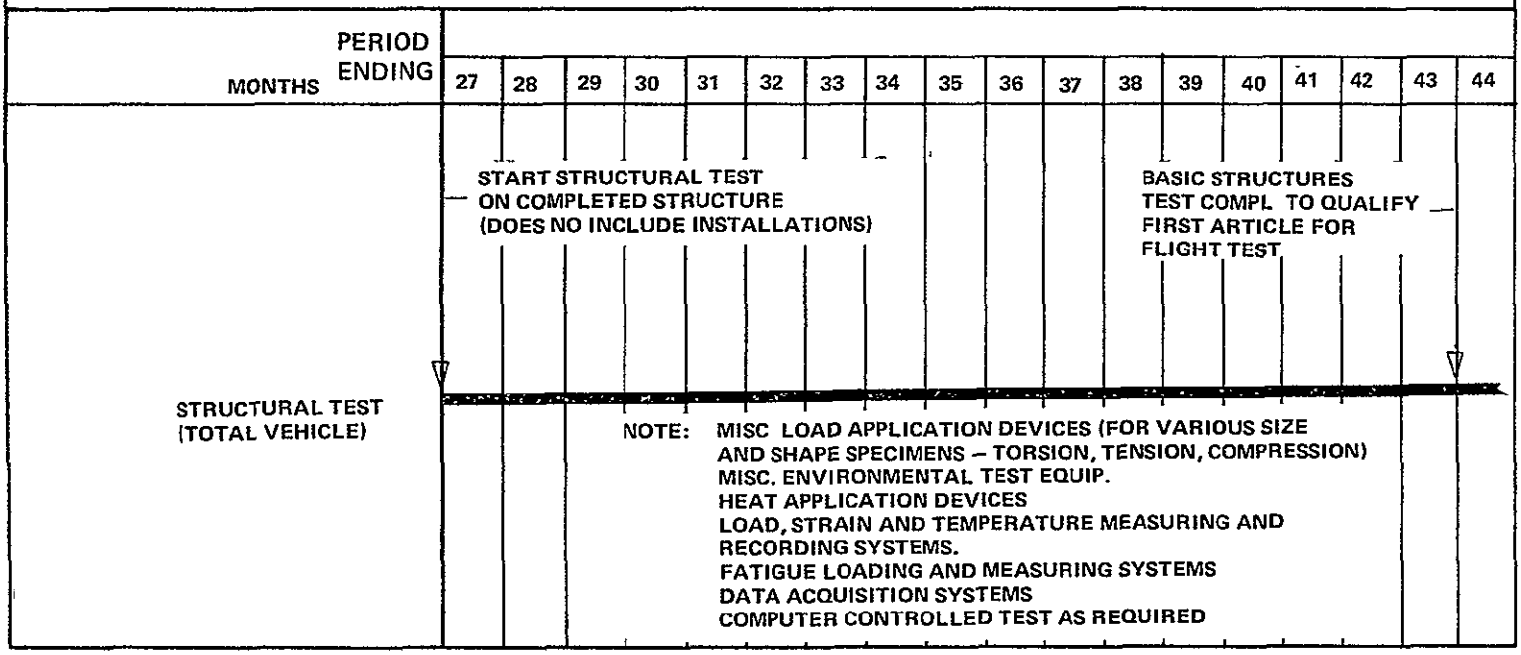
TASK TITLE STRUCTURAL TEST & EVALUATION (STAGE I)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.4.)

TASK SCHEDULE MILESTONES



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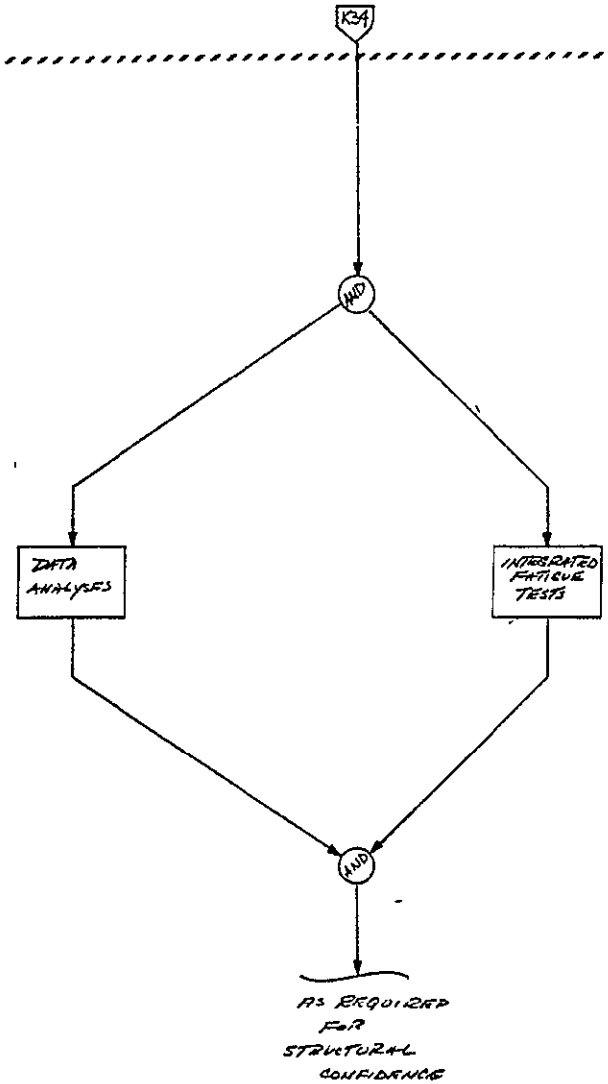


VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4.4.3.0.0
TITLE	STAGE I STRUCTURAL TEST - EVALUATION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	18 JUN 71

OUTPUTS

LOL

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT STUDY

WBS NO 4.5

TASK TITLE STAGE II FLIGHT TESTS (SGL. ELEMENT)

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

A need exists to flight test Stage II of the Space Transport Air Vehicle prior to Air Vehicle (mated) flight test. This phase of development of the Advanced Space Transport Program shall verify both the horizontal flight capability of Stage II as well as the Stage's ground support capability, representing those phases of the operational mission involving single element operation, i.e. cruise to the landing site, approach and land, under either automatic or manual flight mode. In addition, ferry flight capability will be verified. Simulation of full payload capability shall also be demonstrated.

In addition to horizontal flight test, Stage II shall demonstrate its vertical flight capability with ascent (main) engine power. With NASA's approval, vertical flight capability may be limited to hold-down full thrust firing with all subsystems operational.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE LOWER LEVELS FOR DETAIL SCHEDULES

These requirements apply to each flight test vehicle (FTV) developed.

II. SUBSYSTEM-LEVEL DEFINITION

Seventeen major elements at the subsystem level are identified to define the single element Stage II Flight Test program (see Figure 4.0-W-5). These elements, in descending order, are time-phased insofar as testing is concerned and represent steps which must be performed prior to accomplishing the next step. The tests noted apply to each FTV developed.

4.5.1	Test Planning
4.5.2	Stage II Flight Test Vehicles
4.5.3	Integrated Checkout
4.5.4	Pre-Flight Tests and Evaluation
4.5.5	Ferry Tests and Evaluation
4.5.6	Horizontal Flight Test and Evaluation
4.5.7	Vertical Flight Test and Evaluation*
4.5.8	Test Kit Instrumentation
4.5.9	Test Equipment
4.5.10	Test Support Equipment
4.5.11	Flight Crew
4.5.12	Consumables
4.5.13	Engine Simulators
4.5.14	Stage II Spares & Reparable Parts (Test)
4.5.15	On-Board Software (Test)
4.5.16	Ground Software (Test)
4.5.17	Test Facilities Utilization

*Static Firing, only (Hold Down)(NASA Approval required)

III. FUNCTIONAL DESCRIPTION

A preliminary Test Plan has been prepared during Phase B for flight testing Stage II. This plan will be updated, approved and released in Phase C/D (WBS ID 5.0) as the basis for conducting Category II tests on both Stage II and on Stage I (single element tests) and on the Air Vehicle (mated flight test). This Test Plan will specify what tests are to be conducted, what requirements are

to be met (performance, reliability, maintainability, safety, operability, supportability, etc.), where the tests are to take place, against what schedule, and what support shall be provided. These requirements will be specified per Flight Test Vehicle (FTV). Any changes in design (vehicle, support) resulting from these tests shall be incorporated into the designs as specified by the change board, including NASA approval thereof. If the change is significant, repetition of a specific test shall be at the discretion of NASA, subject to renegotiation of effort on costs and schedules as stated in the major supplier's contract agreement.

Significant areas to be demonstrated in the single element flight test program are noted in the matrix of tests shown on the next page.

IV. TEST SUPPORT

The major elements to be tested, in addition to Stage II, OGE and MGE/DMGE, are the consumable requirements (ABES engine fuel, lubricants, hydraulics fluid, greases, main engine propellants, purge gases, conditioning propellants), the test software (on-board, ground), and the total integration of vehicle with ground. Although single element flight test does not exercise Stage II in its total environment, it still offers the opportunity to verify horizontal performance and, through static firing of its main engines, enables exercise of integrated main propulsion, flight control, data management, and structural integrity. Ground support (operating and maintenance) capability can be verified for both pre-flight and post-flight operations. Automatic guidance can be only partially verified (approach and landing). The same is true for Communications, Command and Control, and Data Processing. Full checkout of Stage II and its support elements are exercised in WBS ID 4.7.

It should be noted that the vertical flight simulation is dependent on activating the launch site (see WBS ID 4.7.1.1.1). Similarly, any use of modified recovery sites necessitates activating these for the single element test program (see WBS ID 4.7.3.1.1). Likewise, the turnaround facility must be activated to support the vertical flight test simulation (WBS ID 4.7.3.3.1).

PROGRAM TEST		MAJOR PROGRAM ELEMENT TESTED		
WBS ID	TITLE	STAGE II (WBS ID 1.3)	OGE (WBS ID 2.0)	MGE/DMGE (WBS ID 3.0/8.0)
4.5.1	Test Planning	Documentation	Command & Control, Documentation	Documentation
4.5.2	Stage II FTVs	Producibility (Integration & Assy, WBS ID 1.3.1)	Procurability, Verification, Installation	Procurability, Verification, Installation
4.5.3	Integrated Checkout	On-Board Software Capability to Verify "Go"	Data Processing	Ground Support Capability to Assist in Integrated Checkout
4.5.4	Pre-Flight Tests & Evaluation	Taxi, Simulated Takeoff & Landing, Ground Effects, Weight & Balance, Power Control, Subsystem Performance, Handling Qualities	Command & Control, Data Processing, Communications Test (Recovery)	Ground Support Capability to assist in pre-flight; maintenance support; spares support
4.5.5	Ferry Tests and Evaluation	Takeoff, Cruise, Approach, Land. Ferry Kit performance. Subsystem performance. Flying qualities. Telemtry checkout	Command & Control; Communications; Surveillance, Identification, Tracking; Data Processing; Recovery Equipment checkout	Maintainability, Supportability, Logistics checkout (transport needed MGE). Spares support

PROGRAM TEST		MAJOR PROGRAM ELEMENT TESTED		
WBS ID	TITLE	STAGE II (WBS ID 1.3)	OGE (WBS ID 2.0)	MGE/DMGE (WBS ID 3.0/8.0)
4.5.6	Horizontal Flight Test & Evaluation	Takeoff, Climb Cruise, Descent, Land(auto. vs manual). Crew training. Flight margins check-out. Subsystem performance. Failure reporting capability	C & C; full Recovery Communications; Surv., Ident., Track; Data Processing; Recovery Equipment	Maintainability (MGE, DMGE); Spares Support
4.5.7	Vertical Flight Test & Evaluation	Main Engine performance (integrated). Acoustic/vibration levels. Structural integrity. Subsystem performance	C & C (Launch); Communications (Launch); Data Processing (Launch); Launch Equipment	Maintainability (Pre-Launch, Launch); Spares Support

If main engines are not installed for horizontal flight test or ferry flights, a mass simulator is required (WBS ID 4.5.13).

The developmental instrumentation and telemetry package shall be designed as removable following completion of all flight test, it being NASA's desire to retrofit each FTV into an operational vehicle at the completion of each FTV's test program (see Figure 4.0-W-5, WBS ID 4.5.8 and 4.7.3.1.12).

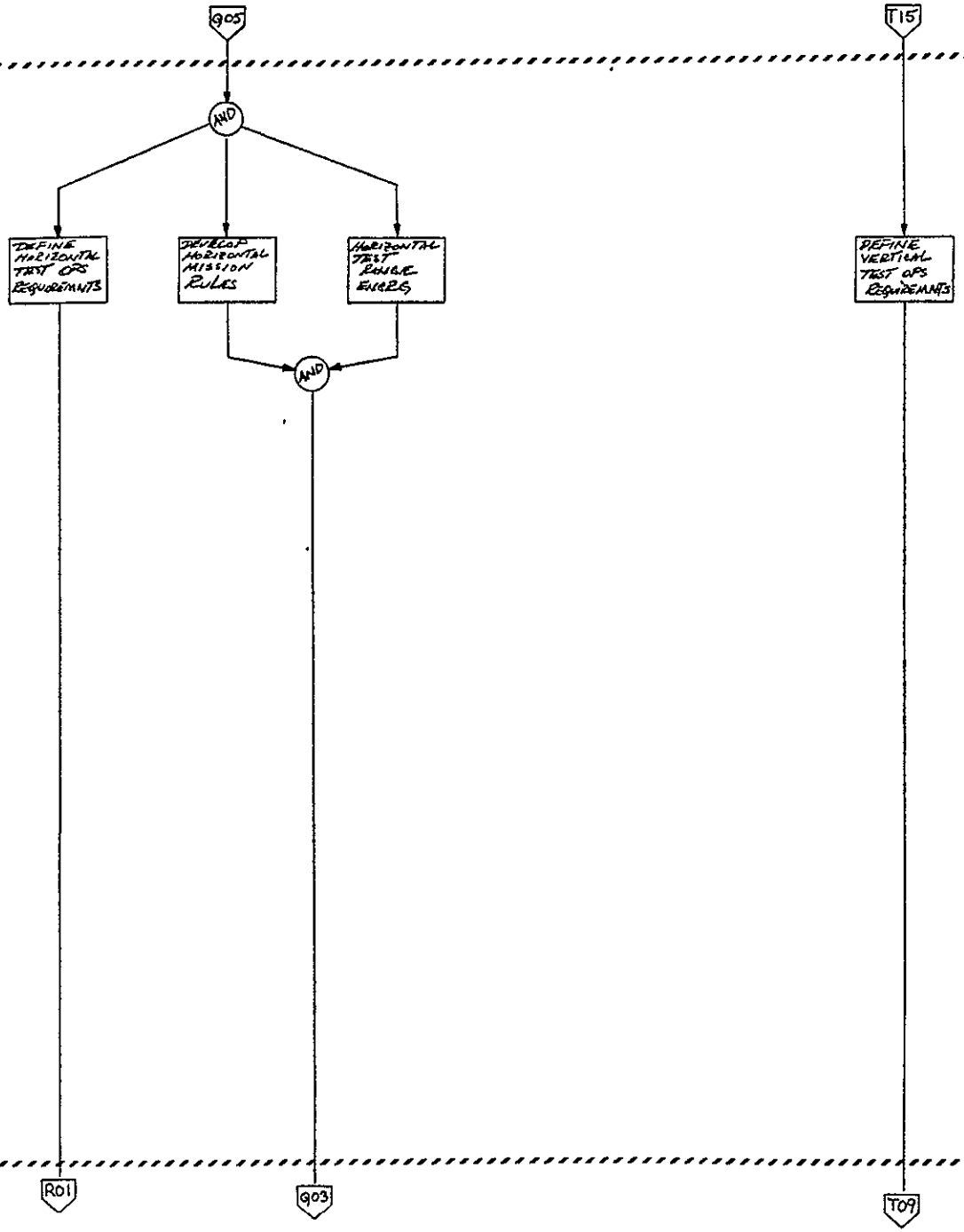
Test facilities are to be defined following Phase C go-ahead. Candidate facilities for this phase of the test program include the following:

TEST OPERATION	LOCATION
Pre-Flight Tests	Contractor Facilities
Ferry Tests	Contractor Facilities-to-EAFB
Horizontal Flight Test	EAFB
Vertical Flight Test	KSC, WTR, Inland Sites

V. REFERENCES

(To be added.)

INPUTS



ENGINEERING

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4.5 1 0.0
TITLE	STAGE 2 TEST PLANNING
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	10 JUN 71

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.5.2

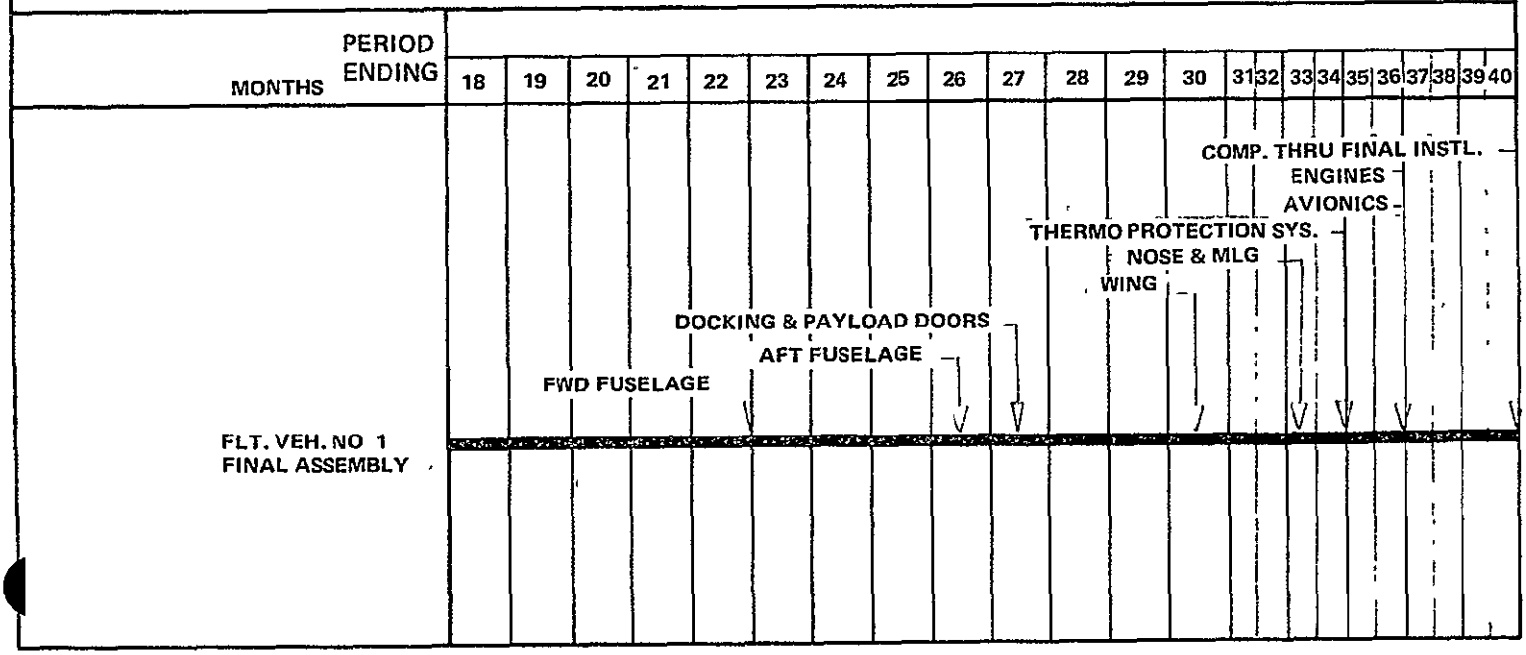
TASK TITLE STAGE II FLIGHT TEST VEHICLE

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.5.)

TASK SCHEDULE MILESTONES



VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.5.3

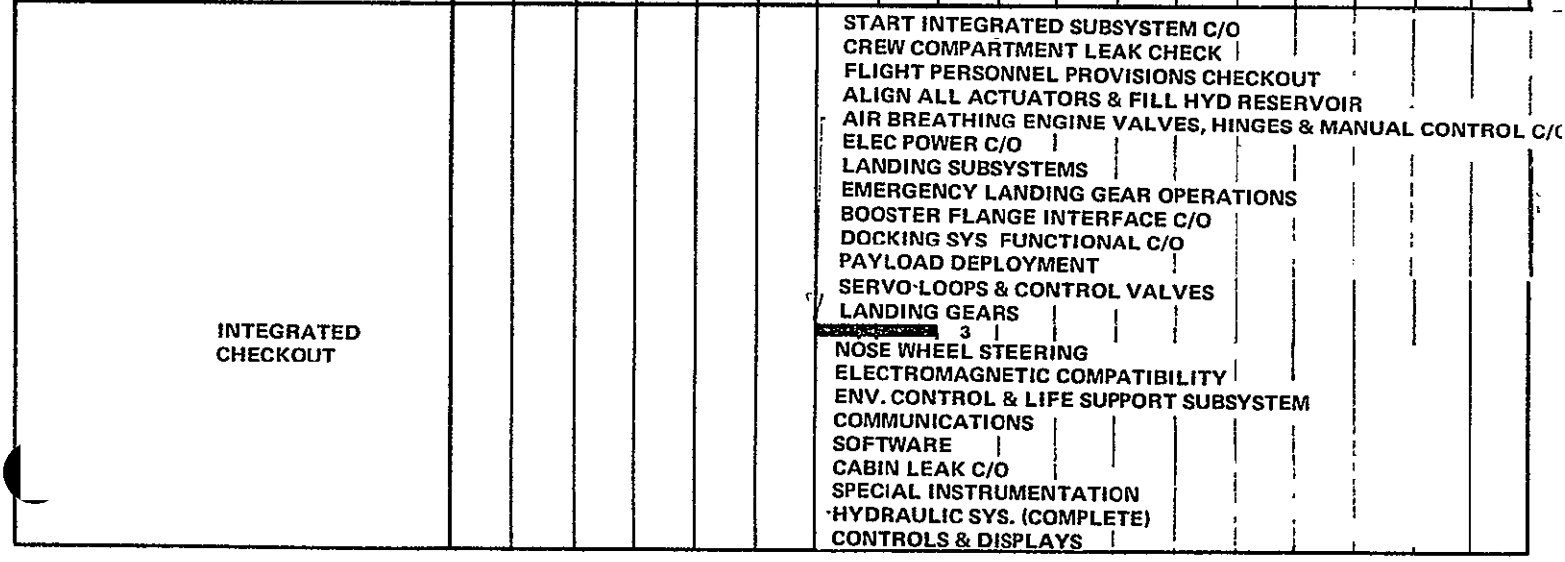
TASK TITLE INTEGRATED CHECKOUT (STAGE II)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.5.)

TASK SCHEDULE MILESTONES



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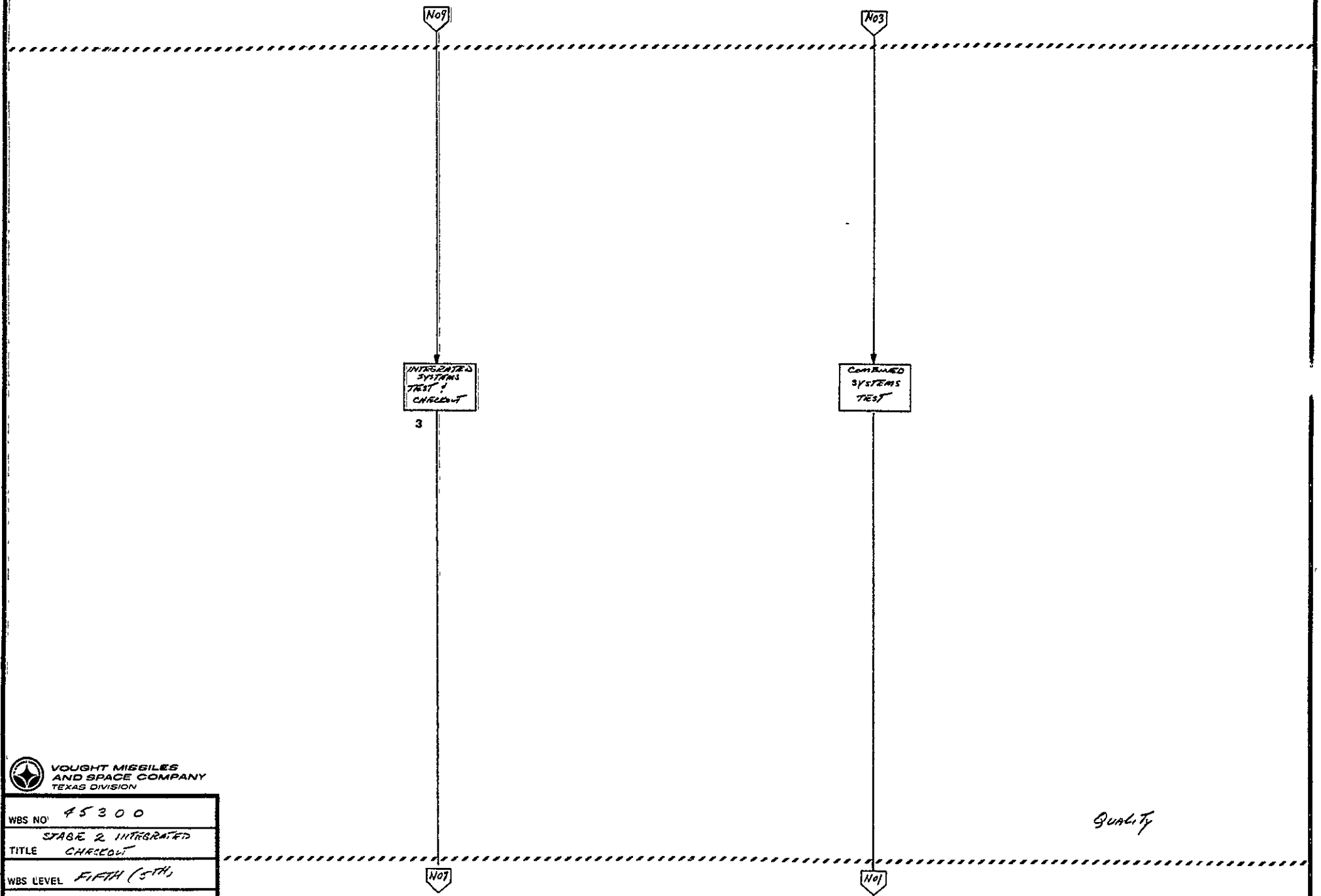


VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	45300
TITLE	STAGE 2 INTEGRATED CHECKOUT
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	10 JUN 71

QUALITY

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.5.4

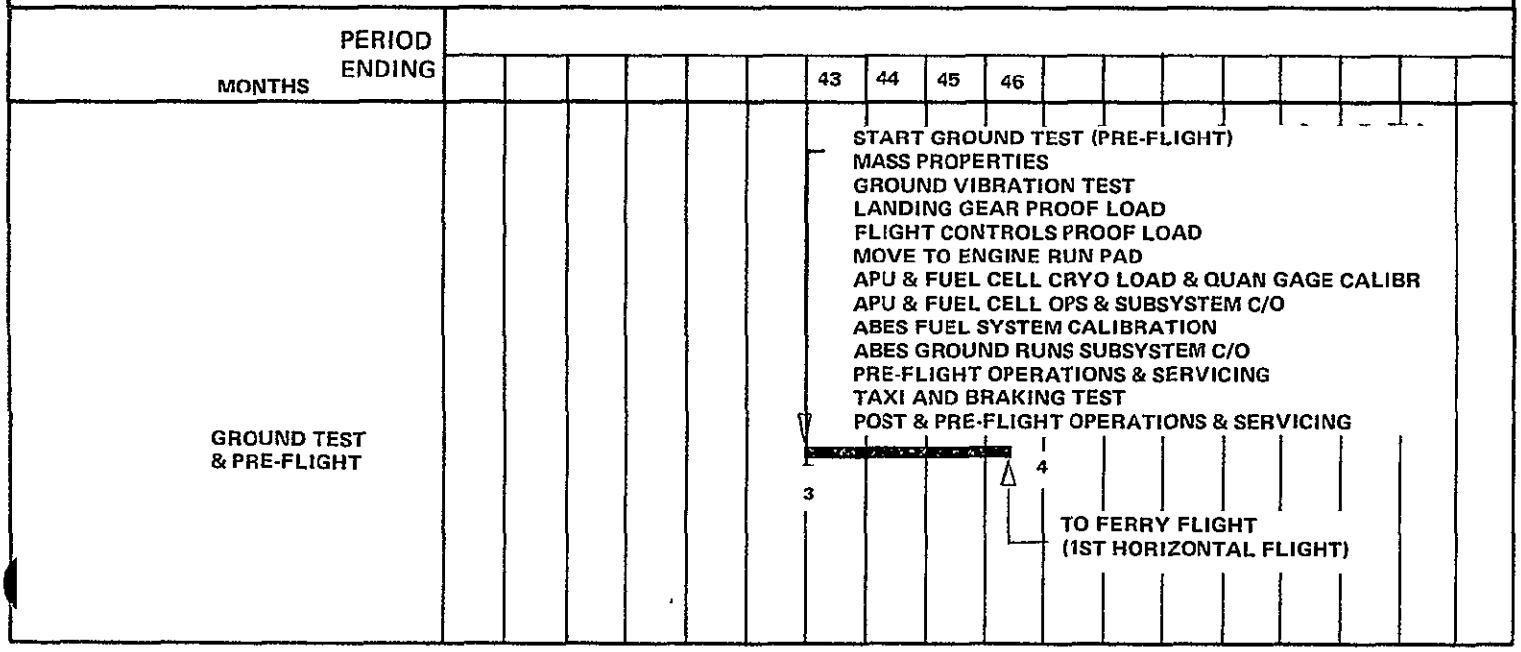
TASK TITLE PRE-FLIGHT TESTS & EVALUATION (STAGE II)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.5.)

TASK SCHEDULE MILESTONES



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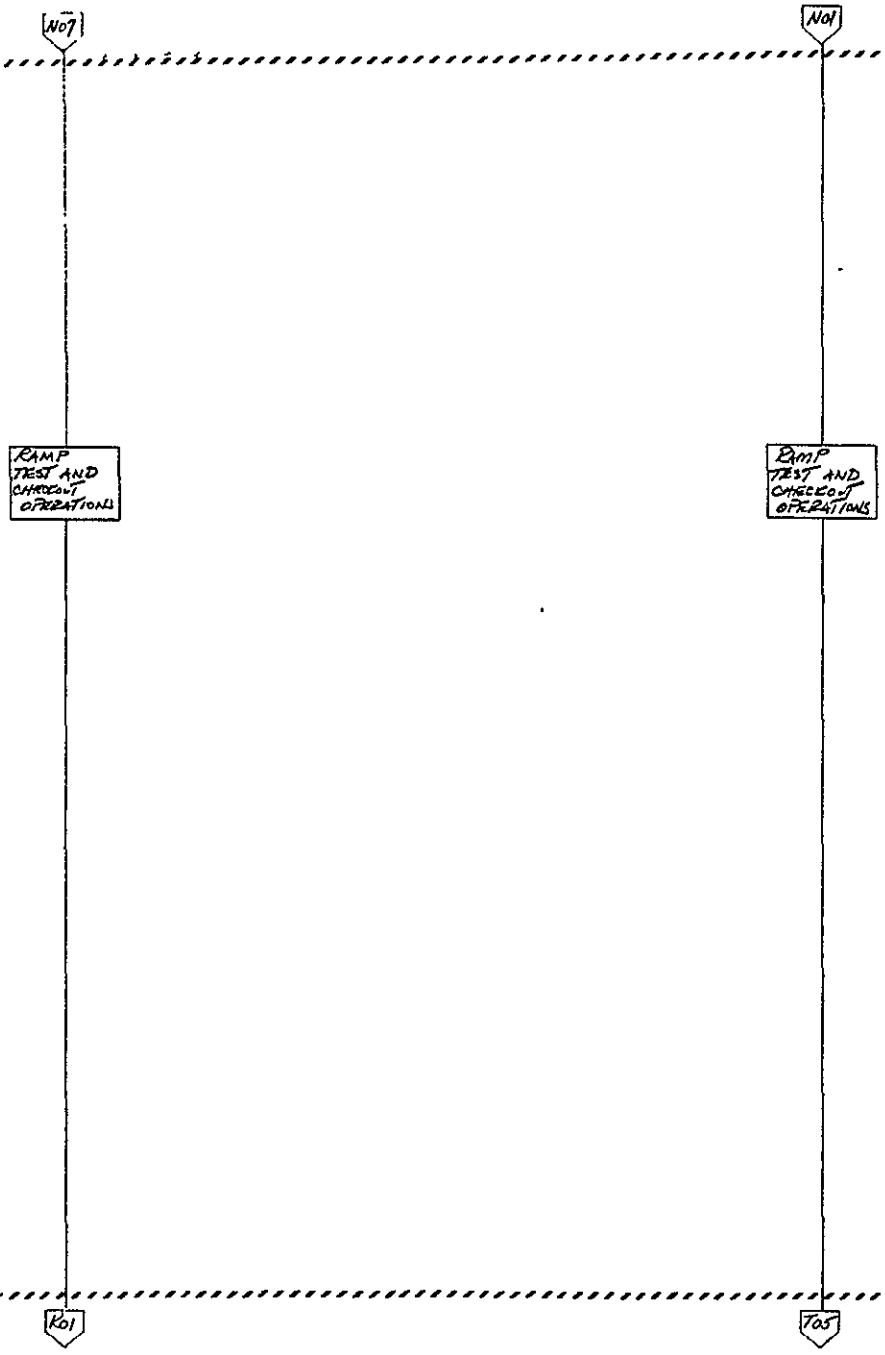


QUALITY

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4540.0
TITLE	STAGE 2 PRE-FLIGHT TEST & EVALUATION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	1 JUN 71

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.5.6

TASK TITLE HORIZONTAL FLIGHT TES AND EVALUATION (STG II)

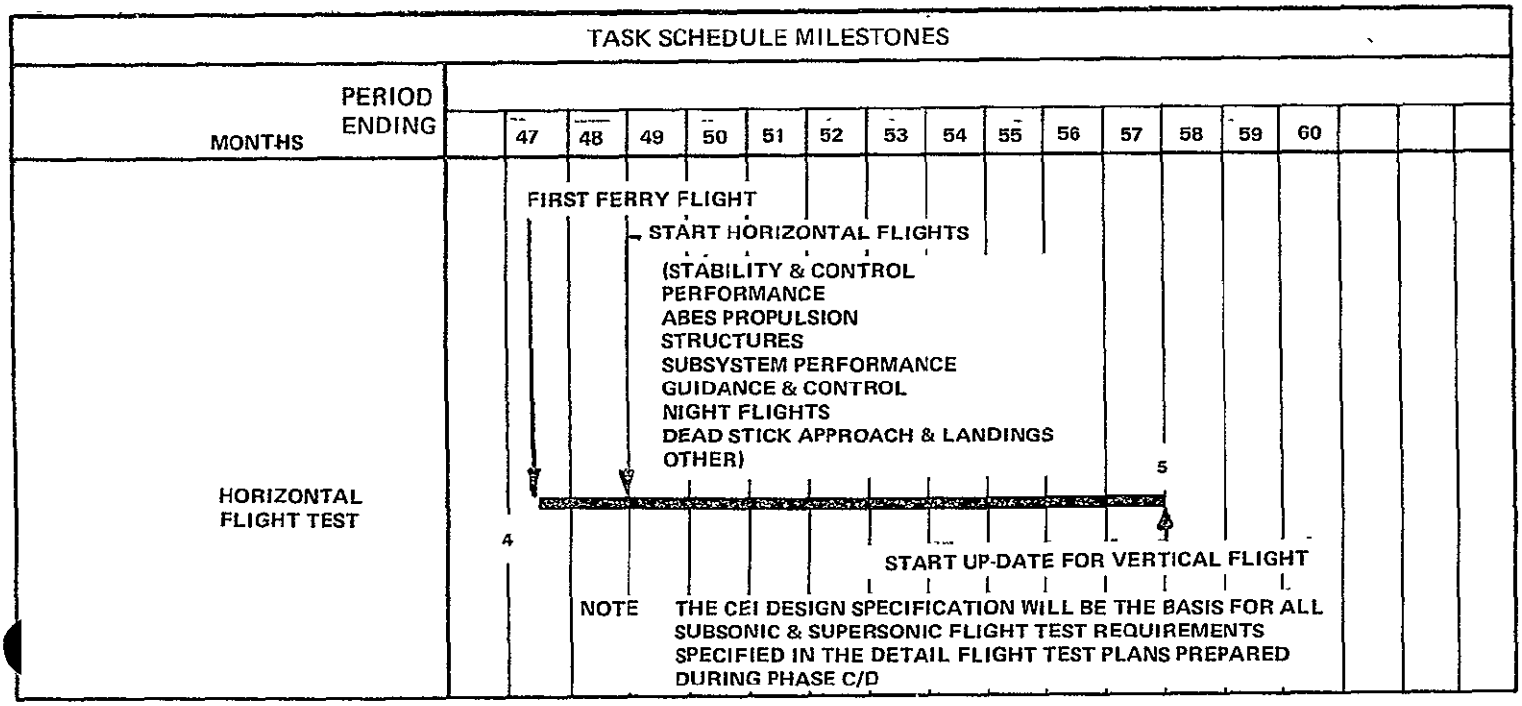
LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

A need exists to demonstrate the horizontal flying qualities of Stage II prior to committing each Flight Test Vehicle (FTV) to manned orbital flight test. This demonstration shall be performed: (1) to verify performance of and provide crew training with each FTV, as specified in CEI specifications on Stage subsystems which are operational during reentry from space missions; (2) to verify automatic vs manual flight modes; (3) to verify ABES Propulsion performance for powered flight; (4) to verify non-powered approach and landing capability; (5) to verify compatibility between on-board and ground-based communications and navaids; (6) to verify air-data accuracy as inputs to guidance, navigation and flight control; (7) to verify flying qualities with zero-to-maximum payload simulations; (8) to demonstrate go-around capability and performance during approach and landing; (9) to verify data management capability to switch guidance modes, monitor subsystem performance and

TASK SCHEDULE MILESTONES



status and to display this status for crew utilization; (10) to demonstrate control capability from either crew station for emergency simulation; (11) to demonstrate safe landing capability under specified weather conditions (visibility, cross winds, wet fields), air traffic status, and on-board status when such status may be marginal such as engine out, secondary power malfunctions, etc.; and (12) to demonstrate ground handling capability for takeoffs, landings, parking, crew/passenger/payload/data removal. As directed by NASA, additional demonstrations may be required to verify compatibility of the FTV with alternate landing sites for both crew familiarization and with integrated vehicle/ground support elements (communications, navaids, ground handling problems).

II. ASSEMBLY LEVEL DEFINITION

The assembly-level elements which comprise horizontal flight test will be developed in Phase C/D. In a sense, they are FTV-oriented, in that each vehicle will have its own set of tests to be conducted. Current concepts are for either two or three FTVs to be built and flown. One may be dedicated to horizontal flight test to "wring out" any problems that may appear as well as thoroughly exercise the flying qualities of this Stage under all design margins (pitch, roll or bank, yaw, stall, min/max cruise capability for red-lining aerodynamic flight, flare specifications, power setting, antenna placements, speed brake settings, flap settings, flight control and flight instrument qualities and accuracies, pilot visibility acceptability, etc.). Other FTVs then would buildup sufficient hours only to verify major requirements are met, relying on the dedicated FTV to resolve any problems to incorporate these either as "CAUTION" items or, if the problem is major, to hold further flight testing until the problem is resolved and remains as a "CAUTION" item or is redesigned into a mod kit.

Accordingly, a tentative assembly-level designation is as follows:

4.5.6.1	Stage II FTV No. 1 Test and Evaluation
4.5.6.2	Stage II FTV No. 2 Test and Evaluation
4.5.6.3	Stage II FTV No. 3 Test and Evaluation*

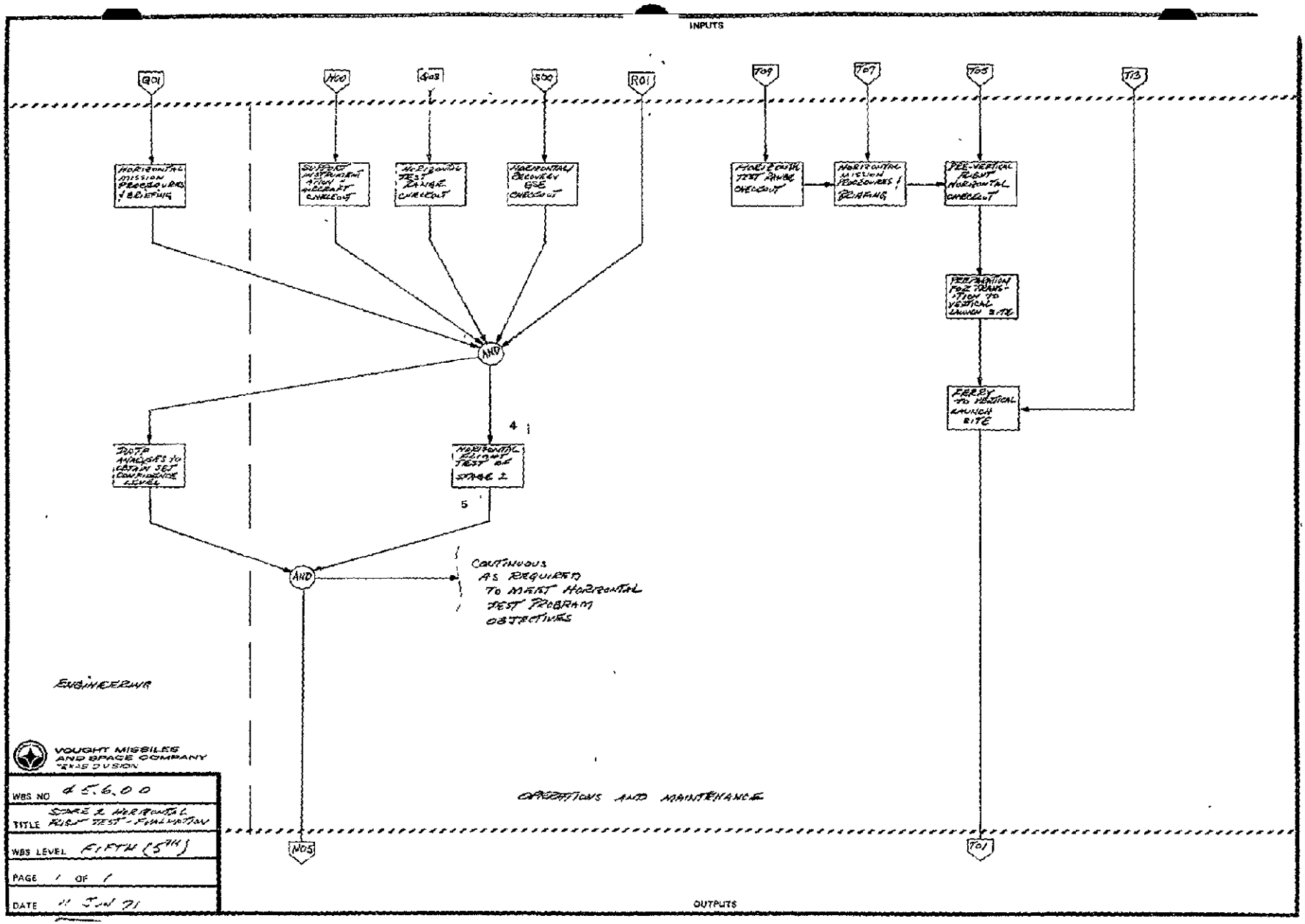
*Assumes 3 FTVs are required.

III. FUNCTIONAL DESCRIPTION

(To be added.)

IV. REFERENCES

(To be added.)


INPUTS
Q01
H00
400
S00
R01
709
707
705
713
HORIZONTAL MISSION PROCEDURES & BRIEFING
SUBSYST INSTRUMENTATION & AIRCRAFT CHECKOUT
AGE & GROUND TEST RANGE CHECKOUT
HORIZONTAL RECOVERY GSE CHECKOUT
FLIGHT & CREW TEST RANGE CHECKOUT
HORIZONTAL MISSION PROCEDURES & BRIEFING
PRE-VERTICAL FLIGHT HORIZONTAL CHECKOUT
PREPARATION FOR TRANSPORTATION TO VERTICAL LAUNCH SITE
FERRY TO VERTICAL LAUNCH SITE
AND
4
5
DATA ANALYSIS TO OBTAIN SET CONFIDENCE LEVEL
HORIZONTAL FLIGHT TEST OF STAGE 2
AND
CONTINUOUS AS REQUIRED TO MEET HORIZONTAL TEST PROGRAM OBJECTIVES
ENGINEERING
VOUGHT MISSILES AND SPACE COMPANY
WBS NO 4.5.6.0.0
TITLE STAGE 2 HORIZONTAL FLIGHT TEST - EVALUATION
WBS LEVEL FIFTH (5TH)
PAGE 1 OF 1
DATE 11 JUN 71
OPERATIONS AND MAINTENANCE
N05
701
OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT STUDY

WBS NO. 4.6

TASK TITLE STAGE I FLIGHT TESTS (SGL. ELEMENT)

LEVEL 4, System Level

WBS DICTIONARY

I.1 REQUIREMENTS

A need exists to flight test Stage I of the Space Transport Air Vehicle prior to Air Vehicle (mated) flight test. This phase of development of the Advanced Space Transport Program shall verify both the horizontal flight capability of Stage I as well as the Stage's ground support capability, representing those phases of the operational mission involving single element operation, i.e. cruise to the landing site, approach and land, under either automatic or manual flight mode. In addition, ferry flight capability will be verified.

In addition to horizontal flight test, Stage I shall demonstrate its vertical flight capability with ascent (main) engine power. With NASA's approval, vertical flight capability may be limited to hold-down full thrust firing with all sybsystems operational.

These requirements apply to each flight test vehicle (FTV) developed.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE LOWER LEVELS FOR DETAIL SCHEDULES

II. SUBSYSTEM-LEVEL DEFINITION

Seventeen major elements at the subsystem level are identified to define the single element Stage I Flight Test program (see Figure 4.0-W-5). These elements, in descending order, are time-phased insofar as testing is concerned and represent steps which must be performed prior to accomplishing the next step. The tests noted apply to each FTV developed.

4.6.1	Test Planning
4.6.2	Stage I Flight Test Vehicles
4.6.3	Integrated Checkout
4.6.4	Pre-Flight Tests and Evaluation
4.6.5	Ferry Tests and Evaluation
4.6.6	Horizontal Flight Test and Evaluation
4.6.7	Vertical Flight Test and Evaluation*
4.6.8	Test Kit Instrumentation
4.6.9	Test Equipment
4.6.10	Test Support Equipment
4.6.11	Flight Crew
4.6.12	Consumables
4.6.13	Engine Simulators
4.6.14	Stage I Spares & Reparable Parts (Test)
4.6.15	On-Board Software (Test)
4.6.16	Ground Software (Test)
4.6.17	Test Facilities Utilization

*Static Firing, only (Hold Down)(NASA Approval required)

III. FUNCTIONAL DESCRIPTION

A preliminary Test Plan has been prepared during Phase B for flight testing Stage I. This plan will be updated, approved and released in Phase C/D (WBS ID 5.0) as the basis for conducting Category II tests on both Stage II and on Stage I (single element tests) and on the Air Vehicle (mated flight test). This Test Plan will specify what tests are to be conducted, what requirements are to be met (performance, reliability, maintainability, safety, operability, supportability, etc.), where the tests are to take place, against what schedule, and what support shall be provided. These requirements will be specified per Flight Test Vehicle (FTV). Any changes in design (vehicle, support) resulting from these tests shall be incorporated into the designs as specified by the change board, including NASA approval thereof. If the change is

significant, repetition of a specific test shall be at the discretion of NASA, subject to renegotiation of effort on costs and schedules as stated in the major supplier's contract agreement.

Significant areas to be demonstrated in the single element flight test program are noted in the matrix of tests shown on the next page.

IV. TEST SUPPORT

The major elements to be tested, in addition to Stage I, OGE and MGE/DMGE, are the consumable requirements (ABES engine fuel, lubricants, hydraulics fluids, greases, main engine propellants, purge gases, conditioning propellants), the test software (on-board, ground), and the total integration of vehicle with ground. Although single element flight test does not exercise Stage I in its total environment, it still offers the opportunity to verify horizontal performance and, through static firing of its main engines, enables exercise of integrated main propulsion, flight control, data management and structural integrity. Ground support (operating and maintenance) capability can be verified for both pre-flight and post-flight operations. Automatic guidance can be only partially verified (approach and landing). The same is true for Communications, Command and Control, and Data Processing. Full checkout of Stage I and its support elements are exercised in WBS ID 4.7.

It should be noted that the vertical flight simulation is dependent on activating the launch site (see WBS ID 4.7.1.1.1). Similarly, any use of modified recovery sites necessitates activating these for the single element test program (see WBS ID 4.7.3.1.1). Likewise, the turnaround facility must be activated to support the vertical flight test simulation (WBS ID 4.7.3.3.1).

If main engines are not installed for horizontal flight test or ferry flights, a mass simulator is required (WBS ID 4.6.13).

The developmental instrumentation and telemetry package shall be designed as removable following completion of all flight test, it being NASA's desire to retrofit each FTV into an operational vehicle at the completion of each FTV's test program (see Figure 4.0-W-5, WBS ID 4.6.8 and 4.7.3.2.10).

PROGRAM TEST		MAJOR PROGRAM ELEMENT TESTED		
WBS ID	TITLE	STAGE I (WBS ID 1.4)	OGE (WBS ID 2.0)	MGE/DMGE (WBS ID 3.0/8.0)
4.6.1	Test Planning	Documentation	Command & Control, Documentation	Documentation
4.6.2	Stage I FTVs	Producibility (Integration & Assy, WBS ID 1.4.1)	Procurability, Verification, Installation	Procurability, Verification, Installation
4.6.3	Integrated Checkout	On-Board Software Capability to Verify "Go"	Data Processing	Ground Support Capability to Assist in Integrated Checkout
4.6.4	Pre-Flight Tests & Evaluation	Taxi, Simulated Takeoff & Landing, Ground Effects, Weight & Balance, Power Control, Subsystem Performance, Handling Qualities	Command & Control, Data Processing, Communications Test (Recovery)	Ground Support Capability to assist in preflight; maintenance support; spares support
4.6.5	Ferry Tests and Evaluation	Takeoff, Cruise, Approach, Land, Subsystem performance. Flying qualities. Telemetry checkout	Command & Control; Communications; Surveillance, Identification, Tracking; Data Processing; Recovery Equipment Checkout	Maintainability, Supportability, Logistics checkout (transport needed MGE). Spares support

PROGRAM TEST		MAJOR ELEMENT TESTED		
WBS ID	TITLE	STAGE I (WBS ID 1.4)	OGE (WBS ID 2.0)	MGE/DMGE (WBS ID 3.0/8.0)
4.6.6	Horizontal Flight Test & Evaluation	Takeoff, Climb Cruise, Descent, Land(auto. vs manual). Crew training. Flight margins check-out. Subsystem performance. Failure reporting capability	C & C; full Recovery Communications; Surv., Ident., Track; Data Processing; Recovery Equipment	Maintainability (MGE, DMGE); Spares Support
4.6.7	Vertical Flight Test & Evaluation	Main Engine performance (integrated). Acoustic/vibration levels. Structural integrity. Subsystem performance	C & C(Launch); Communications(Launch); Data Processing (Launch); Launch Equipment	Maintainability (Pre-Launch, Launch); Spares Support

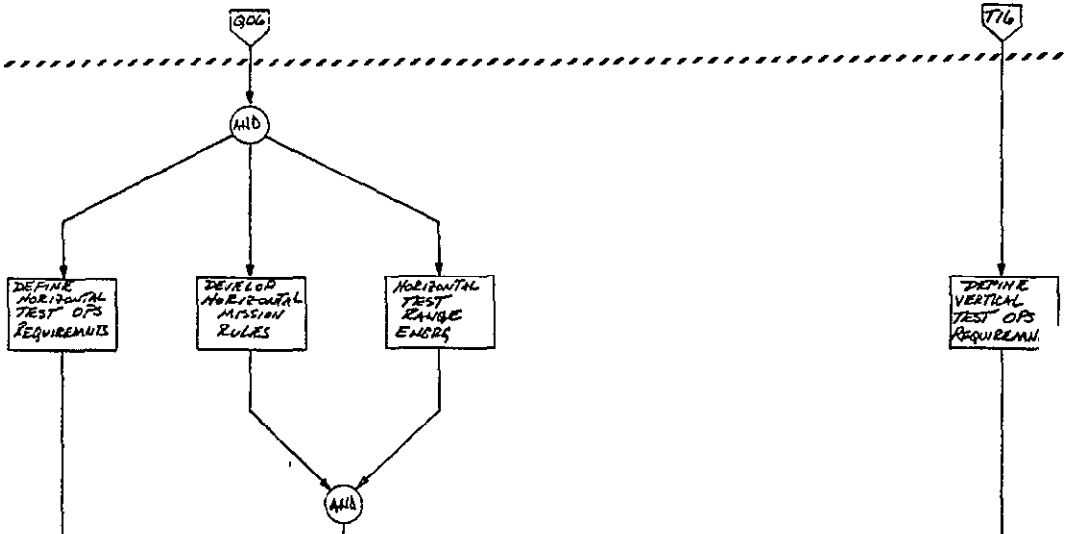
Test facilities are to be defined following Phase C go-ahead. Candidate facilities for this phase of the test program include the following:

TEST OPERATION	LOCATION
Pre-Flight Tests	Contractor Facilities
Ferry Tests	Contractor Facilities-to-EAFB
Horizontal Flight Test	EAFB
Vertical Flight Test	KSC, WTR, Inland Sites

V. REFERENCES

(To be added.)

INPUTS



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4.6.1.0.0
TITLE	STAGE 1 TEST PLANNING
WBS LEVEL	FIFTH
PAGE	1 OF 1
DATE	11 JUN 71

ENGINEERING

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.6.2

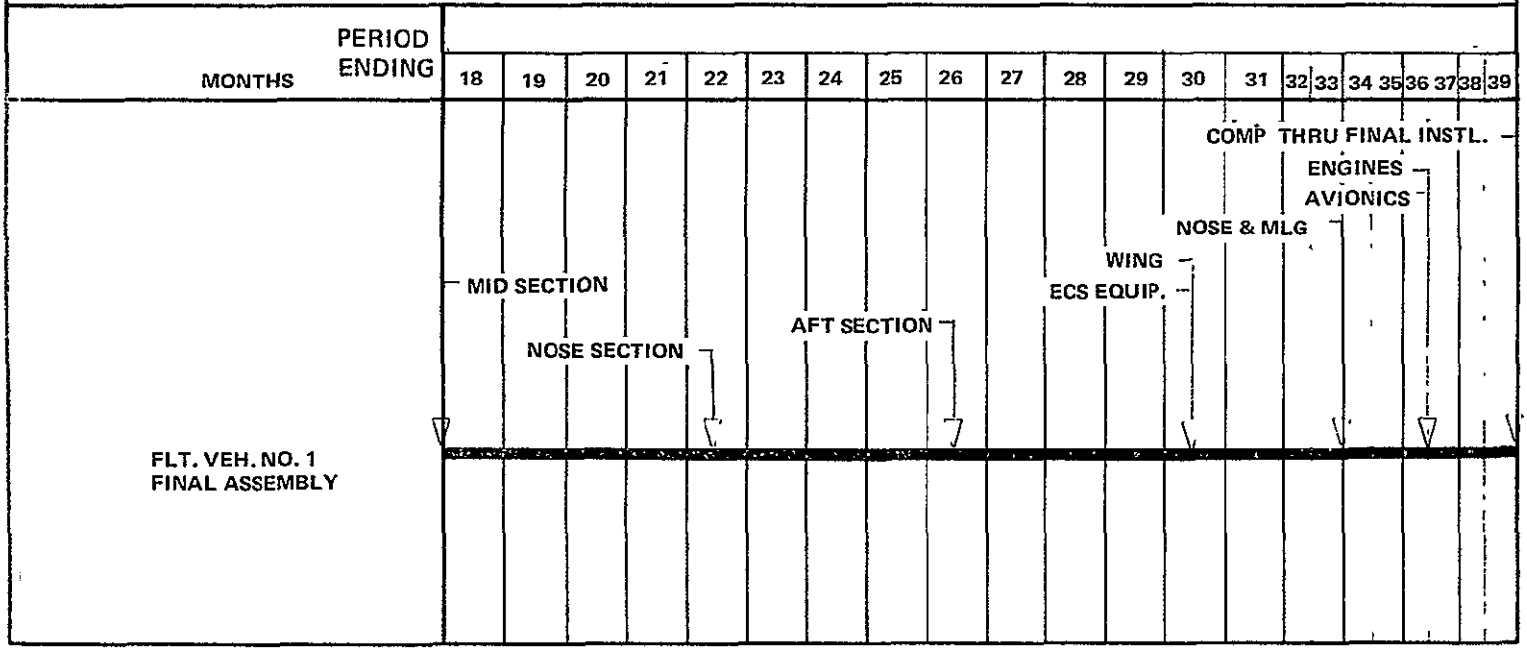
TASK TITLE STAGE I FLIGHT TEST VEHICLE

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.6.)

TASK SCHEDULE MILESTONES



VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.6.3

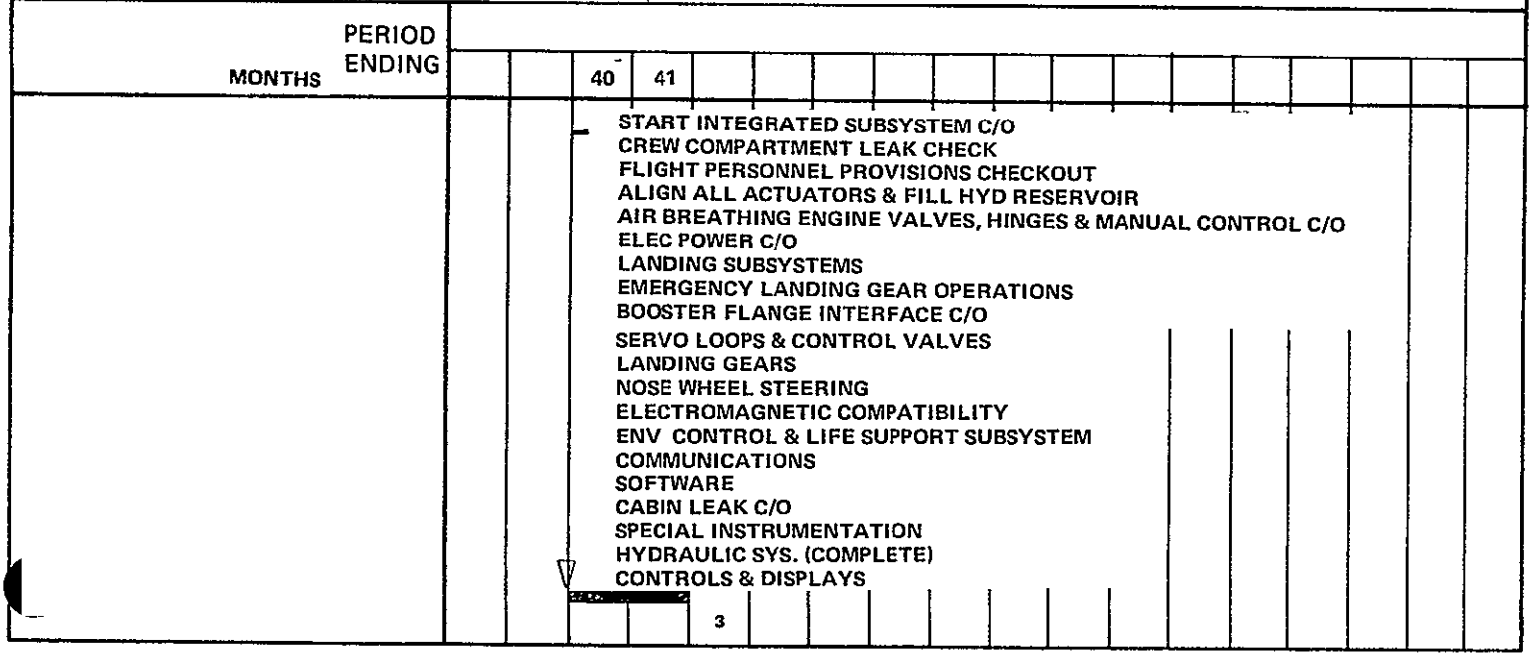
TASK TITLE INTEGRATED CHECKOUT (STAGE I)

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.6.)

TASK SCHEDULE MILESTONES



INPUTS

N10

N04

INTEGRATED SYSTEMS TEST / CHECKOUT

COMBINED SYSTEMS TEST

N08

N02

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	46300
TITLE	STAGE 1 INTEGRATED CHECKOUT
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	11 JUN 71

QUALITY

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.6.4

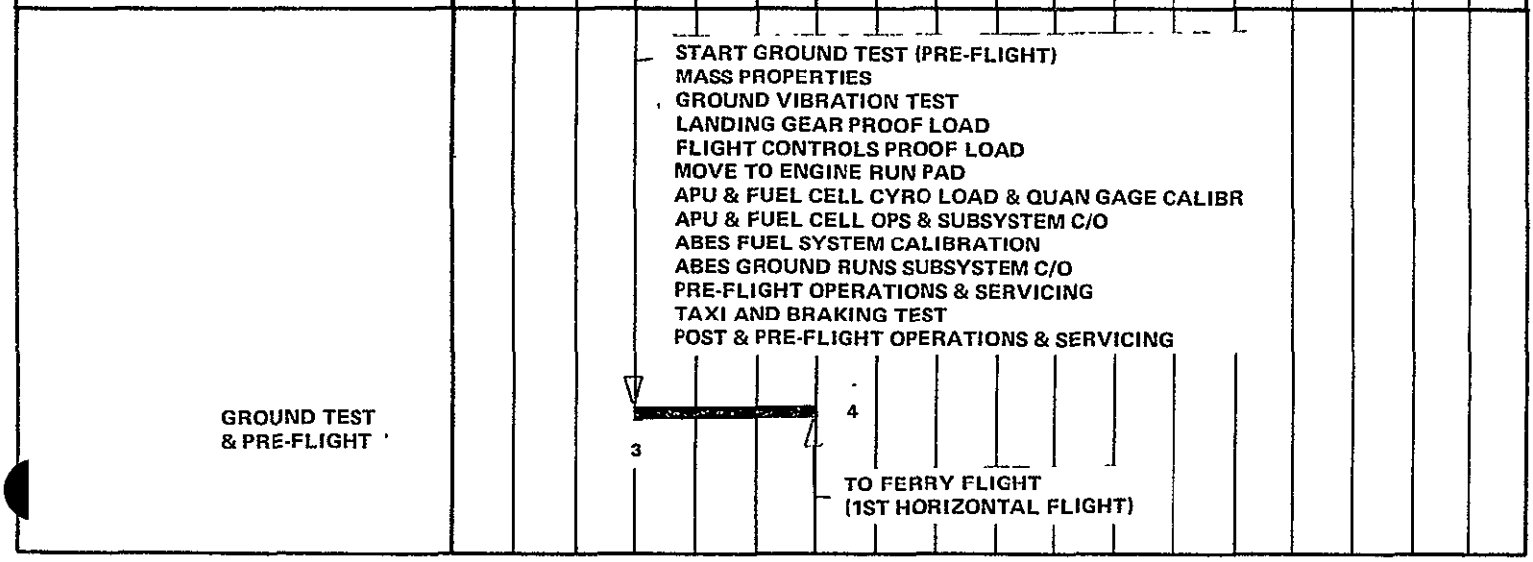
TASK TITLE PRE-FLIGHT TEST & EVALUATION (STAGE I)

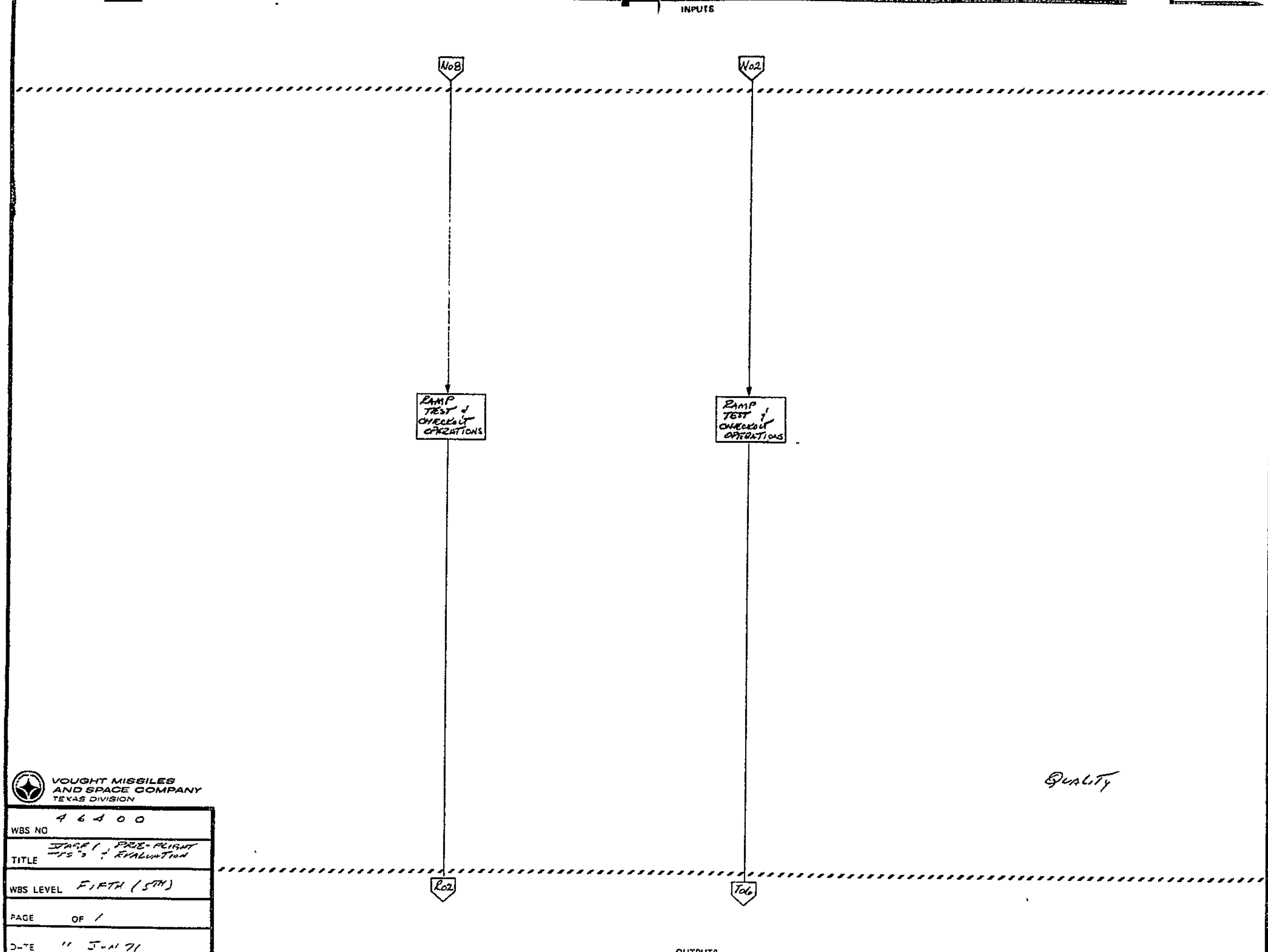
LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.6.)

TASK SCHEDULE MILESTONES





VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	46400
TITLE	STAGE I, PRE-FLIGHT TESTS & EVALUATION
WBS LEVEL	FIFTH (5TH)
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DATE	11 JUN 71

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.6.6

TASK TITLE HORIZONTAL FLIGHT TEST & EVALUATION (STAGE I)

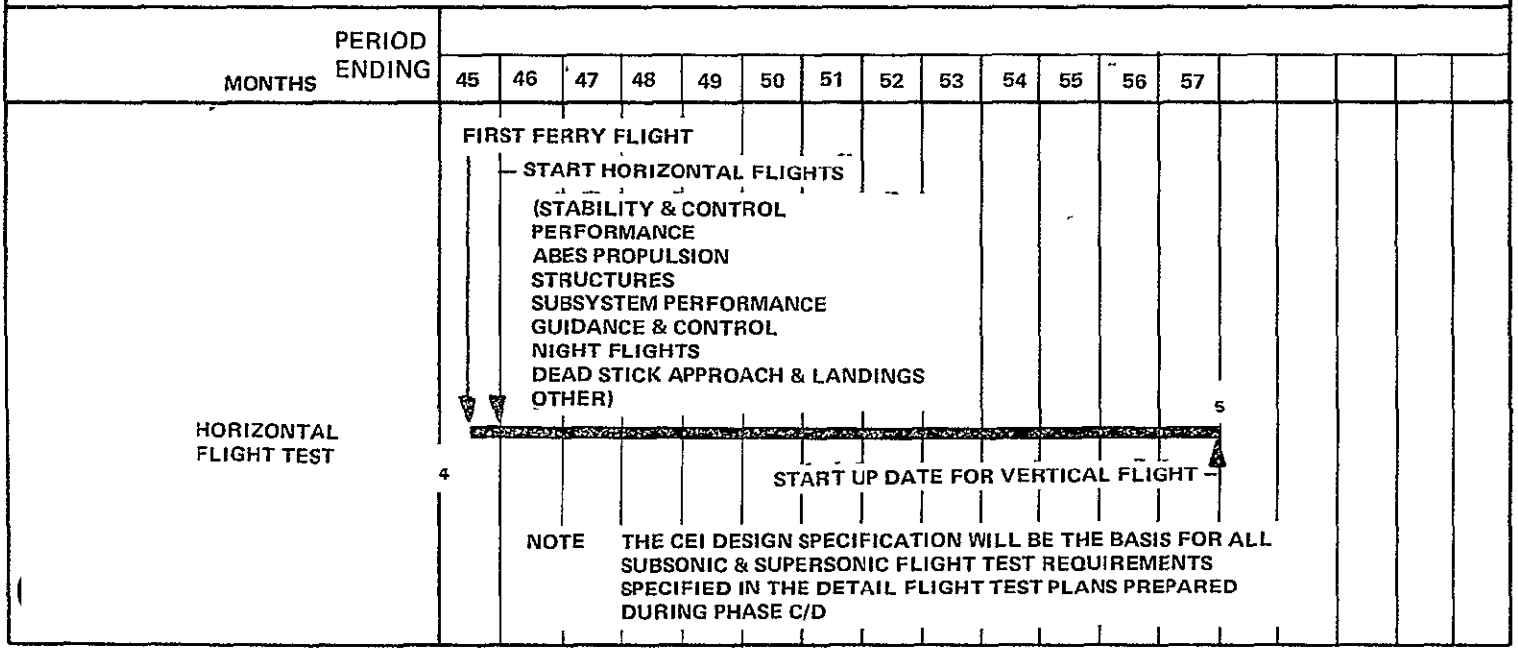
LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

A need exists to demonstrate the horizontal flying qualities of Stage I prior to committing each Flight Test Vehicle (FTV) to manned orbital flight test. This demonstration shall be performed: (1) to verify performance of and provide crew training with each FTV, as specified in CEI specifications on Stage subsystems which are operational during reentry from space mission; (2) to verify automatic vs manual flight modes; (3) to verify ABES Propulsion performance for powered flight; (4) to verify non-powered approach and landing capability; (5) to verify compatibility between on-board and ground-based communications and navaids; (6) to verify air-data accuracy as inputs to guidance, navigation and flight control; (7) to demonstrate go-around capability and performance during approach and landing; (8) to verify data management capability to switch guidance modes, monitor subsystem performance and status and to display this status for crew utilization; (9) to demonstrate control capability from either crew station for emergency simulation;

TASK SCHEDULE MILESTONES



(10) to demonstrate safe landing capability under specified weather conditions (visibility, cross winds, wet fields), air traffic status, and on-board status when such status may be marginal such as engine out, secondary power malfunctions, etc.; and (11) to demonstrate ground handling capability for takeoffs, landings, parking, crew/data removal. As directed by NASA, additional demonstrations may be required to verify compatibility of the FTV with alternate landing sites for both crew familiarization and with integrated vehicle/ground support elements (communications, navaids, ground handling problems).

II. ASSEMBLY LEVEL DEFINITION

The assembly-level elements which comprise horizontal flight test will be developed in Phase C/D. In a sense, they are FTV-oriented, in that each vehicle will have its own set of tests to be conducted. Current concepts are for either two or three FTVs to be built and flown. One may be dedicated to horizontal flight test to "wring out" any problems that may appear as well as thoroughly exercise the flying qualities of this Stage under all design margins (pitch, roll or bank, yaw, stall, min/max cruise capability for red-lining aerodynamic flight, flare specifications, power setting, antenna placements, trim settings, flight control and flight instrument qualities and accuracies, pilot visibility acceptability, etc.). Other FTVs then would buildup sufficient hours only to verify major requirements are met, relying on the dedicated FTV to resolve any problems to incorporate these either as "CAUTION" items or, if the problem is major, to hold further flight testing until the problem is resolved and remains as a "CAUTION" item or is redesigned into a mod kit.

Accordingly, a tentative assembly-level designation is as follows:

4.6.6.1	Stage I FTV No. 1 Test and Evaluation
4.6.6.2	Stage I FTV No. 2 Test and Evaluation
4.6.6.3	Stage I FTV No. 3 Test and Evaluation*

*Assumes 3 FTVs are required

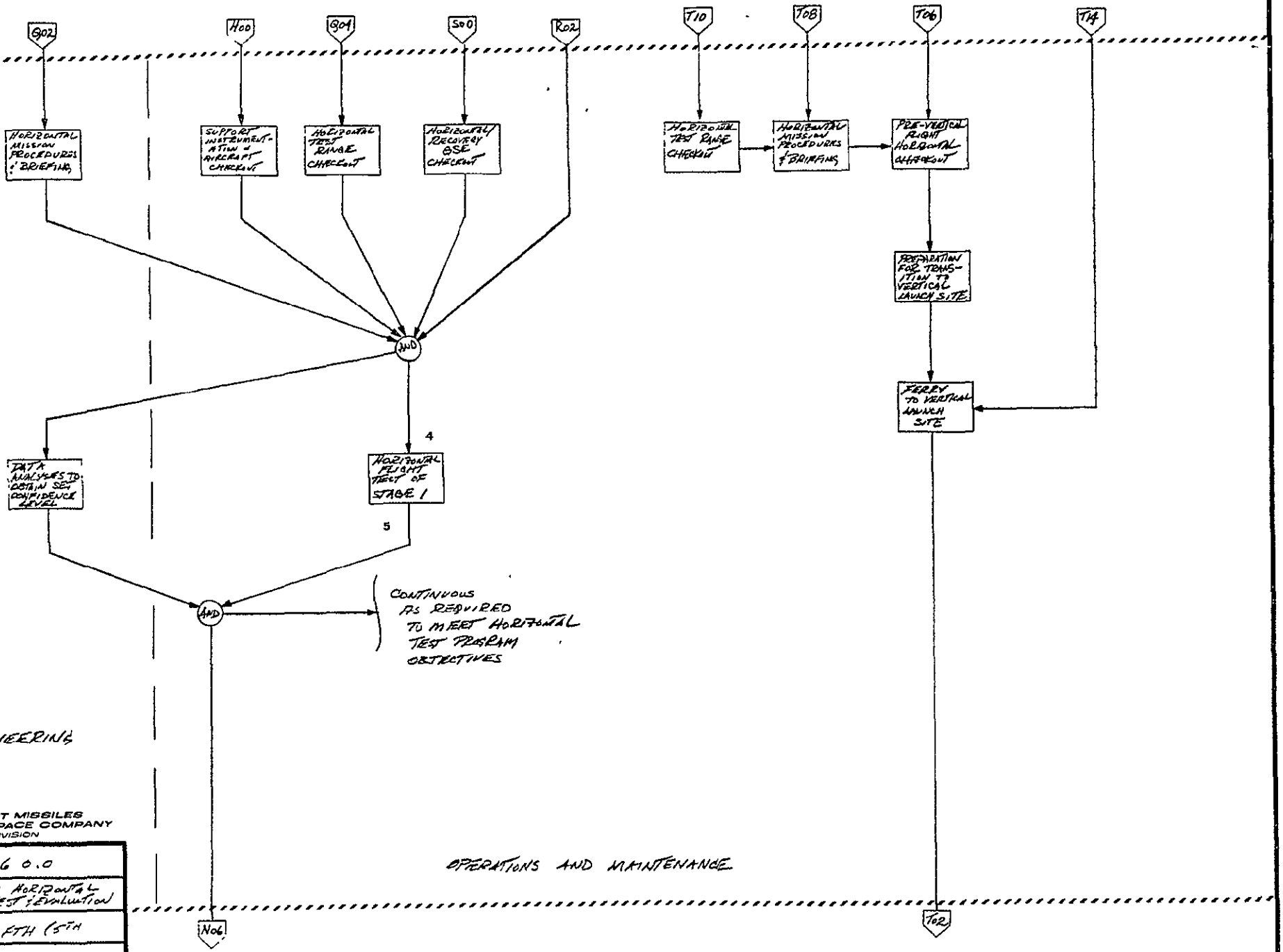
III. FUNCTIONAL DESCRIPTION

(To be added.)

IV. REFERENCES

(To be added.)

INPUTS



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4.6 6 0.0
TITLE	STAGE 1 HORIZONTAL FLIGHT TEST EVALUATION
WBS LEVEL	FIFTH (5TH
PAGE	1 OF 1
DATE	11 JUN 71

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.6.7

TASK TITLE VERTICAL FLIGHT TEST & EVALUATION (STAGE I)

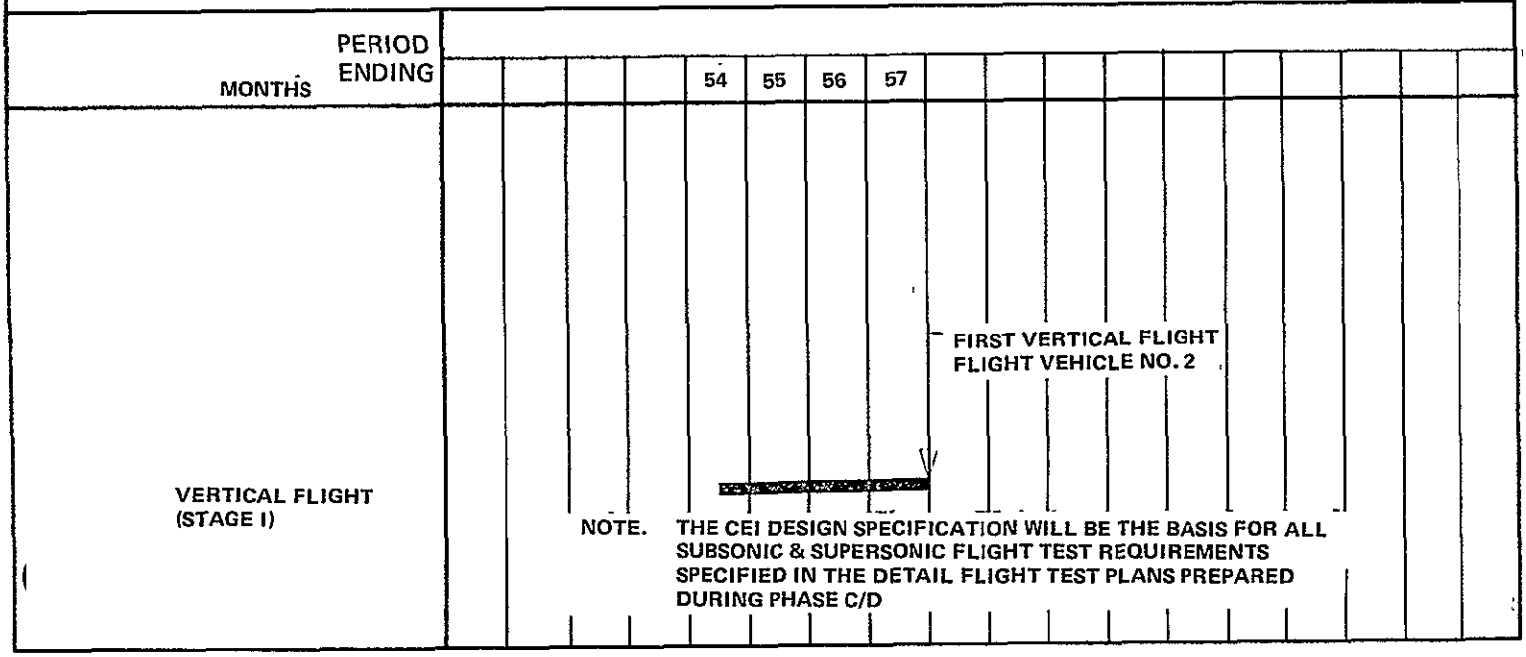
LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.6.)

NOTE: Static Firings (tie-down), only, are currently planned for single element vehicles. Phase C/D will firm up the specific requirements for this test.

TASK SCHEDULE MILESTONES



VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO 4.7

TASK TITLE MANNED ORBITAL FLIGHT TESTS (MATED)

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

To complete Category II testing, a need will exist to demonstrate the Space Transport Air Vehicle's capability and effectiveness to conduct near-operational missions through means of a series of manned orbital flight tests. These tests will have the purpose of demonstrating: (a) Air Vehicle capability for pre-launch operations, launch operations and mated ascent performance to the separation point; (b) Stage I capability to perform separation, cruise to apogee with maneuvers for entry positioning, reenter, transition, approach, land, and perform post-flight operations including return to the turnaround facility for post-flight refurbishment and preparation for the next test mission; (c) Stage II capability to separate under Stage I command (or using Stage II backup separation capability), accelerate to injection using its main propulsion capability, and (depending on specific test objectives) perform orbital operations, deboost, reenter, transition, approach, land, perform post-flight refurbishment and prepare for the next test mission; (d) Operating

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT. SEE MASTER SCHEDULE.

Ground Equipment (OGE) capability to support launch, test missions and recovery; (e) Peculiar and Common Support Equipment (MGE, DMGE) capability to support launch, recovery and turnaround; (f) Training effectiveness (flight crews, ground crews); (g) Facility effectiveness (Turnaround, Logistics Support); (h) deliverable Data effectiveness (Tech Orders, Flight Manuals, Maintenance Manuals, Operations Manuals, As-Delivered Drawings, Test Plans, Safety Plans, etc; and (i) Spares and Refurbishment Parts availability and authenticity.

These requirement will apply to each flight test vehicle (FTV) tested. Specific objectives of each test will be identified in the Test Plan approved in Phase C/D.

II. SUBSYSTEM-LEVEL DEFINITION

Three major elements are defined at the subsystem level (see Figure 4.0-W-5). These elements are mission profile oriented and correspond to the phases of the operational missions which these tests will demonstrate.

4.7.1	Launch Operations and Services
4.7.2	Flight Operations and Services
4.7.3	Recovery Operations and Services

III. FUNCTIONAL DESCRIPTION

The manned orbital flight test program will use near-operational configurations of Stage II, Stage I and ground support elements to demonstrate performance and effectiveness of the integrated Space Transport Program for conducting earth to near-earth space transport missions and to recover therefrom for turnaround capability within a two-week period. Both Stage II and Stage I will carry development flight test instrumentation kits which will be removed at the successfully demonstrated end of mated flight test. All FTV's used in the manned orbital flight test program will refurbished and recycled into operational vehicles per NASA direction.

Lower levels of the WBS Dictionary specify additional details on this phase of Systems Test and Evaluation.

IV. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.7.1

TASK TITLE LAUNCH OPERATIONS AND SERVICES (TEST)

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

A need will exist to launch each flight test vehicle (FTV) developed for the manned orbital flight test program in order to demonstrate launch capability. Launch will be followed by flight (WBS ID 4.7.2) and recovery (WBS ID 4.7.3) to demonstrate integrated Air Vehicle/Ground Support capability to accomplish operational mission objectives (see WBS Dictionary Elements 0.0, 1.0, 1.3, 1.4, 2.0, 3.0/8.0, 12.0).

The manned orbital flight test program will comply with the objectives and requirements specified in the Test Plan (WBS ID 5.0) developed in Phase C/D as approved by NASA.

II. ASSEMBLY-LEVEL DEFINITION

Three major elements are identified at the assembly level. These correspond

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT. SEE MASTER SCHEDULE.

to the three major end items of the Advanced Space Transport Program: Integration, Stage II, and Stage I and include all vehicle and ground elements associated therewith. Figure 4.0-W-5 illustrates the Work Breakdown Structure for WBS ID 4.7.1.

4.7.1.1	Integrated Operations and Services (Test)
4.7.1.2	Stage II Operations and Services (Test)
4.7.1.3	Stage I Operations and Services (Test)

III. FUNCTIONAL DESCRIPTION

At the completion of single element flight tests (WBS ID 4.5 and 4.6), both Stage II and Stage I will have demonstrated ferry flight, horizontal flight, and static firing capability in the vertical mode. In order to demonstrate launch capability in the mated (Air Vehicle, WBS ID 1.0) mode, the following sequence of operations must be demonstrated (reference is made to the WBS Identification shown on Figure 4.0-W-5 and to the corresponding WBS Identification affecting the end item involved: vehicle, OGE, MGE/DMGE).

TEST OPERATION	WBS ID 4.7.1 REFERENCE	AIR VEHICLE WBS REF.	OGE WBS REF.	MGE/DMGE WBS REF.
Launch Site/Range Activation & Initial Checkout	4.7.1.1.1 (see also WBS ID 7.0)	---	2.0	3.0/8.0
Mission Planning	4.7.1.1.2 (see Test Plan, WBS ID 5.0)	1.3.10.7 (Stage II) 1.4.10.5 (Stage I)	2.0	3.0/8.0
Flight Test Vehicle Mods	4.7.1.2.1 (Stage II) 4.7.1.3.2 (Stage I)	1.3 (Stage II) 1.4 (Stage I)	---	3.2 (Stage II) 3.4 (Stage I)

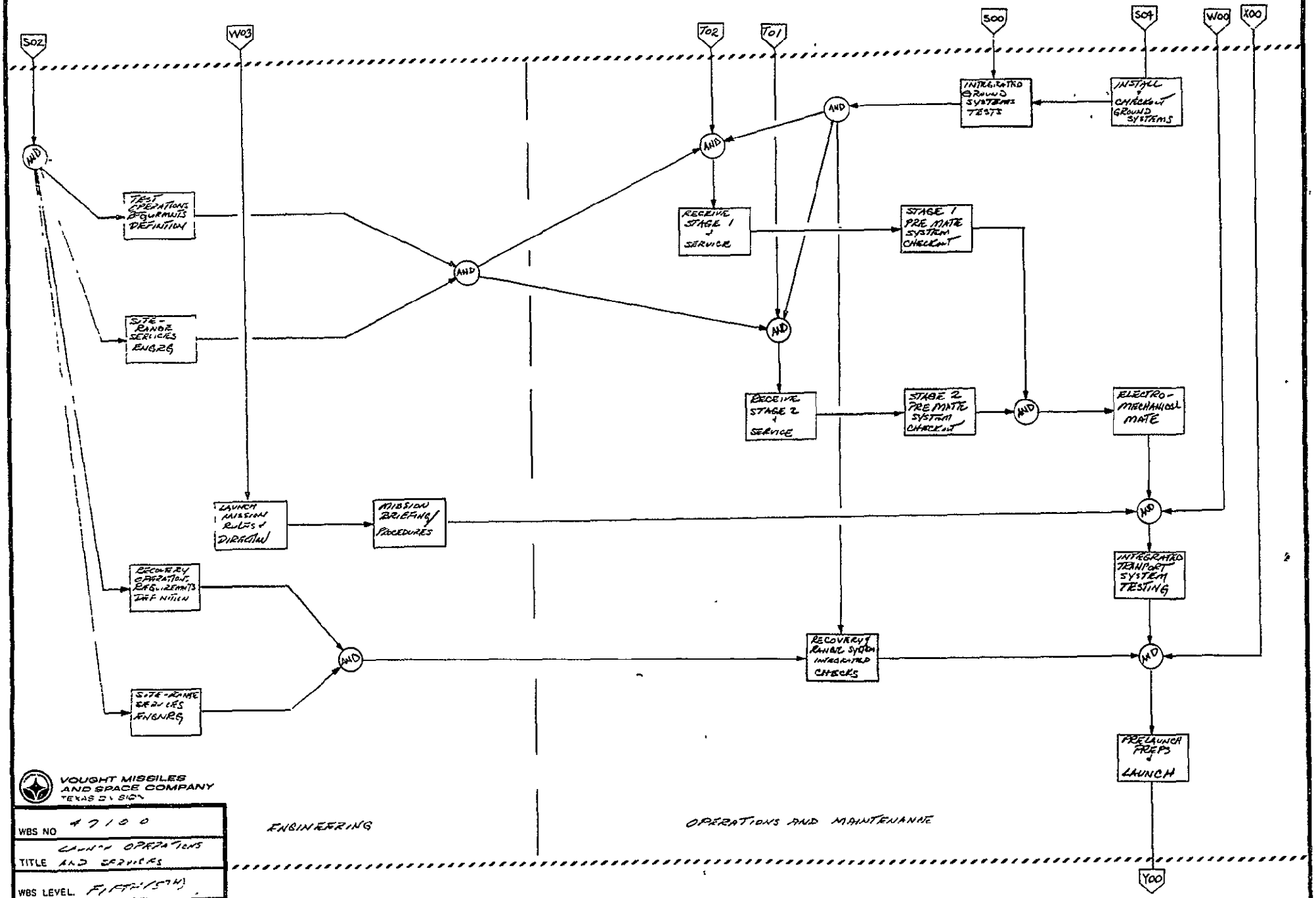
TEST OPERATION	WBS ID 4.7.1 REFERENCE	AIR VEHICLE WBS REF.	OGE WBS REF.	MGE/DMGE WBS REF.
Pre-Launch Integration Checkout & Test	4.7.1.2.2 (Stage II) 4.7.1.3.2 (Stage I)	1.3 (Stg II) 1.4 (Stg I)	2.0	3.2.2/3.2.6 (Stage II) 3.4.2/3.4.6 (Stage I)
Air Vehicle Assy.	4.7.1.1.3	1.1	2.5.3	3.1
Pre-Launch Integ. Checkout & Test	4.7.1.1.4	1.0	2.5/ 2.7	3.1/3.2/ 3.4
Countdown Tests and Operations	4.7.1.1.5	1.3.10(Stg II) 1.4.10(Stg I)	2.5/ 2.7	3.1/3.2/ 3.4
Launch Control Tests & Operations	4.7.1.1.6	---	2.5	---
Range Checks	4.7.1.1.7	---	2.1/ 2.5/ 2.6	---
Launch Support Checks, Operations, Maintenance	7.4.1.1.8	---	2.7	3.1/3.2/ 3.3
Launch Instrumentation & Data Collection	4.7.1.9	1.3.10(Stg II) 1.4.10(Stg I)	2.1/2.2/ 2.3/2.4/ 2.5/2.7	3.1/3.2/ 3.3
Integrated Launch Software	4.7.1.1.11	1.3.10.7 (Stage II) 1.4.10.5 (Stage I)	2.5.4	---
Flight Crew Tests and Operations (Launch)	4.7.1.2.10 (Stage II) 4.7.1.3.10 (Stage I)	1.3.11 (Stage II) 1.4.11 (Stage I)	2.5.1	3.1.1
Stage Servicing	4.7.1.2.4 (Stage II 4.7.1.3.4 (Stage I)	1.3 (Stage II) 1.4 (Stage I)	2.5.1	3.2.5 3.4.5

TEST OPERATION	WBS ID 4.7.1 REFERENCE	AIR VEHICLE WBS REF.	OGE WBS REF.	MGE/DMGE WBS REF.
Stage Pre-Launch Checkout Software	4.7.1.2.12 (Stage II) 4.7.1.3.12 (Stage I)	1.3.10.7 (Stage II) 1.4.10.5 (Stage I)	---	3.2.6 3.4.6
Flight Test Consumables	4.7.1.2.9 (Stage II) 4.7.1.3.9 (Stage I)	1.3 (Stage II) 1.4 (Stage I)	2.5/ 2.7	---
Pad Refurbishment	4.7.1.1.10	---	2.5.3/ 2.7	---

IV. REFERENCES

(To be added.)

INPUTS



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	47100
TITLE	LAUNCH OPERATIONS AND SERVICES
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ENGINEERING

OPERATIONS AND MAINTENANCE

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.7.2

TASK TITLE FLIGHT OPERATIONS & SERVICES (TEST)

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

A need will exist to demonstrate capability of the Space Transport Air Vehicle to successfully accomplish manned orbital test flights prior to committing the Program to Operations. WBS ID 4.7.1 demonstrates launch capability. WBS ID 4.7.2 will demonstrate flight capability. WBS ID 4.7.3 will demonstrate recovery capability. Mission profiles and test objectives will be met as defined in the Test Plan, WBS ID 5.0. In addition to demonstrating capability of the Air Vehicle and its stages to perform per system specification, the capability for the integrated Vehicle/Ground Net to meet specification shall be demonstrated. Applicable requirements are specified in WBS Dictionary Elements 0.0 (Program), 1.0 (Air Vehicle), 1.3 (Stage II), 1.4 (Stage I), 2.0 (Ground Communications, Command and Control, Recovery; i.e., OGE); and 3.0/8.0 (Peculiar and Common Support Equipment, i.e., MGE/DMGE). These represent the end item hardware and software comprising Integration,

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT. SEE MASTER SCHEDULE.

Stage II and Stage I. To demonstrate Payload integration capability (WBS ID 1.2), the test objectives may specify simulations to demonstrate capability to load, checkout, launch, orbit and deploy a payload (and/or to launch empty and retrieve a payload), and to successfully land with or without a payload aboard to demonstrate post-flight ground handling capability.

WBS ID 4.7.2 requirements are basically concerned with manned orbital flight test, the launch and recovery operations being specified in WBS Dictionary elements 4.7.1 and 4.7.3, respectively.

II. ASSEMBLY-LEVEL DEFINITION.

Three major elements are defined at the assembly level. These elements are basically concerned with Stage II air/ground performance, Stage I air/ground performance and Ground Control over the test, including acquiring and processing real time and delayed dissemination data obtained from communications with the vehicle and with the range/recovery sites (see Figure 4.0-W-5).

4.7.2.1	Stage II Flight Test Operations
4.7.2.2	Stage I Flight Test Operations
4.7.2.3	Ground Control Operations and Services

III. FUNCTIONAL DESCRIPTION

The specific objectives to be demonstrated and evaluated during the flight portion of the Manned Orbital Flight Test program will be defined and approved for implementation during Phase C/D of the Advanced Space Transport Program's RDT & E phase. These objectives will, in general, include the following (see WBS Dictionary Element 0.0 and 1.3).

EXPECTED TEST OBJECTIVE	REF. PARAGRAPH (WBS DICT) 0.0	1.3
Level I Requirements:		
1. Demonstrate insertion of Stage II into 50 x 100 nm orbit and circularize at 100 nm. (Translation to higher orbit is option to be determined by NASA on later test flights.)	IV.A.3	See Level III

EXPECTED TEST OBJECTIVE	REF PARAGRAPH (WBS DICT) 0.0	1.3
Level I Requirements:		
2. Demonstrate Stage II nominal hypersonic aerodynamic cross range capability of 1100 nm. Insure a once-around return to launch site for all azimuths.	IV.A.4	See Level III
3. Demonstrate mission duration capability as specified by NASA	IV.A.5	
4. Demonstrate cargo (payload) capability from zero to maximum constraint (weight, volume)	IV.A.6	
5. Demonstrate on-orbit delta V capability	IV.A.7	
6. Demonstrate Stage I and Stage II go-around capability	IV.A.8	
7. Demonstrate shirtsleeve environment, Stage I and Stage II	IV.A.9	
8. Demonstrate Stage I capability to return to launch site	IV.A.10	
9. Demonstrate intact abort capability after liftoff	IV.A.16	
10. Demonstrate rescue mission capability (applies to both WBS ID 4.7.1 and 4.7.2)	IV.A.19	
11. Demonstrate (intentionally, it is hoped!) fail operational/fail safe capability	IV.A.21	
12. Demonstrate 3g load factor limit	IV.A.24	
13. Demonstrate payload weight + vehicle weight landing capability	IV.A.26	
14. Demonstrate one-engine-out go-around capability (Stage II)	IV.A.27	
Level II Requirements		
1. Demonstrate applicable Mission Requirements	IV.B.1	
2. Demonstrate engine-out performance (Stage I, basically; Stage II engine-out test noted under Level I rqts. above)	IV.B.2.1	

EXPECTED TEST OBJECTIVE	REF PARAGRAPH (WBS DICT) 0.0	1.3
Level II Requirements		
3. Demonstrate crew takeover capability from automatic mode as applicable	IV.B.7	See Level III
4. Demonstrate stage separation from either Stage I (normal) or Stage II (backup)	IV.B.8	
5. Demonstrate antenna pointing/ lock-on capability	IV.B.9	
6. Demonstrate propellant dump capability prior to landing	IV.B.13	
7. Demonstrate landing on 10,000-foot runways (sea level, standard day) (NOTE: Test must specify worst conditions. If target runway exceeds worst conditions, integrated Ground Control/Flight Vehicle must demonstrate alternate landing capability. Applies to both Stages.)	IV.B.14.2(i)	
Level III Requirements (Stage II)		
1. Demonstrate CONUS landings under 24-hour or less update	---	IV.A.1
2. Demonstrate rendzvous and docking capability meets spec (as applicable)	---	IV.A.2(b) IV.A.3.1
3. Demonstrate cargo monitoring capability	---	IV.A.6
4. Demonstrate, as directed, capability to reach (and compatibility with) all designated landing sites	---	IV.A.7

IV. SUPPORT DEMONSTRATION

Implicit in meeting the above objectives, the ground support elements will be exercised. These include the WBS ID 2.0 elements (see WBS Dictionary Element 2.0) for Surveillance, Identification and Tracking (WBS ID 2.1), for Command and Control (WBS ID 2.2), for Communications (WBS ID 2.3),

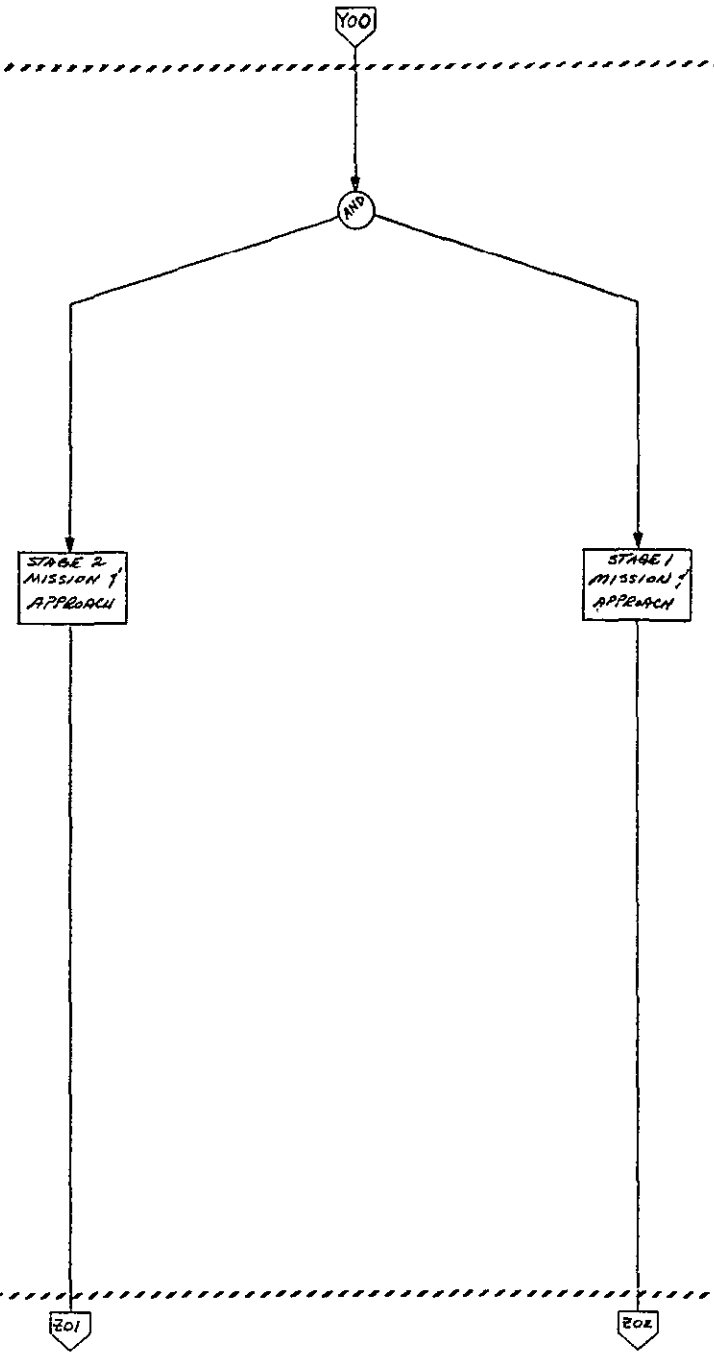
5

for Data Processing (WBS ID 2.4) and for Recovery (WBS ID 2.6), the latter supporting both emergency situations and the normal recovery operations (WBS ID 4.7.3). These elements will demonstrate their integrated capability as will the airborne elements. Specific test objectives for Operating Ground Equipment (OGE) will be included in this portion of the Phase C/D approved Test Plan.

V. REFERENCES

(To be added.)

INPUTS



OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	47200
TITLE	FLIGHT OPERATIONS & SERVICES
WBS LEVEL	FIFTH (5TH)
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VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO 4.7.3

TASK TITLE RECOVERY OPERATIONS & SERVICES (TEST)

LEVEL 5, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

A need will exist to recover Stage II and Stage I following a manned orbital flight test. Following recovery, each Stage (FTV) will be recycled through the turnaround facility for post-flight evaluation, maintenance and refurbishment to prepare it for the next test flight. At an appropriate point, i.e., completion of this test phase, each Stage utilized in the Manned Orbital Flight Test program will be recycled through the factory or designated refurbishment facility to remove test kits and prepare the Stage for final acceptance (DD 250 or equivalent) and turnover to NASA for Operations (WBS ID 12.0).

II. ASSEMBLY-LEVEL DEFINITION

Three major elements comprise the Recovery Operations and Services (Test), as noted on Figure 4.0-W-5. These elements correspond to each Stage, which

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED

is independently recovered, and to the Integration element corresponding to vehicle turnaround. These elements are:

4.7.3.1	Stage II Recovery Operations and Services
4.7.3.2	Stage I Recovery Operations and Services
4.7.3.3	Integrated Operations and Services

III. FUNCTIONAL DESCRIPTION

The operations performed under Recovery Operations and Services (Test) are similar to those which will be performed in the Operations phase of the Advanced Space Transport Program. The difference will lie in the need to activate the landing sites (recovery sites) such as designated airports and runways, landing aids (ground controllers, beacons, transponders, voice communications, logistics supply, stage handling areas, personnel areas, data processing areas - which are peculiar to or used on the Test Program), ferry stations, and the turnaround facility prior to the first mated flight. Included in this activation will be the installation and checkout of fixed and mobil OGE (WBS ID 2.6) and MGE (WBS ID 3.2/3.4/8.2/8.4) and special test equipment needed to support this portion of mated flight test.

Following activation (see Figure 4.0-W-5 for affected WBS functions: 4.7.3.1.1, 4.7.3.1.2, 4.7.3.1.3, 4.7.3.2.1, 4.7.3.2.2, 4.7.3.2.3, 4.7.3.3.1, 4.7.3.3.2, 4.7.3.3.3, 4.7.3.3.4), the sequence of operations will normally be as follows:

TEST OPERATION OR SERVICE	REFERENCE FUNCTION (WBS ID)				
	Stage II (WBS ID)	Stage I (WBS ID)	Integ. Ops/Serv (WBS ID)	OGE/MGE Rqd. (WBS ID)	
				OGE	MGE/DMGE*
. Stage II Recovery . Stage II Data Handling	4.7.3.1.4 4.7.3.1.10	---	---	2.6	3.2/8.2
. Stage II Safe & Purge	4.7.3.1.5	---	---		

TEST OPERATION OR SERVICE	REFERENCE FUNCTION (WBS ID) Stage II (WBS ID)	Stage I (WBS ID)	Integ. Ops/Serv (WBS ID)	OGE/MGE Rqd. (WBS ID) OGE	MGE/DMGE*
. Stage II Ferry Operations	4.7.3.1.6	---	---	2.6	3.2/8.2
. Stage II Ferry Kit(if required)	4.7.3.1.7				
. Stage II Ferry Consumables	4.7.3.1.8				
. Stage II Ferry Crew	4.7.3.1.9				
. Ferry Kit Transporter	4.7.3.1.11				
. Stage I Recovery	----	4.7.3.2.4	---	2.6	3.4/8.4
. Stage I Data Handling		4.7.3.2.9			
. Stage I Safe & Purge	----	4.7.3.2.5	---		
. Stage I Ferry Operations	----	4.7.3.2.6	---		
. Stage I Ferry Consumables		4.7.3.2.7			
. Stage I Ferry Crew		4.7.3.2.8			
. Stage II Post-flight Maintenance & Refurbishment	4.7.3.1.12	---	4.7.3.3.5 (11.1)	---	3.2/3.3/ 8.2/8.3
. Stage II Maintenance Software	4.7.3.1.13	---			
. Stage I Post-flight Maintenance & Refurbishment	----	4.7.3.2.10			3.4/3.5/ 8.4/8.5
. Stage I Maintenance Software	----	4.7.3.2.11			

*As applicable to landing site or turnaround facility

IV. SUPPORT OPERATIONS

It is noted in the preceding matrix that OGE (WBS ID 2.6, principally) and MGE/DMGE (WBS ID 3.2, 3.4, 8.2, 8.4) will be required to support the landing operation, purge and safing, crew and data removal, layover for inspection and servicing, then preparation for ferry flight (if required) to the turnaround facility. At this facility, post-flight inspection will be thorough to effectively inspect each area of each Stage, including handling any maintenance at the organizational, intermediate and depot level (WBS ID 3.2 - 3.5, 8.2 - 8.5). Any abnormal damage or erosion of nose cap, leading edges, thermal protection skin panels, antennae, windshields, access panels, gear, ABES engines, hatches, doors, etc. will require refurbishment prior to next test flight. Consumables will be checked (oils, greases, lubricants, fluids) to verify abnormal depletion. Batteries will be checked to verify electrolyte status (if wet batteries). And, the software records will be thoroughly analyzed to determine performance deficiencies which will require either correction (design) or expected maintenance. Flight crews and ferry crews debriefings will also disclose any problems which need attention. Ground crew (operating and maintenance) debriefings and logs will be reviewed to determine need for improvement in ground surveillance and tracking, communications, command and control, data processing, launch equipment, procedures, logistics support, etc. to verify the integrated net operates smoothly, has minor problems requiring fix before next flight, or has major problems requiring design or procedural change before the next flight.

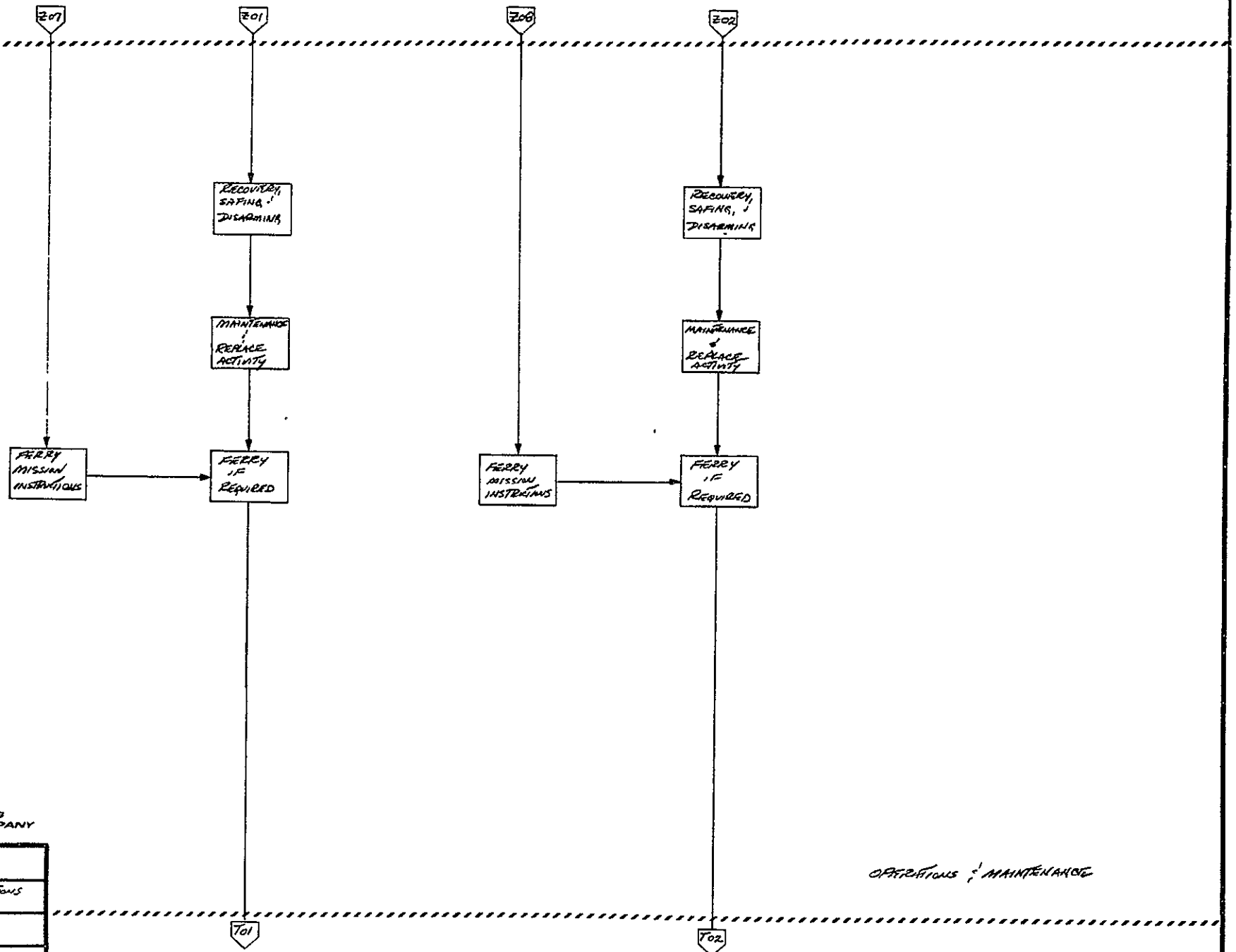
Both the test team and contractor program home teams will be interlocked into this test phase and must be ready to respond as required to continue testing to the satisfaction of NASA.

Further definition must await Phase C/D to define more specifically how this portion of the manned orbital flight test program will be handled.

V. REFERENCES

(To be added.)

INPUTS



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	47300
TITLE	RECOVERY OPERATIONS & SERVICES
WBS LEVEL	FIFTH (5TH)
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OPERATIONS & MAINTENANCE

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.8

TASK TITLE STAGE II MOCKUPS

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

A need will exist, during Phase C/D, to provide engineering mockups which will support design, development, training and change control associated with Stage II RDT & E. As applicable, certain mockups may be required after RDT & E to support change control and training for the Operations phase of the Program. Such requirements, as well as specific needs for RDT & E, will be specified by NASA during or following contract negotiations for Phase C/D. Existing mockups generated for Phase B preliminary design may be utilized, if acceptable, for Phase C/D at the discretion of NASA.

In addition to a full scale mockup of Stage II, other mockups will be required. Their scale and configuration will be based upon design and integration needs, utility, value to the contractor and to NASA, as well as economic factors. Where feasible, "soft" mockups shall be provided.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE LOWER LEVELS FOR DETAIL SCHEDULES

II. SUBSYSTEM-LEVEL DEFINITION

Eight potential mockup categories are specified for Stage II as noted on Figure 4.0-W-5. In addition to full scale mockups of the complete Stage (cutoffs may be permitted if R.H. and L.H. sections are equivalent), other mockups will be needed to ensure integration is accomplished. Models are not included herein, although they will be required to verify integration of Stage II with Stage I and with support equipment and facilities. Mockup elements are specified as follows:

4.8.1	Full Scale Stage II Mockup
4.8.2	Propulsion and Power Plant Mockup(s)*
4.8.3	Flight Controls Mockup **
4.8.4	Secondary Power Mockups**
4.8.5	Environmental Control/Life Support Mockups***
4.8.6	Crew Station/Integrated Avionics Mockups
4.8.7	Payload Integration Mockups
4.8.8	Docking and Payload Transfer Mockups****

* Single Engine and Clustered Engines, including integration with Cryogenic Tankage, Ducting, Venting, Purging, Controls

** May be included with Propulsion and Power Plant (partial), Integrated Avionics (partial) and Full Scale Mockup.

*** May be included with Crew Station/Integrated Avionics (partial) and Full Scale Mockup

**** May be integrated with mockup of Space Station, Space Base, other NASA mockups as applicable.

III. FUNCTIONAL DESCRIPTION

It is anticipated that the Stage II contractor will require various operating, laboratory-type test setups to ascertain performance of prototype and production hardware/software as the design of Stage II crystallizes. Examples include secondary power working mockups, environmental control/cabin working mockups, and integrated avionics working mockups. Thus, the full scale mockup will ensure form and fit and the working mockups can simulate function (see WBS Dictionary Element 4.1 and 4.3).

The need for separate mockups of single and integrated subsystems will thus depend on the tradeoffs of utility vs economy which must be defined by the Stage II contractor and negotiated with NASA.. Propulsion and power plant mockups, for example, will assist the designer and packaging engineer to ensure this subsystem's integration as well as verifying the interface with secondary power, flight controls, structure and avionics (e.g., data management).

Depending on the need for other than full scale mockup, mockup Part I specifications for each required mockup will be generated following Phase C go-ahead, then reviewed in PDR, Part II's prepared, reviewed in CDR to the extent required by the contracting officer, and then fabricated or modified as applicable. Since certain mockups will be required both through RDT & E as well as delivered to NASA for Operations (Investment Phase), they must be maintained, protected, modified as directed by change control and turned over to NASA representing the as-delivered Stage or essential elements thereof.

Final resolution on mockup requirements must await contract negotiation and Phase C go-ahead.

IV. REFERENCES

(To be added)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO 4.8.1

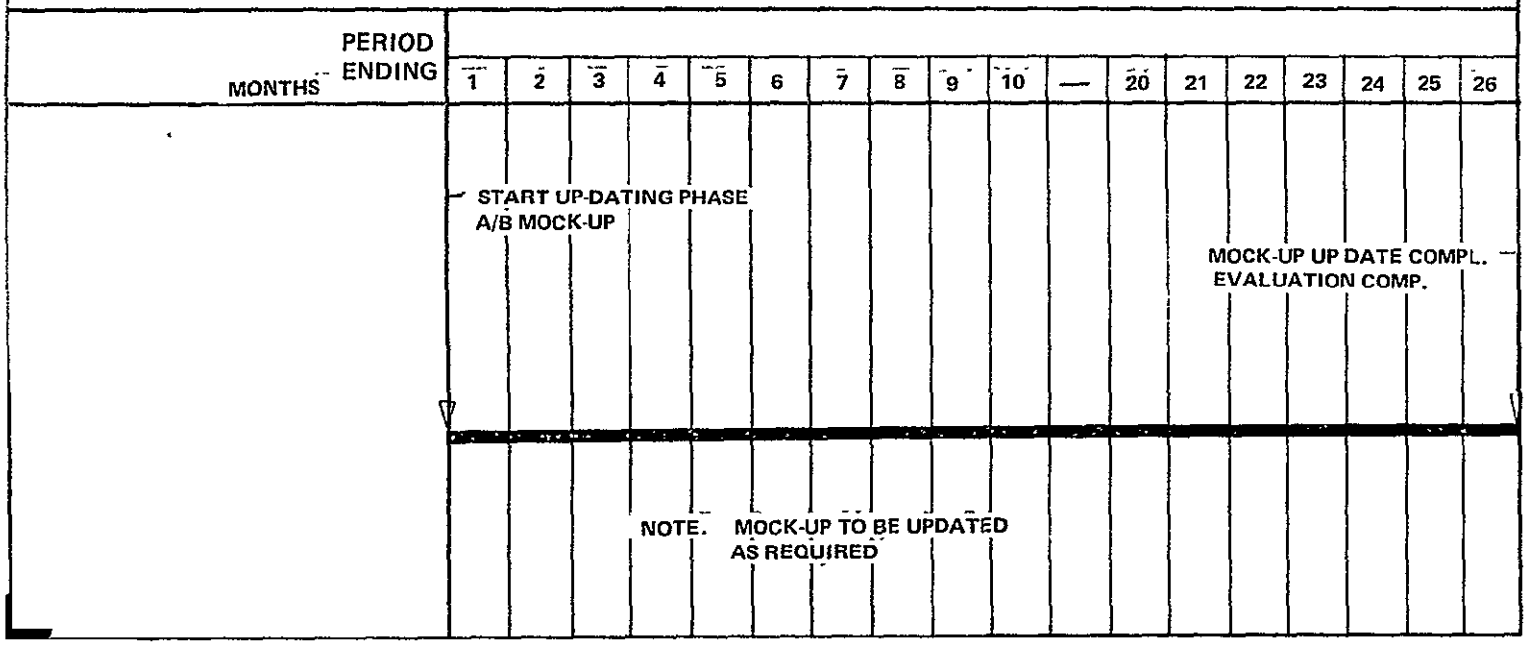
TASK TITLE FULL SCALE STAGE II MOCKUP

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.8.)

TASK SCHEDULE MILESTONES



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GO-AHEAD

A00

DEVELOP STAGE 2 STRUCTURAL MOCKUP

ENGINEERING

B01

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	48100
TITLE	STAGE 2 FULL SCALE MOCKUP
WBS LEVEL	FIFTH (5TH)
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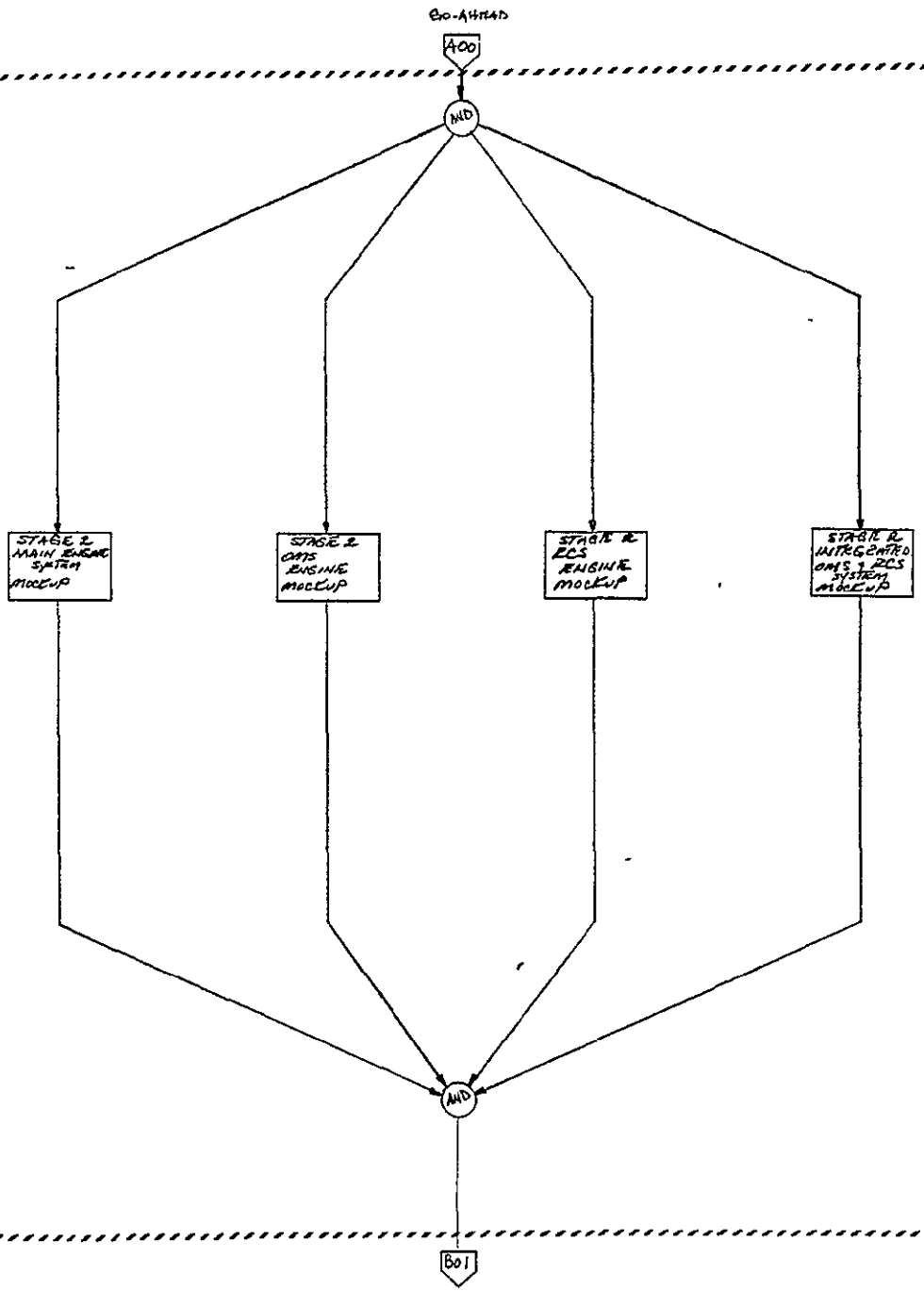

ENGINEERING

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	48200
TITLE	STAGE 2 PROPULSION & POWER MOCKUPS
WBS LEVEL	FIFTH (5TH)
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OUTPUTS

INPUTS

GO AHEAD →

A00

DEVELOP STAGE 2 FLIGHT CONTROLS MOCKUP

ENGINEERING

B01

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

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TITLE	STAGE 2 FLIGHT CONTROLS MOCKUP
WBS LEVEL	FIFTH (5TH)
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INPUTS

GO AHEAD

A00

STAGE 2 SECONDARY POWER MOCKUP

ENGINEERING

801

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

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WBS LEVEL	FIFTH (5TH)
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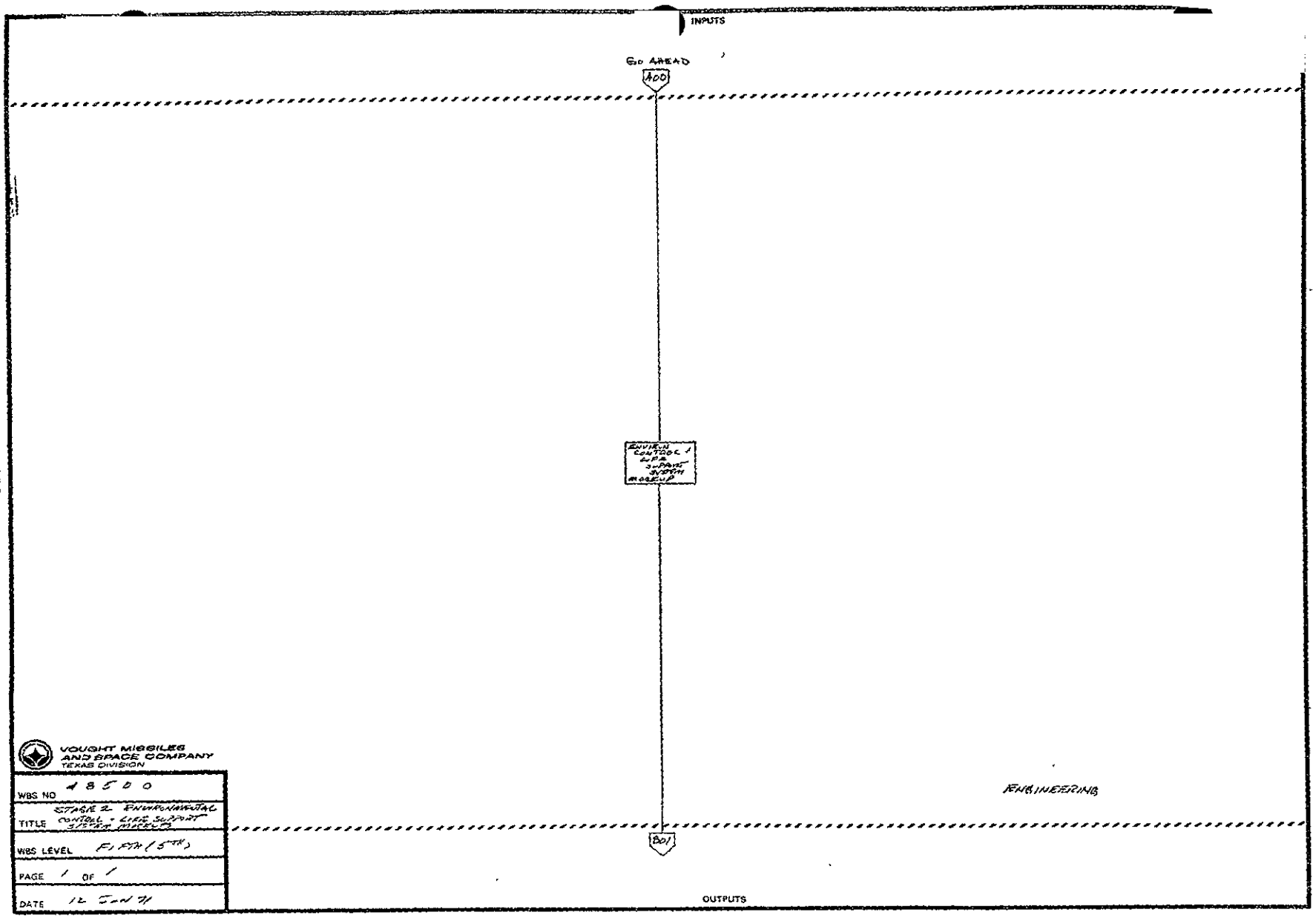
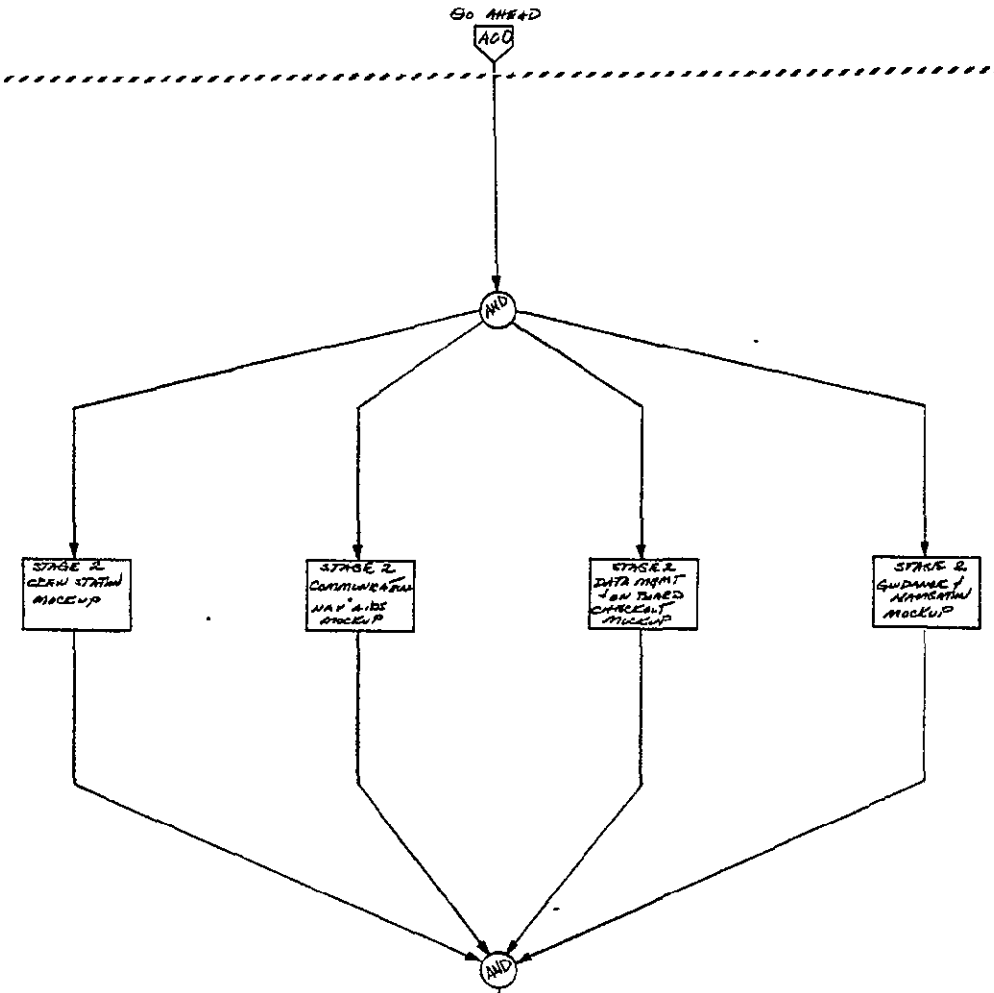

INPUTS
GO AHEAD
400
ENVIRON CONTROL / LIFE SUPPORT SYSTEM MOCK UP
801
ENGINEERING
OUTPUTS
VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION
WBS NO 48500
TITLE STAGE 2 ENVIRONMENTAL CONTROL + LIFE SUPPORT SYSTEM MOCK UP
WBS LEVEL FIFTH (5TH)
PAGE 1 OF 1
DATE 12 JAN 71

INPUTS



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	48600
TITLE	STAGE 2 AVIONICS MOCKUPS
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	11 JUN 91

ENGINEERING

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.9

TASK TITLE STAGE I MOCKUPS

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

A need will exist, during Phase C/D, to provide engineering mockups which will support design, development, training and change control associated with Stage I RDT & E. As applicable, certain mockups may be required after RDT & E to support change control and training for the Operations phase of the Program. Such requirements, as well as specific needs for RDT & E, will be specified by NASA during or following contract negotiations for Phase C/D. Existing mockups generated for Phase B preliminary design may be utilized, if acceptable, for Phase C/D at the discretion of NASA.

In addition to a full scale mockup of Stage I, other mockups will be required. Their scale and configuration will be based upon design and integration needs, utility, value to the contractor and to NASA, as well as economic factors. Where feasible, "soft" mockups shall be provided.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE LOWER LEVELS FOR DETAIL SCHEDULES

II. SUBSYSTEM-LEVEL DEFINITION

Six potential mockup categories are specified for Stage I as noted on Figure 4.0-W-5. In addition to full scale mockups of the complete Stage (cutoffs may be permitted if R.H. and L.H. sections are equivalent), other mockups will be needed to ensure integration is accomplished. Models are not included herein, although they will be required to verify integration of Stage II with Stage I and with support equipment and facilities. Mockup elements are specified as follows:

4.9.1	Full Scale Stage I Mockup
4.9.2	Propulsion and Power Plant Mockup(s)*
4.9.3	Flight Controls Mockup**
4.9.4	Secondary Power Mockups**
4.9.5	Environmental Control/Life Support Mockups***
4.9.6	Crew Station/Integrated Avionics Mockups

* Single Engine and Clustered Engines, including integration with Cryogenic Tankage, Ducting, Venting, Purging, Controls

** May be included with Propulsion and Power Plant (partial), Integrated Avionics (partial) and Full Scale Mockup

*** May be included with Crew Station/Integrated Avionics (partial) and Full Scale Mockup

III. FUNCTIONAL DESCRIPTION

It is anticipated that the Stage I contractor will require various operating, laboratory-type test setups to ascertain performance of prototype and production hardware/software as the design of Stage I crystallizes. Examples include secondary power working mockups, environmental control/cabin working mockups, and integrated avionics working mockups. Thus, the full scale mockup will ensure form and fit and the working mockups can simulate function (see WBS Dictionary Elements 4.2 and 4.4).

The need for separate mockups of single and integrated subsystems will thus depend on the tradeoffs of utility vs economy which must be defined by the Stage I contractor and negotiated with NASA. Propulsion and power plant mockups, for example, will assist the designer and packaging engineer to ensure this subsystem's integration as well as verifying the interface with secondary power, flight controls, structure and avionics (e.g., data management).

Depending on the need for other than full scale mockup, mockup Part I specifications for each required mockup will be generated following Phase C go-ahead, then reviewed in PDR, Part II's prepared, reviewed in CDR to the extent required by the contracting officer, and then fabricated or modified as applicable. Since certain mockups will be required both through RDT & E as well as delivered to NASA for Operations (Investment Phase), they must be maintained, protected, modified as directed by change control and turned over to NASA representing the as-delivered Stage or essential elements thereof.

Final resolution on mockup requirements must await contract negotiation and Phase C go-ahead.

IV. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 4.9.1

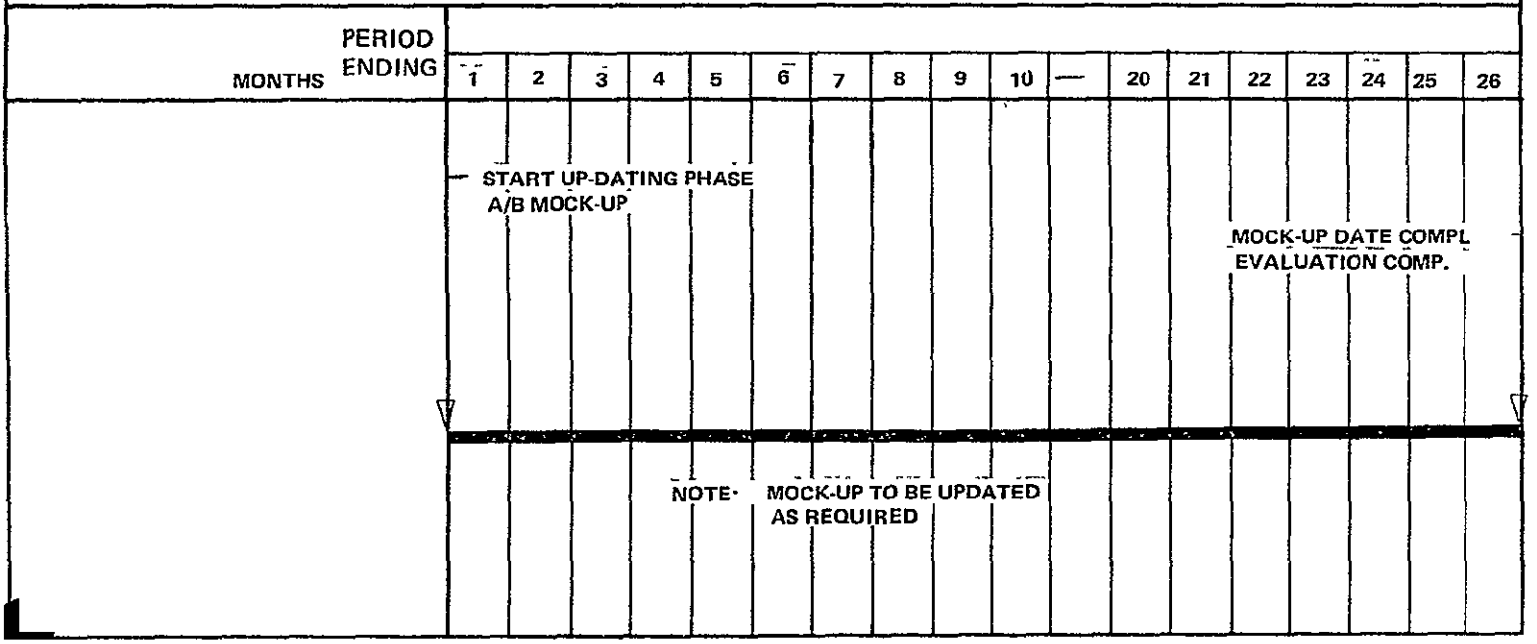
TASK TITLE FULL SCALE STAGE I MOCKUP

LEVEL 5, Subsystem Level

WBS DICTIONARY

(Definition not provided. See WBS Dictionary Element 4.9.)

TASK SCHEDULE MILESTONES



INPUTS

GO AHEAD
A00

STAGE I
STRUCTURAL
MOCKUP

ENGINEERING

801

OUTPUTS

VOUGHT MISSILES
AND SPACE COMPANY
TEXAS DIVISION

WBS NO	49100
TITLE	STAGE I FULL SCALE MOCKUP
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	12 JUN 71

INPUTS

Go AHEAD

A00

A01

MAIN ENGINE SYSTEM MOCKUP

RCS ENGINE SYSTEM MOCKUP

A02

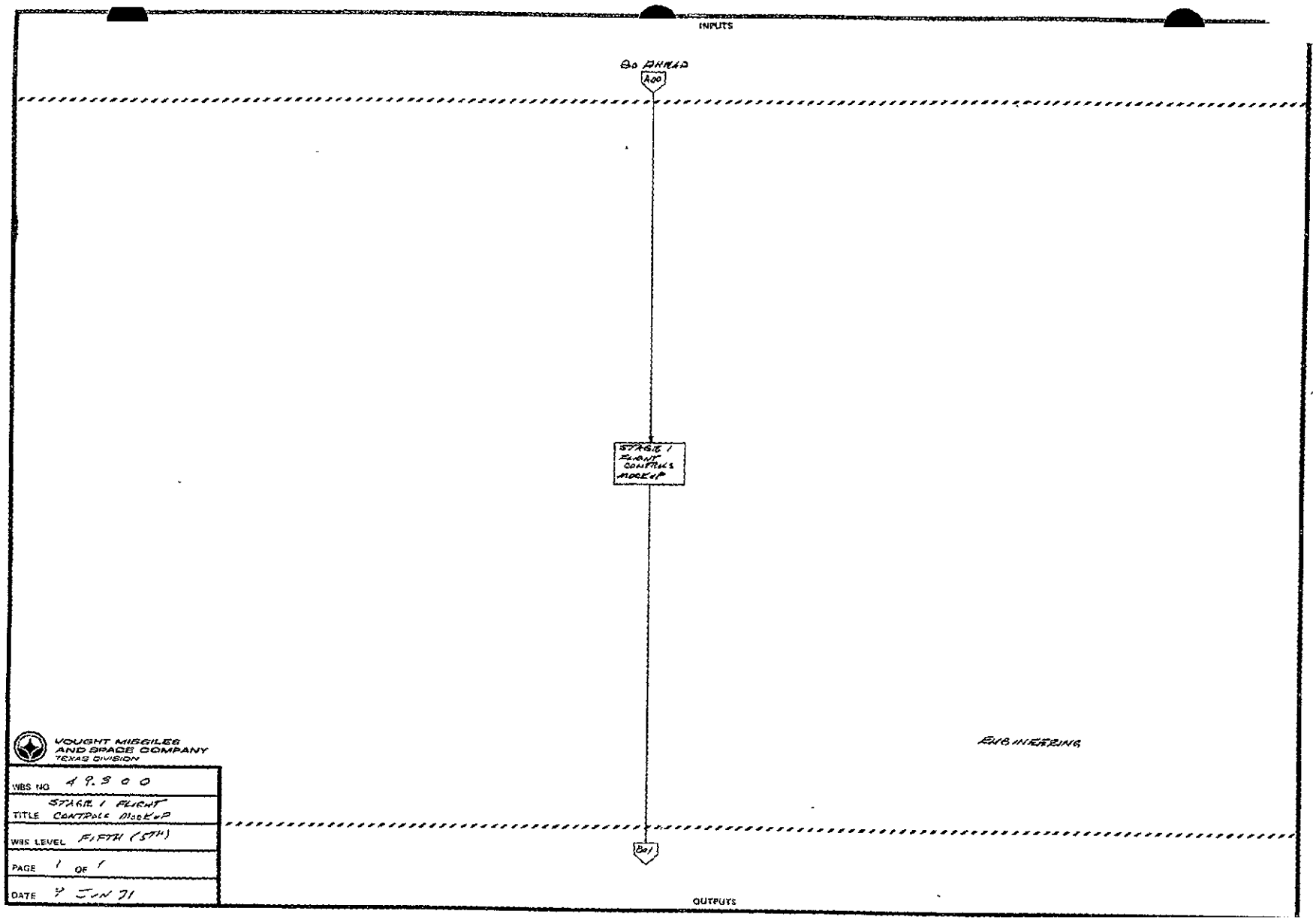
B01

ENGINEERING

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	49200
TITLE	STAGE 1 PROPULSION SYSTEM MOCKUPS
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	9 JUN 71


INPUTS
GO AHEAD
A00
STAGE 1 FLIGHT CONTROLS MOCK-UP
B01
OUTPUTS
VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION
WBS NO 49.300
TITLE STAGE 1 FLIGHT CONTROLS MOCKUP
WBS LEVEL FIFTH (5TH)
PAGE 1 OF 1
DATE 7 JAN 71

INPUTS

GO AHEAD

ADD

STAGE I SECONDARY POWER MOCKUP

ENGINEERING

B01

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	49400
TITLE	STAGE I SECONDARY POWER MOCKUP
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	9 JUN 71

INPUTS

GO AHEAD

100

ENVIRON CONTROL & LIFE SUPPORT SYSTEM MOCKUP

ENGINEERING

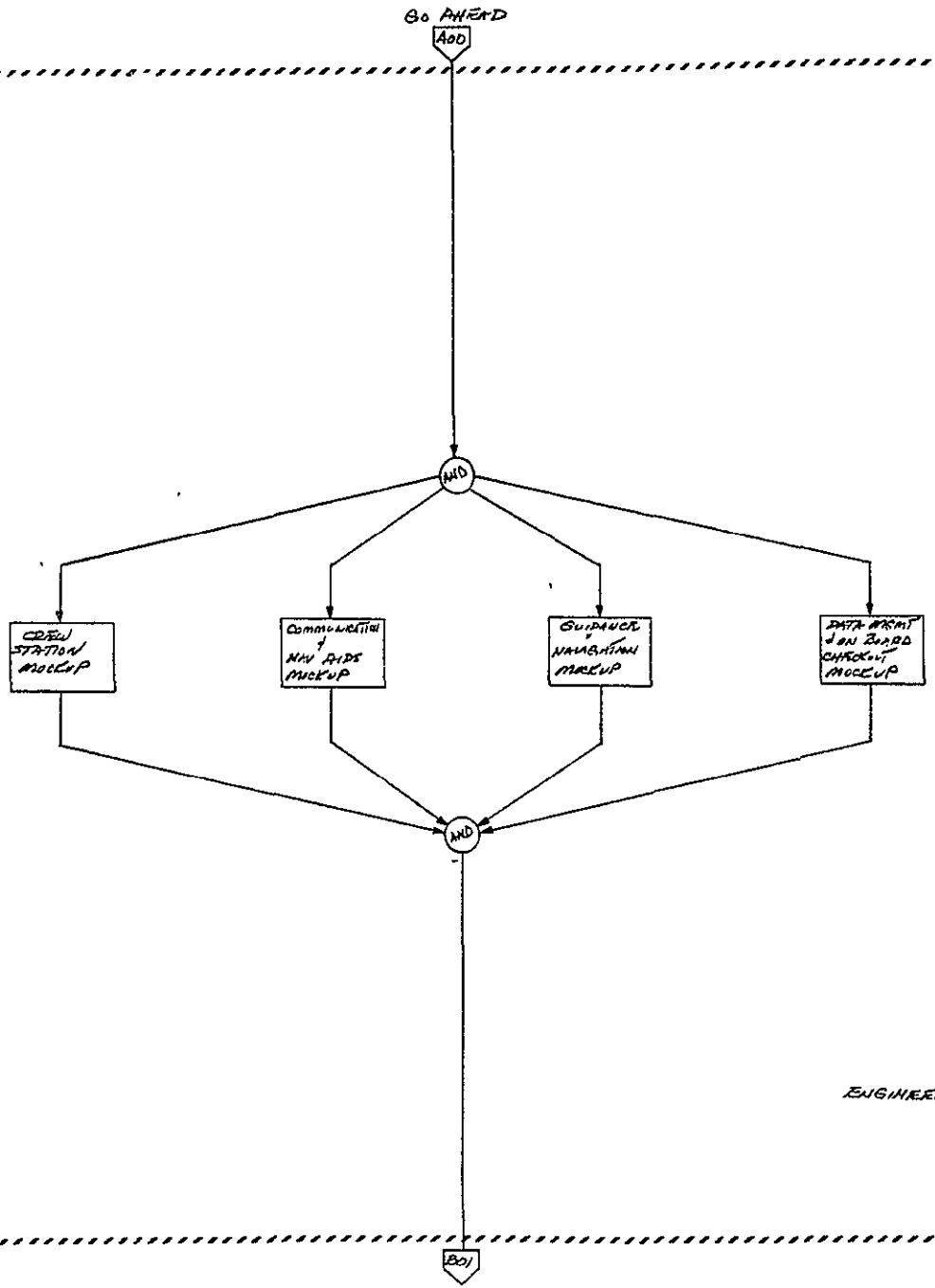
801

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4.9.5.0.0
TITLE	STAGE I ENVIRONMENTAL CONTROL & LIFE SUPPORT SYSTEM MOCKUPS
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	9 JUN 71

INPUTS



ENGINEERING

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	4.0 6 0.0
TITLE	STAGE I AVIONICS MOCKUPS
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	9 JUN 71

OUTPUTS

SYSTEM/PROGRAM MANAGEMENT (5.0)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 5.0

TASK TITLE SYSTEM/PROGRAM MANAGEMENT

LEVEL 3, Project Level

WBS DICTIONARY

I. REQUIREMENTS

NASA has specified a requirement for an Advanced Space Transport Program (Phase C/D) which will develop a manned, two-stage reusable Air Vehicle capable of transporting GFE payloads from earth to near-earth space for deployment into space stations, space bases or free space, retrieving certain payloads from space, then safely reentering and landing at predetermined or alternate landing sites for recycle to the next mission. Ground support equipment will simultaneously be developed to provide the operating and maintenance capability to enable both Air Vehicle and GSE to cycle into a 10-year Operations program to support payload user requirements.

To meet these requirements, program offices are required in major contractor areas with the responsibility to technically direct and

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT. SEE MASTER SCHEDULE.

administratively manage the contracts within three major end item areas (a fourth major contract is with the Main Engine contractor, these engines being GFE to the Stage contractors): Stage II (WBS ID 1.3), Stage I (WBS ID 1.4), and Integration (WBS ID 1.1).. Other major elements of the WBS have similar partitions of responsibility (see Figure 0.0-W-2). The Payload will be GFE to the Vehicle (WBS Dictionary Element 1.2) and will require an office to handle interfaces during RDT & E, Investment and Operations.

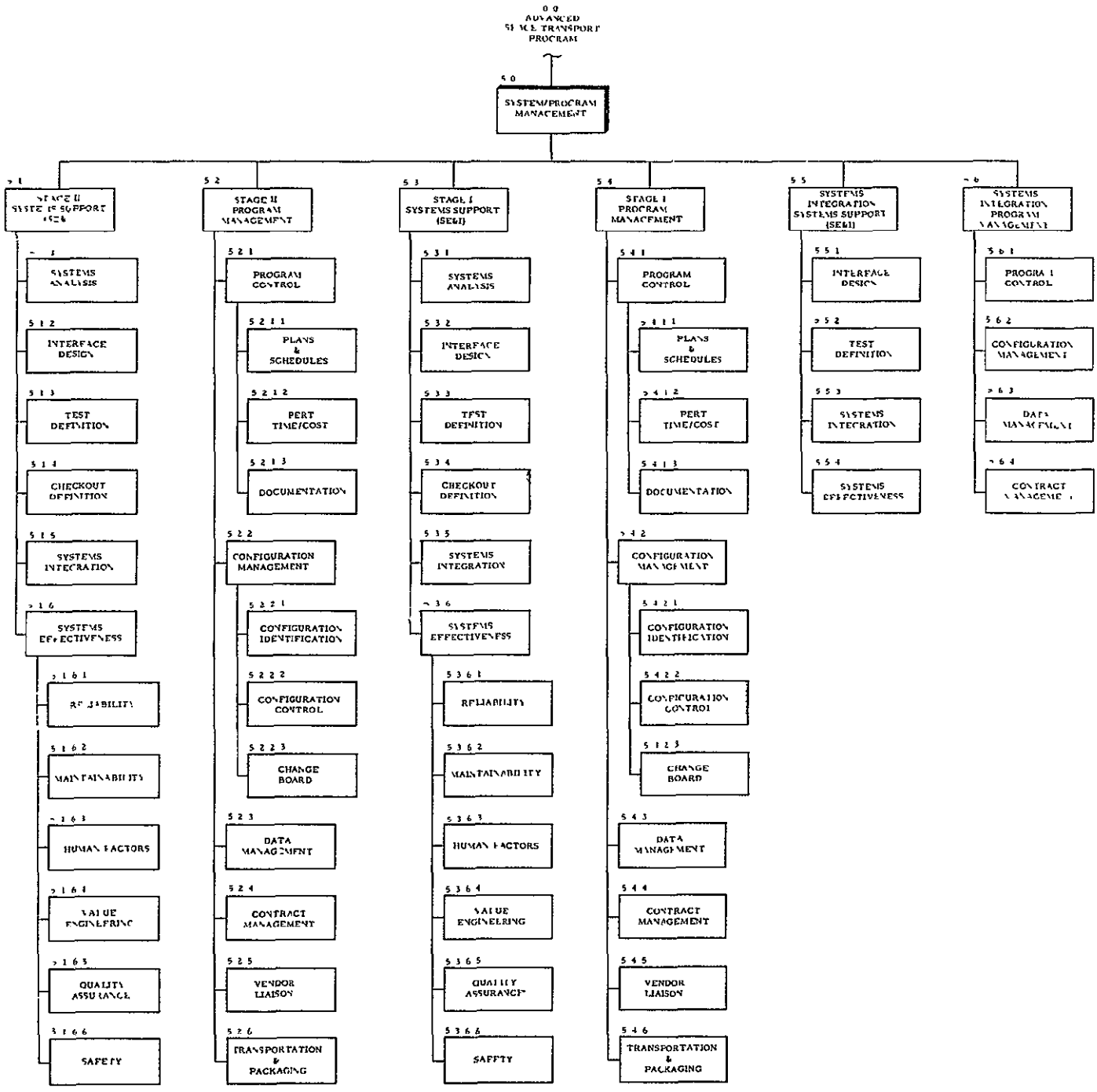
The System/Program Management, under NASA direction and approval, will manage the technical and business responsibilities of the separate major contracts so as to plan, implement and control the Program from contract go-ahead through RDT & E and Investment until IOC. In the Operations phase, depending on NASA requirement, System/Program Management functions will either cease, be diverted into new programs, or reduced to a sustaining level of effort to ensure contract needs are supplied when required (spares, services, etc.)

II. SYSTEM-LEVEL DEFINITION

Six major elements (3 sets) are required to handle the technical and business responsibilities of the RDT & E and Investment phases of the Advanced Space Transport Program on the contract side of the program. These sets are denoted below and represent the three major end items to be designed, developed tested and and qualified (DD 250): Stage II, which is the reusable payload-delivery/retrieval vehicle; Stage I, which is the reusable boost vehicle; and Integration, which assembles the stages and their payload and integrates the Stage-to-Stage ground support equipment and services needed for checkout, launch, flight and recovery through turnaround.

The system-level elements of System/Program Management include (see Figure 5.0-W-6):

5.1	Stage II Systems Support (SE & I)
5.2	Stage II Program Management
5.3	Stage I Systems Support (SE & I)
5.4	Stage I Program Management
5.5	Systems Integration Systems Support (SE & I)
5.6	Systems Integration Program Management



VOUGHT MISSILES AND SPACE COMPANY

FIGURE 5.0-W-6 WBS, SYSTEM /PROGRAM MANAGEMENT (WBS ID 5.0)

As directed by NASA, the Payload Integration Office and GFE Main Engine Integration Office will be assigned into one of the above functions to handle the technical and business interfaces with Payload and with Main Engine contractors.

III. FUNCTIONAL DESCRIPTION

Prior to Phase C go-ahead, the three major end item contractors (Main Engine contractor excluded) will have developed their overall Program Plans on administering the technical and business end of their proposed contracts. Thus, at Phase C go-ahead, these plans will become contractual articles dealing with Systems Engineering and Integration (SE & I) and with Program Management. Breakouts of the Program Plans will include System Development Plans, Manufacturing Plans, Facility Plans, Systems Test and Operations Plans, Training Plans, Reliability Plans, Maintainability Plans, Safety Plans, Quality Assurance Plans and Management Plans. The latter will cover items such as Drawing Control, Configuration Management, Plans and Schedules Control, Subcontract Control, Document Control, Deliverable Data Control, Change Control, etc. Together, these packages will delineate how Management will be excercised, by whom, and when, and will establish the basis for holding PDRs, CDRs, factory qualification, engine PFRTs, structural test and flight test vehicle fabrication, delivery and test, production vehicle fabrication, delivery and test, and spares provisioning. Need for Program support such as government test facilities for development, wind tunnel testing, engine firings, horizontal and vertical flight test, etc. will be defined and refined as the Program progresses. Other support needed will be defined including need for special training facilities, flight test support, FAA and Range Safety reviews, astronaut integration, chase plane support, meteorological support, launch support, global range support, landing site modification and support, data processing support, communications support, consumables provisioning, and myriad of other items which will be either CFE or GFE as agreed upon between NASA and the major contractors.

Details on these elements of System/Program Management are further specified by functional responsibility at lower levels of the WBS Dictionary.

IV. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 5.1

TASK TITLE STAGE II SYSTEMS SUPPORT (SE & I)

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

An organization is required in the Stage II contractor's Advanced Space Transport Program office to manage the Systems Engineering and Integration (SE & I) technical effort associated with RDT & E on the Stage II vehicle, support hardware and software, and interfaces with all other affected elements of the Program. This organization will be directed by the Stage II contractor's Program Management office to analyze and establish requirements for: Stage II missions and trajectories; interfaces with Stage I, with Payload, with space targets, and with all supporting ground elements; and establish the functional requirements and tradeoff analysis needed to define end items and needed support. Where interface design is required, this design shall be either performed within SE & I or delegated, with Program Office approval, to the responsible design group to handle, with SE & I providing monitorship over such design.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT. SEE MASTER SCHEDULE.

SE & I will be responsible, under Systems Integration Systems Support (SE & I), WBS ID 5.5, to develop a Master Test and Operations Plan for Stage II which specifies test objectives, test requirements, test schedules, test support, test organizations and skills, test facilities and test management for conducting needed subsystem development tests, structural tests, single element flight test and mated flight test (Stage II) in accord with the Master Phasing Plan.

SE & I will be responsible, under Systems Integration Systems Support (SE & I), WBS ID 5.5, to develop Checkout Definitions for Stage II vehicle and ground support elements to ensure both vehicle and ground systems are ready for both flight test and Operations such as pre-Vehicle mating in the VAB prior to roll-out for Air Vehicle countdown and launch.

SE & I will be responsible to Stage II Program Mangement, as well as to Systems Integration Program Management (WBS ID 5.6) and to NASA, for establishing and holding PDRs on the Stage II vehicle end items, on Stage II interfacing operating ground equipment (OGE), on Stage II Peculiar Support Equipment (MGE/DMGE), on Stage II mockups, and on any other deliverables needed for Test, Investment and Operations. The same responsibility will extend to participation in major interfacing PDRs including GFE Main Engines and to Stage I. Where CDRs are required, SE & I will participate as support to Design Engineering to ensure Part II Specifications comply with Part I Specifications (prepared by SE & I) or that waivers are acceptable to both the requirements analysis as well as to NASA.

SE & I Systems Integration will be responsible for documenting and distributing the system requirements analysis (functional analysis, requirements analysis, time-line analysis, trade studies, Contract End Item Specifications, maintenanc analysis, calibration requirements analysis, maintenance loadings analysis, reliability analysis, safety analysis, human factors analysis, facilities analysis, etc.) and keeping this analysis up-to-date to reflect Class I and Class II change, once configuration control is established.

SE & I Systems Effectiveness groups will be responsible for effectiveness analysis affecting Stage II vehicle and support and the integration thereof through Systems Integration Systems Effectiveness (WBS ID 5.5.4) with all other Program elements (Stage I, total OGE, Payload). The effectiveness

analysis shall address: Reliability, Maintainability, Human Factors, Value Engineering, Quality Assurance, and Safety. Outputs from this analysis will be reviewed with the Stage II, Stage I, Systems Integration and NASA technical management and affected design areas to ensure understanding of the approach, methods for obtaining compliance, and requirements which will affect design, development, test and Operations. Upon approval in-house, out-of-house and by NASA, the outputs of these various analyses will become Program Plans to be adhered to by affected disciplines: Reliability Plan, Maintainability Plan, Safety Plan, etc. These plans, when released, shall be kept up-to-date through the life of the RDT & E phase and Investment Phase and will be deliverable items under WBS ID 6.0 as specified in the Stage II contract.

II. SUBSYSTEM-LEVEL DEFINITION

Six major elements comprise Stage II Systems Support (SE & I). As noted on Figure 5.0-W-6, these elements include the following:

5.1.1 Systems Analysis
5.1.2 Interface Design
5.1.3 Test Definition
5.1.4 Checkout Definition
5.1.5 Systems Integration
5.1.6 Systems Effectiveness

III. FUNCTIONAL DESCRIPTION

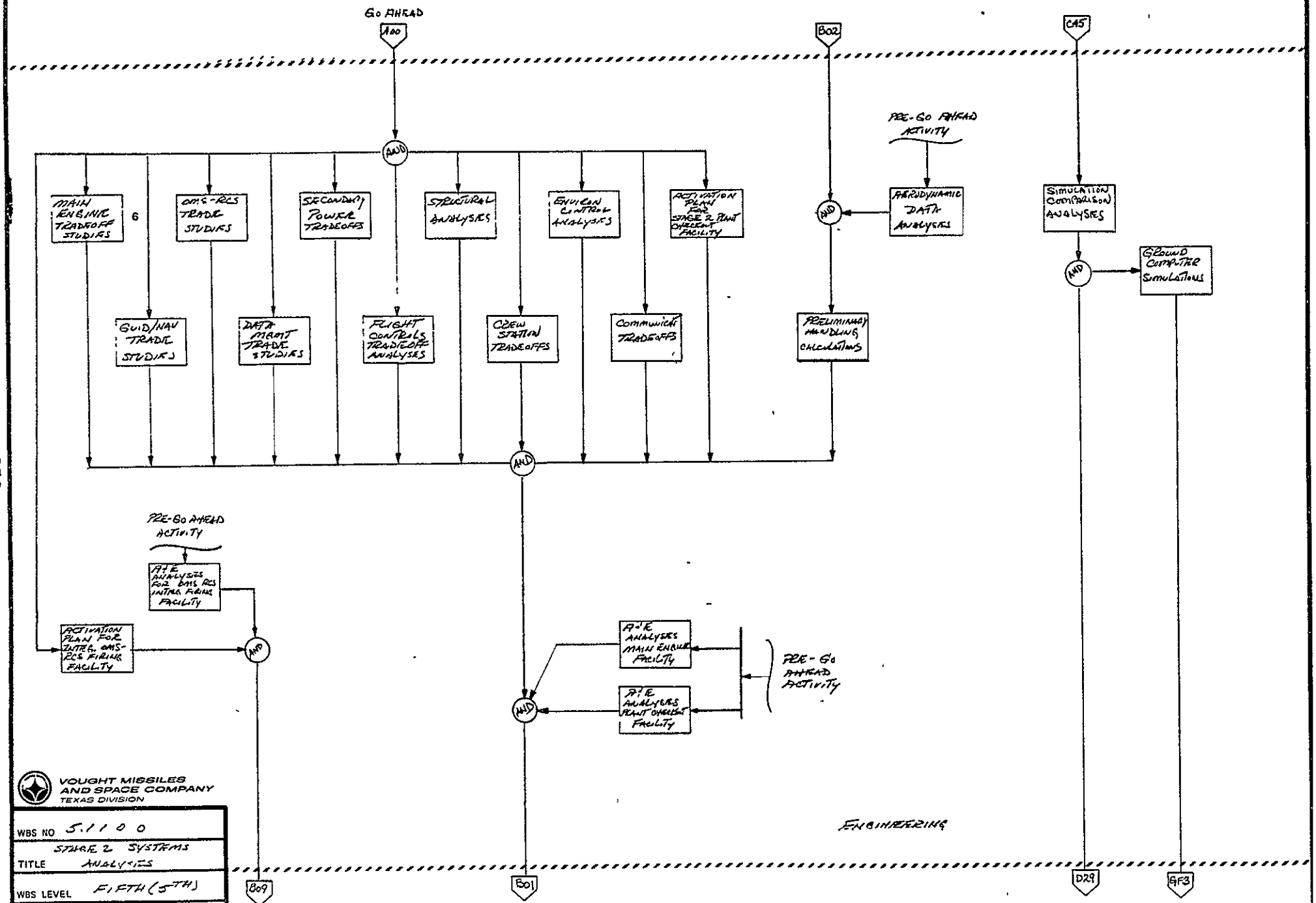
The Stage II Systems Support (Systems Engineering and Integration, SE & I) organization is basically responsible to NASA, through the Stage II Program Management office, for the technical analysis, engineering, integration and documentation, as the basis for design and development of the Stage II vehicle and support end items into the Advanced Space Transport Program. The six interrelated functions which this organization will be responsible for are noted above in Para. II. Specific delegations for this organization in Phase C/D will be at the discretion of the Stage II Program Manager (contractor). Through these six functions, SE & I Management must ensure that each end item delivered at the completion of RDT & E and Investment will meet the Program objectives called for in WBS Dictionary Element 0.0, Para. IV, as these affect Stage II.

As the requirements and integration effort which SE & I provide are turned into qualified hardware and software by the design, manufacturing, materiel and test organizations, then SE & I's role in the RDT & E process is reduced to that of sustaining engineering to monitor change and to deliver to NASA the results of the analysis and integration as the System Specification for entering the Operations phase.

IV. REFERENCES

(To be added.)

INPUTS



OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	5.1.1.0.0
TITLE	STAGE 2 SYSTEMS ANALYSIS
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	12 JUN 71

INPUTS

Go AHEAD
A00

C41

B02

PAYLOAD DEFINITION FINALIZED

BASELINE INTERFACE CONTROL DOCUMENT

STAGE 2 STRUCTURE / THG/FLT CONTROLS SIMULATOR FOR STAGE 2

BASELINE INTERFACE CONTROL DOCUMENT

- CREW STATION / ECLS
- CREW STATION / GUID/NAVIG
- CREW STATION / DATA MGMT
- GUID/NAV / DATA MGMT
- SECONDARY PWR/E / DATA MGMT
- DATA MGMT / MAIN ENGINE
- DATA MGMT / OMS ENGINE
- DATA MGMT / RCS ENGINE
- DATA MGMT / ABES ENGINE
- FLT CONTROLS / ABES ENGINE
- FLT CONTROLS / MAIN ENGINE
- FLT CONTROLS / OMS ENGINE
- FLT CONTROLS / RCS ENGINE
- FLT CONTROLS / DATA MGMT
- FLT CONTROLS / SIMULATOR
- STRUCTURE / CREW STATION
- STRUCTURE / ABES ENGINE
- STRUCTURE / COMMUNICATIONS
- STRUCTURE / OMS ENGINE
- STRUCTURE / RCS ENGINE
- STRUCTURE / MAIN ENGINE

MANAGEMENT

B04

B13

B01

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	51200
TITLE	STAGE 2 INTERFACE DESIGN
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	12 JUN 71

INPUTS

B02

AND

STAGE 2 MISSION ENVELOPE FINALIZED

STAGE 2 TEST PLAN

CMIS-RCS INTEGRATED FIRING TEST PLAN

AND

INTEGRATED STAGE 2 SYSTEM TEST CHECKOUT SPECIFICATION

H00

B01

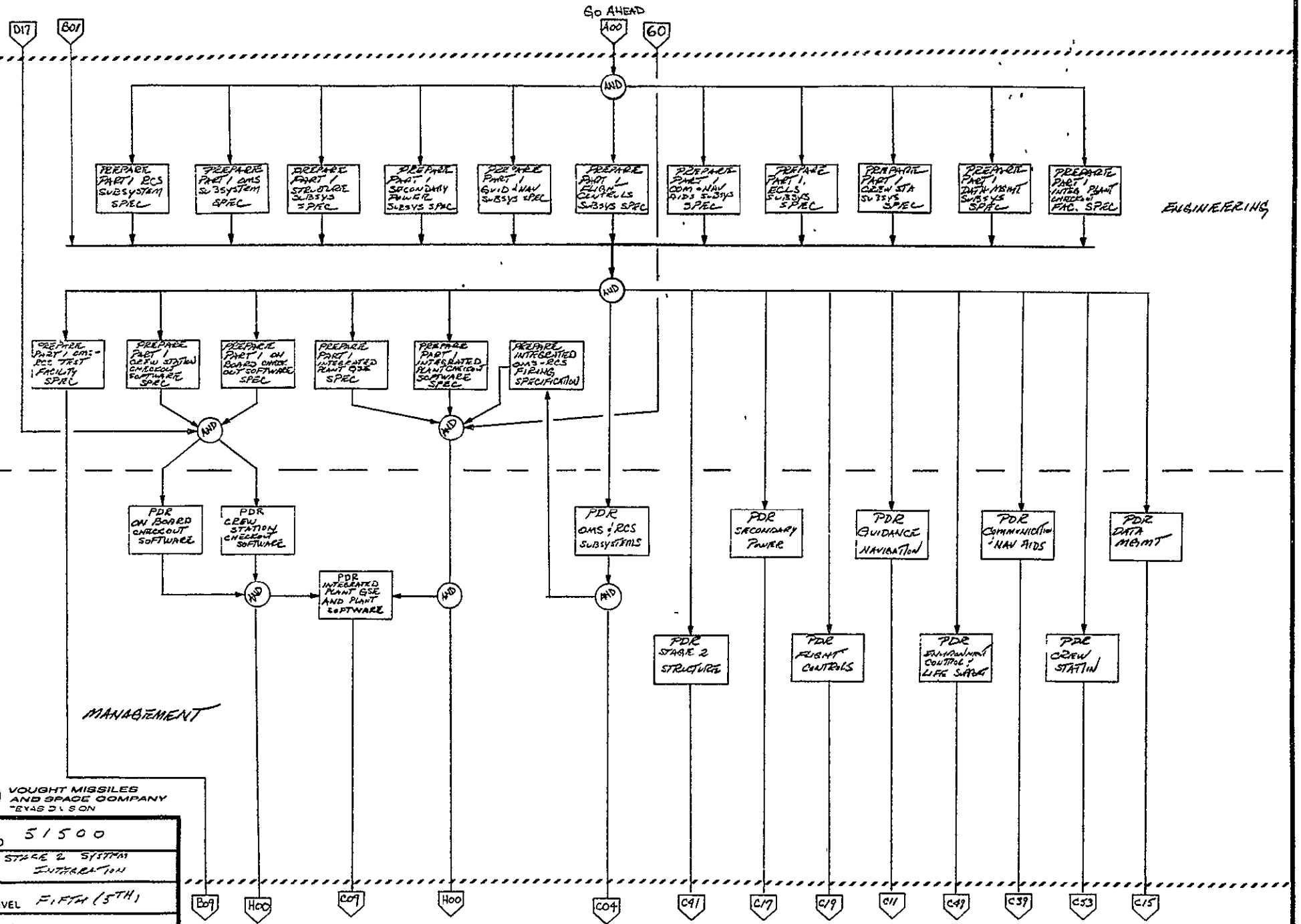
OUTPUTS

ENGINEERING

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	5.1300
TITLE	STAGE 2 TEST DEFINITION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	11 JUN 71

INPUTS



OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	51500
TITLE	STAGE 2 SYSTEM INTEGRATION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	2 JUN 71

INPUTS

C56 C53 C01 C41 C03 C04 C11

START 2 CREW TASK ANALYSES

MAIN PROPULSIVE MAINTAINABILITY ANALYSES

STRUCTURAL AIRFRAME MAINTAINABILITY ANALYSES

ABES MAINTAINABILITY ANALYSES

OMS MAINTAINABILITY ANALYSES

RCS MAINTAINABILITY ANALYSES

GUIDANCE, NAVIGATION MAINTAINABILITY ANALYSES

AND

FLIGHT TEST BIOMEDICAL ENG REQ

CREW STATION INTEGRATION

CREW STATION MAINTAINABILITY ANALYSIS

FLIGHT TEST CREW INSTRUMENTATION REQMNTS

SEQUENTIAL OPS TASK ANALYSES

COMMON SUPPORT EQUIPMENT DEFINITION

ENGINEERING

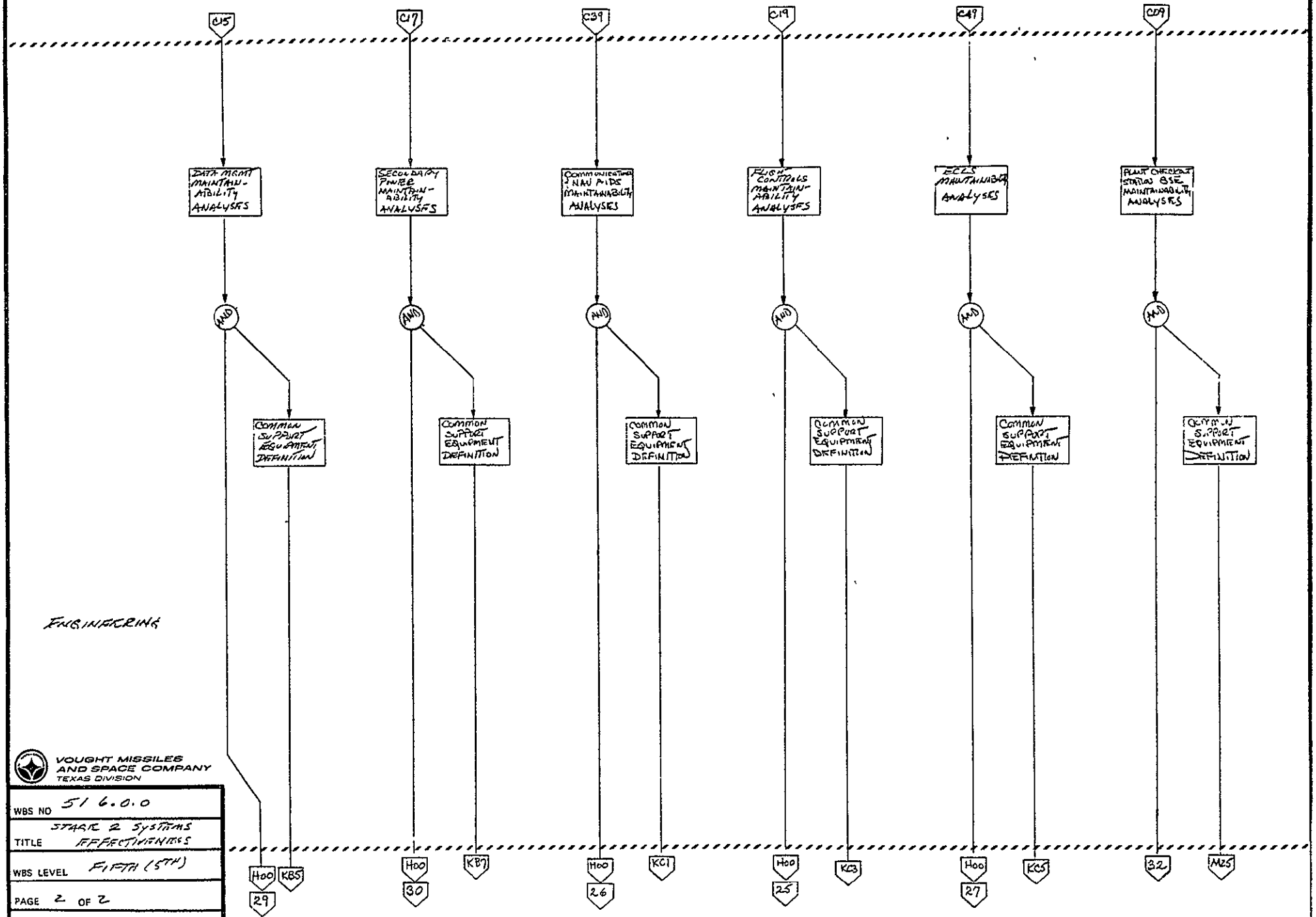
VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	51600
TITLE	STAGE 2 SYSTEMS EFFECTIVENESS
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 2
DATE	JUN 71

D17 CA5 H60 31 KC7 H00 20 KC9 H00 24 QP9 H00 23 K95 H00 21 K97 H001 22 K98 H60 25 K83

OUTPUTS

INPUTS



ENGINEERING

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	51 6.0.0
TITLE	STARK 2 SYSTEMS EFFECTIVENESS
WBS LEVEL	FIFTH (5TH)
PAGE	2 OF 2
DATE	11 JUN 71

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 5.2

TASK TITLE STAGE II PROGRAM MANAGEMENT

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

An organization is required in the Stage II contractor's Advanced Space Transport Program office to administer the Stage II contract and to manage the technical effort through the Systems Support (SE & I) Organization (WBS ID 5.1). Major efforts which the Stage II Contractor Program Office will manage include: Program Control, Configuration Management, Data Management, Contract Management, Vendor Liaison and end item Transportation and Handling.

II. SUBSYSTEM-LEVEL DEFINITION

As noted on Figure 5.0-W-6, six major elements are identified at the subsystem level. These elements correspond to the six requirements specified on the next page.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT. SEE MASTER SCHEDULE.

5.2.1	Program Control
5.2.2	Configuration Management
5.2.3	Data Management
5.2.4	Contract Management
5.2.5	Vendor Liaison
5.2.6	Transportation and Packaging

III. FUNCTIONAL DESCRIPTION

The Stage II Contractor Program Management office will be responsible for the technical and administrative functions associated with Phase C/D contract effort. Technical management will be delegated to Stage II Systems Support (SE & I), WBS ID 5.1. Administrative management will be delegated to six major areas, as noted in Para. II, above. These areas will have the following responsibilities (actual organization is at the discretion of the Stage II Contractor Program Manager).

A. Program Control - Responsible for Plans and Schedules, Cost, and Contract Documentation of an administrative nature. Technical documentation (systems engineering, drawings, specifications, procedures, test reports, Program Plans, tech orders, etc.) are the responsibility of Program Management but may be delegated to technical areas through RDT & E. Deliverable data (WBS ID 6.0) will be handled through the Program Office as approved by Program Control.

B. Configuration Management - Responsible for Configuration Identification, Configuration Control, and Stage II Change Board Management as well as representation on the Integration Change Board (WBS ID 5.6.2).

C. Data Management - Responsible for all contract-generated data which will ultimately become contract-deliverable data (WBS ID 6.0). This effort will include engineering and manufacturing drawing control and storage, test report control and storage, systems engineering documentation control and storage, and administrative data control and storage. Data retrieval capability shall be such that latest approved changes are incorporated into the data for quick response to user's request, both in-house, in the field, for other contractors needs and for customer needs. As required, current lists of released data shall be made available to affected users, including latest approved changes.

D. Contract Management - Responsible for contract compliance both to customer as well as for contract and sub-contract efforts. Submit requests for payment for work accomplished (major milestones). Distribute payments to in-house finance groups for covering contract effort, expenses, vouchers, etc. Contract management is essentially the single representative for the contractor to the customer, and the reverse thereof for interpretation of the contract language.

E. Vendor Liaison - Responsible for Stage II Prime Contractor interface with vendors and subcontractors. As such, Vendor Liaison acts for the Prime Contractor to ensure that vendors and subcontractors are appraised of, and kept up to date on, current requirements imposed by the Prime on the vendor or subcontractor and, in turn, that the Prime is kept appraised of the progress and problems of the vendor or subcontractor.

F. Transportation and Packaging - Responsible for the packaging and transportation of deliverable articles (test and production) to the field, or the receipt thereof from the field to the factory. Will include any deliverable item which must be transmitted to the Stage I contractor such as a simulator, mockup article, etc. Does not normally include data handling.

IV. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 5.3

TASK TITLE STAGE I SYSTEMS SUPPORT (SE & I)

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

An organization is required in the Stage I contractor's Advanced Space Transport Program office to manage the Systems Engineering and Integration (SE & I) technical effort associated with RDT & E on the Stage I vehicle, support hardware and software, and interfaces with all other affected elements of the Program. This organization will be directed by the Stage I contractor's Program Management office to analyze and establish requirements for: Stage I missions and trajectories; interfaces with Stage II, with Payload, and with all supporting ground elements; and establish the functional requirements and tradeoff analysis needed to define end items and needed support. Where interface design is required, this design shall be either performed within SE & I or delegated, with Program Office approval, to the responsible design group to handle, with SE & I providing monitorship over such design.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT. SEE MASTER SCHEDULE.

SE & I will be responsible, under Systems Integration Systems Support (SE & I), WBS ID 5.5, to develop a Master Test and Operations Plan for Stage I which specifies test objectives, test requirements, test schedules, test support, test organizations and skills, test facilities and test management for conducting needed subsystem development tests, structural tests, single element flight test and mated flight test (Stage I) in accord with the Master Phasing Plan.

SE & I will be responsible, under Systems Integration Systems Support (SE & I), WBS ID 5.5, to develop Checkout Definitions for Stage I vehicle and ground support elements to ensure both vehicle and ground systems are ready for both flight test and Operations such as pre-Vehicle mating in the VAB prior to roll-out for Air Vehicle countdown and launch.

SE & I will be responsible to Stage I Program Management, as well as to Systems Integration Program Management (WBS ID 5.6) and to NASA, for establishing and holding PDRs on the Stage I vehicle end items, on Stage I interfacing operating ground equipment (OGE), on Stage I Peculiar Support Equipment (MGE/DMGE), on Stage I mockups, and on any other deliverables needed for Test, Investment and Operations. The same responsibility will extend to participation in major interfacing PDRs including GFE Main Engines and to Stage II. Where CDRs are required, SE & I will participate as support to Design Engineering to ensure Part II Specifications comply with Part I Specifications (prepared by SE & I) or that waivers are acceptable to both the requirements analysis as well as to NASA.

SE & I Systems Integration will be responsible for documenting and distributing the system requirements analysis (functional analysis, requirements analysis, time-line analysis, trade studies, Contract End Item Specifications, maintenance analysis, calibration requirements analysis, maintenance loadings analysis, reliability analysis, safety analysis, human factors analysis, facilities analysis, etc.) and keeping this analysis up-to-date to reflect Class I and Class II change, once configuration control is established.

SE & I Systems Effectiveness groups will be responsible for effectiveness analysis affecting Stage I vehicle and support and the integration thereof through Systems Integration Systems Effectiveness (WBS ID 5.5.4) with all other Program elements (Stage II, total OGE, Payload). The effectiveness

analysis shall address: Reliability, Maintainability, Human Factors, Value Engineering, Quality Assurance, and Safety. Outputs from this analysis will be reviewed with the Stage I, Stage II, Systems Integration and NASA technical management and affected design areas to ensure understanding of the approach, methods for obtaining compliance, and requirements which will affect design, development, test and Operations. Upon approval in-house, out-of-house and by NASA, the outputs of these various analyses will become Program Plans to be adhered to by affected disciplines: Reliability Plan, Maintainability Plan, Safety Plan, etc. These plans, when released, shall be kept up-to-date through the life of the RDT & E phase and Investment Phase and will be deliverable items under WBS ID 6.0 as specified in the Stage I contract.

II. SUBSYSTEM-LEVEL DEFINITION

Six major elements comprise Stage I Systems Support (SE & I). As noted on Figure 5.0-W-6, these elements include the following:

5.3.1	Systems Analysis
5.3.2	Interface Design
5.3.3	Test Definition
5.3.4	Checkout Definition
5.3.5	Systems Integration
5.3.6	Systems Effectiveness

III. FUNCTIONAL DESCRIPTION

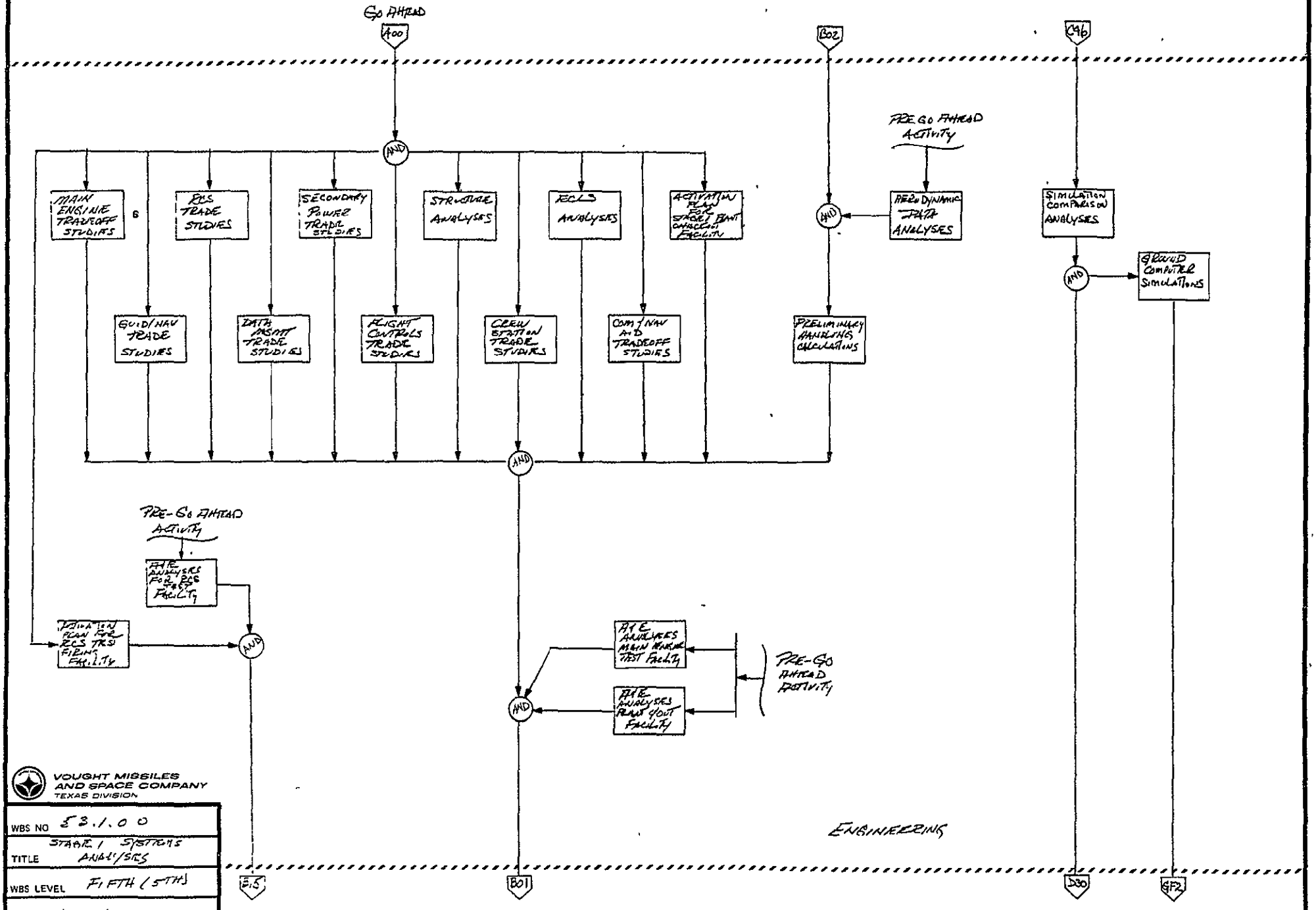
The Stage I Systems Support (Systems Engineering and Integration, SE & I) organization is basically responsible to NASA, through the Stage I Program Management office, for the technical analysis, engineering, integration and documentation, as the basis for design and development of the Stage I vehicle and support end items into the Advanced Space Transport Program. The six interrelated functions which this organization will be responsible for are noted above in Para. II. Specific delegations for this organization in Phase C/D will be at the discretion of the Stage I Program Manager (contractor). Through these six functions, SE & I Management must ensure that each end item delivered at the completion of RDT & E and Investment will meet the Program objectives called for in WBS Dictionary Element 0.0, Para. IV, as these affect Stage I.

As the requirements and integration effort which SE & I provide are turned into qualified hardware and software by the design, manufacturing, materiel and test organizations, then SE & I's role in the RDT & E process is reduced to that of sustaining engineering to monitor change and to deliver to NASA the results of the analysis and integration as the System Specification for entering the Operations phase.

IV. REFERENCES

(To be added.)

INPUTS



ENGINEERING

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	53.1.00
TITLE	STAGE I SYSTEMS ANALYSIS
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	14 JUN 71

INPUTS

C42

B02

BASELINE INTERFACE CONTROL DOCUMENT

STAGE 1
- STRUCTURE ↔ TNG / FLT CONTROLS SIMULATOR FOR STAGE 1

BASELINE INTERFACE CONTROL DOCUMENT

- CREW STATION ↔ ECLS
- CREW STATION ↔ GUID/NAV
- CREW STATION ↔ DATA MGMT
- GUID/NAV ↔ DATA MGMT
- SECONDARY POWER ↔ DATA MGMT
- DATA MGMT ↔ MAIN ENGINE
- DATA MGMT ↔ RCS ENGINE
- DATA MGMT ↔ ABES ENGINE
- FLT CONTROLS ↔ ABES ENGINE
- FLT CONTROLS ↔ MAIN ENGINE
- FLT CONTROLS ↔ RCS ENGINE
- FLT CONTROLS ↔ DATA MGMT
- FLT CONTROLS ↔ SIMULATOR
- STRUCTURE ↔ CREW STATION
- STRUCTURE ↔ ABES ENGINE
- STRUCTURE ↔ COMMUNICATIONS
- STRUCTURE ↔ ECS ENGINE
- STRUCTURE ↔ MAIN ENGINE

MANAGEMENT

B13

B01

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

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TITLE	STAGE 1 INTERFACE DESIGN
WBS LEVEL	FIFTH
PAGE	1 OF 1
DATE	14 JUN 71

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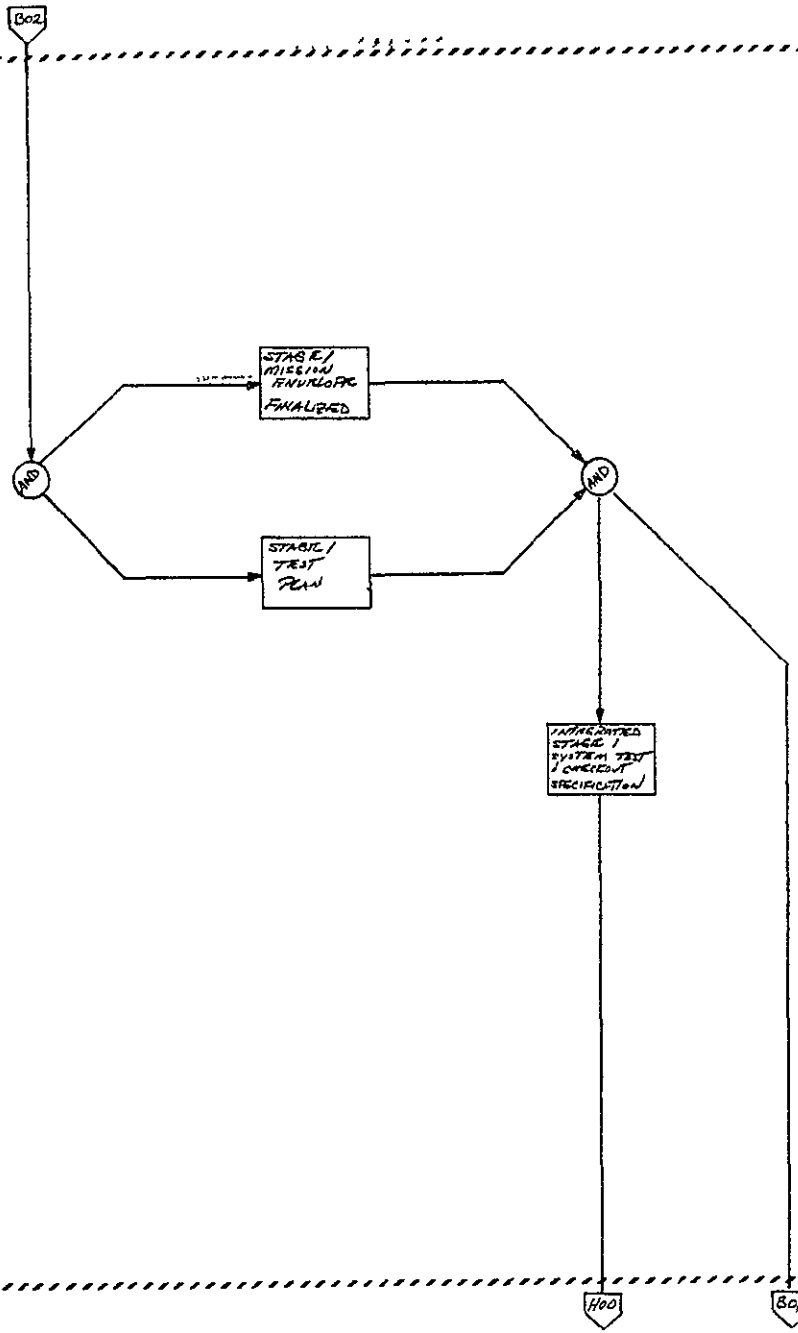
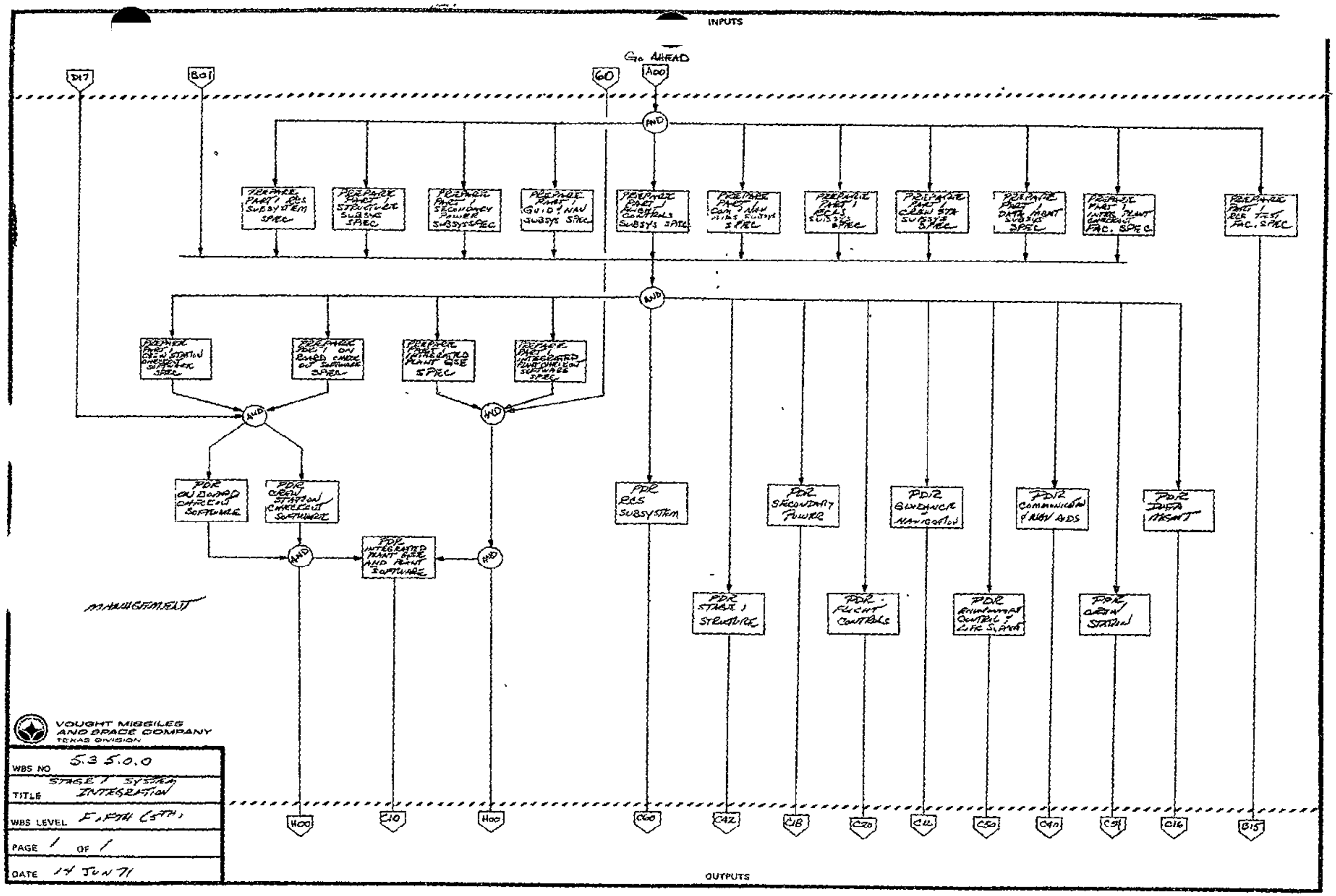


ENGINEERING

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	53300
TITLE	STAGE I TEST DEFINITION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	14 JUN 71

OUTPUTS


INPUTS
Go AHEAD
D17
B01
G0
A00
AND
PDR RCS SUBSYSTEM
PDR SECONDARY POWER
PDR GUIDANCE NAVIGATION
PDR STAGE I STRUCTURE
PDR FLIGHT CONTROLS
PDR CREW STATION
MANAGEMENT
H00
E10
H00
C60
C18
C20
C50
C40
C16
B15
OUTPUTS
VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION
WBS NO 5.3.5.0.0
TITLE STAGE I SYSTEM INTEGRATION
WBS LEVEL FIFTH (5TH)
PAGE 1 OF 1
DATE 14 JUN 71

INPUTS

C56 C54 C02 C42 C60 C12 C16 C18

STAGE 1 CREW TASK ANALYSES

MAIN ENGINE MAINTAINABILITY ANALYSES

STRUCTURE AIRFRAME MAINTAINABILITY ANALYSES

ECS MAINTAINABILITY ANALYSES

GUID/NAV MAINTAINABILITY ANALYSES

DATA MGMT MAINTAINABILITY ANALYSES

SECONDARY POWER MAINTAINABILITY ANALYSES

AND

FLIGHT TEST BIO-MEDICAL ENGR

CREW STATION INTEGRATION

CREW STATION MAINTAINABILITY ANALYSES

FLIGHT TEST CREW INSTRUMENTATION REQMNTS

SEQUENTIAL OPS TASK ANALYSES

COMMON SUPPORT EQUIP DEFINITION

EXCHEETRING

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	53600
TITLE	STAGE 1 SYSTEMS EFFECTIVENESS
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 2
DATE	4 JUN 71

D17 C46 H00 42 KC8 H00 33 K96 H00 35 GP8 H00 34 L65 H00 37 K84 H00 39 K86 H00 41 K88

OUTPUTS

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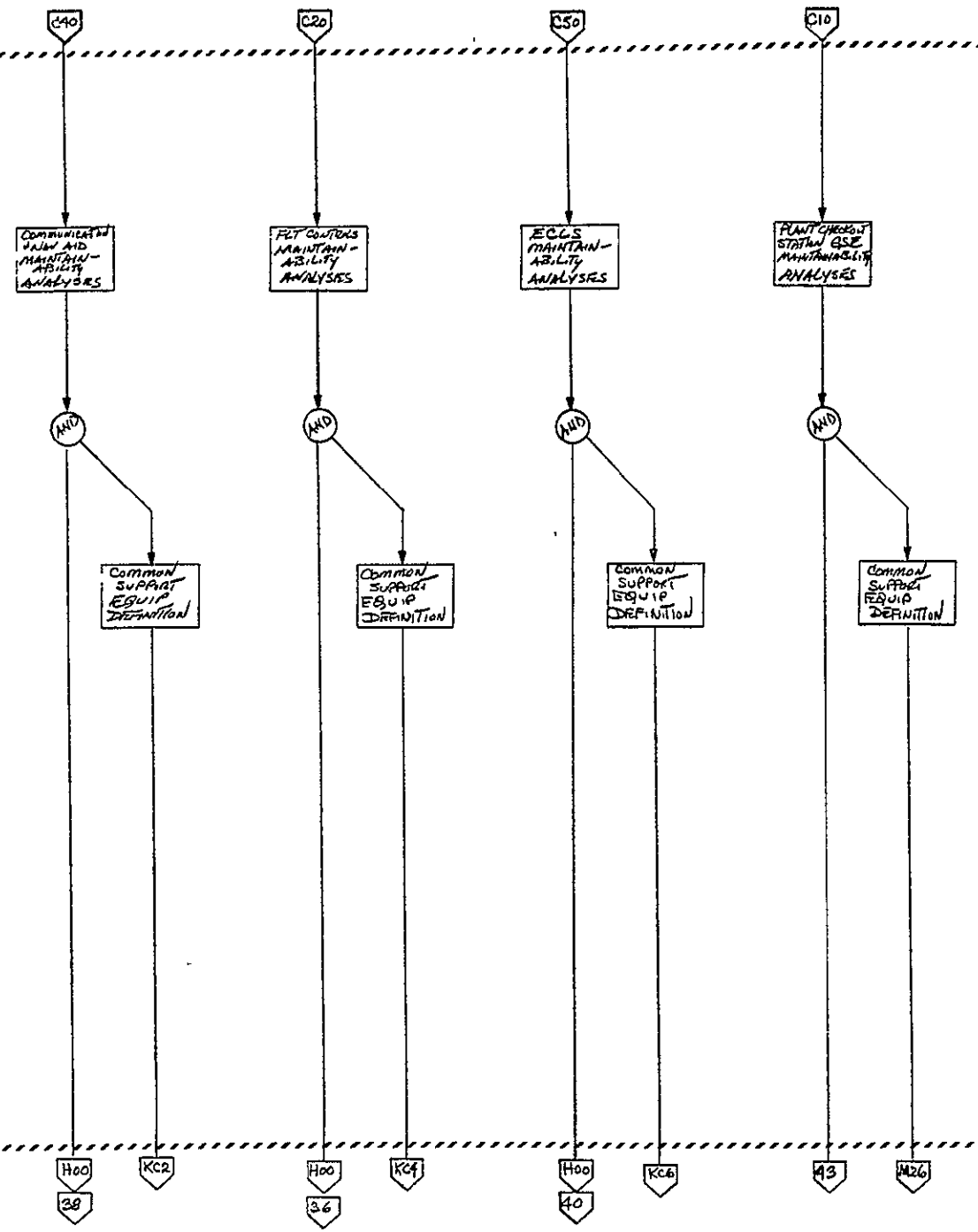

ENGINEERING

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	5.3 6 0.0
TITLE	STAGE 1 SYSTEMS EFFECTIVENESS
WBS LEVEL	FIFTH (5TH)
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VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 5.4

TASK TITLE STAGE I PROGRAM MANAGEMENT

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

An organization is required in the Stage I contractor's Advanced Space Transport Program office to administer the Stage I contract and to manage the technical effort through the Systems Support (SE & I) Organization (WBS ID 5.3). Major efforts which the Stage I Contractor Program Office will manage include: Program Control, Configuration Management, Data Management, Contract Management, Vendor Liaison and end item Transportation and Handling.

II. SUBSYSTEM-LEVEL DEFINITION

As noted on Figure 5.0-W-6, six major elements are identified at the subsystem level. These elements correspond to the six requirements specified on the next page.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT. SEE MASTER SCHEDULE.

5.4.1	Program Control
5.4.2	Configuration Management
5.4.3	Data Management
5.4.4	Contract Management
5.4.5	Vendor Liaison
5.4.6	Transportation and Packaging

III. FUNCTIONAL DESCRIPTION

The Stage I Contractor Program Management office will be responsible for the technical and administrative functions associated with Phase C/D contract effort. Technical management will be delegated to Stage I Systems Support (SE & I), WBS ID 5.3. Administrative management will be delegated to six major areas, as noted in Para. II, above. These areas will have the following responsibilities (actual organization is at the discretion of the Stage I Contractor Program Manager).

A. Program Control - Responsible for Plans and Schedules, Cost, and Contract Documentation of an administrative nature. Technical documentation (systems engineering, drawings, specifications, procedures, test reports, Program Plans, tech orders, etc.) are the responsibility of Program Management but may be delegated to technical areas through RDT & E. Deliverable data (WBS ID 6.0) will be handled through the Program Office as approved by Program Control.

B. Configuration Management - Responsible for Configuration Identification, Configuration Control, and Stage I Change Board Management as well as representation on the Integration Change Board (WBS ID 5.6.2).

C. Data Management - Responsible for all contract-generated data which will ultimately become contract-deliverable data (WBS ID 6.0). This effort will include engineering and manufacturing drawing control and storage, test report control and storage, systems engineering documentation control and storage, and administrative data control and storage. Data retrieval capability shall be such that latest approved changes are incorporated into the data for quick response to user's request, both in-house, in the field, for other contractors needs and for customer needs. As required, current lists of released data shall be made available to affected users, including latest approved changes.

D. Contract Management - Responsible for contract compliance both to customer as well as for contract and sub-contract efforts. Submit requests for payment for work accomplished (major milestones). Distribute payments to in-house finance groups for covering contract effort, expenses, vouchers, etc. Contract management is essentially the single representative for the contractor to the customer, and the reverse thereof for interpretation of the contract language.

E. Vendor Liaison - Responsible for Stage I Prime Contractor interface with vendors and subcontractors. As such, Vendor Liaison acts for the Prime Contractor to ensure that vendors and subcontractors are appraised of, and kept up to date on, current requirements imposed by the Prime on the vendor or subcontractor and, in turn, that the Prime is kept appraised of the progress and problems of the vendor or subcontractor.

F. Transportation and Packaging - Responsible for the packaging and transportation of deliverable articles (test and production) to the field, or the receipt thereof from the field to the factory. Will include any deliverable item which must be transmitted to the Stage II contractor such as a simulator, mockup article, etc. Does not normally include data handling.

IV. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO 5.5

TASK TITLE SYSTEMS INTEGRATION SYS. SPPT. (SE & I)

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

An organization is required in the Systems Integration Contractor's Advanced Space Transport Program office to manage the Systems Engineering and Integration (SE & I) technical effort associated with RDT & E on the Air Vehicle and the integration thereof with the entire ground net for both development, test and turnover for Operations. As such, this organization will be responsible, through the Systems Integration Contractor's Program Management office, to NASA for: (a) integration of the Air Vehicle (Integration and Assembly, WBS ID 1.1; Payload, WBS ID 1.2; Stage II, WBS ID 1.3; and Stage I, WBS ID 1.4); (b) for the integration of OGE (WBS ID 2.0 elements); (c) for integration of the Peculiar and Common Support Equipment, i.e. MGE/DMGE (WBS ID 3.0/8.0); (d) for integrated, i.e. Manned Orbital, testing; and (e) for integrated Industrial Facilities (WBS ID 11.0).

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT. SEE MASTER SCHEDULE.

6

These responsibilities break into four major areas:

1. Interface Design - For the Air Vehicle, the interface between Stage I and Stage II includes mating, checkout, transport to the launch pad, countdown and servicing, launch, ascent, and separation. For OGE, the interfaces include Command and Control of launch, Range readiness and launch support, Communications readiness and launch support, Data Processing readiness and launch support, and Launch Equipment and Auxiliary Equipment readiness and launch support. Whereas both Air Vehicle elements (excluding Payload) and ground support elements are basically Stage-peculiar, there is a need to monitor end item definitions for common utilization and to ensure Part II solutions are, to the extent possible, of common design and perform within the integrated requirements.

2. Test Definition - Tests peculiar to the individual Stages are the responsibility of each Stage contractor. Tests involving integrated Air Vehicle and integrated support are the responsibility of the Integration Contractor. Overall Test Definition, and associated master schedules, may best fit within the Integration Contractor responsibility, coordinating Stage I and Stage II development and flight tests to ensure all necessary tests are satisfactorily completed prior to mated flight tests.

3. Systems Integration - This is an extension of Responsibility 1, above, in that holding an SDR (System Design Review) at the outset of Phase C/D can establish a common basis to proceed. Then, as PDRs and CDRs are held, the Systems Integration contractor (through his attendance and participation) can verify to NASA that all requirements are defined, that Part I Specifications recognize all valid interfaces, that development tests are producing required prototype capability, that Part II Specifications are feasible and producible or procurable end items within schedule, that CDRs review all necessary data, that individual Stage flight tests perform and demonstrate necessary performance and effectiveness, and that mated flight test is ready and can be performed.

4. Systems Effectiveness - Systems Integration's responsibility to NASA here is to ensure that the Reliability Plans, Maintainability Plans, Safety Plans, Human Factors Plans, Quality Plans and Systems Specifications are totally integrated, and that what is specified is in keeping with NASA's objectives, is achievable, and is realizable in terms of budgets and schedules.

II. SUBSYSTEM-LEVEL DEFINITION

To meet these requirements, four major elements are defined at the subsystem level (see Figure 5.0-W-6). These elements are:

5.5.1	Interface Design
5.5.2	Test Definition
5.5.3	Systems Integration
5.5.4	Systems Effectiveness

III. FUNCTIONAL DESCRIPTION

The Systems Integration Systems Support (SE & I) organization is basically responsible to NASA, through the Systems Integration Program Management office, for the technical analysis, engineering, and documentation as the basis for design and development of the Space Transport Air Vehicle and the associated support needed for Manned Orbital Flight Tests prior to turnover of end items to NASA for IOC. Inasmuch as Payload is GFE, its integration into RDT & E effort calls for a Payload Integration Office. This office needs to be established soon after Phase C/D for the impact it will have on Stage II payload design and ground handling, and for the impact it will have on Stage I for boost loads. If NASA desires, the Payload office may best be established within the Systems Integration contractor SE & I organization to ensure design, development, mockups, training, and test properly consider the impact of Payload on Air Vehicle and ground support design as well as to place proper constraints on ultimate Payload designs.

The Systems Integration contractor SE & I role will peak when RDT & E reaches the Manned Orbital Flight test phase, then phase-out as all tests are completed. Sustaining effort for Operations integration can then be assigned to either or both Stage contractors or to a third contractor if necessary.

IV. REFERENCES

(To be added.)

INPUTS

B02

B01

- STAGE 1 STRUCTURE / STAGE 2 STRUCTURE
- STAGE 1 DATA MGMT / STAGE 2 DATA MGMT
- STAGE 1 GUID/NAV / STAGE 2 GUID/NAV
- STAGE 1 FLT CONT / STAGE 2 FLT CONT
- STAGE 1 STRUCTURE / STAGE 2 COMMUNICATIONS
- STAGE 2 STRUCTURE / STAGE 1 COMMUNICATIONS
- STAGE 1 CREW STA / STAGE 2 CREW STA

BASELINE INTERFACE CONTROL DOCUMENTS

AND

BASELINE INTERFACE CONTROL DOCUMENTS

- STAGE 1 INTEGRATED PLANT CHECKOUT SOFTWARE / STAGE 2 INTEGRATED PLANT CHECKOUT SOFTWARE
- STAGE 1 INTEGRATED PLANT CHECKOUT GSE / STAGE 2 INTEGRATED PLANT CHECKOUT GSE
- STAGE 1 PLANT GSE / INTEGRATED SPACE TRANSPORT CHECKOUT GSE
- STAGE 1 PLANT CHECKOUT SOFTWARE / INTEGRATED SPACE TRANSPORT CHECKOUT SOFTWARE
- STAGE 2 PLANT GSE / INTEGRATED SPACE TRANSPORT CHECKOUT GSE
- STAGE 2 PLANT CHECKOUT SOFTWARE / INTEGRATED SPACE TRANSPORT CHECKOUT SOFTWARE

BASELINE INTERFACE CONTROL DOCUMENT

- STAGE 1 TVC/FLT CONTROL SIMULATOR / STAGE 2 TVC/FLT CONTROL SIMULATOR

BASELINE INTERFACE CONTROL DOCUMENT

- SIMULATED MISSION SOFTWARE / STAGE 1 AND STAGE 2 TVC/FLT CONTROLS SIMULATORS

BASELINE INTERFACE CONTROL DOCUMENTS

- STAGE 1 ON BOARD CHECKOUT SOFTWARE / STAGE 2 ON BOARD CHECKOUT SOFTWARE
- STAGE 1 CREW STATION CHECKOUT SOFTWARE / STAGE 2 CREW STATION CHECKOUT SOFTWARE

B60

B13

B05

D17

OUTPUTS

MANAGEMENT

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	55.10.0
TITLE	INTERFACE DESIGN
WBS LEVEL	FIFTH (5TH)
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INPUTS

GO AHEAD

A00

B04

H00

B01

B05

AND

SPACE TRANSPORT MISSION OBJECTIVES FINALIZED

PART I MISSION TRAJECTORIES SPEC

PDR MISSION TRAJECTORY SOFTWARE

SPACE TRANSPORT SYSTEM TEST AND OPS PLAN

SPACE TRANSPORT SYSTEM OPERATIONS CHECKOUT SPEC

PART I SIMULATED MISSION SPEC

PDR SIMULATED MISSION SOFTWARE

TRANSPORT MISSION PLANNING

PART I TRANSPORT INTEGRATED CHECKOUT SOFTWARE SPEC

MISSION 1 TEST OBJECTIVE DEFINITION

TEST SUPPORT REQUIREMENTS DEFINITION

PREPARE MISSION 1 TEST DIRECTIVES

GLOBAL RANGE PLANNING

ENGINEERING

MANAGEMENT

Q01 Q09 T01 W03 Q02 T10 T02

S02

T15 T16 Q05 Q06 S02

61

B02

B13

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

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TITLE	TEST DEFINITION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	14 JUN 71

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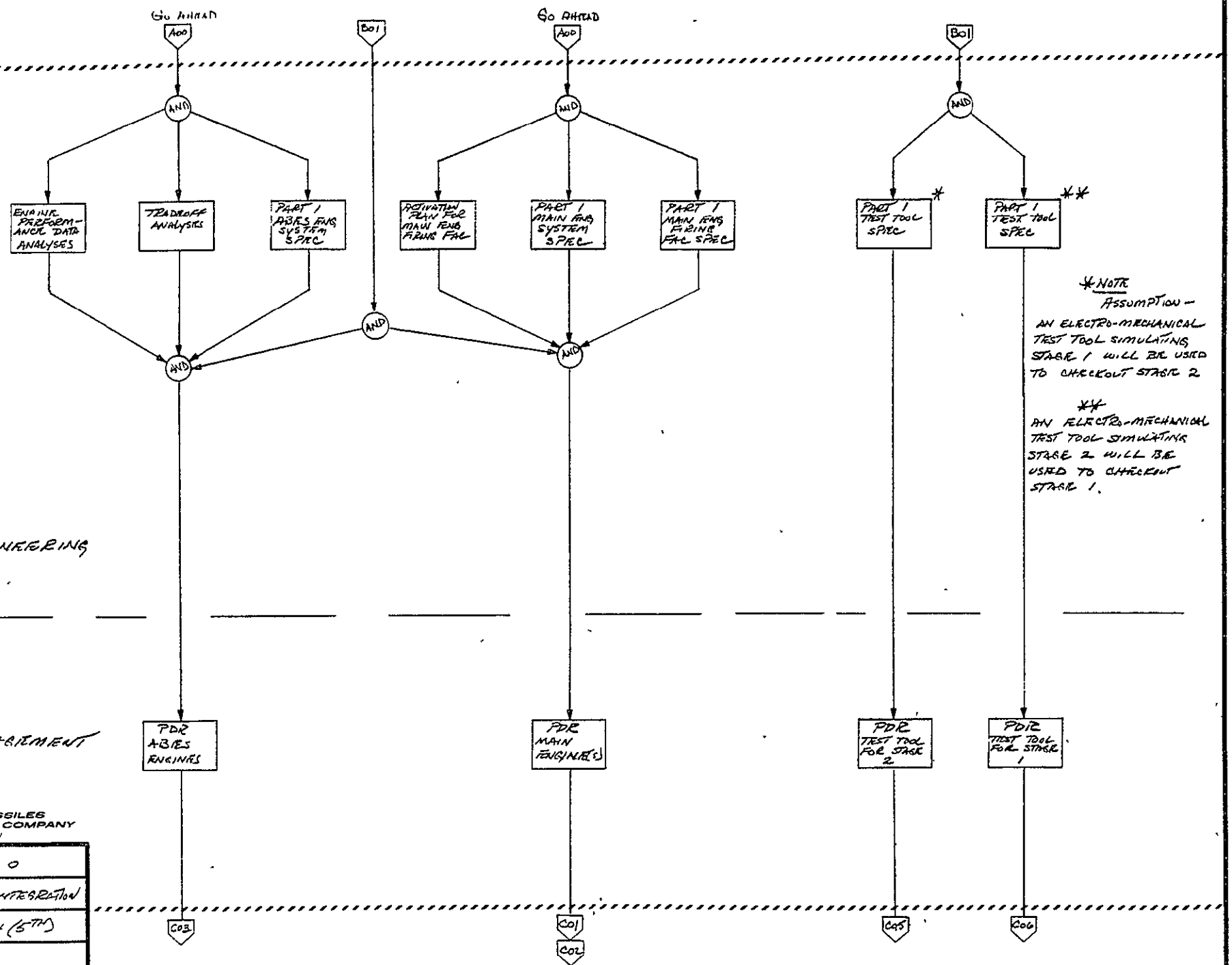

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

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TITLE	SYSTEMS INTEGRATION
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 2
DATE	14 JUN 71

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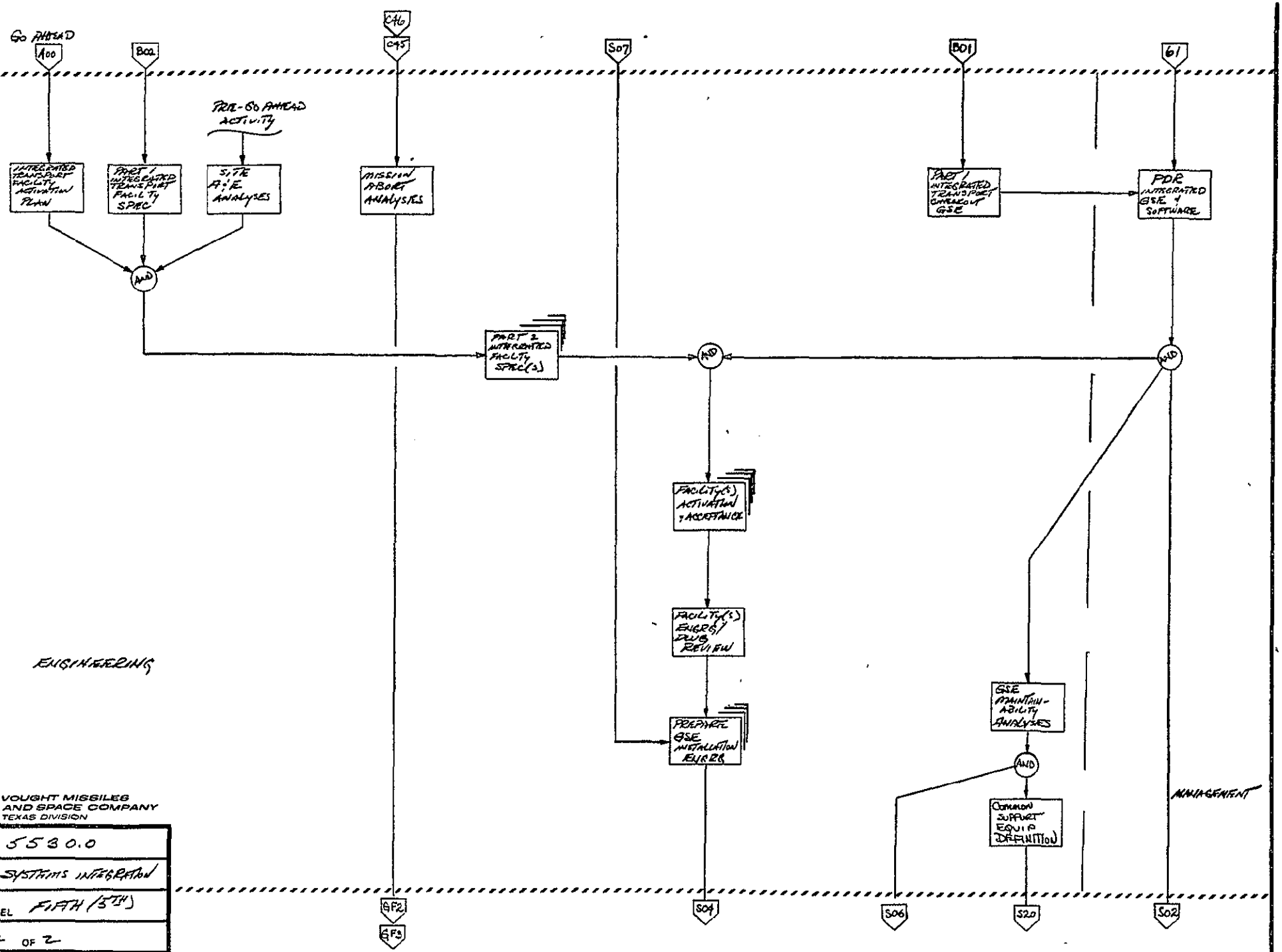


VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	5530.0
TITLE	SYSTEMS INTEGRATION
WBS LEVEL	FIFTH (5TH)
PAGE	2 OF 2
DATE	14 JUN 71

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 5.6

TASK TITLE SYSTEMS INTEGRATION PROGRAM MANAGEMENT

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

An organization is required in the Systems Integration contractor's Advanced Space Transport Program office to administer the Systems Integration contract and to manage the technical effort through the Systems Support (SE &I) Organization (WBS ID 5.5). Major efforts which the Systems Integration Contractor Program Office will manage include: Program Control, Configuration Management, Data Management, and Contract Management. As necessary, additional functions will include Vendor Liaison and end item Transportation and Handling for Systems Integration Contractor end items (basically GSE).

II. SUBSYSTEM-LEVEL DEFINITION

As noted on Figure 5.0-W-6, four major elements are identified at the sub-

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT, SEE MASTER SCHEDULE.

system level. These elements correspond to the four major requirements specified below.

5.6.1	Program Control
5.6.2	Configuration Management
5.6.3	Data Management
5.6.4	Contract Management

(NOTE: Vendor Liaison and Transportation & Packaging responsibilities will be assigned to one of the above disciplines or otherwise assigned as applicable.)

III. FUNCTIONAL DESCRIPTION

The Systems Integration Contractor Program Management office will be responsible for the technical and administrative functions associated with Phase C/D contract effort. Technical management will be delegated to Systems Integration Systems Support (SE & I), WBS ID 5.5. Administrative management will be delegated to four major areas, as noted in Para. II, above. These areas will have the following responsibilities (actual organization is at the discretion of the Systems Integration Contractor Program Manager).

A. Program Control - Responsible for Plans and Schedules, Cost, and Contract Documentation of an administrative nature. Technical documentation (systems engineering, drawings, specifications, procedures, test reports, Program Plans, tech orders, etc.) are the responsibility of Program Management but may be delegated to technical areas through RDT & E. Deliverable data (WBS ID 6.0) will be handled through the Program Office as approved by Program Control.

B. Configuration Management - Responsible for Configuration Identification, Configuration Control, and Systems Integration Change Board Management for all vehicle and ground systems.

C. Data Management - Responsible for all contract-generated data which will ultimately become contract-deliverable data (WBS ID 6.0). This effort will include engineering and manufacturing drawing control and storage, test report control and storage, systems engineering documentation control and storage, and administrative data control and storage.

Data retrieval capability shall be such that latest approved changes are incorporated into the data for quick response to user's request, both in-house, in the field, for other contractors needs and for customer needs. As required, current lists of released data shall be made available to affected users, including latest approved changes.

D. Contract Management - Responsible for contract compliance both to customer as well as for contract and sub-contract efforts. Submit requests for payment for work accomplished (major milestones). Distribute payments to in-house finance groups for covering contract effort, expenses, vouchers, etc. Contract management is essentially the single representative for the contractor to the customer, and the reverse thereof for interpretation of the contract language.

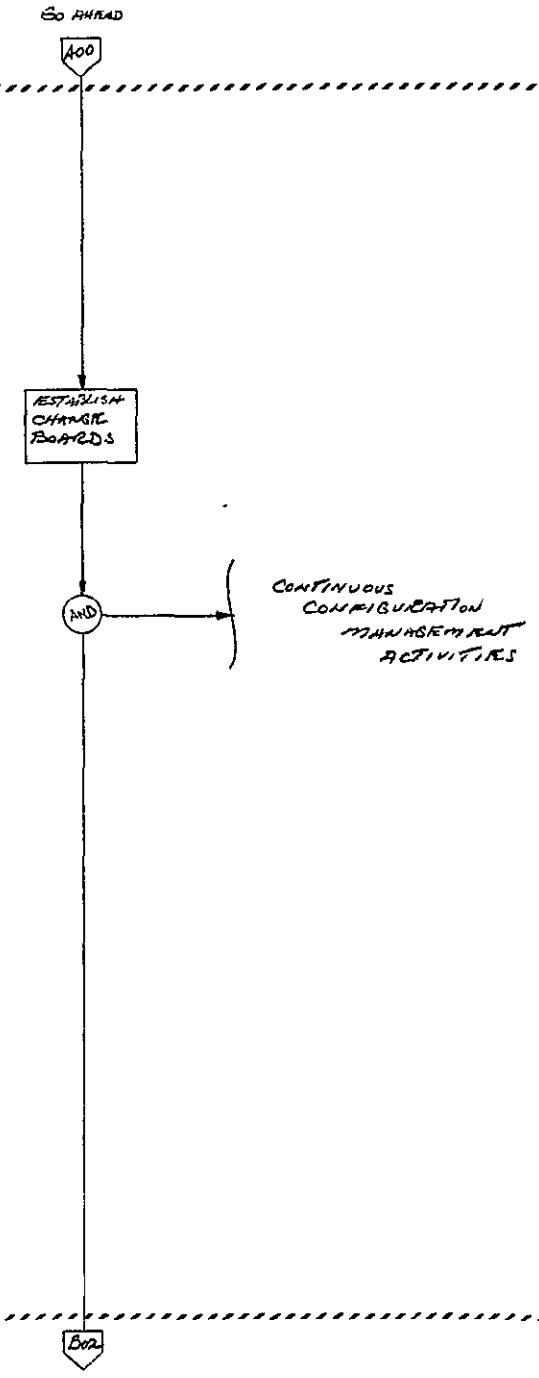
E. Vendor Liaison - Reponsible for Systems Integration Contractor interface with vendors and subcontractors. As such, Vendor Liaison acts for the Systems Integration (S.I.) Contractor to ensure that vendors and sub-contractors are appraised of, and kept up to date on, current requirements imposed by the S. I. Contractor on the vendor or subcontractor and, in turn, that the S. I. Contractor is kept appraised of the progress and problems of the vendor or subcontractor.

F. Transportation and Packaging - Responsible for the packaging and transportation of deliverable articles (test and production) to the field, or the receipt thereof from the field to the factory. Will include any deliverable item which must be transmitted to the Stage I or Stage II contractors. Does not normally include data handling.

IV. REFERENCES

(To be added.)

INPUTS



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	56200
TITLE	CONFIGURATION MANAGEMENT
WBS LEVEL	FIFTH (5TH)
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MANAGEMENT

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 6.0

TASK TITLE DATA (DD FORM 1423)

LEVEL 3, Project Level

WBS DICTIONARY

I. REQUIREMENTS

NASA has specified a requirement for an Advanced Space Transport Program (Phase C/D) which will develop, test and deliver into an operational program manned, reusable Air Vehicles, together with ground support elements, training and spares to accomplish a 10-year operations program for delivering to near-earth space, and retrieving therefrom, certain GFE payloads. Three major end items contractors will participate in the RDT & E and Investment phases of the program: Stage II contractor, Stage I contractor and an Integration contractor. Each represents major efforts in the design, development, test and delivery of production air vehicle/ground support hardware and software. A fourth major contractor at the assembly level is the Main Engine contractor, who supplies GFE Main Propulsion Engines to both Stage II and Stage I.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT. SEE MASTER SCHEDULE.

In accordance with DD Form 1423, or its equivalent, each major end item contractor will deliver to NASA, per contract, certain data which is required by NASA for operations, maintenance and training associated with delivered hardware and software. Specific data will be spelled out in the contracts preceding Phase C go-ahead and will be subject to modification by CCN or other agreed upon methods during the development and investment phases of the program. Format, reproducibility, and quantity - as well as distribution - will be specified by NASA and either be provided on government forms or contractor forms if approved by NASA.

II. SYSTEM - LEVEL DEFINITION

In accordance with a requirement for three major contractors to technically and administratively manage the Advanced Space Transport Program through Phase C/D (WBS Dictionary Element 5.0), three major elements are defined at the system level for providing deliverable data as noted on Figure 6.0-W-7. These elements are:

6.1	Integration Contractor Deliverable Data
6.2	Stage II Contractor Deliverable Data
6.3	Stage I Contractor Deliverable Data

The GFE Main Engine contractor deliverable data is considered to be separate from the scope of the above defined tasks and should be separately negotiated between NASA and that contractor. The same applies to any deliverable data resulting from GFE Payload interfaces to the RDT & E and Investment phases of the Advanced Space Transport Program.

III. FUNCTIONAL DESCRIPTION

The major end item contractors will provide data to NASA in accordance with DD Form 1423 or its equivalence following Phase C go-ahead. Major types of data required include Technical Orders and Manuals, Engineering Data and Management Data. Specification as to what specific data is to be delivered, when, to whom, in what format, and in what quantity will be specified on the Form. In addition to acquiring, writing, assembling, reproducing, and delivering such data, a requirement will be specified for a data depository, i.e. a facility, to act as custodian in establishing

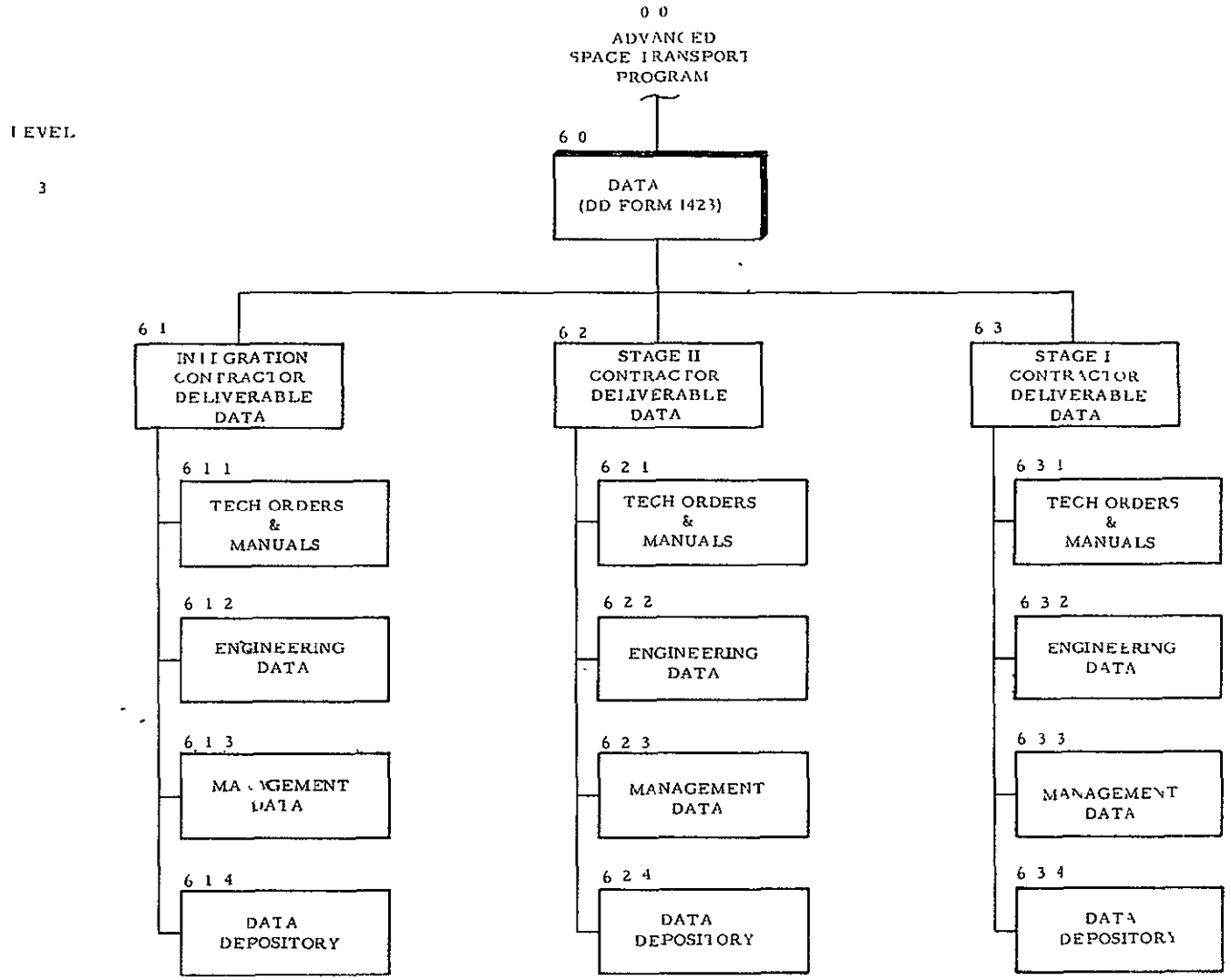


FIGURE 6.0-W-7 WBS, DATA (DD FORM 1423) (WBS ID 6.0)

and maintaining a master engineering specification and drawing depository service for government-approved documents that are the property of the U. S. Government. As custodian for the government, each designated contractor is authorized by approved change orders to maintain these master documents at the latest approved revision level. When documentation is called for on a given item of data retained in the depository, the charges (if charged directly) will be to the appropriate data element. This element represents a distinct entity of its own and includes all effort of drafting, clerical, filing, etc. required to provide the service outlined above. All similar effort for the contractor's internal system, in support of his engineering/production activities, is excluded. Internal effort is part of WBS ID 5.0 during RDT & E and Investment phases of the Program and part of WBS ID 12.0 for the O & M phase of the Program.

IV. REFERENCES

A. MIL-STD-881. Work Breakdown Structures For Defence Materiel Items, 1 November 1965

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 7.0

TASK TITLE OPERATIONAL/SITE ACTIVATION

LEVEL 3, Project Level

WBS DICTIONARY

I. REQUIREMENTS

NASA has specified a requirement for a manned, reusable two-stage Air Vehicle, together with support elements, training and spares, which will deliver GFE payloads to near-earth space, retrieve certain payloads therefrom, and return safely to earth to recycle into the next mission following post-flight maintenance and refurbishment. Ten-year operations, preceded by a design, development and flight test program, are the objectives of the Advanced Space Transport Program

Candidate sites for launching the Space Transport Air Vehicle include Kennedy Spacecraft Center (KSC), Western Test Range (WTR), or an inland site (WBS Dictionary Element 0.0, Para. IV. B. 14.2(h)). The Stage II (orbiting) vehicle, which contains and deploys/retrieves the Payload, shall have a nominal hypersonic aerodynamic cross range capability of

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT. SEE MASTER SCHEDULE.

1100 nm, sufficient to enable it to reach the primary landing site which is to be in the general vicinity of the launch site (WBS Dictionary Element 0.0, Para. IV. A.4 and IV.B. 14.2(a)). Stage I, the boost vehicle, shall also be capable of returning to the primary launch site (WBS Dictionary Element 0.0, Para. IV. A.10).

Air vehicle stages shall be capable of ferry flights between airports, shall be launched vertically in the integrated vehicle configuration and land horizontally and independently, including a safe, intact landing from an aborted flight (WBS Dictionary Element 0.0, Para. IV. A.11, IV. A.12, and IV.A.16).

Total Space Transport turnaround from landing to launch readiness should be less than two weeks (WBS Dictionary Element 0.0, Para. IV. A.23). Any peculiar GSE required to support a remote site landing should be packaged in a manner to be easily flown into the site (WBS Dictionary Element 0.0, Para. IV. B. 4(a)). The vehicles shall incorporate on-board provisions to quickly and easily place the space transport in a safe condition following landing and permit unaided crew and passenger (Stage II) egress (WBS Dictionary Element 0.0, Para. IV. B.7(a)).

Service lines at the launch pad should be minimal, preferably only for the main propulsion system propellants, and no umbilical disconnect actuation should be considered after ignition. Umbilicals that contain functions or services necessary to maintain the Vehicle in a safe condition - or return it to a safe condition - should not be disconnected prior to first motion of the vehicle (WBS Dictionary Element 0.0, Para. IV. B. 14.2(e) and (g)).

The Space Transport elements should have the capability to land horizontally on runways no longer than 10,000 feet (sea level on a standard day) (WBS Dictionary Element 0.0, Para. IV. B. 14.2(i)). Stage II shall be able to land and takeoff at any of 15 possible landing sites described in Landing and Recovery Division Internal Note, MSC-02438 (WBS Dictionary Element 1.3, Para. IV. 7(e)).

II. SYSTEM-LEVEL DEFINITION

The above requirements impose a need for operational sites with the capability to launch, recover and maintain both the Air Vehicle (WBS ID 1.0) and each of the Stages and Payload which comprise the Air Vehicle, i.e. Stage I (WBS ID 1.4), Stage II (WBS ID 1.3) and Payload (WBS ID 1.2). In addition, integrated operations are required for both launch and mission control. Accordingly, the system-level elements which comprise Operational/Site Activation for new or modified sites peculiar only to Operations are noted below. If such site activation is performed to support Test (WBS ID 4.0) and no new activation is required for Operations, then the elements noted below will be performed under WBS ID 4.7 and no further requirement will be needed under WBS ID 7.0 (see Figure 7.0-W-8 for WBS of ID 7.0 and Figure 4.0-W-5 for WBS of ID 4.0).

7.1	Integrated Operational/Site Activation
7.2	Stage II Operational/Site Activation
7.3	Stage I Operational/Site Activation

III. FUNCTIONAL DESCRIPTION

The functions which WBS ID 7.0 provides for new or modified launch and recovery sites needed for Operations (similar requirements exist for Test, WBS ID 4.7) are the conversion of site, utilities and equipment to provide all facilities required to house, service, launch and recover the Air Vehicle (and its reusable independent stages and payload) at the Operational level. All planning necessary to achieve this capability will be performed under this element, except for the System Engineering system requirements analysis effort which establishes the need and interfaces as part of WBS ID 5.0.

Specific activation requirements will be identified following Phase C go-ahead at a point where the Air Vehicle and Ground Support Equipment have been sufficiently identified to finalize the facility and equipment layouts needed for launch, mission control and recovery. The turnaround facility is included in WBS ID 11.0.

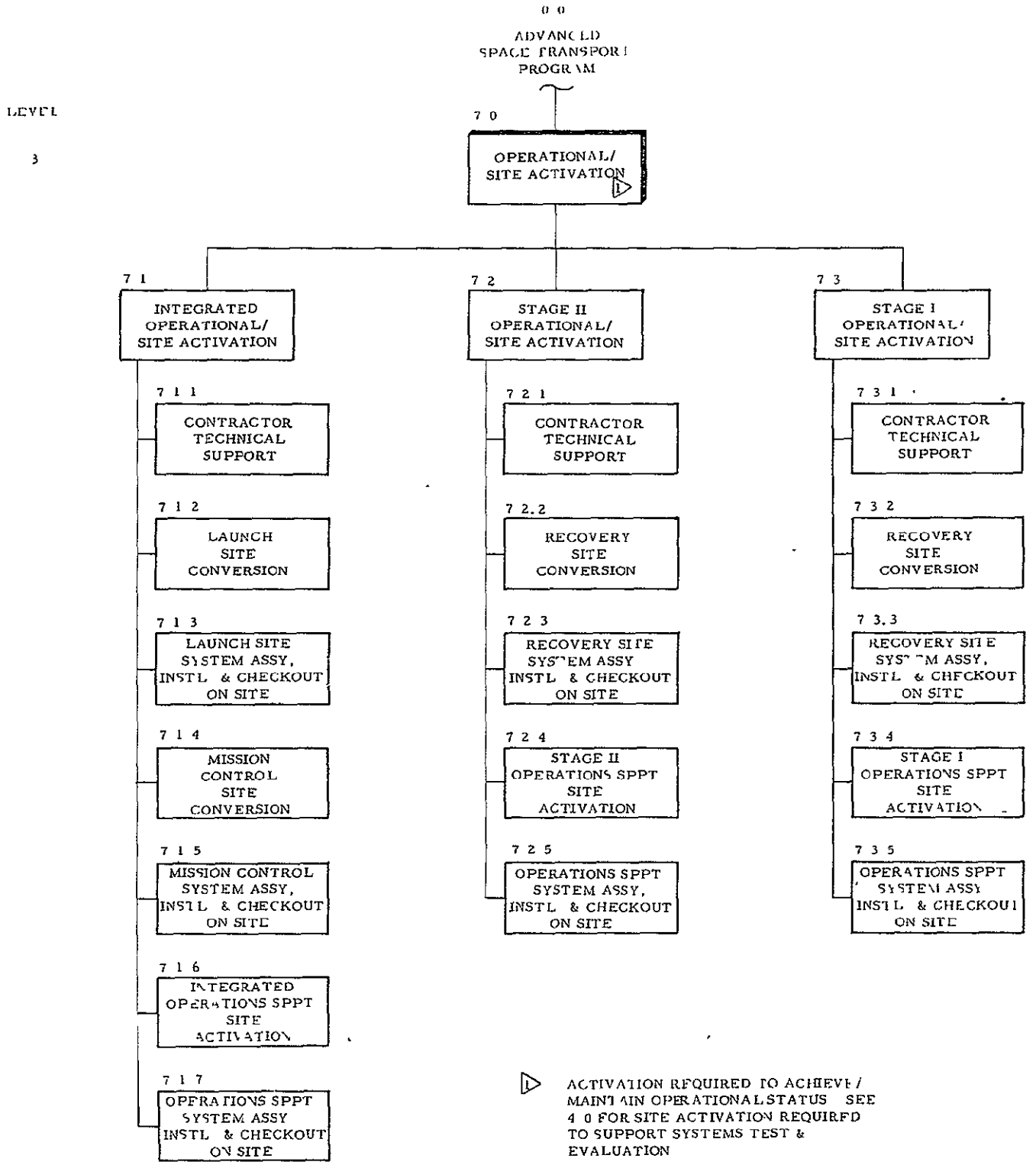


FIGURE 7.0-W-8 WBS, OPERATIONAL/SITE ACTIVATION (WBS ID 7.0)

VOUGHT MISSILES AND SPACE COMPANY

The requirement to provide up to 15 landing sites, using existing runways, will probably require modification to these runways to take landing loads and provide necessary lighting, taxiways and aprons for the unique requirements of the Space Transport stages. Support facilities and equipment, except at the primary landing site, must be surveyed to determine existing capability vs new requirements. Under the concept of alternate landing sites providing purge and safing capability, only (remote sites providing this capability in air-transportable packages), the amount of fixed equipment and facilities will be based on tradeoffs as to the permanency of the support vs the bulkiness of the end items (purge tanks, lines, controls, payload needs, data handling needs, communications needs, crew and passenger needs, takeoff needs, etc.). Resolution of these tradeoffs, if not resolved in Phase B, will be resolved in Phase C/D, and the solution thereto will either affect WBS ID 7.0 and/or WBS 4.7.

Similarly, launch capability must resolve the need for launch pad; Vertical Assembly Building; mated vehicle transport to the pad; launch tower; pad servicing; vehicle monitor and status; vehicle control; vehicle, crew and pad safety; etc. under the concept of minimal ground support/maximum on-board control. If an existing facility will be utilized for Operations, such as KSC, then site activation will occur under WBS ID 4.7. If a new site is required for Operations, then WBS ID 7.0 will handle launch site activation. Again, planning for this effort will fall under WBS ID 4.8 and/or 7.0, based upon the requirements generated in the system requirements analysis, WBS ID 5.0.

Accordingly, no further breakout of WBS ID 7.0 Dictionary will be generated until this problem is resolved.

IV. TEST REQUIREMENTS

(To be determined.)

V. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO 8.0

TASK TITLE COMMON SUPPORT EQUIPMENT

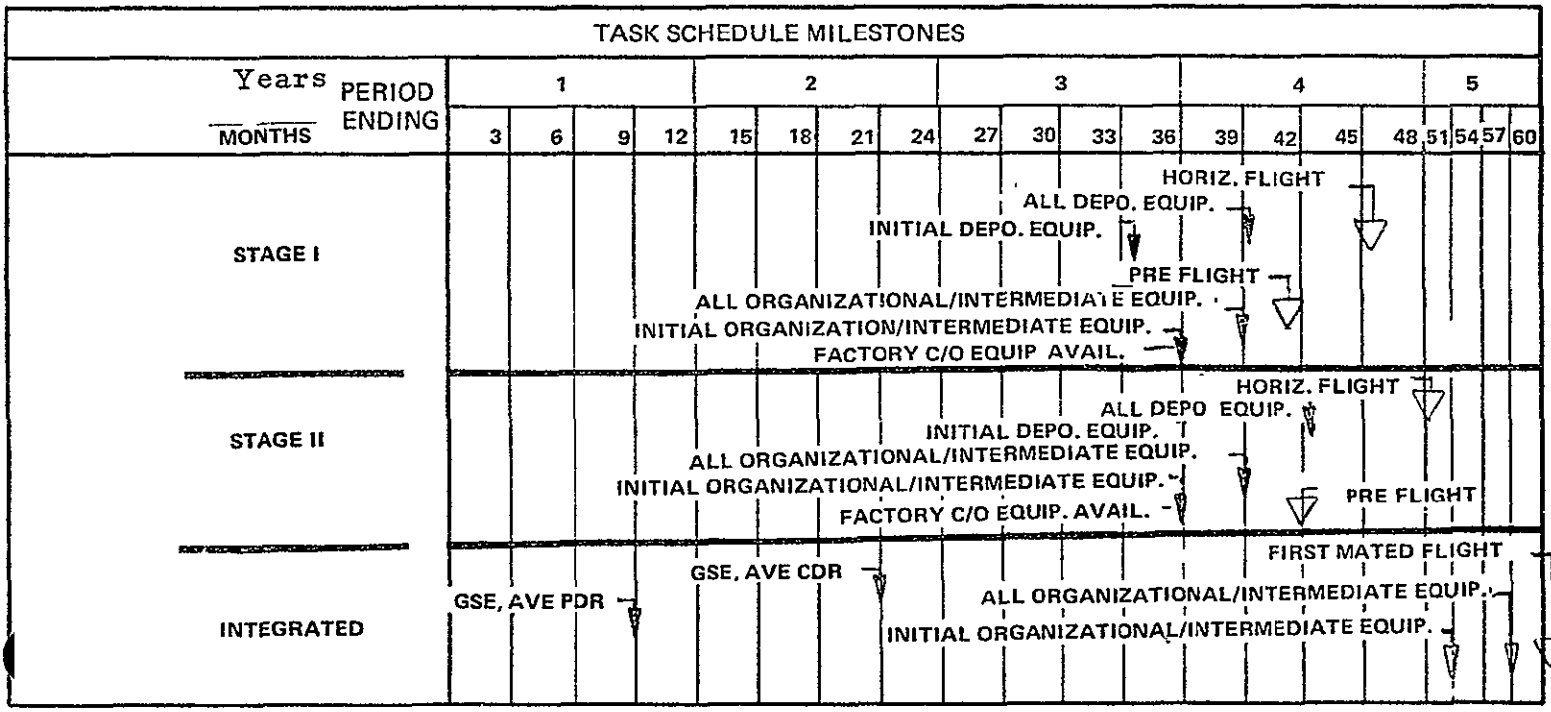
LEVEL 3, Project Level

WBS DICTIONARY

I. REQUIREMENTS

Means are required to maintain the two-stage reusable Space Transport Air Vehicle; to maintain the peculiar operating ground equipment needed to support Vehicle launch, missions and recovery; and to maintain the peculiar maintenance equipment needed to ensure operational capability of the Air Vehicle and its peculiar ground equipment. To satisfy these requirements, which are a part of NASA's Advanced Space Transport Program (WBS ID 0.0), common support equipment, i.e. Federal Stock Numbered equipment, is required which provides the following capability to the operational program, as well as to the RDT & E and Investment phases which precede Operations: (1) provide integrated organizational and intermediate level equipment needed to transport, handle, checkout and service the Air Vehicle and its support equipment; (2) provide organizational, intermediate and depot level equipment needed to transport, handle, calibrate, test and checkout,

TASK SCHEDULE MILESTONES



service, and repair Stage II and its support equipment; and, (3) provide organizational, intermediate and depot level equipment needed to transport, handle, calibrate, test and checkout, service and repair Stage I and its support equipment.

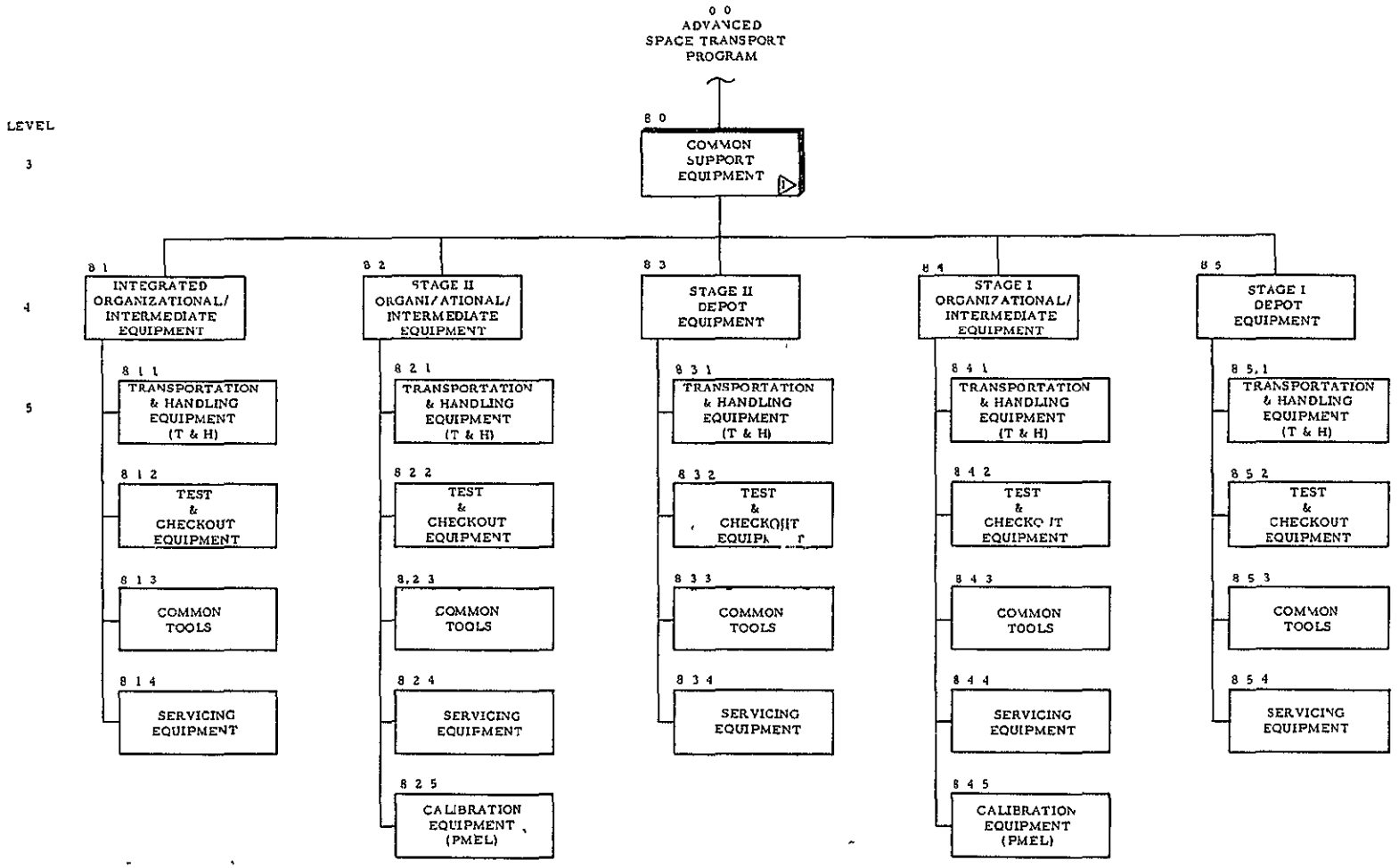
II. SYSTEM-LEVEL DEFINITION

Five major elements define the common maintenance ground equipment (MGE) and depot maintenance ground equipment (DMGE) which comprise the common support equipment for the Advanced Space Transport Program. This equipment is defined in accordance with the three major end items which are a part of this Program (integration, i.e. Air Vehicle peculiar; Stage II peculiar; and Stage I peculiar) and in accordance with the maintenance levels associated with this Program (organizational level, e.g. maintenance associated with the installed on-board vehicle equipment, such as test, fault isolate, remove and replace, checkout; intermediate level, e.g. maintenance associated with the removed air vehicle module or assembly to determine the fault, then remove and replace faulty component or module; and, depot level, e.g. maintenance associated with the faulty component or module to determine the fault, then remove and replace and conduct repair thereon, including post repair checkout). Maintenance associated with the Payload (WBS ID 1.2) is not included, except that transportation and handling (T & H) equipment needed for Integration and Stage II shall, to the extent feasible, be available to support installation/removal of Payload into/from Stage II.

Accordingly, the elements which comprise WBS ID 8.0 (see Figure 8.0-W-9) include the following systems:

8.1	Integrated Organizational/Intermediate Equipment
8.2	Stage II Organizational/Intermediate Equipment
8.3	Stage II Depot Equipment
8.4	Stage Organizational/Intermediate Equipment
8.5	Stage I Depot Equipment

Details on these systems are provided at lower levels of the WBS Dictionary.



▷ MAINTENANCE LOADING TO DETERMINE TYPE & LOCATION OF COMMON (FSN) EQUIPMENT

FIGURE 8.0-W-9 WBS, COMMON SUPPORT EQUIPMENT (WBS ID 8.0)

III. FUNCTIONAL DESCRIPTION

At Phase C go-ahead, final design of the Air Vehicle (WBS ID 1.0) and support elements will be initiated. Preliminary design is assumed to be completed (Phase B). Air Vehicle PDRs (WBS ID 5.0) will be held to review Part I specifications of the Contract End Items (CEIs) which each major air vehicle contractor, together with NASA, have defined. These will establish the air vehicle design which must be satisfied with CEIs Part II (WBS ID 1.0).

Following Air Vehicle PDRs, the system requirements analysis (WBS ID 5.0) can be completed to define the operating ground equipment (OGE) required to support launch, flight and recovery of the Air Vehicle and its elements. OGE PDRs will be held to review Part I specifications of the CEI's which each major ground support contractor, together with NASA, have defined. These will establish the OGE designs which must be satisfied with CEIs Part II (WBS ID 2.0).

Following the Air Vehicle PDR, the maintenance analysis, begun in Phase B, can be completed to define the requirements and solutions to these requirements needed to maintain the Air Vehicle (Integration, Stage II, Stage I) at the organizational, intermediate and depot levels. The equipment needed to satisfy the Air Vehicle maintenance analysis is termed MGE (maintenance ground equipment) and DMGE (depot maintenance ground equipment) and will consist of both peculiar (CFE) and common (GFE) equipment needed to transport, handle, test, check-out, calibrate, service and repair the Air Vehicle in accordance with Program objectives and requirements. Peculiar MGE for the Air Vehicle and its Stages will be designed, developed and tested under WBS ID 3.0 as single end items and installed and tested at the using site under WBS ID 4.0 for the systems test program and under WBS ID 7.0 for any new sites which are required. Common MGE, that is equipment which is identified to already be available by Federal Stock Number (FSN) through government stores, will be procured under WBS ID 8.0 and "loaded" according to site need (WBS ID 4.0, 7.0).

Similarly, following OGE PDRs, the maintenance analysis, begun in Phase B, can be completed to define the requirements and solutions to these requirements needed to maintain the peculiar operating ground equipment (OGE) at the organizational, intermediate and depot levels. This equipment is also termed MGE and DMGE in accordance with where, in the maintenance cycle, it is required. Again, design and development is a function as to whether the equipment is peculiar (CFE) or common (GFE), common being procured as FSN equipment. under WBS ID 8.0.

Following the maintenance analysis on air vehicle and OGE, maintenance analysis on MGE and DMGE can be completed to identify any new equipments, peculiar and common, needed to maintain this equipment.

At appropriate points, PDRs can be held on CEIs Part I for air vehicle MGE/DMGE, OGE MGE/DMGE and MGE and DMGE MGE/DMGE. These PDRs will provide approved requirements for equipment which can be satisfied by either design, development or modified designs or by FSN designation. Thus, CDRs on MGE and DMGE can be held when Part II's or their equivalence demonstrate to NASA that an acceptable end item either exists or can be fabricated or modified to meet the requirement.

IV. DESIGN REQUIREMENTS

The common support equipment (MGE/DMGE) shall be designed to support Program requirements specified in WBS Dictionary Element 0.0, Air Vehicle requirements identified in WBS Dictionary Element 1.0 and lower levels thereof, and operating ground equipment requirements identified in WBS Dictionary Element 2.0 and lower levels thereof. Specific design requirements will be developed in Phase C and delineated on CEIs Part I. Preliminary design requirements for Integrated, Stage II and Stage I vehicle and OGE common support equipment are specified in lower levels of WBS ID 8.0.

V. TEST REQUIREMENTS

Test requirements for common support equipment are not required except for receiving/inspection and verification that the selected items perform as required in their assigned maintenance area.

VI. REFERENCES

(To be added.)

INPUTS

S20

ACQUIRE, DELIVER, ACCOUNT FOR COMMON SUPPORT EQUIP

MANAGEMENT

S00

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	81.000
TITLE	INTEGRATED ORGANIZATIONAL/ INTERMEDIATE EQUIPMENT
WBS LEVEL	FOURTH (4TH)
PAGE	1 OF 1
DATE	14 JUN 71

INPUTS

D71 KC3 KB5 KC7 KC5 KC1 KB7 KB3 GP9 M25 K95 KC9 K98 K97

ACQUIRE, DELIVER ACCOUNT FOR TAG SIMULATOR CSE*

ACQUIRE, DELIVER ACCOUNT FOR FLIGHT CONTROLS CSE

ACQUIRE, DELIVER ACCOUNT FOR DATA MGMT CSE

ACQUIRE, DELIVER ACCOUNT FOR CREW STA CSE

ACQUIRE, DELIVER ACCOUNT FOR ECLS CSE

ACQUIRE, DELIVER ACCOUNT FOR COMMUNICAT CSE

ACQUIRE, DELIVER ACCOUNT FOR SECND PWR CSE

ACQUIRE, DELIVER ACCOUNT FOR GUID/NAV CSE

ACQUIRE, DELIVER ACCOUNT FOR STRUCTURE CSE

ACQUIRE, DELIVER ACCOUNT FOR PROPULSION CSE

ACQUIRE, DELIVER ACCOUNT FOR ABES CSE

ACQUIRE, DELIVER ACCOUNT FOR MAIN ENG CSE

ACQUIRE, DELIVER ACCOUNT FOR 2CS CSE

ACQUIRE, DELIVER ACCOUNT FOR OMS CSE

MANAGEMENT

* NOTE
CSE - COMMON SUPPORT EQUIPMENT

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	82000
TITLE	STAGE 2 ORGANIZATIONAL/ INTERMEDIATE EQUIP
WBS LEVEL	FOURTH (4TH)
PAGE	1 OF 1
DATE	1 JUN 71

F01 GF3 K27 K21 K21 K21 K21 K21 GH1 M01 M01 N05 N05 N05

GC7 N05 N05 N05 K01 K01 K05

M01 M01 M01

OUTPUTS

INPUTS

D70 K04 KB6 KC8 KC6 KC2 K68 KB4 GP8 M26 K96 K95 DC5

ACQUIRE, DELIVER, ACCOUNT FOR SATELLITE CSE *

ACQUIRE, DELIVER, ACCOUNT FOR FLT CONTROL CSE

ACQUIRE, DELIVER, ACCOUNT FOR DATA MGMT CSE

ACQUIRE, DELIVER, ACCOUNT FOR CREW STA CSE

ACQUIRE, DELIVER, ACCOUNT FOR ECLS CSE

ACQUIRE, DELIVER, ACCOUNT FOR COMMUNICATION CSE

ACQUIRE, DELIVER, ACCOUNT FOR SECONDARY PWR CSE

ACQUIRE, DELIVER, ACCOUNT FOR GUID/NAV CSE

ACQUIRE, DELIVER, ACCOUNT FOR STRUCTURE CSE

ACQUIRE, DELIVER, ACCOUNT FOR PROPULSION CSE

ACQUIRE, DELIVER, ACCOUNT FOR MAIN EQ CSE

ACQUIRE, DELIVER, ACCOUNT FOR ABES CSE

ACQUIRE, DELIVER, ACCOUNT FOR RCS CSE

MANAGEMENT

* NOTE
CSE - COMMON SUPPORT EQUIPMENT

F02 G10 GF2 K28 K22 K22 K22 K06 M02 K22 K06 M02 K22 K06 M02 GH2 K06 M02 M02 N06 K02 M02 N06 K02

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	64000
TITLE	STAGE I ORBITAL EQUIP
WBS LEVEL	FOURTH (4TH)
PAGE	1 OF 1
DATE	15 JUN 71

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 9.0

TASK TITLE INITIAL SPARES & REPAIR PARTS

LEVEL 3, Project Level

WBS DICTIONARY

I. REQUIREMENTS

NASA has specified a requirement for a manned, reusable two-stage Air Vehicle, together with support capability, training and spares, to accomplish a 10-year operations in launching GFE payloads to near-earth space, to retrieve certain payloads therefrom, and to safely reenter to a selected or alternate landing site and recycle the Stages for the next mission. The Advanced Space Transport Program (Phase C/D) will consist of RDT & E, Investment and Operations and Services phases where major end items will consist of Stage I-oriented, Stage II-oriented and Integration-oriented air vehicles, operating ground equipment, and maintenance ground equipment together with training and deliverable data to enable IOC, then 10-year operations. Spares and repair parts for test programs will be identified and delivered under WBS ID 4.0. Initial spares and repair parts for first year Operations will be identified and delivered under WBS ID 9.0. CFE

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT. SEE MASTER SCHEDULE.

spares and repair parts will be manufactured under their separate categories (WBS ID 1.3, Stage II; WBS ID 1.4, Stage I; WBS ID 2.0, Operating Ground Equipment, and WBS ID 3.0, Peculiar Maintenance Ground Equipment). Spares for Training aids, simulators, etc. will be manufactured in similar manner, if deliverable to the Operational Program.

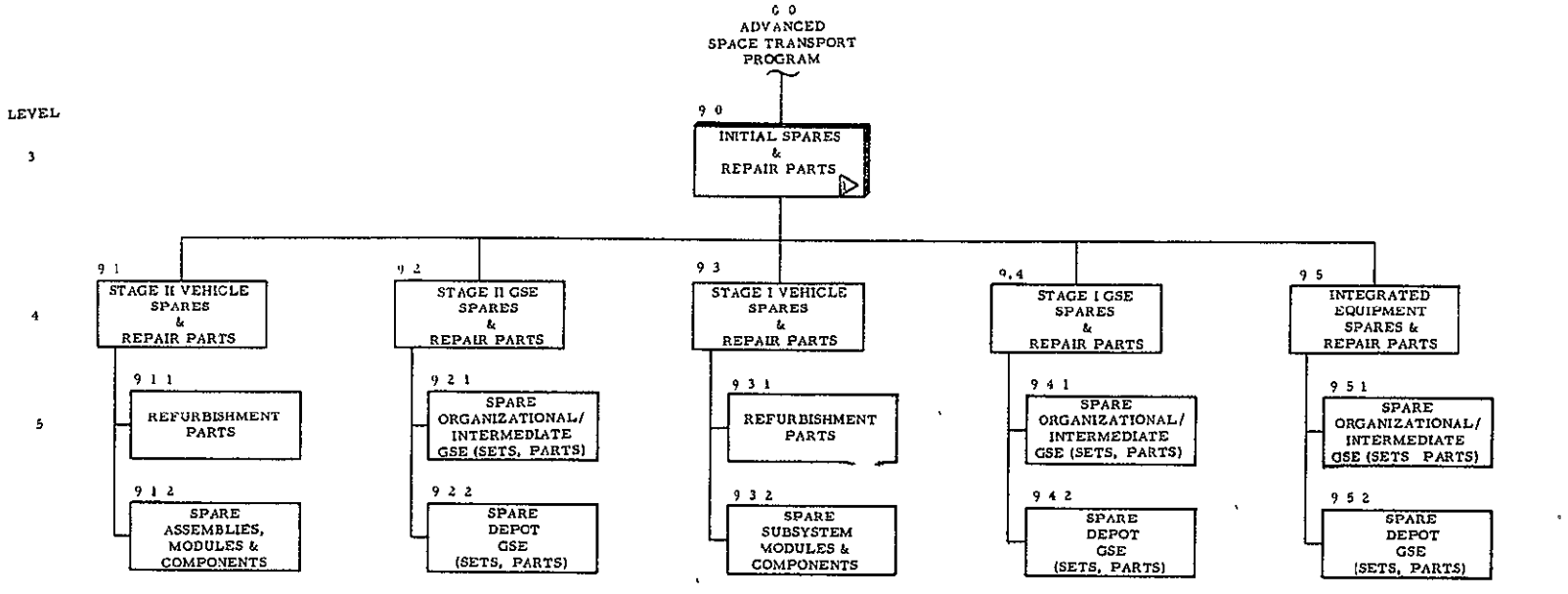
II. SYSTEM-LEVEL DEFINITION

As noted on Figure 9.0-W-10, five major elements comprise initial spares and repair parts at the system level. Details on these elements are defined at lower levels.

9.1	Stage II Vehicle Spares and Repair Parts
9.2	Stage II GSE Spares and Repair Parts
9.3	Stage I Vehicle Spares and Repair Parts
9.4	Stage I GSE Spares and Repair Parts
9.5	Integrated Equipment Spares and Repair Parts

III. FUNCTIONAL DESCRIPTION

Following Phase C go-ahead, design will be completed on the Air Vehicle, OGE and MGE/DMGE to enable the flight test program (pre-flight, taxi, ferry test, horizontal flight test, vertical flight test) to be accomplished. During these phases, the reliability and maintainability plans developed in Phase B and approved and implemented in Phase C will establish reliability and maintainability goals which can be monitored to verify failure rates as well as refurbishment requirements, basically in Air Vehicle elements. Failure rates in GSE will also be monitored to verify spares and refurbishment requirements, particularly in critical equipment. On this basis, a statistical capability will exist toward the end of RDT & E to enable evaluation of the requirement for initial spares and repair parts for Operations. As agreed upon between NASA and the major end item contractors, an order can be placed at an appropriate time to fabricate and/or procure needed spares and repair parts to achieve IOC and enter 10-year Operations. To augment this requirement, any new complete sets of GSE needed because of new sites will be added, together with their spares, to enable Operations to begin.



▷ INITIAL SPARES AND REPAIR PARTS SUFFICIENT FOR IOC PLUS FIRST YEAR OPERATIONS

FIGURE 9.0-W-10 WBS, INITIAL SPARES & REPAIR PARTS (WBS ID 9.0)

IV. TEST REQUIREMENTS

Initial spares and repair parts, as required, will be verified at the contractor or supplier facility prior to shipment. Receiving/inspection should suffice at the received site.

V. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 10.0

TASK TITLE TRAINING

LEVEL 3, Project Level

WBS DICTIONARY

I. REQUIREMENTS

NASA has specified a requirement for an Advanced Space Transport Program (Phase C/D) which will design, develop, test and operate manned, two-stage reusable, i.e. winged, Air Vehicles: (1) to deliver GFE payloads to near-earth space; (2) to rendezvous and dock with space stations and space bases on some missions so as to deliver the payload to the target; (3) to deploy payloads from the space base, space station or from free safe on other missions; and (5) to reenter the earth's atmosphere following a mission so as to cruise to and land at a conventional airport. Following a safe and purge operation at the landing site, a ferry flight (both stages: Stage II, only, conducts the mission; Stage I is the boost vehicle) is conducted to the turnaround facility for post-flight maintenance and refurbishment to prepare for the next mission. Details on the Air Vehicle are to be found in WBS Dictionary Element 1.0 and lower levels thereto.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT. SEE MASTER SCHEDULE.

To support the mission, operating ground equipment (OGE) and maintenance ground equipment (MGE/DMGE) will be provided to enable launch, flight and recovery and necessary maintenance associated therewith. Details on the ground support equipment required for Operations, and for test programs which verify operational capability, are found in WBS Dictionary Elements 2.0 (OGE) and 3.0/8.0 (MGE/DMGE).

To achieve IOC, training will be required to enable flight crews and ground crews to conduct both flight test and Operations. It is NASA's desire to utilize astronauts to man Stage II and Stage I, both during flight test and during Operations. Contractor flight test support will be required throughout the flight test program including use of test pilots in early flights. As astronauts acquire familiarity with the Stages during design phases (including providing recommendations as to how the final design can best result in a well-integrated man-machine product), astronaut proficiency will develop first through flight simulator practice, then through flights in the flight test vehicles, themselves.

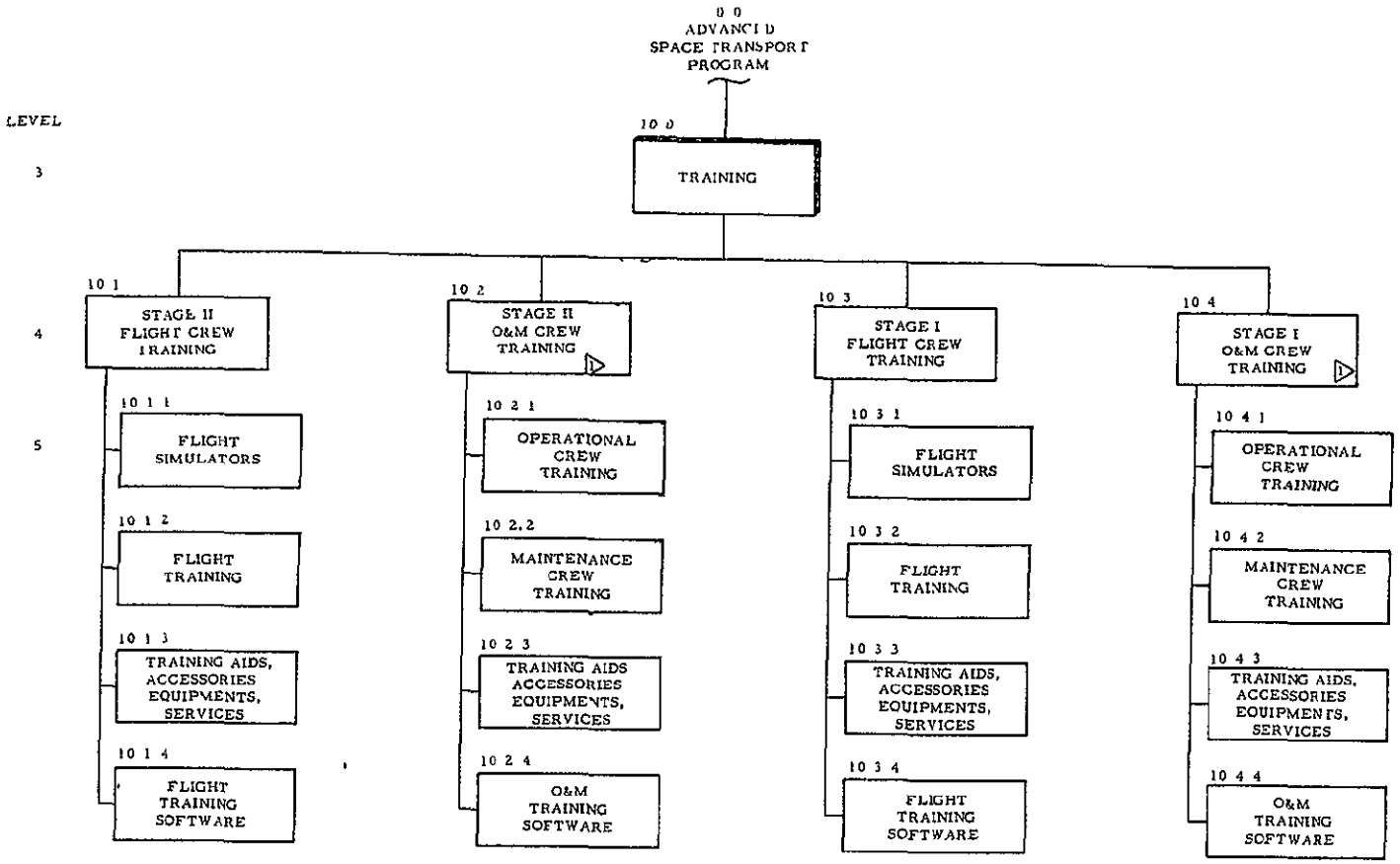
Ground crews will be initially trained through contractor courses which familiarize them with OGE, MGE and DMGE. Later, these crews will be cycled into the test program to assist in operating delivered equipments at the various test facilities and turnaround facility.

II. SYSTEM-LEVEL DEFINITION

Two of the major end items of the Advanced Space Transport Program are Stage II (WBS ID 1.3), which is the orbiting space transport vehicle, and Stage I (WBS ID 1.4), which boosts Stage II and its payload (WBS ID 1.2) to a point in the ascent trajectory to enable orbit to be achieved. Ground support equipment is similarly Stage-oriented. Accordingly, the training effort will be Stage-oriented, as noted on Figure 10.0-W-10.11. Training elements at the system-level, include the following:

10.1	Stage II Flight Crew Training
10.2	Stage II O & M Crew Training*
10.3	Stage I Flight Crew Training
10.4	Stage I O & M Crew Training*

(*O & M: Operations and Maintenance)



▷ *INCLUDE INTEGRATED O&M CREW TRAINING AS APPROPRIATE*

FIGURE 10.0-W-11 WBS, TRAINING (WBS ID 10.0)

A third major end item is Integration. Insofar as end-item hardware is concerned, such hardware is basically ground support-oriented. Any unique training associated with Integration OGE/MGE can be included in 10.1 and 10.2, unless otherwise directed by NASA.

III. FUNCTIONAL DESCRIPTION

At Phase C go-ahead, vehicle design will proceed through PDRs, development testing, CDRs, and fabrication of structural test vehicles and flight test vehicles to enable the flight test program to begin. Similarly, ground support equipments will be defined, proceed through PDRs, development and CDRs, and fabrication and/or procurement to support flight test.

At an appropriate point, training can begin. Flight test training simulators will be defined, reviewed in PDRs, developed, reviewed and approved in CDRs and fabricated and delivered to enable flight training to begin. Dynamic mockup utilization (WBS ID 4.8 and 4.9) will provide vehicle inputs to simulator design to synthesize flight loads and reactions needed to establish vehicle response through the integrated flight control, crew control, and data management network. With simulations of ferry flight, horizontal flight and mated flight (vertical ascent, space injection, space missions, deorbit, reentry, cruise, approach and landing) functions displayed to the trainees, together with both automatic and manual mode control, astronauts can become familiar with both vehicle and mission so that in actual flights they are proficient in the man-machine interface.

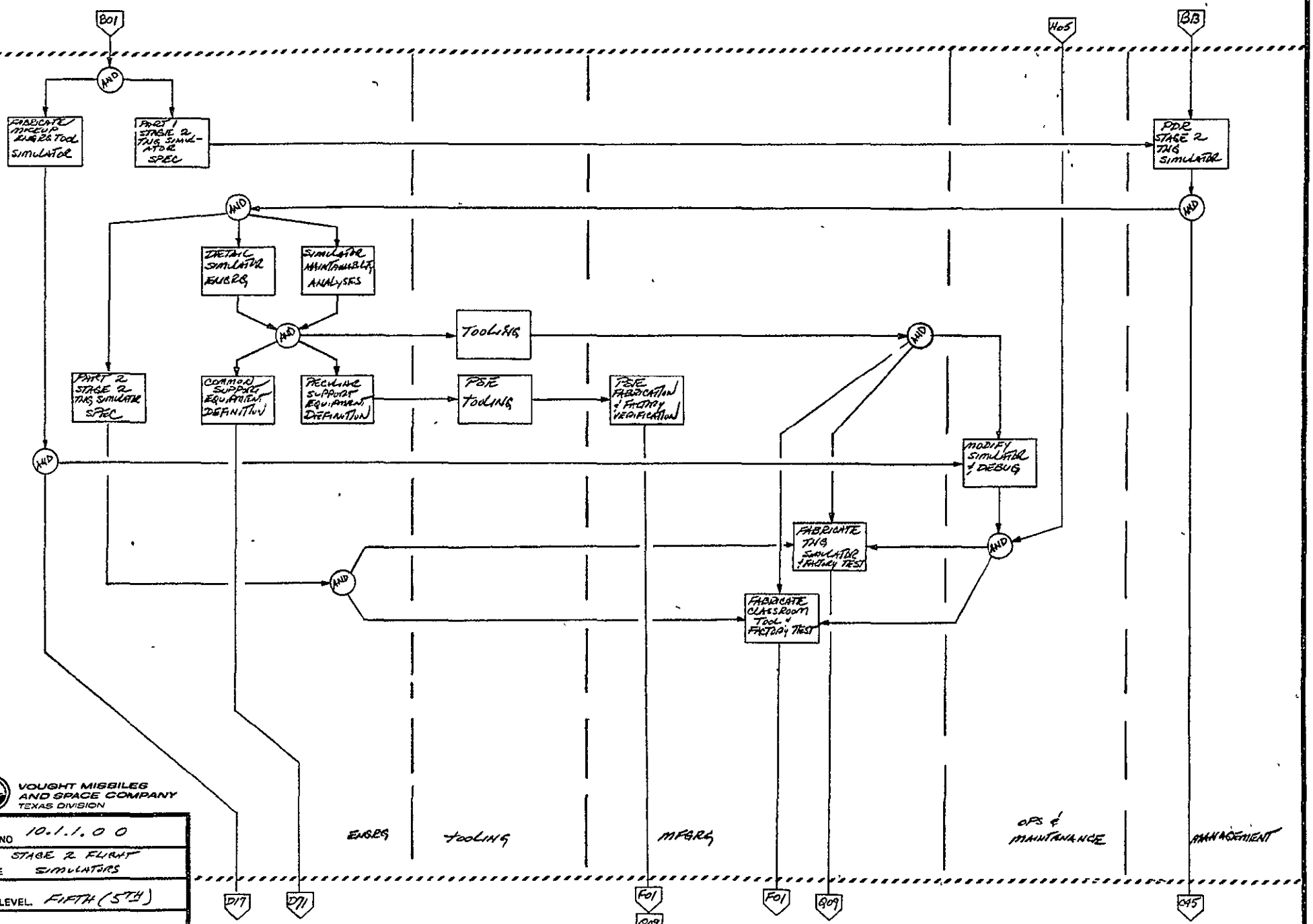
Phasing of flight test simulator hardware and software availability into the test program (WBS ID 4.0) is critical in that authenticity of simulator functions should be available in time to allow flight crews to receive training prior to use of such crews in the flight test vehicle flights. Separate simulators will be required for both Stage II and for Stage I.

Ground crew training can be initiated at such point as GSE is defined, developed, fabricated and/or procured, and delivered to the test site. Contractors will be responsible for much of the operation of GSE in the test phase. However, operational crews can gain proficiency in GSE functions through actual utilization of peculiar GSE during horizontal, vertical and mated test flights, including recovery operations and turn-around operations. Thus, at IOC, ground crews will be fully competent to take over the entire ground operation.

IV. REFERENCES

(To be added.)

INPUTS

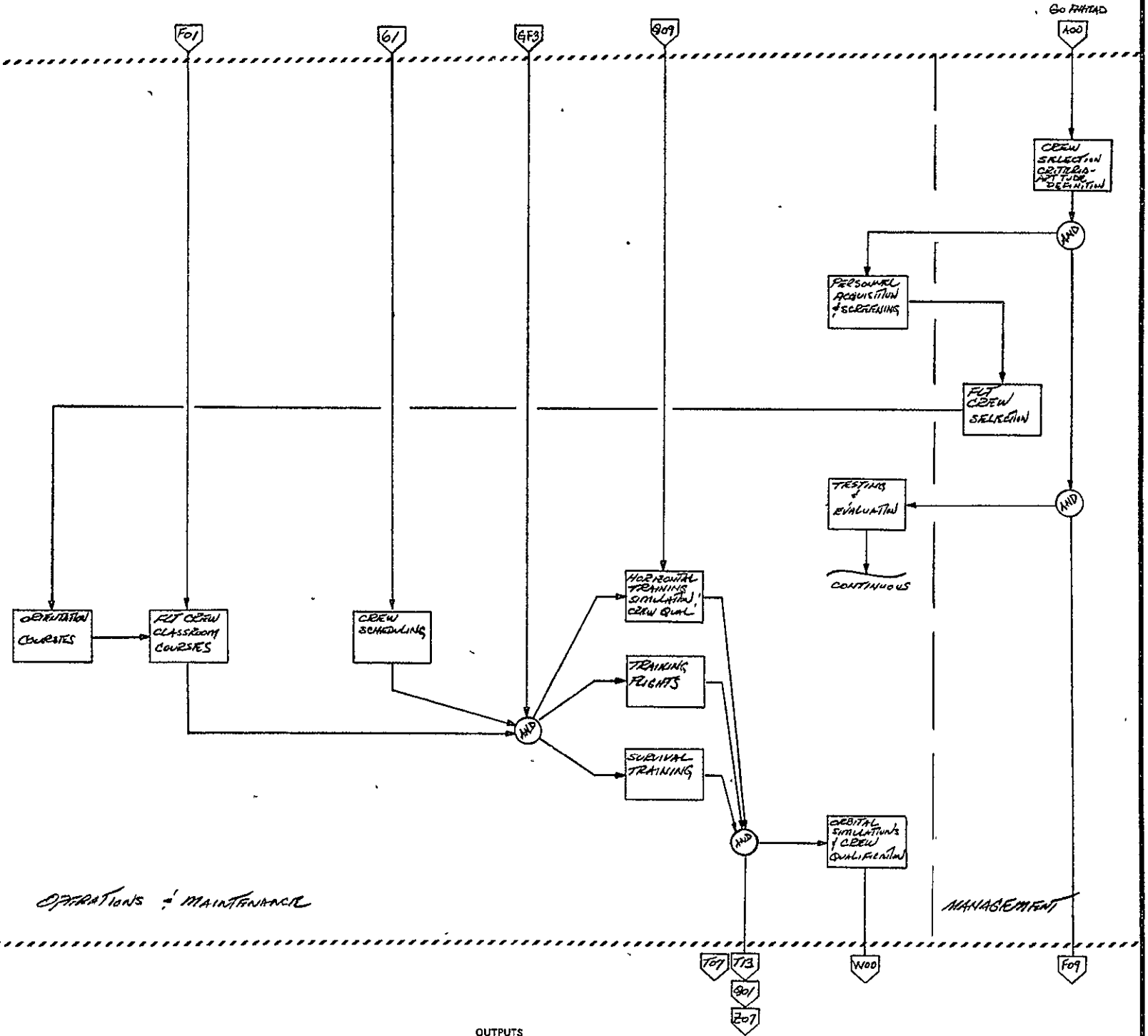


VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS. NO	10.1.1.00
TITLE	STAGE 2 FLIGHT SIMULATORS
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	15 JUN 71

OUTPUTS

INPUTS

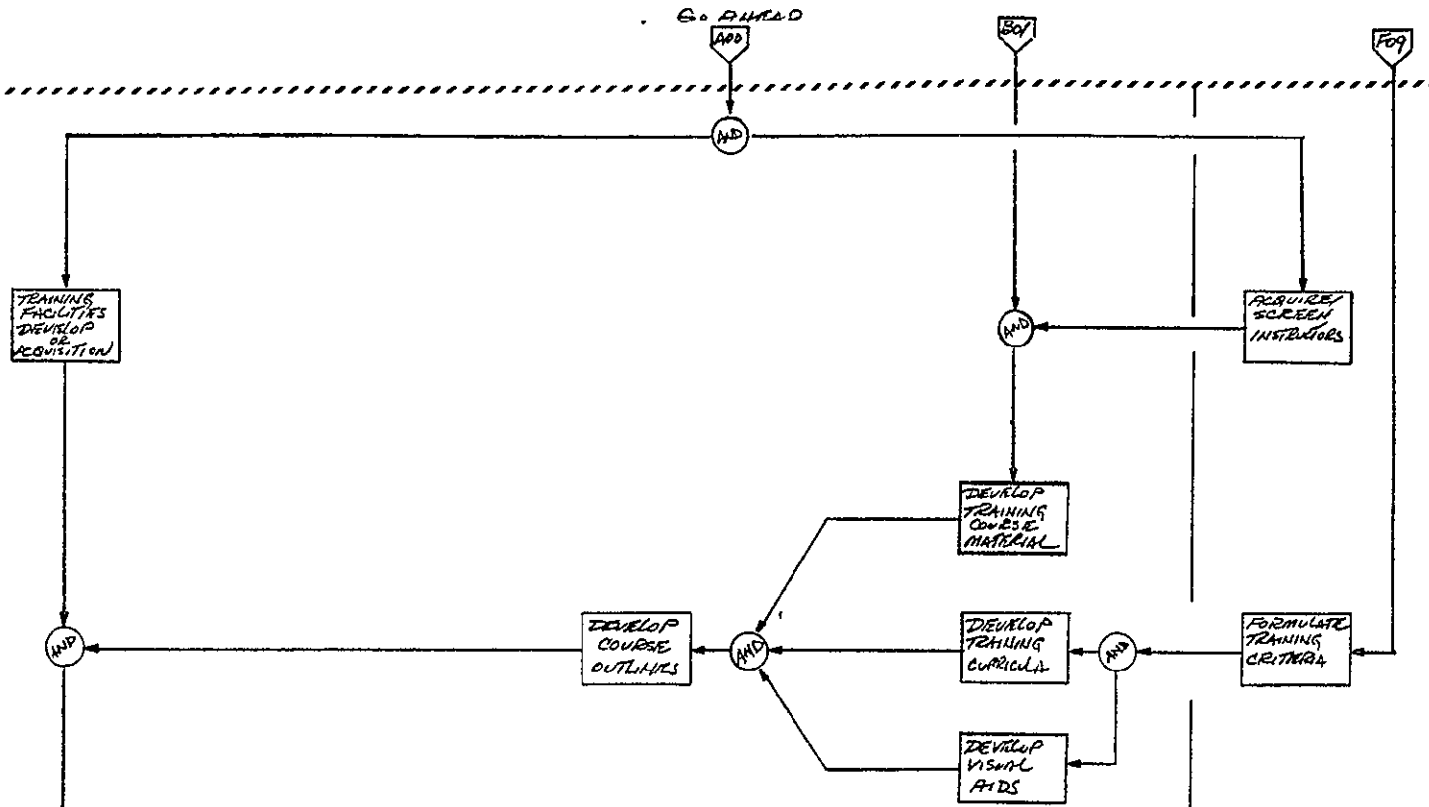


VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	10120.0
TITLE	STAGE 2 FLIGHT TRAINING
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	15 JUN 71

OUTPUTS

INPUTS

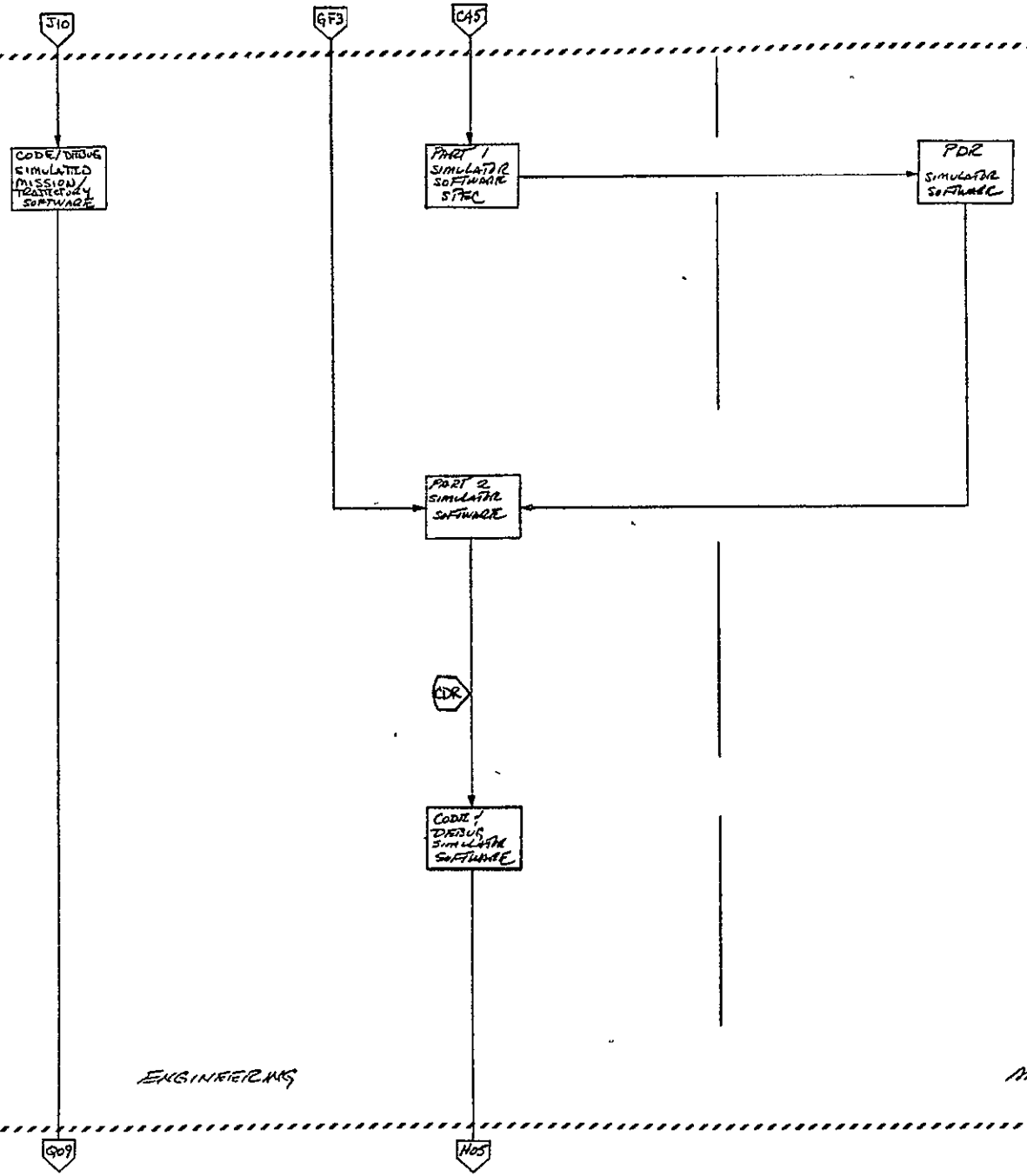


VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	10 1.2 0.0
TITLE	STAGE 2 TRAINING AIDS - ASSESSORIES - EQUIPMENT SERVICES
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	15 JUN 71

OUTPUTS

INPUTS



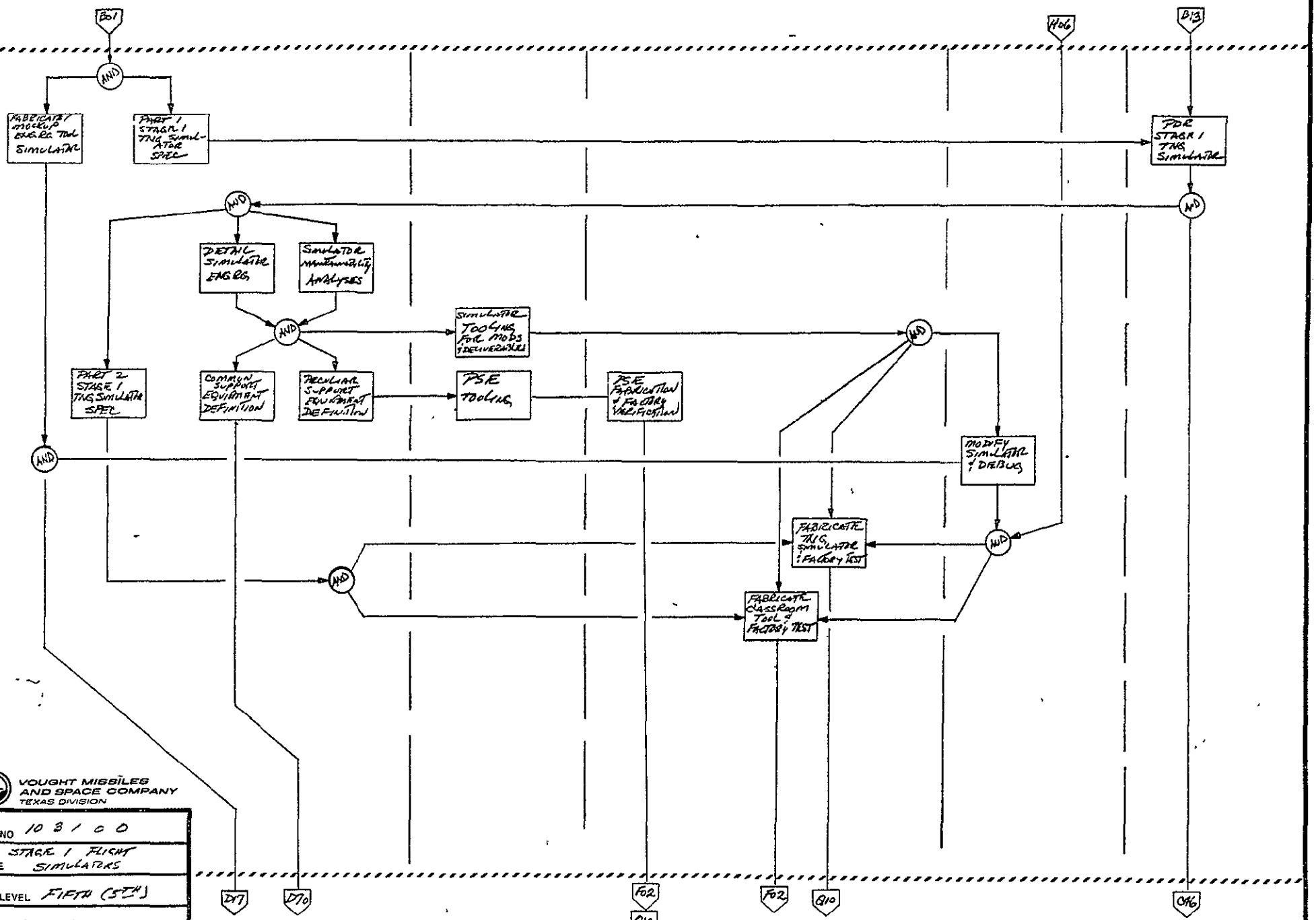
ENGINEERING

MANAGEMENT

OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

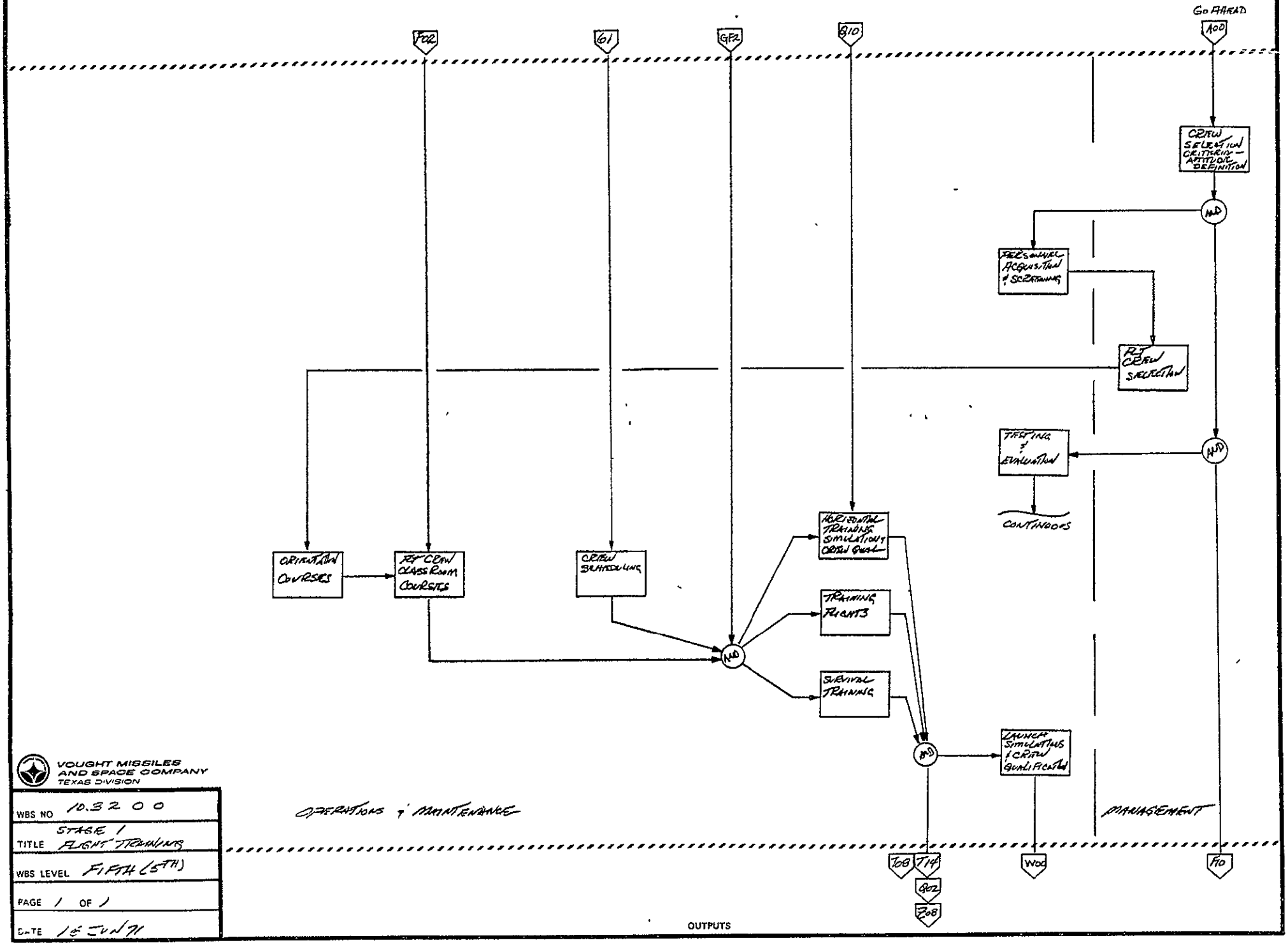
WBS NO	10 1 4 0 0
TITLE	STAGE 2 FLIGHT TRAINING SOFTWARE
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	14 JUN 71



VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	10 3 1 0 0
TITLE	STAGE 1 FLIGHT SIMULATORS
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	16 JUN 71

INPUTS

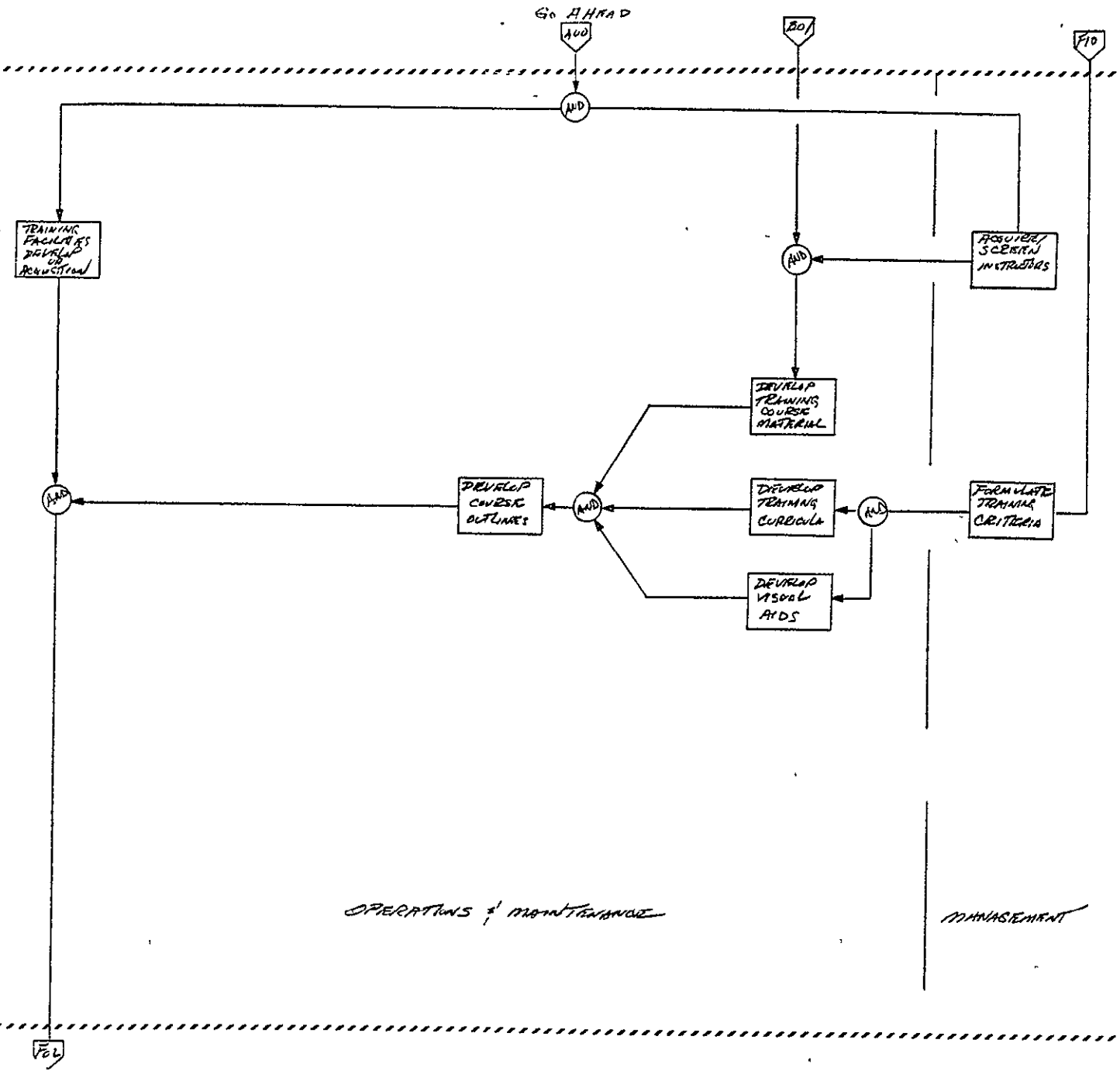


OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	10.3200
TITLE	STAGE I FLIGHT TRAINING
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	15 JUN 71

INPUTS

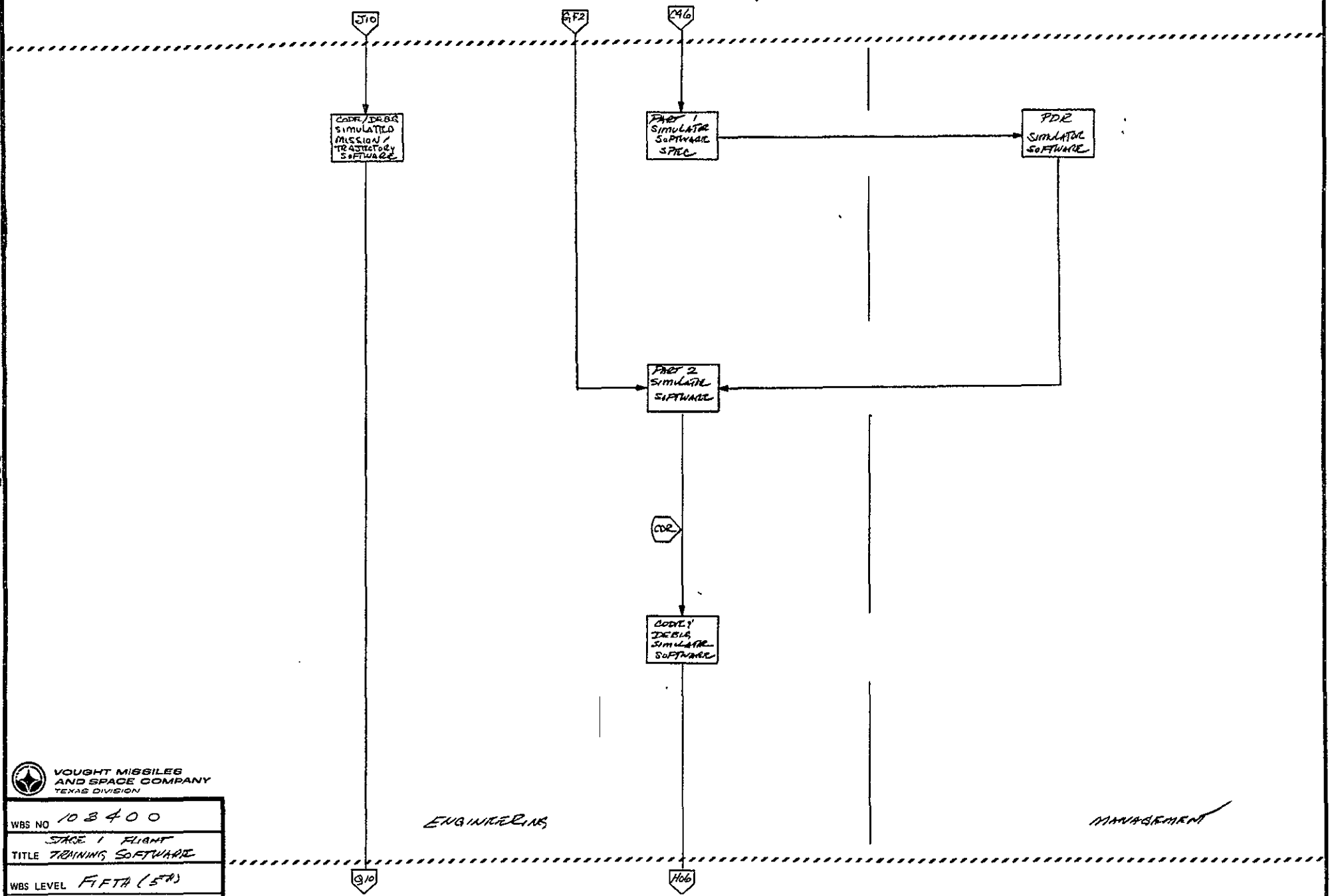


VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	10 3 3 0 0
TITLE	START TRAINING AIDS - ASSESSORIES - EQUIP - DEVICES
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	16 JUN 71

OUTPUTS

INPUTS



OUTPUTS

VOUGHT MISSILES AND SPACE COMPANY
TEXAS DIVISION

WBS NO	103400
TITLE	STAGE 1 FLIGHT TRAINING SOFTWARE
WBS LEVEL	FIFTH (5TH)
PAGE	1 OF 1
DATE	16 JUNE

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 11.0

TASK TITLE INDUSTRIAL FACILITIES (PECULIAR)

LEVEL 3, Project Level

WBS DICTIONARY

I. REQUIREMENTS

NASA has specified a requirement for an Advanced Space Transport Program (Phase C/D) to design, develop, fabricate and test manned, reusable two-stage Air Vehicles capable of delivering GFE payloads to near-earth space, to deploy/retrieve payloads into/from space, and to safely return to a designated or alternate landing site for post-flight purge and safing operations, followed by ferry flights (if required) to the turnaround facility for preparation for next mission. WBS Dictionary Elements 0.0, 1.0, 2.0 and 3.0/8.0 define the total program requirements, vehicle requirements, and support requirements. Other WBS elements define test requirements (4.0), system/program management requirements (5.0), and initial spares and repair parts requirements (9.0). Site activation is defined under WBS ID 4.7 for mated flight tests and under WBS ID 7.0 for new Operational site requirements, if any.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SCHEDULE NOT GENERATED FOR THIS ELEMENT. SEE MASTER SCHEDULE.

To support the RDT & E, Investment and O & M phases of the Advanced Space Transport Program, a need will exist for peculiar industrial facilities which provide: (1) production and support capability to manufacture prototype, test article and production article Air Vehicle stages including tooling and inventory capability therefore; and (2) the turnaround facility at the launch/primary recovery site needed for both mated test flights and for Operations. Other facilities needed for test purposes only are defined under WBS ID 4.0 as appropriate.

The peculiar production facilities needed for vehicle fabrication and factory test may currently exist, in which case the task required here is that of survey, planning, and modification as required to satisfy the producibility and test requirements. If new or expanded production test capability is required, additional effort will be required to ensure parts, components, modules, and assemblies are available as well as to handle the sub-assembly, final assembly, factory test, and roll-out functions.

The turnaround facility shall provide the needed capability to handle stage receiving/inspection and storage; pre-flight/post-flight checkout, test and servicing; and to handle the organizational-level, intermediate-level, and depot-level maintenance needed to support the two-week turnaround requirement (WBS Dictionary Element 0.0, Para. IV. A.23). Special maintenance required for such vehicle assemblies as air-breathing engine maintenance may best be handled other than at the turnaround facility. Other special maintenance (sensitive electronics,for example) may also require off-site maintenance.

The Inventory and Logistics industrial facilities support production as well as Operations through providing storage, warehousing, and support at the contractor facility, the test facility, and the operational site necessary for inventory of parts, modules, assemblies and finished articles as called for by facility contracts which support RDT & E, Investment and O & M.

II. SYSTEM-LEVEL DEFINITION

The three major end items of the Program identify the system-level elements which define the peculiar Industrial Facilities for the Advanced Space

Transport Program. These elements, shown on Figure 11.0-W-12, are:

11.1	Integrated Operations and Support Facilities
11.2	Stage II Operations and Support Facilities
11.3	Stage I Operations and Support Facilities

III. FUNCTIONAL DESCRIPTION

During Phase B, major contractors for Stage I and Stage II will have initially developed their analysis and plans for the facilities required to produce prototype, structural test article, flight test vehicles and production vehicles required for the Advanced Space Transport Program. Initial decisions for parts storage, production test, factory support equipment, tooling, warehousing, sub-assembly and final assembly, factory end-to-end testing and roll-out will have been derived. In addition, initial decision-making on whether the facility exists, requires modification, or requires new capability will have been completed and whether the facility is to be contractor-furnished or government-furnished, including maintenance thereof through the RDT & E and Investment phases.

Based on the above assumptions, the effort at Phase C go-ahead will be to prepare Part I's on each Stage production and inventory facilities, to hold a PDR (WBS 5.0) to review and approve Part I's, and to demonstrate capability to meet Part I's through A & E drawings which will be reviewed in CDR (WBS 11.0). Upon approval thereof, contracts can be let to build, modify or otherwise implement the facility designs. Upon completion of the facility construction/conversion/or expansion, production can begin. The foregoing assumes NASA desires control of the facility through RDT & E and Investment. Maintenance of the facility(ies) will be the responsibility of the contractor or as otherwise specified in the facility contract.

To provide the turnaround facility, preliminary planning in Phase B can be completed in Phase C/D and Part I specifications prepared at such time as the vehicle and ground support equipment (MGE/DMGE) are sufficiently defined to verify turnaround requirements are firm. At this point, a PDR (WBS 5.0) can be held to review the analysis and Part I specification. Upon

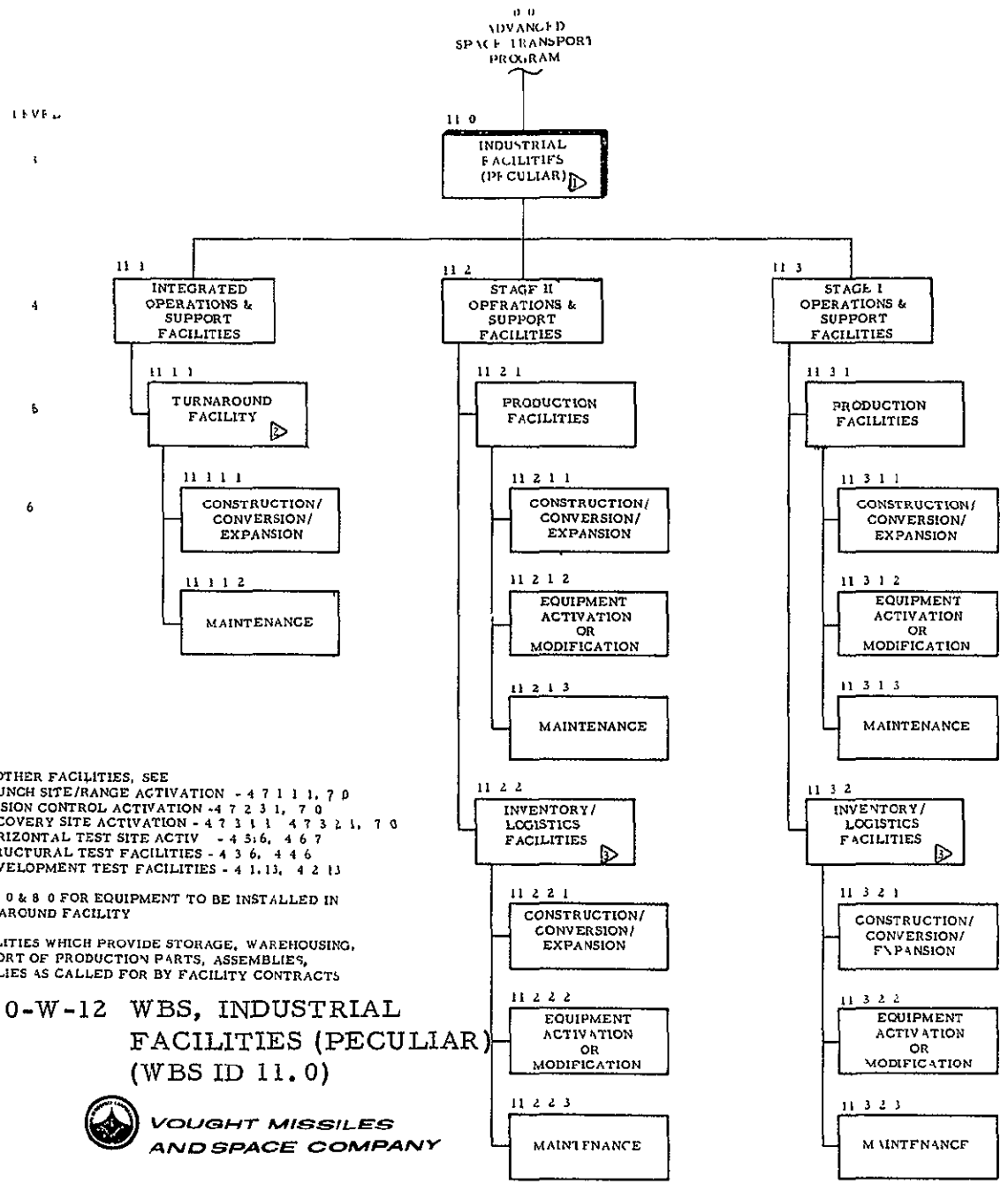


FIGURE 11.0-W-12 WBS, INDUSTRIAL FACILITIES (PECULIAR) (WBS ID 11.0)

VOUGHT MISSILES AND SPACE COMPANY

approval of Part I's, A & E drawings for the turnaround facility can be finalized and reviewed in CDR (WBS ID 11.0). Upon approval of these plans contracts can be let to construct, convert or expand existing or new facilities to satisfy the requirements. Activation of the turnaround facility will be accomplished under WBS ID 4.7.3.

IV. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 12.0

TASK TITLE OPERATIONS AND SERVICES

LEVEL 3, Project Level

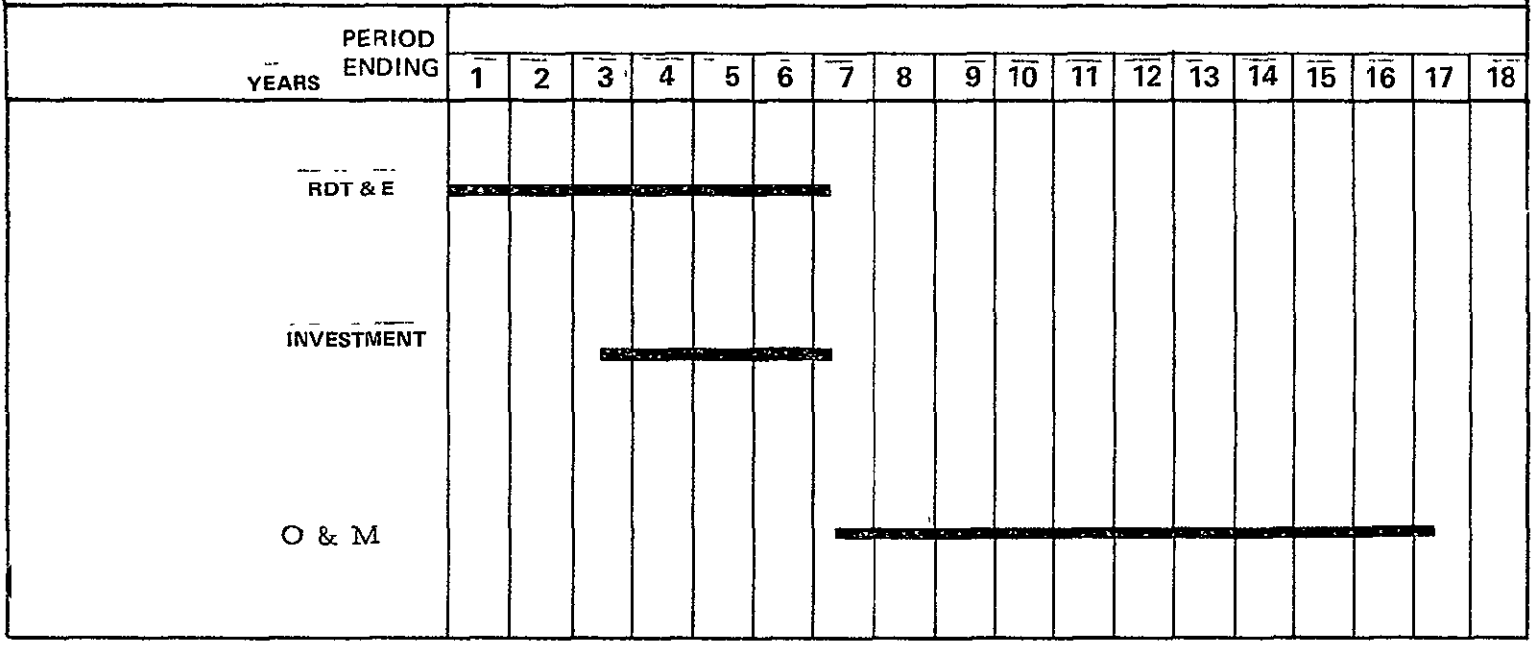
WBS DICTIONARY

I. REQUIREMENTS

NASA has specified a requirement for an Advanced Space Transport Program (Phase C/D) to develop, test and deliver Air Vehicles and support capability (ground support equipment, turnaround facilities, launch and recovery facilities, logistics support capability, flight crews and ground crews, documentation, and all other needed capability) to conduct a 10-year operations in earth to near-earth space transport of GFE payloads. The Air Vehicle is to be manned, is to be reusable, and is to be two-stage.

The operations and services phase of this program requires that payloads be delivered to and retrieved from space in accordance with the following traffic model:

TASK SCHEDULE MILESTONES



OPERATIONAL YEAR	NUMBER OF LAUNCHES/YEAR	TYPES OF MISSIONS	EPHEMERIS OF MISSIONS
1	10	. Planetary . Space Application . Astronomy Experiments . DOD . Bioscience . Space Physics . Non-NASA . Development . Astronomy	. 100 nm Alt., 28.5-33 deg. inclination . 200-270 nm Alt., 28.5-33 deg. inclination . 100 nm Alt., 55-63 deg. inclination . 270 nm Alt., 55-63 deg. inclination . 100 nm Alt., 90-100 deg. inclination
2	15		
3	20		
4	30		
5	40		
6	50		
7	60		
8	70		
9	75		
10	75		
Total Launches	445		

The launch and primary recovery sites, as well as turnaround facility, are to be in the same general vicinity. Alternate landing sites will be available for independent stage landings if required. Characteristics of the Program elements required are denoted in WBS Dictionary elements corresponding to WBS ID 1.0 through 12.0 as noted on Figure 0.0-W-2.

A requirement exists, therefore, that the Operations and Services phase of the Program implement the above Traffic Model as noted in lower levels of WBS ID 12.0 and that the preparations for 10-year Operations be carried out under Phase C/D to transition from RDT & E and Investment into Operations when IOC is available.

II. SYSTEM-LEVEL DEFINITION

Six major elements are defined at the system level to provide an operational capability. Details on these elements (see Figure 12.0-W-12) are further defined at lower levels of the WBS Dictionary.

12.1	Launch Operations and Services
12.2	Flight Operations and Services
12.3	Recovery Operations and Services
12.4	Sustaining Engineering
12.5	Payload Integration Office (Operations)
12.6	Operations and Support Management

III. FUNCTIONAL DESCRIPTION

At IOC, a capability will exist to implement the 10-year Traffic Model in accordance with Payload and/or Space activity requirements. Current planning is to have available 5 Stage II vehicles and 4 Stage I vehicles with demonstrated capability to perform the baseline and reference missions (WBS Dictionary Element 0.0, Para. IV.3).

Launch and primary recovery will be conducted at Kennedy Spacecraft Center (KSC),at Western Test Range (WTR) or at an inland site.

Flight crews will be astronauts trained in Space Transport simulators and flight test vehicles. Ground crews will be NASA or others who have been trained to handle launches, mission control, recovery and maintenance.

During each mission, surveillance, tracking and identification will be handled by the Global Range. SPADATS will be appraised of mission interfaces. FAA will be appraised of CONUS overflights which impact air traffic control. Foreign governments will be notified as required for emergency landings. DOD will be advised as to interfaces affecting remote site support.

FOLDOUT FRAME 1

FOLDOUT FRAME 2

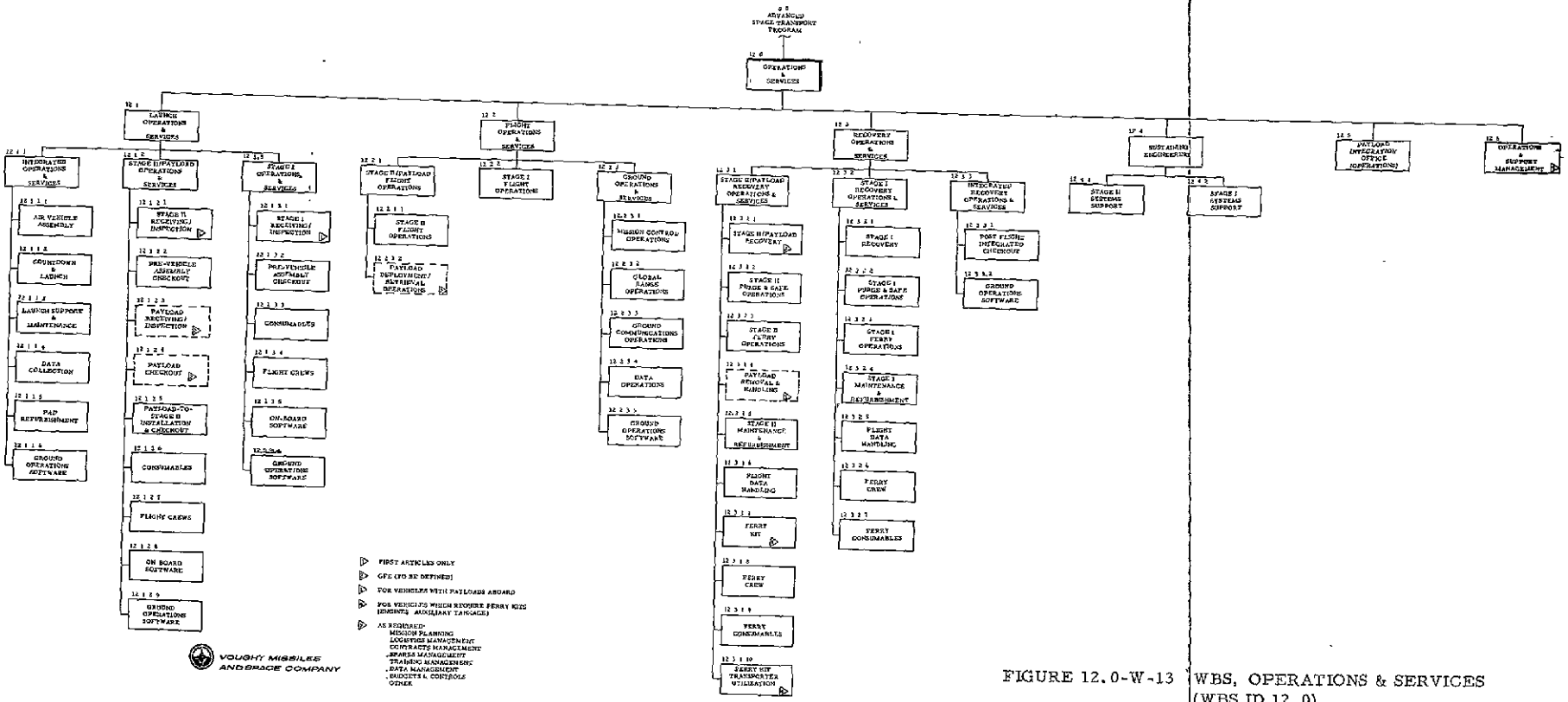


FIGURE 12.0-W-13 WBS, OPERATIONS & SERVICES (WBS ID 12.0)

A capability will exist for retrieving and supplying to the crews and mission planners needed pre-flight data of a statistical nature affecting vehicle status, previous flight histories, expected mission events, target characteristics and status, space activity, recovery status, abort tradeoffs, etc.

Real-time data will be available on conditions affecting the mission: meteorology, vehicle status, target status, air traffic, space traffic, etc.

The Payload Integration Office will handle Payload deliveries, Payload checkout, and Payload and Passenger functions preparatory to flight. Similar services will be provided for post-mission Payload handling.

Services will be provided on such factors as consumables and purging provisioning (launch site, recovery sites), quarters, personnel support, data support, parts control, storage, warehousing, housekeeping, etc.

Operations & Support Management will handle administration, mission planning, training, budgets and controls, finance, contracts administration, security, coordination, personnel, and other controls needed for operations.

Sustaining engineering will be required to handle vehicle and equipment spares and refurbishment provisioning, desired modifications, and other OEM contractor support.

Safety, reliability and other types of effectiveness factors should be monitored, both as to their effect on current operations as well as for statistical bases for future NASA or DOD programs of similar or more advanced nature.

IV. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 12.1

TASK TITLE LAUNCH OPERATIONS & SERVICES

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

A requirement will exist, in the Operations phase of the Advanced Space Transport Program, to launch the NASA Space Transport Air Vehicles at such times as GFE payloads are available or if rescue missions are required. Current requirements (WBS Dictionary Element 0.0, Para. IV) call for turn-arounds, from just-concluded missions, of less than two weeks for nominal capability and an ability to complete rescue missions (including personnel transfer) within 48 hours after notification. Other requirements call for all-azimuth launch capability, launch phasing capability for day and night rendezvous and docking with a space station, launch on time for all azimuths, and a capability to checkout the Stages in a mated and unmated configuration.

II. SUBSYSTEM-LEVEL DEFINITION

The major elements of the Operations phase Launch Operations and Services

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

are identical to those for Manned Orbital Test (WBS ID 4.7.1) at the subsystem (5th) level. At the Assembly (6th) level, the elements are essentially identical with the exception of a need for launch site activation, it being assumed that the Operations phase launch site will be activated for test and retained for Operations. If this assumption is incorrect, new launch sites will be activated under WBS ID 7.0 (see Figure 0.0-W-2) prior to Operations. If new launch sites after activated post-IOC, a need will exist to checkout these new sites prior to meeting launch rates specified in WBS Dictionary Element 12.0.

Accordingly, the subsystem (5th) level elements are:

12.1.1	Integrated Operations and Services
12.1.2	Stage II/Payload Operations and Services
12.1.3	Stage I Operations and Services

III. FUNCTIONAL DESCRIPTION

The applicable functions (see Figure 12.0-W-13) to be performed during launch operations will be similar to those defined in WBS Dictionary Element 4.7.1. New Stages (production and retrofitted flight test vehicles, FTVs) will require receiving/inspection tests after receipt from the factory. Payloads will vary and will require their own receiving/inspections, tests and standby until Stage II is ready to receive them. Flight software must be prepared in advance in accordance with payload needs. For emergency missions, flight software must to the extent feasible be quickly programmable in accordance with rescue needs. Ground software must also be preparable on short notice for emergency requirements to assist in checkouts and launches. Range software must be adaptable to support launch and flight in accordance with flexible mission needs. The Payload Integration Office (WBS ID 12.5) and Operations and Support Management office (WBS ID 12.6) must be thoroughly integrated into launch operations for needed ground personnel support, equipment readiness, spares and repair parts accessibility, flight crew and standby crew readiness, consumables availability, recovery site readiness, etc.

Specific launch plans and contingency plans will be developed during Phase C/D but will be modified during Operations as the Program matures. Further definition must await the experience of test and Operations to be more finite.

IV. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 12.2

TASK TITLE FLIGHT OPERATIONS & SERVICES

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

Operational flights will be conducted to meet Payload user needs and to perform rescue missions in accordance with nominal and emergency plans developed in Phase C/D and upgraded for IOC and for the Operations phase of the Advanced Space Transport Program. The 445-flight Baseline Traffic Model shown in WBS Dictionary Element 12.0 is representative of the missions to be flown during the Operations phase. It is required that the Space Transport Air Vehicles perform these missions on time, for all-azimuth launches, and within their design capability so as to not endanger crew, payload, target vehicle (if applicable) or range.

As noted in WBS Dictionary Element 0.0, Para. IV, payloads will vary from zero to maximum capability, mission durations from liftoff to landing may require seven days or longer, rescue missions must be completed within 48 hours from notification, launch and entry trajectories must not exceed 3 g's

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

for Stage II, and return capability must have go-around to the landing site and/or capability for power-off landings if required. Intact abort for both Stages is required.

II. SUBSYSTEM-LEVEL ELEMENTS

The major elements at the subsystem (5th) level are identical in the Operations phase to those in the Test phase (WBS ID 4.7.2) with the exception that real Payloads (WBS ID 1.2) will be aboard and trajectories will be real rather than test and demonstration. At the assembly (6th) level, all ground functions are grouped together (see Figure 12.0-W-13 for Operations and Figure 4.0-W-5 for Test).

Accordingly, these elements are:

12.2.1 Stage II/Payload Flight Operations
12.2.2 Stage I Flight Operations
12.2.3 Ground Operations and Services

FUNCTIONAL DESCRIPTION

Flight profiles from liftoff to stage separation for the Air Vehicle (WBS ID 1.0) are expected to be identical for Operations to those of Test with the variance being liftoff weight (function of Payload weight, launch azimuth and mission duration) and ascent maneuvers to program the Vehicle onto the desired azimuth at separation. Follow separation, the Stage I vehicle will return to the launch site for refurbishment and preparation for the next mission. Stage II and its payload (may be zero on certain missions) will continue to the injection orbit, circularize to deploy free payloads or translate to target altitudes for rendezvous and docking and/or to deploy free payloads as required. Upon mission completion, Stage II will deorbit and reenter to the selected landing site based upon ground cues. Upon landing and cleanup, including payload and data removal, Stage II will return to the launch site for refurbishment and preparation for the next mission. For major engine overhauls and major refurbishment, downtimes can be minimized by having adequate, checked out spares and repair parts on hand. These latter functions

are part of WBS ID 12.3, but affect WBS 12.2 capability to perform flight operations safely and with minimum equipment failures.

During flight operations, communications with ground control can keep the flight crew appraised of any mission changes including landing site status (weather, equipment problems, heavy traffic, etc.). If a Comsat is available for relay of communications, on-board capability should be used to ensure communications is constant when the Stage is normally out of contact with ground transceivers.

IV. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO 12.3

TASK TITLE RECOVERY OPERATIONS & SERVICES

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

Recovery operations and services for the Operations phase will be required to handle five Stage II vehicles and four Stage I vehicles (current concept) so as to meet the two-week turnaround requirement as well as 48-hour rescue requirement called for in WBS Dictionary Element 0.0, Para. IV. To meet these requirements, a flexible recovery capability (emergency plus normal logistics support) must be on standby, or each alternate landing site (and emergency support base) must be stockpiled with needed ground handling capability (purge, safing, payload/passenger/crew/data handling) including as-called for spares. Experience will resolve this tradeoff.

At the turnaround facility, organizational, intermediate and depot level maintenance must be available to handle scheduled and unscheduled maintenance on engines, batteries, thermal protection components and assemblies, seals, bearings, pumps, valves, tires, brakes, expendables, etc. as well

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

as take care of crew station cleanup, lighting maintenance, filter replacements, and handling maintenance requirements resulting from flight records and ground operations maintenance monitoring.

II. SUBSYSTEM-LEVEL DEFINITION

The major subsystem (5th) level elements for operational Recovery Operations and Services are essentially identical to those for Test (WBS ID 4.7.3) except that real Payloads will be aboard recovered Stage II's. At the assembly (6th) level, operations will be similar to those reported in WBS Dictionary Element 4.7.2. Accordingly, subsystem (5th) level elements are (see Figure 12.0-W-13):

12.3.1 Stage II/Payload Recovery Operations and Services
12.3.2 Stage I Recovery Operations and Services
12.3.3 Integrated Recovery Operations and Services

III. FUNCTIONAL DESCRIPTION

The descriptions provided in WBS Dictionary Element 4.7.3, Paras. III and IV, are applicable to Operations as well as to Test, except that Recovery Site activation and Turnaround Facility activation are assumed to have occurred for Test and/or to have occurred under WBS ID 7.0 if new operational recovery sites are required.

IV. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 12.4

TASK TITLE SUSTAINING ENGINEERING

LEVEL 4, Subsystem Level

WBS DICTIONARY

I. REQUIREMENTS

To maintain a 10-year Operations capability, NASA may choose to retain a Sustaining Engineering effort to support spares provisioning, change engineering and other contractor support for Stage II and Stage I during the Operations phase. If this capability is required, contracts to this effect will be let prior to IOC to preserve critical tooling, documentation, and contractor engineering and services support to transition into Operations from the RDT & E plus Investment phases of the Program.

II. SUBSYSTEM-LEVEL DEFINITION

Assuming Sustaining Engineering is required, two major elements are identified at the subsystem (5th) level. These include support for Stage II vehicles and ground support equipment and for Stage I vehicles and ground support equipment. Other potential support elements may include GFE Main Engines,

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

Integration, and any other GFE equipments which are not expected to be readily off-the-shelf or available from Government stores. Consumables and ground services which were not CFE for RDT & E and Investment can probably best be handled by Operations and Support Management (WBS ID 12.6). Payload Integration may be handled by the Payload Integration Office (WBS ID 12.5), assigned to an Integration Contractor, or assigned to Stage II Sustaining Engineering. At this time, Figure 12.0-W-13 identifies only two major elements at the subsystem (5th) level.

12.4.1 Stage II Systems Support
12.4.2 Stage I Systems Support

III. FUNCTIONAL DESCRIPTION

Stage II and Stage I Systems Support may be required in the Operations phase of the Advanced Space Transport Program to provide spares support, engineering change capability, training support, data support, major vehicle mod programs, research support, etc. The decision for this will need to be made during Phase C/D at that point prior to IOC when: (1) tooling dispositions must be made; (2) test setups dispositions must be reviewed; (3) mockups and simulators dispositions must be considered; and (4) other production or support capabilities generated for RDT & E and investment must be analyzed for continuing need into the Operations phase. At such points in the Program, need for Sustaining Engineering can be resolved. Further definitions of need must, then, await Phase C/D evaluation for further clarification on these decisions.

IV. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 12.5

TASK TITLE PAYLOAD INTEGRATION OFFICE (OPERATIONS)

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

A need will exist during the Operations phase of the Advanced Space Transport Program to integrate GFE Payloads (WBS ID 1.2),with Stage II(WBS ID 1.3) and with Stage I (WBS ID 1.4) as well as with affected launch equipment (WBS ID 2.5/2.7) and recovery equipment (WBS ID 2.6/3.0/8.0). This need will be met through transitioning the Payload Integration functions for RDT & E (WBS ID 5.5) into an as-required capability for Operations.

II. SUBSYSTEM-LEVEL DEFINITION

Functionally, Payload Integration for the Operations phase can be broken into types of Payloads (Planetary, Space Application, Astronomy Experiments, DoD, Bioscience, Space Physics, Non-NASA, Development, Astronomy, etc.) or into types of users (Government, Colleges and Universities, Foreign, Commercial, etc.). No attempt will be made at this time to partition this

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SHCEDULES

Office.

III. FUNCTIONAL DESCRIPTION

The value and utility to NASA in establishing a Payload Integration Office (Operations) as a follow-on to such an office for development of the Space Transport vehicle and support will be in having an engineering and administrative office to integrate payloads into the Space Transport Program which: (1) are compatible with capability of the Transport Vehicle and ground support, (2) make maximum use of ground handling and checkout capability already developed, and (3) can act to program and schedule missions sufficiently in advance so as to not degrade existing schedules and capabilities which are inherent in the as-procured on-going Program. Additionally, the Payload Integration Office will have become thoroughly familiar with Advanced Space Transport Program development history, hardware and software capability and missions capability and can act to procure Payloads which are within the spectra of capability provided by the Space Transport systems.

Further definition of the functions of this Office must await Phase C/D maturity as well as capability to support space bases, space stations and payloads which evolve to utilize the Space Transport potential.

IV. REFERENCES

(To be added.)

VOUGHT MISSILES AND SPACE COMPANY

PROGRAM TITLE ADVANCED SPACE TRANSPORT PROGRAM

WBS NO. 12.6

TASK TITLE OPERATIONS & SUPPORT MANAGEMENT

LEVEL 4, System Level

WBS DICTIONARY

I. REQUIREMENTS

A NASA Program Office will be required for the Operations phase of the Advanced Space Transport Program to administer and manage the Operations and Support functions associated with Space Transport launches and recoveries, provide contracts for services and consumables, and handle the business and technical end of this Program.

II. SUBSYSTEM-LEVEL DEFINITION

Delineation of the organization which will comprise the Operations and Support Management Office, Advanced Space Transport Program, is a NASA responsibility.

TASK SCHEDULE MILESTONES

PERIOD ENDING

SEE HIGHER LEVELS FOR DETAIL SCHEDULES

III. FUNCTIONAL DESCRIPTION

The Operations and Support Management Office will handle the technical and administrative functions associated with 10-year operations of the Advanced Space Transport Program. Types of functions which this office is anticipated to handle include the following:

. Mission Planning	Vehicle assignments vs Payloads, trajectories, provisioning, schedules, support requirements, software programming, contingency plans, crew selection, statistical data retrieval and analysis, security, etc.
. Logistics Management	Ferry Kit Transport Aircraft availability and assignments, consumables provisioning, spares provisioning, GSE assignments, recovery force planning, recovery site stockpiling, etc.
. Contracts Management	Sustaining Engineering contracts, Payload User contracts, Range Support contracts, research and development consultation, consumables contracts, Logistics Support contracts, facility contracts, maintenance contracts, housekeeping contracts, supplies and expendables contracts, sub-contracting, etc.
. Spares Management	Spares and repair parts procurement, provisioning, receiving/inspection, storage, accountability, reliability and maintainability records, etc.
. Training Management	Flight and ground crew training, proficiency testing, personnel records, mockup and simulator operations and services, health records, etc.
. Data Management	Data acquisition, processing, storage, retrieval, and analysis as required per user request.

Budget & Controls	Business management of the Advanced Space Transport Program Operations. Budget requests support. Accounting. Program controls and procedures. Etc.

IV. REFERENCES

(To be added.)

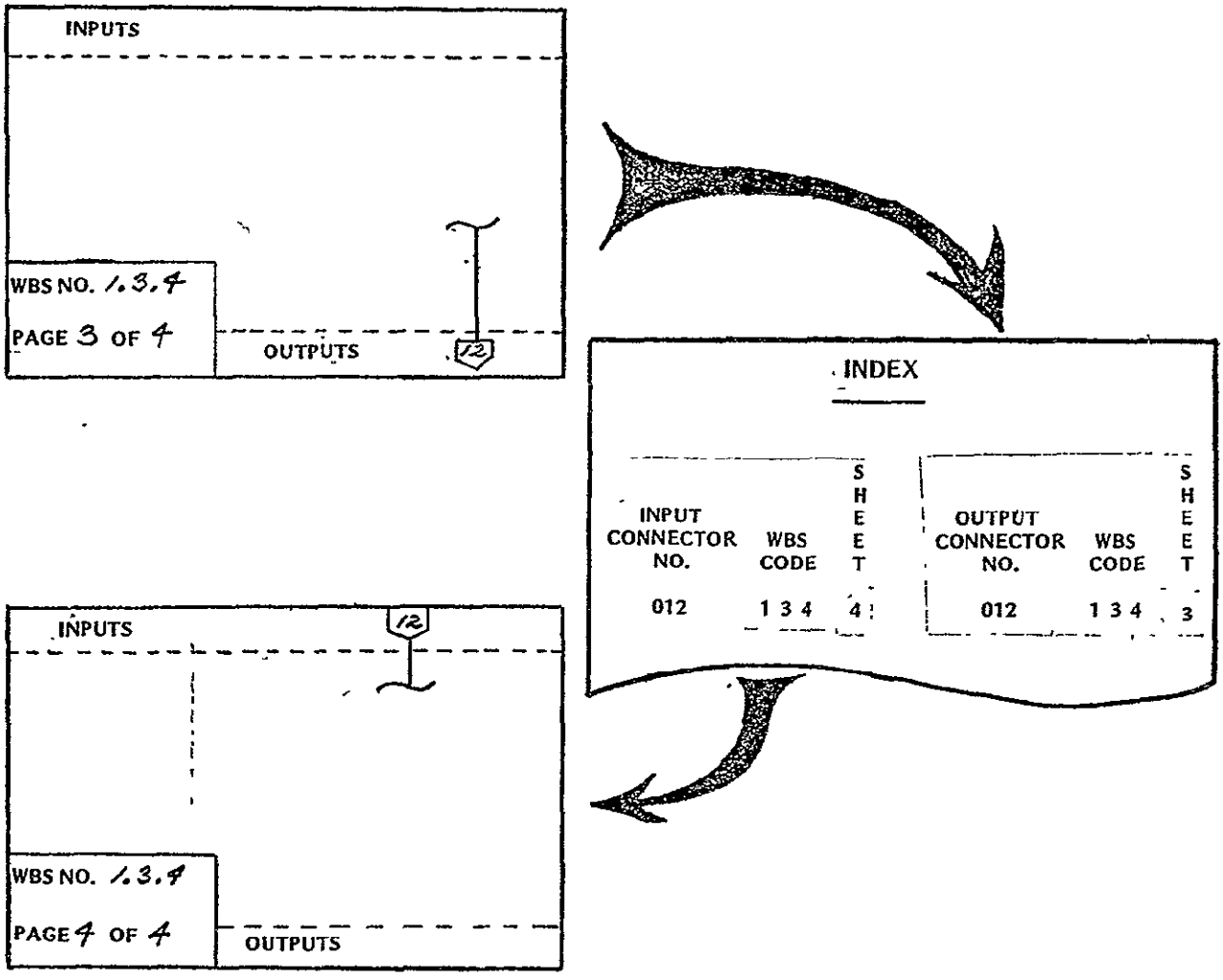
APPENDIX

APPENDIX A

LOGIC DIAGRAM CONNECTOR INDEX

The trail of logic between WBS elements may be traced by using the alpha-numeric, input/output connectors and the following index as shown below:

SAMPLE



LOGIC SHEET MASTER INDEX OF INPUTS/OUTPUTS

INPUT CONNECTOR NUMBERS	W	B	S	E	SHEET
	C	O	D	E	T
001	0	0	0	2	
002	0	0	0	2	
003	0	0	0	2	
004	0	0	0	2	
005	0	0	0	3	
006	0	0	0	3	
007	0	0	0	3	
008	0	0	0	3	
009	0	0	0	3	
010	0	0	0	3	
011	0	0	0	3	
012	1	3	4	4	
013	1	3	4	4	
014	1	3	4	4	
015	1	3	4	4	
016	1	3	6	2	
017	1	3	7	2	
018	1	4	6	2	
019	1	4	7	2	
020	3	2	5	1	
021	3	2	5	1	
022	3	2	5	1	
023	3	2	5	1	
024	3	2	5	1	
025	3	2	5	1	
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028	3	2	5	2	
029	3	2	5	2	
030	3	2	5	2	
031	3	2	5	2	
032	3	2	5	2	
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034	3	4	5	1	
035	3	4	5	1	
036	3	4	5	1	
037	3	4	5	1	
038	3	4	5	1	
039	3	4	5	2	
040	3	4	5	2	
041	3	4	5	2	
042	3	4	5	2	
043	3	4	5	2	
044	4	1	8	1	
045	4	1	8	1	
046	4	1	8	1	
047	4	1	8	1	
048	4	1	8	2	
049	4	1	8	2	
050	4	2	8	1	
051	4	2	8	1	
052	4	2	8	2	
053	4	2	8	2	
060	5	1	5	1	
080	5	3	5	1	

OUTPUT CONNECTOR NUMBERS	W	B	S	E	SHEET
	C	O	D	E	T
001	0	0	0	1	
002	0	0	0	1	
003	0	0	0	1	
004	0	0	0	1	
005	0	0	0	2	
006	0	0	0	2	
007	0	0	0	2	
008	0	0	0	2	
009	0	0	0	2	
010	0	0	0	2	
011	0	0	0	2	
012	1	3	4	3	
012	1	3	4	3	
012	1	3	4	3	
013	1	3	4	3	
013	1	3	4	3	
013	1	3	4	3	
014	1	3	4	3	
015	1	3	4	3	
016	1	3	6	1	
017	1	3	7	1	
018	1	4	6	1	
019	1	4	7	1	
020	5	1	6	1	
021	5	1	6	1	
022	5	1	6	1	
023	5	1	6	1	
024	5	1	6	1	
025	5	1	6	2	
026	5	1	6	2	
027	5	1	6	2	
028	5	1	6	1	
029	5	1	6	2	
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031	5	1	6	1	
032	5	1	6	2	
033	5	3	6	1	
034	5	3	6	1	
035	5	3	6	1	
036	5	3	6	2	
037	5	3	6	1	
038	5	3	6	2	
039	5	3	6	1	
040	5	3	6	2	
041	5	3	6	1	
042	5	3	6	1	
043	5	3	6	2	
044	1	3	4	2	
045	1	3	4	2	
046	1	3	4	2	
047	1	3	4	2	
048	1	3	4	1	
049	1	3	4	1	
050	1	4	4	1	
051	1	4	4	1	

061	5 5 3 2		062	1 4 4 2
061	10 1 2 1		063	1 4 4 2
061	10 3 2 1		060	5 5 1 1
A00	0 0 0 1		061	5 5 2 1
A00	4 8 1 1		001	4 1 4 1
A00	4 8 2 1		001	4 2 4 1
A00	4 8 3 1		B01	4 8 1 1
A00	4 8 4 1		B01	4 8 2 1
A00	4 8 5 1		001	4 8 3 1
A00	4 8 6 1		B01	4 8 4 1
A00	4 9 1 1		B01	4 8 5 1
A00	4 9 2 1		B01	4 8 6 1
A00	4 9 3 1		B01	4 9 1 1
A00	4 9 4 1		B01	4 9 2 1
A00	4 9 5 1		B01	4 9 3 1
A00	4 9 6 1		B01	4 9 4 1
A00	5 1 1 1		B01	4 9 5 1
A00	5 1 2 1		001	4 9 6 1
A00	5 1 5 1		B01	5 1 1 1
A00	5 3 1 1		B01	5 1 2 1
A00	5 3 5 1		001	5 1 5 1
A00	5 5 2 1		001	5 3 1 1
A00	5 5 3 1		B01	5 3 2 1
A00	5 5 3 1		B01	5 3 3 1
A00	5 5 3 2		B02	1 3 5 2
A00	5 6 2 1		B02	1 4 5 2
A00	10 1 3 1		B02	5 5 2 1
A00	10 3 2 1		B02	5 6 2 1
A00	10 3 3 1		B04	5 1 2 1
B01	1 3 5 2		B05	5 5 1 1
B01	1 4 5 2		B09	5 1 1 1
B01	4 113 1		B09	5 1 5 1
B01	4 113 1		B13	1 3 5 2
B01	4 213 1		B13	1 4 5 2
B01	4 213 1		B13	5 1 2 1
B01	5 1 5 1		B13	5 3 2 1
B01	5 3 5 1		B13	5 5 1 1
B01	5 5 1 1		B13	5 5 2 1
B01	5 5 2 1		B15	5 3 1 1
B01	5 5 3 1		B15	5 3 5 1
B01	5 5 3 1		C01	5 5 3 1
B01	5 5 3 2		C02	5 5 3 1
B01	10 1 1 1		C03	5 5 3 1
B01	10 1 3 1		C04	5 1 5 1
B01	10 3 1 1		C05	5 5 3 1
B01	10 3 3 1		C06	5 5 3 1
B02	1 3 8 1		C09	5 1 5 1
B02	1 313 1		C10	5 3 5 1
B02	1 413 1		C11	5 1 5 1
B02	5 1 1 1		C12	5 3 5 1
B02	5 1 2 1		C15	5 1 5 1
B02	5 1 3 1		C16	5 3 5 1
B02	5 3 1 1		C17	5 1 5 1
B02	5 3 2 1		C18	5 3 5 1
B02	5 3 3 1		C19	5 1 5 1
B02	5 5 1 1		C20	5 3 5 1
B02	5 5 3 2		C39	5 1 5 1
B04	5 5 2 1		C40	5 3 5 1
B05	5 5 2 1		C41	5 1 5 1
B09	4 113 1		C42	5 3 5 1
B13	1 3 8 1		C45	5 1 6 1
B13	10 1 1 1		C45	10 1 1 1
B13	10 3 1 1		C46	5 3 6 1

B15	4	2	1	1	C45	10	3	4	1
C01	1	3	4	1	C49	5	1	6	1
C01	3	1	2	2	C50	5	3	6	1
C01	5	1	6	1	C53	5	1	6	1
C02	1	4	4	1	C54	5	3	6	1
C02	3	1	2	2	C55	1	313		1
C02	5	3	6	1	C56	1	413		1
C03	1	3	4	3	C6U	5	3	6	1
C03	5	1	6	1	D06	1	3	4	2
C04	1	3	4	2	D10	1	3	4	2
C04	3	1	2	3	D17	1	3	4	1
C04	5	1	6	1	D17	1	3	4	2
C05	1	4	3	1	D17	1	3	4	3
C06	1	3	6	1	D17	1	3	5	1
C08	3	2	2	1	D17	1	3	6	2
C09	3	2	6	1	D17	1	3	8	1
C09	5	1	6	2	D17	1	3	9	1
C10	3	4	2	1	D17	1	310		1
C10	3	4	6	1	D17	1	311		1
C10	5	3	6	2	D17	1	312		1
C11	1	3	8	1	D17	1	4	4	1
C11	3	3	3	1	D17	1	4	4	2
C11	5	1	6	1	D17	1	4	5	1
C12	1	4	8	1	D17	1	4	6	2
C12	3	5	3	1	D17	1	4	8	1
C12	5	3	6	1	D17	1	4	9	1
C15	1	310		1	D17	1	410		1
C15	5	1	6	2	D17	1	411		1
C16	1	410		1	D17	1	412		1
C16	5	3	6	1	D17	5	1	6	1
C17	1	3	6	1	D17	5	3	6	1
C17	5	1	6	2	D17	5	5	1	1
C18	1	4	6	1	D17	10	1	1	1
C18	5	3	6	1	D17	10	3	1	1
C19	1	3	5	1	D29	5	1	1	1
C19	5	1	6	2	D30	5	3	1	1
C20	1	4	5	1	D65	5	3	6	1
C20	5	3	6	2	D7U	10	3	1	1
C39	1	3	9	1	D71	10	1	1	1
C39	5	1	6	2	F01	8	2	0	1
C40	1	4	9	1	F01	10	1	1	1
C40	5	3	6	2	F01	10	1	1	1
C41	1	3	2	1	F01	10	1	3	1
C41	5	1	2	1	F02	8	4	0	1
C41	5	1	6	1	F02	10	3	1	1
C42	1	4	2	1	F02	10	3	1	1
C42	5	3	2	1	F02	10	3	3	1
C42	5	3	6	1	F09	10	1	2	1
C45	1	3	5	2	F10	10	3	2	1
C45	5	1	1	1	G03	1	3	2	1
C45	5	5	3	2	G03	1	3	4	1
C45	10	1	4	1	G03	1	3	5	2
C46	1	4	5	2	G03	1	310		2
C46	5	3	1	1	G04	1	4	2	1
C46	5	5	3	2	G04	1	4	4	1
C46	10	3	4	1	G04	1	4	5	2
C49	1	3	7	1	G04	1	410		2
C49	5	1	6	2	G07	1	3	4	1
C50	1	4	7	1	G08	1	4	4	1
C50	5	3	6	2	G09	1	3	2	1
C53	1	311		1	G09	3	1	2	2
C53	1	312		1	G10	1	4	2	1
C53	1	313		1	G10	3	1	2	2

C53	5	1	6	1	G11	4	113	1
C54	1	411		1	G12	4	214	1
C54	1	412		1	G31	1	3	5	2
C54	1	41[illegible]			G31	1	310	2
C54	5	3	6	1	G32	1	4	5	2
C55	1	311		1	G32	1	410	2
C55	1	312		1	G41	1	3	4	2
C55	5	1	6	1	G41	1	3	4	2
C56	1	411		1	G41	1	3	4	2
C56	1	412		1	G41	1	3	4	2
C56	5	3	6	1	G48	1	3	4	2
C60	1	4	4	2	G57	3	3	3	1
C60	3	1	2	3	G58	3	5	3	1
C60	5	3	6	1	GF2	1	4	2	1
D08	4	1	8	1	GF2	1	4	5	1
D10	4	1	8	1	GF2	3	4	5	1
D17	1	3	2	1	GF2	5	3	1	1
D17	1	3	5	2	GF2	5	5	3	2
D17	1	4	2	1	GF2	8	4	0	1
D17	1	4	5	2	GF3	1	3	2	1
D17	5	1	5	1	GF3	1	3	5	1
D17	5	3	5	1	GF3	3	4	5	1
D29	1	3	5	2	GF3	5	1	1	1
D30	1	4	5	2	GF3	5	5	3	2
D65	8	4	0	1	GF3	8	2	0	1
D70	8	4	0	1	GH1	1	3	2	1
D71	8	2	0	1	GH1	8	2	0	1
F01	10	1	2	1	GH2	1	4	2	1
F02	10	3	2	1	GH2	8	4	0	1
F09	10	1	3	1	GK7	1	3	2	1
F10	10	3	3	1	GK8	1	4	2	1
G03	4	1	8	2	GP8	5	3	6	1
G04	4	2	8	1	GP9	5	1	6	1
G07	4	1	8	2	H00	1	3	0	1
G08	4	2	8	1	H00	1	3	2	1
G09	1	3	4	1	H00	1	3	4	1
G10	1	4	4	1	H00	1	3	4	2
G11	3	1	2	2	H00	1	3	4	3
G12	3	1	2	2	H00	1	3	5	1
G31	1	3	4	4	H00	1	3	6	1
G32	1	3	4	4	H00	1	3	7	1
G41	4	1	8	1	H00	1	3	8	1
G48	4	1	8	1	H00	1	3	9	1
G57	1	3	8	1	H00	1	310	1
G58	1	4	8	1	H00	1	311	1
GF2	1	4	5	2	H00	1	4	0	1
GF2	10	3	2	1	H00	1	4	2	1
GF2	10	3	4	1	H00	1	4	4	1
GF3	1	3	5	2	H00	1	4	4	2
GF3	10	1	2	1	H00	1	4	5	1
GF3	10	1	4	1	H00	1	4	6	1
GH1	4	3	2	1	H00	1	4	7	1
GH2	4	4	2	1	H00	1	4	8	1
GK7	1	3	4	3	H00	1	4	9	1
GK8	1	3	4	3	H00	1	410	1
GP8	8	4	0	1	H00	1	411	1
GP9	8	2	0	1	H00	5	1	3	1
H00	1	310		2	H00	5	1	5	1
H00	1	410		2	H00	5	1	5	1
H00	3	2	5	1	H00	5	1	6	1
H00	3	4	6	1	H00	5	1	6	1
H00	4	5	6	1	H00	5	1	6	1
H00	4	6	6	1	H00	5	1	6	1

H05	5	5	2	1	H06	5	1 6 1
H05	10	1	1	1	H06	5	1 6 1
H06	10	3	1	1	H06	5	1 6 1
H07	1	3	6	1	H06	5	1 6 2
J09	1	4	8	1	H06	5	1 6 2
J10	1	4	8	1	H06	5	1 6 2
J10	10	1	4	1	H06	5	1 6 2
J10	10	3	4	1	H06	5	1 6 2
K01	1	3	1	1	H06	5	3 3 1
K02	1	4	1	1	H06	5	3 5 1
K05	1	3	1	1	H06	5	3 5 1
K05	1	4	1	1	H06	5	3 6 1
K07	1	3	1	1	H06	5	3 6 1
K07	1	4	1	1	H06	5	3 6 1
K10	4	1	8	1	H06	5	3 6 1
K14	4	1	8	1	H06	5	3 6 1
K16	1	3	4	2	H06	5	3 6 1
K17	3	1	2	3	H06	5	3 6 1
K21	1	3	1	1	H06	5	3 6 2
K22	1	4	1	1	H06	5	3 6 2
K27	1	31	0	2	H06	5	3 6 2
K28	1	41	0	2	H05	1	3 5 2
K29	1	3	6	2	H05	10	1 4 1
K30	1	4	6	2	H06	1	4 5 2
K33	4	1	6	1	H06	10	3 4 1
K33	4	1	7	1	H07	1	313 1
K33	4	3	3	1	H07	1	413 1
K34	4	2	6	1	J09	1	3 6 1
K34	4	2	7	1	J10	1	3 8 1
K34	4	4	3	1	K01	3	2 5 1
K95	8	2	0	1	K01	4	1 6 1
K95	8	4	0	1	K01	8	2 0 1
K96	8	4	0	1	K02	3	4 5 1
K97	8	2	0	1	K02	3	4 5 1
K98	8	2	0	1	K02	4	2 8 1
KA2	4	2	8	2	K02	8	4 0 1
KA4	4	2	8	2	K02	8	4 0 1
KA5	1	4	4	2	K05	3	2 5 1
KA6	3	1	2	3	K05	8	2 0 1
KB3	8	2	0	1	K07	3	2 5 1
KB4	8	4	0	1	K07	8	2 0 1
KB5	8	2	0	1	K10	1	3 4 2
KB6	8	4	0	1	K10	1	3 5 2
KB7	8	2	0	1	K10	1	310 2
KB8	8	4	0	1	K14	1	3 2 1
KC1	8	2	0	1	K14	1	3 4 2
KC2	8	4	0	1	K14	1	3 5 2
KC3	8	2	0	1	K14	1	310 2
KC4	8	4	0	1	K16	3	1 2 3
KC5	8	2	0	1	K17	4	113 1
KC6	8	4	0	1	K21	1	3 2 1
KC7	8	2	0	1	K21	1	3 2 1
KC8	8	4	0	1	K21	1	3 5 2
KC9	8	2	0	1	K21	1	3 6 2
M01	1	3	1	1	K21	1	3 7 1
M02	1	4	1	1	K21	1	3 7 2
M03	3	2	2	1	K21	1	3 8 1
M04	3	4	2	1	K21	1	3 9 1
M09	3	2	2	1	K21	1	3 9 1
M10	3	4	2	1	K21	1	310 2
M23	3	2	2	1	K21	1	311 1
M24	3	4	2	1	K21	1	312 1
M25	8	2	0	1	K21	3	2 5 1

N26	8	4	6	1	K21	3	6	5	2
N01	4	5	4	1	K21	3	6	5	2
N02	4	6	4	1	K21	3	4	5	2
N03	4	5	3	1	K21	8	6	0	1
N04	4	6	3	1	K21	8	6	0	1
N05	1	3	1	1	K21	8	6	0	1
N06	1	4	1	1	K21	8	6	0	1
N07	4	5	4	1	K21	8	2	0	1
N08	4	6	4	1	K22	1	4	2	1
N09	4	5	3	1	K22	1	4	6	1
N10	4	6	3	1	K22	1	4	5	2
Q01	4	5	6	1	K22	1	4	6	2
Q02	4	6	6	1	K22	1	4	7	1
Q03	4	5	6	1	K22	1	4	7	2
Q04	4	6	6	1	K22	1	4	8	1
Q05	4	5	1	1	K22	1	4	9	1
Q06	4	6	1	1	K22	1	4	9	1
Q09	10	1	2	1	K22	1	410	2
Q10	10	3	2	1	K22	1	411	1
R01	4	5	6	1	K22	1	412	1
R02	4	6	6	1	K22	3	4	5	1
S00	4	5	6	1	K22	3	4	5	1
S00	4	6	6	1	K22	3	4	5	2
S00	4	7	1	1	K22	3	4	5	2
S02	2	5	3	1	K22	3	4	5	2
S02	3	1	2	1	K22	8	4	0	1
S02	4	7	1	1	K22	8	4	0	1
S04	4	7	1	1	K22	8	4	0	1
S06	3	1	3	1	K22	8	4	0	1
S07	5	5	5	2	K22	8	4	0	1
S20	8	1	0	1	K27	1	310	1
T01	4	7	1	1	K27	3	2	5	2
T02	4	7	1	1	K27	3	2	5	2
T05	4	5	6	1	K27	8	2	0	1
T06	4	6	6	1	K28	1	410	1
T07	4	5	6	1	K28	3	4	5	2
T08	4	6	6	1	K28	8	4	0	1
T09	4	5	6	1	K29	1	3	6	1
T10	4	6	6	1	K29	1	3	6	1
T13	4	5	6	1	K30	1	4	6	1
T14	4	6	6	1	K30	1	4	6	1
T15	4	5	1	1	K33	4	3	2	1
T16	4	6	1	1	K34	4	4	2	1
W00	4	7	1	1	K95	5	1	6	1
W03	4	7	1	1	K96	5	3	6	1
X00	4	7	1	1	K97	5	1	6	1
Y00	4	7	2	1	K98	5	1	6	1
Z01	4	7	5	1	KA2	1	4	4	2
Z02	4	7	3	1	KA4	1	4	2	1
Z07	4	7	5	1	KA4	1	4	4	2
Z08	4	7	5	1	KA4	1	4	5	2
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					KA5	1	4	2	1
					KA5	3	1	2	3
					KA6	4	213	1
					KB3	5	1	6	1
					KB4	5	3	6	1
					KB5	5	1	6	2
					KB6	5	3	6	1
					KB7	5	1	6	2
					KB8	5	3	6	1
					KC1	5	1	6	2
					KC2	5	3	6	2

KC3	5	1	6	2
KC4	5	3	6	2
KC5	5	1	6	2
KC6	5	3	6	2
KC7	5	1	6	1
KC8	5	3	6	1
KC9	5	1	6	1
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M01	1	3	4	1
M01	1	3	4	2
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M02	1	4	9	1
M02	1	4	9	1
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Q03	4	5	1	1

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Q06	5	5	2	1
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Q10	10	3	1	1
Q10	10	3	4	1
R01	1	3	8	1
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W03	5	5	2	1
X00	1	3	8	1
X00	1	4	8	1
Y00	1	3	8	1
Y00	1	4	8	1
Y00	4	7	1	1
Z01	4	7	2	1

~~Z02~~ 4 7 2 1
Z07 10 1 2 1
Z08 10 3 2 1

COMPARISON
TERs VS CONVENTIONAL
SCHEDULES/LOGIC

FOLDOUT FRAME 1

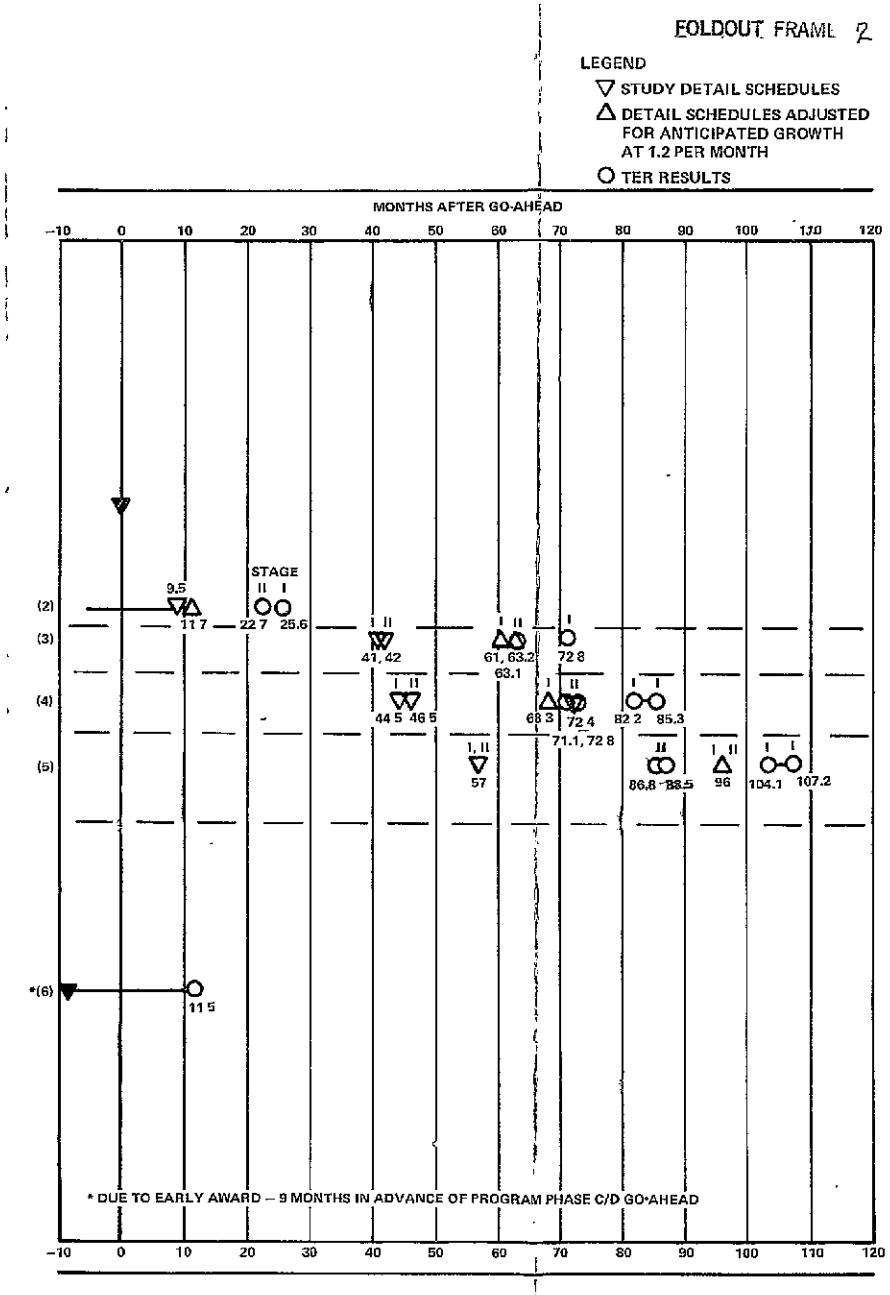
APPENDIX B

COMPARISON OF TER RESULTS WITH DETAIL SCHEDULE/LOGIC RESULTS

Time Estimating Relationships intersect logic and schedules at those points indicated below and within the respective WBS elements. The points of intersection shown below are also identified on those schedules and logic charts containing the particular TER event.

TER Number & Description	Point	WBS	Particular TER Event
7.6 Total Program			Phase C/D go-ahead. Note this point is identified as "go-ahead" or "A00" on logic and schedules.
	(1)		Total program 95% airborne engineering design release.
	(2)		Start detail fabrication.
	(3)	4.5.3.0 0 4.6.3 0.0	Rollout first horizontal flight test vehicle.
(7.7) Horizontal Flight Test	(4)	4.5.6.0.0 4.6 6.0.0	Start horizontal flight testing.
	(5)	4.5.6.0.0 4.6.6.0.0	Complete horizontal flight testing, i.e , obtain sufficient data/confidence to commence vertical flight test phase vehicles 1 and 2.
7 2 Liquid Rocket Engines			Go-ahead for the main engine contract. Note – This point precedes Phase C/D go-ahead and is not shown on logic or schedules.
	(6)	5 1 1.0.0 5.3 1.0 0	Completion of the first main engine test Note – This point and the inherent data contribute to the engine trade-off studies for both Stage 1 (5.3.1.0 0) and Stage 2 (5.1.1 0.0)

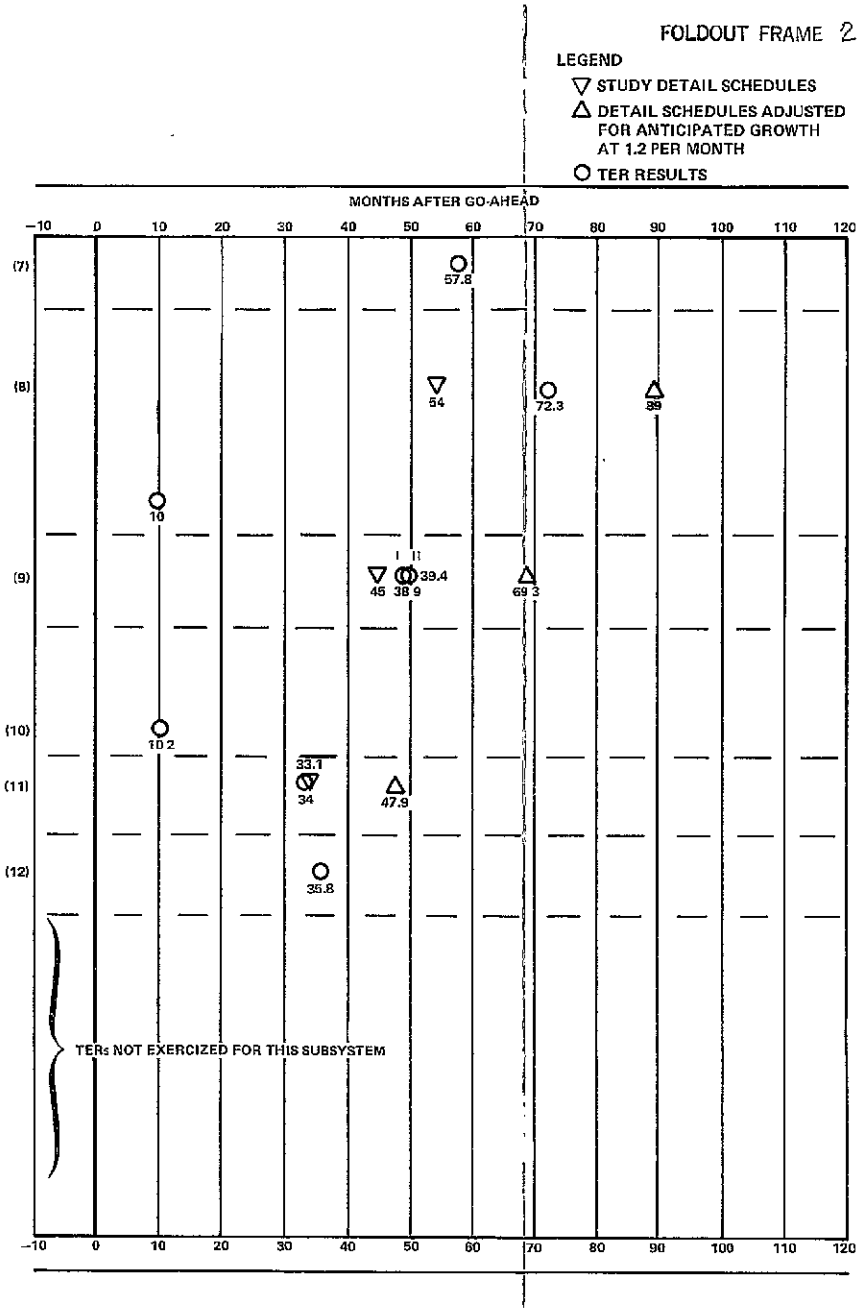
FOLDOUT FRAME 2



FOLDOUT FRAME 1

TER Number & Description	Point	WBS	Particular TER Event
	(7)	4.1 8.0 0 4.2.8 0 0	Single engine PFRT. Recall the logic displays this point admittedly redundantly for both Stage 1 (4.2.8 0 0) and Stage 2 (4.1.8.0.0).
	(8)	4 1.8.0.0 4.2.8.0.0	Single engine qualification testing complete. Same remarks as above.
7.4 Small Gas Turbine Engines			Go-ahead for auxiliary power unit. Note — This point is not shown on logic or schedules. Includes 10 months for vendor selection.
	(9)	1.3 6.0.0 1 4 6 0 0	Qualification of auxiliary power unit as necessary to deliver units to program for Stage 1 (1.4.6.0.0) and Stage 2 (1.3 6.0 0)
7.3 Avionics			Phase C/D go-ahead. Note — This point is identified as "go-ahead" or "A00" on logic and schedules
	(10)	1.3.10.0.0 1.4.10.0.0	Go-ahead to the vendor for the largest, most complex black box.
	(11)	1.3.10.0.0 1.4 10.0.0	Receipt of the first black box for buildup/ assembly of the data management hardware.
	(12)	1.3.10.0.0 1 4.10 0.0	Receipt of the last black box, thereby completing hardware buildup/assembly.
7.3 Avionics			Phase C/D go-ahead. Note — This point is identified as "go-ahead" or "A00" on logic and schedules
	(13)	1 3 8 0.0 1.4.8.0.0	Go-ahead to the vendor for the largest, most complex black box.
	(14)	1 3.8.0.0 1 4.8 0.0	Receipt of the first black box for buildup/ assembly of the prototype guidance and navigation subsystem.
	(15)	1.3.8.0.0 1.4.8 0 0	Receipt of the last black box, thereby completing hardware buildup/assembly

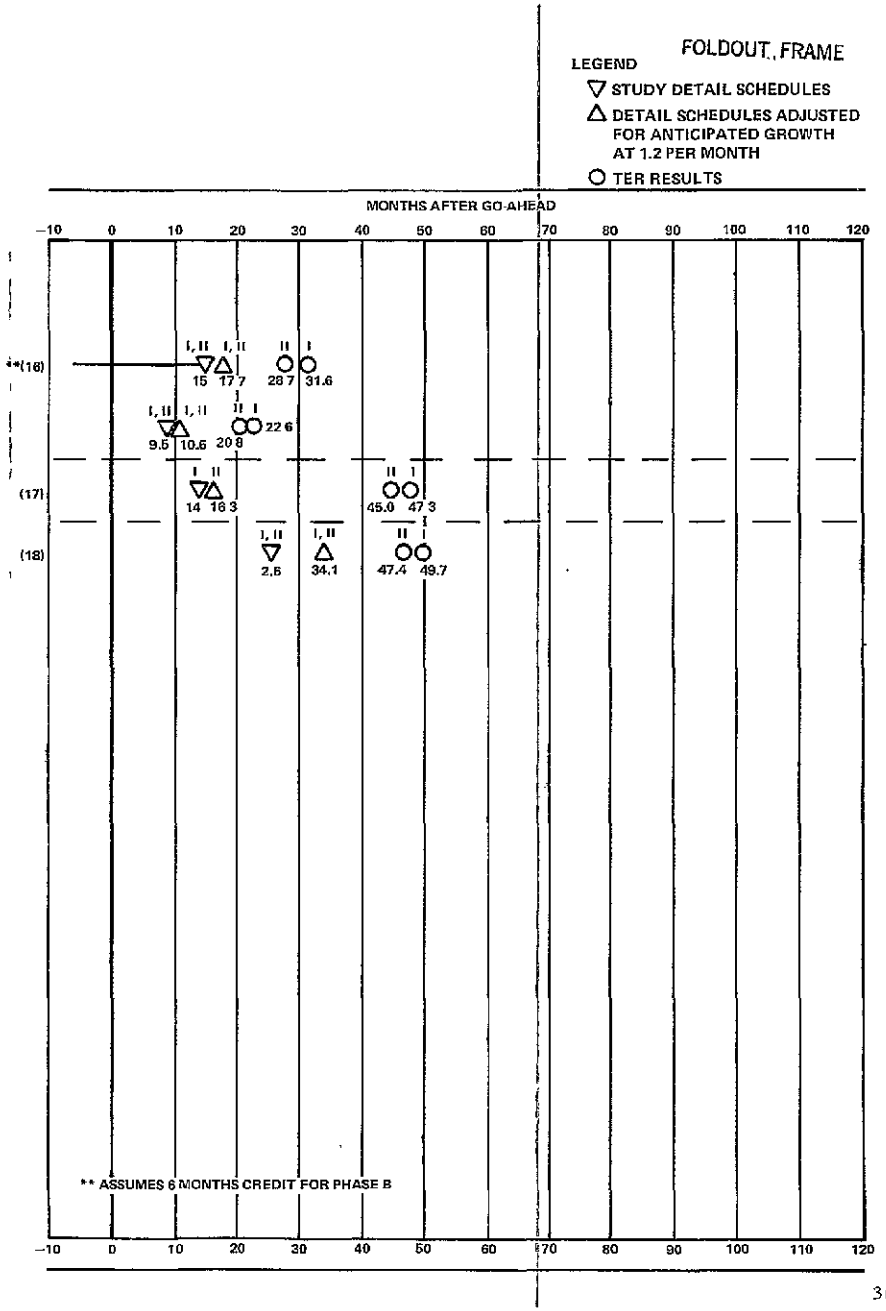
FOLDOUT FRAME 2



FOLDOUT FRAME

TER Number & Description	Point	WBS	Particular TER Event
7.1 Structure			Phase C/D go-ahead Note — This point is identified as "go-ahead" or "A00" on logic and schedules.
	(16)	1.3.2.0.0 1.4.2.0.0	95% structural engineering design release.
			Start detail fabrication. Note — This point does not appear on logic or schedules at the 5th WBS level; it does appear as (2) at program level.
	(17)	4.3.2.0.0 4.4.2.0.0	Complete manufacturing and start assembly of structural test article.
	(18)	4.3.2.0.0 4.4.2.0.0	Complete final assembly of structural test article

FOLDOUT FRAME



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GLOSSARY

APPENDIX C

LIST OF ABBREVIATIONS, SYMBOLS, TERMS (GLOSSARY)

A

ABES	Air Breathing Engine System. The turbojet engine system used on Stage I and Stage II for powered cruise and ferry flights. (See WBS Dictionary Elements 1.3.4.5, Stage II, and 1.4.4, Stage I)
ACPS	Attitude Control Propulsion System (see also RCS). The propulsion assembly used to maintain vehicle stability or to enable attitude change while the vehicle is out of the sensible atmosphere. (See WBS Dictionary Elements 1.3.4.4, Stage II, and 1.4.4, Stage I)
ACT	Acquisition, Control and Test (Unit). (See WBS Dictionary Element 1.4.10)
Advanced Space Transport Program	A Life Cycle NASA program defined to design, develop and produce manned, reusable two-stage vehicles whose missions will include delivering and/or retrieving GFE payloads to/from near earth space in support of manned orbiting space stations and space bases, experiments, developments, etc. In addition to vehicles, necessary ground support will also be developed and produced, including the neccessary data, software, training, facilities and investment to commit the Program to 10-year operations. At IOC, the Program is defined to follow a Traffic Model of flights and turnarounds and provides the hardware, software, support and management to complete the designated Life Cycle.
A & E	Architectural & Engineering
Air Vehicle	The assembly of Stage I, Stage II and Payload

AMPR/DCPR Weight	Aircraft Manufacturers Planning Report/ Defense Contractor Planning Report - A vehicle weight which excludes the following items from empty weight: Wheels, Brakes Tires, Tubes; Engines; Rubber or Nylon fuel cells; Starters, Propellers; APU's, Instruments, Navigation Equipment; Batteries, Conversion Equipment; Electrical and Flight Control Equipment; Turrets and Power Mounts; Air Conditioning, Pressurization, Anti-Icing; Cameras
APU	Auxiliary Power Unit (see WBS Dictionary Elements 1.3.6.2, Stage II and 1.4.6, Stage I)
ATC	Air Traffic Control (or Controller)
	B
BIT	Built-in Test. A capability designed into on-board equipment to enable it to be interrogated by the on-board computer for status checks prior to or during flight. May also include self-test and a means to perform manual checkout.
	C
Category I Testing	(AFR 80-14) Subsystem Development Test and Evaluation. Consists of development testing and evaluation of the individual components, subsystems, and, in certain cases, the complete system. In addition to qualification, the testing provides for redesign, refinement, and reevaluation, as necessary. Conducted predominantly by the contractor under (government) control.

Category II Testing	(AFR 80-14) System Development Test and Evaluation. Consists of testing and evaluation spanning the integration of subsystems into a complete system, and development tests of the completed system in as near an operational configuration and environment as practicable. Suitable instrumentation will be employed to determine the functional capability and compatibility of subsystems. Category II is a (government) effort with contractor participation, under (government) control. Actual test operation and maintenance should be performed by (using agency) personnel who have received formal system training.
C & C	Command and Control
CCN	Contract Change Notice

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CDR

Critical Design Review. A formal technical review conducted for each contract end item. Purpose is to determine acceptability of detail design, performance, test, and activation characteristics depicted by the design solution specified in Part II Specifications. Establishes that recommended design adequately satisfies end-item design and test requirements, including interface with personnel, facilities and other system equipment. Critical Design Review establishes: (1) compatibility between the CEI and the Part I Specification; (2) compatibility between the CEI and the Total System; (3) Design Integrity by way of review of both analytical and test data; and (4) the agreed-to Part II Specification which is the basis for inspecting the "First Article". Upon the logic charts CDR's have only been identified at those points in software developments where at firm baseline is necessary against which to manage subsequent changes. Software, since it is used to checkout/verify the airborne/ground systems, must have a baseline or "First Article" for software configuration control.

Precise definition of CDR for hardware configuration items within the logic has not been possible because no logical point is available within the study confines to indicate the transition from development to production. Without such a point, the logical placement of a First Article Configuration Inspection (FACI) could not be determined and the absence of a FACI point removes the requirement for a CDR. However, the earliest that a CDR could occur would be at that point during the qualification test program where (1) Part II Specifications would be complete or would be nearing completion; and (2) sufficient considence would have been acquired to permit the "cutting of metal" for qualification hardware. Calendar points reflecting these points have been identified on the detail calendar schedules.

CEI	Contract End Item (also, CI - Contract Item)
CFE	Contractor Furnished Equipment
Coefficient of Correlation	A pure number which expresses the degree of relationship between two variables. It varies between 0, when there is no correlation, and 1 or -1, when there is perfect correlation. Simply stated, it is a measure of how well the independent variables in a multiple regression equation explain variances in the value of the dependent variables.
Common Support Equipment	Maintenance equipment required to support Program operations but which is not directly involved in the operations, and which is common, i.e., presently in DoD or other government inventory in support of other systems or programs and which is available for use on subject programs.
Configuration (End) Item (also, Contract End Item, or Contract Item)	(MIL-STD-881) An aggregation of hardware/software, or any of its discrete portions, which satisfies an end-use function and is designated by the government for configuration management. During development and initial production, CI's (CEI's) are only those specification items that are referenced directly in a contract. CI's (CEI's) are also any reparable item(s) designated for separate procurement during operations and maintenance (O & M) periods.
CONUS	Continental United States
CRT	Cathode Ray Tube
CO_2	Carbon Dioxide
	D
D & C	Displays and Controls

Depot Level	The level of maintenance representing lowest level maintenance performed on a removed end item, its modules, or components. If the faulty component or module contains reparable parts, these parts are repaired in the depot. If the faulty part is a 'throw-away', a new part is installed in the component or module, checkout is performed, and the repaired component or module is sent back to Intermediate Level maintenance for use when required. (See Intermediate Level)
Design Mission	(Phase B, Advanced Space Transport Program). The Stage II mission which is the basis for Phase B design, and which, it is assumed, will remain unchanged for Phase C/D. This mission is a 100 nm due east circular orbit formed by insertion into a 50 x 100 nm orbit, then circularizing. The Air Vehicle (Stage II, Stage I, and Payload) is considered to be launched from a latitude of 28.5 degrees north. (See also Reference Missions.)
Design Release, Program - 95%	That point in time when all documentation which requires fabrication of hardware components/elements for the initial configuration have been conveyed to the performing organization - normally manufacturing.
Design Release, Structure - 95%	That point in time when all documentation which requires fabrication of structural elements for the initial configuration have been conveyed to the performing organization - normally manufacturing.
Detail	A single element part or drawing

DD 250	A government form and checklist, which when completed and signed off by the approved, requesting agency, represents end item delivery of a system or systems is satisfactory to the government. Following DD 250, end items, together with all necessary documentation, can receive approval of all contract compliance and result in an initial operational capability (IOC).
DIU	Digital Interface Unit (See WBS Dictionary Element 1.3.10.5).
DME	Distance Measuring Equipment
DMGE	Depot Maintenance Ground Equipment (see GSE; also, see WBS Dictionary Element 3.0 and 8.0).
DoD	Department of Defense
	E
EAFB	Edwards Air Force Base, California
ECLS	Environmental Control and Life Support
ECLSS	Environmental Control and Life Support Subsystem
ECS	Environmental Control (and Life Support) Subsystem
EMI	Electromagnetic Interference
Empty Weight (Dry Weight)	The dry weight of the vehicle including no useful load or payload.
Endoatmosphere	Inside the sensible atmosphere (See Exoatmosphere).
EVA	Extravehicular Activity

Exoatmosphere	Out of the sensible atmosphere. The specific altitude at which the sensible atmosphere ceases. For purposes of Stage II reentry, consider 300,000 - 400,000 ft altitude as the reentry regime. For purposes of Stage I reentry, an altitude of 142,700 feet is used.
	F
FAA	Federal Aviation Agency
FCE	Flight Control Electronics
fps	feet per second
FSE	Factory Support Equipment. Similar to Ground Support Equipment but non-deliverable (see WBS Dictionary Elements 1.3.1, 1.4.1 and 3.3). FSE supports integration and assembly in handling, transporting, testing and servicing the prototype, flight test or production vehicle fabrication and test functions prior to and during rollout and delivery.
FSN	Federal Stock Number
F-Test	A statistical method for determination of the degree of colinearity which exists between candidate independent variables. The result of F-Tests allow selection of the "best" variable for use when colinearity between candidate variables exists. For example, installed thrust may show a strong relationship and therefore very little or no additional variation will be explained by using both variables rather than just one.
FTV	Flight Test Vehicle. An instrumented Stage (I or II) scheduled for a flight test program. For this study, FTVs are to retrofitted to a Production Vehicle at the end of flight test. (See Production Article)

G

G & N	Guidance & Navigation
GFE	Government Furnished Equipment
GH_2	Gaseous Hydrogen
GN_2	Gaseous Nitrogen
GO_2	Gaseous Oxygen
GSE	Ground Support Equipment, i.e., peculiar and common end item ground hardware/ software required to support the airborne elements in an operating and maintenance sense. Consists of operating ground equipment (OGE) and maintenance and depot maintenance equipment (MGE and DMGE). (See also FSE.) GSE is contract-deliverable.
GSFC	Goddard Space Flight Center

I

I & A	Integration and Assembly
ICD	Interface Control Document (or Drawing). A specification of the physical and functional interfaces between an end-item and other end-items which, due to the nature of the interface, requires formal control. May be both inter-vehicle and intra-vehicle and/or between ground equipment.
ILS	Instrument Landing System
IMU	Inertial Measurement(s) Unit

Integration and Assembly	(MIL-STD-881) The technical and functional activities associated with combining all other equivalent level hardware/software elements into a prime mission product.
Intermediate (Field) Level	The level of maintenance representing maintenance performed on the removed end item. For example, intermediate level maintenance on a vehicle end item (e.g., APU) represents the effort needed to determine which component or module of the faulty APU must be removed and replaced to bring the APU back to satisfactory operation. Testing will determine the faulty component or module. Replacement of the faulty component or module, followed by checkout, will verify that the APU is ready for return to the same or another vehicle when required. Otherwise, the APU is "strapped" as OK and placed 'on the shelf' for use when needed. The faulty component or module, if reparable, is sent to the next maintenance level for test, further maintenance, and checkout. (See Depot Level)
I/O	Input/Output
IOC	Initial Operational Capability
I_{xx}, I_{yy}, I_{zz}	Moments of Inertia in the X, Y, and Z planes of the Stage or Air Vehicle
	J
JP	Jet Fuel, i.e., JP-4, JP-5
	K
KSC	Kennedy Space Center
KUTD	Keep Up-to-Date

L

LCC	Launch Control Center
L/D	Lift-to-Drag Ratio
Level I, II, III Requirement	NASA requirements for the Advanced Space Transport Program resulting from development of Program, System, Subsystem, and support through Phase B.
L/G	Landing Gear
LH_2	Liquid Hydrogen
Life Cycle	The complete Program cycle, including RDT & E, Investment and Operations phases of the program. Equivalent to NASA Phases C (Design) and D (Development and Operations).
Li OH	Lithium Hydroxide
LO_2	Liquid Oxygen
LOS	Line of Sight
Lot I	The first set of detail and sub-assemblies usually cover test parts, prototype parts, and a flight test article
Lot II	The second set of detail and sub-assemblies cover follow-on flight test articles and production articles.
LOX	Liquid Oxygen
LUT	Launch Umbilical Tower (mobile)

M

Major Assembly	An assembly such as a Wing, Aft Fuselage, etc.

MGE	Maintenance Ground Equipment (see GSE; also, see WBS Dictionary Element 3.0 and 8.0)
MIL-STD-881	Military Standard, "Work Breakdown Structures for Defense Materiel Items"
MLG	Main Landing Gear
MSC	Manned Spacecraft Center (NASA, Houston)
MSFC	Marshall Space Flight Center
Multiple Regression and Correlation	A straight line of regression (projection of trend) does not always satisfactorily describe the association between two variables. Frequently, the relationship is too complex to be described by means of a simple straight line (linear) and therefore a curve must be used. The procedure of establishing linear or curve linear relationships between two variables is simple correlation analysis. In addition, fluctuations in a given series are seldom dependent upon a single factor or cause. The measurement of the association between such a series and several of the variables causing these fluctuations or associated with the dependent variable is known as multiple correlation. Multiple correlation consists of the measurement of the relationship or association between dependent variables and two or more independent variables. This procedure is similar to that for simple correlation (one independent and one dependent variable) with the exception that other variables are added to the regression equation.
	N
NLG	Nose Landing Gear
nm	nautical miles

O

OEM	Original Equipment Manufacturer
OGE	Operating Ground Equipment (see GSE; also, see WBS Dictionary Element 2.0)
O/I	Organizational and Intermediate Level (Maintenance)
O & M	Operations & Maintenance
OMS	Orbital Maneuvering System. The on-orbit propulsion system used for circularizing Stage II after orbital injection, for translating to a higher orbit, and for providing retro thrust for Stage deorbit. (See WBS Dictionary Element 1.3.4.3)
Organizational Level	The level of maintenance representing maintenance performed on the as-installed end item. For example, organizational level maintenance on a vehicle end item (e.g., APU) represents the effort needed to verify a fault exists on the installed APU, removal and replacement of the APU in the vehicle, then checkout to verify the replaced APU satisfactorily performs its intended function. The faulty APU is then sent to the next maintenance level for test, further maintenance and checkout. (See Intermediate Level, Depot Level)

P

Payload	A Government Furnished Equipment (GFE) package to be delivered to, or retrieved from, near-earth space by Stage II of the Space Transport Air Vehicle (see WBS Dictionary Element 1.2).

PDR	Preliminary Design Review. A formal technical review conducted for each contract end item. Purpose is to evaluate the progress, consistency, and technical adequacy of the selected design and test approach and establish compatibility with program requirements and preliminary design. Establishes Part I Specification, interface drawings, other Systems Engineering documentation, schedules and costs. Preliminary Design Reviews have been assumed to be convened on each Configuration (Contract End) Item sometime shortly after the start of Phase C/D. The period between Go-Ahead to PDR has been assumed to be spent finalizing Part I specifications and mockups and completing any tradeoff studies, analyses, or revisions to document/specification trees as might be required from Phase C/D negotiations. The PDR freezes physical and functional interfaces and establishes: (1) compatibility between Part I Specification and design approach; (2) integrity of the approach and design; and (3) design producability.
Peculiar Support Equipment	Maintenance equipment, services and software which supports the Program operations but is not directly involved in the operations, and which is peculiar to this Program. (See Common Support Equipment)
PFRT	Preliminary Flight Rating Test
Phase B	Definition Phase (NASA)
Phase C	Design Phase (NASA)
Phase D	Development and Operations Phase (NASA)

Planform Area	The profile area of an air vehicle, or segment thereof. For an aircraft, Planform Area is the area based on Top View viewing. For a missile, Planform Area is the area based on Side View viewing.
PMEL	Precision Measuring Equipment Laboratory
Production Article	A Stage (I or II) scheduled to go directly into the Operating phase of the Program. (See Flight Test Vehicle)
PRS	Precision Ranging System
	R
Ramp Time	Encompasses that activity between flight test vehicle rollout and its first flight such as preflight operations, systems checkout and verification, and taxi runs. (See WBS ID 4.5.3 and 4.5.4 for Stage II and WBS ID 4.6.3 and 4.6.4 for Stage I.)
Ratio-Systems Weight/ Empty Weight	The number arrived at by subtracting the weight of the structural subsystem from the empty weight and dividing the remainder by the empty weight: $\frac{\text{Empty Weight-Structure Weight}}{\text{Empty Weight}}$
RCS	Reaction Control System
RDT & E	Research, Development, Test and Evaluation
Reference Missions	(Phase B, Advanced Space Transport Program). The Stage II missions of major interest in addition to the Design Mission. These missions include: (a) a 100 nm south polar circular orbit (south polar mission), and (b) a 270 nm at 55 degrees inclination orbit (resupply) mission. Insertion of reference missions will be from 50 x 100 nm orbits. (See also Design Mission.)

RF	Radio Frequency
RPP	Reinforced Pyrolized Plastic. A matrix of carbon cloth and resin, which when cured, results in a carbon-carbon material with high heat resistance. Used on vehicle leading edges and nose cap to resist ascent and re-entry heating loads for thermal protection of primary and secondary structure and internal subsystems.
	S
S/A	Subassembly. An assembled unit designed to be incorporated with other units in a product.
SARP	The schedule portion of the Manned Space Flight Schedules as presented in OMSF Program Status Review documents.
SAS	Stability Augmentation System. A Flight Control Electronics design concept used to blend Attitude Control Propulsion with Aerodynamic Flight Controls during reentry from exo to endoatmosphere in order to maintain stabilized vehicle control in this flight regime.
SCU	System Control Unit (see WBS Dictionary Element 1.3.10.3).

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SDR	System Design Review. A formal technical review conducted by the contractor when the definition effort has progressed to the point where the program requirements and design approach are more precisely defined from among alternate design approaches, and the contractor has defined and selected the equipment, personnel, test, procedural data, and facilities required. As a product of this review, which is reviewed by the SPO, a technical understanding is to be reached on the allocation of requirements to (1) the system segments identified in the System Specification, and (2) the CEI's identified in Part I Detail Specifications. This review, if conducted late in Phase B or early Phase C, will provide the necessary basis for completion of preliminary design in Phase C.
SE & I	Systems Engineering & Integration
SPADATS	Space Detection and Tracking System. A North American Air Defense Command System headquartered at Ent, AFB, Colorado, which monitors all space objects for SAC et al.

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Specifications	Use of the terms Part I and Part II (see below) presumes a two-step procurement of Configuration (Contract End) Items. The Part I specification is the first part of the Contract End Item Detail Specification and results from the Program Definition Phase (B). Part I specifies the requirements for design, development, and qualification. For purposes of this study, the Part I specification is considered similar/identical to the Development Specification identified in MIL-STD-490. The Part II specification results from the design and development contract and specifies the detail product configuration and acceptance requirements of the item under the design and development contract. The Part II specification typically provides the basis again which the "First Article" is accepted. Part II, for purposes of this study, is considered similar/identical to the Product Function Specification identified in MIL-STD-490. Both Part I and Part II terms have been applied not only to Airborne Configuration Items but also to: -Integrated Checkout and Servicing GSE for the Transport System (Stage I, Stage II and Payload) -Integrated checkout and Servicing Software -On-Board Checkout Software -Integrated Checkout/Assembly Facilities No attempt has been made to distinguish Configuration (Contract End) Items and their specifications into such categories as Critical, Prime Item, Non-Complex, or Requirement Items.

(Continued on Next Page)

Specifications (Continued)	Part I - The design statement specified by Systems Engineering for a required contract end item (CEI). Part I includes: the set of requirements; performance; CEI definition (interface requirements, government designation); design and construction requirements; quality assurance provisions; Category I tests required; and Category II tests required. Part I Specifications are usually available for Preliminary Design Reviews (PDRs). Part II - The design statement specified by Design Engineering to satisfy the Part I specifications for a required contract end item (CEI). Part II is a repeat of Part I except to specify the "solution" which has been demonstrated by test to satisfy the requirements. (See Part I). Together, Part I and Part II form the CEI specifications for an end item which can be given to a manufacturer to produce the required end item as a contract deliverable. Part II Specifications are usually available for Critical Design Reviews (CDRs). When a first article is produced, it may be reviewed and approved in First Article Configuration Inspections (FACIs) to enable Category II (System) testing to proceed.
SRA	System Requirements Analysis (see WBS Dictionary Element 5.0).
Stage I	Boost stage of the Space Transport Air Vehicle (see WBS Dictionary Element 1.4).
Stage II	Orbital stage of the Space Transport Air Vehicle (see WBS Dictionary Element 1.3).

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Stage I (or II) System Test and Checkout Specification	A specification which integrates all system test and checkout requirements, criteria, safety, special test, recycle and support considerations into a single, controlled document for the development and conduct of system (Stage I or Stage II) test, checkout, and handling activities. The document specifies design and test configurations for airborne and ground subsystems and facilities associated with each system-level activity.
Static Firing	A full power hold-down test of Stage I or Stage II on the launch pad to verify ascent capability prior to mated flight test.
Structure Weight	The weight of the structural subsystem including fuselage, wings, tail and landing gears.
Systems Weight	Empty weight less structure weight.
	T
TBD	To Be Determined
TER	Time Estimating Relationship
T & H	Transportation & Handling (Equipment)
TPS	Thermal Protection System. The materials and their configuration which covers and protects the Stage from ascent and reentry heating.

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Traffic Model	A 10-year mission model generated by NASA to scope the expected number of flights needed to satisfy the Advanced Space Transport Program operational requirements. Currently, 445 flights are forecast beginning with 10 flights the first year and leveling off to 75 flights, each, in the 9th and 10th years.
Transport System Test and Operations Plan	A master plan that identifies overall test management philosophy, policy and major criteria/requirements relative to test and operational phases of the Transport System. The document provides the top planning within which Stage I and Stage II Test Plans may be developed and also serves to discipline the transition from test/development phase to Operational.
Transport System Test and Checkout Specification	A specification which integrates all test and checkout requirements, criteria, safety, special transport system test, recycle and supports considerations into a single controlled document for development and conduct of total transport system tests. The document provides the exclusive authorized basis for the preparation and execution of all testing performed upon the transport system. (Stage I, Stage II, payload, and support ground systems)
Turnaround Facility	The facility, located at the launch and prime recovery site configured to receive, maintain and prepare Stage I and Stage II for the next mission. (See WBS Dictionary Element 11.0.)
TVC	Thrust Vector Control. The means to control thrust direction by either moving the nozzle (gimballed), or by deflecting the thrust gases, to achieve vehicle pitch or yaw. When nozzles are vectored asymnetically (opposite), roll is achieved. For purposes of this study, TVC means gimballing the nozzles using hydraulic actuators.
Type I Distribution	A frequency distribution or histogram.

U

UHF	Ultra-high Frequency
USB	Unified S-Band

V

VAB	Vertical Assembly Building. A facility for erecting and mating Stage I to Stage II, then mating the Air Vehicle to the Mobile Launch Umbilical Tower for movement to the launch pad.
VHF	Very High Frequency
VMSC	Vought Missiles and Space Company, LTV Aerospace Corporation (Dallas, Texas)
VOR	VHF Omnidirectional Range
VORTAC	VHF Omnidirectional Range/Tactical Air Navigation (Combination)

W

WBS	Work Breakdown Structure
WBS Dictionary	(VMSC) The compendium of WBS Dictionary Elements which, together, establish the complete set of requirements needed to meet Program objectives
WBS ID	Work Breakdown Structure Identification

WBS Dictionary Element	(VMSC) A preliminary Part I Specification for a Work Breakdown Structure element needed to satisfy one or more Program objectives. The element statement also contains a list of the next lower level elements, a functional description of the element, a set of design requirements (if applicable), the direct interfaces with the element, and the tests (if applicable) which must be conducted during the development phase to ensure the element will meet requirements.
Work Breakdown Structure (WBS)	(NASA) A hierachy of levels of hardware oriented (cost) packages. (MIL-STD-881) A product-oriented family tree composed of hardware, software, services and other work tasks resulting from Project Engineering efforts during the development of a defense materiel item, and which completely defines the project/program. A WBS displays and defines the product(s) to be developed and produced and relates the elements of work to be accomplished to each other and to the end product.
W/T	Wind Tunnel
WTR	Western Test Range
	Y
Y_{act}	Y_{actual} is the actual time a previous hardware program required to complete a predetermined schedule milestone. (See Y_{est})

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Y_{est} - $Y_{estimate}$ is the predicted time to complete a predetermined schedule milestone. This prediction is the output of a selected regression equation. Within this report Y_{est} is used to present the estimated time required to complete a given schedule milestone for the Advanced Space Transport Program. Y_{est} is further used to compare to Y_{act} for each program in the historical data base. As pointed out in Section 3, Introduction to Time Estimating Relationships (TERs)* the multiple regression model has the capability of taking the independent variables for each program in the historical data base, processing these variables through the selected estimating equation and printing out a comparison matrix with how long the program actually took (Y_{act}) and what the selected equation predicted the program would have taken (Y_{est}). If the difference between Y_{act} and Y_{est} is small, then the equation is further screened for potential deficiencies and may ultimately be used on estimating equation. (see Y_{act})

* Vol. I

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF OUTDOOR RECREATION

LAKE CENTRAL REGION
3853 RESEARCH PARK DRIVE
ANN ARBOR, MICHIGAN 48104

M2253
xD6427

April 27, 1971

Mr. J. W. Witters
District Design Engineer
State Highway Building
Paris, Illinois 61944

Dear Mr. Witters:

We have reviewed the highway plans for FAP 411 in Vermillion County, Project P-95-700-69, which were sent us by your office. The freeway does not appear to have any effect on the recreational aspects of the Corps of Engineer's reservoir site near Georgetown, Illinois. We appreciate your sending us these plans for review for possible effects on the recreational values of the proposed reservoir.

Sincerely yours,

ROMAN H. KOENINGS
Regional Director

By: Robert H. Myers
Robert H. Myers
Acting

DEPARTMENT OF THE ARMY
LOUISVILLE DISTRICT CORPS OF ENGINEERS
P O BOX 59
LOUISVILLE KENTUCKY 40201

ORLPD-P

23 April 1971

Mr. J. C. Mulgrew
District Engineer
Division of Highways
State Office Building
Paris, Illinois 61944

Dear Mr. Mulgrew:

This is in reply to your letter of 15 April 1971 concerning the design of Route FAP 411, Vermilion County, P-95-700-69.

Since the considered reservoir site (#12 Little Vermilion River) was not selected for the recommended plan for the Wabash River Basin Comprehensive Plan, we would have no objections to the proposed road plan and design.

We appreciate the opportunity to review the plans and your interest in the matter.

Sincerely yours,

J. M. Fillum
for W. E. LEEGAN
Chief, Planning Division

CF:
Bureau of Outdoor Recreation
Lake Central Region
3853 Research Park Drive
Ann Arbor, Michigan 48104

VERMILION COUNTY CONSERVATION DISTRICT

703 Kimber Street
Telephone 442-1691

Danville, Illinois
61832

June 17, 1971

TO: Mr. J. C. Mulgrew
District Engineer
State Highway Building
Paris, Illinois 61944

SUBJECT: Supplemental Freeway F. A. P. 411
Vermilion County - V2, V3, V4, V5
P-95-700-69

Dear Mr. Mulgrew:

In response to your request to analyze the affect of the proposed routing of supplementary freeway F. A. P. 411 on the environment we wish to address ourselves specifically to questions 4b(7), (8), and (11) as follows:

4b (7) "substantially alter the pattern of behavior for a species" - In view of the fact that the alignment will cross the Vermilion River Valley either over bottom cropland on the east or through relatively large-size suburban homesites on the west, the inventory of wildlife in this Valley consists principally of upland game birds, songbirds and small mammals who have already exhibited the capacity to co-exist with human habitation, and the deer which use the river flood plain as a feeding corridor will still have unrestricted use of the river banks, we believe that there will not be any significant change in the activities of any of these species.

4b (8) "interfere with important breeding, nesting or feeding grounds" - There is no question about the fact that any species of wildlife who has been accustomed to pursuing the above activities directly in the path of the freeway will have to select a satisfactory substitute area. This "inconvenience" will be temporary and will not affect any significant quantities of wildlife.

4b (11) "disturb the ecological balance of a land or water area"- As with all projects involving a disturbance of the land cover (even a new one family dwelling) there will admittedly be some affect on the eco-system. However, we

wish to state emphatically that these disruptions will be of minor consequence and in no way would cause permanent or significant damage to the food chain in the area. As no water course will be altered by the project, no comment is necessary.

Sincerely yours,

RNP:lw

Ronald N. Pennock
Executive Director

Social, Economic, Environmental

and Engineering Influences.

Supplemental Freeway F.A.P. 411

Vermilion County V2, V3, V4, V5

Rural Trunk (B) Highway

"ATTACHMENT ONE"

PURPOSE

The purpose of this study is to determine the most acceptable alignment for FAP 411, from just north of the Vermilion County Airport south to the Little Vermilion River near Georgetown. This selected line is the one which displays the most favorable combination of elements considered; while the cost is of prime importance, equitable consideration must also be given all social, economic, and environmental determinants within the study area. When these goals are met the result is a multi-lane freeway which maximizes safety, convenience, and service and minimizes cost, disruption, and relocation.

STUDY LIMITS

On the basis of facts collected during the corridor study and as a result of public hearings the Illinois Division of Highways recommended that the Federal Highway Administration approve corridor "S" (see attached map). Approval was received from the Federal Highway Administration by letter May 11, 1970.

The 1969 Bond Issue which was to have financed the Supplemental Freeway System was declared unconstitutional. After this development, a short segment was proposed for study in the Danville Urban Area. This length extended from just north of the Vermilion County Airport south to the Little Vermilion River near Georgetown (see attached map).

STUDY DEVELOPMENT

In the beginning of the Design Study it was necessary to assemble the various base data which would supply the information as to limiting factors and service points. This data consisted of utility locations, industrial and commercial business activities, geotechnic reports, land ownership, traffic analysis, drainage data, school and fire district maps, aerial mapping and photography and U.S.C. & G.S. Topographic maps of the area.

In combining this information on a common base map it was possible to project various alignments which would meet various service and design standard requirements and be acceptable from a standpoint of disruption. Since interchanges provide the service potential between the local communities and the freeway it is logical to set these points in conjunction with the functionally classified system, land use, and traffic projections. Controls such as public usage of land, disruption and cost features that would influence the location of the interchange on the cross road were established.

Interchange type studies were then made to determine the type of interchange that would most satisfactorily handle the traffic demands, fit the topographical features and be compatible with present and future land usage of the area.

Vertical and horizontal alignment possibilities were calculated with the aid of the computer from 5' contour aerial topographic mapping. Size and location of drainage structures, right-of-way limits, roadway geometrics and miscellaneous items were designed for each alternate to facilitate a realistic cost comparison.

The preliminary estimate of cost for the 18 mile project is about $35,000,000.

The design of an interchange is primarily dependent upon the analysis of traffic and the natural and man-made features that impose limitation as to size, shape and physical location.

FAS 501 (Poland Road)

An interchange on Poland Road will serve the northern and northeastern sectors of Danville quite efficiently in addition to offering excellent service to the Vermilion County Airport. Through an analysis of the project traffic it became evident that a standard diamond interchange would adequately meet the projected traffic demands with the upgrading of Poland Road. Due to the development west of the airport, the number of displacements that would be made necessary and the engineering design complexity that would ensue due to Stony Creek, Bowman Avenue and the Norfolk & Western Railroad, a location east of the Airport was selected. In an interview with Mr. L. P. Birch, P.E., the Vermilion County Airport Engineer, he pointed out that a location east of the Chicago, Milwaukee, St. Paul and Pacific Railroad would not affect any future expansion of the airport, as the railroad is on a fill through this area and FAA regulations require 25' clearance on approaches over a railroad and 15' clearance over a highway. By selecting a location approximately 1-1/2 miles east of the point of intersection of the Chicago, Milwaukee, St. Paul and Pacific Railraod and Poland Road, the diamond interchange would be built without a portion of it on the structure crossing over the Penn Central Railroad.

C. H. 34 (Voorhees St.)

C. H. 34 is functionally classified as a Minor Arterial. An interchange will offer extremely good service to the industrial sector of Danville. In addition, it will offer service to the population concentration of the north and northeast portion of the city. Its location was dictated by the presence of dense development west of the Chicago, Milwaukee, St. Paul and Pacific Railroad and to allow sufficient room for growth in all four interchange quadrants. It was located far enough east of the railroad and west of the curve to allow development of a full interchange and the development of land adjacent to it in keeping with good planning practices.

Due to capacity problems with a standard diamond and the heavy south to west dirctional traffic a four quadrant parclo type B is proposed at this location.

U.S. 136 (Main Street)

U.S. 136 is functionally classified as a Minor Arterial. An interchange at this point will offer good service to the eastern portion of Danville which will serve the traffic generated by industrial, commercial, and Danville Junior College uses.

Two alignment possibilities are depicted at U.S. 136. A very tight condition exists at this location as the area which is conducive for interchange development is bounded on the west by Lick Creek and on the east by the structures carrying the Chicago, Milwaukee, St. Paul and Pacific Railroad and Central Eastern Illinois Railroad (L & N) across U.S. 136. In addition a cemetery is located at approximately the third point of the distance between these two controls.

After considerable study it was determined that the eastern location was not feasible for interchange development. Due to the limited amount of space between the cemetery and the railroads coupled with the intersection of FAS 503 (Brewer Road) a very hazardous condition would be created without major work being done on the railroad viaducts and a major relocation of Brewer Road.

A compressed diamond was therefore developed for the west location which adequately satisfies the demands of traffic and can be developed to minimize the disruption to the area.

F.A.I. 74

Due to the high type (full cloverleaf) interchange that is required between FAP 411 and FAI 74, the location limitations dictate a location at the point of Daisy Lane extended and FAI 74. This will allow adequate space between the Brewer Road structure and Lick Creek for the development of the interchange. A location east of the Chicago, Milwaukee, St. Paul & Pacific Railroad was explored as a possibility but was discarded due to the limited amount of space between the railroad and the Lynch Spur interchange on FAI 74.

FAS 504, C.H. 6 (Perrysville Road)

FAS 504 is functionally classified as a collector. In the beginning there was some question of the desirability of this interchange from the standpoint of reduction of service on the freeway due to its close proximity to the FAI 74 interchange and user justification. A request from the Danville Planning Commission and the Vermilion County Planning Commission brought about the need for more study at this site.

An interchange at this location would definitely be an asset to further land use development south of FAI 74.

The area bounded by FAI 74 on the north and the Big Vermilion River on the west has been fragmented from the Danville Urban Area by the artificial barrier of FAI 74. This area together with a portion of the area west of the river have historically interacted with each other. Due to the river crossing location and the local road network, these areas together, total approximately twenty-one hundred acres. The disjunction of this area was created by the interchange types which were developed on FAI 74. Two interchanges, Lynch Spur and Bowman Avenue, adequately serve the area to the north of FAI 74. Since these interchanges are trumpet types, development is restricted to the immediate south. An interchange located south of FAI 74 would thus provide transportation potential to this area for north-south as well as east-west trip ends.

An analysis was made first to determine the effect it would have on the operational level of the freeway and the FAI interchange. Through this analysis it was determined that due to the low-weaving volumes the interchange would not reduce the operational level of the freeway.

A cost benefit analysis was performed to determine the warrant for an interchange at this point. A B/C of 4.3 was found which is evidence that the cost saved by the user makes the capital investment in the interchange publically profitable.

It was decided that an interchange on both alternate alignments be taken to the public hearing as design alternates to HB structure. The final recommendation would depend upon the social and environmental factors as brought forth by the local citizens at the hearing.

FAS 505, C.H. 5 (Westville Connection)

FAS 505 is functionally classified as a collector and with upgrading will serve a major role as a connecting link between the population center of Westville and the industry of Danville.

This area has undergone intensive underground coal mining over the past one hundred years. Because of these mining activities a considerable amount of time was spent in analyzing the mine mapping of the area; Drill test hole data was gathered and field exploration trips were made. During the field exploration the soil boring crew made deep borings in this area to determine locations for HB structures that had not been under-mined.

The structure location of the eastern alternate was bored to depths of 162½ and 160 feet. Coal deposits were not encountered in these borings. (During the test borings, water circulation was not lost and drilling resistance was good.) Since this is well below the anticipated depth of the #6 coal, it was determined that coal is absent from this location because of a "pinch-out".

The fact that subsidence will not be a problem, is a strong point for this location. There are additional factors to which consideration must be given such as displacement of dwelling units, disruption of the local road system, angular severance of property, and possible reduction of signal reception to a CATV receiving station.

A preliminary line was studied in this area which would have interchanged with C.H. 5 approximately 3/4 mile closer to Westville.

This preliminary line had the disadvantage of having its structure located over a mined-out area which would cost additional money for foundation treatment and additional long term maintenance cost due to roadway subsidence. In addition to the cost picture there is the matter of safety to the traveling public. Greater utility adjustment costs will be accrued due to the relocation and adjustment of a lateral feed line to Westville from the Panhandle and Eastern Pipeline.

This preliminary line did have some positive attributes which are as follows:

1. Fewer displacements.

2. Less adjustment necessary to the local road system.

3. Upgrading of C.H. 5 is shortened by 3/4 mile.

A compressed diamond would be necessary to prevent major interferences to the mainline of the Panhandle and Eastern Pipeline and its appurtenances and to bring about the reduction of displacements.

Due to the soils problem which exists, and the accompanying costs and safety problem, this preliminary line was discarded, and the single line with its standard diamond interchange utilized.

C.H. 23 (Georgetown Connection)

C.H. 23 is functionally classified as an Area Service highway and an interchange at this location will operate similarly to the Westville interchange. Not only will it load and unload trips between the population center of Georgetown, and the industrial and commercial center of Danville, but it will also serve a high number of recreational trips generated by Forest Glenn Preserve located northeast of Georgetown.

Traffic studies of this area indicate that a diamond interchange will be sufficient. A compressed diamond was utilized at this location to allow for development of land in all four quadrants of the interchange and as an economic measure due to utility adjustment costs. The interchange is bordered on the east by a large Panhandle and Eastern Pipeline and on the west by a stream.

ALIGNMENT INFLUENCES

After selecting the interchange points which were rather restrictive, especially in the immediate Danville area, alignment possibilities were studied to connect these locations in keeping with the following:

1. Interruption to the local road network.
2. Design desideratum as adopted by the Illinois Division of Highways and approved by the Federal Highway Administration.
3. Restrictive Land Use.
4. Dwelling unit relocation.
5. Property severance.
6. Angular severance.
7. Public grounds.
8. Natural and controlled eco-systems.

V-II

V-II extends from south of the Georgetown interchange to just south of the Westville interchange. Between C.H. 23 and T.R. 367 the section line was followed which furnishes an avenue with a low number of property severances. From T.R. 367, FAP 411 curves to the east to avoid a CATV tower and makes the connection with the Westville interchange which is located at the most westerly point in which subsidence due to coal mining will not be a problem.

V-III

From the Westville interchange FAP 411 utilized gentle curvilinear alignment to make the best use of the topographic features of the well established drainage pattern of the Big Vermilion River Valley. Man-made features such as the development at Grape Creek, the C. & E.I. Railroad meandering up the valley floor, corridor boundary limitations imposed by the University of Illinois radio telescope and the historical site of Kygers Mill all served as influences which restrict the alignment possibilities together with high water elevations and crossing points on the Big Vermilion River.

Just north of the river crossing the two alternate alignments utilized test variables encountered in remaining either east or west of the development of Daisy Lane. The west location forms a barrier between the Vermilion Hills Golf Course and the present development and necessitates an HB structure on the east-west portion of Daisy Lane.

The east location tends to retain a larger area of development property adjacent to the Country Club which from the standpoint of present community values would seemingly be the most advantageous.

V-IV

V-IV continues on these two alternates to a point just south of the interchange of FAI 74 and FAP 411 and continues through the interchange on a single alignment possibility. Just north of this interchange two alternates are again utilized to gain passage through a very critical area of development. A CATV tower on the west, a cemetery on US 136, and a series of railroads are the most critical considerations. The eastern alternate possesses much more desirable geometric features, but since its point of intersection with US 136 is in such close proximity to the cemetery, two railroad viaducts and the intersection of Brewer Road (C.H. 4) an interchange at this point would not be feasible.

The western alternate utilizes curvilinear alignment to intersect US 136 at a point in which an interchange can be developed, and continues northward to the interchange point with Voorhees Street (C.H. 34) which is in close proximity to the eastern alternate. Both converge to a single alignment just north of the interchange with Voorhees Street (C.H. 34) at the terminal point of Section V-IV.

V-V

The single alignment continues northward from the Voorhees Street interchange on the section line, avoiding dwelling unit displacements, to the Poland Road interchange which is located east of the Airport at such a distance as to not interfere with glide path requirements of present and anticipated runway lengths. It is also located in such a manner away from the convergence of the Penn Central Railroad and Poland Road (CH 29) as to allow for full development of a diamond interchange. North of the interchange curvilinear alignment is then utilized to make a westerly adjustment which will have less disruption to the local road network and give a more favorable crossing angle on the Stony Creek structure.

ROAD CLOSURES

During the early route planning process special emphasis was placed in locating in such a manner as to create the least amount of disruption to the local road system and to recover interruption to traffic flow patterns.

In certain instances it is necessary to close selected roads due to their adverse location or their incompatibility with the level of service provided. In the case of a fully access controlled freeway such as FAP 411 it is neither practical nor economically feasible to provide a grade crossing structure or interchange at each local road or street. In our study it has been determined that TR 387, TR 345 and TR 181A will be closed. The following is a discussion of some of the considerations leading up to this decision.

V-II

Due to the proximity of TR 387 and TR 385 it would not be practical or feasible to provide a grade crossing structure at each. Since TR 385 provides a longer continuous route of access east and west to farm markets and a grade crossing of TR 387 would be compounded with a stream crossing, it seems more feasible to close TR 387 and provide a grade crossing with TR 385.

V-III

Due to the proximity of the interchange with CH 5 and the low traffic generated on TR 345 it would not be practical or feasible to provide a grade crossing.

However, due to the seasonal flooding condition that exists on the eastern portion of TR 345, and the necessity of providing all weather access to the development east of FAP 411, an access road along the east section line of Section 4 connecting FAS 505 to TR 345 is proposed.

The portion of TR 345 lying west of FAP 411 will be connected to CH 5 by means of a relocation of the Township Road.

V-V

Due to the proximity of TR 181A and the interchange of FAP 411 with Poland Road and east-west continuity of TR 181A being interrupted by the Vermilion County Airport expansion, it would not be practical or feasible to provide a grade crossing structure.

ACCESS CONTROL

The continuity of the local road network is usually maintained by the construction of grade separation structures. Occasionally, a local road serves such a minor role in the total local system, that it can be closed. It is necessary to study mail routes, school bus routes, fire districts, local maintenance facilities, present and future land use and the traffic patterns of the area to determine if the cost of the structure is less than the benefits derived.

FIRE DISTRICTS

The alternate alignments pass through several Fire Protection Districts with similar effect. Some additional travel time for fire fighting equipment would be required to certain properties. This has been kept to a minimum. In other cases, the travel time has been decreased.

We therefore conclude that there will be no overall significant deterimental effect to fire protection efficiency in the area as a result of the freeway.

SCHOOL DISTRICTS

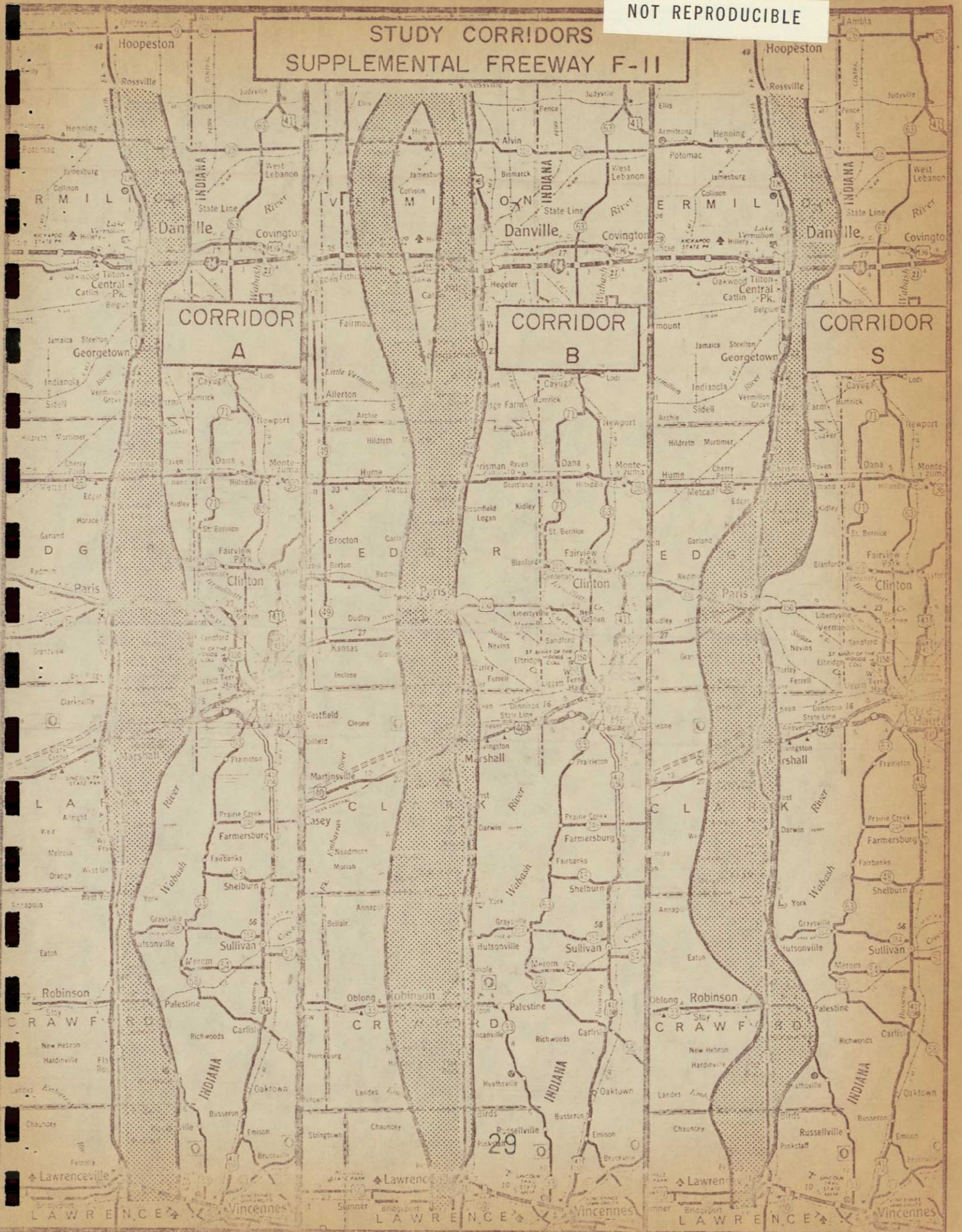
The alternates pass through several school districts with equal disruption.

Because of the random location of rural students most roads must be traveled twice daily for collection and distribution. School bus routes change almost yearly due to student senescence.

We therefore conclude that there is no significant detrimental effect to the school districts as a result of the freeway.

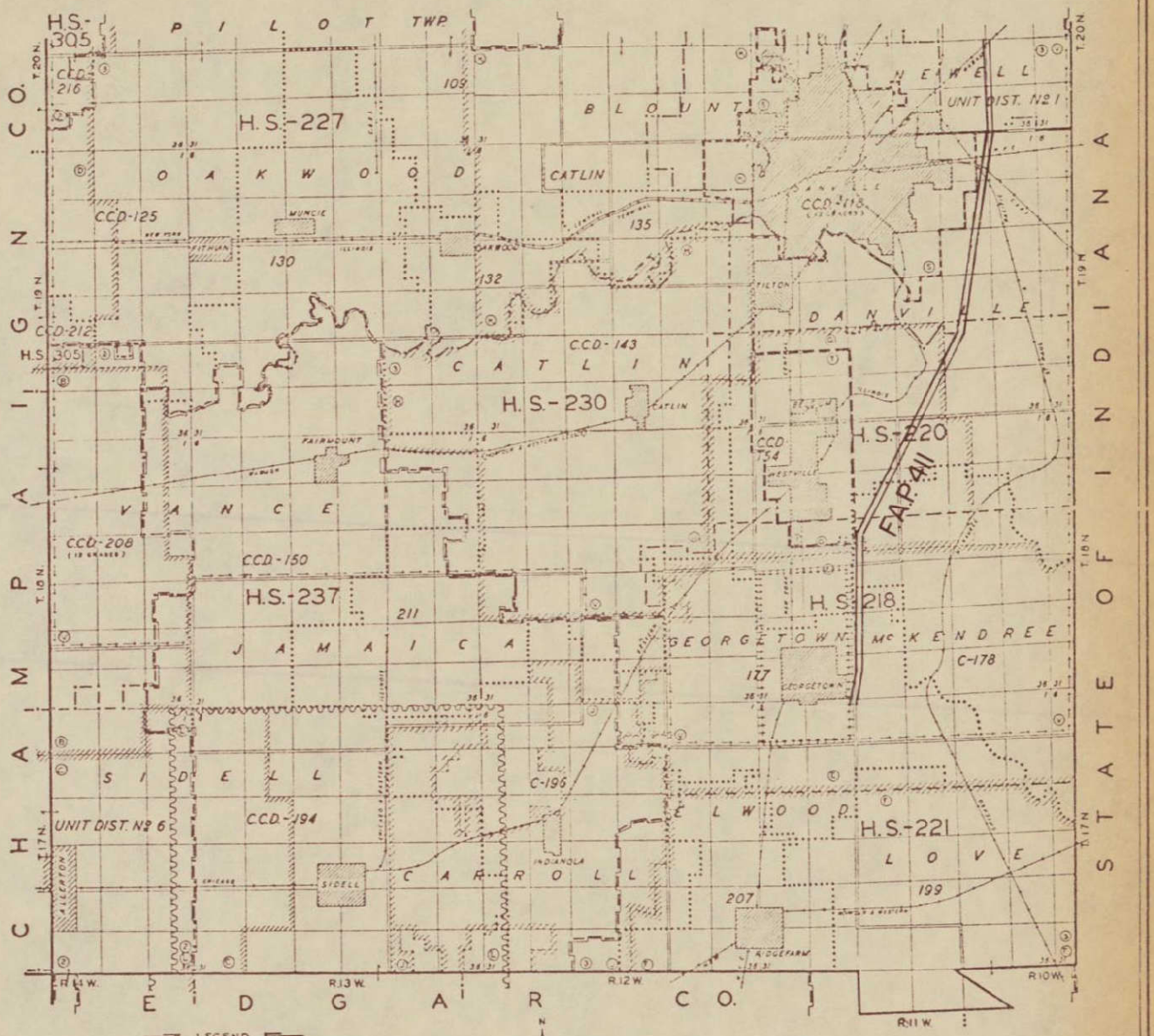
It is felt that the freeway will create a positive impact on the commuter oriented Danville Junior College as ready access will be provided by the US 136 (Main St.) Interchange.

STUDY CORRIDORS
SUPPLEMENTAL FREEWAY F-11



VERMILION COUNTY

SOUTH PART



LEGEND

- COUNTY LINE
- TOWNSHIP LINE
- SECTION LINE
- GRADE SCHOOL DISTRICTS
- HIGH SCHOOL DISTRICTS
- COMB. GRADE-HIGH & UNIT SCHOOL DIST.
- RAILROADS
- CORPORATIONS
- FIRE PROTECTION DISTRICTS
- SANITARY DISTRICTS
- LIBRARY DISTRICTS
- AIRPORT
- SECTION NUMBERS — 36
- UNIT & GRADE SCHOOL NUMBERS — 143
- HIGH SCHOOL NUMBERS — 237
- JUNIOR COLLEGE DISTRICTS

N S E W

CEMETERY MAINTENANCE DISTRICTS

(1) GEORGETOWN

NOTE

SCHOOL DISTRICTS THAT OVERLAP INTO AN ADJOINING COUNTY ARE SHOWN BY —
OTHER OVERLAPPING DISTRICTS ARE SHOWN BY AN EXTENDED LEGEND
UNIT SCHOOL DISTRICTS MAINTAIN 12 GRADES
ENTIRE COUNTY IN VERMILION CO. CONSERVATION DISTRICT

JUNIOR COLLEGE DISTRICTS

(2) N.S.505 (3) N.S.507

FIRE PROTECTION DISTRICTS

(B) HOMER
(C) ALLERTON
(D) OGDEN-ROYAL
(F) GEORGETOWN
(P) RIDGEFARM
(Q) WESTVILLE AREA
(H) CATLIN
(J) CARROLL TOWNSHIP
(K) KICKAPOO

SANITARY DISTRICT

(S) DANVILLE
(T) WESTVILLE-BELGIUM

LIBRARY DISTRICT

(L) SIDELL

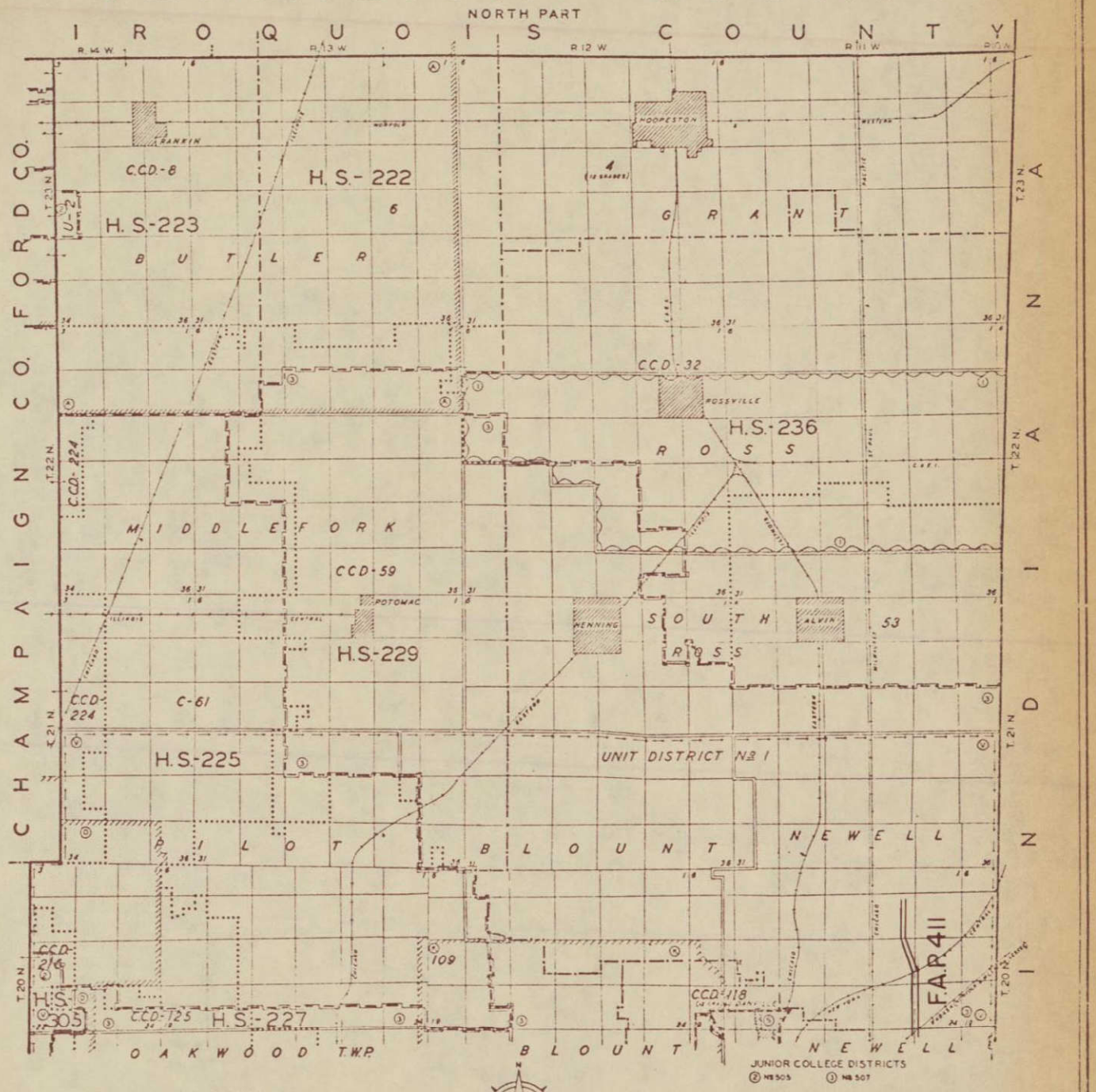
AIRPORT DISTRICT

(V) VERMILION COUNTY

DEPARTMENT OF REGIONAL PLANNING AND DEVELOPMENT — DIVISION OF HIGHWAYS
DRAWN
M. Z. B. 1954
REVISED

W.C.M. 1 1951	W.C.M. 9 1954		
W.C.M. 2 1951	W.C.M. 3 1954		
W.C.M. 11 1951	W.C.M. 2 1955		
W.C.M. 2 1951	W.C.M. 3 1955		
W.C.M. 3 1951	W.C.M. 9 1955		
S.M.B. 1 1952	W.C.M. 11 1955	W.C.M. 8 1955	W.C.M. 10 1955
W.C.M. 3 1952	W.C.M. 11 1954	W.C.M. 8 1956	W.C.M. 10 1956
W.C.M. 11 1952	W.C.M. 10 1955	W.C.M. 10 1956	W.C.M. 11 1956

VERMILION COUNTY



LEGEND

- COUNTY LINE
- TOWNSHIP LINE
- SECTION LINE
- GRADE SCHOOL DISTRICTS
- HIGH SCHOOL DISTRICTS
- COMB GRADE - HIGH & UNIT SCHOOL DIST.
- RAILROADS
- CORPORATIONS
- FIRE PROTECTION DISTRICTS
- PARK DISTRICTS
- SANITARY DISTRICTS
- AIRPORT
- SECTION NUMBERS — 36
- UNIT & GRADE SCHOOL NUMBERS — 56
- HIGH SCHOOL NUMBERS — 222
- JUNIOR COLLEGE DISTRICTS

SCALE IN MILES: 0 1 2 3 4

NOTE

SCHOOL DISTRICTS THAT OVERLAP INTO AN ADJOINING COUNTY ARE SHOWN BY —
OTHER OVERLAPPING DISTRICTS ARE SHOWN BY AN EXTENDED LEGEND
UNIT SCHOOL DISTRICTS MAINTAIN 1-2 GRADES.
ENTIRE COUNTY IN VERMILION CO. CONSERVATION DISTRICT.

FIRE PROTECTION DISTRICTS
- (A) RANKIN
- (D) OGDEN - ROYAL
- (X) KICKAPOO

PARK DISTRICTS
- (1) ROSSVILLE

SANITARY DISTRICT
- (5) DANVILLE

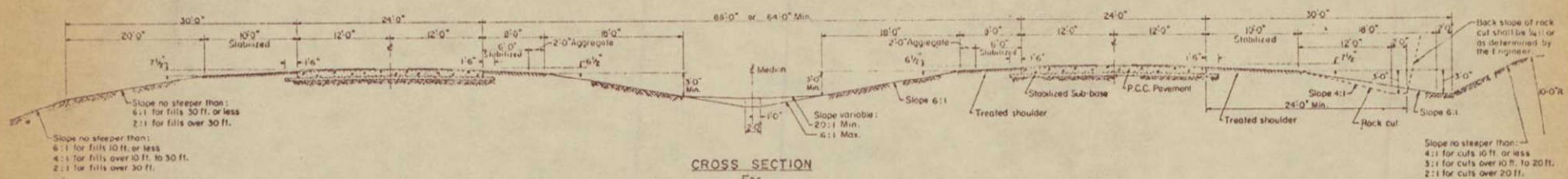
AIRPORT DISTRICT
- (V) VERMILION COUNTY

DRAWN
H.Z. 8-1954
REVISED
H.D.W. SEPT 1954 H.D.W. OCT 1954
H.D.W. AUG 1954 H.D.W. OCT 1955
H.D.W. NOV 1954 H.D.W. NOV 1955
H.D.W. JAN 1956 H.D.W. JAN 1956
H.D.W. AUG 1957 H.D.W. JAN 1957
L.M.B. OCT 1956 H.D.W. OCT 1956 H.D.W. NOV 1957 H.D.W. NOV 1957
H.D.W. OCT 1956 L.M.B. FEB 1958 H.D.W. NOV 1958 H.D.W. DEC 1957
H.D.W. NOV 1958

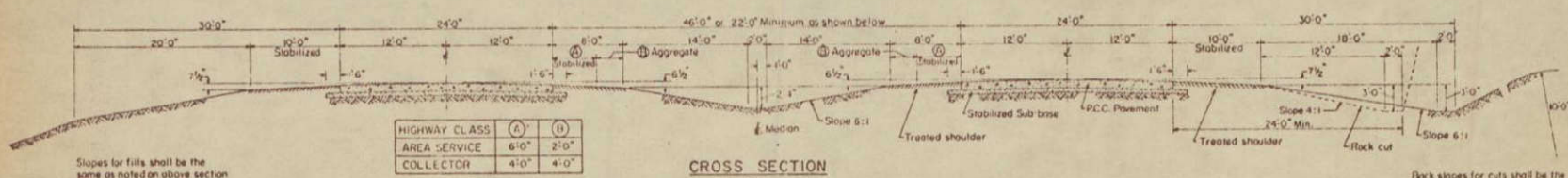
STANDARD DESIGN

ROADWAY CROSS SECTIONS FOR DUAL 24 FT. P.C.C. PAVEMENT

(HIGHWAY CLASSES "TRUNK", "MAJOR", "AREA SERVICE", AND "COLLECTOR")

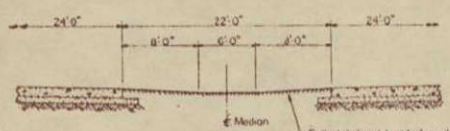


CROSS SECTION
For
"TRUNK" And "MAJOR" Class Highways With One-Way DHV Under 1900

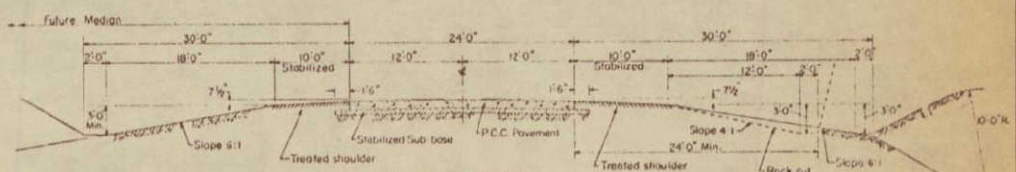


HIGHWAY CLASS	(A)	(B)
AREA SERVICE	6'0"	2'0"
COLLECTOR	4'0"	4'0"

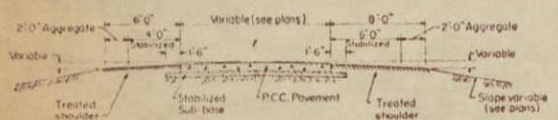
CROSS SECTION
For
"AREA SERVICE" Class Highway With One-Way DHV Under 1900
"COLLECTOR" Class Highway With Two-Way DHV Over 1425



CROSS SECTION
For
22 Ft. Median



CROSS SECTION
For
"MAJOR", "AREA SERVICE", And "COLLECTOR" Class Highways With Future Median.



CROSS SECTION
For
Ramp

Portland Cement Concrete Pavement :-
The thickness and type of the pavement shall be as shown on the plans or specified in the special provisions.
For detail of the pavement see Standards:
2179 Standard reinforced pavement.
2224 and 2261 Continuously reinforced pavement.

Stabilized Sub-base :-
The stabilized sub-base shall be 4 inches thick unless shown otherwise on the plans.
When a slip form paver not equipped with approved automatic grade controls is to be used, it shall operate on the stabilized sub-base which shall be extended so that the overall width is 6 inches greater than the width from outside to outside of the slip form paver's tracks. Such extended width will not be measured for payment but shall be considered incidental to the contract.
If the slip form paver is equipped with approved automatic grade controls that control the four corner supports of the paver and the Contractor elects to use these controls, the stabilized sub-base shall be 12 inches wider than the design pavement width and an appropriate deduction will be made in the quantity of stabilized sub-base.

Treated Shoulder :-
The treated shoulders shall be as detailed on Standard 2237 unless shown otherwise on the plans.

General Notes :-
The superelevation of the pavement shall be as shown on the plans.

STATE OF ILLINOIS DEPARTMENT OF PUBLIC WORKS & BUILDINGS DIVISION OF HIGHWAYS	ISSUED 7-7-66 REVISIONS
PASSED Dec. 1 1969	W.F. 6-12-67
Engineer of Road Plans and Contracts	W.F. 8-15-68
APPROVED Dec. 1 1969	W.F. 12-1-69
Director of Highways	
Redrawn 6-12-67	

STANDARD 2235-3

(Full Size) W.F.

42

C-24-12 b

FAP 411
Vermilion County
V2, V3, V4, V5

Preliminary Family and Business

Relocation Report

The proposed alignments were designed to miss as many homes as possible, and selected for this reason. About 30 families may require relocation by this 18 mile project. They will be compensated and given relocation assistance in order to find similar housing nearby. A relocation comparison will be made between alternate alignments. A relocation study is now in progress by the Bureau of Right-of-Way. The results of these studies will be attached to the final report.

"ATTACHMENT TWO"

FAP 411
Vermilion County
V2, V3, V4, V5

Preliminary Right-Of-Way and Access Report

This 18 mile project will require a strip of land about 300' wide. It will also require additional right-of-way for interchanges and cross structures. The total right-of-way required will be about 950 acres.

Access versus damage studies are being made for about 25 small parcels averaging 15 acres in size. Three parcels are landlocked. The cost of an access road, including damages by building the road, are being compared to appraised damages for the total property without an access road for the present owner. Recommendations will be subject to right-of-way negotiations.

Right-of-way requirements are now being appraised for cost estimates and alignment comparisons to be included in the final report.

Major access features are shown on the project map, "attachment four".

"ATTACHMENT THREE"

STATE CONSTRUCTION SPECIFICATIONS
CONCERNING SOIL, WATER AND POLLUTION EXCERPTED FROM:
STANDARD SPECIFICATIONS FOR ROAD & BRIDGE CONSTRUCTION
ILLINOIS DIVISION OF HIGHWAYS, 1971.

104.07 Final Cleaning Up. Before final acceptance, all borrow pits and ground occupied by the Contractor in connection with the work shall be cleaned of all rubbish, excess materials, temporary structures, and equipment, and all parts of the work shall be left in a neat and presentable condition.

SECTION 107. LEGAL RELATIONS AND RESPONSIBILITY TO PUBLIC

107.01 Laws to be Observed. The Contractor shall at all times observe and comply with all Federal and State laws, local laws, ordinances, and regulations which in any manner affect the conduct of the work, and all such orders or decrees as exist at the present and which may be enacted later, of legislative bodies or tribunals having legal jurisdiction or authority over the work, and no plea of misunderstanding or ignorance thereof will be considered. He shall indemnify and save harmless the State and all of its officers, agents, employees, and servants against any claim or liability arising from or based on the violation of such law, ordinance, regulation, order, or decree, whether by himself or his employees.

107.07 Federal Aid Provisions. When the United States Government pays all or any portion of the cost of a project, the Federal laws and the rules and regulations made pursuant to such laws must be observed by the Contractor, and the work shall be subject to the inspection of the appropriate Federal agency.

Such inspection shall in no sense make the Federal Government a party to this contract and will in no way interfere with the rights of either party hereunder.

107.08 Sanitary Provisions. There shall be no discharge of sewage onto the surface of the ground. When a sewerage system is designed to discharge effluent to a stream or water course, the owner shall obtain a permit for construction and operation from the State Sanitary Water Board.

If sanitary facilities are required on construction sites, they shall be connected to a public sewer system if aviilable, or to a septic-tank system or systems if water carriage toilets are installed. When water carriage toilets are not installed, the site shall be provided with approved type pit privies. Any system shall be such that all waste is disposed of without creating a public nuisance or health hazard and in accordance with Illinois Department of Public Health Circular No. 815 or Educational Health Circular No. 4.001.

The Contractor shall also comply with all rules and regulations of the Federal, State, and local health department, and shall take precautions to avoid creating unsanitary conditions.

107.13 Bridges over Navigable Waters. All work on navigable waters shall be so conducted that free navigation of the waterways will not be interfered with and that the existing navigable depths will not be impaired except as allowed by permit issued by the U. S. Army Corps of Engineers.

107.18 Use of Fire Hydrants. If the Contractor desires to use water from hydrants, he shall make application to the proper authorities, and shall conform to the municapal ordinances, rules, or regulations concerning their use.

Fire hydrants shall be accessible at all times to the Fire Department. No material or other obstructions shall be placed closer to a fire hydrant than permitted by municipal ordinances, rules, or regulations, or within 5 feet of a fire hydrant, in the absence of such ordinances, rules or regulations.

107.19 Protection and Restoration of Property. If corporate or private property interferes with the work, the Contractor shall notify, in writing, the owners of such property, advising them of the nature of the interference and shall arrange to cooperate with them for the protection or disposition of such property. The Contractor shall furnish the Engineer with copies of such notifications and with copies of any agreements between him and the property owners concerning such protection or disposition.

The Contractor shall take all necessary precautions for the protection of corporate or private property, such as walls and foundations of buildings, vaults, underground structures of public utilities, underground drainage facilities, overhead structures of public utilities, trees, shrubbery, crops, and fences contiguous to the work, of which the contract does not provide for removal. The Contractor shall protect and carefully preserve all official survey monuments, property marks, section markers, and Geological Survey Monuments, or other similar monuments, until the owner, or an authorized surveyor or agent has witnessed or otherwise referenced their location or relocation. The Contractor shall notify the Engineer of the presence of any such survey or property monuments as soon as they are discovered.

The Contractor shall be responsible for the damage or destruction of property of any character resulting from neglect, misconduct, or omission in his manner or method of execution or nonexecution of the work, or caused by defective work or the use of unsatisfactory materials, and such responsibility shall not be released until the work shall have been completed and accepted and the requirements of the specifications complied with.

Whenever public or private property is so damaged or destroyed, the Contractor shall at his own expense, restore such property to a condition equal to that existing before such damage or injury was done by repairing, rebuilding, or replacing it as may be directed, or he shall otherwise make good such damage or destruction in an acceptable manner. If he fails to do so the Engineer may after the expiration of a period of 48 hours after giving him notice in writing proceed to repair, rebuild, or otherwise restore such property as may be deemed necessary, and the cost thereof shall be deducted from any compensation due, or which may become due, the Contractor under his contract.

107.20 Protection and Preservation of Aboriginal Records and Antiquities. The Contractor shall take reasonable precaution to avoid disturbing aboriginal records and antiquities of archaeological, paleontological, or historical significance. No objects of this nature shall be disturbed without written permission of the Engineer. When such objects are uncovered unexpectedly, the Contractor shall notify the Engineer of their presence and shall not disturb them until written permission to do so is granted.

If it is determined by the Engineer, in consultation with the Illinois State Museum, that exploration or excavation of aboriginal records or antiquities, on land owned or leased by the State is necessary to avoid loss, the Contractor shall cooperate in the salvage work attendant to preservation. If the Engineer determines that the salvage work will delay the Contractor's work. an appropriate extension of contract time will be granted.

107.21 Forest Protection. In carrying out work within or adjacent to State or National Forests, the Contractor shall comply with all regulations of the State Fire Marshal, Conservation Commission, Forestry Department, or other authority having jurisdiction, governing the protection of forests an

he carrying out of work within forests, and shall observe all sanitary laws and regulations with respect to the performance of work in the forest areas. He shall keep the areas in an orderly condition, dispose of all refuse, obtain permits for the construction and maintenance of all construction camps, stores, warehouses, residences, latrines, cesspools, septic tanks, and other structures in accordance with the requirements of the Forest Supervisor.

The Contractor shall take all reasonable precaution to prevent and suppress forest fires and shall require his employees and subcontractors, both independently and at the request of Forest officials, to do all within their power to prevent and suppress and to assist in preventing and suppressing forest fires and to make every possible effort to notify a Forest official at the earlies possible moment of the location and extent of any fire seen by them.

107.26 Contractor's Responsibility for Utility Property and Services. At points where the Contractor's operations are adjacent to properties of railroad, telegraph, telephone, and power companies, or are adjacent to other property, damage to which might result in considerable expense, loss, or inconvenience, work shall not be commenced until all arrangements necessary for the protection thereof have been made.

The Contractor shall cooperate with the owners of any underground or overhead utility lines in their removal and rearrangement operations in order that these operations may progress in a reasonable manner, that duplication of rearrangement work may be reduced to a minimum, and that services rendered by those parties will not be unnecessarily interrupted.

In the event of interruption to water or utility services as a result of accidental breakage or as a result of being exposed or unsupported, the Contractor shall promptly notify the proper authority and shall cooperate with the said authority in the restoration of service. If water service is interrupted repair work shall be continuous until the service is restored. No work shall be undertaken around fire hydrants until provisions for continued service have been approved by the local fire authority.

107.30 Protection of Streams, Lakes and Reservoirs. The Contractor shall take sufficient precautions to prevent pollution of streams, lakes, and reservoirs with fuels, oils, bitumens, calcium chloride, or other harmful materials. He shall conduct and schedule his operations so as to avoid or minimize siltation of streams, lakes and reservoirs. Where, in the opinion of the Engineer, the land has a high potential for erosion the areas that can be exposed by construction operations at any one time will be subject to approval by the Engineer and the duration of the exposure of the uncompleted construction to the elements shall be as short as practicable. Erosion control features shall be constructed concurrently with other work as directed by the Engineer.

201.05 Protection of Trees and Shrubs. All trees and shrubs designated to be saved shall be protected during clearing and subsequent construction operations. Overhanging limbs shall be trimmed or cut off to provide a minimum vertical clearance of 20 feet from the finished surface of the roadbed. This shall be considered as clearing.

In the event that any tree or shrub designated to be saved is damaged by the Contractor, such plants shall immediately be repaired or replaced as directed by the Engineer in accordance with standard horticultural practice for such work, at the Contractor's expense. All wound surfaces of one inch or more diameter shall be treated with a commercial pruning compound.

202.03 Removal and Disposal of Surplus, Unstable and Unsuitable Materials. When permitted all trees and brush that can be destroyed by burning shall be disposed of within the right of way at locations designated by the Engineer in

such a manner that public or private property will not be damaged or endangered. No burning of surplus materials will be permitted in or near areas designated as natural scenic areas that are to remain undisturbed. Prior to starting excavation operations, existing oiled earth or bituminous surfaces shall be broken into pieces not to exceed 6 inches in largest dimension, and the larger material either embedded in embankments or disposed of as hereinafter specified.

Wherever possible, stones and boulders occurring within the right of way shall be placed in embankments in layers and compacted, in accordance with Section 207. All stones, stumps, boulders, broken rock, broken concrete and related materials that cannot be placed in the embankment shall be disposed of at locations designated by the Engineer within the right of way; in borrow sites on or adjacent to the right of way or at other locations outside the right of way. These materials shall be buried under a minimum of 2 feet of earth cover. These materials shall be disposed of in a neat, orderly manner and shall not create an unsightly condition. Disposal methods shall not change or alter the natural topographic features of an area without written permission from the Engineer.

Surplus excavated material, including excavated material from sewer trenches, catch basins, or other underground construction, shall be used to widen embankments, flatten slopes, or be disposed of otherwise within the right of way as the Engineer may direct. It shall in no case be deposited at an elevation higher than that of the adjacent roadway without permission from the Engineer. If it cannot be used or disposed of within the limits of the right of way, it shall be disposed of by the Contractor at his expense, outside the limits of the right of way.

All unstable and unsuitable material, including excavated material from sewer trenches, catch basins, or other underground construction shall be excavated or removed and replaced with material acceptable to the Engineer. Unstable and unsuitable material shall not be used in embankments. If unsuitable material is present at or below the finished grade, it shall be removed and replaced with suitable material, in accordance with Section 213. Unless otherwise provided in the plans or special provisions, unstable and unsuitable material shall be disposed of by the Contractor at his expense, outside the limits of the right of way.

The manner of disposal of surplus excavated material, unstable and un suitable material by the Contractor outside the right of way limits, shall be subject to the approval of the Engineer, and shall be such as will not create an unsightly or objectionable appearance or detract from natural topographic features. The Contractor shall obtain and file with the Engineer permission in writing, from the property owner, for the use of the property for this purpose.

If surplus excavated material, unstable and unsuitable material is disposed of within the right of way but outside of the balance point in which it occurs, overhaul will be paid for in accordance with Section 206.

202.07 Drainage. The roadway shall be maintained so that it will be well drained at all times. If, during the prosecution of the work, it is necessary to interrupt existing sewer or underdrainage, temporary drainage facilities shall be provided until the permanent drainage work has been completed. Such temporary drainage facilities shall be provided until the permanent drainage work has been completed. Such temporary drainage facilities will be paid for in accordance with the provisions of Article 109.04, unless otherwise provided for in the contract.

The Contractor shall be responsible for, and shall take all necessary precautions to preserve and protect all existing tile drains, sewers, and other sub-surface drains or parts thereof which may be affected by his oper-

ations, and which, may be continued in use without change. He shall repair at his own expense any and all damage to such drainage facilities resulting from negligence on his part.

204.02 Borrow Pits General. Unless otherwise provided, borrow excavation shall be furnished by the Contractor. The Contractor shall furnish and pay for all borrow sites or other sources of borrow and obtain from the property owners the necessary agreements for the removal of the excavated material. Borrow excavation shall not be placed in the embankment until the site location, excavation plan and material have been approved by the Engineer in writing.

Under no conditions shall borrow sites detract from the appearance of the natural topographic features nor increase the potential hazard to a vehicle that has inadvertently left the roadway. In selecting sites for borrow acquisition, preference shall be given to knobs, hills, and rises to reduce the extent of pit development. No portion of any borrow pit shall be located within 50 feet of any highway right of way except when borrow is obtained above pavement elevation. In order to insure an aesthetically acceptable borrow site, the steepest slopes used in excavating borrow shall be 4:1, except as provided in Article 204.04.

Borrow pits shall not change the general pattern of existing drainage and shall be well drained unless suitable for development as ponds or lakes. Pertinent drainage information shall be shown on the excavation plan or topographic map submitted by the Contractor.

Borrow sites shall be seeded in accordance with Section 642. The class of seeding and the application rate of fertilizer nutrients and/or ground limestone shall be determined by the Engineer. If the proposed borrow site is to revert to agricultural purposes, the Contractor shall submit to the Engineer a written statement from the owner that seeding will not be required. All work in connection with seeding at borrow sites will not be paid fro separately but shall be considered as incidental to the contract unit price per cubic yard for Borrow Excavation.

501.13 Preservation of Channels. Unless otherwise specified, the natural stream bed adjacent to the structure shall not be disturbed without permission from the Engineer. No excavated material shall be placed in stream channels without permission of the Engineer, and then only upon condition that final disposal of the material will be made in such manner that there will be no obstruction of the channels. If any excavation is made in stream channels outside the area to be excavated for the structure, the Contractor shall, without extra charge, backfill all such excavations to theoriginal ground surface or bed of stream with material satisfactory to the Engineer.

Within the limits of the right of way, excavated material, brush, logs, and debris of any nature, shall be removed for the full length of the structure, so that the area will present a neat appearance and so that there will be no obstruction to the flow of the stream.

SECTION 609. WATER MAIN

609.01 Description. This work shall consist of constructing water main of the required material and inside diameter.

609.02 Materials. Materials shall be as shown on the plans and in the special provisions and approval therefor shall be obtained from the Illinois Environmental Protection Agency as provided under the Environmental Protection Act.

609.03 Construction Requirements. Installation methods shall conform to the manufacturers recommendations for the type of pipe being installed with the following exceptions:

(a) Excavation and Foundation. The applicable requirements of Article 603.04 shall govern the performance of this work.

(b) Requirements for the Protection of Water Mains from Sewers. The requirements of the Illinois Department of Public Health shall govern the horizontal and vertical separation of water mains from sewers.

(c) Backfilling. The applicable requirements of Article 603.08 shall govern the performance of this work except that backfilling shall not be done in freezing weather without written permission of the Engineer, and it shall not be made with frozen material. No backfill shall be made where the material already in the trench is frozen.

Backfilling around joints shall not be made until the hydrostatic tests have been made and any leaks have been repaired.

609.04 Hydrostatic Tests. Hydrostatic tests shall be performed in accordance with Section 13 of the American Water Works Association Specifications, Designation: AWWA C600. The water main shall be subjected to the hydrostatic pressure and leakage tests specified in the special provisions. Water for making the hyrdrostatic and leakage tests shall be furnished by the Contractor at his own expense and shall be of satisfactory bacteriological quality for drinking purposes.

609.05 Disinfection of Water Main. Upon completion of the newly laid water main, the water main shall be disinfected in accordance with the American Water Works Association, Procedure Designation: AWWA C601.

When a Sanitary District or municipality has jurisdiction of a sanitary sewer or water service line, the work shall be performed as prescribed by the Sanitary District or municipality and shall meet the approval of its Engineer.

642.06 Seeding Methods. No seed shall be sown during high winds or when the ground is not in a proper condition for seeding, nor shall any seed be sown until the purity test has been completed for the seeds to be used, and shows that the seed meets the noxious weed seed requirements. The Engineer shall examine and then approve any equipment to be used. Prior to starting work, seeders shall be calibrated and adjusted to sow seeds at the proper seeding rate. Equipment shall be operated in a manner to insure complete coverage of the entire area to be seeded. The Engineer shall be notified 48 hours prior to beginning the seeding operations so that he may determine by trial runs that a calibration of the seeder will provide uniform distribution at the specified rate per acre. When seed or fertilizer is applied with a hydraulic seeder, the rate of application shall be not less than 1000 gallons of slurry per acre. This slurry shall contain the proper quantity of seed or fertilizer specified per acre. When using a hydraulic seeder the fertilizer nutrients and seed shall be applied in two separate operations.

Within 12 hours all seeded areas, including slopes 3 to 1 or flatter, shall be rolled at right angles to the run off with an approved type roller or cultipacker to compact the seed bed and place the seed in contact with the soil.

Slopes steeper than 3 to 1 need not be rolled. Rolling of the seed bed prior to the mulching operation will not be required when mulching is done by Method I and a mulch stabilizer is used to anchor the mulch. On slopes steeper than 3 to 1 mulch shall be applied in accordance with Section 643. On areas seeded with a hydraulic seeder, rolling shall not be required.

The optimum depth for seeding shall be 1/4 inch.

All legumes (clover, vetch, lespedeza, and alfalfa) shall be inoculated with the proper bacteria in the amounts and manner recommended by the manufacturer of the inoculant before sowing or being mixed with other seeds for sowing. The inoculant shall be furnished by the Contractor and shall be approved by the Engineer. The seed shall be sown as soon as possible after inoculation and seed that has been standing more than 5 hours after inoculation shall be reinoculated before sowing. If legumes are applied by hydro seeder, 3 times the normal amount of inoculant shall be used. The Contractor shall furnish the inoculant and the cost of furnishing same shall be included in the contract unit price per acre for Seeding of the class specified.

(3) All plant material, including collected stock, shall comply with the State and Federal laws with respect to inspection for plant diseases and insect infestation. An inspection certificate, required by law to this effect shall accompany each shipment and on arrival the certificate shall be filed with the Engineer.

717.02 Sod. The sod used shall be approved grass that is native to the locality of work. It shall be either nursery grown or field grown and be well rooted and approved by the Engineer prior to being cut and again before it is laid. Sod that has been grown on soil high in organic matter such as peat will not be acceptable. The consistency of adherent soil shall be such that it will not break, crumble, or tear during handling and placing of the sod.

Each piece of sod shall be well covered with turf grass, shall be free from noxious weeds and other objectionable plants, and shall not contain substances injurious to growth. The grass shall be cut to a length of not less than 1 1/2 inches nor more than 4 inches before the sod is cut. The sod shall be cut in rectangular pieces with its shortest side not less than 12 inches. The sod shall not be cut less than 1 inch thick. This thickness measurement does not include grass.

All sod used shall comply with the State and Federal Laws with respect to inspection for plant diseases and insect infestation. An inspection certificate, required by Law to this effect, shall accompany each shipment and on arrival shall be filed with the Engineer.

717.03 Seeds. This specification covers grass, legume, and other plant seeds used for planting highway shoulders, medians, slopes, and other areas required by the plans, specifications, and special provisions.

(a) Sampling and Testing. The seeds shall be sampled and tested in accordance with the requirements of the U.S. Department of Agriculture Service and Regulatory Announcements No. 156, Rules and Regulations Under the Federal Seed Act of August 9, 1939, issued March 1940, reprinted with amendments August 1963 or any current revisions.

717.04 Top Soil. Top soil shall be relatively free from large roots, sticks, weeds, brush, or stones larger than 1 inch in diameter or other litter

and waste products. It shall be a loamy mixture having at least 90 per cent passing the No. 10 sieve. A sample, free from extraneous materials, shall comply with the following requirements:

It shall contain not less than 1 per cent nor more than 10 per cent organic matter as determined by the test for organic matter in accordance with AASHO T 194.

It shall contain not less than 12 per cent nor more than 50 per cent clay as determined in accordance with AASHO T 88.

The sand content shall not exceed 55 per cent as determined in accordance with AASHO T 88.

The pH of the sample shall not be lower than 5.0 nor higher than 8.0. The PH shall be determined with an acceptable pH meter, on that portion of the sample passing the No. 10 sieve, in accordance with the "Suggested Methods of Tests for Hydrogen Ion Concentration (pH) of Soils" included in the procedures for Testing Soils issued December, 1964 by the American Society for Testing and Materials.

717.05 Mulch Material. Mulch material for seeding and planting shall be non-toxic to vegetation and to the germination of seed and shall be approved by the Engineer.

(a) Seeding. Mulch material for seeding shall be free from the noxious weeds and weed seeds listed in Note 2 Group A of the table in Article 717.03(d).
   (1) Straw. Straw shall be stalks of wheat, rye, oats, or other approved straw, and shall be air-dried.
   (2) Hay. Hay shall be obtained from fields of timothy, red top, mature brome grass, or other mature grasses, or from other sources approved by the Engineer. It shall be air-dried.

(b) Planting. The type of mulch material for planting shall be specified in the Special Provision or on the plans and shall be approved by the Engineer.

717.06 Agricultural Ground Limestone. Agricultural limestone shall meet the following requirements:

Ground limestone containing all of the finer particles obtained in the grinding process and ground sufficiently fine so that no less than 80 per cent will pass through a No. 8 sieve. The calcium carbonate equivalent must be at least 80 per cent. One or both must be greater than 80 so that the multiplication of the per cent of calcium carbonate equivalent by the per cent of material passing through the No. 8 sieve will be equal to or in excess of 0.72. The moisture content at the time of shipment must not exceed 8 per cent.

717.07 Fertilizer. Fertilizer shall be ready mised material of an analysis specified on the plans or as directed by the Engineer. In cases where a single nutrient is requested, unless otherwise specified, the analysis will be optional, provided that it carries sufficient filler to insure adequate

distribution of the nutrient.

The following information shall be shown on the fertilizer bag or package or on a tag attached thereto:

1. Name and address of manufacturer.
2. Name, brand or trade mark.
3. Number of net pounds of ready mixed material in the package.
4. Chemical composition or analysis.
5. Guarantee of analysis.

If a brand or grade of fertilizer is delivered in the bulk, a written statement having the above listed information must accompany each load.

Custom mixed fertilizers shall have a written statement containing the following information with each load:

1. Weight of each commercial fertilizer used in the custom mixing.
2. The guaranteed analysis of each commercial fertilizer used in the custom mixing.
3. Total weight of fertilizer delivered in each load.
4. The manufacturer of each of the commercial fertilizers used in the custom mix.
5. Guaranteed analysis of each load to be stated as follows:

    1. Per cent ot total Nitrogen (N) _____
    2. Per cent of total available Phosphoric (P_2O_5) _____
    3. Per cent of total Soluble Potash (K_2O) _____

6. Name and address of the person selling the fertilizer.

717.08 Peat Moss. Peat moss shall conform to the following requirements:

(a) Peat moss shall be partially decomposed fibrous or cellular stems and leaves of any of several species of sphagnum mosses, and shall conform to the following requirements:

(1) Texture and Composition. Its texture may vary from porous fibrous to spongy fibrous, and it shall be either crumbly or compact, but fairly elastic and substantially homogeneous. It shall be free from decomposed colloidal residue, excessive woody materials (roots and stems), and mineral matter such as iron and sulphur. It shall be essentially dark brown in color. Shredded particles shall not exceed 1/4 inch in size.

(2) Acidity. The pH value shall be not less than 3.2 and not greater than 5.5, at approximately 25°C.

(3) Ash. The ash content, based on the oven-dry weight of the material, shall be not more than 5 per cent.

(4) Water Holding Capacity. The water holding capacity shall be not less than 800 per cent, by weight, on an over-dry basis.

(b) Sampling. A test sample weighing at least one pound shall be taken from each 50 ton lot or fraction thereof. Such samples shall be taken 6 inches below the surface of one or more bales, thoroughly mixed, and placed in a clean, dry, air-tight metal container or in a strong plastic bag, sealed, and forwarded to the testing laboratory.

(c) Testing. The samples shall be tested in accordance with the requirements of Article 4.5 of the Federal Specifications for Peat Moss; Peat, Humus; and Peat, Reed-Sedge, Q-P-166e, of the issue in effect on the date of invitation for bids.

(d) Packing. Unless otherwise specified, the air-dried peat moss shall be packed in bales of the type, size and kind commonly used. Damaged bales will not be accepted.

The peat moss shall be packed in the bales at a compression ratio of at least 2 to 1. Each bale shall be clearly marked with the type of peat moss, the brand name, the country of origin, the cubic feet compressed size, the compression ratio used, and the approximate weight of the bale. In the absence of such marking, each shipment shall be accompanied by a certificate stating the desired information.

717.09 Special Erosion Control Materials.

(a) Jute Matting. Jute matting shall be of plain, uniform open weave of new (unused), and unbleached single jute yarn. The yarn shall be of a loosely twisted construction and shall not vary in thickness by more than one-half its normal diameter.

The matting shall comply with the following specifications:

Width, inches, plus or minus 1 in.	48
Warp, ends per width of cloth	78
Weft, ends per lineal yard.	41
Average weight per lineal yard, pounds, plus or minus 5 per cent	1.22
Length of roll, feet, approx.	.225

The jute matting shall be made smolder resistant by treating at least one side with non-leaching and non-toxic chemicals. The smolder resistant treatment shall be non-toxic to vegetation and to the germination of seed and shall not be injurious to the hands in placing the matting.

The treated matting shall withstand the following tests:

The leaching resistance shall be made in accordance with Federal Specifications CCC-T-191b, Method 5830, except that the continuous flow of water to the bottom of the container shall be at a rate of about five changes per 24 hours. The matting specimen, air dried from the leaching test, shall not flame or smolder for more than a distance of 12 inches from spot where a lighted cigarette is placed on the treated surface of the matting.

Certification. The manufacturer shall furnish a certification with each shipment of jute matting, stating the number of rolls furnished and that the material complies with the requirements of the specifications.

(b) Excelsior Blanket. Excelsior blanket shall consist of a machine produced mat of wood excelsior of 80 per cent eight inch or longer

fiber length. The wood from which the excelsior is cut shall be properly cured to achieve adequately curled and barbed fibers.

The blanket shall be of consistent thickness, with the fiber evenly distributed over the entire area of the blanket. The excelsior blanket shall be covered on the top side with a 3 inch by 1 inch leno weave, twisted kraft paper yarn netting having a high wet strength. The netting shall be entwined with the excelsior mat for maximum strength and ease of handling.

The excelsior blanket shall comply with the following specifications:

Width, inches, plus or minus 1 inch	36	48
Weight per square yard, pounds, plus or minus 5 per cent	0.8	0.8
Length of roll, feet, approximately	150	180

The excelsior blanket specimen shall not flame or smolder for more the following test:

The excelsior blanket specimen shall not flame or smolder for more than a distance of 12 inches from a spot where a lighted cigarette is placed on the surface of the blanket.

Certification. The manufacturer shall furnish a certification with each shipment of excelsior blanket stating the number of rolls furnished and that the material complies with the requirements of the specifications.

(c) Staples. Staples shall be made from No. 11 gage or heavier wire, width 1 or 2 inches at the throat and 6 inches from top to bottom after bending. The staples shall be packaged in cartons.

BITUMINOUS EQUIPMENT. Hot-Mix Plant. The plant shall be equipped with an approved dust collecting system. The collected dust shall be stored in an approved hopper other than the dust collector.

SPECIAL PROVISION
FOR
TEMPORARY PROJECT WATER POLLUTION CONTROL (SOIL EROSION)

Effective July 1, 1970

This Special Provision supercedes Article 107.30 of the Standard Specifications for Road and Bridge Construction.

Description: This work shall consist of erosion control measures ordered by the Engineer during the life of the contract to control water pollution, through use of berms, dikes, dams, sediment basins, fiber mats, netting, gravel, mulches, grasses, slope drains, and other erosion control devices or methods.

Any temporary pollution control provisions ordered by the Engineer shall be coordinated with the permanent erosion control features specified elsewhere in the contract to the extent practical to assume economical, effective and continuous erosion control throughout the construction and postconstruction period.

Materials:

A. Mulches may be hay, straw, fiber mats, netting, wood cellulose corn or tobacco stalks, bark, corn cobs, wood chips, or other suitable material acceptable to the Engineer and shall be reasonable clean and free of noxious weeds and deleterious materials.

B. Slope drains may be constructed of pipe, fiber mats, rubble, portland cement concrete, bituminous concrete, plastic sheets, or other materials acceptable to the Engineer that will adequately control erosion.

C. Grass shall be a quick growing species (such as rye grass, Italian rye grass, or cereal grasses) suitable to the area providing a temporary cover which will not later compete with the grasses sown later for permanent cover.

D. Fertilizer and soil conditioners shall be a standard commercial grade acceptable to the Engineer.

E. Others as specified by the Engineer.

Preconstruction: At the preconstruction conference or prior to the start of the applicable construction, the contractor shall submit for acceptance his schedules for accomplishment of erosion control work, as are applicable for clearing and grubbing; grading; bridges and other structures at water-courses; construction; and paving. He shall also submit for acceptance his proposed method of erosion control on haul roads and borrow pits and his plan for disposal of waste materials. No work shall be started until the erosion control schedules and methods of operations have been approved by the Engineer.

Construction Requirements: The Engineer has the authority to limit the surface area of erodible earth material exposed by clearing and grubbing, the surface area of erodible earth material exposed by excavation, borrow and

fill operations and to direct the contractor to provide immediate permanent or temporary pollution control measures to prevent contamination of adjacent streams or other watercourses, lakes, ponds, or other areas of water impoundment. Such work may involve the construction of temporary berms, dikes, dams, sediment basins, slope drains, and use of temporary mulches, mats, seeding or other control devices or methods as necessary to control erosion. Cut slopes shall be seeded and mulched as the excavation proceeds to the extent considered desirable and practicable.

The contractor will be required to incorporate all permanent erosion control features into the project at the earliest practicable time as outlined in his approved schedule. Temporary pollution control measures will be used to correct conditions that develop during construction that were not foreseen during the design stage; that are needed prior to installation of permanent pollution control features; or that are needed temporarily to control erosion that develops during normal construction practices, but are not associated with permanent control features on the project.

Where erosion is likely to be a problem, clearing and grubbing operations should be so scheduled and performed that grading operations and permanent erosion control features can follow immediately thereafter, if the project conditions permit; otherwise temporary erosion control measures may be required between successive construction stages. Under no conditions shall the surface area of erodible earth material exposed at one time by clearing and grubbing, exceed 40 acres or portion of the project such as an interchange or structure, until satisfactory temporary erosion controls are provided, unless otherwise approved by the Engineer.

The Engineer may limit the area of excavation, borrow and embankment operations in progress commensurate with the contractor's capability and progress in keeping the finish grading, mulching, seeding, and other such permanent pollution control measures current in accordance with the approved schedule. Should seasonal limitations make such coordination unrealistic, temporary erosion control measures shall be taken immediately to the extent feasible and justified.

Under no conditions shall the amount of surface area of erodible earth material exposed at one time by excavation, borrow or fill within the right-of-way exceed 40 acres or portion of the project such as an interchange or structure, until satisfactory temporary erosion controls are provided, unless otherwise approved by the Engineer.

If to accomplish pollution control the Contractor is required or elects to seed the slopes using the permanent or final seeding outlined in the contract, he may request, in accordance with the requirements of Article 105.14(a) of the Standard Specifications, an inspection be made and if satisfactorily completed be relieved of further responsibility for the maintenance of the slopes and seeding.

The Engineer may increase or decrease the amount of surface area of erodible earth material to be exposed at one time by clearing and grubbing, excavation, borrow and fill operations as determined by his analysis of project conditions.

In the event of conflict between these requirements and pollution control laws, rules or regulations of other Federal or State or local agencies, the

more restrictive laws, rules, or regulations shall apply. The Contractor shall take sufficient precautions to prevent pollution of streams, lakes, and reservoirs with fuels, oils, bitumens, calcium chloride or other harmful materials.

Method of Measurement and Payment: In the event that temporary erosion and pollution control measures are required due to the contractor's negligence, carelessness, or failure to install permanent controls as a part of the work as scheduled, and are ordered by the Engineer, such work shall be performed by the contractor at his own expense. Temporary erosion and pollution control work required, which is not attributed to the contractor's negligence, carelessness or failure to install permanent controls, will be performed as ordered by the Engineer.

Where the work to be performed is not attributed to the contractor's negligence, carelessness or failure to install permanent controls and falls within the specifications for a work item that has a contract price, the units of work shall be paid for at the proper contract price. Should the work not be comparable to the project work under the applicable contract items, the contractor shall be ordered to perform the work in accordance with Article 109.04 of the Standard Specifications.

In case of repeated failures on the part of the contractor to control erosion, pollution, and/or siltation, the Engineer reserves the right to employ outside assistance or to use his own forces to provide the necessary corrective measures. Such incurred direct costs plus project engineering costs will be charged to the contractor and appropriate deductions made from the contractor's monthly progress estimate.

Pollution control may include construction work outside the right of way where such work is necessary as a result of roadway construction such as borrow pit operation, haul roads and equipment storage sites.

The erosion control features installed by the contractor shall be acceptably maintained by the contractor.

SUPPLEMENTAL SPECIFICATION FOR ROADWAY EXCAVATION

Effective July 1, 1971

This Supplemental Specification amends the provisions of the Standard Specifications, adopted January 2, 1971, and shall be construed to be a part thereof superseding any conflicting provisions thereof applicable to the work under the contract.

202.03 Removal and Disposal of Surplus, Unstable and Unsuitable Materials. Substitute the following paragraph for the first two sentences of this article:

"The Contractor at his expense shall dispose of all surplus, unstable and unsuitable materials including those which result from the work included in Section 201 in such a manner that public or private property will not be damaged or endangered."