STORABLE SPACE TUG SYSTEMS STUDY

DATA DUMP

VOLUME 8, PROGRAMMATICS & COST: BOOK 2

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8.1 SCHEDULES

8.1.1 SUMMARY PROJECT SCHEDULE

Introduction: The Storable Tug Project schedule was developed to identify the principal project phases and to establish schedule estimates for all hardware and soft ware elements in accordance with the Space Tug Work Breakdown Structure.

The Tug Project Schedule depicts major program milestones and presents project activities at level 5 of the WBS. This schedule establishes the planning baseline for development of the Storable Tug System through design, development, manufacturing, ground test, flight test and operations. It integrates all supporting schedules into an overall project level plan and establishes the sequence and interdependency of activities and events required for the development of an operational Space Tug System.

Groundrules and Assumptions: Following are the ground rules and assumptions used for development of the Storable Tug Project Schedule:

- o ATP is October 1975 at the earliest for Options 1 and 3. ATP for Option 2 to be determined by the contractor.
- o Schedule planning is designed to minimize peak annual funding during DDT&E.
- o Main Stage DDT&E requirements consist of the following major test articles:
  - A structural test article (STA) for dynamic, static and fatigue tests.
  - A main propulsion test vehicle (PTV). Following the completion of live propellant testing the PTV will be refurbished and delivered as an operational flight vehicle.
  - One shipset of Avionics hardware for the Integrated Avionics Test (IAT).
  - A flight test vehicle (MS-1).
- o Operational fleet sizes for each project option are based on a study of traffic capture models.
- o Production rate of vehicles is based on avoiding duplication of major structural assembly tooling and minimizing gaps in manufacturing flow.

- Initial operational capability (IOC) is achieved after completion of one test flight (FOF). IOC dates are as follows:

  Option 1 - December 1979
  Option 2 - December 1983
  Option 3 - December 1979 - initial, December 1983 - evolved.

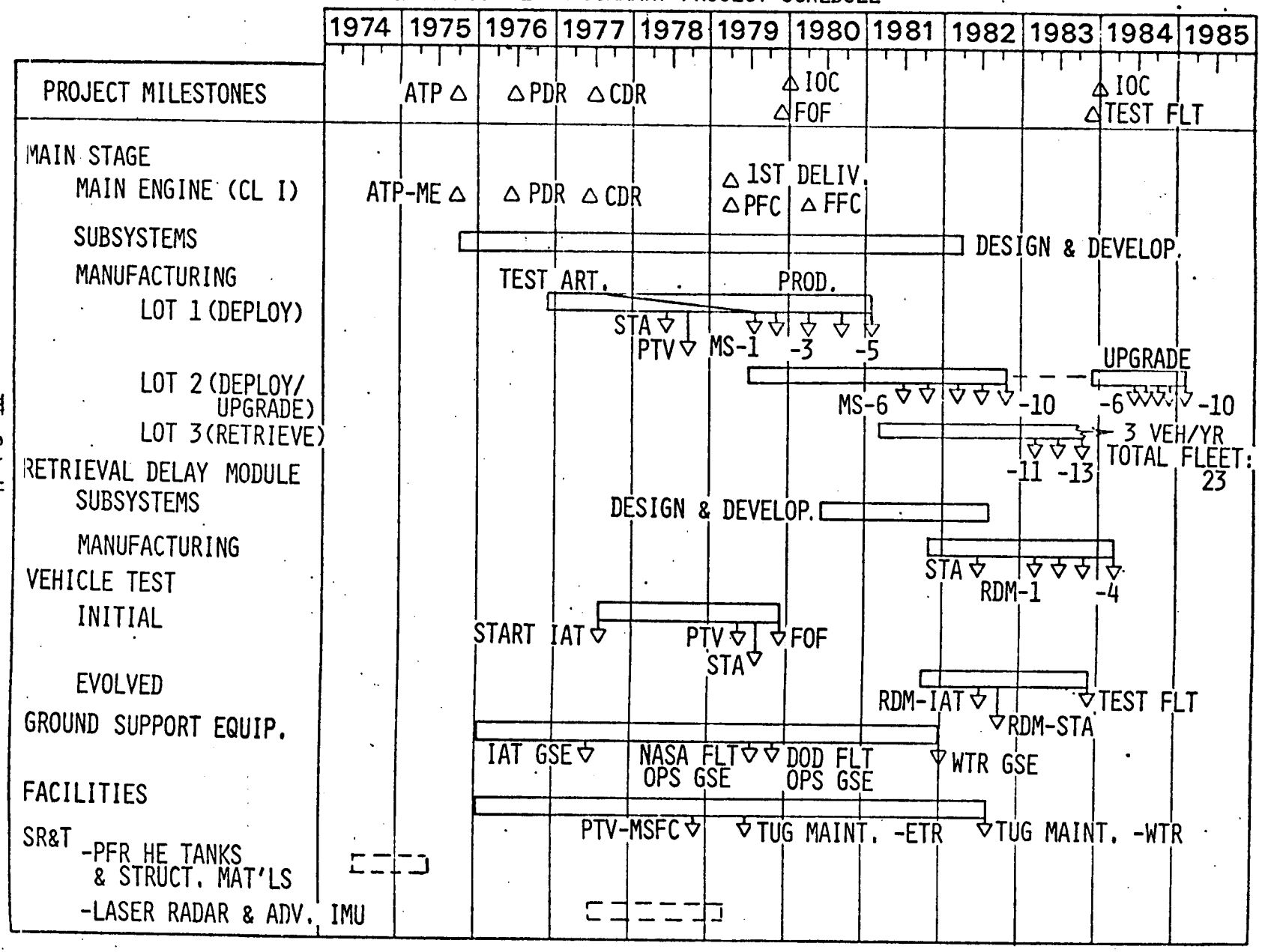
- Maximum number of flights in 1980 is 3, based on the Shuttle traffic model.

Approach: Based on the above groundrules and assumptions a preliminary project milestone schedule was developed to form a baseline for all detail scheduling. Detailed subsystem design and development schedules, manufacturing and factory checkout flows, vehicle test, GSE, facilities, and SR&T Schedules were then developed in conjunction with personnel representing the cognizant management and technical disciplines. These detailed schedules were then summarized and integrated into the Tug Project Schedule through the process of establishing a logical and achievable relationship between the engineering design and development process, procurement of subcontract equipment, hardware fabrication and assembly process and the vehicle test program that minimizes risks and ensures the fulfillment of program objectives. Finally, the major project milestones and activities presented in the Tug Project Schedule were condensed into the Summary Project Schedule.

SUMMARY SCHEDULE - 310-3A/310RE-3A

The primary elements of the 310-3A/310RE-3A Project Schedule include Main Stage, Retrieval Delay Module, Vehicle Test, GSE, Facilities and dependent SR&T. Authorization to Proceed (ATP) occurs on October 1, 1975 with IOC of the initial configuration targeted for December 31, 1979. The Class I main engine ATP occurs at the same time as the main stage with Final Flight Certification occuring 4 months after First Orbital Flight (FOF). Main stage vehicle tests are essentially as described for 110A-1 except that phased retrieval requires additional Integrated Avionics testing and a flight test to demonstrate retrieval capability. First flight of the evolved configuration is targeted for December 1, 1983. Development of the Retrieval Delay Module (RDM) starts on June 1, 1980 with related vehicle tests starting at the same time as main stage evolved vehicle tests. Another feature of the schedule is the 3 Lot buy of production main stages. This production approach was deemed necessary to avoid a manufacturing gap between initial production to meet deploy only operations and production of evolved vehicles. Lot 1 Tugs have deploy only system capability, Lot 2 Tugs begin with deploy capability and are then upgraded to retrieval capability and Lot 3 Tugs will include retrieval capability. Lot 1 includes 5 production vehicles, Lot 2 includes 5 and and Lot 3 includes 13 for a total fleet of 23 vehicles. GSE and Facilities are scheduled essentially as described for 110A-1.

310-3A/310RE-3A SUMMARY PROJECT SCHEDULE

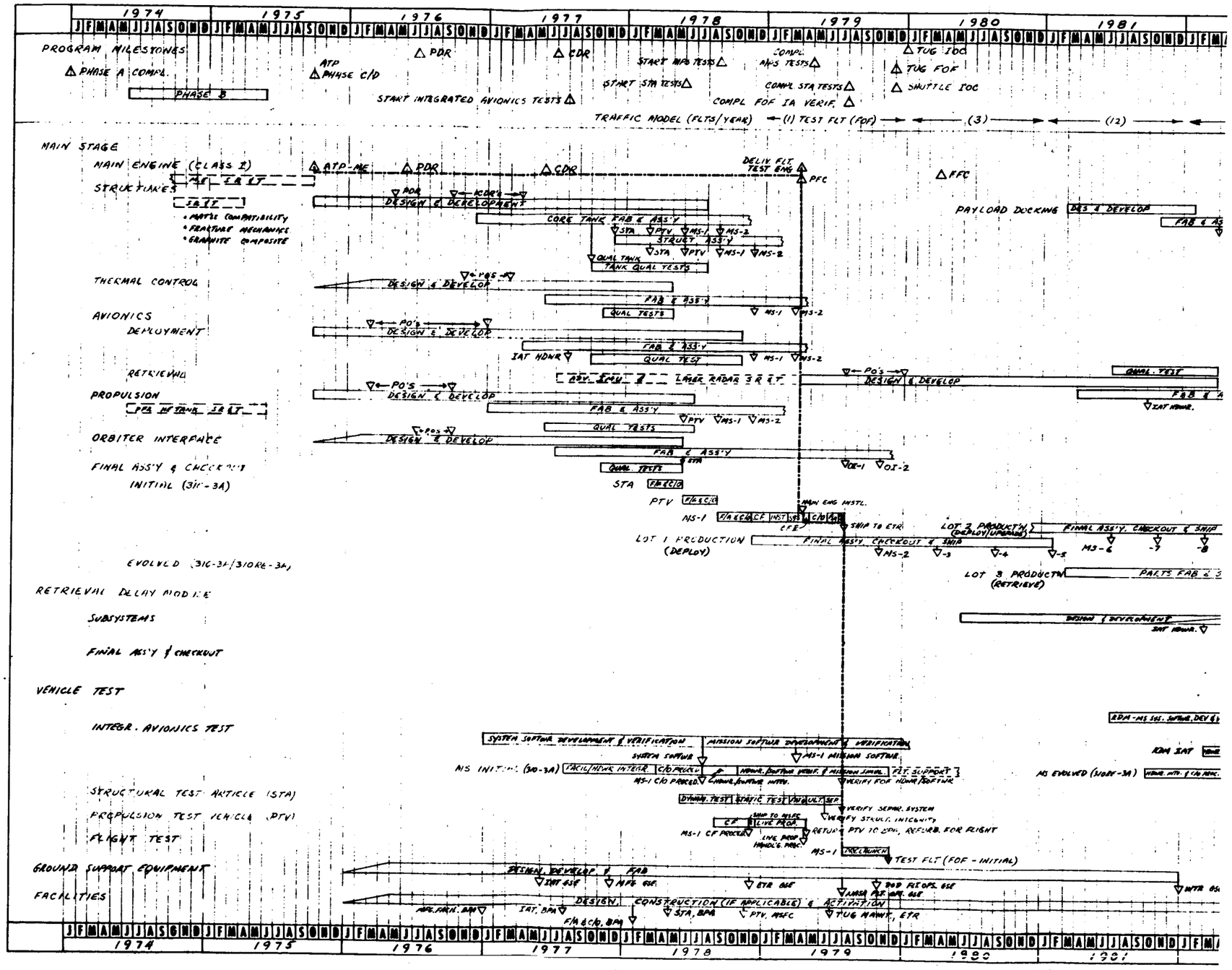


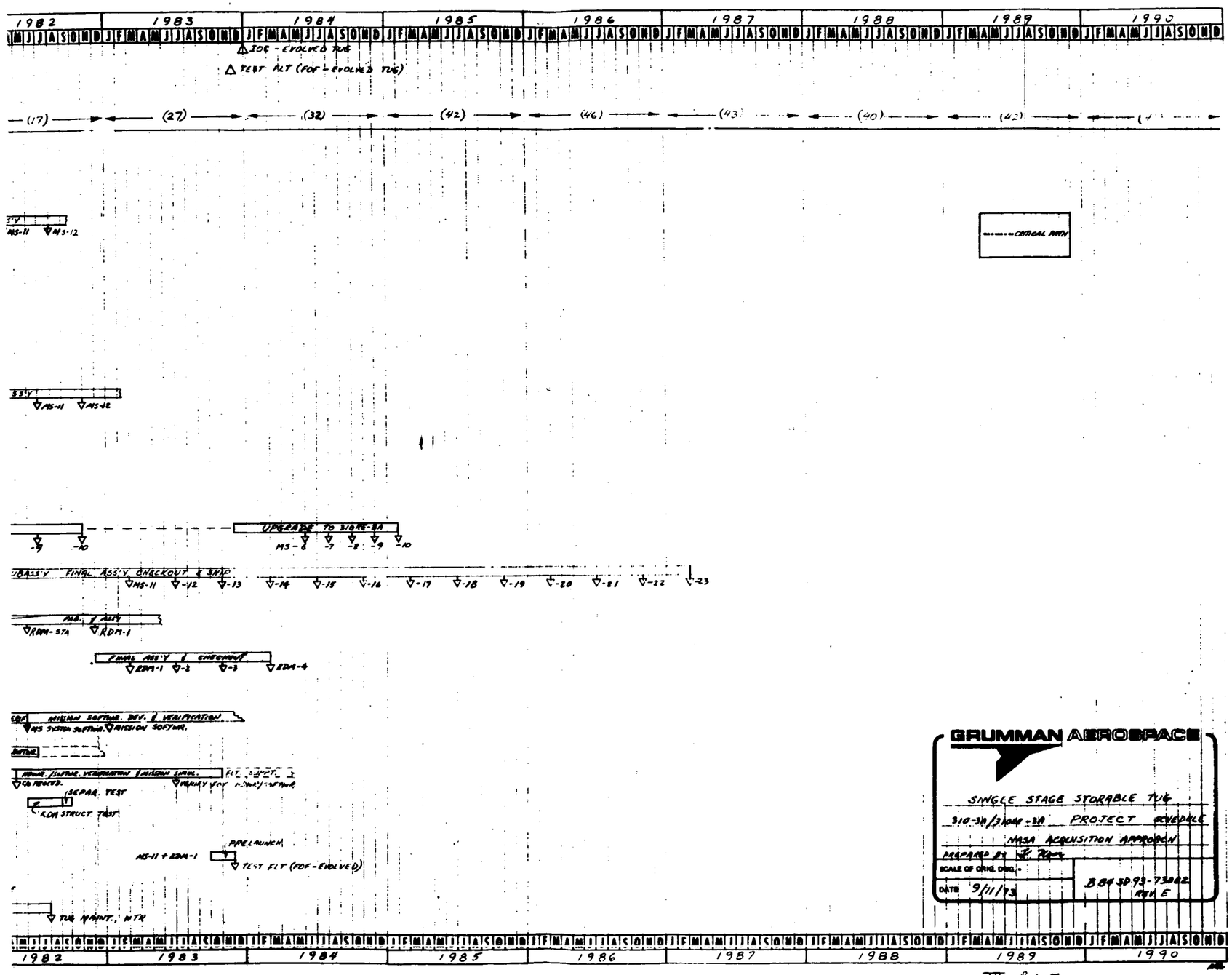
8.1.2 DEVELOPMENT SCHEDULES

8.1.3 PRODUCTION SCHEDULES

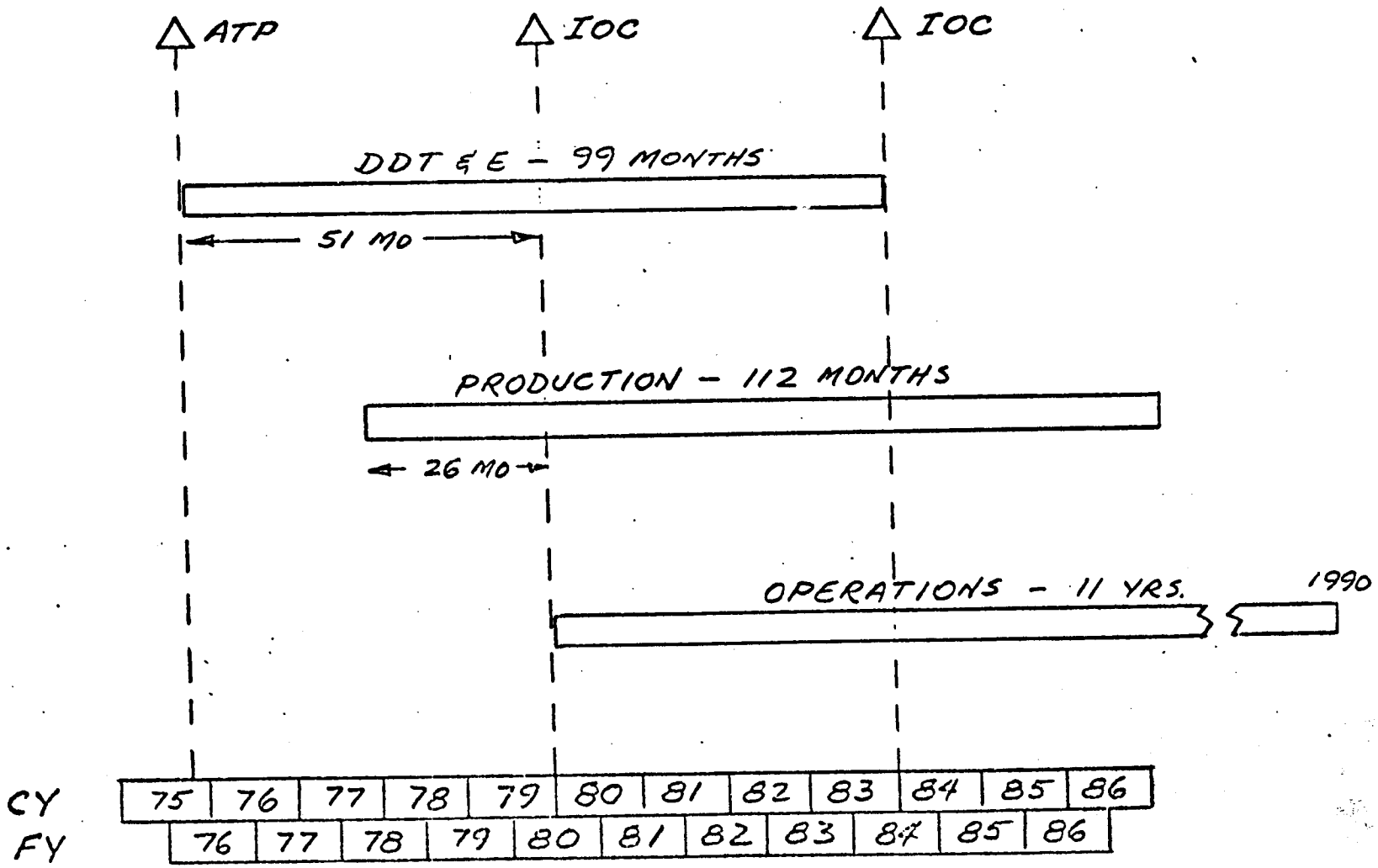
The detailed Project Schedule depicts the total development and production phases for the Main Stage and the Auxiliary Stage(s). The detailed Project Schedule is based on a constraint logic that considers overall program objectives and the detailed interaction of constraints on significant program activities. It provides reasonable margins for development problems and minimizes program front-loading.

The detailed Subsystem Schedules provide an order of magnitude increase in detail from the Project Schedule and depict the subsystem activities in both inhouse and subcontractor areas. Subsystem schedule information is presented at WBS level 6 for Structures, Thermal Control and Orbiter Interface, and at WBS level 7 for Propulsion and Avionics subsystems.

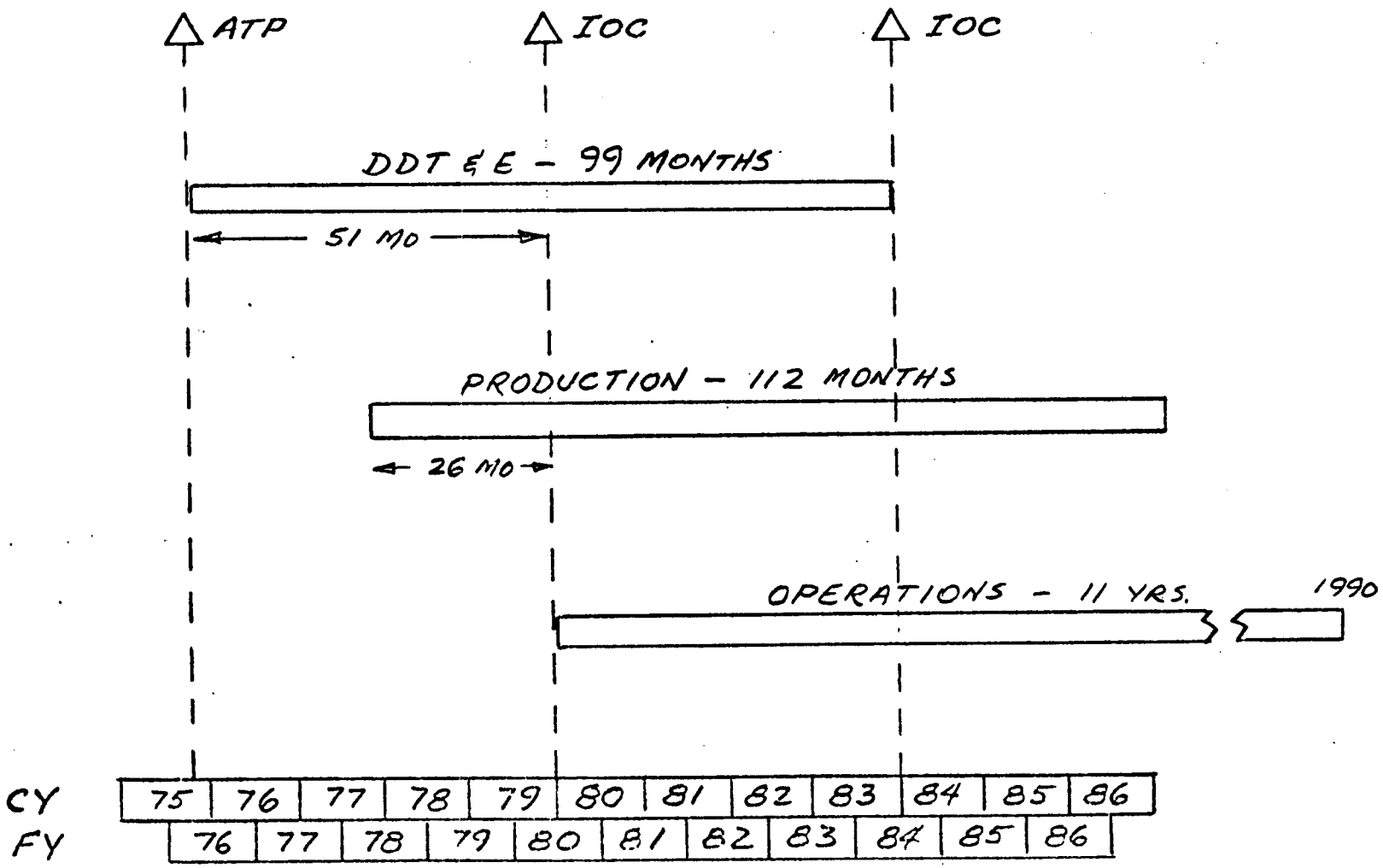

1974
1975
1976
1977
1978
1979
1980
1981
PROGRAM MILESTONES
PHASE A COMPL.
PHASE B
ATP
PHASE C/D
PDR
CDR
START INTEGRATED AVIONICS TESTS
START MPS TESTS
START STA TESTS
COMPL MPS TESTS
COMPL STA TESTS
COMPL FOF IA VERIF.
TUG IOC
TUG FOF
SHUTTLE IOC
TRAFFIC MODEL (FLTS/YEAR)
(1) TEST FLT (FOF)
(3)
(12)
MAIN STAGE
MAIN ENGINE (CLASS I)
ATP-ME
PDR
CDR
DELIV FLT TEST ENG
PFC
FFC
STRUCTURES
DESIGN & DEVELOPMENT
CORE TANK FAB & ASS'Y
STRUCT ASS'Y
QUAL TANK
TANK QUAL TESTS
PAYLOAD DOCKING
DES & DEVELOP
THERMAL CONTROL
DESIGN & DEVELOP
FAB & ASS'Y
QUAL TESTS
AVIONICS
DEPLOYMENT
DESIGN & DEVELOP
FAB & ASS'Y
QUAL TEST
RETRIEVAL
PROPULSION
DESIGN & DEVELOP
FAB & ASS'Y
QUAL TESTS
ORBITER INTERFACE
DESIGN & DEVELOP
FAB & ASS'Y
QUAL TESTS
FINAL ASS'Y & CHECKOUT
INITIAL (310-3A)
STA
PTV
MS-1
LOT 1 PRODUCTION
(DEPLOY)
FINAL ASS'Y, CHECKOUT & SHIP
LOT 2 PRODUCTN
(DEPLOY/UPGRADE)
FINAL ASS'Y, CHECKOUT & SHIP
LOT 3 PRODUCTN
(RETRIEVE)
EVOLVED (310-3A/310RE-3A)
RETRIEVAL DELAY MODULE
SUBSYSTEMS
DESIGN & DEVELOPMENT
FINAL ASS'Y & CHECKOUT
VEHICLE TEST
INTEGR. AVIONICS TEST
SYSTEM SOFTWR DEVELOPMENT & VERIFICATION
MISSION SOFTWR DEVELOPMENT & VERIFICATION
MS-1 MISSION SOFTWR
MS INITIAL (310-3A)
MS EVOLVED (310RE-3A)
STRUCTURAL TEST ARTICLE (STA)
PROPULSION TEST VEHICLE (PTV)
FLIGHT TEST
TEST FLT (FOF - INITIAL)
GROUND SUPPORT EQUIPMENT
DESIGN, DEVELOP & FAB
FACILITIES
DESIGN, CONSTRUCTION (IF APPLICABLE) & ACTIVATION
1974
1975
1976
1977
1978
1979
1980
1981


1982
1983
1984
1985
1986
1987
1988
1989
1990
IOC - EVOLVED TUG
TEST FLT (FOF - EVOLVED TUG)
(17)
(27)
(32)
(42)
(46)
(43)
(40)
(42)
CRITICAL PATH
MS-11
MS-12
UPGRADE TO 310RE-3A
MS-6
-7
-8
-9
-10
FINAL ASS'Y CHECKOUT & SHIP
MS-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
-22
-23
FAB. & ASS'Y
RDM-STA
RDM-1
FINAL ASS'Y & CHECKOUT
RDM-1
-2
-3
RDM-4
MISSION SOFTWR. DEV. & VERIFICATION
MS SYSTEM SOFTWR.
MISSION SOFTWR.
SEPAR. TEST
RDM STRUCT. TEST
PRELAUNCH
MS-11 + RDM-1
TEST FLT (FOF - EVOLVED)
TUG MAINT., WTR
GRUMMAN AEROSPACE
SINGLE STAGE STORABLE TUG
310-3A/310RE-3A PROJECT SCHEDULE
NASA ACQUISITION APPROACH
PREPARED BY
SCALE OF ORIG. DWG.
DATE 9/11/73
B84 SD93-73002
REV E

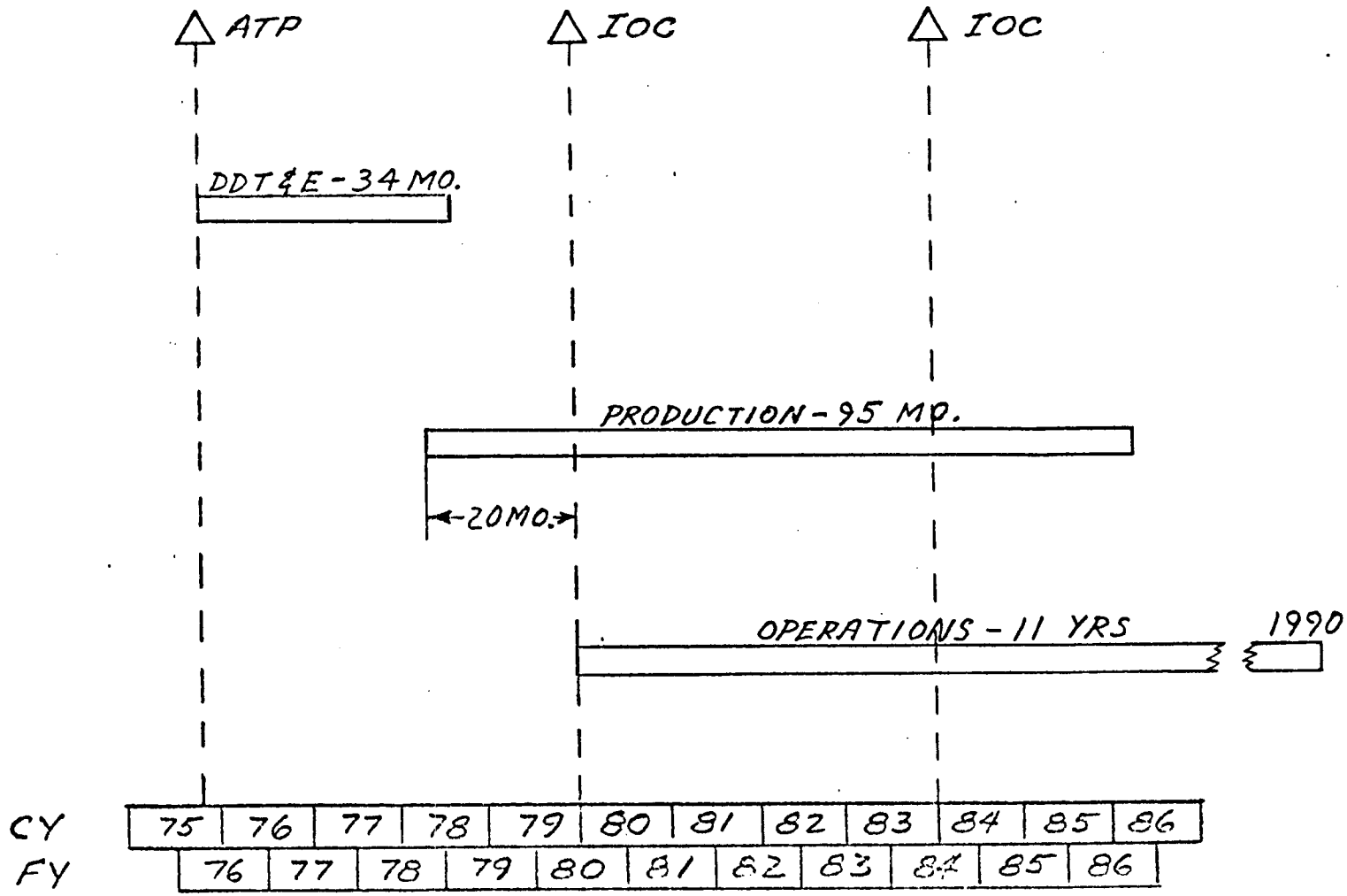
310-3A/310RE-3A PROJECT SUMMARY



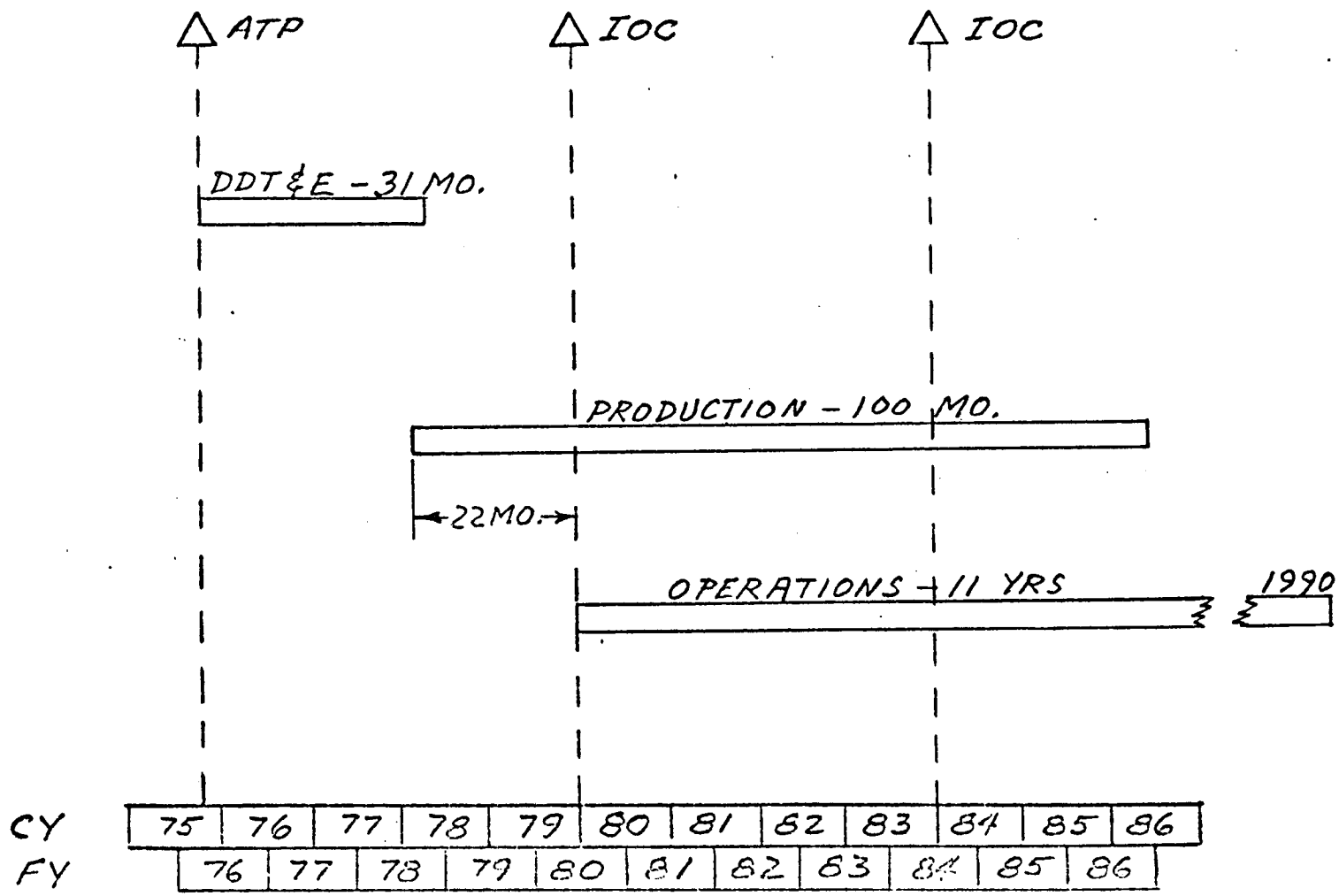
310-3A/310RE-3A MAIN STAGE



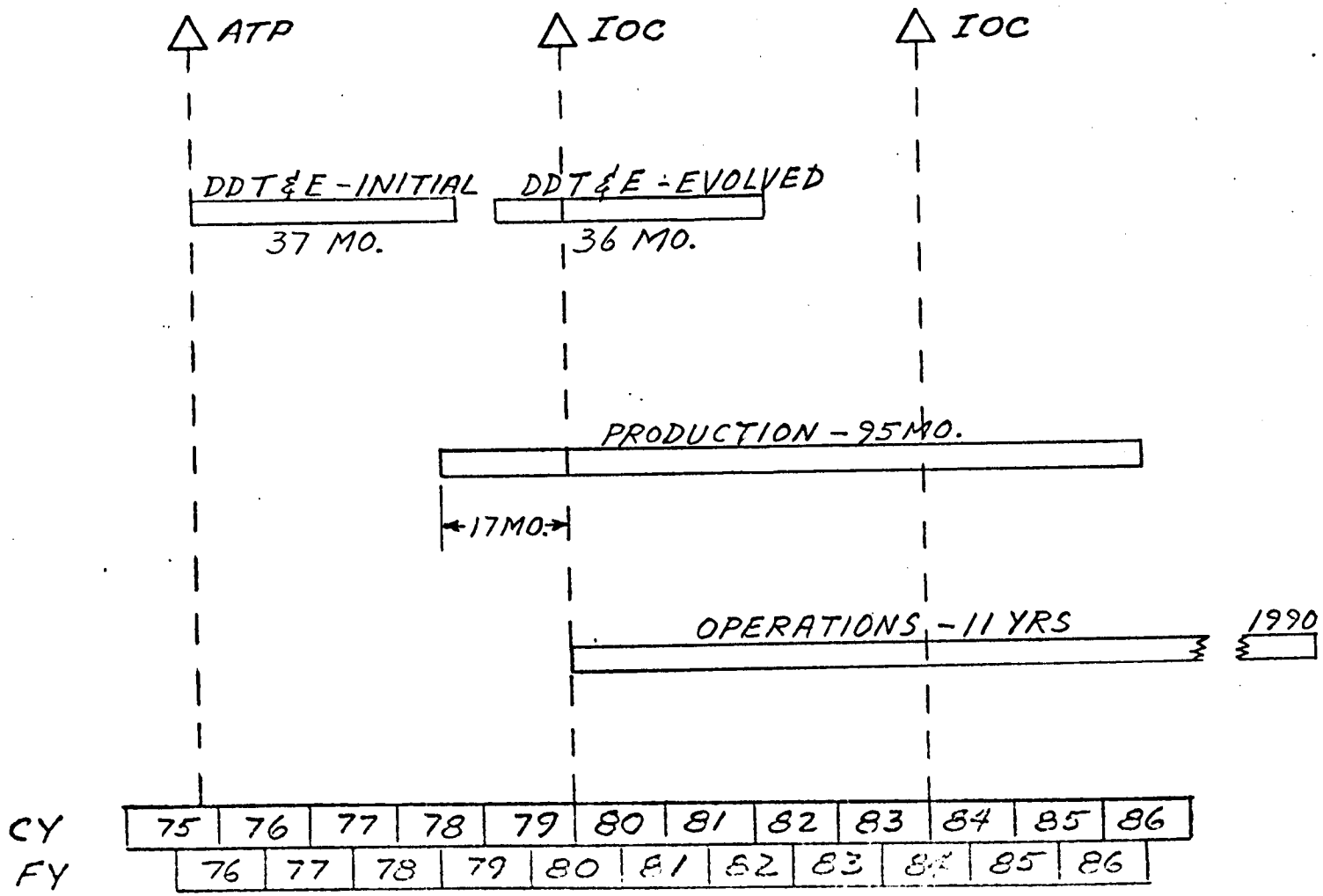
310-3A/310RE-3A STRUCTURES



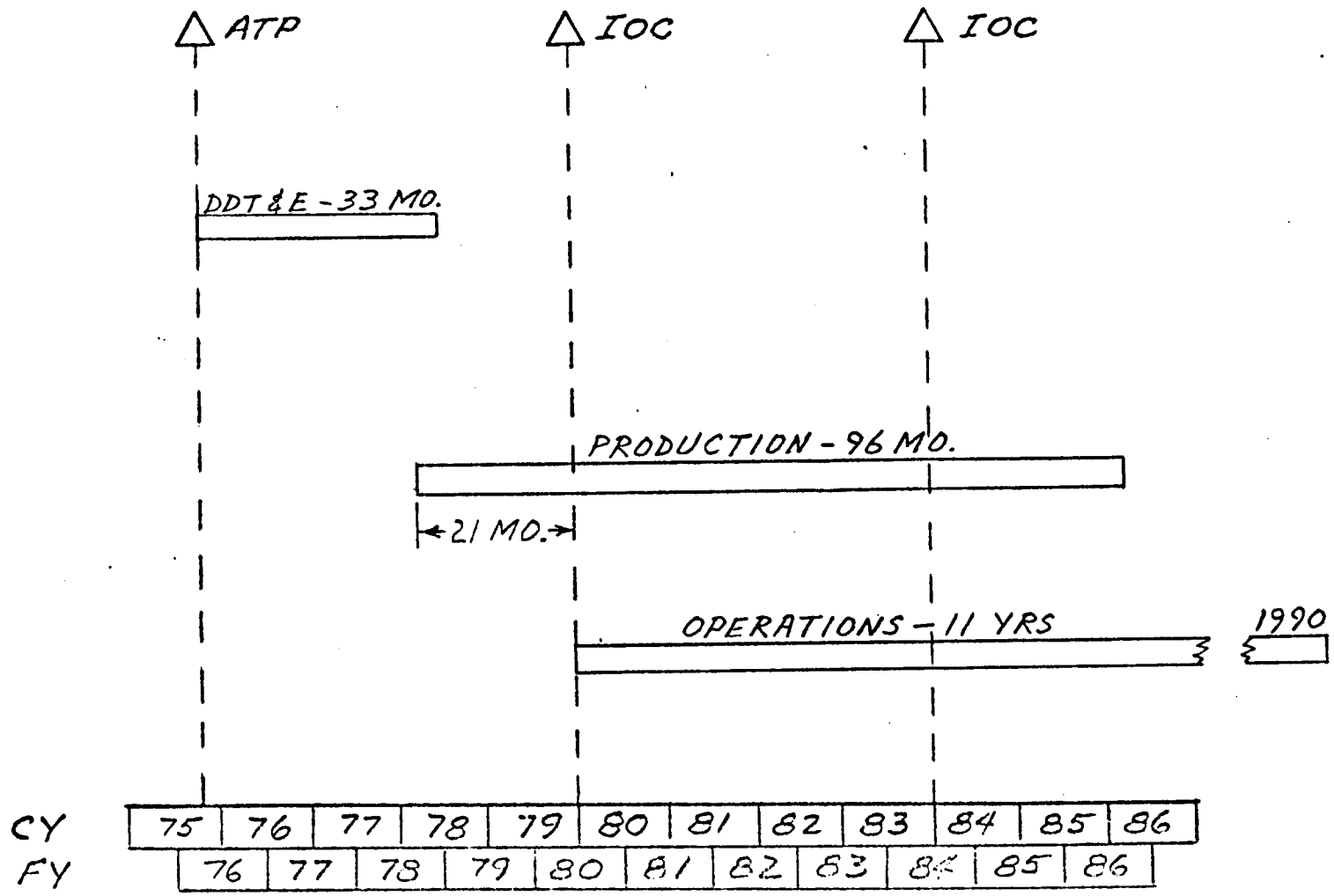
310-3A/310RE-3A THERMAL CONTROL



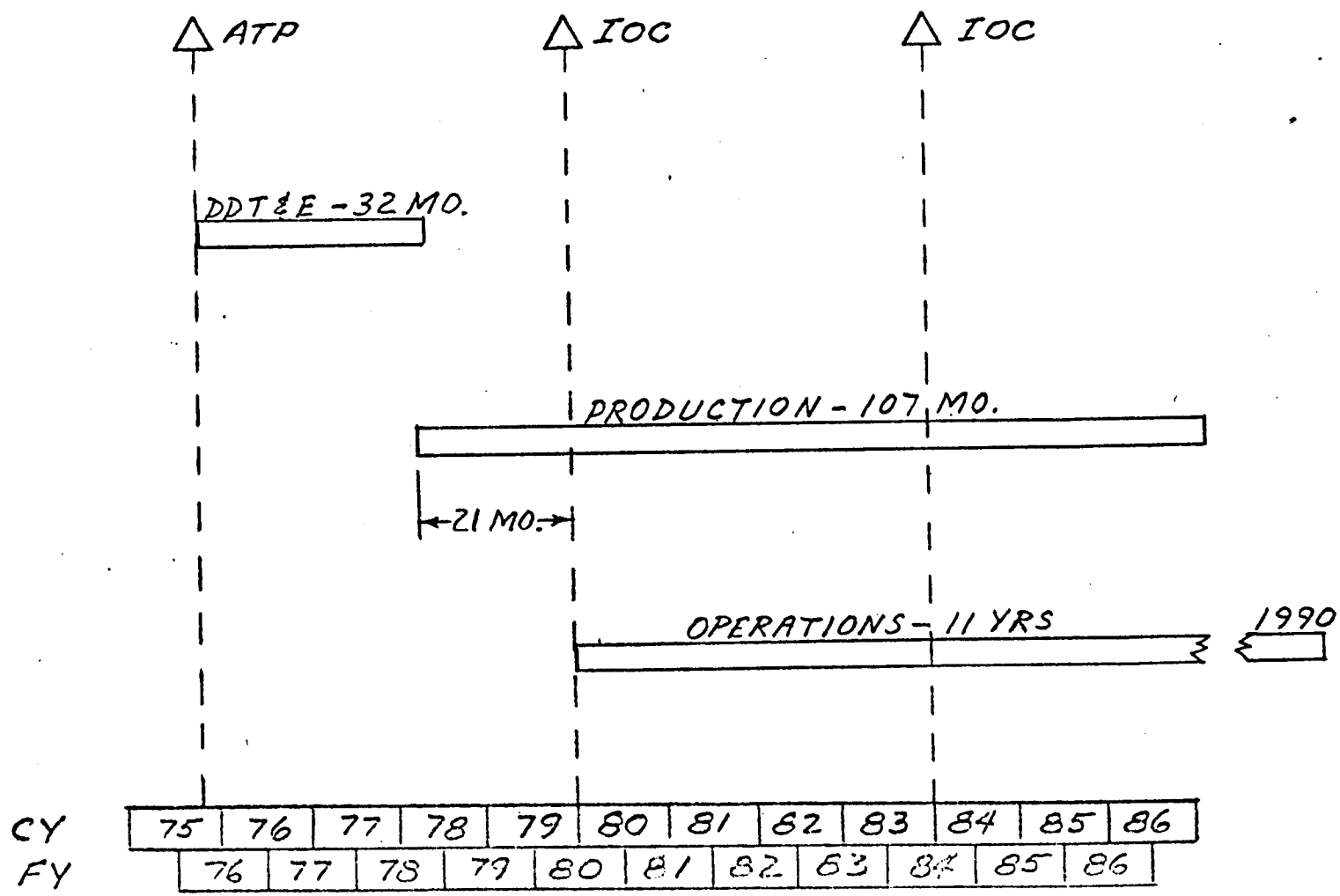
310-3A/310RE-3A AVIONICS

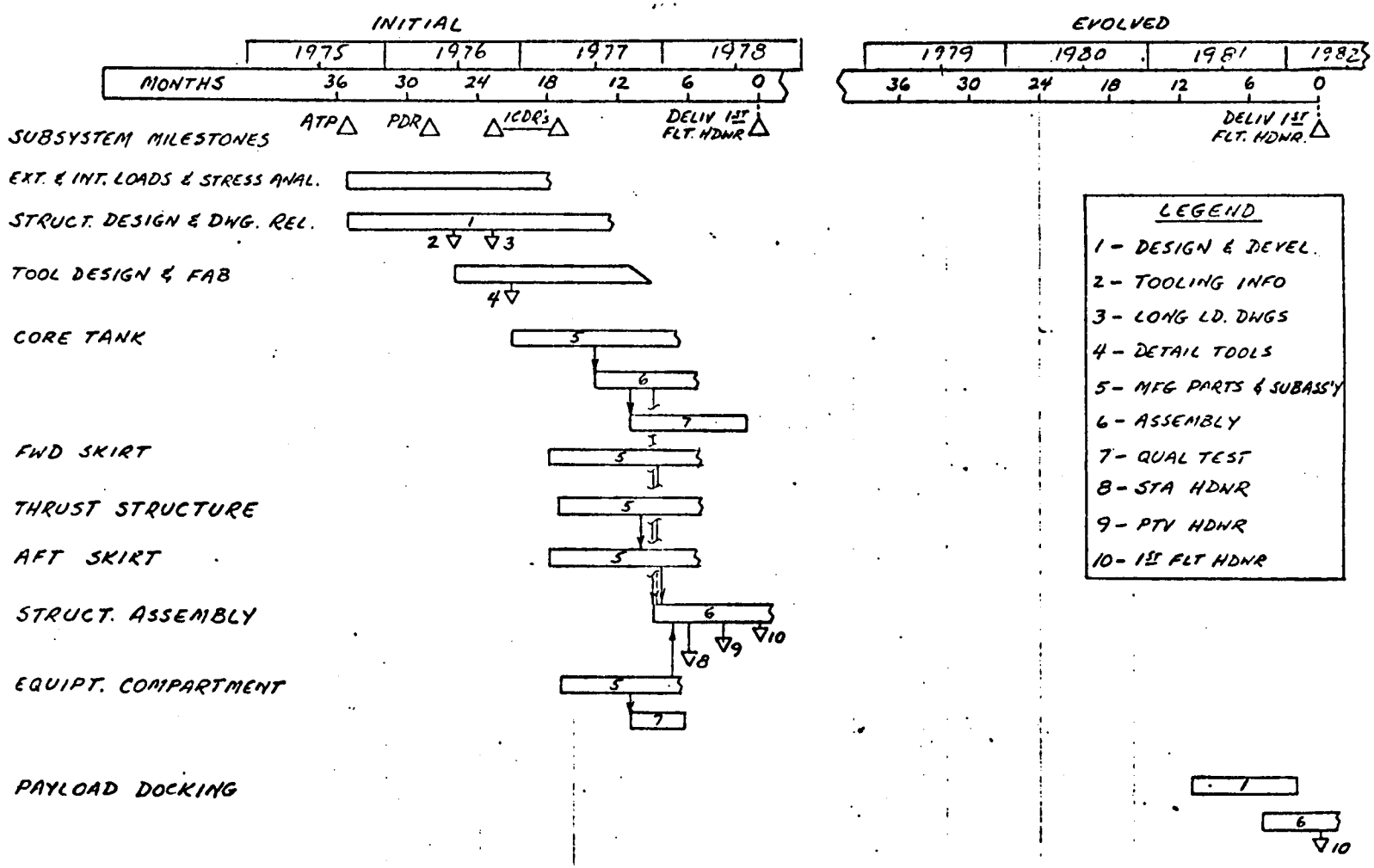


310-3A/310RE-3A PROPULSION

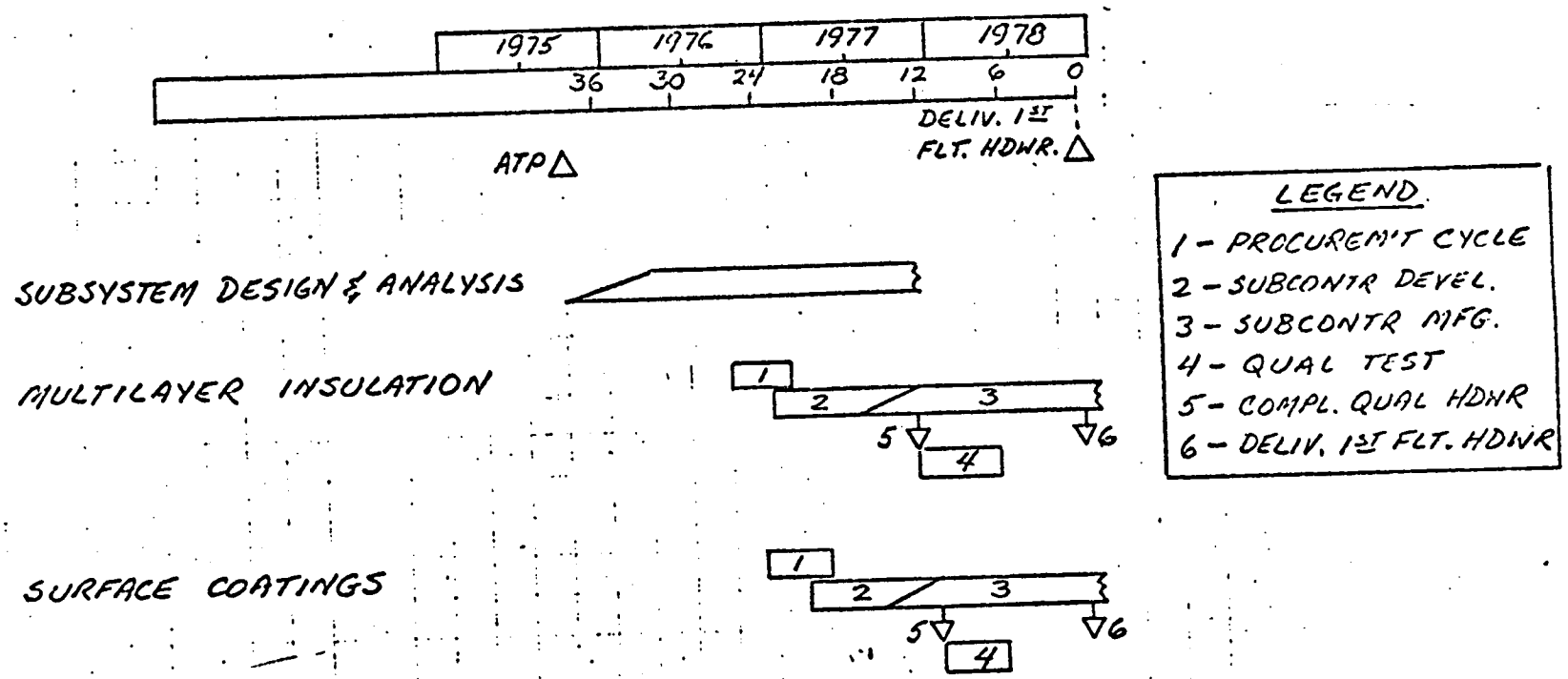


310-3A/310RE-3A ORBITER INTERFACE



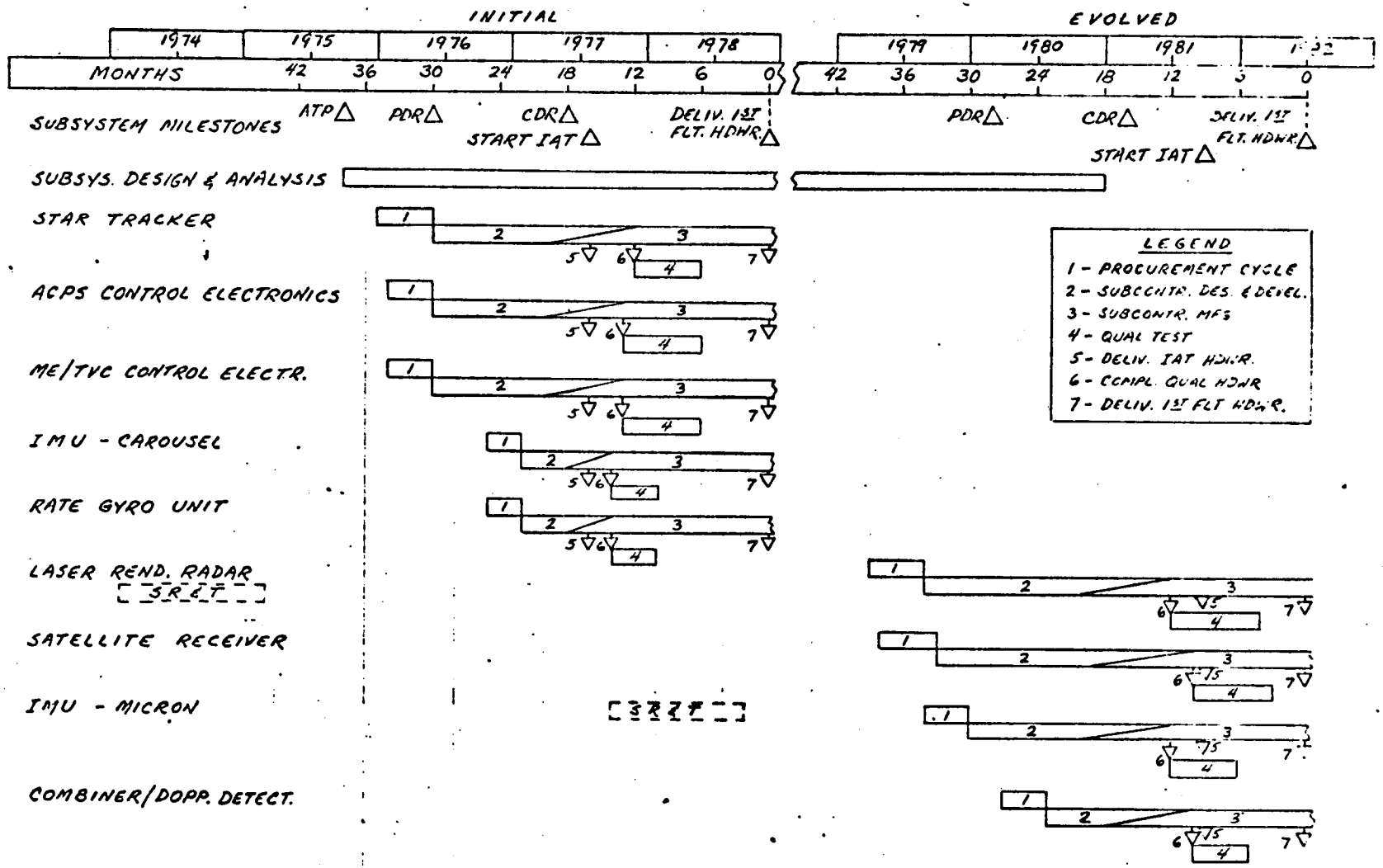


310-3A/310RE-3A STRUCTURES SUBSYSTEM SCHEDULE

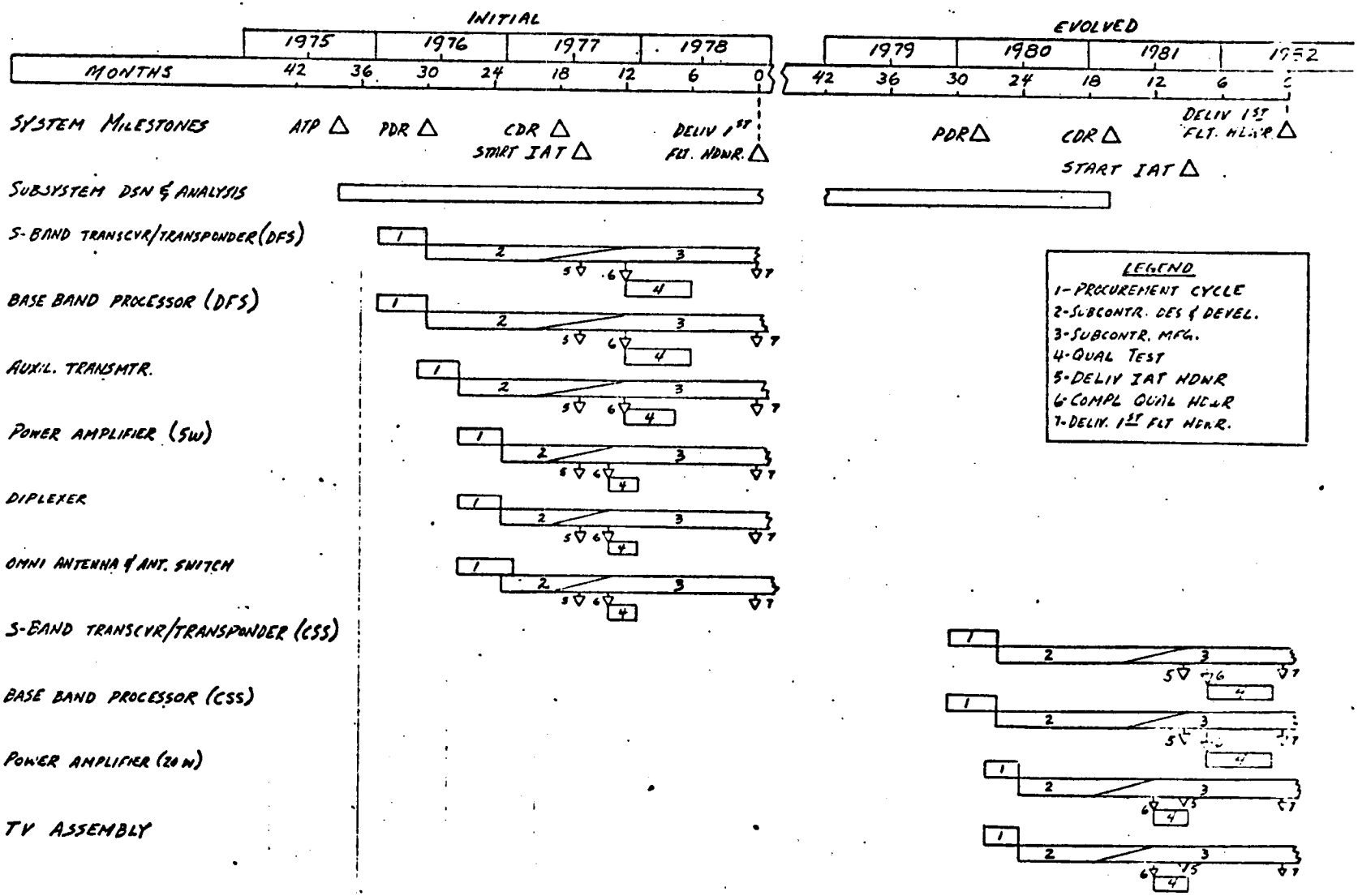


310-3A/310RE-3A THERMAL CONTROL SUBSYSTEM SCHEDULE

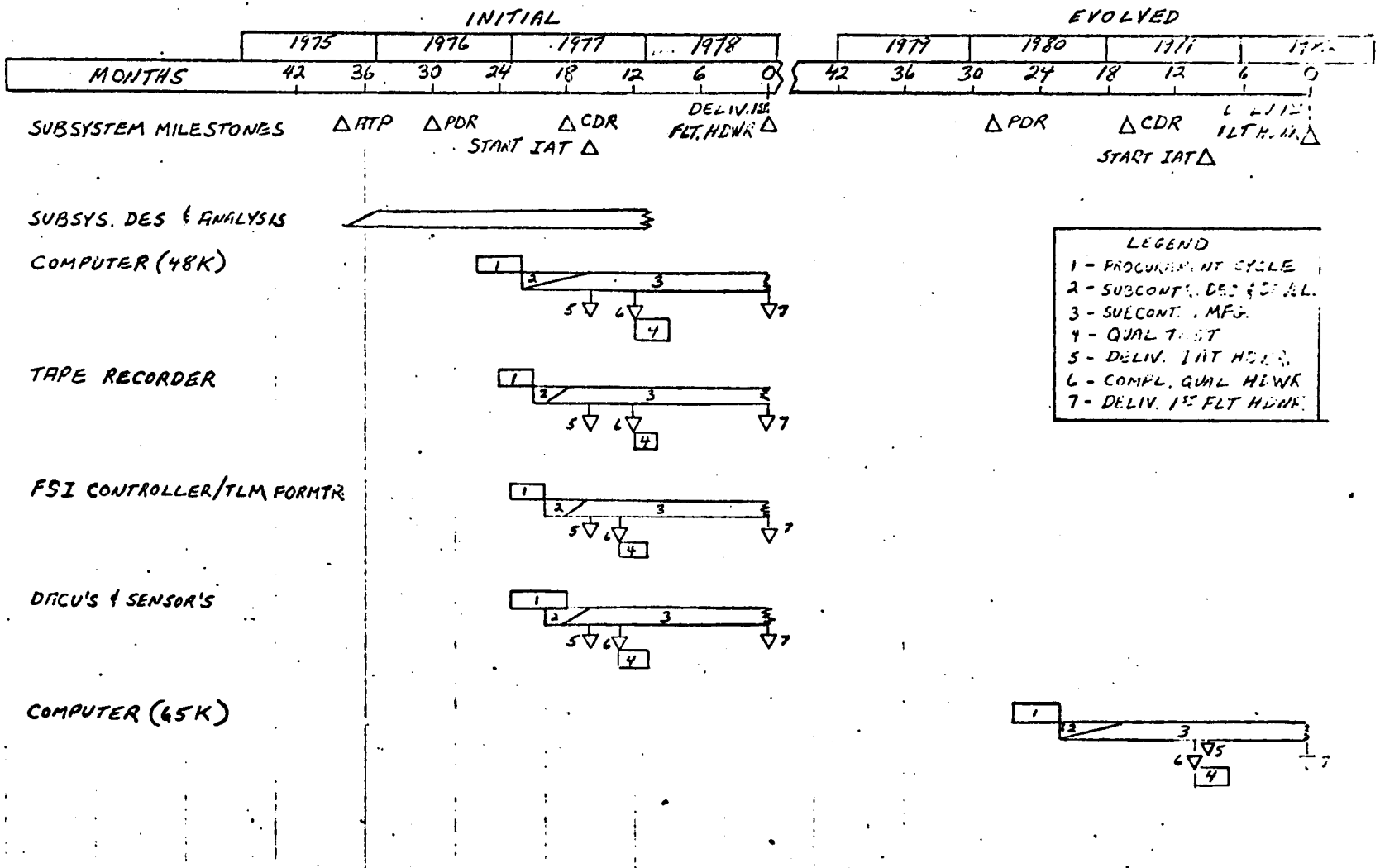
8-27-73



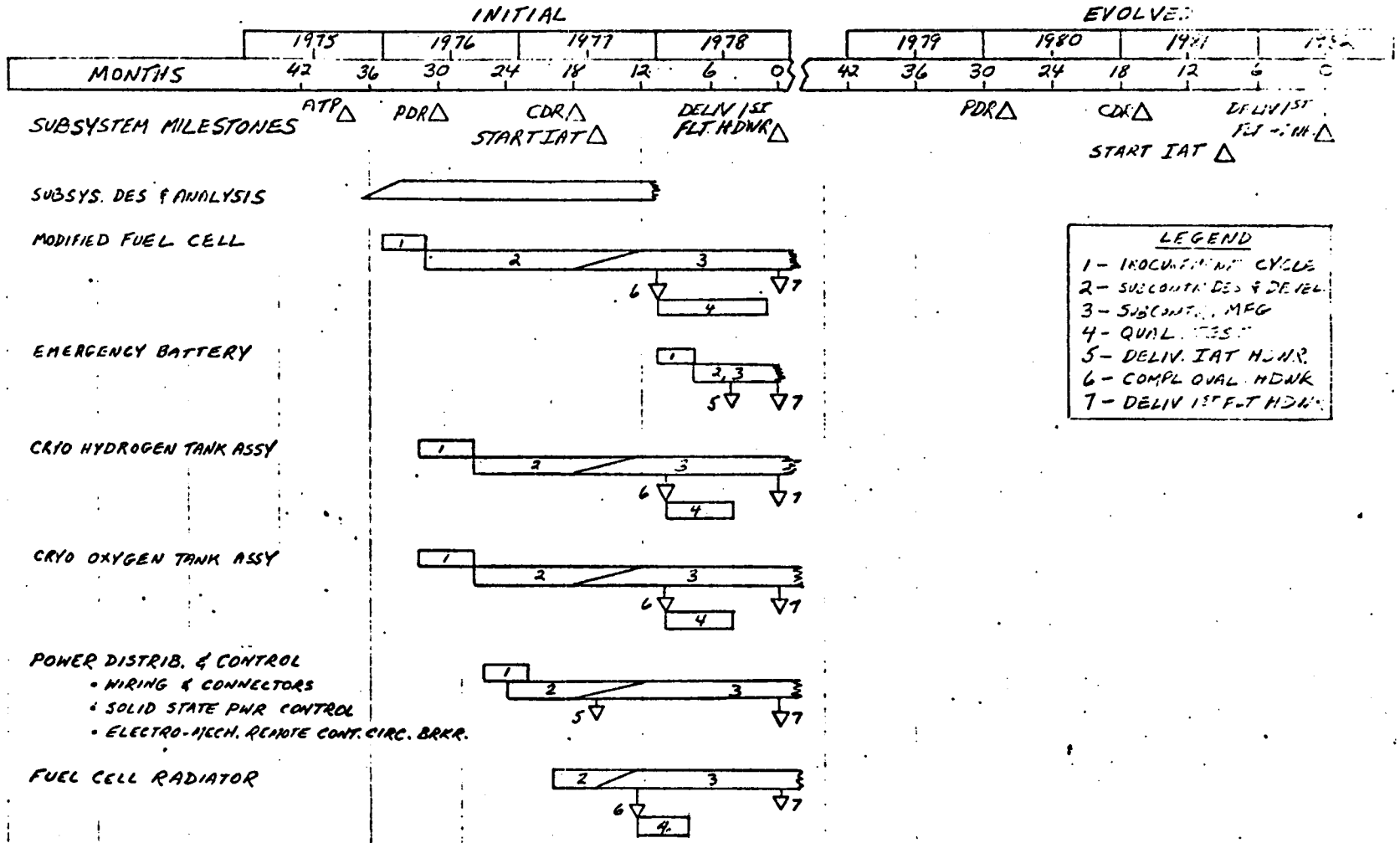
310-3A/310RE-3A GN&C SUBSYSTEM SCHEDULE



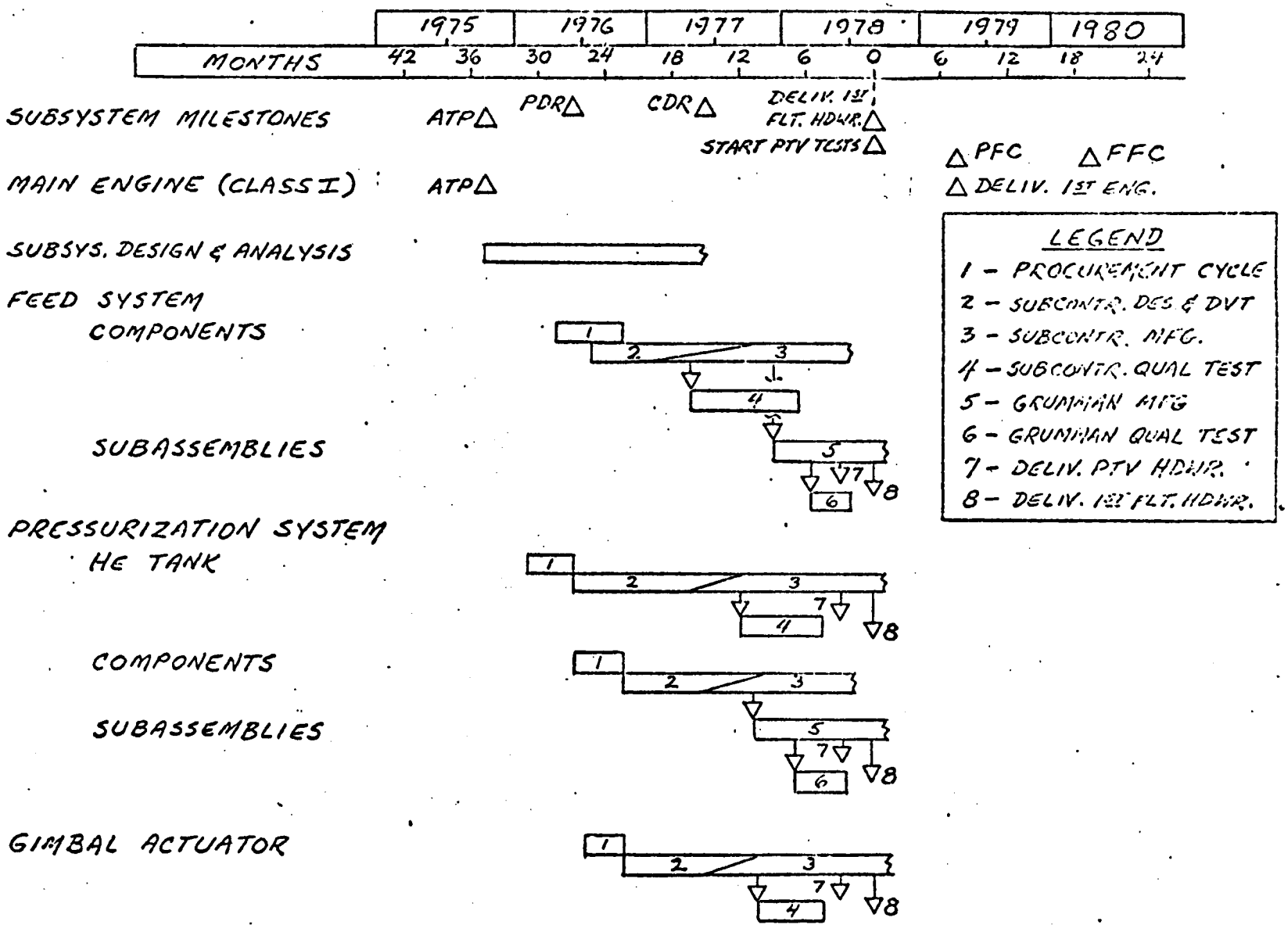
310-3A/310RE-3A COMMUNICATIONS S/S SCHEDULE



310-3A/310RE-3A DATA MANAGEMENT SUBSYSTEM SCHEDULE

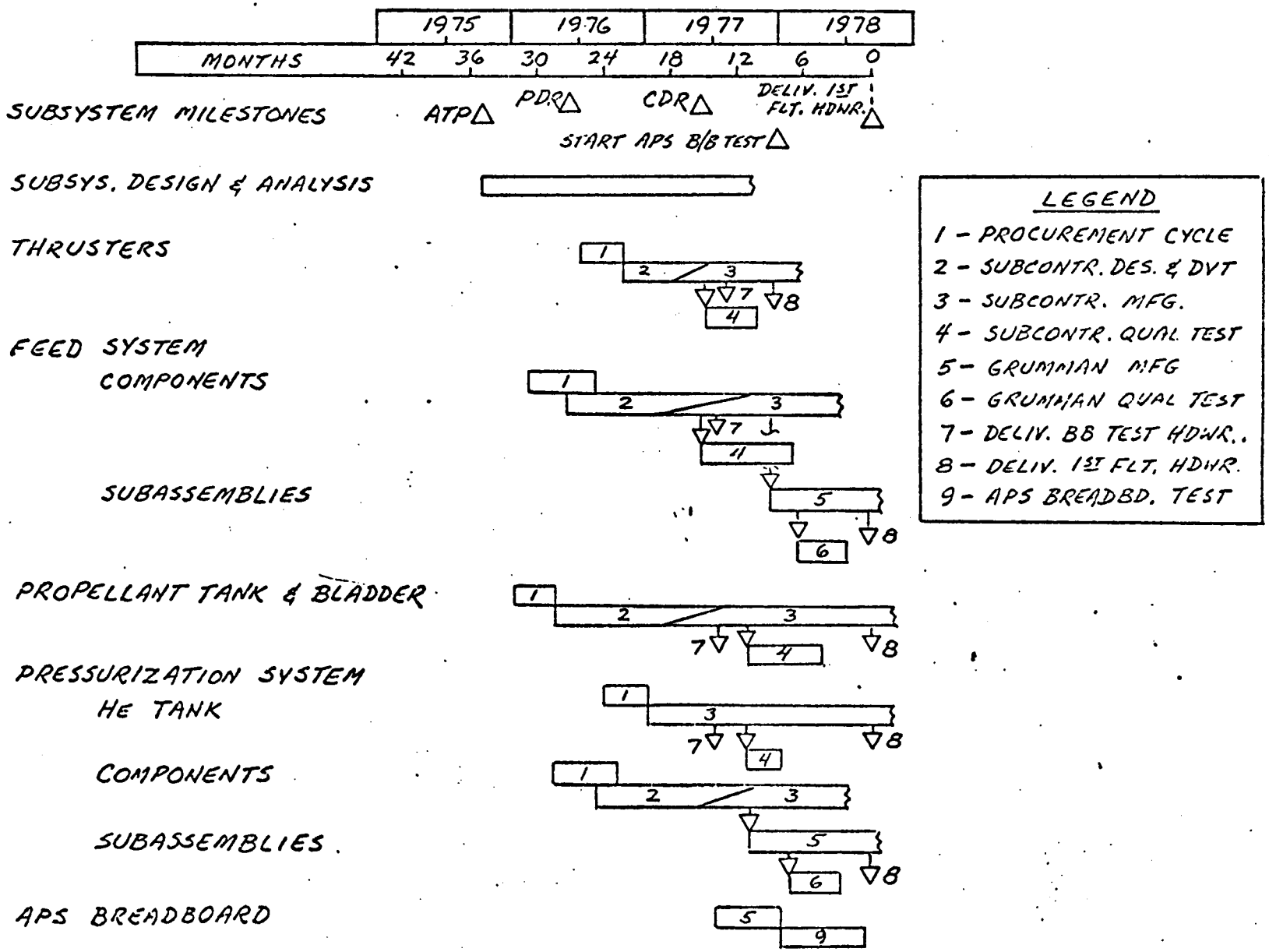


310-3A/310RE-3A ELECTRICAL POWER SUBSYSTEM SCHEDULE

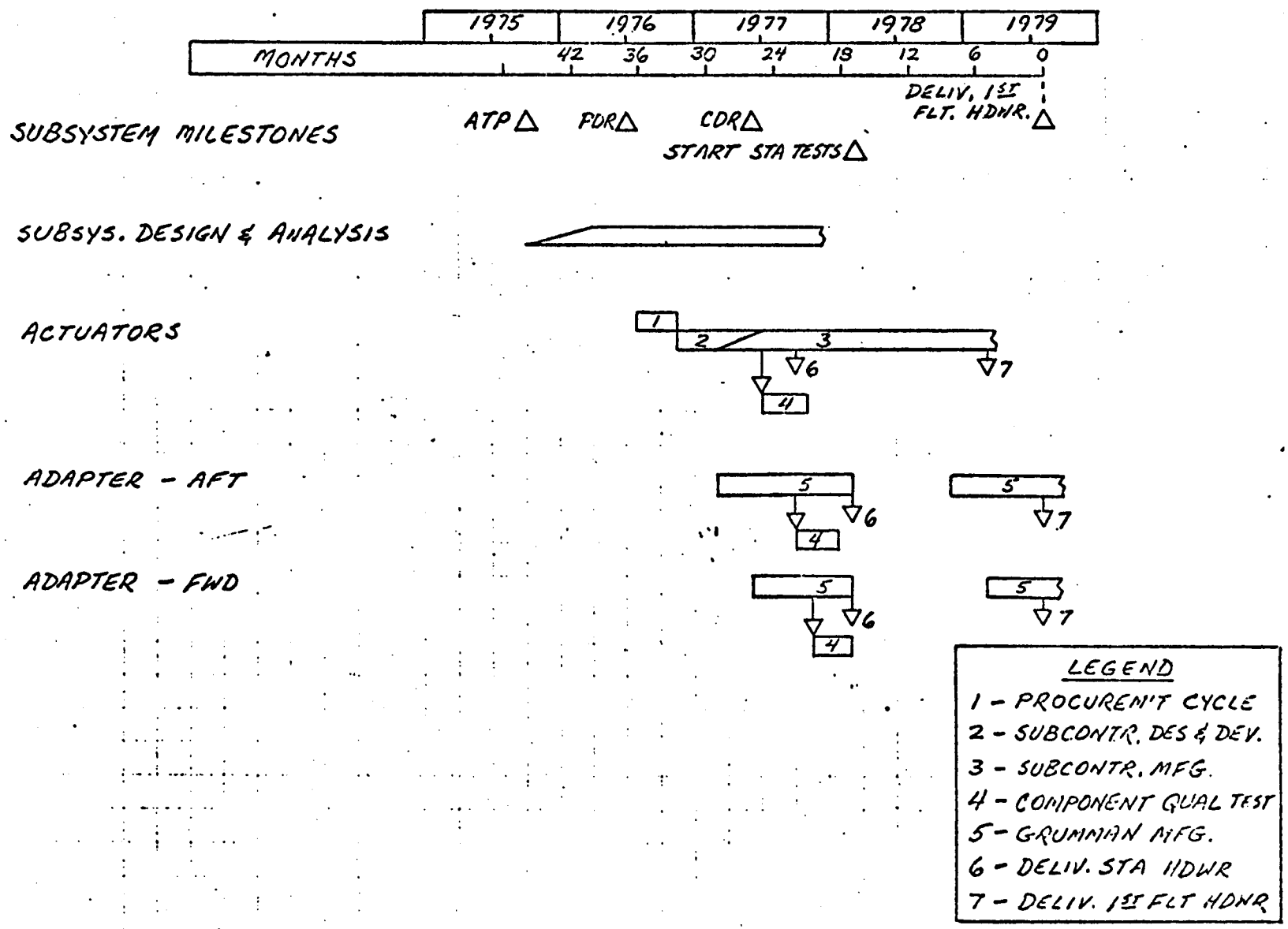


310-3A/310RE-3A MAIN PROPULSION SUBSYS. SCHEDULE

8-22-73

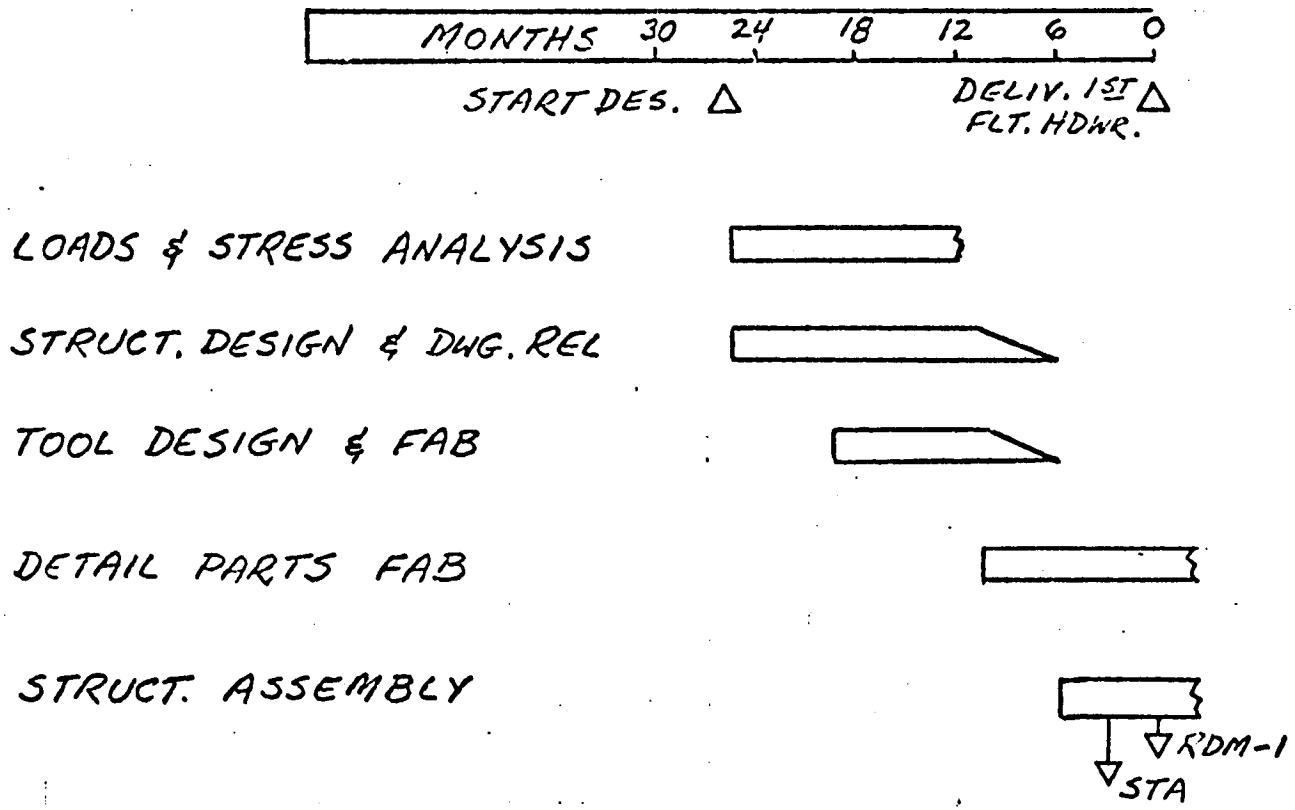


310-3A/310RE-3A AUXIL. PROPULSION SUBSYS. SCHEDULE

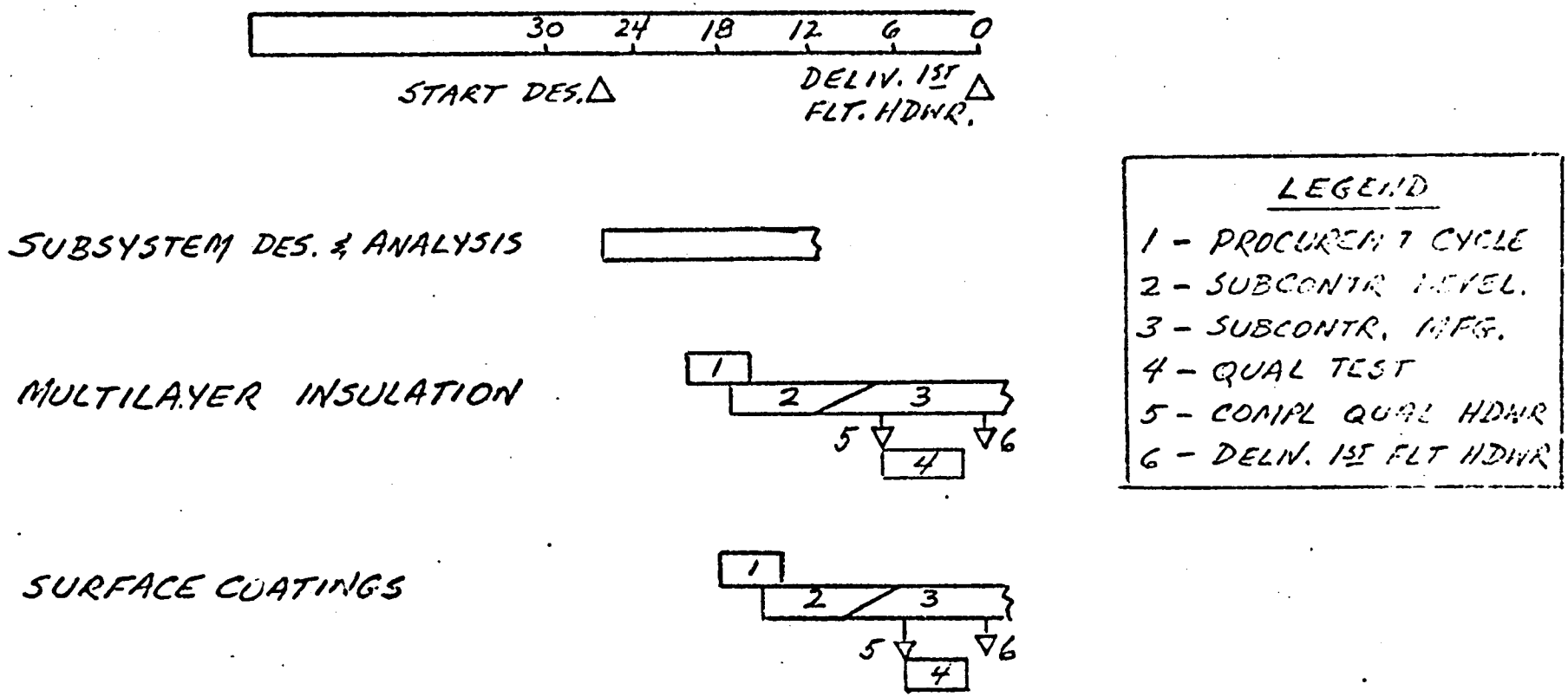


310-3A/310RE-3A ORBITER INTERFACE SUBSYS. SCHEDULE

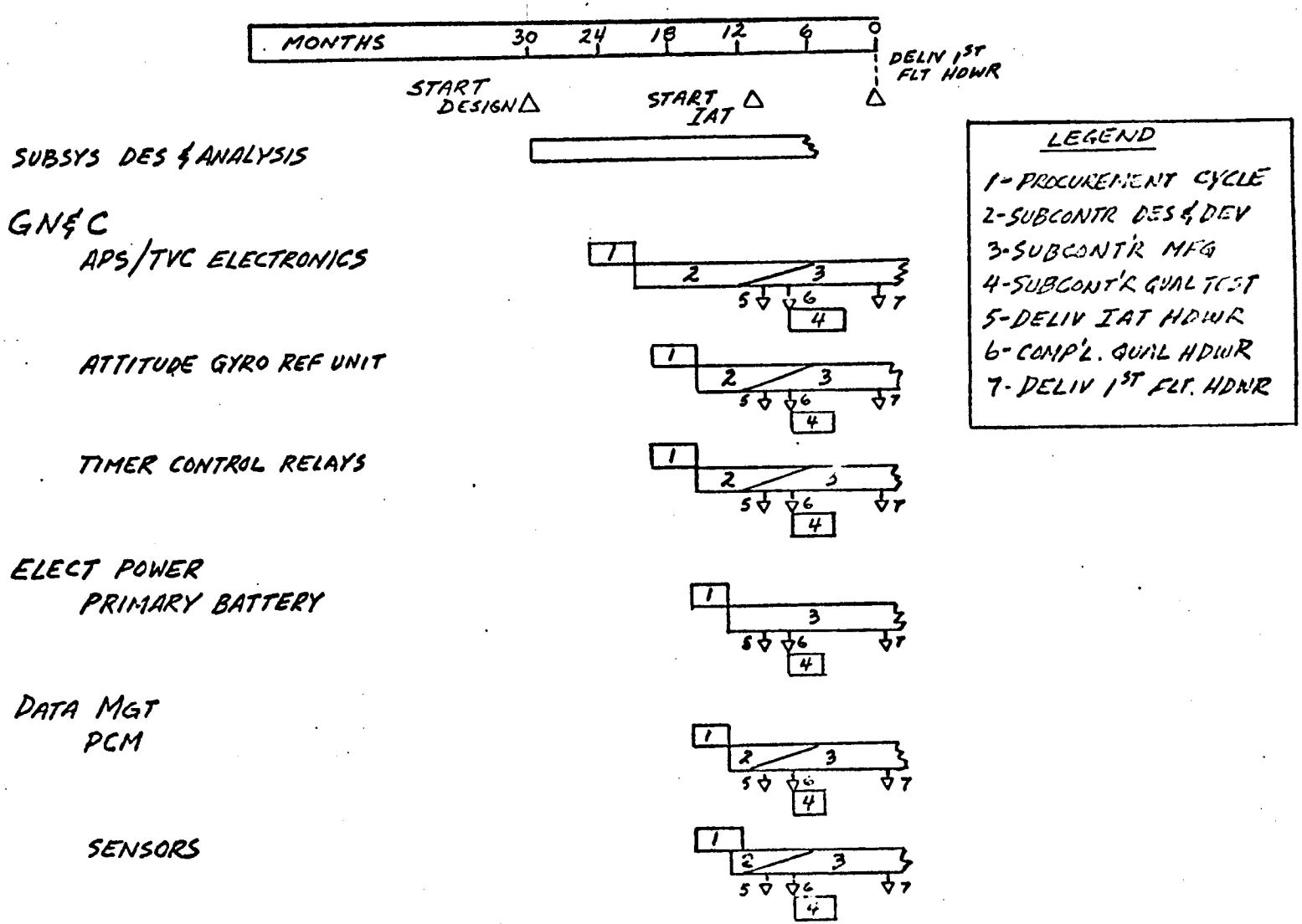
8-24-73



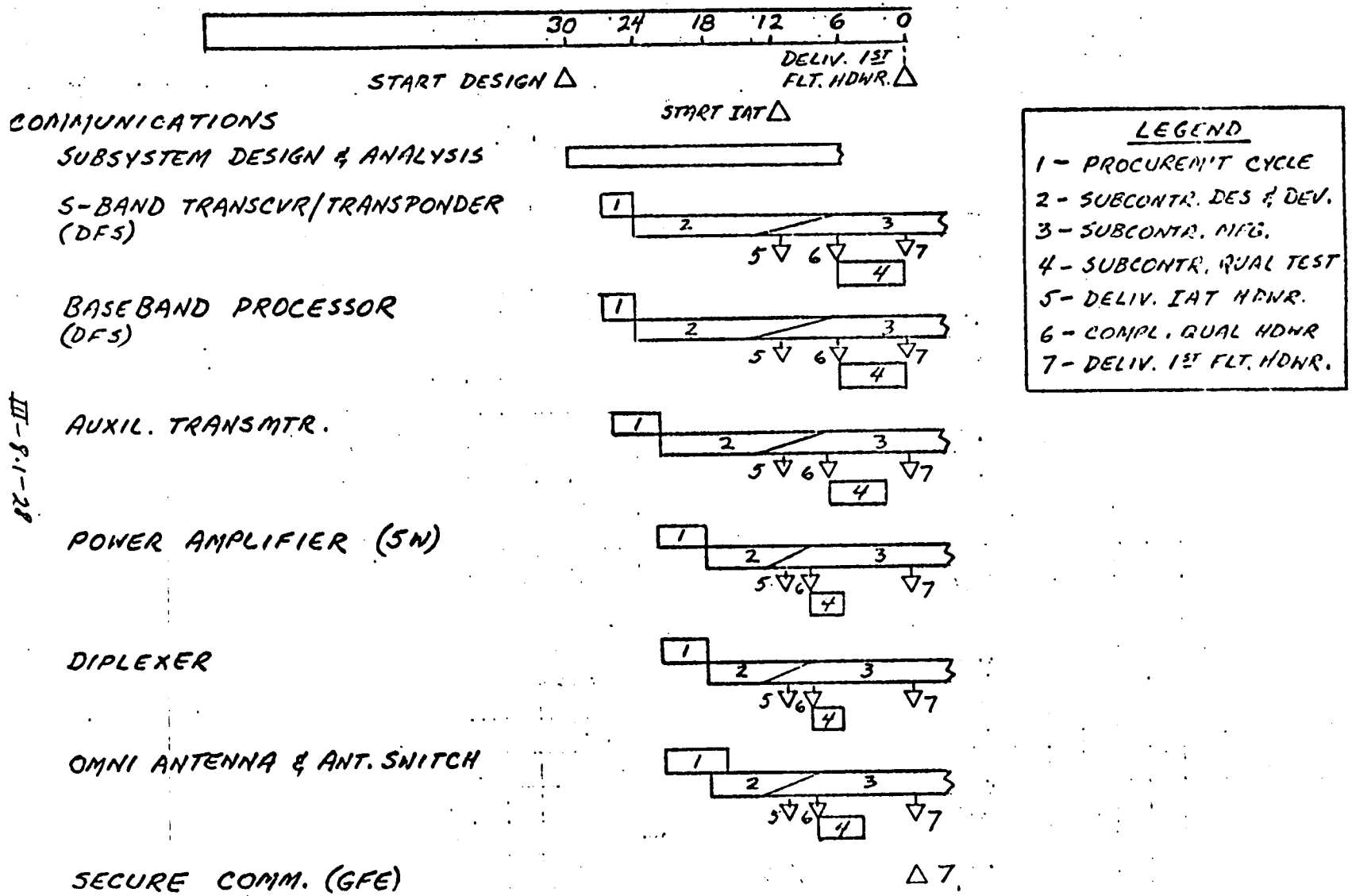
310-3A/310RE-3A RETRIEVAL DELAY MODULE
STRUCTURES SUBSYSTEM SCHEDULE



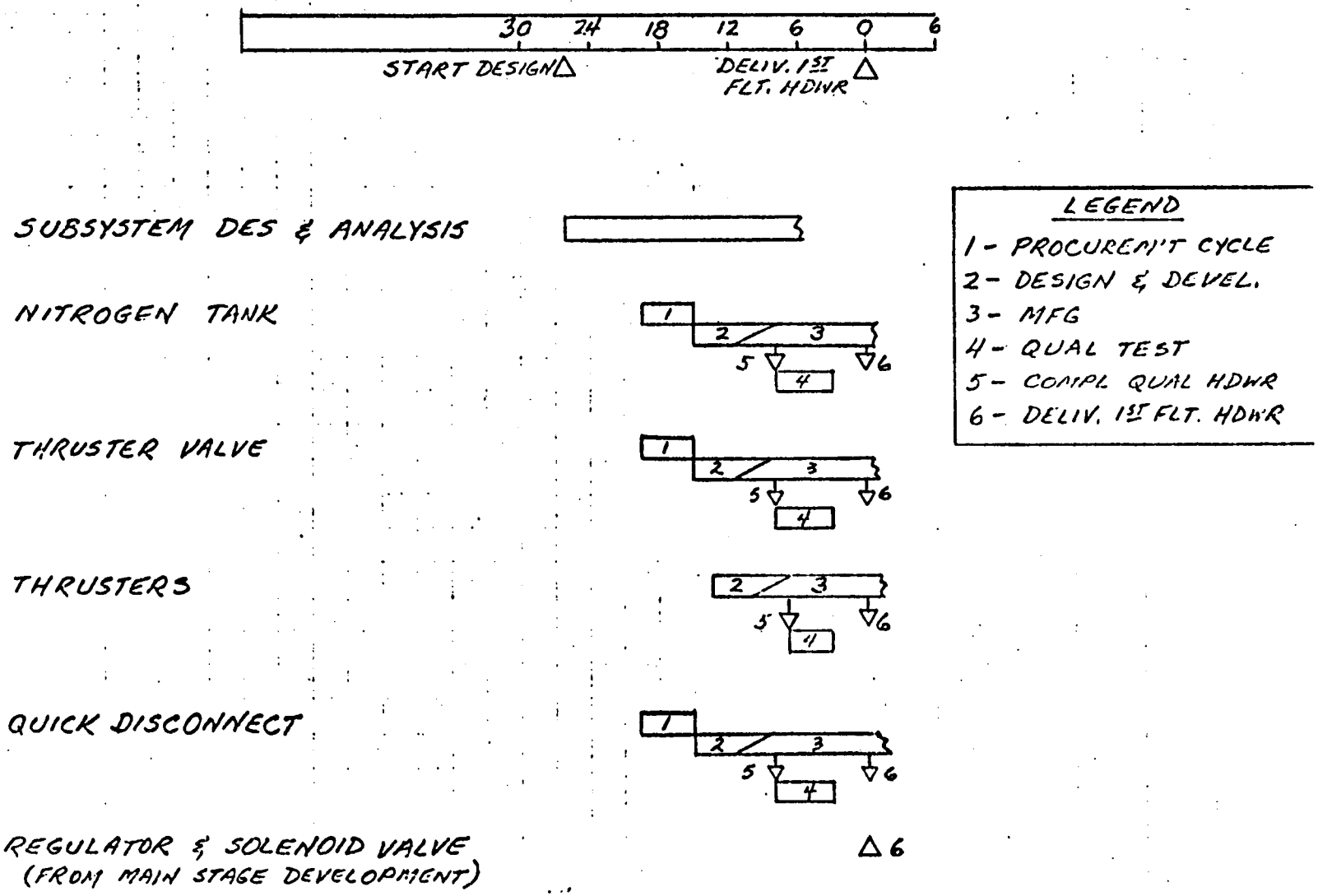
RETRIEVAL DELAY MODULE
THERMAL CONTROL SUBSYSTEM SCHEDULE



RETRIEVAL DELAY MODULE
AVIONICS SUBSYSTEM SCHEDULE



RETRIEVAL DELAY MODULE — AVIONICS SUBSYS. SCHEDULE



RETRIEVAL DELAY MODULE
PROPULSION SUBSYSTEM SCHEDULE

8.1.4 OPERATIONS SCHEDULE

Scheduled and planned for concept 310-3A/310RE-3A, option 3 are 37 launches per year with 10 days between launches. Ground servicing as shown on the programmatics/cost operations schedule from land to launch is 10 Tug work days and 9 Tug/orbiter work days.

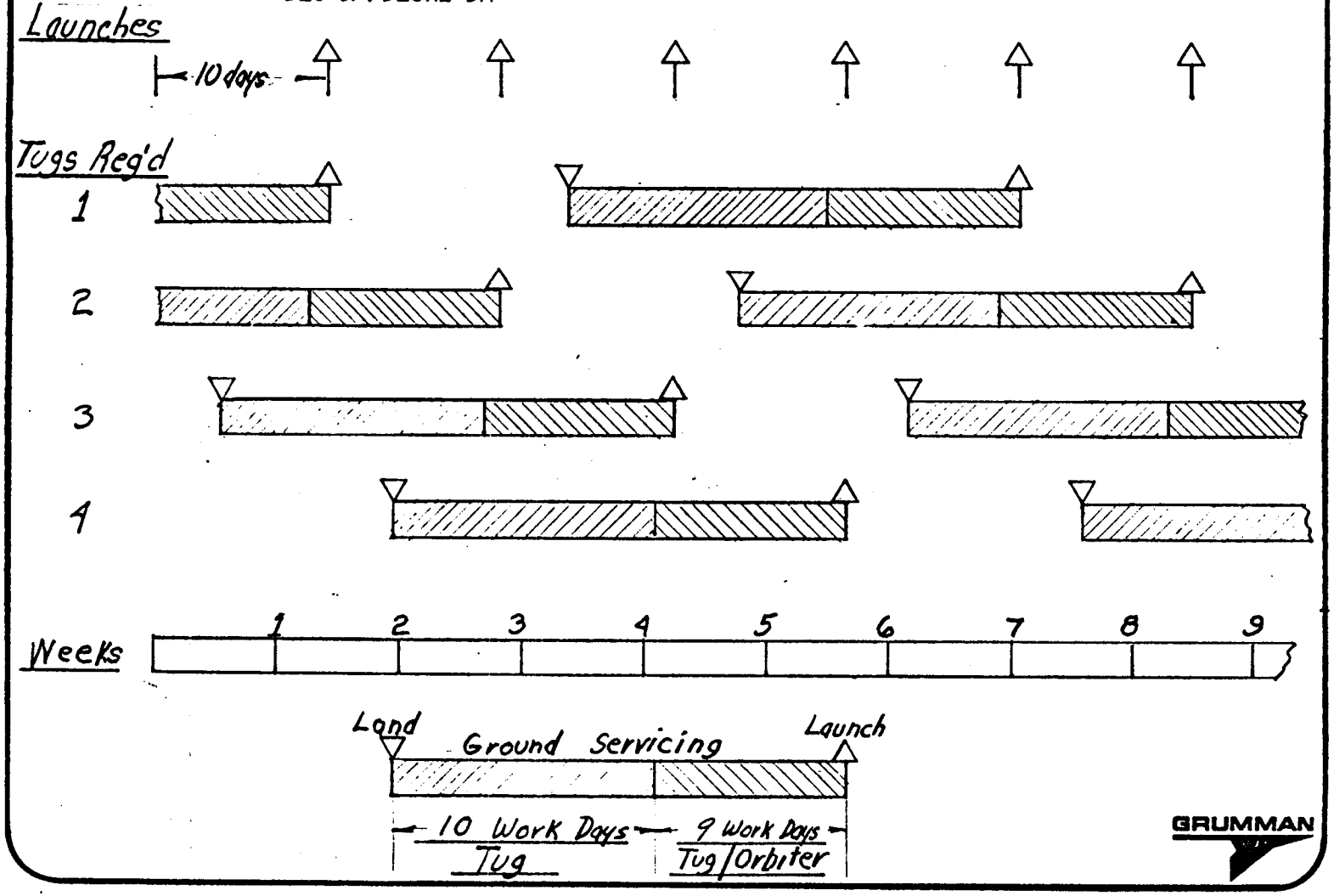
8.1.5 FACILITIES SCHEDULE

Included in the storable space tug facilities schedule for concept 310-3A/310RE-3A are the various tasks to be completed against major program milestones. The fundamental grouping of these tasks are manufacturing, test, maintenance and refurb-ETR, ETR launch, maintenance and refurb-WTR and WTR launch. Under this Tug concept facilities maintenance extends into 1991, with most of design/construction/activation ending by 1982 in support of WTR launch requirements.

PROGRAMMATICS/COST OPERATIONS SCHEDULE

37 Launches Per Year (ETR)

CONCEPT 310-3 /310RE-3A



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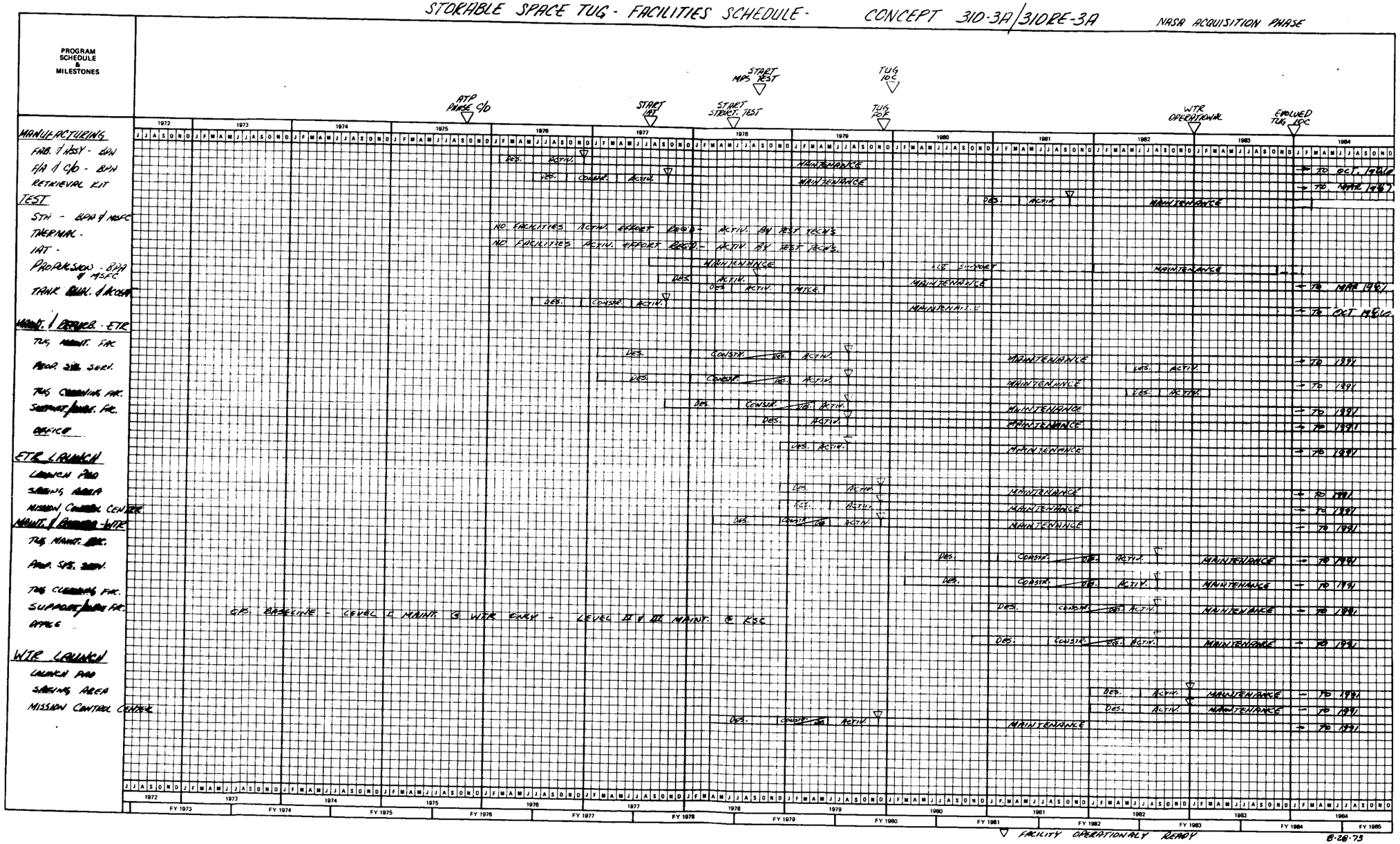
STORABLE SPACE TUG - FACILITIES SCHEDULE - CONCEPT 310-3A/310RE-3A

NASA ACQUISITION PHASE



8.1.6 EVALUATION OF MAJOR SCHEDULE DRIVERS

310-3A/310RE-3A

The critical path for this option involves the Class I main engine development, preliminary flight certification (PFR) and delivery of the first flight engine for the Main Stage (MS-1). The main engine ATP being constrained by the October 1975 groundrule (defined in Section 8.1.1), would not allow us the option of advancing the main engine development as exercised under 410AD-2. As a result, the first flight test engine will be delivered 5 months later than required for our Main Stage flight vehicle flow resulting in out-of-station installation and the addition of Cold Flow II checkout.

The Main Stage production is presented in 3 lots based on a compromise between the traffic model requirements and the desireability of having a continuous manufacturing flow. Lot 1 consists of 4 vehicles which will satisfy the mission requirements for the initial phase of operations (1980-1983). Lot 2 consists of 5 vehicles manufactured for the initial (deploy only) capability and will subsequently be upgraded as the evolved (retrieval) hardware becomes available.

Lot 3 consists of 13 vehicles manufactured to the evolved configuration, with Main Stage production ending in February 1987.

Development of the Retrieval Delay Module starts in 1980 for the November 1983 test flight with the evolved Main Stage.

8.1.7 IMPACT OF OPTION SENSITIVITIES

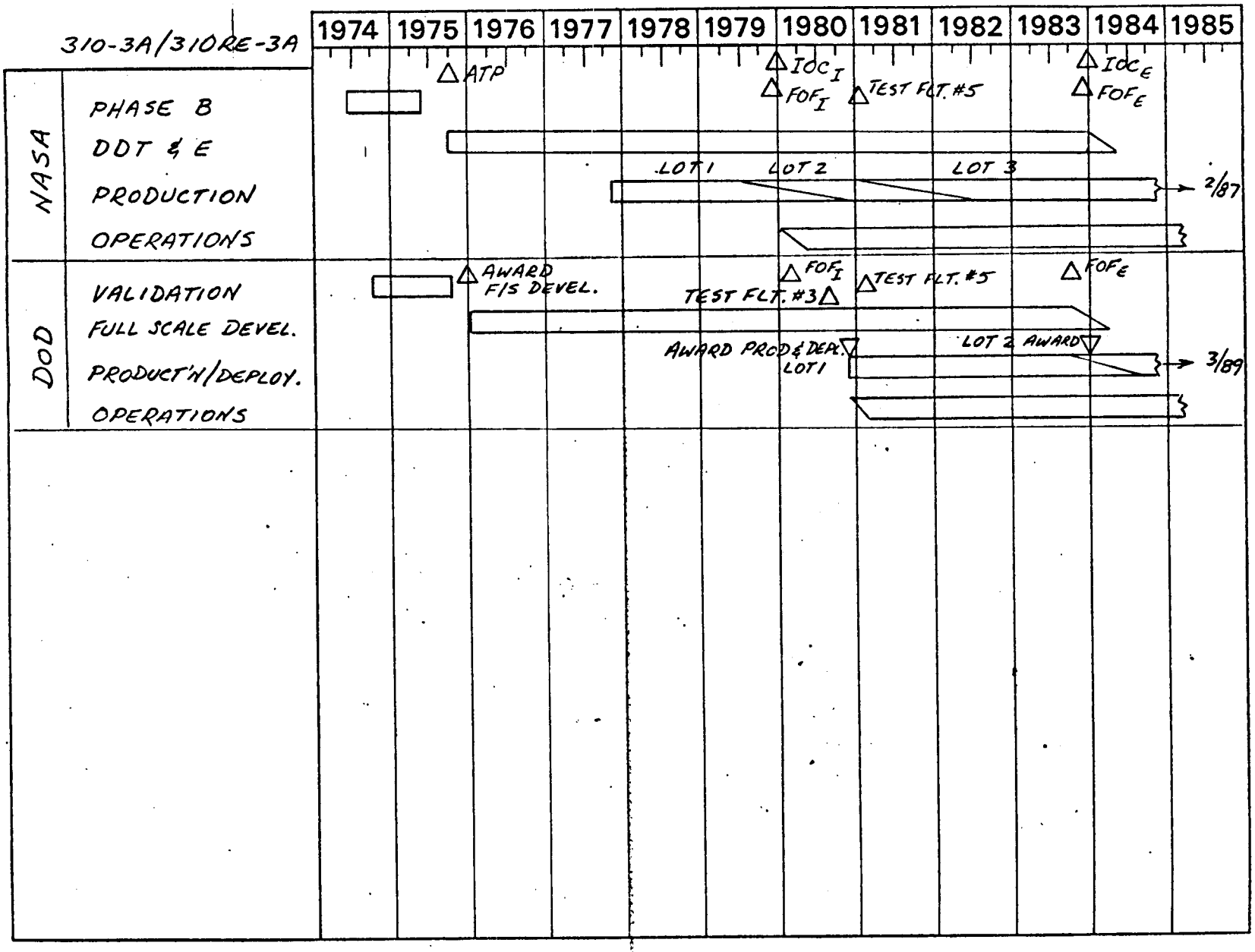
8.1.8 DOD VS NASA SCHEDULES

Phasing of the DOD acquisition process as defined in AFSCP800-4 differs from the NASA acquisition approach as indicated below:

DOD	NASA
Conceptual Phase	Phase A
Validation Phase	Phase B
Full Scale Development Phase)	
Production Phase)	Phase C/D
Deployment Phase)	

310-3A/310RE-3A

The rationale for initial differencies between the DOD and NASA schedules is similar to the 110A-1 discussed above. Three vehicles are required for Initial Tug flight test and for payload missions during the 1980-1983 period. Production contract award is scheduled 3 months after the completion of test flight no. 3. Flight test of the Evolved Tug is accomplished with vehicles upgraded from the initial configuration. Production Go-Ahead will follow the flight test as in the initial configuration. The availability of production vehicles is accelerated a few months by utilizing early funding for long lead items.


310-3A/310RE-3A
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
NASA
PHASE B
DDT & E
PRODUCTION
OPERATIONS
ATP
IOC I
FOF I
TEST FLT. #5
IOC E
FOF E
LOT 1
LOT 2
LOT 3
2/87
DoD
VALIDATION
FULL SCALE DEVEL.
PRODUCT'N/DEPLOY.
OPERATIONS
AWARD F/S DEVEL.
FOF I
TEST FLT. #3
TEST FLT. #5
FOF E
AWARD PROD & DEPL. LOT 1
LOT 2 AWARD
3/89

8.2 VEHICLE TEST PROGRAM (310-3A/310RE-3A)

8.2.0 Test Summary

The approach used to developing the Vehicle Test Program for the 310-3A/310RE-3A configuration is basically the same as described in Part I, paragraph 8.2.1. The addition of a Retrieval Delay Module, MS retrieval electronics and level IIB autonomy to the Tug program for the 310RE-3A configuration will also be verified in both the ground and flight test programs.

Table 8.2-1 summarizes the design verification approach in terms of test verification requirements and method of requirement satisfaction. Figure 8.2-1 presents a summary schedule of the total vehicle test program.

8.2.1 Ground Test Articles - Type and Description

8.2.1.1 Propulsion Test Vehicle (PTV)

The PTV for the 310-3A/310RE-3A is the same as described in Part I, paragraph 8.2.1.1.

8.2.1.2 Structural Test Articles (STA)

The structural test article (STA) for this configuration consists of two major assemblies which are tested, as described in PartII, para. 8.2.1.2.

- o Main Stage (IOC 12/79)
- o Retrieval Delay Module (IOC 12/83)

8.2.1.2.1 Main Stage Structural Test Article

The description of the main stage STA is the same as that described in Part II,paragraph 8.2.1.2.1.

8.2.1.2.2 Retrieval Delay Module (RDM)

The (RDM) is approximately 3 feet long by 12 feet in diameter. The RDM-STA has mass simulated equipment for dynamic test purposes and will require approximately 50 strain gages and 20 dynamic sensors.

310-3A/310RE-3A VEHICLE TEST

EVOLVED RETRIEVAL PLUS RET. DELAY ADDS $10.0LM TO VEHICLE TEST

- o TEST PROGRAM OBJECTIVES:
  - DESIGN VERIFICATION
  - SITE/GSE VALIDATION
  - SYSTEM VERIFICATION
- o GROUND TEST PROGRAM (HARDWARE/OPS = $25.31M)
  - PROP: 1 MS ART. VERIFIES COLD FLOW SYSTEM OPS - REFURBISH TO OPS
  - STRUCT: 2 ART. (1 MS & 1 RDM) VERIFY DYN, STATIC, FATIGUE, SEP - KSC SITE VALIDATION
  - AVIONICS: 2 LABS VERIFY HARDWARE/SOFTWARE FOR INITIAL AND EVOLVED CONFIGURATION
  - MOCKUPS: 2 SOFT & 2 HARD MS & RDM MOCKUPS SUPPORT DESIGN DEVELOPMENT & MAINTENANCE DEMONSTRATION
- o FLIGHT TEST PROGRAM (HARDWARE/OPS = $16.82M)
  - 1 MS & 1 RDM VEHICLE
  - 8 FLIGHTS (1 DEDICATED, 7 OPS)
- o TOTAL VEHICLE TEST = $42.13M

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DESIGN VERIFICATION APPROACH

310-3A/310RE-3A

	MAJOR VERIF REQ'MT	GRND TEST	FLT TEST
STRUCTURE	STATIC MARGIN	QUAL	VERIFY
	FATIGUE LIFE	QUAL	
	VIBRATION MODES	VERIFY	VERIFY
	VEH/ORB, VEH/PL & VEH/RDM SEP	QUAL	VERIFY
	VEH HDLG & MAINT	DEMO	VERIFY
THERMAL CONTROL	PASSIVE/ACTIVE THERMO SYS PERFORM (MS & RDM)	QUAL	VERIFY
	TC/GSE SERVICING & MAINT	DEMO	VERIFY
AVIONICS	INTEG HDWR/SFTWR VEH PERFORM	VERIFY	VERIFY
	AVIONICS/GSE C/O & MAINT	DEMO	VERIFY
	VEH SYS INTERFACE (ORB, GRND, RDM & PL PERFORM)	VERIFY	VERIFY
PROPULSION	MPS NOM/OFF - NOM PERFORM	QUAL	VERIFY
	MPS/GSE SERVICING & MAINT	DEMO	VERIFY
	APS NOM/OFF - NOM PERFORM	QUAL	VERIFY
	APS/GSE SERVICING & MAINT	DEMO	VERIFY
ORBITER INTERFACE	STATIC/FATIGUE STRENGTH	QUAL	VERIFY
	VEH/ORB SEP	QUAL	VERIFY
	AVIONIC/FLUID INTERFACE PERFORM	VERIFY	VERIFY
	ABORT SYSTEM PERFORM	QUAL	VERIFY
	VEH HDLG/GSE SERVICE & MAINT	DEMO	VERIFY

TABLE 8.2-1

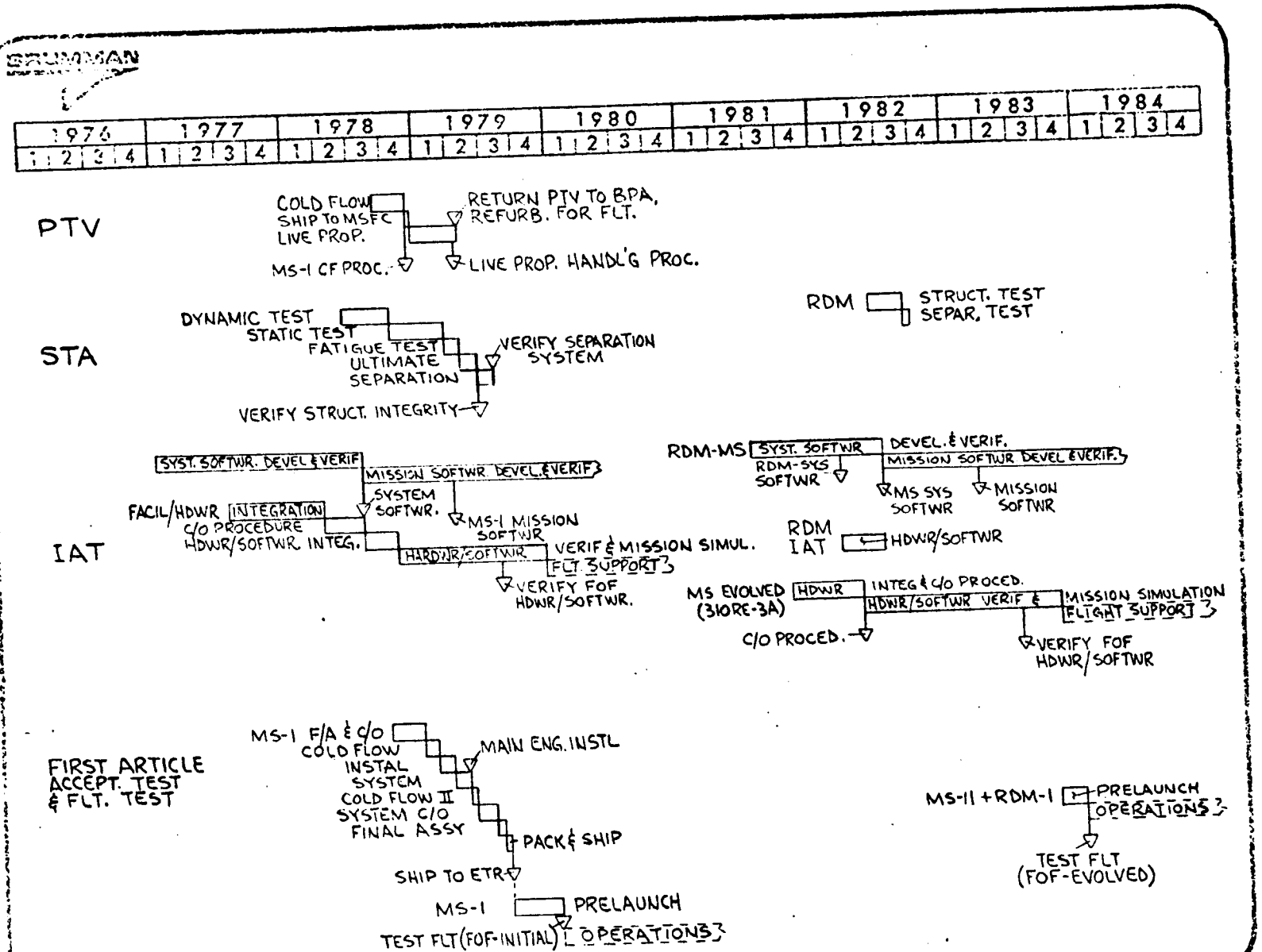


FIG. 8.2-1 310-3A/310RE-3A VEHICLE TEST SCHEDULE

8.2.1.3 Integrated Avionics Testing

8.2.1.3.1 Main Stage (MS) Integrated Avionics Hardware & Software Test Facilities

Integrated avionics hardware and software testing for the 310-3A basic vehicle will be accomplished using an IAT & ASDL facility as described in Part I, paragraph 8.2.1.3.1. As the retrieval capability and autonomy level IIB is incorporated into the MS avionics, the IAT facility and the ASDL will be modified to reflect these changes. The IAT and ASDL will be used for hardware and software verification of the retrieval capability including mission simulations.

8.2.1.3.2 Retrieval Delay Module (RDM)

Integrated avionics hardware testing for the Retrieval Delay Module will be accomplished in the IAT and ASDL facilities developed for the main stage.

A breadboard of the RDM wiring, RDM avionics hardware, and the RDM avionics GSE will be integrated and tested in the same facility as the main stage IAT to permit common usage of facility test equipment.

A software model of the RDM mission and dynamics will be integrated into the MS ASDL for Main Stage RDM mission software development and mission support.

8.2.1.4 Mockups

In addition to the mockups described in Part I, paragraph 8.2.1.4 mockups of the RDM will be required for this configuration.

8.2.2 Flight Test Articles

8.2.2.1 Main Stage (MS)

The main stage (MS) flight test article for the 310-3A configuration will be the same as described in Part I, paragraph 8.2.2.1.

The main stage flight test article for the 310RE-3A configuration will be the first production - configured vehicle with retrieval capability. A DFI system will be installed.

8.2.2.2 Retrieval Delay Module

The Retrieval Delay Module (RDM) will be the first production configured RDM with a DFI system added. Since the RDM operational mode requires the MS to have retrieval capability it will be tested in late 1983 with the FOF of the 310RE-3A MS.

8.2.3 Ground Test Program

This section describes the major elements of the vehicle ground test program. The test programs described in the following paragraphs include the Propulsion Test Vehicle (PTV), Structural Test Article (STA), Integrated Avionics Testing including software development, and mockups required in support of program requirements.

8.2.3.1 Propulsion Test Vehicle (PTV) Program

The Main Propulsion System and Auxiliary Propulsion System Test program for the 310-3A configuration is the same as described in part I, paragraph 8.2.3.1. There is no significant change in the APS test program because of the additional APS thrusters for the 310RE-3A configuration.

The manloading and schedule for the PTV test program as shown in Figure 8.2-2.

8.2.3.2 Structural Test Article (STA) Program

8.2.3.2.1 Main Stage (MS)

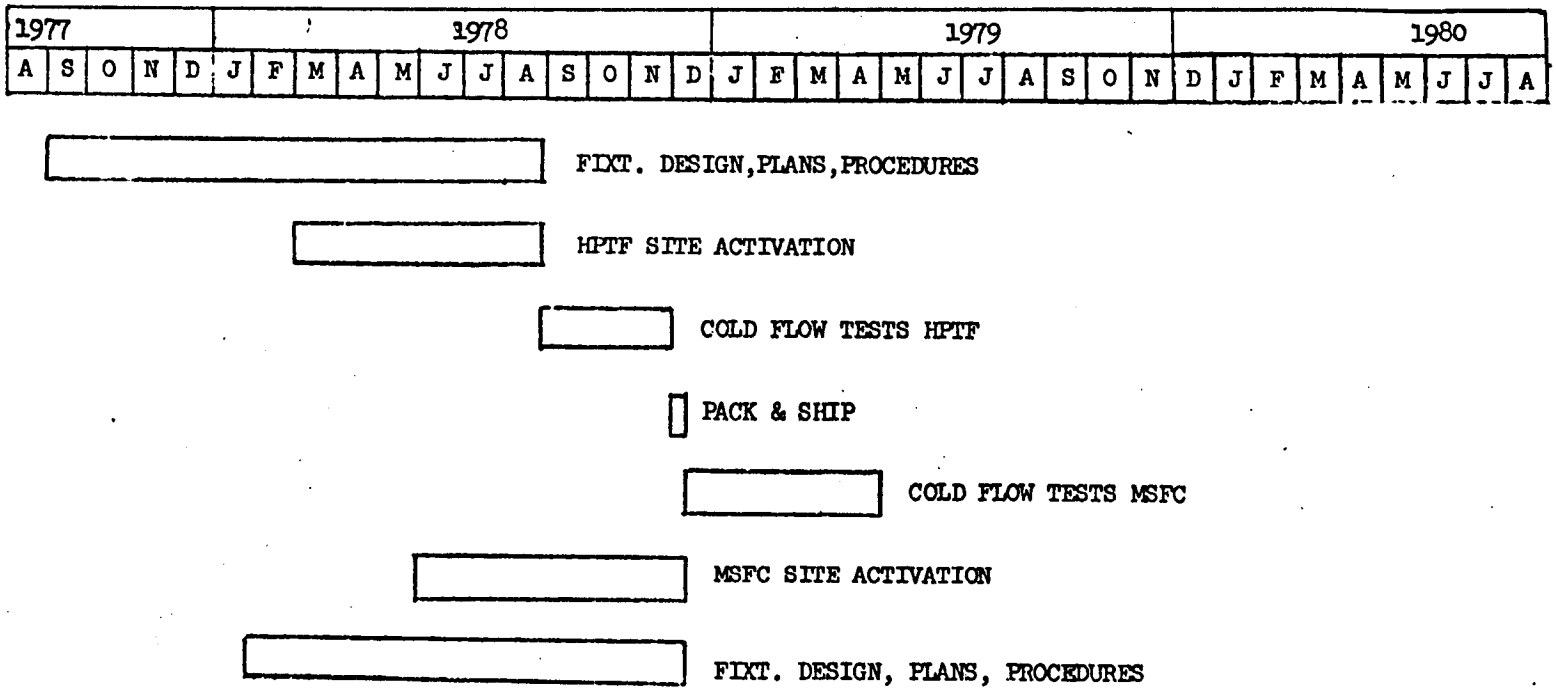
The MS structural test program for the 310-3A/310RE-3A configuration is as described in Part II, paragraph 8.2.3.2.1.

The manloading and test schedule for the 310-3A/310RE-3A configuration is the same as shown in Part I, figure 8.2-3 with the start and end dates shifted three months later.

8.2.3.2.2 Retrieval Delay Module Structural Test Article Program

The structural test program for the retrieval delay module (RDM) is reduced from that of the kick stages in that vibration mode survey is not required. Due to its small size, mass and structural simplicity the static tests provide adequate verification of the dynamic analysis. In other respects the test philosophy is the same as described in part I, paragraph 8.2.3.2.1

Due to the reduced scope of the RDM test program as compared to kick stages, a new schedule and manloading is presented in Figure 8.2-3.

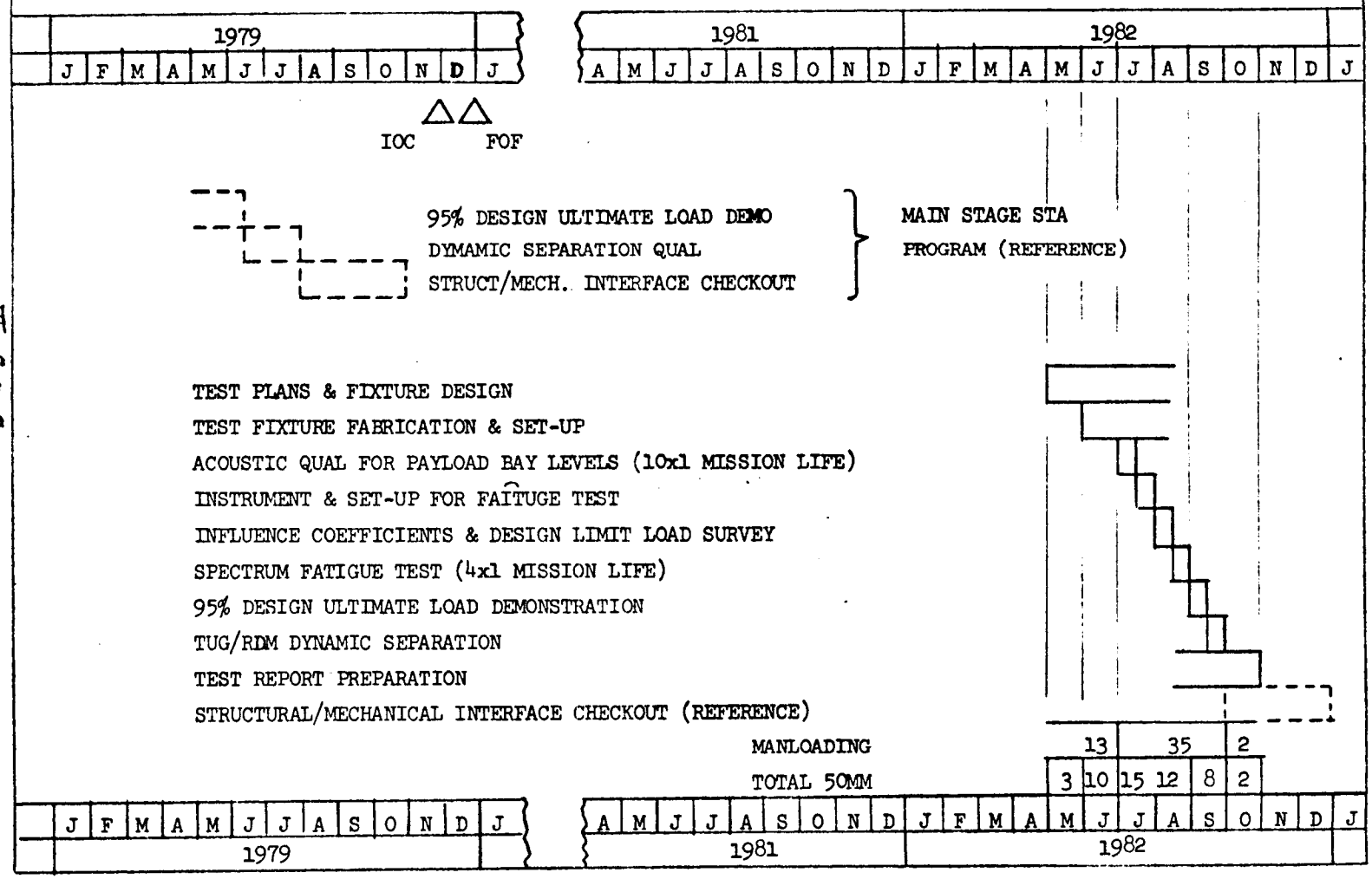


MANPOWER 1 1 2 2 3 6 7 10 16 15 18 24 35 41 44 40 33 29 28 15 7 TOTAL 377 MM

Figure 8.2-2 310-3A/310RE PTV TEST SCHEDULE & MANPOWER

FIGURE 8.2-3 RDM STA PROGRAM (310RE-3A)

SCHEDULE AND MANLOADING



8.2.3.3 Integrated Avionics Test Program

8.2.3.3.1 Main Stage (MS) Avionics Hardware and Software Integrated Avionics

The integrated avionics test philosophy and test program for the 310-3A/310RE-3A configuration is basically the same as described in Part 1, paragraph 8.2.3.3.1. All hardware, software, test procedure, and GSE will be verified using an IAT facility and/or ASDL prior to entry into the flight vehicle flow. The evolution of level IIB autonomy and retrieval capability will be incorporated and verified in the IAT facility and ASDL prior to incorporation the flight vehicle. At the completion of system hardware/software verification, mission simulation will be performed for the evolved MS in the IAT facility.

The test phases for the 310-3A/310RE-3A manpower and schedule are shown in Figure 8.2-4.

In addition to the IAT for the 310-3A/310RE-3A configuration an integrated fuel cell/reactant tank systems test will be performed at the fuel cell subcontractor to verify system energy capacity.

8.2.3.3.2 Retrieval Delay Module (RDM)

The RDM avionics test philosophy is the same as for the main stage. A RDM breadboard will be integrated and GSE, test procedures and functional operation verified. Main stage software for RDM mission will be developed in the ASDL and verified in the main stage IAT.

A RDM antenna pattern test will be performed since the RDM will contain a complete communications system.

The schedule of RDM avionics testing is shown in Figure 8.2-4.

8.2.3.4 Mockups

Mockups will be used throughout the MS and RDM development stage as described in Part I, paragraph 8.2.3.4. In addition the STA will be used for launch operations checkout as described for the 110A configuration.

8.2.4 Flight Test Program

8.2.4.1 Flight Vehicle Test and Checkout

The philosophy and objectives of the Flight Vehicle Test and checkout program are the same as described in Part I, paragraph 8.2.4.1.

The factory testing of the first 310-3A contains the same basic tests as described in Part I, paragraph 8.2.4.1 except that fuel cell tests are required and late engine delivery

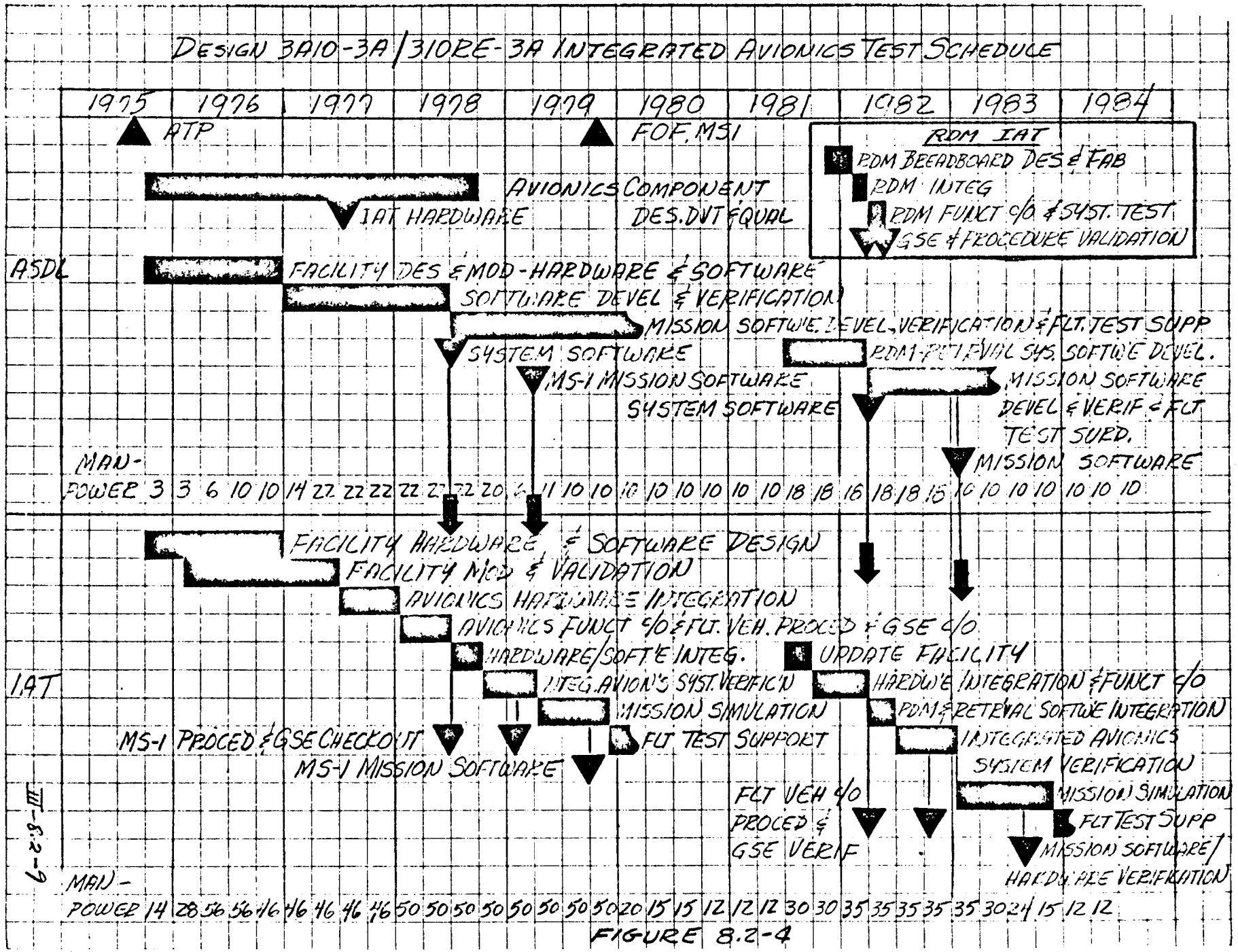

DESIGN 3A10-3A/310RE-3A INTEGRATED AVIONICS TEST SCHEDULE
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
RTP
FOF, MS1
RDM IAT
RDM BREADBOARD DES & FAB
RDM INTEG
RDM FUNCT C/O & SYST. TEST
GSE & PROCEDURE VALIDATION
AVIONICS COMPONENT DES. DVT & QUAL
IAT HARDWARE
ASDL
FACILITY DES & MOD-HARDWARE & SOFTWARE
SOFTWARE DEVEL & VERIFICATION
MISSION SOFTWARE DEVEL, VERIFICATION & FLT. TEST SUPP
SYSTEM SOFTWARE
RDM-RETRIEVAL SYS. SOFTWARE DEVEL.
MS-1 MISSION SOFTWARE
MISSION SOFTWARE DEVEL & VERIF & FLT TEST SUPP.
SYSTEM SOFTWARE
MISSION SOFTWARE
MAN-POWER 3 3 6 10 10 14 22 22 22 22 22 22 20 11 10 10 10 10 10 10 10 10 18 18 16 18 18 15 10 10 10 10 10 10 10
FACILITY HARDWARE & SOFTWARE DESIGN
FACILITY MOD & VALIDATION
AVIONICS HARDWARE INTEGRATION
AVIONICS FUNCT C/O & FLT. VEH. PROCED & GSE C/O
HARDWARE/SOFT'E INTEG.
UPDATE FACILITY
IAT
INTEG. AVION'S SYST. VERIFICN
HARDW'E INTEGRATION & FUNCT C/O
MISSION SIMULATION
PDM & RETRIEVAL SOFTW'E INTEGRATION
MS-1 PROCED & GSE CHECKOUT
FLT TEST SUPPORT
INTEGRATED AVIONICS SYSTEM VERIFICATION
MS-1 MISSION SOFTWARE
FLT VEH C/O PROCED & GSE VERIF
MISSION SIMULATION
FLT TEST SUPP
MISSION SOFTWARE/HARDWARE VERIFICATION
MAN-POWER 14 28 56 56 46 46 46 46 46 50 50 50 50 50 50 50 50 20 15 15 12 12 12 30 30 35 35 35 35 35 30 24 15 12 12

FIGURE 8.2-4

necessitates performing portions of the MPS fluid tests after subsystem build-up.

The facility and equipment requirements are basically the same as described in Part I, except that fuel cell GSE is required in the HPTF for this vehicle.

Test schedules and manpower requirements are presented for the basic 310-3A vehicle in Figures 8.2-5 and 8.2-6, and for the retrieval delay module in Figures 8.2-7 and 8.2-8.

8.2.4.2 Flight Test

The main stage (MS) flight test program for the 310-3A configuration is the same as described in Part I, paragraph 8.2.4

There will be a total of eight flights for the 310-3A/310RE configuration from which flight test data will be obtained. Five data flights are planned for the initial configuration and three for the evolved configuration. A DFI system will be installed on the MS and/or RDM during the flight test program

The first orbital flight (FOF) will be a dedicated flight test deploying a dummy payload.

Flight Test data will be obtained during the following operational flights

(3) Single payload deploy
(1) Multi payload deploy
(1) Retrieval demonstration
(1) Round Trip
(1) Retrieval delay

The retrieval demonstration uses the RDM as a target vehicle. The Shuttle will deploy the RDM and its performance will be evaluated while it is free flying in the vicinity of the Shuttle. When the Tug returns to the vicinity of the Orbiter it will demonstrate the retrieval capability by retrieving the deployed RDM.

The flight test schedule and test costs for this configuration are shown in Figure 8.2-9.

8.2.5 Impact of a Two Year IOC Delay

A two year delay of IOC for the 310-3A/310RE-3A configuration with an identical delay in the ATP of the program,will not impact the Vehicle Test Program other than merely starting the program two years later.

8.2.6 Analysis of the Test Program

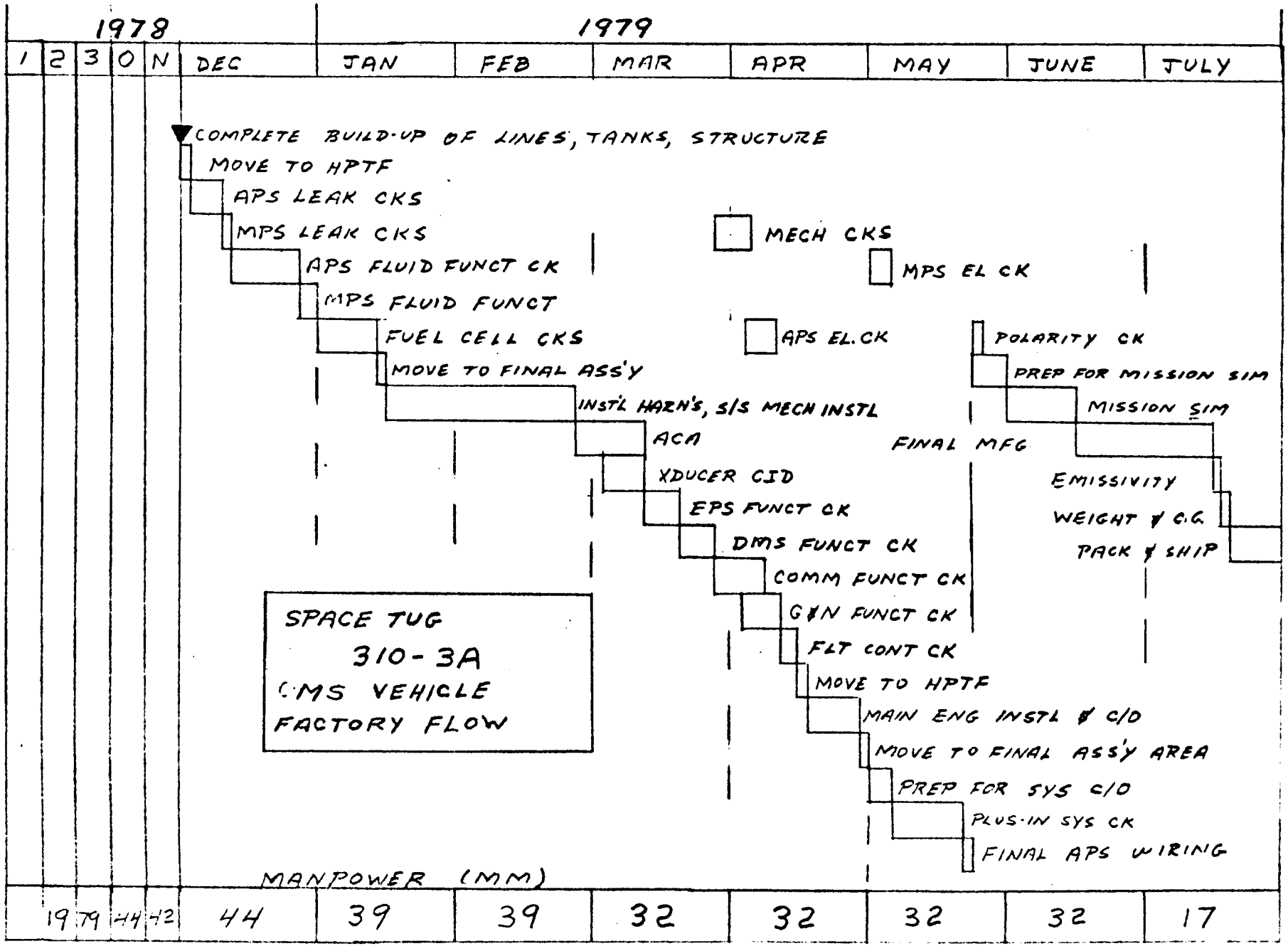

1978
1979
1
2
3
0
N
DEC
JAN
FEB
MAR
APR
MAY
JUNE
JULY
COMPLETE BUILD-UP OF LINES, TANKS, STRUCTURE
MOVE TO HPTF
APS LEAK CKS
MPS LEAK CKS
APS FLUID FUNCT CK
MPS FLUID FUNCT
FUEL CELL CKS
MOVE TO FINAL ASS'Y
INST'L HARN'S, S/S MECH INSTL
ACA
XDUCER CID
EPS FUNCT CK
DMS FUNCT CK
COMM FUNCT CK
G&N FUNCT CK
FLT CONT CK
MOVE TO HPTF
MAIN ENG INSTL & C/O
MOVE TO FINAL ASS'Y AREA
PREP FOR SYS C/O
PLUS-IN SYS CK
FINAL APS WIRING
MECH CKS
MPS EL CK
APS EL. CK
POLARITY CK
PREP FOR MISSION SIM
MISSION SIM
FINAL MFG
EMISSIVITY
WEIGHT & C.G.
PACK & SHIP
SPACE TUG
310-3A
CMS VEHICLE
FACTORY FLOW
MANPOWER (MM)
19
79
44
42
44
39
39
32
32
32
32
17

FIGURE 8.2-5

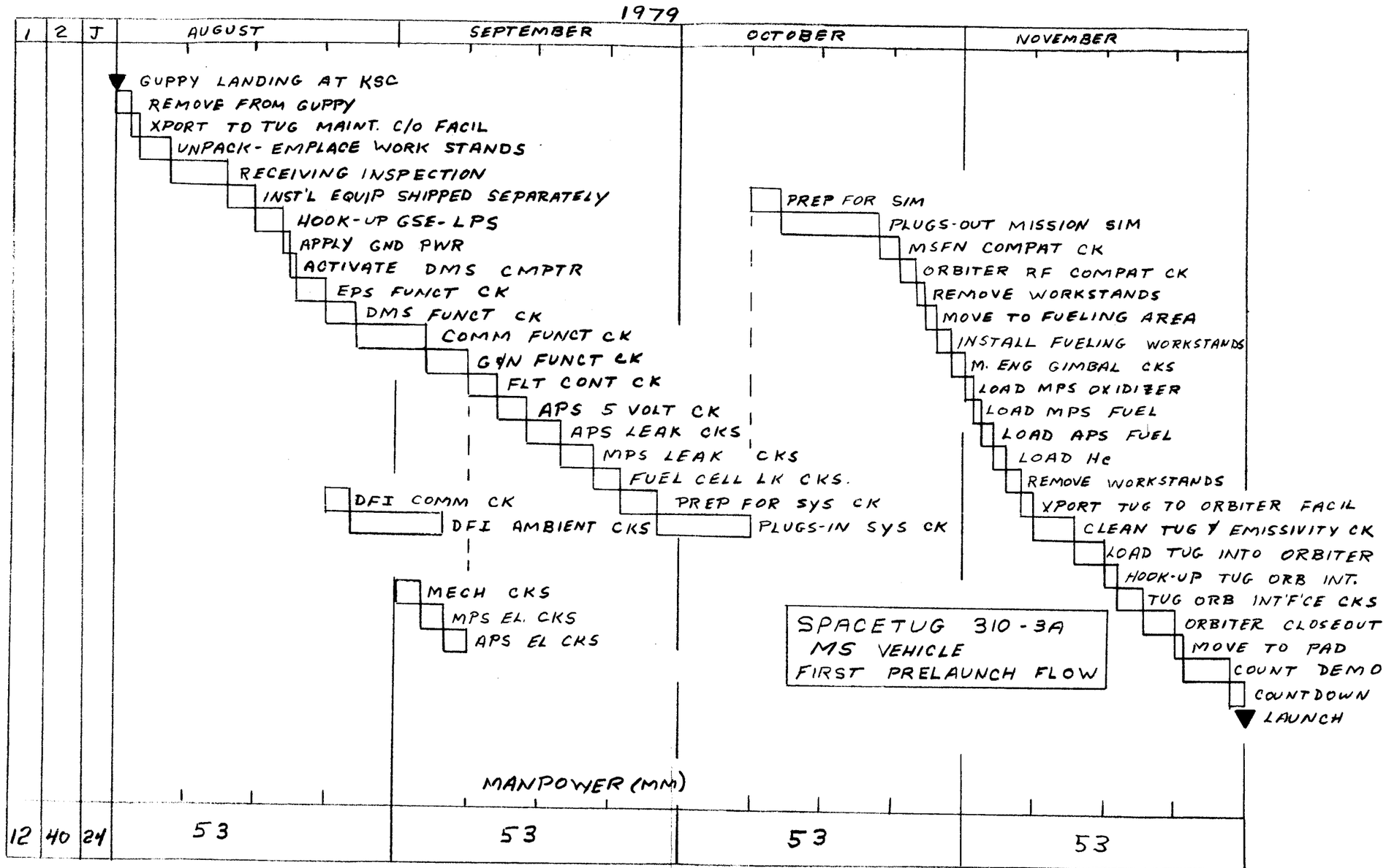
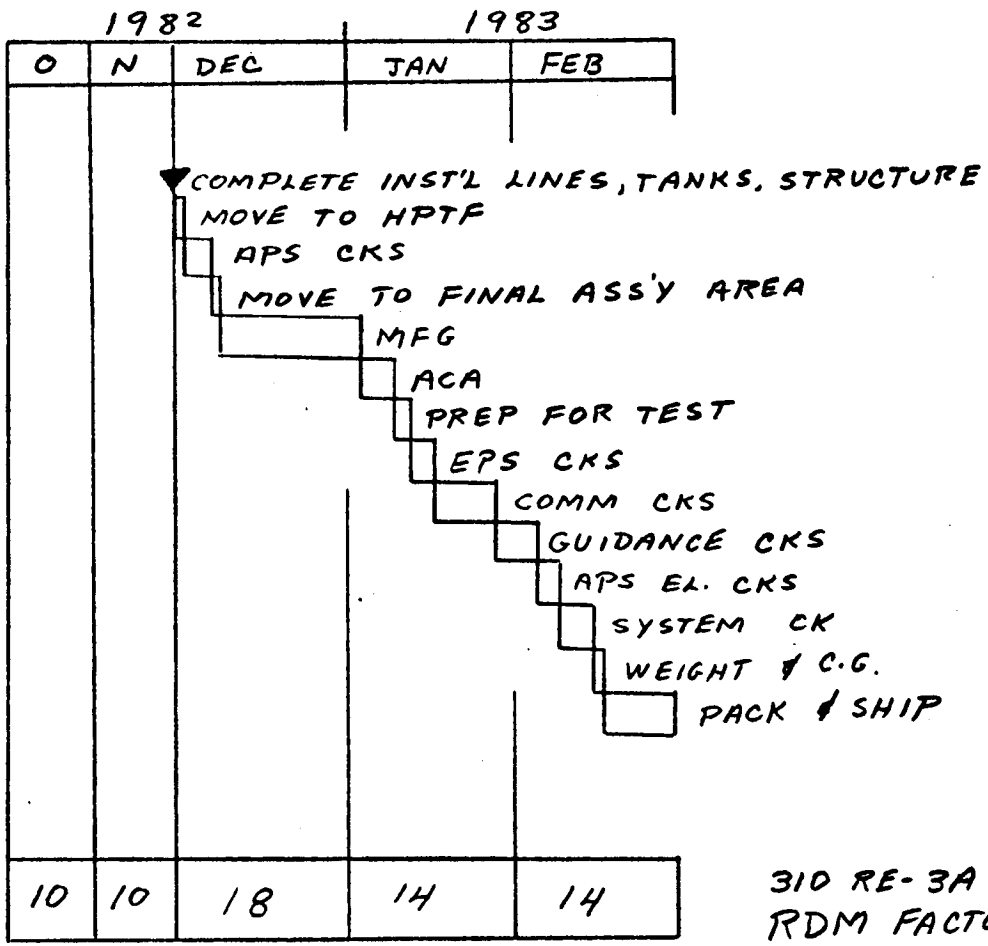

1979
1
2
J
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
GUPPY LANDING AT KSC
REMOVE FROM GUPPY
XPORT TO TUG MAINT. C/O FACIL
UNPACK - EMPLACE WORK STANDS
RECEIVING INSPECTION
INST'L EQUIP SHIPPED SEPARATELY
HOOK-UP GSE - LPS
APPLY GND PWR
ACTIVATE DMS CMPTR
EPS FUNCT CK
DMS FUNCT CK
COMM FUNCT CK
G&N FUNCT CK
FLT CONT CK
APS 5 VOLT CK
APS LEAK CKS
MPS LEAK CKS
FUEL CELL LK CKS.
PREP FOR SYS CK
PLUGS-IN SYS CK
DFI COMM CK
DFI AMBIENT CKS
MECH CKS
MPS EL. CKS
APS EL CKS
PREP FOR SIM
PLUGS-OUT MISSION SIM
MSFN COMPAT CK
ORBITER RF COMPAT CK
REMOVE WORKSTANDS
MOVE TO FUELING AREA
INSTALL FUELING WORKSTANDS
M. ENG GIMBAL CKS
LOAD MPS OXIDIZER
LOAD MPS FUEL
LOAD APS FUEL
LOAD He
REMOVE WORKSTANDS
XPORT TUG TO ORBITER FACIL
CLEAN TUG & EMISSIVITY CK
LOAD TUG INTO ORBITER
HOOK-UP TUG ORB INT.
TUG ORB INT'F'CE CKS
ORBITER CLOSEOUT
MOVE TO PAD
COUNT DEMO
COUNTDOWN
LAUNCH
SPACETUG 310-3A
MS VEHICLE
FIRST PRELAUNCH FLOW
MANPOWER (MM)
12
40
24
53
53
53
53

FIGURE 8.2-6



310 RE-3A
RDM FACTORY FLOW
FIRST UNIT

FIGURE 8.2-7

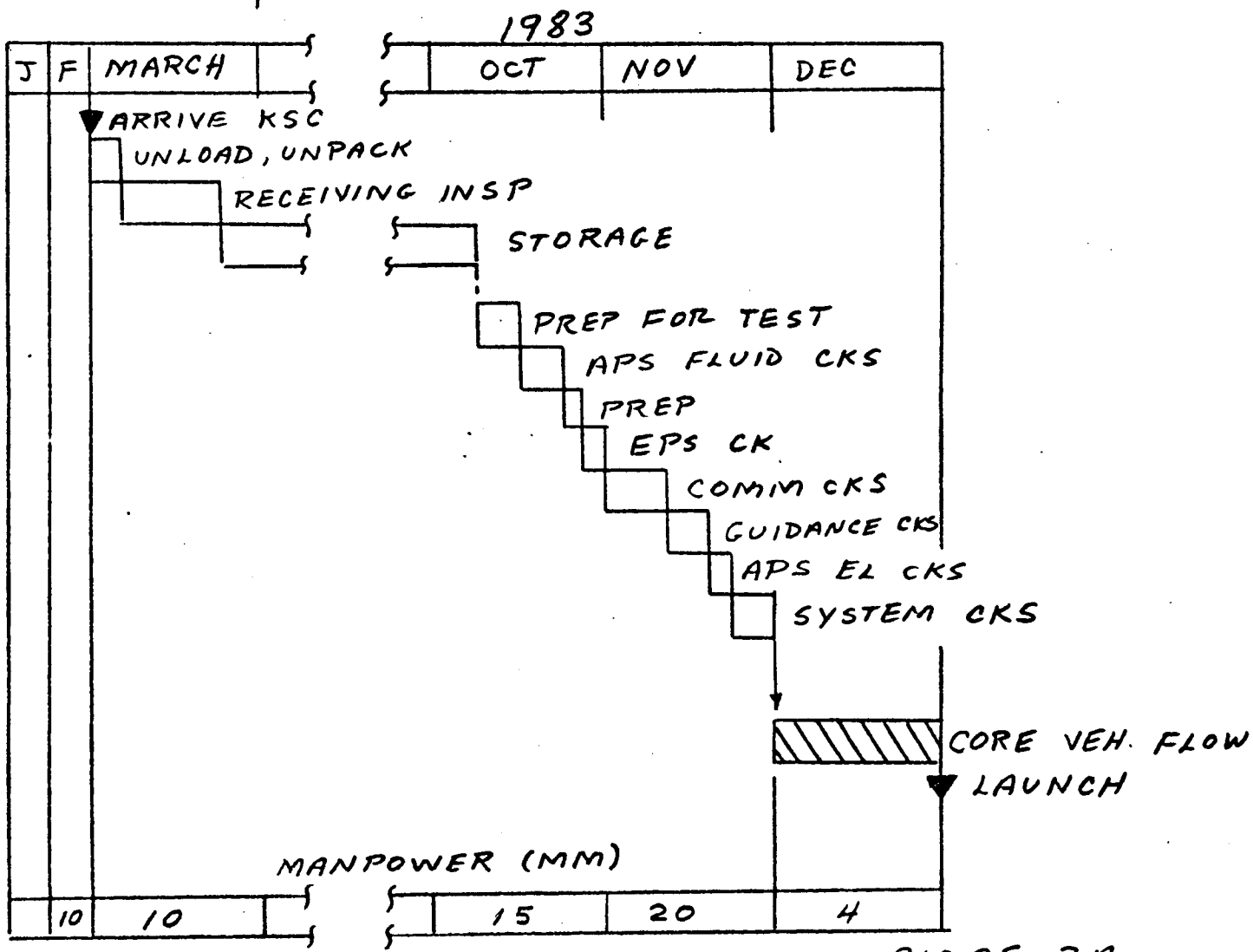
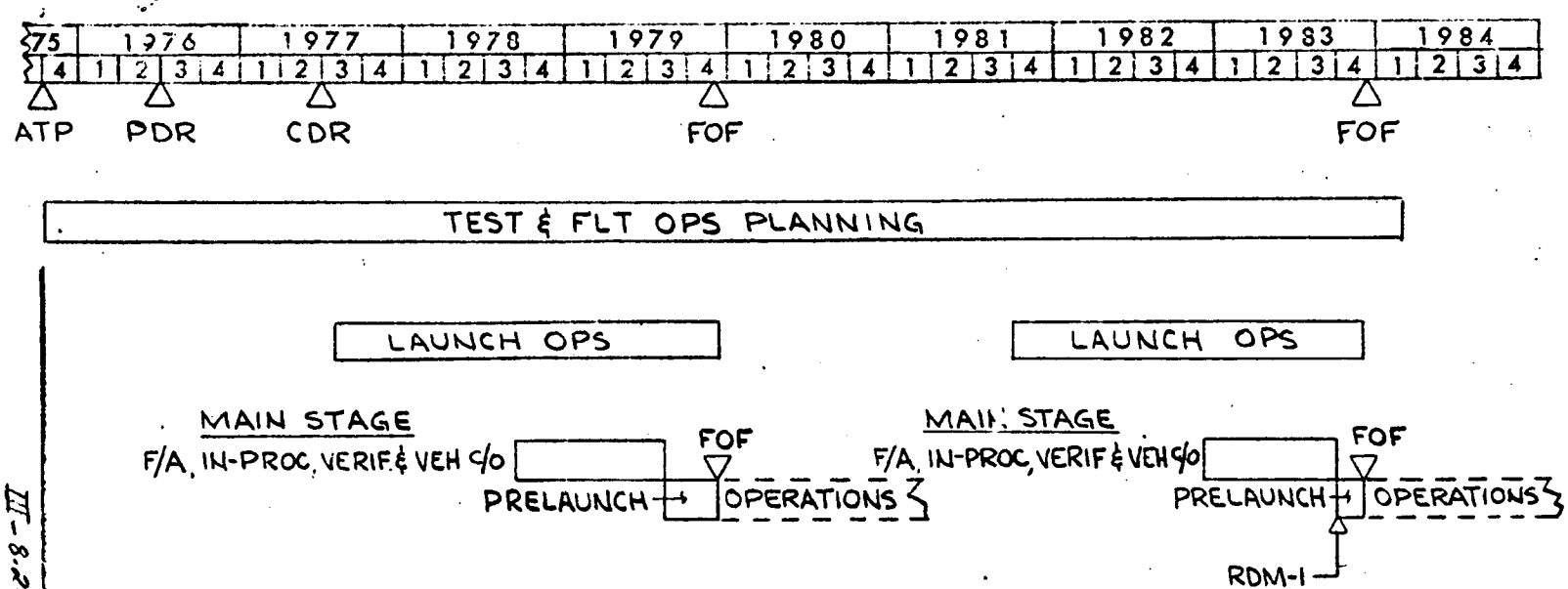


FIGURE 8.2-8

310RE-3A
RDM PRELAUNCH
FIRST RDM FLIGHT



FLIGHT TEST PROGRAM COST

- FLIGHT TEST HARDWARE: 1 TUG + DFI
- FLIGHT TEST MANPOWER (FOF ONLY)
  - TEST OPS: $2.94 M
  - LAUNCH OPS: $1.45 M
  - FLIGHT OPS: $1.80 M
- CONSUMABLES (FOF ONLY): $62 K

FIGURE 8.2-9 FLIGHT TEST PROGRAM SCHEDULE (310-3A/310RE-3A)

8.2.6.1 Key Elements

The analyses of the key elements of the test program for the basic 310-3A configuration are the same as described in Part I, paragraph 8.2.6.1. Specifically the test program key elements and the new issues arising out of the evolved 310RE-3A configuration are as follows:

- No System Level Hot Firing Tests

  The analysis is the same as described in Part I.

- Dynamic Static and Fatigue Tests performed on a single STA

  The analysis is the same as described in Part I.

- Use of a single STA program to cover both the basic and evolved configurations.

  The STA will be configured to include the structure hard points for the retrieval avionics and mechanical interfaces. The test program will include the projected mass simulation for the evolved hardware during dynamic tests and the projected loading for static and fatigue tests. By enveloping the basic and evolved designs in a single STA program both designs will be verified minimizing test program costs.

- Integrated Avionics Testing is accomplished in two separate yet complementary facilities

  The basic analysis is the same as described in Part 1. In addition the IAT and ASDL facilities for this configuration will be used for verification and mission simulations for the incorporation of rendezvous radar, retrieval electronics and level IIb autonomy during transition from the 310-3A to 310RE-3A configurations.

- One dedicated Flight test minimizes risk of losing Tug/Payload

  The Main Stage (MS) flight test program for the 310-3A configuration will be the same as described in Part I, paragraph 8.2.6.1 providing only a single dedicated test flight The Retrieval Delay Module (RDM) and MS retrieval capability will be demonstrated as part of a deploy only operational mission and will not require a separate dedicated flight test program. Since the basic Tug functional operation will have been fully developed by the time the RDM and retrieval capability is ready to be tested, and the test will be conducted within shuttle retrieval range, this approach offers the advantage of minimum risk at minimum test cost.

8.2.6.2 SR&T Assumptions

The basic assumption for the 310-3A/310RE-3A SR&T requirements are described in Part I, paragraph 8.2.6.2. SR&T requirements, test programs affected and a brief description of the interaction with the test programs affected is summarized in Table 8.2-2.

8.2.6.3 Reusability Demonstration

Reusability demonstrations for the 310-3A/310RE-3A are the same as described in Part I, paragraph 8.2.6.3.

8.2.6.4 Life Verification Tests

The life verification test requirements for the 310-3A/310RE-3A are the same as described in Part I paragraph 8.2.6.3

TECHNOLOGY REQUIREMENTS	TEST PROG. AFFECTED	REMARKS
Main engine life and high performance	o GFE eng. devel. prog. o Flight test prog.	Early life verif. of eng. components and area ratio nozzle performance assures phase C/D engine development. PTV is not affected since eng. is not required. FOF could tolerate slightly reduced eng. performance.
PFR helium tank		Early verif. of low weight PFR tank assures maximum tug performance.
Materials compatibility Data	o Tank qual o STA prog. o PTV prog.	Early verif. of material compatibility with MMH and N_2O_4 assures on-time development of main stage tankage including tank qual. STA and PTV testing.
Fracture Mechanics data	o Tank qual. o STA prog.	Early fracture mechanics data allows on-time development of structural subsystem including tankage quals and STA testing.
Heat Pipes	o Flight test prog.	Early verif. of heat pipe design approach allows on-time developments of Thermal Control Subsystem thereby maximizing Tug performance.
Advanced IMU	o Integrated avionics o Flight Vehicle Factory checkout o STA	Early devel of Advanced IMU will assure on time devel of software and integration procedures in the IAT LAB for FLT VEH buildup and test and accurate simulation for STA prog.
Graphite Composite	o STA Prog.	Early Devel of graphite composite honeycomb face sheets assures that STA program progresses as planned.
Laser Radar	o Integrated Avionics o Flight Vehicle factory checkout o STA	Early devel of light weight low power Laser Radar will assure on time development of software and integration procedures in the IAT LAB for FLT VEH buildup & test and accurate simulation for STA program.

Table 8.2-2 SR&T Assumptions

310-3A/310RE-3A GROUND TESTS

EVOLVED RETRIEVAL PLUS RETRIEVAL DELAY ADDS $10.01M TO VEH TEST

TEST	TEST ART.	OBJECTIVES	APPROACH TEST DESCRIPTION
STRUCTURES o 310-3A - MAIN STAGE (MS) o 310-RE - RETRIEVAL DELAY MODULE STRUCT (RDM)	o COMPLETE M.S. PRIM. & SEC. STRUCT. INCL. TUG/ORB., TUG/RDM TUG/P.L. ADAPTERS o COMPLETE RDM PRIM. & SEC. STRUCT.	o EVAL DYN., STATIC STRENGTH, SAFE-LIFE & SEPARATION o VERIFY STRUCT./ MECH. INTERFACES AT LAUNCH SITE	o VIB./ACOUSTIC TESTS o DES. LIMIT STATIC TESTS o STATIC FATIGUE o ULT. STATIC TESTS o SEP. DEMO. o INTERFACE VALIDAT. DEMO. AT KSC o RDM TESTED SEPARATELY AS ABOVE (1982)
PROPULSION (MS 310-3A ONLY)	o FLIGHT WT. MAIN STG. STRUCT. o MAIN ENG. SUPPT. S/S LESS ENG. o ENG. SIMUL. UNIT o PTV REFURB. TO FLIGHT OPS	o DEMO OPS OF ASSEM. COMPONENTS o DEVELOP C/O & OPS PROCEDURES o VERIFY SERV/HANDLG PROCEDURES o DEMO SYS PERF. & CHARACTERISTICS	o COLD FLOW ONLY o REFEREE FLUIDS PHASE -FILL/DRAIN/FLOW TESTS o LIVE PROPELLANTS PHASE - LOAD CONTROL/ACCURACY - SYS. COMPAT. & DYN. - PERF. SERV./HANDLG PROCEDURES

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310-3A/310RE-3A GROUND TESTS

Vehicle Test Program

The vehicle test program for 310-3A/310RE-3A was developed in a similar manner to that described for 110A-1.

Structural Test Article (STA)

The MS structural test program for the 310A-3A/310RE-3A configuration is identical to 110A-1. The differences for this configuration are the deletion of the kickstage, phased addition of the RDM, and added avionic retrieval hardware and mechanical interfaces. The 310-3A STA will be configured to include the evolved 310RE-3A hardware interfaces and the test program will envelope both configurations. The RDM STA will be tested similarily to the mainstage in 1982.

Propulsion Test Vehicle (PTV)

The PTV test program for this configuration is identical to the PTV test program for the 110A-1 configuration.

310-3A/310RE-3A GROUND TESTS (CONTINUED)

TEST	DESCRIPTION	OBJECTIVE	APPROACH
INTEGRATED AVIONICS TEST o INTEG. AVIONICS TEST(IAT) - MS - RDM o AVIONICS SOFTWARE DEVELOPMENT LAB.(ASDL). - MS	o IAT - SHIP SET OF AVIONICS - COMPUTER SIMULATION - SENSOR STIMULUS - FACTORY & LAUNCH GSE o ASDL - COMPUTER FACILITY WITH MATH MODEL SIMULATION OF MS HARDWARE	o VERIFY HARDWARE/SOFTWARE PRIOR TO VEHICLE INSTALLATION & FOF.79 o VERIFY EVOLVED RETRIEVAL AND AUTONOMY LEVEL IIB HARDWARE & SOFTWARE FOR 83 IOC	o IAT - SUBSYSTEM INTEG & END FUNCTIONAL VERIFICATION - VERIFY FACTORY C/O PROCED - HARDWARE/SOFTWARE VERIF. - MISSION SIMULATION - INTEGRATE & VERIFY RETRIEVAL CAPABILITY HARDWARE/SOFTWARE - RETRIEVAL MISSION SIMULATION o ASDL - SOFTWARE DEVELOP FOR BASIC & EVOLVED SYSTEM
MOCKUPS o MS o RDM	o WOOD AND CARDBOARD MOCKUP OF THE TUG MS AND RDM STRUCTURE INCLUDING EQUIPMENT FOR PDR. o WOOD & METAL MOCKUP OF TUG MS AND RDM STRUCT. & EQUIPMENT FOR CDR.	EVALUATE EQUIPMENT ACCESSIBILITY AND MAINTAINABILITY. EVALUATE SHUTTLE & PAYLOAD INTERFACE AND TUG LINES RUN PRIOR TO FAB OF FINAL HARDWARE.	o COMPONENT INSTALLATION o ESTABLISH LINE LENGTHS FOR FINAL HARDWARE FAB o DEMONSTRATE MAINTAINABILITY - ASSESSMENT & DEMOS OF EQUIPMENT CLEARANCES - CONNECTOR & MOUNTING ACCESSIBILITY DEMO. o SHUTTLE & PAYLOAD INTERFACE ASSESSMENT

GROUND TEST COST - INITIAL = $18.74M
- INITIAL & EVOLVED = $25.31M

GRUMMAN

310-3A/310RE-3A GROUND TESTS (CONTINUED)

Integrated Avionics Tests

The MS Integrated Avionics Test program for the 310-3A configuration is the same as for 110A-1.

The IAT and ASDL will be initially configured for the basic mission hardware and software including autonomy level IIIA. As the retrieval capability and Autonomy level II B is evolved, the IAT hardware and ASDL software will be updated and evolved system verification and mission simulation performed.

The RDM bread board will be integrated and functionally tested in the main stage IAT facility to take advantage of the existing facility simulation and GSE capabilities.

Mockups

The Main stage mockups for this configuration are the same as for 110A. In addition a mockup of the RDM will be required for this configuration. The evolved system hardware will also be installed and evaluated using the M.S. mockups.

310-3A/310RE-3A FLIGHT TESTS

TEST ARTICLE	OBJECTIVES	APPROACH
o MAIN STAGE (310-3A)- 1ST PROD. UNIT INCLUDING DFI o MAIN STAGE (310RE-3A) 1ST PROD. UNIT INCLUDING DFI o RDM - 1ST PROD. UNIT INCLUDING DFI	INITIAL IOC o THERMO-VERIFY SYS. THERMAL CONTROL o STRUCT - VERIFY LAUNCH/ ORBIT/ENTRY/LANDING LOADS & DYNAMICS o PROP - VERIFY MPS/APS o AVIONICS - VERIFY AVIONICS OPS o OPS - EVALUATE TUG/ORB, TUG/ PAYLOAD INTERFACES - EVALUATE SYS. PERF. CAPABILITY - DEMO PAYLOAD DEPLOY EVOLVED IOC o EVALUATE TUG/RDM INTERFACES o DEMO PAYLOAD RETRIEVAL AND AUTONOMY LEVEL IIb	o 8 FLIGHT-TEST PROGRAM - 5 INITIAL - 3 EVOLVED o FIRST ORBITAL FLIGHT (FOF) COSTED WITHOUT OPERATIONAL PAYLOAD - FLOWN WITHIN RETRIEVAL CAPABILITY OF ORB. - SEQUENCE INCL: SYS C/O, MPS/APS BURNS, DUMMY PAYLOAD DEPLOY, ORBITER RETRIEVAL o SUBSQ. FLIGHTS DEPLOY OPERATIONAL PAYLOADS SELECTED TO DEMO BUILDUP IN TUG CAPABILITY o FOF OF 310RE-3A IS A DEPLOY ONLY FLIGHT. RETRIEVAL DEMO WITH RDM PERFORMED UPON RETURN TO 160NM ORBIT

FLIGHT TEST COST-INITIAL	= $13.38M
INITIAL & EVOLVED	= $16.82M
TOTAL VEHICLE TEST	= $42.13

GRUMMAN

310-3A/310RE-3A FLIGHT TESTS

Eight flights are included in the flight test program for configuration 310-3A/310RE-3A. The MS Flight test program for the 310-3A configuration is the same as for 110A-1. The major difference is the evolution of the RDM and MS retrieval capability.

The RDM and MS retrieval capability will be demonstrated as part of a normal deploy only operational flight. During this flight an RDM will be deployed from the shuttle. When the tug returns from its deployment mission it will demonstrate retrieval capability by retrieving the RDM. RDM performance will be evaluated while it is free flying in the vicinity of the shuttle. Subsequent operational flights will serve to demonstrate all Tug mission modes.

8.3 Facilities Plan - Option 3A - Concept 310-3A/310 RE-3A

8.3.1 Manufacturing Facility

Same as concept 110A-1 except 25,400 sq. ft. of floor space is required for fabrication and assembly of the TUG.

8.3.2 Test Facilities

Same as concept 110A-1.

8.3.3 Operations Facilities

Same as concept 110A-1 except TUG Maintenance Facility at ETR will have 4 horizontal stations in a 12,000 sq. ft. addition to the Shuttle OMS Facility. The Kickstage SRM Processing Facility is not required.

8.3.4 Impact of 2 Year IOC Delay

Same as concept 110A-1 except expenditure of $3.7 million of facility DDT & E costs can be delayed for 2 years.

STORABLE SPACE TUG

CONCEPT 310-3A/320.RE-3A

Revision Date 9-8-73

FACILITIES FUNDING REQUIREMENTS 10C DEC. '79 ACQUISITION PHASE N-SA

Fiscal Year	'76			'77			'78			'79			'80			'81			'82			'83			'84	'85	'86	'87	'88	'89	'90	'91	TOTALS		
TITLE/WBS # / Level 6 Cat.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	3	3	3	3	3	3	3	3	DDT&E	PROD	OPS
Manufacturing 320-06-01																																			
Structures		2.0		55.0	28.4	3.6		28.4	27.5			11.8 (22.8)			(34.6)			(34.6)			(34.6)			(34.6)	(34.6)	(34.6)	(34.6)	(22.6)					156.7	297.0	–
Retrieval Kit																	7.6			6.0	(5.1)			(6.8)	(4.5)								13.6	16.4	–
Sub-Total		2.0		55.0	28.4	3.6		28.4	27.5			34.6			34.6		7.6	34.6		6.0	39.7			41.4	39.1	34.6	34.6	22.0					170.3	303.4	–
Test 320-06-02																																			
Structural				Existing Facility – No Facility Input Rqd																													–	–	–
Thermal				Existing Facility – No Facility Input Rqd																													–	–	–
IAT								.9				1.0			1.0			1.0			1.0			1.0	.3								6.2	–	–
Propulsion								63.0			27.0	(7.0)			(7.0)			(1.0)			(7.0)			(9.0)	–	–	(7.0)	(6.0)					117.6	61.0	–
Tank Cont. & Accept.				100.0				20.0	1.0			(1.3)			(1.3)			(1.3)			(1.3)			(1.3)	–	–	(1.3)	(1.7)					[illegible]	[illegible]	–
Sub-Total				100.0				103.0	1.9		27.0	9.6			11.3			11.3			11.3			11.3	10.6	10.3	10.3	6.7					233.7	65.1	–
Maint. & Refurb. - ETR 320-06-03																																			
Tug Maint. Fac.				40.0			110.0			54.6	16.0				[20.0]			[22.6]			[22.6]			[22.6]	–	–	–	–	–	–	[22.6]	[11.3]	360.9	–	[illegible]
Prop. Sys. Serv.				25.0			34.2			45.7	19.1				[8.5]			[9.0]			[9.0]		19.4	[1.0]	–	–	–	–	–	–	[1.0]	[illegible]	[illegible]	–	[illegible]
Tug Cleaning							32.0			32.8	53.6				[5.5]			[6.0]			[6.0]		37.4	[6.0]	–	–	–	–	–	–	[6.0]	3.5	222.0	–	14.5
Kick Stage Prom.																																			
Support/Whse. Fac.				Shuttle Shared Facility							27.0																						122.0	–	–
Office											10.0				[5.0]			[5.0]			[5.0]			[5.0]	–	–	–	–	–	–	[5.0]	6.5	16.0	–	57.5
Sub-Total				15.0			139.0			131.2	69.0				38.8			42.6			42.6		1242	42.6	–	–	–	–	–	–	42.6	21.3	2,123.2		444.1
ETR Launch 320-06-04																																			
Launch Pad				Shuttle Facility										5.0																			5.0	–	–
Safing Area				Shuttle Facility							2.0			18.0																			20.0	–	–
Mission Control Center										203.5					[7.0]			[12.0]			[12.0]			[12.0]	–	–				–	[12.0]	[6.0]	412.5	–	132.0
Sub-Total							5.0			203.5	2.0			23.0	7.0			12.0			12.0			12.0	–	–		–		–	12.0	6.0	437.5	–	132.0
Maint. & Refurb.-WTR 320-06-05																																			
Tug Maint. Fac.													20.0			54.2			330.6	130.0				[4.3]	[1.3]	–	–	–	–	–	[1.3]	[1.3]	790.5	–	[illegible]
Prop. Sys. Serv.													30.0			40.1			514.6	55.0				[7.5]	[3.0]	–	–	–	–	–	[3.0]	[1.5]	1166.0	–	[illegible]
Tug Cleaning																34.0			329.5	25.6				[5.1]	[6.0]	–	–	–	–	–	[6.0]	[3.0]	497.6	–	[illegible]
Support/Whse. Fac.																																			
Office																																			
Sub-Total													20.0			261.0			1,174.5	192.6				25.2	30.3	–	–	–	–	–	30.3	15.1	2,647.6	–	[illegible]
WTR Launch 320-06-06																																			
Launch Pad				Shuttle Facility																			5.0										5.0	–	–
Safing Area				Shuttle Facility																2.0			22.0										24.0	–	–
Mission Control Center							6.0			[illegible]					[7.0]			[12.0]			[12.0]			[12.0]	–	–	–	–		–	[12.0]	[6.0]	417.0	–	123.0
Sub-Total							6.0			[illegible]					7.0			12.0		2.0	12.0		27.0	12.0	–					–	12.0	6.0	[illegible]	–	[illegible]
TOTALS		2.0		200.0	71.4	3.6	[illegible]	31.4	27.4	[illegible]	33.0	44.0	50.0	23.0	18.7	261.0	7.6	112.5	1,511.1	155.6	117.6	141.2	7.5	115.6	141.4	44.6	115.6	29.9	16.7	16.9	45.4	[illegible]	3,364.3	[illegible]

GRAND TOTAL 8,364.3

COSTS - $000 (1973)

Col. 1 - Design/Construction Costs
Col. 2 - Activation Costs
Col. 3 - Maintenance Costs

00 - DDT & E Costs
(00) - Production Costs
[00] - Operations Costs

III-8.3-2

8.4 Vehicle Manufacturing

This section establishes the manufacturing requirements for 310A-3A/310RE-3A spacecraft including the assembly sequence, tooling, schedule, manufacturing test, special processes and facilities.

The 310A-3A spacecraft consists of a main stage and a Retrieval Delay Module (RDM), which is phased-in for the evolved configuration (310RE-3A). The main stage is essentially the same as the 410AD-2 configuration. The RDM is a short (27") element added between the payload and the main stage which contains docking provisions and GN&C, communications, data management, APS and EPS equipment.

8.4.1 Plan/Flow/Time

The manufacturing sequence is identical to configuration 410AD-2 discussed in Part II section 8.4.1. The manufacturing flow and master schedule are shown in figures 8.4-1 and 8.4-2 respectively.

8.4.2 Tooling Requirements (including GSE)

See Part II section 8.4.2

8.4.3 Facility Requirements

See Part II section 8.4.3

8.4.4 Special Requirements

See Part II section 8.4.4

8.4.5 Summary Analysis/Philosophy

See Part II section 8.4.5

8.4.6 GSE Requirements

See Part I section 8.4.7

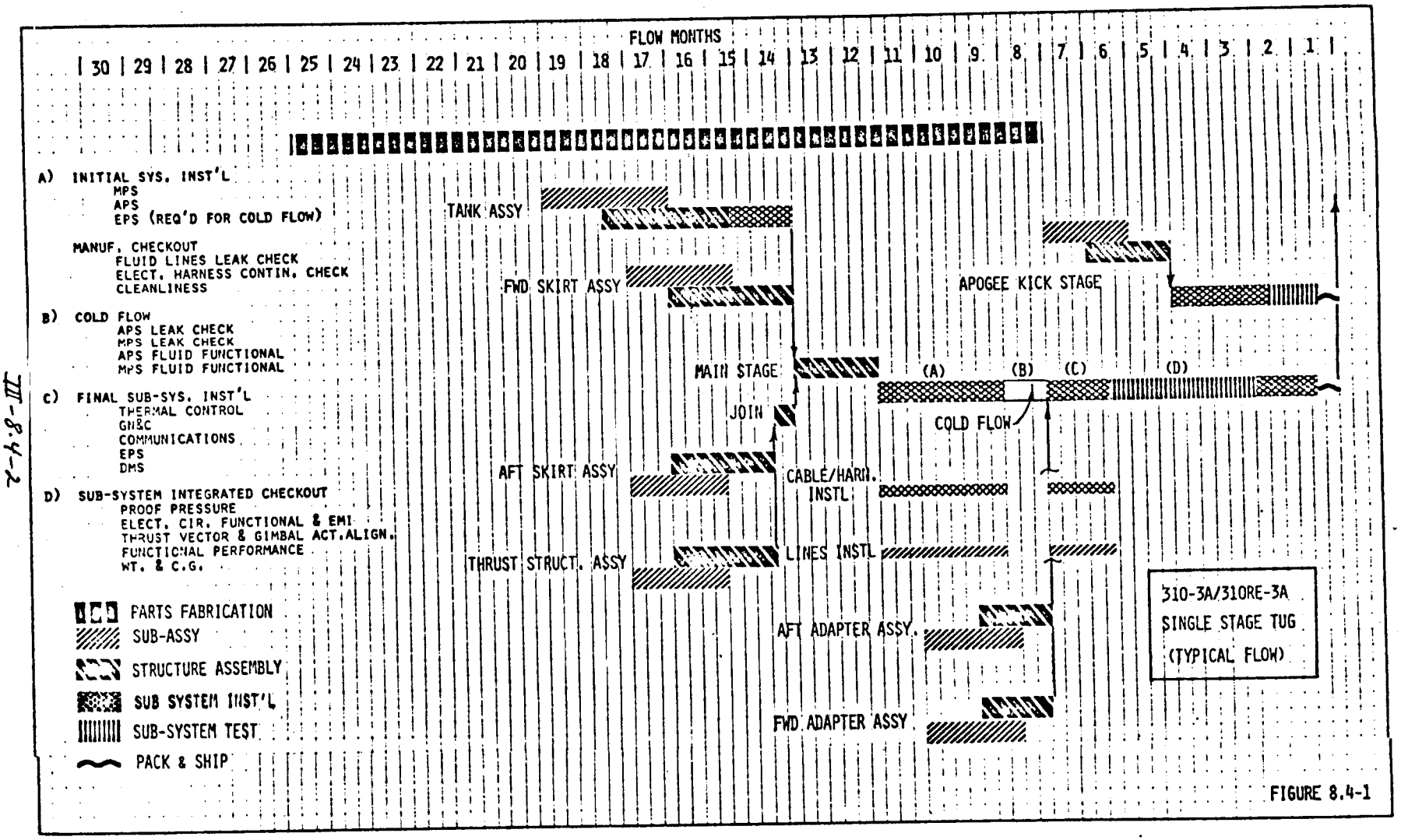
FLOW MONTHS
30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
A) INITIAL SYS. INST'L
MPS
APS
EPS (REQ'D FOR COLD FLOW)
MANUF. CHECKOUT
FLUID LINES LEAK CHECK
ELECT. HARNESS CONTIN. CHECK
CLEANLINESS
B) COLD FLOW
APS LEAK CHECK
MPS LEAK CHECK
APS FLUID FUNCTIONAL
MPS FLUID FUNCTIONAL
C) FINAL SUB-SYS. INST'L
THERMAL CONTROL
GN&C
COMMUNICATIONS
EPS
DMS
D) SUB-SYSTEM INTEGRATED CHECKOUT
PROOF PRESSURE
ELECT. CIR. FUNCTIONAL & EMI
THRUST VECTOR & GIMBAL ACT.ALIGN.
FUNCTIONAL PERFORMANCE
WT. & C.G.
TANK ASSY
FWD SKIRT ASSY
MAIN STAGE
JOIN
AFT SKIRT ASSY
THRUST STRUCT. ASSY
APOGEE KICK STAGE
(A)
(B)
(C)
(D)
COLD FLOW
CABLE/HARN. INSTL
LINES INSTL
AFT ADAPTER ASSY.
FWD ADAPTER ASSY
PARTS FABRICATION
SUB-ASSY
STRUCTURE ASSEMBLY
SUB SYSTEM INST'L
SUB-SYSTEM TEST
PACK & SHIP
310-3A/310RE-3A
SINGLE STAGE TUG
(TYPICAL FLOW)

FIGURE 8.4-1

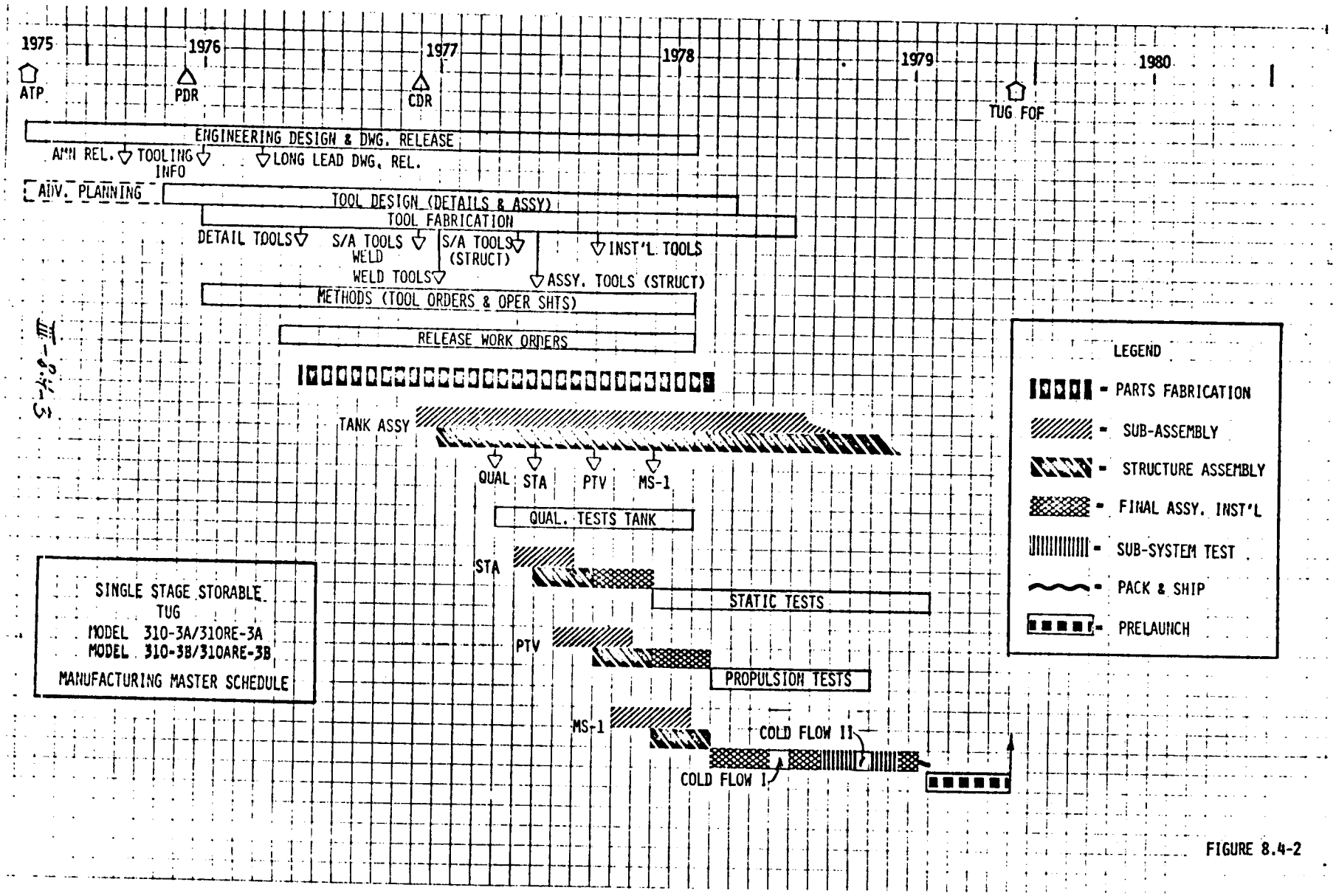
1975
1976
1977
1978
1979
1980
ATP
PDR
CDR
TUG FOF
ENGINEERING DESIGN & DWG. RELEASE
ANN REL.
TOOLING INFO
LONG LEAD DWG. REL.
ADV. PLANNING
TOOL DESIGN (DETAILS & ASSY)
TOOL FABRICATION
DETAIL TOOLS
S/A TOOLS WELD
S/A TOOLS (STRUCT)
INST'L TOOLS
WELD TOOLS
ASSY. TOOLS (STRUCT)
METHODS (TOOL ORDERS & OPER SHTS)
RELEASE WORK ORDERS
TANK ASSY
QUAL
STA
PTV
MS-1
QUAL. TESTS TANK
STA
STATIC TESTS
PTV
PROPULSION TESTS
MS-1
COLD FLOW II
COLD FLOW I
SINGLE STAGE STORABLE TUG
MODEL 310-3A/310RE-3A
MODEL 310-3B/310ARE-3B
MANUFACTURING MASTER SCHEDULE
LEGEND
- PARTS FABRICATION
- SUB-ASSEMBLY
- STRUCTURE ASSEMBLY
- FINAL ASSY. INST'L
- SUB-SYSTEM TEST
- PACK & SHIP
- PRELAUNCH

FIGURE 8.4-2

8.5 310-3A/310RE-3A SPECIAL PROGRAMMATICS

This chart summarizes the salient features defined for implementing and managing Program 310-3A/310RE-3A.

The main factors derived from our analysis of 110A-1 include: defining the initial/evolved flight build up based on Shuttle/Tug launch constraint and ground crew launch capability; implementing a 3 lot main stage production run with deploy capability, deploy capability up graded to retrieval, and retrieval capability vehicles to avoid initial/evolved production gaps; refurbishing the propulsion test article for operational use; and defining a fall back position for every identified risk.

Specific areas for government participation include: establishing Tug/Shuttle interface requirements before Orbiter design freeze; providing payload interface design requirements and mission model data; initiating required activities for supporting Research and Technology; providing GFE systems and components (eg: main engines, and DOD secure comm); supporting propulsion system testing and development; supporting integrated avionics hardware testing and related software development; providing required facilities; performing vehicle flight operations and ground operations; and providing logistic support.

310-3A/310RE-3A SPECIAL PROGRAMMATICS

- o PROGRAM IMPLEMENTATION AND MANAGEMENT
  - INITIAL/EVOLVED FLIGHT BUILD-UP SET BY SHUTTLE/TUG LAUNCH CONSTRAINT AND GROUND CREW LAUNCH CAPABILITY
  - 3 LOT PRODUCTION (DEPLOY, DEPLOY-UPGRADE, AND RETRIEVE) TO AVOID MFG GAP
  - PROPULSION ARTICLE REFURBISHED FOR FLIGHT
  - FALL BACK POSITION SHOWN FOR EVERY IDENTIFIED RISK

- o AREAS FOR GOVERNMENT PARTICIPATION
  - FIRM TUG/SHUTTLE INTERFACES BEFORE ORBITER PDR
  - PROVIDE PAYLOAD INTERFACE DESIGN REQUIREMENTS AND MISSION MODEL DATA
  - INITIATE REQUIRED SR&T
  - SUPPORT SYSTEM TEST - AVIONIC HARDWARE/SOFTWARE, PROPULSION
  - PROVIDE GFE SYSTEMS AND COMPONENTS, FACILITIES, LOGISTIC SUPPORT
  - PERFORM VEHICLE GROUND AND FLIGHT OPERATIONS

GRUMMAN

8.6 COST DATA

Included in this section are the cost data for an evolved tug configuration 310-3A--310RE-3A. Cost data are provided for the initial program 310-3A and the combined total evolved program.

- Initial Program 310-3A
  - o Storable Space Tug System Project Expected Cost-Spares Cost (INT & OPS)-First Unit Cost (Data Forms A, 2 and 3, subparagraph No's 8.6.1, 8.6.2 and 8.6.3) (Computer P/O)
  - o Storable Space Tug Funding Schedules-DDT & E, Production and Operations (Data Form C, subparagraph 8.6.4, 8.6.5, 8.6.6 and 8.6.7.)
  - o First Unit Production Cost per WBS (including Avionics to level 7) Main Stage and Auxiliary Stage(s), (subparagraph 8.6.8)
  - o Form B (Technical Characteristics subparagraph 8.6.11)
- Combined Evolved Program 310-3A/310RE-3A
  - o Same as initial program plus:
    - o Average Cost/Flight (subparagraph 8.6.9)
    - o Storable Space Tug System Project Cost Estimate data by SOW-DDT & E, Production and Operations (Data Form T (SOW'S) subparagraph 8.6.10)

EVOLVED TUG

CONCEPT 310-3A (INITIAL)

OPTION 3

310-3A SEP 73

STORABLE SPACE TUG SYSTEM PROJECT

EXPECTED COST - SPARES COST(INT + OPS) - FIRST UNIT COST

(COSTS IN 1973 CONSTANT DOLLARS (000))

WBS	EXPECTED COST DDT+E			EXPECTED COST PRODUCTION			INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS		
LEVEL	4	5	6	4	5	6			4	5	6
0100 PROJECT MGMT	8038.			2148.				663.	2733.		
0110 COST/PERF MGMT		1206.			322.			99.		911.	
0120 PROJECT DIRECTION		6189.			1654.			511.		911.	
0130 INFO MGMT		643.			172.			53.		911.	
0200 SYS ENG + INTEGR	9645.			2417.				746.	5468.		
0210 TUG SYS ENG		7716.						0.		1367.	
0220 SHUTTLE INTERFACE		965.						0.		1367.	
0230 PAYLOAD INTERFACE		965.						0.		1367.	
0240 SUST ENG						0.		746.		1367.	
0300 TUG VEH MAIN STAGE	139379.			33174.			4817.	9088.	9553.		
0310 STRUCTURES		17149.			5522.		552.	1704.		552.	
0311 FUEL TNK+SPRT			5651.			1873.	187.	578.			187.
0312 OX TANK +SPRT			6817.			2200.	220.	679.			220.
0313 BODY STRUCT			2458.			824.	82.	254.			82.
0314 THRUST STRUCT			480.			108.	11.	33.			11.
0315 METEOROID SHLD			143.			40.	4.	12.			4.
0316 PAYLOAD INTFCE			1600.			476.	48.	147.			48.
0317 INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0320 THERMAL INSULTN		149.			570.		28.	176.		28.	
0321 FUEL TANK INSUL			57.			279.	28.	86.			28.
0322 OX TANK INSUL			92.			291.	0.	90.			0.
0323 PURGE SYS INSUL			0.			0.	0.	0.			0.
0324 CONT SYS			0.			0.	0.	0.			0.
0325 INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0330 AVIONICS		39892.			13107.		3046.	3277.		6699.	
0331 DATA MGMT			5880.			2653.	716.	663.			1725.
0332 G N + C			10420.			5879.	1407.	1470.			3108.
0333 COMMUNICATIONS			5883.			1653.	388.	413.			796.
0334 INSTRUMENTATION			0.			0.	0.	0.			0.
0335 ELEC PWR			16566.			2011.	535.	503.			1070.
0336 PWR DIST + CONT			1143.			911.	0.	228.			0.
0337 INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0340 PROPULSION		71049.			7334.		1033.	1922.		2116.	
0341 MAIN ENGINE			59000.			2845.	937.	800.			1880.
0342 MAIN ENGINE SPT			7563.			1700.	0.	425.			0.
0343 ACPS ENGINE			3000.			1501.	96.	375.			236.
0344 ACPS ENGINE SPT			1486.			1288.	0.	322.			0.
0345 INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0350 ORBITER INTERFACE		6981.			1582.		158.	623.		158.	
0351 STRUCTURE			4900.			675.	68.	266.			68.
0352 INTERFACE PNLS			2081.			906.	91.	357.			91.
0353 PURGE PROVISION			0.			0.	0.	0.			0.
0354 ABORT PROVISION			0.			0.	0.	0.			0.
0355 INSTL.ASSY+C/O			0.			0.	0.	0.			0.

III-8.6-3

MOORE BUSINESS FORMS, INC., MO FORM 14321 PRINTED IN U.S.A.

310-3A SEP 73

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0360	DROP TANKS		0.			0.		0.	0.		0.	
0361	STRUCTURES			0.			0.	0.	0.			0.
0362	THERMAL INSUL			0.			0.	0.	0.			0.
0363	PROP SPRT SYS			0.			0.	0.	0.			0.
0364	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0370	FINAL ASSY + C/O		4159.			5061.		0.	1386.		0.	
0371	FINAL ASSY			4159.			5061.	0.	1386.			0.
0372	CHECKOUT			0.			0.	0.	0.			0.
0400	TUG VEH AUX STAGE	0.			0.			0.	0.	0.		
0410	STRUCTURES		0.			0.		0.	0.		0.	
0411	FUEL TNK+SPRT			0.			0.	0.	0.			0.
0412	OX TANK+SPRT			0.			0.	0.	0.			0.
0413	BODY STRUCT			0.			0.	0.	0.			0.
0414	THRUST STRUCT			0.			0.	0.	0.			0.
0415	METEOROID SHLD			0.			0.	0.	0.			0.
0416	PAYLOAD INTERFC			0.			0.	0.	0.			0.
0417	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0420	THERMAL INSUL		0.			0.		0.	0.		0.	
0421	FUEL TANK INSUL			0.			0.	0.	0.			0.
0422	OX TANK INSUL			0.			0.	0.	0.			0.
0423	PURGE SYS INSUL			0.			0.	0.	0.			0.
0424	CONT SYS			0.			0.	0.	0.			0.
0425	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0430	AVIONICS		0.			0.		0.	0.		0.	
0431	DATA MGMT			0.			0.	0.	0.			0.
0432	G N + C			0.			0.	0.	0.			0.
0433	COMMUNICATIONS			0.			0.	0.	0.			0.
0434	INSTRUMENTATION			0.			0.	0.	0.			0.
0435	ELEC PWR			0.			0.	0.	0.			0.
0436	PWR DIST + CONT			0.			0.	0.	0.			0.
0437	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0440	PROPULSION		0.			0.		0.	0.		0.	
0441	MAIN ENGINE			0.			0.	0.	0.			0.
0442	MAIN ENGINE SPT			0.			0.	0.	0.			0.
0443	ACPS ENGINE			0.			0.	0.	0.			0.
0444	ACPS ENGINE SPT			0.			0.	0.	0.			0.
0445	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0450	INTERSTAGE INTRFC		0.			0.		0.	0.		0.	
0451	STRUCTURE			0.			0.	0.	0.			0.
0452	SEP SYS			0.			0.	0.	0.			0.
0453	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0460	DROP TANK		0.			0.		0.	0.		0.	
0461	STRUCTURE			0.			0.	0.	0.			0.
0462	THERMAL INSUL			0.			0.	0.	0.			0.
0463	PROP SPT SYS			0.			0.	0.	0.			0.
0464	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0470	RDM		0.			0.		0.	0.		0.	

III-86-4

MOORE BUSINESS FORMS INC., HQ FORM 1412 T PRINTED IN U.S.A. 22

310-3A SEP 73

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST. UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0471	STRUCTURE			0.			0.	0.	0.			0.
0472	THERM CONT			0.			0.	0.	0.			0.
0473	AVIONICS			0.			0.	0.	0.			0.
0474	PROPULSION			0.			0.	0.	0.			0.
0475	RDM ASSY+C/O			0.			0.	0.	0.			0.
0480	AKS		0.			0.		0.	0.		0.	
0481	STRUCTURE			0.			0.	0.	0.			0.
0482	SRM			0.			0.	0.	0.			0.
0483	AVIONICS			0.			0.	0.	0.			0.
0484	PROPULSION			0.			0.	0.	0.			0.
0485	AKS ASSY+C/O			0.			0.	0.	0.			0.
0490	DKS		0.			0.		0.	0.		0.	
0491	STRUCTURE			0.			0.	0.	0.			0.
0492	SRM			0.			0.	0.	0.			0.
0493	AVIONICS			0.			0.	0.	0.			0.
0494	PROPULSION			0.			0.	0.	0.			0.
0495	DKS ASSY+C/O			0.			0.	0.	0.			0.
04100	CACHE TANK		0.			0.		0.	0.		0.	
04101	STRUCTURE			0.			0.	0.	0.			0.
04102	THERM CONT			0.			0.	0.	0.			0.
04103	AVIONICS			0.			0.	0.	0.			0.
04104	PROPULSION			0.			0.	0.	0.			0.
04105	CACHE ASSY+C/O			0.			0.	0.	0.			0.
04110	FINAL ASSY + C/O		0.			0.		0.	0.		0.	
04111	FINAL ASSY			0.			0.	0.	0.			0.
04112	CHECKOUT			0.			0.	0.	0.			0.
0500	LOGISTICS	6330.			3672.				3672.			
0510	TRANSPORT+HANDLG		0.			1152.			1152.			
0520	TRAINING		6330.			1950.			1950.			
0521	SIM+EQUIPMENT			1950.			1950.		1950.			
0522	GROUND CREW			2180.			0.		0.			
0523	FLT OPS CREW			2200.			0.		0.			
0530	WAREHSG+INV CONT		0.			570.			570.			

III-8.6-5

MOORE BUSINESS FORMS, INC. NO FORM 14121 PRINTED IN U.S.A.

310-3A SEP 73

WBS	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0600 FACILITIES	7098.			68.					202.		
0610 MANUFACTURING		145.			50.					0.	
0611 DES/CONSTR			145.								
0612 ACT/MAINT			0.			50.					0.
0620 TEST		245.			18.					0.	
0621 DES/CONST			245.								
0622 ACT/MAINT			0.			18.					0.
0630 1ST TR MAINT+REF		2953.			0.					100.	
0631 DES/CONST			2953.								
0632 ACT/MAINT			0.			0.					100.
0640 ETR LAUNCH		475.			0.					26.	
0641 DES/CONST			475.								
0642 ACT/MAINT			0.			0.					26.
0650 2ND TR MAINT+REF		2758.			0.					50.	
0651 DES/CONST			2758.								
0652 ACT/MAINT			0.			0.					50.
0660 WTR LAUNCH		523.			0.					26.	
0661 DES/CONST			523.								
0662 ACT/MAINT			0.			0.					26.
0700 GSE	25780.			0.			0.		2240.		
0710 MFG GSE		2100.									
0711 HARDWARE											
0712 SITE ACT											
0713 MAINT											
0714 SOFTWARE											
0720 ETR GSE		17080.			0.		0.			600.	
0721 HARDWARE			14780.			0.	0.				
0722 SITE ACT			2300.								
0723 MAINT			0.								600.
0724 SOFTWARE			0.								
0730 WTR GSE		0.			0.		0.			1640.	
0731 HARDWARE			0.			0.	0.				
0732 SITE ACT			0.								
0733 MAINT			0.								1640.
0734 SOFTWARE			0.								

310-3A SEP 73

WBS	LEVEL 4	EXPECTED COST DDT+E 5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0740 FL OP NASA		3300.			0.			0.		0.	
0741 HARDWARE			3300.			0.		0.			
0742 SITE ACT			0.								
0743 MAINT			0.								0.
0744 SOFTWARE			0.								
0750 FL OP DOD		3300.			0.			0.		0.	
0751 HARDWARE			3300.			0.		0.			
0752 SITE ACT			0.								
0753 MAINT			0.								0.
0754 SOFTWARE			0.								
0800 VEHICLE TEST	58501.										
0810 GND TEST HARDWARE		8542.									
0811 PTV/BATTLESHIP			2342.								
0812 MAJOR TST ART			5750.								
0813 MOCKUPS			450.								
0820 GND TEST OPS		10200.									
0830 FLT TEST HARDWARE		9139.									
0840 FLT TEST OPS		30620.									
0900 LAUNCH OPS WTR									434.		
0910 LAUNCH SITE SVC										0.	
0920 TUG/SHUTTLE MATG										0.	
0930 PRELAUNCH C/O										0.	
0940 COUNTDOWN										0.	
0950 FLUID+GASES										434.	
0960 POST FLT SAFING										0.	
1000 LAUNCH OPS ETR									5790.		
1010 LAUNCH SITE SVC										0.	
1020 TUG/SHUTTLE MATG										402.	
1030 PRELAUNCH C/O										780.	
1040 COUNTDOWN										24.	
1050 FLUID+GASES										3224.	
1060 POST FLT SAFING										1360.	
1100 FLT OPS DOD	2930								13700.		
1110 MISSION PLAN		1980								4580.	
1120 FLT CONT		610								5740.	
1130 FLT EVALUATION		340								660.	
1140 FLT SPT SOFTWARE		—								2720.	
1200 FLT OPS NASA	23450								22150.		
1210 MISSION PLAN		5220								6950.	
1220 FLT CONT		1190								4140.	
1230 FLT EVALUATION		320								600.	
1240 FLT SPT SOFTWARE		16720								10460.	

NOTE
THESE COSTS INCLUDED
IN VEHICLE TEST.

III-3.6-17

MOORE BUSINESS FORMS, INC. NO. FORM 1412T PRINTED IN U.S.A. 22"

310-3A SEP 73

WBS	EXPECTED COST DDT+E			EXPECTED COST PRODUCTION			INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS		
LEVEL	4	5	6	4	5	6			4	5	6
1300 REF+INT 1ST TR									1600.		
1310 SCHED MAINT+REF										0.	
1320 UNSCHED MAINT+REF										0.	
1330 POST MAINT C/O										0.	
1340 TUG/PAYLOAD MATG										0.	
1350 REF RQMTS PLANNG										0.	
1360 DEPOT MAINT										1600.	
1400 REF+INT 2ND TR									11360.		
1410 SCHED MAINT+REF										1500.	
1420 UNSCHED MAINT+REF										1540.	
1430 POST MAINT C/O										500.	
1440 TUG/PAYLOAD MATG										800.	
1450 REF RQMTS PLANNG										120.	
1460 DEPOT MAINT										6900.	
SPACE TUG TOTALS		254771.			41480.			4817.	14170.	75230.	
32A=		254771.		323=	46297.		32C=	75230.	320=	376299.	

III-16-8

MCDONNELL BUSINESS FORMS INC. HO FORM 14127 PRINTED IN U.S.A.

DEFINITION OF SPREAD

FUNCTION CODES

CODE	DEFINITION
4	Beta Distribution - A = 0.79, B = 0.15 Peak Funding occurs at 28.0% of Time, 73.0% of Dollars consumed at 50% of Time.
6	Beta Distribution - A = 0.68, B = 0.17 Peak Funding occurs at 30.0% of Time, 67.0% of Dollars consumed at 50% of Time.
9	Beta Distribution - A = 0.55, B = 0.05 Peak Funding occurs at 34.0% of Time, 55.0% of Dollars consumed at 50% of Time.
11	Beta Distribution - A = 0.58, B = 0.38 Peak Funding occurs at 34.0% of Time, 67.0% of Dollars consumed at 50% of Time.
16	Beta Distribution - A = 0.47, B = 0.21 Peak Funding occurs at 40.0% of Time, 55.0% of Dollars consumed at 50% of Time.
26	Beta Distribution - A = 0.16, B = 0.45 Peak Funding occurs at 58.0% of Time, 43.0% of Dollars consumed at 50% of Time.

STORABLE SPACE TUG SYSTEM PROJECT SUPPORTING
COST DATA FORM A1, A2, & A3 INFORMATION

CONCEPT #310-3A/Phase I

WBS	DDT&E FORM A1 Design Rating	Config Rating	Td	Ts	SPD Funct	PRODUCTION FORM A2 No Units	Ref Unit	Config Rating	Td	Ts	SPD Funct	LRN IND	OPERATIONS FORM A3 SPD Funct
0100 PROJECT MGM'T		3			32			3			32		32
0110 Cost/Perf. Mgm't		3			32			3			32		32
0120 Project Direction		3			32			3			32		32
0130 Information Mgm't		3			32			3			32		32
0200 SYS. ENG & INTEG		3			32			3			32		32
0210 Tug Sys Engr		3			32			3					32
0220 Shuttle Interface		3			32			3					32
0230 Payload Interface		3			32			3					32
0240 Sustaining Engr.													32
0310 STRUCTURES	1	4	34	50	4	3	1	4	21	36	4	90%	32
0311 Fuel Tnk & Supt	1	4	34	50	4	3	1	4	21	36	4	90%	32
0312 OX Tnk & Supt	1	4	34	50	4	3	1	4	21	36	4	90%	32
0313 Body Structure	1	4	34	50	4	3	1	4	21	36	4	90%	32
0314 Thrust Structure	1	4	34	50	4	3	1	4	21	36	4	90%	32
0315 Meteroid Shield	1	4	34	50	4	3	1	4	21	36	4	90%	32
0316 Payload Interface	1	4	34	50	4	3	1	4	21	36	4	90%	32
0317 Installation, Assmbly, D/O													
0320 THERMAL INSULATION	3	3	31	50	16	3	1	3	18	30	4	90%	32
0321 Fuel Tank Insulation	3	3	31	50	16	3	1	3	18	30	4	90%	32
0322 Ox Tank Insulation	3	3	31	50	16	3	1	3	18	30	4	90%	
0323 Purge Syst. Insulation													
0324 Control System													
0325 Instl. Assy & C/Out													
0330 AVIONICS			37	50	4	3	1		20	32	4		32
0331 Data Management	4	4	30	50	4	3	1	4	20	32	4		32
0332 GN&C	2	3	32	50	4	3	1	3	20	32	4		32
0333 Communications	1	2	34	50	4	3	1	2	20	32	4		32
0334 Instrumentation													
0335 Electr Power	3	3	34	50	4	3	1	3	20	32	4		32
0336 Power Dist & Contr	5	4	34	50	4	3	1	4	20	32	4		
0337 Instl. Assmbly & C/O													
0340 PROPULSION			33	50	4	3	1		20	35	4	90%	32
0341 Main Engine (CFE)	1		33	50	4	3	1		20	35	4	90%	32
0342 Main Eng. Supt	5		33	50	4	3	1		20	35	4	90%	
0343 ACES Engine	4		33	50	4	3	1		20	35	4	90%	32
0344 ACES Eng. Supt	5		33	50	4	3	1		20	35	4	90%	
0345 Instl Assmbly & C/O													

WBS	DDT&E FORM A1 Design Rating	Config Rating	Td	Ts	SPD Funct	PRODUCTION FORM A2 No Units	Ref Unit	Config Rating	Td	Ts	SPD Funct	LRN IND	OPERATIONS FORM A3 SPD Funct
0350 ORBITER INTERFACE	1	4	32	50	9	3	1	4	14	28	4	90%	32
0351 Structures		4	32	50	9	3	1	4	14	28	4	90%	32
0352 Interface Panels		4	32	50	9	3	1	4	14	28	4	90%	32
0353 Purge Provisions													
0354 Abort Provisions													
0355 Instal, Assy & C/O													
0360 DROP TANK		N/A					N/A						
0361 Structures													
0362 Thermal Insulation													
0363 Prop Suppt System													
0364 Instl, Assy & C/O													
0370 FINAL ASSY & C/O		3	23	24	26	3	1	3	11	15	4		
0371 Final Assy		3	23	24	26	3	1	3	11	15	4		
0372 Checkout													

AUXILIARY STAGE

STORABLE SPACE TUG SYSTEM PROJECT SUPPORTING
COST DATA FORM A1, A2, & A3 INFORMATION

WBS	DDT&E FORM A1					PRODUCTION FORM A2						OPERATIONS FORM A3
	Design Rating	Config Rating	Td	Ts	SPD Funct	No Units	Ref Unit	Config Rating	Td	Ts	SPD Funct	LRN IND	SPD Funct
0410 STRUCTURES			N/A					N/A					
0411 Fuel Tnk & Suppt													
0412 Ox Tnk & Suppt													
0413 Body Structure													
0414 Thrust Structure													
0415 Meteroid Shield													
0416 Payload Interface													
0417 Installation Ass'y C/O													
0420 THERMAL INSULATION													
0421 Fuel Tank Insulation													
0422 Ox Tnk Insulation													
0423 Purge Syst Insulation													
0424 Control System													
0425 Instl Ass'y & C/O													
0430 AVIONICS													
0431 Data Management													
0432 GN&C													
0433 Communications													
0434 Instrumentation													
0435 Electric Power													
0436 Power Dist & Contr													
0437 Instl Ass'y & C/O													
0440 PROPULSION													
0441 Main Eng (CFE)													
0442 Main Eng Suppt													
0443 ACPS Engine													
0444 ACPS Eng Suppt													
0445 Instl Ass'y & C/O													
0450 ORBITER INTERFACE													
0451 Structures													
0452 Separation System													
0453 Instl Ass'y & C/O													

STORABLE SPACE TUG SYSTEM PROJECT SUPPORTING
COST DATA FORM A1, A2, & A3 INFORMATION

WBS	DDT&E FORM A1					PRODUCTION FORM A2						OPERATIONS FORM A3
	Design Rating	Config Rating	Td	Ts	SPD Funct	No Units	Ref Unit	Config Rating	Td	Ts	SPD Funct	LRN IND	SPD Funct
	N/A					N/A							
0460 DROP TANK													
0461 Structure													
0462 Thermal Insulation													
0463 Propulsion Suppt System													
0464 Instl, Ass'y & C/O													
0470 RETRIEVAL DELAY MODULE													
0471 Structure													
0472 Therm Control													
0473 Avionics													
0474 Propulsion													
0475 RDM Ass'y & C/O													
0480 APOGEE KICK STAGE													
0481 Structure													
0482 SRM													
0483 Avionics													
0484 Propulsion													
0485 AKS Ass'y & C/O													
0490 DE-ORBIT KICK STAGE													
0491 Structure													
0492 Therm Control													
0493 Avionics													
0494 Propulsion													
0495 De-Orbit Ass'y & C/O													
04100 CACHE TANK													
04101 Structure													
04102 Therm Control													
04103 Avionics													
04104 Propulsion													
04105 Cache Ass'y & C/O													
04110 FINAL ASS'Y & C/O													
04111 Final Ass'y													
04112 Checkout													

STORABLE SPACE TUG SYSTEM PROJECT SUPPORTING
COST DATA FORM A1, A2, & A3 INFORMATION

WBS	DDT&E FORM A1 Design Rating	Config Rating	Td	Ts	SPD Funct	PRODUCTION FORM A2 No Units	Ref Unit	Config Rating	Td	Ts	SPD Funct	LRN IND	OPERATIONS FORM A3 SPD Funct
0510 TRANSP. & HANDLING								3			4		
0520 TRAINING	3				4			3			4		
0521 Simulat & Equip	3				4			3			4		
0522 Ground Crew	3				4								
0523 Flt. Oper. Crew	3				4								
0530 WAREHOUSE/INV. COST								3			4		
0610 MANUFACTURING FACILITIES	3	12	47		6			3			32		
0611 Des/Constr.	3	12	47		6								
0612 Act/Maint								3			32		
0620 TEST FACILITIES	3	19	47		32			3			4		
0621 Des/Constr.	3	19	47		32								
0622 Act/Maint.								3			4		
0630 1st TR MAINT. & REF.	3	42	47		32								32
0631 Des/Constr	3	42	47		32								
0632 Activ/Maint													32
0640 ETR LAUNCH FACILITIES	3	42	47		4								32
0641 Design/Constr.	3	42	47		4								
0642 Activ/Maint.													32
0650 2nd TR MAINT/REF	3	12	15		32								32
0651 Des/Constr	3	12	15		32								
0652 Activ/Maint.													32
0660 WTR LAUNCH	3	12	15		4								32
0661 Des/Constr	3	12	15		4								
0662 Activ/Maint													32
0710 MFG. GSE													
0711 Hardware													
0712 Site Activ													
0713 Maint													
0714 Software													
0720 EAST TEST RANGE	3	35	47		4								
0721 Hardware	3	35	47		4								
0722 Site Activation	3	35	47		4								
0723 Maint	3	35	47		4								
0724 Software													

STORABLE SPACE TUG SYSTEM PROJECT SUPPORTING
COST DATA FORM A1, A2, & A3 INFORMATION

WBS	DDT&E FORM A1 Design Rating	Config Rating	Td	Ts	SPD Funct	PRODUCTION FORM A2 No Units	Ref Unit	Config Rating	Td	Ts	SPD Funct	LRN IND	OPERATIONS FORM A3 SPD Funct
0730 WEST TEST RANGE GSE		3	32	42	4								
0731 Hardware		3	32	42	4								
0732 Site Activation		3	32	42	4								
0733 Maint.													
0734 Software													
0740 FLIGHT OPER. NASA		3	43	47	4								
0741 Hardware		3	43	47	4								
0742 Site Activ													
0743 Maint													
0744 Software													
0750 FLIGHT OPER. D.O.D.		3	46	47	4								
0751 Hardware		3	46	47	4								
0752 Site Activ													
0753 Maint													
0754 Software													
0810 GROUND TEST H'WARE		3	31	35	32								
0811 PFV/Battleship		3	31	35	32								
0812 Major Test Art		3	31	35	32								
0813 Mockups		3	31	35	32								
0820 GROUND TEST OPS		3			32								
0830 Flt Test Hardware		3			32								
0840 Flt. Test Operi.		3			32								
0900 LAUNCH OPS WTR													
0910 Launch Site SVC													
0920 Tug/Shuttle Matg													
0930 PreLaunch C/O													
0940 Countdown													
0950 Fluid & Gases													32
0960 Post Flt. Safing													
1000 LAUNCH OPS ETR													32
1010 Launch Site SVC													
1020 Tug/Shuttle Matg													32
1030 Prelaunch C/O													32
1040 Countdown													32
1050 Fluid & Gases													32
1060 Post Flt. Safing													32

51-9.8-III

STORABLE SPACE TUG SYSTEM PROJECT SUPPORTING
COST DATA FORM A1, A2, & A3 INFORMATION

WBS	DDT&E FORM A1					PRODUCTION FORM A2						OPERATIONS FORM A3
	Design Rating	Config Rating	Td	Ts	SPD Funct	Design Rating	Config Rating	Td	Ts	SPD Funct	LRN IND	SPD Funct
1100 FLT OPS DOD												32
1110 Mission Plan												32
1120 Flt/Contr												32
1130 Flt Evaluation												32
1140 Flt SPT Software												32
1200 FLT OPS NASA												32
1210 Mission Plan												32
1220 Flt Contr												32
1230 Flt Evaluation												32
1240 Flt SPT Software												
1300 REF INT 1st TR												
1310 Sched Maint & Ref												
1320 Unsched Maint & Ref												
1330 Post Main C/O												
1340 Tug/Payload Matg												
1350 Ref Requirements Planning												
1360 Depot Maint												
1400 REF INT 2nd TR												32
1410 Sched Maint & Ref												32
1420 Unsched Maint & Ref												32
1430 Post Maint C/O												32
1440 Tug/Payload Matg												32
1450 Ref Requirements Planning												32
1460 Depot Maint												

1st Phase

310-3A SEP 73

STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

DDTE (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	8.0	1.05	1.89	2.02	1.97	1.11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	9.6	1.25	2.27	2.42	2.37	1.33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	TUG MAIN STAGE	139.4	55.12	58.68	21.21	4.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	STRUCTURE	17.1	~~7.09~~ 3	~~7.65~~ 6	~~1.71~~ 5	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320	THERMAL INSUL	0.1	0.05	0.07	0.04	0.0 7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
330	AVIONICS	39.9	~~12.23~~ 6	~~16.82~~ 12	~~8.85~~ 14	~~1.99~~	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION	71.0	~~32.69~~ 14	~~31.26~~ 25	7.08 16	0.0 12	0.0 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
350	INTERFACE	7.0	2.27	2.96	1.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
360	DROP TANK																	
370	FINAL ASSY	4.2	0.0	0.0	1.78	2.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	TUG AUX STAGE	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
410	STRUCTURE																	
420	THERMAL INSUL	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
430	AVIONICS		-4	-1	+3	+3												
440	PROPULSION		-6	-5	+5	+5												
450	INTERSTAGE		-18	-6	+5	+12	+4											
460	DROP TANK			-8	+4	+4												
470	RDM		28	20	17	24	4											
480	AKS																	
490	DKS																	
4100	CACHE																	
4110	FINAL ASSY	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS	6.3	1.37	2.28	1.69	0.80	0.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600	FACILITIES	7.1	0.48	0.85	1.20	1.55	1.48	0.98	0.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
610	MANUFACTURING	0.1	0.03	0.05	0.04	0.02	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
620	TEST	0.2	0.07	0.10	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
630	1ST MAIN/REF	3.0	0.38	0.70	0.74	0.72	0.41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
640	ETR LAUNCH	0.5	0.0	0.0	0.35	0.13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650	2ND MAIN/REF	2.8	0.0	0.0	0.0	0.51	0.84	0.86	0.54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
660	WTR LAUNCH	0.5	0.0	0.0	0.0	0.16	0.22	0.12	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	GND SUPP EQUIP	25.8	3.23	5.42	6.55	8.23	2.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
710	MFG GSE	2.1	0.0	0.0	1.53	0.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
720	ETR GSE	17.1	2.22	4.03	4.29	4.19	2.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
730	WTR GSE																	
740	FLT OPS NASA	3.3	0.0	0.0	0.0	3.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
750	FLT OPS DOD	3.3	1.01	1.39	0.73	0.16	0.0 11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800	VEHICLE TEST	58.5	2.91	~~13.28~~ 5	~~18.40~~ 22	16.51	~~7.40~~	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
810	GND TEST HWRE	8.5	1.58	2.61	2.68	1.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
820	GND TEST OPS	10.2	1.33	2.40	2.56	2.50	1.41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
830	FLT TEST HWRE	9.1	0.0	2.59	3.81	2.73	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
840	FLT TEST OPS	30.6	0.0	5.67	9.35	9.60	6.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900	LAUNCH OPS WTR		-6	4	+7 4	+5												
1000	LAUNCH OPS ETR		-9	8	+3	+3	+4											
1100	FLIGHT OPS DOD		-18	6	+5	6												
1200	FLIGHT OPS NASA		-28	2	15	14												
1300	REF + INT TR-1																	
1400	REF + INT TR-2																	
	TOTALS	254.8	~~65.42~~ 37	~~84.67~~ 65	~~53.49~~ 71	~~35.79~~ 60	13.86 19	0.98 1	0.57 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

86
16
70

254

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MOORE BUSINESS FORMS, INC. OHIO FORM 14137 PRINTED IN U.S.A.

310-3A SEP 73

STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

PROD (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	2.1	0.0	0.0	0.21	0.40	0.44	0.45	0.42	0.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	2.4	0.0	0.0	0.23	0.45	0.50	0.51	0.48	0.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	TUG MAIN STAGE	38.0	0.0	0.0	5.22	10.59	10.31	7.06	3.57	1.11	0.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	STRUCTURE	6.1	0.0	0.0	0.98	1.82	1.63	1.05	0.48	0.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320	THERMAL INSUL	0.6	0.0	0.0	0.10	0.18	0.16	0.10	0.05	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
330	AVIONICS	16.2	0.0	0.0	2.59	4.84	4.33	2.78	1.29	0.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION	8.4	0.0	0.0	1.34	2.51	2.24	1.44	0.67	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
350	INTERFACE	1.7	0.0	0.0	0.21	0.43	0.44	0.33	0.20	0.09	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
360	DROP TANK																	
370	FINAL ASSY	5.1	0.0	0.0	0.0	0.81	1.52	1.36	0.87	0.40	0.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	TUG AUX STAGE	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
410	STRUCTURE																	
420	THERMAL INSUL	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
430	AVIONICS																	
440	PROPULSION																	
450	INTERSTAGE																	
460	DROP TANK																	
470	RDM																	
480	AKS																	
490	DKS																	
4100	CACHE																	
4110	FINAL ASSY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS	3.7	0.0	0.0	0.36	0.77	0.84	0.71	0.51	0.31	0.14	0.04	0.0	0.0	0.0	0.0	0.0	0.0
600	FACILITIES	0.1	0.01	0.02	0.02	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
610	MANUFACTURING	0.0	0.01	0.02	0.02	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
620	TEST	0.0	0.01	0.01	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
630	1ST MAIN/REF																	
640	ETR LAUNCH																	
650	2ND MAIN/REF																	
660	WTR LAUNCH																	
700	GND SUPP EQUIP																	
710	MFG GSE																	
720	ETR GSE																	
730	WTR GSE																	
740	FLT OPS NASA																	
750	FLT OPS DOD																	
800	VEHICLE TEST																	
810	GND TEST HWRE																	
820	GND TEST OPS																	
830	FLT TEST HWRE																	
840	FLT TEST OPS																	
900	LAUNCH OPS WTR																	
1000	LAUNCH OPS ETR																	
1100	FLIGHT OPS DOD																	
1200	FLIGHT OPS NASA																	
1300	REF + INT TR-1																	
1400	REF + INT TR-2																	
	TOTALS	46.3	0.01	0.02	6.04	12.22	12.09	8.74	4.97	1.89	0.27	0.04	0.0	0.0	0.0	0.0	0.0	0.0
					6	12	12	9	5	2	0	0						46
					6		1											

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MOORE BUSINESS FORMS, INC. HO FORM 14127 PRINTED IN U.S.A.

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STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

DPS (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	2.7	0.0	0.0	0.0	0.0	0.08	0.19	0.24	0.27	0.28	0.28	0.29	0.29	0.28	0.26	0.20	0.08
200	SYS ENG + INTEG	5.5	0.0	0.0	0.0	0.0	0.15	0.37	0.49	0.54	0.56	0.57	0.57	0.58	0.56	0.51	0.39	0.16
300	TUG MAIN STAGE	9.6	0.0	0.0	0.0	0.0	0.27	0.65	0.85	0.94	0.98	0.99	1.00	1.01	0.98	0.90	0.69	0.29
310	STRUCTURE	0.6	0.0	0.0	0.0	0.0	0.02	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.05	0.04	0.02
320	THERMAL INSUL	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
330	AVIONICS	6.7	0.0	0.0	0.0	0.0	0.19	0.46	0.60	0.66	0.69	0.70	0.70	0.71	0.69	0.63	0.48	0.20
340	PROPULSION	2.1	0.0	0.0	0.0	0.0	0.06	0.14	0.19	0.21	0.22	0.22	0.22	0.22	0.22	0.20	0.15	0.06
350	INTERFACE	0.2	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.00
360	DROP TANK																	
370	FINAL ASSY																	
400	TUG AUX STAGE	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
410	STRUCTURE																	
420	THERMAL INSUL	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
430	AVIONICS																	
440	PROPULSION																	
450	INTERSTAGE																	
460	DROP TANK																	
470	RDM																	
480	AKS																	
490	DKS																	
4100	CACHE																	
4110	FINAL ASSY																	
500	LOGISTICS																	
600	FACILITIES	0.2	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
610	MANUFACTURING																	
620	TEST																	
630	1ST MAIN/REF	0.1	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
640	ETR LAUNCH	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
650	2ND MAIN/REF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
660	WTR LAUNCH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
700	GND SUPP EQUIP	2.2	0.0	0.0	1.63	0.61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
710	MFG GSE																	
720	ETR GSE	0.6	0.0	0.0	0.44	0.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
730	WTR GSE	1.6	0.0	0.0	1.19	0.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
740	FLT OPS NASA																	
750	FLT OPS DOD																	
800	VEHICLE TEST																	
810	GND TEST HWRE																	
820	GND TEST OPS																	
830	FLT TEST HWRE																	
840	FLT TEST OPS																	
900	LAUNCH OPS WTR	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.02
1000	LAUNCH OPS ETR	5.8	0.0	0.0	0.0	0.0	0.16	0.39	0.52	0.57	0.59	0.60	0.61	0.61	0.60	0.54	0.42	0.17
1100	FLIGHT OPS DOD	13.7	0.0	0.0	0.0	0.0	0.0	0.0	0.54	1.24	1.56	1.67	1.71	1.73	1.73	1.63	1.31	0.57
1200	FLIGHT OPS NASA	22.1	0.0	0.0	0.0	0.0	0.63	1.51	1.97	2.19	2.27	2.31	2.33	2.34	2.28	2.08	1.60	0.67
1300	REF + INT TR-1	1.6	0.0	0.0	1.16	0.43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1400	REF + INT TR-2	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.45	1.03	1.29	1.39	1.42	1.43	1.43	1.35	1.09	0.48
	TOTALS	75.2	0.0	0.0	~~2.80~~ -0-	~~1.04~~ -0-	~~1.30~~ 3	~~3.11~~ 4	~~5.09~~ 6	~~6.84~~ 7	~~7.61~~ 8	~~7.89~~ 8	8.01 8	8.06 8	7.94 8	7.34 7	5.75 6	2.45 2

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MOORE BUSINESS FORMS, INC. CHO FORM 14121 PRINTED IN U.S.A. 2P

FIRST UNIT PRODUCTION COST
PER WBS (INCLUDING AVIONICS TO LEVEL 7)
MAIN STAGE AND AUXILIARY STAGE(S)
(COST IN THOUSANDS)

Concept 310-3A

WBS	IDENTIFICATION	FIRST UNIT COST LEVEL 1	LEVEL 2	LEVEL 6
0300	TUG VEH. MAIN STAGE	9,088		
0310	STRUCTURES		1,704	
0311	Fuel Tank & Sprt			578
0312	OX Tank & Sprt			679
0313	Body Structure			254
0314	Thrust Structure			33
0315	Metoroid Shield			12
0316	Payload Intface			147
0317	Inst'l Assy & C/O			0
0320	THERMAL INSULTN		176	
0321	Fuel Tank Insul			86
0322	OX Tank Insul			90
0333	Purge Sys Insul			0
0324	Cont Sys			0
0325	Inst'l Assy & C/O			0
0330	AVIONICS		3,277	
0331	Data Management			663
0332	GN&C			1,470
0333	Communications			413
0334	Instrumentation			0
0335	Elec Pwr			503
0336	Pwr Dist & Cont			228
0337	Inst'l Assy & C/O			0
0340	PROPULSION		1,922	
0341	Main Engine			800
0342	Main Engine Sprt			425
0343	ACPS Engine			375
0344	ACPS Engine Sprt			322
0345	Inst'l Assy & C/O			0
0350	ORBITER INTERFACE		623	
0351	Structure			266
0352	Interface PNLS			357
0353	Purge Provision			0
0354	Abort Provision			0
0355	Inst'l Assy & C/O			0
0360	DROP TANKS		0	
0361	Structures			
0362	Thermal Insul			
0363	Prol Sprt Sys			
0364	Inst'l Assy & C/O			
0370	FINAL ASSY & C/O		1,386	
0371	Final Assy			1,386
0372	Checkout			0
0400	TUG VEH. AUX. STAGE	0		
0470	RDM		0	
0471	Structure			
0472	Therm Cont			
0473	Avionics			
0474	Propulsion			
0475	RDM Assy & C/O			
0480	AKS		0	
0481	Structure			
0482	Therm Cont			
0483	Avionics			
0484	Propulsion			
0485	AKS Assy & C/O			
0490	DKS		0	
0491	Structure			
0492	Therm Cont			
0493	Avionics			
0494	Propulsion			
0495	DKS Assy & C/O			
0100	PROJECT MANAGEMENT	1,409		
0200	SYS ENG & INTEGR			
	TOTAL FIRST UNIT COST (Exclusive Logistics)			

LEVEL 7 FIRST UNIT COST (AVIONICS)

WBS	IDENTIFICATION	MAIN STAGE
0330	AVIONICS (MAIN STAGE)	3,277
0331	DATA MANAGEMENT	663
	Computer	174
	Tape Recorder	58
	FSI Cont'r/TIM Form.	55
	DACU	105
	Sensors	75
	In-House	196
0332	GN&C	1,470
	IMU	175
	Star Tracker	162
	Rate Gyro Unit	40
	Laser Revo. Radar	
	Satellite Receiver	
	Doppler Receiver	
	L-Band Antenna	
	Combined/Doppler Det.	
	APS Ct'l Electronics	295
	ME/TVC Ct'l Electron	295
	In-House	503
0333	COMMUNICATIONS	413
	S-Band X'CVR/X'PDR	220
	Aux. Xmtr	43
	Power AMP	10
	Baseband Processor	50
	Diplexer	
	Ant Switch	
	Antenna	4
	Power Splitter	
	TV Assembly	
	In-House	86
0334	INSTRUMENTATION	0
0335	ELEC POWER	503
	Battery	100
	Emergency Battery	2
	Modified Fuel Cell	
	Thermal Control	26
	H Tanks	214
	In-House	161
0336	PWR DIST. & CT'L	228
0337	INST'L ASSY & C/O	0

WBS	IDENTIFICATION	AUX. STAGE
0400	TUG VEH. AUX STAGE	
0470	RDM	
0473	AVIONICS	
	DMS	
	PCM/Sig Cond	
	Sensors	
	GN&C	
	Attitude Gyro Ref Unit	
	Timer/CT'l Relay	
	APS CT'l Electron	
	COMMUNICATIONS	
	S-Band Xcvr/Xpdr	
	Baseband Process	
	Aux. Xmtr	
	Pwr Amplifier	
	Diplexer	
	Antenna Switch	
	Antenna	
	ELEC. POWER	
	Primary Battery	
	Pwr Dist & CT'l	
0480	AKS	
0483	AVIONICS	
	DMS	
	Sensors	
	GN&C	
	Attitude Gyro Ref Unit	
	Timer/CT'l Relay	
	Velocity Meter	
	Sequence Program	
	ELEC POWER	
	Primary Battery	
	Pwr Dist & CT'l	
0490	DKS	
	AVIONICS	
	DMS	
	Sensors	
	PCM	
	GN&C	
	Attitude Gyro Ref Unit	
	Timer/CT'l Relay	
	APS/TVC CT'l Electr	
	Velocity Meter	
	Sequence Program	
	Star Tracker	
	COMMUNICATIONS	
	S-Band Xcvr/Xpdr	
	Baseband Process	
	Aux. Xmtr	
	Pwr Amplifier	
	Diplexer	
	Antenna Switch	
	Antenna	
	ELEC. POWER	
	Primary Battery	
	Pwr Dist & CT'l	
	DeOrbit Battery	
	Solar Cell Pad's	

SPACE TUG CHARACTERISTICS

310-3A→310RE-3A

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	WEIGHT, LB	3190→3394	544
	LENGTH, IN	297	27
	DIAMETER, IN	120	120
TECHNICAL:	REUSABLE	ONE-STAGE	RDM
	AUXILIARY STAGE		RDM
	PAYLOAD RETRIEVAL	CAPABILITY	
	PROPELLANT CAPACITY, LB	59,500	
	THRUST, LB	12,000	
	ISP, SEC	338	
	AUTONOMY LEVEL	IIIA→IIB	
	RELIABILITY	.97 →.9750	.9824

WBS #320-00

GRUMMAN

IE-SL-21

MAIN STAGE CHARACTERISTICS

310-3A→310RE-3A/

PHYSICAL:	WEIGHT, LB	3190→3394
	LENGTH, IN	297
	DIAMETER, IN	120
TECHNICAL:	REUSABLE SINGLE STAGE	
	PROPELLANT CAPABITY, LB	59,500
	PAYLOAD RETRIEVAL CAPABILITY	
	THRUST, LB	12,000
	ISP, SEC	338
	AUTONOMY LEVEL	IIIA→IIB
	RELIABILITY	.97→.9750

WBS #320-03

GRUMMAN

III-8.6-22

VEHICLE TEST CHARACTERISTICS

310-3A→310RE-3A

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	PROP. TEST ARTICLE	X	
	STRUCT. TEST ARTICEL	X	X
	INTEG. AVIONICS TEST	X	X
	MOCK-UPS	X	X
	FLIGHT TEST	X	X

TECHNICAL:
- PTA - COLD FLOW ONLY, NO HOT FIRING
- STA - ONE ART FOR DYNAMICS, STATIC & FATIGUE
- IAT - SOFTWARE & HARDWARE
- MOCK-UPS - WOOD AT PDR, WOOD/METAL AT CDR
- FLIGHT TEST - ONE WITHOUT P/L, SEVEN WITH P/L

WBS #320-08

GRUMMAN

STRUCTURAL CHARACTERISTICS

310-3A → 310RE-3A

PHYSICAL:	WEIGHT, LB	1226 → 1279
	LENGTH, IN	297
	DIAMETER, IN	120
TECHNICAL:	TANK CONFIGURATION	NESTED DOME
	TANK CAPACITY, LB	59,500
	MATERIAL	Ti, COMPOSITE H'COMB
	RELIABILITY ALLOCATION	.99900

WBS #320-03-01

GRUMMAN

CONFIGURATION 310-3A

WBS NO. 320-03-01

SUBSYSTEM/COMPONENT STRUCTURE

DATE: 9/17/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS	RELIABILITY: MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TEST	NOTES
01-Fuel Tanks and Supports	1	44½		Titan.	255	90	120	DIA		Welded Gore Titanium Domes	20	1		2	Tank Leakage Considered Unserviceable
02-Oxid. Tank and Supports	1	44½		Titan.	167	100	120	DIA		Weld Gore Titanium Domes	20	1		2	
03-Body Structure	1	44½		Alum. and Comp.	620	145	120	DIA		Graphite Composite Honeycomb Shell Aluminum Frames	N/A	1		2	Includes Equipment Mounting and Umbilicals
04-Thrust Struct.	1	44½		Alum.	85	35	120 MAX.	DIA		Aluminum Stiffened Sheet	N/A	1		2	
05-Meteoroid Shield	1	44½		Alum.	26	87	126	DIA		Aluminum Sheet	N/A	1	1		
06-Interface	1	46		Alum.	73					Aluminum Machinings and Forgings	N/A	1		2	

BRUMMAN

THERMAL CONTROL CHARACTERISTICS

310-3A 310RE-3A

PHYSICAL: WEIGHT, LB 89

500 FT^2 GOLDIZED MYLAR MLI

AL BASE HEAT SHIELD

SILVER BACKED TEFLON & ALZAK COATINGS

WBS #320-03-02

GRUMMAN

III-3.6-26

CONFIGURATION 310-3A

WBS NO. 320-03-02-01,02

SUBSYSTEM/COMPONENT THERMAL CONTROL

DATE: 8/30/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
THERMAL CONTROL COATINGS	5	0		SBT ALZAK ALCOHOL	9		1500	ft²		0				1			
MULTILAYER INSULATION	3	6		See Mini Spec	16		500	ft²		0				1			
FUEL CELL RADIATOR	2	12		See Mini Spec	17.5		22	ft²						1			INCLUDES CARBURE IMO
~~AVIONICS HEAT PIPE RADIATOR~~	2	12		See Mini Spec						0							
AVIONICS HEATERS	4	6		See Mini Spec	2					25/unit				8			COX & COMPANY, NY, NY.
APS HEATERS*	4	6		See Mini Spec	4					30/unit				16			
BIRD HEAT SHIELD	5	0		AL	14		90	ft²		0							IDENTICAL TO MICROMETEROID SHIELD
PLUMBING	5	0		AL	2												

*CARRIED A. APS WT.

III-8.6-27

GRUMMAN

REPORT
DATE
CODE 20013

AVIONICS CHARACTERISTICS

		310-3A → 310RE-3A
PHYSICAL:	WEIGHT, LB	663 → 758
TECHNICAL:	AUTONOMY LEVEL	IIIA → IIB
	RENDEZVOUS & DOCKING	→ LASER RADAR
	COMMUNICATIONS	DFS → DFS/CSS
	COMPUTER CAPACITY	48K → 65K WORDS
	FUEL CELL POWER	2.5 KW
	RELIABILITY ALLOCATION	.97912 → .98454

WBS #320-03-03

GRUMMAN

REV A

AUTONOMY LEVEL IIIA — CORE CONFIGURATION 310-3A, [redacted] — WBS NO. 320-03-03-01 — SUBSYSTEM/COMPONENT DMS — DATE: 8/7/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES: VENDOR
MAIN STAGE																	
COMPUTER	4	12			13	4.7	5	8.6*	202*	36	48K WORDS - 16 BITS/WORD (PWR REG, SIZED FOR 65K)*	144	18K	2	N/A	1	CDC 469
TAPE RECORDER	5	12	AF/S-3 NIMBUS E		14.5	9	12	5.4	580	8		108	12K	1	N/A	1	ODETICS DDS3000
FSI CONTROLLER/ TLM FORM.	4	8	SHUTTLE		18	8	6	16	540	23		144	12K	1	N/A	1	RADIATION
DACU'S	4	8	"		7	7	4	13	364	21	256 CHANNELS	144	12K	3	N/A	1	"
SENSORS	4	8	"		0.2	N/A	N/A	N/A	N/A	0.1			1M	180 (A)	N/A	10	WHITTAKER TRANSONICS

* EVOLUTION FROM AUTONOMY LEVEL IIIA TO LEVEL IIB WILL REQUIRE INCREASING THE COMPUTER CAPACITY TO 65K WORDS THUS A VOLUME OF 4.7 x 5 x 10.4 (244 CU. IN) SHOULD BE RESERVED FOR THE COMPUTER TO ALLOW FOR THIS GROWTH

BRUMMAN

REPORT
DATE
CODE 28512

CONFIGURATION 310-3A AUTONOMY LEVEL III A WBS NO. 320-03-03-02 SUBSYSTEM/COMPONENT GN&C

REV. B 8-31-73
REV. A 8-16-73
DATE: 8-10-73

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
INERTIAL MEASURING UNIT	4	12	TITAN III C		45	24	12	12.5	3600	125				1			
STAR TRACKER	1	24	SHUTTLE		17	15	6 DIA.		424	28				1			DOES NOT INCLUDE SUNSHADE (1LB)
APS CONTROL ELECTRONICS	1	24	–		18	10	10	5	500	13				2			
ME/TVC CONTROL ELECTRONICS	1	24	–		10	10	10	3.5	350	15				1			
RATE GYRO UNIT	4	12			5	4	4	2	32	25				1			

GRUMMAN

REPORT
DATE
CODE 20512

CONFIGURATION 310-3A

WBS NO. 320-03-03-03

SUBSYSTEM/COMPONENT COMMUNICATIONS

DATE: ~~8/1/73~~ 9-5-73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE (EACH) LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE (EACH) WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE (EACH) HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (EACH) (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/G TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
2. S-Band R'CVR(4) R'CEIVER X'MTR(2) X'POWER		24			4x4 1x5	7 7	9 8	5 5	315 200	8 34	Spread Spectrum CCIR Interference STDN/SGLS Compatible			1			
3. AUX. X'MTR		20			5	7	8	5	280	34	Same as (2) above			1			
4. POWER AMP.		7			1	3	5	2	30	20	R.F. output of SW			2			
7. DIPLEXER		9			1	2	7	3	63	—	—			2			
9. ANTENNA SWITCH		9			1	3	3	4	36	1	—			1			
14. EASECAND PROCESSOR		24			3	3	3	2	18	2	Same as (2) above			1			
15. OMNI ANT.		9			.5	3	6	1	18	—	—			2			
15. SECURE COMM.		—			6	9	5	4	180	8	—			2			DOD ONLY - GFE

III-8.6-31

CONFIGURATION 310-3A -- [redacted] WBS NO. 320-03-03-05 & -06

LEVEL OF AUTONOMY IIIA ---- IIB SUBSYSTEM/COMPONENT ELECTRICAL POWER SUBSYSTEM DATE: 8-29-73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
• MODIFIED SHUTTLE FUEL CELL ASSY	3	30	SHUTTLE	ST STEEL PLAT	90	25	15	15	5630		2.5 KW @ 28V; ___ WATT. AVG LOAD OVER 117 HRS.	144	25,000	1	-	1	REQUIRES AUTO SPACE START-UP SELLERS: PEWA or GE
• EMERGENCY BATTERY	5	6		Ag-Zn Mg	15	9	5	4.5	200		10 AMP-HR RATED CAPACITY, 17 AMP DISCHARGE OVER 0.5 HR	0.5	30,000	1	-	1	SECONDARY SILVER-ZINC BATTERY SELLER: EAGLE-PICHER
• CRYO HYDROGEN TANK ASSY	3	24	GEMINI APOLLO SHUTTLE	T1-INNER T2-OUTER	69	21" 24"	ID OD		7250		250 PSIA - OPERATING PRESSURE 350 PSIA - MAX PRESSURE. 11.5 LB FLUID CAPACITY	144		1	-	1	SELLER: AIRESEARCH, BEECH, BENDIX
• CRYO OXYGEN TANK ASSY	3	24	GEMINI APOLLO SHUTTLE	INC-718 INN INC-750 OUT	71	16½ 19½	ID OD		3900		900 PSIA - OPERATING PRESS 1000 PSIA - MAX. " 32.5 LB FLUID CAPACITY	144		1	-	1	SELLER: AIRESEARCH, BEECH, BENDIX
• VEHICLE WIRING	5		LM		55						6 ga, 14 ga, 16 ga, 20 & 26 ga	144		SHIP SET		SHIP SET	~10,000 FT OF ASSORTED SIZES
• CONNECTORS	5		LM		30						ASSORTED SIZES	144		"		"	~120 MATED PAIRS
• SUNDRIES (- CLAMPS - TAPE)	5		LM		20						" "	144		"		"	
• SOLID STATE POWER CONTROL	5		-		21						90 @ 2 AMP 17 @ 5 AMP 60 @ 3 AMP	144		"		"	2 OZ EACH; SELLER: LEACH CORP
• ELECTRO-MECH RCCB	5		LM		9						2 @ 20 AMP 10 @ 10 AMP	144		"		"	0.75 LB EACH; SELLER CUTLER-HAMMER

DRUMMAN

REPORT DATE CODE 26912

PROPULSION CHARACTERISTICS (310-3A→310RE-3A)

		MAIN PROP.	AUXILIARY PROP.
PHYSICAL:	WEIGHT, LB	547	150→188
	ENGINE/THRUSTER	CLASS I	REA 19
	NO. OF ENGINES/THRUSTERS	1	16→24
TECHNICAL:	FUEL LOAD, LB	20,517	339→495
	OXIDIZER LOAD, LB	38,983	--
	THRUST, LB	12,000	25
	ISP - STEADY STATE, SEC	338	232
	- PULSING, SEC	--	170
	RELIABILITY ALLOCATION	.99249	.99915→.99882

WBS #320-03-04

GRUMMAN

III-6-35

CONFIGURATION 310-3A/310RE-3A

WBS NO. 320-03-04, 320-03-04-01, 320-03-04-02

SUBSYSTEM/~~COMPONENT~~ Main Prop.

REV. [illegible]73

DATE: 8/[illegible]/73

MAJOR COMPONENT	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH/DIA. (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/G TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
																LEGEND: OTS - Off the shelf design; ME - Modified existing design; N - New design
Ox Pre-Vlv.	4	16	OMS		6.5		3 1/4		60	32 Watts	165	20K	1	1	1	ME - Size increase from 1 1/2" D. (OMS Purge/Iso Vlv.)
Fu Pre-Vlv	4	16	OMS		5		2		32	32 Watts	168	100K	1	1	1	ME - Size increase from 1 1/2" D. (OMS Purge/Iso Vlv)
Ox F/D QD	4	16	OMS		1.5		2		36		164	50K	1/2	1/2	1/2	ME - Size increase from 1 1/2" D.
Fu F/D QD	4	16	OMS		1.5		2		36		164	50K	1/2	1/2	1/2	ME - Size increase from 1 1/2" D.
Ox F/D QD	4	16	OMS		1		1		12		144	40K	1/2	1/2	1/2	ME - Size increase from 3/4" D.
Fu F/D QD	4	16	OMS		1		1		12		144	40K	1/2	1/2	1/2	ME - Size increase from 3/4" D.
He F/D QD	5	10	OMS		3		5/8		9		156	50K	1/2	1/2	1/2	OTS
Ox F/D Vlv.	5	10	OMS		5		2		12	32 Watts	144	40K	1	1	1	OTS - OMS Dump Valve
Fu F/D Vlv.	5	10	OMS		5		2		12	32 Watts	144	40K	1	1	1	OTS - OMS Dump Valve
He F/D Vlv.	4	16	OMS		5		5/8		24	84 Watts	144	67K	1	1	1	ME - Size increase from 1/2" D. (OMS Eng. Purge Vlv.
He Iso Vlv.	5	10	LM		2		1/2		16	84 Watts	156	133K	2	1	2	OTS - APS/DPS Latching Sol. Vlv.
He Reg	5	16	OMS		5		1/2		80		156	10^6	1	1	1	ME - Reduced press. setting, single stage
Fu/Ox Reg	5	16	OMS		5		1/2		80		156	10^6	1	1	1	ME - Reduced press. setting, single stage
Ox Burst Dis.	5	16	OMS		1.5		5/8		28		168	10^6	1	1	1	ME - Reduced relief setting
Fu Burst Dis.	5	16	OMS		1.5		5/8		28		168	10^6	1	1	1	ME - Reduced relief setting
Ox Relief Vl.	5	16	OMS		1.5		5/8		20		168	10^6	1	1	1	ME - Reduced relief setting
Fu Relief Vlv	5	16	OMS		1.5		5/8		20		168	10^6	1	1	1	ME - Reduced relief setting
Ox Ck Vlv.	5	10	SPS		3.6		3/4		50		156	10^6	1	1	1	OTS
Fu Ck Vlv.	5	10	SPS		3.6		3/4		50		156	10^6	1	1	1	OTS
Ox Vent Vlv	4	16	OMS		5		5/8		24	84 Watts	168	67K	2	1	2	ME - Size increase from 1/2" D. (OMS Eng. Purge Vlv)
Fu Vent Vlv	4	16	OMS		5		5/8		24	84 Watts	168	67K	2	1	2	ME - Size increase from 1/2" D (OMS Eng. Purge Vlv.
Ox Level Sensor	5	16	Titan		2	3	1		2.5	2 Watts	144	TBD	1	1	1	ME - Modified mounting
Fu Level Sensor	5	16	Titan		2	3	1		2.5	2 Watts	144	TBD	1	1	1	ME - Modified mounting
Ox Flex Joints	5	10	OMS		0.6		2		36		168		3	1	3	OTS
Fu Flex Joints	5	10	OMS		0.6		2		36		168		5	1	5	OTS
Ox Eng. Purge Vlv	5	10	OMS		5		1/2		24	84 Watts	144	67K	1	1	1	OTS - OMS Eng. Purge Vlv.
Fu Eng. Purge Vlv	5	10	OMS		5		1/2		24	84 Watts	144	67K	1	1	1	OTS - OMS Eng. Purge Vlv.

CONFIGURATION 310-3A/310RE-3A

WBS NO 320-03-04, 320-03-04-01, 320-03-04-02

SUBSYSTEM/COMPONENT Main Prop.

REV. 9/5/73

DATE: 8/21/73

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH/DIA. (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
He Tank	1	22	—		41.5		23.0		57%		156	10^6	2	1	2	N- PFR design
Main Eng.	1	54	—		265	116	56		28K	170 Watts, 12,000 lb	6	145K	1	17	—	N- Class I
Green Act	4	15	LM		2.5	5.75	3	1.5	.78	90 Watts	10	20K	2	1	—	ME- Increased strength for higher thrust
Ox Horiz Drain Vlv	4	16	OMS		4		1			32 Watts	144	100K	1	1	1	ME- Size decrease from 1¼" D (OMS crossfeed valve)
Fu Horiz Drain Vlv	4	16	OMS		4		1			32 Watts	144	100K	1	1	1	ME- Size decrease from 1¼" D (OMS crossfeed valve)

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REPORT
DATE
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CONFIGURATION 310-3A/310FE-3A

WBS NO. 320-03-04, 320-03-04-01, 320-03-04-02

SUBSYSTEM/COMPONENT Main Prop.

DATE: 8/21/73

MAJOR COMPONENT	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH/DIA (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
ADAPTER EQUIPMENT																
Ox F/D QD	4	16	OMS		2.5		2		36		168	500K	1/2	1/2	1/2	ME - Size increase from 1½"D
Fu F/D QD	4	16	OMS		2.5		2		36		168	500K	1/2	1/2	1/2	ME - Size increase from 1½"D
Ox F/V QD	4	16	OMS		2		1		12		144	40K	1/2	1/2	1/2	ME - Size increase from 3/4"D
Fu F/V QD	4	16	OMS		2		1		12		144	40K	1/2	1/2	1/2	ME - Size increase from 3/4"D
He F/D QD	5	10	OMS		4		5/8		9		156	500K	1/2	1/2	1/2	OTS
Panel Act.	1	18	—		2				10	30 Watts	10	20K	4	1	4	N
Ox Flex Joint	5	10	OMS		0.6		2		36		144		2	1	2	OTS
Fu Flex Joint	5	10	OMS		0.6		2		36		144		2	1	2	OTS
SHUTTLE EQUIPMENT																
Ox F/D QD	4	16	OMS		1.5		2		36		168	500K	1/2	—	—	Same as Tug hardware.
Fu F/D QD	4	16	OMS		1.5		2		36		168	500K	1/2	—	—	
Ox F/V QD	4	16	OMS		1		1		12		144	40K	1/2	—	—	
Fu F/V QD	4	16	OMS		1		1		12		144	40K	1/2	—	—	
He F/D QD	5	10	OMS		3		5/8		9		156	500K	1/2	—	—	
Ox Flex Joint	5	10	OMS		0.6		2		36		144		1	—	—	
Fu Flex Joint	5	10	OMS		0.6		2		36		144		1	—	—	

"Ground half of Tug QD"

CONFIGURATION 310-3A [redacted] WBS NO. 320-03-04-03 · 320-03-04-04 REV A 6/1/75

SUBSYSTEM/COMPONENT Auxiliary Propulsion System (APS) DATE: 5/1/75

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR [illegible] TEST	PROGRAMATIC: [illegible]	NOTES
																	GENERAL NOTE: TANKAGE WAITS ON USABLE PROPELLANT OF 317 LB PLUS 10% CONTINGENCY
Helium Tank	5	≤12	–		16.1	15.3	15.3	15.3	1695	–	Burst Press = 5200 Operating = 2600	TBD	10^6	1			Airite P/N 6660-1
Helium Filter	5	≤12	LM		0.5					–				1			LSC 310-303-3 (Vacco Vcv)
Helium Latch 16 Solenoid Valve	4	≤12	LM		2.3					54			1.3×10^6	2			LSC 270-713 (AIC Mfg)
Regulator, Dual Stage	5	≤12	LM		2.5					–			1.3×10^6	1			LSC 310-305-3 (Fairchild Stratos)
Regulator, Single Stage	4	≤12	–		1.5					–			1.3×10^6	1			Mod to Dual Stage Reg.
Quad Check Valve	5	≤12	LM		0.7					–	Proof Pressure = 600		2000	1			Mod to LSC 310-306 ([illegible])
Burst Disc/Relief Valve	4	≤12	–		1.5					–	Relief Press ≈ 400		10^6/67K	1			Mod to LSC 310-307 (Calmec)
Vent Valve	3	18	–		2.0					70	Proof Pressure = 600		67000	3			Similar to LSC 310-403 (Parker) Unidirectional flow only; higher operating pressure.
Propellant Tanks	4	≤12	LM		10.5		12.50	× 34	3420	–	Burst Pressure = 650		10^6	3			Modified LM RCS fuel tank with elastomeric bladders. Tank wt. includes bladders
Acquisition Bladders	2	24	–	EPT 10 Elastom.	–					–				3			
Propellant Filter	5	≤12	–		0.5					–				1			
Thruster Isolation Valve	3	18	–		2.0					70	Proof Pressure = 600 psi		67000	8			Same valve as vent valve; same notes apply.
Thrusters	4	≤12	–		2.1	11.4	2.7			24	25 LB thrust @ 325 psi inlet, steady state I_{sp} = 232		1.5×10^6	16			RBA 19-3 (Hamilton Standard)
Thruster Heaters	5	≤12	–		0.2					3.5	Maintain catalyst beds at 150°F.			16			Submitted for pricing by Thermo
Quick Disconnects	5	≤12	–		0.5					–				3			He fill & drain; Prop fill & drain; Prop fill & vent.

One Shipset

None

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REPORT DATE CODE 205

ORBITER INTERFACE CHARACTERISTICS

310-3A → 310RE-3A

PHYSICAL:	WEIGHT, LB	1186
TECHNICAL:	MATERIAL	ALUMINUM
	PIVOT TYPE ADAPTER/DOCKING MECHANISM	
	SERVICE PANELS	GROUND POWER
		INSTRUMENTATION
		ON-PAD EMERGENCY DUMP
		HORIZONTAL PROP. DRAIN
		FUEL CELL REACTANT FILL

WBS #320-03-05

GRUMMAN

CONFIGURATION 310-3A

WBS NO. 320-03-05-01

SUBSYSTEM/COMPONENT ORBITER INTERFACE STRUCT. DATE: 9/17/7

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TEST	
01-Rear Adapter	1	44½		Alum.	652	132	120	D		Aluminum Stiffened Sheet and Machinings	N/A			1	Pivot Type Adapter
01-Fwd Frame	1	44½		Alum.	438					Aluminum Trusses and Machinings	N/A			1	
01-Docking Mechanism	1	46		Alum.	96					Aluminum Machinings and Forgings	N/A			1	

EVOLVED TUG

CONCEPT 310-3A/310RE-3A (COMBINED)

OPTION 3

310-3A/210 RE-3A SEP 73 COMBINED

STORABLE SPACE TUG SYSTEM PROJECT

EXPECTED COST - SPARES COST(INT + OPS) - FIRST UNIT COST

(COSTS IN 1973 CONSTANT DOLLARS (000))

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0100	PROJECT MGMT	12282.			15826.				1842.	5466.		
0110	COST/PERF MGMT		1842.			2374.			276.		1822.	
0120	PROJECT DIRECTION		9457.			12186.			1418.		1822.	
0130	INFO MGMT		983.			1266.			147.		1822.	
0200	SYS ENG + INTEGR	14738.			17804.				2072.	10936.		
0210	TUG SYS ENG		11791.						0.		2734.	
0220	SHUTTLE INTERFACE		1474.						0.		2734.	
0230	PAYLOAD INTERFACE		1474.						0.		2734.	
0240	SUST ENG					0.			2072.		2734.	
0300	TUG VEH MAIN STAGE	168265.			194827.			11197.	23199.	20669.		
0310	STRUCTURES		18858.			26904.		2690.	3547.		2690.	
0311	FUEL TNK+SPRT			5651.			8579.	858.	1156.			858.
0312	OX TANK +SPRT			6817.			10076.	1008.	1358.			1008.
0313	BODY STRUCT			2508.			3800.	380.	511.			380.
0314	THRUST STRUCT			480.			496.	50.	67.			50.
0315	METEOROID SHLD			143.			183.	18.	25.			18.
0316	PAYLOAD INTFCE			3260.			3769.	377.	431.			377.
0317	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0320	THERMAL INSULTN		149.			2611.		128.	352.		128.	
0321	FUEL TANK INSUL			57.			1280.	128.	172.			128.
0322	OX TANK INSUL			92.			1331.	0.	179.			0.
0323	PURGE SYS INSUL			0.			0.	0.	0.			0.
0324	CONT SYS			0.			0.	0.	0.			0.
0325	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0330	AVIONICS		60611.			89683.		6092.	7531.		13398.	
0331	DATA MGMT			6480.			15484.	1432.	1376.			3450.
0332	G N + C			26720.			44320.	2814.	3605.			6216.
0333	COMMUNICATIONS			9128.			16350.	776.	1230.			1592.
0334	INSTRUMENTATION			0.			0.	0.	0.			0.
0335	ELEC PWR			17091.			8520.	1070.	864.			2140.
0336	PWR DIST + CONT			1193.			5010.	0.	455.			0.
0337	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0340	PROPULSION		71049.			40705.		2066.	3983.		4232.	
0341	MAIN ENGINE			59000.			13513.	1874.	1600.			3760.
0342	MAIN ENGINE SPT			7563.			7190.	0.	730.			0.
0343	ACPS ENGINE			3000.			11660.	192.	940.			472.
0344	ACPS ENGINE SPT			1486.			8343.	0.	714.			0.
0345	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0350	ORBITER INTERFACE		6981.			2206.		220.	1246.		220.	
0351	STRUCTURE			4900.			941.	94.	532.			94.
0352	INTERFACE PNLS			2081.			1263.	126.	714.			126.
0353	PURGE PROVISION			0.			0.	0.	0.			0.
0354	ABORT PROVISION			0.			0.	0.	0.			0.
0355	INSTL.ASSY+C/O			0.			0.	0.	0.			0.

III-86-41

MCGRAW-BISHOP-SYPHERS INC. NO FORM 1412T PRINTED IN U.S.A. 27

310-3A/310 RE-3A SEP 73 COMBINED

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0360	DROP TANKS		0.			3000.		0.	3000.		0.	
0361	STRUCTURES			0.			3000.	0.	3000.			0.
0362	THERMAL INSUL			0.			0.	0.	0.			0.
0363	PROP SPRT SYS			0.			0.	0.	0.			0.
0364	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0370	FINAL ASSY + C/O		10616.			29719.		0.	3539.		0.	
0371	FINAL ASSY			10616.			29719.	0.	3539.			0.
0372	CHECKOUT			0.			0.	0.	0.			0.
0400	TUG VEH AUX STAGE	13556.			3626.			152.	1428.	152.		
0410	STRUCTURES		0.			1.		0.	0.		0.	
0411	FUEL TNK+SPRT			0.			0.	0.	0.			0.
0412	OX TANK+SPRT			0.			1.	0.	0.			0.
0413	BODY STRUCT			0.			0.	0.	0.			0.
0414	THRUST STRUCT			0.			0.	0.	0.			0.
0415	METEOROID SHLD			0.			0.	0.	0.			0.
0416	PAYLOAD INTERFC			0.			0.	0.	0.			0.
0417	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0420	THERMAL INSUL		0.			0.		0.	0.		0.	
0421	FUEL TANK INSUL			0.			0.	0.	0.			0.
0422	OX TANK INSUL			0.			0.	0.	0.			0.
0423	PURGE SYS INSUL			0.			0.	0.	0.			0.
0424	CONT SYS			0.			0.	0.	0.			0.
0425	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0430	AVIONICS		0.			0.		0.	0.		0.	
0431	DATA MGMT			0.			0.	0.	0.			0.
0432	G N + C			0.			0.	0.	0.			0.
0433	COMMUNICATIONS			0.			0.	0.	0.			0.
0434	INSTRUMENTATION			0.			0.	0.	0.			0.
0435	ELEC PWR			0.			0.	0.	0.			0.
0436	PWR DIST + CONT			0.			0.	0.	0.			0.
0437	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0440	PROPULSION		0.			0.		0.	0.		0.	
0441	MAIN ENGINE			0.			0.	0.	0.			0.
0442	MAIN ENGINE SPT			0.			0.	0.	0.			0.
0443	ACPS ENGINE			0.			0.	0.	0.			0.
0444	ACPS ENGINE SPT			0.			0.	0.	0.			0.
0445	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0450	INTERSTAGE INTRFC		0.			0.		0.	0.		0.	
0451	STRUCTURE			0.			0.	0.	0.			0.
0452	SEP SYS			0.			0.	0.	0.			0.
0453	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0460	DROP TANK		0.			0.		0.	0.		0.	
0461	STRUCTURE			0.			0.	0.	0.			0.
0462	THERMAL INSUL			0.			0.	0.	0.			0.
0463	PROP SPT SYS			0.			0.	0.	0.			0.
0464	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0470	ROM		13556.			3625.		152.	1428.		152.	

MOORE BUSINESS FORMS, INC., NO. FORM 1412T PRINTED IN U.S.A. 22

310-3A/310 RE-3A SEP 73 COMBINED

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0471	STRUCTURE			4500.			883.	33.	348.			33.
0472	THERM CONT			0.			0.	0.	0.			0.
0473	AVIONICS			5685.			1937.	107.	763.			107.
0474	PROPULSION			489.			251.	12.	99.			12.
0475	RDM ASSY+C/O			2882.			553.	0.	218.			0.
0480	AKS		0.			0.		0.	0.		0.	
0481	STRUCTURE			0.			0.	0.	0.			0.
0482	SRM			0.			0.	0.	0.			0.
0483	AVIONICS			0.			0.	0.	0.			0.
0484	PROPULSION			0.			0.	0.	0.			0.
0485	AKS ASSY+C/O			0.			0.	0.	0.			0.
0490	DKS		0.			0.		0.	0.		0.	
0491	STRUCTURE			0.			0.	0.	0.			0.
0492	SRM			0.			0.	0.	0.			0.
0493	AVIONICS			0.			0.	0.	0.			0.
0494	PROPULSION			0.			0.	0.	0.			0.
0495	DKS ASSY+C/O			0.			0.	0.	0.			0.
04100	CACHE TANK		0.			0.		0.	0.		0.	
04101	STRUCTURE			0.			0.	0.	0.			0.
04102	THERM CONT			0.			0.	0.	0.			0.
04103	AVIONICS			0.			0.	0.	0.			0.
04104	PROPULSION			0.			0.	0.	0.			0.
04105	CACHE ASSY+C/O			0.			0.	0.	0.			0.
04110	FINAL ASSY + C/O		0.			0.		0.	0.		0.	
04111	FINAL ASSY			0.			0.	0.	0.			0.
04112	CHECKOUT			0.			0.	0.	0.			0.
0500	LOGISTICS	6330.			6752.				6752.			
0510	TRANSPORT+HANDLG		0.			1152.			1152.			
0520	TRAINING		6330.			1950.			1950.			
0521	SIM+EQUIPMENT			1950.			1950.		1950.			
0522	GROUND CREW			2180.			0.		0.			
0523	FLT OPS CREW			2200.			0.		0.			
0530	WAREHSG+INV CONT		0.			3650.			3650.			

III-96-45

MOORE BUSINESS FORMS, INC., MO FORM 1417T PRINTED IN U.S.A.

310-3A/310 RE-3A SEP 73 COMBINED

WBS	EXPECTED COST DDT+E			EXPECTED COST PRODUCTION			INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS		
LEVEL	4	5	6	4	5	6			4	5	6
0600 FACILITIES	7108.			348.					1004.		
0610 MANUFACTURING		155.			254.					0.	
0611 DES/CONSTR			155.								
0612 ACT/MAINT			0.			254.					0.
0620 TEST		245.			93.					0.	
0621 DES/CONST			245.								
0622 ACT/MAINT			0.			93.					0.
0630 1ST TR MAINT+REF		2953.			0.					486.	
0631 DES/CONST			2953.								
0632 ACT/MAINT			0.			0.					486.
0640 ETR-LAUNCH		475.			0.					133.	
0641 DES/CONST			475.								
0642 ACT/MAINT			0.			0.					133.
0650 2ND TR MAINT+REF		2758.			0.					252.	
0651 DES/CONST			2758.								
0652 ACT/MAINT			0.			0.					252.
0660 WTR LAUNCH		523.			0.					133.	
0661 DES/CONST			523.								
0662 ACT/MAINT			0.			0.					133.
0700 GSE	26430.			2910.			1018.		4570.		
0710 MFG GSE		2100.									
0711 HARDWARE											
0712 SITE ACT											
0713 MAINT											
0714 SOFTWARE											
0720 ETR GSE		17730.			0.		0.			2140.	
0721 HARDWARE			15430.			0.	0.				
0722 SITE ACT			2300.								
0723 MAINT			0.								2140.
0724 SOFTWARE			0.								
0730 WTR GSE		0.			2910.		1018.			2830.	
0731 HARDWARE			0.			2910.	1018.				
0732 SITE ACT			0.								
0733 MAINT			0.								2830.
0734 SOFTWARE			0.								

MOORE BUSINESS FORMS, INC. NO FORM 1412T PRINTED IN U.S.A.

310-3A/310 RE-3A SEP 73 COMBINED

WBS	LEVEL	4	5	6	4	5	6			4	5	6
		EXPECTED COST DDT+E			EXPECTED COST PRODUCTION			INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS		
0740	FL OP NASA		3300.			0.		0.			0.	
0741	HARDWARE			3300.			0.	0.				
0742	SITE ACT			0.								
0743	MAINT			0.								0.
0744	SOFTWARE			0.								
0750	FL OP DOD		3300.			0.		0.			0.	
0751	HARDWARE			3300.			0.	0.				
0752	SITE ACT			0.								
0753	MAINT			0.								0.
0754	SOFTWARE			0.								
0800	VEHICLE TEST	80623.										
0810	GND TEST HARDWARE		10376.									
0811	PTV/BATTLESHIP			2342.								
0812	MAJOR TST ART			7534.								
0813	MOCKUPS			500.								
0820	GND TEST OPS		14930.									
0830	FLT TEST HARDWARE		10567.									
0840	FLT TEST OPS		44750.									
0900	LAUNCH OPS WTR									6492.		
0910	LAUNCH SITE SVC										0.	
0920	TUG/SHUTTLE MATG										608.	
0930	PRELAUNCH C/O										126.	
0940	COUNTDOWN										4.	
0950	FLUID+GASES										3534.	
0960	POST FLT SAFING										2220.	
1000	LAUNCH OPS ETR									31306.		
1010	LAUNCH SITE SVC										0.	
1020	TUG/SHUTTLE MATG										2162.	
1030	PRELAUNCH C/O										4320.	
1040	COUNTDOWN										124.	
1050	FLUID+GASES										17980.	
1060	POST FLT SAFING										6720.	
1100	FLT OPS DOD	3780								54480.		
1110	MISSION PLAN		2650								14690.	
1120	FLT CONT		680								21180.	
1130	FLT EVALUATION		450								2450.	
1140	FLT SPT SOFTWARE										16160.	
1200	FLT OPS NASA	34720								77570.		
1210	MISSION PLAN		8100								20850.	
1220	FLT CONT		1430								22950.	
1230	FLT EVALUATION		470								2910.	
1240	FLT SPT SOFTWARE		24720								30860.	

NOTE THESE COSTS INCLUDED IN VEHICLE TEST.

III-86-45

MOORE BUSINESS FORMS INC. OHIO FORM 14121 PRINTED IN U.S.A. 2T

310-3A/310 RE-3A SEP 73 COMBINED

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
1300	REF+INT 1ST TR									19880.		
1310	SCHED MAINT+REF										2400.	
1320	UNSCHED MAINT+REF										2540.	
1330	POST MAINT C/O										820.	
1340	TUG/PAYLOAD MATG										1320.	
1350	REF RQMTS PLANNG										200.	
1360	DEPOT MAINT										12600.	
1400	REF+INT 2ND TR									40820.		
1410	SCHED MAINT+REF										7300.	
1420	UNSCHED MAINT+REF										7620.	
1430	POST MAINT C/O										2500.	
1440	TUG/PAYLOAD MATG										4000.	
1450	REF RQMTS PLANNG										400.	
1460	DEPOT MAINT										19000.	
	SPACE TUG TOTALS	329333.			242093.			12367.	35293.	273745.		
	32A= 329333.	32B=	254460.		32C=	273745.		32D=	857538.			

III-8.6-46

MOORE BUSINESS FORMS, INC. NO FORM 1412 T PRINTED IN U.S.A. 27

DEFINITION OF SPREAD

FUNCTION CODES

CODE	DEFINITION
4	Beta Distribution - A = 0.79, B = 0.15 Peak Funding occurs at 28.0% of Time, 73.0% of Dollars consumed at 50% of Time.
6	Beta Distribution - A = 0.68, B = 0.17 Peak Funding occurs at 30.0% of Time, 67.0% of Dollars consumed at 50% of Time.
9	Beta Distribution - A = 0.55, B = 0.05 Peak Funding occurs at 34.0% of Time, 55.0% of Dollars consumed at 50% of Time.
11	Beta Distribution - A = 0.58, B = 0.38 Peak Funding occurs at 34.0% of Time, 67.0% of Dollars consumed at 50% of Time.
16	Beta Distribution - A = 0.47, B = 0.21 Peak Funding occurs at 40.0% of Time, 55.0% of Dollars consumed at 50% of Time.
26	Beta Distribution - A = 0.16, B = 0.45 Peak Funding occurs at 58.0% of Time, 43.0% of Dollars consumed at 50% of Time.

STORABLE SPACE TUG SYSTEM PROJECT SUPPORTING COST DATA FORM A1, A2, & A3 INFORMATION

CONCEPT #310RE-3A PHASE II

WBS	DDT&E FORM A1 Design Rating	Config Rating	Td	Ts	SPD Funct	PRODUCTION FORM A2 No Units	Ref Unit	Config Rating	Td	Ts	SPD Funct	LRN IND	OPERATIONS FORM A3 SPD Funct
0100 PROJECT MGM'T		3			32						32		32
0110 Cost/Perf. Mgm't		3			32						32		32
0120 Project Direction		3			32						32		32
0130 Information Mgm't		3			32						32		32
0200 SYS. ENG & INTEG		3			32						32		32
0210 Tug Sys Engr		3			32								32
0220 Shuttle Interface		3			32								32
0230 Payload Interface		3			32								32
0240 Sustaining Engr.		3											32
0310 STRUCTURES	1	4	34	50	4	18	1	4	21	36	4	90%	32
0311 Fuel Tnk & Supt									21	36	4	90%	32
0312 OX Tnk & Supt									21	36	4	90%	32
0313 Body Structure	1	4	34	50	4	18	1	4	21	36	4	90%	32
0314 Thrust Structure									21	36	4	90%	32
0315 Meteroid Shield									21	36	4	90%	32
0316 Payload Interface	1	4	11	33	4	18	1	4	5	25	4	90%	32
0317 Installation, Assmbly, D/O													
0320 THERMAL INSULATION	3	3	31	50	4	18	1	3	18	30	4	90%	32
0321 Fuel Tank Insulation	3	3	31	50	4	18	1	3	18	30	4	90%	32
0322 Ox Tank Insulation	3	3	31	50	4	18	1	3	18	30	4	90%	
0323 Purge Syst. Insulation													
0324 Control System													
0325 Instl. Assy & C/Out													
0330 AVIONICS			48	68	4	18	1		15	32	4		
0331 Data Management	4	4	30	56	4	18	1	4	15	32	4		
0332 GN&C	1	2	48	68	4	18	1	2	15	32	4		
0333 Communications	1	2	30	56	4	18	1	2	15	32	4		
0334 Instrumentation													
0335 Electr Power	3	3						3	20	32	4		
0336 Power Dist & Contr	5	4			4	18	1	4	20	32	4		
0337 Instl. Assmbly & C/O													
0340 PROPULSION									20	35	4	90%	
0341 Main Engine (CFE)	1								20	35	4	90%	
0342 Main Eng. Supt	5								20	35	4	90%	
0343 ACPS Engine	4								20	35	4	90%	
0344 ACPS Eng. Supt	5								20	35	4	90%	
0345 Instl Assmbly & C/O													

III-8.8-48

WBS	DDT&E FORM A1 Design Rating	Config Rating	Td	Ts	SPD Funct	PRODUCTION FORM A2 No Units	Ref Unit	Config Rating	Td	Ts	SPD Funct	LRN IND	OPERATIONS FORM A3 SPD Funct
0350 ORBITER INTERFACE	1					1	1	4	14	28	4	90%	32
0351 Structures								4	14	28	4	90%	32
0352 Interface Panels								4	14	28	4	90%	32
0353 Purge Provisions													
0354 Abort Provisions													
0355 Instal, Assy & C/O													
0360 DROP TANK									N/A				
0361 Structures													
0362 Thermal Insulation													
0363 Prop Suppt System													
0364 Instl, Assy & C/O													
0370 FINAL ASSY & C/C		3	12	32	4	18	1	3	23	32	4		
0371 Final Assy		3	12	32	4	18	1	3	23	32	4		
0372 Checkout													

AUXILIARY STAGE

STORABLE SPACE TUG SYSTEM PROJECT SUPPORTING
COST DATA FORM A1, A2, & A3 INFORMATION

WBS	DDT&E FORM A1					PRODUCTION FORM A2							OPERATIONS FORM A3
	Design Rating	Config Rating	Td	Ts	SPD Funct	No Units	Ref Unit	Config Rating	Td	Ts	SPD Funct	LRN IND	SPD Funct
0410 STRUCTURES	N/A					N/A							
0411 Fuel Tnk & Suppt													
0412 Ox Tnk & Suppt													
0413 Body Structure													
0414 Thrust Structure													
0415 Meteroid Shield													
0416 Payload Interface													
0417 Installation Ass'y C/O													
0420 THERMAL INSULATION													
0421 Fuel Tank Insulation													
0422 Ox Tnk Insulation													
0423 Purge Syst Insulation													
0424 Control System													
0425 Instl Ass'y & C/O													
0430 AVIONICS													
0431 Data Management													
0432 GN&C													
0433 Communications													
0434 Instrumentation													
0435 Electric Power													
0436 Power Dist & Contr													
0437 Instl Ass'y & C/O													
0440 PROPULSION													
0441 Main Eng (CFE)													
0442 Main Eng Suppt													
0443 ACPS Engine													
0444 ACPS Eng Suppt													
0445 Instl Ass'y & C/O													
0450 ORBITER INTERFACE													
0451 Structures													
0452 Separation System													
0453 Instl Ass'y & C/O													

STORABLE SPACE TUG SYSTEM PROJECT SUPPORTING
COST DATA FORM A1, A2, & A3 INFORMATION

WBS	DDT&E FORM A1					PRODUCTION FORM A2							OPERATIONS FORM A3
	Design Rating	Config Rating	Td	Ts	SPD Funct	No Units	Ref Unit	Config Rating	Td	Ts	SPD Funct	LRN IND	SPD Funct
0460 DROP TANK			N/A						N/A				
0461 Structure													
0462 Thermal Insulation													
0463 Propulsion Suppt System													
0464 Instl, Ass'y & C/O													
0470 RETRIEVAL DELAY MODULE			22	42	4	3	1	4	14	26	4	90%	32
0471 Structure	1	4	22	42	4	3	1	4	14	26	4	90%	32
0472 Therm Control													
0473 Avionics	4	4	22	42	4	3	1	4	14	26	4	90%	32
0474 Propulsion	5	4	22	42	4	3	1	4	14	26	4	90%	32
0475 RDM Ass'y & C/O			22	42	4	3	1	4					
0480 APOGEE KICK STAGE			N/A						N/A				
0481 Structure													
0482 SRM	5												
0483 Avionics													
0484 Propulsion													
0485 AKS Ass'y & C/O													
0490 DE-ORBIT KICK STAGE													
0491 Structure													
0492 Therm Control													
0493 Avionics													
0494 Propulsion													
0495 De-Orbit Ass'y & C/O													
04100 CACHE TANK													
04101 Structure													
04102 Therm Control													
04103 Avionics													
04104 Propulsion													
04105 Cache Ass'y & C/O													
04110 FINAL ASS'Y & C/O								3	3	12	4		
04111 Final Ass'y								3	3	12	4		
04112 Checkout													

STORABLE SPACE TUG SYSTEM PROJECT SUPPORTING
COST DATA FORM A1, A2, & A3 INFORMATION

WBS	DDT&E FORM A1 Design Rating	Config Rating	Td	Ts	SPD Funct	PRODUCTION FORM A2 No Units	Ref Unit	Config Rating	Td	Ts	SPD Funct	LRN IND	OPERATIONS FORM A3 SPD Funct
0510 TRANSP. & HANDLING													
0520 TRAINING													
0521 Simulat & Equip													
0522 Ground Crew													
0523 Flt. Oper. Crew													
0530 WAREHOUSE/INV. COST													
0610 MANUFACTURING FACILITIES		3			4			3			32		
0611 Des/Constr.		3			4			3			32		
0612 Act/Maint													
0620 TEST FACILITIES								3			4		
0621 Des/Constr.													
0622 Act/Maint.								3			4		
0630 1st TR MAINT. & REF.													32
0631 Des/Constr													32
0632 Activ/Maint													32
0640 ETR LAUNCH FACILITIES													
0641 Design/Constr.													32
0642 Activ/Maint.													32
0650 2nd TR MAINT/REF													
0651 Des/Constr													32
0652 Activ/Maint.													32
0660 WTR LAUNCH													
0661 Des/Constr													32
0662 Activ/Maint													32
0710 MFG. GSE													
0711 Hardware													
0712 Site Activ													
0713 Maint													
0714 Software													
0720 EAST TEST RANGE		3			4								
0721 Hardware													
0722 Site Activation													
0723 Maint		3			4								
0724 Software													

STORABLE SPACE TUG SYSTEM PROJECT SUPPORTING
COST DATA FORM A1, A2, & A3 INFORMATION

WBS	DDT&E FORM A1 Design Rating	Config Rating	Td	Ts	SPD Funct	PRODUCTION FORM A2 No Units	Ref Unit	Config Rating	Td	Ts	SPD Funct	LRN IND	OPERATIONS FORM A3 SPD Funct
0730 WEST TEST RANGE GSE	3				4								
0731 Hardware													
0732 Site Activation													
0733 Maint.	3				4								
0734 Software													
0740 FLIGHT OPER. NASA													
0741 Hardware													
0742 Site Activ													
0743 Maint													
0744 Software													
0750 FLIGHT OPER. D.O.D.													
0751 Hardware													
0752 Site Activ													
0753 Maint													
0754 Software													
0810 GROUND TEST H'WARE	3	15	29		32								
0811 PTV/Battleship	3				32								
0812 Major Test Art	3				32								
0813 Mockups	3				32								
0820 GROUND TEST OPS	3				32								
0830 Flt Test Hardware	3				32								
0840 Flt. Test Operi.	3				32								
0900 LAUNCH OPS WTR													32
0910 Launch Site SVC													
0920 Tug/Shuttle Matg													32
0930 Prelaunch C/O													32
0940 Countdown													32
0950 Fluid & Gases													32
0960 Post Flt. Safing													32
1000 LAUNCH OPS ETR													32
1010 Launch Site SVC													
1020 Tug/Shuttle Matg													32
1030 Prelaunch C/O													32
1040 Countdown													32
1050 Fluid & Gases													32
1060 Post Flt. Safing													32

STORABLE SPACE TUG SYSTEM PROJECT SUPPORTING
COST DATA FORM A1, A2, & A3 INFORMATION

WBS	DDT&E FORM A1					PRODUCTION FORM A2						OPERATIONS FORM A3
	Design Rating	Config Rating	Td	Ts	SPD Funct	Design Rating	Config Rating	Td	Ts	SPD Funct	LRN IND	SPD Funct
1100 FLT OPS DOD												32
1110 Mission Plan												32
1120 Flt/Contr												32
1130 Flt Evaluation												32
1140 Flt SPT Software												32
1200 FLT OPS NASA												32
1210 Mission Plan												32
1220 Flt Contr												32
1230 Flt Evaluation												32
1240 Flt SPT Software												32
1300 REF INT 1st TR												32
1310 Sched Maint & Ref												32
1320 Unsched Maint & Ref												32
1330 Post Main C/O												32
1340 Tug/Payload Matg												32
1350 Ref Requirements Planning												32
1360 Depot Maint												
1400 REF INT 2nd TR												32
1410 Sched Maint & Ref												32
1420 Unsched Maint & Ref												32
1430 Post Maint C/O												32
1440 Tug/Payload Matg												32
1450 Ref Requirements Planning												32
1460 Depot Maint												

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STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

DDTE (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	4.2	0.0	0.0	0.31	0.65	0.74	0.76	0.76	0.68	0.33	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	5.1	0.0	0.0	0.38	0.78	0.89	0.91	0.92	0.82	0.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	TUG MAIN STAGE	28.9	0.0	0.0	0.0	3.33	6.21	9.31	7.17	2.47	0.41	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	STRUCTURE	1.7	0.0	0.0	0.0	0.0	0.0	0.79	0.75	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320	THERMAL INSUL																	
330	AVIONICS	20.7	0.0	0.0	0.0	3.33	6.21	5.55	3.57	1.65	0.41	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION																	
350	INTERFACE																	
360	DROP TANK																	
370	FINAL ASSY	6.5	0.0	0.0	0.0	0.0	0.0	2.97	2.84	0.64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	TUG AUX STAGE	13.6	0.0	0.0	0.00	0.00	2.94	4.88	3.62	1.71	0.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0
410	STRUCTURE																	
420	THERMAL INSUL																	
430	AVIONICS																	
440	PROPULSION																	
450	INTERSTAGE																	
460	DROP TANK																	
470	RDM	13.6	0.0	0.0	0.0	0.0	2.94	4.88	3.62	1.71	0.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0
490	DKS																	
4100	CACHE																	
4110	FINAL ASSY																	
480	AKS	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS																	
600	FACILITIES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
610	MANUFACTURING	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
620	TEST																	
630	1ST MAIN/REF																	
640	ETR LAUNCH																	
650	2ND MAIN/REF																	
660	WTR LAUNCH																	
700	GND SUPP EQUIP	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.47	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
710	MFG GSE																	
720	ETR GSE	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.47	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
730	WTR GSE																	
740	FLT OPS NASA																	
750	FLT OPS DOD																	
800	VEHICLE TEST	48.6	0.0	0.0	0.0	0.0	0.0	0.0	5.36	22.46	20.78	0.0	0.0	0.0	0.0	0.0	0.0	0.0
810	GND TEST HWRE	14.2	0.0	0.0	0.0	0.0	0.0	0.0	4.02	5.91	4.23	0.0	0.0	0.0	0.0	0.0	0.0	0.0
820	GND TEST OPS	4.7	0.0	0.0	0.0	0.0	0.0	0.0	1.34	1.97	1.41	0.0	0.0	0.0	0.0	0.0	0.0	0.0
830	FLT TEST HWRE	15.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.65	7.94	0.0	0.0	0.0	0.0	0.0	0.0	0.0
840	FLT TEST OPS	14.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.93	7.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900	LAUNCH OPS WTR																	
1000	LAUNCH OPS ETR																	
1100	FLIGHT OPS DOD																	
1200	FLIGHT OPS NASA																	
1300	REF + INT TR-1																	
1400	REF + INT TR-2																	
	TOTALS	~~101.1~~ 75	0.0	0.0	~~0.69~~	~~4.75~~ 4	~~10.77~~ 8	15.87 10	~~17.83~~ 18	~~28.63~~ 21	~~22.51~~ 15 14	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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MOORE BUSINESS FORMS, INC., HO FORM 14121 PRINTED IN U.S.A. 72

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STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

PROD (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	13.7	0.0	0.0	0.0	0.0	0.0	0.0	1.78	3.22	3.43	3.36	1.88	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	15.4	0.0	0.0	0.0	0.0	0.0	0.0	2.00	3.63	3.86	3.77	2.12	0.0	0.0	0.0	0.0	0.0
300	TUG MAIN STAGE	168.0	0.0	0.0	2.18	0.82	0.0	0.0	19.47	41.82	43.56	32.37	18.52	7.62	1.66	0.01	0.0	0.0
310	STRUCTURE	23.5	0.0	0.0	0.0	0.0	0.0	0.0	3.78	7.04	6.30	4.05	1.88	0.46	0.0	0.0	0.0	0.0
320	THERMAL INSUL	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.26	0.53	0.54	0.41	0.25	0.12	0.03	0.0	0.0	0.0
330	AVIONICS	79.6	0.0	0.0	0.0	0.0	0.0	0.0	9.83	19.83	19.96	15.24	9.30	4.34	1.12	0.0	0.0	0.0
340	PROPULSION	34.4	0.0	0.0	0.0	0.0	0.0	0.0	5.52	10.30	9.22	5.93	2.75	0.68	0.0	0.0	0.0	0.0
350	INTERFACE	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.07	0.14	0.16	0.13	0.10	0.06	0.03	0.01	0.0	0.0
360	DROP TANK	3.0	0.0	0.0	2.18	0.82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
370	FINAL ASSY	24.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.96	7.39	6.61	4.25	1.97	0.49	0.0	0.0	0.0
400	TUG AUX STAGE	3.8	0.0	0.0	0.0	0.0	0.0	0.0	1.74	1.66	0.38	0.00	0.0	0.0	0.0	0.0	0.0	0.0
410	STRUCTURE																	
420	THERMAL INSUL																	
430	AVIONICS																	
440	PROPULSION																	
450	INTERSTAGE																	
460	DROP TANK																	
470	RDM	3.8	0.0	0.0	0.0	0.0	0.0	0.0	1.74	1.66	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0
480	AKS																	
490	DKS																	
4100	CACHE																	
4110	FINAL ASSY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.23	0.47	0.54	0.55	0.55	0.50	0.24	0.0	0.0	0.0
600	FACILITIES	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.05	0.05	0.04	0.04	0.04	0.02	0.0	0.0	0.0
610	MANUFACTURING	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.04	0.04	0.04	0.04	0.02	0.0	0.0	0.0
620	TEST	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.03	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
630	1ST MAIN/REF																	
640	ETR LAUNCH																	
650	2ND MAIN/REF																	
660	WTR LAUNCH																	
700	GND SUPP EQUIP	3.9	0.0	0.0	0.0	0.0	0.0	0.0	1.12	1.64	1.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0
710	MFG GSE																	
720	ETR GSE																	
730	WTR GSE	3.9	0.0	0.0	0.0	0.0	0.0	0.0	1.12	1.64	1.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0
740	FLT OPS NASA																	
750	FLT OPS DOD																	
800	VEHICLE TEST																	
810	GND TEST HWRE																	
820	GND TEST OPS																	
830	FLT TEST HWRE																	
840	FLT TEST OPS																	
900	LAUNCH OPS WTR																	
1000	LAUNCH OPS ETR																	
1100	FLIGHT OPS DOD																	
1200	FLIGHT OPS NASA																	
1300	REF + INT TR-1																	
1400	REF + INT TR-2																	
	TOTALS	208.2	0.0	0.0	2.18	0.82	0.0	0.0	26.36	52.49	52.99	40.10	23.12	8.16	1.93	0.01	0.0	0.0
							16	18	22	42	48	35	17	8	2			

III-96-56

310RE-3A SEP 73

2nd Phase

STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

DPS (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.13	0.29	0.35	0.37	0.38	0.38	0.37	0.31	0.14
200	SYS ENG + INTEG	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.26	0.58	0.71	0.75	0.76	0.77	0.74	0.62	0.28
300	TUG MAIN STAGE	11.1	0.0	0.0	6.42	2.40	0.0	0.0	0.0	0.11	0.24	0.30	0.32	0.32	0.32	0.31	0.26	0.12
310	STRUCTURE	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.23	0.28	0.29	0.30	0.30	0.29	0.24	0.11
320	THERMAL INSUL	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
330	AVIONICS	6.7	0.0	0.0	4.88	1.82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION	2.1	0.0	0.0	1.54	0.58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
350	INTERFACE	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
360	DROP TANK																	
370	FINAL ASSY																	
400	TUG AUX STAGE	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
410	STRUCTURE																	
420	THERMAL INSUL																	
430	AVIONICS																	
440	PROPULSION																	
450	INTERSTAGE																	
460	DROP TANK																	
470	RDM	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
480	AKS																	
490	DKS																	
4100	CACHE																	
4110	FINAL ASSY																	
500	LOGISTICS																	
600	FACILITIES	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.05	0.09	0.12	0.12	0.12	0.12	0.10	0.05
610	MANUFACTURING																	
620	TEST																	
630	1ST MAIN/REF	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.04	0.05	0.05	0.05	0.05	0.05	0.04	0.02
640	ETR LAUNCH	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01
650	2ND MAIN/REF	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.03	0.04	0.04	0.04	0.03	0.02
660	WTR LAUNCH	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01
700	GND SUPP EQUIP	2.7	0.0	0.0	1.99	0.74	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
710	MFG GSE																	
720	ETR GSE	1.5	0.0	0.0	1.12	0.42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
730	WTR GSE	1.2	0.0	0.0	0.87	0.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
740	FLT OPS NASA																	
750	FLT OPS DOD																	
800	VEHICLE TEST																	
810	GND TEST HWRE																	
820	GND TEST OPS																	
830	FLT TEST HWRE																	
840	FLT TEST OPS																	
900	LAUNCH OPS WTR	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.36	0.77	0.91	0.94	0.96	0.94	0.81	0.38
1000	LAUNCH OPS ETR	25.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.50	3.23	3.82	3.97	4.03	3.97	3.41	1.59
1100	FLIGHT OPS DOD	40.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.39	5.16	6.10	6.35	6.44	6.35	5.45	2.54
1200	FLIGHT OPS NASA	55.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.25	7.02	8.30	8.63	8.75	8.62	7.40	3.45
1300	REF + INT TR-1	18.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.07	2.31	2.74	2.85	2.89	2.84	2.44	1.14
1400	REF +INT TR-2	29.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.73	3.73	4.41	4.59	4.65	4.58	3.93	1.83
	TOTALS	198.5	0.0	0.0	~~8.41~~	~~3.14~~	0.0	0.0	0.0	~~0.83~~	~~11.49~~	~~23.69~~	~~27.85~~	~~28.93~~	29.34	28.88	24.74	11.51
		198									111	25	32	32	32	31	25	10

III-86-157

WRIGHT BUSINESS FORMS INC. NY FORM 1413-T PRINTED IN U.S.A. 22"

FIRST UNIT PRODUCTION COST
PER WBS (INCLUDING AVIONICS TO LEVEL 7)
MAIN STAGE AND AUXILIARY STAGE(S)
(COST IN THOUSANDS)

Concept 310RE-3A

WBS	IDENTIFICATION	FIRST UNIT COST LEVEL 4	LEVEL 5	LEVEL 6
0300	TUG VEH. MAIN STAGE	11,110		
0310	STRUCTURES		1,843	
0311	Fuel Tank & Sprt			578
0312	OX Tank & Sprt			679
0313	Body Structure			257
0314	Thrust Structure			33
0315	Metoroid Shield			12
0316	Payload Intface			284
0317	Inst'l Assy & C/O			0
0320	THERMAL INSULTN		176	
0321	Fuel Tank Insul			86
0322	OX Tank Insul			90
0333	Purge Sys Insul			0
0324	Cont Sys			0
0325	Inst'l Assy & C/O			0
0330	AVIONICS		4,254	
0331	Data Management			713
0332	GN&C			2,136
0333	Communications			816
0334	Instrumentation			0
0335	Elec Pwr			362
0336	Pwr Dist & Cont			228
0337	Inst'l Assy & C/O			0
0340	PROPULSION		2,061	
0341	Main Engine			800
0342	Main Engine Sprt			305
0343	ACPS Engine			564
0344	ACPS Engine Sprt			392
0345	Inst'l Assy & C/O			0
0350	ORBITER INTERFACE		633	
0351	Structure			266
0352	Interface PNLS			357
0353	Purge Provision			0
0354	Abort Provision			0
0355	Inst'l Assy & C/O			0
0360	DROP TANKS			
0361	Structures			
0362	Thermal Insul			
0363	Prod Sprt Sys			
0364	Inst'l Assy & C/O			
0370	FINAL ASSY & C/O		2,152	
0371	Final Assy			2,152
0372	Checkout			0
0400	TUG VEH. AUX. STAGE	1,428		
0470	RIM		1,428	
0471	Structure			348
0472	Therm Cont			0
0473	Avionics			763
0474	Propulsion			99
0475	RIM Assy & C/O			218
0480	AKS		0	
0481	Structure			
0482	Therm Cont			
0483	Avionics			
0484	Propulsion			
0485	AKS Assy & C/O			
0490	DKS		0	
0491	Structure			
0492	Therm Cont			
0493	Avionics			
0494	Propulsion			
0495	DKS Assy & C/O			
0100	PROJECT MANAGEMENT			
0200	SYS ENG & INTEGR	2,595		
	TOTAL FIRST UNIT COST (Exclusive Logistics)			

LEVEL 7 FIRST UNIT COSTS (AVIONICS)

WBS	IDENTIFICATION	MAIN STAGE
0330	AVIONICS (MAIN STAGE)	4,254
0331	DATA MANAGEMENT	713
	Computer	209
	Tape Recorder	58
	FSI Cont'r/TLM Form.	55
	DACU	105
	Sensors	75
	In-House	211
0332	GN&C	2,136
	IMU	200
	Star Tracker	162
	Att Ref	53
	Laser Revo. Radar	400
	Satellite Receiver	
	Doppler Receiver	
	L-Band Antenna	
	Combined/Doppler Det.	
	APS Ct'l Electronics	295
	ME/TVC Ct'l Electron	295
	In-House	731
0333	COMMUNICATIONS	816
	S-Band X'CVR/X'PDR	410
	Aux. Xmtr	43
	Power AMP	10
	Baseband Processor	50
	Diplexer	
	Ant Switch	
	Antenna	8
	OCTA	125
	TV Assembly	
	In-House	170
0334	INSTRUMENTATION	0
0335	ELEC POWER	362
	Battery	100
	Emergency Battery	2
	Modified Fuel Cell	
	Thermal Control	30
	H Tanks	214
	In-House	16
0336	PWR DIST. & CT'L	228
0337	INST'L ASSY & C/O	0

WBS	IDENTIFICATION	AUX STAGE
0400	TUG VEH. AUX STAGE	1,428
0470	RIM	1,428
0473	AVIONICS	763
	DMS	93
	PCM/Sig Cond	80
	Sensors	13
	GN&C	200
	Attitude Gyro Ref Unit	100
	Timer/CT'l Relay	50
	APS CT'l Electron	50
	COMMUNICATIONS	111
	S-Band Xcvr/Xpdr	97
	Baseband Process	
	Aux. Xmtr	1
	Pwr Amplifier	8
	Diplexer	1
	Antenna Switch	2
	Antenna	2
	ELEC. POWER	69
	Primary Battery	2
	Pwr Dist & CT'l	67
	In-House	290
0480	AKS	
0483	AVIONICS	
	DMS	
	Sensors	
	GN&C	
	Attitude Gyro Ref Unit	
	Timer/CT'l Relay	
	Velocity Meter	
	Sequence Program	
	ELEC POWER	
	Primary Battery	
	Pwr Dist & CT'l	
0490	DKS	0
	AVIONICS	
	DMS	
	Sensors	
	PCM	
	GN&C	
	Attitude Gyro Ref Unit	
	Timer/CT'l Relay	
	APS/TVC CT'l Electr	
	Velocity Meter	
	Sequence Program	
	Star Tracker	
	COMMUNICATIONS	
	S-Band Xcvr/Xpdr	
	Baseband Process	
	Aux. Xmtr	
	Pwr Amplifier	
	Diplexer	
	Antenna Switch	
	Antenna	
	ELEC. POWER	
	Primary Battery	
	Pwr Dist & CT'l	
	DeOrbit Battery	
	Solar Cell Pad's	

310-3A/310RE-3A

AVERAGE COST/FLIGHT ($ THOUSANDS)

	MODE I REFUSE		MODE II EXPEND TUG		MODE III EXPEND KS	
	NASA	DOD	NASA	DOD	NASA	DOD
Launch Operations	96.69	96.69				
Launch Site Serv & Supt	-----	-----				
Tug Shuttle Mate & C/O	7.98	7.98				
Prelaunch C/O	16.08	16.08				
Countdown	.47	.47				
Propellants & Gasses	46.40	46.40				
Post Flight Safing	25.76	25.76				
Maintenance & Refurb	468.53	468.53				
Sched Mant & Refurb	27.95	27.95				
Unsched Maint & Refurb	29.28	29.28				
Vehicle Opnl Spares (less Me)	181.42	181.42				
M. Eng. Maint & Refurb	80.00	80.00				
M. E. Opnl Spares	35.07	35.07				
Post Maint C/O	9.57	9.57				
Tug/Payload Mate & C/O	15.33	15.33				
Refurb Reqmt Planning	1.73	1.73				
Depot Maint	88.18	88.18				
Total Ground OPS (Launch/Maint/Refb)	565.22	565.22				
Flight Operations	342.64	412.54				
Mission Planning	92.38	110.90				
Flight Control	133.21	122.07				
Flight Evaluation	15.41	15.47				
Flight Supt Software	101.64	164.10				
Operations Support	65.86	65.86				
FSE Maint	1.77	1.77				
Sustaining Eng	31.51	31.51				
Prog Mgt	15.75	15.75				
Transport & Hdlg	3.32	3.32				
Inventory Control & Whseing	11.38	11.38				
Facilities Maint	2.13	2.13				
Expend Veh Avg. Unit Cost			8400			
Total Cost/Flight	974	1044	9374			

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

310-3A/310RE-3A OPNS

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-07-02	ETR		312.		1593.		156.		0.		78.		0.		2140.
	MAJ PROC		0.		578.		0.		0.		0.		0.		578.
	IN-HOUSE	20.	312.	124.	1015.	11.	156.	0.	0.	6.	78.	0.	0.	162.	1562.
320-07-03	WTR		413.		2107.		207.		0.		103.		0.		2830.
	MAJ PROC		0.		765.		0.		0.		0.		0.		765.
	IN-HOUSE	27.	413.	164.	1342.	15.	207.	0.	0.	9.	103.	0.	0.	214.	2065.
320-07-04	FLT OPS NASA		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-07-05	FLT OPS DOD		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08	VEHICLE TEST		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-01	GND TEST HDWR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-02	GND TEST OPS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-03	FLT TEST HDWR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-04	FLT TEST OPS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-09	LAUNCH OPS WTR		597.		1963.		0.		0.		0.		3932.		6492.
	MAJ PROC		0.		0.		0.		0.		0.		3647.		3647.
	IN-HOUSE	38.	597.	240.	1963.	0.	0.	0.	0.	0.	0.	22.	284.	301.	2845.
320-10	LAUNCH OPS ETR		4520.		14851.		0.		0.		0.		11935.		31306.
	MAJ PROC		0.		0.		0.		0.		0.		9783.		9783.
	IN-HOUSE	290.	4520.	1818.	14851.	0.	0.	0.	0.	0.	0.	167.	2152.	2275.	21523.
320-11	FLIGHT OPS WTR		54480.		0.		0.		0.		0.		0.		54480.
	MAJ PROC		5448.		0.		0.		0.		0.		0.		5448.
	IN-HOUSE	3149.	49032.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3149.	49032.
320-12	FLIGHT OPS ETR		77570.		0.		0.		0.		0.		0.		77570.
	MAJ PROC		7757.		0.		0.		0.		0.		0.		7757.
	IN-HOUSE	4484.	69813.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4484.	69813.
320-13	REFB + INTEG WTR		4175.		13717.		0.		0.		0.		1988.		19880.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	268.	4175.	1679.	13717.	0.	0.	0.	0.	0.	0.	154.	1988.	2101.	19880.
320-14	REFB + INTEG ETR		8572.		28166.		0.		0.		0.		4082.		40820.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	551.	8572.	3447.	28166.	0.	0.	0.	0.	0.	0.	316.	4082.	4314.	40820.

III-3.6-60

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

310-3A/310RE-3A OPN'S

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-C4-06	DROP TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-C4-C7	RDM		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-C4-08	AKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-C4-09	DKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-10	CACHE TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-11	FINAL ASSEMBLY		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-05	LOGISTICS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06	FACILITIES		0.		0.		0.		0.		0.		1004.		1004.
	MAJ PROC		0.		0.		0.		0.		0.		804.		804.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	16.	201.	16.	201.
320-06-01	MANUFACTURING		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-02	TEST		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-03	ETR MAINT/REFB		0.		0.		0.		0.		0.		486.		486.
	MAJ PROC		0.		0.		0.		0.		0.		389.		389.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	8.	97.	8.	97.
320-06-C4	ETR LAUNCH		0.		0.		0.		0.		0.		133.		133.
	MAJ PROC		0.		0.		0.		0.		0.		106.		106.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	27.	2.	27.
320-06-05	WTR MAINT/REFB		0.		0.		0.		0.		0.		252.		252.
	MAJ PROC		0.		0.		0.		0.		0.		202.		202.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.	50.	4.	50.
320-06-06	WTR LAUNCH		0.		0.		0.		0.		0.		133.		133.
	MAJ PROC		0.		0.		0.		0.		0.		106.		106.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	27.	2.	27.
320-C7	GSE		725.		3701.		363.		0.		181.		0.		4970.
	MAJ PROC		0.		1343.		0.		0.		0.		0.		1343.
	IN-HOUSE	47.	725.	289.	2357.	26.	363.	0.	0.	15.	181.	0.	0.	377.	3627.
320-C7-01	MANUFACTURING		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

310-3A/310RE-3A OPN'S

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320	SPACE TUG PROJ		162452.		73530.		2124.		3442.		1692.		30353.		273593.
	MAJ PROC		14416.		6105.		726.		161.		404.		15041.		36853.
	IN-HOUSE	9508.	148037.	8253.	67424.	102.	1397.	272.	3281.	107.	1289.	1186.	15312.	19428.	236740.
320-01	PROJECT MGMT		0.		0.		0.		0.		0.		5466.		5466.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	423.	5466.	423.	5466.
320-02	SYS ENGR + INTG		7327.		0.		0.		3281.		0.		328.		10935.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	471.	7327.	0.	0.	0.	0.	272.	3281.	0.	0.	25.	328.	768.	10936.
320-03	SPACE TUG VEH MN		4486.		11132.		1761.		161.		1511.		1617.		20669.
	MAJ PROC		1211.		4762.		726.		161.		404.		807.		8071.
	IN-HOUSE	210.	3275.	780.	6370.	76.	1035.	0.	0.	92.	1107.	63.	810.	1220.	12598.
320-03-01	STRUCTURES		888.		1049.		296.		0.		323.		135.		2690.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	57.	888.	128.	1049.	22.	296.	0.	0.	27.	323.	10.	135.	244.	2690.
320-03-02	THERMAL INSUL		42.		50.		14.		0.		15.		6.		128.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	3.	42.	6.	50.	1.	14.	0.	0.	1.	15.	0.	6.	12.	128.
320-03-03	AVIONICS		2383.		7958.		1046.		161.		723.		1127.		13398.
	MAJ PROC		1211.		4762.		726.		161.		404.		807.		8071.
	IN-HOUSE	75.	1172.	391.	3196.	23.	320.	0.	0.	27.	320.	25.	320.	541.	5327.
320-03-04	PROPULSION		1100.		1989.		381.		0.		423.		339.		4232.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	71.	1100.	243.	1989.	28.	381.	0.	0.	35.	423.	26.	339.	403.	4232.
320-03-05	ORBITER INTF		73.		86.		24.		0.		26.		11.		220.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	5.	73.	11.	86.	2.	24.	0.	0.	2.	26.	1.	11.	20.	220.
320-03-06	DROP TANKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-03-07	FINAL ASSEMBLY		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04	SPACE TUG VEH AU		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-01	STRUCTURES		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-02	THERMAL INSUL		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-03	AVIONICS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-04	PROPULSION		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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MOORE BUSINESS FORMS INC HQ FORM 1412 PRINTED IN U.S.A.

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

3103A/310RE-3A PROD

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-C7-C2	ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-C7-C3	WTR		595.		2888.		297.		0.		149.		0.		3928.
	MAJ PROC		0.		955.		0.		0.		0.		0.		956.
	IN-HOUSE	32.	595.	136.	1932.	18.	297.	0.	0.	8.	149.	0.	0.	195.	2973.
320-C7-C4	FLT OPS NASA		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-C7-C5	FLT OPS DOD		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08	VEHICLE TEST		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-C1	GND TEST HDWR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-02	GND TEST OPS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-03	FLT TEST HDWR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-04	FLT TEST OPS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-C9	LAUNCH OPS WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-10	LAUNCH OPS ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-11	FLIGHT OPS WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-12	FLIGHT OPS ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-13	REFB + INTEG WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-14	REFB + INTEG ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

310-3A/310RE-3A PROD

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-04-06	DROP TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-07	RDM		730.		2252.		270.		29.		212.		284.		3777.
	MAJ PROC		215.		847.		129.		29.		72.		144.		1436.
	IN-HOUSE	28.	515.	99.	1405.	9.	140.	0.	0.	8.	140.	11.	140.	154.	2341.
320-04-08	AKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-09	DKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-10	CACHE TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-11	FINAL ASSEMBLY		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-05	LOGISTICS		6752.		0.		0.		0.		0.		0.		6752.
	MAJ PROC		2199.		0.		0.		0.		0.		0.		2199.
	IN-HOUSE	247.	4553.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	247.	4553.
320-06	FACILITIES		0.		0.		0.		0.		0.		348.		348.
	MAJ PROC		0.		0.		0.		0.		0.		278.		278.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	5.	70.	5.	70.
320-06-01	MANUFACTURING		0.		0.		0.		0.		0.		254.		254.
	MAJ PROC		0.		0.		0.		0.		0.		203.		203.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.	51.	4.	51.
320-06-02	TEST		0.		0.		0.		0.		0.		93.		93.
	MAJ PROC		0.		0.		0.		0.		0.		75.		75.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	19.	1.	19.
320-06-03	ETR MAINT/REFB		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-04	ETR LAUNCH		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-05	WTR MAINT/REFB		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-06	WTR LAUNCH		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-07	GSE		595.		2888.		297.		0.		149.		0.		3928.
	MAJ PROC		0.		956.		0.		0.		0.		0.		956.
	IN-HOUSE	32.	595.	136.	1932.	18.	297.	0.	0.	8.	149.	0.	0.	195.	2973.
320-07-01	MANUFACTURING		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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STORABLE SPACE TUG SYSTEM PROJECT

COST ESTIMATE DATA BY SOW

310-3A/310RE-3A PROD

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320	SPACE TUG PROJ		59606.		93745.		17120.		6606.		14931.		59453.		251460.
	MAJ PROC		11683.		38260.		5690.		1265.		3161.		35306.		95365.
	IN-HOUSE	2604.	47922.	3907.	55485.	711.	11430.	325.	5341.	651.	11769.	1870.	24147.	10070.	156095.
320-01	PROJECT MGMT		0.		0.		0.		0.		0.		15826.		15826.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1226.	15826.	1226.	15826.
320-02	SYS ENGR + INTG		11929.		0.		0.		5341.		0.		534.		17804.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	648.	11929.	0.	0.	0.	0.	325.	5341.	0.	0.	41.	534.	1015.	17804.
320-03	SPACE TUG VEH MN		39600.		88604.		16553.		1236.		14570.		42461.		203024.
	MAJ PROC		9269.		36456.		5561.		1236.		3090.		34884.		90496.
	IN-HOUSE	1648.	30331.	3672.	52148.	684.	10992.	0.	0.	635.	11480.	587.	7577.	7227.	112528.
320-03-01	STRUCTURES		9766.		11542.		3255.		0.		3551.		1480.		29594.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	531.	9766.	813.	11542.	203.	3255.	0.	0.	197.	3551.	115.	1480.	1857.	29594.
320-03-02	THERMAL INSUL		904.		1068.		301.		0.		329.		137.		2739.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	49.	904.	75.	1068.	19.	301.	0.	0.	18.	329.	11.	137.	172.	2739.
320-03-03	AVIONICS		16745.		56847.		7600.		1236.		5129.		8218.		95775.
	MAJ PROC		9269.		36456.		5561.		1236.		3090.		6179.		61791.
	IN-HOUSE	406.	7477.	1436.	20391.	127.	2039.	0.	0.	113.	2039.	158.	2039.	2240.	33985.
320-03-04	PROPULSION		3657.		6611.		1266.		0.		1407.		29831.		42771.
	MAJ PROC		0.		0.		0.		0.		0.		28705.		28705.
	IN-HOUSE	199.	3657.	466.	6611.	79.	1266.	0.	0.	78.	1407.	87.	1125.	908.	14066.
320-03-05	ORBITER INTF		800.		946.		267.		0.		291.		121.		2425.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	43.	800.	67.	946.	17.	267.	0.	0.	16.	291.	9.	121.	152.	2425.
320-03-06	DROP TANKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-03-07	FINAL ASSEMBLY		7727.		11591.		3864.		0.		3864.		2675.		29719.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	420.	7727.	816.	11591.	240.	3864.	0.	0.	214.	3864.	207.	2675.	1898.	29719.
320-04	SPACE TUG VEH AU		731.		2253.		270.		29.		212.		284.		3778.
	MAJ PROC		215.		847.		129.		29.		72.		144.		1436.
	IN-HOUSE	28.	515.	99.	1405.	9.	141.	0.	0.	8.	141.	11.	141.	154.	2342.
320-04-01	STRUCTURES		0.		0.		0.		0.		0.		0.		1.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
320-04-02	THERMAL INSUL		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-03	AVIONICS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-04	PROPULSION		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

III-86-65

MADE IN U.S.A. PRINTED IN U.S.A. FSC 14127 MOORE BUSINESS FORMS, INC. HQ

STORABLE SPACE TUG SYSTEM PROJECT

COST ESTIMATE DATA BY SOW

310-3A/310RE-3A DDT&E

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-07-02	ETR		4270.		10873.		1294.		0.		1294.		0.		17730.
	MAJ PROC		0.		4792.		0.		0.		0.		0.		4792.
	IN-HOUSE	239.	4270.	438.	6081.	99.	1294.	0.	0.	78.	1294.	0.	0.	853.	12938.
320-07-03	WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-07-04	FLT OPS NASA		3300.		0.		0.		0.		0.		0.		3300.
	MAJ PROC		3000.		0.		0.		0.		0.		0.		3000.
	IN-HOUSE	17.	300.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	17.	300.
320-07-05	FLT OPS DOD		3300.		0.		0.		0.		0.		0.		3300.
	MAJ PROC		3000.		0.		0.		0.		0.		0.		3000.
	IN-HOUSE	17.	300.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	17.	300.
320-08	VEHICLE TEST		0.		0.		80410.		0.		0.		0.		80410.
	MAJ PROC		0.		0.		10472.		0.		0.		0.		10472.
	IN-HOUSE	0.	0.	0.	0.	5343.	69938.	0.	0.	0.	0.	0.	0.	5343.	69938.
320-08-01	GND TEST HDWR		0.		0.		10376.		0.		0.		0.		10376.
	MAJ PROC		0.		0.		5188.		0.		0.		0.		5188.
	IN-HOUSE	0.	0.	0.	0.	396.	5188.	0.	0.	0.	0.	0.	0.	396.	5188.
320-08-02	GND TEST OPS		0.		0.		14717.		0.		0.		0.		14717.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	1124.	14717.	0.	0.	0.	0.	0.	0.	1124.	14717.
320-08-03	FLT TEST HDWR		0.		0.		10567.		0.		0.		0.		10567.
	MAJ PROC		0.		0.		5283.		0.		0.		0.		5283.
	IN-HOUSE	0.	0.	0.	0.	404.	5283.	0.	0.	0.	0.	0.	0.	404.	5283.
320-08-04	FLT TEST OPS		0.		0.		44750.		0.		0.		0.		44750.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	3419.	44750.	0.	0.	0.	0.	0.	0.	3419.	44750.
320-09	LAUNCH OPS WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-10	LAUNCH OPS ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-11	FLIGHT OPS WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-12	FLIGHT OPS ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-13	REFB + INTEG WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-14	REFB + INTEG ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

30-3A/310RE-3A DDT&E

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-04-06	DROP TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-07	RDM		8155.		1031.		2518.		155.		846.		852.		13556.
	MAJ PROC		2526.		1031.		670.		155.		258.		515.		5154.
	IN-HOUSE	315.	5629.	0.	0.	141.	1848.	0.	0.	36.	588.	26.	336.	517.	8402.
320-04-08	AKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-09	DKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-10	CACHE TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-11	FINAL ASSEMBLY		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-05	LOGISTICS		6330.		0.		0.		0.		0.		0.		6330.
	MAJ PROC		950.		0.		0.		0.		0.		0.		950.
	IN-HOUSE	301.	5380.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	301.	5380.
320-06	FACILITIES		0.		0.		0.		0.		0.		7077.		7077.
	MAJ PROC		0.		0.		0.		0.		0.		5687.		5687.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	108.	1391.	108.	1391.
320-06-01	MANUFACTURING		0.		0.		0.		0.		0.		124.		124.
	MAJ PROC		0.		0.		0.		0.		0.		124.		124.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-02	TEST		0.		0.		0.		0.		0.		245.		245.
	MAJ PROC		0.		0.		0.		0.		0.		196.		196.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.	49.	4.	49.
320-06-03	ETR MAINT/REFB		0.		0.		0.		0.		0.		2953.		2953.
	MAJ PROC		0.		0.		0.		0.		0.		2363.		2363.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	46.	591.	46.	591.
320-06-04	ETR LAUNCH		0.		0.		0.		0.		0.		475.		475.
	MAJ PROC		0.		0.		0.		0.		0.		380.		380.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	7.	95.	7.	95.
320-06-05	WTR MAINT/REFB		0.		0.		0.		0.		0.		2758.		2758.
	MAJ PROC		0.		0.		0.		0.		0.		2206.		2206.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	43.	552.	43.	552.
320-06-06	WTR LAUNCH		0.		0.		0.		0.		0.		523.		523.
	MAJ PROC		0.		0.		0.		0.		0.		418.		418.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	8.	105.	8.	105.
320-07	GSE		11187.		12417.		1453.		0.		1373.		0.		26430.
	MAJ PROC		6000.		5303.		0.		0.		0.		0.		11303.
	IN-HOUSE	290.	5187.	512.	7114.	111.	1453.	0.	0.	83.	1373.	0.	0.	996.	15127.
320-07-01	MANUFACTURING		318.		1544.		159.		0.		79.		0.		2100.
	MAJ PROC		0.		511.		0.		0.		0.		0.		511.
	IN-HOUSE	18.	318.	74.	1033.	12.	159.	0.	0.	5.	79.	0.	0.	109.	1589.

III-28-67

MOORE BUSINESS FORMS INC. NO. FORM 14127 PRINTED IN U.S.A.

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

310-3A/310RE-3A DDT&E

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320	SPACE TUG PROJ		95837.		21176.		105285.		5321.		15726.		85743.		329088.
	MAJ PROC		21648.		11302.		14371.		900.		1500.		65983.		115704.
	IN-HOUSE	4147.	74189.	711.	9874.	6945.	90914.	267.	4422.	859.	14226.	1531.	19759.	14460.	213385.
320-01	PROJECT MGMT		0.		0.		0.		0.		0.		12282.		12282.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	951.	12282.	951.	12282.
320-02	SYS ENGP + INTG		9875.		0.		0.		4422.		0.		442.		14738.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	552.	9875.	0.	0.	0.	0.	267.	4422.	0.	0.	34.	442.	853.	14738.
320-03	SPACE TUG VEH MN		60291.		7728.		20904.		745.		13507.		65090.		168265.
	MAJ PROC		12172.		4968.		3229.		745.		1242.		59781.		82138.
	IN-HOUSE	2690.	48119.	199.	2760.	1350.	17675.	0.	0.	741.	12265.	411.	5308.	5390.	86127.
320-03-01	STRUCTURES		11692.		0.		2829.		0.		3583.		754.		18858.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	654.	11692.	0.	0.	216.	2829.	0.	0.	216.	3583.	58.	754.	1144.	18858.
320-03-02	THERMAL INSUL		82.		0.		30.		0.		30.		7.		149.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	5.	82.	0.	0.	2.	30.	0.	0.	2.	30.	1.	7.	9.	149.
320-03-03	AVIONICS		35065.		4968.		8953.		745.		5892.		4988.		50511.
	MAJ PROC		12172.		4968.		3229.		745.		1242.		2484.		24841.
	IN-HOUSE	1280.	22893.	0.	0.	437.	5723.	0.	0.	281.	4650.	194.	2504.	2192.	35770.
320-03-04	PROPULSION		7701.		0.		3025.		0.		1650.		58672.		71049.
	MAJ PROC		0.		0.		0.		0.		0.		57297.		57297.
	IN-HOUSE	430.	7701.	0.	0.	231.	3025.	0.	0.	100.	1650.	107.	1375.	868.	13751.
320-03-05	ORBITER INTF		3840.		0.		1396.		0.		1396.		349.		6981.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	215.	3840.	0.	0.	107.	1396.	0.	0.	84.	1396.	27.	349.	433.	6981.
320-03-06	DROP TANKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-03-07	FINAL ASSEMBLY		1911.		2760.		4671.		0.		955.		318.		10616.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	107.	1911.	199.	2760.	357.	4671.	0.	0.	58.	955.	25.	318.	745.	10616.
320-04	SPACE TUG VEH AU		8155.		1031.		2518.		155.		846.		852.		13556.
	MAJ PROC		2526.		1031.		670.		155.		258.		515.		5154.
	IN-HOUSE	315.	5629.	0.	0.	141.	1848.	0.	0.	36.	588.	26.	336.	517.	8402.
320-04-01	STRUCTURES		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-02	THERMAL INSUL		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-03	AVIONICS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-04	PROPULSION		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

III-56-68

MOORE BUSINESS FORMS INC. NO FORM 1412T PHILADELPHIA U.S.A.

SPACE TUG CHARACTERISTICS

310-3A→310RE-3A

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	WEIGHT, LB	3190→3394	544
	LENGTH, IN	297	27
	DIAMETER, IN	120	120
TECHNICAL:	REUSABLE	ONE-STAGE	RDM
	AUXILIARY STAGE		RDM
	PAYLOAD RETRIEVAL	CAPABILITY	
	PROPELLANT CAPACITY, LB	59,500	
	THRUST, LB	12,000	
	ISP, SEC	338	
	AUTONOMY LEVEL	IIIA→IIB	
	RELIABILITY	.97→.9750	.9824

WBS #320-00

GRUMMAN

MAIN STAGE CHARACTERISTICS

310-3A → 310RE-3A

PHYSICAL:	WEIGHT, LB	3190 → 3394
	LENGTH, IN	297
	DIAMETER, IN	120
TECHNICAL:	REUSABLE SINGLE STAGE	
	PROPELLANT CAPABITY, LB	59,500
	PAYLOAD RETRIEVAL CAPABILITY	
	THRUST, LB	12,000
	ISP, SEC	338
	AUTONOMY LEVEL	IIIA → IIB
	RELIABILITY	.97 → .9750

WBS #320-03

GRUMMAN

VEHICLE TEST CHARACTERISTICS

310-3A → 310RE-3A

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	PROP. TEST ARTICLE	X	
	STRUCT. TEST ARTICEL	X	X
	INTEG. AVIONICS TEST	X	X
	MOCK-UPS	X	X
	FLIGHT TEST	X	X

TECHNICAL: PTA - COLD FLOW ONLY, NO HOT FIRING

STA - ONE ART FOR DYNAMICS, STATIC & FATIGUE

IAT - SOFTWARE & HARDWARE

MOCK-UPS - WOOD AT PDR, WOOD/METAL AT CDR

FLIGHT TEST - ONE WITHOUT P/L, SEVEN WITH P/L

WBS #320-08

GRUMMAN

III-8.6-71

STRUCTURAL CHARACTERISTICS

310-3A → 310RE-3A

PHYSICAL:	WEIGHT, LB	1226 → 1279
	LENGTH, IN	297
	DIAMETER, IN	120
TECHNICAL:	TANK CONFIGURATION	NESTED DOME
	TANK CAPACITY, LB	59,500
	MATERIAL	Ti, COMPOSITE H'COMB
	RELIABILITY ALLOCATION	.99900

WBS #320-03-01

GRUMMAN

CONFIGURATION 310RE-3A

WBS NO. 310-03-01

SUBSYSTEM/COMPONENT STRUCTURE

DATE: 7/17/65

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TEST	
01-Fuel Tanks and Supports	1	44½		Titan.	255	90	120	DIA		Welded Gore Titanium Domes	20	1		2	Tank Leakage Considered Unserviceable
02-Oxid. Tank and Supports	1	44½		Titan.	167	100	120	DIA		Weld Gore Titanium Domes	20	1		2	
03-Body Structure	1	44½		Alum. and Comp.	633	145	120	DIA		Graphite Composite Honeycomb Shell Aluminum Frames	N/A	1		2	Includes Equipment Mounting and Umbilicals
04-Thrust Struct.	1	44½		Alum.	88	35	120 MAX.	DIA		Aluminum Stiffened Sheet	N/A	1		2	
05-Meteoroid Shield	1	44½		Alum.	26	87	126	DIA		Aluminum Sheet	N/A	1	1		
06-Interface	1	46		Alum.	113					Aluminum Machinings and Forgings	N/A	1		2	

GRUMMAN

THERMAL CONTROL CHARACTERISTICS

310-3A 310RE-3A

PHYSICAL: WEIGHT, LB 89

500 FT^2 GOLDIZED MYLAR MLI

AL BASE HEAT SHIELD

SILVER BACKED TEFLON & ALZAK COATINGS

WBS #320-03-02

GRUMMAN

III-5.6-74

CONFIGURATION 310RE-3A

WBS NO. 320-03-02-01,01

SUBSYSTEM/COMPONENT THERMAL CONTROL

DATE: 8/30/72

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
THERMAL CONTROL COATINGS	5	0		SBT ALZAK ALCOPINE	9		150	0 ft²		0				1			
MULTILAYER INSULATION	3	6		See Mini Spec	46		500	ft²		0				1			
FUEL CELL RADIATOR	2	12		See Mini Spec	14		17	ft²						1			
AVIONICS HEAT PIPE RADIATOR	2	12		See Mini Spec	4		4	ft²		0							POWER AMP (20W)
AVIONICS HEATERS	4	6		See Mini Spec	2					25/UNIT				8			COX & COMPANY, NY, NY.
APS HEATERS*	4	6		See Mini Spec	6					30/UNIT				24			
PASS HEAT SHIELD	5	0		AL	14					0							IDENTICAL TO MICROMETEROID SHIELD
PLUMBING	5	0		AL	2					0							

*CARRIED AS APS WT.

III-86-75

BRUMMAN

REPORT
DATE
CODE 28912

AVIONICS CHARACTERISTICS

		310-3A → 310RE-3A
PHYSICAL:	WEIGHT, LB	663 → 758
TECHNICAL:	AUTONOMY LEVEL	IIIA → IIB
	RENDEZVOUS & DOCKING	→ LASER RADAR
	COMMUNICATIONS	DFS → DFS/CSS
	COMPUTER CAPACITY	48K → 65K WORDS
	FUEL CELL POWER	2.5 KW
	RELIABILITY ALLOCATION	.97912 → .98454

WBS #320-03-03

GRUMMAN

AUTONOMY LEVEL II B

CORE CONFIGURATION 310RE-3A, ~~[illegible]~~

WBS NO. 320-03-03-01

SUBSYSTEM/COMPONENT DMS

DATE: 7/1/73

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TEST	
[illegible] STAGE																	
COMPUTER	4				15	4.7	5	10.4	244	39	65K WORDS - 16 BITS/WORD	144	14K	2	N/A	1	CDC 469
TAPE RECORDER	5		RF/S-3 [illegible]		14.5	9	12	5.4	530	8		105	12K	1	N/A	1	ODETICS DDS 3000
FSI CONTROLLER/ TLM FORMATTER	4		SHUTTLE		18	8	5	16	640	23		144	12K	1	N/A	1	RADIATION INC.
[illegible]'S	4		SHUTTLE		7	7	4	13	364	21	256 CHANNELS	144	12K	3	N/A	1	RADIATION INC
SENSORS	4		SHUTTLE		0.2	N/A	N/A	N/A	N/A	0.1			1M	190	N/A	10	WHITTAKER TRANSONICS

III-8.6-77

GRUMMAN

REPORT
DATE
CODE 265-2

CONFIGURATION 310 RE-3A
AUTHORITY LEVEL IIB

* NOTE 1 WBS NO. 320-03-03-02
SUBSYSTEM/COMPONENT G N & C

REV A 5-5-73
DATE: 8-1-73

MAJOR COMPONENT	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS (POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE)	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES (1) USES RETRIEVAL DELAY MODULE
INERTIAL REFERENCE UNIT	1	24			10	6.5	6.5	4.7	200	15 WATTS			2			
STAR TRACKER	1		SHUTTLE		17	15	6 DIA.		424	28 WATTS			1			DOES NOT INCLUDE SUNSHADE (1 LB)
SATELLITE RECEIVER	1	30			37	19.5	10.4	7.8	1582	85 WATTS			1			
[illegible] RECEIVER	1	12			8	8	7	5	280	10 WATTS			1			
L BAND ANTENNAS	1	9			0.3	4	4	1	16	—			4			
COMBINER/ [illegible] DETECT	1	18			6	7	7	5	245	4 WATTS			1			
[illegible] RADAR	1	30			40	9 21	9 9	9 6	729 1134	35 WATTS			1			
ACCELEROMETER	1				18	10	10	5	500	13 WATTS			2			
[illegible] INTERFACE	1				10	10	10	3.5	350	15 WATTS			1			

BRUMMAN AEROSPACE CORPORATION
REPORT
DATE
CODE 28512

CONFIGURATION 310RE-3A ; (CORE) WBS NO. 320-03-03-03 SUBSYSTEM/COMPONENT COMM DATE: 7-5-7

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR T&E TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR UNIT	NOTES
1. S-BAND X'CEIVER/ X'PONDER R'CVR-(2) X'MTR-(1)		24			2X4 1X5	7 7	9 8	5 5	315 280	8 34	Spread Spectrum CCIR Interference STDN/SGLS Compatible			1			
2. S-BAND X'CEIVER/ X'PONDER R'CVR-(4) X'MTR-(1)					4X4 1X5	7 7	9 8	5 5	315 280	8 34	Spread Spectrum CCIR Interference STDN/SGLS Compatible						
3. AUX. X'MTR					5	7	8	5	280	34	Same as (2)			1			
4. POWER AMP					1	3	5	2	30	20	R.F. output of 5W			1			
5. POWER AMP		15			3	9	5	3	135	100	R.F. output of 20W			1			
6. Base Band Processor		24			6	7	7	5	245	4	Same as (1) & (2)			1			
7. Diplexer					1	3	7	3	63	—	—			2			
8. Diplexer		9			1	3	7	3	63	—	—			2			
9 Antenna Switch					1	3	3	4	36	1	—			2			
10. Antenna					.5	3	6	1	18	—	—			2			
11 Antenna		9			.5	3	6	1	18	—	—			2			
12. Power Splitter		8			1	2	2	3	12	—	—			1			
13. TV ASSEMBLY		15			12	18	6	4	432	10	Black & White			1			
15. SECURE COMM		—			6	9	5	4	180	8	—			5			DOD ONLY-GFE

III-8.6-19

DRUMMAN

CONFIGURATION [redacted] ...310RE-3A WBS NO. 320-03-03-05 & -06

LEVEL OF AUTONOMY III A ---- II B SUBSYSTEM/COMPONENT ELECTRICAL POWER SUBSYSTEM DATE: 8-27

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
• MODIFIED SHUTTLE FUEL CELL ASSY	3	30	SHUTTLE	ST STEEL PLAT	90	25	15	15	5630		2.5 KW @ 28V; ___ WATT AVG LOAD OVER 117 HRS.	144	25,000	1	-	1	REQUIRES AUTO SPACE START-U SELLERS: PEWA or GE
• EMERGENCY BATTERY	5	6		Ag-Zn Mg	15	9	5	4.5	200		10 AMP-HR RATED CAPACITY, 17 AMP DISCHARGE OVER 0.5 HR	0.5	30,000	1	-	1	SECONDARY SILVER-ZINC BAT SELLER: EAGLE-PICHER
• CRYO HYDROGEN TANK ASSY	3	24	GEMINI APOLLO SHUTTLE	T1-INNER T2-OUTER	69	21" 24"	ID OD		[illegible]		250 PSIA - OPERATING PRESSURE 350 PSIA - MAX PRESSURE. 11.5 LB FLUID CAPACITY	144		1	-	1	SELLER: AIRESEARCH, BEECH, BEN
• CRYO OXYGEN TANK ASSY	3	24	GEMINI APOLLO SHUTTLE	INC-718 INN INC-750 OUT	71	16½ 19½	ID OD		3900		900 PSIA - OPERATING PRESS 1000 PSIA - MAX. " 32.5 LB FLUID CAPACITY	144		1	-	1	SELLER: AIRESEARCH, BEECH, BEN
• VEHICLE WIRING	5		LM		55						6ga, 14ga, 16ga, 20 & 26ga	144		SHIP SET		SHIP SET	~10,000 FT OF ASSORTED SIZE
• CONNECTORS	5		LM		30						ASSORTED SIZES	144		"		"	~120 MATED PAIRS
• SUNDRIES (-CLAMPS -TAPE)	5		LM		20						" "	144		"		"	
• SOLID STATE POWER CONTROL	5		-		21						90 @ 2 AMP 17 @ 5 AMP 60 @ 3 AMP	144		"		"	2 OZ EACH; SELLER: LEACH CO
• ELECTRO-MECH RCCB	5		LM		9						2 @ 20 AMP 10 @ 10 AMP	144		"		"	0.75 LB EACH; SELLER CUTLER-H

GRUMMAN

III-8.6-80

PROPULSION CHARACTERISTICS (310-3A→310RE-3A)

		MAIN PROP.	AUXILIARY PROP.
PHYSICAL:	WEIGHT, LB	547	150→188
	ENGINE/THRUSTER	CLASS I	REA 19
	NO. OF ENGINES/THRUSTERS	1	16→24
TECHNICAL:	FUEL LOAD, LB	20,517	339→495
	OXIDIZER LOAD, LB	38,983	--
	THRUST, LB	12,000	25
	ISP - STEADY STATE, SEC	338	232
	- PULSING, SEC	--	170
	RELIABILITY ALLOCATION	.99249	.99915→.99882

WBS #320-03-04

GRUMMAN

CONFIGURATION 310RE-3A, [redacted] WBS NO. 320-03-04-03 ; 320-03-04-04 REV A 8/3/73

SUBSYSTEM/COMPONENT Auxiliary Propulsion System (APS) DATE: 8/1/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR [illegible] TEST	PROGRAMATIC: [illegible]	NOTES
																	GENERAL NOTE: TANKAGE BASED ON USABLE PROPELLANT OF 450 LB PLUS 10% CONTINGENCY.
Helium Tank	5	≤12	—		12.25	12.34	12.34	12.34	850	—	BURST PRESS = 7800 PSI OPERATING = 3900 PSI	156	10^6	2	ONE SHIPSET	NONE	AIRITE P/N 6524-1
Helium Filter	5	≤12	LM		0.5					—				1			LSC 310-303-3 (VACCO VLV CO)
Helium Latching Solenoid Valve	4	≤12	LM		2.3					84		156	1.3×10^6	2			LSC 270-713 (MC MFG)
Regulator, Dual Stage	5	≤12	LM		2.5					—		156	"	1			LSC 310-305-3 ([illegible])
Regulator, Single Stage	4	≤12	—		1.5					—		156	"	1			MOD TO DUAL STAGE REG.
Quad Check Valve	5	≤12	LM		0.7					—	PROOF PRESS = 600 PSI	156	2000	1			MOD TO LSC 310-306 ([illegible])
Burst Disc/Relief Vlv	4	≤12	—		1.5					—	RELIEF PRESS ≈ 400 PSI	156	10^6/67K	1			MOD TO LSC 310-307 (CALMEC)
Vent Valve	3	18	—		2.0					70	PROOF PRESS = 600 PSI	156	67000	3			SIMILAR TO LSC310-403 (PARKER) UNIDIRECTIONAL FLOW ONLY; HIGHER OPERATING PRESSURE
Propellant Tanks	4	≤12	LM		10.5		12.50	.34	3420	—	BURST PRESSURE = 650 PSI	144	10^6	4			MODIFIED LM RCS FUEL TANK WITH ELASTOMERIC BLADDERS. TANK WT. INCLUDES BLADDERS.
Acquisition Bladders	2	24	—	EPT 10 ELASTOMER	—					—				4			
Propellant Filter	5	≤12	—		0.5					—				1			
Thruster Isolation Valve	3	18	—		2.0					70	PROOF PRESSURE = 600 PSI	168	67000	8			SAME VALVE AS VENT VALVE; SAME NOTES APPLY.
Thrusters	4	≤12	—		2.1	11.4	2.7			24	25 LB THRUST @ 325 PSI INLET, STEADY STATE I_{SP} = 232	144	1.5×10^6	24			REA 19-3 (HAMILTON STANDARD)
Thruster Heaters	5	≤12	—		0.2					3.5	MAINTAIN CATALYST BEDS AT 150°F			24			SUBMITTED FOR PRICING BY THE AMB
Quick Disconnects	5	≤12	—		0.5									3			HE FILL & DRAIN PROP FILL & DRAIN PROP FILL & VENT

III-8.6-82

GRUMMAN

REPORT
DATE
CODE 50912

ORBITER INTERFACE CHARACTERISTICS

310-3A → 310RE-3A

PHYSICAL:	WEIGHT, LB	1186
TECHNICAL:	MATERIAL	ALUMINUM
	PIVOT TYPE ADAPTER/DOCKING MECHANISM	
	SERVICE PANELS	GROUND POWER
		INSTRUMENTATION
		ON-PAD EMERGENCY DUMP
		HORIZONTAL PROP. DRAIN
		FUEL CELL REACTANT FILL

WBS #320-03-05

GRUMMAN

CONFIGURATION 310RE-3A

WBS NO. 320-03-05-01

SUBSYSTEM/COMPONENT ORBITER INTERFACE STRUCT. DATE: 9/17/[illegible]

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TEST	
01-Rear Adapter	1	[illegible]		Alum.	652	132	120	D		Aluminum Stiffened Sheet and Machinings	N/A			1	Pivot Type Adapter
01-Fwd Frame	1	44½		Alum.	438					Aluminum Trusses and Machinings	N/A			1	
01-Docking Mechanism	1	46		Alum.	96					Aluminum Machinings and Forgings	N/A			1	

III-8.6-84

GRUMMAN

REPORT
DATE
CODE 28512

RETRIEVAL DELAY MODULE CHARACTERISTICS

310-3A→310RE-3A

PHYSICAL:	WEIGHT, LB	544
	LENGHT, IN	27
	DIAMETER, IN	120
TECHNICAL:	MATERIAL	ALUMINUM
	INSULATION	GOLDIZED MYLAR MLI
	PULSE CODE MODULATOR	
	ATTITUDE GYRO	
	S-BAND EQUIP/OMNI ANTENNAS	
	BATTERY POWER	250 AMP HR
	AUXILIARY PROP. SYS	12 COLD GAS THRUSTERS
	RELIABILITY	.9824

WBS #320-04-07

GRUMMAN

III-6.6-85

CONFIGURATION 310RE-3A WBS NO. 320-04-01

SUBSYSTEM/COMPONENT RETRIEVAL DELAY MODULE STRUCT. DATE: 9/17/85

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR SYS TEST	EQUIVALENT UNITS FOR MAJOR GND TEST	
03-Body Structure	1	84		Alum.	120	27	120	D		Aluminum Stiffened Sheet	N/A	1		1	Includes Equipment Mounting Structure
06-Payload Interface	1	84		Alum.	125					Aluminum Machings and Forgings	N/A	1		1	

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PAGE

CONFIGURATION AKS & RDM

WBS NO. ____

SUBSYSTEM/COMPONENT THERMAL

DATE:

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
COATINGS	5	0	LM	PAINT	1	←	150	ft^2	→		6dys	NA	1	1	NA	
INSULATION	5	6	LM	MLI	4	←	50	ft^2	→		6dys	NA	1	1	NA	ALUMINIZED MYLAR/NYLON NET

LP-9.8-III

ALL AUTONOMY LEVELS

CONFIGURATION RETRIEVAL DELAY MODULE (RDM) WBS NO. 320-04-07-03

SUBSYSTEM/COMPONENT DMS

DATE: 8/27/77

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR [illegible] TEST	[illegible] MAJOR [illegible]	
PCM/SIG. COND	4	5	P72-2 SPACECRAFT		4.6	9	5.5	7	347	9				2	N/A	1	SPACETAC
SENSORS	4	8	SHUTTLE		0.2	N/A	N/A	N/A	N/A	0.1			1M	10	N/A	2	WHITTAKER TRANSONICS

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CONFIGURATION Retrieval Delay Module

WBS NO. 320-04-07-03

SUBSYSTEM/COMPONENT GN&C

REV A 8-31-73

DATE: 8-1-73

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
ATTITUDE ZERO [illegible] UNIT	4	12	IMP ITJS		13	10.6	8 DIA		533	25 WATTS			1			
[illegible]	4	12	IMP ITJS		3	6	3.4	2.4	49	2 WATTS			2			
[illegible]	1	18			7.6	3.6	7.1	5.5	336	12 WATTS			2			

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RDM

CONFIGURATION 310BE-3A (ADD ON) WBS NO. 320-03-03-03 9-5-73

SUBSYSTEM/COMPONENT COMMUNICATIONS DATE: 8/7/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE (each) LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE (each) WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE (each) HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (each) (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS: SI	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
1. S-Band X'CEIVER / X'POWER — R'CVR (4)					4X4	7	9	5	315	8	Spread Spectrum						
X'MTR (1)					1X5	7	8	5	280	34	CCIR Interference STDN/SGLS Compatible			1			
3. AUX. X'MTR					5	7	8	5	280	34	Same as (2) above			1			
4. POWER AMP.					1	3	5	2	30	20	R.F. output of SW			2			
7. DIPLEXER					1	2	7	3	63	—	—			2			
9. ANTENNA SWITCH					1	3	3	4	36	1	—			1			
14. BASEBAND PROCESSOR					3	3	3	2	18	2	Same as (2) above			1			
13. OMNI ANT.					.5	3	6	1	18	—	—			2			
15. SECURE COMM.		—			6	9	5	4	180	8	—			2			DOD ONLY - GFE

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TABLE 52.3-B EQUIPMENT LIST

PAGE 7 SEPT. 1973 REV 1
27 AUG., 1973 REV 1.

CONFIGURATION Retrieval Delay Module — WBS NO. 320-03-03-05 & -06 — SUBSYSTEM/COMPONENT Electrical Power Subsystem — DATE: 13 AUG, 1973

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
PRIMARY BATTERY	5	6		Mg-Zn Mg	88	15	8	8	760	250 AMP-HR RATED CAPACITY @ 30V: 0.7 AMP DISCH. over 336 HRS + 4 AMP over 6 HRS.	342	30,000	1	—	1	MANUALLY ACTIVATED AG-ZN BATTERY SELLER: EAGLE-PICHER
Power Dist. & Control	5	—	LM		42	—	—	—	—	ASSORTED WIRE, CONNECTORS, & SOLID STATE CONTROLLERS.	342		SHIP SET	—	SHIP SET	

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CONFIGURATION Retrieval Delay Module (RDM) WBS NO. 320-03-01-03; 320-03-01-04 SUBSYSTEM/COMPONENT Auxiliary Propulsion System (APS) DATE: 6/3/75

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR G/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR [illegible]	NOTES
Nitrogen Tank	5	≤12	–	6AL4V	6.0	9.9D	–	–	445	–	Burst Pressure = 7215 Operating = 3000 PSI	↑	10^7	1	↑	↑	Airite P/N 6435
Solenoid Valve	5	≤12	–		2.3					84			67,000	1			LSC 270-713
Regulator (dual stage)	4	≤12	–		2.5					–		336	67,000	1			LSC 310-305-3 (MOD TO ONE STAGE)
Thruster Valve	4	≤12	–		0.75					10	0.25" I.D. REQUIRED		333,000	12	One Shipset	None	
Thruster	5	–	–		0.2					–			–	12			Nozzle Machinings
Quick Disconnect	5	≤12	–		0.5					–		↓	10^6	1			Nitrogen Fill & Vent

GENERAL NOTE:
TANK SIZED TO PROVIDE 14 DAYS WIDE DEADBAND AND 1 HOUR NARROW DEADBAND CONTROL.

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8.7 FLIGHT SCHEDULE

Included in support of our flight schedule definition for concept 310-3A/310RE-3A are the following tables:

- Fleet Size & Vehicle Usage
- Flight Element Requirements
- Payload Flown
- 310-3A/310RE-3A Flight Operations Buildup
- Programmatic Data Summary Storable Tug Concept 310-3A/310RE-3A

310-1/310RE-1 (3A) FLEET SIZE & VEHICLE USAGE

	1979	80	81	82	83	84	85	86	87	88	89	90	TOTAL
Capture Model													
Total Flts		20	15	17	27	51	42	46	43	40	42	47	390
Frog Build Up Model													
ETR Reuse		3	12	15	20	23	34	33	32	34	31	41	278
Expend				2		4		4	3		3	1	17
WTR Reuse					7	5	8	9	8	6	8	5	56
Total Flts.		3	12	17	27	32	42	46	43	40	42	47	351
National Fleet													
Veh. 1		2	6	6E									
2		1	6	7E									
3 Int.				4	17	1E							
4 Int.					10	1E							
5 Int.						14E							
6 Evl.						15E							
7						1	17	1E					
8							17	6E					
9							8	17E					
10								17E					
11								5	15E				
12									17E				
13									10E				
14									1	17	4E		
15										17	4E		
16										6	17E		
17											17	17E	
18												17	
19												13	
20 Lost Tug													
21 Lost Tug													
22 Lost Tug													
23 Lost Tug													

310-1/310RE-1 (3A) FLEET SIZE & VEHICLE USAGE

	1979	80	81	82	83	84	85	86	87	88	89	90	TOTAL
DOD Traffic													
Total Flts		1	6	9	15	14	13	20	19	21	17	22	157
										Lost Missions			+2
DOD Fleet													
Veh. 1		1	6	9	15	14	13	17	2	4	1	5	
2								3	17	17	16	17	
3 Lost Tug													
4 Lost Tug													
RDM Traffic						6	10	8	5	6	9	11	55
RDM Fleet													
Veh. 1						4	5	4	3	3	4	5	
2						2	5	4	2	3	5	6	
3 Lost RDM													
4 Lost RDM													

FLIGHT ELEMENT REQUIREMENTS — OPTION: 3A 310/310RE-3A

ITEM			CALENDAR YEAR 80	81	82	83	84	85	86	87	88	89	90	TOTAL
SHUTTLE FLIGHTS		TOTAL	9	9	8	12	30	29	26	24	19	25	25	216
BASIC TUG FLIGHTS	ETR	RECOVERED	9	9	6	9	22	23	18	15	15	18	20	164
		EXPENDED			2		4		4	3		3	1	17
	WTR	RECOVERED				3	4	6	4	6	4	4	4	35
	(TOTAL)		(9)	(9)	(8)	(12)	(30)	(29)	(26)	(24)	(19)	(25)	(25)	(216)
RETRIEVAL DELAY MODULES							8	9	7	3	4	6	7	44

NASA TRAFFIC

FIGURE 1.3.3.2-5

FLIGHT ELEMENT REQUIREMENTS — OPTION: 3A 310/310RE-3A

ITEM			CALENDAR YEAR 80	81	82	83	84	85	86	87	88	89	90	TOTAL
SHUTTLE FLIGHTS		TOTAL	11	6	9	15	21	13	20	19	21	17	22	174
BASIC TUG FLIGHTS	ETR	RECOVERED	11	6	9	11	20	11	15	17	19	13	21	153
		EXPENDED												0
	WTR	RECOVERED				4	1	2	5	2	2	4	1	21
	(TOTAL)		(11)	(6)	(9)	(15)	(21)	(13)	(20)	(19)	(21)	(17)	(22)	(174)
RETRIEVAL DELAY MODULES							2	1	1	2	2	3	4	15

DOD TRAFFIC

FIGURE 4.3.3.2-6

FLIGHT ELEMENT REQUIREMENTS — OPTION: 3A 310/310RE-3A

ITEM			CALENDAR YEAR											TOTAL
			80	81	82	83	84	85	86	87	88	89	90	
SHUTTLE FLIGHTS		TOTAL	20	15	17	27	51	42	46	43	40	42	47	390
BASIC TUG FLIGHTS	ETR	RECOVERED	20	15	15	20	42	34	33	32	34	31	41	317
		EXPENDED			2		4		4	3		3	1	17
	WTR	RECOVERED				7	5	8	9	8	6	8	5	56
	(TOTAL)		(20)	(15)	(17)	(27)	(51)	(42)	(46)	(43)	(40)	(42)	(47)	(390)
RETRIEVAL DELAY MODULES							10	10	8	5	6	9	11	59
									RELIABILITY				=	+4 FLTS

COMBINED NASA/DOD TRAFFIC

FIGURE 4.3.3.2-7

FLIGHT	PAYLOAD FLOWN					
	1980	1981	1982	1983	1984	1985
1	D-9	D-9	ALL	ALL	D-9	ALL
2	D-17	D-11			D-10	
3	D-35	D1 + D8			D-18	
4		D2 + D3			D-20 (EXP)	
5		D3 + D3			D-20 (EXP)	
6		D4 + D7			D-24 (EXP)	
7		D-31			D-24 (EXP)	
8		D-31			R-1	
9		D-34			R-1	
10		D-35			R-2 (DR)	
11		D-35			R-2 (DR)	
12		D25 + D25			R-3 (DR)	
13					R-3 (DR)	
14					RD-2	
15					RD-2	
16					D3 + RD3	
17					D8 + RD3	
18					D14 + R14	
19					D-28	
20					D-28	
21					D-31	
22					D-31	
23					R-26 (DR)	
24					R-27 (DR)	
25					D32 + D32	
26					D32 + D32	
27					D25 + R25	
28					D26 + RD26	
29					D27 + RD27	
30					D37 + D37 + D37	
31					D39 + D39 + D39	
32					D-18	
FLTS FLOWN / SCHED	3/20	12/15	17/17	27/27	32/51	42/42
P/L'S DEPLOYED FLOWN / SCHED	3/34	17/23	24/24	47/47	28/37	36/36
P/L'S RETRIEVED FLOWN / SCHED	0/0	0/0	0/0	0/0	10/25	24/24
SORTIES FLOWN / SCHED	0/0	0/0	0/0	1/1	0/0	1/1

CONCEPT 310/310RE-3A

COSTED FLIGHT BUILD-UP

TABLE 4.3.3.2-8

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310-3A/310RE-3B FLIGHT OPERATIONS BUILDUP

The methodology used to establish the 310-3A/310RE-3A flight buildup is keyed to achieving all flights defined by the 100% payload capture analysis after the second year of initial operations and the first year of evolved operations. The primary factors considered include: NASA defined Shuttle/Tug launch constraints, initial ETR ground crew launch capabilities, and flight mode buildup.

Shuttle/Tug launch constraints affect the first year of operations and allow only 3 flights. During the second year of operations the allowable Shuttle/Tug launches exceed the payload capture traffic model.

Initial ground crew launch capability is derived in the same manner as that described for 110A-1. We approached the evolved flight build up in a similar fashion. The ground crew capability for 1984 was based on the learning effect of adding additional personnel to accommodate the increase flight rate between 1983 and 1985.

As in the prior options, we recommend that initial/evolved flight crew experience be developed by starting with the simplest flight mode and then progressively introducing the more complex flight modes required initially for 1982 and subsequently for 1985.

Our recommended flight buildup for 310-3A/310RE-3A, including 3 flights in 1980, 12 flights in 1981, and 27 flights in 1984 encompasses 355 total flights through 1990 or 35 less than 100% payload capture traffic.

310-3A/310RE-3A FLIGHT OPERATIONS BUILDUP

INPUTS	CY 80	81	82	83	84	85	86	TOTAL FLTS.
	▽ IOC_I				▽IOC_E			
o 100% P/L CAPTURE - ETR+WTR FLTS	20	15	17	27	51	42	46	390
ETR FLTS	20	15	17	20	46	34	37	
o SHUTTLE/TUG LAUNCH CONSTRAINT-ETR	3	21						
o INITIAL GND CREW LAUNCH CAPABIL.-ETR	12	15	16					
o EVOLVED IOC GND CREW LAUNCH CAPAB/ETR				20	27	34	37	
o TUG FLIGHT MODE BUILDUP								
SINGLE DEPLOY	3	ALL	ALL	ALL	ALL	ALL	ALL	
MULTI DEPLOY	NONE	SOME	ALL	ALL	ALL	ALL	ALL	
SORTIE	NONE	NONE	NONE	ALL	ALL	ALL	ALL	
RETRIEVE	NONE	NONE	NONE	NONE	SOME	ALL	ALL	
ROUND TRIP	NONE	NONE	NONE	NONE	SOME	ALL	ALL	
RETRIEVAL DELAY	NONE	NONE	NONE	NONE	SOME	ALL	ALL	
RECOMMENDED FLIGHT BUILDUP ETR+WTR	3	12	17	27	32	42	46	355
ETR	3	12	17	20	27	34	37	

BUILDUP RATIONALE

- o EARLY BUILDUP - SAME AS 110A-1
- o PRE IOC_E FLT CREW EXPERIENCE ALLOWS EVOLVED FLIGHT BUILDUP IN 1 YEAR
- o EASE INTO EVOLVED OPERATIONS TO MAXIMIZE BENEFITS OF GROUND/FLIGHT CREW LEARNING WITHOUT EXCEEDING DOWN STREAM OPERATIONS

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PROGRAMMATIC DATA SUMMARY
STORABLE TUG CONCEPT 310-3A/310RE-3A

PROJECT HARDWARE UTILIZATION (AUTONOMY IIIA/IIB)

	MAIN STAGE INIT	MAIN STAGE EVOL	ORBITER INTERFACE	RDM				
VEHICLE TEST								
PTV	1*	-	-	-				
STA	1	-	1	1				
1 AT	1	1	-	1				
FLT TEST VEH	1*	-	1*	1*				
VEHICLE OPS								
TEST HDWR CONV	*		*	*				
NATIONAL FLEET	5	18	5	4				
NASA	3	16	3	2				
DOD	2	2	2	2				
TOTAL OPS FLEET	23			4R				

SHUTTLE FLIGHTS

	TEST	OPERATIONS		
	INIT	INIT	EVOL	TOTAL
ETR	1	52	238	290
WTR	-	7	50	57
COMBINED	1	59	288	347
NASA	1	28	160	188
DOD	-	31	128	159

OPNL YEARS

	INIT	EVOL	TOTAL
ETR	4	7	11
WTR	1	7	8

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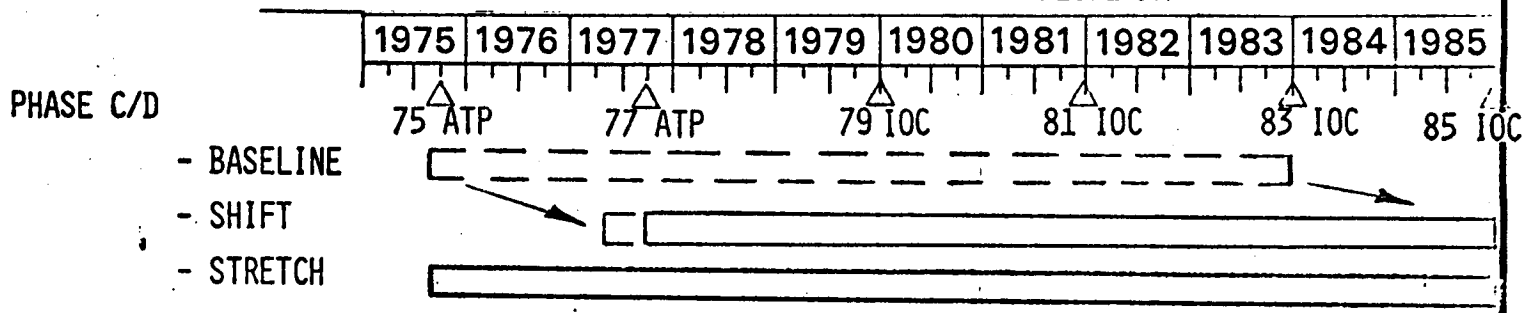
PROGRAM SENSITIVITY TO IOC SHIFT - 310-3A/310RE-3A

The schedule shift and stretch programmatic options can also be used for implementing program concept 310-3A/310RE-3A under a 2 year delay.

In this program IOC delay results in 68 undeployed payloads and 52 unretrieved payloads. Similar conclusions can be drawn on production impact as in the two prior options.

In addition, development impact conclusions considering type of contractor support available to NASA/DOD for defining Tug/Shuttle systems and interfaces, vehicle test, facilities and SR&T are also similar to the results of 110A-1. However, in the stretch program the IOC delay allows a more relaxed schedule for Class I main engine development to avoid the critical path. Assuming that the initial period of schedule stretch is devoted to systems engineering studies we estimate that cost of stretch-out will be $8M. Peak funding occurs in 1980 and is $66M for the schedule stretch option.

PROGRAM SENSITIVITY TO IOC SHIFT 310-3A/310-3A/310RE-3A



	SHIFT	STRETCH
OPERATIONS IMPACT		
UNCAPTURED PAYLOADS	66 DEPLOY/52 RETRIEVE	66 DEPLOY/52 RETRIEVE
PRODUCTION IMPACT		
MFG TEST ART/PROD LEARN	BEST	FAIR
EXIST HDWR AVAIL	FAIR	BEST
DEVELOPMENT IMPACT		
SCHEDULE	99 + 6(ME-ATP)MO	112 MO
SYS & INTERFACE DEFN BY	GOVT + STUDY CONTR	GOVT + PRIME CONTR
- VEH. TEST	2 YEAR DELAY	1½ YEAR DELAY
- FACILITIES	2 YEAR DELAY	
- SR&T	EXTEND	CONTINUE
- DDT&E - INITIAL/TOTAL	255/329	263/337
- "PAF"(YR)	85(81)	66(80)

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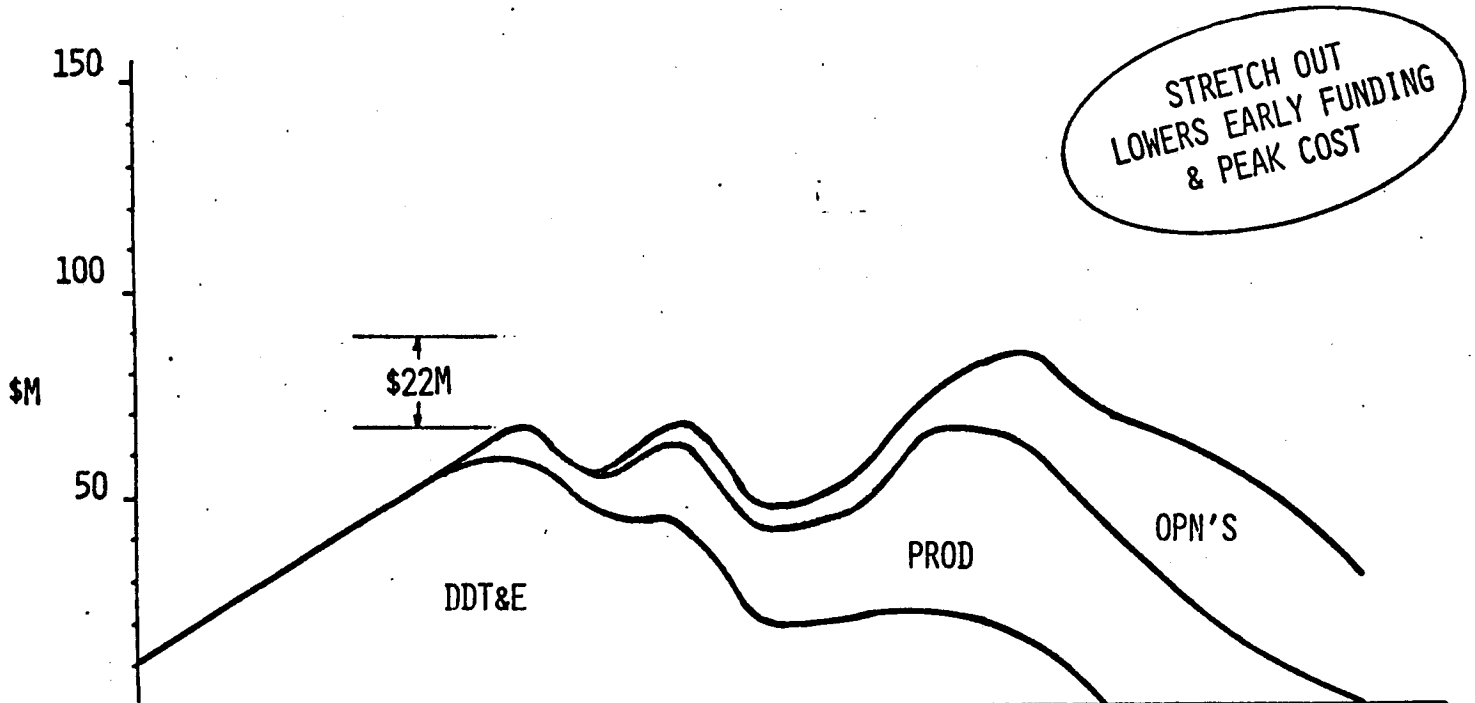
III-8.8-2

PHASE C/D STRETCH FOR DELAYED IOC - 310-3A/310RE-3A



CY	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
FY	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
DDT&E	13	27	40	51	54	41	41	16	19	21	14				
PROD					12	12	22	27	27	44	46	35	19	8	2
OPS							3	4	6	7	19	33	40	40	38
TOTAL	13	27	40	51	66	53	66	47	52	72	79	68	59	48	40

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III-8.8-3

8.9 Risk Assessment

In making an assessment of the risk associated with each configuration in each capability option we have considered the type of technology items associated with each vehicle and the impact that it would have on the program if, for one reason or another, the item would be unavailable and an alternative solution would be required. The impact is defined, usually, in terms of added weight, lost performance and total program cost increase; in some cases the impact can be decreased weight or reduced cost.

It is assumed that all of the weight increases and all of the cost increases will occur simultaneously without benefit of any offsetting decreases in either weight or cost. For example in configuration 110A-1 we have assumed that the 44 lb. weight impact of abandoning spun aluminum tanks in favor of welded aluminum tanks is combined with a $10.0 million cost increase as a result of abandoning aluminum tanks in favor of titanium tanks due to materials compatibility or fracture mechanic issues.

Taking the summation of all the weight increases, these are converted to costs by using the $75K/lb. figure derived when we were first selecting subsystem options for incorporation with 110A-1. The $75K/lb. number represents the last step (actually the slope of the line) in our subsystems synthesis process which provides a curve of Δ weight versus Δ total program costs as we added lighter and more costly subsystems options to achieve a behicle with 3500 lb. deploy capability. In this manner we arrived at a estimate of the costs expected if we had to recover the weight growth.

In similar fashion we then summed all of the potential cost increases, ignori any offsetting cost decreases, and added these to the dollars representing the weig increases. The 110A-1 has no projected performance loss since it uses the OME 7.5K engine; the assumption is that the basic OME will have been developed to meet its weight, performance and reusability goals for the Shuttle Orbiter. In the case of configurations which use the Class I engine, for example 410AD-2, we have assumed that a 3 second Isp performance loss is possible. To convert this performance loss to costs we use the payload sensitivity factor to loss in Isp (97 lbs/sec), divide this by the payload sensitivity to inert weight and then multiply by $111/lb. to convert it to costs.

Taking all of the costs and adding them together we get a total low cost risk value of $15.3M for 110A-1 which ranges to a high value of 94.3M for 320A-3A/320AE-3A.

8.10 RISK ASSESSMENT (continued)

Where no suitable alternative exists (for example the Class I engine, or the laser radar, or the Space Storable SRM) we have identified that item as both a cost and a schedule risk without attempting to quantify the risk. In general, we are relying on the successful completion of the proposed SR&T programs to reduce or eliminate the risk of schedule slippage.

Taking configuration 110A as an example:

110A-1: This is an extremely low risk program with only two items representing a technical risk, the spun-form aluminum tanks and the prestressed filament reinforced (PFR) helium tanks. Both of these items are low risk and both have suitable, low risk alternatives available.

The incorporation of separate tanks (rather than the nested tanks used in the other configurations) further reduces the risk associated with this configuration. Level III (rather than Level IIB) autonomy also reduces the risk since there is no reliance on the 621B Navigation Satellite program. The OME 7.5K engine is the lowest risk engine program available, so its use on 110A-1 further reduces risk. The use of scaled-up LM batteries rather than fuel cells with their associated cryogenic storage tanks and valves is again the lowest risk approach available for providing electrical power. The all-aluminum structure is the lowest cost/lowest risk approach available. The short mission duration (34 hours) eliminates the need for multi-layer insulation (MLI) on most of the external surfaces there minimizing the risk of damage to the MLI during vehicle ground operations.

Since the 110A-1 does not have to communicate with payloads it has the the lowest risk communications equipment, a dedicated frequency station, to develop. Although our current approach includes making the communications equipment compatible with the NASA Tracking and Data Relay Satellite System (TDRSS) an option which can further reduce risk, is to eliminate the requirement for this equipment to meet the spread spectrum and CCIR interference requirements associated with TDRSS. The modifications of an existing IMU (the Carousel VB) and an existing computer (the CDC 469) are again the lowest risk approach identified in the GN&C and DMS areas.

Although the use of an apogee kick stage (AKS) to deploy heavier payloads reduces the sensitivity of the configuration to inert weight growth or I_{sp} loss, it does add complication to flight operations, increasing risk. Elimination of the AKS can further reduce the risk of this configuration.

310-3A/310 RE-3A RISK ASSESSMENT

TECHNOLOGY ITEM IMPACT	
• CLASS I ENG	-3 SEC ISP
• PFR TANK	+48 LB
• ADVANCED IMU	+30 LB
• GRAPHITE COMPOSITE	+38 LB
• LASER RADAR	COST/SCHED
• MATERIALS COMPATIBILITY	+13 LB
• FRACTURE MECHANICS	+13 LB
• HEAT PIPES	SCHED

VEHICLE SENSITIVITY (DEPLOY)	PLAIN
$\frac{\partial P/L}{\partial W \text{ FIXED}}$ (LB/LB)	-3.66
$\frac{\partial P/L}{\partial ISP}$ (LB/SEC)	96

- TECHNICAL RISK
  - POTENTIAL WT IMPACT: +129 LB } ≈ 760 LB OF PAYLOAD
  - POTENTIAL ISP LOSS: -3 SEC }
  - OPEN WEIGHT REDUCTION OPTION: ADV. FUEL CELL
- SCHEDULE RISK
  - PROPOSED SR&T PROGRAMS COMPLETED PRIOR TO ATP PROTECT AGAINST SCHEDULE SLIP
  - AVAILABILITY OF 621 B SATELLITES & MAIN ENGINE
- COST RISK
  - POTENTIAL Δ COST $25.9M

MODERATE RISK PROGRAM

310-3A/310RE-3A RISK ASSESSMENT

The technology items and their potential impact are shown on the opposite chart. If the PFR helium tank does not meet its goals, a 6Al4V titanium tank adds 48 lbs. to the vehicle. If the advanced IMU (Micron) is unavailable, a Carousel VB IMU plus a rate gyro unit adds 30 lbs. If the graphite composite shell fails to meet its objectives an aluminum honeycomb shell adds 30 lbs. The laser radar is an item for which no attractive alternative exists, hence it represents both a cost and schedule risk. If materials compatibility or fracture mechanics data indicate the need to change propellant tank materials from titanium to either aluminum or stainless steel the added weight would: be + 13 lbs. or +3 lbs. respectively. If the heat pipes are replaced by incorporating high heat rejection items on the active loop, there are no weight changes. To recover the weight impact on payload capability due to these possible weight increases, the advanced fuel cell is an open option.

The Class I engine is a new design based on current technology with the exception of the uncertainity in engine life and in the predicted performance with the high expansion ratio nozzles used. It is estimated that this engine can miss its performance goals by -3 seconds Isp.

Although the proposed SR&T programs protect against schedule slippage by virtue of being completed at ATP, the availability of both the main engine and the 621B Navigation Satellites remain schedule risk items.

Converting the potential Isp loss and weight increases to a total program cost at a $111K/lb value and adding the potential cost increase items, yields a total cost risk of $25.9M for 310-3A/310RE-3A.

RISK ASSESSMENT 310-3A/310RE-3A

BASELINE	ALTERNATIVE	WEIGHT, LBS	TOTAL PROGRAM COST, $M
CLASS I ENGINE	NO ALTERNATIVE	-	COST/SCHED RISK
LASER RADAR	RF RADAR PLUS REMOTE TV DOCKING (ALSO A TECHNOLOGY ISSUE) HENCE NO ALTERNATIVE	-	COST/SCHED RISK
PFR HELIUM TANK	6 AL 4V TITANIUM TANK	+48	+2.80
ADVANCED IMU (MICRON)	CAROUSEL VB IMU + RATE GYRO UNIT	+30	-7.60
GRAPHITE COMPOSITE SHELL	ALUM. HONEYCOMB SHELL	+38	+0.94
TITANIUM TANKS (COMPATIBILITY DATA & FRACTURE MECHANICS DATA)	STAINLESS STEEL, OR ALUMINUM	+3, OR +13	TBD
HEAT PIPES	USE ACTIVE LOOP/BYPASS	NONE	NONE

SUMMING HIGHER WEIGHTS & COSTS ONLY ---------- 129 LBS ---------- $3.74M

CONVERT WEIGHT TO $ at $111K/LB ---------- (129 X 111K) ---------- 14.30

CONVERT - 3 ISP TO $ ---------- $\left(\frac{3 \times 96}{3.66} \times 111K\right)$ ---------- 7.85

TOTAL COST RISK ---------- $25.89M

Section 8.10 Supporting Research and Technology

This section includes a summary matrix chart which identifies all of the SR & T items and where they are applied to each configuration in each capability option.

Following the summary matrix there are individual tables for each configuration which summarize the technology items for that particular configuration and give a very brief synopsis of the type of SR & T program proposed and the estimated funding and schedule requirements. The text following each table is the facing page text prepared for the main presentation.

Following the tables for each configuration, an additional form is filled out for each technology item providing status information, justification for the proposed SR & T program, objectives, technical approach, and a more detailed schedule showing when the proposed program must be completed in order to support the particular configuration.

In dealing with the subject of SR & T we have identified two distinct groups - one where technology is needed and the other where there is no doubt that the technology is available and it is a straightforward engineering task to accumulate data that will preclude making a "false start" where several alternates are under study; we have called the latter group "desired data".

The storable Tug will benefit from the fact that the APOLLO LM program has used similar materials, propellants, equipments and procedures; the Shuttle Orbiter will expand on this data base for the Tug. The low number of identified SR & T items and the modest sums projected are based on the assumption that several existing or planned efforts related to the Shuttle will continue to provide data. These include the planned propellant and materials compatibility testing in support of the Shuttle Orbital Maneuvering Subsystem, its engines, tanks and components both at NASA/WSTF and at the Shuttle contractor's facilities. In addition, we have identified the Air Force funded efforts to develop the advanced Micron IMU for aircraft programs, as an effort which we would build-on rather than to start from scratch.

We have not attempted to detail the SR & T programs required on the Class I engine (with or without the two position nozzle) except to point out the uncertainty associated with the anticipated engine life and the predicted performance of very high expansion ratios within the mixture ratio of interest. The engine contractor will provide the proposed SR & T efforts required on the engine and we will provide comments on same at NASA's request.

The overall "message" which we hope will become obvious to the reader is that there are no real "show-stoppers" among the SR & T items identified.

TECHNOLOGY REQUIREMENTS AND "DESIRED DATA"

		110-A1	410AD-2	310-3A 310RE-3A	320-3A 320AE-3A	310-3B 310ARE-3B	510A-3B 510ADE-3B
S R & T	CLASS I ENGINE, HIGH E PERF		X	X	X	X	
	TWO-POSITION NOZZLE				X		
	LASER RADAR		X	(X)	(X)	(X)	(X)
	PFR HELIUM TANK	X	X	X	X	X	X
	ADVANCED FUEL CELL				X		
	ADVANCED IMU		X	(X)	(X)	(X)	(X)
	GRAPHITE COMPOSITE		X	X	X	X	
	SPUN-FORM ALUM. TANKS	X					X
	LONG TERM SPACE STORABLE SRM		X				(X)
DESIRED DATA	MATERIALS COMPATIBILITY DATA	X	X	X	X	X	X
	FRACTURE MECHANICS DATA	X	X	X	X	X	X
	HEAT PIPE DATA	X	X	X	X	X	X

(X) REQUIRED PRIOR TO GO AHEAD ON EVOLVED TUG CONFIGURATIONS

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310-3A/310RE-3A TECHNOLOGY REQUIREMENTS & DESIRABLE DATA

	ITEM	SR&T FUNDS $K	SR&T SCHEDULE MOS.	PROPOSED PROGRAM
SR&T	CLASS I ENGINE	TBD	TBD	HIGH ALT. TESTS TO OBTAIN PREF. DATA ON HIGH ϵ NOZZLE FOR MIXTURE RATIO RANGE
	LASER RADAR	500	12	FAB & TEST LIGHTWEIGHT, LOW POWER UNIT USING IMPROVED OPTICS & LIGHTER MIRROR DRIVES
	PFR HELIUM TANK	125	12	FAB & TEST 3 TANKS UNDER STATIC & DYNAMIC LOADING: AND ENVIRONMENTAL & COMPATIBILITY TESTS
	ADVANCED IMU	500	18	DEVELOP SOFTWARE FOR REDUNDANCY MGMT AND CALIBRATION OF 2 MULTI-SENSOR TYPE IMU'S
	GRAPHITE COMPOSITE	15	6	FAB GRAPHITE EPOXY HONEYCOMB SAMPLES & TEST IN VARIOUS PLY DIRECTIONS FOR DESIGN DATA
DESIRABLE DATA	MATERIALS COMPATIBILITY DATA	25	6	2219-T87, 2218-T81 & 6Al4Al4VTi; WITH N_2O_4 & MMH UP TO 130°F
	FRACTURE MECHANICS DATA	25	6	2219-T87 & 6Al4VTi; Kic Kth & FLAW GROWTH WITH N_2O_4 & MMH UP TO 130°F
	HEAT PIPES	100	12	FAB & TEST VARIABLE CONDUCTANCE HEAT PIPE RADIATOR & HEADER FOR TURN DOWN RATIO AND SHUTOFF HEAT FLUX DATA

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TECHNOLOGY REQUIREMENTS AND DESIRED DATA - 310-3A/310RE-3A

The upper part of the facing chart contains the supporting research and technology (SR&T) items required for 310-3A/310RE-3A; the lower part of the chart contains what we have termed as "desired data". The distinction between the two is that the "desired data" items do not require technology but are considered straightforward engineering development tasks to produce design data prior to Tug program go-ahead (ATP); this will preclude impacting Tug schedules should the data indicate the desirability of an alternative approach, (vis., aluminum or stainless steel tanks rather than titanium).

Excluding the SR&T on the Class I engine, the total SR&T funds requested for 310-3A/310RE-3A is $1,290 K to be expended over an 18 month period culminating at Tug ATP or prior to go-ahead on the evolved Tug. The advanced (Micron) IMU is the long lead item (18 months), again excluding the Class I engine.

410 AD-2, 310 RE-3A, 320 AE-3A, 310 ARE-3B, 510 ADE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Avionics (GN&C)
(Discipline)

TITLE Low Weight/Power, (Rendezvous and Docking) Laser Radar

WBS No. 320-03-03-02

STATUS ITT-Gilfillan has been under NASA Contracts since 1964 to design, develop, build, and test various spaceborne laser radar systems. The third generation system will be delivered in late November 1973.

JUSTIFICATION The application of the above developed technology to meet specific space tug rendezvous and docking requirements is desired.

In addition in order to improve the payload capability of the storable tug, low weight Avionics equipments (specifically, low weight/low power laser radar) are required.

OBJECTIVES To design, develop, fabricate, and test a low weight, low power, rendezvous and docking laser radar.

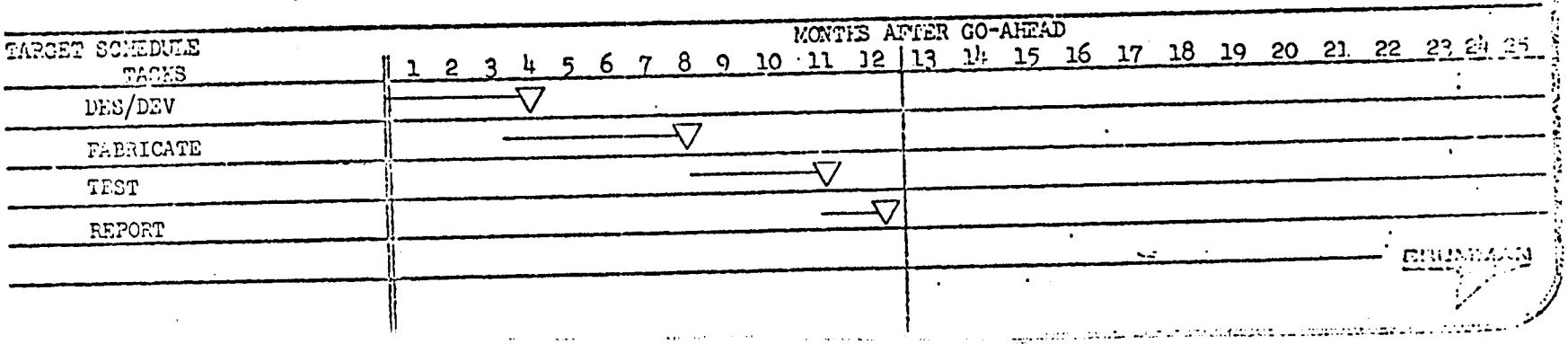
III-8.10-5

TECHNICAL APPROACH Using Tug requirements, design for light weight, low power by using new components, lighter mirror drives and improved optics

MANPOWER

FUNDING $500 K

SPECIALIZED FACILITIES Development and testing at ITT



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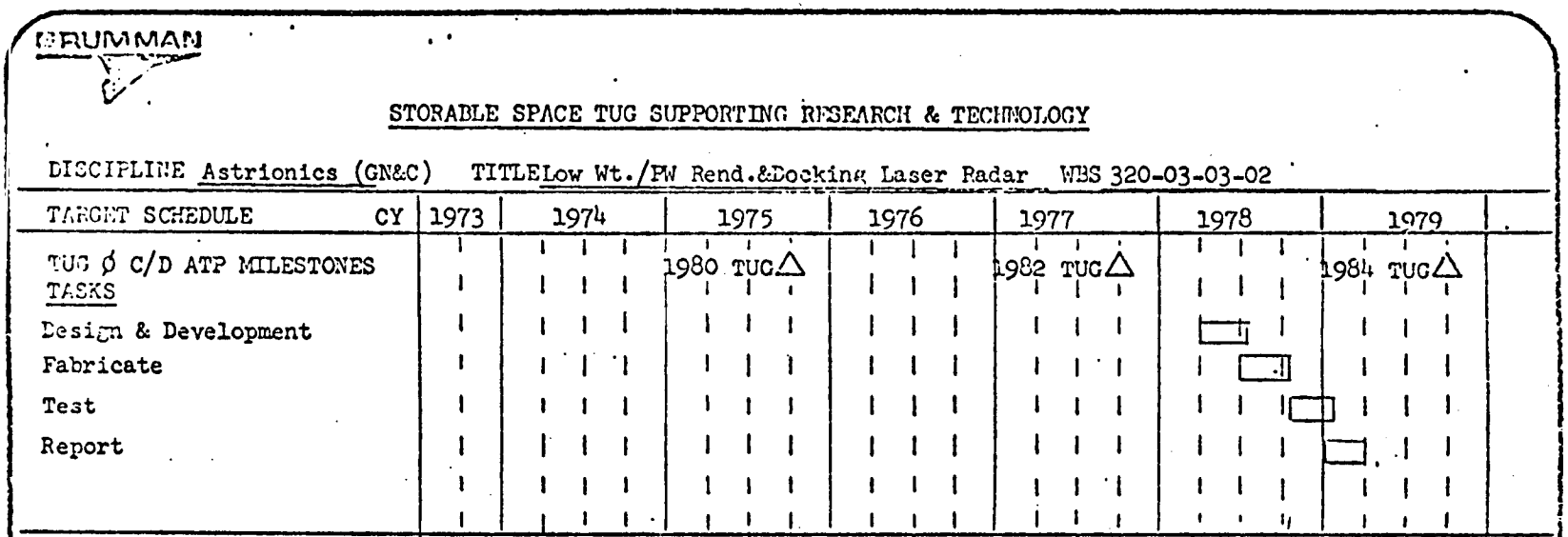
STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE Astrionics (GN&C) TITLE Low Wt./PW Rend.&Docking Laser Radar WBS 320-03-03-02



RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)					4	12	16
FUNDING							
a) DIRECT LABOR					100K	300K	400 K
b) EQUIPMENT & MAT'L					20K	40K	60 K
c) FACILITIES					40K	--	40 K
d) OTHER (SPECIFY)							
TOTAL					160K	340K	500 K

SPECIALIZED FACILITIES
TYPE/LOCATION/AVAILABILITY
FACILITIES DEV. TIME & COST

Optics bench, dark rooms, test range

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Main Propulsion
(Discipline)

TITLE Prestressed Filament Reinforced (PFR) Tanks

WBS No. 320-03-04-02

STATUS Structural Composites Industries, Inc. (SCI) and Arde-Portland, Inc. are under contract to LeRC to demonstrate the feasibility of the PFR tanks. This program will result in the construction of a 24 in. diam. Ardeform PFR tank of the type assumed by our study. If successful the basic technology will be proven.

JUSTIFICATION
A PFR ambient helium storage tank is comparable with the weight of a SHe tank and its associated heat exchanger. It provides a simple and less operationally complex system compared to the SHe tank. The PFR tank also provides a leak-before-burst design which results in increased Tug safety.

OBJECTIVES
Design, fabricate, and test 3 to 6 PFR tanks to demonstrate that current manufacturing and quality control techniques are adequate to produce a reliable, low weight tank suitable for containing gaseous helium (or hydrogen and oxygen in the case of fuel cell reactant tanks). The program will resemble a pre-qualification test program which will demonstrate the ability of the PFR tank to undergo the dynamic loading, compatibility, environmental exposure and etc. tests required for acceptance as a flight item.

III-9.10-1

TECHNICAL APPROACH

Fabricate 3 to 6 tanks and subject them to a pre-qualification test program to demonstrate the maturity of the design.

MANPOWER 2 man years

FUNDING $125,000

SPECIALIZED FACILITIES
Available at tank manufacturers

TARGET SCHEDULE

TASKS	MONTHS AFTER GO-AHEAD 1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Fabricate Tanks		
Test Program		
Analysis and Report		

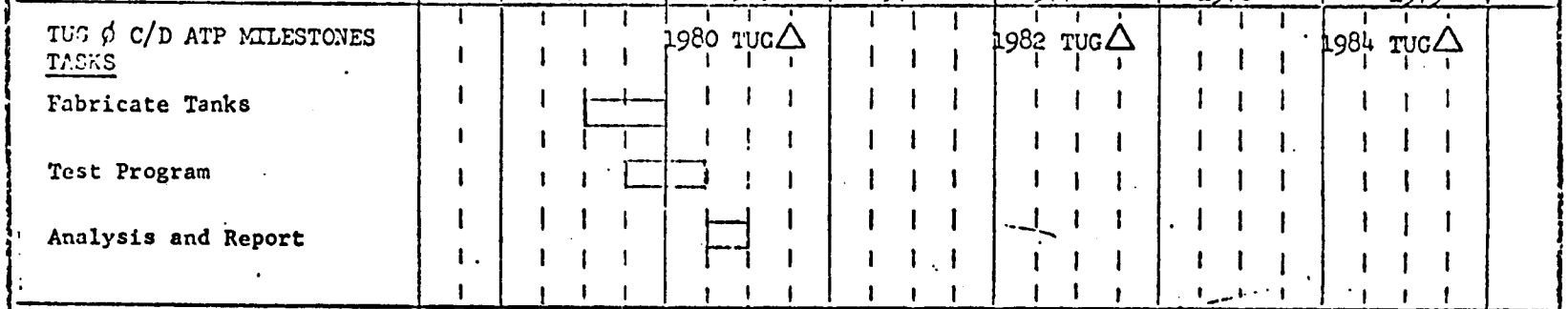
GRUMMAN

BOEING

ALL EXCEPT 410AD-2

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE MAIN PROPULSION (MPS) TITLE PRESTRESSED FILAMENT REINFORCED (PFR) TANKS WBS 320-03-04-02



RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)	1	1					
FUNDING							
a) DIRECT LABOR	$ 38,000	$ 37,000					$ 75,000
b) EQUIPMENT & MAT'L	$ 30,000	$ 20,000					$ 50,000
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL	$ 68,000	$ 57,000					$125,000

SPECIALIZED FACILITIES

TYPE/LOCATION/AVAILABILITY: ARDE, SCI, or Similar

FACILITIES DEV. TIME & COST: None

410 AD-2, 310 RE-3A, 320 AE-3A, 310 ARE-3B, 510 ADE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Astrionics (GN&C)
(Discipline) WBS #320-03-03-02

TITLE Advanced (Low Weight) Inertial Measurement Unit for Space Application

STATUS Advanced Lightweight Unit being developed under Air Force Contract. Primarily for aircraft application.

JUSTIFICATION To improve payload capability of a storable tug, low weight Astrionics Equipments are required.

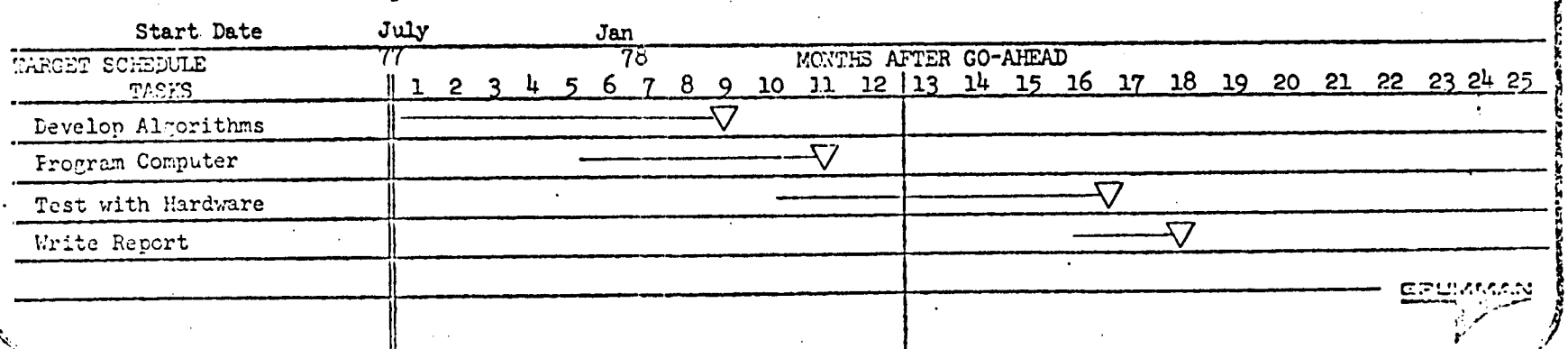
OBJECTIVES To develop the advanced IMU to the point where it can be used in a space application.

II-8.10-9

TECHNICAL APPROACH
1. Develop software mechanizations for redundancy management.
2. Develop software and procedures for calibration of gyros on the launch pad.
3. Test the software with the hardware in the lab.

MANPOWER FUNDING $500 K

SPECIALIZED FACILITIES Development and test in subcontractor's facility.



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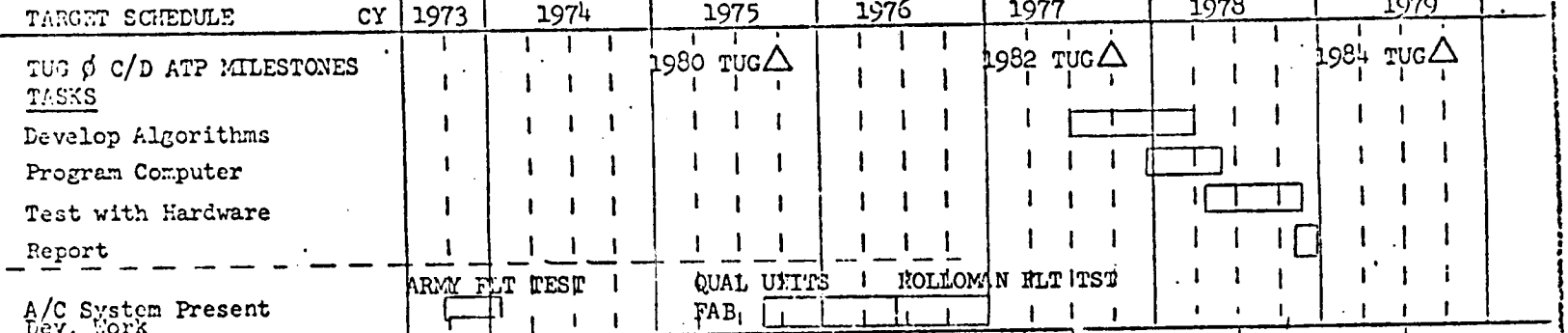
STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE Astrionics (GN&C) TITLE Advanced IMU WBS 320-03-03-02



RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)				4	8		12
FUNDING							
a) DIRECT LABOR				100 K	200 K		300 K
b) EQUIPMENT & MAT'L					100 K		100 K
c) FACILITIES Inertial Test Stand					100 K		100 K
d) OTHER (SPECIFY)							
TOTAL				100 K	100 K		500 K

SPECIALIZED FACILITIES TYPE/LOCATION/AVAILABILITY FACILITIES DEV. TIME & COST	Development and test at subcontractor's facility.

III-8.10-12

410 AD-2, 310-3A/310 RE-3A, 320 A-3A/320 AC-3A, 310-3B/310 ARE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - STRUCTURES
(Discipline)

TITLE GRAPHITE/EPOXY HONEYCOMB WBS No. 320-03-01-03

STATUS Graphite/Epoxy honeycomb is well within Grumman's capability; however, the use of .0025" single ply to achieve a buildup to 0.012 face sheets requires further development.

JUSTIFICATION This design provides the lightest weight shell structure.

OBJECTIVES To establish, by test, design allowables for honeycomb structural components using metallic honeycomb core with graphite/epoxy face sheets utilizing 2.5 mil ply thickness to achieve a total face sheet thickness of 12 Mil.

III-5.10-11

TECHNICAL APPROACH Std. Test specimens will be fabricated using various combinations of ply directions to validate design allowables obtained from classic lamination theory.

MANPOWER Tooling 100 MHRS FUNDING $15K
Mfg. 400 MHRS M & P 160 HRS. -
SPECIALIZED FACILITIES

TARGET SCHEDULE — MONTHS AFTER GO-AHEAD

TASKS	1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Fabricate Test Specimens	├──┤	
Test	├──┤	
Report	▽	

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE STRUCTURES TITLE GRAPHITE/EPOXY HONEYCOMB THIN GAGES WBS 320-03-01-03

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG ø C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS							
o FABRICATE GR/EP HONEYCOMB USING .0025 PLIES to obtain UP TO 0.012 FACE SHEETS.							
o STANDARD TEST SPECIMENS WITH VARIOUS PLY DIRECTIONS TESTED TO OBTAIN DESIGN DATA							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS) ½ MAN YEAR							
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L							
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							

SPECIALIZED FACILITIES

TYPE/LOCATION/AVAILABILITY

FACILITIES DEV. TIME & COST

21-01-8-III

ALL TUG VEHICLES

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Structures
(Discipline)

TITLE Material Compatibility

WBS No. 320-03-01-01-02

STATUS Material compatibility of Ti-6AL-4V STA and 2219-TS7 Aluminum alloy in the presence of MMH at temperatures up to 150°F is required. Compatibility of N_2O_4 with 2219-T87 is also required.

JUSTIFICATION Compatibility of propellants with tankage material must be assessed to obtain the reuse life of the tanks under cyclic loads.

OBJECTIVES The objective of the program is to obtain the static and fatigue properties of the tankage parent and weldment materials under cyclic exposure to propellants and load.

TECHNICAL APPROACH Static and fatigue properties of candidate materials specimens will be obtained prior to and after exposure to the propellants. Tests will be performed at R.T. and 150°F.

MANPOWER One man-year

FUNDING $ 25 K

SPECIALIZED FACILITIES

TARGET SCHEDULE TASKS	MONTHS AFTER GO-AHEAD 1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Test Plan		
Spec. Fab.		
Test		
Report		

ALL TUG VEHICLES

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE STRUCTURES TITLE MATERIALS COMPATIBILITY DATA WBS 320-03-01

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG Ø C/D ATP MILESTONES			1980 TUG△		1982 TUG△		1984 TUG△
TASKS o FABRICATE & TEST MATERIAL SPECIMENS OF PARENT MAT'L & WELDMENTS TO OBTAIN COMPATIBILITY DATA FOR N_2O_4 & MMH UP TO 200°F. MATERIALS GAL-4V, 2219-T87 & T-81							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS) ONE MANYEAR							
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L							
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							

SPECIALIZED FACILITIES
TYPE/LOCATION/AVAILABILITY
FACILITIES DEV. TIME & COST

ALL TUG VEHICLES

STORABLE SPACE PROPULSION SUBSYSTEM TECHNOLOGY - Structure
(Discipline)

WBS No. 320-03-01-01-02

TITLE Fracture Mechanics Test Data

STATUS Fracture mechanics test data for thin gage (.020 to .040) for Titanium 6AL-4V STA and 2219-T87 aluminum alloy exposed to N_2O_4 and MMH at temperatures up to 200°F is not available.

JUSTIFICATION Fracture mechanics data for thin gage tank material are required to assess the fracture mode and life cycle of the tug propellant tanks.

OBJECTIVES The objectives of the program are to obtain K_{ic}, K_{th} and flaw growth data for parent and weldment materials in the induced thermal environment up to 200°F. Data to be obtained prior to and after exposure to the candidate propellants. In addition to fracture mechanics data, NDE techniques are to be employed on the test specimens to assess flaw detection capability.

III-8.10-15

TECHNICAL APPROACH Standard fracture elemental specimens are to be employed. Tests are to be employed. Tests are to be conducted at room temperature and at 150 and 200°F. Surface flaws of various sizes are to be used and NDE techniques are to be employed to document size where practical.

MANPOWER One man-year

FUNDING $25K

SPECIALIZED FACILITIES

TARGET SCHEDULE

MONTHS AFTER GO-AHEAD

TASKS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Test Plan	├─┤																								
Spec. Fab.		├─┤																							
Test			├─┤	├─┤	├─┤	├─┤																			
Report						▽																			

ALL TUG VEHICLES

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE STRUCTURES

TITLE FRACTURE MECHANICS DATA

WBS 320-03-01 = 01 02

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG Ø C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS							
o FABRICATE & TEST MAT'L SPECIMENS (Parent metal & weldments) to obtain K_{IC} K_{TH} & FLAW GROWTH DATA FOR INDUCED ENVIRONMENTS INCL. 200°F. ALSO STATIC & FATIGUE DATA. MAT'LS 6AL-4V & 2219-T87 & T81							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)							
ONE MAN YEAR							
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L							
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							

SPECIALIZED FACILITIES

TYPE/LOCATION/AVAILABILITY

FACILITIES DEV. TIME & COST

III-8.10-16

110A-1, 410AD-2, 310-3A/310AE-3A, 320A-3A/320AE-3A, 310-3B/310AE-3B, 610A-3B/610ADE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Thermal Control
(Discipline)

TITLE SPACE TUG HEAT PIPES WBS No. 320-04-02

STATUS

Heat pipes (HP) are currently being used in both ground and space application. The variable conductance heat pipe (VCHP) principle is particularly attractive for Tug application but requires further development.

JUSTIFICATION

The fuel cell and certain high power density avionics units carried on the Space Tug require active cooling. Trade studies which have examined pumped loop radiators, sublimators and various heat pipes have indicated the obvious merits of the variable conductance heat pipe. A VCHP radiator could interface with the pumped loop heat transport system of the fuel cell, eliminating the cost and complexity of a selective stagnation radiator with its associated unreliable automatic bypass valves. A VCHP header, a heat transport device, could provide for high power density avionics heat transport without recourse to the active loop.

61-01-8-III

OBJECTIVES

Emphasis will be placed on experimentally obtaining the large turn down ratios which appear theoretically achievable and in developing predictive techniques.

TECHNICAL APPROACH

Design, fabricate and test a VCHP radiator and VCHP header and experimentally determine performance with emphasis on turn down ratio and shut off heat flux levels.

MANPOWER 5580 manhours FUNDING $100K

SPECIALIZED FACILITIES

Grumman Thermal Laboratory

TARGET SCHEDULE — MONTHS AFTER GO-AHEAD

TASKS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Establish Test Plan	-																								
Material Procurement		-																							
Design & Fab Test Specimens		—	—	—	—																				
Conduct Engineering Tests						—	—	—	—																
Analyse Test Results									—	—	—	—													
Final Report											—	—													

GRUMMAN

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE _____ TITLE _____ WBS _____

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG Ø C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS							
TEST PLAN							
DESIGN & FAB TEST SPECIMEN							
CONDUCT TEST							
ANALYSIS & FINAL RPT							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)	1.5	1.5					
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L	100K						
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							

SPECIALIZED FACILITIES TYPE/LOCATION/AVAILABILITY FACILITIES DEV. TIME & COST: GRUMMAN THERMAL LAB, BETHPAGE N.Y., AVAILABLE & FULLY DEVELOPED

III-8.10-15

8.11 SPECIAL COST SENSITIVITIES

REFERENCE:

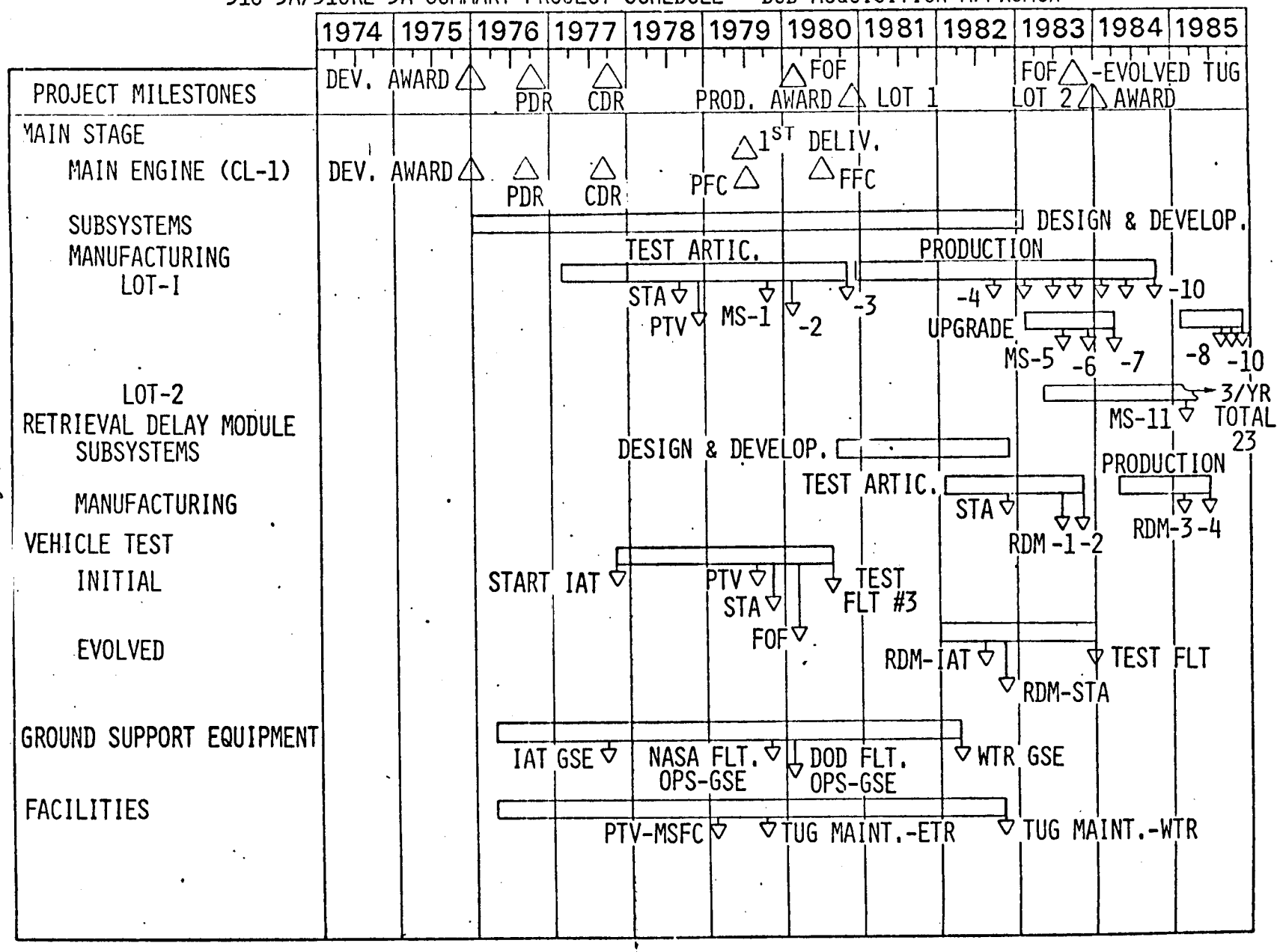
Due to the size and development of the Special Cost Sensitivities Analysis reference is made herein to Part I, concept 110A-1, paragraph 8.11 of Volume 8.

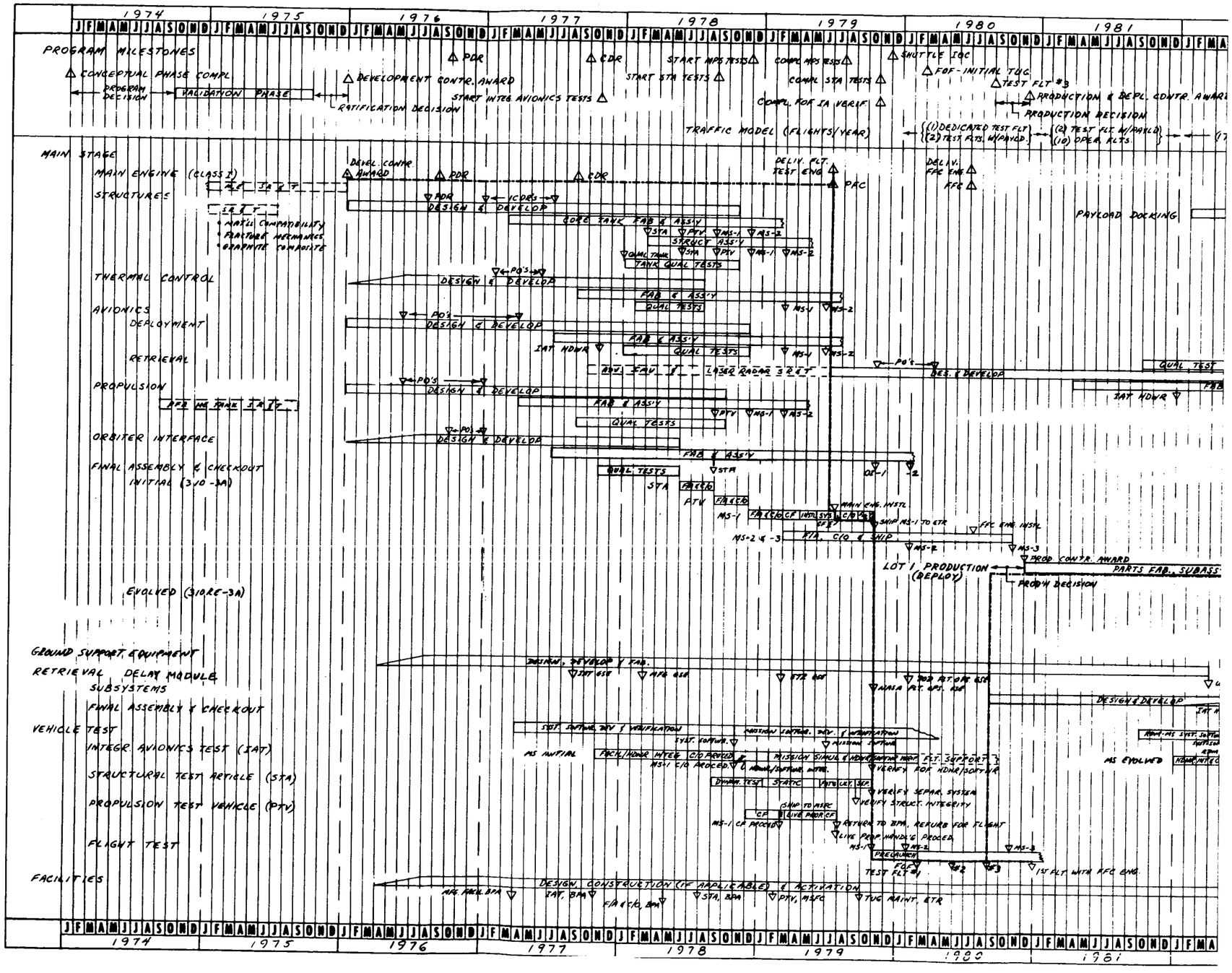
8.12 DOD ACQUISITION APPROACH

310-3A/310RE-3A

The rationale for phasing from the Full Scale Development Phase to the Production Phase for the initial 310-3A configuration is as described in Part I, Paragraph 8.12.2. Production go-ahead for the evolved 310RE configuration is based upon completion of the First Orbital Flight (FOF) which is planned to demonstrate retrieval during an operational deploy only mission. Upon the Tugs return to the vicinity of the Shuttle a retrieval demonstration will be conducted using a shuttle deployed Retrieval Delay Module (RDM) as the target vehicle. This flight, together with the previous years of deploy only operations, will provide the assurance to allow for production go-ahead.

310-3A/310RE-3A SUMMARY PROJECT SCHEDULE – DOD ACQUISITION APPROACH




1974
1975
1976
1977
1978
1979
1980
1981
PROGRAM MILESTONES
CONCEPTUAL PHASE COMPL
PROGRAM DECISION
VALIDATION PHASE
RATIFICATION DECISION
DEVELOPMENT CONTR. AWARD
PDR
CDR
START INTEG. AVIONICS TESTS
START STA TESTS
START MPS TESTS
COMPL. MPS TESTS
COMPL. STA TESTS
COMPL. FOF IA VERIF.
SHUTTLE IOC
FOF - INITIAL TUG
TEST FLT #3
PRODUCTION & DEPL. CONTR. AWARD
PRODUCTION DECISION
TRAFFIC MODEL (FLIGHTS/YEAR)
(1) DEDICATED TEST FLT
(2) TEST FLTS. W/PAYLD.
(2) TEST FLT. W/PAYLD.
(10) OPER. FLTS.
MAIN STAGE
MAIN ENGINE (CLASS I)
DEVEL. CONTR. AWARD
DELIV. FLT. TEST ENG.
DELIV. FOR ENG.
FFC
PAC
STRUCTURES
PDR
DESIGN & DEVELOP
CORE TANK FAB & ASS'Y
STA
PTV
MS-1
MS-2
STRUCT ASS'Y
COMPL. TANK
TANK QUAL TESTS
PAYLOAD DOCKING
• MAT'L COMPATIBILITY
• FRACTURE MECHANICS
• GRAPHITE COMPOSITE
THERMAL CONTROL
DESIGN & DEVELOP
FAB & ASS'Y
QUAL TESTS
AVIONICS
DEPLOYMENT
RETRIEVAL
IAT HDWR
ADV. SAV. & LASER RADAR TARGET
DES. & DEVELOP
QUAL TEST
PROPULSION
AFE
HP TANK
SAT
ORBITER INTERFACE
FINAL ASSEMBLY & CHECKOUT
INITIAL (310-3A)
QUAL TESTS
STA
FAILED
PTV
MAIN ENG. INSTL.
SHIP MS-1 TO ETR
FFC ENG. INSTL.
MS-2 & -3
F/A, C/O & SHIP
MS-2
MS-3
PROD CONTR. AWARD
LOT I PRODUCTION (REPLOY)
PARTS FAB. SUBASS.
PROD'N DECISION
EVOLVED (310RE-3A)
GROUND SUPPORT EQUIPMENT
RETRIEVAL DELAY MODULE
SUBSYSTEMS
FINAL ASSEMBLY & CHECKOUT
VEHICLE TEST
INTEGR. AVIONICS TEST (IAT)
STRUCTURAL TEST ARTICLE (STA)
PROPULSION TEST VEHICLE (PTV)
FLIGHT TEST
FACILITIES
DESIGN, DEVELOP & FAB.
DESIGN & DEVELOP
AS INITIAL
AS EVOLVED
PRELAUNCH
TEST FLT #1
1ST FLT. WITH AFC ENG.
DESIGN, CONSTRUCTION (IF APPLICABLE) & ACTIVATION
IAT, BPA
STA, BPA
PTV, MSFC
TUG MAINT. ETR

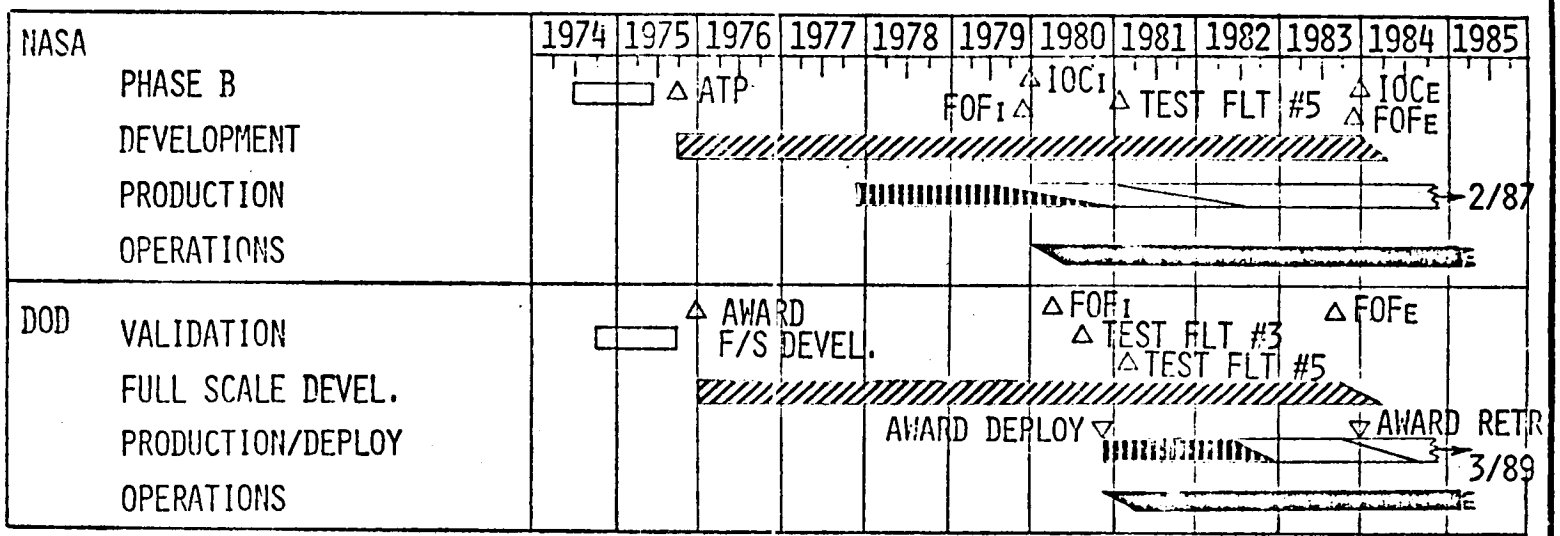
DOD ACQUISITION APPROACH (AFSCP 800-3) 310-3A/310RE-3A

Implementing program concept 310-3A/310RE-3A in accordance with DOD full funding requirements (AFSCP 800-3) results in a longer development activity plus a delay in the start of production and operations.

In this program the initial Full Scale Development Phase as in 110A-1, also lasts 63 months (1 year longer than the NASA equivalent DDT&E Phase) and includes all test flights. The evolved development activity is similarly defined and ends at the 84 IOC milestone.

The initial production award is keyed to the third test flight as in Option 1 and evolved production is keyed to the first evolved test flight. Initial payload deploy operations are performed with the three flight test vehicles. Similarly, initial payload retrieval operations are performed with two upgraded deploy/retrieval test vehicles. Through the initial/evolved program the operational fleet will be supplemented with production vehicles as they become available. We recommend that production article procurement follow a 2 lot deploy buy (4/3 vehicles per lot), a 2 block vehicle upgrade (2 vehicles for evolved flight test and 3 vehicles for operations), plus a 4 lot retrieve buy (3/3/3 and 4 vehicles per lot).

DOD ACQUISITION APPROACH (AFSCP 800-3) 310A/310RE-3A



FULL SCALE DEVELOPMENT

- o EXTEND TO INCLUDE 5 INITIAL & 3 EVOLVED TEST FLIGHTS
- o USE FLIGHT TEST VEHICLES FOR INITIAL PAYLOAD OPERATIONS
- o ADD 2ND & 3RD DEPLOY VEHICLES FOR INITIAL OPERATIONS

PRODUCTION/DEPLOYMENT

- o PROVIDE 7 ADDITIONAL DEPLOY VEHICLES (4/3 - 2 LOT BUY)
- o UPGRADE 2 DEPLOY VEHICLES FOR EVOLVE FLIGHT TEST
- o PROVIDE 13 ADDITIONAL RETRIEVE VEHICLES (3/3/3/4-4 LOT BUY) AND UPGRADE 3 DEPLOY VEHICLES

OPERATIONS

- o DELETE 7 TEST FLIGHTS - 348 TOTAL FLIGHTS
- o TOTAL FLEET - 23 MAIN STAGES AND 4 RDM

GRUMMAN

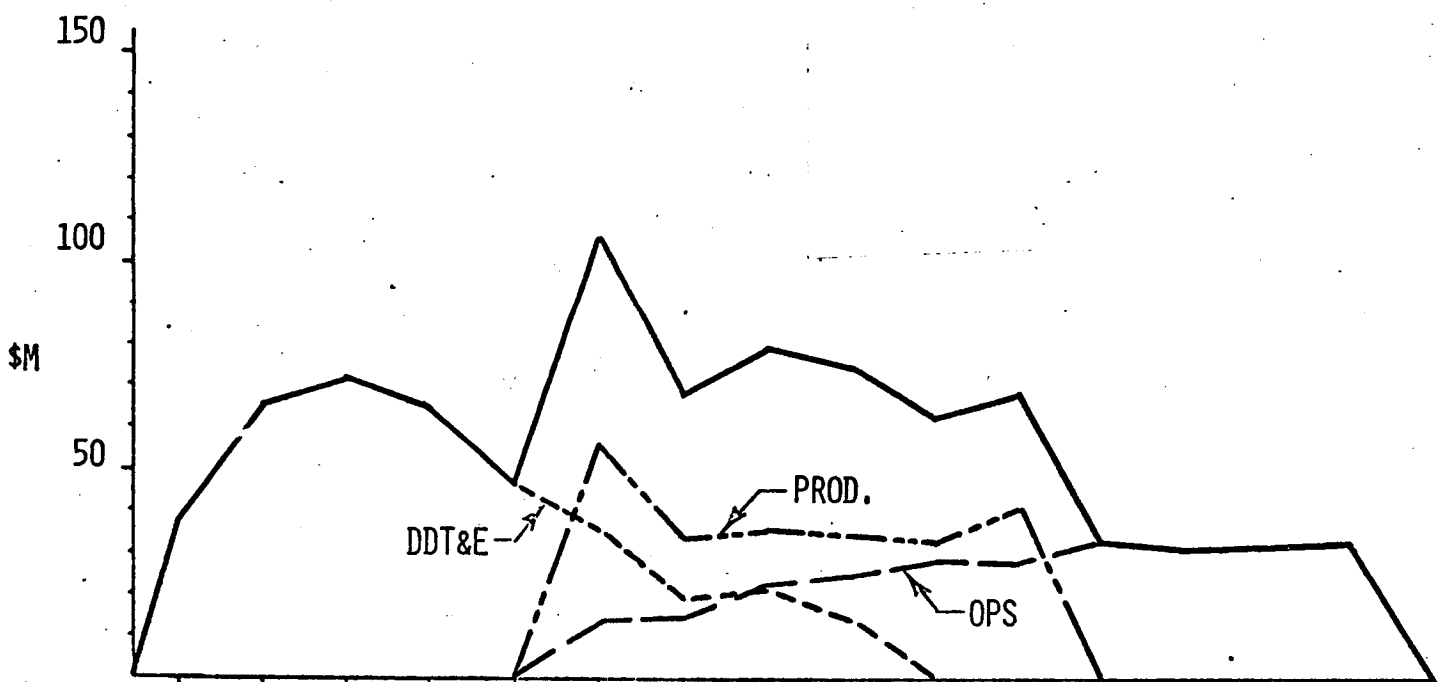
DOD ACQUISITION FUNDING 310-3A/310RE-3A

DOD funding is shown in the accompanying chart. A total of 23 vehicles is costed. Three Tugs are included in DDT&E. Seven are produced of the initial 310 configuration of which six are upgraded to the evolved 310RE configuration. Thirteen 310RE Tugs are produced in addition to the above vehicles. In comparison with the NASA 310-3A/310RE-3A program, costs have been adjusted for transfer of the cost of two Tugs to DDT&E plus transfers of early Operations Costs during initial testing, and costs associated with extension of Engineering and ground test operations. For reduction of changes, $4M was deleted for changes avoided by delaying production as compared with the "NASA" schedule.

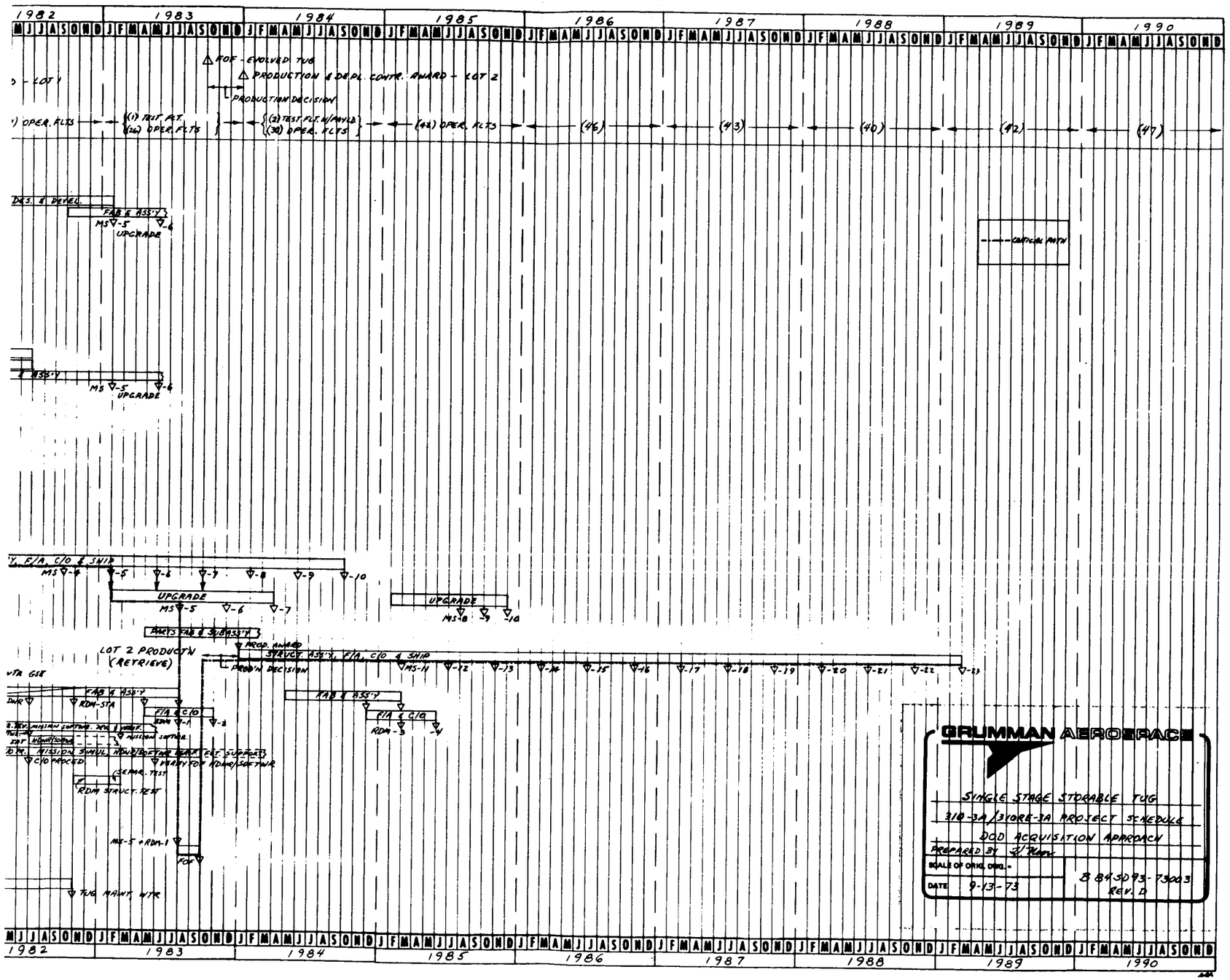
Total program funding is $871M and peak annual funding is $106M. This compares with $858M and $85M on the NASA program.

DOD AQUISITION APPROACH (AFSCP 800-3) 310-3A/310RE-3A

ANNUAL PROJECT COSTS



CY	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	
FY	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
DDT&E	37	65	71	64	47	36	19	21	14							374
PROD						56	34	36	34	33	40					233
OPS						14	15	22	26	29	28	34	31	32	33	264
TOTAL	37	65	71	64	47	106	68	79	74	62	68	34	31	32	33	871


1982
1983
1984
1985
1986
1987
1988
1989
1990
FOF - EVOLVED TUG
PRODUCTION & DEPL. CONTR. AWARD - LOT 2
PRODUCTION DECISION
OPER. FLTS
(1) TEST FLT.
(26) OPER. FLTS
(2) TEST FLT. W/PAYLD
(30) OPER. FLTS
(42) OPER. FLTS
(46)
(43)
(40)
(42)
(47)
DES. & DEVEL.
FAB & ASS'Y
MS -5
-6
UPGRADE
CRITICAL PATH
F/A, C/O & SHIP
MS -4
-5
-6
-7
-8
-9
-10
UPGRADE
MS -5
-6
-7
UPGRADE
MS -8
-9
-10
PARTS FAB & SUBASS'Y
PROD. AWARD
LOT 2 PRODUCTN
(RETRIEVE)
STRUCT. ASS'Y, F/A, C/O & SHIP
PROD'N DECISION
MS -11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
-22
-23
FAB & ASS'Y
RDM-STA
F/A & C/O
RDM -1
-2
FAB & ASS'Y
F/A & C/O
RDM -3
-4
MISSION SOFTWR.
MISSION SIMUL. HDWR/SOFTWR VERIF. FOR HDWR/SOFTWR
C/O PROCED
SEPAR. TEST
RDM STRUCT. TEST
MS -5 + RDM -1
FOF
TUG MAINT. WTR
GRUMMAN AEROSPACE
SINGLE STAGE STORABLE TUG
310-3A/310RE-3A PROJECT SCHEDULE
DOD ACQUISITION APPROACH
PREPARED BY
SCALE OF ORIG. DWG. -
DATE 9-13-73
B 84SD93-73003
REV. D

8.13 ESTIMATING TECHNIQUE APPLIED

WBS ELEMENT	DDT&E	PRODUCTION	OPN
320-01 Proj. Management	CER's Based on LM Experience	Same as DDT&E	Same as DDT&E
320-02 Syst Eng & Integ	Same as 320-01	Same as 320-01	Same as 320-01
320-03-01 Structure	CER's Lower Level Analysis	Same as DDT&E	N/A
320-03-02 Thermal Insul	Same as 320-03-01	Same as 320-03 -01	N/A
320-03-03 Avionics	Vendor Est/Manpower/Wrap-around	Same as DDT&E	N/A
320-03-04 Propulsion	Gov't Est/Vendor Est/Wrap-around	Same as DDT&E	Same as DDT&E
320-03-05 Orbiter Interface	CER's Vendor Est/Wraparound	Same as DDT&E	N/A
320-03-06 Drop Tanks	N/A	N/A	N/A
320-03-07 Final Assy & C/O	Same as 320-01	Same as 320-01	N/A
320-04-01 Structure	Same as 320-03-01	Same as 320-03 -01	N/A
320-04-02 Thermal Insul	Same as 320-03-02	Same as 320-03 -02	N/A
320-04-03 Avionics	Same as 320-03-03	Same as 320-03 -03	N/A
320-04-04 Propulsion	Same as 320-03-04	Same as 320-03 -04	Same as 320-03-04
320-04-05 Interstage Interface	Same as 320-03-01	Same as 320-03 -01	N/A
320-04-06 Drop Tanks	N/A	N/A	N/A
320-04-07 RDM	Gov't est, CER's Vendor Est, wraparound	Same as DDT&E	Same as DDT&E
320-04-08 AKS	Same as 320-04-07	Same as 320-04 -07	Same as 320-04-07
320-04-09 DKS	Same as 320-04-07	Same as 320-04 -07	Same as 320-04-07
320-04-10 Cache Tank	N/A	N/A	N/A
320-04-11 Final Assy & C/O	Same as 320-03-07	Same as 320-03 -07	N/A
320-05 Logistics	CER's	Same as DDT&E	Same as DDT&E
320-06 Facilities	CER's	Same as DDT&E	Same as DDT&E
320-07 GSE	CER's, and End-item analysis	Same as DDT&E	Same as DDT&E
320-08 Vehicle Test	CER's, Manpower Loading	N/A	N/A
320-09 Launch Ops WTR	N/A	N/A	Manpower Loading
320-10 Launch Ops ETR	N/A	N/A	Manpower Loading

WBS ELEMENT	DDT&E	PRODUCTION	OPN
320-11 Flt Ops DOD	CER's & Manpower Loading	N/A	Same as DDT&E
320-12 Flt Ops NASA	Same as 320-11	N/A	Same as DDT&E
320-13 Ref & Int, 1st TR	N/A	N/A	Manpower Loading
320-14 Ref & Int, 2nd TR	N/A	N/A	Manpower Loading

COST = A (BASE)^B	PROGRAM BASIS	BASE	A DDT&E	A PROD	B DDT&E	B PROD
PROJECT MGMT.	LM	VEH COST	.1	.09	1	1
	LM	LESS ENG.				
SE & E	LM	VEH COST LESS ENG.	.13	.08	1	1
STRUCTURE	LM	WEIGHT				
SPUN AL. TANKS			124	15	.71	.61
TI TANKS			140	24.3	.71	.61
BODY SHELL			25	2.8	.71	.61
THRUST STRUCTURE			5.5	0.4	1	1
METEOROID SHIELD			5.5	.47	1	1
PAYLOAD INTERFACE			37.2	3.4	1	1
PROPULSION						
ACPS THRUSTERS		VENDOR COST	2	1.66	.7	.7
ACPS SUPPORT		VENDOR COST	2.4	1.84		
EPS WIRING	LM	(WEIGHT)	39.7	7	.7	.7
ORBITER INTERFACE, STRUCTURE	LM	WEIGHT	5.5	.4	1	1
FINAL ASSY & C/O	LM	VEH COST	.54	.18	1	1

8.1.1 SUMMARY PROJECT SCHEDULE

Introduction: The Storable Tug Project schedule was developed to identify the principal project phases and to establish schedule estimates for all hardware and soft ware elements in accordance with the Space Tug Work Breakdown Structure.

The Tug Project Schedule depicts major program milestones and presents project activities at level 5 of the WBS. This schedule establishes the planning baseline for development of the Storable Tug System through design, development, manufacturing, ground test, flight test and operations. It integrates all supporting schedules into an overall project level plan and establishes the sequence and interdependency of activities and events required for the development of an operational Space Tug System.

Groundrules and Assumptions: Following are the ground rules and assumptions used for development of the Storable Tug Project Schedule:

- o ATP is October 1975 at the earliest for Options 1 and 3. ATP for Option 2 to be determined by the contractor.
- o Schedule planning is designed to minimize peak annual funding during DDT&E.
- o Main Stage DDT&E requirements consist of the following major test articles:
  - A structural test article (STA) for dynamic, static and fatigue tests.
  - A main propulsion test vehicle (PTV). Following the completion of live propellant testing the PTV will be refurbished and delivered as an operational flight vehicle.
  - One shipset of Avionics hardware for the Integrated Avionics Test (IAT).
  - A flight test vehicle (MS-1).
- o Operational fleet sizes for each project option are based on a study of traffic capture models.
- o Production rate of vehicles is based on avoiding duplication of major structural assembly tooling and minimizing gaps in manufacturing flow.

- Initial operational capability (IOC) is achieved after completion of one test flight (FOF). IOC dates are as follows:

  Option 1 - December 1979
  Option 2 - December 1983
  Option 3 - December 1979 - initial, December 1983 - evolved.

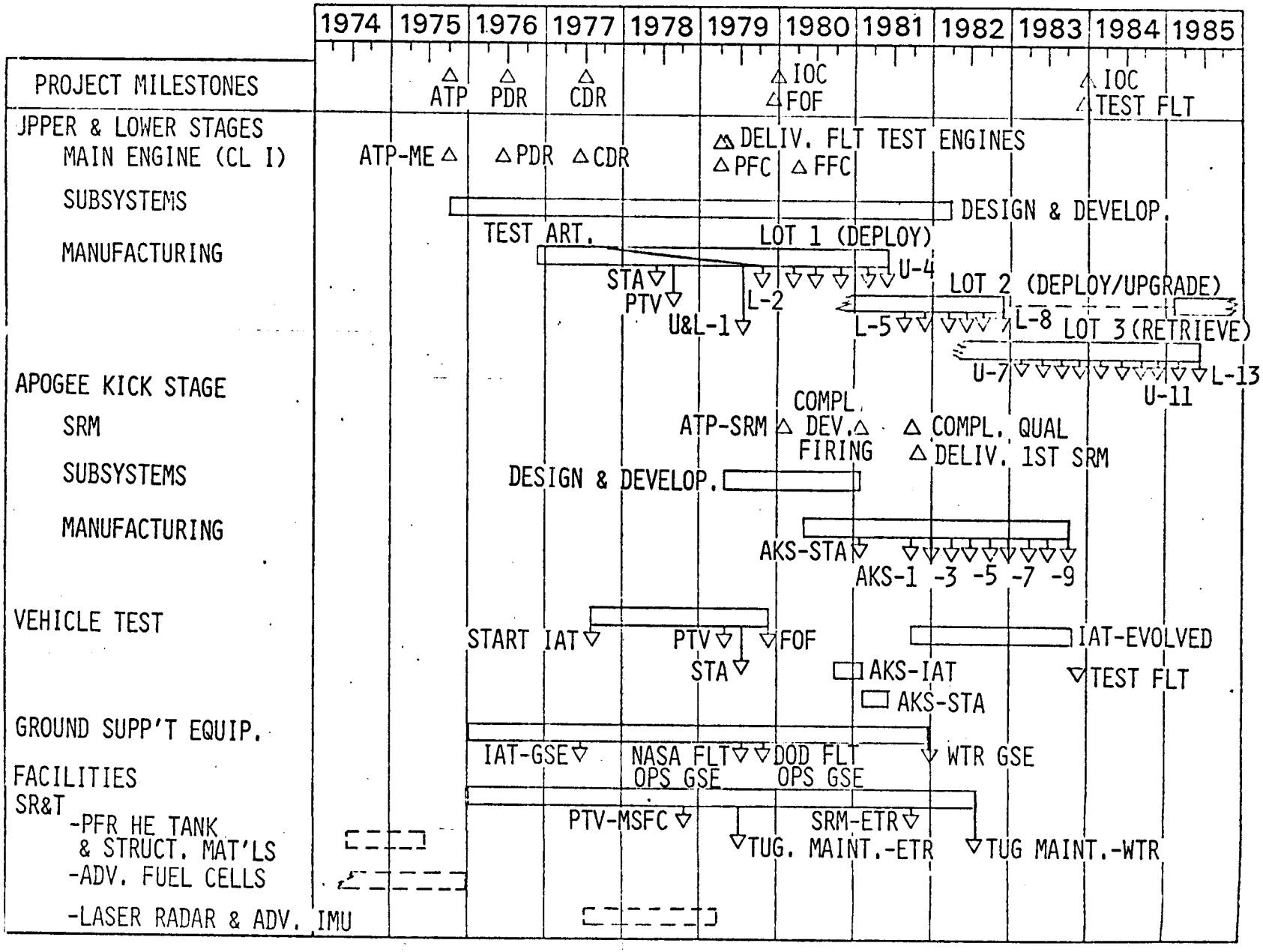
- Maximum number of flights in 1980 is 3, based on the Shuttle traffic model.

Approach: Based on the above groundrules and assumptions a preliminary project milestone schedule was developed to form a baseline for all detail scheduling. Detailed subsystem design and development schedules, manufacturing and factory checkout flows, vehicle test, GSE, facilities, and SR&T Schedules were then developed in conjunction with personnel representing the cognizant management and technical disciplines. These detailed schedules were then summarized and integrated into the Tug Project Schedule through the process of establishing a logical and achievable relationship between the engineering design and development process, procurement of subcontract equipment, hardware fabrication and assembly process and the vehicle test program that minimizes risks and ensures the fulfillment of program objectives. Finally, the major project milestones and activities presented in the Tug Project Schedule were condensed into the Summary Project Schedule.

SUMMARY SCHEDULE - 320A-3A/320AE-3A

The primary elements of the 320A-3A/320AE-3A Project Schedule include Upper and Lower Main Stages, Apogee Kick Stage, Vehicle Test, GSE, Facilities and dependent SR&T. Authorization to Proceed (ATP) occurs on October 1, 1975, with IOC of the initial configuration targeted for December 31, 1979. The Class I main engine milestones are the same as for 310-3A/310RE-3A except that quantities of engines are doubled since this is a two stage vehicle. Main Stage vehicle tests are essentially the same as for 110A-1 except for additional Integrated Avionics testing to demonstrate retrieval capability. First flight of the evolved configuration is targeted for December 1, 1983. Upper and Lower Stage manufacturing begins December 1, 1976 with production of the major ground test articles and continues through production of 11 upper and 13 lower stages to support fleet operations. These are manufactured in 3 Lots similar to 310-3A/310RE-3A for the purpose of avoiding a manufacturing gap between deploy only vehicles and evolved vehicles. As with 110A-1, development of the Apogee Kick Stage starts in May 1979 ($3\frac{1}{2}$ years after main stage ATP) and continues through the same vehicle tests to an operational test flight during the second year of operations. Nine kick stages will be manufactured to support fleet operations. GSE and Facilities are scheduled essentially the same as for 110A-1.

320A-3A/320AE-3A SUMMARY PROJECT SCHEDULE

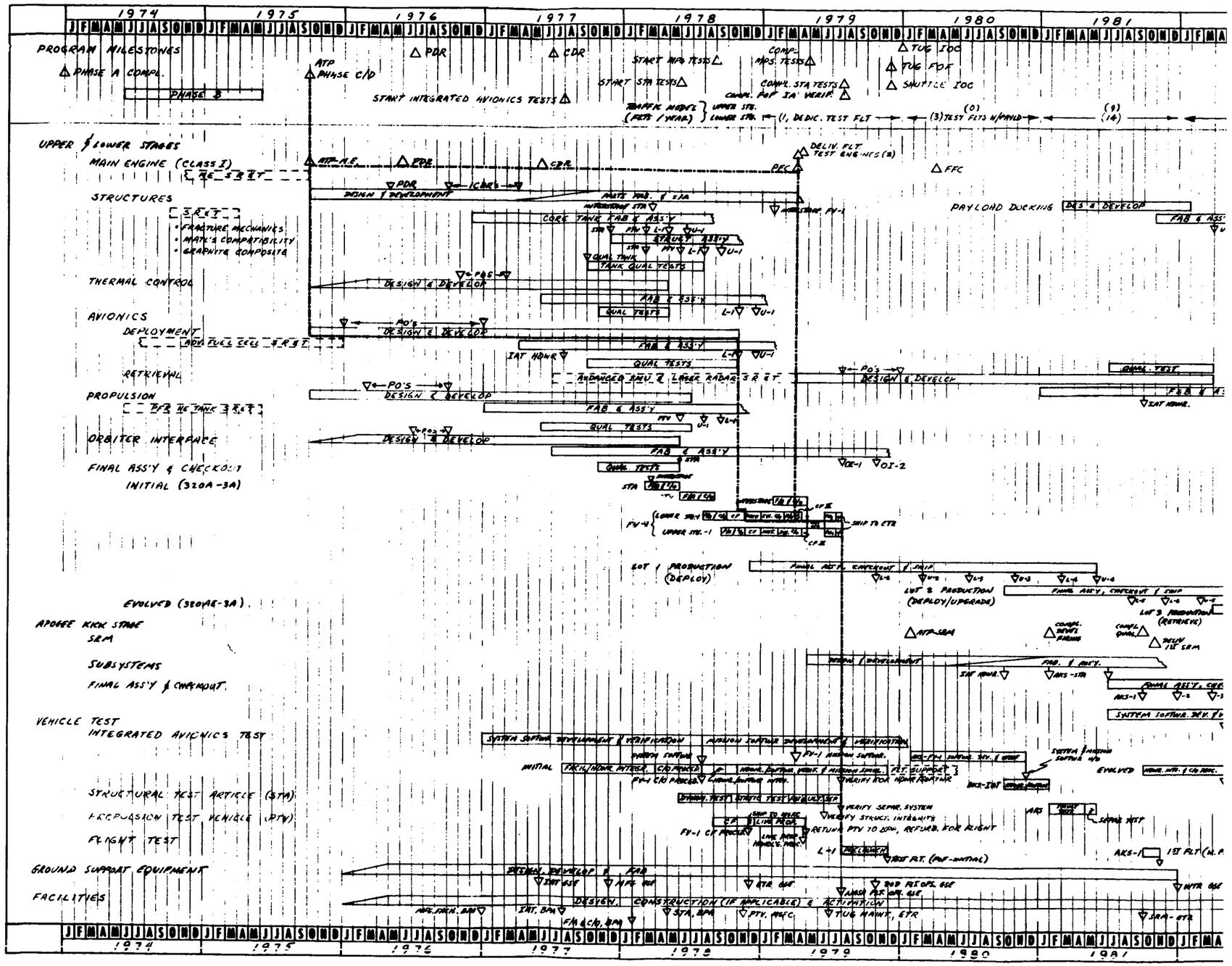


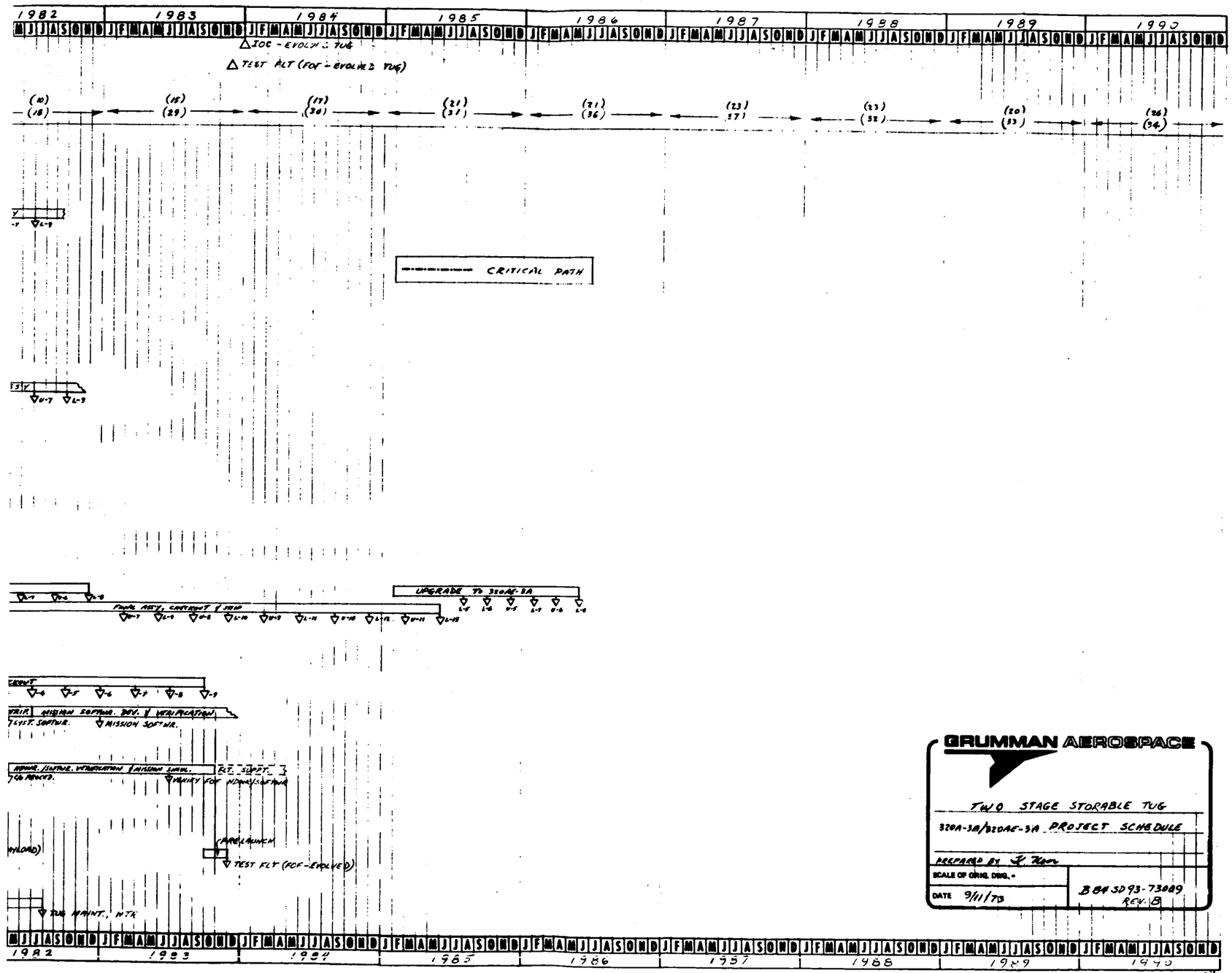
8.1.2 DEVELOPMENT SCHEDULES

8.1.3 PRODUCTION SCHEDULES

The detailed Project Schedule depicts the total development and production phases for the Main Stage and the Auxiliary Stage(s). The detailed Project Schedule is based on a constraint logic that considers overall program objectives and the detailed interaction of constraints on significant program activities. It provides reasonable margins for development problems and minimizes program front-loading.

The detailed Subsystem Schedules provide an order of magnitude increase in detail from the Project Schedule and depict the subsystem activities in both inhouse and subcontractor areas. Subsystem schedule information is presented at WBS level 6 for Structures, Thermal Control and Orbiter Interface, and at WBS level 7 for Propulsion and Avionics subsystems.


1974
1975
1976
1977
1978
1979
1980
1981
PROGRAM MILESTONES
PHASE A COMPL.
PHASE B
PDR
CDR
ATP PHASE C/D
START INTEGRATED AVIONICS TESTS
START MPS TESTS
START STA TESTS
COMP. MPS. TESTS
COMPL. STA TESTS
COMPL. POF IA' VERIF.
TUG IOC
TUG FDR
SHUTTLE IOC
TRAFFIC MODEL (FLTS / YEAR)
UPPER STA.
LOWER STA.
(1) DEDIC. TEST FLT
(3) TEST FLTS W/PAYLD
(0)
(9)
(14)
UPPER & LOWER STAGES
MAIN ENGINE (CLASS I)
ATP-M.E.
PDR
CDR
PEC
DELIV. FLT. TEST ENGINES (2)
FFC
STRUCTURES
• FRACTURE MECHANICS
• MAT'L COMPATIBILITY
• GRAPHITE COMPOSITE
PAYLOAD DOCKING
DES & DEVELOP
FAB & ASS'Y
THERMAL CONTROL
DESIGN & DEVELOP
QUAL TESTS
AVIONICS
DEPLOYMENT
RETRIEVAL
PROPULSION
ORBITER INTERFACE
FINAL ASS'Y & CHECKOUT
INITIAL (320A-3A)
EVOLVED (320AE-3A)
LOT 1 PRODUCTION (DEPLOY)
LOT 2 PRODUCTION (DEPLOY/UPGRADE)
LOT 3 PRODUCTION (RETRIEVE)
SHIP TO ETR
APOGEE KICK STAGE
SRM
SUBSYSTEMS
FINAL ASS'Y & CHECKOUT
VEHICLE TEST
INTEGRATED AVIONICS TEST
STRUCTURAL TEST ARTICLE (STA)
PROPULSION TEST VEHICLE (PTV)
FLIGHT TEST
GROUND SUPPORT EQUIPMENT
FACILITIES
DESIGN, CONSTRUCTION (IF APPLICABLE) & ACTIVATION



GRUMMAN AEROSPACE

TWO STAGE STORABLE TUG

320A-3A/320AE-3A PROJECT SCHEDULE

PREPARED BY [illegible]

SCALE OF ORIG. DWG. -

DATE 9/11/73

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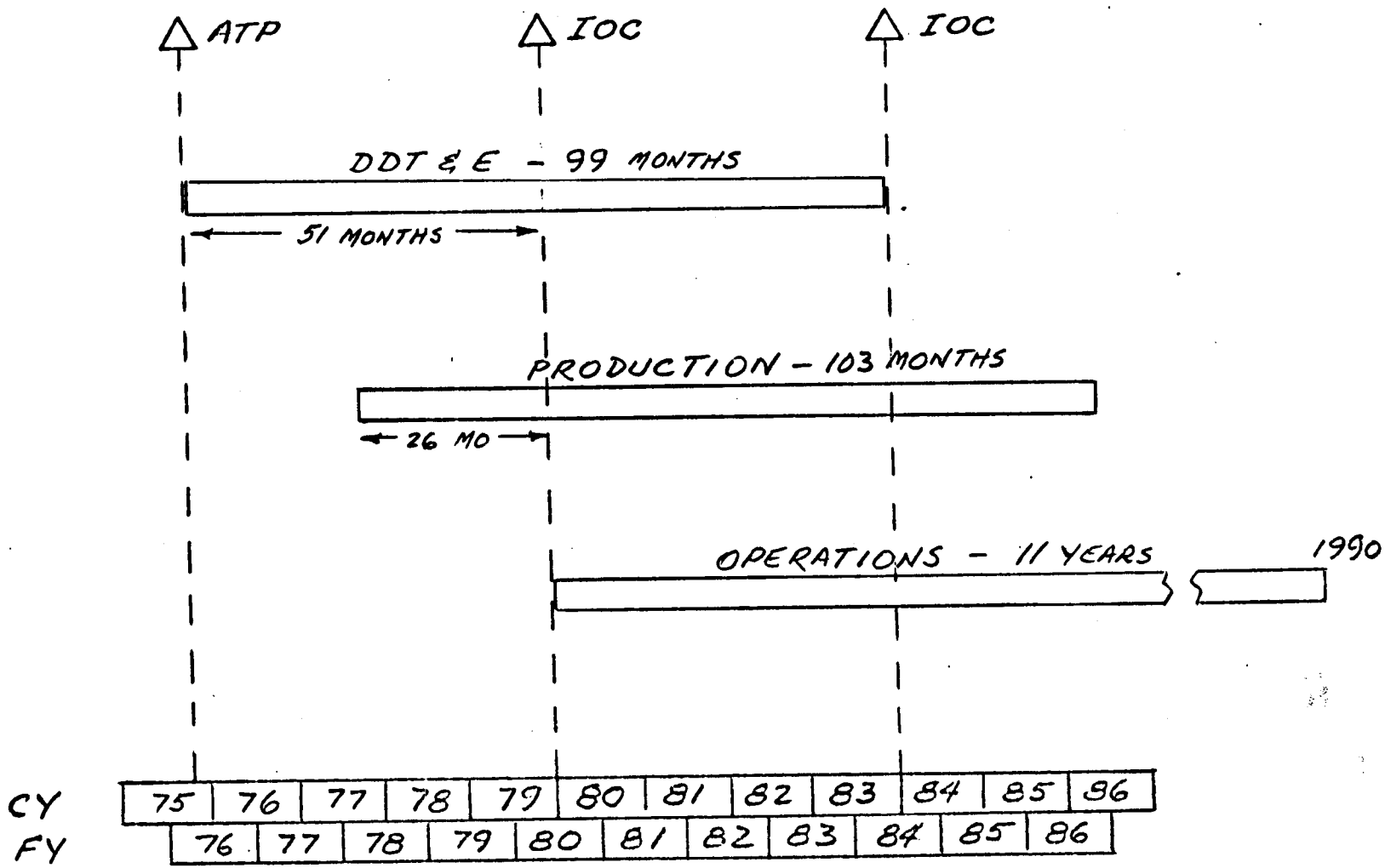
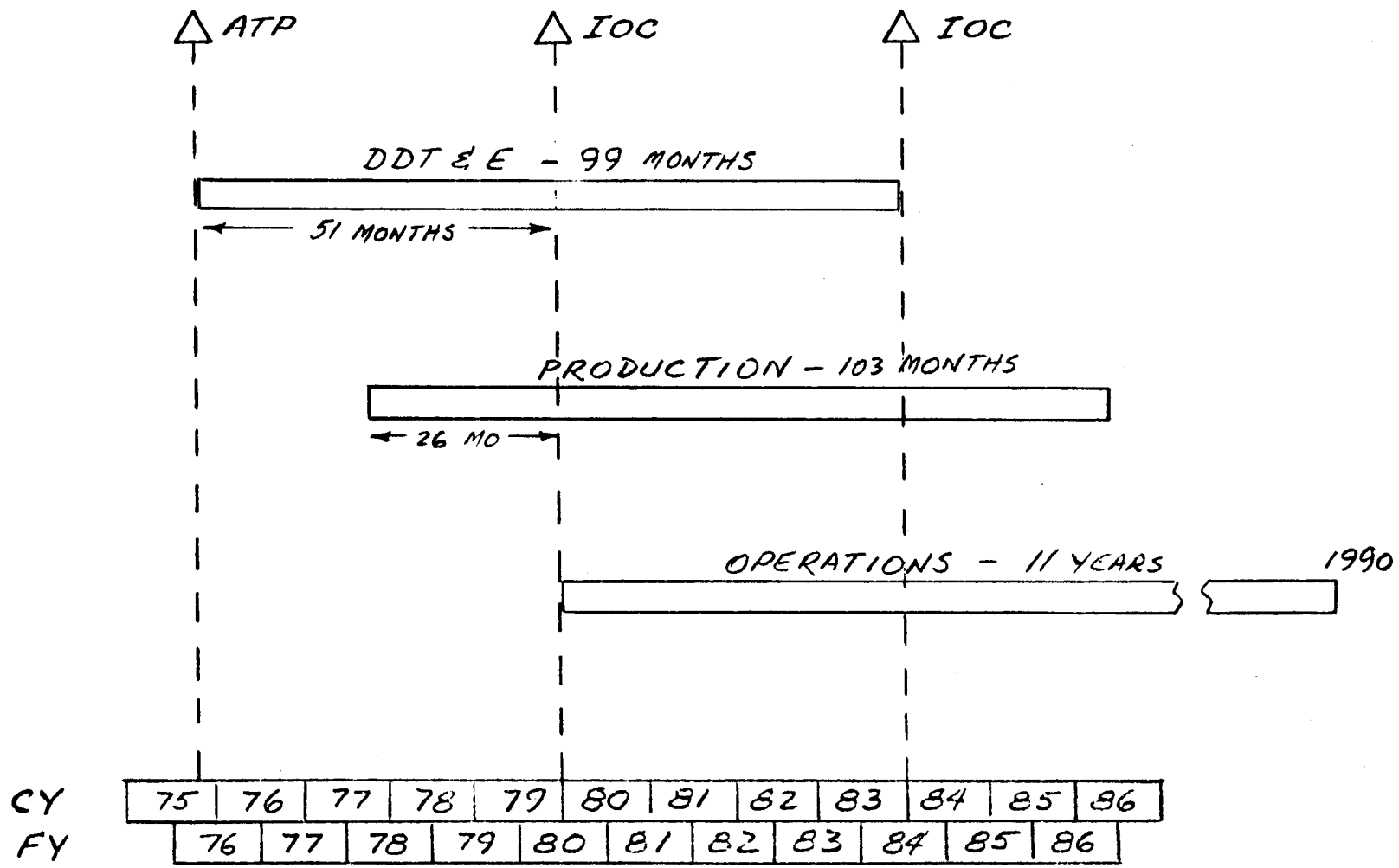
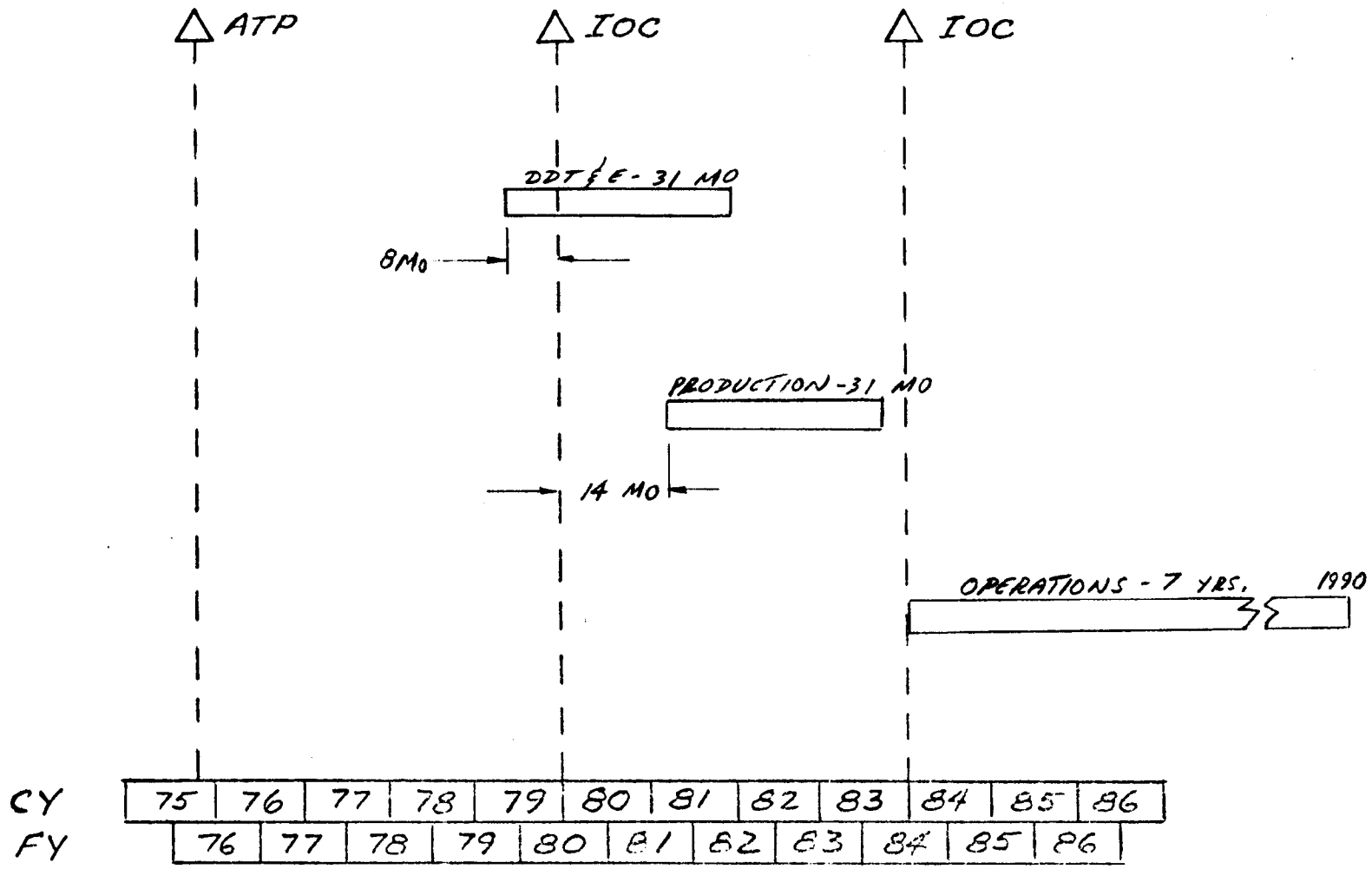
320A-3A/320AE-3A PROJECT SUMMARY

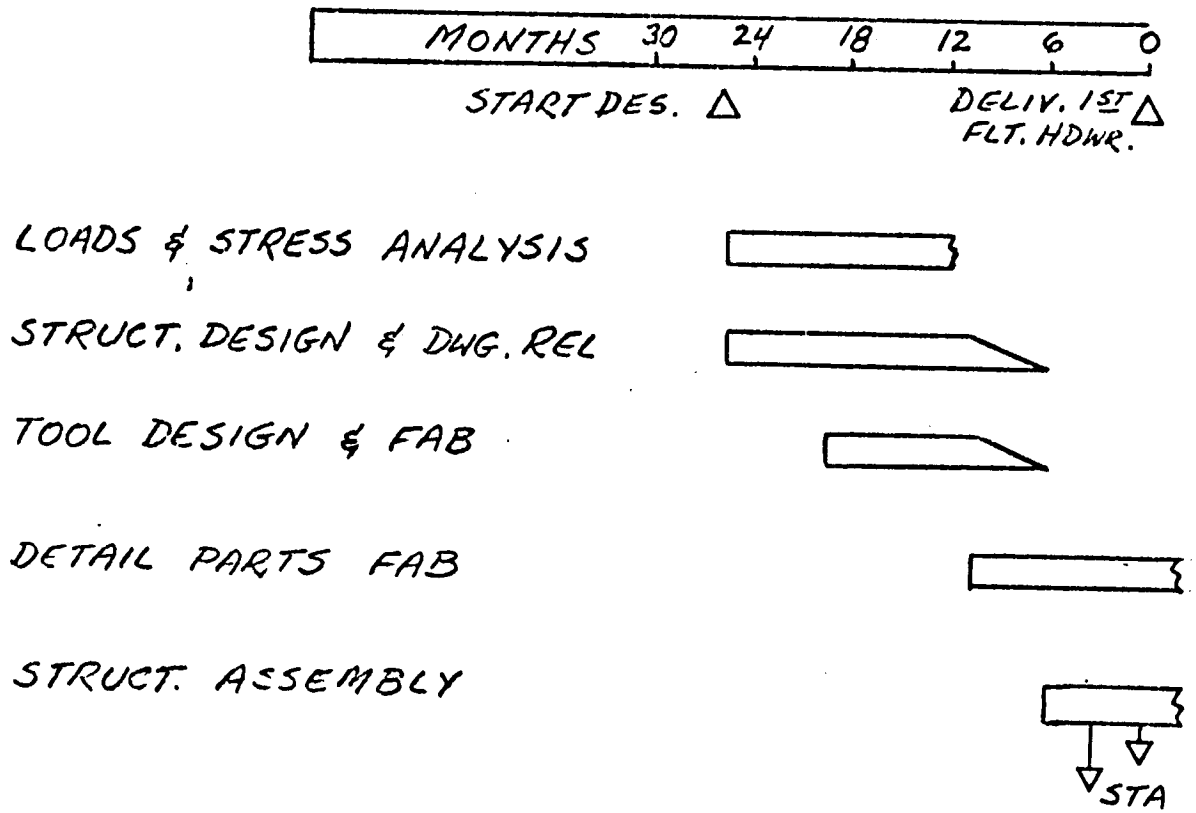


320A-3A/320AE-3A MAIN STAGE

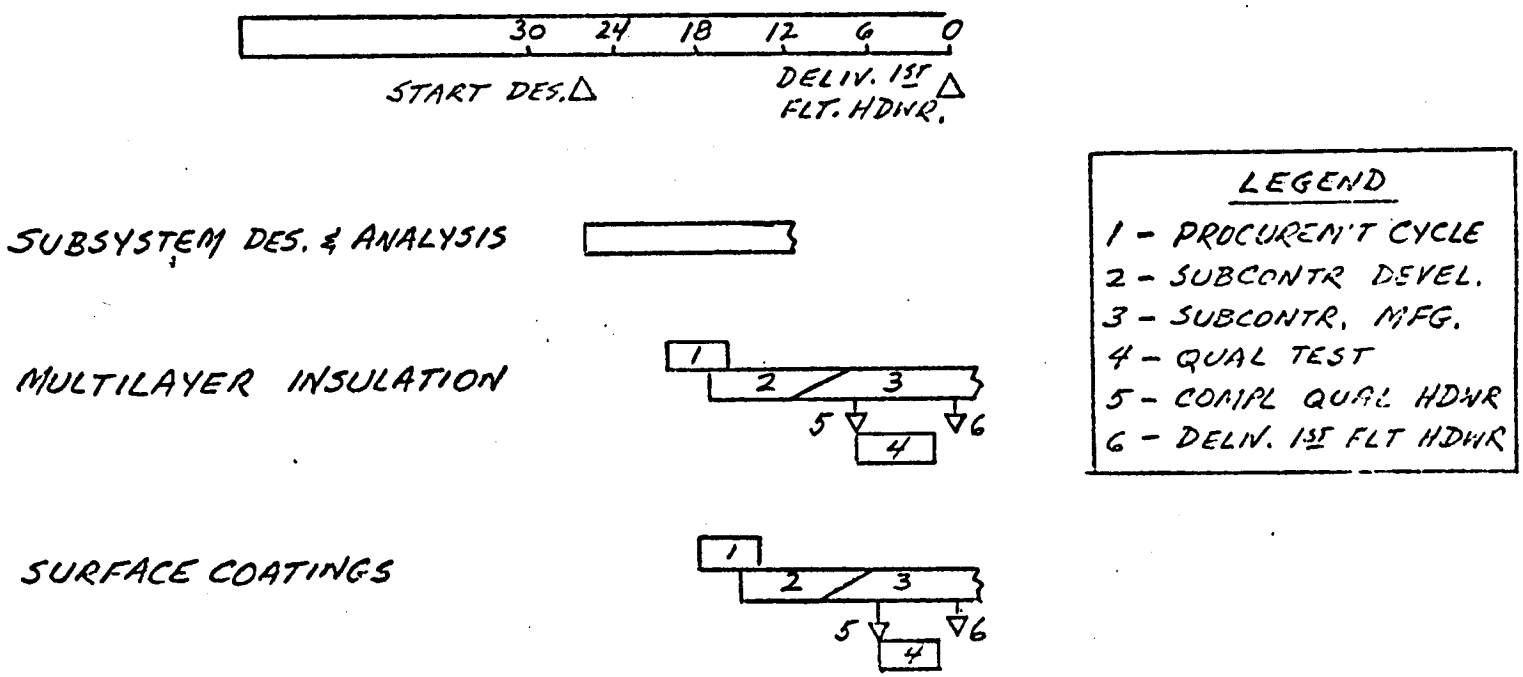


320A-3A/320AE-3A AUXILIARY STAGE-AKE



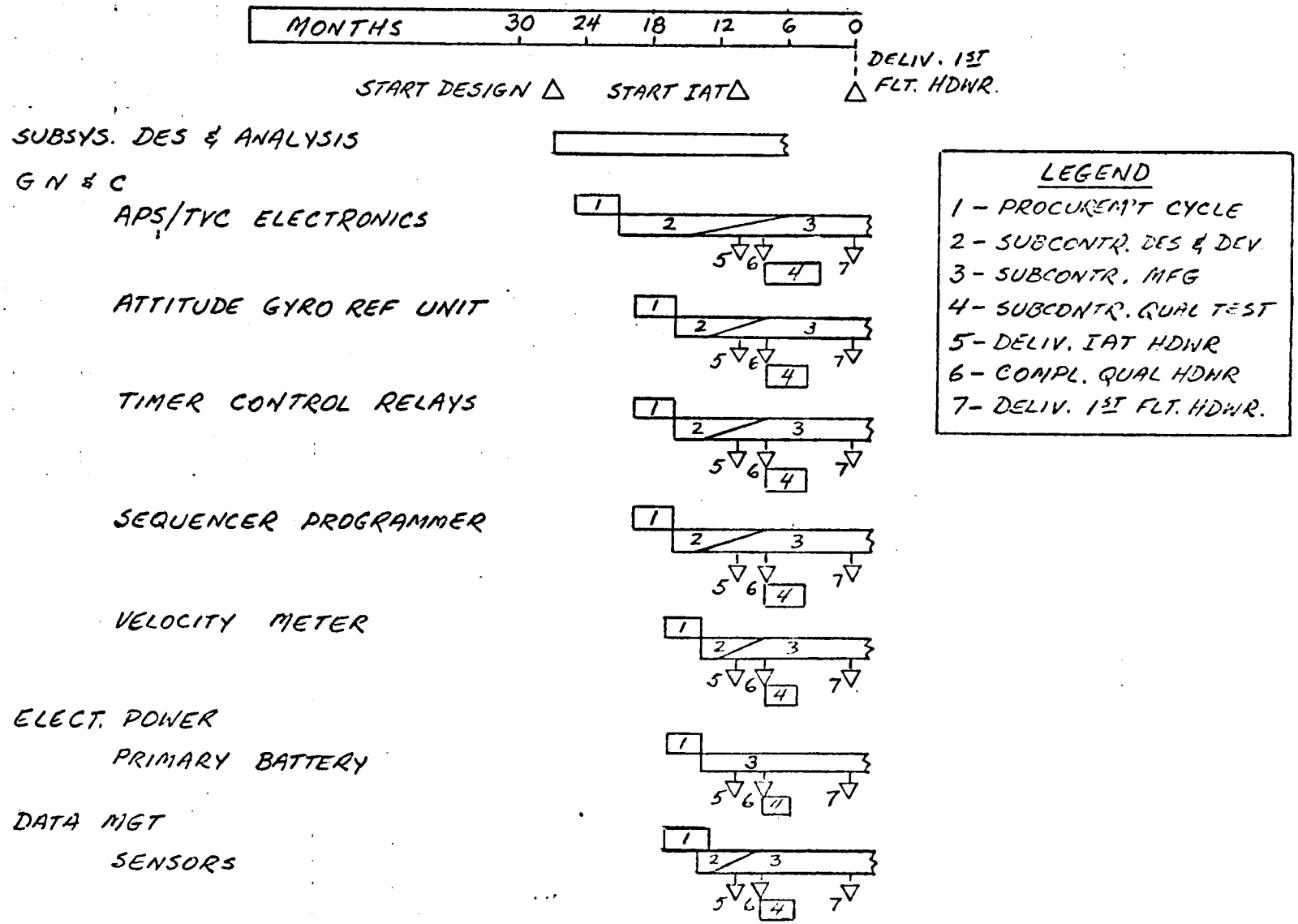


320A-3A/320A+-3A APOGEE KICK STAGE
STRUCTURES SUBSYSTEM SCHEDULE

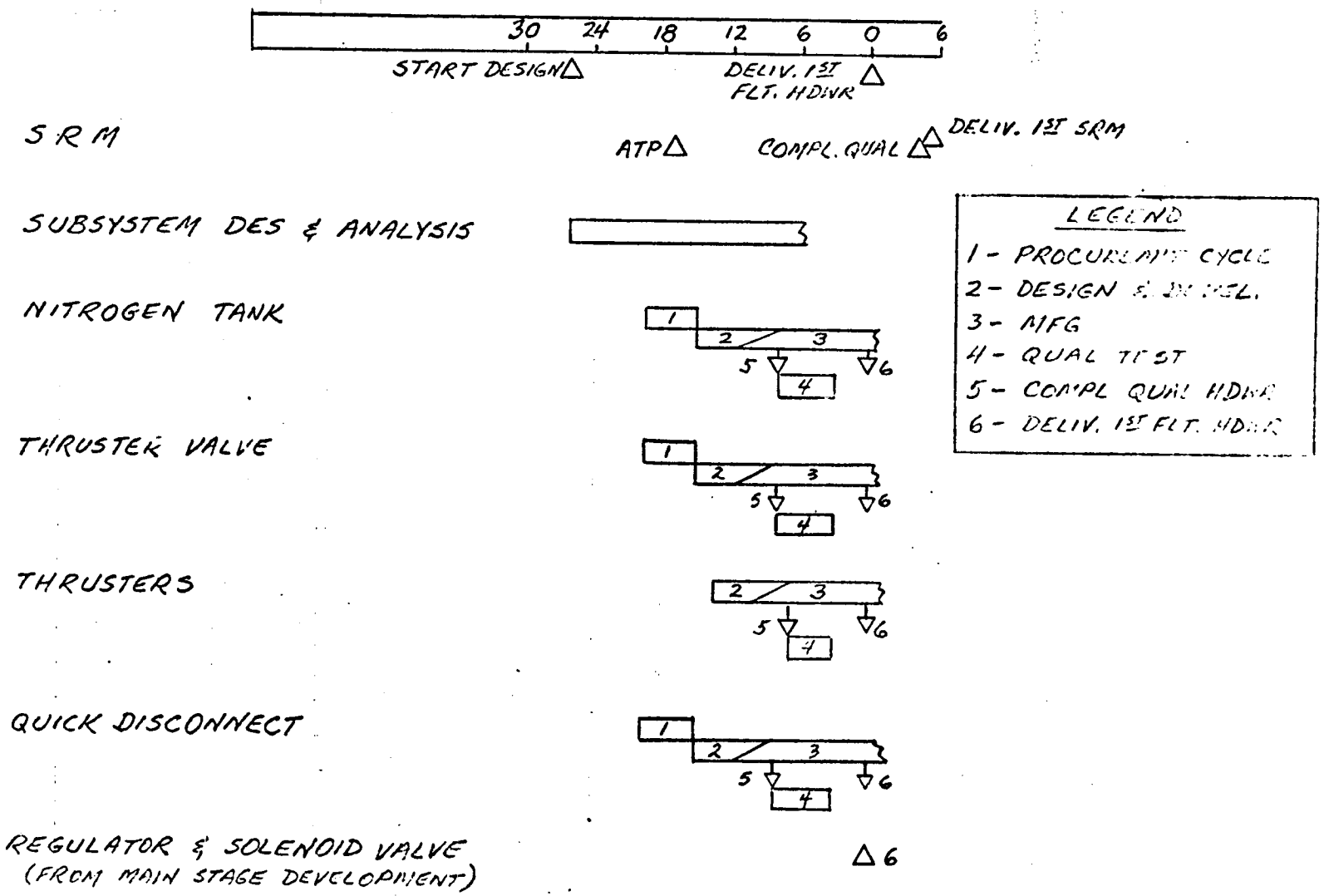


APOGEE KICK STAGE

THERMAL CONTROL SUBSYSTEM SCHEDULE



APOGEE KICK STAGE
AVIONICS SUBSYSTEM SCHEDULE



APOGEE KICK STAGE
PROPULSION SUBSYSTEM SCHEDULE

8.1.4 OPERATIONS SCHEDULE

Scheduled and planned for concept 320A-3A/320AE-3A, option 3 are 30 launches per year with 12 days between launches. Ground servicing as shown on the programmatics/cost operations schedule from land to launch is 10 tug work days and 9 tug/orbiter work days.

8.1.5 FACILITIES SCHEDULE

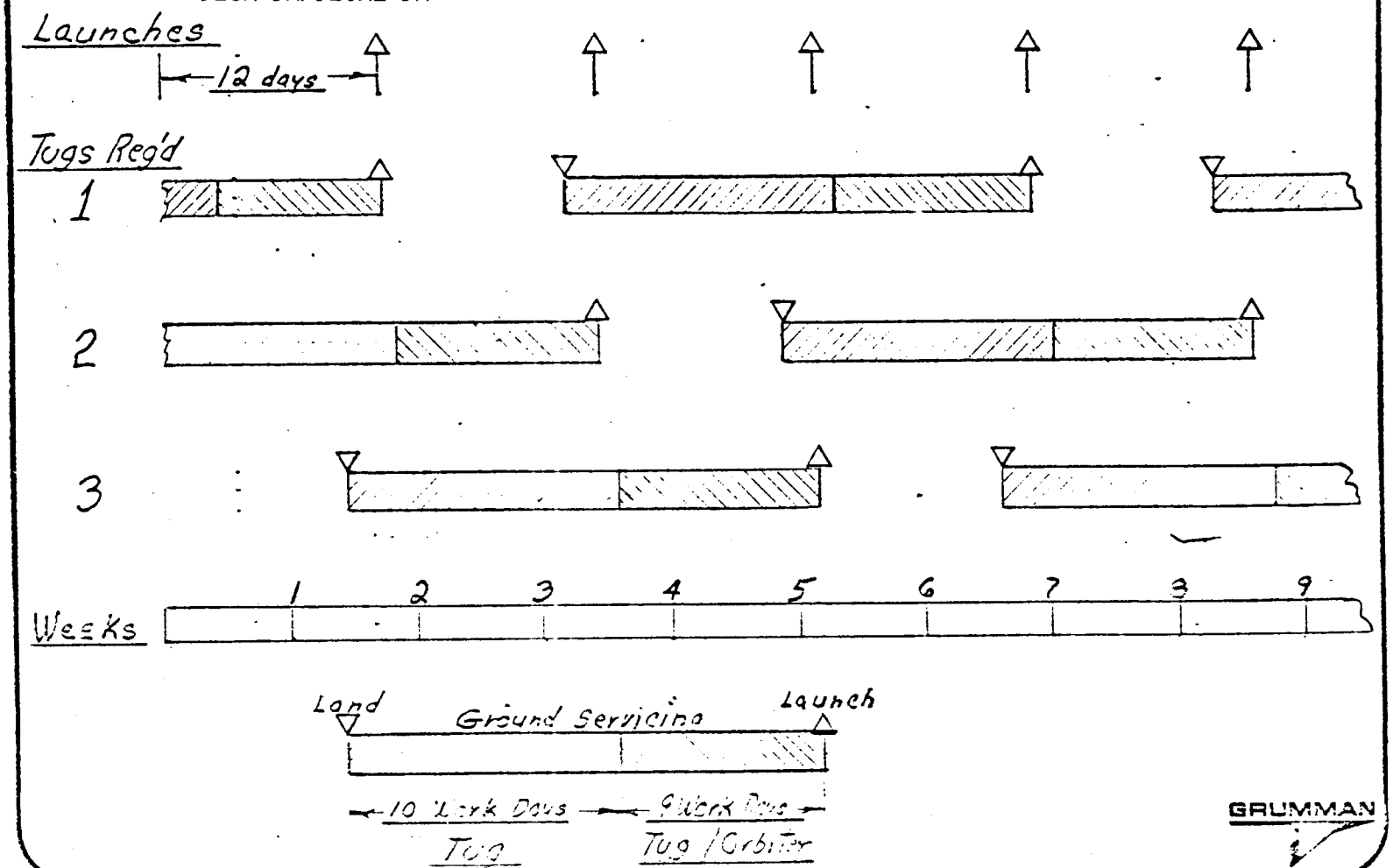
Included in the storable space tug facilities schedule for concept 320A-3A/320AE-3A are the various tasks to be completed against major program milestones. The fundamental grouping of these tasks are manufacturing, test, maintenance and refurb-ETR, ETR launch, maintenance and refurb-WTR and WTR launch. Under this tug concept facilities maintenance extends into 1991, with most of design/construction/activation ending by 1982in support of WTR launch requirements.

PROGRAMMATICS/COST OPERATIONS SCHEDOLE

30 Launches Per Year (ETR)

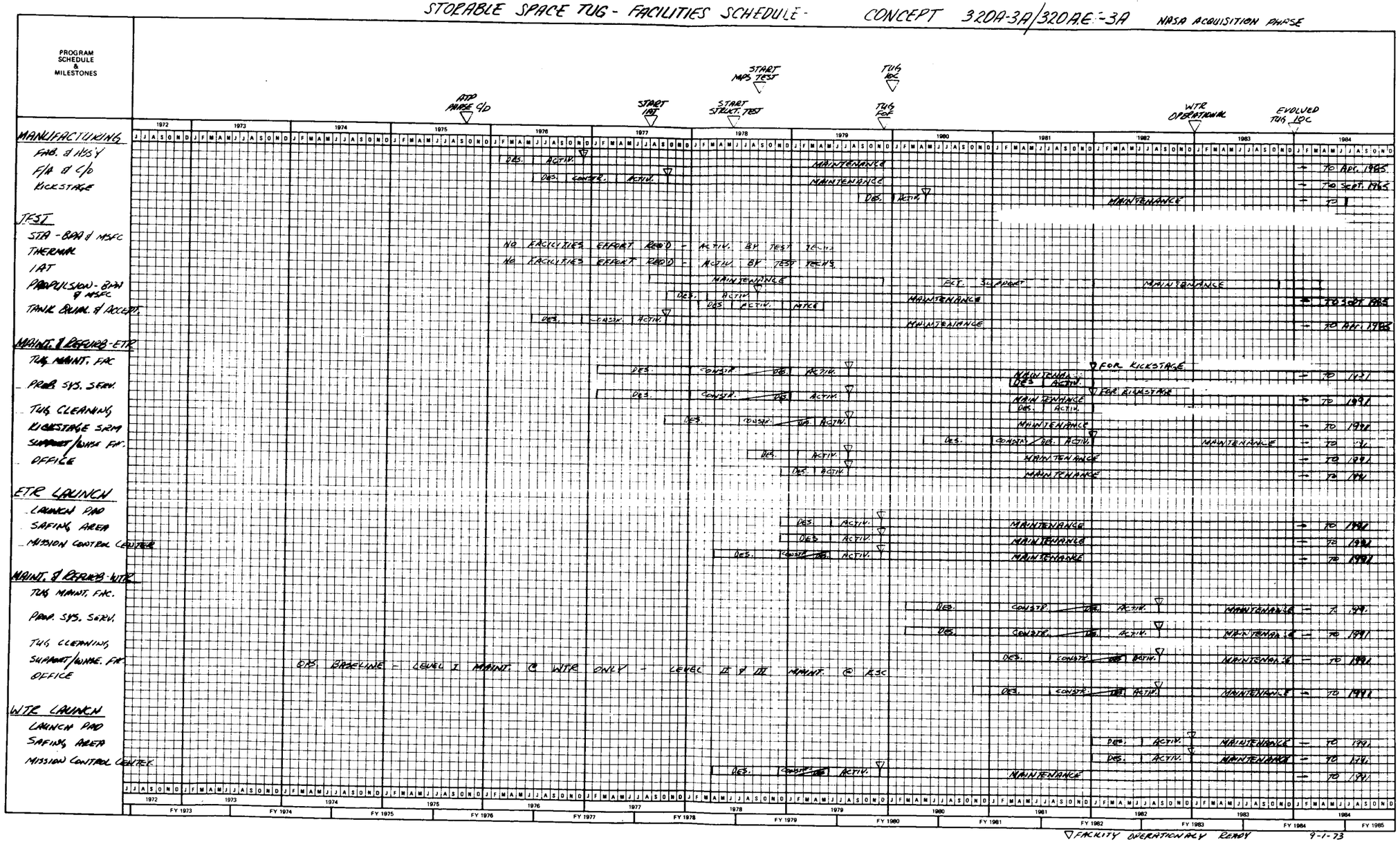
(UPPER AND LOWER STAGES)

CONCEPT 320A-3A/320AE-3A



GRUMMAN

STORABLE SPACE TUG - FACILITIES SCHEDULE - CONCEPT 320A-3A/320A.E.-3A NASA ACQUISITION PHASE



8.1.6 EVALUATION OF MAJOR SCHEDULE DRIVERS (cont'd)

320A-3A/320AE-3A

The avionics subsystem appears on the critical path for the Two Stage Tug option resulting from the introduction of an Advanced Fuel Cell. The purchase order for the Advanced Fuel Cell would have to be issued shortly after ATP to allow for the long development time (minimum of 34 months). In addition, a two year period of SR&T effort would have to precede the P.O., thus placing the start of SR&T in early 1974.

Also on the critical path (as in option 310-3A/310RE-3A) is the main engine for reasons discussed above.

Production of the Two Stage Tug is scheduled in 3 lots of upper and lower stages, manufactured alternately, and providing a continuous manufacturing flow at 3 month centers. Total fleet consists of 11 upper and 13 lower stages.

Development of the Apogee Kick Stage is delayed until 1979 to meet a late 1981 first flight requirement.

8.2 Vehicle Test Program (320A-3A/320AE-3A)

8.2.0 Our approach to development of the 320A-3A/320AE-3A Vehicle Test Program is essentially as described in Part I, Paragraph 8.2.0. The mission flight modes for this option include both single stage and two stage operations. The main stages are essentially identical and are connected when in the two stage mode by an interstage structure. As such, the various test articles in the Vehicle Test Program include only one stage with interfaces being simulated as required. Table 8.2-1 summarizes the design verification approach in terms of major test verification requirements and method of requirement satisfaction. Figure 8.2-1 presents a summary schedule of the total 320A-3A/320AE-3A Vehicle Test Program.

8.2.1 Ground Test Articles - Type and Description

8.2.1.1 Propulsion Test Vehicle (PTV)

Since the two main stages are identical in terms of Structure and propulsion subsystems, the PTV for this program consists of one stage only as described in Part I, Paragraph 8.2.1.1

8.2.1.2 Structural Test Article (STA)

Although the 320A-3A configuration has twin stages the STA will consist of only one of these stages since they are structurally identical. Both the orbiter/stage adapter and the interstage adapter will be included in the main stage STA, forming an assembly 24 feet long by 15 feet wide. Other details of the STA are the same as described in Part II, Paragraph 8.2.1.2.

The Apogee Kick Stage (AKS) STA is as described in Part I, Paragraph 8.2.1.2.2.

8.2.1.3 Integrated Avionics Testing

8.2.1.3.1 Main Stage (MS) Avionics Hardware and Software

The integrated avionics hardware and software testing for the 320A-3A/320AE-3A is the same as described in Part I, Paragraph 8.2.1.3.1. The second stage hardware and software interfaces will be simulated for the IAT program. IAT facility computers, dummy loads and controlled signal simulators will be used to simulate the second stage avionics where concurrent functional operation is required for mission simulation

320A-3A/320AE-3A VEHICLE TEST

$19.23M OVER 1 STAGE TEST

- o TEST PROGRAM OBJECTIVES
  - DESIGN VERIFICATION
  - SITE/GSE VALID
  - SYSTEM VERIFICATION
- o GROUND TEST PROGRAM (HARDWARE/OPS = $25.00M)
  - PROP: 1 MS ART. VERIFIES COLD FLOW SYSTEM OPS - REFURBISH TO OPS
  - STRUCT: 1 ART. (1 LOWER MS & 1 AKS) VERIFY DYN, STATIC, FATIGUE, SEP - KSC VALIDATION
  - AVIONICS: 2 LABS VERIFY HARDWARE/SOFTWARE FOR INITIAL AND EVOLVED CONFIGURATION
  - MOCKUPS: 2 SOFT & 2 HARD MS & AKS MOCKUPS SUPPORT DESIGN DEVELOPMENT & MAINTENANCE DEMONSTRATION
- o FLIGHT TEST PROGRAM (HARDWARE/OPS = $27.06M)
  - 1 LOWER MS & 1 AKS VEHICLE
  - 10 FLIGHTS (1 DEDICATED, 9 OPS)
- o TOTAL VEHICLE TEST = $52.05M

GRUMMAN

DESIGN VERIFICATION APPROACH

	MAJOR VERIF REQ'MT	GRND TEST	FLT TEST
STRUCTURE	STATIC MARGIN	QUAL	VERIFY
	FATIGUE LIFE	QUAL	VERIFY
	VIBRATION MODES	VERIFY	VERIFY
	VEH/ORB, VEH/PL STG/STG & VEH/AKS SEP	QUAL	VERIFY
	VEH HDLG & MAINT	DEMO	VERIFY
THERMAL CONTROL	PASSIVE/ACTIVE THERMO SYS PERFORM	QUAL	VERIFY
	TC/GSE SERVICING & MAINT	DEMO	VERIFY
AVIONICS	INTEG HDWR/SFTWR VEH PERFORM	VERIFY	VERIFY
	AVIONICS/GSE C/O & MAINT	DEMO	VERIFY
	VEH SYS INTERFACE (ORB, GRND, STG-TO-STG, AKS & PL PERFORM)	VERIFY	VERIFY
PROPULSION	MPS NOM/OFF - NOM PERFORM	QUAL	VERIFY
	MPS/GSE SERVICING & MAINT	DEMO	VERIFY
	APS NOM/OFF - NOM PERFORM	QUAL	VERIFY
	APS/GSE SERVICING & MAINT	DEMO	VERIFY
	AKS SRM PERFORM	QUAL	VERIFY
ORBITER INTERFACE	STATIC/FATIGUE STRENGTH	QUAL	VERIFY
	VEH/ORB SEP	QUAL	VERIFY
	AVIONIC/FLUID INTERFACE PERFORM	VERIFY	VERIFY
	ABORT SYSTEM PERFORM	QUAL	VERIFY
	VEH HDLG/GSE SERVICE & MAINT	DEMO	VERIFY

TABLE 8.2-1

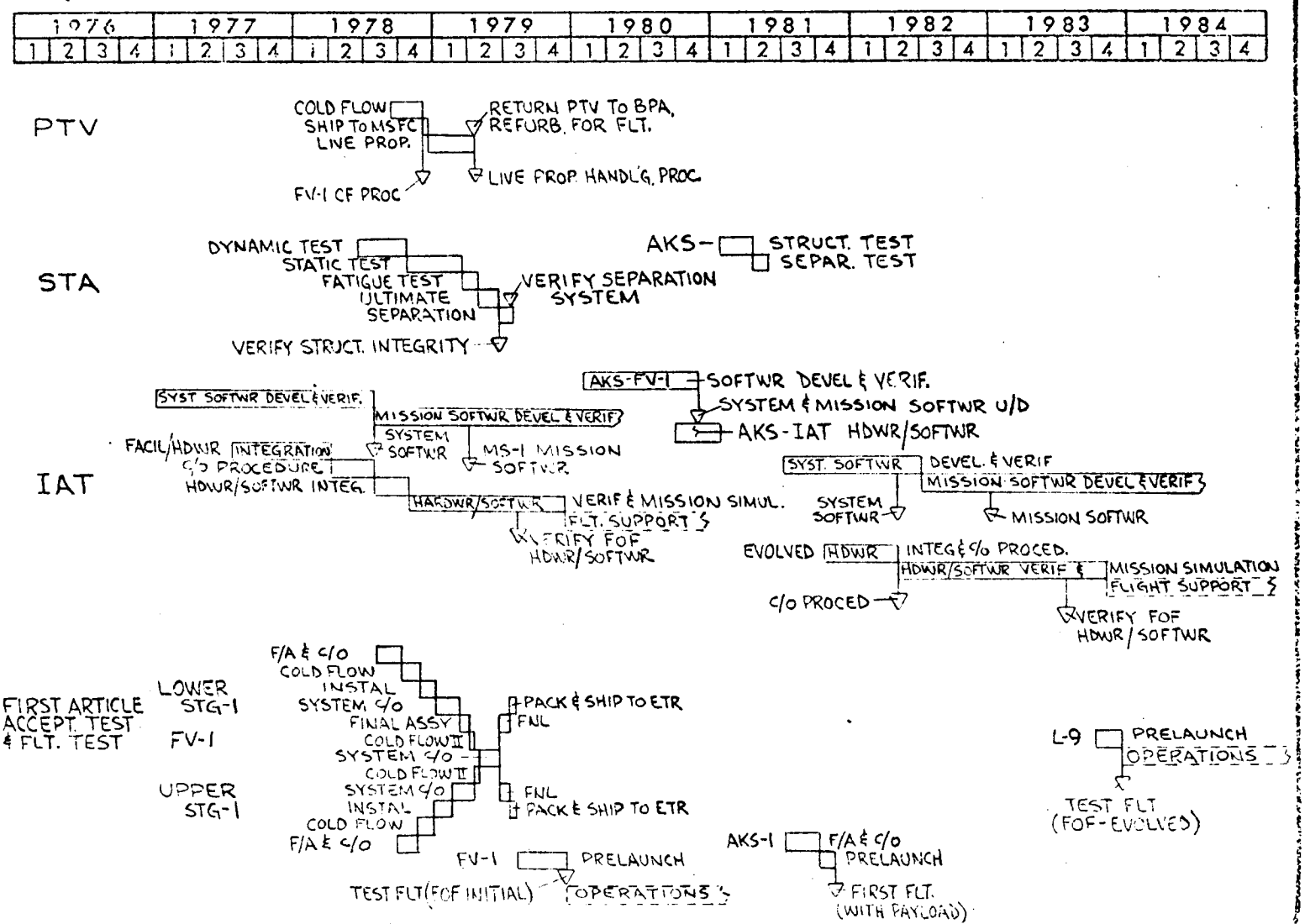


FIG. 8.2-1 320A-3A/320AE-3A VEHICLE TEST SCHEDULE

8.2.1.3.2 Apogee Kick Stage (AKS)

A breadboard of the Apogee Kick Stage will be integrated in the IAT facility and tested as described in Part I, Paragraph 8.2.1.3.2

8.2.1.4 Mockups

Mockups will be provided for all elements of this configuration as described in Part I, Paragraph 8.2.1.4.

8.2.2 Flight Test Article - Description

Since the flight test program for this configuration will include a single stage Tug flight test without payload, only the lower stage will be provided as described in Part I, Paragraph 8.2.2.1. The AKS flight test article is as described in Part I, Paragraph 8.2.2.2.

8.2.3 Ground Test Program

This section describes the major elements of the vehicle ground test program. The test programs described in the following paragraphs include the Propulsion Test Vehicle (PTV), Structural Test Article (STA), Integrated Avionics Testing including software development, and mockups required in support of program requirements.

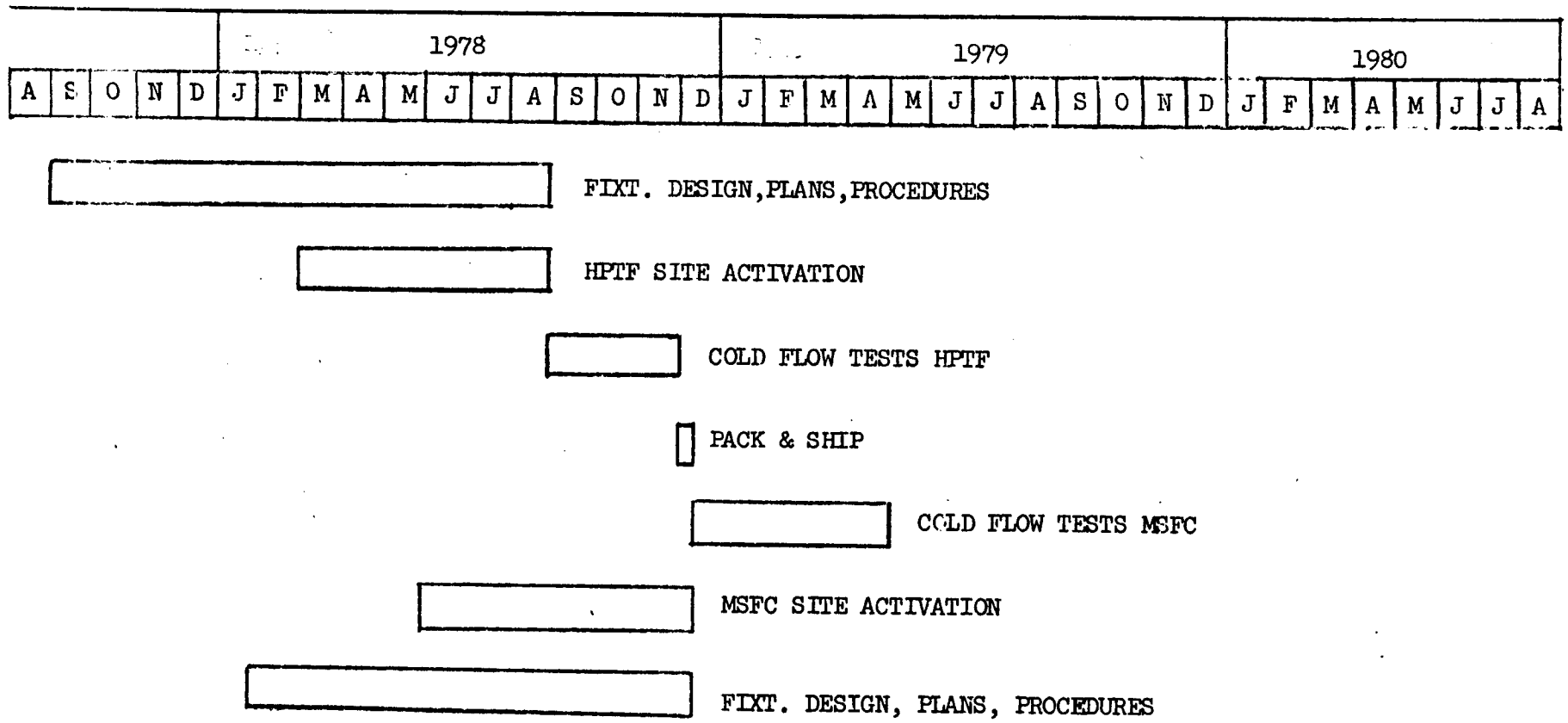
8.2.3.1 Propuslion Test Vehicle Program

The single article Propulsion Test Program is as described in Part I, Paragraph 8.2.3.1. The test schedule and manloading is shown in Figure 8.2-2. AKS SRM development and qualification will be accomplished at the engine contractors facilities as described in Part I, Paragraph 8.2.3.1

8.2.3.2 Structural Test Article (STA) Program

8.2.3.2.1 Main Stage

Since only one of the main stages will be tested the test program is essentially as described in Part II, Paragraph 8.2.3.2.1. The test schedule and manloading are the same as that shown in Part I, Figure 8.2-3 except the test program starts in June 1978.



MANPOWER 1 1 2 2 3 5 7 10 16 15 18 24 35 41 44 40 33 29 28 15 7 TOTAL 377 MM

Figure 8.2-2 320A-3A/320AE-3A PTV TEST SCHEDULE & MANPOWER

8.2.3.2.2 Apogee Kick Stage (AKS)

The AKS STA program is as described in Part I, Paragraph 8.2.3.2.2. The test schedule and manpower is as shown in Part I, Figure 8.2-4.

8.2.3.3 Integrated Avionics Test Program

8.2.3.3.1 Main Stage (MS) Avionics Hardware and Software

The integrated avionics test philosophy and test program for the 320A-3A/320AE-3A is essentially the same as described in Part I, Paragraph 8.2.3.3.1. The second stage avionics for this configuration is similar to the first stage and from a hardware viewpoint will be simulated for IAT. The ASDL will be used for development of software for both stages and the same set of MS avionics hardware will be used in the IAT for mission simulation for each stage. The evolution of this configuration to include retrieval capability will be incorporated into the IAT and ASDL facilities. System Hardware/Software verification and mission simulation will be performed for the evolved configuration in the IAT facility.

The test schedule and manloading are shown in figure 8.2-3. Test logic and constraints are the same as those described for configuration 110A.

8.2.3.3.2 Apogee Kick Stage (AKS)

A breadboard of the Apogee Kick Stage will be integrated into the IAT facility and tested as described for configuration 110A.

The schedule for the AKS avionics is also shown in figure 8.2-3.

8.2.3.4 Mockups

The 320A-3A/320AE-3A mockup program is essentially as described in Part I, Paragraph

8.2.4 Flight Test Program

This section describes the flight test program for the 320A-3A/320AE-3A configuration. In addition, the section also includes a description of the vehicle level factory and launch site test and checkout approach. In order to maintain continuity the section begins with the checkout and test approach and follows with the discussion of the flight test program.

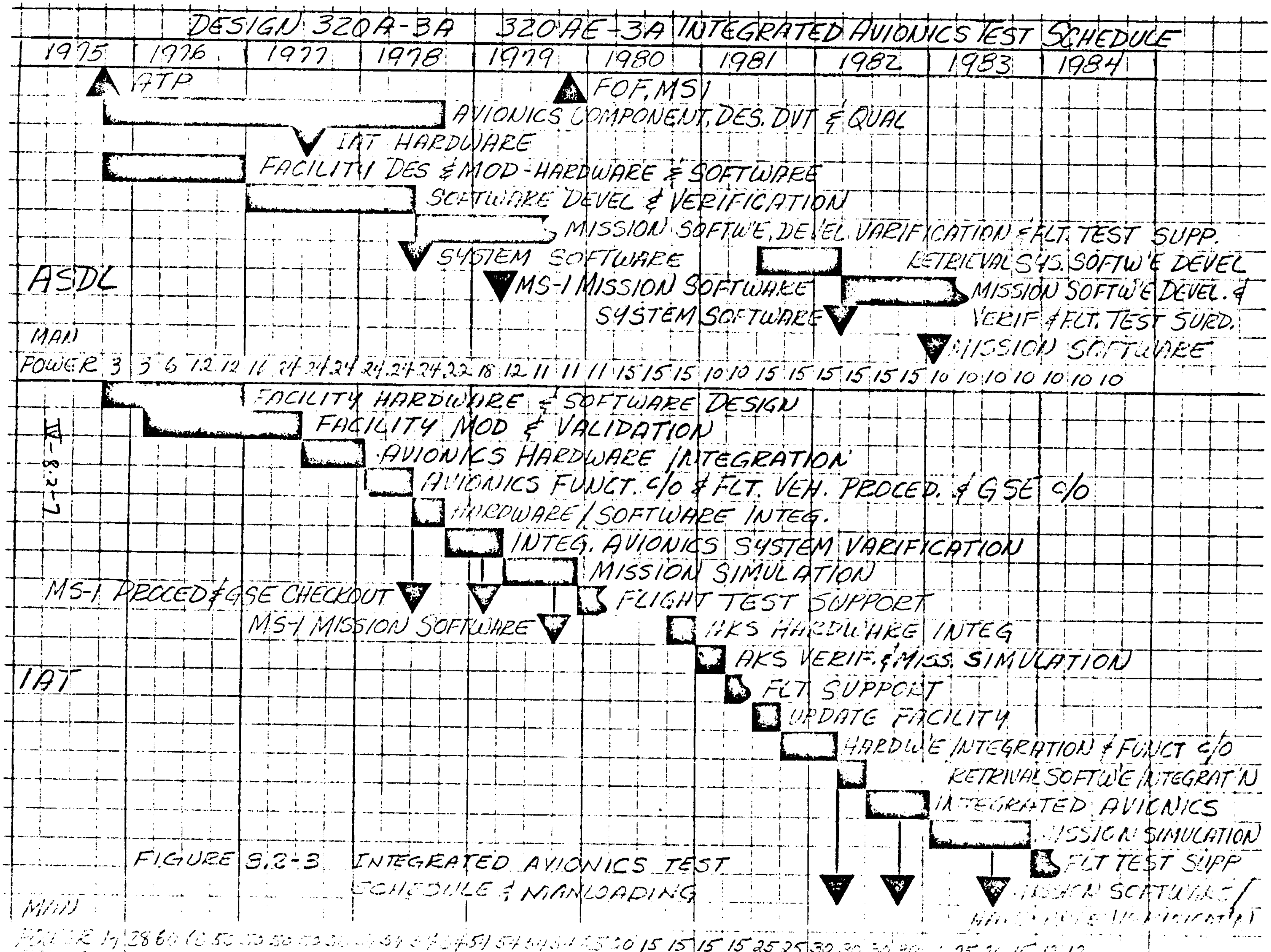


FIGURE 9.2-3 INTEGRATED AVIONICS TEST SCHEDULE & MANLOADING

8.2.4.1 Flight Vehicle Checkout and Test

The philosophy and objectives of the flight vehicle ground test program are the same as those described in Part I, Paragraph 8.2.4.1

The Factory Testing of the first 320A-3A contains the same tests as the 110A-1, except that two stages are staggered through fluid and subsystem checkout avoiding the need for two sets of checkout equipment. The final plugs out system check is performed on the two stages together to demonstrate the ability of the electrically isolated stages to mate (structure to structure electrical continuity) without adverse effect on system operation. Subsequent stages will be tested as independent vehicles with the same basic flow as the 110A-1 main stage.

The pre launch testing initially includes a single stage only and is as that described in Part III, Paragraph 8.2.4.1.

The facilities and equipment requirements are the same as those described in Part I, Paragraph 8.2.4.1.4 except for the addition of fuel cell related GSE.

The factory Test Schedule and Manpower Requirements are shown in Figure 8.2-4 while the prelaunch schedule and manpower is the same as described in Part III, Figure 8.2-6.

The AKS schedules and manpower requirements for first vehicle factory flow and prelaunch are the same as those described in Part I, Figures 8.2-9 and 8.2-10 respectively.

8.2.4.2 Flight Test

Since the first year of 320A-3A operations includes single stage deploy only flights, First Orbital Flight (FOF) will be a dedicated flight test using only one main stage essentially as described in Part I, Paragraph 8.2.4.2.

There will be a total of nine additional operational flights for the 320A-3A/320AE-3A configuration from which flight test data will be obtained. Six data flights are planned for the initial configuration and three for the evolved.

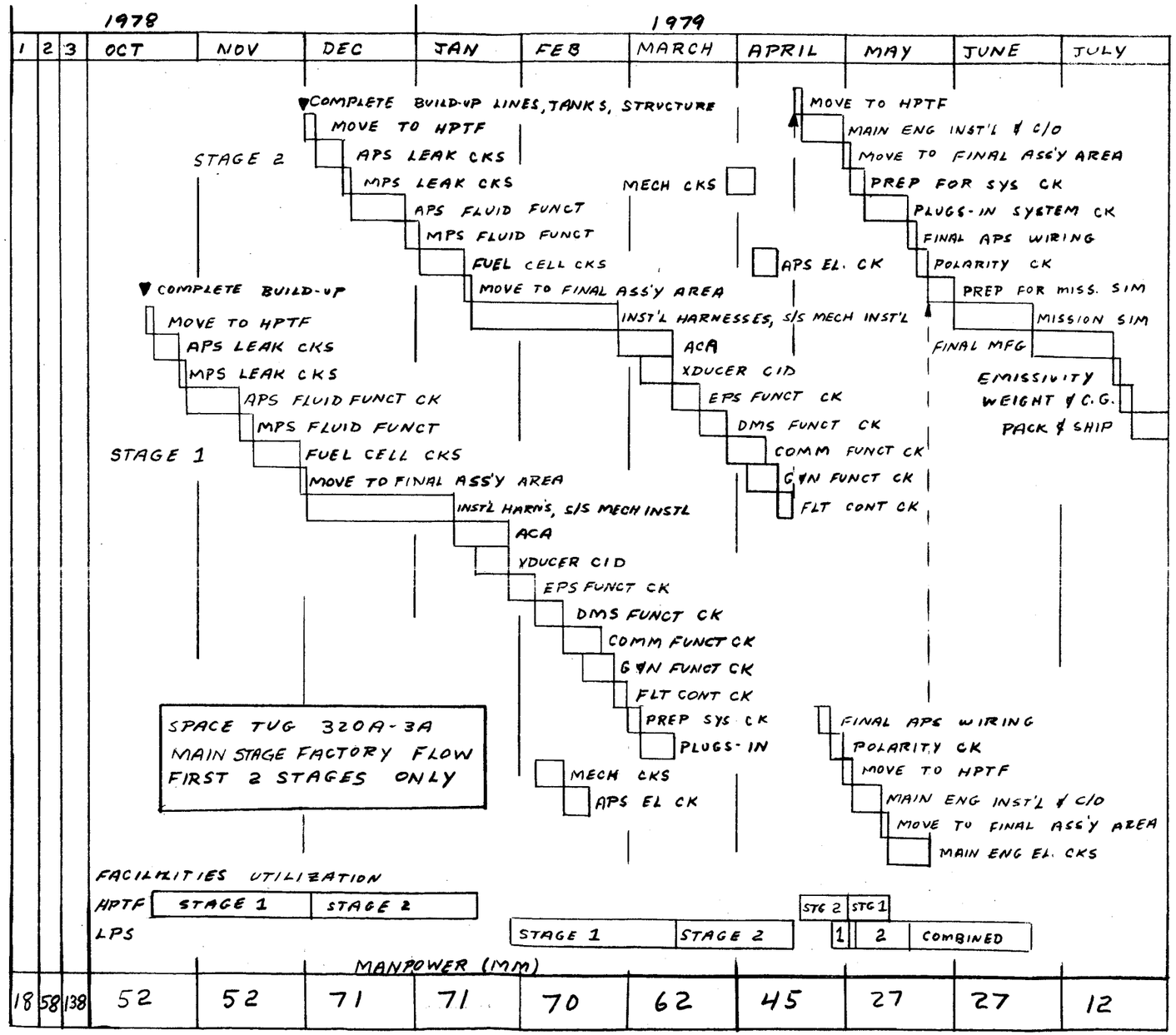

1978
1979
1 2 3
OCT
NOV
DEC
JAN
FEB
MARCH
APRIL
MAY
JUNE
JULY
COMPLETE BUILD-UP LINES, TANKS, STRUCTURE
MOVE TO HPTF
APS LEAK CKS
MPS LEAK CKS
APS FLUID FUNCT
MPS FLUID FUNCT
FUEL CELL CKS
MOVE TO FINAL ASS'Y AREA
INST'L HARNESSES, S/S MECH INST'L
ACA
XDUCER CID
EPS FUNCT CK
DMS FUNCT CK
COMM FUNCT CK
G&N FUNCT CK
FLT CONT CK
PREP SYS CK
PLUGS-IN
MECH CKS
APS EL CK
STAGE 2
COMPLETE BUILD-UP
MOVE TO HPTF
APS LEAK CKS
MPS LEAK CKS
APS FLUID FUNCT CK
MPS FLUID FUNCT
STAGE 1
FUEL CELL CKS
MOVE TO FINAL ASS'Y AREA
INST'L HARN'S, S/S MECH INSTL
ACA
XDUCER CID
EPS FUNCT CK
DMS FUNCT CK
COMM FUNCT CK
G&N FUNCT CK
FLT CONT CK
PREP SYS CK
PLUGS-IN
MECH CKS
APS EL CK
MOVE TO HPTF
MAIN ENG INST'L & C/O
MOVE TO FINAL ASS'Y AREA
PREP FOR SYS CK
PLUGS-IN SYSTEM CK
FINAL APS WIRING
POLARITY CK
PREP FOR MISS. SIM
MISSION SIM
FINAL MFG
EMISSIVITY
WEIGHT & C.G.
PACK & SHIP
FINAL APS WIRING
POLARITY CK
MOVE TO HPTF
MAIN ENG INST'L & C/O
MOVE TO FINAL ASS'Y AREA
MAIN ENG EL. CKS
SPACE TUG 320A-3A
MAIN STAGE FACTORY FLOW
FIRST 2 STAGES ONLY
FACILITIES UTILIZATION
HPTF
STAGE 1
STAGE 2
LPS
STAGE 1
STAGE 2
STG 2
STG 1
1
2
COMBINED
MANPOWER (MM)
18 58 138
52
52
71
71
70
62
45
27
27
12

FIGURE 8.2-4

Introduction of single stage retrieval will be accomplished during an operational deploy only flight in 1983. A telescoping test fixture deployed from the Shuttle will serve as the retrieval target. Two stage round trip operations will be demonstrated during a normal operational flight in 1984. Flight test data will be acquired during the first two years of 320AE-3A operations via the installed DFI system. Flight test data will be obtained, as a minimum, on the following operationa flights:

(3) Single payload deploy - single stage
(1) Multi payload deploy - single stage
(1) Single payload deploy - single stage with AKS
(1) Single payload deploy - two stage
(1) Retrieval demonstration - single stage
(1) Round trip - single stage
(1) Retrieve/round trip - two stage

The flight test schedule and test program costs are shown in Figure 8.2-5.

8.2.5 Analysis of the Test Program

8.2.5.1 Key Elements

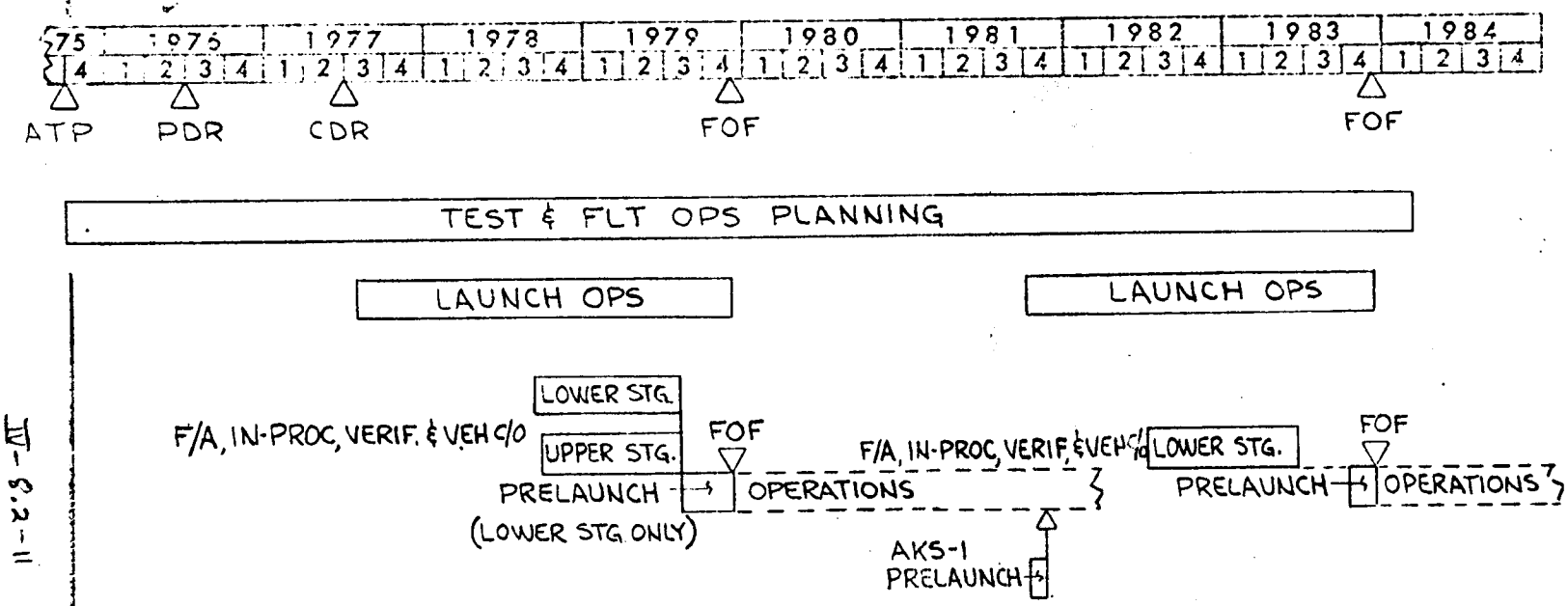
The analysis of the key elements of the test program for the 320A-3A configuration is basically as described in Part I, Paragraph 8.2.6.1. The following summary highlights only those new issues arising from the two stage operational mode and the evolved 320AE-3A configuration.

- No System Level Hot Firing Tests:
  As described in Part I

- Dynamic Static and Fatigue Tests performed on a single STA:
  As described in Part I

- Use of a Single STA program to cover both the Basic and Evolved Configuration:
  As described in Part III

- Integrated Avionics Testing Accomplished in two separate yet Complimentary Facilities:
  Essentially as described in Part III except that the evolved configuration will contain Level III a autonomy through all program phases



FLIGHT TEST PROGRAM COST

- FLIGHT TEST HARDWARE: 1 MAIN STAGE + DFI
- FLIGHT TEST MANPOWER (FOF ONLY)
  - TEST OPS: $3.74 M
  - LAUNCH OPS: $1.84 M
  - FLIGHT OPS: $2.36 M
- CONSUMABLES (FOF ONLY): $31 K

FIGURE 8.2-5 - FLIGHT TEST PROGRAM SCHEDULE (320A-3A/320AE-3A)

- One Dedicated Flight Test Minimizes Risk of Losing Tug/Payload:
  The main stage flight test program for the 320A-3A configuration is essentially as described in Part I, Paragraph 8.2.6. Demonstration of retrieval will be accomplished as part of a single stage 320AE-3A deploy only mission and will not require a separate dedicated flight test. The retrieval target could involve an extension boom mounted to the Orbiter of the variety used to deploy solar panels

- No System Level Thermal Vacuum Test
  As described in Part I.

8.2.5.2 SR&T Assumptions

The basic assumption for the 320A-3A/320AE-3A SR&T requirements are described in Part I, Paragraph 8.2.6.2. SR&T requirements, test programs affected and a brief description of the interaction with the test programs affected is summarized in Table 8.2-2.

8.2.5.3 Reusability Demonstration

Reusability demonstrations are as described in Part I, Paragraph 8.2.6.3.

8.2.5.4 Life Verification Tests

Life verification tests are as described in Part I, Paragraph 8.2.6.4

TECHNOLOGY REQUIREMENTS	TEST PROG. AFFECTED	REMARKS
Main engine life and high performance	o GFE eng. devel. prog. o Flight test prog.	Early life verif. of eng. components and area ratio nozzle performance assures phase C/D engine development. PTV is not affected since eng. is not required. FOF could tolerate slightly reduced eng. performance.
PFR helium tank		Early verif. of low weight PFR tank assures maximum tug performance.
Materials compatibility Data	o Tank qual o STA prog. o PTV prog.	Early verif. of material compatibility with MMH and N_2O_4 assures on-time development of main stage tankage including tank qual. STA and PTV testing.
Fracture Mechanics data	o Tank qual. o STA prog.	Early fracture mechanics data allows on-time development of structural subsystem including tankage quals and STA testing.
Heat Pipes	o Flight test prog.	Early verif. of heat pipe design approach allows on-time developments of Thermal Control Subsystem thereby maximizing Tug performance.
Advanced IMU	o Integrated avionics o Flight Vehicle Factory checkout o STA	Early devel of Advanced IMU will assure on time devel of software and integration procedures in the IAT LAB for FLT VEH buildup and test and accurate simulation for STA prog.
Graphite Composite	o STA Prog.	Early Devel of graphite composite honeycomb face sheets assures that STA program progresses as planned.
Laser Radar	o Integrated Avionics o Flight Vehicle factory checkout o STA	Early devel of light weight low power Laser Radar will assure on time development of software and integration procedures in the IAT LAB for FLT VEH buildup & test and accurate simulation for STA program.

Table 8.2-2 SR&T Assumptions
(Page 1 of 2)

TECHNOLOGY REQUIREMENTS	TEST PROG. AFFECTED	REMARKS
2-Position Main Engine Nozzle	o GFE eng. Devel. prog. o Flight test	Early assurance of 2-position feasibility assure eng. develop and viability of 2 stage configuration. Delay in devel could severely curtail initial ops.
Advanced Fuel Cell	o Fuel Cell Qual o Integrated Fuel Cell/ Feed sys. test	Early devel. of light weight high power fuel cell assure on-time completion of fuel cell qual and integrated tests.

Figure 8.2- SR&T Assumptions
(Page 2 of 2)

320A-3A/320AE-3A GROUND TESTS

$19.23M Δ OVER 1 STAGE TEST

TEST	TEST ARTICLE	OBJECTIVES	APPROACH
STRUCTURES o 320A-3A - MAIN STAGE (MS) - APOGEE KICK STAGE (AKS)	o COMPLETE LOWER STAGE PRIM. & SEC. STRUCT. o INTERSTAGE & TUG/ORB. ADAPT. o COMPLETE AKS PRIM. & SEC. STRUCT.	o EVALUATE DYN, STATIC STRENGTH, SAFE-LIFE & SEPARATION o VERIFY STRUCT./MECH. INTERFACES AT LAUNCH SITE	o VIB/ACOUSTIC TESTS o DES. LIMIT STATIC TESTS o STATIC FATIGUE o ULT. STATIC TEST o SEP. DEMO. o INTERFACE VALID. DEMO AT KSC o AKS TESTED SEPARATELY AS ABOVE (1982)
PROPULSION (MS-320A-3A ONLY)	o FLIGHT WT. LOWER STAGE STRUCT. o MAIN ENG. SUPPT. S/S LESS ENG. o ENG. SIMUL. UNIT o PTV REFURB. TO FLIGHT OPS	o DEMO OPS OF ASSEM. COMPONENTS o DEVELOP C/O & OPS PROCEDURES o VERIFY SERV/HANDLG PROCEDURES o DEMO. SYS. PERF & CHARACTERISTICS	o COLD FLOW ONLY o REFEREE FLUIDS PHASE - FILL/DRAIN/FLOW TESTS o LIVE PROPELLANTS PHASE - LOAD CONTROL/ACCURACY - SYS. COMPAT. & DYN. - PERF. SERV./HANDLING PROCEDURES

SUMMARY

320A-3A/320AE-3A - GROUND TESTS

Vehicle Test Program

The vehicle test program for 320A-3A/320AE-3A was developed in a similar manner to that described for 110A-1

Structural Test Article (STA)

Since the two 320A Main Stages are basically structurally identical only one MS STA will be tested. The STA program for this configuration is essentially the same as that described for the 110A STA. The 320A STA will be configured to include the evolved 320AE-3A avionic retrieval hardware and mechanical interfaces, and testing will envelope both configurations.

Propulsion Test Vehicle (PTV)

The PTV and AKS propulsion test programs for this configuration are the same as those described for the 110A configuration. The two-position nozzle will be developed and qualified along with the engine at the engine contractors facility.

320A-3A/320AE-3A GROUND TESTS (CONT'D)

TEST	TEST ARTICLE/FACILITY	OBJECTIVES	TEST DESCRIPTION
INTEGRATED AVIONICS o INTEG. AVIONICS TEST (IAT) FAC. - MS - AKS o AVIONICS SOFTWARE DEVELOPMENT LAB (ASDL) - MS	o IAT - SHIP SET OF AVIONICS - COMPUTER SIMULATION - SENSOR STIMULUS - FACTORY & LAUNCH GSE o ASDL - COMPUTER FACILITY WITH MATH MODEL SIMULATION OF MS HARDWARE	o VERIFY HARDWARE/SOFTWARE PRIOR TO VEHICLE INSTALLATION & FOF-79 o VERIFY EVOLVED RETRIEVAL HARDWARE/SOFTWARE FOR 83 IOC.	o IAT - SUBSYSTEM INTEG. & END TO END FUNCTIONAL VERIFICATION - VERIFY FACTORY C/O PROCED. - HARDWARE/SOFTWARE VERIF. - MISSION SIMULATION - INTEGRATE AND VERIFY RETRIEVAL CAPABILITY HARDWARE/SOFTWARE - RETRIEVAL MISSION SIMULATION o ASDL - SOFTWARE DEVELOPMENT FOR BASIC & EVOLVED SYSTEM
MOCKUPS o MS o AKS	o WOOD AND CARDBOARD MOCKUP OF THE TUG MS STAGES & AKS STRUCTURE INCLUDING EQUIPMENT FOR PDR. o WOOD & METAL MOCKUP OF TUG MS STAGES AND AKS STRUCT. & COMPONENTS FOR CDR	EVALUATE EQUIPMENT ACCESSABILITY & MAINTAINABILITY. EVALUATE SHUTTLE & PAYLOAD INTERFACES & LINES RUN PRIOR TO FAB OF FINAL HARDWARE	o COMPONENT INSTALLATION o ESTABLISH LINE LENGTHS FOR FINAL HARDWARE FAB. o DEMONSTRATE MAINTAIN. - ASSESSMENTS & DEMOS OF EQUIPMENT & LINES CLEARANCES - CONNECTOR & MOUNTING ACCESSIBILITY DEMO. o SHUTTLE & PAYLOAD INTERFACE ASSESSMENT

320A-3A/320AE-3A GROUND TEST (Cont'd)

Integrated Avionics Test

The 320A MS and AKS integrated avionics test program is the same as described for the 110A configuration. The second stage will be simulated for the IAT software verification and mission simulations. The retrieval capability will be incorporated in the IAT facility and ASDL software as it is developed. IAT testing for the evolved system will include hardware and software verifications and mission simulations.

Mockups

The mockups required for the 320A MS and AKS are the same as the mockups described for the 110A configuration and includes all stages. Installation of the evolved configuration hardware will be verified using the MS mockup.

320A-3A / 320AE-3A FLIGHT TESTS

TEST ARTICLE	OBJECTIVES	APPROACH
o LOWER STAGE 320A-3A-1ST PROD. UNIT INCLUDING DFI o 1ST PRODUCTION AKS INCLUDING DFI o LOWER STAGE 320AE-3A-1ST PRODUCTION UNIT INCLUDING DFI	INITIAL IOC o THERMO-VERIFY SYS. THERMAL CONTROL o STRUCT.-VERIFY LAUNCH/ORBIT/ENTRY/LANDING LOADS & DYNAMICS o PROP-VERIFY MPS/APS o AVIONICS-VERIFY AVIONICS OPS o OPS - EVALUATE TUG/ORB. TUG/PAYLOAD INTERFACES - EVALUATE SYS. PERF. CAPABILITY - DEMO PAYLOAD DEPLOY EVOLVED IOC o DEMO PAYLOAD & TUG RETRIEVAL	o 10 FLIGHT TEST PROGRAM - 7 INITIAL - 3 EVOLVED o FOF COSTED WITHOUT OPERATIONAL PAYLOAD - FLOWN WITHIN RETRIEVAL CAPABILITY OF ORB - SEQUENCE INCL: SYS. C/O, STAGE SEP., MPS/APS BURNS OF ONE STAGE, DUMMY PAYLOAD DEPLOY, ORBITER RETRIEVAL. o SUBSQ. FLIGHTS DEPLOY PAYLOADS SELECTED TO DEMO BUILDUP IN TUG CAPABILITY o AKS INTRODUCED DURING 1981 OPS FLIGHT o FOF OF 320AE-3A IS A DEPLOY ONLY FLIGHT WITH TUG RETRIEVAL DEMO PERFORMED USING ORB. MOUNTED TEST FIXTURE o SUBSEQUENT OPS FLTS - DEMO BUILDUP IN CAPABILITY

320A-3A/320AE-3A FLIGHT TESTS

10 flights are included in the 320A-3A/320AE-3A Flight Test Program. Since the first year of operations for 320A-3A includes single stage deploy only flights, FOF will be a dedicated flight test using only one main stage in a manner similar to that described for 110A-1. Single stage multi deploy, single stage with AKS and two stage deploy missions will be introduced incrementally during the second year of operations to demonstrate a build-up in Tug flight modes and operations. Flight test data will be acquired via the DFI during these payload deploy operational missions. Introduction of single stage retrieval (320AE-3A) will be accomplished during an operational deploy only flight in 1983 using as a retrieval target a telescoping test fixture deployed from the Shuttle. Two stage round trip operations will be demonstrated during a normal operational flight in 1984. Flight test data will also be acquired during the first two years of 320AE-3A operations via the installed DFI system.

8.3 Facilities Plan - Option 3A - Concept 320A-3A/320 ARE-3A

8.3.1 Manufacturing Facilities

Same as concept 110A-1 except 39,900 sq. ft. of floor space is required for fabrication and assembly of the TUG.

8.3.2 Test Facilities

Same as concept 110A-1.

8.3.3 Operations Facilities

Same as concept 110A-1 except TUG Maintenance Facility at ETR will have 6 horizontal stations in a 18,000 sq. ft. addition to the Shuttle OMS Facility. TUG Maintenance Facility at WTR will have 4 horizontal stations in a 12,000 sq. ft. addition to the Shuttle OMS Facility.

STORABLE SPACE TUG

CONCEPT 320A-3A/320AE-3A

Revision Date - 9-7-73

FACILITIES FUNDING REQUIREMENTS

IOC DEC. '79

ACQUISITION PHASE [illegible]

Fiscal Year	'76			'77			'78			'79			'80			'81			'82			'83			'84	'85	'86	'87	'88	'89	'90	'91	TOTALS		
TITLE/WBS # / Level 6 Cat.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	3	3	3	3	3	3	3	3	DDT&E	PROD	OPS
Manufacturing 320-06-01																																			
Structures		3.6		128.0	50.6	5.3		50.6	47.0			30.0			57.6			57.6			57.6			57.6	57.6	17.0							314.5	374.6	-
												(31.6)		13.6				(6.8)			(6.8)			(6.8)	(6.8)								13.6	37.2	-
Kickstage																																			-
Sub-Total		3.0		128.0	50.6	5.3		50.6	47.0			57.6		13.6	57.6			64.4			64.4			64.4	64.4	17.0							326.1	371.8	-
Test 320-06-02																																			
Structural				Existing	Facility	-	No	Facilities		Input	Rqd																								
Thermal				Existing	Facility	-	No	Facilities		Input	Rqd																								
IAM							1.2		1.3						1.3			1.3			1.3			1.3	.9								6.6	-	-
Propulsion							83.0		27.0			7.5			(7.0)			(7.0)			(7.0)			(7.0)	(7.0)	9.0							117.5	54.0	-
Tank Qual. & Accept.				170.0			20.0		1.0			(1.3)			(1.3)			(1.3)			(1.3)			(1.3)	(1.3)	(.7)							[illegible]	[illegible]	-
Sub-Total				160.0			103.0		2.2			27.0	10.1		11.6			11.6			11.6			11.6	11.2	9.7							[illegible]	62.5	-
Maint. & Refurb. - ETR 320-06-03																																			
Tug Maint. Fac.				60.0			170.0			170.0	327.0				30.0		21.0	33.1		133.4	33.1		134.4	33.1	-	-	-	-	-	33.1	21.0	1232.6		366.6
Prop. Sys. Serv.				25.0			[illegible]			[illegible]	116.0				(8.3)		6.0	1.0		53.0	1.0		57.4	1.0	-	-	-	-	-	1.0	3.0	1164.4	-	[illegible]
Tug Cleaning							37.0			521.5	53.0				(5.5)			[6.0]			[6.0]			[6.0]	-	-	-	-	-	6.0	13.0	[illegible]	-	[illegible]
Kick Stage Proc.																72.0				15.4	[1.6]			[1.6]	-	-	-	-	-	[1.6]	[1.6]	[illegible]	-	16.0
Support/Whse. Fac.				Shuttle		Shared		Facilities		122.0															-	-	-	-	-	-	-	[illegible]	-	-
Office										10.0					[5.0]			[5.0]			[5.0]			[5.0]	-	-	-	-	-	[5.0]	2.5	16.0	-	[illegible]
Sub-Total				85.0			[illegible]			1511.0	712.0				19.8	72.0	27.0	53.9		241.8	54.5		255.6	55.0	-	-	-	-	-	55.0	27.4	3172.6		[illegible]
ETR Launch 320-06-04																																			
Launch Pad				Shuttle		Facility								5.0																			5.0	-	-
Safing Area				Shuttle		Facility					2.0			18.0																			[illegible]	-	-
Mission Control Center							5.0			402.5					[7.0]			[12.0]			[12.0]			[12.0]	-	-	-	-	-	[12.0]	[illegible]	412.5	-	[illegible]
Sub-Total							[illegible]			402.5	2.0			23.0	7.0			12.0			12.0			12.0	-	-	-	-	-	12.0	2.5	[illegible]	-	[illegible]
Maint. & Refurb.-WTR 320-06-05																																			
Tug Maint. Fac.													40.0			140.0			160.0	[illegible]				[illegible]	-	-	-	-	-	[illegible]	[illegible]	[illegible]	-	[illegible]
Prop. Sys. Serv.													3.0			24.5			54.0	27.0				3.0	-	-	-	-	-	[illegible]	2.5	[illegible]	-	[illegible]
Tug Cleaning																31.0			365.1	63.1				[5.0]	-	-	-	-	-	[6.0]	[3.0]	[illegible]	-	[illegible]
Support/Whse. Fac.						Present	Co[illegible]	Base	line	-	Level	I	Manpower						WTR	only														-	[illegible]
Office																16.0			[illegible]	16.0					-	-	-	-	-	[illegible]	[illegible]	[illegible]	-	[illegible]
Sub-Total													10.0			41.0			639.1	77.6				37.6	11.6	-	-	-	-	11.6	10.6	727.6	-	[illegible]
WTR Launch 320-06-06																																			
Launch Pad				Shuttle		Facility																5.0											5.0	-	-
Safing Area				Shuttle		Facility														2.0		22.0											24.0	-	-
							6.0			168.0					[7.0]			[12.0]			[12.0]			[12.0]	-	-			-	[12.0]	[illegible]	214.0	-	[illegible]
Sub-Total							6.0			168.0					7.0			12.0		2.0	12.0		27.0	12.0	-	-	-	-	-	12.0	6.5	233.0	-	[illegible]
TOTALS		3.0		213.0	50.6	5.3	[illegible]	103.6	77.2	[illegible]	741.0	127.7	10.0	36.6	134.0	[illegible]	27.0	155.9	1639.1	271.4	[illegible]	[illegible]	[illegible]	[illegible]	111.6	87.7	47.3	20.6	120.6	20.6	126.6	26.6	26.2	[illegible]	2324.3	[illegible]

GRAND TOTAL 10,417.5

COSTS - $000 (1973)

Col. 1 - Design/Construction Costs
Col. 2 - Activation Costs
Col. 3 - Maintenance Costs

00 - DDT & E Costs
(00) - Production Costs
[00] - Operations Costs

8.4 Vehicle Manufacturing

This section establishes the requirements for the 320A-1/320AE-1 spacecraft including the assembly sequence, tooling, schedule, manufacturing test, special processes and facilities.

The spacecraft is a two stage vehicle with apogee kick stage. Each stage of the spacecraft is interchangeable and can be used as the first or second stage of the stack by replacing adapter fittings. Manufacture of the stages is the same as the single stage vehicle with the basic diameter reduced from 10 feet to roughly 8 feet. A special adapter to the orbiter is required and so is an interstage structure. Each spacecraft has nested titanium propellant tanks and a composite honeycomb outer shell. The orbiter adapter and interstage construction use aluminum sheetmetal substructure and a composite honeycomb outer shell.

8.4.1 Plan/Flow/Time

The assembly breakdown of the two stage Tug is shown in figure 8.4-1. The manufacturing sequence is the same as the single stage vehicle discussed in Part II Section 8.4. A major problem with the two stage vehicle is that two sets of weld assembly tooling and additional assembly/checkout stations are required to meet early schedule committments. The typical manufacturing flow and master schedule are shown in Figure 8.4-2 and 8.4-3 respectively.

8.4.2 Tooling Requirements (including GSE)

Tooling requirements are the same as discussed in Part II Section 8.4.2 however an additional set of weld fixtures and another final assembly fixture are required.

8.4.3 Facility Requirements

The two stage vehicle requires additional floor space in structural and final assembly areas as shown in Fig. 8.4-4. Supporting areas in Plant 2 and 3 and cold flow (HPTF) will be the same as discussed in Part I section 8.4.3.

8.4.4 Special Requirements

See Part II Section 8.4.4

8.4.5 Summary Analysis/Philosophy

See Part II section 8.4.5

8.4.6 GSE Requirements

See Part I section 8.4.7

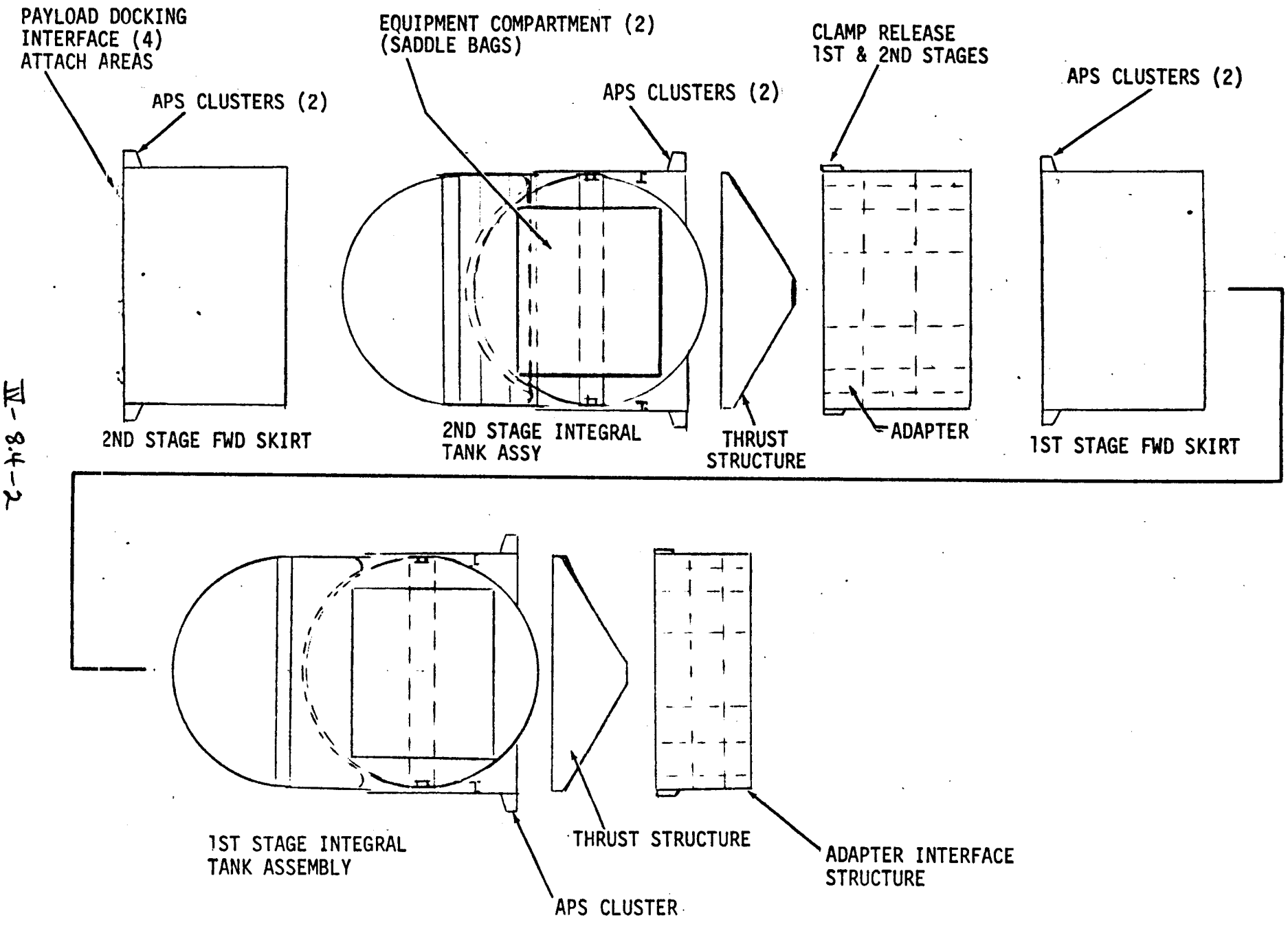


Figure 8.4-1 Assembly Breakdown 2 Stage Tug

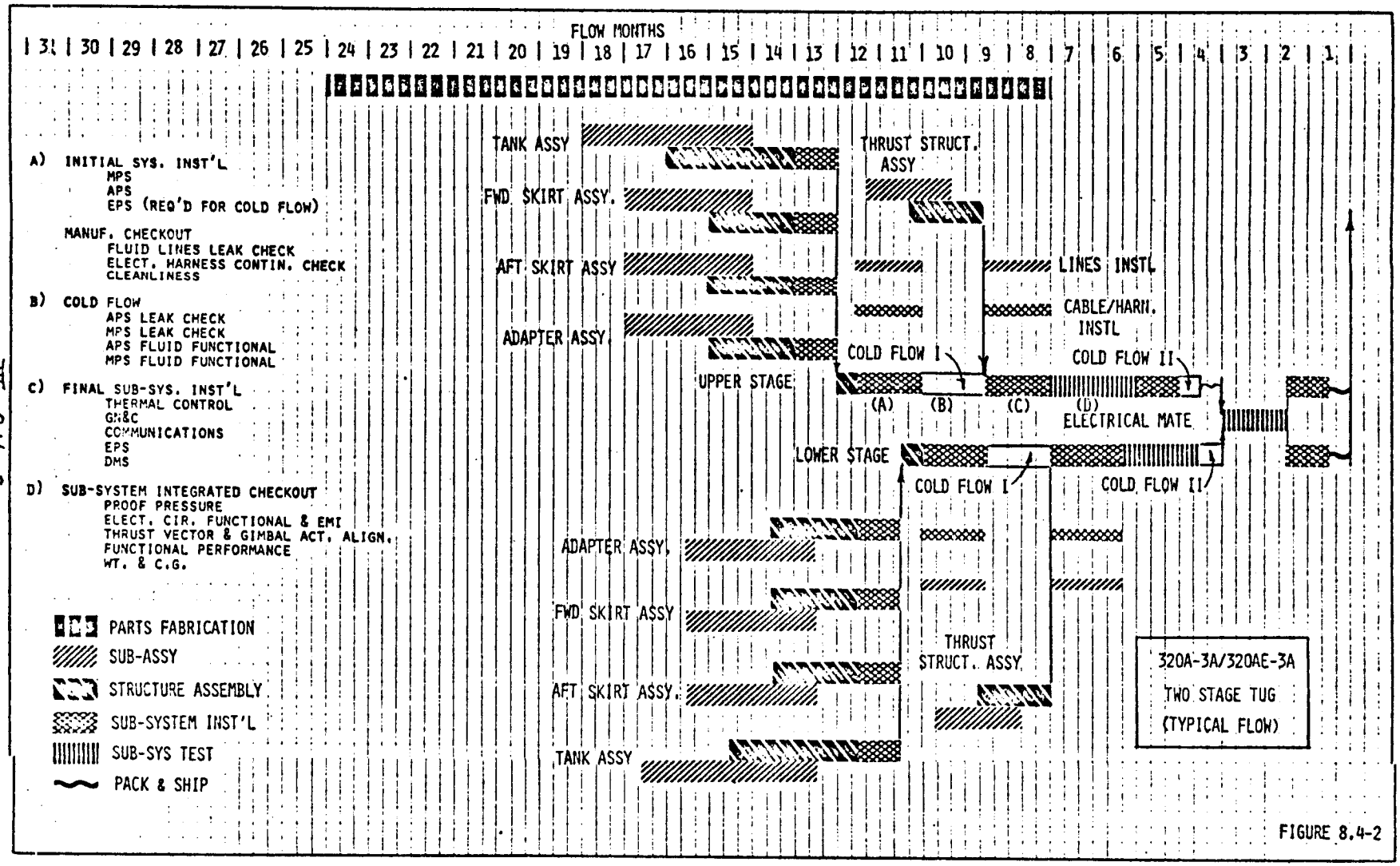

FLOW MONTHS
31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
A) INITIAL SYS. INST'L
MPS
APS
EPS (REQ'D FOR COLD FLOW)
MANUF. CHECKOUT
FLUID LINES LEAK CHECK
ELECT. HARNESS CONTIN. CHECK
CLEANLINESS
B) COLD FLOW
APS LEAK CHECK
MPS LEAK CHECK
APS FLUID FUNCTIONAL
MPS FLUID FUNCTIONAL
C) FINAL SUB-SYS. INST'L
THERMAL CONTROL
G&C
COMMUNICATIONS
EPS
DMS
D) SUB-SYSTEM INTEGRATED CHECKOUT
PROOF PRESSURE
ELECT. CIR. FUNCTIONAL & EMI
THRUST VECTOR & GIMBAL ACT. ALIGN.
FUNCTIONAL PERFORMANCE
WT. & C.G.
PARTS FABRICATION
SUB-ASSY
STRUCTURE ASSEMBLY
SUB-SYSTEM INST'L
SUB-SYS TEST
PACK & SHIP
TANK ASSY
FWD SKIRT ASSY.
AFT SKIRT ASSY
ADAPTER ASSY
THRUST STRUCT. ASSY
LINES INSTL
CABLE/HARN. INSTL
COLD FLOW I
COLD FLOW II
UPPER STAGE
(A)
(B)
(C)
(D)
ELECTRICAL MATE
LOWER STAGE
COLD FLOW I
COLD FLOW II
ADAPTER ASSY.
FWD SKIRT ASSY
THRUST STRUCT. ASSY
AFT SKIRT ASSY.
TANK ASSY
320A-3A/320AE-3A
TWO STAGE TUG
(TYPICAL FLOW)

FIGURE 8.4-2

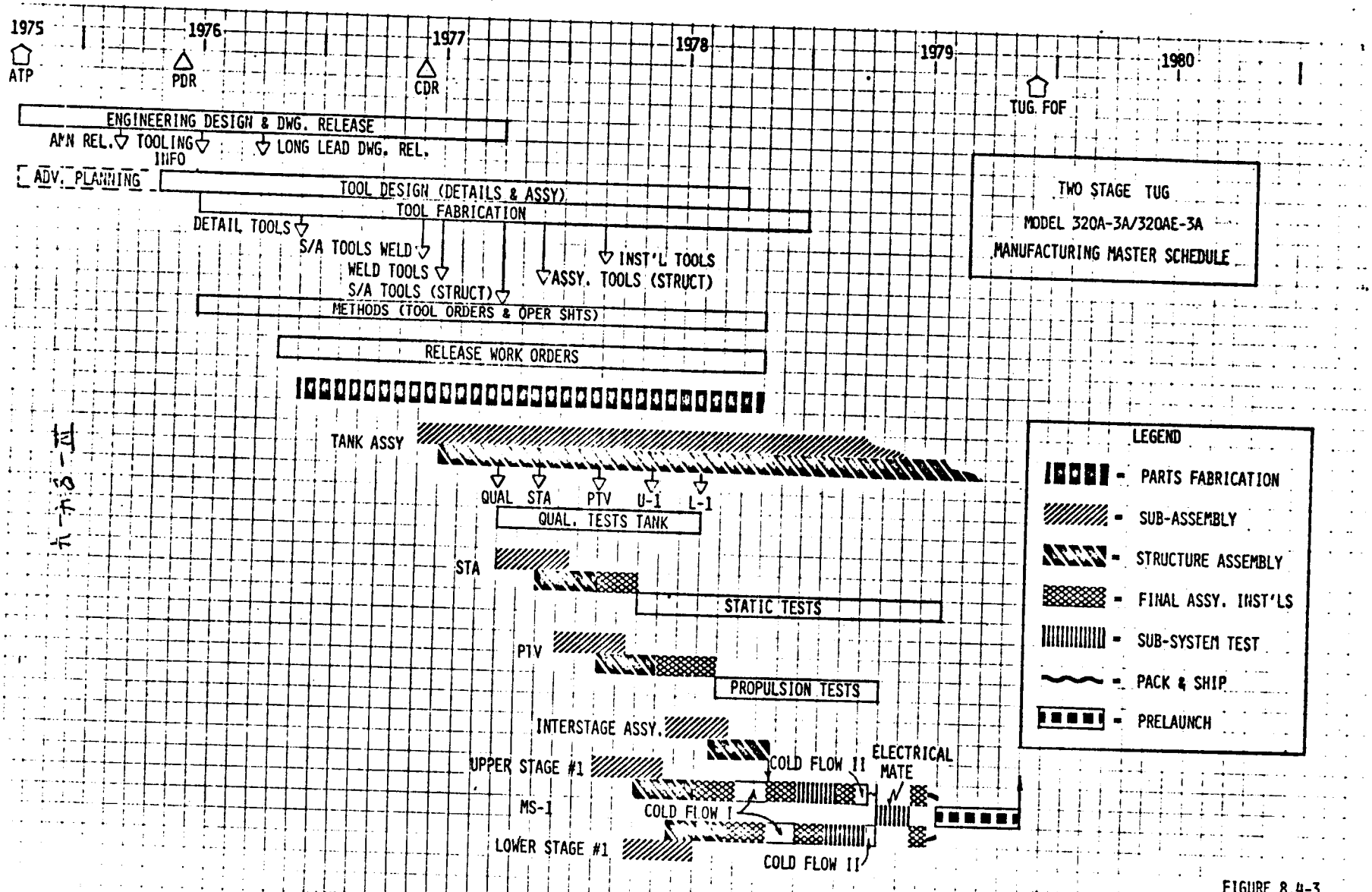
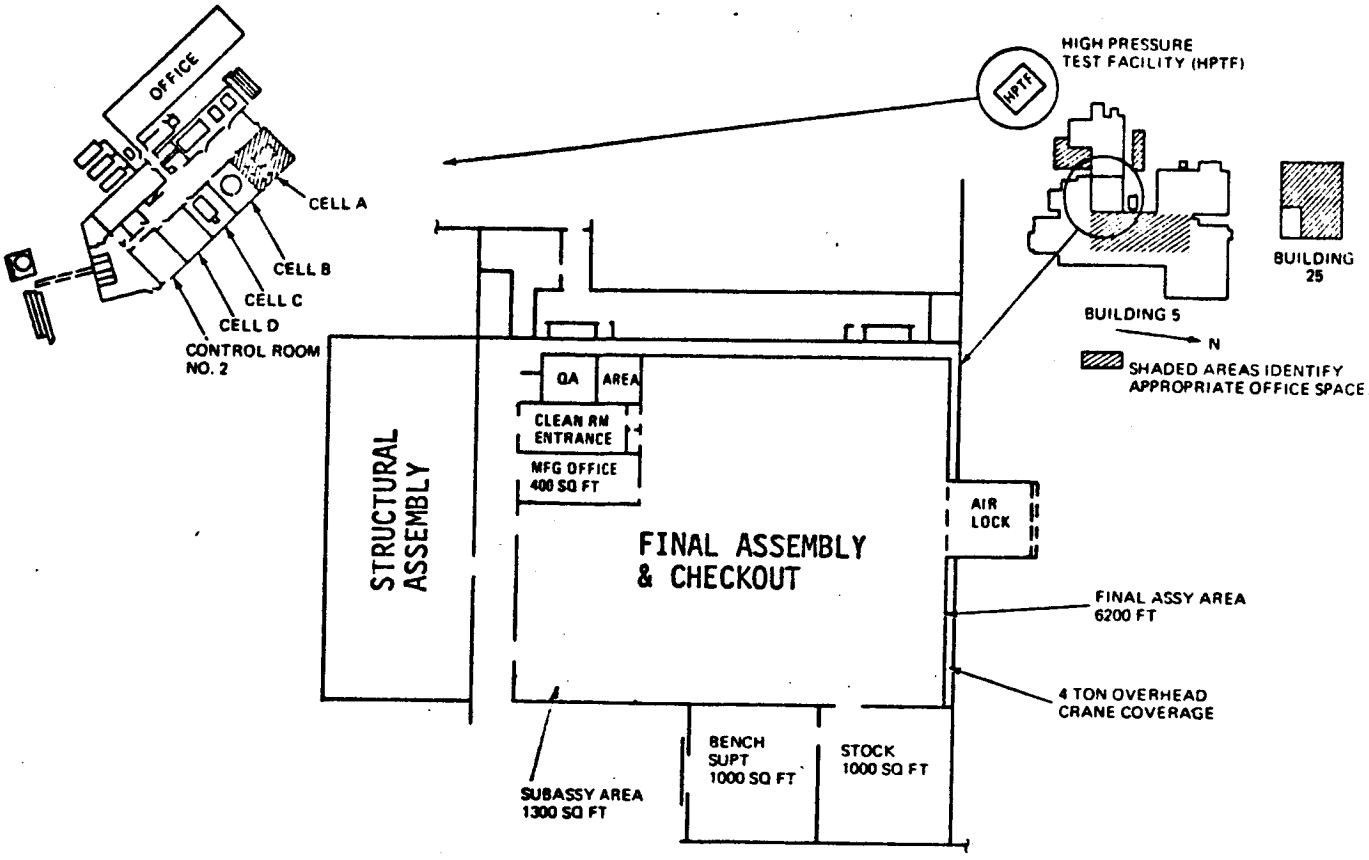

1975
1976
1977
1978
1979
1980
ATP
PDR
CDR
TUG FOF
ENGINEERING DESIGN & DWG. RELEASE
AMN REL.
TOOLING INFO
LONG LEAD DWG. REL.
ADV. PLANNING
TOOL DESIGN (DETAILS & ASSY)
TOOL FABRICATION
DETAIL TOOLS
S/A TOOLS WELD
WELD TOOLS
S/A TOOLS (STRUCT)
INST'L TOOLS
ASSY. TOOLS (STRUCT)
METHODS (TOOL ORDERS & OPER SHTS)
RELEASE WORK ORDERS
TANK ASSY
QUAL
STA
PTV
U-1
L-1
QUAL. TESTS TANK
STA
STATIC TESTS
PTV
PROPULSION TESTS
INTERSTAGE ASSY.
UPPER STAGE #1
COLD FLOW II
ELECTRICAL MATE
MS-1
COLD FLOW I
LOWER STAGE #1
COLD FLOW II
TWO STAGE TUG
MODEL 320A-3A/320AE-3A
MANUFACTURING MASTER SCHEDULE
LEGEND
- PARTS FABRICATION
- SUB-ASSEMBLY
- STRUCTURE ASSEMBLY
- FINAL ASSY. INST'LS
- SUB-SYSTEM TEST
- PACK & SHIP
- PRELAUNCH

FIGURE 8.4-3



Final Assembly Facility

ACTIVITY	MAIN STAGE	KICK STAGE
FINAL ASSY & C/O	9,800 sq. ft.	1,100 sq. ft.
STRUCT ASSY.	15,500	2,300
TANK ASSY (PL #3)	7,200	-
TOTAL	32,500 sq. ft.	3,400 sq. ft.

Figure 8.4-4

8.5 320A-3/320AE-3A SPECIAL PROGRAMMATICS

The salient features defined for implementing and managing Program 320A-3A/320AE-3A include: defining the initial/evolved flight build up based on Shuttle/Tug launch constraint and ground crew launch capability; implementing 3 lot production (deploy, deploy-upgrade and retrieve); developing common upper stage and lower stage subsystems; using lower stage to perform single stage payload deploys; refurbishing the propulsion test article for operational use; and defining a fall back position for every identified risk.

Specific areas for government participation include: establishing Tug/Shuttle interface requirements before Orbiter design freeze; providing payload interface design requirements and mission model data; initiating required activities for supporting Research and Technology; providing GFE systems and components (eg: main engines, and DOD secure comm); supporting propulsion system testing and development and supporting as integrated avionics hardware testing and related software development; providing required facilities; performing vehicle ground operations, and logistic support operations.

320A-3A/320AE-3A SPECIAL PROGRAMMATICS

- o PROGRAM IMPLEMENTATION AND MANAGEMENT
  - INITIAL/EVOLVED FLIGHT BUILD-UP SET BY SHUTTLE/TUG LAUNCH CONSTRAINTS AND GROUND CREW LAUNCH CAPABILITY
  - 3 LOT PRODUCTION (DEPLOY, DEPLOY-UPGRADE, AND RETRIEVE) TO AVOID MFG GAP
  - COMMON UPPER/LOWER SUBSYSTEMS
  - LOWER STAGE USED AS SINGLE STAGE
  - PROPULSION ARTICLE REFURBED FOR FLIGHT
  - FALL BACK POSITION SHOWN FOR EVERY IDENTIFIED RISK

- o AREAS FOR GOVERNMENT PARTICIPATION
  - FIRM TUG/SHUTTLE INTERFACES BEFORE ORBITER PDR
  - PROVIDE PAYLOAD INTERFACE DESIGN REQUIREMENTS AND MISSION MODEL DATA
  - INITIATE REQUIRED SR&T
  - SUPPORT SYSTEM TEST - AVIONIC HARDWARE/SOFTWARE, PROPULSION
  - PROVIDE GFE SYSTEMS AND COMPONENTS, FACILITIES, LOGISTIC SUPPORT
  - PERFORM VEHICLE GROUND AND FLIGHT OPERATIONS

GRUMMAN

8.6 COST DATA

Included in this section are the cost data for an evolved tug configuration 320A-3A/320AE-3A. Cost data are provided for the initial program 320A-3A and the combined total evolved program.

- Initial Program 320A-3A
  - Storable Space Tug System Project Expected Cost-Spares Cost (INT & OPS)-First Unit Cost (Data Forms A1, 2 and 3, subparagraph no's 8.6.1, 8.6.2 and 8.6.3) (Computer P/O)
  - Storable Space Tug Funding Schedules-DDT & E, Production and Operations (Data Form C, subparagraph 8.6.4, 8.6.5, 8.6.6 and 8.6.7)
  - First Unit Production Cost per WBS (including Avionics to level 7) Main Stage and Auxiliary Stage(s), (subparagraph 8.6.8)
  - Form B (Technical Characteristics subparagraph 8.6.11)
- Combined Evolved Program 320A-3A/320AE-3A
  - Same as initial program plus:
    - Average Cost/Flight (subparagraph 8.6.9)
    - Storable Space Tug System Project Cost Estimate data by SOW-DDT & E, Production and Operations (Data Form T (SOW'S) subparagraph 8.6.10)

EVOLVED TUG

CONCEPT 320A-3A (INITIAL)

OPTION 3

320A-3A SEPT 73 (PHASE I)

STORABLE SPACE TUG SYSTEM PROJECT

EXPECTED COST - SPARES COST(INT + OPS) - FIRST UNIT COST

(COSTS IN 1973 CONSTANT DOLLARS (000))

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0100	PROJECT MGMT	11938.			3259.				1284.	2733.		
0110	COST/PERF MGMT		1791.			489.			193.		911.	
0120	PROJECT DIRECTION		9192.			2509.			988.		911.	
0130	INFO MGMT		955.			261.			103.		911.	
0200	SYS ENG + INTEGR	14326.			3666.				1444.	5468.		
0210	TUG SYS ENG		11461.						0.		1367.	
0220	SHUTTLE INTERFACE		1433.						0.		1367.	
0230	PAYLOAD INTERFACE		1433.						0.		1367.	
0240	SUST ENG					0.			1444.		1367.	
0300	TUG VEH MAIN STAGE	162600.			24727.			4628.	8725.	9364.		
0310	STRUCTURES		14397.			3735.		374.	1471.		374.	
0311	FUEL TNK+SPRT			4522.			1212.	121.	478.			121.
0312	OX TANK +SPRT			5271.			1382.	138.	545.			138.
0313	BODY STRUCT			2044.			557.	56.	219.			56.
0314	THRUST STRUCT			218.			39.	4.	15.			4.
0315	METEOROID SHLD			110.			24.	2.	9.			2.
0316	PAYLOAD INTFCE			2232.			521.	52.	205.			52.
0317	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0320	THERMAL INSULTN		149.			286.		14.	113.		14.	
0321	FUEL TANK INSUL			57.			140.	14.	55.			14.
0322	OX TANK INSUL			92.			146.	0.	57.			0.
0323	PURGE SYS INSUL			0.			0.	0.	0.			0.
0324	CONT SYS			0.			0.	0.	0.			0.
0325	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0330	AVIONICS		60481.			9753.		3046.	3251.		6699.	
0331	DATA MGMT			5880.			1989.	716.	663.			1726.
0332	C N + C			10420.			4410.	1407.	1470.			3108.
0333	COMMUNICATIONS			5883.			1240.	388.	413.			796.
0334	INSTRUMENTATION			0.			0.	0.	0.			0.
0335	ELEC PWR			37251.			1482.	535.	494.			1070.
0336	PWR DIST + CONT			1047.			632.	0.	211.			0.
0337	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0340	PROPULSION		76449.			5563.		1033.	1922.		2116.	
0341	MAIN ENGINE			64000.			2197.	937.	800.			1880.
0342	MAIN ENGINE SPT			7963.			1275.	0.	425.			0.
0343	ACPS ENGINE			3000.			1125.	96.	375.			236.
0344	ACPS ENGINE SPT			1486.			966.	0.	322.			0.
0345	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0350	ORBITER INTERFACE		7131.			1617.		162.	637.		162.	
0351	STRUCTURE			5050.			711.	71.	280.			71.
0352	INTERFACE PNLS			2081.			906.	91.	357.			91.
0353	PURGE PROVISION			0.			0.	0.	0.			0.
0354	ABORT PROVISION			0.			0.	0.	0.			0.
0355	INSTL.ASSY+C/O			0.			0.	0.	0.			0.

IV-86-B

MOORE BUSINESS FORMS, INC., NO FORM 1412T PRINTED IN U.S.A. 77

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0360	DROP TANKS		0.			0.		0.	0.		0.	
0361	STRUCTURES			0.			0.	0.	0.			0.
0362	THERMAL INSUL			0.			0.	0.	0.			0.
0363	PROP SPRT SYS			0.			0.	0.	0.			0.
0364	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0370	FINAL ASSY + C/O		3993.			3772.		0.	1331.		0.	
0371	FINAL ASSY			3993.			3772.	0.	1331.			0.
0372	CHECKOUT			0.			0.	0.	0.			0.
0400	TUG VEH AUX STAGE	20781.			29797.			1702.	8921.	1702.		
0410	STRUCTURES		0.			3053.		305.	1203.		305.	
0411	FUEL TNK+SPRT			0.			818.	82.	322.			82.
0412	OX TANK+SPRT			0.			1382.	138.	545.			138.
0413	BODY STRUCT			0.			362.	36.	143.			36.
0414	THRUST STRUCT			0.			20.	2.	8.			2.
0415	METEOROID SHLD			0.			13.	1.	5.			1.
0416	PAYLOAD INTERFC			0.			457.	46.	180.			46.
0417	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0420	THERMAL INSUL		57.			286.		14.	113.		14.	
0421	FUEL TANK INSUL			57.			140.	14.	55.			14.
0422	OX TANK INSUL			0.			146.	0.	57.			0.
0423	PURGE SYS INSUL			0.			0.	0.	0.			0.
0424	CONT SYS			0.			0.	0.	0.			0.
0425	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0430	AVIONICS		10.			7808.		0.	3076.		0.	
0431	DATA MGMT			0.			1683.	0.	663.			0.
0432	G N + C			0.			3577.	0.	1409.			0.
0433	COMMUNICATIONS			0.			1049.	0.	413.			0.
0434	INSTRUMENTATION			0.			0.	0.	0.			0.
0435	ELEC PWR			0.			963.	0.	379.			0.
0436	PWR DIST + CONT			10.			535.	0.	211.			0.
0437	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0440	PROPULSION		0.			4880.		0.	1922.		0.	
0441	MAIN ENGINE			0.			2031.	0.	800.			0.
0442	MAIN ENGINE SPT			0.			1079.	0.	425.			0.
0443	ACPS ENGINE			0.			952.	0.	375.			0.
0444	ACPS ENGINE SPT			0.			817.	0.	322.			0.
0445	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0450	INTERSTAGE INTRFC		1900.			244.		24.	96.		24.	
0451	STRUCTURE			1900.			244.	24.	96.			24.
0452	SEP SYS			0.			0.	0.	0.			0.
0453	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0460	DROP TANK		0.			0.		0.	0.		0.	
0461	STRUCTURE			0.			0.	0.	0.			0.
0462	THERMAL INSUL			0.			0.	0.	0.			0.
0463	PROP SPT SYS			0.			0.	0.	0.			0.
0464	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0470	RDM		0.			0.		0.	0.		0.	

320A-3A SEPT 73 (PHASE I)

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0471	STRUCTURE			0.			0.	0.	0.			0.
0472	THERM CONT			0.			0.	0.	0.			0.
0473	AVIONICS			0.			0.	0.	0.			0.
0474	PROPULSION			0.			0.	0.	0.			0.
0475	RDM ASSY+C/O			0.			0.	0.	0.			0.
0480	AKS		15353.			10598.		1358.	1358.		1358.	
0481	STRUCTURE			4950.			2404.	0.	373.			0.
0482	SRM			1680.			2282.	578.	68.			578.
0483	AVIONICS			5000.			3939.	688.	611.			688.
0484	PROPULSION			459.			638.	92.	99.			92.
0485	AKS ASSY+C/O			3264.			1335.	0.	207.			0.
0490	DKS		0.			0.		0.	0.		0.	
0491	STRUCTURE			0.			0.	0.	0.			0.
0492	SRM			0.			0.	0.	0.			0.
0493	AVIONICS			0.			0.	0.	0.			0.
0494	PROPULSION			0.			0.	0.	0.			0.
0495	DKS ASSY+C/O			0.			0.	0.	0.			0.
04100	CACHE TANK		0.			0.		0.	0.		0.	
04101	STRUCTURE			0.			0.	0.	0.			0.
04102	THERM CONT			0.			0.	0.	0.			0.
04103	AVIONICS			0.			0.	0.	0.			0.
04104	PROPULSION			0.			0.	0.	0.			0.
04105	CACHE ASSY+C/O			0.			0.	0.	0.			0.
04110	FINAL ASSY + C/O		3461.			2929.		0.	1154.		0.	
04111	FINAL ASSY			3461.			2929.	0.	1154.			0.
04112	CHECKOUT			0.			0.	0.	0.			0.
0500	LOGISTICS	6330.			5910.				5910.			
0510	TRANSPORT+HANDLG		0.			1150.			1150.			
0520	TRAINING		6330.			4130.			4130.			
0521	SIM+EQUIPMENT			1950.			1950.		1950.			
0522	GROUND CREW			2180.			2180.		2180.			
0523	FLT OPS CREW			2200.			0.		0.			
0530	WAREHSG+INV CONT		0.			630.			630.			

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MOORE BUSINESS FORMS, INC., INC. FORM 1412T PRINTED IN U.S.A.

320A-3A SEPT 73 (PHASE I)

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0600	FACILITIES	8665.			331.					783.		
0610	MANUFACTURING		328.			288.					0.	
0611	DES/CONSTR			328.								0.
0612	ACT/MAINT			0.			288.					
0620	TEST		248.			43.					0.	
0621	DES/CONST			248.								0.
0622	ACT/MAINT			0.			43.					
0630	1ST TR MAINT+REF		3723.			0.					570.	
0631	DES/CONST			3723.								570.
0632	ACT/MAINT			0.			0.					
0640	ETR LAUNCH		438.			0.					110.	
0641	DES/CONST			438.								110.
0642	ACT/MAINT			0.			0.					
0650	2ND TR MAINT+REF		3428.			0.					0.	
0651	DES/CONST			3428.								0.
0652	ACT/MAINT			0.			0.					
0660	WTR LAUNCH		500.			0.					103.	
0661	DES/CONST			500.								103.
0662	ACT/MAINT			0.			0.					
0700	GSE	26120.			8290.			910.		4050.		
0710	MFG GSE		0.									
0711	HARDWARE											
0712	SITE ACT											
0713	MAINT											
0714	SOFTWARE											
0720	ETR GSE		18160.			1550.		310.			880.	
0721	HARDWARE			14780.			1550.	310.				
0722	SITE ACT			3100.								880.
0723	MAINT			0.								
0724	SOFTWARE			280.								
0730	WTR GSE		0.			3000.		600.			1810.	
0731	HARDWARE			0.			3000.	600.				
0732	SITE ACT			0.								1810.
0733	MAINT			0.								
0734	SOFTWARE			0.								

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MOOSE BUSINESS FORMS INC. NO FORM 14121 PRINTED IN U.S.A.

320A-3A SEPT 73 (PHASE I)

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0740	FL OP NASA		3980.			1870.		0.			680.	
0741	HARDWARE			3300.			1870.	280.				
0742	SITE ACT			400.								680.
0743	MAINT			0.								
0744	SOFTWARE			280.								
0750	FL OP DOD		3980.			1870.		0.			680.	
0751	HARDWARE			3300.			1870.	0.				
0752	SITE ACT			400.								680.
0753	MAINT			0.								
0754	SOFTWARE			280.								
0800	VEHICLE TEST	81948.										
0810	GND TEST HARDWARE		8382.									
0811	PTV/BATTLESHIP			2086.								
0812	MAJOR TST ART			5595.								
0813	MOCKUPS			700.								
0820	GND TEST OPS		10810.									
0830	FLT TEST HARDWARE		17696.									
0840	FLT TEST OPS		45060.									
0900	LAUNCH OPS WTR									434.		
0910	LAUNCH SITE SVC										0.	
0920	TUG/SHUTTLE MATG										0.	
0930	PRELAUNCH C/O										0.	
0940	COUNTDOWN										0.	
0950	FLUID+GASES										434.	
0960	POST FLT SAFING										0.	
1000	LAUNCH OPS ETR									7051.		
1010	LAUNCH SITE SVC										0.	
1020	TUG/SHUTTLE MATG										550.	
1030	PRELAUNCH C/O										1000.	
1040	COUNTDOWN										33.	
1050	FLUID+GASES										3658.	
1060	POST FLT SAFING										1810.	
1100	FLT OPS DOD	4420								18280.		
1110	MISSION PLAN		2990								6800.	
1120	FLT CONT		920								7250.	
1130	FLT EVALUATION		510								960.	
1140	FLT SPT SOFTWARE										3270.	
1200	FLT OPS NASA	35410								36530.		
1210	MISSION PLAN		7880								10560.	
1220	FLT CONT		1800								8960.	
1230	FLT EVALUATION		490								930.	
1240	FLT SPT SOFTWARE		25240								16080.	

NOTE
THESE COSTS INCLUDED
IN VEHICLE TEST

MOORE BUSINESS FORMS, INC. NO. FORM 1412 T PRINTED IN U.S.A. 22

32CA-3A SEPT 73 (PHASE I)

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
1300	REF+INT 1ST TR									1600.		
1310	SCHED MAINT+REF										0.	
1320	UNSCHED MAINT+REF										0.	
1330	POST MAINT C/O										0.	
1340	TUG/PAYLOAD MATG										0.	
1350	REF RQMTS PLANNG										0.	
1360	DEPOT MAINT										1600.	
1400	REF+INT 2ND TR									12794.		
1410	SCHED MAINT+REF										1950.	
1420	UNSCHED MAINT+REF										2050.	
1430	POST MAINT C/O										673.	
1440	TUG/PAYLOAD MATG										1070.	
1450	REF RQMTS PLANNG										151.	
1460	DEPOT MAINT										6900.	
	SPACE TUG TOTALS	332708.			75980.			7240.	26284.	100789.		
	32A= 332708.	32B=	83220.		32C=	100789.		32D=	516717.			

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MOORE BUSINESS FORMS, INC. NO. FORM 1412T PRINTED IN U.S.A.

1st phase
3201-3A SEPT 73

For Summary Plot 7/15

STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

NOTE (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	11.9	1.55	2.81	3.00	2.93	1.64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	14.3	1.86	3.38	3.60	3.51	1.97	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	TUG MAIN STAGE	162.6	62.70	68.59	26.01	5.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	STRUCTURE	14.4	6.62	6.34	1.43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320	THERMAL INSUL	0.1	0.05	0.07	0.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
330	AVIONICS	60.5	18.54	25.50	13.43	3.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION	76.4	~~34.17~~	~~33.44~~	7.61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
350	INTERFACE	7.1	2.32	3.02	1.79	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
360	DROP TANK																	
370	FINAL ASSY	4.0	0.0	0.0	1.71	2.28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	TUG AUX STAGE	20.8	0.0	0.0	0.05	6.11	9.51	4.35	0.77	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
410	STRUCTURE																	
420	THERMAL INSUL	0.1	0.0	0.0	0.04	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
430	AVIONICS	0.0	0.0	0.0	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
440	PROPULSION																	
450	INTERSTAGE	1.9	0.0	0.0	0.0	1.38	0.52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
460	DROP TANK																	
470	RCM																	
480	AKS	15.4	0.0	0.0	0.0	4.71	6.47	3.41	0.77	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
490	DKS																	
4100	CACHE																	
4110	FINAL ASSY	3.5	0.0	0.0	0.0	0.0	2.52	0.94	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS	6.3	1.37	2.28	1.69	0.80	0.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600	FACILITIES	8.7	0.55	0.99	1.52	1.88	1.73	1.23	0.77	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
610	MANUFACTURING	0.3	0.06	0.11	0.09	0.05	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
620	TEST	0.2	0.0	0.0	0.18	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
630	1ST MAIN/REF	3.7	0.48	0.88	0.93	0.91	0.51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
640	ETR LAUNCH	0.4	0.0	0.0	0.32	0.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650	2ND MAIN/REF	3.4	0.0	0.0	0.0	0.64	1.05	1.07	0.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
660	WTR LAUNCH	0.5	0.0	0.0	0.0	0.09	0.15	0.16	0.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	GND SUPP EQUIP	26.1	9.58	9.67	2.69	4.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			1	4	8	10	3											
710	MFC GSE																	
720	ETR GSE	18.2	8.36	8.00	1.81	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
730	WTR GSE																	
740	FLT OPS NASA	4.0	0.0	0.0	0.0	3.98	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
750	FLT OPS DOD	4.0	1.22	1.68	0.88	0.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800	VEHICLE TEST	81.9	2.96	10.13	~~19.73~~ 36	~~54.64~~ 30	1.49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
810	GND TEST HWRE	8.4	1.55	2.56	2.63	1.64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
820	GND TEST OPS	10.8	1.41	2.55	2.71	2.65	1.49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
830	FLT TEST HWRE	17.7	0.0	5.02	7.38	5.29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
840	FLT TEST OPS	45.1	0.0	0.0	0.0	45.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900	LAUNCH OPS WTR																	
1000	LAUNCH OPS ETR																	
1100	FLIGHT OPS DOD																	
1200	FLIGHT OPS NASA																	
1300	REF + INT TR-1			84	102 ~~95~~	66 ~~67~~												
1400	REF + INT TR-2		~~1~~	~~94~~	~~71~~	~~85~~	23											
	TOTALS	332.7	~~80.57~~	~~97.85~~	51.28	79.35	16.54	5.58	1.54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

IHC208I IBCOM - PROGRAM INTERRUPT (P) - UNDERFLOW OLD PSW IS FFA5000DA21932D0 . REGISTER CONTAINED 7D6D800000000000

TRACEBACK ROUTINE	CALLED FROM ISN	REG. 14	REG. 15	REG. 0	REG. 1
OUT	0058	62192638	001929E0	00000030	0018EB40
SPREAD	0593	5218CC00	001BEA20	00000000	00181C58

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MOORE BUSINESS FORMS, INC., HO FORM 14121 PRINTED IN U.S.A.

320A-3A SEPT 73

STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

PROD (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	~~1976~~ 76	~~1977~~ 77	~~1978~~ 78	~~1979~~ 79	~~1980~~ 80	~~1981~~ 81	~~1982~~ 82	~~1983~~ 83	~~1984~~ 84	1984- 85	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	3.3	0.31	0.61	0.67	0.69	0.64	0.33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	3.7	0.35	0.69	0.76	0.77	0.72	0.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	TUG MAIN STAGE	29.4	0.0	4.51	8.51	7.77	5.16	2.55	0.77	0.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	STRUCTURE	4.1	0.0	0.66	1.23	1.10	0.71	0.33	0.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320	THERMAL INSUL	0.3	0.0	0.05	0.09	0.08	0.05	0.02	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
330	AVIONICS	12.8	0.0	2.05	3.83	3.43	2.21	1.02	0.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION	6.6	0.0	1.06	1.98	1.77	1.14	0.53	0.13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
350	INTERFACE	1.8	0.0	0.22	0.44	0.45	0.34	0.21	0.10	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
360	DROP TANK																		
370	FINAL ASSY	3.8	0.0	0.47	0.94	0.95	0.72	0.44	0.21	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	TUG AUX STAGE	31.5	0.0	0.0	3.88	6.85	7.71	6.54	4.12	1.93	0.47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
410	STRUCTURE	3.4	0.0	0.0	0.0	0.0	0.73	1.21	0.90	0.42	0.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
420	THERMAL INSUL	0.3	0.0	0.0	0.22	0.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
430	AVIONICS	7.8	0.0	0.0	0.0	1.25	2.34	2.09	1.35	0.62	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
440	PROPULSION	6.0	0.0	0.0	0.0	0.0	1.06	1.76	1.30	0.62	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
450	INTERSTAGE	0.3	0.0	0.0	0.0	0.0	0.06	0.10	0.07	0.03	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
460	DROP TANK																		
470	PDM																		
480	AKS	12.0	0.0	0.0	3.67	5.04	2.65	0.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
490	DKS																		
4100	CACHE																		
4110	FINAL ASSY	2.0	0.0	0.0	0.0	0.47	0.88	0.79	0.50	0.23	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS	5.0	0.0	0.0	0.95	1.77	1.58	1.02	0.47	0.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600	FACILITIES	0.3	0.07	0.11	0.10	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
610	MANUFACTURING	0.3	0.05	0.09	0.09	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
620	TEST	0.0	0.01	0.02	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
630	1ST MAIN/REF																		
640	ETR LAUNCH																		
650	2ND MAIN/REF																		
660	WTR LAUNCH																		
700	GND SUPP EQUIP	9.2	0.0	0.0	4.08	4.14	0.98	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
710	MFG GSE																		
720	ETR GSE	1.9	0.0	0.0	1.35	0.51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
730	WTR GSE	3.6	0.0	0.0	0.0	2.62	0.98	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
740	FLT OPS NASA	1.9	0.0	0.0	1.36	0.51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
750	FLT OPS DOD	1.9	0.0	0.0	1.36	0.51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800	VEHICLE TEST																		
810	GND TEST HWRE																		
820	GND TEST OPS																		
830	FLT TEST HWRE																		
840	FLT TEST OPS																		
900	LAUNCH OPS WTR																		
1000	LAUNCH OPS ETR																		
1100	FLIGHT OPS DOD																		
1200	FLIGHT OPS NASA																		
1300	REF + INT TR-1																		
1400	REF + INT TR-2																		
	TOTALS	83.2	0.73	5.91	18.95	22.05	16.80	10.81	5.37	2.13	0.47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

IV-86-10

MOORE BUSINESS FORMS, INC. HQ FORM 14741 PRINTED IN U.S.A.

320A-3A SEPT 73

STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

OPS (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	2.7	0.0	0.0	0.0	0.0	0.08	0.19	0.24	0.27	0.28	0.28	0.29	0.29	0.28	0.26	0.20	0.08
200	SYS ENG + INTEG	5.5	0.0	0.0	0.0	0.0	0.15	0.37	0.49	0.54	0.56	0.57	0.57	0.58	0.56	0.51	0.39	0.16
300	TUG MAIN STAGE	9.4	0.0	0.0	0.0	0.0	0.26	0.64	0.83	0.92	0.96	0.98	0.98	0.99	0.96	0.88	0.67	0.28
310	STRUCTURE	0.4	0.0	0.0	0.0	0.0	0.01	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.01
320	THERMAL INSUL	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
330	AVIONICS	6.7	0.0	0.0	0.0	0.0	0.19	0.46	0.60	0.66	0.69	0.70	0.70	0.71	0.69	0.63	0.48	0.20
340	PROPULSION	2.1	0.0	0.0	0.0	0.0	0.06	0.14	0.19	0.21	0.22	0.22	0.22	0.22	0.22	0.20	0.15	0.06
350	INTERFACE	0.2	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.00
360	DROP TANK																	
370	FINAL ASSY																	
400	TUG AUX STAGE	1.7	0.0	0.0	0.01	0.00	0.01	0.02	0.08	0.16	0.19	0.20	0.20	0.21	0.21	0.19	0.15	0.07
410	STRUCTURE	0.3	0.0	0.0	0.0	0.0	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01
420	THERMAL INSUL	0.0	0.0	0.0	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
430	AVIONICS																	
440	PROPULSION																	
450	INTERSTAGE	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
460	DROP TANK																	
470	RDM																	
480	AKS	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.05	0.12	0.15	0.17	0.17	0.17	0.17	0.16	0.13	0.06
490	DKS																	
4100	CACHE																	
4110	FINAL ASSY																	
500	LOGISTICS																	
600	FACILITIES	0.8	0.0	0.0	~~0.07~~	0.21	~~0.0~~	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
610	MANUFACTURING																	
620	TEST																	
630	1ST MAIN/REF	0.6	0.0	0.0	~~0.02~~	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
640	ETR LAUNCH	0.1	0.0	0.0	~~0.00~~	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650	2ND MAIN/REF																	
660	WTR LAUNCH	0.1	0.0	0.0	0.07	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	GND SUPP EQUIP	4.0	0.0	0.0	~~0.00~~	0.39	0.05 1.04	0.14	0.24	0.29	0.31	0.31	0.31	0.31	0.30	0.25	0.13	0.02
710	MFG GSE																	
720	ETR GSE	0.9	0.0	0.0	0.0	0.02	0.05	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.08	0.07	0.06	0.02
730	WTR GSE	1.8	0.0	0.0	0.0	0.0	0.0	0.07	0.16	0.21	0.22	0.23	0.23	0.23	0.22	0.17	0.08	0.0
740	FLT OPS NASA	0.7	0.0	0.0	0.50	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
750	FLT OPS DOD	0.7	0.0	0.0	0.50	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800	VEHICLE TEST																	
810	GND TEST HWRE																	
820	GND TEST OPS																	
830	FLT TEST HWRE																	
840	FLT TEST OPS																	
900	LAUNCH OPS WTR	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.02
1000	LAUNCH OPS ETR	7.1	0.0	0.0	0.0	0.0	0.20	0.48	0.63	0.70	0.72	0.73	0.74	0.74	0.73	0.66	0.51	0.21
1100	FLIGHT OPS DOD	18.3	0.0	0.0	~~13.31~~	~~4.97~~	~~0.0~~	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1200	FLIGHT OPS NASA	36.5	0.0	0.0	0.0	0.0	1.03	2.48	3.25	3.61	3.75	3.80	3.84	3.85	3.76	3.42	2.63	1.10
1300	REF + INT TR-1	1.6	0.0	0.0	0.0	0.0	0.05	0.11	0.14	0.16	0.16	0.17	0.17	0.17	0.16	0.15	0.12	0.05
1400	REF + INT TR-2	12.8	0.0	0.0	0.0	0.0	0.0	0.0	0.50	1.16	1.45	1.56	1.60	1.62	1.61	1.53	1.23	0.54
	TOTALS	100.8	0.0	0.0	~~14.88~~	~~5.58~~	~~1.88~~ 11.64	4.43 9.31	6.43	7.84	8.43	8.66	8.77	8.81	8.63	7.90	6.07	2.53

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II-9.8-II

MODAL BUSINESS FORMS, INC. NO FORM 1412T PRINTED IN U.S.A.

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FIRST UNIT PRODUCTION COST
PER WBS (INCLUDING AVIONICS TO LEVEL 7)
MAIN STAGE AND AUXILIARY STAGE(S)
(COST IN THOUSANDS)

Concept 320A-3A

WBS	IDENTIFICATION	FIRST UNIT COST LEVEL 4	LEVEL 5	LEVEL 6
0300	TUG VEH. MAIN STAGE	8,725		
0310	STRUCTURES		1,471	
0311	Fuel Tank & Sprt			478
0312	OX Tank & Sprt			545
0313	Body Structure			219
0314	Thrust Structure			15
0315	Meteroid Shield			9
0316	Payload Intface			205
0317	Inst'l Assy & C/O			0
0320	THERMAL INSULTN		113	
0321	Fuel Tank Insul			55
0322	OX Tank Insul			57
0333	Purge Sys Insul			0
0324	Cont Sys			0
0325	Inst'l Assy & C/O			0
0330	AVIONICS		3,251	
0331	Data Management			663
0332	GN&C			1,470
0333	Communications			413
0334	Instrumentation			0
0335	Elec Pwr			494
0336	Pwr Dist & Cont			211
0337	Inst'l Assy & C/O			0
0340	PROPULSION		1,922	
0341	Main Engine			800
0342	Main Engine Sprt			425
0343	ACPS Engine			375
0344	ACPS Engine Sprt			322
0345	Inst'l Assy & C/O			0
0350	ORBITER INTERFACE		637	
0351	Structure			280
0352	Interface PNLS			357
0353	Purge Provision			0
0354	Abort Provision			0
0355	Inst'l Assy & C/O			
0360	DROP TANKS		0	
0361	Structures			
0362	Thermal Insul			
0363	Prod Sprt Sys			
0364	Inst'l Assy & C/O			
0370	FINAL ASSY & C/O		1,331	
0371	Final Assy			1,331
0372	Checkout			0
0400	TUG VEH. AUX. STAGE	8,921		
0470	RIM		0	
0471	Structure			
0472	Therm Cont			
0473	Avionics			
0474	Propulsion			
0475	RIM Assy & C/O			
0480	AKS		1,358	
0481	Structure			373
0482	SRM			68
0483	Avionics			611
0484	Propulsion			99
0485	AKS Assy & C/O			207
0490	DKS		0	
0491	Structure			
0492	Therm Cont			
0493	Avionics			
0494	Propulsion			
0495	DKS Assy & C/O			
0100	PROJECT MANAGEMENT			
0200	SYS ENG & INTEGR	2,728		
	TOTAL FIRST UNIT COST			

LEVEL 7 FIRST UNIT COSTS (AVIONICS)

WBS	IDENTIFICATION	MAIN Stage
0330	AVIONICS (MAIN STAGE)	3,251
0331	DATA MANAGEMENT	663
	Computer	174
	Tape Recorder	58
	FSI Cont'r/PIM Form.	55
	DACU	105
	Sensors	75
	In-House	196
0332	GN&C	1,470
	IMU	175
	Star Tracker	162
	Att Ref	40
	Laser Revo. Radar	
	Satellite Receiver	
	Doppler Receiver	
	L-Band Antenna	
	Combined/Doppler Det.	
	APS Ct'l Electronics	295
	MF/TVC Ct'l Electron.	295
	In-House	503
0333	COMMUNICATIONS	413
	S-Band X'CVR/X'PDR	220
	Aux. Xmtr	43
	Power AMP	10
	Baseband Processor	50
	Diplexer	
	Ant Switch	
	Antenna	4
	Power Splitter	
	TV Assembly	
	In-House	86
0334	INSTRUMENTATION	0
0335	ELEC POWER	494
	Battery	100
	Emergency Battery	2
	Modified Fuel Cell	
	Thermal Control	20
	Cryo Tanks	214
	In-House	158
0336	PWR DIST. & CT'L	211
0337	INST'L ASSY & C/O	0

WBS	IDENTIFICATION	Aux Stage
0400	TUG VEH. AUX STAGE	8,921
0470	RIM	0
0473	AVIONICS	0
	DMS	
	PCM/Sig Cond	
	Sensors	
	GN&C	
	Attitude Gyro Ref Unit	
	Timer/CT'l Relay	
	APS CT'l Electron	
	COMMUNICATIONS	
	S-Band Xcvr/Xpdr	
	Baseband Process	
	Aux. Xmtr	
	Pwr Amplifier	
	Diplexer	
	Antenna Switch	
	Antenna	
	ELEC. POWER	
	Primary Battery	
	Pwr Dist & CT'l	
0480	AKS	1,358
0483	AVIONICS	611
	DMS	13
	Sensors	13
	GN&C	300
	Att Gyro Ref U	100
	APS/TVC	50
	Timer/CT'l Relay	50
	Velocity Meter	50
	Sequence Program	50
	ELEC POWER	69
	Primary Battery	2
	Pwr Dist & CT'l	67
	In-House	229
0490	DKS	0
	AVIONICS	
	DMS	
	Sensors	
	PCM	
	GN&C	
	Attitude Gyro Ref Unit	
	Timer/CT'l Relay	
	APS/TVC CT'l Electr	
	Velocity Meter	
	Sequence Program	
	Star Tracker	
	COMMUNICATIONS	
	S-Band Xcvr/Xpdr	
	Baseband Process	
	Aux. Xmtr	
	Pwr Amplifier	
	Diplexer	
	Antenna Switch	
	Antenna	
	ELEC. POWER	
	Primary Battery	
	Pwr Dist & CT'l	
	DeOrbit Battery	
	Solar Cell Pad'l's	

SPACE TUG CHARACTERISTICS

320A-3A→320AE-3A

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	WEIGHT, LB	2695→2768	545
	LENGTH, IN	205 EACH	80
	DIAMETER, IN	98	180
TECHNICAL:	REUSABLE	TWO-STAGE	
	AUXILIARY STAGE		AKS
	PAYLOAD RETRIEVAL	CAPABILITY	
	PROPELLANT CAPACITY, LB	59,500	
	THRUST, LB	12,000	
	ISP, SEC	338	295
	AUTONOMY LEVEL	IIIA	
	RELIABILITY	.9763/.9936	.9987

WBS #320-00

GRUMMAN

MAIN STAGE CHARACTERISTICS

		320A-3A → 320AE-3A
PHYSICAL:	WEIGHT, LB	2695 → 2768
	LENGTH, IN	205 EACH
	DIAMETER, IN	98
TECHNICAL:	REUSABLE TWO STAGE	
	PROPELLANT CAPABITY, LB	32,000 EACH
	PAYLOAD RETRIEVAL CAPABILITY	
	THRUST, LB	12,000
	ISP, SEC	338
	AUTONOMY LEVEL	IIIA
	RELIABILITY	.9763/.9936

WBS #320-03

GRUMMAN

VEHICLE TEST CHARACTERISTICS

320A-3A → 320AE-3A

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	PROP. TEST ARTICLE	X	
	STRUCT. TEST ARTICEL	X	X
	INTEG. AVIONICS TEST	X	X
	MOCK-UPS	X	X
	FLIGHT TEST	X	X

TECHNICAL:

PTA - COLD FLOW ONLY, NO HOT FIRING

STA - ONE ART FOR DYNAMICS, STATIC & FATIGUE

IAT - SOFTWARE & HARDWARE

MOCK-UPS - WOOD AT PDR, WOOD/METAL AT CDR

FLIGHT TEST - ONE WITHOUT P/L, NINE WITH P/L

WBS #320-08

GRUMMAN

STRUCTURAL CHARACTERISTICS

320A-3A → 320AE-3A

PHYSICAL:	WEIGHT, LB	946 → 988
	LENGTH, IN	205
	DIAMETER, IN	98
TECHNICAL:	TANK CONFIGURATION	NESTED DOME
	TANK CAPACITY, LB	32,000
	MATERIAL	Ti, COMPOSITE H'COMB
	RELIABILITY ALLOCATION	.99900

WBS #320-03-01

GRUMMAN

CONFIGURATION 320A-3A

WBS NO. 320-03-01

SUBSYSTEM/COMPONENT STRUCTURE

DATE: 9/17/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS	RELIABILITY: MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TEST	NOTES
01-Fuel Tank and Supports	1	44½		Titan.	177	73	98	D		Welded Gore Titanium Domes	20	1		2	Tank Leakage considered. Unservice able
02-Oxid. Tank and Supports	1	44½		Titan.	113	82	98	D		Welded Gore Titanium Domes	20	1		2	
03-Body Structure	1	44½		Alum. and Comp.	474	120	98	D		Graphite Composite Honeycomb Shell Aluminum Frames	N/A	1		2	Includes Equipment Mounting and Umbilicals
04-Thrust Structure	1	44½		Alum.	65	31	98 MAX.	D		Aluminum Stiffened Sheet	N/A	1		2	
05-Meteroid Shield	1	44½		Alum.	20	76	104	D		Aluminum Sheet	N/A	1	1		
06-Interface	1	46		Alum.	97					Aluminum Machinings and Forgings	N/A	1		2	

BRUMMAN

REPORT
DATE
CODE 20512

THERMAL CONTROL CHARACTERISTICS

320A-3A → 320AE-3A

PHYSICAL: WEIGHT, LB 61 → 62

300 FT^2 GOLDIZED MYLAR MLI

AL BASE HEAT SHIELD

SILVER BACKED TEFLON & ALZAK COATINGS

WBS #320-03-02

GRUMMAN

IV-5.6-18

CONFIGURATION 320A-3A

WBS NO. 320-03-02-01,02

SUBSYSTEM/COMPONENT THERMAL CONTROL

DATE: 8/30/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR G/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
THERMAL CONTROL COATINGS	5	0		SBT ALZAK ALCLAD	6		1000 ft²			0				1			
MULTILAYER INSULATION	3	6		See Mini Spec	28		300 ft²			0				1			
FUEL CELL RADIATOR	2	12		See Mini Spec	19		24 ft²							1			INCLUDES 2 CAROUSEL IMU
AVIONICS HEAT PIPE REPAIR	2	12		See Mini Spec						0							
AVIONICS HEATERS	4	6		See Mini Spec	2					75/UNIT				8			COX & COMPANY, NY, NY.
APS HEATERS*	4	6		See Mini Spec	4					20/UNIT				16			COX & COMPANY, NY, NY.
PAGE HEAT SHIELD	5	0		AL	10.5		67 ft²			0							IDENTICAL TO MICROMETEROID SHIELD
PROPELLANT	5	0		AL	2												

*CARRIED AS APS WT

IV-8.6-19

AVIONICS CHARACTERISTICS

320-3A → 320AE-3A

PHYSICAL:	WEIGHT, LB	612 → 616
TECHNICAL:	AUTONOMY LEVEL	IIIA
	RENDEZVOUS & DOCKING	→ LASER RADAR
	COMMUNICATIONS	DFS → DFS/CSS
	COMPUTER CAPACITY	48K WORDS
	FUEL CELL POWER	2.5 KW
	RELIABILITY ALLOCATION	.98614 → .98562

WBS #320-03-03

GRUMMAN

ROTORAMY LEVEL III A — CORE CONFIGURATION 320A-3A, ~~[illegible]~~ — WBS NO. 320-03-03-01 — SUBSYSTEM/COMPONENT DMS — DATE: [illegible]

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TEST	NOTES
MAIN STAGES #1 & #2 COMPUTER	4	12			13	4.7	5	8.6	202	36	48 KWORDS - 16 BITS/WORD	144	18K	2	N/A	1	CDC 469
TAPE RECORDER	5	12	AF/S-3 VIMBUSE		14.5	9	12	5.4	580	8		108	12K	1		1	CDETICS DDS 3000
FSI CONTROLLER / TLM FORMATTER	4	8	SHUTTLE		13	8	5	16	640	23		144	12K	1		1	RADIATION INC
DACU'S	4	8	SHUTTLE		7	7	4	13	364	21	256 CHANNELS	144	12K	3		1	"
SENSORS	4	8	SHUTTLE		0.2	N/A	N/A	N/A	N/A	0.1			1M	180		10	WHITTAKER TRANSONICS

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REPORT
DATE
CODE 28512

CONFIGURATION 320A-3A AUTONOMY LEVEL III A

WBS NO. 320-03-03-02

SUBSYSTEM/COMPONENT GN&C

REV. 9-31-73

DATE: 8-20-73

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
INERTIAL MEASURING UNIT	4	12	TITAN III C		45	24	12	12.5	3600	125			2			
STAR TRACKER	1	24			17	15	6 DIA		424	28			1			DOES NOT INCLUDE SUNSHADE
APS CONTROL ELECTRONICS	1	24			18	10	10	5	500	13			2			
ME/TVC CONTROL ELECTRONICS	1	24			10	10	10	3.5	350	15			1			

GAC 322 REV 1 10 66 50

GRUMMAN

REPORT DATE CODE 26012

CONFIGURATION 320A-3A (TUG 1+2) WBS NO. 320-03-03-03 SUBSYSTEM/COMPONENT COMMUNICATIONS 9-5-73 DATE: 8/7/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE (each) LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE (each) WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE (each) HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (each) (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS: [illegible]	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
2. S-Band X'CEIVER / X'PONDER — R'CVR (4) X'MTR (1)		24			4X4 1X5	7 7	9 8	5 5	315 280	8 34	Spread Spectrum CCIR Interference STDN/SGLS Compatible			1			NO SIMULTANEOUS COMM. BETWEEN VEHICLES + ONE GROUND STATION
3. AUX. X'MTR		20			5	7	8	5	280	34	Same as (2) above			1			
4. POWER AMP.		9			1	3	5	2	30	20	R.F. output of SW			2			
7. DIPLEXER		9			1	2	7	3	63	—	—			2			
9. ANTENNA SWITCH		9			1	3	3	4	36	1	—			1			
14. BASEBAND PROCESSOR		24			3	3	3	2	18	2	Same as (2) above			1			
10. OMNI ANT.		9			.5	3	6	1	18	—	—			2			
15. SECURE COMM.		—			6	9	5	4	180	8	—			2			DOD ONLY - GFE

TABLE 5.5.2-E EQUIPMENT LIST

9-8-73 REV 3
8-24-73 REV 2
8-22-73 REV 1

CONFIGURATION 320A-3A-320AE-3A CORE VEHICLE WBS NO. 320-03-03-05 & -06 SUBSYSTEM/COMPONENT ELECTRICAL POWER SUBSYSTEM DATE: 8-10-73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND. TEST	NOTES
• ADVANCED FUEL CELL	1	42	–		40	15	6	12	1100		2.5 KW @ 28V. 750W AVG. LOAD OVER 124 HR MISSION	144	10,000	1 PER STAGE	—	1	REQUIRES AUTO SPACE START-UP SELLERS: PRWA, GE
• EMERGENCY BATTERY	5	6	–	Ag-Zn, Mg	15	9	5	4 1/2	200	–	10 AMP-HR RATED CAP. 1/2 HR NOM. DISCHARGE	1/2	30,000	1 PER STAGE	—	1	SECONDARY SILVER-ZN BATT, SELLER EAGLE-PICHER
• CRYO HYDROGEN TANK ASSY	3	24	GENINI APOLLO SHUTTLE	T1-INNER T2-OUTER	64	18 1/4 21	ID OD		3140		250 PSIA OPERATING PRESSURE 350 " MAX " 8 LB FLUID CAP.	144	500,000	1 PER STAGE	—	1	SELLER: AIRESEARCH, BEECH, BENDIX
• CRYO OXYGEN TANK ASSY	3	24	GENINI APOLLO SHUTTLE	INC-718 INNER INC-750-OUTER	66	14 1/2 17 1/2	ID OD		1550		400 PSIA OPERATING PRESSURE 1000 PSIA MAX " 64 LB FLUID CAP.	144	500,000	1 PER STAGE	—	1	-DITTO-
• VEHICLE WIRING	5	–	LM		44						6 ga, 14 ga, 16, 20 & 26 ga	144		SHIP SET PER STAGE	—	SHIP SET PER STAGE	8000 FT OF VARIOUS SIZES
• CONNECTORS	5	–	LM		30						VARIOUS SIZES	"		"	—	"	120 MATED PAIRS
• SUNDRIES (1a CLAMPS TAPE)	5	–	LM		16						" "	"		"	—	"	
• SOLID STATE POWER CONTRL	5	–			21						90-2 amp 17-5 amp 60-3 amp	"		"	—	"	2 OZ EA; SELLER LEACH CORP
• ELECTRO-MECH RCCB	3	12	LM		9						2-20 amp 10-100 amp	"		"	—	"	.75 LB EA; " : CUTLER HAMMER
					120	POWER	D&C	SUBTOTAL									

GENERATION

DIST. & CONTROL & POWER C.

IV-8.6-24

GAC 322 REV 1
10 69 SM

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REPORT
DATE
CODE 26912

PROPULSION CHARACTERISTICS

320A-3A → 320AE-3A

		MAIN PROP.	AUXILIARY PROP.
PHYSICAL:	WEIGHT, LB	552	146 166
	ENGINE/THRUSTER	CLASS I	REA 19
	NO. OF ENGINES/THRUSTERS	1	16 → 24
TECHNICAL:	FUEL LOAD, LB	11,034	327
	OXIDIZER LOAD, LB	20,966	--
	THRUST, LB	12,000	25
	ISP - STEADY STATE, SEC	338	232
	- PULSING, SEC	--	170
	RELIABILITY ALLOCATION	.99249	.99899

WBS #320-03-04

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CONFIGURATION 320A-3A/320AE-3A WBS NO. 320-03-04, 320-03-04-01, 320-03-04-02 REV. 5/73
SUBSYSTEM/COMPONENT Main Prop. DATE: 8/1/73

MAJOR COMPONENT	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH/DIA. (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER ** VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR G/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
																LEGEND: OTS - Off the shelf design; ME - Modified existing design; N - New design
Ox Pre-Vlv.	4	16	OMS		6.5		3 1/4		60	32 Watts	163	40K	1	1	1	ME - Size increase from 1 1/2" D. (OMS Pu[illegible] Iso Vlv.
Fu Pre-Vlv.	4	16	OMS		5		2		42	32 Watts	165	40K	1	1	1	ME - Size increase from 1 1/2" D. (OMS Pu[illegible] Iso Vlv)
Ox F/D QD	4	16	OMS		1.5		2		36		165	50K	1/2	1/2	1/2	ME - Size increase from 1 1/2" D.
Fu F/D QD	4	16	OMS		1.5		2		36		165	50K	1/2	1/2	1/2	ME - Size increase from 1 1/2" D.
Ox F/D QD	4	16	OMS		1		1		12		144	40K	1/2	1/2	1/2	ME - Size increase from 3/4" D.
Fu F/D QD	4	16	OMS		1		1		12		144	40K	1/2	1/2	1/2	ME - Size increase from 3/4" D.
He F/D QD	5	10	OMS		3		5/8		9		156	50K	1/2	1/2	1/2	OTS
Ox F/D Vlv.	5	10	OMS		5		2		12	32 Watts	143	40K	1	1	1	OTS - OMS Dump Valve
Fu F/D Vlv.	5	10	OMS		5		2		12	32 Watts	144	40K	1	1	1	OTS - OMS Dump Valve
He F/D Vlv.	4	16	OMS		5		4/3		24	84 Watts	144	67K	1	1	1	ME - Size increase from 1/2" D. (OMS Eng. Purge
He Isol. Vlv.	5	10	LM		2		1/2		16	84 Watts	156	133K	2	1	2	OTS - AP/DPS Latching Sol. Vlv.
He/Ox Reg	5	16	OMS		5		1/2		80		156	10^6	1	1	1	ME - Reduced press. setting, single stage
He/Fu Reg	5	16	OMS		5		1/2		80		156	10^6	1	1	1	ME - Reduced press. setting, single stage
Ox Burst Dis.	5	16	OMS		1.5		5/8		28		165	10^6	1	1	1	ME - Reduced relief setting
Fu Burst Dis.	5	16	OMS		1.5		5/8		28		165	10^6	1	1	1	ME - Reduced relief setting
Ox Relief Vl.	5	16	OMS		1.5		5/8		20		164	10^6	1	1	1	ME - Reduced relief setting
Fu Relief Vlv	5	16	OMS		1.5		5/8		20		165	10^6	1	1	1	ME - Reduced relief setting
Ox Ck Vlv.	5	10	SPS		3.6		3/4		50		156	10^6	1	1	1	OTS
Fu Ck Vlv.	5	10	SPS		3.6		3/4		50		156	10^6	1	1	1	OTS
Ox Vent Vlv	4	16	OMS		5		5/8		24	84 Watts	163	67K	2	1	2	ME - Size increase from 1/2" D. (OMS Eng. Purge V.
Fu Vent Vlv	4	16	OMS		5		5/8		24	84 Watts	165	67K	2	1	2	ME - Size increase from 1/2" D (OMS Eng. Purge V.
Ox Level Sensor	5	16	Titan		2	3	1		2.5	2 Watts	144	TBD	1	1	1	ME - Modified mounting
Fu Level Sensor	5	16	Titan		2	3	1		2.5	2 Watts	144	TBD	1	1	1	ME - Modified mounting
Ox Flex Joints	5	10	OMS		0.6		2		36		168		3	1	3	OTS
Fu Flex Joints	5	10	OMS		0.6		2		36		168		5	1	5	OTS
Ox Eng. Purge Vlv.	5	10	OMS		5		1/2		24	84 Watts	144	67K	1	1	1	OTS - OMS Eng. Purge Vlv.
Fu Eng. Purge Vlv.	5	10	OMS		5		1/2		24	84 Watts	144	67K	1	1	1	OTS - OMS Eng. Purge Vlv.

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CONFIGURATION 320-3A/320AE-3A

WBS NO. 320-03-04, 320-03-04-01, 320-03-04-02

SUBSYSTEM/COMPONENT Main Prop.

REV [illegible]/73

DATE: 8/[illegible]/73

MAJOR COMPONENT	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH/DIA. (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (INPUT/OUTPUT), DATA TRANSFER RATE, COMPUTER STORAGE CAP., NUMBER OF CIRCUITS, THRUST, SPECIFIC IMPULSE	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER ** VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
He Tank	1	22	—		23		19		57[illegible]		156	10^6	2	1	2	N- PFR design
[illegible] Eng.	1	54	—		265	116*	56		28[illegible]	170 Watts, 12,000 lb	6	145K	1	17	—	N- Class I
[illegible] Act	4	15	LM		2.5	5.75	3	1.5	78	90 Watts	10	20K	2	1	—	ME- Increased strength for higher thrust
[illegible] Horiz Drain Vlv	4	16	OMS		4		1			32 Watts	144	[illegible]	1	1	1	ME- Size decrease from 1 1/4" D (OMS crossfeed valve)
Fu Horiz Drain Vlv	4	16	OMS		4		1			32 Watts	14[illegible]	10[illegible]	1	1	1	ME- Size decrease from 1 1/4" D (OMS crossfeed valve)

* Stowed length = 58"

** Quantity required for each stage.

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REPORT
DATE
CODE 26912

CONFIGURATION 320A-3A/320AE-3A

WBS NO. 320-03-04, 320-03-04-01, 320-03-04-02

SUBSYSTEM/COMPONENT Main Prop.

Rev. 8/22/73

DATE: 8/21/73

MAJOR COMPONENT	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH/DIA (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE **	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
ADAPTER EQUIPMENT																
Ox F/D QD	4	16	OMS		2.5		2		36		168	500K	1/2	1/2	1/2	ME- Size increase from 1½"D
Fu F/D QD	4	16	OMS		2.5		2		36		168	500K	1/2	1/2	1/2	ME- Size increase from 1½"D
Ox F/V QD	4	16	OMS		2		1		12		144	40K	1/2	1/2	1/2	ME- Size increase from 3/4"D
Fu F/V QD	4	16	OMS		2		1		12		144	40K	1/2	1/2	1/2	ME- Size increase from 3/4"D
He F/D QD	5	10	OMS		4		5/8		9		156	500K	1/2	1/2	1/2	OTS
Panel Act.	1	18	—		2				10	30 Watts	10	20K	4	1	4	N
Ox Flex Joint	5	10	OMS		0.6		2		36		144		2	1	2	OTS
Fu Flex Joint	5	10	OMS		0.6		2		36		144		2	1	2	OTS
SHUTTLE EQUIPMENT													***			
Ox F/D QD	4	16	OMS		1.5		2		36		168	500K	1/2	—	—	Same as Tug hardware.
Fu F/D QD	4	16	OMS		1.5		2		36		168	500K	1/2	—	—	
Ox F/V QD	4	16	OMS		1		1		12		144	40K	1/2	—	—	
Fu F/V QD	4	16	OMS		1		1		12		144	40K	1/2	—	—	
He F/D QD	5	10	OMS		3		5/8		9		156	500K	1/2	—	—	
Ox Flex Joint	5	10	OMS		0.6		2		36		144		1	—	—	
Fu Flex Joint	5	10	OMS		0.6		2		36		144		1	—	—	

"Ground hardware" Tug

*** Shuttle equipment is common to both stages.

CONFIGURATION 320A-3A

WBS NO. 320-03-04-03; 320-03-04-04

SUBSYSTEM/COMPONENT Auxiliary Propulsion System (APS)

DATE: [illegible]

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMMATIC: UNITS PER VEHICLE	PROGRAMMATIC: EQUIVALENT UNITS PER [illegible] TEST	PROGRAMMATIC: [illegible]	NOTES
																	GENERAL NOTE: TANKAGE BASED ON USABLE PROPELLANT OF 245 LB PLUS 10% CONTINGENCY.
Helium Tank	5	≤12	-		11.5	12.27	12.27	12.27	375	-	Burst Press = 6850 Operating = 3425	156	10^6	2			Airite P/N 6372
Helium Filter	5	≤12	LM		0.5					-				1			LSC 310-303-3 ([illegible])
Helium Latching Solenoid Valve	4	≤12	LM		2.3					84		156	1.3×10^6	2			LSC 270-713 (MC [illegible])
Regulator, Dual Stage	5	≤12	LM		2.5					-		156	1.3×10^6	1			LSC 310-305-3 ([illegible])
Regulator, Single Stage	4	≤12	-		1.5					-		156	1.3×10^6	1			Mod to dual stage [illegible]
Dual Check Valve	5	≤12	LM		0.7					-	Proof press. = 600 psi	156	2000	1			Mod to LSC 310-306 ([illegible])
[illegible] Valve	4	≤12	-		1.5					-	Relief press ≈ 400 psi	156	10^6/67K	1			Mod to LSC 310-307 (Calmec)
Vent Valve	3	18	-		2.0					70	Proof press = 600 psi	156	67000	3			Similar to LSC 310-[illegible] ([illegible]) [illegible]
Mortgage Tanks	4	≤12	LM		12.5		12.5	39	4100	-	Burst Press = 650 psi	144	10^6	3			Modified [illegible] OX tanks with elastomeric bladders. Tank wt. includes bladders
Propellant Bladders	2	24	-	EPT-10 Elastomer	-					-				3			
Propellant Filter	5	≤12	-		0.5					-				1			
Thruster Isolation Valve	3	18	-		2.0					70	Proof press = 600 psi	168	67000	6			Sand valve as Vent Valve same notes apply.
Thrusters	4	≤12	-		2.1	11.4	2.7			24	25 LB thrust @ 325 psi inlet, steady state Isp = 232	144	1.5×10^6	16			R6A 19-3 (Hamilton Standard)
Thruster Heaters	5	≤12	-		0.2					3.5	Maintain catalyst bed at 150°F			16			Submitted for [illegible] by [illegible]
Tube Disconnects	5	≤12	-		0.5									3			He fill & drain Prop fill & drain Prop fill & vent

One Shipset

None

ORBITER INTERFACE CHARACTERISTICS

320A-3A → 320AE-3A

PHYSICAL:	WEIGHT, LB	1119
TECHNICAL:	MATERIAL	ALUMINUM
	PIVOT TYPE ADAPTER/DOCKING MECHANISM	
	SERVICE PANELS	GROUND POWER
		INSTRUMENTATION
		ON-PAD EMERGENCY DUMP
		HORIZONTAL PROP. DRAIN
		FUEL CELL REACTANT FILL

WBS #320-03-05

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CONFIGURATION 320A - 3A

WBS NO. 320-04-05

SUBSYSTEM/COMPONENT INTERSTAGE STRUCTURE

DATE: 9/17/73

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TEST	
01-Structure	1	44½		Alum.	257	85	98	D		Aluminum Stiffened Sheet	N/A			1	
02-Seperation System	1	46		Alum	92					Aluminum Machings and Forgings	N/A			1	Latches and Mechanism

CONFIGURATION 320A-3A

WBS NO. 320-05-03-01

SUBSYSTEM/COMPONENT ORBITER INTERFACE STRUCT. DATE: 9/17/72

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TEST	
01-Rear Adapter	1	44½		Alum.	611	64	98	D		Aluminum Stiffened Sheet and Machinings	N/A			1	Pivot Type Adapter
01-Fwd Frame	1	44½		Alum.	400					Aluminum Trusses and Machinings	N/A			1	
01-Docking Mechanism	1	46		Alum.	108					Aluminum Machinings and Forgings	N/A			1	
															Interstage Required For Two Stage Operation

BRUMMAN

REPORT DATE CODE 28512

APOGEE KICK STAGE CHARACTERISTICS

320A-3A 320AE-3A

		PLANETARY	GEOSYNCH
PHYSICAL:	WEIGHT (MAX.), LB	545	
	LENGTH, IN	80	
	DIAMETER, IN	180	
TECHNICAL:	MATERIAL	ALUMINUM	
	INSULATION	ALUMINIZED MYLAR MLI	
	ATTITUDE GYRO		
	BATTERY POWER	2 AMP HR	
	DMS/COMM	NONE	
	PROPULSION - MAIN	9 SRM'S	
	- AUX.	12 COLD GAS THRUSTERS	
	RELIABILITY ALLOCATION	.9987	

WBS #320-04-08

GRUMMAN

EVOLVED TUG

CONCEPT 320A-3A/320AE-3A (COMBINED

OPTION 3

320A-3A/320AE-3A SEPT 73 COMBINED

STORABLE SPACE TUG SYSTEM PROJECT

EXPECTED COST - SPARES COST(INT + OPS) - FIRST UNIT COST

(COSTS IN 1973 CONSTANT DOLLARS (000))

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0100	PROJECT MGMT	13742.			14933.				3095.	5466.		
0110	COST/PERF MGMT		2061.			2240.			464.		1822.	
0120	PROJECT DIRECTION		10582.			11498.			2383.		1822.	
0130	INFO MGMT		1099.			1195.			248.		1822.	
0200	SYS ENG + INTEGR	16491.			16800.				3482.	10936.		
0210	TUG SYS ENG		13193.						0.		2734.	
0220	SHUTTLE INTERFACE		1649.						0.		2734.	
0230	PAYLOAD INTERFACE		1649.						0.		2734.	
0240	SUST ENG					0.			3482.		2734.	
0300	TUG VEH MAIN STAGE	174584.			107020.			9690.	23944.	19162.		
0310	STRUCTURES		15597.			13204.		1320.	2941.		1320.	
0311	FUEL TNK+SPRT			4522.			4290.	429.	955.			429.
0312	OX TANK +SPRT			5271.			4892.	489.	1089.			489.
0313	BODY STRUCT			2044.			1956.	196.	437.			196.
0314	THRUST STRUCT			218.			137.	14.	30.			14.
0315	METEOROID SHLD			110.			85.	9.	19.			9.
0316	PAYLOAD INTFCE			3432.			1843.	184.	410.			184.
0317	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0320	THERMAL INSULTN		149.			1012.		50.	225.		50.	
0321	FUEL TANK INSUL			57.			496.	50.	110.			50.
0322	OX TANK INSUL			92.			517.	0.	115.			0.
0323	PURGE SYS INSUL			0.			0.	0.	0.			0.
0324	CONT SYS			0.			0.	0.	0.			0.
0325	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0330	AVIONICS		64300.			47264.		6092.	7419.		13398.	
0331	DATA MGMT			5880.			7958.	1432.	1326.			3450.
0332	G N + C			10420.			23452.	2814.	3586.			6216.
0333	COMMUNICATIONS			9128.			8588.	776.	1230.			1592.
0334	INSTRUMENTATION			0.			0.	0.	0.			0.
0335	ELEC PWR			37776.			4736.	1070.	856.			2140.
0336	PWR DIST + CONT			1097.			2530.	0.	422.			0.
0337	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0340	PROPULSION		76449.			23198.		2066.	4034.		4232.	
0341	MAIN ENGINE			64000.			8029.	1874.	1600.			3760.
0342	MAIN ENGINE SPT			7963.			5100.	0.	850.			0.
0343	ACPS ENGINE			3000.			6205.	192.	940.			472.
0344	ACPS ENGINE SPT			1486.			3864.	0.	644.			0.
0345	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0350	ORBITER INTERFACE		7131.			1617.		162.	1273.		162.	
0351	STRUCTURE			5050.			711.	71.	559.			71.
0352	INTERFACE PNLS			2081.			906.	91.	714.			91.
0353	PURGE PROVISION			0.			0.	0.	0.			0.
0354	ABORT PROVISION			0.			0.	0.	0.			0.
0355	INSTL.ASSY+C/O			0.			0.	0.	0.			0.

IV-86-35

MOORE BUSINESS FORMS, INC. HQ FORM 1412T PRINTED IN U.S.A. 72

320A-3A/320AE-3A SEPT 73 COMBINED

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0360	DROP TANKS		0.			4400.		0.	4400.		0.	
0361	STRUCTURES			0.			4400.	0.	4400.			0.
0362	THERMAL INSUL			0.			0.	0.	0.			0.
0363	PROP SPRT SYS			0.			0.	0.	0.			0.
0364	INSTL,ASSY+C/O			0.			0.	0.	0.			0.
0370	FINAL ASSY + C/O		10957.			16325.		0.	3652.		0.	
0371	FINAL ASSY			10957.			16325.	0.	3652.			0.
0372	CHECKOUT			0.			0.	0.	0.			0.
0400	TUG VEH AUX STAGE	26841.			76205.			3715.	17946.	3715.		
0410	STRUCTURES		0.			9319.		932.	2406.		932.	
0411	FUEL TNK+SPRT			0.			2497.	250.	645.			250.
0412	OX TANK+SPRT			0.			4218.	422.	1089.			422.
0413	BODY STRUCT			0.			1109.	111.	286.			111.
0414	THRUST STRUCT			0.			62.	6.	16.			6.
0415	METEOROID SHLD			0.			39.	4.	10.			4.
0416	PAYLOAD INTERFC			0.			1394.	139.	360.			139.
0417	INSTL,ASSY+C/O			0.			0.	0.	0.			0.
0420	THERMAL INSUL		57.			873.		43.	225.		43.	
0421	FUEL TANK INSUL			57.			428.	43.	110.			43.
0422	OX TANK INSUL			0.			445.	0.	115.			0.
0423	PURGE SYS INSUL			0.			0.	0.	0.			0.
0424	CONT SYS			0.			0.	0.	0.			0.
0425	INSTL,ASSY+C/O			0.			0.	0.	0.			0.
0430	AVIONICS		20.			29288.		0.	7200.		0.	
0431	DATA MGMT			0.			5137.	0.	1326.			0.
0432	G N + C			0.			14279.	0.	3464.			0.
0433	COMMUNICATIONS			0.			5301.	0.	1230.			0.
0434	INSTRUMENTATION			0.			0.	0.	0.			0.
0435	ELEC PWR			0.			2938.	0.	759.			0.
0436	PWR DIST + CONT			20.			1633.	0.	422.			0.
0437	INSTL,ASSY+C/O			0.			0.	0.	0.			0.
0440	PROPULSION		0.			15875.		0.	4034.		0.	
0441	MAIN ENGINE			0.			6197.	0.	1600.			0.
0442	MAIN ENGINE SPT			0.			3292.	0.	850.			0.
0443	ACPS ENGINE			0.			3892.	0.	940.			0.
0444	ACPS ENGINE SPT			0.			2494.	0.	644.			0.
0445	INSTL,ASSY+C/O			0.			0.	0.	0.			0.
0450	INTERSTAGE INTRFC		3820.			244.		24.	192.		24.	
0451	STRUCTURE			3820.			244.	24.	192.			24.
0452	SEP SYS			0.			0.	0.	0.			0.
0453	INSTL,ASSY+C/O			0.			0.	0.	0.			0.
0460	DROP TANK		0.			0.		0.	0.		0.	
0461	STRUCTURE			0.			0.	0.	0.			0.
0462	THERMAL INSUL			0.			0.	0.	0.			0.
0463	PROP SPT SYS			0.			0.	0.	0.			0.
0464	INSTL,ASSY+C/O			0.			0.	0.	0.			0.
0470	RDM		0.			0.		0.	0.		0.	

IV-8.6-36

MOORE BUSINESS FORMS, INC. INC. FORM 1412T PRINTED IN U.S.A. 22

320A-3A/320AE-3A SEPT 73 COMBINED

WPS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0471	STRUCTURE			0.			0.	0.	0.			0.
0472	THERM CONT			0.			0.	0.	0.			0.
0473	AVIONICS			0.			0.	0.	0.			0.
0474	PROPULSION			0.			0.	0.	0.			0.
0475	RDM ASSY+C/O			0.			0.	0.	0.			0.
0480	AKS		15353.			10598.		2716.	1358.		2716.	
0481	STRUCTURE			4950.			2404.	0.	373.			0.
0482	SRM			1680.			2282.	1156.	68.			1156.
0483	AVIONICS			5000.			3939.	1376.	611.			1376.
0484	PROPULSION			459.			638.	184.	99.			184.
0485	AKS ASSY+C/O			3264.			1335.	0.	207.			0.
0490	DKS		0.			0.		0.	0.		0.	
0491	STRUCTURE			0.			0.	0.	0.			0.
0492	SRM			0.			0.	0.	0.			0.
0493	AVIONICS			0.			0.	0.	0.			0.
0494	PROPULSION			0.			0.	0.	0.			0.
0495	DKS ASSY+C/O			0.			0.	0.	0.			0.
04100	CACHE TANK		0.			0.		0.	0.		0.	
04101	STRUCTURE			0.			0.	0.	0.			0.
04102	THERM CONT			0.			0.	0.	0.			0.
04103	AVIONICS			0.			0.	0.	0.			0.
04104	PROPULSION			0.			0.	0.	0.			0.
04105	CACHE ASSY+C/O			0.			0.	0.	0.			0.
04110	FINAL ASSY + C/O		7591.			10008.		0.	2530.		0.	
04111	FINAL ASSY			7591.			10008.	0.	2530.			0.
04112	CHECKOUT			0.			0.	0.	0.			0.
0500	LOGISTICS	6330.			9340.				9340.			
0510	TRANSPORT+HANDLG		0.			1150.			1150.			
0520	TRAINING		6330.			4130.			4130.			
0521	SIM+EQUIPMENT			1950.			1950.		1950.			
0522	GROUND CREW			2180.			2180.		2180.			
0523	FLT OPS CREW			2200.			0.		0.			
0530	WAREHSG+INV CONT		0.			4060.			4060.			

MOORE BUSINESS FORMS INC. HO FORM 14127 PRINTED IN U.S.A. 22"

320A-3A/320AE-3A SEPT 73 COMBINED

WBS		EXPECTED COST DDT+E			EXPECTED COST PRODUCTION			INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS		
	LEVEL	4	5	6	4	5	6			4	5	6
0600	FACILITIES	8942.			434.					1238.		
0610	MANUFACTURING		328.			371.					0.	
0611	DES/CONSTR			328.								
0612	ACT/MAINT			0.			371.					0.
0620	TEST		248.			63.					0.	
0621	DES/CONST			248.								
0622	ACT/MAINT			0.			63.					0.
0630	1ST TR MAINT+REF		3977.			0.					625.	
0631	DES/CONST			3977.								
0632	ACT/MAINT			0.			0.					625.
0640	ETR LAUNCH		438.			0.					133.	
0641	DES/CONST			438.								
0642	ACT/MAINT			0.			0.					133.
0650	2ND TR MAINT+REF		3428.			0.					347.	
0651	DES/CONST			3428.								
0652	ACT/MAINT			0.			0.					347.
0660	WTR LAUNCH		523.			0.					133.	
0661	DES/CONST			523.								
0662	ACT/MAINT			0.			0.					133.
0700	GSE	26770.			8290.			910.		5160.		
0710	MFG GSE		0.									
0711	HARDWARE											
0712	SITE ACT											
0713	MAINT											
0714	SOFTWARE											
0720	ETR GSE		18810.			1550.		310.			2420.	
0721	HARDWARE			15430.			1550.	310.				
0722	SITE ACT			3100.								
0723	MAINT			0.								2420.
0724	SOFTWARE			280.								
0730	WTR GSE		0.			3000.		600.			3000.	
0731	HARDWARE			0.			3000.	600.				
0732	SITE ACT			0.								
0733	MAINT			0.								3000.
0734	SOFTWARE			0.								

MOORE BUSINESS FORMS, INC. MO FORM 14131 PRINTED IN U.S.A. 22"

320A-3A/320AE-3A SEPT 73 COMBINED

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0740	FL OP NASA		3980.			1870.		0.			1870.	
0741	HARDWARE			3300.			1870.	280.				
0742	SITE ACT			400.								
0743	MAINT			0.								1870.
0744	SOFTWARE			280.								
0750	FL OP DOD		3980.			1870.		0.			1870.	
0751	HARDWARE			3300.			1870.	0.				
0752	SITE ACT			400.								
0753	MAINT			0.								1870.
0754	SOFTWARE			280.								
0800	VEHICLE TEST	96202.										
0810	GND TEST HARDWARE		9625.									
0811	PTV/PATTLESHIP			2086.								
0812	MAJOR TST ART			6839.								
0813	MOCKUPS			700.								
0820	GND TEST OPS		14350.									
0830	FLT TEST HARDWARE		17696.									
0840	FLT TEST OPS		54530.									
0900	LAUNCH OPS WTR									7936.		
0910	LAUNCH SITE SVC										0.	
0920	TUG/SHUTTLE MATG										710.	
0930	PRELAUNCH C/O										1320.	
0940	COUNTDOWN										42.	
0950	FLUID+GASES										3534.	
0960	POST FLT SAFING										2330.	
1000	LAUNCH OPS ETR									30543.		
1010	LAUNCH SITE SVC										0.	
1020	TUG/SHUTTLE MATG										2550.	
1030	PRELAUNCH C/O										4720.	
1040	COUNTDOWN										155.	
1050	FLUID+GASES										15124.	
1060	POST FLT SAFING										8390.	
1100	FLT OPS DOD	4420								60510.		
1110	MISSION PLAN		2990								17770.	
1120	FLT CONT		920								21710.	
1130	FLT EVALUATION		510								2890.	
1140	FLT SPT SOFTWARE										19140.	
1200	FLT OPS NASA									89490.		
1210	MISSION PLAN		9760								24460.	
1220	FLT CONT		1950								26120.	
1230	FLT EVALUATION		580								3280.	
1240	FLT SPT SOFTWARE		30460								35630.	

NOTE
THESE COSTS INCLUDED
IN VEHICLE TEST

IV-86-39

320A-3A/320AE-3A SEPT 73 COMBINED

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
1300 REF+INT 1ST TR										20205.		
1310	SCHED MAINT+REF										2500.	
1320	UNSCHED MAINT+REF										2660.	
1330	POST MAINT C/O										865.	
1340	TUG/PAYLOAD MATG										1380.	
1350	REF RQMTS PLANNG										200.	
1360	DEPOT MAINT										12600.	
1400 REF+INT 2ND TR										37719.		
1410	SCHED MAINT+REF										6150.	
1420	UNSCHED MAINT+REF										6470.	
1430	POST MAINT C/O										2113.	
1440	TUG/PAYLOAD MATG										3380.	
1450	REF RQMTS PLANNG										706.	
1460	DEPOT MAINT										18900.	
SPACE TUG TOTALS		369902.			233022.			14315.	57807.	296480.		
32A=	369902.	32B=	247336.		32C=	296480.		320=	913718.			

IV-8.6-40

MOORE BUSINESS FORMS INC., HO FORM 1412T PRINTED IN U.S.A. 22"

2nd Phase

330AE-3A SEPT 73 (PHASE II)

~~STORABLE SPACE TUG SYSTEM PROJECT~~

FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

DDTE (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1980 ~~1976~~	81 ~~1977~~	82 ~~1978~~	83 ~~1979~~	84 ~~1980~~	85 ~~1981~~	86 ~~1982~~	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	1.8	0.23	0.43	0.45	0.44	0.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	2.2	0.28	0.51	0.54	0.53	0.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	TUG MAIN STAGE	12.0	1.72	2.14	3.95	4.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	STRUCTURE	1.2	0.55	0.53	0.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320	THERMAL INSUL																	
330	AVIONICS	3.8	1.17	1.61	0.85	0.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION																	
350	INTERFACE																	
360	DROP TANK																	
370	FINAL ASSY	7.0	0.0	0.0	2.98	3.98	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	TUG AUX STAGE	6.1	0.0	0.0	4.41	1.65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
410	STRUCTURE																	
420	THERMAL INSUL																	
430	AVIONICS	0.0	0.0	0.0	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
440	PROPULSION																	
450	INTERSTAGE	1.9	0.0	0.0	1.40	0.52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
460	DROP TANK																	
470	RCM																	
480	AKS																	
490	DKS																	
4100	CACHE																	
4110	FINAL ASSY	4.1	0.0	0.0	3.01	1.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS																	
500	FACILITIES	0.3	0.03	0.06	0.06	0.07	0.04	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
510	MANUFACTURING																	
520	TEST																	
530	1ST MAIN/REF	0.3	0.03	0.06	0.06	0.06	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
640	ETR LAUNCH																	
650	2ND MAIN/REF																	
660	WTR LAUNCH	0.0	0.0	0.0	0.0	0.01	0.01	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	GND SUPP EQUIP	0.6	0.08	0.15	0.16	0.16	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
710	MFG GSE																	
720	ETR GSE	0.6	0.08	0.15	0.16	0.16	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
730	WTR GSE																	
740	FLT OPS NASA																	
750	FLT OPS DOD																	
800	VEHICLE TEST	14.3	0.69	2.57	4.17	4.08	2.34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
810	GND TEST HWRE	1.2	0.23	0.38	0.39	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
820	GND TEST OPS	3.5	0.46	0.83	0.89	0.87	0.49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
830	FLT TEST HWRE																	
840	FLT TEST OPS	9.5	0.0	1.75	2.89	2.97	1.85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900	LAUNCH OPS WTR																	
1000	LAUNCH OPS ETR																	
1100	FLIGHT OPS DOD																	
1200	FLIGHT OPS NASA																	
1300	REF + INT TR-1																	
1400	REF + INT TR-2																	
	TOTALS	37.2	3.05	6.26	13.76	11.11	3.02	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

II-98-H

MADE IN U.S.A. FORM 1412F PRINTED IN U.S.A. 22"

320AE-3A SEPT 73 (PHASE II)

STORABLE SPACE TUG SYSTEM PROJECT

FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

PROD (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	~~1976~~ 1981	~~1977~~ 1982	~~1978~~ 83	~~1979~~ 84	~~1980~~ 85	~~1981~~ 86	~~1982~~ 87	~~1983~~ 88	~~1984~~ 89	~~1985~~ 90	1986 91	1987 92	1988 93	1989 94	1990	1991
100	PROJECT MGMT	11.7	1.12	2.19	2.41	2.46	2.30	1.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	13.1	1.26	2.47	2.71	2.77	2.58	1.34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0300	TUG MAIN STAGE	87.4	0.0	12.71	24.11	22.23	15.10	7.91	2.99	1.05	0.66	0.42	0.18	0.0	0.0	0.0	0.0	0.0
310	STRUCTURE	10.4	0.0	1.67	3.12	2.79	1.79	0.83	0.21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320	THERMAL INSUL	0.8	0.0	0.12	0.23	0.20	0.13	0.06	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
330	AVIONICS	40.6	0.0	6.51	12.15	10.87	6.99	3.24	0.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION	18.7	0.0	3.00	5.59	5.00	3.22	1.49	0.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
350	INTERFACE																	
0360	DROP TANKS	4.4	0.0	0.17	0.40	0.50	0.54	0.55	0.56	0.55	0.52	0.42	0.18	0.0	0.0	0.0	0.0	0.0
370	FINAL ASSY	12.6	0.0	1.23	2.62	2.86	2.44	1.74	1.04	0.49	0.13	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0400	TUG AUX STAGE	48.4	0.0	1.58	4.45	6.31	6.80	6.63	6.22	5.74	5.10	3.92	1.67	0.0	0.0	0.0	0.0	0.0
0410	STRUCTURES	6.9	0.0	0.27	0.63	0.78	0.94	0.86	0.87	0.87	0.82	0.66	0.29	0.0	0.0	0.0	0.0	0.0
0420	THERMAL INSUL	0.5	0.0	0.02	0.06	0.07	0.08	0.08	0.08	0.08	0.07	0.06	0.03	0.0	0.0	0.0	0.0	0.0
0430	AVIONICS	21.5	0.0	0.85	1.95	2.44	2.62	2.68	2.71	2.71	2.56	2.06	0.90	0.0	0.0	0.0	0.0	0.0
0440	PROPULSION	11.0	0.0	0.43	1.00	1.25	1.34	1.37	1.39	1.39	1.31	1.05	0.46	0.0	0.0	0.0	0.0	0.0
0450	INTERFACE																	
0460	DROP TANKS																	
0470	NUDGE																	
480	AKS	1.4	0.0	0.0	0.13	0.28	0.31	0.26	0.19	0.11	0.05	0.01	0.0	0.0	0.0	0.0	0.0	0.0
490	OKS																	
04100	CACHE																	
4110	FINAL ASSY	7.1	0.0	0.0	0.69	1.48	1.61	1.37	0.98	0.59	0.28	0.07	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS	3.4	0.0	0.0	0.16	0.39	0.50	0.53	0.49	0.43	0.34	0.25	0.17	0.10	0.05	0.02	0.0	0.0
0500	FACILITIES	0.1	0.03	0.04	0.03	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
510	MANUFACTURING	0.1	0.02	0.03	0.02	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
520	TEST	0.0	0.01	0.01	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
530	1ST MAIN/REF																	
540	ETR LAUNCH																	
550	2ND MAIN/REF																	
560	WTR LAUNCH																	
0700	GND SUPP EQUIP																	
0710	MFG GSE																	
720	ETR GSE																	
730	WTR GSE																	
740	FLT OPS NASA																	
750	FLT OPS DOD																	
0800	VEHICLE TEST																	
0810	GND TEST HWRE																	
0820	GND TEST OPS																	
0830	FLT TEST HWRE																	
0840	FLT TEST OPS																	
0900	LAUNCH OPS WTR																	
1000	LAUNCH OPS ETR																	
1100	FLIGHT OPS WTR																	
1200	FLIGHT OPS ETR																	
1300	REF + INT TR-1																	
1400	REF + INT TR-2																	
	TOTALS	164.1	2.42	18.98	33.87	34.15	27.28	17.60	9.70	7.22	6.10	4.60	2.03	0.10	0.05	0.02	0.0	0.0

IV-8.6-42

MOORE BUSINESS FORMS, INC. NO FORM 1412T PRINTED IN U.S.A.

320AE-3A SEPT 73 (PHASE II)

STORABLE SPACE TUG SYSTEM PROJECT

FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

OPS (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	2.7	0.0	0.0	0.0	0.0	0.08	0.19	0.24	0.27	0.28	0.28	0.29	0.29	0.28	0.26	0.20	0.08
200	SYS ENG + INTEG	5.5	0.0	0.0	0.0	0.0	0.15	0.37	0.49	0.54	0.56	0.57	0.57	0.58	0.56	0.51	0.39	0.16
0300	VEH OPS SPARES	9.8	0.0	0.0	0.0	0.0	0.28	0.67	0.87	0.97	1.00	1.02	1.03	1.03	1.01	0.92	0.71	0.29
310	STRUCTURE	0.9	0.0	0.0	0.0	0.0	0.03	0.06	0.08	0.09	0.10	0.10	0.10	0.10	0.10	0.09	0.07	0.03
320	THERMAL INSUL	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
330	AVIONICS	6.7	0.0	0.0	0.0	0.0	0.19	0.46	0.60	0.66	0.69	0.70	0.70	0.71	0.69	0.63	0.48	0.20
340	PROPULSION	2.1	0.0	0.0	0.0	0.0	0.06	0.14	0.19	0.21	0.22	0.22	0.22	0.22	0.22	0.20	0.15	0.06
350	INTERFACE																	
360	DROP TANK																	
0370	FINAL ASSY																	
0400	TUG AUX STAGE	2.0	0.03	0.12	0.20	0.21	0.10	0.0	0.05	0.12	0.15	0.17	0.17	0.17	0.17	0.16	0.13	0.06
0410	STRUCTURES	0.6	0.03	0.11	0.19	0.20	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0420	THERMAL INSUL	0.0	0.00	0.01	0.01	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0430	AVIONICS																	
0440	PROPULSION																	
0450	INTERFACE																	
0460	DROP TANKS																	
0470	NUDGE																	
480	AKS	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.05	0.12	0.15	0.17	0.17	0.17	0.17	0.16	0.13	0.06
490	DKS																	
04100	CACHE																	
04110	FINAL ASSY																	
0500	LOGISTICS																	
0600	FACILITIES	0.5	0.0	0.0	0.0	0.0	0.00	0.01	0.02	0.04	0.05	0.05	0.06	0.06	0.06	0.05	0.04	0.02
610	MANUFACTURING																	
620	TEST																	
630	1ST MAIN/REF	0.1	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
640	ETR LAUNCH	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
650	2ND MAIN/REF	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.01
660	WTR LAUNCH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0700	GND SUPP EQUIP	5.1	0.0	0.0	1.73	0.65	0.04	0.10	0.19	0.26	0.29	0.31	0.31	0.31	0.31	0.29	0.23	0.10
710	MFG GSE																	
720	ETR GSE	1.5	0.0	0.0	0.0	0.0	0.04	0.10	0.14	0.15	0.16	0.16	0.16	0.16	0.16	0.14	0.11	0.05
730	WTR GSE	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.05	0.11	0.14	0.15	0.15	0.15	0.15	0.14	0.11	0.05
740	FLT OPS NASA	1.2	0.0	0.0	0.87	0.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
750	FLT OPS DOD	1.2	0.0	0.0	0.87	0.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0900	VEHICLE TEST																	
0810	GND TEST HWRE																	
0820	GND TEST OPS																	
0830	FLT TEST HWRE																	
0840	FLT TEST OPS																	
900	LAUNCH OPS WTR	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.30	0.68	0.85	0.92	0.94	0.95	0.95	0.89	0.72	0.31
1000	LAUNCH OPS ETR	23.9	0.0	0.0	0.0	0.0	0.68	1.62	2.13	2.36	2.45	2.49	2.51	2.52	2.46	2.24	1.72	0.72
1100	FLIGHT OPS DOD	42.2	0.0	0.0	0.0	0.0	0.0	0.0	1.66	3.83	4.80	5.15	5.27	5.33	5.32	5.03	4.05	1.77
1200	FLIGHT OPS NASA	53.0	0.0	0.0	0.0	0.0	1.50	3.60	4.71	5.23	5.43	5.51	5.57	5.58	5.45	4.97	3.81	1.59
1300	REF + INT TR-1	18.6	0.0	0.0	0.0	0.0	0.53	1.26	1.66	1.84	1.91	1.94	1.96	1.96	1.92	1.74	1.34	0.55
1400	REF + INT TR-2	24.9	0.0	0.0	0.0	0.0	0.0	0.0	0.98	2.26	2.83	3.04	3.11	3.15	3.14	2.97	2.39	1.04
	TOTALS	195.7	~~0.03~~	~~0.12~~	~~1.93~~	~~0.85~~	3.35	7.82	13.30	18.39	20.62	21.45	21.78	21.93	21.63	20.04	15.73	6.70
		196.									15	26	29	29	30	29	26	12	196

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MOORE BUSINESS FORMS, INC. HO FORM 1413 T PRINTED IN U.S.A.

FIRST UNIT IN-HOUSE COST
PER WBS (INCLUDING AVIONICS TO LEVEL 7)
MAIN STAGE AND AUXILIARY STAGE(S)
(COST IN THOUSANDS)

Concept 320AE-3A

WBS	IDENTIFICATION	FIRST UNIT COST LEVEL 4	LEVEL 5	LEVEL 6
0300	TUG VEH. MAIN STAGE	10,819		
0310	STRUCTURES		1,469	
0311	Fuel Tank & Sprt			478
0312	OX Tank & Sprt			545
0313	Body Structure			217
0314	Thrust Structure			15
0315	Metoroid Shield			9
0316	Payload Intface			205
0317	Inst'l Assy & C/O			0
0320	THERMAL INSULTN		113	
0321	Fuel Tank Insul			55
0322	OX Tank Insul			57
0333	Purge Sys Insul			0
0324	Cont Sys			0
0325	Inst'l Assy & C/O			0
0330	AVIONICS		4,168	
0331	Data Management			663
0332	GN&C			2,116
0333	Communications			816
0334	Instrumentation			0
0335	Elec Pwr			362
0336	Pwr Dist & Cont			211
0337	Inst'l Assy & C/O			0
0340	PROPULSION		2,111	
0341	Main Engine			800
0342	Main Engine Sprt			425
0343	ACPS Engine			564
0344	ACPS Engine Sprt			322
0345	Inst'l Assy & C/O			0
0350	ORBITER INTERFACE		636	
0351	Structure			279
0352	Interface PNLS			357
0353	Purge Provision			0
0354	Abort Provision			0
0355	Inst'l Assy & C/O			0
0360	DROP TANKS			
0361	Structures			
0362	Thermal Insul			0
0363	Prod Sprt Sys			0
0364	Inst'l Assy & C/O			0
0370	FINAL ASSY & C/O		2,321	
0371	Final Assy			2,321
0372	Checkout			0
0400	TUG VEH. AUX. STAGE	9,025		
0470	RDM		0	
0471	Structure			
0472	Therm Cont			
0473	Avionics			
0474	Propulsion			
0475	RDM Assy & C/O			
0480	AKS			
0481	Structure			
0482	Therm Cont			
0483	Avionics			
0484	Propulsion			
0485	AKS Assy & C/O			
0490	DKS		0	
0491	Structure			
0492	Therm Cont			
0493	Avionics			
0494	Propulsion			
0495	DKS Assy & C/O			
0100	PROJECT MANAGEMENT			
0200	SYS ENG & INTEGR	3,849		
	TOTAL FIRST UNIT COST			

LEVEL 7 FIRST UNIT COST (AVIONICS)

WBS	IDENTIFICATION	MAIN STAGE
0330	AVIONICS (MAIN STAGE)	4,168
0331	DATA MANAGEMENT	663
	Computer	174
	Tape Recorder	58
	FGI Cont'r/TIM Form.	55
	DACU	105
	Sensors	75
	In-House	196
0332	GN&C	2,116
	IMU	200
	Star Trucker	162
	Att Ref	40
	Laser Revo. Radar	400
	Satellite Receiver	
	Doppler Receiver	
	L-Band Antenna	
	Combined/Doppler Det.	
	APS Ct'l Electronics	295
	ME/TVC Ct'l Electron	295
	In-House	734
0333	COMMUNICATIONS	816
	S-Band X'CVR/X'PDR	410
	Aux. Xmtr	43
	Power AMP	10
	Baseband Processor	50
	Diplexer	
	Ant Switch	
	Antenna	8
	Power Splitter	
	GCTA	125
	In-House	170
0334	INSTRUMENTATION	0
0335	ELEC POWER	362
	Battery	100
	Emergency Battery	2
	Modified Fuel Cell	
	Thermal Control	30
	Cryo Tanks	214
	In-House	18
0336	PWR DIST. & CT'L	211
0337	INST'L ASSY & C/O	0

WBS	IDENTIFICATION	AUX. STAGE
0400	TUG VEH. AUX STAGE	9,025
0470	RDM	0
0473	AVIONICS	0
	DMS	
	PCM/Sig Cond	
	Sensors	
	GN&C	
	Attitude Gyro	
	Ref Unit	
	Timer/CT'l Relay	
	APS CT'l Electron.	
	COMMUNICATIONS	
	S-Band Xcvr/Xpdr	
	Baseband Process	
	Aux. Xmtr	
	Pwr Amplifier	
	Diplexer	
	Antenna Switch	
	Antenna	
	ELEC. POWER	
	Primary Battery	
	Pwr Dist & CT'l	
0480	AKS	0
0483	AVIONICS	0
	DMS	
	Sensors	
	GN&C	
	Attitude Gyro	
	Ref Unit	
	Timer/CT'l Relay	
	Velocity Meter	
	Sequence Program	
	ELEC POWER	
	Primary Battery	
	Pwr Dist & CT'l	
0490	DKS	0
	AVIONICS	
	DMS	
	Sensors	
	PCM	
	GN&C	
	Attitude Gyro	
	Ref Unit	
	Timer/CT'l Relay	
	APS/TVC CT'l Electr	
	Velocity Meter	
	Sequence Program	
	Star Tracker	
	COMMUNICATIONS	
	S-Band Xcvr/Xpdr	
	Baseband Process	
	Aux. Xmtr	
	Pwr Amplifier	
	Diplexer	
	Antenna Switch	
	Antenna	
	ELEC. POWER	
	Primary Battery	
	Pwr Dist & CT'l	
	DeOrbit Battery	
	Solar Cell Pad'l's	

IV-8.6-44

320A-3A/320AE-3A
AVERAGE COST/FLIGHT ($ THOUSANDS)

	MODE I REFUSE		MODE II EXPEND TUG		MODE III EXPEND KS	
	NASA	DOD	NASA	DOD	NASA	DOD
Launch Operations	129.16	129.16				
Launch Site Serv & Supt	------	------				
Tug Shuttle Mate & C/O	10.83	10.83				
Prelaunch C/O	20.07	20.07				
Countdown	.65	.65				
Propellants & Gasses	62.0	62.0				
Post Flight Safing	35.61	35.61				
Maintenance & Refurb	518.20	518.20				
Sched Mant & Refurb	28.74	28.74				
Unsched Maint & Refurb	30.33	30.33				
Vehicle Opnl Spares (less Me)	214.54	214.54				
M. Eng. Maint & Refurb	80	80				
M. E. Opnl Spares	31.23	31.23				
Post Maint C/O	9.89	9.89				
Tug/Payload Mate & C/O	15.81	15.81				
Refurb Reqmt Planning	3.01	3.01				
Depot Maint	104.65	104.65				
Total Ground OPS (Launch/Maint/Refb)	647.36	647.36				
Flight Operations	448.21	539.10				
Mission Planning	131.63	147.35				
Flight Control	160.8	157.35				
Flight Evaluation	21.41	19.76				
Flight Supt Software	134.37	214.64				
Operations Support	77.02	77.02				
FSE Maint	1:99	1.99				
Sustaining Eng	36.33	36.33				
Prog Mgt	18.16	18.16				
Transport & Hdlg	3.82	3.82				
Inventory Control & Whseing	13.49	13.49				
Facilities Maint	3.23	3.23				
Expend Veh Avg. Unit Cost			16.5		1250	
Total Cost/Flight	1173	1263	17,700		2423	

STORABLE SPACE TUG SYSTEM PROJECT 320A-3A/320AE-3A DDT&E

COST ESTIMATE DATA BY SOW

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320	SPACE TUG PROJ		102147.		22191.		124576.		5822.		17008.		93989.		365733.
	MAJ PROC		22477.		10917.		17452.		875.		1458.		71722.		124901.
	IN-HOUSE	4453.	79670.	812.	11274.	8181.	107124.	299.	4947.	939.	15550.	1725.	22267.	16411.	240832.
320-01	PROJECT MGMT		0.		0.		0.		0.		0.		13742.		13742.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1064.	13742.	1064.	13742.
320-02	SYS ENGR + INTG		11049.		0.		0.		4947.		0.		495.		16491.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	618.	11049.	0.	0.	0.	0.	299.	4947.	0.	0.	38.	495.	955.	16491.
320-03	SPACE TUG VEH MN		61132.		8119.		21370.		791.		13432.		69740.		174583.
	MAJ PROC		12913.		5271.		3426.		791.		1318.		64287.		88005.
	IN-HOUSE	2695.	48219.	205.	2849.	1371.	17944.	0.	0.	732.	12114.	422.	5433.	5425.	86579.
320-03-01	STRUCTURES		9670.		0.		2340.		0.		2963.		624.		15597.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	541.	9670.	0.	0.	179.	2340.	0.	0.	179.	2963.	48.	624.	947.	15597.
320-03-02	THERMAL INSUL		82.		0.		30.		0.		30.		7.		149.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	5.	82.	0.	0.	2.	30.	0.	0.	2.	30.	1.	7.	9.	149.
320-03-03	AVIONICS		37199.		5271.		9497.		791.		6251.		5292.		64300.
	MAJ PROC		12913.		5271.		3426.		791.		1318.		2635.		26353.
	IN-HOUSE	1358.	24286.	0.	0.	454.	6072.	0.	0.	298.	4533.	206.	2656.	2325.	37948.
320-03-04	PROPULSION		8286.		0.		3255.		0.		1776.		63132.		76449.
	MAJ PROC		0.		0.		0.		0.		0.		61652.		61652.
	IN-HOUSE	463.	8286.	0.	0.	249.	3255.	0.	0.	107.	1776.	115.	1480.	934.	14796.
320-03-05	ORBITER INTF		3922.		0.		1426.		0.		1426.		357.		7131.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	219.	3922.	0.	0.	109.	1426.	0.	0.	86.	1426.	28.	357.	442.	7131.
320-03-06	DROP TANKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-03-07	FINAL ASSEMBLY		1972.		2849.		4821.		0.		586.		329.		10957.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	110.	1972.	205.	2849.	368.	4821.	0.	0.	60.	586.	25.	329.	769.	10957.
320-04	SPACE TUG VEH AU		11147.		2536.		5837.		84.		2203.		1136.		22944.
	MAJ PROC		1378.		562.		366.		84.		141.		281.		2812.
	IN-HOUSE	546.	9769.	142.	1974.	418.	5472.	0.	0.	125.	2063.	66.	855.	1297.	20132.
320-04-01	STRUCTURES		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-02	THERMAL INSUL		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-03	AVIONICS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-04	PROPULSION		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

320A-3A/320ABE-3A DDT&E

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-04-06	DROP TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-07	RDM		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-08	AKS		9780.		562.		2498.		84.		1520.		909.		15353.
	MAJ PROC		1378.		562.		366.		84.		141.		281.		2812.
	IN-HOUSE	470.	8403.	0.	0.	163.	2132.	0.	0.	83.	1380.	49.	627.	764.	12541.
320-04-09	DKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-10	CACHE TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-11	FINAL ASSEMBLY		1366.		1974.		3340.		0.		683.		228.		7591.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	76.	1366.	142.	1974.	255.	3340.	0.	0.	41.	683.	18.	228.	533.	7591.
320-05	LOGISTICS		6330.		0.		0.		0.		0.		0.		6330.
	MAJ PROC		950.		0.		0.		0.		0.		0.		950.
	IN-HOUSE	301.	5380.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	301.	5380.
320-06	FACILITIES		0.		0.		0.		0.		0.		8876.		8876.
	MAJ PROC		0.		0.		0.		0.		0.		7154.		7154.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	133.	1723.	133.	1723.
320-06-01	MANUFACTURING		0.		0.		0.		0.		0.		262.		262.
	MAJ PROC		0.		0.		0.		0.		0.		262.		262.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-02	TEST		0.		0.		0.		0.		0.		248.		248.
	MAJ PROC		0.		0.		0.		0.		0.		198.		198.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.	50.	4.	50.
320-06-03	ETR MAINT/REFB		0.		0.		0.		0.		0.		3977.		3977.
	MAJ PROC		0.		0.		0.		0.		0.		3182.		3182.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	62.	795.	62.	795.
320-06-04	ETR LAUNCH		0.		0.		0.		0.		0.		438.		438.
	MAJ PROC		0.		0.		0.		0.		0.		350.		350.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	7.	88.	7.	88.
320-06-05	WTR MAINT/REFB		0.		0.		0.		0.		0.		3428.		3428.
	MAJ PROC		0.		0.		0.		0.		0.		2742.		2742.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	53.	686.	53.	686.
320-06-06	WTR LAUNCH		0.		0.		0.		0.		0.		523.		523.
	MAJ PROC		0.		0.		0.		0.		0.		418.		418.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	8.	105.	8.	105.
320-07	GSE		12490.		11535.		1373.		0.		1373.		0.		26770.
	MAJ PROC		7236.		5084.		0.		0.		0.		0.		12320.
	IN-HOUSE	294.	5253.	464.	6451.	105.	1373.	0.	0.	83.	1373.	0.	0.	946.	14450.
320-07-01	MANUFACTURING		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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STORABLE SPACE TUG SYSTEM PROJECT 320A-3A/320ARE-3A DDT&E

COST ESTIMATE DATA BY SOW

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-07-02	ETR		4530.		11535.		1373.		0.		1373.		0.		18810.
	MAJ PROC		0.		5084.		0.		0.		0.		0.		5084.
	IN-HOUSE	253.	4530.	464.	6451.	105.	1373.	0.	0.	83.	1373.	0.	0.	905.	13726.
320-07-03	WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-07-04	FLT OPS NASA		3980.		0.		0.		0.		0.		0.		3980.
	MAJ PROC		3618.		0.		0.		0.		0.		0.		3618.
	IN-HOUSE	20.	362.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	20.	362.
320-07-05	FLT OPS DOD		3980.		0.		0.		0.		0.		0.		3980.
	MAJ PROC		3618.		0.		0.		0.		0.		0.		3618.
	IN-HOUSE	20.	362.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	20.	362.
320-08	VEHICLE TEST		0.		0.		95997.		0.		0.		0.		95997.
	MAJ PROC		0.		0.		13661.		0.		0.		0.		13661.
	IN-HOUSE	0.	0.	0.	0.	6290.	82336.	0.	0.	0.	0.	0.	0.	6290.	82336.
320-08-01	GND TEST HDWR		0.		0.		9625.		0.		0.		0.		9625.
	MAJ PROC		0.		0.		4813.		0.		0.		0.		4813.
	IN-HOUSE	0.	0.	0.	0.	368.	4813.	0.	0.	0.	0.	0.	0.	368.	4813.
320-08-02	GND TEST OPS		0.		0.		14145.		0.		0.		0.		14145.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	1081.	14145.	0.	0.	0.	0.	0.	0.	1081.	14145.
320-09-03	FLT TEST HDWR		0.		0.		17696.		0.		0.		0.		17596.
	MAJ PROC		0.		0.		8848.		0.		0.		0.		8848.
	IN-HOUSE	0.	0.	0.	0.	676.	8848.	0.	0.	0.	0.	0.	0.	676.	8848.
320-08-04	FLT TEST OPS		0.		0.		54530.		0.		0.		0.		54530.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	4166.	54530.	0.	0.	0.	0.	0.	0.	4166.	54530.
320-09	LAUNCH OPS WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-10	LAUNCH OPS ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-11	FLIGHT OPS WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-12	FLIGHT OPS ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-13	REFB + INTEG WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-14	REFB + INTEG ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

SA-318-II

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STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

320A-3A/320ARE-3A PROD

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320	SPACE TUG PROJ		72456.		86480.		19359.		5777.		13605.		44075.		241752.
	MAJ PROC		11972.		23077.		3318.		737.		1843.		20989.		61936.
	IN-HOUSE	3287.	60484.	4465.	63403.	998.	16042.	307.	5040.	651.	11762.	1788.	23086.	11496.	179817.
320-01	PROJECT MGMT		0.		0.		0.		0.		0.		14933.		14933.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1157.	14933.	1157.	14933.
320-02	SYS ENGR + INTG		11256.		0.		0.		5040.		0.		504.		16800.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	612.	11256.	0.	0.	0.	0.	307.	5040.	0.	0.	39.	504.	958.	16800.
320-03	SPACE TUG VEH MN		21464.		48713.		9014.		688.		7894.		24535.		112310.
	MAJ PROC		5164.		20310.		3098.		688.		1721.		20398.		51379.
	IN-HOUSE	886.	16300.	2000.	28404.	368.	5916.	0.	0.	342.	6173.	321.	4138.	3916.	60931.
320-03-01	STRUCTURES		4793.		5664.		1598.		0.		1743.		726.		14524.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	260.	4793.	399.	5664.	99.	1598.	0.	0.	96.	1743.	56.	726.	912.	14524.
320-03-02	THERMAL INSUL		350.		414.		117.		0.		127.		53.		1062.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	19.	350.	29.	414.	7.	117.	0.	0.	7.	127.	4.	53.	67.	1062.
320-03-03	AVIONICS		9329.		31669.		4234.		688.		2857.		4578.		53356.
	MAJ PROC		5164.		20310.		3098.		688.		1721.		3442.		34423.
	IN-HOUSE	226.	4165.	800.	11360.	71.	1136.	0.	0.	63.	1136.	88.	1136.	1248.	18933.
320-03-04	PROPULSION		2160.		3905.		748.		0.		831.		17620.		25264.
	MAJ PROC		0.		0.		0.		0.		0.		16956.		16956.
	IN-HOUSE	117.	2160.	275.	3905.	47.	748.	0.	0.	46.	831.	51.	665.	536.	8308.
320-03-05	ORBITER INTF		587.		694.		196.		0.		213.		89.		1779.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	32.	587.	49.	694.	12.	196.	0.	0.	12.	213.	7.	89.	112.	1779.
320-03-06	DROP TANKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-03-07	FINAL ASSEMBLY		4245.		6367.		2122.		0.		2122.		1469.		16325.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	231.	4245.	448.	6367.	132.	2122.	0.	0.	117.	2122.	114.	1469.	1042.	16325.
320-04	SPACE TUG VEH AU		25830.		33752.		9932.		49.		5505.		3668.		78736.
	MAJ PROC		366.		1439.		219.		49.		122.		244.		2439.
	IN-HOUSE	1384.	25464.	2276.	32314.	604.	9713.	0.	0.	298.	5383.	265.	3424.	4827.	76297.
320-04-01	STRUCTURES		2870.		5228.		1025.		0.		820.		308.		10251.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	156.	2870.	368.	5228.	64.	1025.	0.	0.	45.	820.	24.	308.	657.	10251.
320-04-02	THERMAL INSUL		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-03	AVIONICS		12887.		9372.		4979.		0.		1172.		879.		29288.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	700.	12887.	660.	9372.	310.	4979.	0.	0.	65.	1172.	68.	879.	1803.	29288.
320-04-04	PROPULSION		4604.		7938.		1429.		0.		1111.		794.		15875.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	250.	4604.	559.	7938.	89.	1429.	0.	0.	61.	1111.	61.	794.	1021.	15875.

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

320A-3A/320ARE-3A PROD

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-04-C6	DROP TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-C7	RDM		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-08	AKS		2867.		7312.		1198.		49.		1101.		788.		13314.
	MAJ PROC		366.		1439.		219.		49.		122.		244.		2439.
	IN-HOUSE	136.	2501.	414.	5873.	61.	979.	0.	0.	54.	979.	42.	544.	707.	10876.
320-04-09	DKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-10	CACHE TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-11	FINAL ASSEMBLY		2602.		3903.		1301.		0.		1301.		901.		10008.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	141.	2602.	275.	3903.	81.	1301.	0.	0.	72.	1301.	70.	901.	639.	10008.
320-05	LOGISTICS		9340.		0.		0.		0.		0.		0.		9340.
	MAJ PROC		3042.		0.		0.		0.		0.		0.		3042.
	IN-HOUSE	342.	6298.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	342.	6298.
320-06	FACILITIES		0.		0.		0.		0.		0.		434.		434.
	MAJ PROC		0.		0.		0.		0.		0.		347.		347.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	7.	87.	7.	87.
320-06-01	MANUFACTURING		0.		0.		0.		0.		0.		371.		371.
	MAJ PROC		0.		0.		0.		0.		0.		297.		297.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	6.	74.	6.	74.
320-06-02	TEST		0.		0.		0.		0.		0.		63.		63.
	MAJ PROC		0.		0.		0.		0.		0.		50.		50.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	13.	1.	13.
320-06-03	ETR MAINT/REFB		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-04	ETR LAUNCH		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-05	WTR MAINT/REFB		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-06	WTR LAUNCH		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-07	GSE		4566.		4014.		413.		0.		207.		0.		9200.
	MAJ PROC		3400.		1328.		0.		0.		0.		0.		4728.
	IN-HOUSE	63.	1166.	189.	2685.	26.	413.	0.	0.	11.	207.	0.	0.	290.	4472.
320-07-01	MANUFACTURING		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

320A-3A/320ARE-3A PROD

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-07-02	ETR		281.		1367.		141.		0.		70.		0.		1860.
	MAJ PROC		0.		453.		0.		0.		0.		0.		453.
	IN-HOUSE	15.	281.	64.	915.	9.	141.	0.	0.	4.	70.	0.	0.	92.	1407.
320-07-03	WTR		545.		2647.		272.		0.		136.		0.		3600.
	MAJ PROC		0.		876.		0.		0.		0.		0.		876.
	IN-HOUSE	30.	545.	125.	1771.	17.	272.	0.	0.	8.	136.	0.	0.	179.	2724.
320-07-04	FLT OPS NASA		1870.		0.		0.		0.		0.		0.		1870.
	MAJ PROC		1700.		0.		0.		0.		0.		0.		1700.
	IN-HOUSE	9.	170.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9.	170.
320-07-05	FLT OPS DOD		1870.		0.		0.		0.		0.		0.		1870.
	MAJ PROC		1700.		0.		0.		0.		0.		0.		1700.
	IN-HOUSE	9.	170.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9.	170.
320-08	VEHICLE TEST		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-01	GND TEST HDWR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-02	GND TEST OPS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-03	FLT TEST HDWR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-04	FLT TEST OPS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-09	LAUNCH OPS WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-10	LAUNCH OPS ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-11	FLIGHT OPS WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-12	FLIGHT OPS ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-13	REFB + INTEG WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-14	REFB + INTEG ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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STORABLE SPACE TUG SYSTEM PROJECT

COST ESTIMATE DATA BY SOW

320A-3A/320ARE-3A OPN'S

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320	SPACE TUG PROJ		183771.		73250.		2169.		3452.		1686.		31152.		295480.
	MAJ PROC		19685.		6520.		771.		171.		428.		15975.		43552.
	IN-HOUSE	10539.	164085.	8168.	66730.	102.	1398.	272.	3281.	104.	1257.	1176.	15177.	20360.	251928.
320-01	PROJECT MGMT		0.		0.		0.		0.		0.		5466.		5466.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	423.	5466.	423.	5466.
320-02	SYS ENGR + INTG		7327.		0.		0.		3281.		0.		328.		10936.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	471.	7327.	0.	0.	0.	0.	272.	3281.	0.	0.	25.	328.	768.	10936.
320-03	SPACE TUG VEH MN		3988.		10544.		1595.		161.		1330.		1542.		19162.
	MAJ PROC		1211.		4762.		726.		161.		404.		807.		8071.
	IN-HOUSE	178.	2778.	708.	5783.	63.	869.	0.	0.	77.	927.	57.	735.	1083.	11091.
320-03-01	STRUCTURES		436.		515.		145.		0.		158.		66.		1320.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	28.	436.	63.	515.	11.	145.	0.	0.	13.	158.	5.	66.	120.	1320.
320-03-02	THERMAL INSUL		16.		19.		5.		0.		6.		2.		50.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	1.	16.	2.	19.	0.	5.	0.	0.	0.	6.	0.	2.	5.	50.
320-03-03	AVIONICS		2383.		7958.		1046.		161.		723.		1127.		13398.
	MAJ PROC		1211.		4762.		726.		161.		404.		807.		8071.
	IN-HOUSE	75.	1172.	391.	3196.	23.	320.	0.	0.	27.	320.	25.	320.	541.	5327.
320-03-04	PROPULSION		1100.		1989.		381.		0.		423.		339.		4232.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	71.	1100.	243.	1989.	28.	381.	0.	0.	35.	423.	26.	339.	403.	4232.
320-03-05	ORBITER INTF		53.		63.		18.		0.		19.		8.		162.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	3.	53.	8.	63.	1.	18.	0.	0.	2.	19.	1.	8.	15.	162.
320-03-06	DROP TANKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-03-07	FINAL ASSEMBLY		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04	SPACE TUG VEH AU		563.		1625.		178.		10.		158.		183.		2716.
	MAJ PROC		75.		293.		45.		10.		25.		50.		497.
	IN-HOUSE	31.	488.	163.	1331.	10.	133.	0.	0.	11.	133.	10.	133.	225.	2219.
320-04-01	STRUCTURES		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-02	THERMAL INSUL		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-03	AVIONICS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-04	PROPULSION		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

320A-3A/320ARE-3A OPNS

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-04-06	DROP TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-07	RDM		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-08	AKS		563.		1625.		178.		10.		158.		183.		2716.
	MAJ PROC		75.		293.		45.		10.		25.		50.		497.
	IN-HOUSE	31.	488.	163.	1331.	10.	133.	0.	0.	11.	133.	10.	133.	225.	2219.
320-04-09	DKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-10	CACHE TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-11	FINAL ASSEMBLY		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-05	LOGISTICS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06	FACILITIES		0.		0.		0.		0.		0.		1238.		1238.
	MAJ PROC		0.		0.		0.		0.		0.		990.		990.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	19.	248.	19.	248.
320-06-01	MANUFACTURING		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-02	TEST		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-03	ETR MAINT/REFB		0.		0.		0.		0.		0.		625.		625.
	MAJ PROC		0.		0.		0.		0.		0.		500.		500.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	10.	125.	10.	125.
320-06-04	ETR LAUNCH		0.		0.		0.		0.		0.		133.		133.
	MAJ PROC		0.		0.		0.		0.		0.		106.		106.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	27.	2.	27.
320-06-05	WTR MAINT/REFB		0.		0.		0.		0.		0.		347.		347.
	MAJ PROC		0.		0.		0.		0.		0.		279.		279.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	5.	69.	5.	69.
320-06-06	WTR LAUNCH		0.		0.		0.		0.		0.		133.		133.
	MAJ PROC		0.		0.		0.		0.		0.		106.		106.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	27.	2.	27.
320-07	GSE		4531.		4036.		396.		0.		198.		0.		9160.
	MAJ PROC		3400.		1465.		0.		0.		0.		0.		4865.
	IN-HOUSE	73.	1131.	315.	2571.	29.	396.	0.	0.	16.	198.	0.	0.	433.	4295.
320-07-01	MANUFACTURING		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

II-8.6-63

MOORE BUSINESS FORMS, INC. NO. FORM 14122 PRINTED IN U.S.A.

STORABLE SPACE TUG SYSTEM PROJECT

COST ESTIMATE DATA BY SOW

320A-3A/320AE-3A

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-07-02	ETR		353.		1802.		177.		0.		88.		0.		2420.
	MAJ PROC		0.		654.		0.		0.		0.		0.		654.
	IN-HOUSE	23.	353.	140.	1148.	13.	177.	0.	0.	7.	88.	0.	0.	183.	1766.
320-07-03	WTR		438.		2234.		219.		0.		109.		0.		3000.
	MAJ PROC		0.		811.		0.		0.		0.		0.		811.
	IN-HOUSE	28.	438.	174.	1423.	16.	219.	0.	0.	9.	109.	0.	0.	227.	2189.
320-07-04	FLT OPS NASA		1870.		0.		0.		0.		0.		0.		1870.
	MAJ PROC		1700.		0.		0.		0.		0.		0.		1700.
	IN-HOUSE	11.	170.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	11.	170.
320-07-05	FLT OPS DOD		1870.		0.		0.		0.		0.		0.		1870.
	MAJ PROC		1700.		0.		0.		0.		0.		0.		1700.
	IN-HOUSE	11.	170.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	11.	170.
320-08	VEHICLE TEST		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-09-01	GND TEST HDWR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-02	GND TEST OPS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-03	FLT TEST HDWR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-04	FLT TEST OPS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-09	LAUNCH OPS WTR		730.		2400.		0.		0.		0.		4806.		7936.
	MAJ PROC		0.		0.		0.		0.		0.		4458.		4458.
	IN-HOUSE	47.	730.	294.	2400.	0.	0.	0.	0.	0.	0.	27.	348.	368.	3478.
320-10	LAUNCH OPS ETR		4467.		14679.		0.		0.		0.		11797.		30943.
	MAJ PROC		0.		0.		0.		0.		0.		9670.		9670.
	IN-HOUSE	287.	4467.	1797.	14679.	0.	0.	0.	0.	0.	0.	165.	2127.	2248.	21273.
320-11	FLIGHT OPS WTR		60510.		0.		0.		0.		0.		0.		60510.
	MAJ PROC		6051.		0.		0.		0.		0.		0.		6051.
	IN-HOUSE	3498.	54459.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3498.	54459.
320-12	FLIGHT OPS ETR		89490.		0.		0.		0.		0.		0.		89490.
	MAJ PROC		8949.		0.		0.		0.		0.		0.		8949.
	IN-HOUSE	5173.	80541.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	5173.	80541.
320-13	REFB + INTEG WTR		4243.		13941.		0.		0.		0.		2020.		20205.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	273.	4243.	1706.	13941.	0.	0.	0.	0.	0.	0.	157.	2020.	2135.	20205.
320-14	REFB + INTEG ETR		7921.		26026.		0.		0.		0.		3772.		37719.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	509.	7921.	3186.	26026.	0.	0.	0.	0.	0.	0.	292.	3772.	3986.	37719.

II-8.6-53A

MOORE BUSINESS FORMS, INC., HO FORM 14127 PRINTED IN U.S.A.

SPACE TUG CHARACTERISTICS

320A-3A→320AE-3A

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	WEIGHT, LB	2695→2768	545
	LENGTH, IN	205 EACH	80
	DIAMETER, IN	98	180
TECHNICAL:	REUSABLE	TWO-STAGE	
	AUXILIARY STAGE		AKS
	PAYLOAD RETRIEVAL	CAPABILITY	
	PROPELLANT CAPACITY, LB	59,500	
	THRUST, LB	12,000	
	ISP, SEC	338	295
	AUTONOMY LEVEL	IIIA	
	RELIABILITY	.9763/.9936	.9987

WBS #320-00

GRUMMAN

II-8.6-54

MAIN STAGE CHARACTERISTICS

320A-3A → 320AE-3A

PHYSICAL:	WEIGHT, LB	2695 → 2768
	LENGTH, IN	205 EACH
	DIAMETER, IN	98
TECHNICAL:	REUSABLE TWO STAGE	
	PROPELLANT CAPABITY, LB	32,000 EACH
	PAYLOAD RETRIEVAL CAPABILITY	
	THRUST, LB	12,000
	ISP, SEC	338
	AUTONOMY LEVEL	IIIA
	RELIABILITY	.9763/.9936

WBS #320-03

GRUMMAN

VEHICLE TEST CHARACTERISTICS

320A-3A→320AE-3A

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	PROP. TEST ARTICLE	X	
	STRUCT. TEST ARTICEL	X	X
	INTEG. AVIONICS TEST	X	X
	MOCK-UPS	X	X
	FLIGHT TEST	X	X

TECHNICAL: PTA - COLD FLOW ONLY, NO HOT FIRING

STA - ONE ART FOR DYNAMICS, STATIC & FATIGUE

IAT - SOFTWARE & HARDWARE

MOCK-UPS - WOOD AT PDR, WOOD/METAL AT CDR

FLIGHT TEST - ONE WITHOUT P/L, NINE WITH P/L

WBS #320-08

GRUMMAN

STRUCTURAL CHARACTERISTICS

320A-3A → 320AE-3A

PHYSICAL:	WEIGHT, LB	946 → 988
	LENGTH, IN	205
	DIAMETER, IN	98
TECHNICAL:	TANK CONFIGURATION	NESTED DOME
	TANK CAPACITY, LB	32,000
	MATERIAL	Ti, COMPOSITE H'COMB
	RELIABILITY ALLOCATION	.99900

WBS #320-03-01

GRUMMAN

IV-8.6-57

CONFIGURATION 320AE-3A

WBS NO. 320-03-01

SUBSYSTEM/COMPONENT STRUCTURE

DATE: 9/17/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS	RELIABILITY: MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TEST	NOTES
01-Fuel Tank and Supports	1	44½		Titan.	177	73	98	D		Welded Gore Titanium Domes	20	1		2	Tank Leakage considered. Unserviceable
02-Oxid. Tank and Supports	1	44½		Titan.	113	82	98	D		Welded Gore Titanium Domes	20	1		2	
03-Body Structure	1	44½		Alum. and Comp.	476	120	98	D		Graphite Composite Honeycomb Shell Aluminum Frames	N/A	1		2	Includes Equipment Mounting and Umbilicals
04-Thrust Structure	1	44½		Alum.	65	31	98	D MAX.		Aluminum Stiffened Sheet	N/A	1		2	
05-Meteroid Shield	1	44½		Alum.	20	76	104	D		Aluminum Sheet	N/A	1	1		
06-Interface	1	46		Alum.	137					Aluminum Machinings and Forgings	N/A	1		2	

DRUMMAN

THERMAL CONTROL CHARACTERISTICS

320A-3A → 320AE-3A

PHYSICAL: WEIGHT, LB 61 → 62

300 FT^2 GOLDIZED MYLAR MLI

AL BASE HEAT SHIELD

SILVER BACKED TEFLON & ALZAK COATINGS

WBS #320-03-02

GRUMMAN

IV-86-59

CONFIGURATION 320AE-3A

WBS NO. 320-03-02-01.02

SUBSYSTEM/COMPONENT THERMAL CONTROL

DATE: 8/30/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
THERMAL CONTROL COATINGS	5	0		SBT ALZAK ALCLAD	5		1000 ft²			0				1			
MULTILAYER INSULATION	3	6		SIC MINI SPEC	28		300 ft²			0				1			
FUEL CELL RADIATOR	2	12		SIC MINI SPEC	11		12.6 ft²							1			POWER AMP (20W)
AVIONICS HEAT PIPE RADIATOR	2	12		SIC MINI SPEC	4		4 ft²			0							
AVIONICS HEATERS	4	6		SIC MINI SPEC	2					75/UNIT				8			COX & COMPANY, NY, NY.
APS HEATERS*	4	6		SIC MINI SPEC	6					20/UNIT				28			IDENTICAL TO MICROMETEROID SHIELD
BASE HEAT SHIELD	5	0		AL	10.5		67 ft²			0							
PLUMBING	5	0		AL	2					0							

* [illegible] AS APS [illegible].

09-93-II

BRUMMAN

REPORT
DATE
CODE 20513

AVIONICS CHARACTERISTICS

320A-3A → 320AE-3A

PHYSICAL:	WEIGHT, LB	612 → 616
TECHNICAL:	AUTONOMY LEVEL	IIIA
	RENDEZVOUS & DOCKING	→ LASER RADAR
	COMMUNICATIONS	DFS → DFS/CSS
	COMPUTER CAPACITY	48K WORDS
	FUEL CELL POWER	2.5 KW
	RELIABILITY ALLOCATION	.98614 → .98562

WBS #320-03-03

GRUMMAN

19-9.8-II

[illegible] LEVEL III A | CORE CONFIGURATION [redacted], 320 AE-3A | WBS NO. 320-03-03-01 | SUBSYSTEM/COMPONENT DMS | DATE: [illegible]

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
MAIN STAGES #1 & #2 COMPUTER	4	12			13	4.7	5	8.6	202	36	48 KWORDS - 16 BITS/WORD	144	18K	2	N/A	1	CDC 469
TAPE RECORDER	5	12	AF/S-3 [illegible]		14.5	9	12	5.4	560	8		165	12K	1		1	CDETICS DDS 3000
FSI CONTROLLER / TLM FORMATTER	4	8	SHUTTLE		13	8	5	16	640	23		144	12K	1		1	RADIATION INC
DACU'S	4	8	SHUTTLE		7	7	4	13	364	21	256 CHANNELS	144	12K	3		1	"
SENSORS	4	8	SHUTTLE		0.2	N/A	N/A	N/A	N/A	0.1			1M	180	↓	10	WHITTAKER TRANSONICS

GRUMMAN

WBS NO. 320-03-03-02

Rev. A 8-31-73
DATE: 8-20-73

CONFIGURATION 320AE-3A AUTONOMY LEVEL III A SUBSYSTEM/COMPONENT GN&C

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
INERTIAL MEASURING UNIT	1	24			10	6.5	6.5	4.7	200	5				2			HAS SOME PROCESSING CAPABILITY
STAR TRACKER	1				17	15	6	DIA	424	28				1			DOES NOT INCLUDE SUNSHADE (1 LB)
LASER RENDEZVOUS RADAR	1	30			40	9 21	9 9	9 6	729 1134	35				1			
APS CONTROL ELECTRONICS	1				18	10	10	5	500	13				2			
ME/TVC CONTROL ELECTRONICS	1				10	10	10	3.5	350	15				1			

GRUMMAN

REPORT
DATE
CODE 28512

IV-8.6-63

CONFIGURATION 320AE-3A

WBS NO. 320-03-03-03

SUBSYSTEM/COMPONENT COMM

DATE: 9-5-7

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR S/S TEST	NOTES
1. S-BAND X'CEIVER/X'PONDER R'CVR-(2) X'MT-(1)		24			2X4 1X5	7 7	9 8	5 5	315 280	8 34	Spread Spectrum CCIR Interference STDN/SGLS Compatible			1			NO SIMULTANEOUS COMM BETWEEN VEHICELES & ONE GROUND STATION
2. S-BAND X'CEIVER/X'PONDER R'CVR-(4) X'MTR-(1)					4X4 1X5	7 7	9 8	5 5	315 280	8 34	Spread Spectrum CCIR Interference STDN/SGLS Compatible			1			
3. AUX. X'MTR					5	7	8	5	280	34	Same as (2)			1			
4. POWER AMP.					1	3	5	2	30	20	R.F. output of 5W			1			
5. POWER AMP.		15			3	9	5	3	135	100	R.F. output of 20W			1			
6. Base band Processor		24			6	7	7	5	245	4	Same as (1) & (2)			1			
7. Diplexer					1	3	7	3	63	—	—			2			
8. Diplexer		9			1	3	7	3	63	—	—			2			
9 Antenna Switch					1	3	3	4	36	1	—			2			
10. Antenna					.5	3	6	1	18	—	—			2			
11 Antenna		9			.5	3	6	1	18	—	—			2			
12. Power Splitter		8			1	2	2	3	12	—	—			1			
13. TV ASSEMBLY		15			12	18	6	4	432	10	Black & White			1			
15. SECURE COMM		—			6	9	5	4	180	8	—			5			DOD ONLY-GFE

GRUMMAN

REPORT
DATE
CODE 26512

TABLE 5.5.2-E EQUIPMENT LIST

9-8-73 RE
8-24 [illegible]
8-22-7[illegible]

CONFIGURATION [redacted]-320AE-3A CORE VEHICLE WBS NO. 320-03-03-05 & -06 SUBSYSTEM/COMPONENT ELECTRICAL POWER SUBSYSTEM DATE: 8-10-73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TEST	NOTES
• ADVANCED FUEL CELL	1	42	—		40	15	6	12	1100		2.5KW @ 28V; 750W AVG. LOAD OVER 124HR MISSION	144	10,000	1 PER STAGE	—	1	REQUIRES AUTO SPACE START-UP SELLERS: PCWA, GE
• EMERGENCY BATTERY	5	6	—	Ag-Zn, Mg	15	9	5	4 1/2	200	—	10 AMP-HR RATED CAP. 1/2 HR NOM. DISCHARGE	1/2	30,000	1 PER STAGE	—	1	SECONDARY SILVER-ZN BATT, SELLER EAGLE-PICHER
• CRYO HYDROGEN TANK ASSY	3	24	GEMINI APOLLO SHUTTLE	Ti-INNER Ti-OUTER	64	18 1/4 21	ID OD		3140		250 PSIA OPERATING PRESSURE 350 " MAX " 8 LB FLUID CAP.	144	500,000	1 PER STAGE	—	1	SELLER: AIRESEARCH, BEECH, BENDIX
• CRYO OXYGEN TANK ASSY	3	24	GEMINI APOLLO SHUTTLE	INC 718 INNER INC-750 OUTER	66	14 1/2 17 1/2	ID OD		1550		900 PSIA OPERATING PRESSURE 1000 PSIA MAX " 64 LB FLUID CAP.	144	500,000	1 PER STAGE	—	1	-DITTO-
• VEHICLE WIRING	5	—	LM		44						6ga, 14ga, 16, 20 & 26ga	144		SHIP SET PER STAGE	—	SHIP SET PER STAGE	8000 FT OF VARIOUS SIZES
• CONNECTORS	5	—	LM		30						VARIOUS SIZES	"		"	—	"	120 MATED PAIRS
• SUNDRIES (1" CLAMPS TAPE)	5	—	LM		16						" "	"		"	—	"	
• SOLID STATE POWER CONTRL	5	—			21						90-2amp 17-5amp 60-3amp	"		"	—	"	2 OZ EA; SELLER LEACH CORP
• ELECTRO-MECH RCCB	3	12	LM		9						2-20 amp 10-100 amp	"		"	—	"	.75 LB EA; " : CUTLER HAMMER
					120	POWER	D&C	SUBTOTAL									

59-9.8-II

GRUMMAN

REPORT
DATE
CODE 20512

PROPULSION CHARACTERISTICS

320A-3A → 320AE-3A

		MAIN PROP.	AUXILIARY PROP.
PHYSICAL:	WEIGHT, LB	552	146 → 166
	ENGINE/THRUSTER	CLASS I	REA 19
	NO. OF ENGINES/THRUSTERS	1	16 → 24
TECHNICAL:	FUEL LOAD, LB	11,034	327
	OXIDIZER LOAD, LB	20,966	--
	THRUST, LB	12,000	25
	ISP - STEADY STATE, SEC	338	232
	- PULSING, SEC	--	170
	RELIABILITY ALLOCATION	.99249	.99899

WBS #320-03-04

GRUMMAN

WBS NO. 320-03-04-03; 320-03-04-04

CONFIGURATION 320 AE-3A

SUBSYSTEM/COMPONENT Auxiliary Propulsion System (APS)

DATE: 8/1/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR U/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MOVING	NOTES
																	GENERAL NOTE: TANKAGE BASED ON USABLE PROPELLANT OF 398 LB PLUS 10% CONTINGENCY.
Helium Tank	5	≤12	-		11.5	12.27	12.27	12.27	678	-	Burst Press = 6850 Operating = 3425	156	10^6	2			Airite P/N 6372
Helium Filter	5	≤12	LM		0.5					-				1			LSC 310-303-3 (Vacco Valve)
Helium Latching Solenoid Valve	4	≤12	LM		2.3					84		156	1.3×10^6	2			LSC 270-713 (MC Mfg)
Regulator, Dual Stage	5	≤12	LM		2.5					-		156	1.3×10^6	1			LSC 310-305-3 (Fairchild Stratos)
Regulator, Single Stage	4	≤12	-		1.5					-		156	1.3×10^6	1			Mod to dual stage reg.
Quad Check Valve	5	≤12	LM		0.7					-	Proof press. = 600 PSI	156	2000	1			Mod to LSC 310-306 (Accessory Products)
Burst Disc/Relief Vlv	4	≤12	-		1.5					-	Relief press ≈ 400 PSI	156	10^6/67K	1			Mod to LSC 310-307 (Calmec)
Vent Valve	3	18	-		2.0					70	Proof Press = 600 PSI	156	67000	3			Similar to LSC 310-403 (Parker) Unidirectional flow only; Nigheric operating pressure
Propellant Tanks	4	≤12	LM		12.5		12.50	×39	4100	-	Burst Press = 650 PSI	144	10^6	3			Modified LM RCS OX tanks with elastomeric bladders.
Acquisition Bladders	2	24	-	EPT-10 Elastomer	-					-				3			Tank wt. includes bladders
Propellant Filter	5	≤12	-		0.5					-				1			
Thruster Isolation Valve	3	18	-		2.0					70	Proof press = 600 PSI	168	67000	8			Same valve as Vent Valve same notes apply.
Thrusters	4	≤12	-		2.1	11.4	2.7			24	25 LB thrust @ 325 PSI inlet, steady state Isp = 232	144	1.3×10^6	24			REA 19-3 (Hamilton Standard)
Thruster Heaters	5	≤12	-		0.2					3.5	Maintain catalyst beds at 150°F			24			Submitted for pricing by Thermo
Quick Disconnects	5	≤12	-		0.5									3			He fill & drain Prop fill & drain Prop fill & vent

One Shipset

None

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ORBITER INTERFACE CHARACTERISTICS

320A-3A → 320AE-3A

PHYSICAL:	WEIGHT, LB	1119
TECHNICAL:	MATERIAL	ALUMINUM
	PIVOT TYPE ADAPTER/DOCKING MECHANISM	
	SERVICE PANELS	GROUND POWER
		INSTRUMENTATION
		ON-PAD EMERGENCY DUMP
		HORIZONTAL PROP. DRAIN
		FUEL CELL REACTANT FILL

WBS #320-03-05

GRUMMAN

CONFIGURATION 320AE-3A

WBS NO. 320-05-03-01

SUBSYSTEM/COMPONENT ORBITER INTERFACE STRUCT. DATE: 9/17/73

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICIAL	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GNDTEST	
01-Rear Adapter	1	44½		Alum.	611	64	98	D		Aluminum Stiffened Sheet and Machinings	N/A			1	Pivot Type Adapter
01-Fwd Frame	1	44½		Alum.	400					Aluminum Trusses and Machinings	N/A			1	
01-Docking Mechanism	1	46		Alum.	108					Aluminum Machinings and Forgings	N/A			1	
															Interstage Required For Two Stage Operation

GRUMMAN

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CONFIGURATION 320AE-3A

WBS NO. 320-04-05

SUBSYSTEM/COMPONENT INTERSTAGE STRUCTURE

DATE: 9/17/73

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC				NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR SPA TEST	EQUIVALENT UNITS FOR MAJOR GNDTEST		
01-Structure	1	14½		Alum.	259	85	98	D		Aluminum Stiffened Sheet	N/A			1		
02-Seperation System	1	46		Alum	92					Aluminum Machings and Forgings	N/A			1		Latches and Mechanism

II-8-9-70

APOGEE KICK STAGE CHARACTERISTICS

320A-3A 320AE-3A

		PLANETARY	GEOSYNCH
PHYSICAL:	WEIGHT (MAX.), LB	545	
	LENGTH, IN	80	
	DIAMETER, IN	180	
TECHNICAL:	MATERIAL	ALUMINUM	
	INSULATION	ALUMINIZED MYLAR MLI	
	ATTITUDE GYRO		
	BATTERY POWER	2 AMP HR	
	DMS/COMM	NONE	
	PROPULSION - MAIN	9 SRM'S	
	- AUX.	12 COLD GAS THRUSTERS	
	RELIABILITY ALLOCATION	.9987	

WBS #320-04-08

GRUMMAN

CONFIGURATION 320A-3A

WBS NO. 320-04-01

SUBSYSTEM/COMPONENT KICK STAGE STRUCTURE

DATE: 9/17/72

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GNDTEST	
03-Body Structure	1	68		Alum.	368	65	98	DIA		Aluminum Stiffened Sheet and Fittings	N/A	1		1	Payload 23
06-Payload Interface	1	68			40							1		1	
03-Body Structure	1	68		Alum.	336					Aluminum Stiffened Sheet and Fittings	N/A	1		1	Double Deploy
06-Payload Interface	1	68			40							1		1	

II-8.6-22

PAGE

CONFIGURATION AKS & RDM

WBS NO. ——

SUBSYSTEM/COMPONENT THERMAL

DATE:

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE, COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR SYS TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
COATINGS	5	0	LM	PAINT	1	←	150	4²	→		6 day	NA	1	1	NA	ALUMINIZED MYLAR/NYLON NET
INSULATION	5	6	LM	MLI	4	←	50	4²	→		6 day	NA	1	1	NA	

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REPORT
DATE
CODE 70512

ALL AUTHORITY LEVELS

CONFIGURATION APOGEE KICK STAGE (AKS) WBS NO. 320-04-08-03

SUBSYSTEM/COMPONENT DMS

DATE: 7/[illegible]

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR [illegible] TEST	[illegible]	
SENSORS	4	8	SHUTTLE		0.2	N/A	N/A	N/A	N/A	0.1			1M	2	N/A	2	WHITAKER TRANSDUCERS

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CONFIGURATION Apogee Kick Stage

WBS NO. 320-04-08-03

SUBSYSTEM/COMPONENT GNTC

DATE: 8-2-73

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
ATTITUDE GYRO [illegible] UNIT	4	12	IMP ITOS		13	10.6	8	DIA.	533	25 WATTS			1			120 WATTS WARM UP
VELOCITY METER	4	8	IMP ITOS		5.7	5.9	5.5	4.3	156	28 WATTS			1			40 WATTS WARM UP
[illegible]	1	18			7.6	8.6	7.1	5.5	336	18.5 WATTS			1			
[illegible] RELAYS	4	12	IMP ITOS		3	6	3.4	2.4	49	2 WATTS			1			
SEQUENCER PROGRAMMER	4	12	IMP ITOS		2	6.4	4.3	2.8	77	6.3 WATTS			1			

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REPORT
DATE
CODE 26512

CONFIGURATION 320A-2A, 320AE-3A WBS NO. 320-09-08-04

SUBSYSTEM/~~COMPONENT~~ MPS (AUX. STAGE) DATE:

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/G TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
SRM #1	3	24	DELTA, BURNER II, ETC.		1900	77	37	—	83K	180	I_{SP} = 295, λ' = .92 E = 50			9	0	0	ME - TEM 364 OR SVM 9A
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	"

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CONFIGURATION Apogee Kick Stage (AKS) WBS NO. 320-03-04-03; 320-03-04-04

SUBSYSTEM/COMPONENT Auxiliary Propulsion System (APS) DATE: 5/3/75

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR S/S TEST	NOTES
Nitrogen Tank	5	<12	–	6Al 4V	1.02	4.75	–	–	50	–	Burst Press. = 6660 PSI Operating = 3000 PSI		10^7	1			Airite P/N 6389
Solenoid Valve	5	<12	–		2.3					84			67,000	1			LSC 270-713
Regulator (single stage)	4	<12	–		1.5					–		2	67000	1			LSC 310-305-3 (Mod to one stage)
Thruster Valve	4	<12	–		0.75					10	0.25" I.D. required		533,000	12	One Shipset	None	
Thrusters	5	–	–		0.2					–			–	12			Nozzle machinings
Quick Disconnect	5	<12			0.5					–			10^6	1			Nitrogen fill & vent

General Notes:
Tank sized to provide 12 hr. wide deadband and 1 hr. narrow deadband control.

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8.7 FLIGHT SCHEDULE

Included in support of our flight schedule definition for concept 320A-3A/320AE-3A are the following tables:

- Fleet Size and Vehicle Usage
- Flight Element Requirements
- Kick Stage Definition
- 320A-3A/320AE-3A Flight Operations Buildup
- Payload Flown
- Programmatic Data Summary Storable Tug Concept 320A-3A/320AE-3A

320A-3A/320AE-3A FLEET SIZE & VEHICLE USAGE

	1979	80	81	82	83	84	85	86	87	88	89	90	TOTAL
Capture Model													
Total Flts.		21	16	18	29	38	31	36	37	32	33	34	325
											Lost Missions		+3
Prog Build Up													
ETR Reuse		3	15	18	22	23	23	26	28	26	22	28	234
Expend						2		1	1		3	1	8
WTR Reuse					7	5	8	9	8	6	8	5	56
Total		3	15	18	29	30	31	36	37	32	33	34	298
											Lost Missions		+3
Lower Stage Flts.													
Reuse		3	15	18	29	28	31	35	36	32	30	33	
Expend						2		1	1		3	1	
Total		3	15	18	29	30	31	36	37	32	33	34	298
National Fleet													
Lower Stg													
VEH 1		2	8	9	11	2E							
2 Int.		1	7	9	11	4E							
3 Int.					7	7	6	10E					
4 Int.						5	17	9	12E				
5 Evl.						12	8	17	17	6	2E		
6									8	17	6E		
7										11	17E		
8											8	12E	
9												17	
10												5	
11 Lost Tug													
12 Lost Tug													
13 Lost Tug													
DOD TRAFFIC													
Lower Stg Flts.		1	6	9	15	12	12	17	15	17	14	16	134
VEH 1		1	6	9	15	8	Modify	5	2	10	7	8	
2						4	12	12	13	7	7	8	
3 Lost Tug													

320A-3A/320AE-3A FLEET SIZE & VEHICLE USAGE

	1979	80	81	82	83	84	85	86	87	88	89	90	Total
Upper Stg Flts													
Reuse			10	10	15	15	21	20	22	23	17	25	
Expend						2		1	1		3	1	
Total			10	10	15	17	21	21	23	23	20	26	178
										Lost Missions			+2
National Fleet													
Upper Stg Veh 1	Int.		5	6	7	1E							
2	Int.		5	4	8	6E							
3	Evl.					5	12	10E					
4						5	9	11	12E				
5									11	12	2E		
6										11	6E		
7											10E		
8											2	12E	
9												14	
10	Lost Tug												
11	Lost Tug												
DOD Traffic													
Upper Stg Flts			3	3	5	8	8	9	11	12	8	13	80
Veh 1			3	3	5	Modify	4	5	5	6	5	6	
2						4	4	4	6	6	3	7	
3	Lost Tug												

FLIGHT ELEMENT REQUIREMENTS

OPTION: 3A 320A/320AE-3A

ITEM			CALENDAR YEAR 80	81	82	83	84	85	86	87	88	89	90	TOTAL
SHUTTLE FLIGHTS		TOTAL	21	16	18	29	38	31	36	37	32	33	34	325
BASIC TUG FLIGHTS (ONE STAGE)	ETR	RECOVERED	7	5	8	7	8	2	6	6	3	5	3	60
		EXPENDED												0
	WTR	RECOVERED				7	5	8	9	8	6	8	5	56
	(TOTAL)		(7)	(5)	(8)	(14)	(13)	(10)	(15)	(14)	(9)	(13)	(8)	(116)
BASIC TUG FLIGHTS (TWO STAGE)	ETR	RECOVERED	14	11	10	15	23	21	20	22	23	17	25	201
		EXPENDED					2		1	1		3	1	8
	WTR	RECOVERED												0
	(TOTAL)		(14)	(11)	(10)	(15)	(25)	(21)	(21)	(23)	(23)	(20)	(26)	(209)
TOTAL TUG STAGES FLOWN			35	27	28	44	63	52	57	60	55	53	60	534
KICK STAGES (USED ONLY WITH RECOVERABLE ONE STAGE FLIGHTS FROM ETR)	KS 321				2		2		3	2				9
	(TOTAL)				(2)		(2)		(3)	(2)				(9)

RELIABILITY = +3 FLTS

RAS 9-6-73

COMBINED NASA/DOD TRAFFIC

TABLE [illegible]

FLIGHT ELEMENT REQUIREMENTS

OPTION: 3A 320A/320AE-3A

ITEM			CALENDAR YEAR 80	81	82	83	84	85	86	87	88	89	90	TOTAL
SHUTTLE FLIGHTS		TOTAL	10	10	9	14	22	19	19	22	15	19	18	177
BASIC TUG FLIGHTS (ONE STAGE)	ETR	RECOVERED	2	2	2	1	5		3	4		3	1	23
		EXPENDED												0
	WTR	RECOVERED				3	4	6	4	6	4	4	4	35
	(TOTAL)		(2)	(2)	(2)	(4)	(9)	(6)	(7)	(10)	(4)	(7)	(5)	(58)
BASIC TUG FLIGHTS (TWO STAGE)	ETR	RECOVERED	8	8	7	10	11	13	11	11	11	9	12	111
		EXPENDED					2		1	1		3	1	8
	WTR	RECOVERED												0
	(TOTAL)		(8)	(8)	(7)	(10)	(13)	(13)	(12)	(12)	(11)	(12)	(13)	(119)
TOTAL TUG STAGES FLOWN			18	18	16	24	35	32	31	34	26	31	31	296
KICK STAGES (USED ONLY WITH RECOVERABLE ONE STAGE FLIGHTS FROM ETR)	KS 321				2		2		3	2				9
	(TOTAL)				(2)		(2)		(3)	(2)				(9)

BAS 9-6-73

NASA TRAFFIC

TABLE 4.2.3.3-4

FLIGHT ELEMENT REQUIREMENTS

OPTION: 3A 320A/320AE-3A

ITEM			CALENDAR YEAR											TOTAL
			80	81	82	83	84	85	86	87	88	89	90	
SHUTTLE FLIGHTS		TOTAL	11	6	9	15	16	12	17	15	17	14	16	148
BASIC TUG FLIGHTS (ONE STAGE)	ETR	RECOVERED	5	3	6	6	3	2	3	2	3	2	2	37
		EXPENDED												0
	WTR	RECOVERED				4	1	2	5	2	2	4	1	21
	(TOTAL)		(5)	(3)	(6)	(10)	(4)	(4)	(8)	(4)	(5)	(6)	(3)	(58)
BASIC TUG FLIGHTS (TWO STAGE)	ETR	RECOVERED	6	3	3	5	12	8	9	11	12	8	13	90
		EXPENDED												0
	WTR	RECOVERED												0
	(TOTAL)		(6)	(3)	(3)	(5)	(12)	(8)	(9)	(11)	(12)	(8)	(13)	(90)
TOTAL TUG STAGES FLOWN			17	9	12	20	28	20	26	26	29	22	29	238
KICK STAGES	KS 321													0
	(TOTAL)													0

BAS 9-6-73

DOD TRAFFIC

TABLE 4.2.2.3-5

CONCEPT 320A/320AE-3A
KICK STAGE DEFINITION

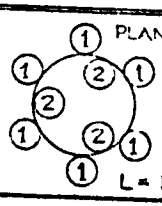
KICK STAGE DESIGNATION	GEOMETRY (all stages >10 ft diam. & are 5.5 ft long unless otherwise noted)		PERFORMANCE (Geosynch Payload) (lbs)	SRM CHARACTERISTICS INDIVIDUAL WEIGHT (lbs)	NUMBER	TOTAL SRM WEIGHT (lbs)	STAGE INERT WEIGHT (lbs)	TOTAL STAGE WEIGHT (lbs)
KS321	 PLANETARY L = 100"	STAGE 1	5000 lbs TO ΔV = 18400 fps	1900	6	11400	-	11400
		STAGE 2		1900	3	5700	545	6245
		(TOTAL)						17645

TABLE 4.3.3.3-7

BAS 9-6-73

320A-3A/320AE-3A FLIGHT OPERATIONS BUILDUP

The 320A-3A/320AE-3A flight buildup is defined with the same methodology used in 310-3A/310RE-3A, ie considering: NASA defined Shuttle/Tug launch constraints, initial and evolved ETR ground crew launch capabilities, and flight mode buildup.

However, in this program a slightly larger ground crew had to be used to accommodate multiple stages during the buildup from 3 flights in 1980 to 18 flights in 1982. During the evolved period the same crew size was increased to handle the higher flight rate needed for 1986.

During the flight buildup period we recommend that initial/evolved flight crew experience be developed by starting with the simplest flight mode and then progressively introducing the more complex flight modes required for 1982 and beyond.

Our recommended flight buildup for 320A-3A/320AE-3A, including 3 flights in 1980, 15 flights in 1981, and 30 flights in 1984, encompasses 301 total flights through 1990 or 24 less than 100% payload capture traffic.

320A-3A/320AE-3A FLIGHT OPERATIONS BUILDUP

INPUTS	CY 80	81	82	83	84	85	86	TOTAL FLTS.
	▽ IOC_I				▽ IOC_E			
o 100% PAYLOAD CAPTURE - ETR+WTR FLTS	21	16	18	29	38	31	36	325
ETR FLTS	21	16	18	22	33	23	27	
o SHUTTLE/TUG LAUNCH CONSTRAINT - ETR	3	21						
o INITIAL GND CREW LAUNCH CAPABIL.-ETR	15	16	19					
o EVOLVED IOC GND CREW LAUNCH CAPAB/ETR				22	25	23	27	
o TUG FLIGHT MODE BUILDUP								
SINGLE DEPLOY - 1 STAGE	3	ALL	ALL	ALL	ALL	ALL	ALL	
MULTI DEPLOY - 1 STAGE	NONE	NONE	ALL	ALL	ALL	ALL	ALL	
SINGLE DEPLOY - 1 STG. W/KS	NONE	SOME	ALL	ALL	ALL	ALL	ALL	
SINGLE/MULTI DEPLOY - 2 STAGE	NONE	SOME	ALL	ALL	ALL	ALL	ALL	
SORTIE - 1 STAGE	NONE	NONE	NONE	ALL	ALL	ALL	ALL	
RETRIEVE - 1 STAGE	NONE	NONE	NONE	NONE	ALL	ALL	ALL	
ROUND TRIP	NONE	NONE	NONE	NONE	ALL	ALL	ALL	
RETRIEVE/ROUND TRIP 2 STAGE	NONE	NONE	NONE	NONE	SOME	ALL	ALL	
RECOMMENDED FLIGHT BUILDUP ETR+WTR	3	15	18	29	30	31	36	301
ETR	3	15	18	22	25	23	27	

BUILDUP RATIONALE

- o SAME AS 310-3A/310RE-3A

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FLIGHT	PAYLOAD FLOWN					
	1980	1981	1982	1983	1984	1985
1	D-11 (IS)	D-7	ALL	ALL	D-9	ALL
2	D-17 (IS)	D-8			D-10 (IS)	
3	D-35 (IS)	D-10 (IS)			D-18 (IS)	
4		D-11 (IS)			D-18 (IS)	
5		D1 + D1			D-20 (IS+KS)	
6		D2 + D2			D-20 (IS+KS)	
7		D3 + D3			D-24 (EXP)	
8		D3 + D3			D-24 (EXP)	
9		D3 + D4			R-2	
10		D-31			R-3	
11		D-31			R-3	
12		D-34 (IS)			D1 + R1	
13		D-35 (IS)			D7 + R4	
14		D-35 (IS)			D8 + R2	
15		D25 + D25			D14 + R14 (IS)	
16					D15 + R15 (IS)	
17					R-12 (IS) +	
18					R-13 (IS)	
19					D-31	
20					D-31	
21					R-34	
22					D23 + D23	
23					D37 + D37 + D37	
24					D25 + R25	
25					D25 + R25	
26					D26 + R26	
27					D32 + R32	
28					D35 + R35 (IS)	
29					D35 + D35	
30					D39 + D39 + D39	
FLTS FLOWN / SCHED	3/21	15/16	18/18	29/29	30/33	31/31
DEPLOY P/L FLOWN / SCHED	3/34	21/23	24/24	47/47	29/37	36/36
DEPLOY E.A. FLOWN / SCHED	0/0	0/0	0/0	0/0	17/25	24/24
SORTIES FLOWN / SCHED	0/0	0/0	0/0	1/1	0/0	1/1

CONCEPT 320A/320AE-3A

COSTED FLIGHT BUILD-UP

TABLE 4.3.3.3-8

PAGE 4-170

IV-8.7-9

PROGRAMMATIC DATA SUMMARY
STORABLE TUG CONCEPT 320A-3A/320AE-3A

PROJECT HARDWARE UTILIZATION (AUTONOMY IIIA)

VEHICLE	LOWER MAIN STAGE INIT	LOWER MAIN STAGE EVOL	UPPER MAIN STAGE INIT	UPPER MAIN STAGE EVOL	INTER-STAGE	ORBITER INTERFACE	AKB 321		
VEHICLE TEST									
PTV	1*	-	-	-	-	-	-		
STA	1	-	-	-	1	1	1		
1 AT	1	1	-	-	-	-	1		
FLT TEST VEH	1*	-	1*	-	1*	1*	1		
VEHICLE OPS									
TEST HDWR CONV	*		*		*	*	-		
NATIONAL FLEET	4	9	3	8	4	4	9		
NASA	2	7	2	6	2	2	9		
DOD	2	2	1	2	2	2	-		
TOTAL FLEET	24						9A		

	TEST	OPERATIONS		
	INIT	INIT	EVOL	TOTAL
ETR	1	59	185	244
WTR	-	7	50	57
COMBINED		66	235	301
NASA		35	131	166
DOD		31	104	135

OPNL YEARS

	INIT	EVOL	TOTAL
ETR	4	7	11
WTR	1	7	8

GRUMMAN

8.9 Risk Assessment

In making an assessment of the risk associated with each configuration in each capability option we have considered the type of technology items associated with each vehicle and the impact that it would have on the program if, for one reason or another, the item would be unavailable and an alternative solution would be required. The impact is defined, usually, in terms of added weight, lost performance and total program cost increase; in some cases the impact can be decreased weight or reduced cost.

It is assumed that all of the weight increases and all of the cost increases will occur simultaneously without benefit of any offsetting decreases in either weight or cost. For example in configuration 110A-1 we have assumed that the +4 lb. weight impact of abandoning spun aluminum tanks in favor of welded aluminum tanks is combined with a $10.0 million cost increase as a result of abandoning aluminum tanks in favor of titanium tanks due to materials compatibility or fracture mechanics issues.

Taking the summation of all the weight increases, these are converted to costs by using the $75K/lb. figure derived when we were first selecting subsystem options for incorporation with 110A-1. The $75K/lb. number represents the last step (actually the slope of the line) in our subsystems synthesis process which provides a curve of Δ weight versus Δ total program costs as we added lighter and more costly subsystems options to achieve a behicle with 3500 lb. deploy capability. In this manner we arrived at a estimate of the costs expected if we had to recover the weight growth.

In similar fashion we then summed all of the potential cost increases, ignoring any offsetting cost decreases, and added these to the dollars representing the weight increases. The 110A-1 has no projected performance loss since it uses the OME 7.5K engine; the assumption is that the basic OME will have been developed to meet its weight, performance and reusability goals for the Shuttle Orbiter. In the case of configurations which use the Class I engine, for example 410AD-2, we have assumed that a 3 second Isp performance loss is possible. To convert this performance loss to costs we use the payload sensitivity factor to loss in Isp (97 lbs/sec), divide this by the payload sensitivity to inert weight and then multiply by $111/lb. to convert it to costs.

Taking all of the costs and adding them together we get a total low cost risk value of $15.3M for 110A-1 which ranges to a high value of 94.3M for 320A-3A/ 320AE-3A.

320A-3A/320AE-3A RISK ASSESSMENT

TECHNOLOGY ITEM IMPACT	
• CLASS I ENG	-3 SEC ISP
• 2-POSITION NOZZLE	+10 LB
• PFR TANK	+39 LB
• ADV FUEL CELL	+50 LB
• ADV IMU	+30 LB
• GRAPHITE COMPOSITE	+23 LB
• LASER RADAR	COST/SCHED
• MATERIALS COMPATIBILITY	+10 LB
• FRACTURE MECHANICS	+10 LB
• HEAT PIPES	SCHED

VEHICLE SENSITIVITY (DEPLOY	PLAIN	WITH AKS
$\frac{\partial P/L}{\partial W \text{ FIXED}}$ (LB/LB)	TBD	TBD
$\frac{\partial P/L}{\partial ISP}$ (LB/SEC)	TBD	TBD

- TECHNICAL RISK
  - POTENTIAL WT IMPACT: +162 LB } ≈ PAYLOAD IMPACT TBD
  - POTENTIAL ISP LOSS: -3 SEC }
  - NO OPEN WEIGHT REDUCTION OPTIONS
- SCHEDULE RISK
  - PROPOSED SR&T PROGRAMS (COMPL PRIOR TO ATP) PROTECT AGAINST SCHEDULE SLIPPAGE
  - AVAILABILITY OF MAIN ENGINE & ADV FUEL CELL
- COST RISK
  - POTENTIAL Δ COST $94.3 M

HIGH RISK PROGRAM

RISK ASSESSMENT 320A-3A/320AE-3A

The following items and their potential impact are shown on the opposite chart. The Class I engine is a new design based on current technology with the exception of the uncertainty in engine life and in the predicted performance with the high expansion, 2-position nozzle used. The 2-position, radiation cooled nozzle is itself a technology issue which complicates and increases the risk associated with the development of this engine. It is estimated engine performance can be low by 3 seconds Isp and engine nozzle/actuation system weight can increase by 10 lbs.

All existing weight reduction options have been incorporated into this vehicle; if any or all of these options fail to meet their goals there are no lighter weight alternatives available; the only recourse is to incorporate the Class II engine at a $72M cost increase, and to initiate a super weight reduction program (SWIP) down to the piece-part by piece-part level.

Although the proposed SR & T programs protect against schedule slippage by virtue of being completed at ATP, the availability of both the main engine and the advanced fuel cell remain schedule risk items.

Converting the potential weight increases to a total program cost at a $125K/lb value and adding to that the potential cost increase items, yields a total cost risk of $94.3M for 320A-3A/320AE-3A.

RISK ASSESSMENT 320-3A/320AE-3A

BASELINE	ALTERNATIVE	WEIGHT LBS	TOTAL PROGRAM COST, $M
CLASS I ENGINE WITH TWO-POSITION NOZZLE	NO ALTERNATIVE	+10	COST/SCHED RISK
LASER RADAR	RF RADAR PLUS REMOTE TV DOCKING (ALSO A TECHNOLOGY ISSUE), HENCE NO ALTERNATIVE	-	COST/SCHED RISK
PFR HELIUM TANK	6AL 4V TITANIUM TANK	+39	+1.1
ADVANCED FUEL CELL	MODIFIED FUEL CELL	+50	-26.0
ADVANCED IMU (MICRON)	CAROUSEL VB IMU + RATE GYRO UNIT	+30	- 7.6
GRAPHITE COMPOSITE SHELL	ALUMINUM HONEYCOMB SHELL	+23	+0.94
TITANIUM TANKS (COMPATIBILITY DATA & FRACTURE MECHANICS DATA)	STAINLESS STEEL, OR ALUMINUM	+1, OR +10	TBD
HEAT PIPES	USE ACTIVE LOOP/BYPASS	NONE	NONE

SUMMING HIGHER WEIGHTS & COSTS ONLY	162 LBS	$2.04M
CONVERT WEIGHT TO $ at $125K/LB ----------	(162 X 125K) ----------	20.3
Add TO GO TO CLASS II ENGINE (NO OPEN WEIGHT OPTIONS) ----------		72.0
TOTAL COST RISK ----------		$94.34M

Section 8.10 Supporting Research and Technology

This section includes a summary matrix chart which identifies all of the SR & T items and where they are applied to each configuration in each capability option.

Following the summary matrix there are individual tables for each configuration which summarize the technology items for that particular configuration and give a very brief synopsis of the type of SR & T program proposed and the estimated funding and schedule requirements. The text following each table is the facing page text prepared for the main presentation.

Following the tables for each configuration, an additional form is filled out for each technology item providing status information, justification for the proposed SR & T program, objectives, technical approach, and a more detailed schedule showing when the proposed program must be completed in order to support the particular configuration.

In dealing with the subject of SR & T we have identified two distinct groups - one where technology is needed and the other where there is no doubt that the technology is available and it is a straightforward engineering task to accumulate data that will preclude making a "false start" where several alternates are under study; we have called the latter group "desired data".

The storable Tug will benefit from the fact that the APOLLO LM program has used similar materials, propellants, equipments and procedures; the Shuttle Orbiter will expand on this data base for the Tug. The low number of identified SR & T items and the modest sums projected are based on the assumption that several existing or planned efforts related to the Shuttle will continue to provide data. These include the planned propellant and materials compatibility testing in support of the Shuttle Orbital Maneuvering Subsystem, its engines, tanks and components both at NASA/WSTF and at the Shuttle contractor's facilities. In addition, we have identified the Air Force funded efforts to develop the advanced Micron IMU for aircraft programs, as an effort which we would build-on rather than to start from scratch.

We have not attempted to detail the SR & T programs required on the Class I engine (with or without the two position nozzle) except to point out the uncertainty associated with the anticipated engine life and the predicted performance of very high expansion ratios within the mixture ratio of interest. The engine contractor will provide the proposed SR & T efforts required on the engine and we will provide comments on same at NASA's request.

The overall "message" which we hope will become obvious to the reader is that there are no real "show-stoppers" among the SR & T items identified.

TECHNOLOGY REQUIREMENTS AND "DESIRED DATA"

		110-A1	410AD-2	310-3A 310RE-3A	320-3A 320AE-3A	310-3B 310ARE-3B	510A-3B 510ADE-3B
S R & T	CLASS I ENGINE, HIGH E PERF		X	X	X	X	
	TWO-POSITION NOZZLE				X		
	LASER RADAR		X	(X)	(X)	(X)	(X)
	PFR HELIUM TANK	X	X	X	X	X	X
	ADVANCED FUEL CELL				X		
	ADVANCED IMU		X	(X)	(X)	(X)	(X)
	GRAPHITE COMPOSITE		X	X	X	X	
	SPUN-FORM ALUM. TANKS	X					X
	LONG TERM SPACE STORABLE SRM		X				(X)
DESIRED DATA	MATERIALS COMPATIBILITY DATA	X	X	X	X	X	X
	FRACTURE MECHANICS DATA	X	X	X	X	X	X
	HEAT PIPE DATA	X	X	X	X	X	X

(X) REQUIRED PRIOR TO GO AHEAD ON EVOLVED TUG CONFIGURATIONS

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320A-3A/320AE-3A TECHNOLOGY REQUIREMENTS & DESIRABLE DATA

	ITEM	SR&T FUNDS $K	SR&T SCHEDULE MOS.	PROPOSED PROGRAM
SR&T	CLASS I ENGINE WITH 2 POSITION NOZZLE	TBD	TBD	HIGH ALT. TESTS TO OBTAIN PERF. DATA ON HIGH ε NOZZLE FOR MIXTURE RATIO RANGE
	LASER RADAR	500	12	FAB & TEST LIGHTWEIGHT, LOW POWER UNIT USING IMPROVED OPTICS & LIGHTER MIRROR DRIVES
	PFR HELIUM TANK	125	12	FAB & TEST 3 TANKS UNDER STATIC & DYNAMIC LOADING: AND ENVIRONMENTAL & COMPATIBILITY TESTS
	ADVANCED FUEL CELL	2000	24	FAB & TEST 3 UNITS WITH INCREASED CURRENT DENSITY, PASSIVE H_2O REMOVAL AND O_2-DRIVEN DIAPHRAGM COLLAND PUMP
	ADVANCED IMU	500	18	DEVELOP SOFTWARE FOR REDUNDANCY MGMT AND CALIBRATION OF 2 MULTI-SENSOR TYPE IMU'S
	GRAPHITE COMPOSITE	15	6	FAB GRAPHITE EPOXY HONEYCOMB SAMPLES & TEST IN VARIOUS PLY DIRECTIONS FOR DESIGN DATA
DESIRABLE DATA	MATERIALS COMPATIBILITY DATA	25	6	6A14VT1; 2219-T87 & 2219T81; WITH N_2O_4 AND MMH UP TO 130°F
	FRACTURE MECHANICS DATA			6A14VT1 & 2219-T87; Kic, Kth & FLAW GROWTH WITH N_2O_4 & MMH UP TO 130°F
	HEAT PIPES	100	12	FAB & TEST VARIABLE CONDUCTANCE HP RADIATOR PANEL & HEADER FOR TURN DOWN RATIO & SHUT OFF HEAT FLUX DATA

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TECHNOLOGY REQUIREMENTS AND DESIRED DATA - 320-3A/320AE-3A

The upper part of the facing chart contains the supporting research and technology (SR&T) items required for 320-3A/320AE-3A; the lower part of the chart contains what we have termed as "desired data". The distinction between the two is that the "desired data" items do not require technology but are considered straightforward engineering development tasks to produce design data prior to Tug program go-ahead (ATP); this will preclude impacting Tug schedules should the data indicate the desirability of an alternative approach, (vis., aluminum or stainless propellant tanks rather than titanium.

Excluding the SR&T on the Class I engine with its two-position nozzle, the total SR&T funds requested for 320-3A/320AE-3A is $3,290 K to be expended over a 24 month period culminating at Tug ATP or prior to go-ahead on the evolved Tug. The advanced fuel cell is the long lead item (24 months) followed by the advanced (Micron) IMU (18 months). The unusually large sum for the advanced fuel cell ($2,000 K) is the result of compressing the SR&T program to support advanced fuel cell availability prior to Tug ATP.

The SR&T for the Class I engine with a two-position nozzle will be provided by the engine contractor.

410 AD-2, 310RE-3A, 320AE-3A, 310 ARE-3B, 510ADE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Avionics (CN&C)
(Discipline)

TITLE Low Weight/Power, (Rendezvous and Docking) Laser Radar WBS No. 320-03-03-02

STATUS ITT-Gilfillan has been under NASA Contracts since 1964 to design, develop, build, and test various spaceborne laser radar systems. The third generation system will be delivered in late November 1973.

JUSTIFICATION The application of the above developed technology to meet specific space tug rendezvous and docking requirements is desired.

In addition in order to improve the payload capability of the storable tug, low weight Avionics equipments (specifically, low weight/low power laser radar) are required.

OBJECTIVES To design, develop, fabricate, and test a low weight, low power, rendezvous and docking laser radar.

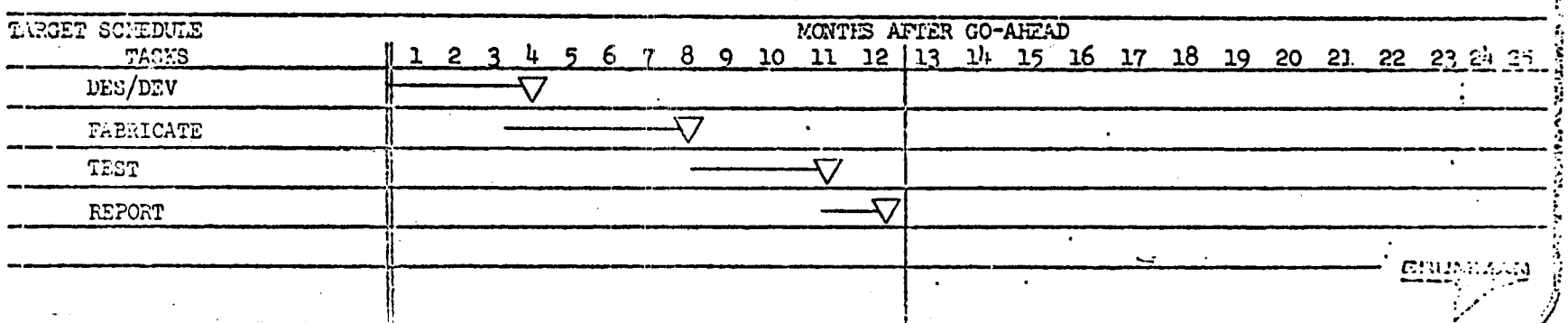
5-01.8-II

TECHNICAL APPROACH Using Tug requirements, design for light weight, low power by using new components, lighter mirror drives and improved optics

MANPOWER FUNDING $500 K

SPECIALIZED FACILITIES Development and testing at ITT

TARGET SCHEDULE



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STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE Astrionics (GN&C) TITLE Low Wt./PW Rend.&Docking Laser Radar WBS 320-03-03-02

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG ϕ C/D ATP MILESTONES			1980 TUG△		1982 TUG△		1984 TUG△
TASKS							
Design & Development							
Fabricate							
Test							
Report							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)					4	12	16
FUNDING							
a) DIRECT LABOR					100K	300K	400 K
b) EQUIPMENT & MAT'L					20K	40K	60 K
c) FACILITIES					40K	--	40 K
d) OTHER (SPECIFY)							
TOTAL					160K	340K	500 K

SPECIALIZED FACILITIES
TYPE/LOCATION/AVAILABILITY
FACILITIES DEV. TIME & COST

Optics bench, dark rooms, test range

IV-8.10-6

[illegible] 310-3A/310AE-3A, 320A-3A/320AE-3A, 310-3B/310 ARE-3B, 510A-3B/510ADE-

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Main Propulsion (Discipline)

TITLE Prestressed Filament Reinforced (PFR) Tanks WBS No. 320-03-04-02

STATUS Structural Composites Industries, Inc. (SCI) and Arde-Portland, Inc. are under contract to LeRC to demonstrate the feasibility of the PFR tanks. This program will result in the construction of a 24 in. diam. Ardeform PFR tank of the type assumed by our study. If successful the basic technology will be proven.

JUSTIFICATION

A PFR ambient helium storage tank is comparable with the weight of a SHe tank and its associated heat exchanger. It provides a simple and less operationally complex system compared to the SHe tank. The PFR tank also provides a leak-before-burst design which results in increased Tug safety.

OBJECTIVES

Design, fabricate, and test 3 to 6 PFR tanks to demonstrate that current manufacturing and quality control techniques are adequate to produce a reliable, low weight tank suitable for containing gaseous helium (or hydrogen and oxygen in the case of fuel cell reactant tanks). The program will resemble a pre-qualification test program which will demonstrate the ability of the PFR tank to undergo the dynamic loading, compatibility, environmental exposure and etc. tests required for acceptance as a flight item.

TECHNICAL APPROACH

Fabricate 3 to 6 tanks and subject them to a pre-qualification test program to demonstrate the maturity of the design.

MANPOWER 2 man years FUNDING $125,000

SPECIALIZED FACILITIES

Available at tank manufacturers

TARGET SCHEDULE TASKS	MONTHS AFTER GO-AHEAD 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Fabricate Tanks																									
Test Program																									
Analysis and Report																									

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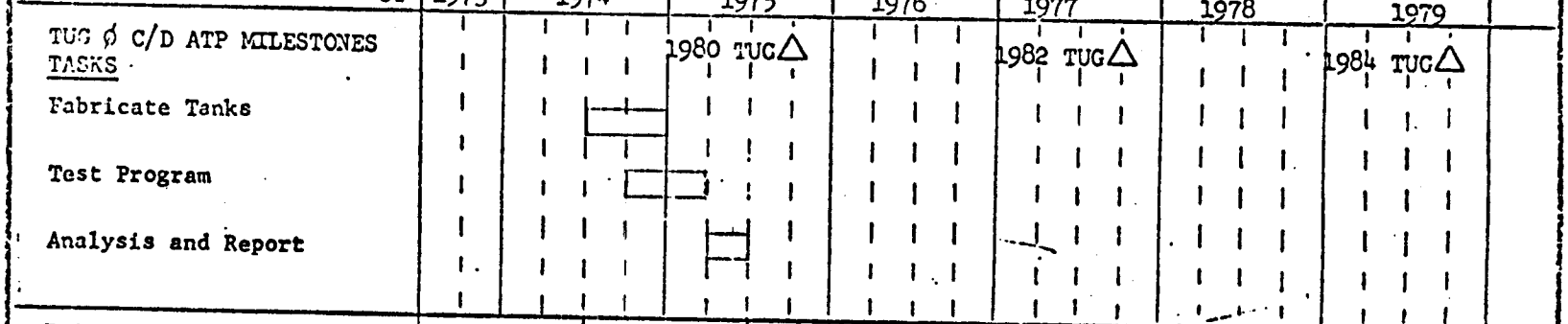
IV-8.10-7

BRUNSMAN

ALL EXCEPT 410AD-2

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE MAIN PROPULSION (MPS) TITLE PRESTRESSED FILAMENT REINFORCED (PFR) TANKS WBS 320-03-04-02



RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)	1	1					
FUNDING							
a) DIRECT LABOR	$ 38,000	$ 37,000					$ 75,000
b) EQUIPMENT & MAT'L	$ 30,000	$ 20,000					$ 50,000
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL	$ 68,000	$ 57,000					$125,000

SPECIALIZED FACILITIES	
TYPE/LOCATION/AVAILABILITY	ARDE, SCI, or Similar
FACILITIES DEV. TIME & COST	None

320 A-3A / 320 AE-3A

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - AVIONICS - EPS
(Discipline)

TITLE ADVANCED FUEL CELLS - WBS No. 320-03-03-05

STATUS NASA-Lewis & AF-Aero Propulsion Lab are supporting advanced fuel cell technology and an aircraft high power fuel cell program, respectively. Total funding for fiscal '72 thru '74 by these agencies ~ $1.5 million. The supporting program that is recommended is in addition to the on-going contracts.

JUSTIFICATION

Significant improvement is required in the development of long life, high energy density cells resulting in a substantial weight advantage plus improved, simpler maintainability requirements.

OBJECTIVES

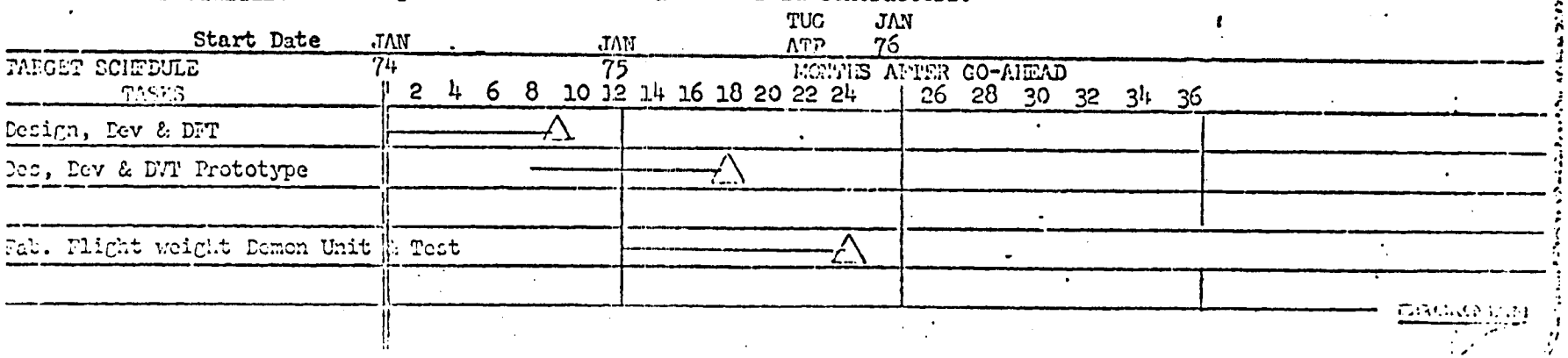
To develop a low weight high performance fuel cell with a wide range of power output without voltage degradation, eliminating membrane hot spots. In addition, develop advanced heat & water removal concepts to eliminate components.

II-8-10-9

TECHNICAL APPROACH Increase current density, resulting in decreased electrode area. Replace water separator with jet pump. Replace coolant pump with oxygen driven diaphram pump. Test highly stable long life materials and passive water removal concept.

MANPOWER FUNDING $.2 Million

SPECIALIZED FACILITIES Development at P&WA or GE and their subcontractors.



320A-3A/320NE-3A

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FIGURE 5.2.4.7-3

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE ASTRIONICS - EPS TITLE ADVANCED FUEL CELLS WBS 320-03-03-05

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG ∅ C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS							
Design, Fab & Test breadboard		DES TEST					
Design, Fab & Test Prototype		DES	TEST				
Design, Fab & Test Demo Unit			FAB TEST				

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)	10	30	15				55
FUNDING							
a) DIRECT LABOR (Eng., Prod, & Technicians)	250K	750K	375K				1375K
b) EQUIPMENT & MAT'L	50K	375K	100K				525K
c) FACILITIES - TEST EQUIP	25K	50K	25K				100K
d) OTHER (SPECIFY)							
TOTAL	325K	1175K	500K				2000K

SPECIALIZED FACILITIES TYPE/LOCATION/AVAILABILITY FACILITIES DEV. TIME & COST	Development at Fuel Cell contractors and their subcontractors.

410 AD-2, 310 RE-3A, 320 AE-3A, 310 ARE-3B, 510 ADE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Astrionics (GN&C)
(Discipline) WBS #320-03-03-02

TITLE Advanced (Low Weight) Inertial Measurement Unit for Space Application

STATUS Advanced Lightweight Unit being developed under Air Force Contract. Primarily for aircraft application.

JUSTIFICATION To improve payload capability of a storable tug, low weight Astrionics Equipments are required.

OBJECTIVES To develop the advanced IMU to the point where it can be used in a space application.

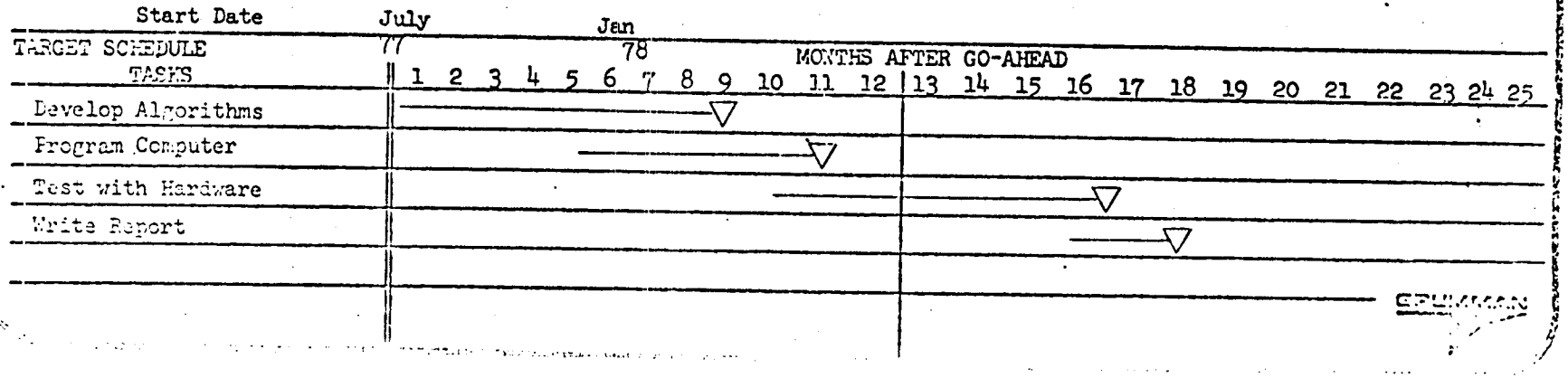
IV-8.10-11

TECHNICAL APPROACH
1. Develop software mechanizations for redundancy management.
2. Develop software and procedures for calibration of gyros on the launch pad.
3. Test the software with the hardware in the lab.

MANPOWER

FUNDING $500 K

SPECIALIZED FACILITIES Development and test in subcontractor's facility.

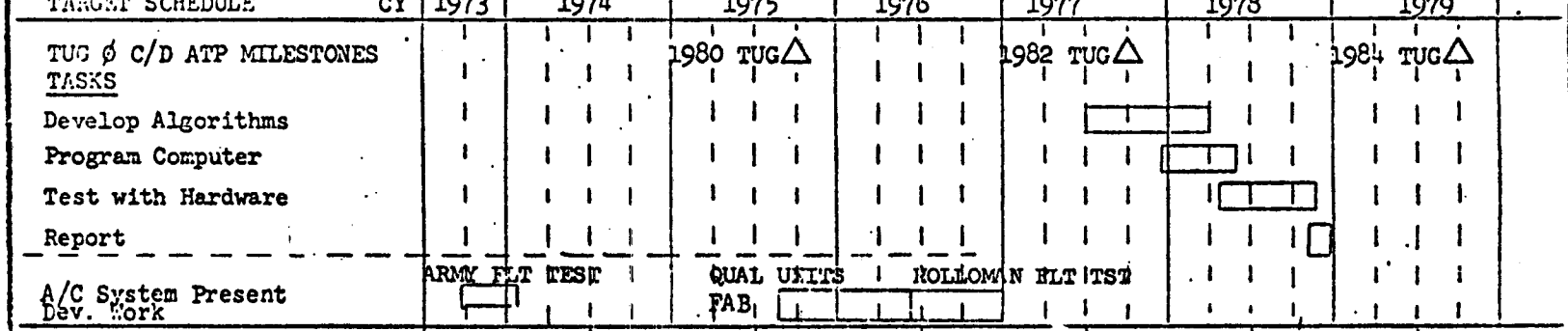


GRUMMAN

GRUMMAN

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE Astrionics (GN&C) TITLE Advanced IMU WBS 320-03-03-02



RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)				4	8		12
FUNDING							
a) DIRECT LABOR				100 K	200 K		300 K
b) EQUIPMENT & MAT'L					100 K		100 K
c) FACILITIES Inertial Test Stand					100 K		100 K
d) OTHER (SPECIFY)							
TOTAL				100 K	100 K		500 K

SPECIALIZED FACILITIES

TYPE/LOCATION/AVAILABILITY

FACILITIES DEV. TIME & COST

Development and test at subcontractor's facility.

410 AD-2, 310-3A/310RE-3A, 320 A-3A/320 AC-3A, 310-3B/310 ARE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - STRUCTURES
(Discipline)

TITLE GRAPHITE/EPOXY HONEYCOMB WBS No. 320-03-01-03

STATUS Graphite/Epoxy honeycomb is well within Grumman's capability; however, the use of .0025" single ply to achieve a buildup to 0.012 face sheets requires further development.

JUSTIFICATION This design provides the lightest weight shell structure.

OBJECTIVES To establish, by test, design allowables for honeycomb structural components using metallic honeycomb core with graphite/epoxy face sheets utilizing 2.5 mil ply thickness to achieve a total face sheet thickness of 12 Mil.

TECHNICAL APPROACH Std. Test specimens will be fabricated using various combinations of ply directions to validate design allowables obtained from classic lamination theory.

MANPOWER Tooling 100 MHRS FUNDING $15K
Mfg. 400 MHRS M & P 160 HRS. -
SPECIALIZED FACILITIES

TARGET SCHEDULE

TASKS	MONTHS AFTER GO-AHEAD 1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Fabricate Test Specimens	←——→	
Test	←——→	
Report	▽	

SECRET

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE STRUCTURES TITLE GRAPHITE/EPOXY HONEYCOMB THIN GAGES WBS 320-03-01-03

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG Ø C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS							
o FABRICATE GR/EP HONEYCOMB USING .0025 PLIES to obtain UP TO 0.012 FACE SHEETS.							
o STANDARD TEST SPECIMENS WITH VARIOUS PLY DIRECTIONS TESTED TO OBTAIN DESIGN DATA							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)							
½ MAN YEAR							
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L							
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							

SPECIALIZED FACILITIES

TYPE/LOCATION/AVAILABILITY

FACILITIES DEV. TIME & COST

ALL TOV VEHICLES

STORABLE SPACE TOV SUPPORTING RESEARCH AND TECHNOLOGY - Structures
(Discipline)

TITLE Material Compatibility WBS No. 320-03-01-01-02

STATUS Material compatibility of Ti-6AL-4V STA and 2219-T37 Aluminum alloy in the presence of MMH at temperatures up to 150°F is required. Compatibility of N_2O_4 with 2219-T87 is also required.

JUSTIFICATION Compatibility of propellants with tankage material must be assessed to obtain the reuse life of the tanks under cyclic loads.

OBJECTIVES The objective of the program is to obtain the static and fatigue properties of the tankage parent and weldment materials under cyclic exposure to propellants and load.

TECHNICAL APPROACH Static and fatigue properties of candidate materials specimens will be obtained prior to and after exposure to the propellants. Tests will be performed at R.T. and 150°F.

MANPOWER One man-year FUNDING $ 25 K

SPECIALIZED FACILITIES

TARGET SCHEDULE TASKS	MONTHS AFTER GO-AHEAD 1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Test Plan		
Spec. Fab.		
Test		
Report		

ALL TUG VEHICLES

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE STRUCTURES TITLE MATERIALS COMPATIBILITY DATA WBS 320-03-01

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG Ø C/D ATP MILESTONES			1980 TUG△		1982 TUG△		1984 TUG△
TASKS							
o FABRICATE & TEST MATERIAL SPECIMENS OF PARENT MAT'L & WELDMENTS TO OBTAIN COMPATIBILITY DATA FOR N_2O_4 & MMH UP TO 200°F. MATERIALS 6AL-4V, 2219-T87 & T-81							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS) ONE MANYEAR							
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L							
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							

SPECIALIZED FACILITIES

TYPE/LOCATION/AVAILABILITY

FACILITIES DEV. TIME & COST

ALL TUG VEHICLES

STORABLE STAGE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Structure
(Discipline)

WBS No. 320-03-01-01-02

TITLE Fracture Mechanics Test Data

STATUS Fracture mechanics test data for thin gage (.020 to .040) for Titanium 6AL-4V STA and 2219-T87 aluminum alloy exposed to N_2O_4 and MMH at temperatures up to 200°F is not available.

JUSTIFICATION Fracture mechanics data for thin gage tank material are required to assess the fracture mode and life cycle of the tug propellant tanks.

OBJECTIVES The objectives of the program are to obtain K_{ic}, K_{th} and flaw growth data for parent and weldment materials in the induced thermal environment up to 200°F. Data to be obtained prior to and after exposure to the candidate propellants. In addition to fracture mechanics data, NDE techniques are to be employed on the test specimens to assess flaw detection capability.

TECHNICAL APPROACH Standard fracture elemental specimens are to be employed. Tests are to be employed. Tests are to be conducted at room temperature and at 150 and 200°F. Surface flaws of various sizes are to be used and NDE techniques are to be employed to document size where practical.

MANPOWER One man-year

FUNDING $25K

SPECIALIZED FACILITIES

TARGET SCHEDULE

MONTHS AFTER GO-AHEAD

TASKS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Test Plan	├─┤																								
Spec. Fab.		├─┤																							
Test		├─	─	─	─	─┤																			
Report						▽																			

L1-01-8-IV

ALL TUG VEHICLES

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE STRUCTURES TITLE FRACTURE MECHANICS DATA WBS 320-03-01 = 01 02

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG ∅ C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1981 TUG △
TASKS							
o FABRICATE & TEST MAT'L SPECIMENS (Parent metal & weldments) to obtain K_{IC} K_{TH} & FLAW GROWTH DATA FOR INDUCED ENVIRONMENTS INCL. 200°F. ALSO STATIC & FATIGUE DATA. MAT'LS 6AL-4V & 2219-T87 & T81							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)							
ONE MAN YEAR							
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L							
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							

SPECIALIZED FACILITIES
TYPE/LOCATION/AVAILABILITY
FACILITIES DEV. TIME & COST

81-01-8-IV

110A-1, 410AD-2, 310-3A/310RE-3A, 320A-3A/320AE-3A, 310-3B/310ARE-3B, 610A-3B/610ADE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Thermal Control
(Discipline)

TITLE SPACE TUG HEAT PIPES

WBS No. 320-04-02

STATUS

Heat pipes (HP) are currently being used in both ground and space application. The variable conductance heat pipe (VCHP) principle is particularly attractive for Tug application but requires further development.

JUSTIFICATION

The fuel cell and certain high power density avionics units carried on the Space Tug require active cooling. Trade studies which have examined pumped loop radiators, sublimators and various heat pipes have indicated the obvious merits of the variable conductance heat pipe. A VCHP radiator could interface with the pumped loop heat transport system of the fuel cell, eliminating the cost and complexity of a selective stagnation radiator with its associated unreliable automatic bypass valves. A VCHP header, a heat transport device, could provide for high power density avionics heat transport without recourse to the active loop.

OBJECTIVES

Emphasis will be placed on experimentally obtaining the large turn down ratios which appear theoretically achievable and in developing predictive techniques.

TECHNICAL APPROACH

Design, fabricate and test a VCHP radiator and VCHP header and experimentally determine performance with emphasis on turn down ratio and shut off heat flux levels.

MANPOWER 5580 manhours

FUNDING $100K

SPECIALIZED FACILITIES

Grumman Thermal Laboratory

TARGET SCHEDULE

MONTHS AFTER GO-AHEAD

TASKS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Establish Test Plan	-																								
Material Procurement		-																							
Design & Fab Test Specimens		—	—	—	—																				
Conduct Engineering Tests						—	—	—	—																
Analyze Test Results									—	—	—	—													
Final Report											—	—													

GRUMMAN

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE _____ TITLE _____ WBS _____

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG Ø C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS							
TEST PLAN							
DESIGN & FAB TEST SPECIMEN							
CONDUCT TEST							
ANALYSIS & FINAL RPT							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)	1.5	1.5					
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L	100K						
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							

SPECIALIZED FACILITIES TYPE/LOCATION/AVAILABILITY FACILITIES DEV. TIME & COST: GRUMMAN THERMAL LAB, BETHPAGE N.Y., AVAILABLE & FULLY DEVELOPED

8.11 SPECIAL COST SENSITIVITIES

REFERENCE:

Due to the size and development of the special cost sensitivities analysis reference is made herein to Part I, concept 110A-1, paragraph 8.11 of Volume 8.

8.12 DOD ACQUISITION APPROACH

TO BE PROVIDED

8.13 ESTIMATING TECHNIQUE APPLIED

WBS ELEMENT	DDT&E	PRODUCTION	OPN
320-01 Proj. Management	CER's Based on LM Experience	Same as DDT&E	Same as DDT&E
320-02 Syst Eng & Integ	Same as 320-01	Same as 320-01	Same as 320-01
320-03-01 Structure	CER's Lower Level Analysis	Same as DDT&E	N/A
320-03-02 Thermal Insul	Same as 320-03-01	Same as 320-03 -01	N/A
320-03-03 Avionics	Vendor Est/Manpower/Wrap-around	Same as DDT&E	N/A
320-03-04 Propulsion	Gov't Est/Vendor Est/Wrap-around	Same as DDT&E	Same as DDT&E
320-03-05 Orbiter Interface	CER's Vendor Est/Wraparound	Same as DDT&E	N/A
320-03-06 Drop Tanks	N/A	N/A	N/A
320-03-07 Final Assy & C/O	Same as 320-01	Same as 320-01	N/A
320-04-01 Structure	Same as 320-03-01	Same as 320-03 -01	N/A
320-04-02 Thermal Insul	Same as 320-03-02	Same as 320-03 -02	N/A
320-04-03 Avionics	Same as 320-03-03	Same as 320-03 -03	N/A
320-04-04 Propulsion	Same as 320-03-04	Same as 320-03 -04	Same as 320-03-04
320-04-05 Interstage Interface	Same as 320-03-01	Same as 320-03 -01	N/A
320-04-06 Drop Tanks	N/A	N/A	N/A
320-04-07 RDM	Gov't est, CER's Vendor Est, wraparound	Same as DDT&E	Same as DDT&E
320-04-08 AKS	Same as 320-04-07	Same as 320-04 -07	Same as 320-04-07
320-04-09 DKS	Same as 320-04-07	Same as 320-04 -07	Same as 320-04-07
320-04-10 Cache Tank	N/A	N/A	N/A
320-04-11 Final Assy & C/O	Same as 320-03-07	Same as 320-03 -07	N/A
320-05 Logistics	CER's	Same as DDT&E	Same as DDT&E
320-06 Facilities	CER's	Same as DDT&E	Same as DDT&E
320-07 GSE	CER's, and End-item analysis	Same as DDT&E	Same as DDT&E
320-08 Vehicle Test	CER's, Manpower Loading	N/A	N/A
320-09 Launch Ops WTR	N/A	N/A	Manpower Loading
320-10 Launch Ops ETR	N/A	N/A	Manpower Loading

WBS ELEMENT	DDT&E	PRODUCTION	OPN
320-11 Flt Ops DOD	CER's & Manpower Loading	N/A	Same as DDT&E
320-12 Flt Ops NASA	Same as 320-11	N/A	Same as DDT&E
320-13 Ref & Int, 1st TR	N/A	N/A	Manpower Loading
320-14 Ref & Int, 2nd TR	N/A	N/A	Manpower Loading

COST = A (BASE)^B	PROGRAM BASIS	BASE	A DDT&E	A PROD	B DDT&E	B PROD
PROJECT MGMT.	LM	VEH COST	.1	.09	1	1
	LM	LESS ENG.				
SE & E	LM	VEH COST	.13	.08	1	1
		LESS ENG.				
STRUCTURE	LM	WEIGHT				
SPUN AL. TANKS			124	15	.71	.61
TI TANKS			140	24.3	.71	.61
BODY SHELL			25	2.8	.71	.61
THRUST STRUCTURE			5.5	0.4	1	1
METEOROID SHIELD			5.5	.47	1	1
PAYLOAD INTERFACE			37.2	3.4	1	1
PROPULSION						
ACPS THRUSTERS		VENDOR COST	2	1.66	.7	.7
ACPS SUPPORT		VENDOR COST	2.4	1.84		
EPS WIRING	LM	(WEIGHT)	39.7	7	.7	.7
ORBITER INTERFACE, STRUCTURE	LM	WEIGHT	5.5	,4	1	1
FINAL ASSY & C/O	LM	VEH COST	.54	.18	1	1

8.1.1 SUMMARY PROJECT SCHEDULE

Introduction: The Storable Tug Project schedule was developed to identify the principal project phases and to establish schedule estimates for all hardware and soft ware elements in accordance with the Space Tug Work Breakdown Structure.

The Tug Project Schedule depicts major program milestones and presents project activities at level 5 of the WBS. This schedule establishes the planning baseline for development of the Storable Tug System through design, development, manufacturing, ground test, flight test and operations. It integrates all supporting schedules into an overall project level plan and establishes the sequence and interdependency of activities and events required for the development of an operational Space Tug System.

Groundrules and Assumptions: Following are the ground rules and assumptions used for development of the Storable Tug Project Schedule:

- o ATP is October 1975 at the earliest for Options 1 and 3. ATP for Option 2 to be determined by the contractor.
- o Schedule planning is designed to minimize peak annual funding during DDT&E.
- o Main Stage DDT&E requirements consist of the following major test articles:
  - A structural test article (STA) for dynamic, static and fatigue tests.
  - A main propulsion test vehicle (PTV). Following the completion of live propellant testing the PTV will be refurbished and delivered as an operational flight vehicle.
  - One shipset of Avionics hardware for the Integrated Avionics Test (IAT).
  - A flight test vehicle (MS-1).
- o Operational fleet sizes for each project option are based on a study of traffic capture models.
- o Production rate of vehicles is based on avoiding duplication of major structural assembly tooling and minimizing gaps in manufacturing flow.

- Initial operational capability (IOC) is achieved after completion of one test flight (FOF). IOC dates are as follows:

  Option 1 - December 1979
  Option 2 - December 1983
  Option 3 - December 1979 - initial, December 1983 - evolved.

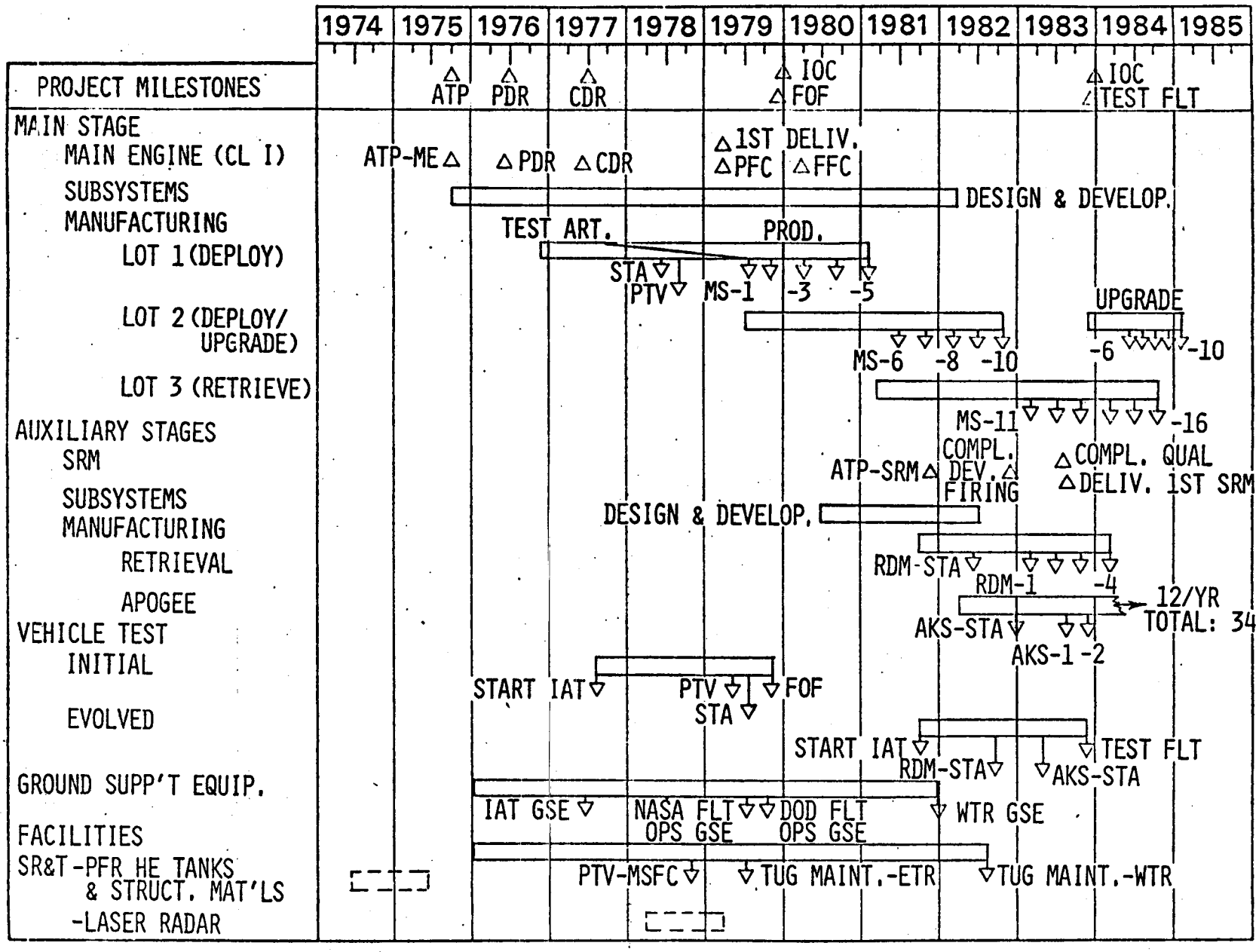
- Maximum number of flights in 1980 is 3, based on the Shuttle traffic model.

Approach: Based on the above groundrules and assumptions a preliminary project milestone schedule was developed to form a baseline for all detail scheduling. Detailed subsystem design and development schedules, manufacturing and factory checkout flows, vehicle test, GSE, facilities, and SR&T Schedules were then developed in conjunction with personnel representing the cognizant management and technical disciplines. These detailed schedules were then summarized and integrated into the Tug Project Schedule through the process of establishing a logical and achievable relationship between the engineering design and development process, procurement of subcontract equipment, hardware fabrication and assembly process and the vehicle test program that minimizes risks and ensures the fulfillment of program objectives. Finally, the major project milestones and activities presented in the Tug Project Schedule were condensed into the Summary Project Schedule.

SUMMARY SCHEDULE - 310-3B/310ARE-3B

The primary elements of the 310-3B/310ARE-3B Project Schedule are as described for 310-3A/310RE-3A except for addition of an Apogee Kick Stage. Authorization to Proceed (ATP) occurs on October 1, 1975 with IOC of the initial configuration target for December 31, 1979. The Class I main engine milestones are the same as for 310-3A/310RE-3A with Final Flight Certification occuring 4 months after First Orbital Flight (FOF). Vehicle tests are essentially the same as for 310-3A/310RE-3A except for the addition of structural testing of the Apogee Kick Stage (AKS-STA). First flight of the evolved vehicle is targeted for December 1, 1983. Main Stage Manufacturing begins December 1, 1976 with production of the major ground test articles and continues through production of 16 vehicles to support fleet operations. These are manufactured in 3 Lots for the purpose of avoiding manufacturing gaps. Development of the Apogee Kick Stage and the Retrieval Delay Module begins in June 1980, with related vehicle tests starting at the same time as main stage evolved vehicle tests. 34 Apogee Kick Stages and 4 Retrieval Delay Modules will be manufactured to support fleet operations. GSE and Facilities are scheduled essentially the same as for 110A-1.

310-3B/310ARE-3B SUMMARY PROJECT SCHEDULE

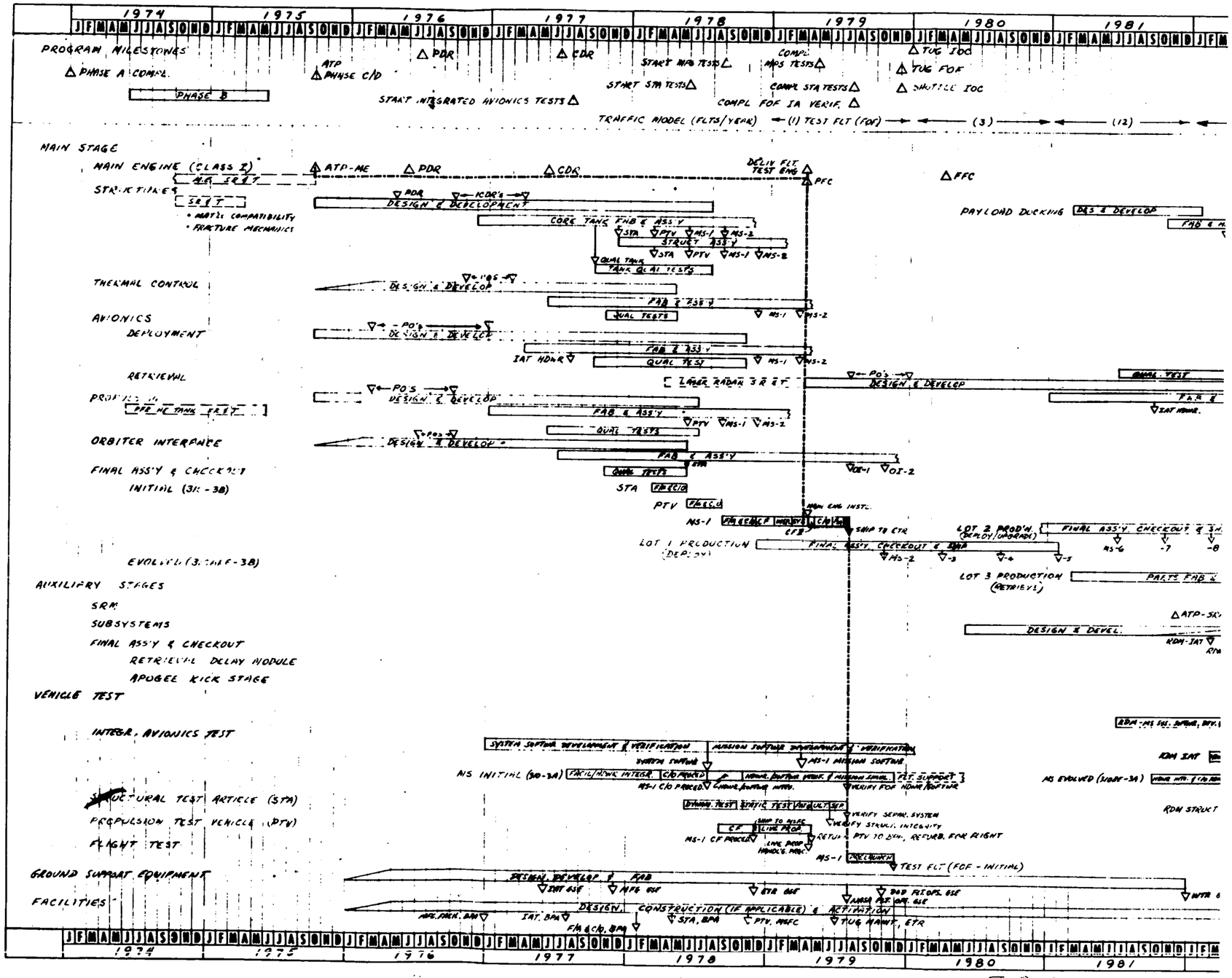


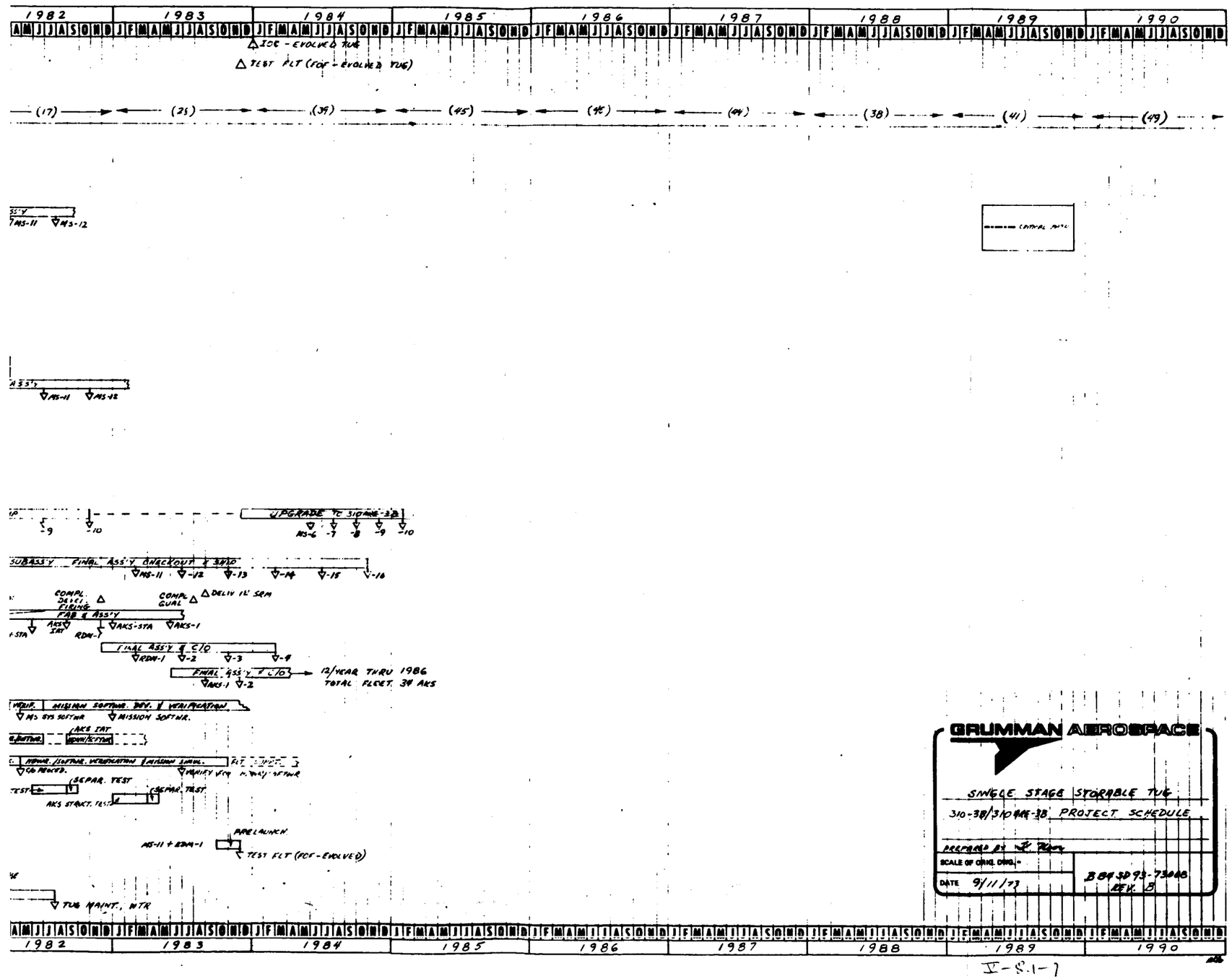
8.1.2 DEVELOPMENT SCHEDULES

8.1.3 PRODUCTION SCHEDULES

The detailed Project Schedule depicts the total development and production phases for the Main Stage and the Auxiliary Stage(s). The detailed Project Schedule is based on a constraint logic that considers overall program objectives and the detailed interaction of constraints on significant program activities. It provides reasonable margins for development problems and minimizes program front-loading.

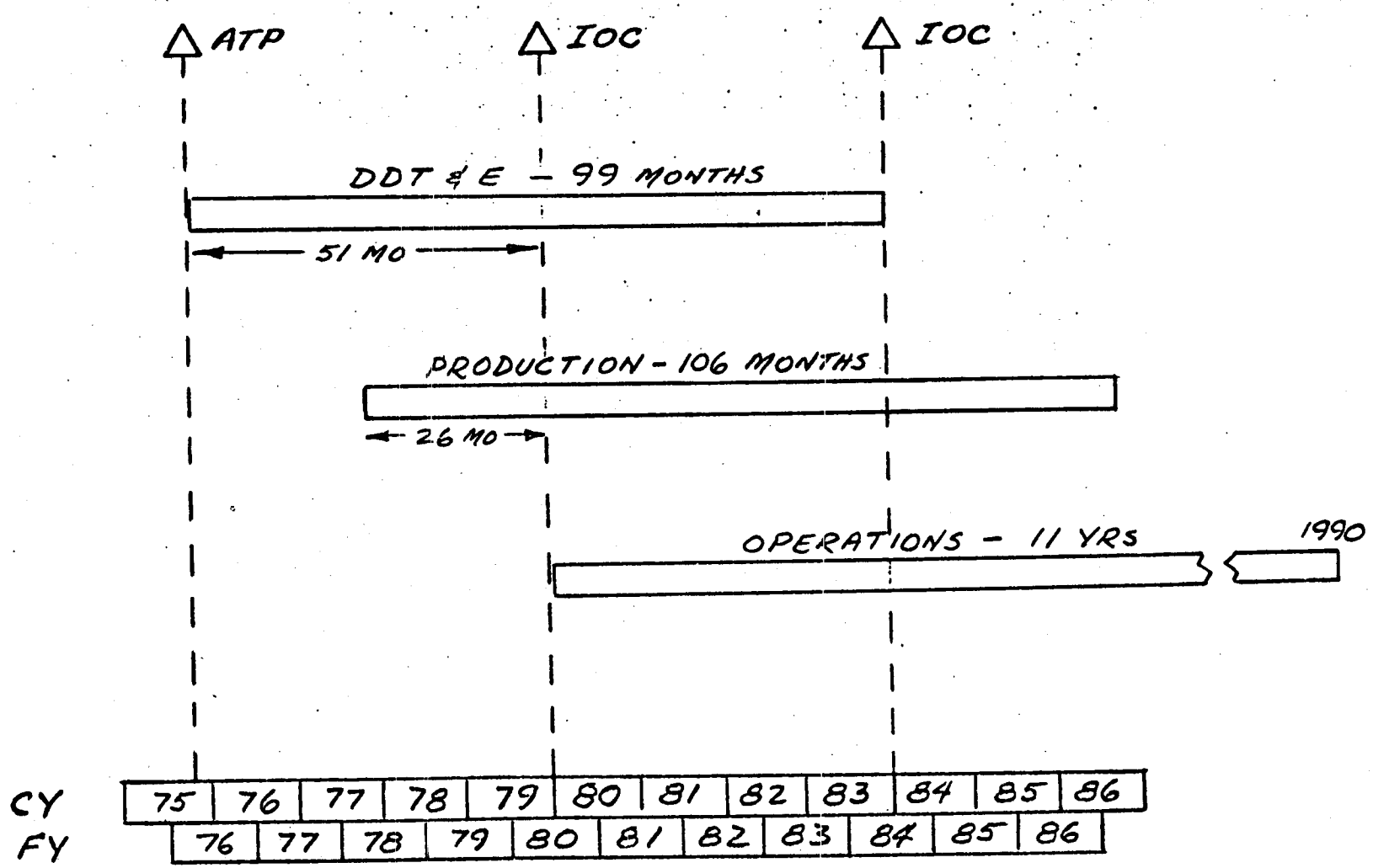
The detailed Subsystem Schedules provide an order of magnitude increase in detail from the Project Schedule and depict the subsystem activities in both inhouse and subcontractor areas. Subsystem schedule information is presented at WBS level 6 for Structures, Thermal Control and Orbiter Interface, and at WBS level 7 for Propulsion and Avionics subsystems.


1974
1975
1976
1977
1978
1979
1980
1981
PROGRAM MILESTONES
PHASE A COMPL.
PHASE B
ATP PHASE C/D
PDR
CDR
START INTEGRATED AVIONICS TESTS
START MPS TESTS
START STA TESTS
COMPL MPS TESTS
COMPL STA TESTS
COMPL FOF IA VERIF.
TUG IOC
TUG FOF
SHUTTLE IOC
TRAFFIC MODEL (FLTS/YEAR)
(1) TEST FLT (FOF)
(3)
(12)
MAIN STAGE
MAIN ENGINE (CLASS I)
ATP-ME
PDR
CDR
DELIV FLT. TEST ENG
PFC
FFC
STRUCTURES
DESIGN & DEVELOPMENT
CORE TANK FAB & ASS'Y
STRUCT ASS'Y
QUAL TANK
TANK QUAL TESTS
PAYLOAD DOCKING
THERMAL CONTROL
DESIGN & DEVELOP
FAB & ASS'Y
QUAL TESTS
AVIONICS
DEPLOYMENT
IAT HDWR
QUAL TEST
RETRIEVAL
LASER RADAR S R & T
ORBITER INTERFACE
FINAL ASS'Y & CHECKOUT
INITIAL (3K-38)
STA
PTV
MS-1
MAIN ENG INSTL.
SHIP TO ETR
LOT 1 PRODUCTION (DEPLOY)
LOT 2 PROD'N (DEPLOY/UPGRADE)
FINAL ASS'Y, CHECKOUT & SHIP
LOT 3 PRODUCTION (RETRIEVE)
PARTS FAB &
EVOLVED (3K-38)
AUXILIARY STAGES
SRM
SUBSYSTEMS
FINAL ASS'Y & CHECKOUT
RETRIEVAL DELAY MODULE
APOGEE KICK STAGE
DESIGN & DEVEL.
RDM-IAT
VEHICLE TEST
INTEGR. AVIONICS TEST
SYSTEM SOFTWARE DEVELOPMENT & VERIFICATION
MISSION SOFTWARE DEVELOPMENT & VERIFICATION
MS INITIAL (3K-3A)
MS EVOLVED (3K-3A)
RDM STRUCT
STRUCTURAL TEST ARTICLE (STA)
PROPULSION TEST VEHICLE (PTV)
FLIGHT TEST
TEST FLT (FOF - INITIAL)
GROUND SUPPORT EQUIPMENT
FACILITIES
DESIGN, DEVELOP & FAB
DESIGN, CONSTRUCTION (IF APPLICABLE) & ACTIVATION
IAT, BPA
STA, BPA
PTV, MSFC
TUG MAINT, ETR

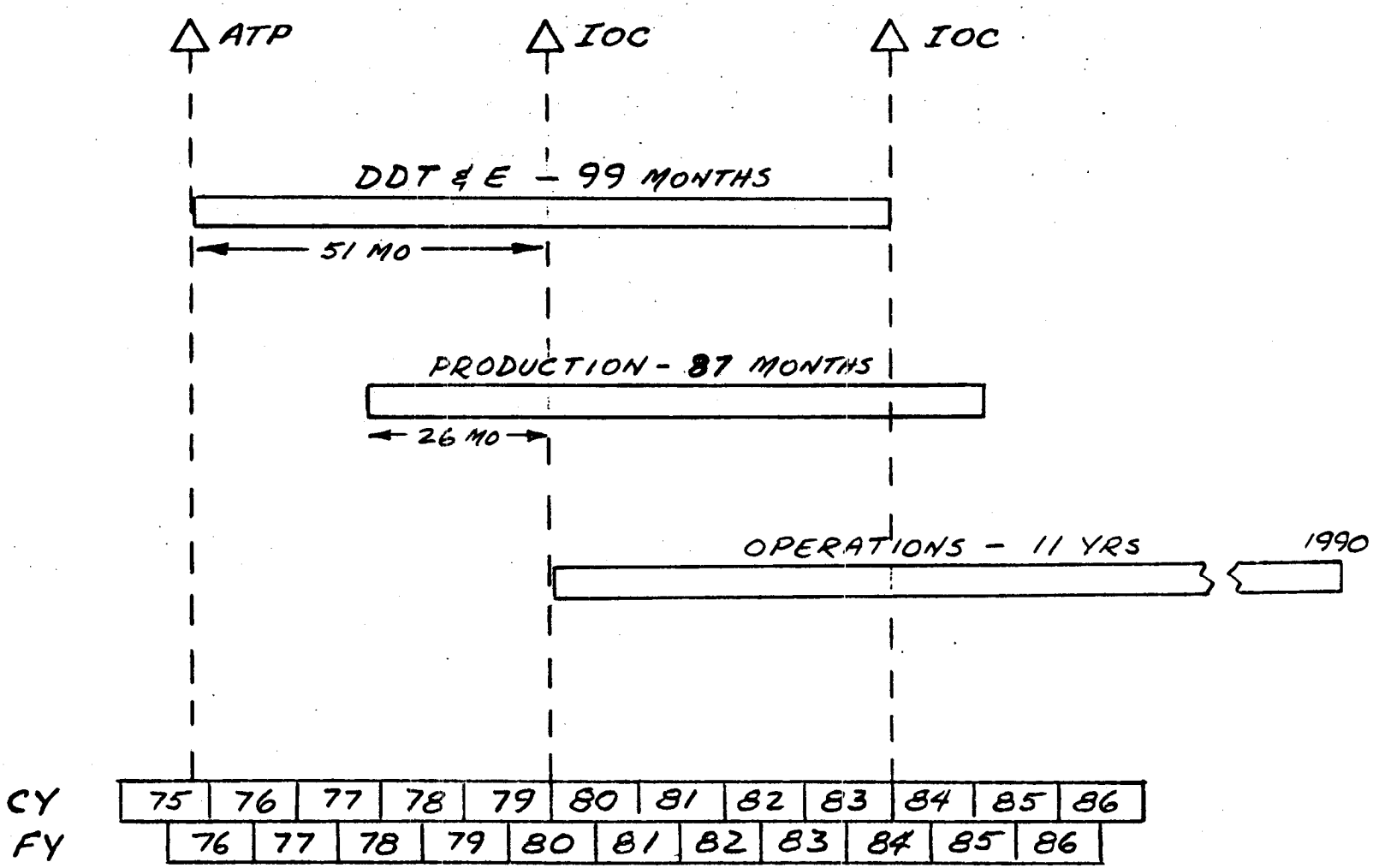

1982
1983
1984
1985
1986
1987
1988
1989
1990
IOC - EVOLVED TUG
TEST FLT (FOF - EVOLVED TUG)
(17)
(25)
(39)
(45)
(45)
(44)
(38)
(41)
(49)
MS-11
MS-12
UPGRADE TO 310AKE-3B
MS-6
-7
-8
-9
-10
SUBASS'Y FINAL ASS'Y CHECKOUT & SHIP
MS-11
-12
-13
-14
-15
-16
COMPL. DEVEL. FIRING
COMPL. QUAL
DELIV 12' SRM
FAB & ASS'Y
AKS IAT
AKS-STA
AKS-1
RDM-1
FINAL ASS'Y & C/O
RDM-1
-2
-3
-4
FINAL ASS'Y & C/O
AKS-1
-2
12/YEAR THRU 1986
TOTAL FLEET 34 AKS
MISSION SOFTWR. DEV. & VERIFICATION
MS SYS SOFTWR
MISSION SOFTWR.
AKS IAT
C/O PROCED.
SEPAR. TEST
AKS STRUCT. TEST
SEPAR. TEST
PRELAUNCH
MS-11 + RDM-1
TEST FLT (FOF - EVOLVED)
TUG MAINT., WTR
GRUMMAN AEROSPACE
SINGLE STAGE STORABLE TUG
310-3B/310AKE-3B PROJECT SCHEDULE
PREPARED BY
SCALE OF ORIG. DWG. -
DATE 9/11/73
B84SD93-73008
REV. B

V-S.1-7

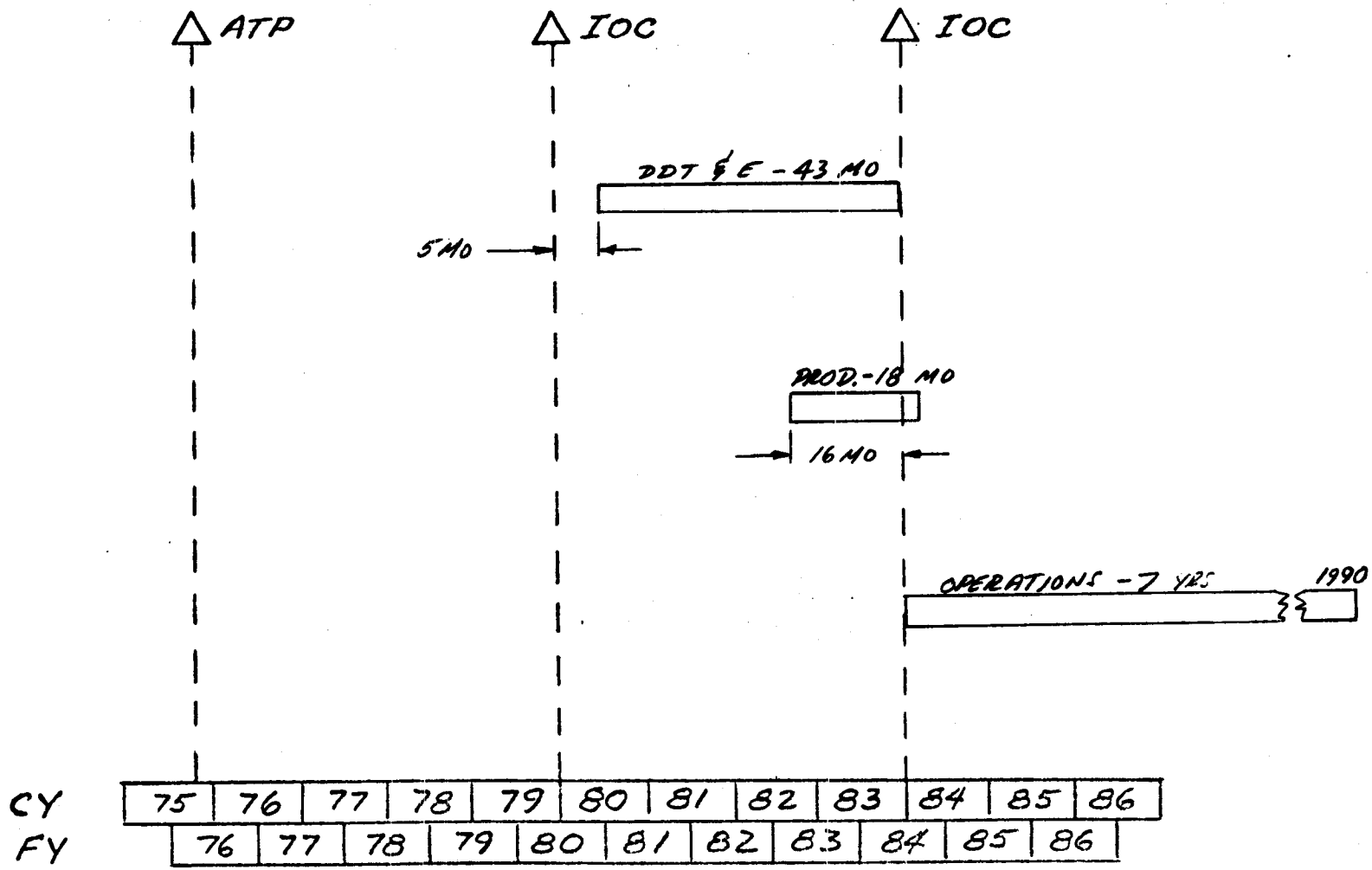
310-3B/310ARE-3B PROJECT SUMMARY



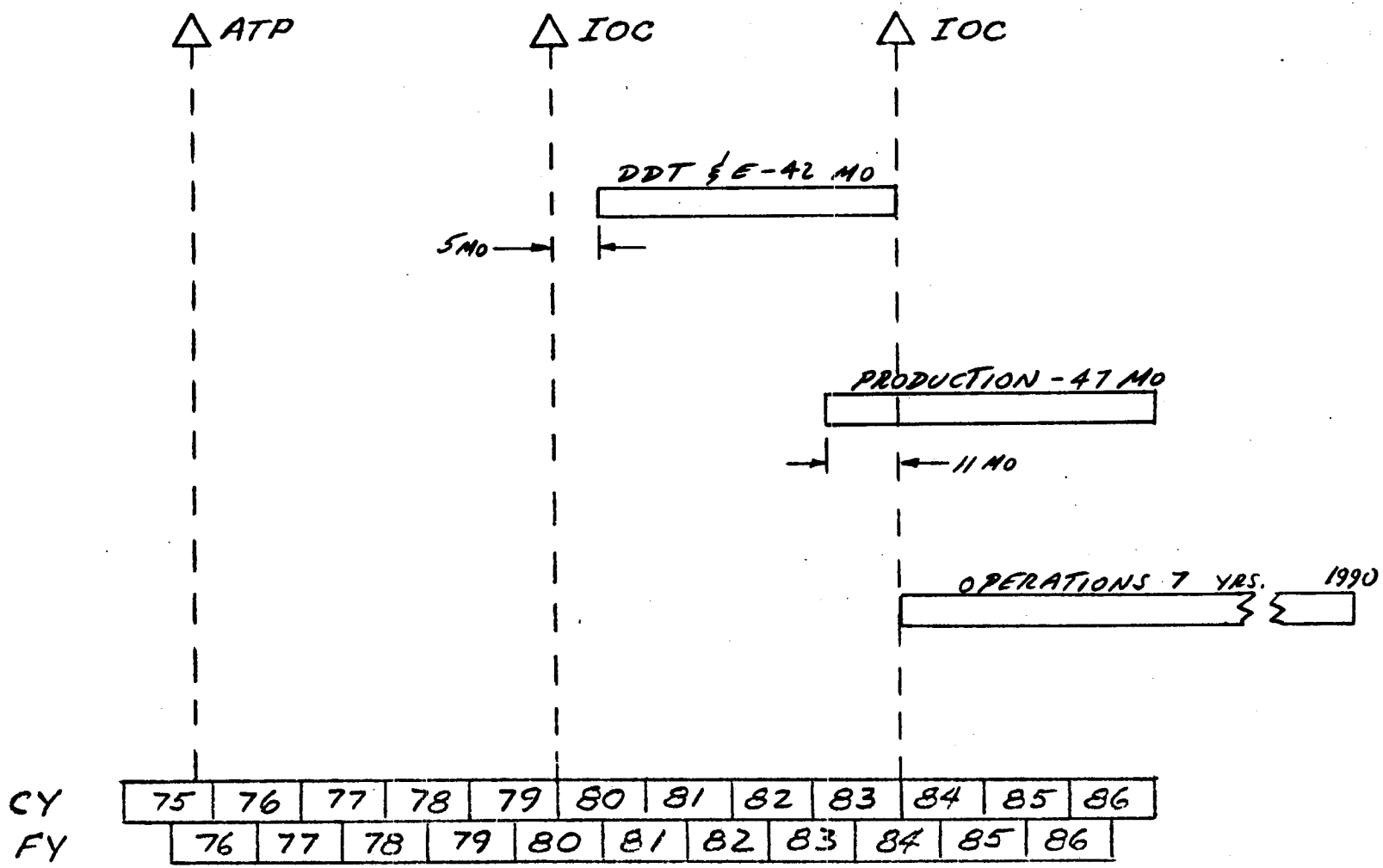
310-3B/310ARE-3B MAIN STAGE

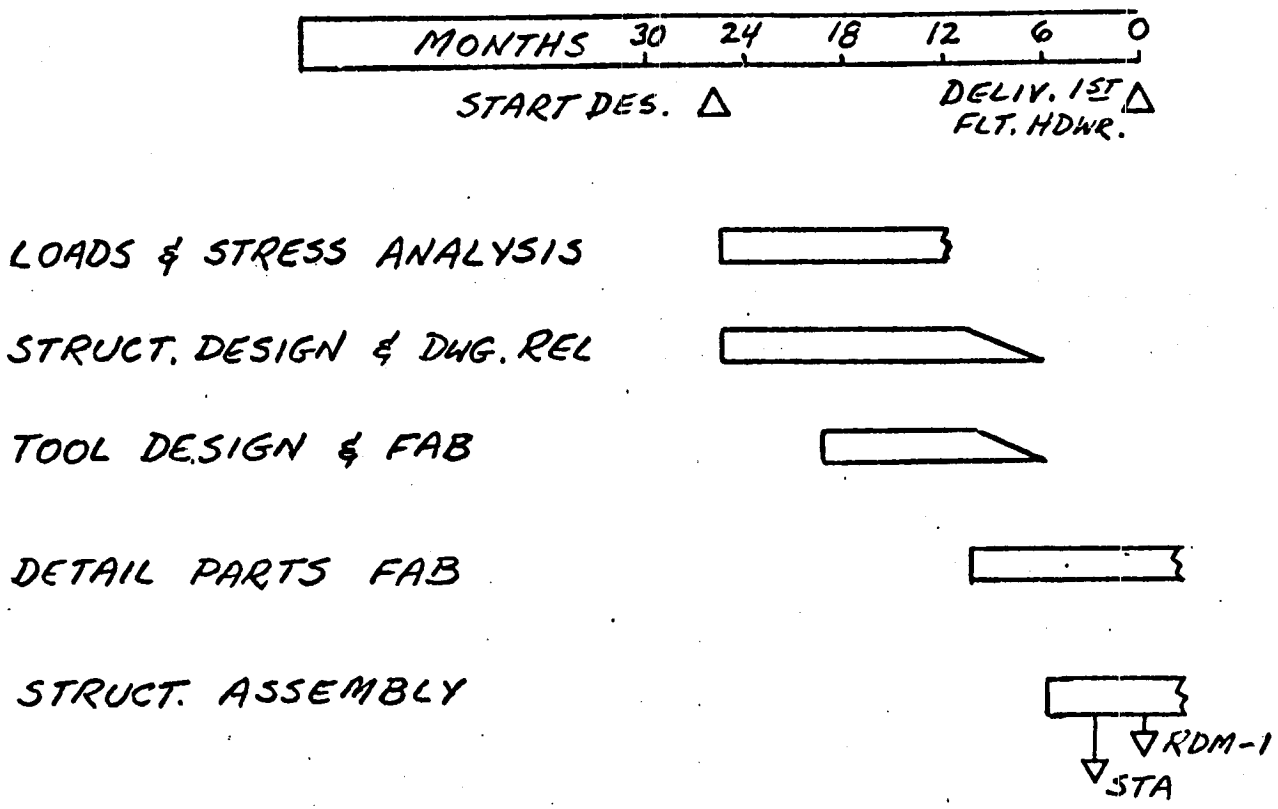


310-3B/310ARE-3B AUXILIARY STAGE - RDM

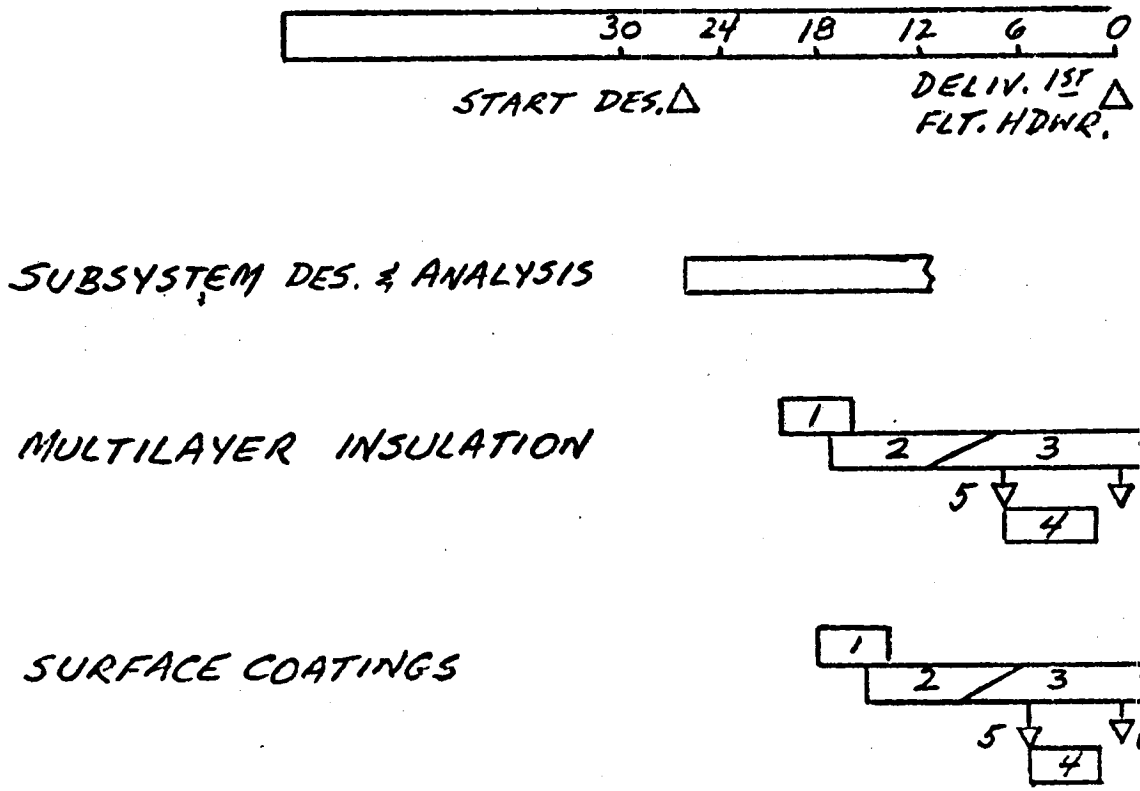


310-3B/310ARE-3B AUXILIARY STAGE - AKS





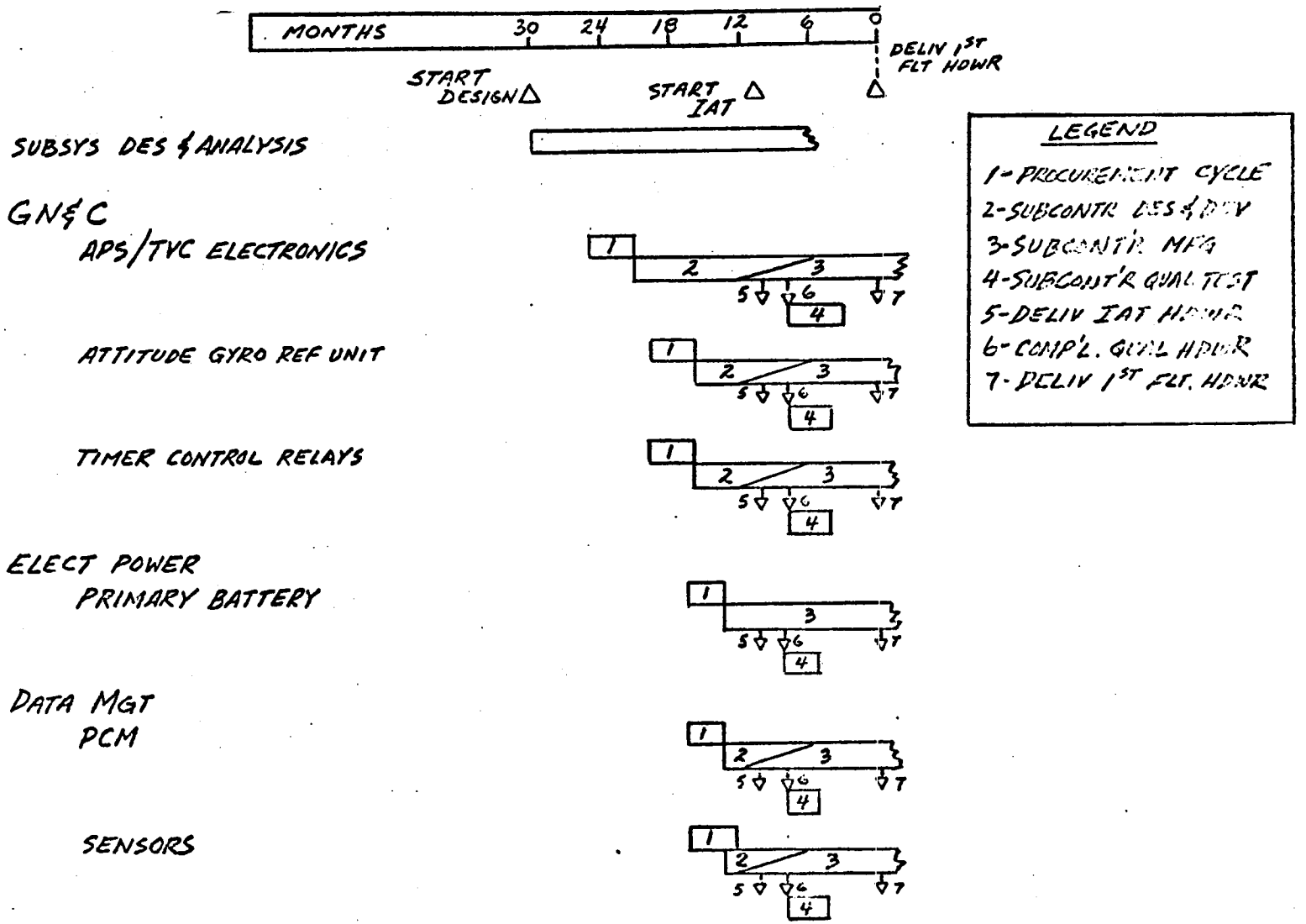
310-3B/310ARE-3B RETRIEVAL DELAY MODULE
STRUCTURES SUBSYSTEM SCHEDULE



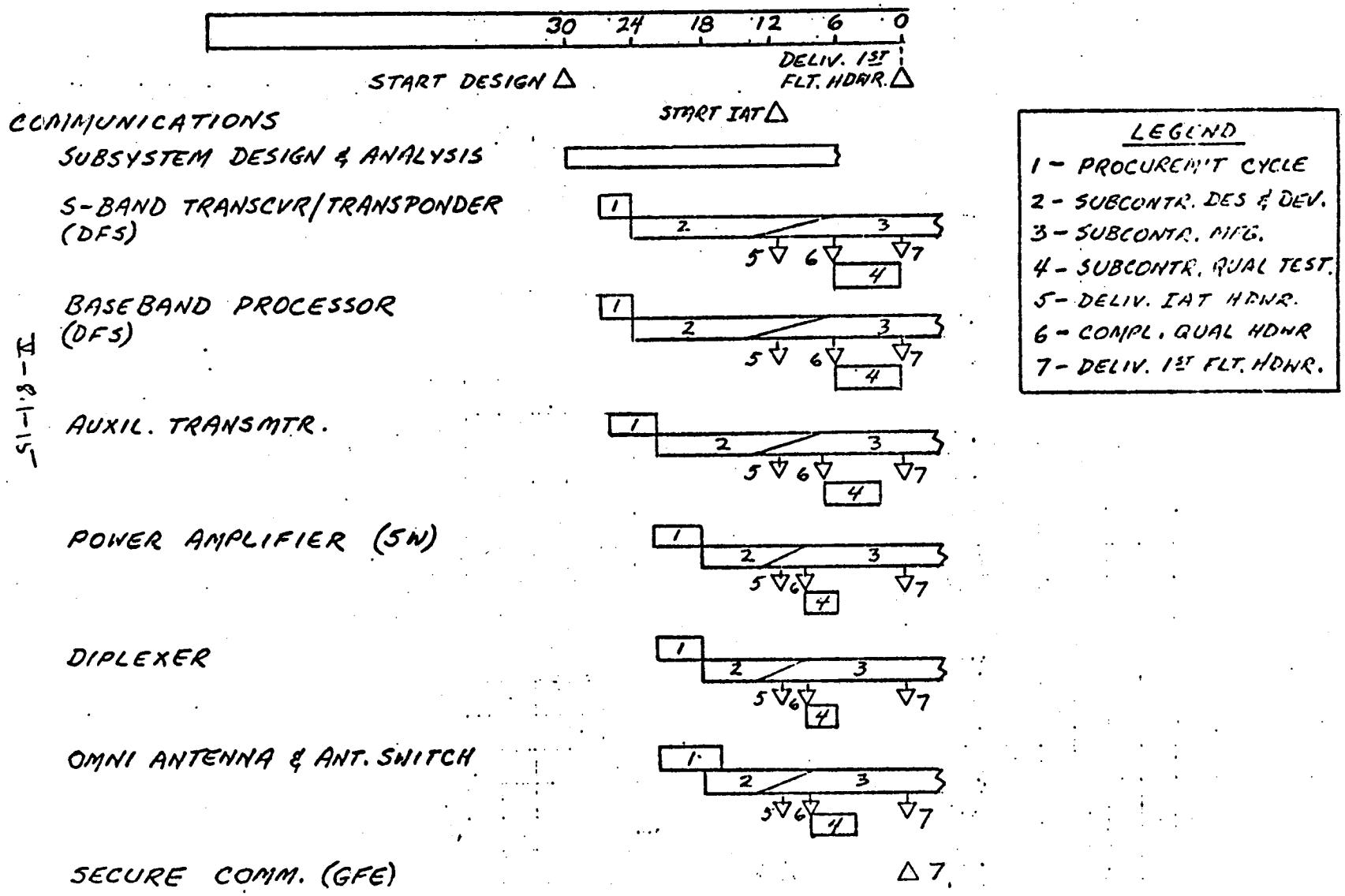
LEGEND

1 - PROCUREMENT CYCLE
2 - SUBCONTR. LEVEL.
3 - SUBCONTR. MFG.
4 - QUAL TEST
5 - COMPL QUAL HDWR
6 - DELIV. 1ST FLT HDWR

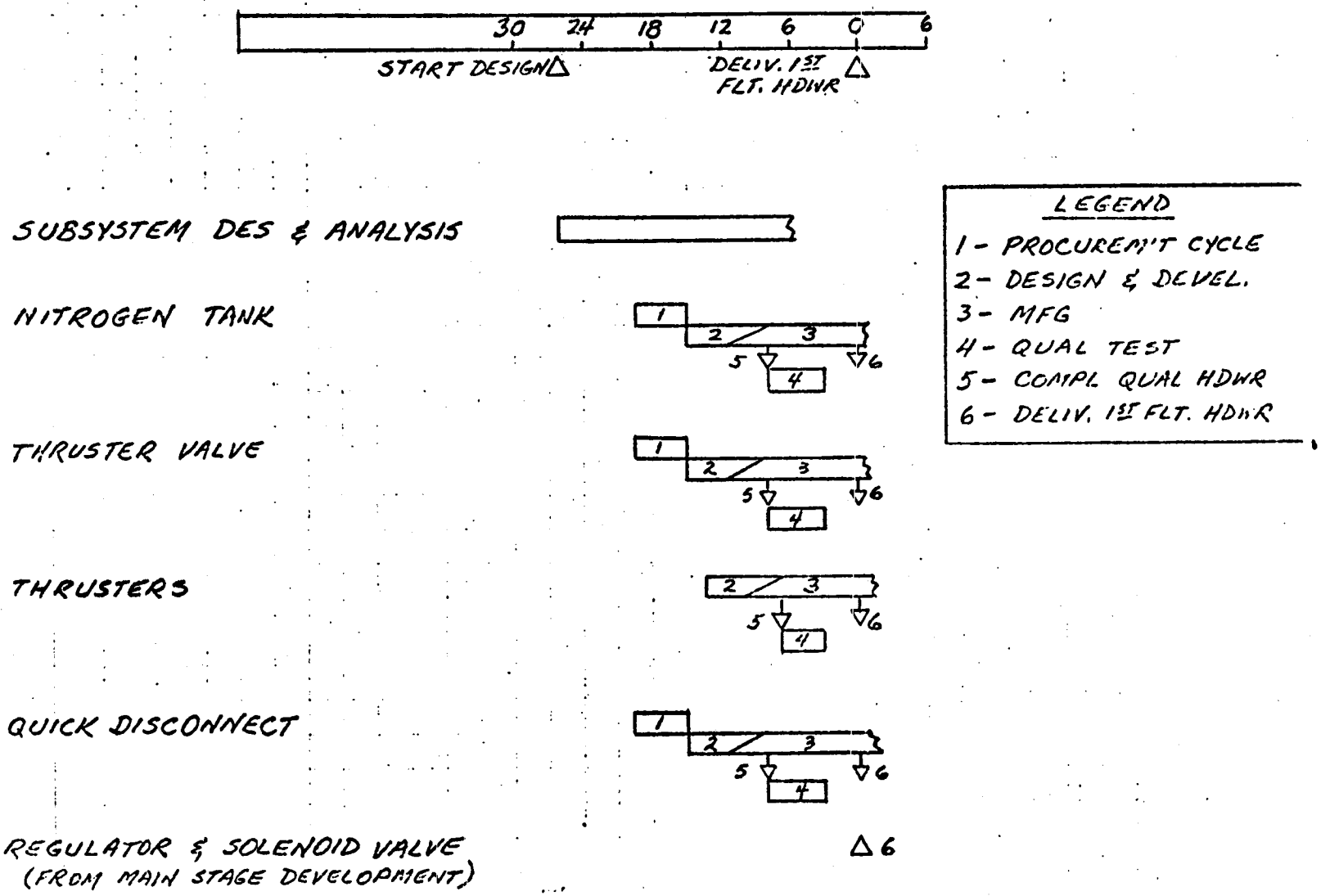
RETRIEVAL DELAY MODULE
THERMAL CONTROL SUBSYSTEM SCHEDULE



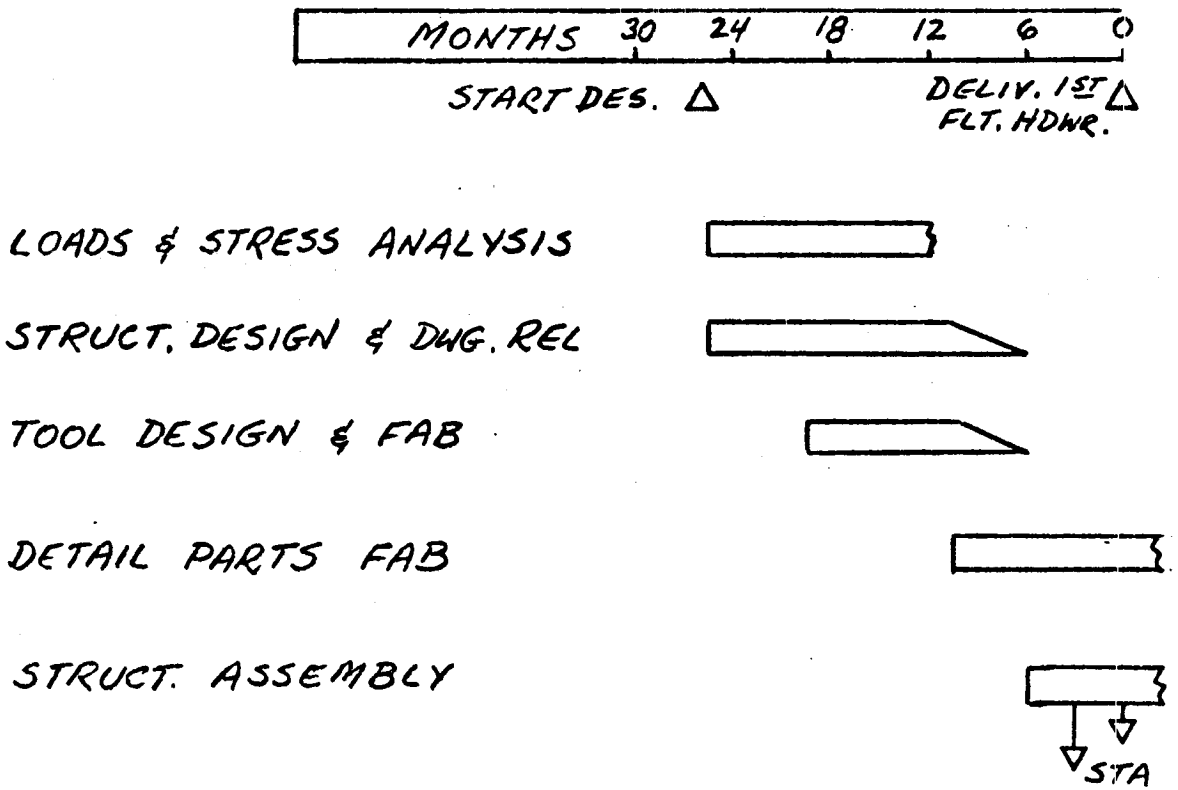
RETRIEVAL DELAY MODULE
AVIONICS SUBSYSTEM SCHEDULE



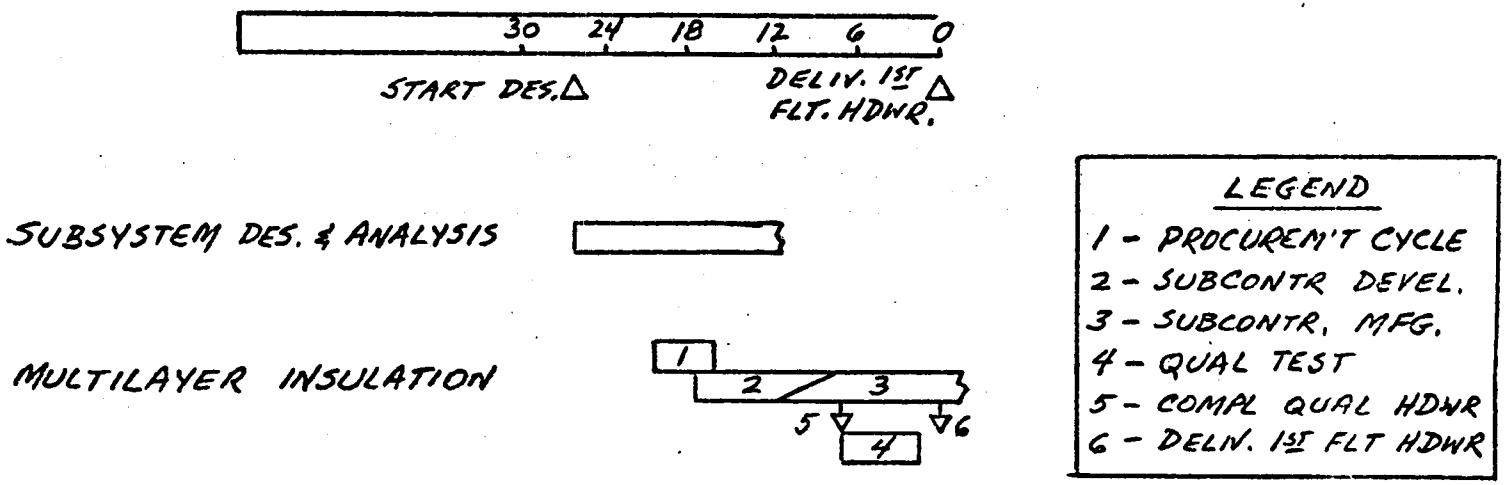
RETRIEVAL DELAY MODULE — AVIONICS SUBSYS. SCHEDULE



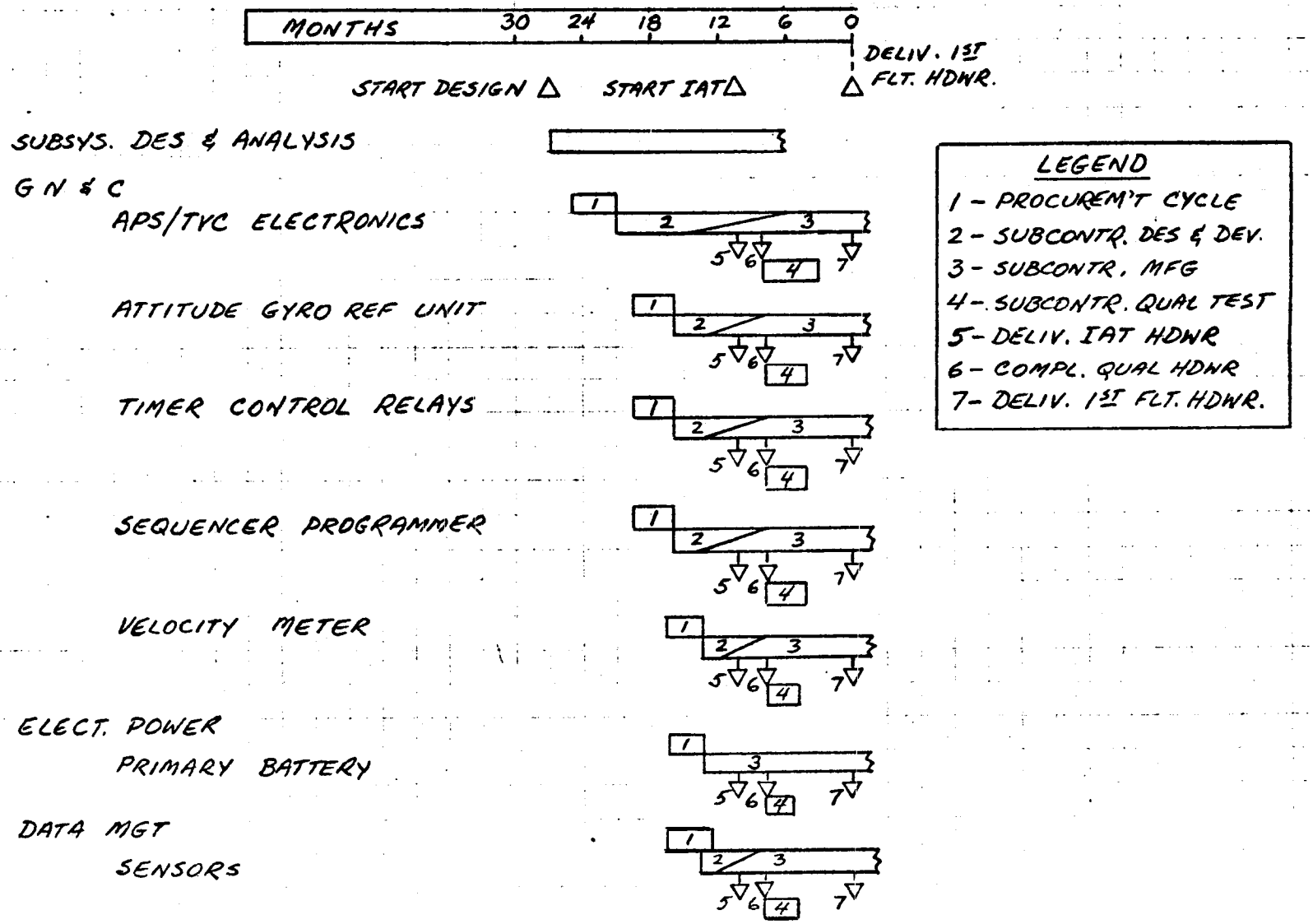
RETRIEVAL DELAY MODULE
PROPULSION SUBSYSTEM SCHEDULE



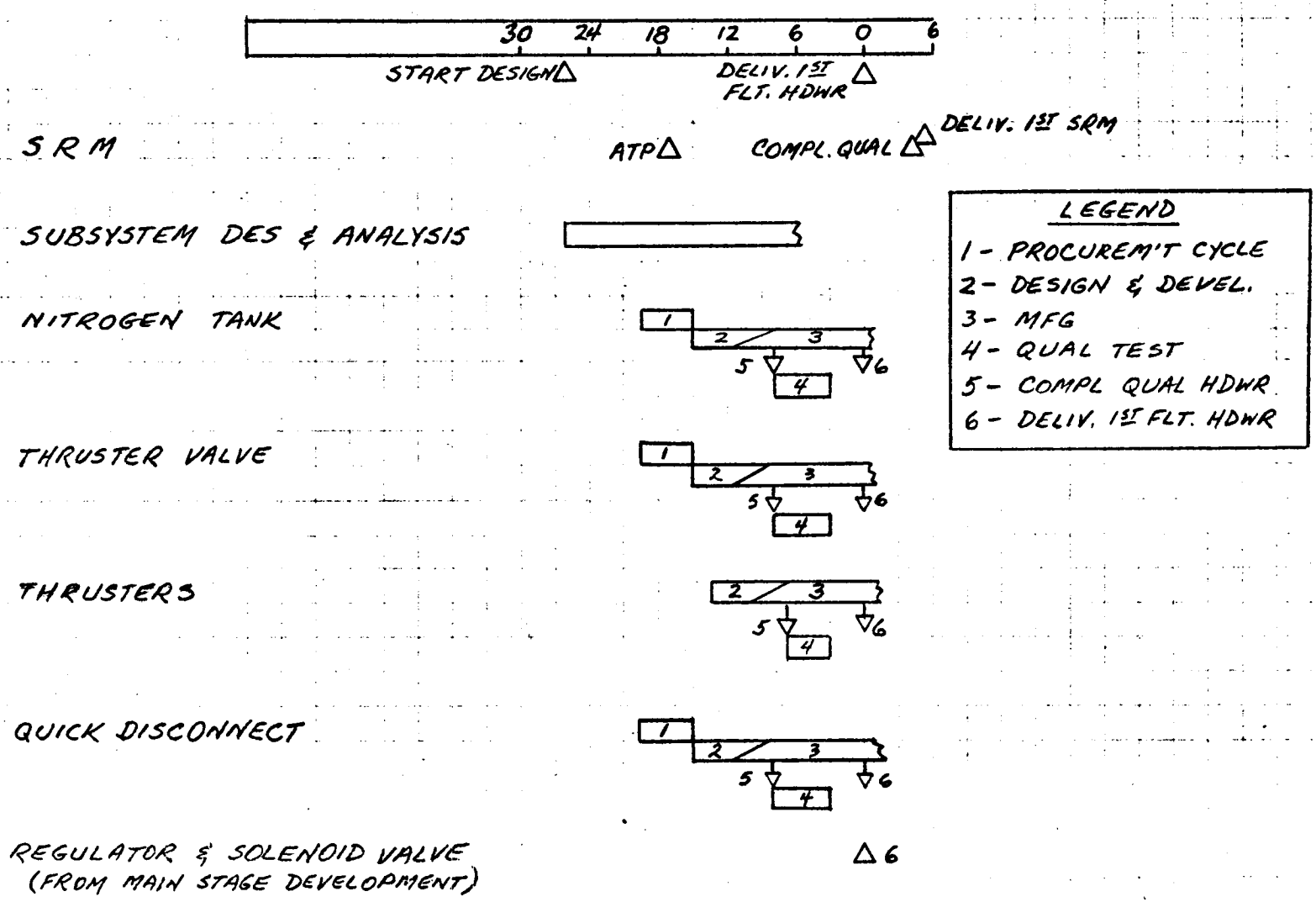
310-3B/310ARE-3B APOGEE KICK STAGE
STRUCTURES SUBSYSTEM SCHEDULE



APOGEE KICK STAGE
THERMAL CONTROL SUBSYSTEM SCHEDULE



APOGEE KICK STAGE
AVIONICS SUBSYSTEM SCHEDULE



APOGEE KICK STAGE
PROPULSION SUBSYSTEM SCHEDULE

8.1.4 OPERATIONS SCHEDULE

Scheduled and planned for concept 310-3B/310ARE-3B, option 3 are 37 launches per year with 10 days between launches. Ground servicing as shown on the programmatics/cost operations schedule from land to launch is 10 Tug work days and 9 Tug/orbiter work days.

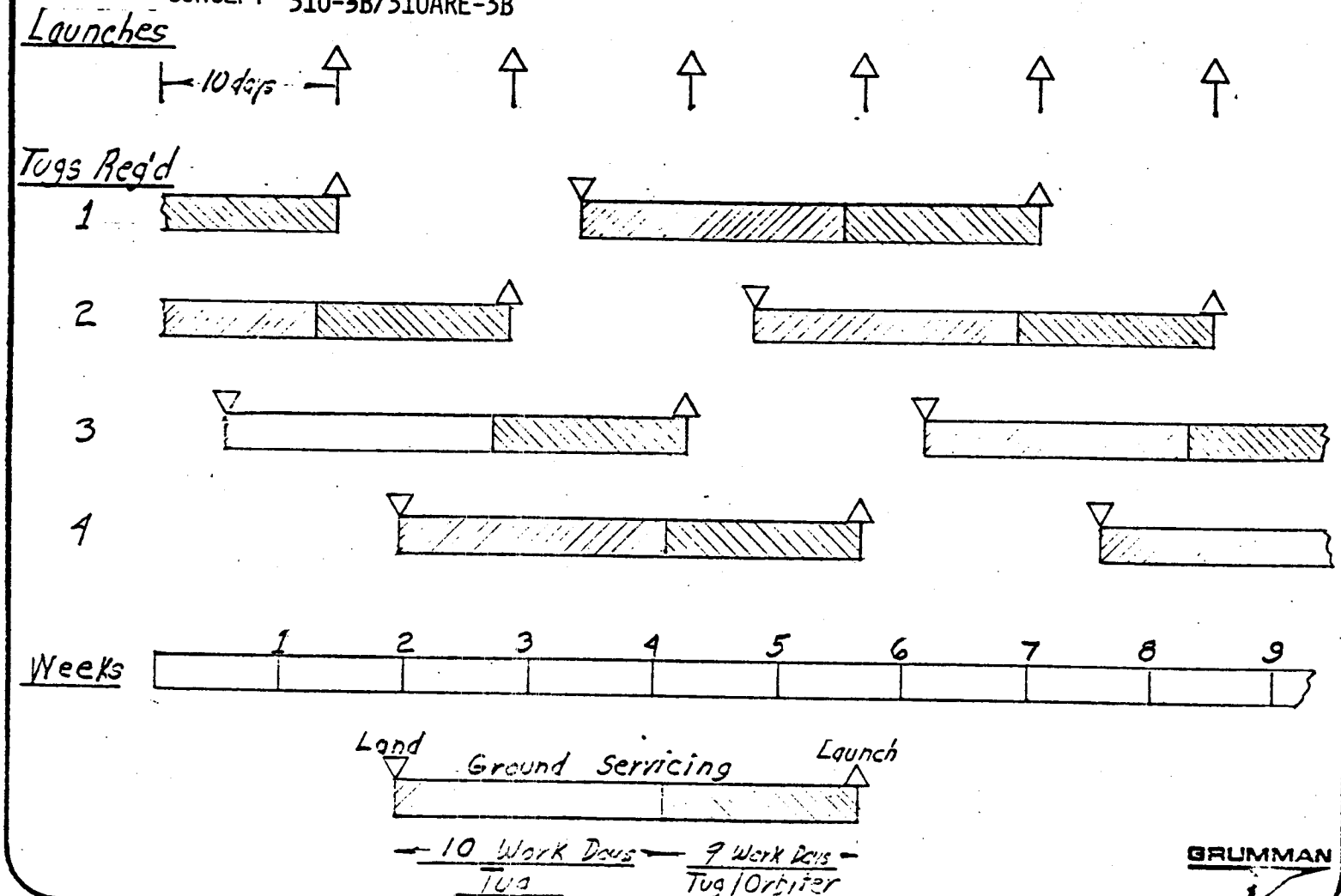
8.1.5 FACILITIES SCHEDULE

Included in the storable space tug facilities schedule for concept 310-3B/310ARE-3B are the various tasks to be completed against major program milestones. The fundamental grouping of these tasks are manufacturing, test, maintenance and refurb-ETR, ETR launch, maintenance and refurb-WTR and WTR launch. Under this Tug concept facilities maintenance extends into 1991, with most of design/construction/activation ending by 1982 in support of WTR launch requirements.

PROGRAMMATICS/COST OPERATIONS SCHEDULE

37 Launches Per Year (ETR)

CONCEPT 310-3B/310ARE-3B



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STORABLE SPACE TUG - FACILITIES SCHEDULE - CONCEPT 310-3B/310ARE-3B

NASA ACQUISITION PHA-E

PROGRAM SCHEDULE & MILESTONES

ATP PHASE C/D · START IAT · START STRUCT. TEST · START MPS TEST · TUG FOF · TUG IOC · WTR OPERATIONAL · EVOLVED TUG

1972 · 1973 · 1974 · 1975 · 1976 · 1977 · 1978 · 1979 · 1980 · 1981 · 1982 · 1983 · 1984

J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D

MANUFACTURING

- FAB. & ASSY — DES. / ACTIV. — MAINTENANCE
- F/A & C/O — DES. / CONSTR. / ACTIV. — MAINTENANCE — → TO FEB. 1983
- RETRIEVAL, KICK STAGE — DES. / ACTIV. — MAINTENANCE — → TO OCT 1986

TEST

- STA. - BPN & MSFC — NO FACILITIES ACTIV. EFFORT REQ'D. - ACTIV. BY TEST TECHS.
- THERMAL — NO FACILITIES ACTIV. EFFORT REQ'D. - ACTIV. BY TEST TECHS
- IAT — MAINTENANCE — FLT. SUPPORT — MAINTENANCE
- PROPULSION - BPN & MSFC — DES. / ACTIV. / DES. / ACTIV. / MTRE — MAINTENANCE — → TO FEB 1985
- TANK QUAL. & ACCEPT. — DES. / CONSTR. / ACTIV. — MAINTENANCE

MAINT. & REFURB - ETR

- TUG MAINT. FAC. — DES. / CONSTR. / DES. / ACTIV. — MAINTENANCE — FOL. RETRIEVAL & KICKSTAGE RAS → TO 1991
- PROP. SYS. SERV. — DES. / CONSTR. / DES. / ACTIV. — MAINTENANCE — DES. / ACTIV. — FOL. RETRIEVAL & KICKSTAGE R/S → TO 1991
- TUG CLEANING FAC. — DES. / CONSTR. / DES. / ACTIV. — MAINTENANCE — DES. / ACTIV. — → TO 1991
- KICKSTAGE SEM — DES. / CONSTR. / DES. / ACTIV. — MAINTENANCE — → TO 1991
- SUPPORT/WARE. FAC. — DES. / ACTIV. — MAINTENANCE — DES. / CONSTR. / DES. / ACTIV. — MAINTENANCE — → TO 1991
- OFFICE — DES. / ACTIV. — MAINTENANCE — → TO 1991

ETR LAUNCH

- LAUNCH PAD — DES. / ACTIV. — MAINTENANCE — → TO 1991
- SAFING AREA — DES. / ACTIV. — MAINTENANCE — → TO 1991
- MISSION CONTROL CENTER — DES. / CONSTR. / DES. / ACTIV. — MAINTENANCE — → TO 1991

MAINT. & REFURB - WTR

- TUG MAINT. FAC. — DES. / CONSTR. / DES. / ACTIV. — MAINTENANCE — → TO 1991
- PROP. SYS. SERV. — DES. / CONSTR. / DES. / ACTIV. FOR KICKSTAGE — MAINTENANCE — → TO 1991
- TUG CLEANING — DES. / CONSTR. / DES. / ACTIV. — MAINTENANCE — → TO 1991
- SUPPORT/WARE. FAC. — DES. / CONSTR. / DES. / ACTIV. — MAINTENANCE — → TO 1991
- OFFICE — DES. BASELINE - LEVEL I MAINT. @ WTR ONLY - LEVEL II & III MAINT. @ RSC

WTR LAUNCH

- LAUNCH PAD — DES. / ACTIV. — MAINTENANCE — → TO 1991
- SAFING AREA — DES. / ACTIV. — MAINTENANCE — → TO 1991
- MISSION CONTROL CENTER — DES. / CONSTR. / DES. / ACTIV. — MAINTENANCE — → TO 1991

FY 1973 · FY 1974 · FY 1975 · FY 1976 · FY 1977 · FY 1978 · FY 1979 · FY 1980 · FY 1981 · FY 1982 · FY 1983 · FY 1984 · FY 1985

▽ FACILITY OPERATIONALY READY

8-31-73

8.1.6 EVALUATION OF MAJOR SCHEDULE DRIVERS (cont'd)

310-3B/310ARE-3B

The project schedule for this option is identical to the 310-3A/310RE-3A schedule except for the following areas: Lot 3 of the Main Stage production consists of 6 vehicles, with MS production ending in January 1985.

In addition to the Retrieval Delay Module an Apogee Kick Stage is developed and ready for deployment by the end of 1983.

8.2 VEHICLE TEST PROGRAMS (310-3B/310ARE-3B)

8.2.0 Test Summary

The approach used to develope the Vehicle Test Program for the 310-3B/310ARE-3B configuration is basically the same as described in Part I, Paragraph 8.1.2. The addition of an Apogee Kick Stage, Retrieval Delay Module, MS Retrieval Electronics and Level IIb autonomy to the Tug program for the 310ARE-3B configuration will also be verified in both the ground and flight test programs.

Table 8.2 -1 summarizes the test verification approach in terms of major verification requirements and method of requirement satisfaction. Figure 8.2-1 presents a summary schedule of the total Vehicle Test Program.

8.2.1 Ground Test Articles - Type and Description

8.2.1.1 Propulsion Test Vehicle (PTV)

The PTV for the 310-3B/310ARE-3B configuration is the same as described in Part I, Paragraph 8.2.1.1.

8.2.1.2 Structural Test Articles (STA)

The structural test article (STA) for this configuration consists of three major assemblies which are tested, as described in Part II, Paragraph 8.2.1.2.

- Main Stage STA(IOC 12/79)
- Apogee Kick Stage (IOC 1984)
- Retrieval Delay Module (IOC 12/83)

The description of the main stage STA is the same as that described in Part II, Paragraph 8.2.1.2.1

There are two auxiliary stages developed for this configuration. The Apogee kick stage STA is the same as described in Part II, Paragraph 8.2.1.2.2. The Retrieval Delay Module STA is the same as described in Part III, Paragraph 8.2.1.2.2.

8.2.1.3 Integrated Avionics Test Facilities

Integrated avionics hardware and software testing for the 310-3B basic vehicle will be accomplished using an IAT and ASDL facility as described in Part I, Paragraph 8.2.1.3.1. As the retrieval capability and level IIB autonomy is incorporated into the MS avionics, the IAT facility and/or ASDL will be updated to reflect these changes.

310-3B/310ARE-3B VEHICLE TEST

EVOLVED RETRIEVAL, RETRIEVAL DELAY & KICK ADDS $14.21M TO VEHICLE TEST

- o TEST PROGRAM OBJECTIVES
  - DESIGN VERIFICATION
  - SITE/GSE VALIDATION
  - SYSTEM VERIFICATION
- o GROUND TEST PROGRAM (HARDWARE/OPS = $26.53M)
  - PROP: 1 MS ART. VERIFIES COLD FLOW SYSTEM OPS - REFURBISH TO OPS
  - STRUCT: 3 ART. (1 MS, 1 AKS & 1 RDM) VERIFY DYN, STATIC, FATIGUE, SEP - KSC SITE VALIDATION
  - AVIONICS: 2 LABS VERIFY HARDWARE/SOFTWARE FOR INITIAL AND EVOLVED CONFIGURATION
  - MOCKUPS: 3 SOFT & 3 HARD MS, AKS & RDM MOCKUPS SUPPORT DESIGN DEVELOPMENT & MAINTENANCE DEMONSTRATION
- o FLIGHT TEST PROGRAM (HARDWARE/OPS = $19.83M)
  - 1 MS, 1 AKS & 1 RDM VEHICLE
  - 9 FLIGHTS (1 DEDICATED, 8 OPS)
- o TOTAL VEHICLE TEST = $46.36M

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DESIGN VERIFICATION APPROACH
310-3B/310RE-3B

	MAJOR VERIF REQMT.	GRND TEST	FLT TEST
STRUCTURE	STATIC MARGIN	QUAL	VERIFY
	FATIGUE LIFE	QUAL	
	VIBRATION MODES	VERIFY	VERIFY
	VEH/ORB,VEH/PL, VEH/RDM & VEH/AKS SEP	QUAL	VERIFY
	VEH HDLG & MAINT	DEMO	VERIFY
THERMAL CONTROL	PASSIVE/ACTIVE THERMO SYS PERFORM	QUAL	VERIFY
	TC/GSE SERVICING & MAINT	DEMO	VERIFY
AVIONICS	INTEG HDWR/SFTWR VEH PERFORM	VERIFY	VERIFY
	AVIONICS/GSE C/O & MAINT.	DEMO	VERIFY
	VEH SYS INTERFACE (ORB, GRND, AKS, RDM & PL PERFORM)	VERIFY	VERIFY
PROPULSION	MPS NOM/OFF - NOM PERFORM	QUAL	VERIFY
	MPS/GSE SERVICING & MAINT	DEMO	VERIFY
	APS NOM/OFF-NOM PERFORM	QUAL	VERIFY
	APS/GSE SERVICING & MAINT	DEMO	VERIFY
	AKS SRM PERFORM	QUAL	VERIFY
ORBITER INTERFACE	STATIC/FATIGUE STRENGTH	QUAL	VERIFY
	VEH/ORB SEP	QUAL	VERIFY
	AVIONIC/FLUID INTERFACE PERFORM	VERIFY	VERIFY
	ABORT SYSTEM PERFORM	QUAL	VERIFY
	VEH HDLG/GSE SERVICE & MAINT	DEMO	VERIFY

TABLE 8-2-1

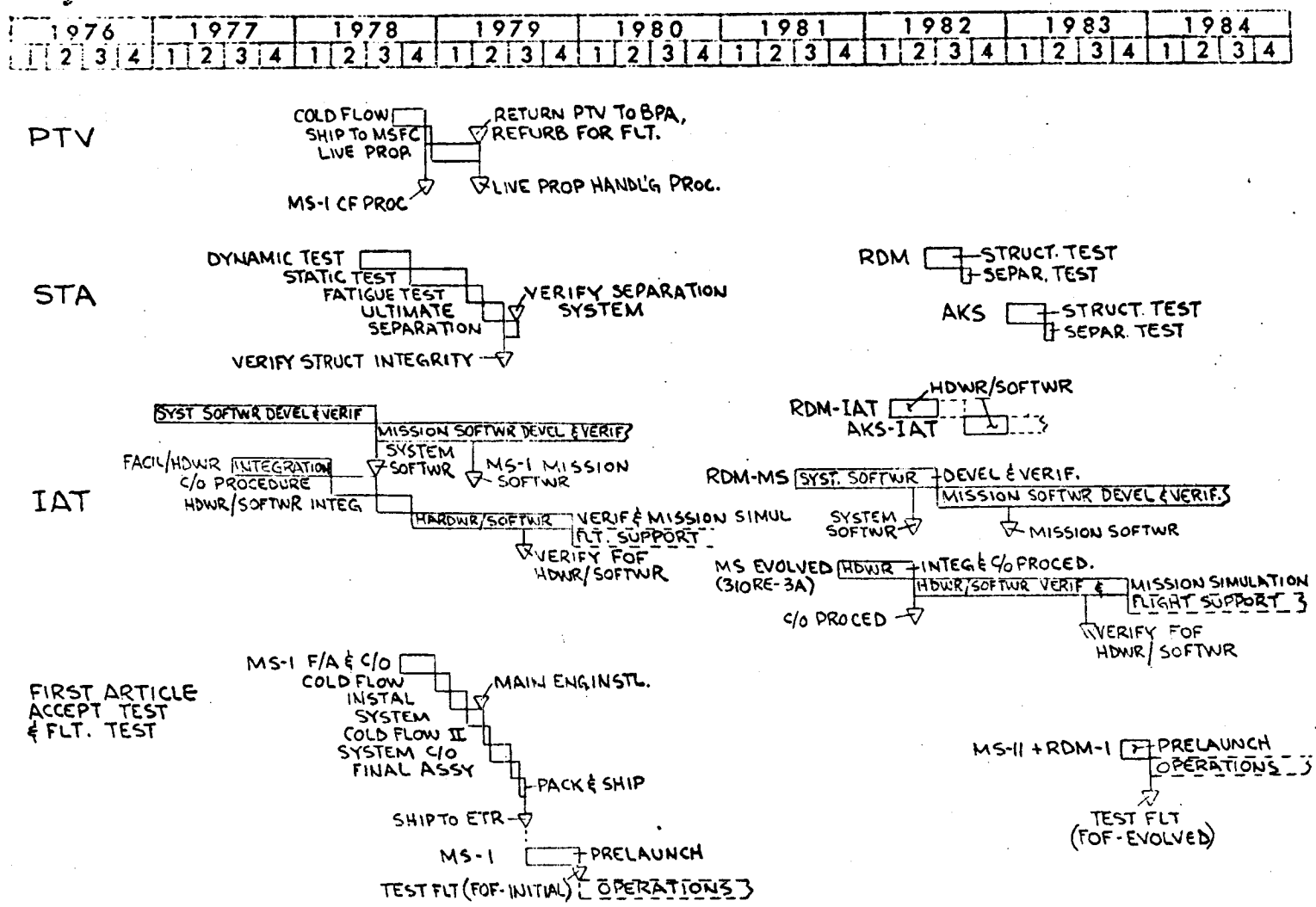


FIG. 8.2-1 310-3B/310ARE-3B VEHICLE TEST SCHEDULE

A breadboard of the Retrieval Delay Module will be integrated in the IAT facility and tested as described in Part III, Paragraph 8.2.1.3.2.

A breadboard of the Apogee Kick Stage will be integrated in the IAT facility and tested as described in Part I, Paragraph 8.2.1.3.2.

8.2.1.4 Mockups

The mockups for this configuration are the same as described in Parts I and III, Paragraph 8.2.1.4.

8.2.2 Flight Test Articles

The Main Stage (MS) Flight Test Article and the Apogee Kick Stage (AKS) Flight Test Articles are as described in Part I, Paragraphs 8.2.2.1 and 8.2.2.2, with the AKS not flight tested until late 1983.

The MS Flight Test Article for the 310ARE-3B configuration is the first flight - configured vehicle with retrieval capability and includes a DFI system.

The Retrieval Delay Module Flight Test Article is the same as described in Part III, Paragraph 8.2.2.2.

8.2.3 Ground Test Program

This section describes the major elements of the vehicle ground test program. The test programs described in the following paragraphs include the Propulsion Test Vehicle (PTV), Structural Test Article (STA), Integrated Avionics Testing including software development, and mockups required in support of program requirements.

8.2.3.1 Propulsion Test Vehicle (PTV) Program

The Main Propulsion System and Auxiliary Propulsion System test program for the 310-3B configuration is the same as described in Part I, Paragraph 8.2.3.1.

8.2.3.2 Structural Test Article (STA) Program

The MS Structural Test Program for the 310-3B/310ARE-3B configuration is as described in Part II, Paragraph 8.2.3.2.1.

The manloading and test schedule for the 310-3B/310ARE-3B configuration is the same as shown in Part I, Figure 8.2-3 with the start and end dates shifted three months later.

The Apogee Kick Stage structural test program is the same as described in Part I, Paragraph 8.2.3.2.2 except that it starts in January of 1983. The Retrieval Delay Module structural test program is the same as described in Part III, Paragraph 8.2.3.2.2.

8.2.3.3 Integrated Avionics Test Program

The integrated avionics test philosophy and test program for the 310-3B/310ARE-3B configuration is basically the same as described in Part I, Paragraph 8.2.3.3.1. In addition to those tests defined in Part I, the evolution of the Retrieval Capability and Level IIB autonomy will be incorporated and verified in the IAT facility and ASDL prior to incorporation in the flight vehicle. At the completion of system hardware/software verification, mission simulation will be performed for the evolved MS in the IAT facility.

Fuel Cell - Reactant tank systems test will also be conducted the same as those described in Part III, Paragraph 8.2.3.3.1.

The RDM test program for the 310-3B/310ARE-3B is the same as described in Part III, Paragraph 8.2.1.3.2.

The AKS test program for the 310-3B/310ARE-3B is the same as described in Part I, Paragraph 8.2.1.3.2.

The test program, for the 310-3B/310ARE-3B configuration and schedule are shown in Figure 8.2 -2.

8.2.3.4 Mockups

The mockups will be used throughout the MS, RDM and AKS development stage as described in Part I, Paragraph 8.2.3.4. In addition the STA will be used for launch operations check-out as described for the 110A configuration.

8.2.4. Flight Test Program

8.2.4.1 Flight Vehicle Test and Checkout

The 310-3B configuration mainstage vehicle factory and pre-launch test and checkout requirements, schedule and manpower is the same as described in Part III, Paragraph 8.2.4.1.

The AKS factory and pre-launch (IOC TBD) flow is the same as shown in Part I, Figure 8.2-9 and the RDM factory and pre-launch flow is the same as described in Part III, Figure 8.2-9.

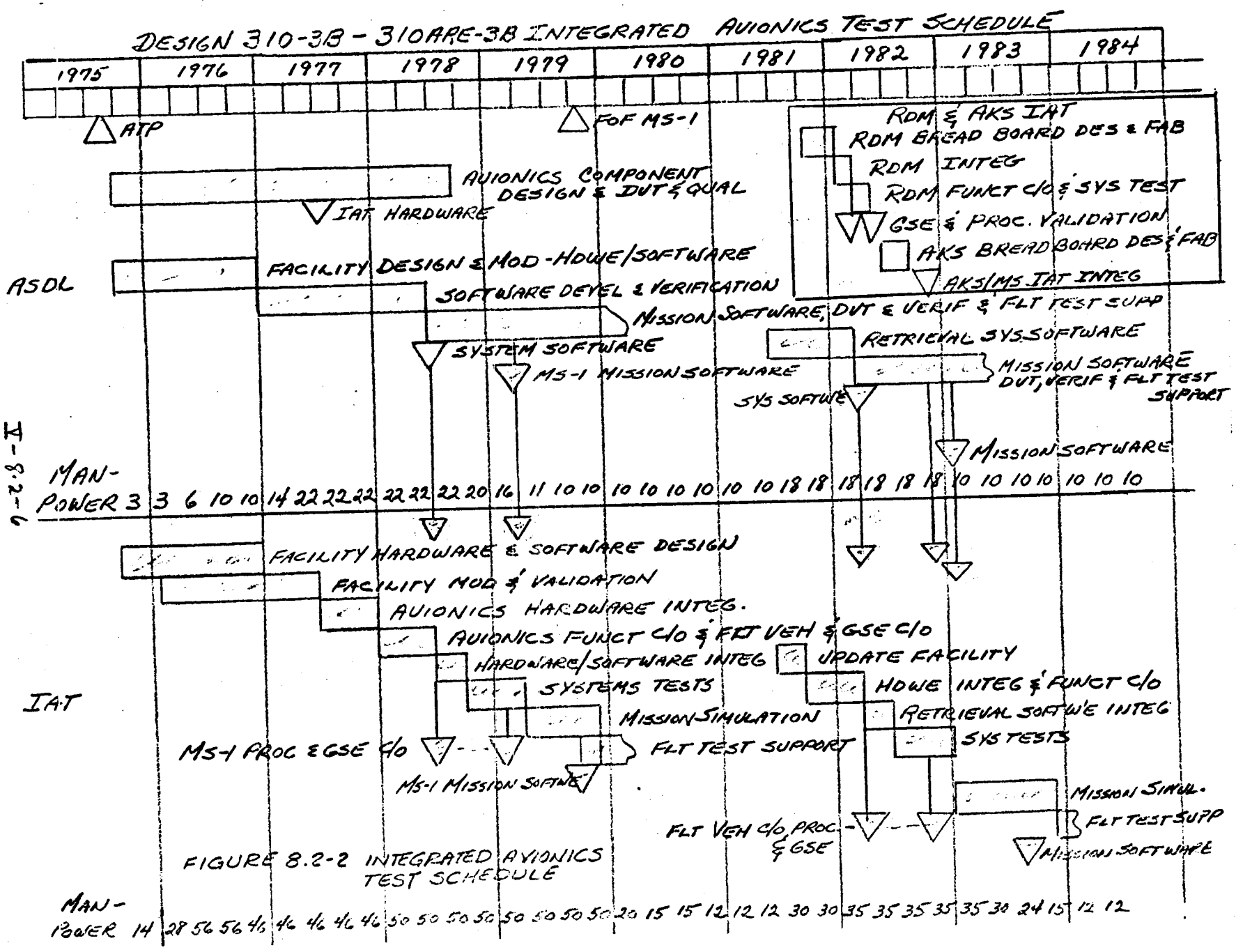


FIGURE 8.2-2 INTEGRATED AVIONICS TEST SCHEDULE

8.2.4.2 Flight Test

In addition to the eight flights described for the 310-3A/310RE3A configuration in Part III, Paragraph 8.2.3.2, one additional deploy only data flight with an AKS will be required for this configuration. The flight test schedule and test costs for this configuration are shown in Figure 8.2-3.

8.2.5 Analysis of the Test Program

8.2.5.1 Key Elements

The key elements of the 310-3B/310ARE-3b configuration, Vehicle Test Program, are the same as described in Part III, Paragraph 8.2.6.1.

8.2.5.2 SR&T Assumptions

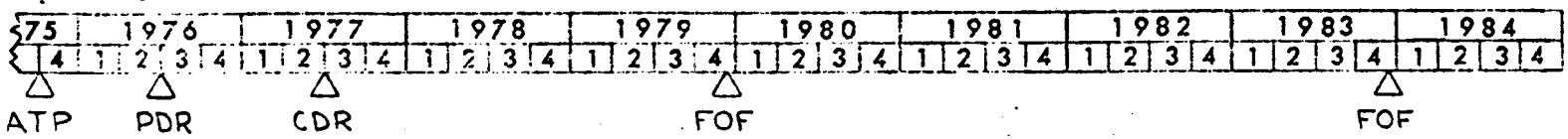
The basic assumptions for the 310-3B/310ARE-3B SR&T requirements are described in Part I, Paragraph 8.2.6.2. SR&T requirements, test programs affected and a brief description of the interaction with the test programs affected is summarized in Table 8.2-2.

8.2.5.3 Reusability Demonstration

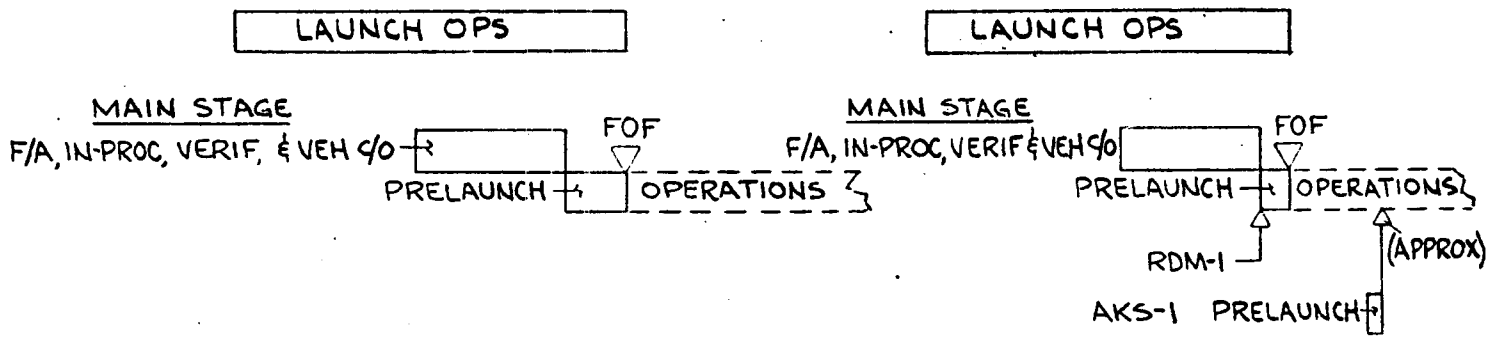
Reusability demonstrations for the 310-3B/310ARE-3B configuration are the same as described in Part I, Paragraph 8.2.6.3.

8.2.5.4 Life Verification Tests

The life verification test requirements for the 310-3B/310ARE-3B configuration are the same as described in Part I, Paragraph 8.2.6.4.



TEST & FLT OPS PLANNING



FLIGHT TEST PROGRAM COST

- FLIGHT TEST HARDWARE: 1 MAIN STAGE + DFI
  1 RDM + DFI
- FLIGHT TEST MANPOWER (FOF ONLY)
  - TEST OPS: $2.94 M
  - LAUNCH OPS: $1.51 M
  - FLIGHT OPS: $2.28 M
- CONSUMABLES (FOF ONLY): $62 K

FLIGHT TEST PROGRAM SCHEDULE (310-3B/310ARE-3B)

FIG. 8.2-3

TECHNOLOGY REQUIREMENTS	TEST PROG. AFFECTED	REMARKS
Main engine life and high performance	o GFE eng. devel. prog. o Flight test prog.	Early life verif. of eng. components and area ratio nozzle performance assures phase C/D engine development. PTV is not affected since eng. is not required. FOF could tolerate slightly reduced eng. performance.
PFR helium tank		Early verif. of low weight PFR tank assures maximum tug performance.
Materials compatibility Data	o Tank Qual o STA prog. o PTV prog.	Early verif. of material compatibility with MMH and N_2O_4 assures on-time development of main stage tankage including tank qual. STA and PTV testing.
Fracture Mechanics data	o Tank qual. o STA prog.	Early fracture mechanics data allows on-time development of structural subsystem including tankage quals and STA testing.
Heat Pipes	o Flight test prog.	Early verif. of heat pipe design approach allows on-time developments of Thermal Control Subsystem thereby maximizing Tug performance.
Laser Radar	o Integrated Avionics o Flight Vehicle factory checkout o STA	Early devel. of light weight low power Laser Radar will assure on time development of software and integration procedures in the IAT LAB for FLT VEH buildup & test and accurate simulation for STA program.

TABLE 8.2-2

310-3B/310ARE-3B GROUND TESTS

EVOLVED RETRIEVAL, RETRIEVAL DELAY AND KICK ADDS $14.21M TO VEH. TEST

TEST	TEST ART.	OBJECTIVES	APPROACH
STRUCTURES o 310-3B - MAIN STAGE(MS) o 310-RE - RETRIEVAL DELAY MODULE (RDM) STRUCT. - APOGEE KICK STAGE (AKS) STRUCT.	o COMPLETE M.S. PRIM. & SEC. STRUCT. INCL. TUG/ORB & TUG/P.L. ADAPTERS o COMPLETE RDM PRIME & SEC. STRUCT. o COMPLETE AKS PRIME & SEC. STRUCT.	o EVAL. DYN., STATIC STRENGTH, SAFE-LIFE & SEPARATION. o VERIFY STRUCT./MECH. INTERFACES AT LAUNCH SITE.	o VIB/ACOUSTIC TESTS o DES. LIMIT STATIC TESTS o STATIC FATIGUE o ULT. STATIC TESTS o SEP. DEMO. o INTERFACE VALID. DEMO. AT KSC. o RDM & AKS TESTED SEPARATELY AS ABOVE (1982,1983 RESPECT.)
PROPULSION o MAIN STAGE (310-3B ONLY)	o FLIGHT WT. MAIN STG. STRUCT. o MAIN ENG. SUPPT. S/S LESS ENG. o ENG. SIMUL. UNIT. o PTV REFURB. TO FLIGHT OPS	o DEMO OPS OF ASSEM. COMPONENTS o DEVELOP C/O & OPS PROCEDURES o VERIFY SERV/HANDLG. PROCEDURES o DEMO SYS. PERF. & CHARACTERISTICS	o COLD FLOW ONLY o REFERENCE FLUIDS PHASE -FILL/DRAIN/FLOW TESTS o LIVE PROPELLANTS PHASE - LOAD CONTROL/ ACCURACY - SYS. COMPAT. & DYN. - PERF. SERV./HANDLG PROCEDURES.

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310-3B/310ARE-3B GROUND TESTS

VEHICLE TEST PROGRAM

The vehicle test program for 310-3B/310ARE-3B was developed in a similar manner to that described for 110A-1.

STRUCTURAL TEST ARTICLES (STA)

The structural test programs for the 310-3B/310ARE-3B are identical to those described for the MS 110A and the RDM for the 310RE configuration. The AKS STA for this configuration will be tested as described for the 110A STA test program, however, the test will be accomplished in 1983. The 310-3B STA will be configured to include the evolved 310ARE-3B avionic retrieval hardware and mechanical interfaces, and the test loads will envelope both configurations.

PROPULSION TEST VEHICLE (PTV)

The PTV and AKS PTV and AKS propulsion test programs for this configuration are the same as those described for configuration 110A.

310-3B/310ARE-3B GROUND TEST (cont'd)

TEST	TEST ART.	OBJECTIVES	APPROACH
INTEGRATED AVIONICS o INTEG.AVIONICS TEST (IAT) FACILITY - MS - RDM - AKS o AVIONICS SOFTWARE DEVELOPMENT LAB (ASDL) - MS	o IAT - SHIP SET OF AVIONICS - COMPUTER-SIMULATION - SENSOR STIMULUS - FACTORY & LAUNCH GSE o ASDL - COMPUTER FACILITY WITH MATH MODEL SIMULATION OF MS HARDWARE	o VERIFY HARDWARE/SOFTWARE PRIOR TO VEHICLE INSTALLATION & FOF o VERIFY EVOLVED RETRIEVAL AND AUTONOMY LEVEL IIB HARDWARE AND SOFTWARE FOR 83-IOC	o IAT - SUBSYSTEM INTEG & END TO END FUNCTIONAL VERIF. - VERIFY FACTORY C/O PROCED. - HARDWARE/SOFTWARE VERIF. - MISSION SIMULATION - INTEGRATE AND VERIFY RETRIEVAL CAPABILITY HARDWARE/SOFTWARE - RETRIEVAL MISSION SIMULATION o ASDL - SOFTWARE DEVELOPMENT FOR BASIC & EVOLVED CONFIG.
MOCKUPS o MS o RDM o AKS	o WOOD & CARDBOARD MOCKUPS OF THE TUG MS, RDM & AKS STRUCTURE INCLUDING EQUIPMENT FOR PDR, o WOOD & METAL MOCKUPS OF TUG MS, RDM, AND AKS STRUCT. & COMPONENTS FOR CDR.	EVALUATE EQUIPMENT ACCESSABILITY AND MAINTAINABILITY. EVALUATE SHUTTLE & PAYLOAD INTERFACE AND LINES RUN PRIOR TO FAR OR FINAL HARDWARE.	o COMPONENT INSTALLATION o ESTABLISH LINE LENGTHS FOR FINAL HARDWARE FAB. o DEMONSTRATE MAINTAINABILITY - ASSESSMENT & DEMO OF EQUIP CLEARANCES, LINES CLEARANCES - CONNECTOR & MOUNTING ACCESSABILITY DEMO o SHUTTLE & PAYLOAD INTERFACE ASSESSMENT.

GROUND TEST COST - INITIAL = $18.76M
INITIAL + EVOLVED = $26.53M

310-3B/310ARE-3B GROUND TESTS (cont'd)

INTEGRATED AVIONICS TESTS

The MS and Integrated Avionics Test program for the 310-3B configuration is the same as for 110A-1. The IAT and ASDL will initially be configured for the basic mission hardware and software including autonomy level IIIA.

As the retrieval capability and Autonomy Level IIB is evolved, the IAT hardware and ASDL software will be updated and evolved system verification and mission simulations performed.

The RDM and AKS breadboards will be integrated and functionally tested in the main stage IAT facility to take advantage of the existing facility simulation and GSE capabilities.

MOCKUPS

The MS and AKS mockups for this configuration will be the same as those described for configuration 110A. In addition mockups of the RDM will be required for this configuration. Installation of the evolved configuration hardware will also be evaluated using the MS mockups.

310-3B/310ARE-3B FLIGHT TESTS

TEST	OBJECTIVES	APPROACH
o MAIN STAGE (310-3B) - 1ST PROD UNIT INCLUDING DFI o MAIN STAGE (310ARE-3B) - 1ST PROD UNIT INCLUDING DFI o RDM - 1ST PROD. UNIT INCLUDING DFI o AKS - 1ST PROD. UNIT INCLUDING DFI	INITIAL IOC o THERMO-VERIFY SYS. THERMAL CONTROL o STRUCT - VERIFY LAUNCH/ ORBIT/ENTRY/LANDING LOADS & DYNAMICS o PROP-VERIFY MPS/APS o AVIONICS - VERIFY AVIONICS OPS o OPS - EVALUATE TUG/ORB & TUG PAYLOAD INTERFACES - EVALUATE SYS. PERF. CAPABILITY - DEMO PAYLOAD DEPLOY EVOLVED IOC o EVALUATE TUG/RDM & TUG/AKS INTERFACES o DEMO PAYLOAD RETRIEVAL & AUTONOMY LEVEL IIB.	o 9 FLIGHT TEST PROGRAM - 5 INITIAL - 4 FINAL o FIRST ORBITAL FLIGHT (FOF) COSTED WITHOUT OPERATIONAL PAYLOADS - FLOWN WITHIN RETRIEVAL CAPABILITY OF ORB. - SEQUENCE INCL: SYS C/O MPS/APS BURNS, DUMMY PAYLOAD DEPLOY, ORBITER RETRIEVAL o SUBSEQ. FLIGHTS DEPLOY OPERATIONAL PAYLOADS SELECTED TO DEMO BUILD-UP IN TUG CAPABILITY o FOF OF 310ARE-3B IS A DEPLOY ONLY FLIGHT. RETRIEVAL DEMO WITH RDM PERFORMED UPON RETURN TO 160NM ORBIT o AKS VERIFIED ON OPERATIONAL FLIGHT

FLIGHT TEST COST - INITIAL = $13.39M
- INITIAL + EVOLVED = $19.83M

TOTAL VEHICLE TEST = $46.36M

310-3B-310ARE-3B FLIGHT TESTS

Nine flights are included in the 310-3B/310ARE-3B flight test program.

The MS flight test program for the 310-3B configuration will be the same as described for 110A. The AKS flight test program is also the same as described for 110A-1 with FOF of the AKS occuring in 1984.

The RDM and MS retrieval capability will be flight verified as described for configuration 310RE-3A.

8.3 Facilities Plan - Option 3B - Concept 310A-3B/310 ARE-3B

8.3.1 Manufacturing Facilities

Same as concept 110A-1 except 29,700 sq. ft. of floor space is required for fabrication and assembly of the TUG.

8.3.2 Test Facilities

Same as concept 110A-1 except 1AT will require 1300 sq. ft. of floor space at JSC.

8.3.3 Operations Facilities

Same as concept 110A-1 except TUG Maintenance Facility at ETR will have 4 horizontal stations in a 12,000 sq. ft. addition to the Shuttle OMS Facility.

STORABLE SPACE TUG

CONCEPT 310-38/310ARE-38 — Revision Date 9-7-73

FACILITIES FUNDING REQUIREMENTS — IOC Dec. '79 — ACQUISITION PHASE NASA

Fiscal Year	'76			'77			'78			'79			'80			'81			'82			'83			'84	'85	'86	'87	'88	'89	'90	'91	TOTALS		
TITLE/WBS # / Level 6 Cat.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	3	3	3	3	3	3	3	3	DDT&E	PROD	CPS
Manufacturing 320-06-01																																			
Structures		2.0		55.0	43.4	9.9		28.4	28.6			6.4 (26.0)			(32.4)			(32.4)			(32.4)			(32.4)	(32.4)	(7.8)							173.7	115.6	–
Retrieval Kit & Kickstage																	15.0			15.8	(11.5)			(15.4)	(15.4)	(15.4)	(15.4)	(5.0)					30.8	78.1	–
Sub-Total		2.0		55.0	43.4	9.9		28.4	28.6			32.4			32.4		15.0	32.4		15.8	43.9			47.8	47.8	23.2	15.4	5.0					204.5	273.1	–
Test 320-06-02																																			
Structural				Existing Facility – No Facilities Install Beyond Sight																													–	–	–
Thermal				Existing Facility – No Facilities Install Beyond Sight																													–	–	–
IAT									1.2			1.3			1.3			1.3			1.3			1.3	.4								6.1	–	–
Propulsion								63.0			23.0	3.5			(9.0)			(9.0)			(9.0)			(9.0)	(9.0)	(6.0)							117.5	51.0	–
Tank Qual. & Accept.								25.3	1.0			1.3			(1.3)			(1.3)			(1.3)			(1.3)	(1.3)								1[illegible]	6.2	–
Sub-Total				20.0				103.0	2.2		27.0	10.1			11.6			11.6			11.6			11.6	16.7	6.0							247.1	57.5	–
Maint. & Refurb. - STR 320-06-03																																			
Tug Maint. Fac.				40.0			40.0			56.0	216.0				[20.0]			[22.4]			[22.4]		64.8	[22.4]	←					→	[22.4]	[11.3]	1360.8	–	[illegible]
Prop. Sys. Serv.				25.0			[illegible]			[illegible]	116.0				[5.3]			[illegible]			[illegible]		57.8	[7.0]	←	–				→	[illegible]	[illegible]	1047.4	–	[illegible]
Tug Cleaning							32.0			221.5	53.0				[illegible]			[illegible]			[illegible]			[illegible]	←	–		–		→	[illegible]	[illegible]	[illegible]	–	[illegible]
Kick Stage Proc.																			77.0				15.4	[illegible]	[illegible]	—	—	—		→	[illegible]	[illegible]	[illegible]	–	[illegible]
Support/Whse. Fac.				Shuttle Shared Facility							122.0																						127.0	–	–
Office											16.0				[5.0]			[5.0]			[5.0]			[5.0]	←	—	—	—		→	[illegible]	[illegible]	[illegible]	–	[illegible]
Sub-Total				65.0			8[illegible]			1[illegible]	[illegible]				29.6			42.6	77.0		42.6		126.2	43.2	43.7	←	—	—	—	→	43.7	21.9	3[illegible]5.6	–	[illegible]
ETR Launch 320-06-04																																			
LA [illegible] PSS				Shuttle Facility							–			5.0																			[illegible]	–	–
Safing Area				Shuttle Facility							2.0			10.0																			[illegible]	–	–
Mission Control Center							5.0			307.5					[2.0]			(12.0)			(12.0)			(12.0)	←	—	—	—		→	(12.0)	[illegible]	412.5		[illegible]
Sub-Total							5.0			307.5	2.0			15.0	2.0			12.0			12.0			12.0	←	—	—	—		→	12.0	2.0	437.5	–	[illegible]
Maint. & Refurb.-WTR 320-06-05																																			
Tug Maint. Fac.													20.0			2[illegible]			310.0	130.0				[7.8]	(11.3)	←	—	—	—	→	(11.3)	[5.6]	791.0	–	[illegible]
Prop. Sys. Serv.													30.0			[illegible]			518.0	238.0				[7.5]	(9.0)	←	—	—	—	→	(9.0)	(3.5)	1155.0	–	[illegible]
Tug Cleaning																37.0			365.0	63.6				[5.0]	[6.0]	←	—	—	—	→	[6.0]	[3.0]	467.6	–	[illegible]
Support/Whse. Fac.							Present Ops Hysetac – Level 6 Maint. @ WTR Only																												
Office																16.0			140.0	12.0				[3.3]	(3.0)	←	—	—	—	→	[4.0]	[2.0]	172.0	–	[illegible]
Sub-Total													50.0			761.0			1[illegible]	447.6				25.2	30.3	←	—	—	—	→	30.3	15.1	2,647.6	–	[illegible]
WTR Launch 320-06-06																																			
Launch Pad				Shuttle Facility																–			5.0										5.0	–	–
Safing Area				Shuttle Facility																2.0			22.0										24.0	–	–
Mission Control Center							6.0			1[illegible]					[illegible]			(12.0)			(12.0)			(12.0)	←	—	—	—		→	(12.0)	[6.0]	4[illegible]		[illegible]
Sub-Total							6.0			[illegible]					[illegible]			12.0		2.0	12.0		27.0	12.0	←	—	—	—		→	12.0	6.0	[illegible]	–	[illegible]
TOTALS		2.0		[illegible]	[illegible]	9.9	[illegible]	[illegible]	30.8	[illegible]	[illegible]	12.5	[illegible]	23.0	[illegible]	101.0	15.0	[illegible]	[illegible]	165.4	[illegible]		151.2	[illegible]	[illegible]	[illegible]	113.4	109.0	98.0	98.0	98.0	[illegible]	7,166.1	331.2	[illegible]

GRAND TOTAL 6,836.7

COSTS - $000 (1973)

Col. 1 - Design/Construction Costs
Col. 2 - Activation Costs
Col. 3 - Maintenance Costs

00 - DDT & E Costs
(00) - Production Costs
[00] - Operations Costs

8.4 Vehicle Manufacturing

This section establishes the requirements for the 310-3B/310ARE-3B spacecraft including the assembly sequence, tooling, schedule, manufacturing test, special processes and facilities.

The 310-3B spacecraft is a single stage vehicle with a kick stage (AKS) and a retrieval module (RDM) added for the evolved configuration 310ARE/3B. The spacecraft is essentially the same as the 410 and 310 vehicles described in Parts II and III.

8.4.1 Plan/Flow/Time

The manufacturing sequence is identical to configuration 410AD-2 discussed in Part II section 8.4.1. The manufacturing flow and master schedule are shown in figures 8.4-1 and 8.4-2 respectively.

8.4.2 Tooling Requirements (including GSE)

See Part II section 8.4.2.

8.4.3 Facility Requirements

See Part II section 8.4.3.

8.4.4 Special Requirements

See Part II section 8.4.4.

8.4.5 Summary Analysis/Philosophy

See Part II section 8.4.5

8.4.6 GSE Requirements

See Part I section 8.4.7

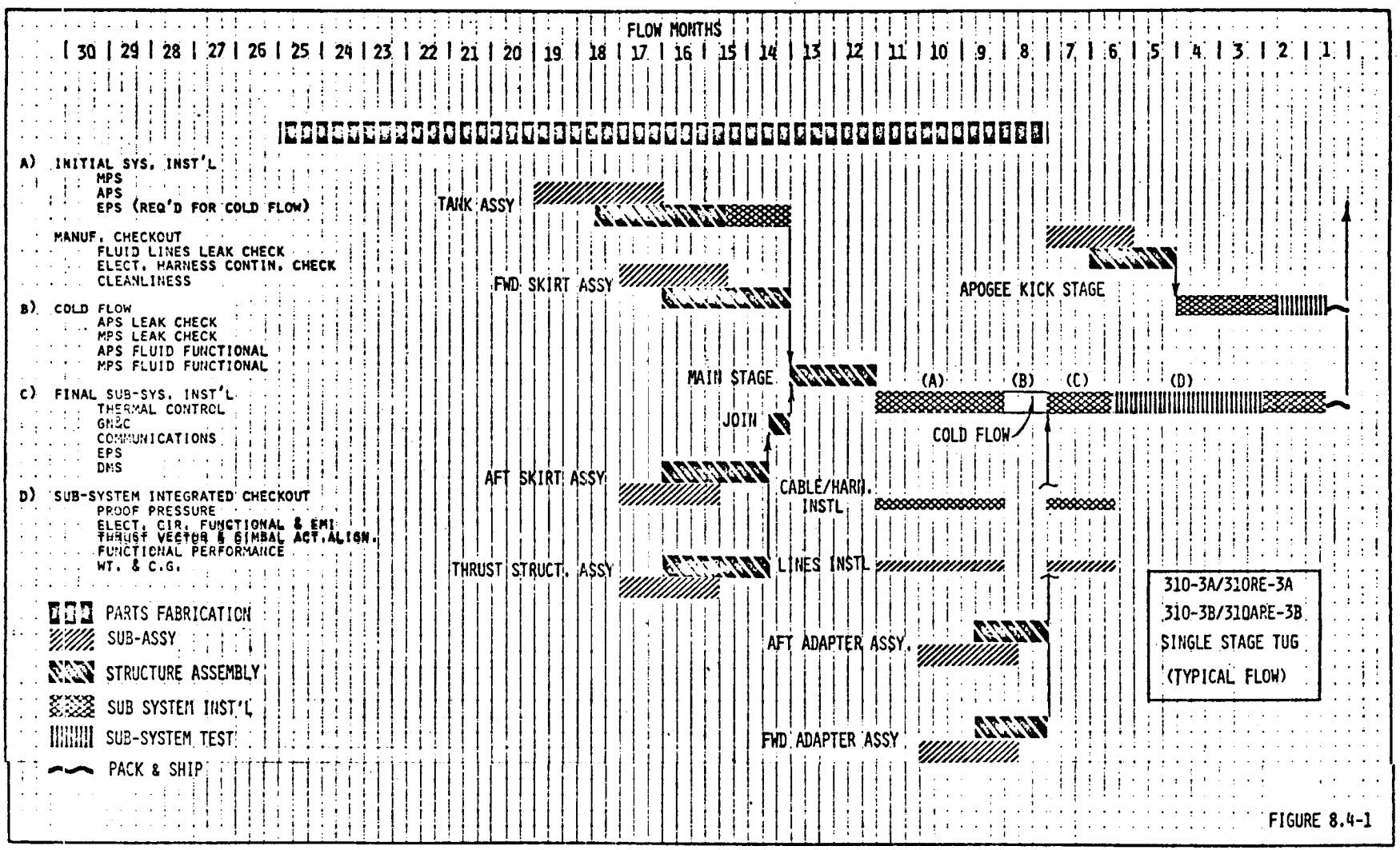
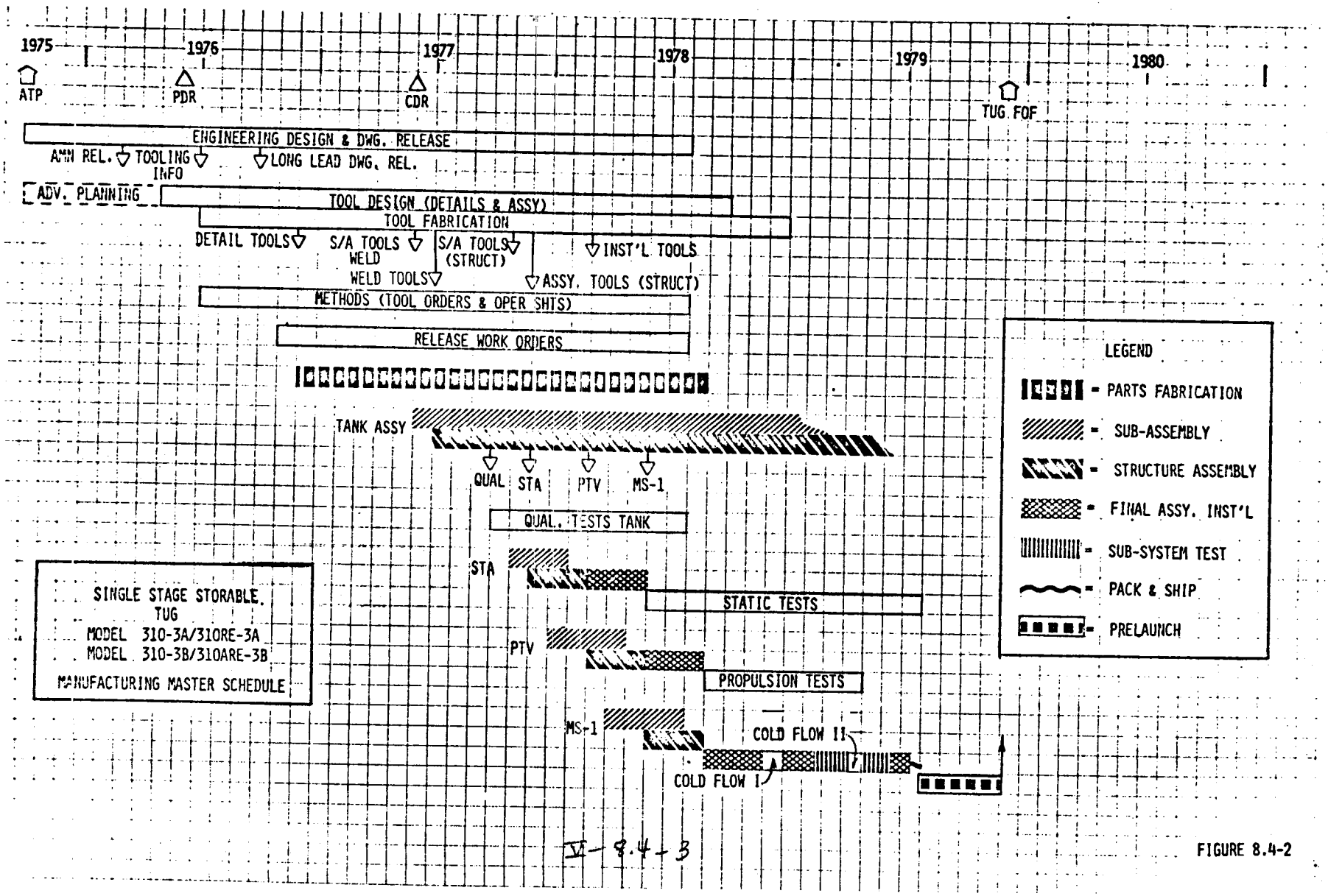

FLOW MONTHS
30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
A) INITIAL SYS. INST'L
MPS
APS
EPS (REQ'D FOR COLD FLOW)
MANUF. CHECKOUT
FLUID LINES LEAK CHECK
ELECT. HARNESS CONTIN. CHECK
CLEANLINESS
B) COLD FLOW
APS LEAK CHECK
MPS LEAK CHECK
APS FLUID FUNCTIONAL
MPS FLUID FUNCTIONAL
C) FINAL SUB-SYS. INST'L
THERMAL CONTROL
GN&C
COMMUNICATIONS
EPS
DMS
D) SUB-SYSTEM INTEGRATED CHECKOUT
PROOF PRESSURE
ELECT. CIR. FUNCTIONAL & EMI
THRUST VECTOR & GIMBAL ACT.ALIGN.
FUNCTIONAL PERFORMANCE
WT. & C.G.
PARTS FABRICATION
SUB-ASSY
STRUCTURE ASSEMBLY
SUB SYSTEM INST'L
SUB-SYSTEM TEST
PACK & SHIP
TANK ASSY
FWD SKIRT ASSY
APOGEE KICK STAGE
MAIN STAGE
(A)
(B)
(C)
(D)
JOIN
COLD FLOW
AFT SKIRT ASSY
CABLE/HARN. INSTL
THRUST STRUCT. ASSY
LINES INSTL
AFT ADAPTER ASSY.
FWD ADAPTER ASSY
310-3A/310RE-3A
310-3B/310ARE-3B
SINGLE STAGE TUG
(TYPICAL FLOW)

FIGURE 8.4-1



VI-8.4-3

FIGURE 8.4-2

8.5 310-3B/310ARE-3B SPECIAL PROGRAMMATICS

Program 310-3B/310ARE-3B has features similar to those defined for implementing and managing Program 310-3A/310RE-3A.

These features include: defining the initial/evolved flight build up based on Shuttle/Tug launch constraint and ground crew launch capability; implementing 3 lot production (deploy, deploy-upgrade, and retrieve); refurbishing the propulsion test article for operational use; and defining a fall back position for every identified risk.

Specific areas for government participation in 310-313/310ARE-3B include: establishing Tug/Shuttle interface requirements before Orbiter design freeze; providing payload interface design requirements and mission model data; initiating required activities for supporting Research and Technology; providing GFE systems and components (eg: main engines, and DOD secure comm); supporting propulsion system testing and development and supporting integrated avionics hardware testing and related software development; providing required facilities; and performing vehicle ground operations, flight operations, and logistic support operations.

310-3B/310ARE-3B SPECIAL PROGRAMMATICS

- o PROGRAM IMPLEMENTATION AND MANAGEMENT
  - INITIAL/EVOLVED FLIGHT BUILD UP SET BY SHUTTLE/TUG LAUNCH CONSTRAINT AND GROUND CREW LAUNCH CAPABILITY
  - 3 LOT PRODUCTION (DEPLOY, DEPLOY-UPGRADE, AND RETRIEVE) TO AVOID MFG GAP
  - PROPULSION ARTICLE REFURBED FOR FLIGHT
  - FALL BACK POSITION SHOWN FOR EVERY IDENTIFIED RISK

- o AREAS FOR GOVERNMENT PARTICIPATION
  - FIRM TUG/SHUTTLE INTERFACES BEFORE ORBITER PDR
  - PROVIDE TUG/PAYLOAD INTERFACE DESIGN REQUIREMENTS AND MISSION MODEL DATA
  - INITIATE REQUIRED SR&T
  - SUPPORT SYSTEM TEST - AVIONIC HARDWARE/SOFTWARE PROPULSION
  - PROVIDE GFE SYSTEMS AND COMPONENTS, FACILITIES, LOGISTIC SUPPORT
  - PERFORM VEHICLE GROUND AND FLIGHT OPERATIONS

GRUMMAN

8.6 COST DATA

Included in this section are the cost data for an evolved tug configuration 310-3B/310ARE-3B. Cost data are provided for the initial program 310-3B and the combined total evolved program.

- Initial Program 310-3B
  - Storable Space Tug System Project Expected Cost-Spares Cost (INT & OPS)-First Unit Cost (Data Forms A1, 2 and 3, subparagraph No's 8.6.1, 8.6.2 and 8.6.3) (Computer P/O)
  - Storable Space Tug Funding Schedules -DDT & E, Production and Operations (Data Form C, Subparagraph 8.6.4, 8.6.5, 8.6.6 and 8.6.7)
  - Form B (Technical Characteristics subparagraph 8.6.11)
- Combined Evolved Program 310-3B/310ARE-3B
  - Same as initial program plus:
    - Average Cost/Flight (subparagraph 8.6.9)
    - Storable Space Tug System Project Cost Estimate data by SOW-DDT & E, Production and Operations (Data Form T (SOW'S) subparagraph 8.6.10)

EVOLVED TUG

CONCEPT 310-3B (INITIAL)

OPTION 3

310-38 SEP 73

STORABLE SPACE TUG SYSTEM PROJECT

EXPECTED COST - SPARES COST(INT + OPS) - FIRST UNIT COST

(COSTS IN 1973 CONSTANT DOLLARS (000))

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0100	PROJECT MGMT	8047.			2151.				664.	2733.		
0110	COST/PERF MGMT		1207.			323.			100.		911.	
0120	PROJECT DIRECTION		6196.			1656.			511.		911.	
0130	INFO MGMT		644.			172.			53.		911.	
0200	SYS ENG + INTEGR	9656.			2419.				747.	5468.		
0210	TUG SYS ENG		7725.						0.		1367.	
0220	SHUTTLE INTERFACE		966.						0.		1367.	
0230	PAYLOAD INTERFACE		966.						0.		1367.	
0240	SUST ENG					0.			747.		1367.	
0300	TUG VEH MAIN STAGE	139471.			33201.			4820.	9097.	9556.		
0310	STRUCTURES		17237.			5545.		554.	1711.		554.	
0311	FUEL TNK+SPRT			5651.			1873.	187.	578.			187.
0312	OX TANK +SPRT			6817.			2200.	220.	679.			220.
0313	BODY STRUCT			2472.			825.	82.	255.			82.
0314	THRUST STRUCT			480.			108.	11.	33.			11.
0315	METEOROID SHLD			143.			40.	4.	12.			4.
0316	PAYLOAD INTFCE			1674.			499.	50.	154.			50.
0317	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0320	THERMAL INSULTN		149.			570.		28.	176.		28.	
0321	FUEL TANK INSUL			57.			279.	28.	86.			28.
0322	OX TANK INSUL			92.			291.	0.	90.			0.
0323	PURGE SYS INSUL			0.			0.	0.	0.			0.
0324	CONT SYS			0.			0.	0.	0.			0.
0325	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0330	AVIONICS		39892.			13107.		3046.	3277.		6699.	
0331	DATA MGMT			5880.			2653.	716.	663.			1725.
0332	G N + C			10420.			5879.	1407.	1470.			3108.
0333	COMMUNICATIONS			5883.			1653.	388.	413.			796.
0334	INSTRUMENTATION			0.			0.	0.	0.			0.
0335	ELEC PWR			16566.			2011.	535.	503.			1070.
0336	PWR DIST + CONT			1143.			911.	0.	228.			0.
0337	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0340	PROPULSION		71049.			7334.		1033.	1922.		2116.	
0341	MAIN ENGINE			59000.			2845.	937.	800.			1880.
0342	MAIN ENGINE SPT			7563.			1700.	0.	425.			0.
0343	ACPS ENGINE			3000.			1501.	96.	375.			236.
0344	ACPS ENGINE SPT			1486.			1288.	0.	322.			0.
0345	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0350	ORBITER INTERFACE		6981.			1582.		158.	623.		158.	
0351	STRUCTURE			4900.			675.	68.	266.			68.
0352	INTERFACE PNLS			2081.			906.	91.	357.			91.
0353	PURGE PROVISION			0.			0.	0.	0.			0.
0354	ABORT PROVISION			0.			0.	0.	0.			0.
0355	INSTL.ASSY+C/O			0.			0.	0.	0.			0.

MOORE BUSINESS FORMS, INC. HO FORM 14127 PRINTED IN U.S.A.

WBS LEVEL		EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0350	DROP TANKS		0.			0.		0.	0.		0.	
0351	STRUCTURES			0.			0.	0.	0.			0.
0352	THERMAL INSUL			0.			0.	0.	0.			0.
0353	PROP SPRT SYS			0.			0.	0.	0.			0.
0354	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0370	FINAL ASSY + C/O		4163.			5065.		0.	1388.		0.	
0371	FINAL ASSY			4163.			5065.	0.	1388.			0.
0372	CHECKOUT			0.			0.	0.	0.			0.
0400	TUG VEH AUX STAGE	0.			0.			0.	0.	0.		
0410	STRUCTURES		0.			0.		0.	0.		0.	
0411	FUEL TNK+SPRT			0.			0.	0.	0.			0.
0412	OX TANK+SPRT			0.			0.	0.	0.			0.
0413	BODY STRUCT			0.			0.	0.	0.			0.
0414	THRUST STRUCT			0.			0.	0.	0.			0.
0415	METEOROID SHLD			0.			0.	0.	0.			0.
0416	PAYLOAD INTERFC			0.			0.	0.	0.			0.
0417	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0420	THERMAL INSUL		0.			0.		0.	0.		0.	
0421	FUEL TANK INSUL			0.			0.	0.	0.			0.
0422	OX TANK INSUL			0.			0.	0.	0.			0.
0423	PURGE SYS INSUL			0.			0.	0.	0.			0.
0424	CONT SYS			0.			0.	0.	0.			0.
0425	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0430	AVIONICS		0.			0.		0.	0.		0.	
0431	DATA MGMT			0.			0.	0.	0.			0.
0432	G N + C			0.			0.	0.	0.			0.
0433	COMMUNICATIONS			0.			0.	0.	0.			0.
0434	INSTRUMENTATION			0.			0.	0.	0.			0.
0435	ELEC PWR			0.			0.	0.	0.			0.
0436	PWR DIST + CONT			0.			0.	0.	0.			0.
0437	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0440	PROPULSION		0.			0.		0.	0.		0.	
0441	MAIN ENGINE			0.			0.	0.	0.			0.
0442	MAIN ENGINE SPT			0.			0.	0.	0.			0.
0443	ACPS ENGINE			0.			0.	0.	0.			0.
0444	ACPS ENGINE SPT			0.			0.	0.	0.			0.
0445	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0450	INTERSTAGE INTRFC		0.			0.		0.	0.		0.	
0451	STRUCTURE			0.			0.	0.	0.			0.
0452	SEP SYS			0.			0.	0.	0.			0.
0453	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0460	DROP TANK		0.			0.		0.	0.		0.	
0461	STRUCTURE			0.			0.	0.	0.			0.
0462	THERMAL INSUL			0.			0.	0.	0.			0.
0463	PROP SPT SYS			0.			0.	0.	0.			0.
0464	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0470	ROM		0.			0.		0.	0.		0.	

MOORE BUSINESS FORMS INC. NO FORM 14121 PRINTED IN U.S.A.

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WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0471	STRUCTURE			0.			0.	0.	0.			0.
0472	THERM CONT			0.			0.	0.	0.			0.
0473	AVIONICS			0.			0.	0.	0.			0.
0474	PROPULSION			0.			0.	0.	0.			0.
0475	RDM ASSY+C/O			0.			0.	0.	0.			0.
0480	AKS		0.			0.		0.	0.		0.	
0481	STRUCTURE			0.			0.	0.	0.			0.
0482	SRM			0.			0.	0.	0.			0.
0483	AVIONICS			0.			0.	0.	0.			0.
0484	PROPULSION			0.			0.	0.	0.			0.
0485	AKS ASSY+C/O			0.			0.	0.	0.			0.
0490	DKS		0.			0.		0.	0.		0.	
0491	STRUCTURE			0.			0.	0.	0.			0.
0492	SRM			0.			0.	0.	0.			0.
0493	AVIONICS			0.			0.	0.	0.			0.
0494	PROPULSION			0.			0.	0.	0.			0.
0495	DKS ASSY+C/O			0.			0.	0.	0.			0.
04100	CACHE TANK		0.			0.		0.	0.		0.	
04101	STRUCTURE			0.			0.	0.	0.			0.
04102	THERM CONT			0.			0.	0.	0.			0.
04103	AVIONICS			0.			0.	0.	0.			0.
04104	PROPULSION			0.			0.	0.	0.			0.
04105	CACHE ASSY+C/O			0.			0.	0.	0.			0.
04110	FINAL ASSY + C/O		0.			0.		0.	0.		0.	
04111	FINAL ASSY			0.			0.	0.	0.			0.
04112	CHECKOUT			0.			0.	0.	0.			0.
0500	LOGISTICS	6330.			3672.				3672.			
0510	TRANSPORT+HANDLG		0.			1152.			1152.			
0520	TRAINING		6330.			1950.			1950.			
0521	SIM+EQUIPMENT			1950.			1950.		1950.			
0522	GROUND CREW			2180.			0.		0.			
0523	FLT OPS CREW			2200.			0.		0.			
0530	WAREHSG+INV CONT		0.			570.			570.			

S-9.8-II

MOORE BUSINESS FORMS, INC. NO. FORM 14212 PRINTED IN U.S.A.

310-38 SEP 73

WBS	LEVEL 4	5	6	4	5	6	INITIAL SPARES	1ST UNIT COST	4	5	6
	EXPECTED COST DDT+E			EXPECTED COST PRODUCTION					EXPECTED COST OPN SP/OPS		
0600 FACILITIES	7015.			688.					157.		
0610 MANUFACTURING		168.			145.					0.	
0611 DES/CONSTR			168.								
0612 ACT/MAINT			0.			145.					0.
0620 TEST		248.			48.					0.	
0621 DES/CONST			248.								
0622 ACT/MAINT			0.			48.					0.
0630 1ST TR MAINT+REF		2953.			0.					100.	
0631 DES/CONST			2953.								
0632 ACT/MAINT			0.			0.					100.
0640 ETR LAUNCH		475.			0.					31.	
0641 DES/CONST			475.								
0642 ACT/MAINT			0.			0.					31.
0650 2ND TR MAINT+REF		2648.			0.					0.	
0651 DES/CONST			2648.								
0652 ACT/MAINT			0.			0.					0.
0660 WTR LAUNCH		523.			495.					26.	
0661 DES/CONST			523.								
0662 ACT/MAINT			0.			495.					26.
0700 GSE	25780.			0.			0.		2240.		
0710 MFG GSE		2100.									
0711 HARDWARE											
0712 SITE ACT											
0713 MAINT											
0714 SOFTWARE											
0720 ETR GSE		17080.			0.		0.			600.	
0721 HARDWARE			14780.			0.	0.				
0722 SITE ACT			2300.								
0723 MAINT			0.								600.
0724 SOFTWARE			0.								
0730 WTR GSE		0.			0.		0.			1640.	
0731 HARDWARE			0.			0.	0.				
0732 SITE ACT			0.								
0733 MAINT			0.								1640.
0734 SOFTWARE			0.								

MOORE BUSINESS FORMS, INC. NYC FORM 14127 PRINTED IN U.S.A. 27

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WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0740	FL OP NASA		3300.			0.		0.			0.	
0741	HARDWARE			3300.			0.	0.				
0742	SITE ACT			0.								
0743	MAINT			0.								0.
0744	SOFTWARE			0.								
0750	FL OP DOD		3300.			0.		0.			0.	
0751	HARDWARE			3300.			0.	0.				
0752	SITE ACT			0.								
0753	MAINT			0.								0.
0754	SOFTWARE			0.								
0800	VEHICLE TEST	58525.										
0810	GND TEST HARDWARE		8558.									
0811	PTV/BATTLESHIP			2350.								
0812	MAJOR TST ART			5758.								
0813	MOCKUPS			450.								
0820	GND TEST OPS		10200.									
0830	FLT TEST HARDWARE		9147.									
0840	FLT TEST OPS		30620.									
0900	LAUNCH OPS WTR									434.		
0910	LAUNCH SITE SVC										0.	
0920	TUG/SHUTTLE MATG										0.	
0930	PRELAUNCH C/O										0.	
0940	COUNTDOWN										0.	
0950	FLUID+GASES										434.	
0960	POST FLT SAFING										0.	
1000	LAUNCH OPS ETR									5852.		
1010	LAUNCH SITE SVC										0.	
1020	TUG/SHUTTLE MATG										402.	
1030	PRELAUNCH C/O										780.	
1040	COUNTDOWN										24.	
1050	FLUID+GASES										3286.	
1060	POST FLT SAFING										1360.	
1100	FLT OPS DOD	2930								13700.		
1110	MISSION PLAN		1980								4580.	
1120	FLT CONT		610								5740.	
1130	FLT EVALUATION		340								660.	
1140	FLT SPT SOFTWARE										2720.	
1200	FLT OPS NASA	23450								24230.		
1210	MISSION PLAN		5220								7100.	
1220	FLT CONT		1190								5890.	
1230	FLT EVALUATION		320								630.	
1240	FLT SPT SOFTWARE		16720								10610.	

NOTE
THESE COSTS INCLUDED
IN VEHICLE TEST

V-8.6-7

MOORE BUSINESS FORMS, INC. NO FORM 1412T PRINTED IN U.S.A.

210-38 SEP 73

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
1300	REF+INT 1ST TR									12050.		
1310	SCHED MAINT+REF										10450.	
1320	UNSCHED MAINT+REF										0.	
1330	POST MAINT C/O										0.	
1340	TUG/PAYLOAD MATG										0.	
1350	REF RQMTS PLANNG										0.	
1360	DEPOT MAINT										1600.	
1400	REF+INT 2ND TR									11360.		
1410	SCHED MAINT+REF										1500.	
1420	UNSCHED MAINT+REF										1540.	
1430	POST MAINT C/O										500.	
1440	TUG/PAYLOAD MATG										800.	
1450	REF RQMTS PLANNG										120.	
1460	DEPOT MAINT										6900.	
	SPACE TUG TOTALS	254824.			42132.			4820.	14179.	87780.		
	32A= 254824.		32B=	46951.		32C=	87780.		32D=	389655.		

For Summary Plot 9/16

310-3B SEP 73

STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

DOTE (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	8.0	1.05	1.90	2.02	1.97	1.11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	9.7	1.26	2.28	2.42	2.37	1.33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	TUG MAIN STAGE	139.5	55.16	58.72	21.22	4.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	STRUCTURE	17.2	~~7.93~~ 3	~~7.54~~ 6	~~1.79~~ 5	~~0.03~~ 3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320	THERMAL INSUL	0.1	0.05	0.07	0.04	0.06	0.0 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
330	AVIONICS	39.9	~~12.03~~ 4	~~16.20~~ 14	~~8.05~~ 24	1.99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION	71.0	32.69 12	31.28 28	7.08 19	0.0 8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
350	INTERFACE	7.0	2.27	2.96	1.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
360	DROP TANK																	
370	FINAL ASSY	4.2	0.0	0.0	1.78	2.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	TUG AUX STAGE	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
410	STRUCTURE																	
420	THERMAL INSUL																	
430	AVIONICS																	
440	PROPULSION																	
450	INTERSTAGE																	
460	DROP TANK																	
470	RCM																	
480	AKS																	
490	DKS																	
4100	CACHE																	
4110	FINAL ASSY	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS	6.3	1.37	2.28	1.69	0.80	0.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600	FACILITIES	7.0	0.49	0.85	1.21	1.47	1.38	0.99	0.62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
610	MANUFACTURING	0.2	0.03	0.06	0.05	0.03	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
620	TEST	0.2	0.07	0.10	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
630	1ST MAIN/REF	3.0	0.38	0.70	0.74	0.72	0.41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
640	FTR LAUNCH	0.5	0.0	0.0	0.35	0.13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650	2ND MAIN/REF	2.6	0.0	0.0	0.0	0.49	0.81	0.83	0.52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
660	WTR LAUNCH	0.5	0.0	0.0	0.0	0.10	0.16	0.16	0.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	GNR SUPP EQUIP	25.8	8.87	8.91	3.96	4.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
710	MFG GSE	2.1	0.0	0.0	1.53	0.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
720	FTR GSE	17.1	7.86 3	7.52 3	1.70 8	0.0 3	0.0 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
730	WTR GSE																	
740	FLT OPS NASA	3.3	0.0	0.0	0.0	3.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
750	FLT OPS DOD	3.3	1.01	1.39	0.73	0.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800	VEHICLE TEST	58.5	2.91	7.61	19.06	~~37.53~~ 21	6.41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
810	GND TEST HWRE	8.6	1.59	2.61	2.68	1.68	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
820	GND TEST OPS	10.2	1.33	2.40	2.56	2.50	1.41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
830	FLT TEST HWRE	9.1	0.0	2.60	3.82	2.73	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
840	FLT TEST OPS	30.6	0.0	0.0	0.0	30.62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900	LAUNCH OPS WTR		-5	-2	+3	+3	+2											
1000	LAUNCH OPS FTR		-8	-3	+3	+4	+4											
1100	FLIGHT OPS DOD		-20	-3	+11	+3	+2											
1200	FLIGHT OPS NASA		-5	-5	+6	+10	+6											
1300	REF + INT TR-1		-38	-13	+10	-38	-14											
1400	REF + INT TR-2			14	33	-15 +5												
	TOTALS	254.8	71.11	82.55	41.58	52.55	5.42	0.99	0.62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			33	68	95	58	20	1	0									

IH2081 IPCOM - PROGRAM INTERRUPT (P) - UNDERFLOW OLD PSW IS FFA5000DA2084200 . REGISTER CONTAINED 7D6D800000000000

TRACEBACK	ROUTINE	CALLED FROM	ISN	REG. 14	REG. 15	REG. 0	REG. 1
	OUT		0058	62083638	000839F0	00000030	0007F840
	SPREAD		0593	52070C00	0007FA20	00000000	00072C58

II-8-6-19

MOORE BUSINESS FORMS, INC. NO FORM 1612T PRINTED IN U.S.A.

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310-39 SEP 73

STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

PROD (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	2.2	0.21	0.40	0.44	0.45	0.42	0.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	2.4	0.23	0.45	0.50	0.51	0.48	0.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	TUG MAIN STAGE	38.0	0.0	5.85	11.04	10.07	6.68	3.29	0.99	0.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	STRUCTURE	6.1	0.0	0.98	1.83	1.63	1.05	0.49	0.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320	THERMAL INSUL	0.6	0.0	0.10	0.18	0.16	0.10	0.05	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
330	AVIONICS	16.2	0.0	2.59	4.84	4.33	2.78	1.29	0.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION	8.4	0.0	1.34	2.51	2.24	1.44	0.67	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
350	INTERFACE	1.7	0.0	0.21	0.43	0.44	0.33	0.20	0.09	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
360	DROP TANK																	
370	FINAL ASSY	5.1	0.0	0.63	1.26	1.27	0.97	0.59	0.28	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	TUG AUX STAGE	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
410	STRUCTURE																	
420	THERMAL INSUL																	
430	AVIONICS																	
440	PROPULSION																	
450	INTERSTAGE																	
460	DROP TANK																	
470	RDM																	
480	AKS																	
490	DKS																	
4100	CACHE																	
4110	FINAL ASSY	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS	3.7	0.0	0.0	0.59	1.10	0.98	0.63	0.29	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600	FACILITIES	0.7	0.04	0.06	0.42	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
610	MANUFACTURING	0.1	0.03	0.04	0.05	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
620	TEST	0.0	0.01	0.02	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
630	1ST MAIN/REF																	
640	ETR LAUNCH																	
650	2ND MAIN/REF																	
660	WTR LAUNCH	0.5	0.0	0.0	0.36	0.13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	GND SUPP EQUIP																	
710	MFG GSE																	
720	ETR GSE																	
730	WTR GSE																	
740	FLT OPS NASA																	
750	FLT OPS DOD																	
800	VEHICLE TEST																	
810	GND TEST HWRE																	
820	GND TEST OPS																	
830	FLT TEST HWRE																	
840	FLT TEST OPS																	
900	LAUNCH OPS WTR																	
1000	LAUNCH OPS ETR																	
1100	FLIGHT OPS DOD																	
1200	FLIGHT OPS NASA																	
1300	REF + INT TR-1																	
1400	REF + INT TR-2																	
	TOTALS	47.0	0.48	6.77	13.00	12.30	8.56	4.39	1.28	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
						14	11	7	2									

II-8.6-10

ACCOR BUSINESS FORMS, INC. OHIO FORM 14121 PRINTED IN U.S.A.

310-38 SEP 73

STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

OPS (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	2.7	0.0	0.0	0.0	0.0	0.08	0.19	0.24	0.27	0.28	0.28	0.29	0.29	0.28	0.26	0.20	0.08
200	SYS ENG + INTEG	5.5	0.0	0.0	0.0	0.0	0.15	0.37	0.49	0.54	0.56	0.57	0.57	0.58	0.56	0.51	0.39	0.16
300	TUG MAIN STAGE	9.6	0.0	0.0	0.0	0.0	0.27	0.65	0.85	0.94	0.98	1.00	1.00	1.01	0.98	0.90	0.69	0.29
310	STRUCTURE	0.6	0.0	0.0	0.0	0.0	0.02	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.05	0.04	0.02
320	THERMAL INSUL	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
330	AVIONICS	6.7	0.0	0.0	0.0	0.0	0.19	0.46	0.60	0.66	0.69	0.70	0.70	0.71	0.69	0.63	0.48	0.20
340	PROPULSION	2.1	0.0	0.0	0.0	0.0	0.06	0.14	0.19	0.21	0.22	0.22	0.22	0.22	0.22	0.20	0.15	0.06
350	INTERFACE	0.2	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.00
360	DROP TANK																	
370	FINAL ASSY																	
400	TUG AUX STAGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
410	STRUCTURE																	
420	THERMAL INSUL																	
430	AVIONICS																	
440	PROPULSION																	
450	INTERSTAGE																	
460	DROP TANK																	
470	PDM																	
480	AKS																	
490	DKS																	
4100	CACHE																	
4110	FINAL ASSY																	
500	LOGISTICS																	
600	FACILITIES	0.2	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.00
610	MANUFACTURING																	
620	TEST																	
630	1ST MAIN/REF	0.1	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
640	ETR LAUNCH	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
650	2ND MAIN/REF																	
660	WTR LAUNCH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
700	GND SUPP EQUIP	2.2	0.0	0.0	0.0	0.01	0.04	0.11	0.20	0.24	0.26	0.26	0.27	0.26	0.25	0.21	0.11	0.02
710	MFG GSE																	
720	ETR GSE	0.6	0.0	0.0	0.0	0.01	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.04	0.02
730	WTR GSE	1.6	0.0	0.0	0.0	0.0	0.0	0.06	0.15	0.19	0.20	0.20	0.21	0.21	0.20	0.16	0.07	0.0
740	FLT OPS NASA																	
750	FLT OPS DOD																	
800	VEHICLE TEST																	
810	GND TEST HWRE																	
820	GND TEST OPS																	
830	FLT TEST HWRE																	
840	FLT TEST OPS																	
900	LAUNCH OPS WTR	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.02
1000	LAUNCH OPS ETR	5.9	0.0	0.0	0.0	0.0	0.17	0.40	0.52	0.58	0.60	0.61	0.62	0.62	0.60	0.55	0.42	0.18
1100	FLIGHT OPS DOD	13.7	0.0	0.0	9.98	3.72	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1200	FLIGHT OPS NASA	24.2	0.0	0.0	0.0	0.0	0.69	1.65	2.16	2.39	2.48	2.52	2.55	2.56	2.49	2.27	1.74	0.73
1300	REF + INT TR-1	12.0	0.0	0.0	0.0	0.0	0.34	0.82	1.07	1.19	1.24	1.25	1.27	1.27	1.24	1.13	0.87	0.36
1400	REF + INT TR-2	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.45	1.03	1.29	1.39	1.42	1.43	1.43	1.35	1.09	0.48
	TOTALS	87.8	0.0	0.0	9.98	3.74	1.73	4.19	6.01	7.24	7.76	7.96	8.05	8.09	7.92	7.24	5.56	2.31
							3	5	7	8	9	10	10	10	9	8	6	3

II-98

MOORE BUSINESS FORMS, INC. MO FORM 14117. PRINTED IN U.S.A. 23

SPACE TUG CHARACTERISTICS

310-3B→310ARE-3B

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	WEIGHT, LB	3212→3416	545/544
	LENGTH, IN	297	80/ 27
	DIAMETER, IN	120	180/120
TECHNICAL:	REUSABLE	ONE-STAGE	RDM
	AUXILIARY STAGE		AKS/RDM
	PAYLOAD RETRIEVAL	CAPABILITY	
	PROPELLANT CAPACITY, LB	59,500	
	THRUST, LB	12,000	
	ISP, SEC	338	287 & 295
	AUTONOMY LEVEL	IIIA→IIB	
	RELIABILITY	.97→.9750	.9987/.9824

WBS #320-00

GRUMMAN

MAIN STAGE CHARACTERISTICS

310-3B → 310ARE-3B

PHYSICAL:	WEIGHT, LB	3212 → 3416
	LENGTH, IN	297
	DIAMETER, IN	120
TECHNICAL:	REUSABLE SINGLE STAGE	
	PROPELLANT CAPABITY, LB	59,500
	PAYLOAD RETRIEVAL CAPABILITY	
	THRUST, LB	12,000
	ISP, SEC	338
	AUTONOMY LEVEL	IIIA → IIB
	RELIABILITY	.97 → .9750

WBS #320-03

GRUMMAN

VEHICLE TEST CHARACTERISTICS

310-3B→310ARE-3B

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	PROP. TEST ARTICLE	X	
	STRUCT. TEST ARTICEL	X	X
	INTEG. AVIONICS TEST	X	X
	MOCK-UPS	X	X
	FLIGHT TEST	X	X

TECHNICAL:
- PTA - COLD FLOW ONLY, NO HOT FIRING
- STA - ONE ART FOR DYNAMICS, STATIC & FATIGUE
- IAT - SOFTWARE & HARDWARE
- MOCK-UPS - WOOD AT PDR, WOOD/METAL AT CDR
- FLIGHT TEST - ONE WITHOUT P/L, EIGHT WITH P/L

WBS #320-08

GRUMMAN

STRUCTURAL CHARACTERISTICS

310-3B → 310ARE-3B

PHYSICAL:	WEIGHT, LB	1233 → 1286
	LENGTH, IN	297
	DIAMETER, IN	120
TECHNICAL:	TANK CONFIGURATION	NESTED DOME
	TANK CAPACITY, LB	59,500
	MATERIAL	Ti, COMPOSITE H'COMB
	RELIABILITY ALLOCATION	.99900

WBS #320-03-01

GRUMMAN

CONFIGURATION 310-3B

WBS NO. 320-03-01

SUBSYSTEM/COMPONENT STRUCTURE

DATE: 7/17/[illegible]

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS	RELIABILITY: MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TEST	NOTES
01-Fuel Tanks and Supports	1	44½		Titan.	255	90	120	DIA		Welded Gore Titanium Domes	20	1		2	Tank Leakage Considered Unserviceable
02-Oxid. Tank and Supports	1	44½		Titan.	167	100	120	DIA		Weld Gore Titanium Domes	20	1		2	
03-Body Structure	1	44½		Alum. and Comp.	625	145	120	DIA		Graphite Composite Honeycomb Shell Aluminum Frames	N/A	1		2	Includes Equipment Mounting and Umbilicals
04-Thrust Struct.	1	44½		Alum.	85	35	120 MAX	DIA		Aluminum Stiffened Sheet	N/A	1		2	
05-Meteoroid Shield	1	44½		Alum.	26	87	126	DIA		Aluminum Sheet	N/A	1	1		
06-Interface	1	46		Alum.	75					Aluminum Machinings and Forgings	N/A	1		2	

GRUMMAN

THERMAL CONTROL CHARACTERISTICS

310-3B→310ARE-3B

PHYSICAL: WEIGHT, LB 89

500 FT^2 GOLDIZED MYLAR MLI

AL BASE HEAT SHIELD

SILVER BACKED TEFLON & ALZAK COATINGS

WBS #320-03-02

GRUMMAN

II-8.6-17

CONFIGURATION 310-3B

WBS NO. 320-03-02-01.02

SUBSYSTEM/COMPONENT THERMAL CONTROL

DATE: 8/30/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
THERMAL CONTROL COATINGS	5	0		SBT ALZAK ALCLINE	9		1500	ft²		0				1			
MULTILAYER INSULATION	3	6		Sec Mini Spec	16		500	ft²		0				1			
FUEL CELL RADIATOR	2	12		Sec Mini Spec	17.5		22 ft²							1			INCLUDES CARROUSEL IMO
~~AVIONICS HEAT PIPE RADIATOR~~	2	12		Sec Mini Spec						0							
AVIONICS HEATERS	4	6		Sec Mini Spec	2					75/unit				8			COX & COMPANY, NY, NY.
APS HEATERS*	4	6		Sec Mini Spec	4					20/unit				16			
FUSE HEAT SHIELD	5	0		AL	14		90 ft²			0							IDENTICAL TO MICROMETEROID SHIELD
PLUMBING	5	0		AL	2												

*CARRIED IN APS WT.

AVIONICS CHARACTERISTICS

		310-3B → 310ARE-3B
PHYSICAL:	WEIGHT, LB	673 → 768
TECHNICAL:	AUTONOMY LEVEL	IIIA → IIB
	RENDEZVOUS & DOCKING	→ LASER RADAR
	COMMUNICATIONS	DFS → DFS/CSS
	COMPUTER CAPACITY	48K → 65K WORDS
	FUEL CELL POWER	2.5 KW
	RELIABILITY ALLOCATION	.97912 → .98454

WBS #320-03-03

GRUMMAN

PEV A

AUTONOMY LEVEL IIIA | CORE CONFIGURATION ~~[illegible]~~ 310-3B | WBS NO. 320-03-02-01 | SUBSYSTEM/COMPONENT DMS | DATE: 6/7/72

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES: VENDOR
MAIN STAGE COMPUTER	4	12			13	4.7	5	8.6*	202*	36	48K WORDS - 16 BITS/WORD (PWR REQ, SIZED FOR 65K)*	144	18K	2	N/A	1	CDC 469
TAPE RECORDER	5	12	AF/S-3 NIMBUS E		14.5	9	12	5.4	580	8		108	12K	1	N/A	1	ODETICS DDS 3000
FSI CONTROLLER/ TLM FORM.	4	8	SHUTTLE		18	8	6	16	640	23		144	12K	1	N/A	1	RADIATION
DACU'S	4	8	"		7	7	4	13	364	21	256 CHANNELS	144	12K	3	N/A	1	"
SENSORS	4	8	"		0.2	N/A	N/A	N/A	N/A	0.1			1M	180 (A)	N/A	10	WHITTAKER TRANSONICS

* EVOLUTION FROM AUTONOMY LEVEL IIIA TO LEVEL IIB WILL REQUIRE INCREASING THE COMPUTER CAPACITY TO 65K WORDS THUS A VOLUME OF 4.7 x 5 x 10.4 (244 CU. IN.) SHOULD BE RESERVED FOR THE COMPUTER TO ALLOW FOR THIS GROWTH

GRUMMAN

CONFIGURATION 310-38 WBS NO. 320-03-03-02

AUTHORITY LEVEL IIIA SUBSYSTEM/COMPONENT GN&C

REV. B 8-31-72
REV. A 8-16-72
DATE: 8-10-72

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR G/G TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
INERTIAL MEASURING UNIT	4	12	TITAN IIIC		45	24	12	12.5	3600	125				1			
STAR TRACKER	1	24	SHUTTLE		17	15	6 DIA.		424	28				1			DOES NOT INCLUDE SUNSHADE (1 LB)
APS CONTROL ELECTRONICS	1	24	–		18	10	10	5	500	13				2			
ME/TVC CONTROL ELECTRONICS	1	24	–		10	10	10	3.5	350	15				1			
RATE GYRO UNIT	4	12			5	4	4	2	32	25				1			

GRUMMAN
REPORT
DATE
CODE 20012

CONFIGURATION 310-3B

WBS NO. 320-03-03-03

SUBSYSTEM/COMPONENT COMMUNICATIONS

9-5-73

DATE: 8/7/93

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE (EACH) LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE (EACH) WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE (EACH) HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (EACH) (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS: [illegible]	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
2. S-Band X'CEIVER / X POWER — R'CVR (4)					4X4	7	9	5	315	8	Spread Spectrum						
X'MTR (1)		24			1X5	7	8	5	280	34	CCIR Interference STDN/SGLS Compatible			1			
3. AUX. X'MTR		20			5	7	8	5	280	34	Same as (2) above			1			
4. POWER AMP.		9			1	3	5	2	30	20	R.F. output of 5W			2			
7. DIPLEXER		9			1	2	7	3	63	—	—			2			
9. ANTENNA SWITCH		9			1	3	3	4	36	1	—			1			
14. BASEBAND PROCESSOR		24			3	3	3	2	18	2	Same as (2) above			1			
10. OMNI ANT.		9			.5	3	6	1	18	—	—			2			
15. SECURE COMM.		—			6	9	5	4	180	8	—			2			DOD ONLY - GFE

CONFIGURATION 310-38 --- ~~B10A~~ ~~38~~ ~~TIME~~ LEVEL OF AUTONOMY

WBS NO. 320-03-03-05 6-06

SUBSYSTEM/COMPONENT ELECTRICAL POWER SUBSYSTEM

DATE: 8-27-73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR G/G TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
• MODIFIED SHUTTLE FUEL CELL ASSY	3	30	SHUTTLE	ST. STEEL PLAT	90	25	15	15	5620		2.5 KW @ 28V; ___ WATT AVG. LOAD OVER 117 HRS.	144	25000	1	-	1	REQUIRES AUTO SPACE START-UP SELLERS: PGWA or GE
• EMERGENCY BATTERY	5	6		Ag-Zn-Mg	15	9	5	4.5	200		10 AMP-HR RATED CAPACITY, 17 AMP DISCHARGE OVER 0.5 HR	0.5	30,000	1	-	1	SECONDARY SILVER-ZINC BATTERY SELLER: EAGLE-PICHER
• CRYO HYDROGEN TANK ASSY	3	24	GEMINI APOLLO SHUTTLE	T1-Inner T2-Outer	69	21" 24"	ID OD		7250		250 PSIA - OPERATING PRESS 350 PSIA - MAX PRESSURE. 11.5 LB FLUID CAPACITY	144		1	-	1	SELLER: AiResearch, Beech, Bendix
• CRYO OXYGEN TANK ASSY	3	24	GEMINI APOLLO SHUTTLE	Inc. .718 Inn Inc. .750 Out	71	16½ 19½	ID OD		3900		900 PSIA - OPERATING PRESS 1000 PSIA - MAX. " 92.5 LB FLUID CAPACITY	144		1	-	1	SELLER: AiResearch, Beech, Bendix
• VEHICLE WIRING	5		LM		53						6ga, 14ga, 16ga, 20 & 26 ga	144		SHIP SET		SHIP SET	~10,000 FT OF ASSORTED SIZES
• CONNECTORS	5		LM		30						ASSORTED SIZES	144		"		"	~120 MATED PAIRS
• SUNDRIES (-CLAMPS -TAPE)	5		LM		20						" "	144		"		"	
• SOLID STATE POWER CONTROL	5		-		21						90 @ 2 AMP 17 @ 5 AMP 60 @ 3 AMP	144		"		"	2 oz EACH; SELLER: LEACH CORP
• ELECTRO-MECH RCCB	5		LM		9						2 @ 20 AMP 10 @ 10 AMP	144		"		"	0.75 LB EACH; SELLER CUTLER-HAMMER

PROPULSION CHARACTERISTICS

310-3B → 310ARE-3B

		MAIN PROP.	AUXILIARY PROP.
PHYSICAL:	WEIGHT, LB	550	150 → 188
	ENGINE/THRUSTER	CLASS I	REA 19
	NO. OF ENGINES/THRUSTERS	1	16 → 24
TECHNICAL:	FUEL LOAD, LB	20,517	349 → 495
	OXIDIZER LOAD, LB	38,983	--
	THRUST, LB	12,000	25
	ISP - STEADY STATE	338	232
	- PULSING	--	170
	RELIABILITY ALLOCATION	.99259	.99915 → .99882

WBS #320-03-04

GRUMMAN

CONFIGURATION 310-3C/310 ACE-3B

WBS NO. 320-03-04, 320-03-04-01, 320-03-04-02

SUBSYSTEM/~~COMPONENT~~ Main Prop

REV. [illegible]/73

DATE: 6/[illegible]/73

MAJOR COMPONENT	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH/DIA. (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
																LEGEND: OTS - Off the shelf design; ME - Modified existing design; N - New design
Ox Fro-Vlv.	4	16	OMS		6.5		3 1/4		60	32 Watts	165	400K	1	1	1	ME - Size increase from 1 1/2" D. (OMS Pu[illegible] Fuel Vlv)
Fu Fro-Vlv.	4	16	OMS		5		2		42	32 Watts	165	400K	1	1	1	ME - Size increase from 1 1/2" D. (OMS Pu[illegible] Fuel Vlv)
Ox F/D QD	4	16	OMS		1.5		2		36		165	500K	1/2	1/2	1/2	ME - Size increase from 1 1/2" D.
Fu F/D QD	4	16	OMS		1.5		2		36		165	500K	1/2	1/2	1/2	ME - Size increase from 1 1/2" D.
Ox F/D QD	4	16	OMS		1		1		12		144	40K	1/2	1/2	1/2	ME - Size increase from 3/4" D.
Fu F/D QD	4	16	OMS		1		1		12		144	40K	1/2	1/2	1/2	ME - Size increase from 3/4" D.
He F/D QD	5	10	OMS		3		5/8		9		156	500K	1/2	1/2	1/2	OTS
Ox F/D Vlv.	5	10	OMS		5		2		12	32 Watts	144	400K	1	1	1	OTS - OMS Dump Valve
Fu F/D Vlv.	5	10	OMS		5		2		12	32 Watts	144	400K	1	1	1	OTS - OMS Dump Valve
He F/D Vlv.	4	16	OMS		5		5/8		24	84 Watts	144	67K	1	1	1	ME - Size increase from 1/2" D. (OMS Eng. Purge Vlv
He Iso. Vlv.	5	10	LM		2		1/2		16	84 Watts	156	133K	2	1	2	OTS - APS/DPS Latching Sol. Vlv.
He Reg	5	16	OMS		5		1/2		80		156	10^6	1	1	1	ME - Reduced press. setting, single stage
Ox/Fu Reg	5	16	OMS		5		1/2		80		156	10^6	1	1	1	ME - Reduced press. setting, single stage
Ox Burst Dis.	5	16	OMS		1.5		5/8		28		168	10^6	1	1	1	ME - Reduced relief setting
Fu Burst Dis.	5	16	OMS		1.5		5/8		28		168	10^6	1	1	1	ME - Reduced relief setting
Ox Relief Vl.	5	16	OMS		1.5		5/8		20		168	10^6	1	1	1	ME - Reduced relief setting
Fu Relief Vlv	5	16	OMS		1.5		5/8		20		168	10^6	1	1	1	ME - Reduced relief setting
Ox Ck Vlv.	5	10	SPS		3.6		3/4		50		156	10^6	1	1	1	OTS
Fu Ck Vlv.	5	10	SPS		3.6		3/4		50		156	10^6	1	1	1	OTS
Ox Vent Vlv	4	16	OMS		5		5/8		24	84 Watts	168	67K	2	1	2	ME - Size increase from 1/2" D. (OMS Eng. Purge Vlv
Fu Vent Vlv	4	16	OMS		5		5/8		24	84 Watts	165	67K	2	1	2	ME - Size increase from 1/2" D (OMS Eng. Purge Vlv
Ox Lo-level Sensor	5	16	Titan		2	3	1		2.5	2 Watts	144	TBD	1	1	1	ME - Modified mounting
Fu Lo-level Sensor	5	16	Titan		2	3	1		2.5	2 Watts	144	TBD	1	1	1	ME - Modified mounting
Ox Flex Joints	5	10	OMS		0.6		2		36		168		3	1	3	OTS
Fu Flex Joints	5	10	OMS		0.6		2		36		168		5	1	5	OTS
Ox OMS Drain Vlv.	5	10	OMS		5		1/2		24	84 Watts	144	67K	1	1	1	OTS - OMS Eng. Purge Vlv.
Fu OMS Drain Vlv.	5	10	OMS		5		1/2		24	84 Watts	144	67K	1	1	1	OTS - OMS Eng. Purge Vlv.

GRUMMAN

REPORT
DATE
CODE 20912

CONFIGURATION 310-3B/310ARE-3B

WBS NO. 320-03 01, 320-03-01-01, 320-03-01-02

SUBSYSTEM/COMPONENT Main Prop.

REV. 7/12/73

DATE: 8/21/73

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MOVING TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH/DIA. (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR 6 MO TEST	EQUIVALENT UNITS FOR MAJOR GND TEST	
He Tank	1	22	—		11.5		23.6		5700		156	10^6	2	1	2	N- PFR design
Main Eng.	1	54	—		266	116	56		280K	170 Watts, 12,000 lb	6	115K	1	17	—	N- Class I
Power Act	4	15	LM		2.5	5.25	3	1.5	78	90 Watts	10	20K	2	1	—	ME- Increased strength for higher thrust
Oxi Horiz Drain Vlv	4	16	OMS		4		1			32 Watts	144	100K	1	1	1	ME- Size decrease from 1½" D (OMS crossfeed valve)
Fu Horiz Drain Vlv	4	16	OMS		4		1			32 Watts	144	100K	1	1	1	ME- Size decrease from 1½" D (OMS crossfeed valve)

DRUMMAN

REPORT
DATE
COLL 2691-2

CONFIGURATION 310-3B/310ARE-3B — WBS NO. 320-03-04, 320-03-04-01, 320-03-04-02 — SUBSYSTEM/COMPONENT Main Prop. — DATE: 8/21/72

MAJOR COMPONENT	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	WIDTH/DIA (INCHES)	HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	RELIABILITY: EQUIVALENT OPERATING HOURS	MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
ADAPTER EQUIPMENT																
Ox F/D QD	4	16	OMS		2.5		2		36		168	500K	1/2	1/2	1/2	ME - Size increase from 1½"D
Fu F/D QD	4	16	OMS		2.5		2		36		168	500K	1/2	1/2	1/2	ME - Size increase from 1½"D
Ox F/V QD	4	16	OMS		2		1		12		144	40K	1/2	1/2	1/2	ME - Size increase from 3/4"D
Fu F/V QD	4	16	OMS		2		1		12		144	40K	1/2	1/2	1/2	ME - Size increase from 3/4"D
He F/D QD	5	10	OMS		4		5/8		9		156	500K	1/2	1/2	1/2	OTS
Panel Act.	1	18	—		2				10	30 Watts	10	20K	4	1	4	N
Ox Flex Joint	5	10	OMS		0.6		2		36		144		2	1	2	OTS
Fu Flex Joint	5	10	OMS		0.6		2		36		144		2	1	2	OTS
SHUTTLE EQUIPMENT																
Ox F/D QD	4	16	OMS		1.5		2		36		168	500K	1/2	—	—	Same as Tug hardware.
Fu F/D QD	4	16	OMS		1.5		2		36		168	500K	1/2	—	—	
Ox F/V QD	4	16	OMS		1		1		12		144	40K	1/2	—	—	
Fu F/V QD	4	16	OMS		1		1		12		144	40K	1/2	—	—	
He F/D QD	5	10	OMS		3		5/3		9		156	500K	1/2	—	—	
Ox Flex Joint	5	10	OMS		0.6		2		36		144		1	—	—	
Fu Flex Joint	5	10	OMS		0.6		2		36		144		1	—	—	

"Ground half of Tug [illegible]"

CONFIGURATION [redacted] 310-33 [redacted]

WBS NO. 3.0-03-04-03; 3.0-03-04-04

SUBSYSTEM/COMPONENT Auxiliary Propulsion System (APS)

DATE: 5/1/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR TEST	PROGRAMATIC: [illegible]	NOTES
																	GENERAL NOTES: TANKAGE ORIENTED ON USABLE PROPELLANT OF 317 LB PLUS 10% CONTINGENCY
HELIUM TANK	5	≤12	–		16.1	15.3	15.3	15.3	1695	–	BURST PRESS = 5200 OPERATING = 3600	TBD	10^6	1			AIRITE P/N 6660-1
HELIUM FILTER	5	≤12	LM		0.5					–				1			LSC 310-303-3 (VACCO VLV)
HELIUM LATCHING SOLENOID VALVE	4	≤12	LM		2.3					54			1.3×10^6	2			LSC 270-713 (A/C MFG)
REGULATOR, DUAL STAGE	5	≤12	LM		2.5					–			1.3×10^6	1			LSC 310-305-3 (FAIRCHILD INTERNATIONAL)
REGULATOR, SINGLE STAGE	4	≤12	–		1.5					–			1.3×10^6	1			MOD TO DUAL STAGE REG.
DUAL CHECK VALVE	5	≤12	LM		0.7					–	PROOF PRESSURE = 600		2000	1			MOD TO LSC 310-306 (ARCCO VALVE)
SAFETY DISC/RELIEF VALVE	4	≤12	–		1.5					–	RELIEF PRESS = 400		10^6/STA	1			MOD TO LSC 310-307 (VACCO)
FILL VALVE	3	18	–		2.0					70	PROOF PRESSURE = 600		67000	3			SIMILAR TO LSC 310-403 (ALCOR) UNIDIRECTIONAL FLOW CAPS, HIGHER OPERATING PRESSURE.
PROPELLANT TANKS	4	≤12	LM		10.5		12.50	× 34	3420	–	BURST PRESSURE = 650		10^6	3			MODIFIED LM ECS FUEL TANK WITH ELASTOMERIC BLADDERS. TANK WT. INCLUDES BLADDERS
PROPELLANT BLADDERS	2	24	–	EPT 10 CUSTOM	–					–				3			
PROPELLANT FILTER	5	≤12	–		0.5					–				1			
THRUSTER ISOLATION VALVE	3	18	–		2.0					70	PROOF PRESSURE = 600 PSI		67000	8			SAME VALVE AS VENT VALVE; SAME NOTES APPLY.
THRUSTERS	4	≤12	–		2.1	11.4	2.7			24	25 LB THRUST @ 325 PSI INLET, STEADY STATE I_{sp} = 232		1.5×10^6	16			DEA 19-5 (HAMILTON STANDARD)
THRUSTER HEATERS	5	≤12	–		0.2					3.5	MAINTAIN CATALYST BEDS AT 150°F.			16			SUBMITTED FOR PRICING BY TRICHO
QUICK DISCONNECTS	5	≤12	–		0.5					–				3			HE FILL & DRAIN; PROP FILL & DRAIN; PROP FILL & VENT.

ONE SHIPSET

NONE

8C-9-3-II

ORBITER INTERFACE CHARACTERISTICS

310-3B → 310ARE-3B

PHYSICAL:	WEIGHT, LB	1186
TECHNICAL:	MATERIAL	ALUMINUM
	PIVOT TYPE ADAPTER/DOCKING MECHANISM	
	SERVICE PANELS	GROUND POWER
		INSTRUMENTATION
		ON-PAD EMERGENCY DUMP
		HORIZONTAL PROP. DRAIN
		FUEL CELL REACTANT FILL

WBS #320-03-05

GRUMMAN

CONFIGURATION 310-3B

WBS NO. 320-03-05-01

SUBSYSTEM/COMPONENT ORBITER INTERFACE STRUCT. DATE: 9/17/7

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC				NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TEST		
01-Rear Adapter	1	44½		Alum.	652	132	120	D		Aluminum Stiffened Sheet and Machinings	N/A			1		Pivot Type Adapter
01-Fwd Frame	1	44½		Alum.	438					Aluminum Trusses and Machinings	N/A			1		
01-Docking Mechanism	1	46		Alum.	96					Aluminum Machinings and Forgings	N/A			1		

GRUMMAN

EVOLVED TUG

CONCEPT 310-3B/310ARE-3B (COMBINED

OPTION 3

310-38/310ARE-38 SEP 73 COMBINED

STORABLE SPACE TUG SYSTEM PROJECT

EXPECTED COST - SPARES COST(INT + OPS) - FIRST UNIT COST

(COSTS IN 1973 CONSTANT DOLLARS (000))

WBS	EXPECTED COST DDT+E			EXPECTED COST PRODUCTION			INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS		
LEVEL	4	5	6	4	5	6			4	5	6
0100 PROJECT MGMT	13213.			12755.				2052.	5466.		
0110 COST/PERF MGMT		1982.			1913.			308.		1822.	
0120 PROJECT DIRECTION		10174.			9821.			1580.		1822.	
0130 INFO MGMT		1057.			1020.			164.		1822.	
0200 SYS ENG + INTEGR	15656.			14349.				2308.	10936.		
0210 TUG SYS ENG		12685.						0.		2734.	
0220 SHUTTLE INTERFACE		1586.						0.		2734.	
0230 PAYLOAD INTERFACE		1586.						0.		2734.	
0240 SUST ENG					0.			2308.		2734.	
0300 TUG VEH MAIN STAGE	168459.			137040.			10441.	23352.	19913.		
0310 STRUCTURES		18982.			19689.		1969.	3563.		1969.	
0311 FUEL TNK+SPRT			5651.			6290.	629.	1156.			629.
0312 OX TANK +SPRT			6817.			7387.	739.	1358.			739.
0313 BODY STRUCT			2517.			2794.	279.	512.			279.
0314 THRUST STRUCT			480.			364.	36.	67.			36.
0315 METEOROID SHLD			143.			134.	13.	25.			13.
0316 PAYLOAD INTFCE			3374.			2720.	272.	445.			272.
0317 INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0320 THERMAL INSULTN		149.			1914.		94.	352.		94.	
0321 FUEL TANK INSUL			57.			938.	94.	172.			94.
0322 OX TANK INSUL			92.			976.	0.	179.			0.
0323 PURGE SYS INSUL			0.			0.	0.	0.			0.
0324 CONT SYS			0.			0.	0.	0.			0.
0325 INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0330 AVIONICS		60611.			59904.		6092.	7531.		13398.	
0331 DATA MGMT			6480.			10494.	1432.	1376.			3450.
0332 G N + C			26720.			29371.	2814.	3605.			6216.
0333 COMMUNICATIONS			9128.			10634.	776.	1230.			1592.
0334 INSTRUMENTATION			0.			0.	0.	0.			0.
0335 ELEC PWR			17091.			5989.	1070.	864.			2140.
0336 PWR DIST + CONT			1193.			3416.	0.	455.			0.
0337 INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0340 PROPULSION		71049.			29424.		2066.	4098.		4232.	
0341 MAIN ENGINE			59000.			9796.	1874.	1600.			3760.
0342 MAIN ENGINE SPT			7563.			6320.	0.	845.			0.
0343 ACPS ENGINE			3000.			7709.	192.	940.			472.
0344 ACPS ENGINE SPT			1486.			5599.	0.	714.			0.
0345 INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0350 ORBITER INTERFACE		6981.			2205.		220.	1246.		220.	
0351 STRUCTURE			4900.			941.	94.	532.			94.
0352 INTERFACE PNLS			2081.			1263.	126.	714.			126.
0353 PURGE PROVISION			0.			0.	0.	0.			0.
0354 ABORT PROVISION			0.			0.	0.	0.			0.
0355 INSTL.ASSY+C/O			0.			0.	0.	0.			0.

MOORE BUSINESS FORMS, INC. OHIO FORM 14121 PRINTED IN U.S.A.

310-38/310ARE-38 SEP 73 COMBINED

WBS		EXPECTED COST DDT+E			EXPECTED COST PRODUCTION			INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS		
	LEVEL	4	5	6	4	5	6			4	5	6
0360	DROP TANKS		0.			3000.		0.	3000.		0.	
0361	STRUCTURES			0.			3000.	0.	3000.			0.
0362	THERMAL INSUL			0.			0.	0.	0.			0.
0363	PROP SPRT SYS			0.			0.	0.	0.			0.
0364	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0370	FINAL ASSY + C/O		10687.			20904.		0.	3562.		0.	
0371	FINAL ASSY			10687.			20904.	0.	3562.			0.
0372	CHECKOUT			0.			0.	0.	0.			0.
0400	TUG VEH AUX STAGE	22676.			34002.			1067.	3895.	1067.		
0410	STRUCTURES		0.			1.		0.	0.		0.	
0411	FUEL TNK+SPRT			0.			0.	0.	0.			0.
0412	OX TANK+SPRT			0.			1.	0.	0.			0.
0413	BODY STRUCT			0.			0.	0.	0.			0.
0414	THRUST STRUCT			0.			0.	0.	0.			0.
0415	METEOROID SHLD			0.			0.	0.	0.			0.
0416	PAYLOAD INTERFC			0.			0.	0.	0.			0.
0417	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0420	THERMAL INSUL		0.			0.		0.	0.		0.	
0421	FUEL TANK INSUL			0.			0.	0.	0.			0.
0422	OX TANK INSUL			0.			0.	0.	0.			0.
0423	PURGE SYS INSUL			0.			0.	0.	0.			0.
0424	CONT SYS			0.			0.	0.	0.			0.
0425	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0430	AVIONICS		0.			0.		0.	0.		0.	
0431	DATA MGMT			0.			0.	0.	0.			0.
0432	G N + C			0.			0.	0.	0.			0.
0433	COMMUNICATIONS			0.			0.	0.	0.			0.
0434	INSTRUMENTATION			0.			0.	0.	0.			0.
0435	ELEC PWR			0.			0.	0.	0.			0.
0436	PWR DIST + CONT			0.			0.	0.	0.			0.
0437	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0440	PROPULSION		0.			0.		0.	0.		0.	
0441	MAIN ENGINE			0.			0.	0.	0.			0.
0442	MAIN ENGINE SPT			0.			0.	0.	0.			0.
0443	ACPS ENGINE			0.			0.	0.	0.			0.
0444	ACPS ENGINE SPT			0.			0.	0.	0.			0.
0445	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0450	INTERSTAGE INTRFC		0.			0.		0.	0.		0.	
0451	STRUCTURE			0.			0.	0.	0.			0.
0452	SEP SYS			0.			0.	0.	0.			0.
0453	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0460	DROP TANK		0.			0.		0.	0.		0.	
0461	STRUCTURE			0.			0.	0.	0.			0.
0462	THERMAL INSUL			0.			0.	0.	0.			0.
0463	PROP SPT SYS			0.			0.	0.	0.			0.
0464	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0470	RCM		9589.			3416.		152.	1346.		152.	

310-38/310ARE-38 SEP 73 COMBINED

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0471	STRUCTURE			4480.			883.	33.	348.			33.
0472	THERM CONT			0.			0.	0.	0.			0.
0473	AVIONICS			2843.			1816.	107.	716.			107.
0474	PROPULSION			228.			195.	12.	77.			12.
0475	RDM ASSY+C/O			2039.			521.	0.	205.			0.
0480	AKS		11461.			11137.		692.	1289.		692.	
0481	STRUCTURE			4950.			2857.	117.	374.			117.
0482	SRM			1360.			1812.	249.	68.			249.
0483	AVIONICS			2500.			4378.	287.	573.			287.
0484	PROPULSION			214.			588.	39.	77.			39.
0485	AKS ASSY+C/O			2437.			1502.	0.	197.			0.
0490	DKS		1626.			19447.		223.	1260.		223.	
0491	STRUCTURE			0.			5027.	44.	352.			44.
0492	SRM			1280.			2393.	49.	66.			49.
0493	AVIONICS			0.			8183.	115.	573.			115.
0494	PROPULSION			0.			1100.	15.	77.			15.
0495	DKS ASSY+C/O			346.			2745.	0.	192.			0.
04100	CACHE TANK		0.			0.		0.	0.		0.	
04101	STRUCTURE			0.			0.	0.	0.			0.
04102	THERM CONT			0.			0.	0.	0.			0.
04103	AVIONICS			0.			0.	0.	0.			0.
04104	PROPULSION			0.			0.	0.	0.			0.
04105	CACHE ASSY+C/O			0.			0.	0.	0.			0.
04110	FINAL ASSY + C/O		0.			0.		0.	0.		0.	
04111	FINAL ASSY			0.			0.	0.	0.			0.
04112	CHECKOUT			0.			0.	0.	0.			0.
0500	LOGISTICS	6430.			8280.				6952.			
0510	TRANSPORT+HANDLG		0.			1152.			1152.			
0520	TRAINING		6430.			3478.			2150.			
0521	SIM+EQUIPMENT			1950.			1950.		1950.			
0522	GROUND CREW			2180.			0.		0.			
0523	FLT OPS CREW			2300.			1528.		200.			
0530	WAREHSG+INV CONT		0.			3650.			3650.			

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MOORE BUSINESS FORMS, INC., NO. FORM 1412T PRINTED IN U.S.A.

310-3B/310ARE-3B SEP 73 COMBINED

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0600	FACILITIES	7136.			868.					1013.		
0610	MANUFACTURING		168.			281.					0.	
0611	DES/CONSTR			168.								
0612	ACT/MAINT			0.			281.					0.
0620	TEST		248.			92.					0.	
0621	DES/CONST			248.								
0622	ACT/MAINT			0.			92.					0.
0630	1ST TR MAINT+REF		3046.			0.					495.	
0631	DES/CONST			3046.								
0632	ACT/MAINT			0.			0.					495.
0640	ETR LAUNCH		475.			0.					133.	
0641	DES/CONST			475.								
0642	ACT/MAINT			0.			0.					133.
0650	2ND TR MAINT+REF		2648.			0.					252.	
0651	DES/CONST			2648.								
0652	ACT/MAINT			0.			0.					252.
0660	WTR LAUNCH		551.			495.					133.	
0661	DES/CONST			551.								
0662	ACT/MAINT			0.			495.					133.
0700	GSE	26430.			2910.			1018.		4970.		
0710	MFG GSE		2100.									
0711	HARDWARE											
0712	SITE ACT											
0713	MAINT											
0714	SOFTWARE											
0720	ETR GSE		17730.			0.		0.			2140.	
0721	HARDWARE			15430.			0.	0.				
0722	SITE ACT			2300.								
0723	MAINT			0.								2140.
0724	SOFTWARE			0.								
0730	WTR GSE		0.			2910.		1018.			2830.	
0731	HARDWARE			0.			2910.	1018.				
0732	SITE ACT			0.								
0733	MAINT			0.								2830.
0734	SOFTWARE			0.								

MOORE BUSINESS FORMS INC., PO FORM 1412T PRINTED IN U.S.A. 22

310-38/310ARE-38 SEP 73 COMBINED

WBS	LEVEL 4	5	6	4	5	6	4	5	6
		EXPECTED COST DDT+E			EXPECTED COST PRODUCTION		INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS
0740 FL OP NASA		3300.			0.		0.		0.
0741 HARDWARE			3300.			0.	0.		
0742 SITE ACT			0.						
0743 MAINT			0.						0.
0744 SOFTWARE			0.						
0750 FL OP DOD		3300.			0.		0.		0.
0751 HARDWARE			3300.			0.	0.		
0752 SITE ACT			0.						
0753 MAINT			0.						0.
0754 SOFTWARE			0.						
0800 VEHICLE TEST	85930.								
0810 GND TEST HARDWARE		12289.							
0811 PTV/RATTLESHIP			2350.						
0812 MAJOR TST ART			9439.						
0813 MOCKUPS			500.						
0820 GND TEST OPS		14240.							
0830 FLT TEST HARDWARE		13041.							
0840 FLT TEST OPS		46360.							
0900 LAUNCH OPS WTR							7662.		
0910 LAUNCH SITE SVC									0.
0920 TUG/SHUTTLE MATG									608.
0930 PRELAUNCH C/O									1260.
0940 COUNTDOWN									40.
0950 FLUID+GASES									3534.
0960 POST FLT SAFING									2220.
1000 LAUNCH OPS ETR							32422.		
1010 LAUNCH SITE SVC									0.
1020 TUG/SHUTTLE MATG									2162.
1030 PRELAUNCH C/O									4320.
1040 COUNTDOWN									124.
1050 FLUID+GASES									19096.
1060 POST FLT SAFING									6720.
1100 FLT OPS DOD	4360						84350.		
1110 MISSION PLAN		3130							15580.
1120 FLT CONT		730							19300.
1130 FLT EVALUATION		500							2590.
1140 FLT SPT SOFTWARE									16880.
1200 FLT OPS NASA	35210						83390.		
1210 MISSION PLAN		8230							22380.
1220 FLT CONT		1440							24040.
1230 FLT EVALUATION		470							2830.
1240 FLT SPT SOFTWARE		25070							34140.

310-38/310ARE-38 SEP 73 COMBINED

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
1300	REF+INT 1ST TR									30330.		
1310	SCHED MAINT+REF										12850.	
1320	UNSCHED MAINT+REF										2540.	
1330	POST MAINT C/O										820.	
1340	TUG/PAYLOAD MATG										1320.	
1350	REF RQMTS PLANNG										200.	
1360	DEPOT MAINT										12600.	
1400	REF+INT 2ND TR									40820.		
1410	SCHED MAINT+REF										7300.	
1420	UNSCHED MAINT+REF										7620.	
1430	POST MAINT C/O										2500.	
1440	TUG/PAYLOAD MATG										4000.	
1450	REF RQMTS PLANNG										400.	
1460	DEPOT MAINT										19000.	
	SPACE TUG TOTALS	346130.			210204.			12527.	38559.	292339.		
	32A= 346130.	32B=	222731.		32C=	292339.		320=	861200.			

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MOORE BUSINESS FORMS, INC. HQ FORM 1412 T PRINTED IN U.S.A. 22

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310ARE-38 SEP 73

STORABLE SPACE TUG SYSTEM PROJECT

FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

DDTE (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	~~1976~~ 1980	~~1977~~ 81	~~1978~~ 82	~~1979~~ 83	~~1980~~ 84	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	5.2	0.67	1.22	1.30	1.27	0.71	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	6.2	1.08	2.07	1.82	1.00	0.23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0300	TUG MAIN STAGE	29.0	4.87	8.09	7.30	6.03	2.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	STRUCTURE	1.7	0.38	0.63	0.47	0.22	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320	THERMAL INSUL																	
330	AVIONICS	20.7	4.49	7.46	5.54	2.62	0.62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION																	
350	INTERFACE																	
0360	DROP TANKS																	
370	FINAL ASSY	6.5	0.0	0.0	1.29	3.19	2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0400	TUG AUX STAGE	22.7	0.48	2.05	3.45	8.83	6.73	1.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0410	STRUCTURES																	
0420	THERMAL INSUL																	
0430	AVIONICS																	
0440	PROPULSION																	
0450	INTERFACE																	
0460	DROP TANKS																	
0470	NUDGE	9.6	0.41	1.75	2.95	3.04	1.44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
480	AKS	11.5	0.0	0.0	0.0	5.27	5.05	1.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0490	DKS	1.6	0.07	0.30	0.50	0.52	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
04100	CACHE																	
04110	FINAL ASSY	0.0	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS	0.1	0.02	0.04	0.03	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0600	FACILITIES	0.1	0.01	0.02	0.04	0.03	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
610	MANUFACTURING																	
620	TEST																	
630	1ST MAIN/REF	0.1	0.01	0.02	0.02	0.02	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
640	ETR LAUNCH																	
650	END MAIN/REF																	
660	WTR LAUNCH	0.0	0.0	0.0	0.02	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0700	GND SUPP EQUIP	0.6	0.30	0.29	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0710	MFG GSE																	
720	ETR GSE	0.6	0.30	0.29	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
730	WTR GSE																	
740	FLT OPS NASA																	
750	FLT OPS DOD																	
0800	VEHICLE TEST	27.4	1.22	3.20	3.81	18.63	0.56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
810	GND TEST HWRE	3.7	0.69	1.14	1.17	0.73	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
820	GND TEST OPS	4.0	0.53	0.95	1.01	0.99	0.56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
830	FLT TEST HWRE	3.9	0.0	1.11	1.63	1.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
840	FLT TEST OPS	15.7	0.0	0.0	0.0	15.74	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0900	LAUNCH OPS WTR																	
1000	LAUNCH OPS ETR																	
1100	FLIGHT OPS WTR																	
1200	FLIGHT OPS ETR																	
1300	REF + INT TR-1																	
1400	REF + INT TR-2																	
	TOTALS	91.3	8.65	16.97	17.81	35.80	10.94	1.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			9	17	18	36	11											

MOORE BUSINESS FORMS, INC. NO FORM 1412T PRINTED IN U.S.A. 22

310ARE-38 SEP 73

STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

PROC (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	~~1976~~	~~1977~~	~~1978~~	~~1979~~	~~1980~~	~~1981~~	~~1982~~	~~1983~~	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	10.6	1.02	1.99	2.19	2.23	2.09	1.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	11.9	1.15	2.24	2.47	2.51	2.35	1.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0300	TUG MAIN STAGE	109.5	0.0	16.19	30.69	28.22	19.07	9.83	3.51	1.01	0.52	0.29	0.13	0.0	0.0	0.0	0.0	0.0
310	STRUCTURE	15.6	0.0	2.50	34.66	4.17	2.69	1.24	0.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320	THERMAL INSUL	1.4	0.0	0.23	0.42	0.38	0.24	0.11	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
330	AVIONICS	49.9	0.0	8.00	10.93	13.36	8.59	3.98	0.98	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION	23.1	0.0	3.71	6.93	6.20	3.98	1.85	0.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
350	INTERFACE	0.7	0.0	0.08	0.17	0.17	0.13	0.08	0.04	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0360	DROP TANKS	3.0	0.0	0.12	0.27	0.34	0.37	0.37	0.38	0.38	0.36	0.29	0.13	0.0	0.0	0.0	0.0	0.0
370	FINAL ASSY	15.8	0.0	1.55	3.31	3.60	3.07	2.20	1.32	0.62	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0400	TUG AUX STAGE	35.1	0.0	0.14	3.41	6.98	7.60	6.56	4.82	3.07	1.67	0.67	0.15	0.0	0.0	0.0	0.0	0.0
0410	STRUCTURES																	
0420	THERMAL INSUL																	
0430	AVIONICS																	
0440	PROPULSION																	
0450	INTERFACE																	
0460	DROP TANKS																	
0470	NUDGE	3.6	0.0	0.14	0.32	0.41	0.44	0.45	0.45	0.45	0.43	0.34	0.15	0.0	0.0	0.0	0.0	0.0
480	AKS	11.8	0.0	0.0	1.16	2.47	2.69	2.30	1.64	0.98	0.47	0.12	0.0	0.0	0.0	0.0	0.0	0.0
490	DKS	19.7	0.0	0.0	1.92	4.11	4.48	3.82	2.73	1.64	0.77	0.21	0.0	0.0	0.0	0.0	0.0	0.0
0410C	CACHE																	
4110	FINAL ASSY	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS	4.6	0.0	0.0	0.22	0.52	0.67	0.71	0.66	0.57	0.46	0.34	0.23	0.14	0.07	0.02	0.0	0.0
0500	FACILITIES	0.2	0.05	0.07	0.04	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
510	MANUFACTURING	0.1	0.04	0.05	0.03	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
520	TEST	0.0	0.01	0.02	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
630	1ST MAIN/REF																	
640	ETR LAUNCH																	
650	2ND MAIN/REF																	
660	WTR LAUNCH																	
0700	GND SUPP EQUIP	3.9	0.0	0.0	0.0	1.20	1.66	0.87	0.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0710	MFG GSE																	
720	ETR GSE																	
730	WTR GSE	3.9	0.0	0.0	0.0	1.20	1.66	0.87	0.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
740	FLT OPS NASA																	
750	FLT OPS DOD																	
0800	VEHICLE TEST																	
0810	GND TEST HWRE																	
0820	GND TEST OPS																	
0830	FLT TEST HWRE																	
0840	FLT TEST OPS																	
0900	LAUNCH OPS WTR																	
1000	LAUNCH OPS ETR																	
1100	FLIGHT OPS WTR																	
1200	FLIGHT OPS ETR																	
1300	REF + INT TR-1																	
1400	REF + INT TR-2																	
	TOTALS	175.8	~~2.22~~ 10	20.64	~~39.01~~ 41 31	~~41.69~~ 44	33.43	~~20.27~~ 22	9.19 9	4.65 6	~~2.65~~ ~~1.30~~	0.50	0.14	0.07	0.02	0.0	0.0

MOORE BUSINESS FORMS, INC. NO FOR-14127 PRINTED IN U.S.A.

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310APE-38 SEP 73

STORABLE SPACE TUG SYSTEM PROJECT

FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

OPS (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	~~1976~~	~~1977~~	~~1978~~	~~1979~~	~~1980~~	~~1981~~ 1984	~~1982~~ 85	~~1983~~ 86	~~1984~~ 87	~~1985~~ 88	~~1986~~ 89	~~1987~~ 90	~~1988~~ 91	1989	1990	1991
100	PROJECT MGMT	2.7	0.0	0.0	0.0	0.0	0.08	0.19	0.24	0.27	0.28	0.28	0.29	0.29	0.28	0.26	0.20	0.08
200	SYS ENG + INTEG	5.5	0.0	0.0	0.0	0.0	0.15	0.37	0.49	0.54	0.56	0.57	0.57	0.58	0.56	0.51	0.39	0.16
0300	VEH OPS SPARES	10.4	0.0	0.0	0.0	0.0	0.29	0.70	0.92	1.02	1.06	1.08	1.09	1.09	1.07	0.97	0.75	0.31
310	STRUCTURE	1.4	0.0	0.0	0.0	0.0	0.04	0.10	0.13	0.14	0.15	0.15	0.15	0.15	0.15	0.13	0.10	0.04
320	THERMAL INSUL	0.1	0.0	0.0	0.0	0.0	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
330	AVIONICS	6.7	0.0	0.0	0.0	0.0	0.19	0.46	0.60	0.66	0.69	0.70	0.70	0.71	0.69	0.63	0.48	0.20
340	PROPULSION	2.1	0.0	0.0	0.0	0.0	0.06	0.14	0.19	0.21	0.22	0.22	0.22	0.22	0.22	0.20	0.15	0.06
350	INTERFACE	0.1	0.0	0.0	0.0	0.0	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
360	DROP DANK																	
0370	FINAL ASSY																	
0400	TUG AUX STAGE	1.1	0.01	0.03	0.05	0.05	0.02	0.0	0.04	0.08	0.10	0.11	0.11	0.12	0.12	0.11	0.09	0.04
0410	STRUCTURES																	
0420	THERMAL INSUL																	
0430	AVIONICS																	
0440	PROPULSION																	
0450	INTERFACE																	
0460	DROP TANKS																	
0470	NUDGE	0.2	0.01	0.03	0.05	0.05	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
480	AKS	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.06	0.08	0.08	0.09	0.09	0.09	0.08	0.07	0.03
490	DKS	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01
04100	CACHE																	
04110	FINAL ASSY																	
0500	LOGISTICS																	
0600	FACILITIES	0.9	0.0	0.0	0.0	0.0	0.01	0.03	0.06	0.08	0.09	0.10	0.10	0.10	0.10	0.09	0.07	0.03
610	MANUFACTURING																	
620	TEST																	
630	1ST MAIN/REF	0.4	0.0	0.0	0.0	0.0	0.01	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.01
640	ETR LAUNCH	0.1	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
650	2ND MAIN/REF	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01
660	WTR LAUNCH	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
0700	GND SUPP EQUIP	2.7	0.0	0.0	0.0	0.0	0.04	0.10	0.18	0.26	0.29	0.31	0.31	0.31	0.31	0.29	0.23	0.10
710	MFG GSE																	
720	ETR GSE	1.5	0.0	0.0	0.0	0.0	0.04	0.10	0.14	0.15	0.16	0.16	0.16	0.16	0.16	0.14	0.11	0.05
730	WTR GSE	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.05	0.11	0.14	0.15	0.15	0.15	0.15	0.14	0.11	0.05
740	FLT OPS NASA																	
750	FLT OPS DOD																	
0800	VEHICLE TEST																	
0810	GND TEST HWRE																	
0820	GND TEST OPS																	
0830	FLT TEST HWRE																	
0840	FLT TEST OPS																	
900	LAUNCH OPS WTR	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.28	0.66	0.82	0.88	0.90	0.91	0.91	0.86	0.69	0.30
1000	LAUNCH OPS ETR	26.6	0.0	0.0	0.0	0.0	0.75	1.81	2.36	2.62	2.72	2.77	2.79	2.80	2.74	2.49	1.91	0.80
1100	FLIGHT OPS DOD	40.6	0.0	0.0	0.0	0.0	0.0	0.0	1.60	3.69	4.62	4.96	5.07	5.13	5.13	4.85	3.90	1.70
1200	FLIGHT OPS NASA	59.2	0.0	0.0	0.0	0.0	1.67	4.02	5.27	5.84	6.07	6.16	6.22	6.24	6.09	5.55	4.26	1.78
1300	REF + INT TR-1	18.3	0.0	0.0	0.0	0.0	0.52	1.24	1.63	1.80	1.97	1.90	1.92	1.93	1.88	1.71	1.32	0.55
1400	REF + INT TR-2	29.5	0.0	0.0	0.0	0.0	0.0	0.0	1.16	2.67	3.35	3.60	3.68	3.72	3.71	3.51	2.83	1.23
	TOTALS	204.6	~~0.01~~	~~0.03~~	~~0.05~~	~~0.05~~	~~3.55~~	8.47	14.24	19.54	21.85	22.71	23.06	23.22	22.89	~~21.20~~	~~16.63~~	~~7.08~~
						6	15	12	22	26	28	32	31	27	27	0	0	0

MOORE BUSINESS FORMS, INC., NO FORM 14127 PRINTED IN U.S.A.

310-3B/310ARE-3B
AVERAGE COST/FLIGHT ($ THOUSANDS)

	MODE I REFUSE		MODE II EXPEND TUG		MODE III EXPEND KS	
	NASA	DOD	NASA	DOD	NASA	DOD
Launch Operations	109.82	109.82				
Launch Site Serv & Supt	------	------				
Tug Shuttle Mate & C/O	7.59	7.59				
Prelaunch C/O	15.29	15.29				
Countdown	.45	.45				
Propellants & Gasses	62.00	62.00				
Post Flight Safing	24.49	24.49				
Maintenance & Refurb	454.17	454.17				
Sched Mant & Refurb	26.58	26.58				
Unsched Maint & Refurb	27.83	27.83				
Vehicle Opnl Spares (less Me)	174.53	174.53				
M. Eng. Maint & Refurb	80.00	80.00				
M. E. Opnl Spares	33.33	33.33				
Post Maint C/O	9.09	9.09				
Tug/Payload Mate & C/O	14.58	14.58				
Refurb Reqmt Planning	1.64	1.64				
Depot Maint	86.59	86.59				
Total Ground OPS (Launch/Maint/Refb)	563.99	563.99				
Flight Operations	428.18	411.05				
Mission Planning	94.36	111.9				
Flight Control	116.97	120.25				
Flight Evaluation	19.21	15.85				
Flight Supt Software	197.64	163.05				
Operations Support	61.79	61.79				
FSE Maint	1.64	1.64				
Sustaining Eng	29.96	29.96				
Prog Mgt	14.98	14.98				
Transport & Hdlg	3.16	3.16				
Inventory Control & Whseing	10.00	10.00				
Facilities Maint	2.05	2.05				
Expend Veh Avg. Unit Cost			8400		1050	1050
Total Cost/Flight	1054	1037	9454		2104	2087

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

310-33/310ARE-3B DDT&E

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320	SPACE TUG PROJ		102726.		21372.		112043.		5683.		16804.		87265.		345893.
	MAJ PROC		22098.		11480.		16680.		927.		1544.		66094.		118823.
	IN-HOUSE	4507.	80627.	712.	9892.	7285.	95363.	287.	4757.	921.	15260.	1640.	21170.	15353.	227070.
320-01	PROJECT MGMT		0.		0.		0.		0.		0.		13213.		13213.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1024.	13213.	1024.	13213.
320-02	SYS ENGR + INTG		10624.		0.		0.		4757.		0.		476.		15856.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	594.	10624.	0.	0.	0.	0.	287.	4757.	0.	0.	37.	476.	918.	15856.
320-03	SPACE TUG VEH MN		60380.		7747.		20953.		745.		13537.		65097.		168458.
	MAJ PROC		12172.		4968.		3229.		745.		1242.		59781.		92138.
	IN-HOUSE	2695.	48208.	200.	2779.	1354.	17724.	0.	0.	742.	12295.	412.	5315.	5403.	86321.
320-03-01	STRUCTURES		11769.		0.		2847.		0.		3607.		759.		18982.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	658.	11769.	0.	0.	218.	2847.	0.	0.	218.	3607.	59.	759.	1152.	18982.
320-03-02	THERMAL INSUL		82.		0.		30.		0.		30.		7.		149.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	5.	82.	0.	0.	2.	30.	0.	0.	2.	30.	1.	7.	9.	149.
320-03-03	AVIONICS		35065.		4968.		8953.		745.		5892.		4988.		60611.
	MAJ PROC		12172.		4968.		3229.		745.		1242.		2484.		24841.
	IN-HOUSE	1280.	22893.	0.	0.	437.	5723.	0.	0.	281.	4650.	194.	2504.	2192.	35770.
320-03-04	PROPULSION		7701.		0.		3025.		0.		1650.		58672.		71049.
	MAJ PROC		0.		0.		0.		0.		0.		57297.		57297.
	IN-HOUSE	430.	7701.	0.	0.	231.	3025.	0.	0.	100.	1650.	107.	1375.	868.	13751.
320-03-05	ORBITER INTF		3840.		0.		1396.		0.		1396.		349.		6981.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	215.	3840.	0.	0.	107.	1396.	0.	0.	84.	1396.	27.	349.	433.	6981.
320-03-06	DROP TANKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-03-07	FINAL ASSEMBLY		1924.		2779.		4702.		0.		962.		321.		10687.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	108.	1924.	200.	2779.	359.	4702.	0.	0.	58.	962.	25.	321.	750.	10687.
320-04	SPACE TUG VEH AU		14105.		1209.		3910.		181.		1894.		1377.		22676.
	MAJ PROC		2961.		1209.		786.		181.		302.		604.		6043.
	IN-HOUSE	623.	11144.	0.	0.	239.	3125.	0.	0.	96.	1592.	60.	772.	1018.	16633.
320-04-01	STRUCTURES		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-02	THERMAL INSUL		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-03	AVIONICS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-04	PROPULSION		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

310-38/310ARE-3B DDT&E

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-04-06	DROP TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-07	RDM		5769.		729.		1782.		109.		598.		602.		9589.
	MAJ PROC		1787.		729.		474.		109.		182.		365.		3646.
	IN-HOUSE	223.	3982.	0.	0.	100.	1308.	0.	0.	25.	416.	18.	238.	366.	5943.
320-04-08	AKS		7301.		420.		1864.		63.		1135.		678.		11461.
	MAJ PROC		1029.		420.		273.		63.		105.		210.		2099.
	IN-HOUSE	351.	6272.	0.	0.	122.	1591.	0.	0.	62.	1030.	36.	468.	571.	9362.
320-04-09	DKS		1036.		60.		264.		9.		161.		96.		1626.
	MAJ PROC		146.		60.		39.		9.		15.		30.		298.
	IN-HOUSE	50.	890.	0.	0.	17.	226.	0.	0.	9.	146.	5.	66.	81.	1328.
320-04-10	CACHE TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-11	FINAL ASSEMBLY		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-05	LOGISTICS		6430.		0.		0.		0.		0.		0.		6430.
	MAJ PROC		965.		0.		0.		0.		0.		0.		965.
	IN-HOUSE	305.	5465.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	305.	5465.
320-06	FACILITIES		0.		0.		0.		0.		0.		7102.		7102.
	MAJ PROC		0.		0.		0.		0.		0.		5709.		5709.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	108.	1394.	108.	1394.
320-06-01	MANUFACTURING		0.		0.		0.		0.		0.		134.		134.
	MAJ PROC		0.		0.		0.		0.		0.		134.		134.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-02	TEST		0.		0.		0.		0.		0.		248.		248.
	MAJ PROC		0.		0.		0.		0.		0.		198.		198.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.	50.	4.	50.
320-06-03	ETR MAINT/REFB		0.		0.		0.		0.		0.		3046.		3045.
	MAJ PROC		0.		0.		0.		0.		0.		2437.		2437.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	47.	609.	47.	609.
320-06-04	ETR LAUNCH		0.		0.		0.		0.		0.		475.		475.
	MAJ PROC		0.		0.		0.		0.		0.		380.		380.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	7.	95.	7.	95.
320-06-05	WTR MAINT/REFB		0.		0.		0.		0.		0.		2648.		2648.
	MAJ PROC		0.		0.		0.		0.		0.		2118.		2118.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	41.	530.	41.	530.
320-06-06	WTR LAUNCH		0.		0.		0.		0.		0.		551.		551.
	MAJ PROC		0.		0.		0.		0.		0.		441.		441.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9.	110.	9.	110.
320-07	GSE		11187.		12417.		1453.		0.		1373.		0.		26430.
	MAJ PROC		6000.		5303.		0.		0.		0.		0.		11303.
	IN-HOUSE	290.	5187.	512.	7114.	111.	1453.	0.	0.	83.	1373.	0.	0.	996.	15127.
320-07-01	MANUFACTURING		318.		1544.		159.		0.		79.		0.		2100.
	MAJ PROC		0.		511.		0.		0.		0.		0.		511.
	IN-HOUSE	18.	318.	74.	1033.	12.	159.	0.	0.	5.	79.	0.	0.	109.	1589.

EA-78-43

MOORE PRINTING STORES, INC. MD FORM 14171 PRINTED IN U.S.A.

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

310-3B/310ARE-3B DDT&E

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-07-02	ETR		4270.		10873.		1294.		0.		1294.		0.		17730.
	MAJ PROC		0.		4792.		0.		0.		0.		0.		4792.
	IN-HOUSE	239.	4270.	438.	6081.	99.	1294.	0.	0.	78.	1294.	0.	0.	853.	12938.
320-07-03	WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-07-04	FLT OPS NASA		3300.		0.		0.		0.		0.		0.		3300.
	MAJ PROC		3000.		0.		0.		0.		0.		0.		3000.
	IN-HOUSE	17.	300.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	17.	300.
320-07-05	FLT OPS DOD		3300.		0.		0.		0.		0.		0.		3300.
	MAJ PROC		3000.		0.		0.		0.		0.		0.		3000.
	IN-HOUSE	17.	300.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	17.	300.
320-08	VEHICLE TEST		0.		0.		85727.		0.		0.		0.		85727.
	MAJ PROC		0.		0.		12665.		0.		0.		0.		12665.
	IN-HOUSE	0.	0.	0.	0.	5581.	73062.	0.	0.	0.	0.	0.	0.	5581.	73062.
320-08-01	GND TEST HDWR		0.		0.		12289.		0.		0.		0.		12289.
	MAJ PROC		0.		0.		6144.		0.		0.		0.		6144.
	IN-HOUSE	0.	0.	0.	0.	469.	6144.	0.	0.	0.	0.	0.	0.	469.	6144.
320-08-02	GND TEST OPS		0.		0.		14037.		0.		0.		0.		14037.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	1072.	14037.	0.	0.	0.	0.	0.	0.	1072.	14037.
320-08-03	FLT TEST HDWR		0.		0.		13041.		0.		0.		0.		13041.
	MAJ PROC		0.		0.		6521.		0.		0.		0.		6521.
	IN-HOUSE	0.	0.	0.	0.	498.	6521.	0.	0.	0.	0.	0.	0.	498.	6521.
320-08-04	FLT TEST OPS		0.		0.		46360.		0.		0.		0.		46360.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	3542.	46360.	0.	0.	0.	0.	0.	0.	3542.	46360.
320-09	LAUNCH OPS WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-10	LAUNCH OPS ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-11	FLIGHT OPS WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-12	FLIGHT OPS ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-13	REFB + INTEG WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-14	REFB + INTEG ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

II-96-44

MOORE BUSINESS FORMS, INC. FORM 14121 PRINTED IN U.S.A.

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

310-3B/310ARE-3B PROD

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320	SPACE TUG PROJ		54239.		84681.		15144.		5299.		13371.		46997.		219731.
	MAJ PROC		10153.		30291.		4473.		994.		2485.		26799.		75186.
	IN-HOUSE	2396.	44086.	3831.	54400.	664.	10670.	262.	4305.	602.	10886.	1565.	20198.	9320.	144545.
320-01	PROJECT MGMT		0.		0.		0.		0.		0.		12755.		12755.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	988.	12755.	988.	12755.
320-02	SYS ENGR + INTG		9614.		0.		0.		4305.		0.		430.		14349.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	523.	9614.	0.	0.	0.	0.	262.	4305.	0.	0.	33.	430.	818.	14349.
320-03	SPACE TUG VEH MN		28276.		62367.		11757.		852.		10418.		30812.		144481.
	MAJ PROC		6387.		25121.		3832.		852.		2129.		25392.		63712.
	IN-HOUSE	1190.	21889.	2623.	37246.	493.	7925.	0.	0.	459.	8289.	420.	5419.	5184.	80769.
320-03-01	STRUCTURES		7147.		8445.		2382.		0.		2599.		1083.		21657.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	388.	7147.	595.	8446.	148.	2392.	0.	0.	144.	2599.	84.	1083.	1359.	21657.
320-03-02	THERMAL INSUL		663.		783.		221.		0.		241.		100.		2008.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	36.	663.	55.	783.	14.	221.	0.	0.	13.	241.	8.	100.	126.	2008.
320-03-03	AVIONICS		11539.		39172.		5237.		852.		3534.		5663.		65996.
	MAJ PROC		6387.		25121.		3832.		852.		2129.		4258.		42578.
	IN-HOUSE	280.	5152.	989.	14051.	87.	1405.	0.	0.	78.	1405.	109.	1405.	1544.	23418.
320-03-04	PROPULSION		2693.		4867.		932.		0.		1036.		21963.		31490.
	MAJ PROC		0.		0.		0.		0.		0.		21135.		21135.
	IN-HOUSE	146.	2693.	343.	4867.	58.	932.	0.	0.	57.	1036.	64.	328.	669.	10356.
320-03-05	ORBITER INTF		800.		946.		267.		0.		291.		121.		2425.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	43.	800.	67.	946.	17.	267.	0.	0.	16.	291.	9.	121.	152.	2425.
320-03-06	DROP TANKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-03-07	FINAL ASSEMBLY		5435.		8153.		2718.		0.		2718.		1881.		20904.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	295.	5435.	574.	8153.	169.	2718.	0.	0.	150.	2718.	146.	1881.	1335.	20904.
320-04	SPACE TUG VEH AU		7474.		19426.		3090.		143.		2805.		2132.		35069.
	MAJ PROC		1069.		4204.		641.		143.		356.		713.		7126.
	IN-HOUSE	348.	6405.	1072.	15222.	152.	2449.	0.	0.	136.	2449.	110.	1419.	1818.	27943.
320-04-01	STRUCTURES		0.		0.		0.		0.		0.		0.		1.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
320-04-02	THERMAL INSUL		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-03	AVIONICS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-04	PROPULSION		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

II-B.6-45

STORABLE SPACE TUG SYSTEM PROJECT 310-3B/310ARE-3B PROD

COST ESTIMATE DATA BY SOW

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-04-06	DROP TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-07	RDM		690.		2128.		255.		27.		201.		268.		3568.
	MAJ PROC		204.		801.		122.		27.		68.		136.		1357.
	IN-HOUSE	26.	487.	93.	1327.	8.	133.	0.	0.	7.	133.	10.	133.	146.	2212.
320-04-08	AKS		2547.		6496.		1065.		43.		578.		700.		11829.
	MAJ PROC		325.		1278.		195.		43.		108.		217.		2167.
	IN-HOUSE	121.	2222.	367.	5218.	54.	870.	0.	0.	48.	870.	37.	483.	628.	9663.
320-04-09	DKS		4236.		10802.		1770.		72.		1626.		1164.		19670.
	MAJ PROC		540.		2126.		324.		72.		180.		360.		3603.
	IN-HOUSE	201.	3696.	611.	8676.	90.	1446.	0.	0.	80.	1446.	62.	903.	1044.	16067.
320-04-10	CACHE TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-11	FINAL ASSEMBLY		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-05	LOGISTICS		8280.		0.		0.		0.		0.		0.		8280.
	MAJ PROC		2697.		0.		0.		0.		0.		0.		2697.
	IN-HOUSE	303.	5583.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	303.	5583.
320-06	FACILITIES		0.		0.		0.		0.		0.		868.		868.
	MAJ PROC		0.		0.		0.		0.		0.		694.		694.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	13.	174.	13.	174.
320-06-01	MANUFACTURING		0.		0.		0.		0.		0.		281.		281.
	MAJ PROC		0.		0.		0.		0.		0.		225.		225.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.	56.	4.	56.
320-06-02	TEST		0.		0.		0.		0.		0.		92.		92.
	MAJ PROC		0.		0.		0.		0.		0.		74.		74.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	18.	1.	18.
320-06-03	ETR MAINT/REFB		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-04	ETR LAUNCH		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-05	WTR MAINT/REFB		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-06	WTR LAUNCH		0.		0.		0.		0.		0.		495.		495.
	MAJ PROC		0.		0.		0.		0.		0.		396.		396.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	8.	99.	8.	99.
320-07	GSE		595.		2888.		297.		0.		149.		0.		3928.
	MAJ PROC		0.		956.		0.		0.		0.		0.		956.
	IN-HOUSE	32.	595.	136.	1932.	18.	297.	0.	0.	8.	149.	0.	0.	195.	2973.
320-07-01	MANUFACTURING		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

II-8.6-46

ALTONE BUSINESS FORMS INC HO PRINTED IN U.S.A.

STORABLE SPACE TUG SYSTEM PROJECT

COST ESTIMATE DATA BY SOW

310-3B/310ARE-3B PROD

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-07-02	ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-07-03	WTR		595.		2888.		297.		0.		149.		0.		3928.
	MAJ PROC		0.		956.		0.		0.		0.		0.		956.
	IN-HOUSE	32.	595.	136.	1932.	18.	297.	0.	0.	8.	149.	0.	0.	195.	2973.
320-07-04	FLT OPS NASA		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-07-05	FLT OPS DOD		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08	VEHICLE TEST		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-01	GND TEST HDWR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-02	GND TEST OPS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-03	FLT TEST HDWR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-04	FLT TEST OPS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-09	LAUNCH OPS WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-10	LAUNCH OPS ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-11	FLIGHT OPS WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-12	FLIGHT OPS ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-13	REFB + INTEG WTR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-14	REFB + INTEG ETR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

310-3B/310ARE-3B OPN'S

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320	SPACE TUG PROJ		170546.		81876.		2101.		3446.		1655.		32564.		292187.
	MAJ PROC		15010.		6204.		741.		165.		412.		16071.		38603.
	IN-HOUSE	9989.	155536.	9262.	75672.	99.	1359.	272.	3281.	103.	1243.	1278.	16494.	21004.	253584.
320-01	PROJECT MGMT		0.		0.		0.		0.		0.		5466.		5466.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	423.	5466.	423.	5466.
320-02	SYS ENGR + INTG		7327.		0.		0.		3281.		0.		328.		10936.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	471.	7327.	0.	0.	0.	0.	272.	3281.	0.	0.	25.	328.	768.	10936.
320-03	SPACE TUG VEH MN		4236.		10838.		1678.		161.		1420.		1579.		19913.
	MAJ PROC		1211.		4762.		726.		161.		404.		807.		8071.
	IN-HOUSE	194.	3026.	744.	6076.	70.	952.	0.	0.	84.	1017.	60.	772.	1152.	11842.
320-03-01	STRUCTURES		650.		768.		217.		0.		236.		98.		1969.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	42.	650.	94.	768.	16.	217.	0.	0.	20.	236.	8.	98.	179.	1969.
320-03-02	THERMAL INSUL		31.		37.		10.		0.		11.		5.		94.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	2.	31.	4.	37.	1.	10.	0.	0.	1.	11.	0.	5.	9.	94.
320-03-03	AVIONICS		2383.		7958.		1046.		161.		723.		1127.		13398.
	MAJ PROC		1211.		4762.		726.		161.		404.		807.		8071.
	IN-HOUSE	75.	1172.	391.	3195.	23.	320.	0.	0.	27.	320.	25.	320.	541.	5327.
320-03-04	PROPULSION		1100.		1989.		381.		0.		423.		339.		4232.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	71.	1100.	243.	1989.	28.	381.	0.	0.	35.	423.	26.	339.	403.	4232.
320-03-05	ORBITER INTF		73.		85.		24.		0.		26.		11.		220.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	5.	73.	11.	85.	2.	24.	0.	0.	2.	26.	1.	11.	20.	220.
320-03-06	DROP TANKS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-03-07	FINAL ASSEMBLY		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04	SPACE TUG VEH AU		190.		547.		60.		3.		53.		62.		915.
	MAJ PROC		25.		99.		15.		3.		8.		17.		168.
	IN-HOUSE	11.	164.	55.	448.	3.	45.	0.	0.	4.	45.	3.	45.	76.	747.
320-04-01	STRUCTURES		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-02	THERMAL INSUL		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-03	AVIONICS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-04	PROPULSION		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

X-86-48

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

310-3B/310ARE-3B OPN5

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-04-06	DROP TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-07	RDM		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-08	AKS		143.		414.		45.		3.		40.		47.		692.
	MAJ PROC		19.		75.		11.		3.		6.		13.		127.
	IN-HOUSE	8.	124.	42.	339.	2.	34.	0.	0.	3.	34.	3.	34.	57.	565.
320-04-09	DKS		46.		133.		15.		1.		13.		15.		223.
	MAJ PROC		6.		24.		4.		1.		2.		4.		41.
	IN-HOUSE	3.	40.	13.	109.	1.	11.	0.	0.	1.	11.	1.	11.	19.	182.
320-04-10	CACHE TANK		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-04-11	FINAL ASSEMBLY		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-05	LOGISTICS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06	FACILITIES		0.		0.		0.		0.		0.		1013.		1013.
	MAJ PROC		0.		0.		0.		0.		0.		810.		810.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	16.	203.	16.	203.
320-06-01	MANUFACTURING		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-02	TEST		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-06-03	ETR MAINT/REFB		0.		0.		0.		0.		0.		495.		495.
	MAJ PROC		0.		0.		0.		0.		0.		396.		396.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	8.	99.	8.	99.
320-06-04	ETR LAUNCH		0.		0.		0.		0.		0.		133.		133.
	MAJ PROC		0.		0.		0.		0.		0.		106.		106.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	27.	2.	27.
320-06-05	WTR MAINT/REFB		0.		0.		0.		0.		0.		252.		252.
	MAJ PROC		0.		0.		0.		0.		0.		202.		202.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.	50.	4.	50.
320-06-06	WTR LAUNCH		0.		0.		0.		0.		0.		133.		133.
	MAJ PROC		0.		0.		0.		0.		0.		106.		106.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	27.	2.	27.
320-07	GSE		725.		3701.		363.		0.		181.		0.		4970.
	MAJ PROC		0.		1343.		0.		0.		0.		0.		1343.
	IN-HOUSE	47.	725.	289.	2357.	26.	363.	0.	0.	15.	181.	0.	0.	377.	3627.
320-07-01	MANUFACTURING		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STORABLE SPACE TUG SYSTEM PROJECT
COST ESTIMATE DATA BY SOW

310-3B/310ARE-3B OPN'S

SUBDIVISIONS OF WORK

WBS ID	NAME	ENGINEERING HRS	ENGINEERING $	MANUFACTURING HRS	MANUFACTURING $	TEST HRS	TEST $	QUALITY ASSR HRS	QUALITY ASSR $	TOOLING/STE HRS	TOOLING/STE $	MGMT AND OTHER HRS	MGMT AND OTHER $	TOTAL HRS	TOTAL $
320-07-02	ETR		312.		1593.		156.		0.		78.		0.		2140.
	MAJ PROC		0.		578.		0.		0.		0.		0.		578.
	IN-HOUSE	20.	312.	124.	1015.	11.	156.	0.	0.	6.	78.	0.	0.	162.	1562.
320-07-03	WTR		413.		2107.		207.		0.		103.		0.		2830.
	MAJ PROC		0.		765.		0.		0.		0.		0.		765.
	IN-HOUSE	27.	413.	164.	1342.	15.	207.	0.	0.	9.	103.	0.	0.	214.	2065.
320-07-04	FLT OPS NASA		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-07-05	FLT OPS DOD		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08	VEHICLE TEST		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-01	GND TEST HDWR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-02	GND TEST OPS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-03	FLT TEST HDWR		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-08-04	FLT TEST OPS		0.		0.		0.		0.		0.		0.		0.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320-09	LAUNCH OPS WTR		705.		2317.		0.		0.		0.		4640.		7662.
	MAJ PROC		0.		0.		0.		0.		0.		4304.		4304.
	IN-HOUSE	45.	705.	284.	2317.	0.	0.	0.	0.	0.	0.	26.	336.	355.	3358.
320-10	LAUNCH OPS ETR		4681.		15380.		0.		0.		0.		12361.		32422.
	MAJ PROC		0.		0.		0.		0.		0.		10132.		10132.
	IN-HOUSE	301.	4681.	1883.	15380.	0.	0.	0.	0.	0.	0.	173.	2229.	2356.	22290.
320-11	FLIGHT OPS WTR		54350.		0.		0.		0.		0.		0.		54350.
	MAJ PROC		5435.		0.		0.		0.		0.		0.		5435.
	IN-HOUSE	3142.	48915.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3142.	48915.
320-12	FLIGHT OPS ETR		83390.		0.		0.		0.		0.		0.		83390.
	MAJ PROC		8339.		0.		0.		0.		0.		0.		8339.
	IN-HOUSE	4820.	75051.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4820.	75051.
320-13	REFB + INTEG WTR		6369.		20928.		0.		0.		0.		3033.		30330.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	409.	6369.	2562.	20928.	0.	0.	0.	0.	0.	0.	235.	3033.	3206.	30330.
320-14	REFB + INTEG ETR		8572.		28166.		0.		0.		0.		4082.		40820.
	MAJ PROC		0.		0.		0.		0.		0.		0.		0.
	IN-HOUSE	551.	8572.	3447.	28166.	0.	0.	0.	0.	0.	0.	316.	4082.	4314.	40820.

I-86-50

MOORE BUSINESS FORMS INC. NO 10004 14121 PRINTED IN U.S.A.

SPACE TUG CHARACTERISTICS

310-3B→310ARE-3B

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	WEIGHT, LB	3212→3416	545/544
	LENGTH, IN	297	80/ 27
	DIAMETER, IN	120	180/120
TECHNICAL:	REUSABLE	ONE-STAGE	RDM
	AUXILIARY STAGE		AKS/RDM
	PAYLOAD RETRIEVAL	CAPABILITY	
	PROPELLANT CAPACITY, LB	59,500	
	THRUST, LB	12,000	
	ISP, SEC	338	287/& 295
	AUTONOMY LEVEL	IIIA→IIB	
	RELIABILITY	.97→.9750	.9987/.9824

WBS #320-00

GRUMMAN

MAIN STAGE CHARACTERISTICS

310-3B → 310ARE-3B

PHYSICAL:	WEIGHT, LB	3212 → 3416
	LENGTH, IN	297
	DIAMETER, IN	120
TECHNICAL:	REUSABLE SINGLE STAGE	
	PROPELLANT CAPABITY, LB	59,500
	PAYLOAD RETRIEVAL CAPABILITY	
	THRUST, LB	12,000
	ISP, SEC	338
	AUTONOMY LEVEL	IIIA → IIB
	RELIABILITY	.97 → .9750

WBS #320-03

GRUMMAN

VEHICLE TEST CHARACTERISTICS

310-3B→310ARE-3B

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	PROP. TEST ARTICLE	X	
	STRUCT. TEST ARTICEL	X	X
	INTEG. AVIONICS TEST	X	X
	MOCK-UPS	X	X
	FLIGHT TEST	X	X

TECHNICAL:

PTA - COLD FLOW ONLY, NO HOT FIRING

STA - ONE ART FOR DYNAMICS, STATIC & FATIGUE

IAT - SOFTWARE & HARDWARE

MOCK-UPS - WOOD AT PDR, WOOD/METAL AT CDR

FLIGHT TEST - ONE WITHOUT P/L, EIGHT WITH P/L

WBS #320-08

GRUMMAN

STRUCTURAL CHARACTERISTICS

310-3B—310ARE-3B

PHYSICAL:	WEIGHT, LB	1233 —— 1286
	LENGTH, IN	297
	DIAMETER, IN	120
TECHNICAL:	TANK CONFIGURATION	NESTED DOME
	TANK CAPACITY, LB	59,500
	MATERIAL	Ti, COMPOSITE H'COMB
	RELIABILITY ALLOCATION	.99900

WBS #320-03-01

GRUMMAN

CONFIGURATION 310 ABE-3B WBS NO. 320-03-01

SUBSYSTEM/COMPONENT STRUCTURE

DATE: 7/17/[illegible]

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS	RELIABILITY: MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TEST	NOTES
01-Fuel Tanks and Supports	1	44½		Titan.	255	90	120	DIA		Welded Gore Titanium Domes	20	1		2	Tank Leakage Considered Unserviceable
02-Oxid. Tank and Supports	1	44½		Titan.	164	100	120	DIA		Weld Gore Titanium Domes	20	1		2	
03-Body Structure	1	44½		Alum. and Comp.	638	145	120	DIA		Graphite Composite Honeycomb Shell Aluminum Frames	N/A	1		2	Includes Equipment Mounting and Umbilicals
04-Thrust Struct.	1	44½		Alum.	85	35	120 MAX	DIA		Aluminum Stiffened Sheet	N/A	1		2	
05-Meteoroid Shield	1	44½		Alum.	26	87	126	DIA		Aluminum Sheet	N/A	1	1		
06-Interface	1	46		Alum.	115					Aluminum Machinings and Forgings	N/A	1		2	

II-8.6-55

GRUMMAN

REPORT
DATE
CODE 20012

THERMAL CONTROL CHARACTERISTICS

310-3B → 310ARE-3B

PHYSICAL: WEIGHT, LB 89

500 FT^2 GOLDIZED MYLAR MLI

AL BASE HEAT SHIELD

SILVER BACKED TEFLON & ALZAK COATINGS

WBS #320-03-02

GRUMMAN

IV-86-56

CONFIGURATION: 310ARE-3B

WBS NO. 320-03-02-01,02

SUBSYSTEM/COMPONENT THERMAL CONTROL

DATE: 8/30/72

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
THERMAL CONTROL COATINGS	5	0		SBT ALZAK ALCOPINE	9		15	00 ft²		0				1			
MULTILAYER INSULATION	3	6		SEE MINI SPEC	46		50	0 ft²		0				1			
FUEL CELL RADIATOR	2	12		SEE MINI SPEC	14		17	ft²						1			
AVIONICS HEAT PIPE RADIATOR	2	12		SEE MINI SPEC	4		4	ft²		0							POWER AMP (20W)
AVIONICS HEATERS	4	6		SEE MINI SPEC	2					75/UNIT				8			COX & COMPANY, NY, NY.
APS HEATERS*	4	6		SEE MINI SPEC	6					20/UNIT				24			
BASE HEAT SHIELD	5	0		AL	14					0							IDENTICAL TO MICROMETEROID SHIELD
PLUMBING	5	0		AL	2					0							

*CARRIED AS APS WT.

DRUMMAN

REPORT
DATE
CODE 20012

II-8.6-57

AVIONICS CHARACTERISTICS

		310-3B → 310ARE-3B
PHYSICAL:	WEIGHT, LB	673 → 768
TECHNICAL:	AUTONOMY LEVEL	IIIA → IIB
	RENDEZVOUS & DOCKING	→ LASER RADAR
	COMMUNICATIONS	DFS → DFS/CSS
	COMPUTER CAPACITY	48K → 65K WORDS
	FUEL CELL POWER	2.5 KW
	RELIABILITY ALLOCATION	.97912 → .98454

WBS #320-03-03

GRUMMAN

85-98-II

[illegible] LEVEL II B — CORE CONFIGURATION [redacted], 310ARE-3B — WBS NO. 320-03-03-01 — SUBSYSTEM/COMPONENT UMS — DATE: [illegible]

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
[illegible] STAGE																	
COMPUTER	4				15	4.7	5	10.4	244	39	65K WORDS - 16 BITS/WORD	144	14K	2	N/A	1	CDC 469
TAPE RECORDER	5		RF/S-3 MIDDLE		14.5	9	12	5.4	530	8		105	12K	1	N/A	1	ODETICS DDS 3000
FSI CONTROLLER/ TLM FORMATTER	4		SHUTTLE		18	8	5	16	640	23		144	12K	1	N/A	1	RADIATION INC.
[illegible]	4		SHUTTLE		7	7	4	13	364	21	256 CHANNELS	144	12K	3	N/A	1	RADIATION INC
SENSORS	4		SHUTTLE		0.2	N/A	N/A	N/A	N/A	0.1			1M	190	N/A	10	WHITTAKER TRANSONICS

GRUMMAN

CONFIGURATION 310ARE-3B * NOTE 1 WBS NO. 320-03-05-02

AUTONOMY LEVEL IIB SUBSYSTEM/COMPONENT G N & C

REV. A 9-31-73
DATE: 8-1-73

MAJOR COMPONENT	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
ENGINE MEASURING UNIT	1	24			10	6.5	6.5	4.7	200	15 WATTS			2			
STAR TRACKER	1				17	15	6 DIA.		424	28 WATTS			1			DOES NOT INCLUDE SUNSHADE (1 LB)
SATELLITE RECEIVER	1	30	—		37	19.5	10.4	7.8	1582	85 WATTS			1			
DOPPLER RECEIVER	1	12	-		8	8	7	5	280	10 WATTS			1			
L BAND ANTENNA	1	9	-		0.3	4	4	1	16	—			4			
[illegible]	1	18	-		6	7	7	5	245	4 WATTS			1			
APS CONT ELECT	1		-		18	10	10	5	500	13 WATTS			2			
VEHICLE CONT ELEC	1		-		10	10	10	3.5	350	15 WATTS			1			
LASER RANGE FINDER	1	30	-		40	9 21	9 9	9 6	729 1134	35 WATTS			1			* USED FOR RETRIEVAL ONLY

① USES APOGEE KICK STAGE FOR DEPLOY ONLY MISSION

② USES RETRIEVAL DELAY MODULE FOR RETRIEVAL MISSIONS

GRUMMAN AEROSPACE CORPORATION

CONFIGURATION 310ARE-3B (CORE) WBS NO. 320-02-02-03

SUBSYSTEM/COMPONENT COMM

DATE: 9-5-

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TEST	NOTES
1. S-BAND X'CEIVER/ X'PONDER R'CVR-(2) X'MT-(1)		24			2X4 1X5	7 7	9 8	5 5	315 280	8 34	Spread Spectrum CCIR Interference STDN/SGLS compatible			1			
2. S-BAND X'CEIVER/ X'PONDER R'CVR-(4) X'MTR-(1)					4X4 1X5	7 7	9 8	5 5	315 280	8 34	Spread Spectrum CCIR Interference STDN/SGLS Compatible			1			
3. AUX. X'MTR					5	7	8	5	280	34	Same as (2)			1			
4. POWER AMP.					1	3	5	2	30	20	R.F. output of 5W			1			
5. POWER AMP.		15			3	9	5	3	135	100	R.F. output of 20W			1			
6. Base band Processor		24			6	7	7	5	245	4	Same as (1) + (2)			1			
7. Diplexer					1	3	7	3	63	—	—			2			
8. Diplexer		9			1	3	7	3	63	—	—			2			
9 Antenna Switch					1	3	3	4	36	1	—			2			
10. Antenna					.5	3	6	1	18	—	—			2			
11 Antenna		9			.5	3	6	1	18	—	—			2			
12. Power Splitter		8			1	2	2	3	12	—	—			1			
13. TV ASSEMBLY		15			12	18	6	4	432	10	Black + White			1			
15. SECURE COMM		—			6	9	5	4	180	8	—			5			DOD ONLY-GFE

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REPORT
DATE
CODE 20512

19-9.8-II

CONFIGURATION [redacted] 310ARE-3B
LEVEL OF AUTONOMY IIB

WBS NO. 320-03-03-05 & -06

SUBSYSTEM/COMPONENT ELECTRICAL POWER SUBSYSTEM

DATE: 8 2

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
• MODIFIED SHUTTLE FUEL CELL ASSY	3	30	SHUTTLE	ST STEEL PLAT	90	25	15	15	5630		2.5 KW @ 28V; WATT AVG. LOAD OVER 117 HRS.	144	25,000	1	-	1	REQUIRES AUTO SPACE START SELLERS: PEWA or GE
• EMERGENCY BATTERY	5	6		Ag-Zn Mg	15	9	5	4.5	200		10 AMP-HR RATED CAPACITY, 17 AMP DISCHARGE OVER 0.5 HR	0.5	30,000	1	-	1	SECONDARY SILVER-ZINC BA SELLER: EAGLE-PICHER
• CRYO HYDROGEN TANK ASSY	3	24	GEMINI APOLLO SHUTTLE	T1-INNER T2-OUTER	69	21" 24"	ID OD		7250		250 PSIA - OPERATING PRESSURE 350 PSIA - MAX PRESSURE. 11.5 LB FLUID CAPACITY	144		1	-	1	SELLER: AIRESEARCH, BEECH, BE
• CRYO OXYGEN TANK ASSY	3	24	GEMINI APOLLO SHUTTLE	INC-718 INN INC-750 OUT	71	16½ 19½	ID OD		3900		900 PSIA - OPERATING PRESS 1000 PSIA - MAX. " 92.5 LB FLUID CAPACITY	144		1	-	1	SELLER: AIRESEARCH, BEECH, BE
• VEHICLE WIRING	5		LM		55						6ga, 14ga, 16ga, 20 & 26ga	144		SHIP SET		SHIP SET	~10,000 FT OF ASSORTED SIZ
• CONNECTORS	5		LM		30						ASSORTED SIZES	144		"		"	~120 MATED. PAIRS
• SUNDRIES (-CLAMPS -TAPE)	5		LM		20						" "	144		"		"	
• SOLID STATE POWER CONTROL	5		-		21						90 @ 2 AMP 17 @ 5 AMP 60 @ 3 AMP	144		"		"	2 OZ EACH; SELLER: LEACH C
• ELECTRO-MECH RCCB	5		LM		9						2 @ 20 AMP 10 @ 10 AMP	144		"		"	0.75 LB EACH; SELLER CUTLER-

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PROPULSION CHARACTERISTICS (310-3B → 310ARE-3B)

		MAIN PROP.	AUXILIARY PROP.
PHYSICAL:	WEIGHT, LB	550	150 → 188
	ENGINE/THRUSTER	CLASS I	REA 19
	NO. OF ENGINES/THRUSTERS	1	16 → 24
TECHNICAL:	FUEL LOAD, LB	20,517	349 → 495
	OXIDIZER LOAD, LB	38,983	--
	THRUST, LB	12,000	25
	ISP - STEADY STATE	338	232
	- PULSING	--	170
	RELIABILITY ALLOCATION	.99259	.99915 → .99882

WBS #320-03-04

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CONFIGURATION [redacted] 310ATE-15, [redacted] WBS NO. 320-03-04-05; 320-03-04-06 REV A 6/3/73

SUBSYSTEM/COMPONENT AUXILIARY PROPULSION SYSTEM (APS) DATE: 5/1/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR [illegible] TEST	PROGRAMATIC: [illegible] MAJOR	NOTES
																	GENERAL NOTE: TANKAGE BASED ON USABLE PROPELLANT OF 450 LB PLUS 10% CONTINGENCY.
HELIUM TANK	5	≤12	—		12.25	12.34	12.34	12.34	550	—	BURST PRESS = 7500 PSI OPERATING = 3900 PSI	156	10^6	2	ONE SHIPSET	NONE	AIRITE P/N 6524-1
HELIUM FILTER	5	≤12	LM		0.5					—				1			LSC 310-303-3 (VACCO VLV CO)
HELIUM LATCHING SOLENOID VALVE	4	≤12	LM		2.3					84		156	1.3×10^6	2			LSC 270-713 (MC NEG)
REGULATOR, DUAL STAGE	5	≤12	LM		2.5					—		156	"	1			LSC 310-305-3 ([illegible])
REGULATOR, SINGLE STAGE	4	≤12	—		1.5					—		156	"	1			MOD TO DUAL STAGE REG.
LOAD CHECK VALVE	5	≤12	LM		0.7					—	PROOF PRESS = 600 PSI	156	2000	1			MOD TO LSC 310-306 ([illegible])
BURST DISC/RELIEF VLV	4	≤12	—		1.5					—	RELIEF PRESS ≈ 400 PSI	156	10^6/67K	1			MOD TO LSC 310-307 (CALMER)
VENT VALVE	3	18	—		2.0					70	PROOF PRESS = 600 PSI	156	67000	3			SIMILAR TO LSC310-403 (PARKER) UNIDIRECTIONAL FLOW ONLY; HIGHER OPERATING PRESSURE
PROPELLANT TANKS	4	≤12	LM		10.5		12.50	.34	3420	—	BURST PRESSURE = 650 PSI	144	10^6	4			MODIFIED LM ECS FUEL TANK WITH ELASTOMERIC BLADDERS; TANK WT. INCLUDES BLADDERS;
PROPELLANT BLADDERS	2	24	—	EPT 10 ELASTOMER	—					—				4			
PROPELLANT FILTER	5	≤12	—		0.5					—				1			
THRUSTER ISOLATION VALVE	3	18	—		2.0					70	PROOF PRESSURE = 600 PSI	168	67000	8			SAME VALVE AS VENT VALVE; SAME NOTES APPLY
THRUSTERS	4	≤12	—		2.1	11.4	2.7			24	25 LB THRUST @ 325 PSI INLET, STEADY STATE ISP = 232	144	1.5×10^6	24			REA 19-3 (HAMILTON STANDARD)
THRUSTER HEATERS	5	≤12	—		0.2					3.5	MAINTAIN CATALYST BEDS AT 150°F			24			SUBMITTED FOR PRICING BY THE AMB
QUICK DISCONNECTS	5	≤12	—		0.5									3			HE FILL & DRAIN PROP FILL & DRAIN PROP FILL & VENT

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REPORT DATE CODE 75512

X-8-6-64

ORBITER INTERFACE CHARACTERISTICS

310-3B → 310ARE-3B

PHYSICAL:	WEIGHT, LB	1186
TECHNICAL:	MATERIAL	ALUMINUM
	PIVOT TYPE ADAPTER/DOCKING MECHANISM	
	SERVICE PANELS	GROUND POWER
		INSTRUMENTATION
		ON-PAD EMERGENCY DUMP
		HORIZONTAL PROP. DRAIN
		FUEL CELL REACTANT FILL

WBS #320-03-05

GRUMMAN

CONFIGURATION 310ARE-3B

WBS NO. 320-03-05-01

SUBSYSTEM/COMPONENT ORBITER INTERFACE STRUCT. DATE: 9/17/72

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TEST	
01-Rear Adapter	1	44½		Alum.	652	132	120	D		Aluminum Stiffened Sheet and Machinings	N/A			1	Pivot Type Adapter
01-Fwd Frame	1	44½		Alum.	438					Aluminum Trusses and Machinings	N/A			1	
01-Docking Mechanism	1	46		Alum.	96					Aluminum Machinings and Forgings	N/A			1	

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RETRIEVAL DELAY MODULE CHARACTERISTICS

310-3B→310ARE-3B

PHYSICAL:	WEIGHT, LB	544
	LENGHT, IN	27
	DIAMETER, IN	120
TECHNICAL:	MATERIAL	ALUMINUM
	INSULATION	GOLDIZED MYLAR MLI
	PULSE CODE MODULATOR	
	ATTITUDE GYRO	
	S-BAND EQUIP/OMNI ANTENNAS	
	BATTERY POWER	250 AMP HR
	AUXILIARY PROP. SYS	12 COLD GAS THRUSTERS
	RELIABILITY	.9824

WBS #320-04-07

GRUMMAN

CONFIGURATION 310 ARE-3B

WBS NO. 320-04-01

SUBSYSTEM/COMPONENT RETRIEVAL DELAY MODULE STRUCT.

DATE: 9/17/68

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S.E. TEST	EQUIVALENT UNITS FOR MAJOR GND TEST	
013-Body Structure	1	84		Alum.	120	27	120	D		Aluminum Stiffened Sheet	N/A	1		1	Includes Equipment Mounting Structure
016-Payload Interface	1	84		Alum.	125					Aluminum Machings and Forgings	N/A	1		1	

IX-8.6-68

CONFIGURATION AKS & RDM

WBS NO. ____

SUBSYSTEM/COMPONENT THERMAL

DATE:

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
COATINGS	5	0	LM	PAINT	1	←	150	ft^2	→		6 dry	NA	1	1	NA	ALUMINIZED MYLAR/NYLON NET
INSULATION	5	6	LM	MLI	4	←	50	ft^2	→		6 dry	NA	1	1	NA	

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REPORT
DATE
CODE 20912

ALL AUTONOMY LEVELS

CONFIGURATION RETRIEVAL DELAY MODULE (RDM) WBS NO. 320-04-07-03

SUBSYSTEM/COMPONENT DMS

DATE: 8/27/77

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR [illegible] TEST	[illegible] MAJOR [illegible]	
PCM/SIG. COND	4	5	P72-2 SPACECRAFT		4.6	9	5.5	7	347	9				2	N/A	1	SPACETAC
SENSORS	4	8	SHUTTLE		0.2	N/A	N/A	N/A	N/A	0.1			1M	10	N/A	2	WHITTAKER TRANSONICS

GRUMMAN

REPORT
DATE
CODE 26512

CONFIGURATION RETRIEVAL DELAY MODULE

WBS NO. 320-04-09-03

SUBSYSTEM/COMPONENT GN&C

REV A 8-31-73

DATE: 8-1-73

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
ATTITUDE GYRO [illegible] UNIT	4	12	IMP ITOS		13	10.6	8 DIA		533	25 WATTS			1			
TIMER/[illegible] DELAYS	4	12	IMP ITOS		3	6	3.4	2.4	49	2 WATTS			2			
[illegible] CONTROL ELECT.	1	18			7.6	8.6	7.1	5.5	336	12 WATTS			2			

GRUMMAN [illegible]

REPORT
DATE
CODE 26512

RDM

CONFIGURATION 310ARE-3B (ADD ON) WBS NO. 320-03-03-03 SUBSYSTEM/COMPONENT COMMUNICATIONS DATE: ~~8/9/73~~ 9-5-73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO GOAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE (EACH) LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE (EACH) WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE (EACH) HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (EACH) (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS: SI	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR GS TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
2 S-Band R'CVR (4) X'CLIPER / X'MTR (1) X'SHEER					4x4	7	9	5	315	8	Spread Spectrum						
					1x5	7	8	5	280	34	CCIR Interference STDN/SGLS Compatible			1			
3. FDX. X'MTR					5	7	8	5	280	34	Same as (2) above			1			
4. POWER AMP.					1	3	5	2	30	20	R.F. output of 5W			2			
7. DIPLEXER					1	2	7	3	63	—	—			2			
9. ANTENNA SWITCH					1	3	3	4	36	1	—			1			
14. BASEBAND PROCESSOR					3	3	3	2	18	2	Same as (2) above			1			
10. OMNI ANT.					.5	3	6	1	18	—	—			2			
15. SECURE COMM.		—			6	9	5	4	180	8	—			2			POD ONLY - GFE

V-86-72

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TABLE 5A.3-B EQUIPMENT LIST

PAGE 7 SEPT., 1973 REV (2)
27 AUG., 1973 REV. (1)

CONFIGURATION RETRIEVAL DELAY MODULE — WBS NO. 320-03-03-05 & -06 — SUBSYSTEM/COMPONENT ELECTRICAL POWER SUBSYSTEM — DATE: 13 AUG, 1973

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
PRIMARY BATTERY	5	6		Ag-Zn, Mg	88	15	8	8	960	250 AMP-HR RATED CAPACITY @ 30V: 0.7 AMP DISCH. OVER 336 HRS + 4 AMP OVER 6 HRS.	342	30,000	1	—	1	MANUALLY ACTIVATED AG-ZN BATTERY SELLER: EAGLE-PICHER
POWER DIST. & CONTROL	5	—	LM		42	—	—	—	—	ASSORTED WIRE, CONNECTORS, & SOLID STATE CONTROLLERS.	342		SHIP SET	—	SHIP SET	

GRUMMAN DESIGN & CONSTRUCTION

REPORT
DATE
CODE 26912

II-8.6-73

CONFIGURATION Retrieval Delay Module (RDM) WBS NO. 320-03-01-03; 320-03-01-04 SUBSYSTEM/COMPONENT Auxiliary Propulsion System (APS) DATE: 8/3/75

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR 1/3 TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR [illegible]	NOTES
Nitrogen Tank	5	≤12	-	6AL4V	6.0	9.9D	-	-	445	-	Burst Pressure = 7215 Operating = 3000 PSI	↑	10^7	1	↑	↑	Airite P/N 6435
Solenoid Valve	5	≤12	-		2.3					84			67,000	1			LSC 270-713
Regulator (dual stage)	4	≤12	-		2.5					-		336	67,000	1			LSC 310-305-3 (MOD TO ONE STAGE)
Thruster Valve	4	≤12	-		0.75					10	0.25" I.D. REQUIRED		333,000	12			
Thruster	5	-	-		0.2					-			-	12	One Shipset	None	Nozzle Machinings
Quick Disconnect	5	≤12	-		0.5					-		↓	10^6	1			Nitrogen Fill & Vent

GENERAL NOTE:
TANK SIZED TO PROVIDE 14 DAYS WIDE DEADBAND AND 1 HOUR NARROW DEADBAND CONTROL.

GRUMMAN

APOGEE KICK STAGE CHARACTERISTICS

310ARE-3B

		PLANETARY	GEOSYNCH
PHYSICAL:	WEIGHT (MAX.), LB	545	523
	LENGTH, IN	80	64
	DIAMETER, IN	180	180
TECHNICAL:	MATERIAL	ALUMINUM	
	INSULATION	ALUMINIZED MYLAR MLI	
	ATTITUDE GYRO		
	BATTERY POWER	2 AMP HR	
	DMS/COMM	NONE	
	PROPULSION - MAIN	6 SRM'S	3 SRM'S
	- AUX.	12 COLD GAS THRUSTERS	
	RELIABILITY ALLOCATION	.9987	

WBS #320-04-08

GRUMMAN

CONFIGURATION 310ARE-3B

WBS NO. 320-04-01

SUBSYSTEM/COMPONENT KICK STAGE STRUCTURE

DATE: 9/17/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS	RELIABILITY: MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR [illegible] TEST	PROGRAMATIC: [illegible] MAJOR [illegible]	NOTES
03-Body Structure	1	92		Alum.	366	65	120	DIA		Aluminum Stiffened	N/A	1		1	Payload 23
06-Payload Interface	1	92			40					Sheet and Fittings		1		1	
03-Body Structure	1	92		Alum.	343	48	120	DIA		Aluminum Stiffened		1		1	Single Deploy
06-Payload Interface	1	92			40					Sheet and Fittings		1		1	
03-Body Structure	1	92		Alum.	336	48	120	DIA		Aluminum Stiffened	N/A	1		1	Double Deploy
06-Payload Interface	1	92			40					Sheet and Fittings		1		1	

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PAGE

CONFIGURATION AKS & RDM

WBS NO. ——

SUBSYSTEM/COMPONENT THERMAL

DATE:

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
COATINGS	5	0	LM	PAINT	1	←	160	ft^2	→		6dry	NA	1	1	NA	ALUMINIZED MYLAR/NYLON NET
INSULATION	5	6	LM	MLI	4	←	50	ft^2	→		6dry	NA	1	1	NA	

V-8.6-77

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ALL AUTONOMY LEVELS

CONFIGURATION APOGEE KICK STAGE (AKS) WBS NO. 320-04-08-03

SUBSYSTEM/COMPONENT DMS

DATE: 8/27/78

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
						SIZE											
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	LENGTH (INCHES)	WIDTH (INCHES)	HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR [illegible] TEST	EQUIVALENT UNITS FOR MAJOR [illegible]	
SENSORS	4	8	SHUTTLE		0.2	N/A	N/A	N/A	N/A	0.1			1M	2	N/A	2	WHITTAKER TRANSONICS

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DATE
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CONFIGURATION APOGEE KICK STAGE

WBS NO. 320-04-08-03

SUBSYSTEM/COMPONENT GN&C

DATE: 8-2-73

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
ATTITUDE GYRO [illegible]	4	12	IMP ITOS		13	10.6	8 DIA.		533	25 WATTS			1			120 WATTS WARM UP
VELOCITY METER	4	8	IMP ITOS		5.7	5.9	5.5	4.3	156	28 WATTS			1			40 WATTS WARM UP
[illegible]	1	18			7.6	8.6	7.1	5.5	336	18.5 WATTS			1			
TIMER [illegible] RELAYS	4	12	IMP ITOS		3	6	3.4	2.4	49	2 WATTS			1			
SEQUENCER PROGRAMMER	4	12	IMP ITOS		2	6.4	4.3	2.8	77	6.3 WATTS			1			

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DATE
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TABLE 5.2.3 - C EQUIPMENT LIST

27 AUG, 1973 REV. 1

WBS NO. 320-03-03-05 & -06

CONFIGURATION APOSEE KICK STAGE SUBSYSTEM/COMPONENT ELECTRICAL POWER SUBSYSTEM DATE: 13 AUG., 1973

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
PRIMARY BATTERY	5	6	-	AG-ZN, MG	3	7	4	4	112	2 AMP-HR RATED CAPACITY @ 30 V; 3 AMP AVG. DISCH OVER 0.5 HR.	0.5	39,000	1	-	1	MANUALLY ACTIVATED AG-ZN BATTERY SELLER: EAGLE PICHER.
POWER DIST & CONTROL	5	-	LM		25	-	-	-	-	ASSOCIED WIRE, CONNECTORS & SOLID STATE POWER CONTROLLERS	0.5		SHIP SET	-	SHIP SET	

II-8.6-80

CONFIGURATION 310ARE-3B

WBS NO. 220-04-02-04

SUBSYSTEM/COMPONENT MPS (AUX. STAGE)

DATE:

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
SRM #1	3	24	DELTA, SUNSAT II, ETC		1880	77	37	–	23K	180	I_{sp} = 295, λ' = .92 ϵ = 50			6	0	0	ME. – TEM 364 OR SVM 4A
SRM #2	3	24	"		1880	61	37	–	66K	180	I_{sp} = 287, λ' = .909 ϵ = 34			1	0	0	M.E. – "
SRM #3	3	24	"		1983	58	37	–	62K	180	I_{sp} = 287, λ' = .909 ϵ = 34			3	0	0	M.E. – "

CONFIGURATION Apogee Kick Stage (AKS) WBS NO. 5.0-03-02-03; 5.0-03-07-04 SUBSYSTEM/COMPONENT Auxiliary Propulsion System (APS) DATE: 5/3/[illegible]

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR GSE TEST	PROGRAMATIC: EQUIVALENT UNITS FOR FLIGHT MAJOR	NOTES
Nitrogen Tank	5	<12	-	6Al 4V	1.02	1.70	-	-	50	-	Burst Press. = 6660 PSI Operating = 3000 PSI	2	10^7	1	One Shipper	None	Airite P/N 6359
Solenoid Valve	5	<12	-		2.3					64			67,000	1			LSC 270-713
Regulator (Single Stage)	4	<12	-		1.5					-			67000	1			LSC 310-305-3 (Mod to one stage)
Thr Stee Valve	4	<12	-		0.75					10	0.25" I.D. required		333,000	12			Nozzle Machinings
Thrusters	5	-	-		0.2					-			—	12			Nitrogen Fill & Vent
Quick Disconnect	5	<12			0.5					-			10^6	1			

General Notes
Tank sized to provide 12 hr. wide deadband and 1 hr. narrow deadband control.

V-P-6-82

8.7 FLIGHT SCHEDULE

Included in support of our flight schedule definition for concept 310-3B/310ARE-3B are the following tables:

- Fleet Size & Vehicle Usage
- Flight Elements Requirements
- Kick Stage Definition
- Payload Flown
- 310-3B/310ARE-3B Flight Operations Buildup
- Programmatic Data Summary Storable Tug Concept 310-3B/310ARE-3B

310-3B/310ARE-3B FLEET SIZE & VEHICLE USAGE

	1979	80	81	82	83	84	85	86	87	88	89	90	TOTAL
Capture Model													
Total Flts		20	15	17	28	52	45	45	44	38	41	49	394
Prog Buildup Model													
ETR Reuse		3	12	15	21	32	37	35	35	32	30	43	295
Expend				2		2		1	1		3	1	10
WTR Reuse					7	5	8	9	8	6	8	5	56
Total Flts		3	12	17	28	39	45	45	44	38	41	49	361
											Lost Missions =		+4
National Fleet													
Veh. 1		2	6	6E									
2		1	6	7E									
3 Int.				4	17	1E							
4 Int.					11	5E							
5 Int.						17	8	2E					
6 Evl.						16	17	9	2E				
7							17	17	8	17	2E		
8							3	17	17	6	4E		
9									17	15	6E		
10											17	15E	
11											12	17	
12												17	
13 Lost Tug													
14 Lost Tug													
15 Lost Tug													
16 Lost Tug													
DOD Traffic													
Total Flts		1	6	9	15	16	13	20	21	21	17	24	163
											Lost Missions =		+2
DOD Fleet													
Veh. 1		1	6	9	15	16	13	3	17	4	1	7	
2								17	4	17	16	17	

310-3B/310ARE-3B FLEET SIZE & VEHICLE USAGE

	1979	80	81	82	83	84	85	86	87	88	89	90	TOTAL
RDM Flts.						6	13	7	7	6	9	12	60
Total Flts.													
Veh. 1						4	6	3	4	3	5	6	
2						2	7	4	3	3	4	6	
3 Lost RDM													
4 Lost RDM													

FLIGHT ELEMENT REQUIREMENTS OPTION: (310/310 ARE - 3B)

ITEM			CALENDAR YEAR											TOTAL
			80	81	82	83	84	85	86	87	88	89	90	
SHUTTLE FLIGHTS		TOTAL	9	9	8	13	30	32	25	23	17	24	25	215
BASIC TOP FLIGHTS	ETR	RECOVERED	9	9	6	10	24	26	20	16	13	17	20	170
		EXPENDED			2		2		1	1		3	1	10
	WTR	RECOVERED				3	4	6	4	6	4	4	4	35
	(TOTAL)		(9)	(9)	(8)	(13)	(30)	(32)	(25)	(23)	(17)	(24)	(25)	(215)
RETRIEVAL DELAY MODULES (ALL AT ETR)							8	12	6	3	4	6	6	45
KICK STAGES	KS 301						2		3	2				7
	KS 302											2		2
	KS 303						3	5	3	3	4	4	3	25
	(TOTAL)						(5)	(5)	(6)	(5)	(4)	(6)	(3)	(34)

BAS 9-1-73

NASA TRAFFIC

TABLE 4.3.4.2-5

FLIGHT ELEMENT REQUIREMENTS OPTION: (310/310ARE-3B)

ITEM			CALENDAR YEAR 80	81	82	83	84	85	86	87	88	89	90	TOTAL
SHUTTLE FLIGHTS		TOTAL	11	6	9	15	22	13	20	21	21	17	24	179
BASIC TUG FLIGHTS	ETR	RECOVERED	11	6	9	11	21	11	15	19	19	13	23	158
		EXPENDED												0
	WTR	RECOVERED				4	1	2	5	2	2	4	1	21
	(TOTAL)		(11)	(6)	(9)	(15)	(22)	(13)	(20)	(21)	(21)	(17)	(24)	(179)
RETRIEVAL DELAY MODULES (ALL AT ETR)							4	1	1	4	2	3	6	21
KICK STAGES	KS 301													
	KS 302						2							2
	KS 303													
	(TOTAL)						(2)							(2)

BAS 9-7-73

DOD TRAFFIC

TABLE 4.3.4.2-6

FLIGHT ELEMENT REQUIREMENTS — OPTION: (310 / 310ARE - 3B)

ITEM			CALENDAR YEAR 80	81	82	83	84	85	86	87	88	89	90	TOTAL
SHUTTLE FLIGHTS		TOTAL	20	15	17	28	52	45	45	44	38	41	49	394
BASIC TUG FLIGHTS	ETR	RECOVERED	20	15	15	21	45	37	35	35	32	30	43	328
		EXPENDED			2		2		1	1		3	1	10
	WTR	RECOVERED				7	5	8	9	8	6	8	5	56
	(TOTAL)		(20)	(15)	(17)	(28)	(52)	(45)	(45)	(44)	(38)	(41)	(49)	(394)
RETRIEVAL DELAY MODULES (ALL AT ETR)							12	13	7	7	6	9	12	66
KICK STAGES	KS 301						2		3	2				7
	KS 302						2					2		4
	KS 303						3	5	3	3	4	4	3	25
	(TOTAL)						(7)	(5)	(6)	(5)	(4)	(6)	(3)	(36)

RELIABILITY = + 4 FLTS

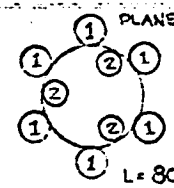
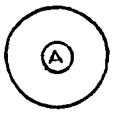
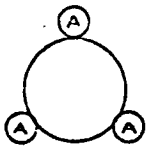
BAS 9-1-73

COMBINED NASA / DOD TRAFFIC

TABLE 4.3.1.2-7

CONCEPT 310ARE-3B

KICK STAGE DEFINITION

KICK STAGE DESIGNATION	GEOMETRY (all stages >10 ft diam. & are 5.5 ft long unless otherwise noted)		PERFORMANCE (geosynch payload) (lbs)	SRM CHARACTERISTICS INDIVIDUAL WEIGHT (lbs)	NUMBER	TOTAL SRM WEIGHT (lbs)	STAGE INERT WEIGHT (lbs)	TOTAL STAGE WEIGHT (lbs)
KS 301	 PLANETARY L=80 in	STAGE 1	5000 lbs TO ΔV=18400 fps	1880	6	11280	-	11280
		STAGE 2		1880	3	5640	494	6134
		(TOTAL)						17,414
KS 302		DOUBLE DEPLOY AKS	3515 (each P/L)	1880	1	1880	516	2396
KS 303		DELAYED RETRIEVE SINGLE DEPLOY AKS	P/L = f(RTRV'D P/L)	1483	3	4449	523	4972

BAS 9-4-73

TABLE 4.3.4.2-8

FLIGHT	PAYLOAD FLOWN					
	1980	1981	1982	1983	1984	1985
1	D-3	D-10	ALL	ALL	D-9	ALL
2	D-11	D-11			D-10	
3	D-35	D1 + D3			D-18	
4		D1 + D8			D-18	
5		D2 + D7			D-20 (KS)	
6		D3 + D3			D-20 (KS)	
7		D-31			D-24 (EXP)	
8		D-31			D-24 (EXP)	
9		D-34			R-1	
10		D-35			R-1	
11		D-35			R-12	
12		D25 + D25			R-13	
13					RD-2	
14					RD-2	
15					RD-2	
16					R-2	
17					R-2	
18					R-2	
19					RD-4	
20					R-4	
21					D1 + RD 3	
22					D8 + DR 3	
23					D14 + R 14	
24					D15 + R 15	
25					D28 + D 28 (KS)	
26					D32 + D32	
27					D32 + D32	
28					D37 + D37 + D37	
29					D39 + D39 + D39	
30					R-32	
31					R-32	
32					R-32	
33					R-32	
34					R-34	
35					D27 + RD 27	
36					DR-27	
37					D25 + R 25	
38					D25 + R 25	
39					D35 + R 35	
FLIGHTS FLOWN/SCHED	3/20	12/15	17/17	28/28	39/52	45/45
DEPLOY P/L'S FLOWN/SCHED	3/34	17/23	24/24	47/47	28/37	36/36
RTRV P/L'S FLOWN/SCHED	0/0	0/0	0/0	0/0	18/27	27/27
SORTIES FLOWN/SCHED	0/0	0/0	0/0	1/1	0/0	1/1

CONCEPT 310/310ARC-38

COSTED TRAFFIC BUILD-UP

TABLE 4.3.4.2-9

310-3B/310ARE-3B FLIGHT OPERATIONS BUILDUP

The same methodology was used to establish the 310-3B/310ARE-3B flight buildup as in the two prior phased programs.

Our recommended flight buildup for 310-3B/310ARE-3B, including 3 flights in 1980, 12 flights in 1981, and 39 flights in 1984, encompasses 365 total flights through 1990 or 29 less than 100% payload capture traffic.

310-3B/310ARE-3B FLIGHT OPERATIONS BUILDUP

INPUTS	CY 80	81	82	83	84	85	86	TOTAL FLTS.
	▽ IOC_I				▽ IOC_E			
o 100% PAYLOAD CAPTURE - ETR+WTR FLTS	20	15	17	28	52	45	45	394
ETR FLTS	20	15	17	21	47	37	36	
o SHUTTLE/TUG LAUNCH CONSTRAINT - ETR	3	21						
o INITIAL GND CREW LAUNCH CAPABIL.-ETR	12	15	16					
o EVOLVED IOC GND CREW LAUNCH CAPAB/ETR				21	34	37	36	
o TUG FLIGHT MODE BUILDUP								
SINGLE DEPLOY	3	ALL	ALL	ALL	ALL	ALL	ALL	
MULTI DEPLOY	NONE	SOME	ALL	ALL	ALL	ALL	ALL	
SORTIE	NONE	NONE	NONE	ALL	ALL	ALL	ALL	
DEPLOY WITH KICK STAGE	NONE	NONE	NONE	NONE	ALL	ALL	ALL	
RETRIEVE	NONE	NONE	NONE	NONE	ALL	ALL	ALL	
ROUND TRIP	NONE	NONE	NONE	NONE	SOME	ALL	ALL	
RETRIEVAL DELAY	NONE	NONE	NONE	NONE	SOME	ALL	ALL	
RECOMMENDED FLIGHT BUILDUP ETR+WTR	3	12	17	28	39	45	45	365
ETR	3	12	17	21	34	37	36	

BUILDUP RATIONALE

- o SAME AS 310-3A/310RE-3A

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PROGRAMMATIC DATA SUMMARY
STORABLE TUG CONCEPT 310-3B/310ARE-3B

PROJECT HARDWARE UTILIZATION (AUTONOMY IIIA/IIB)

	MAIN STAGE INIT	MAIN STAGE EVOL	ORBITER INTERFACE	AKS 301	AKS 302	AKS 303	RDM	
VEHICLE TEST								
PTV	1*		-	-	-	-	-	
STA	1		1	1	-	-	1	
1 AT	1	1	-	1	-	-	1	
FLT TEST VEH	1*		1*	1	-	-	1*	
VEHICLE OPS								
TEST HDWR CONV	*		*	-	-	-	*	
NATIONAL FLEET	5	11	5	7	4	23	4	
NASA	3	9	3	7	2	23	2	
DOD	2	2	2	-	2	-	2	
TOTAL FLEET		16			34A		4R	

SHUTTLE FLIGHTS

	TEST	OPERATIONS		
	INIT	INIT	EVOL	TOTAL
ETR	1	53	255	308
WTR	-	7	50	57
COMBINED	1	60	305	365
NASA	1	29	171	200
DOD	-	31	134	165

OPNL YEARS

	INIT	EVOL	TOTAL
ETR	4	7	11
WTR	1	7	8

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8.9 Risk Assessment

In making an assessment of the risk associated with each configuration in each capability option we have considered the type of technology items associated with each vehicle and the impact that it would have on the program if, for one reason or another, the item would be unavailable and an alternative solution would be required. The impact is defined, usually, in terms of added weight, lost performance and total program cost increase; in some cases the impact can be decreased weight or reduced cost.

It is assumed that all of the weight increases and all of the cost increases will occur simultaneously without benefit of any offsetting decreases in either weight or cost. For example in configuration 110A-1 we have assumed that the +4 lb. weight impact of abandoning spun aluminum tanks in favor of welded aluminum tanks is combined with a $10.0 million cost increase as a result of abandoning aluminum tanks in favor of titanium tanks due to materials compatibility or fracture mechanics issues.

Taking the summation of all the weight increases, these are converted to costs by using the $75K/lb. figure derived when we were first selecting subsystem options for incorporation with 110A-1. The $75K/lb. number represents the last step (actually the slope of the line) in our subsystems synthesis process which provides a curve of Δ weight versus Δ total program costs as we added lighter and more costly subsystems options to achieve a behicle with 3500 lb. deploy capability. In this manner we arrived at a estimate of the costs expected if we had to recover the weight growth.

In similar fashion we then summed all of the potential cost increases, ignoring any offsetting cost decreases, and added these to the dollars representing the weight increases. The 110A-1 has no projected performance loss since it uses the OME 7.5K engine; the assumption is that the basic OME will have been developed to meet its weight, performance and reusability goals for the Shuttle Orbiter. In the case of configurations which use the Class I engine, for example 410AD-2, we have assumed that a 3 second Isp performance loss is possible. To convert this performance loss to costs we use the payload sensitivity factor to loss in Isp (97 lbs/sec), divide this by the payload sensitivity to inert weight and then multiply by $111/lb. to convert it to costs.

Taking all of the costs and adding them together we get a total low cost risk value of $15.3M for 110A-1 which ranges to a high value of 94.3M for 320A-3A/320AE-3A.

Where no suitable alternative exists (for example the Class I engine, or the laser radar, or the Space Storable SRM) we have identified that item as both a cost and a schedule risk without attempting to quantify the risk. In general, we are relying on the successful completion of the proposed SR&T programs to reduce or eliminate the risk of schedule slippage.

Taking configuration 110A as an example:

110A-1: This is an extremely low risk program with only two items representing a technical risk, the spun-form aluminum tanks and the prestressed filament reinforced (PFR) helium tanks. Both of these items are low risk and both have suitable, low risk alternatives available.

The incorporation of separate tanks (rather than the nested tanks used in the other configurations) further reduces the risk associated with this configuration. Level III (rather than Level IIB) autonomy also reduces the risk since there is no reliance on the 621B Navigation Satellite program. The OME 7.5K engine is the lowest risk engine program available, so its use on 110A-1 further reduces risk. The use of scaled-up LM batteries rather than fuel cells with their associated cryogenic storage tanks and valves is again the lowest risk approach available for providing electrical power. The all-aluminum structure is the lowest cost/lowest risk approach available. The short mission duration (34 hours) eliminates the need for multi-layer insulation (MLI) on most of the external surfaces there minimizing the risk of damage to the MLI during vehicle ground operations.

Since the 110A-1 does not have to communicate with payloads it has the the lowest risk communications equipment, a dedicated frequency station, to develop. Although our current approach includes making the communications equipment compatible with the NASA Tracking and Data Relay Satellite System (TDRSS) an option which can further reduce risk, is to eliminate the requirement for this equipment to meet the spread spectrum and CCIR interference requirements associated with TDRSS. The modifications of an existing IMU (the Carousel VB) and an existing computer (the CDC 469) are again the lowest risk approach identified in the GN&C and DMS areas.

Although the use of an apogee kick stage (AKS) to deploy heavier payloads reduces the sensitivity of the configuration to inert weight growth or I_{sp} loss, it does add complication to flight operations, increasing risk. Elimination of the AKS can further reduce the risk of this configuration.

310-3B/310ARE-3B RISK ASSESSMENT

TECHNOLOGY ITEM IMPACT	
• CLASS I ENG	-3 SEC ISP
• PFR TANK	+48 LB
• ADV IMU	+30 LB
• GRAPHITE COMPOSITE	+38 LB
• LASER RADAR	COST/SCHED
• MATERIALS COMPATIBILITY • FRACTURE MECHANICS	+13 LB
• HEAT PIPES	SCHED

VEHICLE SENSITIVITY (DEPLOY)	PLAIN	WITH AKS
$\frac{\partial P/L}{\partial W \text{ FIXED}}$ (LB/LB)	-3.66	266
$\frac{\partial P/L}{\partial ISP}$ (LB/SEC)	96	93

II-8.9-2

TECHNICAL RISK
- POTENTIAL WT IMPACT: +129 LB } ≈ 622 LB OF PAYLOAD (W AKS)
- POTENTIAL ISP LOSS: -3 SEC }
- OPEN WEIGHT REDUCTION OPTION: ADV FUEL CELL

SCHEDULE RISK
- PROPOSED SR&T PROGRAMS (COMPLETED PRIOR TO ATP) PROTECT AGAINST SCHEDULE SLIP
- AVAILABILITY OF 621 B SATELLITES & MAIN ENGINE

• COST RISK
- POTENTIAL Δ COST $23.1 M

MODERATE RISK PROGRAM

310-3B/310ARE-3B RISK ASSESSMENT

The technology items and their potential impact are shown on the opposite page. If the prestressed filament reinforced (PFR) helium tank fails to meet its goals, a 6Al4V titanium tank adds 48 lbs to the vehicle. If the advanced (Micron) IMU is unavailable, a Carousel VB IMU plus a rate gyro unit adds 30 lbs. If the graphite composite shell fails to meet its objectives, an aluminum honeycomb shell adds 38 lbs. The laser radar is an item which has no alternative, hence it represents both a schedule and cost risk. If materials compatibility or fracture mechanics data indicate the need to change propellant tank material from titanium to either aluminum or stainless steel, the added weight would be +13 lbs or +3 lbs respectively. If the heat pipes are replaced by incorporating high heat rejection items on the active loop, there are no weight changes. To recover the weight impact on payload capability due to these possible weight increases, the advanced fuel cell is an open option.

The Class I engine is a new design based on current technology with the exception of the uncertainty in engine life and in the predicted performance with the high expansion ratio nozzles used. It is estimated this engine can miss its performance goals by -3 seconds Isp.

Although the proposed SR&T programs protect against schedule slippage by virtue of being completed at ATP, the availability of both the main engine and the 621B Navigation Satellites remain schedule risk items.

Converting the potential Isp loss and weight increases to a total program cost at a $111/lb value and adding to the potential cost increase items, yields a total cost risk of $23.1M for 310-3B/310ARE-3B.

RISK ASSESSMENT 310-3B/310ARE-3B

BASELINE	ALTERNATIVE	WEIGHT LBS	TOTAL PROGRAM COSTS, $M
CLASS I ENGINE	NO ALTERNATIVE	-	COST/SCHED RISK
LASER RADAR	RF RADAR PLUS REMOTE TV DOCKING (ALSO A TECHNOLOGY ISSUE), HENCE NO ALTERNATIVE	-	COST/SCHED RISK
PFR HELIUM TANK	6 AL 4V TITABIUM TANK	+48	+1.0
ADVANCED IMU (MICRON)	CAROUSEL IIB IMU + RATE GYRO UNIT	+30	-7.8
GRAPHITE COMPOSITE SHELL	ALUM. HONEYCOMB SHELL	+38	+0.65
TITANIUM TANKS (COMPATIBILITY DATA & FRACTURE MECHANICS DATA)	STAINLESS STEEL, OR ALUMINUM	+3, OR +13	TBD
HEAT PIPES	USE ACTIVE LOOP/BYPASS	NONE	NONE

SUMMING HIGHER WEIGHTS & COSTS ONLY	129 LBS	$1.65M
CONVERT WEIGHT TO $ at $111K/LB	(129 X 111 K)	14.30
CONVERT - 3 SEC ISP TO $	$\frac{(3 \times 96}{3.66} \times 111$ K)	7.85
TOTAL COST RISK		$ 23.80M

Section 8.10 Supporting Research and Technology

This section includes a summary matrix chart which identifies all of the SR & T items and where they are applied to each configuration in each capability option.

Following the summary matrix there are individual tables for each configuration which summarize the technology items for that particular configuration and give a very brief synopsis of the type of SR & T program proposed and the estimated funding and schedule requirements. The text following each table is the facing page text prepared for the main presentation.

Following the tables for each configuration, an additional form is filled out for each technology item providing status information, justification for the proposed SR & T program, objectives, technical approach, and a more detailed schedule showing when the proposed program must be completed in order to support the particular configuration.

In dealing with the subject of SR & T we have identified two distinct groups - one where technology is needed and the other where there is no doubt that the technology is available and it is a straightforward engineering task to accumulate data that will preclude making a "false start" where several alternates are under study; we have called the latter group "desired data".

The storable Tug will benefit from the fact that the APOLLO LM program has used similar materials, propellants, equipments and procedures; the Shuttle Orbiter will expand on this data base for the Tug. The low number of identified SR & T items and the modest sums projected are based on the assumption that several existing or planned efforts related to the Shuttle will continue to provide data. These include the planned propellant and materials compatibility testing in support of the Shuttle Orbital Maneuvering Subsystem, its engines, tanks and components both at NASA/WSTF and at the Shuttle contractor's facilities. In addition, we have identified the Air Force funded efforts to develop the advanced Micron IMU for aircraft programs, as an effort which we would build-on rather than to start from scratch.

We have not attempted to detail the SR & T programs required on the Class I engine (with or without the two position nozzle) except to point out the uncertainty associated with the anticipated engine life and the predicted performance of very high expansion ratios within the mixture ratio of interest. The engine contractor will provide the proposed SR & T efforts required on the engine and we will provide comments on same at NASA's request.

The overall "message" which we hope will become obvious to the reader is that there are no real "show-stoppers" among the SR & T items identified.

TECHNOLOGY REQUIREMENTS AND "DESIRED DATA"

		110-A1	410AD-2	310-3A 310RE-3A	320-3A 320AE-3A	310-3B 310ARE-3B	510A-3B 510ADE-3B
S R & T	CLASS I ENGINE, HIGH E PERF		X	X	X	X	
	TWO-POSITION NOZZLE				X		
	LASER RADAR		X	(X)	(X)	(X)	(X)
	PFR HELIUM TANK	X	X	X	X	X	X
	ADVANCED FUEL CELL				X		
	ADVANCED IMU		X	(X)	(X)	(X)	(X)
	GRAPHITE COMPOSITE		X	X	X	X	
	SPUN-FORM ALUM. TANKS	X					X
	LONG TERM SPACE STORABLE SRM		X				(X)
DESIRED DATA	MATERIALS COMPATIBILITY DATA	X	X	X	X	X	X
	FRACTURE MECHANICS DATA	X	X	X	X	X	X
	HEAT PIPE DATA	X	X	X	X	X	X

(X) REQUIRED PRIOR TO GO AHEAD ON EVOLVED TUG CONFIGURATIONS

GRUMMAN

310-3B/310ARE-3B TECHNOLOGY REQUIREMENTS & DESIRABLE DATA

	ITEM	SR&T FUNDS $K	SR&T SCHEDULE MOS.	PROPOSED PROGRAM
SR&T	CLASS I ENGINE	TBD	TBD	HIGH ALT. TESTS TO OBTAIN PREF. DATA ON HIGH ϵ NOZZLE FOR MIXTURE RATIO RANGE
	LASER RADAR	500	12	FAB & TEST LIGHTWEIGHT, LOW POWER UNIT USING IMPROVED OPTICS & LIGHTER MIRROR DRIVES
	PFR HELIUM TANK	125	12	FAB & TEST 3 TANKS UNDER STATIC & DYNAMIC LOADING: AND ENVIRONMENTAL & COMPATIBILITY TESTS
	ADVANCED IMU	500	18	DEVELOP SOFTWARE FOR REDUNDANCY MGMT AND CALIBRATION OF 2 MULTI-SENSOR TYPE IMU'S
	GRAPHITE COMPOSITE	15	6	FAB GRAPHITE EPOXY HONEYCOMB SAMPLES & TEST IN VARIOUS PLY DIRECTIONS FOR DESIGN DATA
DESIRABLE DATA	MATERIALS COMPATIBILITY DATA	25	6	2219-T87, 2218-T81 & 6Al4Al4VTi; WITH N_2O_4 & MMH UP TO 130°F
	FRACTURE MECHANICS DATA	25	6	2219-T87 & 6Al4VTi; Kic Kth & FLAW GROWTH WITH N_2O_4 & MMH UP TO 130°F
	HEAT PIPES	100	12	FAB & TEST VARIABLE CONDUCTANCE HEAT PIPE RADIATOR & HEADER FOR TURN DOWN RATIO AND SHUTOFF HEAT FLUX DATA

GRUMMAN

TECHNOLOGY REQUIREMENTS AND DESIRED DATA - 310-3B/310ARE-3B

The upper part of the facing chart contains the supporting research and technology (SR&T) items required for 310-3B/310ARE-3B; the lower part of the chart contains what we have termed as "desired data". The distinction between the two is that the "desired data" items do not require technology but are considered straightforward engineering development tasks to produce design data prior to Tug program go-ahead (ATP); this will preclude impacting Tug schedules should the data indicate the desirability of an alternate approach, (vis., aluminum or stainless steel propellant tanks rather than titanium).

Excluding the SR&T on the Class I engine the total SR&T funds requested for 310-3B/310ARE-3B is $1290K to be expended over an 18 month period cluminating at Tug ATP or prior to go-ahead on the evolved Tug. The advanced (Micron) IMU is the long lead item (18 months), again excluding the Class I engine.

410 AD-2, 310RE-3A, 320AE-3A, 310 ARE-3B, 510ADE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Avionics (CN&C)
(Discipline)

TITLE Low Weight/Power, (Rendezvous and Docking) Laser Radar

WBS No. 320-03-03-02

STATUS ITT-Gilfillan has been under NASA Contracts since 1964 to design, develop, build, and test various spaceborne laser radar systems. The third generation system will be delivered in late November 1973.

JUSTIFICATION The application of the above developed technology to meet specific space tug rendezvous and docking requirements is desired.

In addition in order to improve the payload capability of the storable tug, low weight Avionics equipments (specifically, low weight/low power laser radar) are required.

OBJECTIVES To design, develop, fabricate, and test a low weight, low power, rendezvous and docking laser radar.

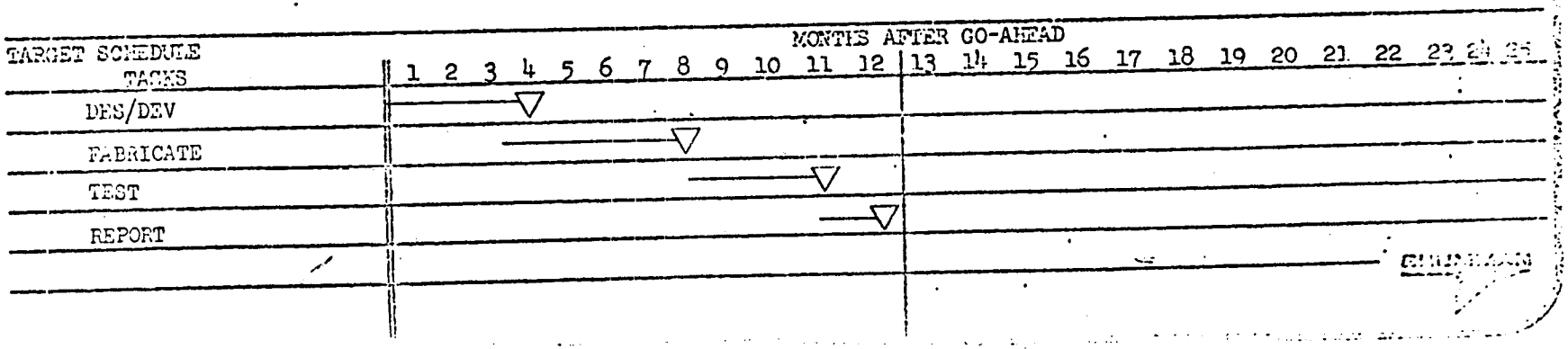
V-8.4-4

TECHNICAL APPROACH Using Tug requirements, design for light weight, low power by using new components, lighter mirror drives and improved optics

MANPOWER

FUNDING $500 K

SPECIALIZED FACILITIES Development and testing at ITT



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STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE Astrionics (GN&C) TITLE Low Wt./PW Rend.&Docking Laser Radar WBS 320-03-03-02

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG ∅ C/D ATP MILESTONES			1980 TUG△		1982 TUG△		1984 TUG△
TASKS							
Design & Development							
Fabricate							
Test							
Report							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)					4	12	16
FUNDING							
a) DIRECT LABOR					100K	300K	400 K
b) EQUIPMENT & MAT'L					20K	40K	60 K
c) FACILITIES					40K	--	40 K
d) OTHER (SPECIFY)							
TOTAL					160K	340K	500 K

SPECIALIZED FACILITIES

TYPE/LOCATION/AVAILABILITY

FACILITIES DEV. TIME & COST

Optics bench, dark rooms, test range

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Main Propulsion
(Discipline)

TITLE Prestressed Filament Reinforced (PFR) Tanks

WBS No. 320-03-04-02

STATUS Structural Composites Industries, Inc. (SCI) and Arde-Portland, Inc. are under contract to LeRC to demonstrate the feasibility of the PFR tanks. This program will result in the construction of a 24 in. diam. Ardeform PFR tank of the type assumed by our study. If successful the basic technology will be proven.

JUSTIFICATION

A PFR ambient helium storage tank is comparable with the weight of a SHe tank and its associated heat exchanger. It provides a simple and less operationally complex system compared to the SHe tank. The PFR tank also provides a leak-before-burst design which results in increased Tug safety.

OBJECTIVES

Design, fabricate, and test 3 to 6 PFR tanks to demonstrate that current manufacturing and quality control techniques are adequate to produce a reliable, low weight tank suitable for containing gaseous helium (or hydrogen and oxygen in the case of fuel cell reactant tanks). The program will resemble a pre-qualification test program which will demonstrate the ability of the PFR tank to undergo the dynamic loading, compatibility, environmental exposure and etc. tests required for acceptance as a flight item.

TECHNICAL APPROACH

Fabricate 3 to 6 tanks and subject them to a pre-qualification test program to demonstrate the maturity of the design.

MANPOWER 2 man years

FUNDING $125,000

SPECIALIZED FACILITIES

Available at tank manufacturers

TARGET SCHEDULE

TASKS	MONTHS AFTER GO-AHEAD 1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Fabricate Tanks		
Test Program		
Analysis and Report		

GRUMMAN

BRUNSMAN

ALL EXCEPT 410AD-2

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE MAIN PROPULSION (MPS) TITLE PRESTRESSED FILAMENT REINFORCED (PFR) TANKS WBS 320-03-04-02

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG ∅ C/D ATP MILESTONES			1980 TUG△		1982 TUG△		1984 TUG△
TASKS							
Fabricate Tanks							
Test Program							
Analysis and Report							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)	1	1					
FUNDING							
a) DIRECT LABOR	$ 38,000	$ 37,000					$ 75,000
b) EQUIPMENT & MAT'L	$ 30,000	$ 20,000					$ 50,000
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL	$ 68,000	$ 57,000					$125,000

SPECIALIZED FACILITIES	
TYPE/LOCATION/AVAILABILITY	ARDE, SCI, or Similar
FACILITIES DEV. TIME & COST	None

410 AD-2, 310 RE-3A, 320 AE-3A, 310 ARE-3B, 510 ADE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Astrionics (GN&C)
(Discipline) WBS #320-03-03-02

TITLE: Advanced (Low Weight) Inertial Measurement Unit for Space Application

STATUS: Advanced Lightweight Unit being developed under Air Force Contract. Primarily for aircraft application.

JUSTIFICATION: To improve payload capability of a storable tug, low weight Astrionics Equipments are required.

OBJECTIVES: To develop the advanced IMU to the point where it can be used in a space application.

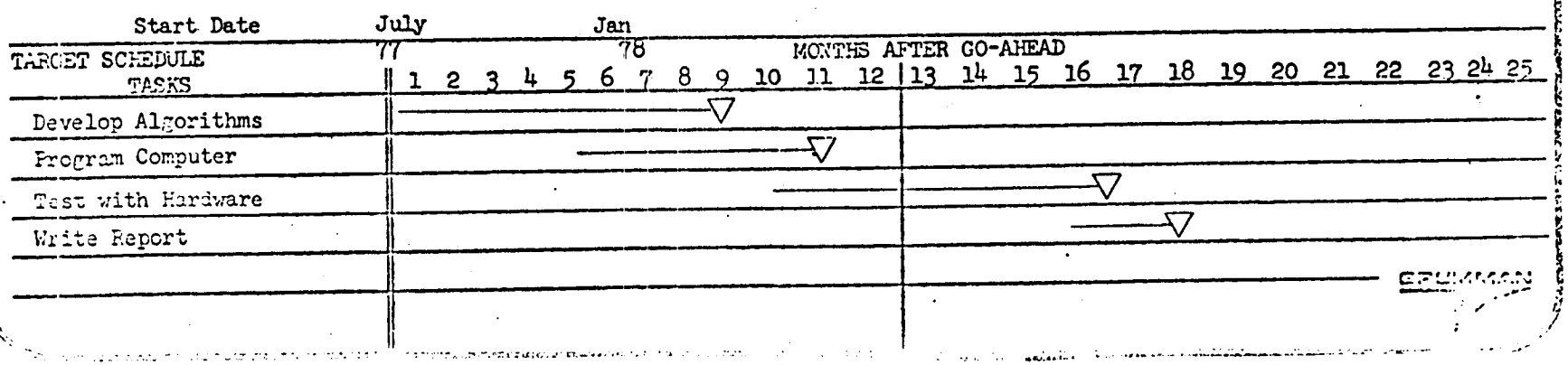
T-84-13

TECHNICAL APPROACH:
1. Develop software mechanizations for redundancy management.
2. Develop software and procedures for calibration of gyros on the launch pad.
3. Test the software with the hardware in the lab.

MANPOWER

FUNDING $500 K

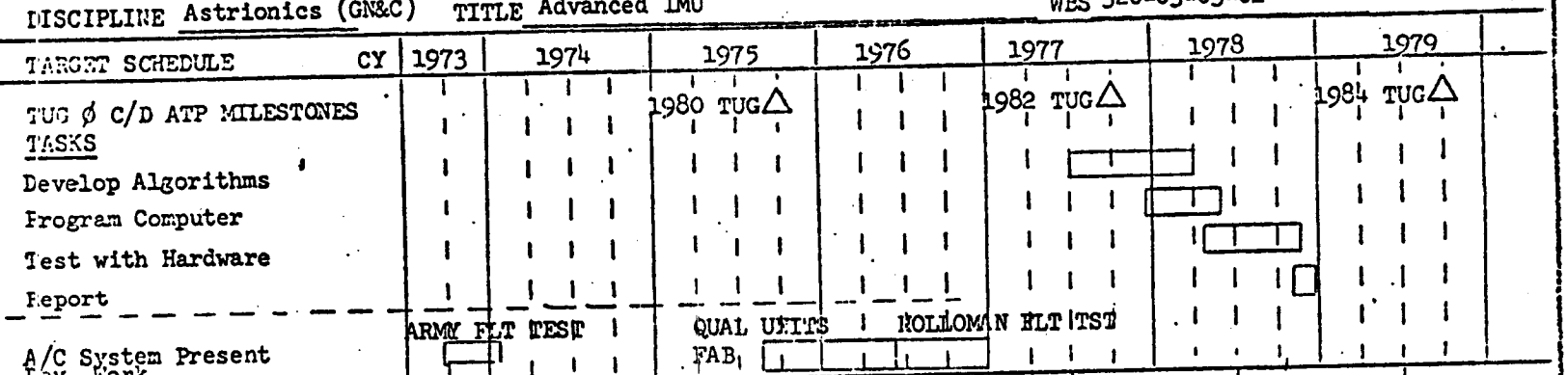
SPECIALIZED FACILITIES: Development and test in subcontractor's facility.



GRUMMAN

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE Astrionics (GN&C) TITLE Advanced IMU WBS 320-03-03-02



RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)				4	8		12
FUNDING							
a) DIRECT LABOR				100 K	200 K		300 K
b) EQUIPMENT & MAT'L					100 K		100 K
c) FACILITIES Inertial Test Stand					100 K		100 K
d) OTHER (SPECIFY)							
TOTAL				100 K	100 K		500 K

SPECIALIZED FACILITIES
TYPE/LOCATION/AVAILABILITY
FACILITIES DEV. TIME & COST

Development and test at subcontractor's facility.

410 AD-2, 310-3A/310RE-3A, 320 A-3A/320 AE-3A, 310-3B/310 ARE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - STRUCTURES
(Discipline)

TITLE GRAPHITE/EPOXY HONEYCOMB WBS No. 320-03-01-03

STATUS Graphite/Epoxy honeycomb is well within Grumman's capability; however, the use of .0025" single ply to achieve a buildup to 0.012 face sheets requires further development.

JUSTIFICATION This design provides the lightest weight shell structure.

OBJECTIVES To establish, by test, design allowables for honeycomb structural components using metallic honeycomb core with graphite/epoxy face sheets utilizing 2.5 mil ply thickness to achieve a total face sheet thickness of 12 Mil.

TECHNICAL APPROACH Std. Test specimens will be fabricated using various combinations of ply directions to validate design allowables obtained from classic lamination theory.

MANPOWER Tooling 100 MHRS FUNDING $ 15 K
Mfg. 400 MHRS M & P 160 HRS. -
SPECIALIZED FACILITIES

TARGET SCHEDULE — MONTHS AFTER GO-AHEAD

TASKS	1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Fabricate Test Specimens	⟷	
Test	⟷	
Report	▽	

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE STRUCTURES — TITLE GRAPHITE/EPOXY HONEYCOMB THIN GAGES WBS 320-03-01-03

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG Ø C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS							
o FABRICATE GR/EP HONEYCOMB USING .0025 PLIES to obtain UP TO 0.012 FACE SHEETS.							
o STANDARD TEST SPECIMENS WITH VARIOUS PLY DIRECTIONS TESTED TO OBTAIN DESIGN DATA							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS) ½ MAN YEAR							
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L							
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							
SPECIALIZED FACILITIES TYPE/LOCATION/AVAILABILITY FACILITIES DEV. TIME & COST	—						

K-8,9-16

ALL TUG VEHICLES

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Structures
(Discipline)

WBS No. 320-03-01-01-02

TITLE Material Compatibility

STATUS Material compatibility of Ti-6AL-4V STA and 2219-T87 Aluminum alloy in the presence of MMH at temperatures up to 150°F is required. Compatibility of N_2O_4 with 2219-T87 is also required.

JUSTIFICATION Compatibility of propellants with tankage material must be assessed to obtain the reuse life of the tanks under cyclic loads.

OBJECTIVES The objective of the program is to obtain the static and fatigue properties of the tankage parent and weldment materials under cyclic exposure to propellants and load.

TECHNICAL APPROACH Static and fatigue properties of candidate materials specimens will be obtained prior to and after exposure to the propellants. Tests will be performed at R.T. and 150°F.

FUNDING $ 25 K

MANPOWER One man-year

SPECIALIZED FACILITIES

TARGET SCHEDULE TASKS	MONTHS AFTER GO-AHEAD 1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Test Plan		
Spec. Fab.		
Test		
Report		

ALL TUG VEHICLES

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE STRUCTURES TITLE MATERIALS COMPATIBILITY DATA WBS 320-03-01

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG Ø C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS o FABRICATE & TEST MATERIAL SPECIMENS OF PARENT MAT'L & WELDMENTS TO OBTAIN COMPATIBILITY DATA FOR N_2O_4 & MMH UP TO 200°F. MATERIALS 6AL-4V, 2219-T87 & T-81							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS) ONE MANYEAR							
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L							
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							
SPECIALIZED FACILITIES TYPE/LOCATION/AVAILABILITY FACILITIES DEV. TIME & COST							

ALL TUG VEHICLES

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Structure (Discipline)

WBS No. 320-03-01-01 02

TITLE Fracture Mechanics Test Data

STATUS Fracture mechanics test data for thin gage (.020 to .040) for Titanium 6AL-4V STA and 2219-T87 aluminum alloy exposed to N_2O_4 and MMH at temperatures up to 200°F is not available.

JUSTIFICATION Fracture mechanics data for thin gage tank material are required to assess the fracture mode and life cycle of the tug propellant tanks.

OBJECTIVES The objectives of the program are to obtain K_{ic}, K_{th} and flaw growth data for parent and weldment materials in the induced thermal environment up to 200°F. Data to be obtained prior to and after exposure to the candidate propellants. In addition to fracture mechanics data, NDE techniques are to be employed on the test specimens to assess flaw detection capability.

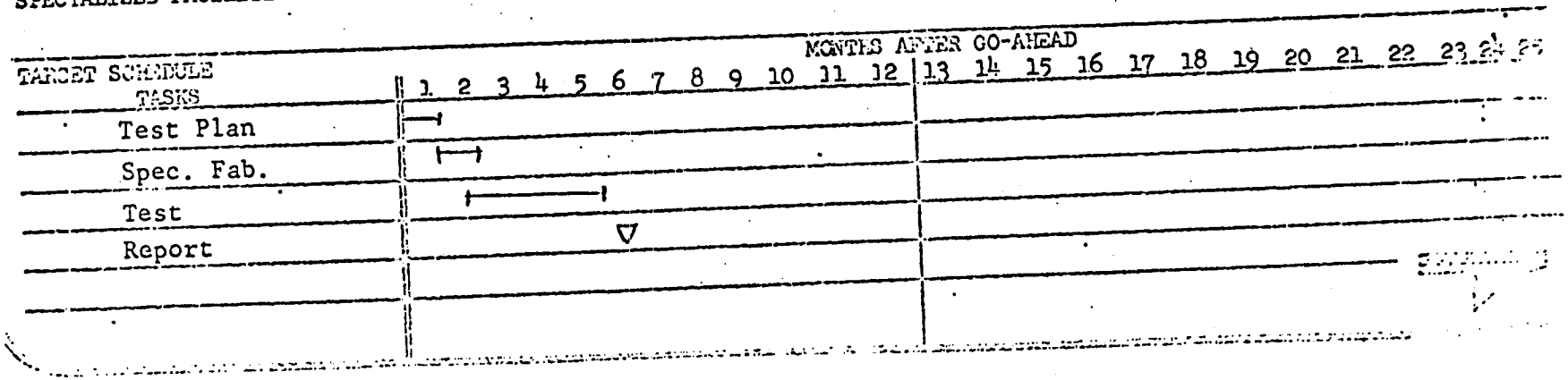
V-8.9-19

TECHNICAL APPROACH Standard fracture elemental specimens are to be employed. Tests are to be employed. Tests are to be conducted at room temperature and at 150 and 200°F. Surface flaws of various sizes are to be used and NDE techniques are to be employed to document size where practical.

MANPOWER One man-year

FUNDING $25K

SPECIALIZED FACILITIES



TARGET SCHEDULE

TASKS	MONTHS AFTER GO-AHEAD 1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Test Plan		
Spec. Fab.		
Test		
Report	▽	

ALL TUG VEHICLES

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE STRUCTURES TITLE FRACTURE MECHANICS DATA WBS 320-03-01 = 01 02

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG ϕ C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS							
o FABRICATE & TEST MAT'L SPECIMENS (Parent metal & weldments) to obtain K_{IC} K_{TH} & FLAW GROWTH DATA FOR INDUCED ENVIRONMENTS INCL. 200°F. ALSO STATIC & FATIGUE DATA. MAT'LS 6AL-4V & 2219-T81 & T87							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS) ONE MAN YEAR							
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L							
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							

SPECIALIZED FACILITIES

TYPE/LOCATION/AVAILABILITY

FACILITIES DEV. TIME & COST

110 A-1, 410 AD-2, 310-3A/310 RE-3A, 320 A-3A/320 AE-3A, 310-3B/310 ARE-3B, 670 A-3B/670 ADE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Thermal Control
(Discipline)

TITLE SPACE TUG HEAT PIPES

WBS No. 320-04-02

STATUS

Heat pipes (HP) are currently being used in both ground and space application. The variable conductance heat pipe (VCHP) principle is particularly attractive for Tug application but requires further development.

JUSTIFICATION

The fuel cell and certain high power density avionics units carried on the Space Tug require active cooling. Trade studies which have examined pumped loop radiators, sublimators and various heat pipes have indicated the obvious merits of the variable conductance heat pipe. A VCHP radiator could interface with the pumped loop heat transport system of the fuel cell, eliminating the cost and complexity of a selective stagnation radiator with its associated unreliable automatic bypass valves. A VCHP header, a heat transport device, could provide for high power density avionics heat transport without recourse to the active loop.

V-89-21

OBJECTIVES

Emphasis will be placed on experimentally obtaining the large turn down ratios which appear theoretically achievable and in developing predictive techniques.

TECHNICAL APPROACH

Design, fabricate and test a VCHP radiator and VCHP header and experimentally determine performance with emphasis on turn down ratio and shut off heat flux levels.

MANPOWER 5580 manhours

FUNDING $100K

SPECIALIZED FACILITIES

Grumman Thermal Laboratory

TARGET SCHEDULE

MONTHS AFTER GO-AHEAD

TASKS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Establish Test Plan	-																								
Material Procurement		-																							
Design & Fab Test Specimens		—	—	—	—																				
Conduct Engineering Tests						—	—	—	—																
Analyse Test Results									—	—	—	—													
Final Report											—	—													

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STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE _____ TITLE _____ WBS _____

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG Ø C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS							
TEST PLAN							
DESIGN & FAB TEST SPECIMEN							
CONDUCT TEST							
ANALYSIS & FINAL RPT							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)	1.5	1.5					
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L	100K						
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							

SPECIALIZED FACILITIES TYPE/LOCATION/AVAILABILITY FACILITIES DEV. TIME & COST	GRUMMAN THERMAL LAB, BETHPAGE N.Y., AVAILABLE & FULLY DEVELOPED

8.11 SPECIAL COST SENSITIVITIES

REFERENCE:

Due to the size and development of the Special Cost Sensitivities Analysis reference is made herein to Part I, concept 110A-1, paragraph 8.11 of Volume 8.

8.13 ESTIMATING TECHNIQUE APPLIED

WBS ELEMENT	DDT&E	PRODUCTION	OPN
320-01 Proj. Management	CER's Based on LM Experience	Same as DDT&E	Same as DDT&E
320-02 Syst Eng & Integ	Same as 320-01	Same as 320-01	Same as 320-01
320-03-01 Structure	CER's Lower Level Analysis	Same as DDT&E	N/A
320-03-02 Thermal Insul	Same as 320-03-01	Same as 320-03 -01	N/A
320-03-03 Avionics	Vendor Est/Manpower/Wrap-around	Same as DDT&E	N/A
320-03-04 Propulsion	Gov't Est/Vendor Est/Wrap-around	Same as DDT&E	Same as DDT&E
320-03-05 Orbiter Interface	CER's Vendor Est/Wraparound	Same as DDT&E	N/A
320-03-06 Drop Tanks	N/A	N/A	N/A
320-03-07 Final Assy & C/O	Same as 320-01	Same as 320-01	N/A
320-04-01 Structure	Same as 320-03-01	Same as 320-03 -01	N/A
320-04-02 Thermal Insul	Same as 320-03-02	Same as 320-03 -02	N/A
320-04-03 Avionics	Same as 320-03-03	Same as 320-03 -03	N/A
320-04-04 Propulsion	Same as 320-03-04	Same as 320-03 -04	Same as 320-03-04
320-04-05 Interstage Interface	Same as 320-03-01	Same as 320-03 -01	N/A
320-04-06 Drop Tanks	N/A	N/A	N/A
320-04-07 RDM	Gov't est, CER's Vendor Est, wraparound	Same as DDT&E	Same as DDT&E
320-04-08 AKS	Same as 320-04-07	Same as 320-04 -07	Same as 320-04-07
320-04-09 DKS	Same as 320-04-07	Same as 320-04 -07	Same as 320-04-07
320-04-10 Cache Tank	N/A	N/A	N/A
320-04-11 Final Assy & C/O	Same as 320-03-07	Same as 320-03 -07	N/A
320-05 Logistics	CER's	Same as DDT&E	Same as DDT&E
320-06 Facilities	CER's	Same as DDT&E	Same as DDT&E
320-07 GSE	CER's, and End-Item analysis	Same as DDT&E	Same as DDT&E
320-08 Vehicle Test	CER's, Manpower Loading	N/A	N/A
320-09 Launch Ops WTR	N/A	N/A	Manpower Loading
320-10 Launch Ops ETR	N/A	N/A	Manpower Loading

WBS ELEMENT	DDT&E	PRODUCTION	OPN
320-11 Flt Ops DOD	CER's & Manpower Loading	N/A	Same as DDT&E
320-12 Flt Ops NASA	Same as 320-11	N/A	Same as DDT&E
320-13 Ref & Int, 1st TR	N/A	N/A	Manpower Loading
320-14 Ref & Int, 2nd TR	N/A	N/A	Manpower Loading

COST = A (BASE)^B	PROGRAM BASIS	BASE	A DDT&E	A PROD	B DDT&E	B PROD
PROJECT MGMT.	LM	VEH COST	.1	.09	1	1
	LM	LESS ENG.				
SE & E	LM	VEH COST	.13	.08	1	1
		LESS ENG.				
STRUCTURE	LM	WEIGHT				
SPUN AL. TANKS			124	15	.71	.61
TI TANKS			140	24.3	.71	.61
BODY SHELL			25	2.8	.71	.61
THRUST STRUCTURE			5.5	0.4	1	1
METEOROID SHIELD			5.5	.47	1	1
PAYLOAD INTERFACE			37.2	3.4	1	1
PROPULSION						
ACPS THRUSTERS		VENDOR COST	2	1.66	.7	.7
ACPS SUPPORT		VENDOR COST	2.4	1.84		
EPS WIRING	LM	(WEIGHT)	39.7	7	.7	.7
ORBITER INTERFACE, STRUCTURE,	LM	WEIGHT	5.5	,4	1	1
FINAL ASSY & C/O	LM	VEH COST	.54	.18	1	1

8.1 SCHEDULES

8.1.1 SUMMARY PROJECT SCHEDULE

Introduction: The Storable Tug Project schedule was developed to identify the principal project phases and to establish schedule estimates for all hardware and soft ware elements in accordance with the Space Tug Work Breakdown Structure.

The Tug Project Schedule depicts major program milestones and presents project activities at level 5 of the WBS. This schedule establishes the planning baseline for development of the Storable Tug System through design, development, manufacturing, ground test, flight test and operations. It integrates all supporting schedules into an overall project level plan and establishes the sequence and interdependency of activities and events required for the development of an operational Space Tug System.

Groundrules and Assumptions: Following are the ground rules and assumptions used for development of the Storable Tug Project Schedule:

- o ATP is October 1975 at the earliest for Options 1 and 3. ATP for Option 2 to be determined by the contractor.
- o Schedule planning is designed to minimize peak annual funding during DDT&E.
- o Main Stage DDT&E requirements consist of the following major test articles:
  - A structural test article (STA) for dynamic, static and fatigue tests.
  - A main propulsion test vehicle (PTV). Following the completion of live propellant testing the PTV will be refurbished and delivered as an operational flight vehicle.
  - One shipset of Avionics hardware for the Integrated Avionics Test (IAT).
  - A flight test vehicle (MS-1).
- o Operational fleet sizes for each project option are based on a study of traffic capture models.
- o Production rate of vehicles is based on avoiding duplication of major structural assembly tooling and minimizing gaps in manufacturing flow.

- Initial operational capability (IOC) is achieved after completion of one test flight (FOF). IOC dates are as follows:

  Option 1 - December 1979
  Option 2 - December 1983
  Option 3 - December 1979 - initial, December 1983 - evolved.

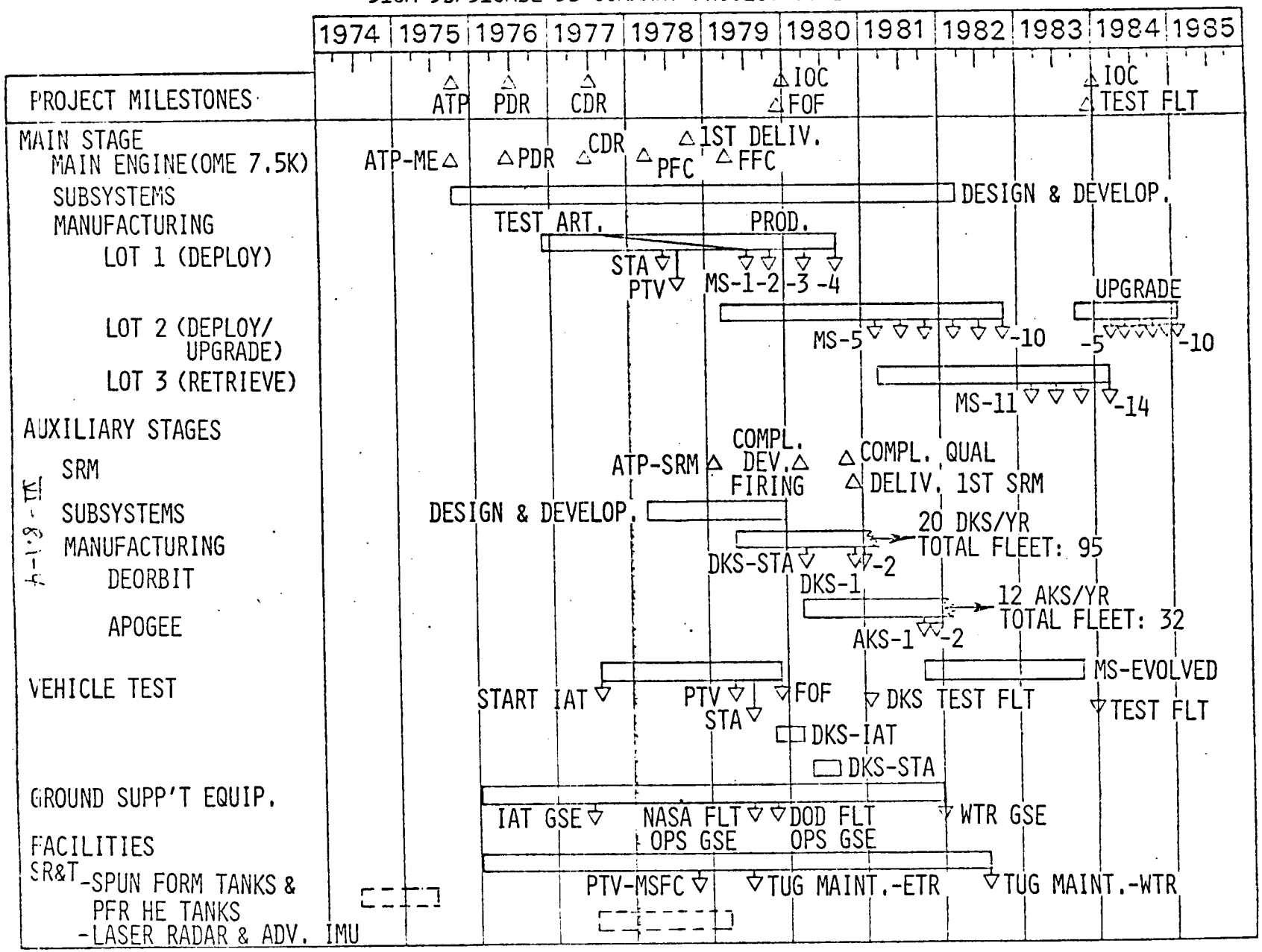
- Maximum number of flights in 1980 is 3, based on the Shuttle traffic model.

Approach: Based on the above groundrules and assumptions a preliminary project milestone schedule was developed to form a baseline for all detail scheduling. Detailed subsystem design and development schedules, manufacturing and factory checkout flows, vehicle test, GSE, facilities, and SR&T Schedules were then developed in conjunction with personnel representing the cognizant management and technical disciplines. These detailed schedules were then summarized and integrated into the Tug Project Schedule through the process of establishing a logical and achievable relationship between the engineering design and development process, procurement of subcontract equipment, hardware fabrication and assembly process and the vehicle test program that minimizes risks and ensures the fulfillment of program objectives. Finally, the major project milestones and activities presented in the Tug Project Schedule were condensed into the Summary Project Schedule.

SUMMARY SCHEDULE 510A-3B/510ADE-3B

The primary elements of the 510A-3B/510ADE-3B Project Schedule are as described for 310-3A/310RE-3A except for addition of an Apogee Kick Stage an substitution of a Deorbit Kick Stage for the Retrieval Delay Module. Authorization to Proceed (ATP) occurs on October 1,1975 with IOC of the initial configuration targeted for December 31, 1979. The OME main engine milestones are the same as for 110A-1 with Final Flight Certification occuring 8 months before First Orbital Flight (FOF). Main Stage vehicle tests are essentially the same as for 310-3A/310RE-3A. First flight of the evolved vehicle is targeted for December 1, 1983. Main Stage manufacturing begins December 1, 1976 with production of the major ground test articles and continues through production of 14 vehicles to support fleet operations. They are manufactured in 3 lots for the purpose of avoiding manufacturing gaps between deploy only vehicles and evolved vehicles. Development of the Apogee and Deorbit Kick Stages begins in March 1978, to permit deployment of the DKS with payloads in 1981, approximately 3 years prior to the evolved vehicle IOC. The Apogee Kick Stage is scheduled for deployment in November 1981. 95 Deorbit Kick Stages and 32 Apogee Kick Stages will be manufactured to support fleet operations. GSE and Facilities are scheduled essentially the same as for 110A-1.

510A-3B/510ADE-3B SUMMARY PROJECT SCHEDULE

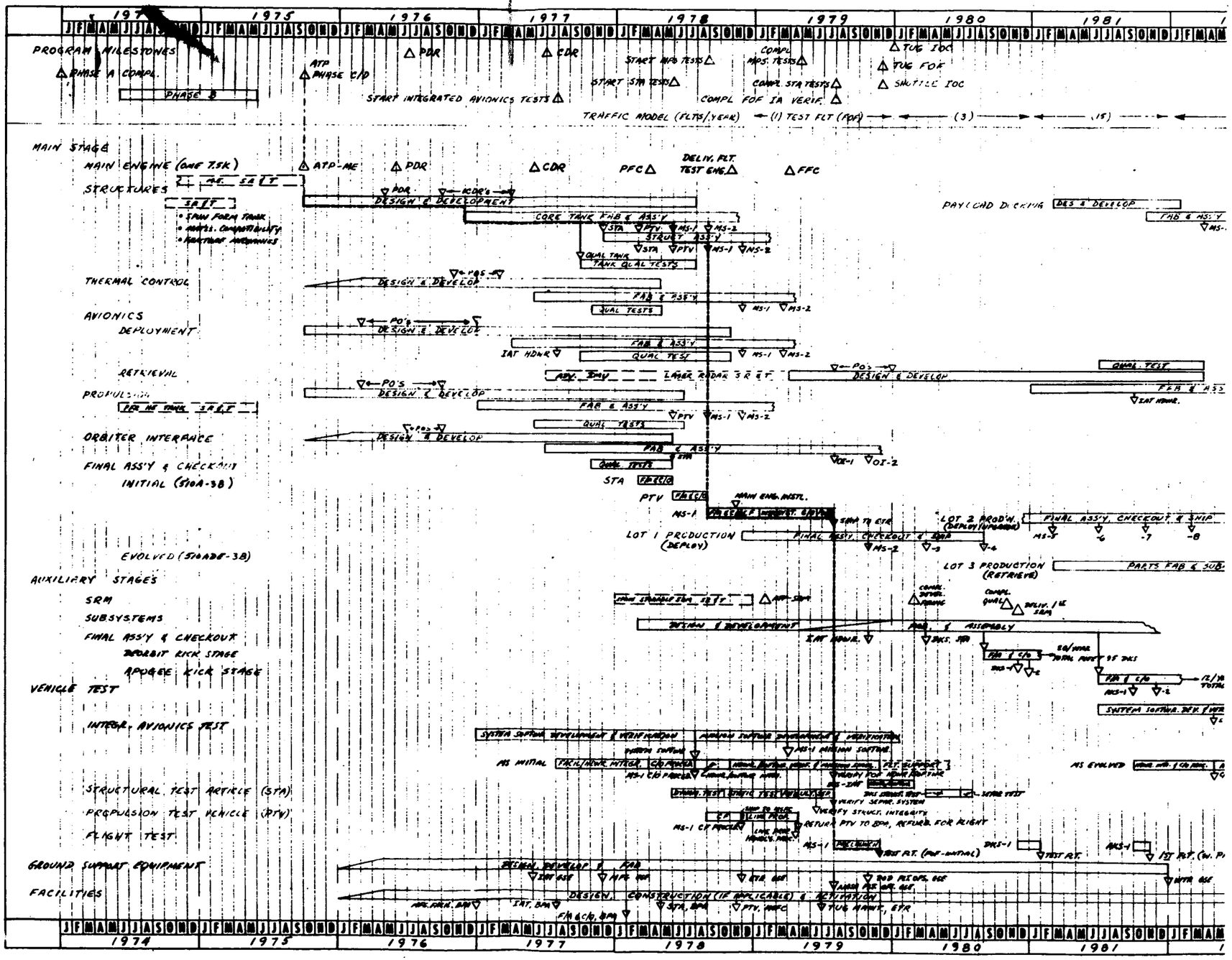


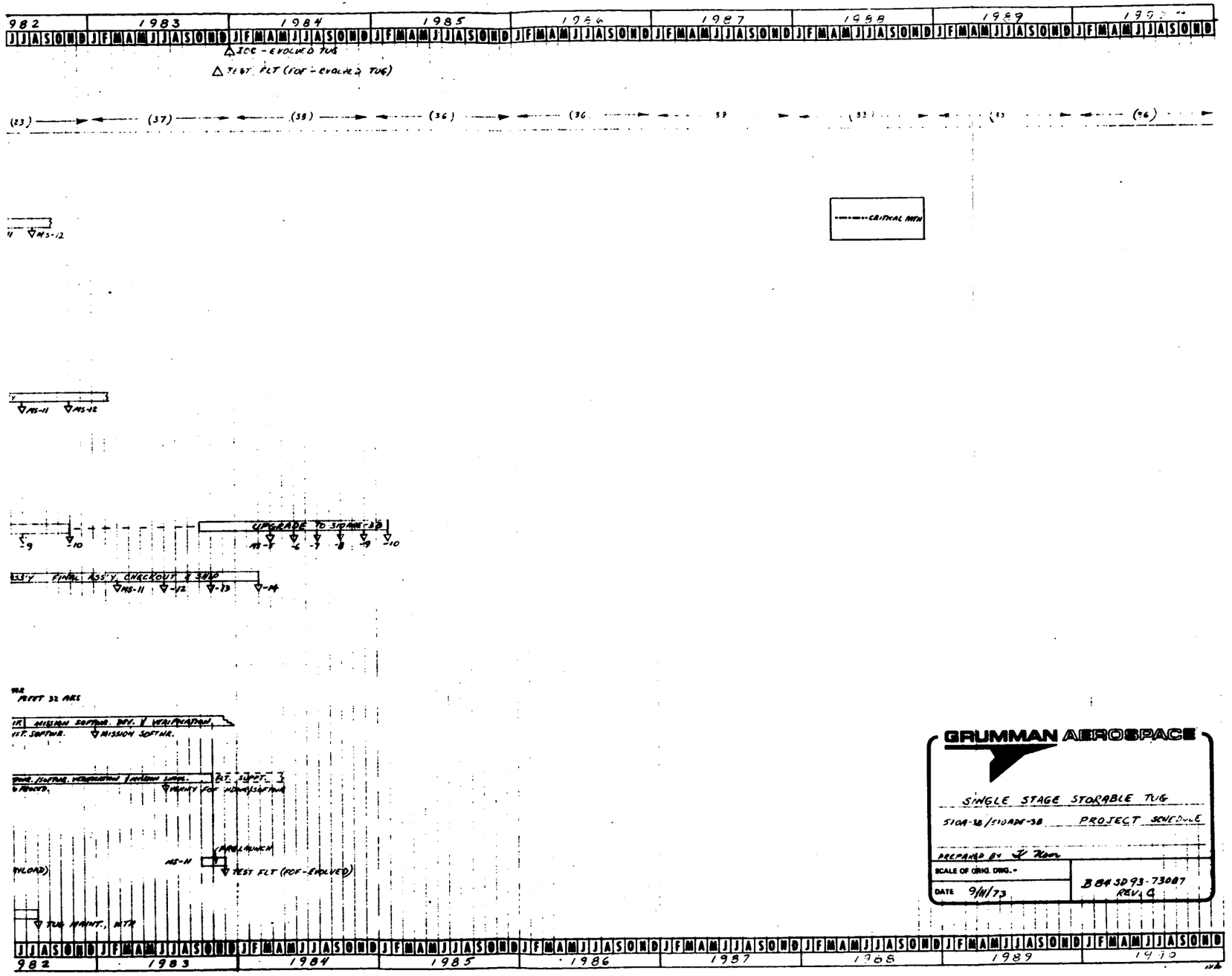
8.1.2 DEVELOPMENT SCHEDULES

8.1.3 PRODUCTION SCHEDULES

The detailed Project Schedule depicts the total development and production phases for the Main Stage and the Auxiliary Stage(s). The detailed Project Schedule is based on a constraint logic that considers overall program objectives and the detailed interaction of constraints on significant program activities. It provides reasonable margins for development problems and minimizes program front-loading.

The detailed Subsystem Schedules provide an order of magnitude increase in detail from the Project Schedule and depict the subsystem activities in both inhouse and subcontractor areas. Subsystem schedule information is presented at WBS level 6 for Structures, Thermal Control and Orbiter Interface, and at WBS level 7 for Propulsion and Avionics subsystems.


1974
1975
1976
1977
1978
1979
1980
1981
PROGRAM MILESTONES
PHASE A COMPL.
PHASE B
ATP PHASE C/D
PDR
CDR
START INTEGRATED AVIONICS TESTS
START MPS TESTS
COMPL MPS. TESTS
START STA TESTS
COMPL STA TESTS
COMPL FOF IA VERIF.
TUG IOC
TUG FOF
SHUTTLE IOC
TRAFFIC MODEL (FLTS/YEAR) (1) TEST FLT (PDR) (3) (15)
MAIN STAGE
MAIN ENGINE (ONE 7.5K)
ATP-ME
PDR
CDR
PFC
DELIV. FLT. TEST ENG.
FFC
STRUCTURES
DESIGN & DEVELOPMENT
CORE TANK FAB & ASS'Y
STRUCT ASS'Y
TANK QUAL TESTS
PAYLOAD DOCKING
DES & DEVELOP
THERMAL CONTROL
DESIGN & DEVELOP
FAB & ASS'Y
QUAL TESTS
AVIONICS
DEPLOYMENT
DESIGN & DEVELOP
FAB & ASS'Y
QUAL TEST
RETRIEVAL
LASER RADAR S R & T
DESIGN & DEVELOP
QUAL. TEST
PROPULSION
DESIGN & DEVELOP
FAB & ASS'Y
QUAL TESTS
ORBITER INTERFACE
DESIGN & DEVELOP
FAB & ASS'Y
QUAL TESTS
FINAL ASS'Y & CHECKOUT
INITIAL (STOA-3B)
STA
PTV
MS-1
MAIN ENG. INSTL.
LOT 1 PRODUCTION (DEPLOY)
LOT 2 PROD'N. (DEPLOY/RETRIEVE)
FINAL ASS'Y, CHECKOUT & SHIP
LOT 3 PRODUCTION (RETRIEVE)
PARTS FAB & SUB.
EVOLVED (STOADE-3B)
AUXILIARY STAGES
SRM
SUBSYSTEMS
FINAL ASS'Y & CHECKOUT
DEORBIT KICK STAGE
APOGEE KICK STAGE
VEHICLE TEST
INTEGR. AVIONICS TEST
AS INITIAL
AS EVOLVED
STRUCTURAL TEST ARTICLE (STA)
PROPULSION TEST VEHICLE (PTV)
FLIGHT TEST
GROUND SUPPORT EQUIPMENT
FACILITIES
DESIGN, CONSTRUCTION (IF APPLICABLE) & ACTIVATION



GRUMMAN AEROSPACE

SINGLE STAGE STORABLE TUG

S10A-3B / S10ADE-3B PROJECT SCHEDULE

PREPARED BY

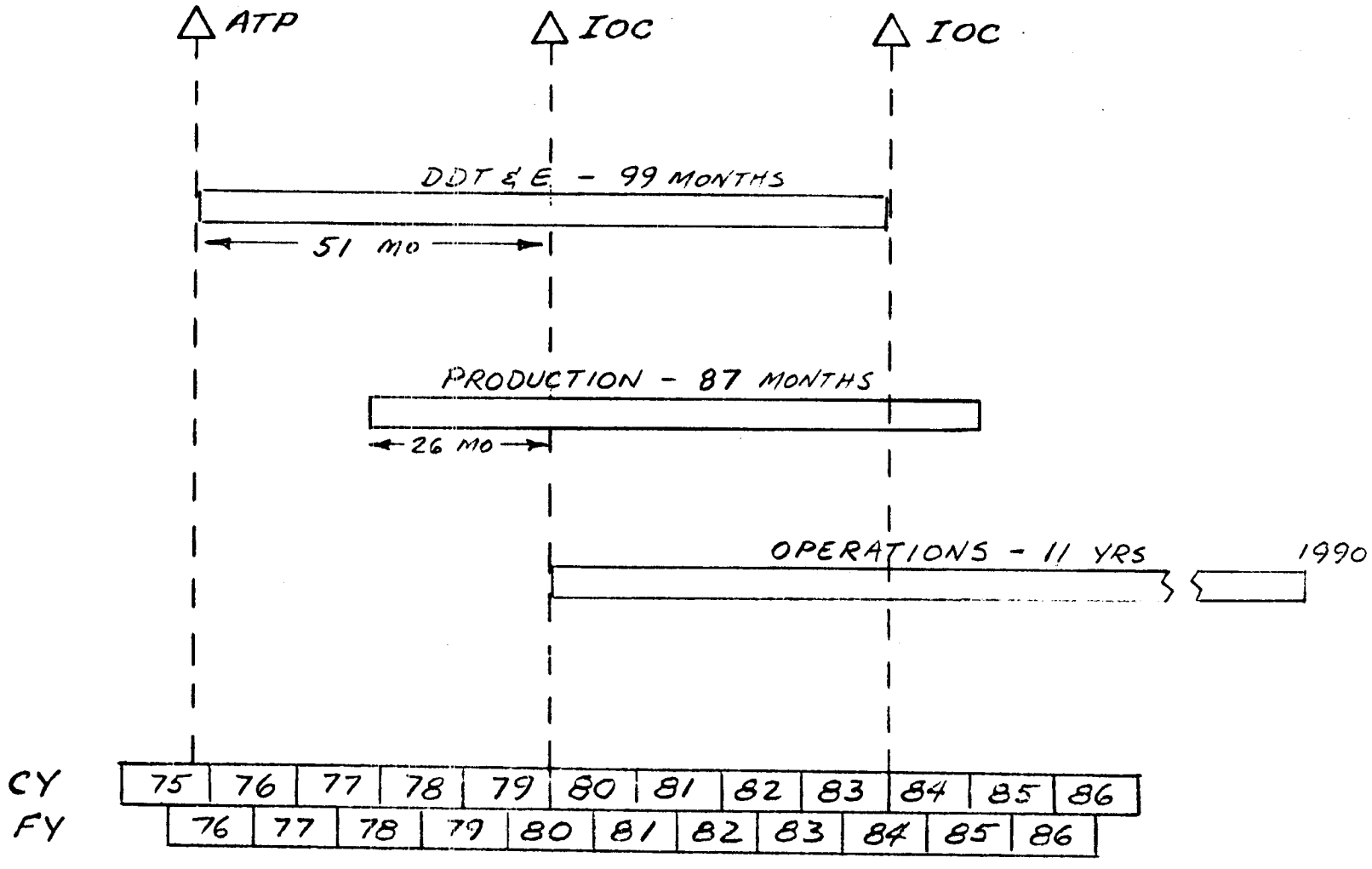
SCALE OF ORIG. DWG. =

DATE 9/11/73

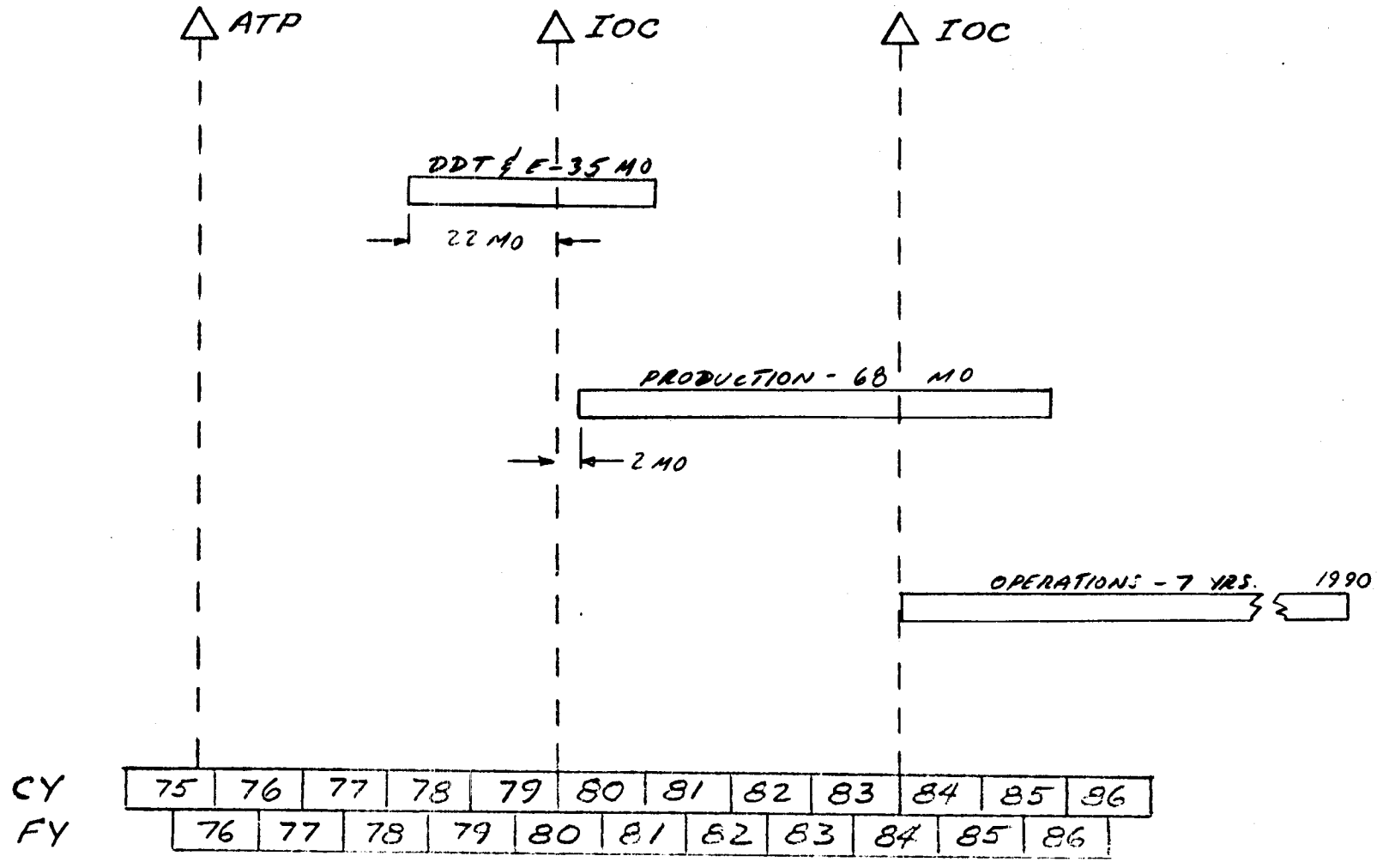
B84SD93-73087
REV. A

VI-8.1-1

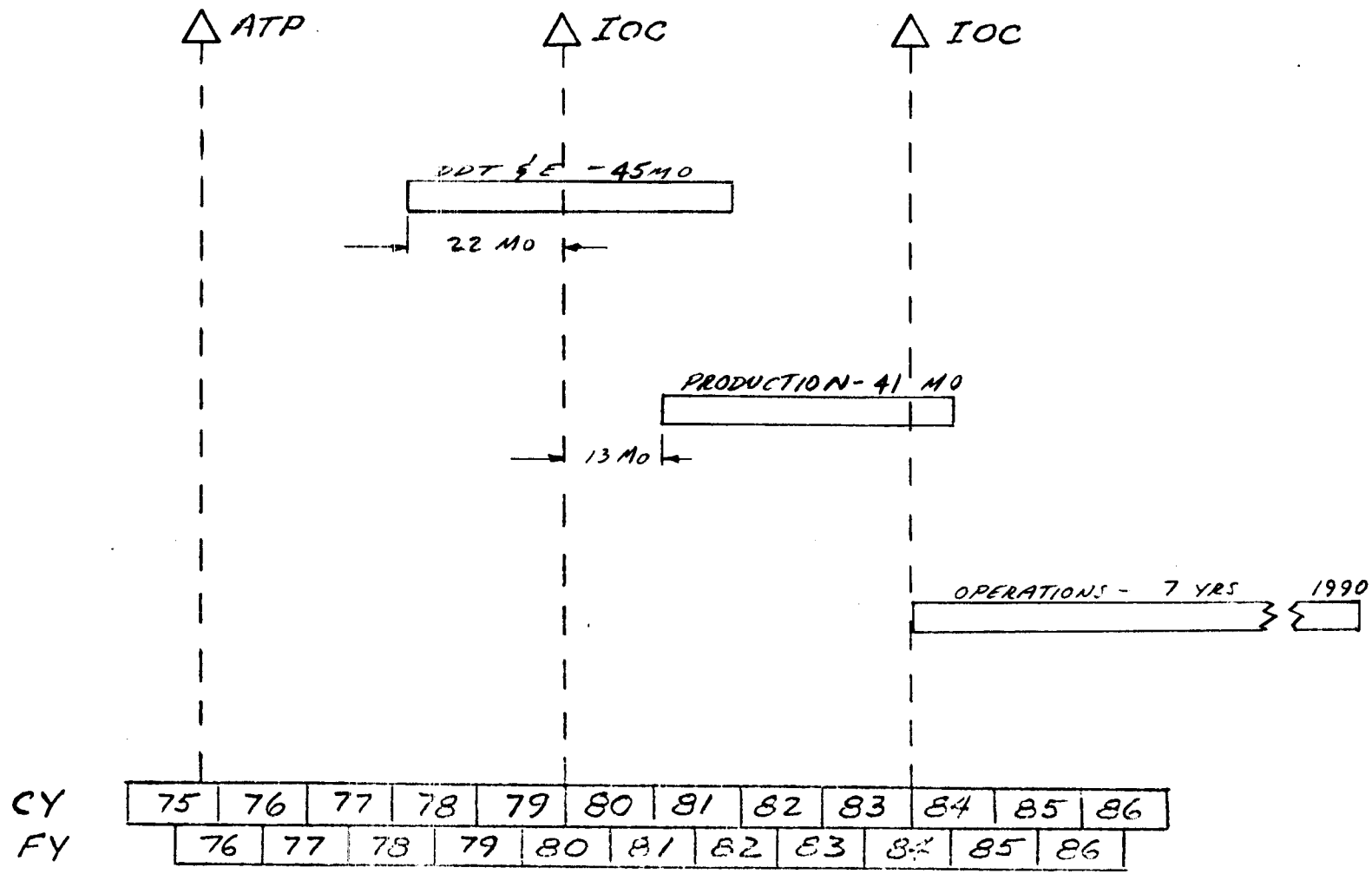
510A-3B/510ADE-3B MAIN STAGE

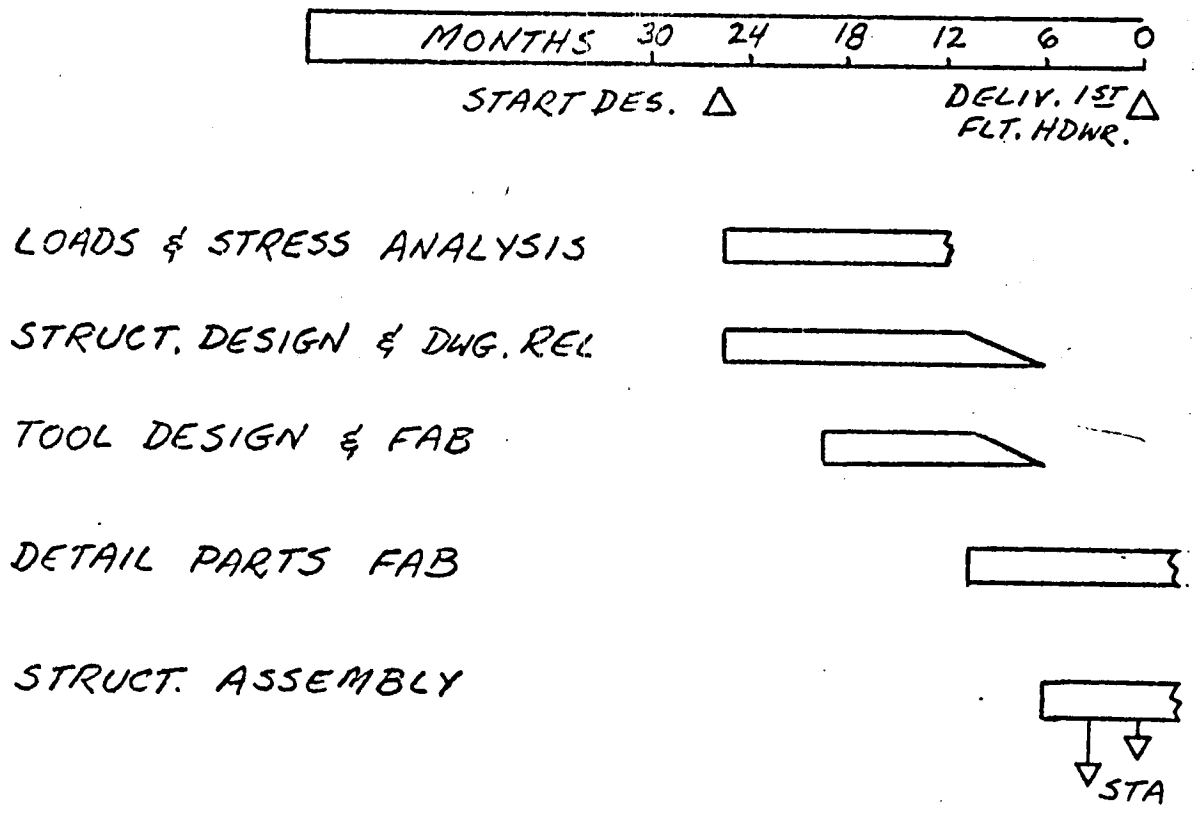


510A-3B/510ADE-3B AUXILIARY STAGE-DKS

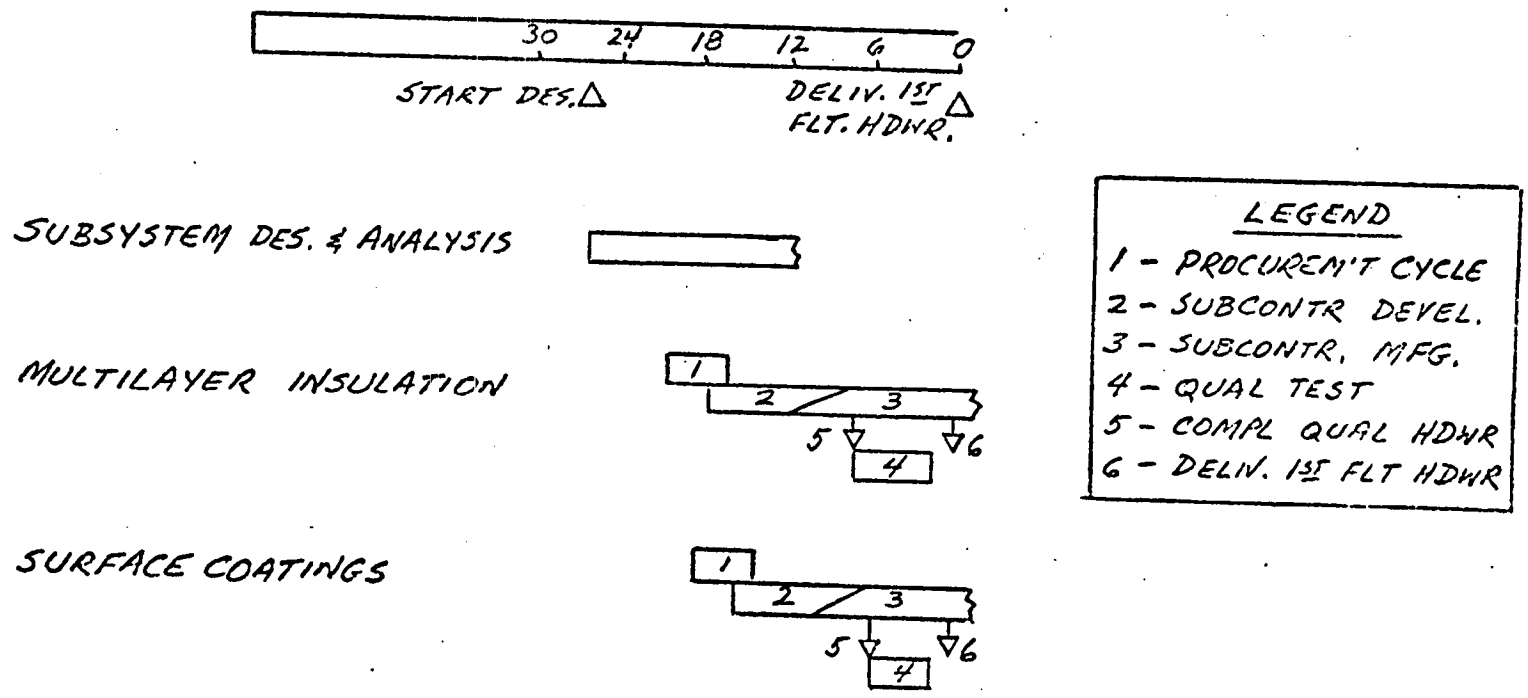


510A-3B/510ADE-3B AUXILIARY STAGE -AKS

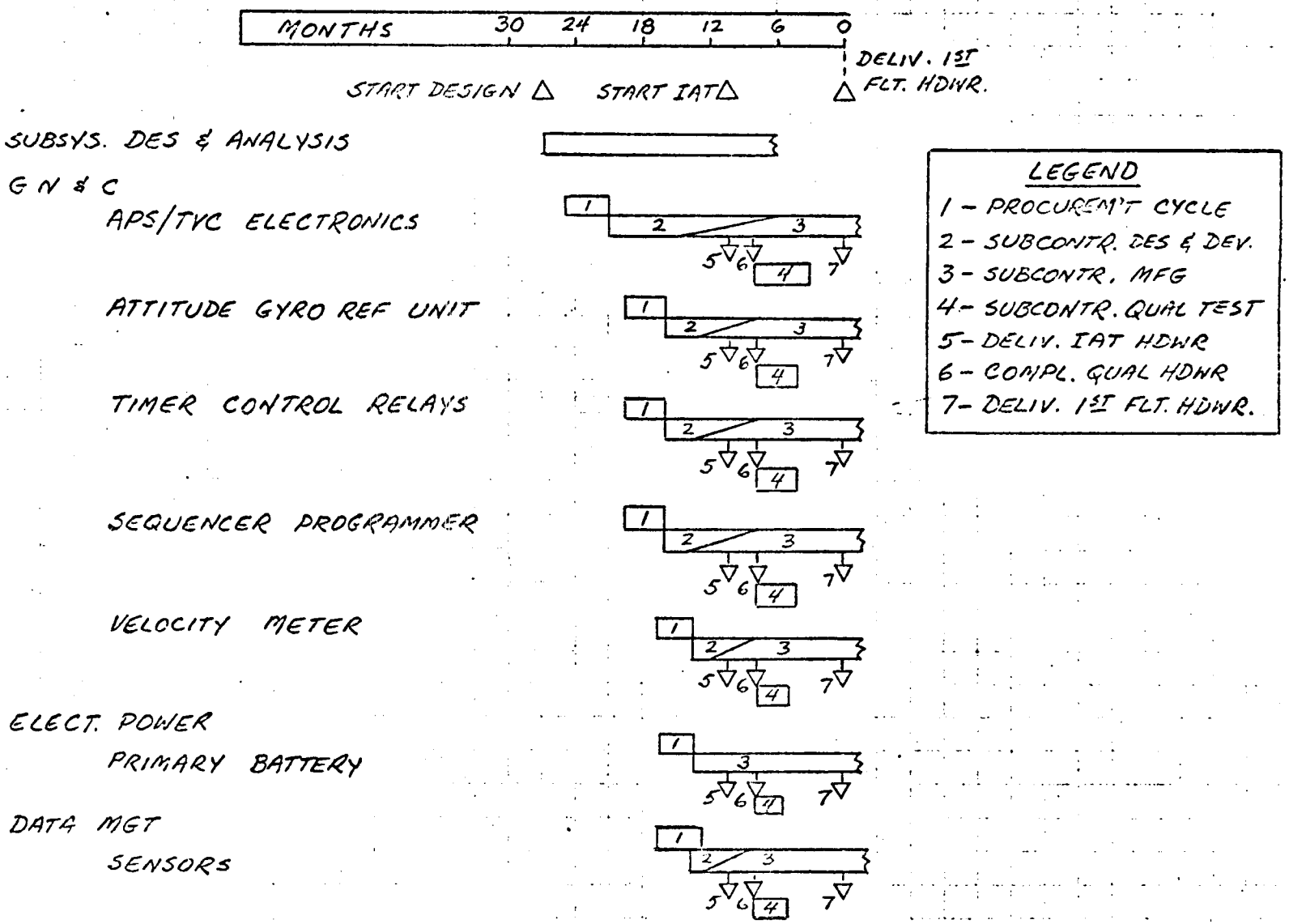




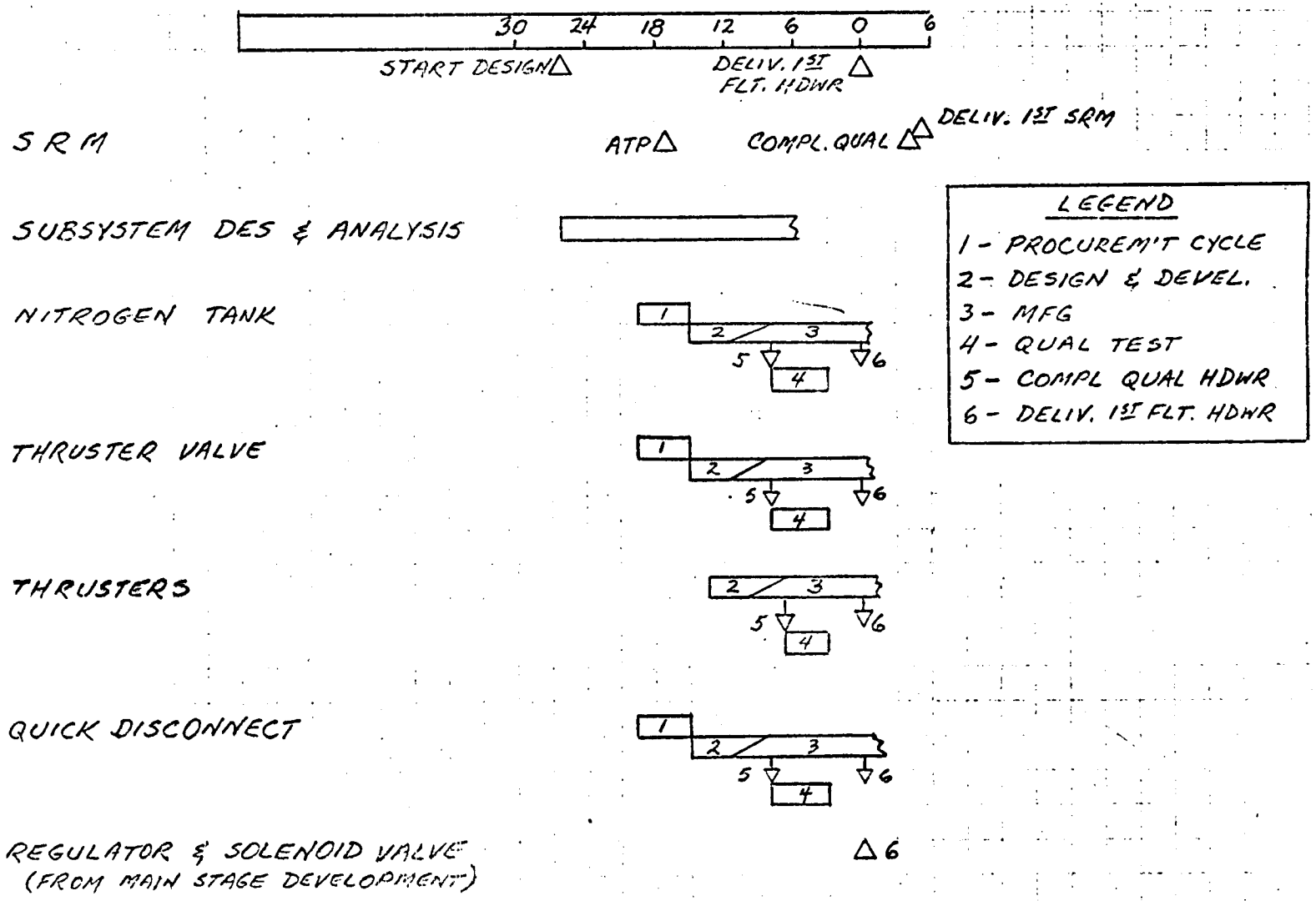
510A-3B/510AIE-3B APOGEE KICK STAGE
STRUCTURES SUBSYSTEM SCHEDULE



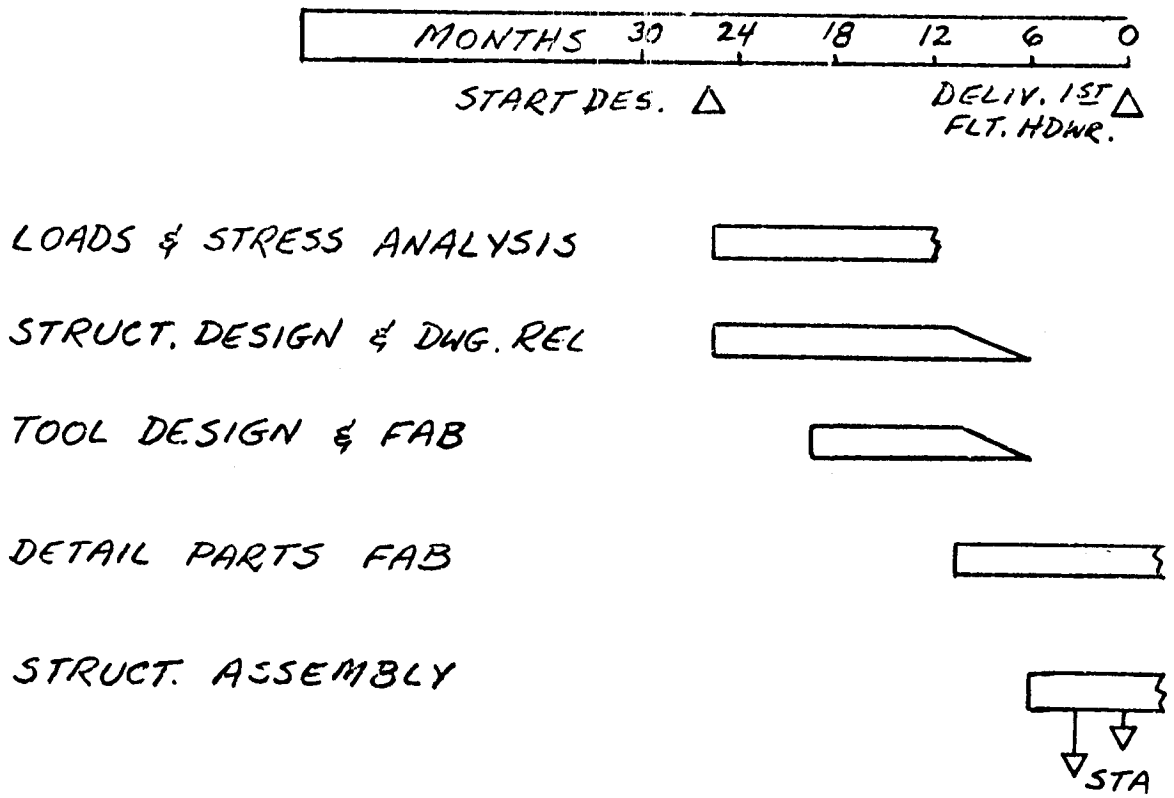
APOGEE KICK STAGE
THERMAL CONTROL SUBSYSTEM SCHEDULE



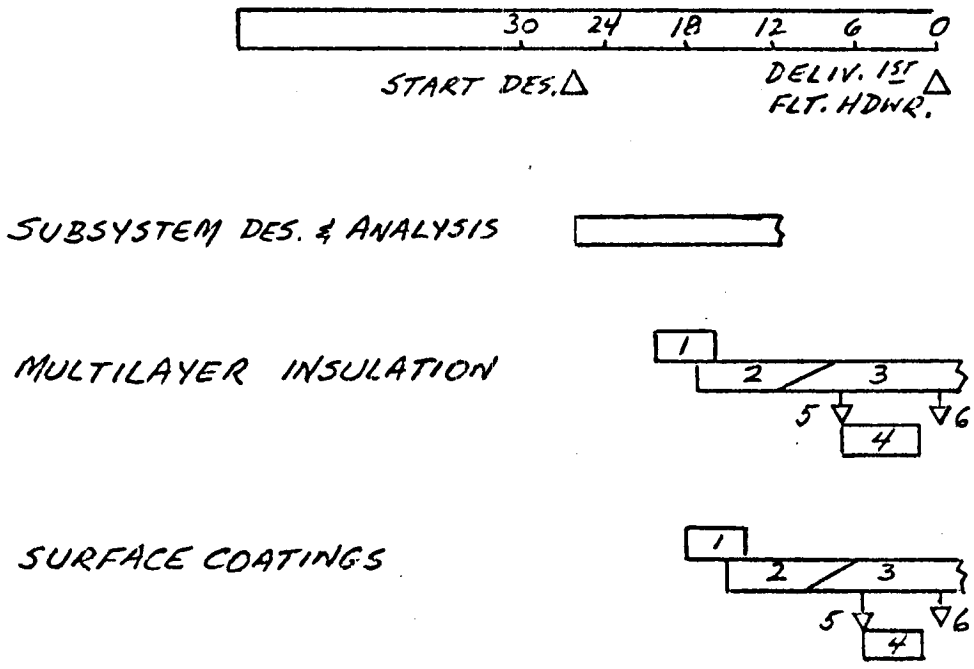
APOGEE KICK STAGE
AVIONICS SUBSYSTEM SCHEDULE



APOGEE KICK STAGE
PROPULSION SUBSYSTEM SCHEDULE



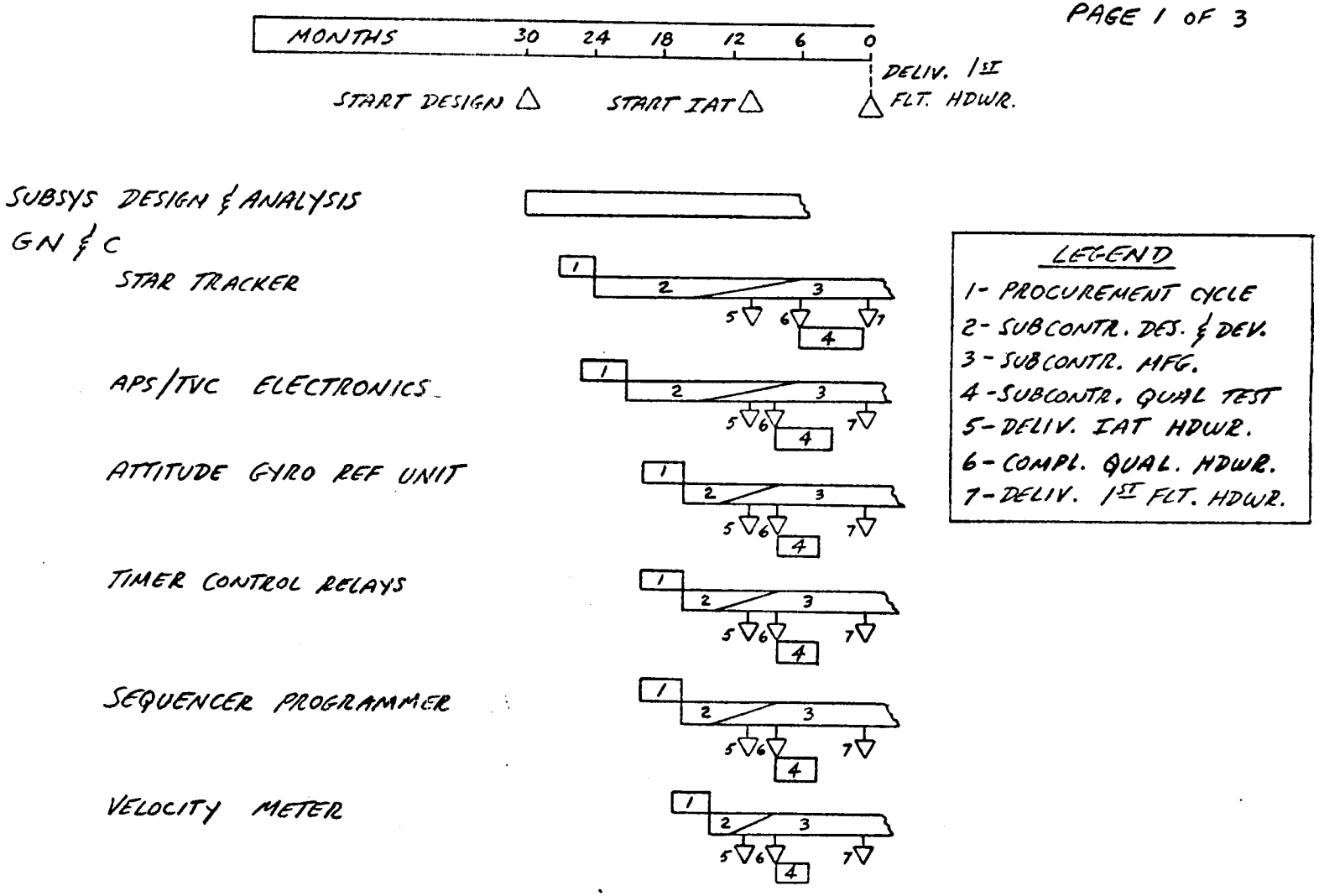
510A-3B/510ADE-3B DEORBIT KICK STAGE
STRUCTURES SUBSYSTEM SCHEDULE



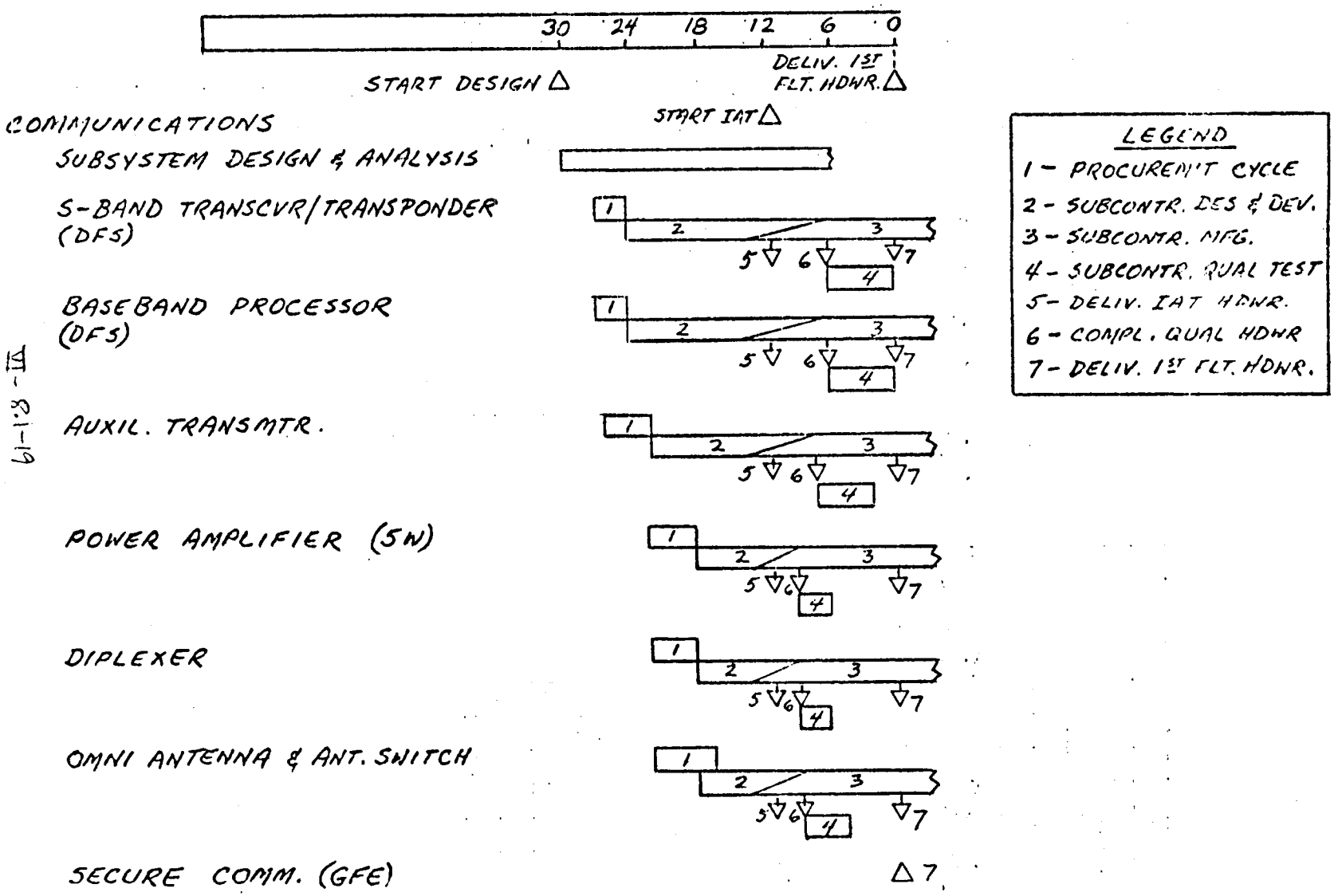
LEGEND

1 - PROCUREM'T CYCLE
2 - SUBCONTR DEVEL.
3 - SUBCONTR. MFG.
4 - QUAL TEST
5 - COMPL QUAL HDWR
6 - DELIV. 1ST FLT HDWR

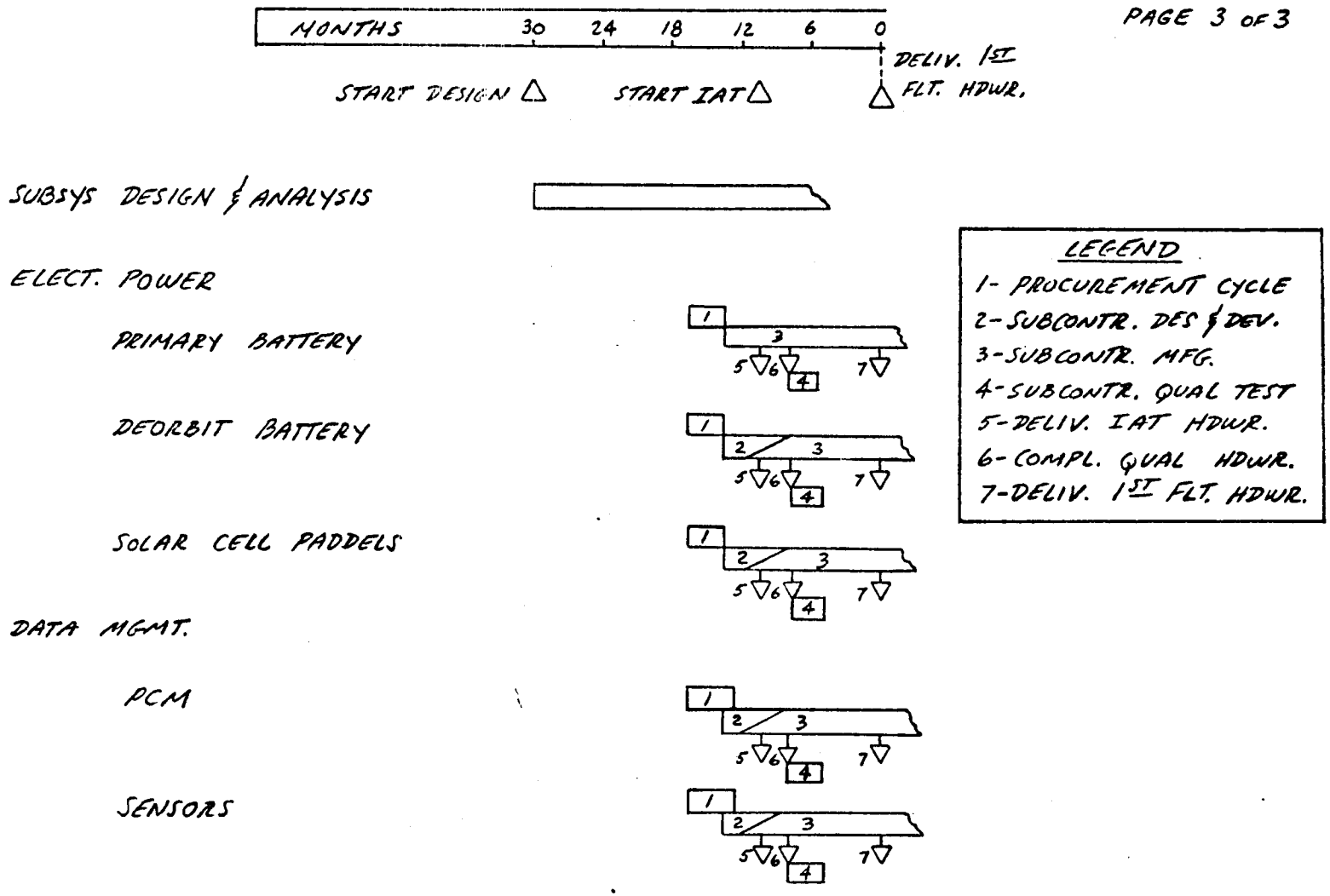
DEORBIT KICK STAGE
THERMAL CONTROL SUBSYSTEM SCHEDULE



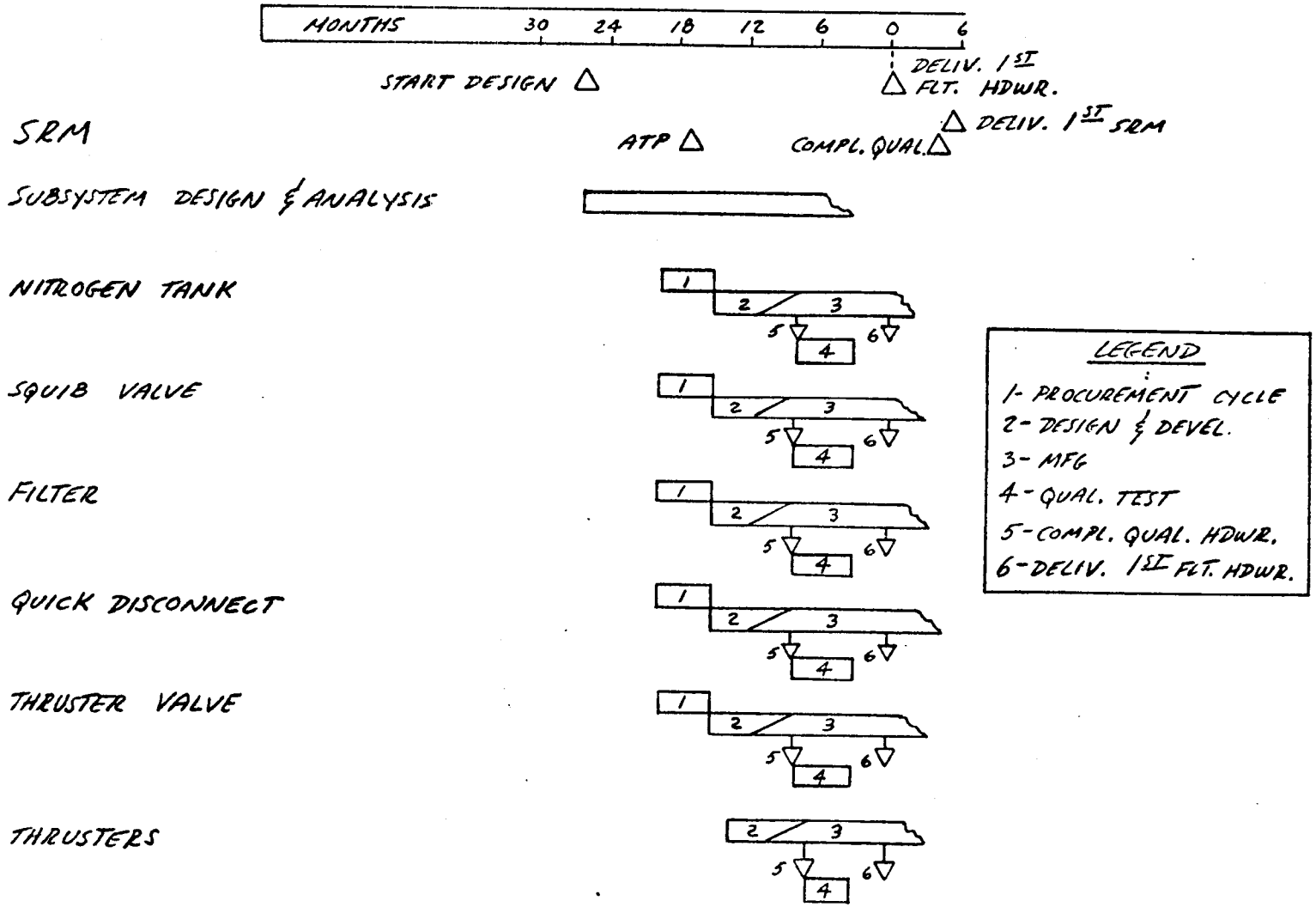
DEORBIT KICK STAGE
AVIONICS SUBSYSTEM SCHEDULE



DEORBIT KICK STAGE – AVIONICS SUBSYS. SCHEDULE



DEORBIT KICK STAGE
AVIONICS SUBSYSTEM SCHEDULE



DEORBIT KICK STAGE
PROPULSION SUBSYSTEM SCHEDULE

8.1.4 OPERATIONS SCHEDULE

Scheduled and planned for concept 510A-3B/510ADE-3B, option 3 are 30 launches per year with 12 days between launches. Ground servicing as shown on the programmatics/cost operations schedule from land to launch is 10 tug work days and 9 tug/orbiter work days.

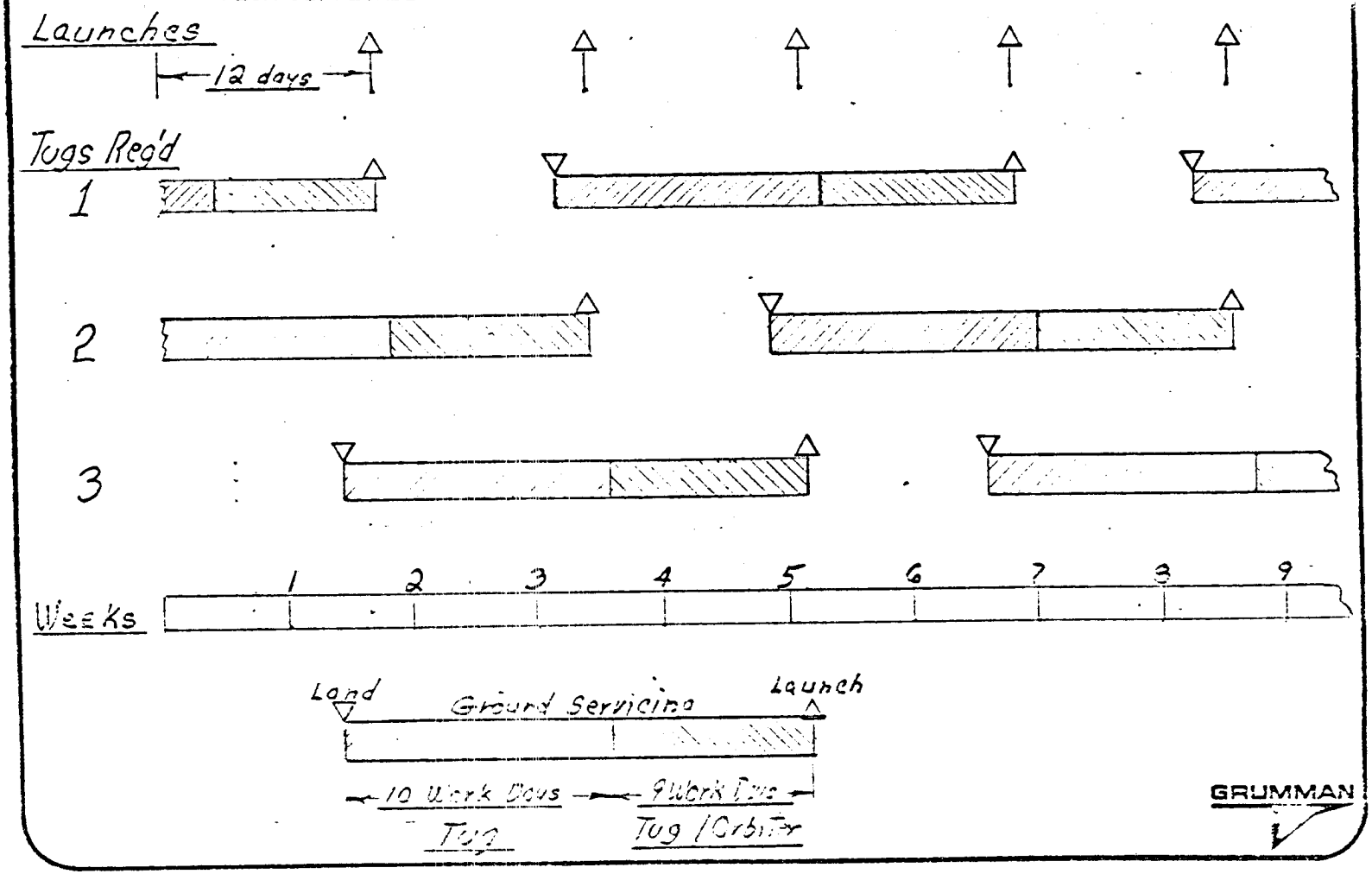
8.1.5 FACILITIES SCHEDULE

Included in the storable space tug facilities schedule for concept 510A-3B/510ADE-3B are the various tasks to be completed against major program milestones. The fundamental grouping of these tasks are manufacturing, test, maintenance and refurb-ETR, ETR launch, maintenance and refurb-WTR and WTR launch. Under this tug concept facilities maintenance extends into 1991, with most of design/construction/activation ending by 1982 in support of WTR launch requirements.

PROGRAMMATICS/COST OPERATIONS SCHEDOLE

30 Launches Per Year (ETR)

CONCEPT 510A-3B/510ADE-3B



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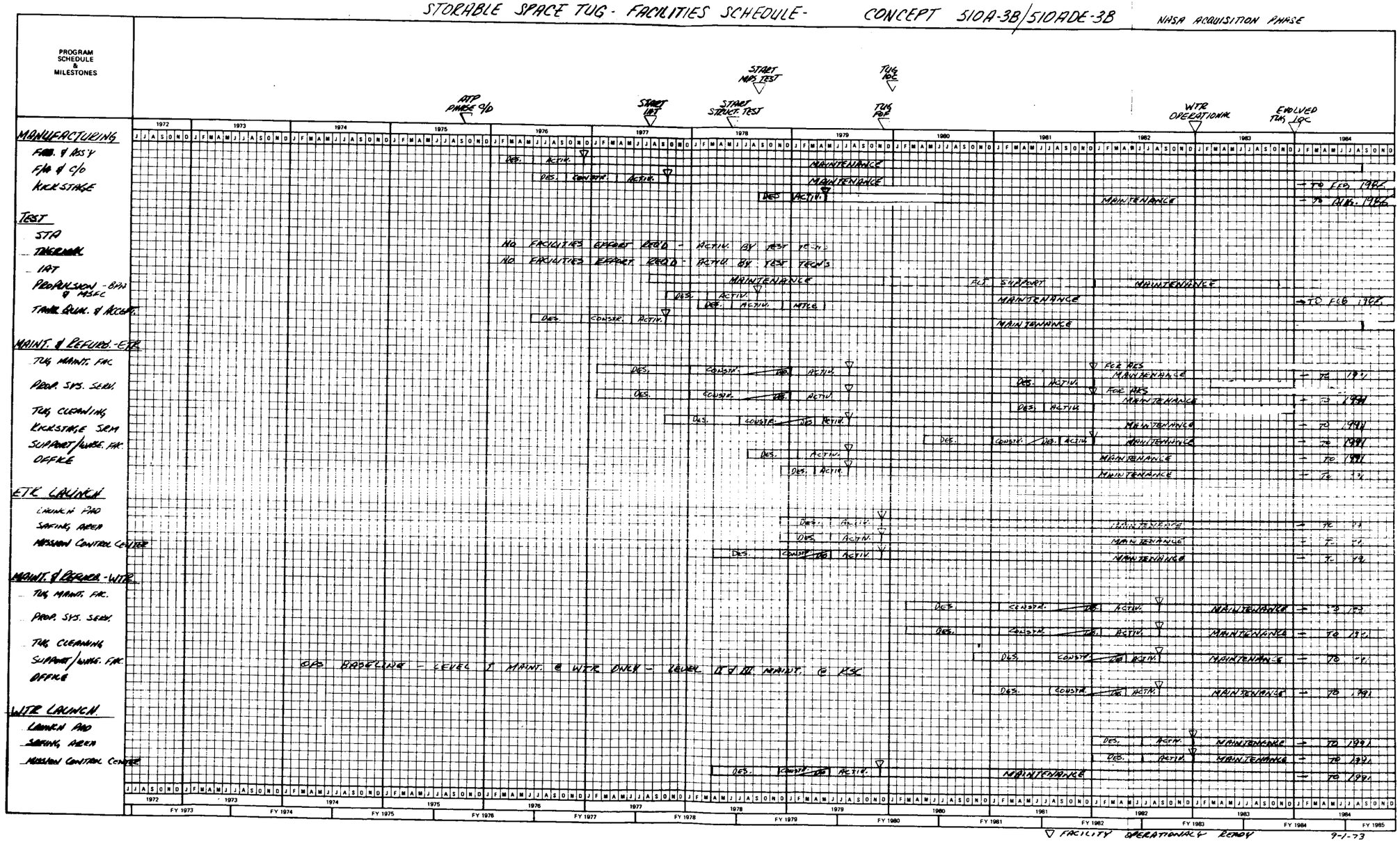
STORABLE SPACE TUG - FACILITIES SCHEDULE - CONCEPT 510A-3B/510ADE-3B NASA ACQUISITION PHASE



VI-8.1-24

8.1.6 EVALUATION OF MAJOR SCHEDULE DRIVERS (cont'd)

510A-3B/510DE-3B

The critical path for the option may be traced through the following tasks:

- o Structural design, including the integral nested tank design.
- o Spun form tank fabrication and assembly.
- o Main Stage structural assembly
- o Flight test vehicle (MS-1) final assembly, equipment installation and checkout.
- o Ship to ETR.
- o Prelaunch activity for FOF in December 1983.

Development of the Deorbit Kick Stage is advanced to 1978 allowing deployment of the DKS with payloads in 1981. Approximately 3 years prior to the evolved Tug IOC.

The Apogee Kick Stage is subsequently manufactured for deployment in November 1981. Production of the Main Stage consists of 3 lots as in other evolved programs. Total fleet size is 14 Main Stage Vehicles.

8.2 VEHICLE TEST PROGRAM (510A-3B/510ADE-3B)

8.2.0 Test Summary

The approach used to develop the Vehicle Test Program for the 510A-3B/510ADE-3B configuration is basically the same as described in Part I, paragraph 8.2.1. The addition of a Retrieval Delay Module, Deorbit Kick Stage, MS retrieval electronics and level IIb autonomy to the Tug Program for the 510A-3B/510ADE-3B configuration will also be verified in both the ground and flight test programs.

Table 8.2-1 summarizes the test verification approach in terms of major verification requirements and method of requirement satisfaction. Figure 8.2-1 presents a summary schedule of the total Vehicle test program.

8.2.1 Ground Test Articles - Type and Description

8.2.1.1 Propulsion Test Vehicle (PTV)

The PTV for the 510A-3B/510ADE-3B configuration is the same as described in Part I, paragraph 8.2.1.1

8.2.1.2 Structural Test Articles (STA)

The Structural Test Articles for this configuration are the same as described in Part II, paragraph 8.2.1.2

8.2.1.3 Integrated Avionics Testing

The integrated avionics hardware and software testing for the 510A-3B/510A-3B main stage will be accomplished using an IAT and ASDL facility as described in Part III, paragraph 8.2.1.3. , and the AKS/DKS as described in Part II.

8.2.1.4 Mock-ups

Mock-ups will be provided for both the main stage and the kick stages as described in Part I, paragraph 8.2.1.4. The early Deorbit kick stage mock-ups will be modified to serve as the later Apogee Kick State mock-ups.

8.2.2 Flight Test Articles

The main stage and Apogee kick stage flight test articles are the same as described in Part I, paragraphs 8.2.2.1 and 8.2.2.2

The Deorbit Kick stage flight test article will be the same as described in Part II, paragraph 8.2.2

510A-3B/510ADE-3B VEHICLE TEST

- o TEST PROGRAM OBJECTIVES
  - DESIGN VERIFICATION
  - SITE/GSE VALIDATION
  - SYSTEM VERIFICATION
- o GROUND TEST PROGRAM (HARDWARE/OPS = $26.85M)
  - PROP: 1 MS ART. VERIFIES COLD FLOW SYSTEM OPS - REFURB TO OPS
  - STRUCT: 2 ART. (1 MS & 1 DKS) VERIFY DYN, STATIC, FATIGUE, SEP - KSC SITE VALIDATION
  - AVIONICS: 2 LABS VERIFY HARDWARE/SOFTWARE FOR INITIAL AND EVOLVED CONFIGURATION
  - MOCKUPS; 2 SOFT & 2 HARD MS & AKS/DKS MOCKUPS SUPPORT DESIGN DEVELOPMENT & MAINTENANCE DEMONSTRATION
- o FLIGHT TEST PROGRAM (HARDWARE/OPS = $23.04M)
  - 1 MS & 1 DKS VEHICLE
  - 9 FLIGHTS (1 DEDICATED, 8 OPS)
- o TOTAL VEHICLE TEST = $49.91M

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DESIGN VERIFICATION APPROACH

510A-3B/510ADE-3B

	MAJOR VERIF. REQMT.	GRND TEST	FLT TEST
STRUCTURE	STATIC MARGIN	QUAL.	VERIFY
	FATIGUE LIFE	QUAL.	
	VIBRATION MODES	VERIFY	VERIFY
	VEH/ORB & VEH/PL & VEH/KS SEP.	QUAL.	VERIFY
	VEH. HDLG & MAINT.	DEMO	VERIFY
THERMAL CONTROL	PASSIVE/ACTIVE THERMO SYS PERFORM	QUAL.	VERIFY
	TC/GSE SERVICING & MAINT.	DEMO	VERIFY
AVIONICS	INTEG HDWR/SFTWR VEH. PERFORM	VERIFY	VERIFY
	AVIONIC/GSE C/O & MAINT	DEMO	VERIFY
	VEH SYS INTERFACE (ORB, GRND, KS, & PL) PERFORM	VERIFY	VERIFY
PROPULSION	MPS NOM/OFF-NOM PERFORM	QUAL	VERIFY
	MPS/GSE SERVICING & MAINT	DEMO	VERIFY
	APS NOM/OFF-NOM PERFORM	QUAL	VERIFY
	APS/GSE SERVICING & MAINT	DEMO	VERIFY
	KS SRM PERFORM	QUAL	VERIFY
ORBITER INTERFACE	STATIC/FATIGUE STRENGTH	QUAL	VERIFY
	VEH/ORB SEP	QUAL	VERIFY
	AVIONIC/FLUID INTERFACE PERFORM	VERIFY	VERIFY
	ABORT SYS PERFORM	QUAL	VERIFY
	VEH HDLG/GSE SERVICE & MAINT	DEMO	VERIFY

TABLE 8.2-1

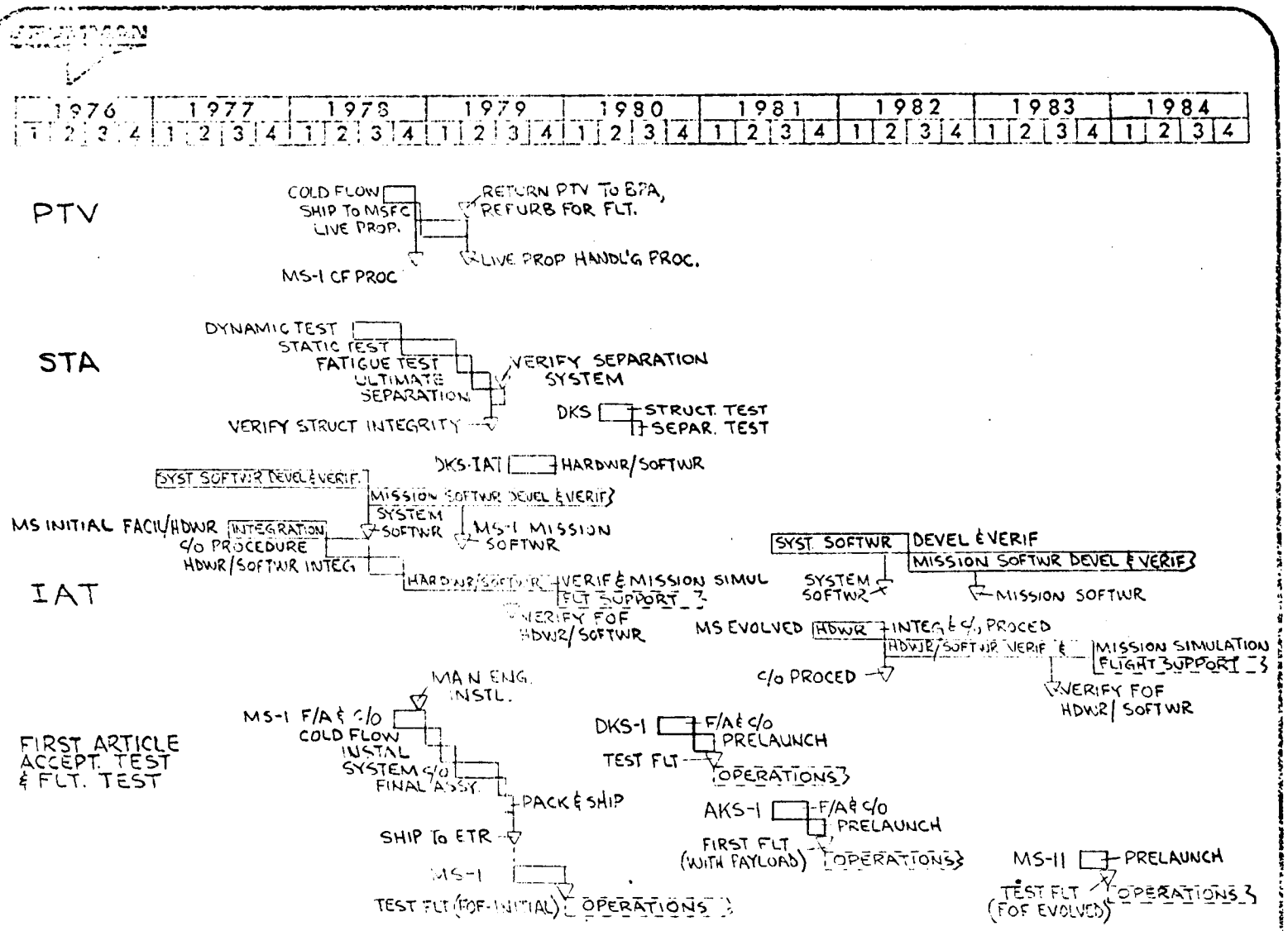


FIG. 8.2-1 510A-3B/510ADE-3B VEHICLE TEST SCHEDULE

8.2.3 Ground Test Program

This section describes the major elements of the vehicle ground test program. The test program described in the following paragraphs include the propulsion test vehicle (PTV), Structural Test Article (STA), Integrated Avionics Testing including software development, and mock-ups required in support of program requirements.

8.2.3.1 Propulsion Test Vehicle (PTV) Program

The Main Propulsion System and Auxiliary Propulsion System test program for the 510A-3B configuration is the same as described in Part I, paragraph 8.2.3.1

The DKS/AKS SRM test program will be conducted at the engine manufacturer as described for the 110A configuration AKS in Part I, paragraph 8.2.3.1.1

8.2.3.2 Structural Test Articles

The main stage structural test program, is the same as described in Part II, paragraph 8.2.3.2. The main stage test schedule and manloading is the same as shown in Part I, Figure 8.2-3 except that it is shifted three months later.

The DKS/AKS auxiliary stage begins as a Deorbit kick stage and later is flown with AKS capability only. Since there are no structural changes required, only one STA is provided. The structural tests are all performed for the most critical conditions for either AKS, DKS or combined AKS/DKS. Hence the initial test program satisfies all requirements for all configurations. In other respects the test program is the same as described for the 110A configuration AKS in Part I, paragraph 8.2.3.2.2. The schedule and manloading is the same as for the 110A AKS except that it starts in 2/80 instead of 12/80 because of the early flight requirements of the DKS.

8.2.3.3 Integrated Avionics Test Program

The mainstage integrated avionics test aprogram for the 510A-3B/510ADE-3B configuration is the same as described in Part III paragraph 8.2.3.3

The DKS/AKS integrated avionics test program is the same as described in Part II, paragraph 8.2.3.3.

The schedule and manloading for integrated avionics testing is shown in figure 8.2-2.

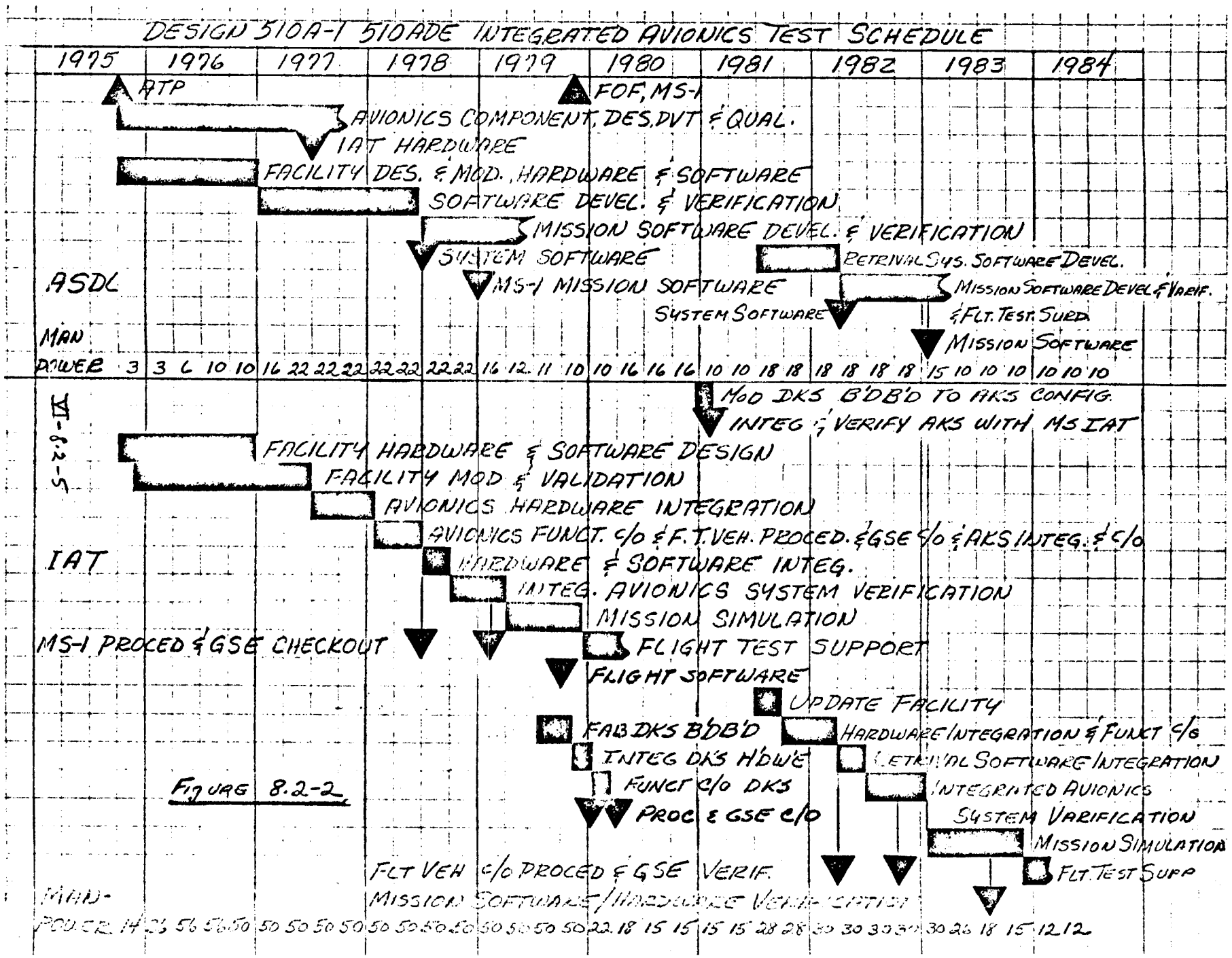

DESIGN 510A-1 510ADE INTEGRATED AVIONICS TEST SCHEDULE
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
RTP
FOF, MS-1
AVIONICS COMPONENT, DES, DVT & QUAL.
IAT HARDWARE
FACILITY DES. & MOD., HARDWARE & SOFTWARE
SOFTWARE DEVEL. & VERIFICATION
MISSION SOFTWARE DEVEL. & VERIFICATION
SYSTEM SOFTWARE
RETRIVAL SYS. SOFTWARE DEVEL.
ASDL
MS-1 MISSION SOFTWARE
MISSION SOFTWARE DEVEL & VARIF.
SYSTEM SOFTWARE
& FLT. TEST SUPP.
MISSION SOFTWARE
MAN POWER 3 3 6 10 10 16 22 22 22 22 22 22 22 22 16 12 11 10 10 16 16 16 10 10 18 18 18 18 18 18 15 10 10 10 10 10 10
MOD DKS B'DB'D TO AKS CONFIG.
INTEG & VERIFY AKS WITH MS IAT
VI-8.2-5
FACILITY HARDWARE & SOFTWARE DESIGN
FACILITY MOD & VALIDATION
AVIONICS HARDWARE INTEGRATION
AVIONICS FUNCT. C/O & F.T. VEH. PROCED. & GSE C/O & AKS INTEG. & C/O
IAT
HARDWARE & SOFTWARE INTEG.
INTEG. AVIONICS SYSTEM VERIFICATION
MISSION SIMULATION
MS-1 PROCED & GSE CHECKOUT
FLIGHT TEST SUPPORT
FLIGHT SOFTWARE
UPDATE FACILITY
FAB DKS B'DB'D
HARDWARE INTEGRATION & FUNCT C/O
INTEG DKS H'DW'E
RETRIVAL SOFTWARE INTEGRATION
FUNCT C/O DKS
INTEGRATED AVIONICS
PROC & GSE C/O
SYSTEM VARIFICATION
MISSION SIMULATION
FLT VEH C/O PROCED & GSE VERIF.
FLT. TEST SUPP
MISSION SOFTWARE/HARDWARE VERIFICATION
MAN-POWER 14 23 56 56 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50 22 18 15 15 15 15 28 28 30 30 30 30 30 26 18 15 12 12

FIGURE 8.2-2

8.2.4 Flight Test Program

8.2.4.1 Flight Vehicle Test and Checkout

The Main Stage (MS) factory and prelaunch flow, schedule and manpower requirements are the same as described in Part III, paragraph 8.2.4.1.

The AKS/DKS factory and prelaunch flow, schedule and manpower requirements are shown in Figures 8.2-3 and 8.2-4.

8.2.4.2 Flight Test

Eight flights are planned for the 510A-3B/510ADE-3B configuration flight test program.

The main stage (MS) and Apogee kick stage (AKS) flight test program for configuration 510A-3B is essentially as described in Part I, paragraph 8.2.4, with the AKS not tested until late 1981.

The MS flight test program for configuration 510ADE-3B is the same as described in Part III, paragraph 8.2.4 using the DKS as the retrieval target.

Since the DKS is developed and flown earlier than the main stage, a separate and dedicated flight test is planned to verify the capability of the DKS to function during and after extended exposure to orbital environments. This flight will occur in early 1981 and could be accomplished as part of a normal shuttle launch or by some other means.

The schedule and test costs for the flight test program is shown in Figure 8.2-5.

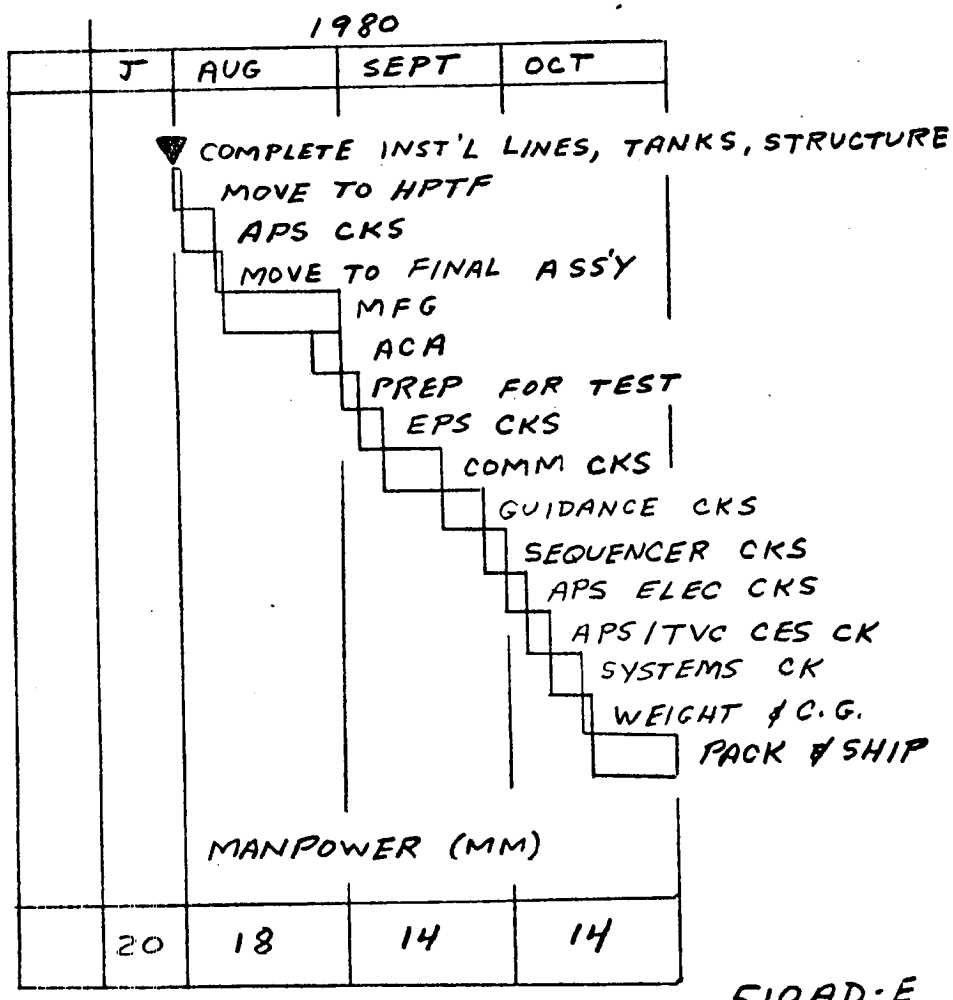
8.2.5 Analysis of the Test Program

8.2.5.1 Key Elements

The key elements of the 510-3B/510ADE-3B configuration Vehicle Test Program, are the same as described in Parts II and III, Paragraph 8.2.6.1

8.2.5.2 SR&T Assumptions

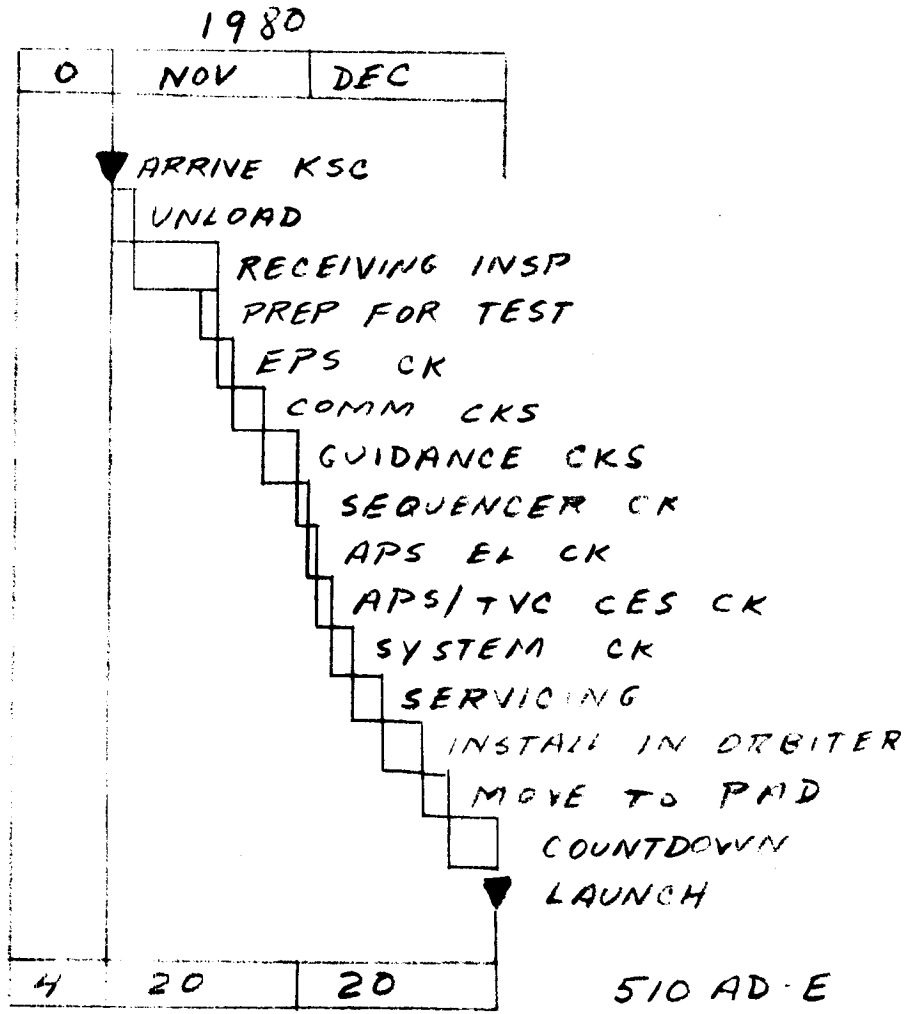
The basic assumptions for the 510-3B/510ADE-3B SR&T requirements are described in Part I, paragraph 8.2.6.2.- SR&T requirements. Test programs affected and a brief description of the interaction with the test programs affected is summarized in Table 8.2-2



510AD-E

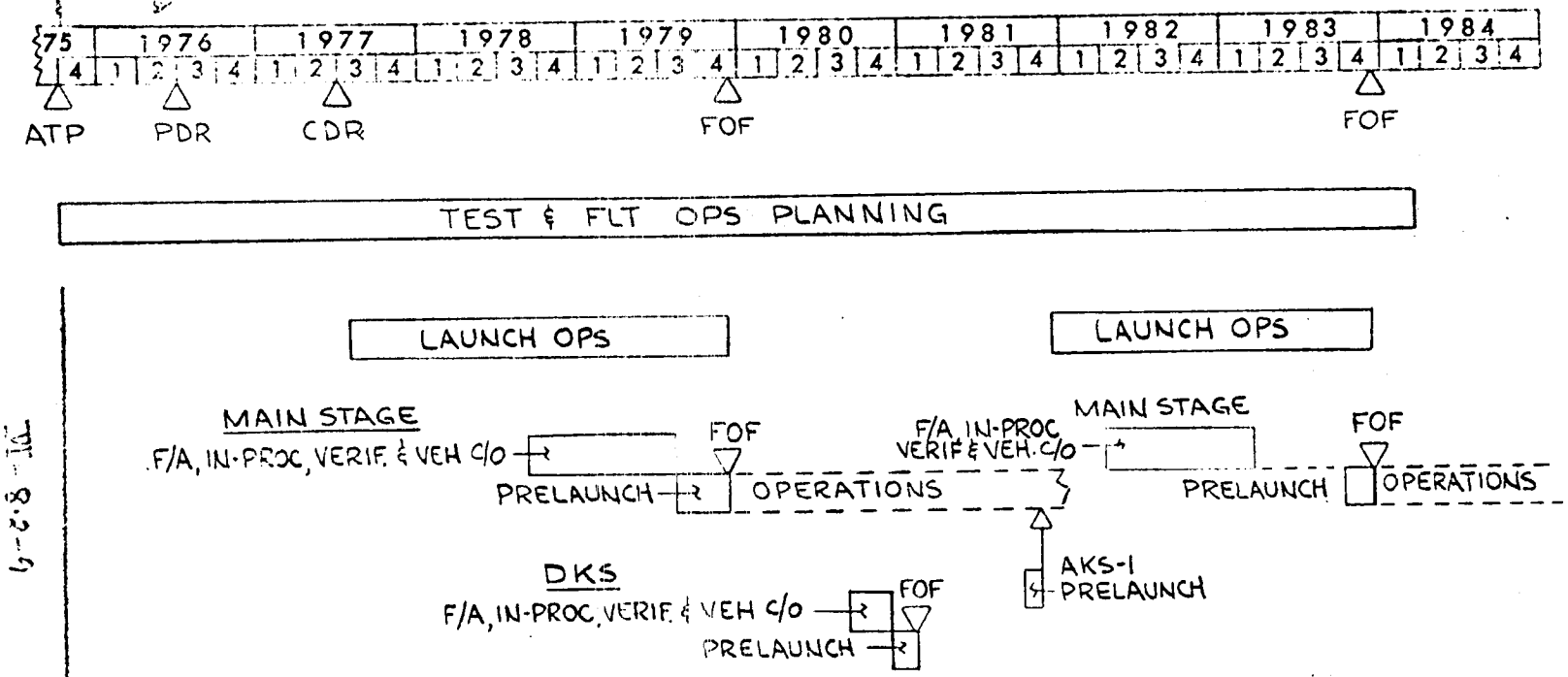
FIGURE 8.2-3

DEORBIT KICK STAGE
FACTORY FLOW



510 AD-E
DEORBIT KICK STAGE
FIRST PRELAUNCH

FIGURE 8.2-4



FLIGHT TEST PROGRAM COST

- FLIGHT TEST HARDWARE: 1 MAIN STAGE + DFI
- FLIGHT TEST MANPOWER (FOF ONLY)
  - TEST OPS: $3.29 M
  - LAUNCH OPS: $1.61 M
  - FLIGHT OPS: $2.30 M
- CONSUMABLES (FOF ONLY): $62 K

FIGURE 8.2-5 -FLIGHT TEST PROGRAM SCHEDULE (510A-3B/510 ADE-3B)

TECHNOLOGY REQUIREMENTS	TEST PROG. AFFECTED	REMARKS
Main engine life and high performance	- GFE eng. devel. prog. - Flight test prog.	Early life verif. of eng. components and area ration nozzle performance assures phase C/D engine development. PTV is not affected since eng. is not required. FOF could tolerate slightly reduced eng. performance.
PFR helium tank		Early verif. of low weight PFR tank assures maximum tug performance.
Materials compatibility Data	- Tank Qual. - STA prog. - PTV prog.	Early verif. of material compatibility with MMH and N_2O_4 assures on-time development of main stage tankage including tank qual. STA and PTV testing.
Fracture Mechanics Data	- Tank Qual. - STA prog.	Early fracture mechanics data allows on-time development of structural subsystem including tankage quals and STA testing.
Heat Pipes	- Flight test prog.	Early verif. of heat pipe design approach allows on time developments of Thermal Control Subsystem thereby maximizing Tug performance
Advanced IMU	- Integrated avionics - Flight Vehicle Factory checkout - STA	Early devel. of Advanced IMU will assure on time devel. of software and integration procedures in the IAT LAB for FLT VEH buildup and test and accurate simulation for STA prog.
Laser Radar	- Integrated Avionics - Flight Vehicle factory checkout - STA	Early devel. of light weight low power Laser Radar will assure on time development of software and integration procedures in the IAT LAB for FLT VEH buildup and test and accurate simulation for STA program.
Long Term Space Storable SRM	- SRM Qual.	Early verif. of long term space storable SRM assures an on-time development and qual.
Spun-form 2219-T81 tanks	- STA test program	Early verification of manufacturing techniques and and material property data allows on-time development of struct. subsystem including qual. on STA

TABLE 8.2-2 SR&T ASSUMPTIONS

8.2.5.3 Reusability Demonstration

Reusability demonstrations for the 510-3B/510ADE-3B configuration are the same as described in Part I, paragraph 8.2.6.3

8.2.5.4 Life Verification Tests

The Life Verification Test requirements for the 510-3B/510ADE-3B configuration are the same as described in Part I, paragraph 8.2.6.4.

510A-3B/510ADE-3B GROUND TESTS

TEST	TEST ART.	OBJECTIVES	APPROACH
STRUCTURES o 510-3B ONLY - MAIN STG (MS) - APOGEE KICK STAGE (AKS)/ DEORBIT KICK STAGE (DKS)	o COMPLETE M.S. PRIM & SEC. STRUCT. INCL. TUG/ORB, TUG/AKS TUG/P.L. ADAPTERS o COMPLETE AKS/DKS PRIM & SEC. STRUCT.	o EVAL. DYN., STATIC STRENGTH, SAFE-LIFE & SEPARATION o VERIFY STRUCT./MECH INTERFACES AT LAUNCH SITE	o VIB/ACOUSTIC TESTS o DES. LIMIT STATIC TESTS o STATIC FATIGUE o ULT. STATIC TESTS o SEP. DEMO. o INTERFACE VALID DEMO. AT KSC. o COMMON AKS/DKS TESTED SEPARATELY AS ABOVE (1980)
PROPULSION MS 510-3B ONLY	o FLIGHT WT. MAIN STAGE STRUCT. o MAIN ENG. SUPPT. S/S LESS ENG. o ENG. SIMUL. UNIT o PTV REFURB. TO FLIGHT OPS	o DEMO OPS OF ASSEM COMPONENTS o DEVELOP C/O & OPS PROCEDURES o VERIFY SERV./HANDLG. PROCEDURES o DEMO SYS. PERF. & CHARACTERISTICS	o COLD FLOW ONLY o REFERENCE FLUIDS PHASE - FILL/DRAIN/FLOW TESTS o LIVE PROPELLANTS PHASE - LOAD CONTROL/ACCURACY - SYS. COMPAT & DYN. - PERF. SERV./HANDLG. PROCEDURES

510A-3B/510ADE-3B GROUND TESTS

Vehicle Test Program

The vehicle test program for 510A-3B/510ADE-3B was developed in a similar manner to that described for 110A-1

Structural Test Articles

The Structural test program for the 510A-3B is the same as that described for the 110A-1. The DKS Structural test philosophy is basically the same as the MS test program. The AKS structure is the same as the DKS and therefore does not require a separate structural test program. The 510A-3B STA will be configured to include the evolved 310ADE-3B avionic retrieval hardware and mechanical interfaces with test loads enveloping both configurations.

Propulsion Test Vehicle

The M.S. Propulsion test program for the 510A-3B configuration is the same as that described for the 110A-1. The DKS propulsion test philosophy is also the same as for the 110A-1 AKS. Since the only difference between the DKS and AKS propulsion system is a reconfiguration in SRM's no additional DKS propulsion tests are required.

510A/510ADE GROUND TESTS (CONT'D)

TEST	DESCRIPTION	OBJECTIVES	APPROACH
INTEGRATED AVIONICS o INTEG. AVIONIC TEST (IAT) FACILITY - MS - DKS - AKS o AVIONICS SOFTWARE DEVELOPMENT LAB (ASDL) - MS	o IAT - SHIP SET OF AVIONICS - COMPUTER SIMULATION - SENSOR STIMULUS - FACTORY & LAUNCH GSE o ASDL - COMPUTER FACILITY WITH MATH MODEL SIMULATION OF MS HARDWARE	o VERIFY HARDWARE/ SOFTWARE PRIOR TO VEHICLE INSTALLATION & FOF o VERIFY EVOLVED RETRIEVAL HARDWARE/SOFTWARE PRIOR TO VEHICLE INSTALLATION & FOR 83 IOC.	o IAT - SUBSYSTEM INTEG. & END-TO-END FUNCTIONAL VERIFICATION - VERIFY FACTORY C/O PROCED - HARDWARE/SOFTWARE VERIF. - MISSION SIMULATION - INTEGRATE & VERIFY RETRIEVAL CAPABILITY HARDWARE/SOFTWARE - RETRIEVAL MISSION SIMULATION o ASDL SOFTWARE VERIFICATION FOR BASIC & EVOLVED CONFIGURATION
MOCKUPS o MS o DKS o AKS	o WOOD & CARDBOARD MOCKUP OF THE TUG MS, DKS & AKS STRUCTURE INCLUDING EQUIPMENT FOR PDR. o WOOD & METAL MOCKUP OF MS, DKS & AKS STRUCT. & COMPONENTS FOR CDR	EVALUATE EQUIPMENT ACCESSIBILITY & MAINTAINABILITY. EVALUATE SHUTTLE & PAYLOAD INTERFACE AND LINES RUN PRIOR TO FAB OF FINAL HARDWARE	o COMPONENT INSTALLATION o ESTABLISH LINE LENGTHS. FOR FINAL HARDWARE FAB. o DEMONSTRATE MAINTAINABILITY - ASSESSMENT & DEMOS OF EQUIPMENT CLEARANCES - CONNECTOR & MOUNTING ACCESSIBILITY DEMO o SHUTTLE & PAYLOAD INTERFACE ASSESSMENT

GROUND TEST COST = $26.85M

510A-3B/510ADE-3B GROUND TESTS (CONT'D)

Integrated Avionics Tests

The MS Integrated Avionics Test program for the 510A configuration will be the same as the 110A-1 test program. The DKS will be integrated in the same facility as the MS IAT to take advantage of the facility simulation and GSE capability. The DKS will be modified to simulate the AKS for MS-AKS IAT Mission Simulations. The IAT and ASDL facilities will initially be configured for the basic mission hardware and software including autonomy level III A. As the retrieval capability and autonomy level II B is evolved the IAT hardware and ASDL software will be updated and the evolved system verifications and mission simulation performed.

Mockups

The MS mockups for this configuration will be the same as those required for 110A. The DKS will also require mockup which will be modified at a later date to serve as AKS mockups.

510A-3B/510ADE-3B FLIGHT TESTS

TEST ARTICLE	OBJECTIVES	APPROACH
o MAIN STAGE (510A-3B) - 1ST PROD. UNIT INCLUDING DFI o MAIN STAGE (510ADE-3B) - 1ST PROD. UNIT INCLUDING DFI o DKS 1ST PROD. UNIT INCLUDING DFI.	INITIAL IOC o THERMO-VERIFY SYS. THERMAL CONTROL o STRUCT-VERIFY LAUNCH/ORBIT/ ENTRY/LANDING LOADS & DYNAMICS o PROP-VERIFY MPS/APS o AVIONICS - VERIFY AVIONICS OPS o OPS - EVALUATE TUG/ORB & TUG/PAYLOAD & TUG/AKS INTERFACES - EVALUATE SYS. PERF. CAPABILITY - DEMO. PAYLOAD DEPLOY EVOLVED IOC o DEMO PAYLOAD RETRIEVAL AND AUTONOMY LEVEL IIB. o DKS - DEMO SYS. PERF. AFTER EXTENDED ON-ORBIT OPS	o 9 FLIGHT-TEST PROGRAM - 6 INITIAL - 3 FINAL o FIRST ORBITAL FLIGHT (FOF) COSTED WITHOUT OPERATIONAL PAYLOAD - FLOWN WITHIN RETRIEVAL CAPABILITY OF ORBITER - TEST SEQUENCE INCL: SYS C/O, MPS/APS BURNS, DUMMY PAYLOAD DEPLOY, ORBITER RETRIEVAL o SUBSEQ. FLIGHTS DEPLOY OPERATIONAL PAYLOADS SELECTED TO DEMO BUILD-UP IN TUG CAPABILITY o FOF OF 310ADE-3B IS A DEPLOY ONLY FLIGHT. RETRIEVAL DEMO WITH DKS PERFORMED UPON RETURN TO 160NM ORBIT o ONE DEDICATED FLIGHT TEST OF DKS IN 1982

FLIGHT TEST COST = $23.04M

TOTAL VEHICLE TEST = $49.91M

GRUMMAN

510A-3B/510ADE-3B FLIGHT TESTS

Nine flights are included in the 510A-3B/510ADE-3B flight test program.

The main stage flight test program is essentially as described for configuration 110A-1. The test sequence for the evolved configuration includes a retrieval demonstration as described in 310RE-3A using a DKS to serve as the retrieval target.

Since the DKS is developed and flown earlier than the main stage a separate and dedicated flight test is planned to verify the capability of the DKS to function during and after extended exposure to orbital environments. This flight will occur in early 1981 and could be accomplished as part of a normal Shuttle launch or by some other means.

8.3 Facilities Plan - Option 3B - Concept 510A-3B/510 ADE-3B

8.3.1 Manufacturing Facilities

Same as concept 110A-1 except 39,200 sq. ft. of floor space is required for fabrication and assembly of the TUG.

8.3.2 Test Facilities

Same as concept 110A-1 except 1AT will require 1300 sq. ft. of floor space at JSC.

8.3.3 Operations Facilities

Same as concept 110A-1 except TUG Maintenance Facility at ETR will have 4 horizontal stations in a 12,000 sq. ft. addition to the Shuttle OMS Facility. The Kickstage SRM Processing Facility will require 2800 sq. ft. of floor space.

STORABLE SPACE TUG

CONCEPT 510A-3B/510AWE-3B

Revision Date 9-7-73

FACILITIES FUNDING REQUIREMENTS

IOC DEC. '79

ACQUISITION PHASE NASA

Fiscal Year	'76			'77			'78			'79			'80			'81			'82			'83			'84	'85	'86	'87	'88	'89	'90	'91	TOTALS		
TITLE/WBS # / Level 6 Cat.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	3	3	3	3	3	3	3	3	DDT&E	PROD	OPS
Manufacturing 320-06-01																																			
Structures		2.0		55.0	28.8	3.6		28.8	22.4			14.2 (30.9)			(34.6)			(34.6)			(34.6)			(34.6)	(34.6)	(21.2)							157.8	214.6	–
Mockups											66.8				(34.4)			(30.4)			(34.4)			(34.4)	(34.4)	(34.4)							66.8	204.4	–
Sub-Total		2.0		55.0	28.8	3.6		28.8	22.4		66.8	34.6			69.0			64.0			69.0			69.0	69.0	55.6							224.6	418.0	
Test 320-06-02																																			
Structural																																	–	–	–
Thermal																																	–	–	–
LAT																																	–	–	–
Propulsion																																			
Sub-Total																																			
Maint. & Refurb. - ETR 320-06-03																																			
Tug Maint. Fac.																																			
Prop. Sys. Serv.																																			
Tug Cleaning																																			
Kick Stage Proc.																																			
Support/Whse. Fac.																																			
Office																																			
Sub-Total																																			
ETR Launch 320-06-04																																			
Launch Pad																																			
Safing Area																																			
Mission Control Center																																			
Sub-Total																																			
Maint. & Refurb.-WTR 320-06-05																																			
Tug Maint. Fac.																																			
Prop. Sys. Serv.																																			
Tug Cleaning																																			
Support/Whse. Fac.																																			
Office																																			
Sub-Total																																			
WTR Launch 320-06-06																																			
Launch Pad																																			
Safing Area																																			
Mission Control Center																																			
Sub-Total																																			
TOTALS		2.0		210.0	28.8	3.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	90.0	23.0	[illegible]	155.0		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

COSTS - $000 (1973)

Col. 1 - Design/Construction Costs
Col. 2 - Activation Costs
Col. 3 - Maintenance Costs

00 - DDT & E Costs
(00) - Production Costs
[00] - Operations Costs

GRAND TOTAL 8727.4

8.4 Vehicle Manufacturing

This section establishes the manufacturing requirements for the 510A-3B/510ADE-3B spacecraft including the assembly sequence, tooling, schedule, manufacturing test, special processes and facilities.

The 510A-3B spacecraft consists of a main stage and an apogee kick stage (AKS) with phased introduction of a deorbit kick stage (DKS). The configuration is essentially the same as the 310 and 410 configurations except that the OMS engine is used and lower construction cost is achieved by using aluminum propellant tanks and a stiffened sheet outer shell. Use of the OME increases the length of the orbiter adapter and relocates the forward support pickup structure.

8.4.1 Plan/Flow/Time

The manufacturing sequence for the main stage and propellant tanks are included in the Part II Section 8.4 manufacturing discussion. The kick stage is essentially standard for all configurations and is discussed in Part I Section 8.4.1.2.

The manufacturing flow and master schedule are shown in figures 8.4-1 and 8.4-2 respectively.

8.4.2 Tooling Requirements (including GSE)

Tooling requirements for the main stage are shown in Figure 8.4-1. The kick stage requirements are the same as those discussed in Part I Section 8.4.2.2.

8.4.3 Facilities Requirements

See Part II section 8.4.3

8.4.4 Special Requirements

See Part I Section 8.4.4

8.4.5 Summary Analysis/Philosophy

See Part I section 8.4.5

8.4.6 GSE Requirements

See Part I section 8.4.7

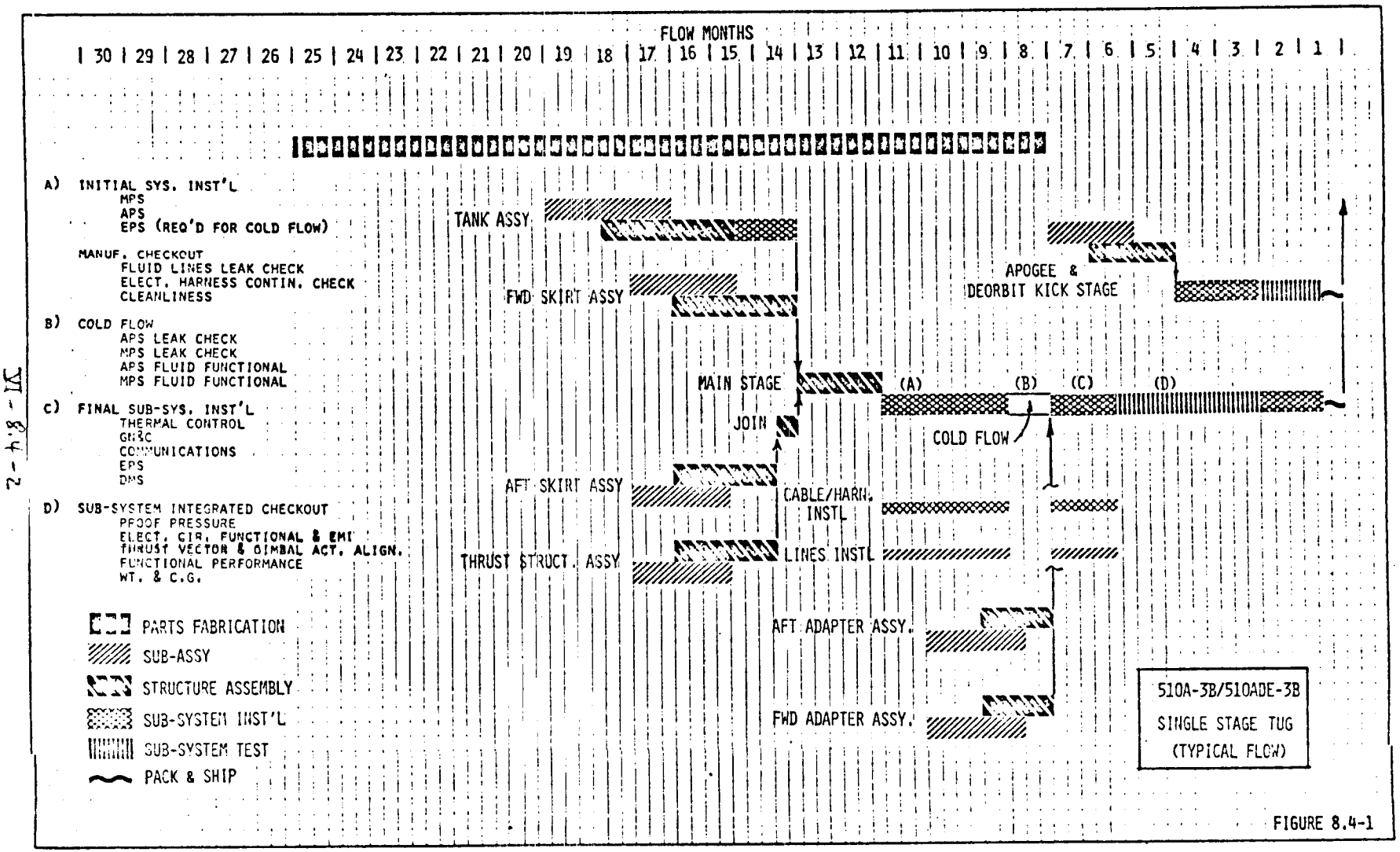

FLOW MONTHS
30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
A) INITIAL SYS. INST'L
MPS
APS
EPS (REQ'D FOR COLD FLOW)
MANUF. CHECKOUT
FLUID LINES LEAK CHECK
ELECT. HARNESS CONTIN. CHECK
CLEANLINESS
B) COLD FLOW
APS LEAK CHECK
MPS LEAK CHECK
APS FLUID FUNCTIONAL
MPS FLUID FUNCTIONAL
C) FINAL SUB-SYS. INST'L
THERMAL CONTROL
GN&C
COMMUNICATIONS
EPS
DMS
D) SUB-SYSTEM INTEGRATED CHECKOUT
PROOF PRESSURE
ELECT. CIR. FUNCTIONAL & EMI
THRUST VECTOR & GIMBAL ACT. ALIGN.
FUNCTIONAL PERFORMANCE
WT. & C.G.
TANK ASSY
FWD SKIRT ASSY
MAIN STAGE
JOIN
AFT SKIRT ASSY
THRUST STRUCT. ASSY
CABLE/HARN. INSTL
LINES INSTL
AFT ADAPTER ASSY.
FWD ADAPTER ASSY.
APOGEE & DEORBIT KICK STAGE
(A)
(B)
(C)
(D)
COLD FLOW
PARTS FABRICATION
SUB-ASSY
STRUCTURE ASSEMBLY
SUB-SYSTEM INST'L
SUB-SYSTEM TEST
PACK & SHIP
510A-3B/510ADE-3B
SINGLE STAGE TUG
(TYPICAL FLOW)

FIGURE 8.4-1

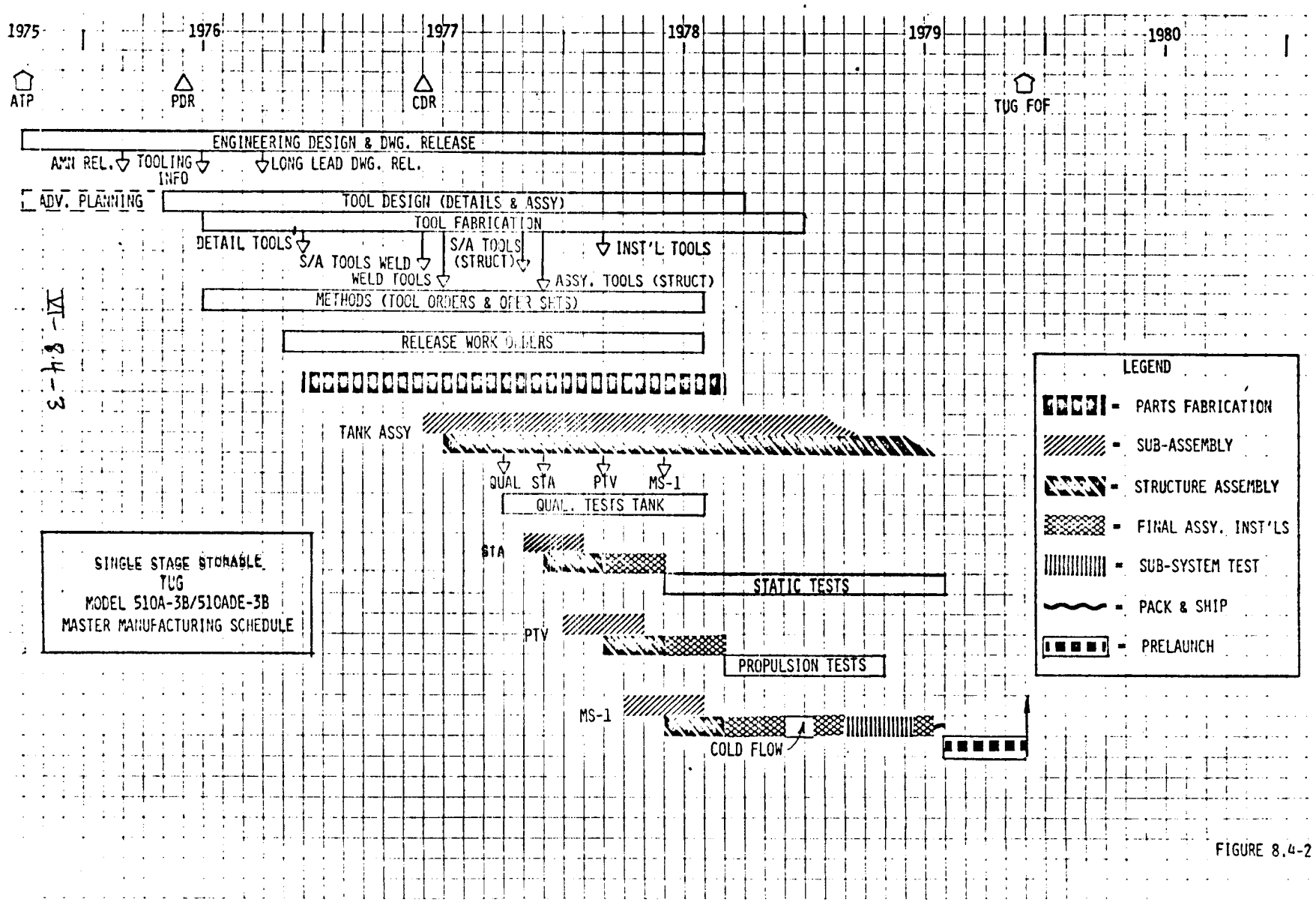

1975
1976
1977
1978
1979
1980
ATP
PDR
CDR
TUG FOF
ENGINEERING DESIGN & DWG. RELEASE
AMN REL.
TOOLING INFO
LONG LEAD DWG. REL.
ADV. PLANNING
TOOL DESIGN (DETAILS & ASSY)
TOOL FABRICATION
DETAIL TOOLS
S/A TOOLS WELD
WELD TOOLS
S/A TOOLS (STRUCT)
INST'L TOOLS
ASSY. TOOLS (STRUCT)
METHODS (TOOL ORDERS & OPER SHTS)
RELEASE WORK ORDERS
TANK ASSY
QUAL
STA
PTV
MS-1
QUAL. TESTS TANK
STA
STATIC TESTS
PTV
PROPULSION TESTS
MS-1
COLD FLOW
SINGLE STAGE STORABLE
TUG
MODEL 510A-3B/510ADE-3B
MASTER MANUFACTURING SCHEDULE
LEGEND
PARTS FABRICATION
SUB-ASSEMBLY
STRUCTURE ASSEMBLY
FINAL ASSY. INST'LS
SUB-SYSTEM TEST
PACK & SHIP
PRELAUNCH

FIGURE 8.4-2

TABLE 8.4-1

TOOLING REQUIREMENTS

510A-3B

PART/ASSEMBLY	OPERATIONS	TOOL/GSE
PROPELLANT TANK - ALUMINUM		
Domes (4)	Spin Form Chemmill Trim & Weld Prep	Spinning Chuck Chemmill Templates (4) Spinning Chuck Above
Polar Ring (2)	Form Machine	Press Die Holding Fixture
Polar Cap (2)	Form Machine	Press Die Holding Fixture
Access Covers (2)	Form Machine	Press Die (Polar Cap Die) Holding Fixture
Cylinder	Form Weld Chemmill Trim & Weld Prep	Standard Rollers Standard Longitudinal Stake Welder Chemmill Template Trim Fixture
Fwd Frame	Machine Roll Forging Form Seal Channel Weld Final Machine	Holding Fixture, NC Tape Standard Rollers Weld Fixture Holding Fixture Above
"Y" Ring	Machine Roll Forging	Holding Fixture, NC Tape
Cove	Form Chemmill Trim & Weld Prep Weld	Press Die Chemmill Templates Trim Fixture Weld Fixture
Aft. Frame	Machine Roll Forging Form Cover Plate Weld Final Machine	Holding Fixture, NC Tape Standard Rollers Weld Fixture Holding Fixture Above
Stiffeners	Form Chemmill Trim	Standard Brake Die Chemmill Template Drill & Scribe Template
Tank Assembly-Fuel	Weld Domes, Cylinder & Y Rings	Weld Fixture (includes mandrel, Back-up bars, clamps and rotating mechanism)
Tank Assembly - Oxidizer	Weld Domes, Cylinder & Y Rings	Weld Fixture (includes mandrel, Back-up bars, clamps and rotating mechanism)

TABLE 8.4-1

TOOLING REQUIREMENTS (cont)

510A-3B

PART/ASSEMBLY	OPERATIONS	TOOL/GSE
PROPELLANT TANK - ALUMINUM		
Installation Fixture	Install Propellant Acquisition Screens Fuel Tank	Drill/Installation Fixture
Installation Fixture	Install Propellant Acquisition Screens Fuel Tank	Drill/Installation Fixture
Assembly	Handling	Slings (2) (GSE)
Assembly	Transportation	Dolly (2) (GSE)
FORWARD SKIRT		
Outer Shell	Roll form sheet Brake form stiffeners Chemmill skin Trim stiffeners	Standard rollers Standard Dies Chemmill templates (2) Drill & scribe templates (8)
Fwd Frame	Form members Chemmill	Press blocks (4) Chemmill templates
Intermed Frame(2)	Form members Chemmill	Press block (3) Chemmill templates
Docking Probes (4)	Machine	Holding fixtures, NC Tapes
Latches (12 & Ftgs.	Machine	Holding fixtures, NC Tapes
Assembly	Assemble Skin, Stiffeners, Frames, Docking Interfaces, APS clusters	Assembly fixture
Assembly	Handling & Transportatin	Standard sling & dolly with adapters
AFT SKIRT		
Outer Shell	Roll Form Sheet Brake form stiffeners Chemmill skin Trim stiffeners	Standard rollers Standard Dies Chemmill templates (2) Drill & scribe templates (8)
Frame	Form members Chemmill	Press blocks (3) Chemmill templates
Aft Frame	Form members Chemmill	Press blocks (4) Chemmill templates

TABLE 8.4-1
TOOLING REQUIREMENTS (Cont)

510A-3B

PART/ASSEMBLY	OPERATIONS	TOOL/GSE
AFT SKIRT (Cont)		
Assembly	Assemble Skin, stiffeners, frames, docking interfaces, APS clusters	Assembly fixture
Assembly	Handling & transportation	Standard sling & dolly with adapters
THRUST STRUCTURE		
Conical Shell	Roll Form sheet Form stiffeners Chemmill sheet	Standard rollers Standard brake dies Chemmill templates (3)
Engine Suppt. Ftg.	Machine	Holding fixture
Gimbal Fittings	Machine	Holding fixtures (2)
Base Heat Shield	Roll form Alzak sheet	Standard rollers
Assembly	Assemble sheet, stiffeners, fittings, & base heat shield	Assembly fixture
APS CLUSTERS		
Fwd (2)	Machine cluster parts (3)	Holding fixtures (3)
Aft (2)	Weld Machine assembly	Weld fixtures (2) Holding fixture
EQUIPMENT COMPARTMENT		
Sheetmetal parts	Form Drill & trim Chemmill	Press blocks & standard dies Drill & scribe templates & router boards Chemmill templates
Fittings	Machine	Holding fixtures
FLUIDS ASSEMBLIES		
Tubing	Form Weld connectors	Standard bending dies & set-up gages (SUGS) Standard Orbital welding equipment adapters & welding schedules
Assembly	Assemble fluid lines and purchased components such as valves, filters, regulators	Assembly fixtures and standard cryofit and brazing tools.
ELECTRICAL HARNESSING		
	Wire cutting and prep Assembly	Standard cutting, stripping, marking tools Harness boards

TABLE 8.4-1

TOOLING REQUIREMENTS (Cont)

510A-3B

PART/ASSEMBLY	OPERATION	TOOL/GSE
INSTALLATIONS		
	Install subassemblies and components	Installation fixtures
FINAL ASSEMBLY		
	Structural Assembly Installations Handling Transportation Shipping	Final assembly fixture Work stand Slings (2) (GSE) Dolly (GSE) Container (GSE)

8.4 Vehicle Manufacturing

This section establishes the manufacturing requirements for the 510A-3B/510ADE-3B spacecraft including the assembly sequence, tooling, schedule, manufacturing test, special processes and facilities.

The 510A-3B spacecraft consists of a main stage and an apogee kick stage (AKS) with phased introduction of a deorbit kick stage (DKS). The configuration is essentially the same as the 310 and 410 configurations except that the OMS engine is used and lower construction cost is achieved by using aluminum propellant tanks and a stiffened sheet outer shell. Use of the OME increases the length of the orbiter adapter and relocates the forward support pickup structure.

8.4.1 Plan/Flow/Time

The manufacturing sequence for the main stage and propellant tanks are included in the Part II Section 8.4 manufacturing discussion. The kick stage is essentially standard for all configurations and is discussed in Part I Section 8.4.1.2.

The manufacturing flow and master schedule are shown in figures 8.4-1 and 8.4-2 respectively.

8.4.2 Tooling Requirements (including GSE)

Tooling requirements for the main stage are shown in Figure 8.4-1. The kick stage requirements are the same as those discussed in Part I Section 8.4.2.2.

8.4.3 Facilities Requirements

See Part II section 8.4.3

8.4.4 Special Requirements

See Part I Section 8.4.4

8.4.5 Summary Analysis/Philosophy

See Part I section 8.4.5

8.4.6 GSE Requirements

See Part I section 8.4.7

TABLE 8.4-1

TOOLING REQUIREMENTS

510A-3B

PART/ASSEMBLY	OPERATIONS	TOOL/GSE
PROPELLANT TANK - ALUMINUM		
Domes (4)	Spin Form Chemmill Trim & Weld Prep	Spinning Chuck Chemmill Templates (4) Spinning Chuck Above
Polar Ring (2)	Form Machine	Press Die Holding Fixture
Polar Cap (2)	Form Machine	Press Die Holding Fixture
Access Covers (2)	Form Machine	Press Die (Polar Cap Die) Holding Fixture
Cylinder	Form Weld Chemmill Trim & Weld Prep	Standard Rollers Standard Longitudinal Stake Welder Chemmill Template Trim Fixture
Fwd Frame	Machine Roll Forging Form Seal Channel Weld Final Machine	Holding Fixture, NC Tape Standard Rollers Weld Fixture Holding Fixture Above
"Y" Ring	Machine Roll Forging	Holding Fixture, NC Tape
Cove	Form Chemmill Trim & Weld Prep Weld	Press Die Chemmill Templates Trim Fixture Weld Fixture
Aft. Frame	Machine Roll Forging Form Cover Plate Weld Final Machine	Holding Fixture, NC Tape Standard Rollers Weld Fixture Holding Fixture Above
Stiffeners	Form Chemmill Trim	Standard Brake Die Chemmill Template Drill & Scribe Template
Tank Assembly-Fuel	Weld Domes, Cylinder & Y Rings	Weld Fixture (includes mandrel, Back-up bars, clamps and rotating mechanism)
Tank Assembly - Oxidizer	Weld Domes, Cylinder & Y Rings	Weld Fixture (includes mandrel, Back-up bars, clamps and rotating mechanism)

TABLE 8.4-1

TOOLING REQUIREMENTS (cont)

510A-3B

PART/ASSEMBLY	OPERATIONS	TOOL/GSE
PROPELLANT TANK - ALUMINUM		
Installation Fixture	Install Propellant Acquisition Screens Fuel Tank	Drill/Installation Fixture
Installation Fixture	Install Propellant Acquisition Screens Fuel Tank	Drill/Installation Fixture
Assembly	Handling	Slings (2) (GSE)
Assembly	Transportation	Dolly (2) (GSE)
FORWARD SKIRT		
Outer Shell	Roll form sheet Brake form stiffeners Chemmill skin Trim stiffeners	Standard rollers Standard Dies Chemmill templates (2) Drill & scribe templates (8)
Fwd Frame	Form members Chemmill	Press blocks (4) Chemmill templates
Intermed Frame(2)	Form members Chemmill	Press block (3) Chemmill templates
Docking Probes (4)	Machine	Holding fixtures, NC Tapes
Latches (12 & Ftgs.	Machine	Holding fixtures, NC Tapes
Assembly	Assemble Skin, Stiffeners, Frames, Docking Interfaces, APS clusters	Assembly fixture
Assembly	Handling & Transportatin	Standard sling & dolly with adapters
AFT SKIRT		
Outer Shell	Roll Form Sheet Brake form stiffeners Chemmill skin Trim stiffeners	Standard rollers Standard Dies Chemmill templates (2) Drill & scribe templates (8)
Frame	Form members Chemmill	Press blocks (3) Chemmill templates
Aft Frame	Form members Chemmill	Press blocks (4) Chemmill templates

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TABLE 8.4-1
TOOLING REQUIREMENTS (Cont)

510A-3B

PART/ASSEMBLY	OPERATIONS	TOOL/GSE
AFT SKIRT (Cont)		
Assembly	Assemble Skin, stiffeners, frames, docking interfaces, APS clusters	Assembly fixture
Assembly	Handling & transportation	Standard sling & dolly with adapters
THRUST STRUCTURE		
Conical Shell	Roll Form sheet Form stiffeners Chemmill sheet	Standard rollers Standard brake dies Chemmill templates(3)
Engine Suppt. Ftg.	Machine	Holding fixture
Gimbal Fittings	Machine	Holding fixtures (2)
Base Heat Shield	Roll form Alzak sheet	Standard rollers
Assembly	Assemble sheet, stiffeners, fittings, & base heat shield	Assembly fixture
APS CLUSTERS		
Fwd (2)	Machine cluster parts (3)	Holding fixtures (3)
Aft (2)	Weld Machine assembly	Weld fixtures (2) Holding fixture
EQUIPMENT COMPARTMENT		
Sheetmetal parts	Form Drill & trim Chemmill	Press blocks & standard dies Drill & scribe templates & router boards Chemmill templates
Fittings	Machine	Holding fixtures
FLUIDS ASSEMBLIES		
Tubing	Form Weld connectors	Standard bending dies & set-up gages (SUGS) Standard Orbital welding equipment adapters & welding schedules
Assembly	Assemble fluid lines and purchased components such as valves, filters, regulators	Assembly fixtures and standard cryofit and brazing tools.
ELECTRICAL HARNESSING		
	Wire cutting and prep Assembly	Standard cutting, stripping, marking tools Harness boards

TABLE 8.4-1

TOOLING REQUIREMENTS (Cont)

510A-3B

PART/ASSEMBLY	OPERATION	TOOL/GSE
INSTALLATIONS		
	Install subassemblies and components	Installation fixtures
FINAL ASSEMBLY		
	Structural Assembly Installations Handling Transportation Shipping	Final assembly fixture Work stand Slings (2) (GSE) Dolly (GSE) Container (GSE)

5.5 510A-3B/510ADE-3B SPECIAL PROGRAMMATICS

The main features defined for implementing and managing Program 510A-3B/510ADE-3B include: defining the initial/evolved flight build up based on Shuttle/Tug launch constraint and ground crew launch capability; timing DKS development to capture 1984 retrievals: implementing 3 lot vehicle production (deploy, deploy-upgrade, and retrieve); refurbishing the propulsion test article for operational use; and defining a fall back position for every identified risk.

Specific areas for government participation include: establishing Tug/Shuttle interface requirements before Orbiter design freeze; providing payload interface design requirements and mission model data; initiating required activities for supporting Research and Technology; providing GFE systems and components (eg: main engines, and DOD secure comm); supporting propulsion system testing and development and supporting integrated avionics hardware testing and related software development; providing required facilities; and performing vehicle ground operations, flight operations, and logistic support operations.

510A-3B/510ADE-3B SPECIAL PROGRAMMATICS

- o PROGRAM IMPLEMENTATION AND MANAGEMENT
  - INITIAL/EVOLVED FLIGHT BUILD-UP SET BY SHUTTLE/TUG LAUNCH CONSTRAINT AND GROUND CREW LAUNCH CAPABILITY
  - 3 LOT PRODUCTION (DEPLOY, DEPLOY-UPGRADE AND RETRIEVE) TO AVOID MFG GAP
  - DKS TIMED TO CAPTURE '84 RETRIEVALS
  - PROPULSION ARTICLE REFURBED FOR FLIGHT
  - FALL BACK POSITION SHOWN FOR EVERY IDENTIFIED RISK

- o AREAS FOR GOVERNMENT PARTICIPATION
  - FIRM TUG/SHUTTLE INTERFACES BEFORE ORBITER PDR
  - PROVIDE PAYLOAD INTERFACE DESIGN REQUIREMENTS AND MISSION MODEL DATA
  - INITIATE REQUIRED SR&T
  - SUPPORT SYSTEM TEST - AVIONIC HARDWARE/SOFTWARE, PROPULSION
  - PROVIDE GFE SYSTEMS AND COMPONENTS, FACILITIES AND LOGISTIC SUPPORT
  - PERFORM VEHICLE GROUND AND FLIGHT OPERATIONS

GRUMMAN

8.6 COST DATA

Included in this section are the cost data for an evolved tug configuration 510A-3B-510ADE-3B. Cost data are provided for the initial program 510A-3B and the combined total evolved program.

- Initial Program 510A-3B
  - Storable Space Tug System Project Expected Cost-Spares Cost (INT & OPS)-First Unit Cost (Data Forms A1, 2 and 3, subparagraph No's 8.6.1, 8.6.2 and 8.6.3) (Computer P/O)
  - Storable Space Tug Funding Schedules-DDT & E, Production and Operations (Date Form C, subparagraph 8.6.4, 8.6.5, 8.6.6 and 8.6.7)
  - Form B (Technical Characteristics subparagraph 8.6.11)
- Combined Evolved Program 510A-3B/510ADE-3B
  - Same as initial program plus:
    - Average Cost/Flight (subparagraph 8.6.9)

EVOLVED TUG

CONCEPT 510A-3B (INITIAL)

OPTION 3

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STORABLE SPACE TUG SYSTEM PROJECT

EXPECTED COST - SPARES COST(INT + OPS) - FIRST UNIT COST

(COSTS IN 1973 CONSTANT DOLLARS (000))

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0100	PROJECT MGMT	10274.			2304.				907.	2733.		
0110	COST/PERF MGMT		1541.			346.			136.		911.	
0120	PROJECT DIRECTION		7911.			1774.			699.		911.	
0130	INFO MGMT		822.			184.			73.		911.	
0200	SYS ENG + INTEGR	12329.			2592.				1021.	5468.		
0210	TUG SYS ENG		9853.						0.		1367.	
0220	SHUTTLE INTERFACE		1233.						0.		1367.	
0230	PAYLOAD INTERFACE		1233.						0.		1367.	
0240	SUST ENG					0.			1021.		1367.	
0300	TUG VEH MAIN STAGE	100111.			24654.			4551.	8652.	9287.		
0310	STRUCTURES		15878.			2918.		292.	1149.		292.	
0311	FUEL TNK+SPRT			5161.			930.	93.	366.			93.
0312	OX TANK +SPRT			6129.			1078.	108.	424.			108.
0313	BODY STRUCT			2299.			402.	40.	158.			40.
0314	THRUST STRUCT			436.			77.	8.	30.			8.
0315	METEOROID SHLD			143.			32.	3.	12.			3.
0316	PAYLOAD INTFCE			1711.			399.	40.	157.			40.
0317	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0320	THERMAL INSULTN		149.			447.		22.	176.		22.	
0321	FUEL TANK INSUL			57.			219.	22.	86.			22.
0322	OX TANK INSUL			92.			228.	0.	90.			0.
0323	PURGE SYS INSUL			0.			0.	0.	0.			0.
0324	CONT SYS			0.			0.	0.	0.			0.
0325	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0330	AVIONICS		39892.			9831.		3046.	3277.		6699.	
0331	DATA MGMT			5880.			1989.	716.	663.			1725.
0332	G N + C			10420.			4410.	1407.	1470.			3108.
0333	COMMUNICATIONS			5883.			1240.	388.	413.			796.
0334	INSTRUMENTATION			0.			0.	0.	0.			0.
0335	ELEC PWR			16566.			1510.	535.	503.			1070.
0336	PWR DIST + CONT			1143.			683.	0.	228.			0.
0337	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0340	PROPULSION		33252.			6116.		1033.	2106.		2116.	
0341	MAIN ENGINE			24000.			2197.	937.	800.			1880.
0342	MAIN ENGINE SPT			4766.			1260.	0.	420.			0.
0343	ACPS ENGINE			3000.			1693.	96.	564.			236.
0344	ACPS ENGINE SPT			1486.			966.	0.	322.			0.
0345	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0350	ORBITER INTERFACE		6981.			1582.		158.	623.		158.	
0351	STRUCTURE			4900.			675.	68.	266.			68.
0352	INTERFACE PALS			2081.			906.	91.	357.			91.
0353	PURGE PROVISION			0.			0.	0.	0.			0.
0354	ABORT PROVISION			0.			0.	0.	0.			0.
0355	INSTL.ASSY+C/O			0.			0.	0.	0.			0.

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WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0360	DROP TANKS		0.			0.		0.	0.		0.	
0361	STRUCTURES			0.			0.	0.	0.			0.
0362	THERMAL INSUL			0.			0.	0.	0.			0.
0363	PROP SPRT SYS			0.			0.	0.	0.			0.
0364	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0370	FINAL ASSY + C/O		3959.			3761.		0.	1320.		0.	
0371	FINAL ASSY			3959.			3761.	0.	1320.			0.
0372	CHECKOUT			0.			0.	0.	0.			0.
0400	TUG VEH AUX STAGE	26633.			134982.			257.	3491.	257.		
0410	STRUCTURES		0.			0.		0.	0.		0.	
0411	FUEL TNK+SPRT			0.			0.	0.	0.			0.
0412	OX TANK+SPPT			0.			0.	0.	0.			0.
0413	BODY STRUCT			0.			0.	0.	0.			0.
0414	THRUST STRUCT			0.			0.	0.	0.			0.
0415	METEOROID SHLD			0.			0.	0.	0.			0.
0416	PAYLOAD INTERFC			0.			0.	0.	0.			0.
0417	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0420	THERMAL INSUL		0.			0.		0.	0.		0.	
0421	FUEL TANK INSUL			0.			0.	0.	0.			0.
0422	OX TANK INSUL			0.			0.	0.	0.			0.
0423	PURGE SYS INSUL			0.			0.	0.	0.			0.
0424	CONT SYS			0.			0.	0.	0.			0.
0425	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0430	AVIONICS		0.			0.		0.	0.		0.	
0431	DATA MGMT			0.			0.	0.	0.			0.
0432	G N + C			0.			0.	0.	0.			0.
0433	COMMUNICATIONS			0.			0.	0.	0.			0.
0434	INSTRUMENTATION			0.			0.	0.	0.			0.
0435	ELEC PWR			0.			0.	0.	0.			0.
0436	PWR DIST + CONT			0.			0.	0.	0.			0.
0437	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0440	PROPULSION		0.			0.		0.	0.		0.	
0441	MAIN ENGINE			0.			0.	0.	0.			0.
0442	MAIN ENGINE SPT			0.			0.	0.	0.			0.
0443	ACPS ENGINE			0.			0.	0.	0.			0.
0444	ACPS ENGINE SPT			0.			0.	0.	0.			0.
0445	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0450	INTERSTAGE INTRFC		0.			0.		0.	0.		0.	
0451	STRUCTURE			0.			0.	0.	0.			0.
0452	SEP SYS			0.			0.	0.	0.			0.
0453	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0460	DROP TANK		0.			0.		0.	0.		0.	
0461	STRUCTURE			0.			0.	0.	0.			0.
0462	THERMAL INSUL			0.			0.	0.	0.			0.
0463	PROP SPT SYS			0.			0.	0.	0.			0.
0464	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0470	FDM		0.			0.		0.	0.		0.	

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WBS	LEVEL 4	5	6	4	5	6	INITIAL SPARES	1ST UNIT COST	4	5	6
		EXPECTED COST DDT+E			EXPECTED COST PRODUCTION					EXPECTED COST OPN SP/OPS	
0471 STRUCTURE			0.			0.	0.	0.			0.
0472 THERM CONT			0.			0.	0.	0.			0.
0473 AVIONICS			0.			0.	0.	0.			0.
0474 PROPULSION			0.			0.	0.	0.			0.
0475 RDM ASSY+C/O			0.			0.	0.	0.			0.
0480 AKS		15315.			39928.		257.	1358.		257.	
0481 STRUCTURE			4950.			7067.	47.	374.			47.
0482 SRM			1650.			15525.	80.	67.			80.
0483 AVIONICS			5000.			11549.	115.	611.			115.
0484 PROPULSION			459.			1871.	15.	99.			15.
0485 AKS ASSY+C/O			3256.			3916.	0.	207.			0.
0490 DKS		11318.			95055.		0.	2132.		0.	
0491 STRUCTURE			5300.			17995.	0.	400.			0.
0492 SRM			1800.			2450.	0.	74.			0.
0493 AVIONICS			1593.			54632.	0.	1214.			0.
0494 PROPULSION			219.			5344.	0.	119.			0.
0495 DKS ASSY+C/O			2406.			14634.	0.	325.			0.
04100 CACHE TANK		0.			0.		0.	0.		0.	
04101 STRUCTURE			0.			0.	0.	0.			0.
04102 THERM CONT			0.			0.	0.	0.			0.
04103 AVIONICS			0.			0.	0.	0.			0.
04104 PROPULSION			0.			0.	0.	0.			0.
04105 CACHE ASSY+C/O			0.			0.	0.	0.			0.
04110 FINAL ASSY + C/O		0.			0.		0.	0.		0.	
04111 FINAL ASSY			0.			0.	0.	0.			0.
04112 CHECKOUT			0.			0.	0.	0.			0.
0500 LOGISTICS	6330.			3672.				3672.			
0510 TRANSPORT+HANDLG		0.			1152.			1152.			
0520 TRAINING		6330.			1950.			1950.			
0521 SIM+EQUIPMENT			1950.			1950.		1950.			
0522 GROUND CREW			2180.			0.		0.			
0523 FLT OPS CREW			2200.			0.		0.			
0530 WAREHSG+INV CONT		0.			570.			570.			

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WBS	LEVEL 4	EXPECTED COST DDT+E 5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0600 FACILITIES	7099.			68.					202.		
0610 MANUFACTURING		145.			50.					0.	
0611 DES/CONSTR			145.								
0612 ACT/MAINT			0.			50.					0.
0620 TEST		245.			18.					0.	
0621 DES/CONST			245.								
0622 ACT/MAINT			0.			18.					0.
0630 1ST TF MAINT+REF		2953.			0.					100.	
0631 DES/CONST			2953.								
0632 ACT/MAINT			0.			0.					100.
0640 ETR LAUNCH		475.			0.					26.	
0641 DES/CONST			475.								
0642 ACT/MAINT			0.			0.					26.
0650 2ND TF MAINT+REF		2758.			0.					50.	
0651 DES/CONST			2758.								
0652 ACT/MAINT			0.			0.					50.
0660 WTR LAUNCH		523.			0.					26.	
0661 DES/CONST			523.								
0662 ACT/MAINT			0.			0.					26.
0700 GSE	25780.			0.			0.		2240.		
0710 MFG GSE		2100.									
0711 HARDWARE											
0712 SITE ACT											
0713 MAINT											
0714 SOFTWARE											
0720 ETR GSE		17080.			0.		0.			600.	
0721 HARDWARE			14780.			0.	0.				
0722 SITE ACT			2300.								
0723 MAINT			0.								600.
0724 SOFTWARE			0.								
0730 WTR GSE		0.			0.		0.			1640.	
0731 HARDWARE			0.			0.	0.				
0732 SITE ACT			0.								
0733 MAINT			0.								1640.
0734 SOFTWARE			0.								

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WBS		EXPECTED COST DDT+E LEVEL 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0740	FL OP NASA		3300.			0.		0.			0.	
0741	HARDWARE			3300.			0.	0.				
0742	SITE ACT			0.								0.
0743	MAINT			0.								
0744	SOFTWARE			0.								
0750	FL OP DOD		3300.			0.		0.			0.	
0751	HARDWARE			3300.			0.	0.				
0752	SITE ACT			0.								0.
0753	MAINT			0.								
0754	SOFTWARE			0.								
0800	VEHICLE TEST	65325.										
0810	GND TEST HARDWARE		9152.									
0811	PTV/BATTLESHIP			1726.								
0812	MAJOR TST ART			6975.								
0813	MOCKUPS			450.								
0820	GND TEST OPS		10800.									
0830	FLT TEST HARDWARE		12193.									
0840	FLT TEST OPS		33180.									
0900	LAUNCH OPS WTR									434.		
0910	LAUNCH SITE SVC										0.	
0920	TUG/SHUTTLE MATG										0.	
0930	PRELAUNCH C/O										0.	
0940	COUNTDOWN										0.	
0950	FLUID+GASES										434.	
0960	POST FLT SAFING										0.	
1000	LAUNCH OPS ETR									7216.		
1010	LAUNCH SITE SVC										0.	
1020	TUG/SHUTTLE MATG										402.	
1030	PRELAUNCH C/O										780.	
1040	COUNTDOWN										24.	
1050	FLUID+GASES										4650.	
1060	POST FLT SAFING										1360.	
1100	FLT OPS DOD	3110								16530.		
1110	MISSION PLAN		2100								5230.	
1120	FLT CONT		650								5990.	
1130	FLT EVALUATION		360								780.	
1140	FLT SPT SOFTWARE										3530.	
1200	FLT OPS NASA	24,840								16300.		
1210	MISSION PLAN		5530								3630.	
1220	FLT CONT		1260								7910.	
1230	FLT EVALUATION		340								660.	
1240	FLT SPT SOFTWARE		17710								4090.	

NOTE: THESE COSTS INCLUDED IN VEHICLE TEST

4-9-8-TM

MOORE BUSINESS FORMS, INC. HO FORM 14127 PRINTED IN U.S.A.

510A-3B SEP 73

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
1300	REF+INT 1ST TR									1600.		
1310	SCHED MAINT+REF										0.	
1320	UNSCHED MAINT+REF										0.	
1330	POST MAINT C/O										0.	
1340	TUG/PAYLOAD MATG										0.	
1350	REF PQMTS PLANNG										0.	
1360	DEPOT MAINT										1600.	
1400	REF+INT 2ND TR									11360.		
1410	SCHED MAINT+REF										1500.	
1420	UNSCHED MAINT+REF										1540.	
1430	POST MAINT C/O										500.	
1440	TUG/PAYLOAD MATG										800.	
1450	REF PQMTS PLANNG										120.	
1460	DEPOT MAINT										6900.	
	SPACE TUG TOTALS	253881.			168272.			4808.	17743.	73627.		
	32A= 253881.		32B=	173080.		32C=	73627.		32D=	500588.		

VI-8-8

MOORE BUSINESS FORMS, INC., HO FORM 1412T PRINTED IN U.S.A. 22

1st Phase

For Summary Plot 9/15

510A-38 SEP 73

STORABLE SPACE TUG SYSTEM PROJECT

FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

DDTE (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	10.3	1.34	2.42	2.58	2.52	1.42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	12.3	2.15	4.12	3.62	1.99	0.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0300	TUG MAIN STAGE	100.1	20.35	33.94	26.40	14.74	4.68	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	STRUCTURE	15.9	3.44	5.72	4.24	2.01	0.47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320	THERMAL INSUL	0.1	0.02	0.04	0.04	0.03	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
330	AVIONICS	39.5	8.64	14.36	10.66	5.04	1.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION	33.3	7.20	11.97	8.88	4.20	0.99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
350	INTERFACE	7.0	1.05	1.85	1.78	1.52	0.73	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0360	DROP TANKS		16	31	20	6	4											
370	FINAL ASSY	4.0	0.0	0.0	0.79	1.94	1.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0400	TUG AUX STAGE	26.6	0.48	2.07	3.48	10.64	8.44	1.53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0410	STRUCTURES																	
0420	THERMAL INSUL																	
0430	AVIONICS																	
0440	PROPULSION																	
0450	INTERFACE																	
0460	DROP TANKS																	
0470	NUDGE																	
480	AKS	15.3	0.0	0.0	0.0	7.05	6.74	1.53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0490	DKS	11.3	0.48	2.07	3.48	3.59	1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
04100	CACHE																	
04110	FINAL ASSY	0.0	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS	6.3	1.37	2.28	1.69	0.80	0.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0600	FACILITIES	7.1	0.48	0.85	2.93	2.42	0.41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
610	MANUFACTURING	0.1	0.03	0.05	0.04	0.02	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
620	TEST	0.2	0.07	0.10	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
630	1ST MAIN/REF	3.0	0.38	0.70	0.74	0.72	0.41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
640	ETR LAUNCH	0.5	0.0	0.0	0.35	0.13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650	2ND MAIN/REF	2.8	0.0	0.0	1.35	1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
660	WTR LAUNCH	0.5	0.0	0.0	0.38	0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0700	GND SUPP EQUIP	25.8	7.95	7.90	4.75	4.86	0.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0710	MFG GSE	2.1	0.09	0.38	0.65	0.67	0.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
720	ETR GSE	17.1	7.86	7.52	1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
730	WTR GSE																	
740	FLT OPS NASA	3.3	0.0	0.0	0.0	3.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
750	FLT OPS DOD	3.3	0.0	0.0	2.40	0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0800	VEHICLE TEST	65.3	3.10	8.80	~~13.57~~ 13	~~21.20~~ 24	1.49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
810	GND TEST HWRE	9.2	1.70	2.79	2.87	1.79	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
820	GND TEST OPS	10.8	1.41	2.55	2.71	2.65	1.49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
830	FLT TEST HWRE	12.2	0.0	3.46	5.09	3.64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
840	FLT TEST OPS	33.2	0.0	0.0	0.0	33.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0900	LAUNCH OPS WTR																	
1000	LAUNCH OPS ETR																	
1100	FLIGHT OPS WTR																	
1200	FLIGHT OPS ETR																	
1300	REF + INT TR-1																	
1400	REF + INT TR-2																	
	TOTALS	253.9	~~37.71~~ 39	~~62.39~~ 65	54.12 74	~~79.24~~ 56	17.39 18	1.53 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

MOORE BUSINESS FORMS, INC., NO FORM 14121 PRINTED IN U.S.A. 27

510A-39 SEP 73

STORABLE SPACE TUG SYSTEM PROJECT

FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

PROD (ALL COSTS IN MILLIONS)

FISCAL YEARS

WPS	TITLE	TOTAL	~~1976~~	~~1977~~	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	2.3	0.22	0.43	0.48	0.49	0.45	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	2.6	0.25	0.49	0.54	0.55	0.51	0.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0300	TUG MAIN STAGE	29.2	0.0	4.39	8.32	7.63	5.15	2.62	0.88	0.17	0.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	STRUCTURE	3.2	0.0	0.52	0.96	0.86	0.55	0.26	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320	THERMAL INSUL	0.5	0.0	0.08	0.14	0.13	0.08	0.04	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
330	AVIONICS	12.9	0.0	2.07	3.86	3.45	2.22	1.03	0.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION	7.1	0.0	1.15	2.14	1.92	1.23	0.57	0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
350	INTERFACE	1.7	0.0	0.21	0.43	0.44	0.33	0.20	0.09	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0360	DROP TANKS																	
370	FINAL ASSY	3.9	0.0	0.37	0.78	0.86	0.73	0.52	0.31	0.15	0.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0400	TUG AUX STAGE	135.2	0.0	0.0	13.23	28.22	30.77	26.24	18.77	11.25	5.33	1.42	0.0	0.0	0.0	0.0	0.0	0.0
0410	STRUCTURES																	
0420	THERMAL INSUL																	
0430	AVIONICS																	
0440	PROPULSION																	
0450	INTERFACE																	
0460	DROP TANKS																	
0470	NUDGE																	
480	AKS	40.2	0.0	0.0	3.93	8.39	9.14	7.80	5.58	3.34	1.58	0.42	0.0	0.0	0.0	0.0	0.0	0.0
490	DKS	95.1	0.0	0.0	9.30	19.84	21.63	18.45	13.19	7.91	3.74	1.00	0.0	0.0	0.0	0.0	0.0	0.0
04100	CACHE																	
4110	FINAL ASSY	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS	3.7	0.0	0.0	0.17	0.42	0.54	0.56	0.53	0.46	0.36	0.27	0.18	0.11	0.06	0.02	0.0	0.0
0600	FACILITIES	0.1	0.02	0.03	0.02	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
610	MANUFACTURING	0.0	0.01	0.02	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
620	TEST	0.0	0.01	0.01	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
630	1ST MAIN/REF																	
640	ETR LAUNCH																	
650	2ND MAIN/REF																	
660	WTR LAUNCH																	
0700	GND SUPP EQUIP																	
0710	MFG GSE																	
720	ETR GSE																	
730	WTR GSE																	
740	FLT OPS NASA																	
750	FLT OPS DOD																	
0800	VEHICLE TEST																	
0810	GND TEST HWRE																	
0820	GND TEST OPS																	
0830	FLT TEST HWRE																	
0840	FLT TEST OPS																	
0900	LAUNCH OPS WTR																	
1000	LAUNCH OPS ETR																	
1100	FLIGHT OPS WTR																	
1200	FLIGHT OPS ETR																	
1300	REF + INT TR-1																	
1400	REF + INT TR-2		-0-	-0- ~~26~~ 23					23	14								
	TOTALS	173.1	~~0.49~~	~~5.33~~ ~~22.75~~		37.32	37.42	29.92	~~20.18~~	~~11.88~~	5.73	1.69	0.18	0.11	0.06	0.02	0.0	0.0
				~~32~~					23	14								

MOORE BUSINESS FORMS, INC., MO FORM 14127 PRINTED IN U.S.A.

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STORABLE SPACE TUG SYSTEM PROJECT

FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

OPS (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	2.7	0.0	0.0	0.0	0.0	0.08	0.19	0.24	0.27	0.28	0.28	0.29	0.29	0.28	0.26	0.20	0.08
200	SYS ENG + INTEG	5.5	0.0	0.0	0.0	0.0	0.15	0.37	0.49	0.54	0.56	0.57	0.57	0.58	0.56	0.51	0.39	0.16
0300	VEH OPS SPARES	6.3	0.0	0.0	0.0	0.0	0.26	0.63	0.83	0.92	0.95	0.97	0.98	0.98	0.96	0.87	0.67	0.28
310	STRUCTURE	0.3	0.0	0.0	0.0	0.0	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01
320	THERMAL INSUL	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
330	AVIONICS	6.7	0.0	0.0	0.0	0.0	0.19	0.46	0.60	0.66	0.69	0.70	0.70	0.71	0.69	0.63	0.48	0.20
340	PROPULSION	2.1	0.0	0.0	0.0	0.0	0.06	0.14	0.19	0.21	0.22	0.22	0.22	0.22	0.22	0.20	0.15	0.06
350	INTERFACE	0.2	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.00
360	DROP DANK																	
0370	FINAL ASSY																	
0400	TUG AUX STAGE	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01
0410	STRUCTURES																	
0420	THERMAL INSUL																	
0430	AVIONICS																	
0440	PROPULSION																	
0450	INTERFACE																	
0460	DROP TANKS																	
0470	NUDGE																	
480	AKS	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01
490	DKS																	
04100	CACHE																	
04110	FINAL ASSY																	
0500	LOGISTICS																	
0600	FACILITIES	0.2	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
610	MANUFACTURING																	
620	TEST																	
630	1ST MAIN/REF	0.1	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
640	ETR LAUNCH	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
650	2ND MAIN/REF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
660	WTR LAUNCH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0700	GND SUPP EQUIP	2.2	0.0	0.0	0.0	0.0	0.02	0.04	0.12	0.21	0.25	0.26	0.27	0.27	0.27	0.25	0.20	0.09
710	MFG GSE																	
720	ETR GSE	0.6	0.0	0.0	0.0	0.0	0.02	0.04	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.04	0.02
730	WTR GSE	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.06	0.15	0.19	0.20	0.20	0.21	0.21	0.20	0.16	0.07
740	FLT OPS NASA																	
750	FLT OPS DOD																	
0800	VEHICLE TEST																	
0810	GND TEST HWRE																	
0820	GND TEST OPS																	
0830	FLT TEST HWRE																	
0840	FLT TEST OPS																	
900	LAUNCH OPS WTR	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.02
1000	LAUNCH OPS ETR	7.2	0.0	0.0	0.0	0.0	0.23	0.49	0.64	0.71	0.74	0.75	0.76	0.76	0.74	0.68	0.52	0.22
1100	FLIGHT OPS DOD	16.5	0.0	0.0	0.0	0.0	0.0	0.0	0.65	1.50	1.88	2.02	2.06	2.09	2.08	1.97	1.59	0.69
1200	FLIGHT OPS NASA	16.3	0.0	0.0	0.0	0.0	0.46	1.11	1.45	1.61	1.67	1.70	1.71	1.72	1.68	1.53	1.17	0.49
1300	REF + INT TR-1	1.6	0.0	0.0	0.0	0.0	0.05	0.11	0.14	0.16	0.16	0.17	0.17	0.17	0.16	0.15	0.12	0.05
1400	REF + INT TR-2	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.45	1.03	1.29	1.39	1.42	1.43	1.43	1.35	1.09	0.48
	TOTALS	73.6	0.0	0.0	0.0	0.0	1.23	2.95	5.05	~~7.03~~ 6.5	~~7.89~~ 7.00	8.21 7.5	8.34	8.39	8.28	7.67	6.03	2.57
							3	4										

MCGAW BUSINESS FORMS, INC. NO FORM 14131 PRINTED IN U.S.A.

SPACE TUG CHARACTERISTICS

510A-3B→510ADE-3B

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	WEIGHT, LB	3329→3534	864
	LENGTH, IN	300	80
	DIAMETER, IN	120	180
TECHNICAL:	REUSABLE	ONE-STAGE	DKS
	AUXILIARY STAGE		AKS→AKS/DKS
	PAYLOAD RETRIEVAL	CAPABILITY	
	PROPELLANT CAPACITY, LB	59,500	
	THRUST, LB	7,500	
	ISP, SEC	327.2	287 & 295
	AUTONOMY LEVEL	IIIA→IIB	
	RELIABILITY	.97→.9750	.9791

WBS #320-00

GRUMMAN

MAIN STAGE CHARACTERISTICS

510A-3B → 510ADE-3B

PHYSICAL:	WEIGHT, LB	3329 → 3534
	LENGTH, IN	300
	DIAMETER, IN	120
TECHNICAL:	REUSABLE SINGLE STAGE	
	PROPELLANT CAPABITY, LB	59,500
	PAYLOAD RETRIEVAL CAPABILITY	
	THRUST, LB	7,500
	ISP, SEC	327.2
	AUTONOMY LEVEL	IIIA → IIB
	RELIABILITY	.97 → .9750

WBS #320-03

GRUMMAN

VEHICLE TEST CHARACTERISTICS (510A-3B→510ADE-3B)

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	PROP. TEST ARTICLE	X	
	STRUCT. TEST ARTICEL	X	X
	INTEG. AVIONICS TEST	X	X
	MOCK-UPS	X	X
	FLIGHT TEST	X	X

TECHNICAL:
- PTA - COLD FLOW ONLY, NO HOT FIRING
- STA - ONE ART FOR DYNAMICS, STATIC & FATIGUE
- IAT - SOFTWARE & HARDWARE
- MOCK-UPS - WOOD AT PDR, WOOD/METAL AT CDR
- FLIGHT TEST - ONE WITHOUT P/L, EIGHT WITH P/L
  - ONE DKS ONLY

WBS #320-08

GRUMMAN

STRUCTURAL CHARACTERISTICS

510A-3B → 510ADE-3B

PHYSICAL:	WEIGHT, LB	1285 → 1338
	LENGTH, IN	300
	DIAMETER, IN	120
TECHNICAL:	TANK CONFIGURATION	NESTED DOME
	TANK CAPACITY, LB	59,500
	MATERIAL	AL, AL STIFFENED SHEET
	RELIABILITY ALLOCATION	.99900

WBS #320-03-01

GRUMMAN

CONFIGURATION 510A-3B

WBS NO. 320-03-01

SUBSYSTEM/COMPONENT STRUCTURE

DATE: 9/17/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS	RELIABILITY: MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GNDTEST	NOTES
01-Fuel Tank and supports	1	44½		Alum.	252	91	120	DIA		Welded Aluminum Cylinder Spun Aluminum Domes	20	1		2	Tank Leakage Considered Unserviceable
02-Oxid. Tank and Supports	1	44½		Alum.	180	100	120	DIA		Welded Aluminum Cylinder Spun Aluminum Domes	20	1		2	
03-Body Structure	1	44½		Alum.	671	145	120	DIA		Aluminum Stiffened Sheet Shell Aluminum Frames	N/A	1		2	Includes Equipment Mounting and Umbilicals
04-Thrust structure	1	44½		Alum.	80	35	120 MAX	DIA		Aluminum Stiffened Sheet	N/A	1		2	
05-Meteoroid shield	1	44½		Alum.	26	85	126	DIA		Aluminum Sheet	N/A	1	1		
06-Interface	1	46		Alum	76					Aluminum Machinings and Forgings	N/A	1		2	

91-9.8-16

GRUMMAN

REPORT
DATE
CODE 28812

THERMAL CONTROL CHARACTERISTICS

510A-3B → 510ADE-3B

PHYSICAL: WEIGHT, LB 89

500 FT^2 GOLDIZED MYLAR MLI

AL BASE HEAT SHIELD

SILVER BACKED TEFLON & ALZAK COATINGS

WBS #320-03-02

GRUMMAN

CONFIGURATION: 51A-3B

WBS NO. 320-03-02-01,02

SUBSYSTEM/COMPONENT THERMAL CONTROL

DATE: 8/30/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
THERMAL CONTROL COATINGS	5	0		SBT ALZAK ALCLAD	9		1500	ft^2		0				1			
MULTILAYER INSULATION	3	6		See Mini Spec	16		500	ft^2		0				1			
FUEL CELL RADIATOR	2	12		See Mini Spec	17.1		22.4	ft^2						1			INCLUDES CARRIED IMU
~~AVIONICS HEAT PIPE RADIATOR~~	2	12		See Mini Spec						0							
AVIONICS HEATERS	4	6		See Mini Spec	2					75/unit				8			COX & COMPANY, NY, NY.
APS HEATERS*	4	6		See Mini Spec	4					20/unit				16			
FWD HEAT SHIELD	5	0		AL	14		90	ft^2		0							LOGICAL TO MICROMETEOROID SHIELD
PLUMBING	5	0		AL	2												

*CARRIED A. APS WT.

31-9.8-IV

AVIONICS CHARACTERISTICS

		510A-3B → 510ADE-3B
PHYSICAL:	WEIGHT, LB	673 → 768
TECHNICAL:	AUTONOMY LEVEL	IIIA → IIB
	RENDEZVOUS & DOCKING	→ LASER RADAR
	COMMUNICATIONS	DFS → DFS/CSS
	COMPUTER CAPACITY	48K → 65K WORDS
	FUEL CELL POWER	2.5 KW
	RELIABILITY ALLOCATION	.97912 → .98461

WBS #320-03-03

GRUMMAN

[redacted]

REV. A

AUTONOMY LEVEL IIA CONFIGURATION 510A-3B

WBS NO. 320-03-03-01

SUBSYSTEM/COMPONENT DMS

DATE: 2/12/73

MAJOR COMPONENT	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (INPUT/OUTPUT) (WATTS)	TECHNICAL CHARACTERISTICS: DATA TRANSFER RATE, COMPUTER STORAGE CAP., NUMBER OF CIRCUITS, THRUST, SPECIFIC IMPULSE	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR G/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES: VENDOR
MINISTAGE																	
COMPUTER	4	12			13	4.7	5	8.6*	202*	36	48 KWORDS - 16 BIT/WORD (POWER REQ. SIZED FOR 65K)*	144	18K	2	N/A	1	CDC 469
TIE PACKAGE	5	12	AF/S-3, MINEWAR		14.5	9	12	5.4	520	8		108	12K	1	N/A	1	OPTICS DDS 3000
FSI (OTAV, TVM, FWVA)	4	8	SHUTTLE		18	8	5	16	640	23		144	12K	1	N/A	1	RAYATION INC.
MICU'S	4	8	SHUTTLE		7	7	4	13	364	21	256 CHANNELS	144	12K	3	N/A	1	"
SENSORS	4	8	"		0.2	N/A	N/A	N/A	N/A	0.1			1M	180 @	N/A	10	WHITAKER, TRANSONICS

*EVOLUTION FROM AUTONOMY LEVEL IIA TO LEVEL IIB WILL REQUIRE INCREASING THE COMPUTER CAPACITY TO 65K WORDS. THUS A VOLUME OF 4.7 x 5 x 10.4 (244 CU. IN) SHOULD BE RESERVED FOR THE COMPUTER TO ALLOW FOR THIS GROWTH.

GRUMMAN

CONFIGURATION 510A-3B WBS NO. 320-03-03-02

AUTONOMOUS LEVEL III.A SUBSYSTEM/COMPONENT GN&C

REV A 8-16-73
DATE: 8-10-73

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	① USES APOGEE KICK STAGE
INERTIAL MEASURING UNIT	4	12	TITAN IIIC		45	24	12	12.5	3600	125				1			
STAR TRACKER	1	24	SHUTTLE		17	15	6 DIA		424	28				1			DOES NOT INCLUDE SUNSHADE (1 LB)
ATS CONTROL ELECTRONICS	1	24	—		18	10	10	5	500	13				2			
ME/TVC CONTROL ELECTRONICS	1	24	—		10	10	10	3.5	350	15				1			
RATE GYRO UNIT	4	12			5	4	4	2	32	25				1			

VI-8.6-21

CONFIGURATION 510A-3B

WBS NO. 320-03-03-03

SUBSYSTEM/COMPONENT COMMUNICATIONS

DATE: 8/9/73 9-5-73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE (EACH) LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE (EACH) WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE (EACH) HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (EACH) (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS: SI	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/C TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND. TST	NOTES
2 S-Band X'CEIVER / X'MTR / XPONDER (R'CVR (4), X'MTR (1))		24			4x4 1x5	7 7	9 8	5 5	315 280	8 34	Spread Spectrum CCIR Interference STDN/SGLS Compatible			1			
3. AUX. X'MTR		20			5	7	8	5	280	34	Same as (2) above			1			
4. POWER AMP.		9			1	3	5	2	30	20	R.F. output of 5W			2			
7. DIPLEXER		9			1	2	7	3	63	—	—			2			
9. ANTENNA SWITCH		9			1	3	3	4	36	1	—			1			
14. BASEBAND PROCESSOR		24			3	3	3	2	18	2	Same as (2) above			1			
15. OMNI ANT.		9			.5	3	6	1	18	—	—			2			
15. SECURE COMM.		—			6	9	5	4	180	8	—			2			POD ONLY - GFE

CONFIGURATION 510A-3B ---- ~~[illegible]~~ WBS NO. 320-03-03-05 & -06

LEVEL OF AUTONOMY III A --- II B SUBSYSTEM/COMPONENT ELECTRICAL POWER SUBSYSTEM DATE: 8-29-73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
• MODIFIED SHUTTLE FUEL CELL ASSY	3	30	SHUTTLE	ST STEEL PLAT.	90	25	15	15	5630		2.5 KW @ 28V; ___ WATT AVG. LOAD OVER 117 HRS.	144	25000	1	-	1	REQUIRES AUTO SPACE START-UP SELLERS: PEWA or GE
• EMERGENCY BATTERY	5	6		Ag-Zn Mg	15	9	5	4.5	200		10 AMP-HR RATED CAPACITY, 17 AMP DISCHARGE OVER 0.5 HR	0.5	30,000	1	-	1	SECONDARY SILVER-ZINC BATTERY SELLER: EAGLE-PICHER
• CRYO HYDROGEN TANK ASSY	3	24	GEMINI APOLLO SHUTTLE	Ti-INNER Ti-OUTER	69	21" ID 24" OD			7250		250 PSIA - OPERATING PRESSURE 350 PSIA - MAX PRESSURE. Lb FLUID CAPACITY	144		1	-	1	SELLER: AiResearch, Beech, Bendix
• CRYO OXYGEN TANK ASSY	3	24	GEMINI APOLLO SHUTTLE	INC-718 INN INC-750 OUT	71	16½ ID 19½ OD			3900		900 PSIA - OPERATING PRESS 1000 PSIA - MAX. " Lb FLUID CAPACITY	144		1	-	1	SELLER: AiResearch, Beech, Bendix
• VEHICLE WIRING	5		LM		53						6ga, 14ga, 16ga, 20 & 26ga	144		SHIP SET		SHIP SET	~10,000 FT OF ASSORTED SIZES
• CONNECTORS	5		LM		30						ASSORTED SIZES	144		"		"	~120 MATED PAIRS
• SUNDRIES (-CLAMPS -TAPE)	5		LM		20						" "	144		"		"	
• SOLID STATE POWER CONTROL	5		-		21						90 @ 2 AMP 17 @ 5 AMP 60 @ 3 AMP	144		"		"	2 OZ EACH; SELLER: LEACH CORP
• ELECTRO-MECH RCCB	5		LM		9						2 @ 20 AMP 10 @ 10 AMP	144		"		"	0.75 Lb EACH; SELLER CUTLER-HAMMER

GRUMMAN

PROPULSION CHARACTERISTICS

510A-3B→510ADE-3B

		MAIN PROP.	AUXILIARY PROP.
PHYSICAL:	WEIGHT, LB	605	150→188
	ENGINE/THRUSTER	OME 7.5K	REA 19
	NO. OF ENGINES/THRUSTERS	1	24
TECHNICAL:	FUEL LOAD, LB	20,517	339→495
	OXIDIZER LOAD, LB	38,983	--
	THRUST, LB	7,500	25
	ISP - STEADY STATE, SEC	327.2	232
	- PULSING, SEC	--	170
	RELIABILITY ALLOCATION	.99249	.99915→.99882

WBS #320-03-04

GRUMMAN

CONFIGURATION 510A-35/510ADE-3B WBS NO. 320-03-04, 320-03-04-01, 320-03-04-02. REV. 1/5/73
SUBSYSTEM/~~COMPONENT~~ Main. Prop. DATE: 5/21/73

MAJOR COMPONENT	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH/DIA. (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS (POWER (INPUT/OUTPUT), DATA TRANSFER RATE, COMPUTER STORAGE CAP., NUMBER OF CIRCUITS, THRUST, SPECIFIC IMPULSE)	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES (LEGEND: OTS - Off the shelf design; ME - Modified existing design; N - New design)
Ox Pro-Vlv.	4	16	OMS		6.5		3 1/4		60	32 Watts	163	420K	1	1	1	ME - Size increase from 1 1/2" D. (OMS Pro. Isol. Vlv)
Fu Pro-Vlv.	4	16	OMS		5		2		42	32 Watts	163	420K	1	1	1	ME - Size increase from 1 1/2" D. (OMS Pro. Isol. Vlv)
Ox F/D QD	4	16	OMS		1.5		2		36		144	500K	1/2	1/2	1/2	ME - Size increase from 1 1/2" D.
Fu F/D QD	4	16	OMS		1.5		2		36		144	500K	1/2	1/2	1/2	ME - Size increase from 1 1/2" D.
Ox F/D QD	4	16	OMS		1		1		12		144	400K	1/2	1/2	1/2	ME - Size increase from 3/4" D.
Fu F/D QD	4	16	OMS		1		1		12		144	400K	1/2	1/2	1/2	ME - Size increase from 3/4" D.
He F/D QD	5	10	OMS		3		5/8		9		156	500K	1/2	1/2	1/2	OTS
Ox F/D Vlv.	5	10	OMS		5		2		12	32 Watts	144	400K	1	1	1	OTS - OMS Dump Valve
Fu F/D Vlv.	5	10	OMS		5		2		12	32 Watts	144	400K	1	1	1	OTS - OMS Dump Valve
He F/D Vlv	4	16	OMS		5		5/8		24	84 Watts	144	67K	1	1	1	ME - Size increase from 1/2" D. (OMS Eng. Purge Vlv)
He Iso Vlv.	5	10	LM		2		1/2		16	84 Watts	156	133K	2	1	2	OTS - APS/DES Latching Sol Vlv.
He Reg	5	16	OMS		5		1/2		80		156	10^6	1	1	1	ME - Reduced press. setting, single stage
Fu Reg	5	16	OMS		5		1/2		80		156	10^6	1	1	1	ME - Reduced press. setting, single stage
Ox Burst Dis	5	16	OMS		1.5		5/8		28		168	10^6	1	1	1	ME - Reduced relief setting
Fu Burst Dis	5	16	OMS		1.5		5/8		28		168	10^6	1	1	1	ME - Reduced relief setting
Ox Relief Vlv	5	16	OMS		1.5		5/8		20		168	10^6	1	1	1	ME - Reduced relief setting
Fu Relief Vlv	5	16	OMS		1.5		5/8		20		168	10^6	1	1	1	ME - Reduced relief setting
Ox Ck Vlv.	5	10	SPS		3.6		3/4		50		156	10^6	1	1	1	OTS
Fu Ck Vlv.	5	10	SPS		3.6		3/4		50		156	10^6	1	1	1	OTS
Ox Vent Vlv	4	16	OMS		5		5/8		24	84 Watts	168	67K	2	1	2	ME - Size increase from 1/2" D. (OMS Eng. Purge Vlv)
Fu Vent Vlv	4	16	OMS		5		5/8		24	84 Watts	168	67K	2	1	2	ME - Size increase from 1/2" D. (OMS Eng. Purge Vlv)
Ox Lo-level Sensor	5	16	Titan		2	3	1		2.5	2 Watts	144	TBD	1	1	1	ME - Modified mounting
Fu Lo-level Sensor	5	16	Titan		2	3	1		2.5	2 Watts	144	TBD	1	1	1	ME - Modified mounting
Ox Flex Joints	5	10	OMS		0.6		2		36		168		3	1	3	OTS
Fu Flex Joints	5	10	OMS		0.6		2		36		168		5	1	5	OTS
Ox Eng. Purge Vlv	5	10	OMS		5		1/2		24	84 Watts	144	67K	1	1	1	OTS - OMS Eng. Purge Vlv.
Fu Eng. Purge Vlv	5	10	OMS		5		1/2		24	84 Watts	144	67K	1	1	1	OTS - OMS Eng. Purge Vlv.

GRUMMAN
REPORT
DATE
COLO 25512

CONFIGURATION 510A-3B/510ADE-3B

WBS NO. 320-02 04, 320-03-04-01, 320-03-04-02

SUBSYSTEM/COMPONENT Main Prop.

REV 9/5/73

DATE: 8/[illegible]/73

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE OF THE ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH/DIA. (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
He Tank	1	22	—		41.5		23		57[illegible]		156	10^6	2	1	2	N- PFR design
[illegible] Eng.	1	54	—		[illegible]	116	56		28[illegible]	170 Watts, 12,000 lb	6	145[illegible]	1	17	—	N- Class I
[illegible] Act	4	15	LM		2.5	5.75	3	1.5	78	90 Watts	10	20[illegible]	2	1	—	ME- Increased strength for higher thrust
Ox Horiz Drain Vlv	4	16	OMS		4		1			32 Watts	144	[illegible]	1	1	1	ME- Size decrease from 1¼" D (OMS crossfeed valve)
Fu Horiz Drain Vlv	4	16	OMS		4		1			32 Watts	14[illegible]	[illegible]	1	1	1	ME- Size decrease from 1¼" D (OMS crossfeed valve)

ORBITER INTERFACE CHARACTERISTICS

510A-3B → 510ADE-3B

PHYSICAL:	WEIGHT, LB	1186
TECHNICAL:	MATERIAL	ALUMINUM
	PIVOT TYPE ADAPTER/DOCKING MECHANISM	
	SERVICE PANELS	GROUND POWER
		INSTRUMENTATION
		ON-PAD EMERGENCY DUMP
		HORIZONTAL PROP. DRAIN
		FUEL CELL REACTANT FILL

WBS #320-03-05

GRUMMAN

CONFIGURATION 510A-3B

WBS NO. 320-03-05-01

SUBSYSTEM/COMPONENT ORBITER INTERFACE STRUCT. DATE: 9/11/[illegible]

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TEST	
01-Rear Adapter	1	44½		Alum.	652	149	120	D		Aluminum Stiffened Sheet and Machinings	N/A			1	Pivot Type Adapter
01-Fwd Frame	1	44½		Alum.	438					Aluminum Trusses and Machinings	N/A			1	
01-Docking Mechanism	1	46		Alum.	96					Aluminum Machinings and Forgings	N/A			1	

GRUMMAN

REPORT
DATE
CODE 26812

CONFIGURATION 510A-3B

WBS NO. 320-04--01

SUBSYSTEM/COMPONENT KICK STAGE STRUCTURE

DATE: 9/17/72

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR SIS TEST	EQUIVALENT UNITS FOR MAJOR GNDTEST	
03-Body Structure	1	44½		Alum.	368	65	120	D.		Aluminum Stiffened	N/A	1		1	Payload 23
06-Payload Interface	1	44½			40					Sheet and Fittings		1		1	
03-Body Structure	1	44½		Alum.	330	48	120	D		Aluminum Stiffened	N/A	1		1	Double Deploy
06-Payload Interface	1	44½			40					Sheet and Fittings		1		1	

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PAGE

CONFIGURATION AKS & RDM

WBS NO. ——

SUBSYSTEM/COMPONENT THERMAL

DATE:

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/G TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
COATINGS	5	0	LM	PAINT	1	←	150	ft^2	→		60 days	NA	1	1	NA	
INSULATION	5	6	LM	MLI	4	←	50	ft^2	→		60 days	NA	1	1	NA	ALUMINIZED MYLAR/NYLON NET

GRUMMAN AEROSPACE CORPORATION

REPORT
DATE
CODE 20912

ALL AUTHORITY LEVELS

CONFIGURATION APOGEE KICK STAGE (AKS) WBS NO. 320-04-08-03

SUBSYSTEM/COMPONENT DMS

DATE: [illegible]

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR TEST	MAJOR [illegible]	
SENSORS	4	8	SHUTTLE		0.2	N/A	N/A	N/A	N/A	0.1			1M	2	N/A	2	WHITAKER TRANSONICS

GRUMMAN

CONFIGURATION APOGEE KICK STAGE

WBS NO. 320-04-06-03

SUBSYSTEM/COMPONENT GN&C

DATE: 8-2-73

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
ATTITUDE GYRO REF. UNIT	4	12	IMP ITOS		13	10.6	8.0	14.	533	2.5 WATTS			1			120 WATTS WARM UP
VELOCITY METER	4	8	IMP ITOS		5.7	5.9	5.5	4.3	156	2.8 WATTS			1			40 WATTS WARM UP
[illegible]	1	18			7.6	8.6	7.1	5.5	336	18.5 WATTS			1			
[illegible]	4	12	IMP ITOS		3	6	3.4	2.4	49	2. WATTS			1			
SEQUENCER PROGRAMMER	4	12	IMP ITOS		2	6.4	4.3	2.8	77	6.3 WATTS			1			

TABLE 5.2.3 - 2 EQUIPMENT LIST

CONFIGURATION APOGEE KICK STAGE — WBS NO. 320-03-03-05 & -06 — SUBSYSTEM/COMPONENT ELECTRICAL POWER SUBSYSTEM — 27 AUG., 1973 REV. (1) — DATE: 13 AUG., 1973

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR G/G TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
PRIMARY BATTERY	5	-	-	AG-ZN, MG	3	7	4	4	112	2 AMP HR RATED CAPACITY @ 30V; 5 AMP AVG. DISCH. OVER 0.5 HR.	0.5	30,000	1	-	1	MANUALLY ACTIVATED AG-ZN BATTERY SELLER: EAGLE PICHER.
POWER DIST & CONTROL	5	-	LM		25	-	-	-	-	ASSOCIED WIRE, CONNECTORS & SOLID STATE POWER CONTROLLERS	0.5		SHIP SET	-	SHIP SET	

CONFIGURATION Apogee Kick Stage (AKS) WBS NO. 5[illegible]-03-04-03; 5[illegible]-03-04-04

SUBSYSTEM/COMPONENT Auxiliary Propulsion System (APS) DATE: 5/3/[illegible]

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR S/S TEST	NOTES
Nitrogen Tank	5	<12	–	6Al 4V	1.02	4.7[illegible]	–	–	50	–	Burst Press. = 6660 PSI Operating = 3000 PSI		10^7	1			Airite P/N 6389
Solenoid Valve	5	<12	–		2.3					84			67,000	1			LSC 270-713
Regulator (single stage)	4	<12	–		1.5					–		2	67000	1			LSC 310-305-3 (Mod to one stage)
Thruster Valve	4	<12	–		0.75					10	0.25" I.D. required		333,000	12	One Shipset	None	
Thrusters	5	–	–		0.2					–			–	12			Nozzle machinings
Quick Disconnect	5	<12			0.5					–			10^6	1			Nitrogen fill & vent

General Note: Tank sized to provide 12 hr. wide deadband and 1 hr narrow deadband control.

EVOLVED TUG

CONCEPT 510A-3B/510ADE-3B (COMBINED)

OPTION 3

510A-38/510ADE-38 SEP 73 COMBINED

STORABLE SPACE TUG SYSTEM PROJECT

EXPECTED COST - SPARES COST(INT + OPS) - FIRST UNIT COST

(COSTS IN 1973 CONSTANT DOLLARS (000))

WPS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0100	PROJECT MGMT	13315.			9691.				1956.	5466.		
0110	COST/PERF MGMT		1997.			1434.			293.		1822.	
0120	PROJECT DIRECTION		10253.			7462.			1506.		1822.	
0130	INFO MGMT		1065.			775.			156.		1822.	
0200	SYS ENG + INTEGR	15978.			10902.				2200.	10936.		
0210	TUG SYS ENG		12783.						0.		2734.	
0220	SHUTTLE INTERFACE		1598.						0.		2734.	
0230	PAYLOAD INTERFACE		1598.						0.		2734.	
0240	SUST ENG					0.			2200.		2734.	
0300	TUG VEH MAIN STAGE	130521.			112399.			9598.	21197.	19070.		
0310	STRUCTURES		19123.			11994.		1199.	2437.		1199.	
0311	FUEL TNK+SPRT			5161.			3511.	351.	733.			351.
0312	OX TANK +SPRT			6129.			4069.	407.	849.			407.
0313	BODY STRUCT			2345.			1531.	153.	319.			153.
0314	THRUST STRUCT			436.			291.	29.	61.			29.
0315	METEOROID SHLD			143.			120.	12.	25.			12.
0316	PAYLOAD INTFCE			4910.			2472.	247.	451.			247.
0317	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0320	THERMAL INSULTN		241.			1687.		83.	352.		83.	
0321	FUEL TANK INSUL			57.			827.	83.	172.			83.
0322	OX TANK INSUL			184.			860.	0.	179.			0.
0323	PURGE SYS INSUL			0.			0.	0.	0.			0.
0324	CONT SYS			0.			0.	0.	0.			0.
0325	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0330	AVIONICS		61224.			52716.		6092.	7566.		13398.	
0331	DATA MGMT			6430.			9118.	1432.	1376.			3450.
0332	G N + C			26720.			25766.	2814.	3605.			6216.
0333	COMMUNICATIONS			9128.			9405.	776.	1230.			1592.
0334	INSTRUMENTATION			0.			0.	0.	0.			0.
0335	ELEC PWR			17703.			5126.	1070.	865.			2140.
0336	PWR DIST + CONT			1193.			3303.	0.	490.			0.
0337	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0340	PROPULSION		33252.			25075.		2066.	4163.		4232.	
0341	MAIN ENGINE			24000.			8593.	1874.	1600.			3760.
0342	MAIN ENGINE SPT			4766.			4260.	0.	720.			0.
0343	ACPS ENGINE			3000.			7337.	192.	1129.			472.
0344	ACPS ENGINE SPT			1486.			4885.	0.	714.			0.
0345	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0350	ORBITER INTERFACE		6981.			1582.		158.	1246.		158.	
0351	STRUCTURE			4900.			675.	68.	532.			68.
0352	INTERFACE PNLS			2081.			906.	91.	714.			91.
0353	PURGE PROVISION			0.			0.	0.	0.			0.
0354	ABORT PROVISION			0.			0.	0.	0.			0.
0355	INSTL.ASSY+C/O			0.			0.	0.	0.			0.

MOORE BUSINESS FORMS, INC. NO FORM 14137 PRINTED IN U.S.A. 22"

510A-3B/510ADE-3B SEP 73 COMBINED

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0360	DROP TANKS		0.			2200.		0.	2200.		0.	
0361	STRUCTURES			0.			2200.	0.	2200.			0.
0362	THERMAL INSUL			0.			0.	0.	0.			0.
0363	PROP SPRT SYS			0.			0.	0.	0.			0.
0364	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0370	FINAL ASSY + C/O		9700.			17146.		0.	3233.		0.	
0371	FINAL ASSY			9700.			17146.	0.	3233.			0.
0372	CHECKOUT			0.			0.	0.	0.			0.
0400	TUG VEH AUX STAGE	26633.			134983.			12888.	4850.	12888.		
0410	STRUCTURES		0.			1.		0.	0.		0.	
0411	FUEL TNK+SPRT			0.			0.	0.	0.			0.
0412	OX TANK+SPRT			0.			0.	0.	0.			0.
0413	BODY STRUCT			0.			0.	0.	0.			0.
0414	THRUST STRUCT			0.			0.	0.	0.			0.
0415	METEOROID SHLD			0.			0.	0.	0.			0.
0416	PAYLOAD INTERFC			0.			0.	0.	0.			0.
0417	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0420	THERMAL INSUL		0.			0.		0.	0.		0.	
0421	FUEL TANK INSUL			0.			0.	0.	0.			0.
0422	OX TANK INSUL			0.			0.	0.	0.			0.
0423	PURGE SYS INSUL			0.			0.	0.	0.			0.
0424	CONT SYS			0.			0.	0.	0.			0.
0425	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0430	AVIONICS		0.			0.		0.	0.		0.	
0431	DATA MGMT			0.			0.	0.	0.			0.
0432	G N + C			0.			0.	0.	0.			0.
0433	COMMUNICATIONS			0.			0.	0.	0.			0.
0434	INSTRUMENTATION			0.			0.	0.	0.			0.
0435	ELEC PWR			0.			0.	0.	0.			0.
0436	PWR DIST + CONT			0.			0.	0.	0.			0.
0437	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0440	PROPULSION		0.			0.		0.	0.		0.	
0441	MAIN ENGINE			0.			0.	0.	0.			0.
0442	MAIN ENGINE SPT			0.			0.	0.	0.			0.
0443	ACPS ENGINE			0.			0.	0.	0.			0.
0444	ACPS ENGINE SPT			0.			0.	0.	0.			0.
0445	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0450	INTERSTAGE INTRFC		0.			0.		0.	0.		0.	
0451	STRUCTURE			0.			0.	0.	0.			0.
0452	SEP SYS			0.			0.	0.	0.			0.
0453	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0460	DROP TANK		0.			0.		0.	0.		0.	
0461	STRUCTURE			0.			0.	0.	0.			0.
0462	THERMAL INSUL			0.			0.	0.	0.			0.
0463	PROP SPT SYS			0.			0.	0.	0.			0.
0464	INSTL.ASSY+C/O			0.			0.	0.	0.			0.
0470	RDM		0.			0.		0.	0.		0.	

VI-36-39

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510A-3B/510ADE-3B SEP 73 COMBINED

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0471	STRUCTURE			0.			0.	0.	0.			0.
0472	THERM CONT			0.			0.	0.	0.			0.
0473	AVIONICS			0.			0.	0.	0.			0.
0474	PROPULSION			0.			0.	0.	0.			0.
0475	RCM ASSY+C/O			0.			0.	0.	0.			0.
0480	AKS		15315.			39929.		2153.	2717.		2153.	
0481	STRUCTURE			4950.			7067.	397.	748.			397.
0482	SRM			1650.			15525.	683.	134.			683.
0483	AVIONICS			5000.			11549.	975.	1222.			975.
0484	PROPULSION			459.			1871.	98.	198.			98.
0485	AKS ASSY+C/O			3256.			3916.	0.	414.			0.
0490	DKS		11318.			95055.		10735.	2132.		10735.	
0491	STRUCTURE			5300.			17995.	1313.	400.			1313.
0492	SRM			1800.			2450.	2960.	74.			2960.
0493	AVIONICS			1593.			54632.	5977.	1214.			5977.
0494	PROPULSION			219.			5344.	485.	119.			485.
0495	DKS ASSY+C/O			2406.			14634.	0.	325.			0.
04100	CACHE TANK		0.			0.		0.	0.		0.	
04101	STRUCTURE			0.			0.	0.	0.			0.
04102	THERM CONT			0.			0.	0.	0.			0.
04103	AVIONICS			0.			0.	0.	0.			0.
04104	PROPULSION			0.			0.	0.	0.			0.
04105	CACHE ASSY+C/O			0.			0.	0.	0.			0.
04110	FINAL ASSY + C/O		0.			0.		0.	0.		0.	
04111	FINAL ASSY			0.			0.	0.	0.			0.
04112	CHECKOUT			0.			0.	0.	0.			0.
0500	LOGISTICS	6330.			6752.				6752.			
0510	TRANSPORT+HANDLG		0.			1152.			1152.			
0520	TRAINING		6330.			1950.			1950.			
0521	SIM+EQUIPMENT			1950.			1950.		1950.			
0522	GROUND CREW			2180.			0.		0.			
0523	FLT OPS CREW			2200.			0.		0.			
0530	WAREHSG+INV CONT		0.			3650.			3650.			

VI-8.6-40

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510A-3B/510ADE-3B SEP 73 COMBINED

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0600	FACILITIES	7109.			347.					1004.		
0610	MANUFACTURING		155.			254.					0.	
0611	DES/CONSTR			155.								
0612	ACT/MAINT			0.			254.					0.
0620	TEST		245.			93.					0.	
0621	DES/CONST			245.								
0622	ACT/MAINT			0.			93.					0.
0630	1ST TR MAINT+REF		2953.			0.					486.	
0631	DES/CONST			2953.								
0632	ACT/MAINT			0.			0.					486.
0640	ETR LAUNCH		475.			0.					133.	
0641	DES/CONST			475.								
0642	ACT/MAINT			0.			0.					133.
0650	2ND TR MAINT+REF		2758.			0.					252.	
0651	DES/CONST			2758.								
0652	ACT/MAINT			0.			0.					252.
0660	WTR LAUNCH		523.			0.					133.	
0661	DES/CONST			523.								
0662	ACT/MAINT			0.			0.					133.
0700	GSE	26430.			2910.			1018.		4975.		
0710	MFG GSE		2100.									
0711	HARDWARE											
0712	SITE ACT											
0713	MAINT											
0714	SOFTWARE											
0720	ETR GSE		17730.			0.		0.			2140.	
0721	HARDWARE			15430.			0.	0.				
0722	SITE ACT			2300.								
0723	MAINT			0.								2140.
0724	SOFTWARE			0.								
0730	WTR GSE		0.			2910.		1018.			2835.	
0731	HARDWARE			0.			2910.	1018.				
0732	SITE ACT			0.								
0733	MAINT			0.								2835.
0734	SOFTWARE			0.								

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510A-3B/510ADE-3B SEP 73 COMBINED

WBS	LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
0740	FL OP NASA		3300.			0.		0.			0.	
0741	HARDWARE			3300.			0.	0.				
0742	SITE ACT			0.								
0743	MAINT			0.								0.
0744	SOFTWARE			0.								
0750	FL OP DOD		3300.			0.		0.			0.	
0751	HARDWARE			3300.			0.	0.				
0752	SITE ACT			0.								
0753	MAINT			0.								0.
0754	SOFTWARE			0.								
0800	VEHICLE TEST	91349.										
0810	GND TEST HARDWARE		10868.									
0811	PTV/BATTLESHIP			1726.								
0812	MAJOR TST ART			8642.								
0813	MOCKUPS			500.								
0820	GND TEST OPS		14340.									
0830	FLT TEST HARDWARE		13551.									
0840	FLT TEST OPS		.52590.									
0900	LAUNCH OPS WTR									7724.		
0910	LAUNCH SITE SVC										0.	
0920	TUG/SHUTTLE MATG										608.	
0930	PRELAUNCH C/O										1260.	
0940	COUNTDOWN										40.	
0950	FLUID+GASES										3596.	
0960	POST FLT SAFING										2220.	
1000	LAUNCH OPS ETR									30062.		
1010	LAUNCH SITE SVC										0.	
1020	TUG/SHUTTLE MATG										2162.	
1030	PRELAUNCH C/O										3820.	
1040	COUNTDOWN										124.	
1050	FLUID+GASES										17236.	
1060	POST FLT SAFING										6720.	
1100	FLT OPS DOD	4980								61160.		
1110	MISSION PLAN		3,610								17450.	
1120	FLT CONT		800								21720.	
1130	FLT EVALUATION		570								2890.	
1140	FLT SPT SOFTWARE										19100.	
1200	FLT OPS NASA	40250								72460.		
1210	MISSION PLAN		9470								18510.	
1220	FLT CONT		1580								24760.	
1230	FLT EVALUATION		540								3040.	
1240	FLT SPT SOFTWARE		28660								25150.	

NOTE:
THESE COSTS INCLUDED
IN Vehicle Test

VI-8.6-42

MOORE BUSINESS FORMS, INC., NO FORM 1412 T PRINTED IN U.S.A. 22

510A-3B/510ADE-3B SEP 73 COMBINED

WBS LEVEL	EXPECTED COST DDT+E 4	5	6	EXPECTED COST PRODUCTION 4	5	6	INITIAL SPARES	1ST UNIT COST	EXPECTED COST OPN SP/OPS 4	5	6
1300 REF+INT 1ST TR									19880.		
1310 SCHED MAINT+REF										2400.	
1320 UNSCHED MAINT+REF										2540.	
1330 POST MAINT C/O										820.	
1340 TUG/PAYLOAD MATG										1320.	
1350 REF RQMTS PLANNG										200.	
1360 DEPOT MAINT										12600.	
1400 REF+INT 2ND TR									40820.		
1410 SCHED MAINT+REF										7300.	
1420 UNSCHED MAINT+REF										7620.	
1430 POST MAINT C/O										2500.	
1440 TUG/PAYLOAD MATG										4000.	
1450 REF RQMTS PLANNG										400.	
1460 DEPOT MAINT										19000.	
SPACE TUG TOTALS	317666.			277985.			23505.	36954.	286445.		
32A= 317666.	323=	301489.		32C=	286445.		320=	605600.			

MOORE BUSINESS FORMS, INC., MO FORM 14121 PRINTED IN U.S.A. 22

510ADE-38 SEP 73

2nd share

STORABLE SPACE TUG SYSTEM PROJECT

FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

DDTE (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	~~1976~~ 1980	~~1977~~ 81	~~1978~~ 82	~~1979~~ 83	~~1980~~ 84	~~1981~~ 85	~~1982~~ 86	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	3.2	0.42	0.76	0.80	0.79	0.44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	3.8	0.50	0.91	0.97	0.94	0.53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	TUG MAIN STAGE	32.0	8.06	10.46	8.23	5.28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	STRUCTURE	3.2	1.49	1.43	0.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320	THERMAL INSUL	0.1	0.03	0.04	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
330	AVIONICS	21.3	6.54	8.99	4.74	1.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION																	
350	INTERFACE																	
360	DROP TANK																	
370	FINAL ASSY	7.4	0.0	0.0	3.15	4.21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	TUG AUX STAGE	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
410	STRUCTURE																	
420	THERMAL INSUL																	
430	AVIONICS																	
440	PROPULSION																	
450	INTERSTAGE																	
460	DROP TANK																	
470	RDM																	
480	AKS																	
490	DKS																	
4100	CACHE																	
4110	FINAL ASSY	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	LOGISTICS																	
600	FACILITIES	0.0	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
610	MANUFACTURING	0.0	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
620	TEST																	
630	1ST MAIN/REF																	
640	ETR LAUNCH																	
650	2ND MAIN/REF																	
660	WTR LAUNCH																	
700	GND SUPP EQUIP	0.6	0.08	0.15	0.16	0.16	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
710	MFG GSE																	
720	ETR GSE	0.6	0.08	0.15	0.16	0.16	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
730	WTR GSE																	
740	FLT OPS NASA																	
750	FLT OPS DOD																	
800	VEHICLE TEST	26.0	0.78	5.34	7.92	7.70	4.29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
810	GND TEST HWRE	1.7	0.32	0.52	0.54	0.34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
820	GND TEST OPS	3.5	0.46	0.83	0.89	0.87	0.49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
830	FLT TEST HWRE	1.4	0.0	0.39	0.57	0.41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
840	FLT TEST OPS	19.4	0.0	3.60	5.93	6.09	3.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900	LAUNCH OPS WTR																	
1000	LAUNCH OPS ETR																	
1100	FLIGHT OPS DOD																	
1200	FLIGHT OPS NASA																	
1300	REF + INT TR-1																	
1400	REF + INT TR-2																	
	TOTALS	95.8	9.84	17.62	18.09	14.86	5.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

VI-1-8.6-144

MOORE BUSINESS FORMS, INC. MO FORM 14133 PRINTED IN U.S.A. 27"

510ADE-38 SEP 73

STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

MOD (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.71	1.39	1.53	1.56	1.45	0.75	0.0	0.0	0.0	0.0
200	SYS ENG + INTEG	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.80	1.56	1.72	1.75	1.63	0.85	0.0	0.0	0.0	0.0
300	TUG MAIN STAGE	62.8	0.0	0.0	1.60	0.60	0.0	3.21	13.47	22.33	21.99	15.42	8.97	3.79	0.91	0.0	0.0	0.0
310	STRUCTURE	10.0	0.0	0.0	0.0	0.0	0.0	0.0	1.60	2.99	2.68	1.72	0.80	0.20	0.0	0.0	0.0	0.0
320	THERMAL INSUL	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.21	0.39	0.35	0.22	0.10	0.03	0.0	0.0	0.0	0.0
330	AVIONICS	45.9	0.0	0.0	0.0	0.0	0.0	0.0	5.67	11.44	11.51	8.79	5.37	2.50	0.65	0.0	0.0	0.0
340	PROPULSION	20.0	0.0	0.0	0.0	0.0	0.0	3.21	5.99	5.36	3.44	1.60	0.39	0.0	0.0	0.0	0.0	0.0
350	INTERFACE																	
360	DROP TANK	2.2	0.0	0.0	1.60	0.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
370	FINAL ASSY	13.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.15	4.01	3.59	2.31	1.07	0.26	0.0	0.0	0.0
400	TUG AUX STAGE	12.6	0.0	0.0	9.20	3.43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
410	STRUCTURE																	
420	THERMAL INSUL																	
430	AVIONICS																	
440	PROPULSION																	
450	INTERSTAGE																	
460	DROP TANK																	
470	RDM																	
490	DKS	1.9	0.0	0.0	1.38	0.52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4100	CACHE	10.7	0.0	0.0	7.82	2.92	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600	FACILITIES																	
630	1ST MAIN/REF	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
640	ETR LAUNCH	3.1	0.0	0.0	2.24	0.84	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650	2ND MAIN/REF	0.3	0.0	0.0	0.20	0.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
660	WTR LAUNCH	0.2	0.0	0.0	0.15	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	GND SUPP EQUIP	0.1	0.0	0.0	0.05	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
710	MFG GSE																	
720	ETR GSE																	
730	WTR GSE																	
740	FLT OPS NASA																	
750	FLT OPS DOD	3.9	0.0	0.0	2.86	1.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800	VEHICLE TEST																	
810	GND TEST HWRE																	
820	GND TEST OPS	3.9	0.0	0.0	2.86	1.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
830	FLT TEST HWRE																	
840	FLT TEST OPS																	
900	LAUNCH OPS WTR																	
1000	LAUNCH OPS ETR																	
1100	FLIGHT OPS DOD																	
1200	FLIGHT OPS NASA																	
1300	REF + INT TR-1																	
1400	REF + INT TR-2																	
	TOTALS	128.4	0.0	0.0	~~16.11~~	~~6.01~~	0.0	~~3.21~~	14.98	25.27	25.23	19.23	12.06	5.40	~~0.91~~	0.0	0.0	0.0
									4	7	7	4	4	2				
									18	32	32	23	16	7				

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MOORE BUSINESS FORMS INC. NO FORM 14121 PRINTED IN U.S.A. 27

510ADE-38 SEP 73

STORABLE SPACE TUG SYSTEM PROJECT
FUNDING SCHEDULE DATA BY FISCAL YEAR

DATA FORM C

OPS (ALL COSTS IN MILLIONS)

FISCAL YEARS

WBS	TITLE	TOTAL	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
100	PROJECT MGMT	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.13	0.29	0.35	0.37	0.38	0.38	0.37	0.31	0.14
200	SYS ENG + INTEG	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.26	0.58	0.71	0.75	0.76	0.77	0.74	0.62	0.28
300	TUG MAIN STAGE	9.8	0.0	0.0	6.42	2.40	0.0	0.0	0.0	0.05	0.10	0.13	0.13	0.14	0.14	0.13	0.11	0.05
310	STRUCTURE	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.04	0.10	0.12	0.12	0.13	0.13	0.12	0.10	0.05
320	THERMAL INSUL	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
330	AVIONICS	6.7	0.0	0.0	4.88	1.82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
340	PROPULSION	2.1	0.0	0.0	1.54	0.58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
350	INTERFACE																	
360	DROP TANK																	
370	FINAL ASSY																	
400	TUG AUX STAGE	12.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.60	1.34	1.64	1.73	1.76	1.78	1.71	1.42	0.64
410	STRUCTURE																	
420	THERMAL INSUL																	
430	AVIONICS																	
450	INTERSTAGE																	
460	DROP TANK																	
440	PROPULSION																	
470	RDM																	
480	AKS	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.09	0.20	0.25	0.26	0.26	0.27	0.26	0.21	0.10
490	DKS	10.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.51	1.14	1.39	1.47	1.50	1.51	1.46	1.21	0.54
4100	CACHE																	
4110	FINAL ASSY																	
500	LOGISTICS																	
600	FACILITIES	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.05	0.09	0.11	0.12	0.12	0.12	0.11	0.05
610	MANUFACTURING																	
620	TEST																	
630	1ST MAIN/REF	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.04	0.05	0.05	0.05	0.05	0.05	0.04	0.02
640	ETR LAUNCH	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01
650	2ND MAIN/REF	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.03	0.04	0.04	0.04	0.03	0.02
660	WTR LAUNCH	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.02	0.02	0.02	0.02	0.02	0.01
700	GND SUPP EQUIP	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.07	0.16	0.29	0.39	0.42	0.43	0.42	0.37	0.17
710	MFG GSE																	
720	ETR GSE	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.07	0.16	0.20	0.21	0.21	0.22	0.21	0.17	0.08
730	WTR GSE	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.09	0.18	0.21	0.21	0.22	0.19	0.09
740	FLT OPS NASA																	
750	FLT OPS DOD																	
800	VEHICLE TEST																	
810	GND TEST HWRE																	
820	GND TEST OPS																	
830	FLT TEST HWRE																	
840	FLT TEST OPS																	
900	LAUNCH OPS WTR	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.54	1.11	1.27	1.31	1.31	1.17	0.57
1000	LAUNCH OPS ETR	22.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.09	2.43	2.97	3.13	3.19	3.21	3.10	2.57	1.15
1100	FLIGHT OPS DOD	44.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.30	6.82	7.79	8.01	8.03	7.18	3.50
1200	FLIGHT OPS NASA	56.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.67	5.98	7.29	7.70	7.84	7.90	7.62	6.32	2.84
1300	REF + INT TR-1	18.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.87	1.95	2.37	2.51	2.55	2.57	2.48	2.06	0.92
1400	REF + INT TR-2	29.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.18	4.50	5.14	5.29	5.30	4.74	2.31
	TOTALS	212.8	0.0	0.0	6.42	2.40	0.0	0.0	0.0	5.77	12.89	21.87	29.27	31.37	31.90	31.36	26.95	12.63
										8	14	24	31					

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MOORE BUSINESS FORMS, INC. NO FORM 14127 PRINTED IN U.S.A. 27

510A-3B/510ADE-3B
AVERAGE COST/FLIGHT ($ THOUSANDS)

	MODE I REFUSE		MODE II EXPEND TUG		MODE III EXPEND KS	
	NASA	DOD	NASA	DOD	NASA	DOD
Launch Operations	106.71	106.71				
Launch Site Serv & Supt	------	------				
Tug Shuttle Mate & C/O	7.46	7.46				
Prelaunch C/O	14.39	14.39				
Countdown	.46	.46				
Propellants & Gasses	59.0	59.0				
Post Flight Safing	25.4	25.4				
Maintenance & Refurb	612.41	612.41				
Sched Mant & Refurb	27.49	27.49				
Unsched Maint & Refurb	28.83	28.83				
Vehicle Opnl Spares (less Me)	325.85	325.85				
M. Eng. Maint & Refurb	80	80				
M. E. Opnl Spares	34.47	34.47				
Post Maint C/O	9.44	9.44				
Tug/Payload Mate & C/O	15.08	15.08				
Refurb Reqmt Planning	1.73	1.73				
Depot Maint	89.52	89.52				
Total Ground OPS (Launch/Maint/Refb)	719.12	719.12				
Flight Operations	404.90	388.97				
Mission Planning	115.43	100.05				
Flight Control	143.84	131.14				
Flight Evaluation	19.14	16.43				
Flight Supt Software	126.49	141.35				
Operations Support	63.91	63.91				
FSE Maint	1.70	1.70				
Sustaining Eng	30.98	30.98				
Prog Mgt	15.48	15.48				
Transport & Hdlg	3.26	3.26				
Inventory Control & Whseing	10.34	10.34				
Facilities Maint	2.15	2.15				
Expend Veh Avg. Unit Cost			800		1250	
Total Cost/Flight	1188	1172	9188		2438	

SPACE TUG CHARACTERISTICS

510A-3B→510ADE-3B

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	WEIGHT, LB	3329→3534	864
	LENGTH, IN	300	80
	DIAMETER, IN	120	180
TECHNICAL:	REUSABLE	ONE-STAGE	DKS
	AUXILIARY STAGE		AKS→AKS/DKS
	PAYLOAD RETRIEVAL	CAPABILITY	
	PROPELLANT CAPACITY, LB	59,500	
	THRUST, LB	7,500	
	ISP, SEC	327.2	287 & 295
	AUTONOMY LEVEL	IIIA→IIB	
	RELIABILITY	.97→.9750	.9791

WBS #320-00

GRUMMAN

MAIN STAGE CHARACTERISTICS

510A-3B → 510ADE-3B

PHYSICAL:	WEIGHT, LB	3329 → 3534
	LENGTH, IN	300
	DIAMETER, IN	120
TECHNICAL:	REUSABLE SINGLE STAGE	
	PROPELLANT CAPABITY, LB	59,500
	PAYLOAD RETRIEVAL CAPABILITY	
	THRUST, LB	7,500
	ISP, SEC	327.2
	AUTONOMY LEVEL	IIIA → IIB
	RELIABILITY	.97 → .9750

WBS #320-03

GRUMMAN

VEHICLE TEST CHARACTERISTICS

510A-3B→510ADE-3B

		MAIN STAGE	AUXILIARY STAGE
PHYSICAL:	PROP. TEST ARTICLE	X	
	STRUCT. TEST ARTICEL	X	X
	INTEG. AVIONICS TEST	X	X
	MOCK-UPS	X	X
	FLIGHT TEST	X	X

TECHNICAL: PTA - COLD FLOW ONLY, NO HOT FIRING

STA - ONE ART FOR DYNAMICS, STATIC & FATIGUE

IAT - SOFTWARE & HARDWARE

MOCK-UPS - WOOD AT PDR, WOOD/METAL AT CDR

FLIGHT TEST - ONE WITHOUT P/L, EIGHT WITH P/L

- ONE DKS ONLY

WBS #320-08

GRUMMAN

STRUCTURAL CHARACTERISTICS

510A-3B → 510ADE-3B

PHYSICAL:	WEIGHT, LB	1285 → 1338
	LENGTH, IN	300
	DIAMETER, IN	120
TECHNICAL:	TANK CONFIGURATION	NESTED DOME
	TANK CAPACITY, LB	59,500
	MATERIAL	AL, AL STIFFENED SHEET
	RELIABILITY ALLOCATION	.99900

WBS #320-03-01

GRUMMAN

CONFIGURATION 510ADE-3B

WBS NO. 320-03-01

SUBSYSTEM/COMPONENT STRUCTURE

DATE: 9/17/73

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GNDTEST	
01-Fuel Tank and supports	1	44 1/2		Alum.	252	91	120	DIA		Welded Aluminum Cylinder Spun Aluminum Domes	20	1		2	Tank Leakage Considered Unserviceable
02-Oxid. Tank and Supports	1	44 1/2		Alum.	180	100	120	DIA		Welded Aluminum Cylinder Spun Aluminum Domes	20	1		2	
03-Body Structure	1	44 1/2		Alum.	684	145	120	DIA		Aluminum Stiffened Sheet Shell Aluminum Frames	N/A	1		2	Includes Equipment Mounting and Umbilicals
04-Thrust structure	1	44 1/2		Alum.	80	35	120	DIA MAX		Aluminum Stiffened Sheet	N/A	1		2	
05-Meteoroid shield	1	44 1/2		Alum.	26	85	126	DIA		Aluminum Sheet	N/A	1	1		
06-Interface	1	46		Alum	116					Aluminum Machinings and Forgings	N/A	1		2	

VI-8.6-52

THERMAL CONTROL CHARACTERISTICS

510A-3B→510ADE-3B

PHYSICAL: WEIGHT, LB 89

500 FT^2 GOLDIZED MYLAR MLI

AL BASE HEAT SHIELD

SILVER BACKED TEFLON & ALZAK COATINGS

WBS #320-03-02

GRUMMAN

CONFIGURATION 510ADE-3B

WBS NO. 320-03-02-01,02

SUBSYSTEM/COMPONENT THERMAL CONTROL

DATE: 8/30/72

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
THERMAL CONTROL COATINGS	5	0		SBT ALZAK ALCOHOL	9		1500 ft^2			0				1			
MULTILAYER INSULATION	3	6		SEE MINI SPEC	46		500 ft^2			0				1			
FUEL CELL RADIATOR	2	12		SEE MINI SPEC	14		17 ft^2							1			
AVIONICS HEAT PIPE RADIATOR	2	12		SEE MINI SPEC	4		4 ft^2			0							POWER AMP (20W)
AVIONICS HEATERS	4	6		SEE MINI SPEC	2					75/UNIT				8			COX & COMPANY, NY, NY.
APS HEATERS*	4	6		SEE MINI SPEC	6					20/UNIT				24			
BASE HEAT SHIELD	5	0		AL	14					0							IDENTICAL TO MICROMETEROID SHIELD
PLUMBING	5	0		AL	2					0							

*CARRIED AS APS WT.

AVIONICS CHARACTERISTICS

		510A-3B → 510ADE-3B
PHYSICAL:	WEIGHT, LB	673 → 768
TECHNICAL:	AUTONOMY LEVEL	IIIA → IIB
	RENDEZVOUS & DOCKING	→ LASER RADAR
	COMMUNICATIONS	DFS → DFS/CSS
	COMPUTER CAPACITY	48K → 65K WORDS
	FUEL CELL POWER	2.5 KW
	RELIABILITY ALLOCATION	.97912 → .98461

WBS #320-03-03

GRUMMAN

CORE CONFIGURATION 510 ADE-3B

WBS NO. 320-03-03-01

SUBSYSTEM/COMPONENT DMS

DATE: 8/13/73

MAJOR COMPONENT	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE: POWER (WATTS)	TECHNICAL CHARACTERISTICS: POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
MAIN STAGE COMPUTER	4				15	4.7	5	10.4	244	39	6.5 K WORDS - 16 BITS/WORD	144	14K	2	N/A	1	CDC 469
TAPE RECORDER	5		AF/S-3 4 MOBILE		14.5	9	12	5.4	580	8		108	12K	1	N/A	1	ODETR'S DDS 3000
FSI CONTROL T.M. FORM.	4		SINTRE		18	8	5	16	640	23		144	12K	1	N/A	1	RADIATION
DACU'S	4		"		7	7	4	13	364	21	2.56 CHANNELS	144	12K	3	N/A	1	"
SENSORS	4		"		0.2	N/A	N/A	N/A	N/A	0.1			1M	190	N/A	10	WHITTAKER, TRANSONICS

VI-8.6-56

CONFIGURATION 510 ADE-3B (NOTE 1) AUTONOMY LEVEL II B

WBS NO. 320-03-03-02

SUBSYSTEM/COMPONENT GN & C

REV A 8-31-73

DATE: 9-10-73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
INERTIAL MEASURING UNIT	1	24			10	6.5	6.5	4.7	200	15				2			
STAR TRACKER	1		SHUTTLE		17	15	6	1A	424	28				1			DOES NOT INCLUDE SUNSHADE (1LB)
LASER RENDEZVOUS RADAR	1	30			40	9 21	9 9	9 6	729 1134	35				1			FOR RETRIEVAL ONLY
SATELLITE RECEIVER	1	30			37	19.5	10.4	7.9	1592	85				1			
DOPPLER RECEIVER	1	12			8	9	7	5	280	10				1			
L BAND ANTENNAS	1	9			0.3	4	4	1	16	—				4			
COMBINER/DOPPLER DETECTOR	1	18			6	7	7	5	245	4				1			
APS CONTROL ELECTRONICS	1		—		19	10	10	5	500	13				2			
ME/TVC CONTROL ELECTRONICS	1		—		10	10	10	3.5	350	15				1			

NOTES:
1. USES APOGEE KICK STAGE FOR DEPLOY ONLY MISSION
2. USES DEORBIT KICK STAGE FOR DEPLOY AND RETRIEVE MISSION

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REPORT
DATE
CODE 28812

CONFIGURATION 510ADE-3B (CORE) WBS NO. 320-03-03-03 SUBSYSTEM/COMPONENT COMM DATE: 9-5-

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR G/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR G/S TEST	NOTES
1. S-BAND X'CEIVER/X'PONDER R'CVR-(2) X'MT-(1)		24			2X4 1X5	7 7	9 8	5 5	315 280	8 34	Spread Spectrum CCIR Interference STDN/SGLS compatible			1			
2. S-BAND X'CEIVER/X'PONDER R'CVR-(4) X'MTR-(1)					4X4 1X5	7 7	9 8	5 5	315 280	8 34	Spread Spectrum CCIR Interference STDN/SGLS compatible			1			
3. AUX. X'MTR					5	7	8	5	280	34	Same as (2)			1			
4. POWER AMP.					1	3	5	2	30	20	R.F. output of 5W			1			
5. POWER AMP.		15			3	9	5	3	135	100	R.F. output of 20W			1			
6. Base band Processor		24			6	7	7	5	245	4	Same as (1) + (2)			1			
7. Diplexer					1	3	7	3	63	—	—			2			
8. Diplexer		9			1	3	7	3	63	—	—			2			
9 Antenna Switch					1	3	3	4	36	1	—			2			
10. Antenna					.5	3	6	1	18	—	—			2			
11. Antenna		9			.5	3	6	1	18	—	—			2			
12. Power Splitter		8			1	2	2	3	12	—	—			1			
13. TV ASSEMBLY		15			12	18	6	4	432	10	Black + White			1			
15. SECURE COMM		—			6	9	5	4	180	8	—			5			DOD ONLY-GFE

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REPORT DATE CODE 20012

VI-8.6-58

CONFIGURATION [redacted] ---- 510ADE-3B WBS NO. 320-03-03-05 & -06

LEVEL OF AUTONOMY JTCA --- II B SUBSYSTEM/COMPONENT ELECTRICAL POWER SUBSYSTEM DATE: 8-27-7[illegible]

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
• MODIFIED SHUTTLE FUEL CELL ASSY	3	30	SHUTTLE	ST STEEL PLAT.	90	25	15	15	5630		2.5 KW @ 28V; ___ WATT AVG LOAD OVER 117 HRS.	144	25000	1	-	1	REQUIRES AUTO SPACE START-UP SELLERS: PGWA or GE
• EMERGENCY BATTERY	5	6	—	Ag-Zn Mg	15	9	5	4.5	200		10 AMP-HR RATED CAPACITY, 17 AMP DISCHARGE OVER 0.5 HR	0.5	30,000	1	—	1	SECONDARY SILVER-ZINC BATT. SELLER: EAGLE-PICHER
• CRYO HYDROGEN TANK ASSY	3	24	GEMINI APOLLO SHUTTLE	Ti-INNER Ti-OUTER	69	21" 24"	ID OD		7250		250 PSIA - OPERATING PRESSURE 350 PSIA - MAX PRESSURE. Lb FLUID CAPACITY	144		1	—	1	SELLER: AiResearch, BEECH, BEND.
• CRYO OXYGEN TANK ASSY	3	24	GEMINI APOLLO SHUTTLE	INC-718 INN INC-750 OUT	71	16½ 19½	ID OD		3900		900 PSIA - OPERATING PRESS 1000 PSIA - MAX. " Lb FLUID CAPACITY	144		1	—	1	SELLER: AiResearch, BEECH, BEND.
• VEHICLE WIRING	5		LM		55						6ga, 14ga, 16ga, 20 & 26 ga	144		SHIP SET		SHIP SET	~10,000 FT OF ASSORTED SIZES
• CONNECTORS	5		LM		30						ASSORTED SIZES	144		"		"	~120 MATED PAIRS
• SUNDRIES (-CLAMPS -TAPE)	5		LM		20						" "	144		"		"	
• SOLID STATE POWER CONTROL	5		-		21						90 @ 2 AMP 17 @ 5 AMP 60 @ 3 AMP	144		"		"	2 OZ EACH; SELLER: LEACH CORP
• ELECTRO-MECH RCCB	5		LM		9						2 @ 20 AMP 10 @ 10 AMP	144		"		"	0.75 Lb EACH; SELLER CUTLER-HA[illegible]

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REPORT DATE CODE 14

PROPULSION CHARACTERISTICS 510A-3B → 510ADE-3B

		MAIN PROP.	AUXILIARY PROP.
PHYSICAL:	WEIGHT, LB	605	150 → 188
	ENGINE/THRUSTER	OME 7.5K	REA 19
	NO. OF ENGINES/THRUSTERS	1	24
TECHNICAL:	FUEL LOAD, LB	20,517	339 → 495
	OXIDIZER LOAD, LB	38,983	--
	THRUST, LB	7,500	25
	ISP - STEADY STATE, SEC	327.2	232
	- PULSING, SEC	--	170
	RELIABILITY ALLOCATION	.99249	.99915 → .99882

WBS #320-03-04

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CONFIGURATION [redacted], SIDADE-33 WBS NO. 320-03-04-03 ; 320-03-04-04 Rev A 6/3/73

SUBSYSTEM/COMPONENT Auxiliary Propulsion System (APS) DATE: 5/1/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR [illegible] TEST	PROGRAMATIC: [illegible]	NOTES
																	General Note: Tankage based on usable propellant of 450 LB plus 10% contingency.
Helium Tank	5	≤12	—		12.25	12.34	12.34	12.34	550	—	Burst Press = 7500 PSI Operating = 3900 PSI	156	10^6	2	One Shipset	None	Airite P/N 6524-1
Helium Filter	5	≤12	LM		0.5					—				1			LSC 310-303-3 (Vacco Vlv Co)
Helium Latching Solenoid Valve	4	≤12	LM		2.3					84		156	1.3×10^6	2			LSC 270-713 (MC Mfg)
Regulator, Dual Stage	5	≤12	LM		2.5					—		156	"	1			LSC 310-305-3 (Fairchild Stratus)
Regulator, Single Stage	4	≤12	—		1.5					—		156	"	1			Mod to dual stage reg.
Hard Check Valve	5	≤12	LM		0.7					—	Proof Press = 600 PSI	156	2000	1			Mod to LSC 310-306 (Accident Product)
Burst Disc/Relief Vlv	4	≤12	—		1.5					—	Relief Press ≈ 400 PSI	156	10^6/67K	1			Mod to LSC 310-307 (Chemical
Vent Valve	3	18	—		2.0					70	Proof Press = 600 PSI	156	67000	3			Similar to LSC 310-403 (Parker) Unidirectional flow only; higher operating pressure
Propellant Tanks	4	≤12	LM		10.5		12.50	34	3420	—	Burst Pressure = 650 PSI	144	10^6	4			Modified LM ECS fuel tank with elastomeric bladders. Tank wt. includes bladders.
Acquisition Bladders	2	24	—	EPT 10 Elastomer	—					—				4			
Propellant Filter	5	≤12	—		0.5					—				1			
Thruster Isolation Valve	3	18	—		2.0					70	Proof Pressure = 600 PSI	168	67000	8			Same valve as vent valve; same notes apply
Thrusters	4	≤12	—		2.1	11.4	2.7			24	25 LB thrust @ 325 PSI inlet, steady state Isp = 232	144	1.5×10^6	24			REA 19-3 (Hamilton Standard)
Thruster Heaters	5	≤12	—		0.2					3.5	Maintain catalyst beds at 150°F			24			Submitted for pricing by Thermo
Quick Disconnects	5	≤12	—		0.5									3			He fill & drain Prop fill & drain Prop fill & vent

VI-8.6-61

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REPORT
DATE
CODE 70040

ORBITER INTERFACE CHARACTERISTICS

510A-3B → 510ADE-3B

PHYSICAL:	WEIGHT, LB	1186
TECHNICAL:	MATERIAL	ALUMINUM
	PIVOT TYPE ADAPTER/DOCKING MECHANISM	
	SERVICE PANELS	GROUND POWER
		INSTRUMENTATION
		ON-PAD EMERGENCY DUMP
		HORIZONTAL PROP. DRAIN
		FUEL CELL REACTANT FILL

WBS #320-03-05

GRUMMAN

CONFIGURATION 510ADE-3B

WBS NO. 320-03-05-01

SUBSYSTEM/COMPONENT ORBITER INTERFACE STRUCT.

DATE: 9/17/72

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY	PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)		MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TEST	
01-Rear Adapter	1	44 1/2		Alum.	652	149	120	D		Aluminum Stiffened Sheet and Machinings	N/A			1	Pivot Type Adapter
01-Fwd Frame	1	44 1/2		Alum.	438					Aluminum Trusses and Machinings	N/A			1	
01-Docking Mechanism	1	46		Alum.	96					Aluminum Machinings and Forgings	N/A			1	

VI-8-6-63

DEORBIT KICK STAGE CHARACTERISTICS (510A-3B→510ADE-3B)

		PLANETARY	GEOSYNCH
PHYSICAL:	WEIGHT (MAX.), LB	545	864
	LENGTH, IN	80	64
	DIAMETER, IN	180	180
TECHNICAL:	MATERIAL	ALUMINUM	
	INSULATION	GOLDIZER MYLAR MLI	
	PULSE CODE MODULATOR		
	ATTITUDE GYRO		
	S-BAND EQUIP/OMNI ANTENNAS		
	ELECTRICAL POWER	BATTERY & SOLAR CELLS	
	PROPULSION - MAIN	9 SRM'S	6 SRM'S
	- AUX.	12 COLD GAS THRUSTERS	
	RELIABILITY ALLOCATION	.9791	

WBS #320-04-09

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VI-8.1-64

CONFIGURATION 510 ADE-3B

WBS NO. 320-04-01

SUBSYSTEM/COMPONENT KICK STAGE STRUCTURE

DATE: 9/17/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS	RELIABILITY: MIN. NO. OF MISSIONS BEFORE COMPONENT BECOMES UNSERVICEABLE	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR SIS TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TEST	NOTES
03-Body Structure	1	44½		Alum.	363	65	120	D		Aluminum Stiffened	N/A	1		1	Payload 23
06-Payload Interface	1	44½			40					Sheet and Fittings		1		1	
03-Body Structure	1	58		Alum.	408	48	120	D		Aluminum Stiffened		1		1	Round Trip
06-Payload Interface	1	58			40					Sheet and Fittings		1		1	
03-Body Structure	1	58		Alum.	353	48	120	D		Aluminum Stiffened		1		1	Deploy/Retrieve
06-Payload Interface	1	58			40					Sheet and Fittings		1		1	
03-Body Structure	1	58		Alum.	366	48	120	D		Aluminum Stiffened		1		1	Double Deploy With
06-Payload Interface	1	58			40					Sheet and Fittings		1		1	Individual Retrieve
03-Body Structure	1	44½		Alum.	336	48	120	D		Aluminum Stiffened	N/A	1		1	Double Deploy
06-Payload Interface	1	44½			40					Sheet and Fittings		1		1	

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PAGE

CONFIGURATION A/DKS

WBS NO. ____

SUBSYSTEM/COMPONENT THERMAL

DATE:

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
COATINGS	5	0	LM	PAINT	1	←	150-ft^2	—			6yrs	NA	1	1	NA	
INSULATION	5	6	LM	ML1	4	←	50-ft^2	—			6yrs	NA	1	1	NA	ALUMINIZED MYLAR/NYLON NET
HEATERS	5	3	LM	—	2	NEGLIGIBLE				15 watts/unit	6yrs		8	1	NA	COX ELECTRICAL HEATERS

GRUMMAN

REPORT
DATE
CODE 26812

ALL AUTONOMY LEVELS

CONFIGURATION DEORBIT KICK STAGE (DKS) WBS NO. 320-04-07-03

SUBSYSTEM/COMPONENT DMS

DATE: 7/[illegible]

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR [illegible] TEST	[illegible] MAJOR [illegible]	
PCM/SIG. COND.	4	5	P72-2 SPACECRAFT		4.6	9	5.5	7	347	9				2	N/A	1	SPACETAC
SENSORS	4	8	SHUTTLE		0.2	N/A	N/A	N/A	N/A	0.1			1M	17	N/A	2	WHITTAKER TRANSONICS

VI-8.6-67

CONFIGURATION DEORBIT KICK STAGE

WBS NO. 320-04-09-03

SUBSYSTEM/COMPONENT GN&C

ISAA 8-31-73

DATE: 8-3-73

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
ATTITUDE GYRO REFERENCE UNIT	4	12	IMP ITOS		13	10.6	8	DIA.	533	25				2			120 WATTS WARM UP
VELOCITY METER	4	8	IMP ITOS		5.7	5.9	5.5	4.8	156	28				1			40 WATTS WARM UP
APS/TVC CONTROL ELECTRONICS	1	18			7.6	8.6	7.1	5.5	336	18.5				2			
TIMER/CONTROL RELAYS	4	12	IMP ITOS		3	6	3.4	2.4	43	2				1			
SEQUENCER PROGRAMMER	4	12	IMP ITOS		2	6.4	4.3	2.8	77	6.3				2			
STAR TRACKER	1	24	SHUTTLE		17	15	6	DIA	424	28				2			DOES NOT INCLUDE SUNSHADE (1LB)

VI-8.6-68

GRUMMAN

REPORT
DATE
CODE 20812

DICS

CONFIGURATION 510 ADE-3B (ADD ON) WBS NO. 320-03-03-03 SUBSYSTEM/COMPONENT COMMUNICATIONS 9-5-73 DATE: 8/4/73

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE (each) LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE (each) WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE (each) HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (each) (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS: ST[illegible]	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR S/S TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR GND TST	NOTES
2. S-Band X'CEIVER / X'POWER — R'CVR (4) X'MTR (1)					4X4 1X5	7 7	9 8	5 5	315 280	8 34	Spread Spectrum CCIR Interference STDN/SGLS Compatible			1			
3. AUX. X'MTR					5	7	8	5	280	34	Same as (2) above			1			
4. POWER AMP.					1	3	5	2	30	20	R.F. output of 5W			2			
7. DIPLEXER					1	2	7	3	63	—	—			2			
9. ANTENNA SWITCH					1	3	3	4	36	1	—			1			
14. BASEBAND PROCESSOR					3	3	3	2	18	2	Same as (2) above			1			
10. OMNI ANT.					.5	3	6	1	18	—	—			2			
15. SECURE COMM.		—			6	9	5	4	180	8	—			2			DOD ONLY - GFE

VI-8.6-69

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REPORT DATE CODE 20513

TABLE 5.3.3-C EQUIPMENT LIST

CONFIGURATION DE ORBIT KICK STAGE WBS NO. 320-03-03-05 & -06 SUBSYSTEM/COMPONENT ELECTRICAL POWER SUBSYSTEM DATE: 27 AUG, 1972 REV (1) 13 AUG. 1973

MAJOR COMPONENT	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS	RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE LENGTH (INCHES)	SIZE WIDTH (INCHES)	SIZE HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (INPUT/OUTPUT) DATA TRANSFER RATE COMPUTER STORAGE CAP. NUMBER OF CIRCUITS THRUST SPECIFIC IMPULSE	EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
PRIMARY BATTERY	5	6	—	Ag-Zn Mg	3	7	4	4	102	2 AMP-HR RATED CAPACITY @ 30V, 3 AMP DISCHARGE OVER 0.5 HR	0.5	30,000	1	—	1	MANUALLY ACTIVATED AG-ZN BATTERY SELLER: EAGLE-PICHER
DE-ORBIT BATTERY	4	9	—	Ag-Zn Mg	75	13	8	10	1040	36 AMP-HR RATED CAPACITY @ 30V, 6 AMP DISCHARGE OVER 6 HRS.	6	30,000	1	—	1	REMOTELY ACTIVATED AG-ZN BATTERY SELLER: EAGLE-PICHER
SOLAR CELL PADDLES	4	9	OAO		6	6	SQ. FT			12% EFF IN-on-P SILICON SOLAR CELLS, 10 Ω cm.	5 YRS		3	—	—	SOLAR CELLS ON BOTH SIDES OF PADDLE END OF MISSION OUTPUT EACH SIDE 22W PADDLES RETRACT BEFORE DEORBIT
POWER DIST & CONTROL	5	—	LM		44	—	—	—	—	ASSORTED WIRE, CONNECTORS & SOLID STATE POWER CONVERTERS	5 YRS	—	SHIP SET	—	SHIP SET	—

VI-8.6-70

CONFIGURATION 510A-3B, 510ADE-3B WBS NO. 320-04-08-04

SUBSYSTEM/~~COMPONENT~~ MPS (AUX. STAGE) DATE:

COMPONENT NAME	DEVELOPMENT STATUS			PHYSICAL CHARACTERISTICS						TECHNICAL CHARACTERISTICS		RELIABILITY		PROGRAMATIC			NOTES
	STATE-OF-THE-ART RATING	MONTHS TO QUAL	OTHER PROGRAM USAGE	MATERIALS	WEIGHT (LBS)	SIZE: LENGTH (INCHES)	SIZE: WIDTH (INCHES)	SIZE: HEIGHT (INCHES)	VOLUME (CUBIC INCHES)	POWER (WATTS)		EQUIVALENT OPERATING HOURS	MTBF (HOURS)	UNITS PER VEHICLE	EQUIVALENT UNITS FOR S/S TEST	EQUIVALENT UNITS FOR MAJOR GND TST	
SRM #1	3	24	DELTA, BURNER II, ETC.		1742	74	37	--	[redacted] 80K	180	$I_{sp}=295$, $\lambda'=.92$ $\epsilon=50$			9	0	0	M.E.- TEM 364 OR SUM-9A
SRM #2	3	24	"		1742	60	37	--	[redacted] 65K	180	$I_{sp}=287$, $\lambda'=.909$ $\epsilon=34$			2/6	0	0	M.E.- "
SRM #3	3	24	"		2500	72	37	--	[redacted] 77K	180	$I_{sp}=287$, $\lambda'=.907$ $\epsilon=34$			2	0	0	M.E.- "
SRM #4	3	24	"		1400	70	28	-	[redacted] 43K	180	$I_{sp}=287$, $\lambda'=.909$ $\epsilon=34$			1	0	0	M.E.- TEM 616

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CONFIGURATION Deorbit Kick Stage (DKS)

WBS NO. 320-03-01-03; 320-03-01-04

SUBSYSTEM/COMPONENT Auxiliary Propulsion System (APS)

DATE: 5/3/-

COMPONENT NAME	DEVELOPMENT STATUS: STATE-OF-THE-ART RATING	DEVELOPMENT STATUS: MONTHS TO QUAL	DEVELOPMENT STATUS: OTHER PROGRAM USAGE	PHYSICAL CHARACTERISTICS: MATERIALS	PHYSICAL CHARACTERISTICS: WEIGHT (LBS)	PHYSICAL CHARACTERISTICS: SIZE: LENGTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: WIDTH (INCHES)	PHYSICAL CHARACTERISTICS: SIZE: HEIGHT (INCHES)	PHYSICAL CHARACTERISTICS: VOLUME (CUBIC INCHES)	TECHNICAL CHARACTERISTICS: POWER (WATTS)	TECHNICAL CHARACTERISTICS	RELIABILITY: EQUIVALENT OPERATING HOURS	RELIABILITY: MTBF (HOURS)	PROGRAMATIC: UNITS PER VEHICLE	PROGRAMATIC: EQUIVALENT UNITS FOR LIFE TEST	PROGRAMATIC: EQUIVALENT UNITS FOR MAJOR	NOTES
Nitrogen Tanks	5	≤12	–	6Al4V	6.0	9.90			445	–	Burst Press = 7215 PSI Operating = 3600 PSI	117	10^7	2	One Shipset	None	Arite P/N 6435
Solid Valve	5	≤12	–		0.5					30	Normally Closed		10^6	1			LSC 310-302-1
Filter	5	≤12	–		0.5					–			10^6	1			Nitrogen Fill & Vent
Quick Disconnect	5	≤12	–		0.5					–			10^6	1			

GENERAL NOTES:
1) Assumes DKS use with ARS only; DKS blocks the ARS regulator and thrusters.
2) Tanks are sized to provide roll control during deorbit, 72 hrs or 4 DB deadband and 1 hr of minimum deadband control.

VI-8.6-72

DRUMMAN

8.7 FLIGHT SCHEDULE

Included in support of our flight schedule definition for concept 510A-3B/510ADE-3B are the following tasks:

- Fleet size and Vehicle Usage
- Kick Stage Usage
- Flight Element Requirements
- Kick Stage Definition
- Payload Flown
- 510A-3B/510ADE-3B Flight Operations Buildup
- Programmatic Data Summary Storable Tug Concept 510A-3A/510ADE-3A

510A-3B/510ADE-3B FLEET SIZE & VEHICLE USAGE

1979	80	81	82	83	84	85	86	87	88	89	90	TOTAL
Capture Model												
Total Flts	26	21	23	37	41	36	36	39	33	33	36	361
Prog Build up Model												
ETR Reuse	3	18	23	30	31	27	26	30	27	22	30	267
Expend					2		1	1		3	1	8
WTR Reuse				7	5	9	9	8	6	8	5	57
Total Flts	3	18	23	37	38	36	36	39	33	33	36	332
										Lost Missions		+4
National Fleet												
Veh. 1	2	9	11	7	6E							
2 Int.	1	9	12	15	1E							
3 Int.				15	17	9	1E					
4 Int.					14	17	9	4E				
5 Int.						10	17	8	6	2E		
6 Evl.							9	17	10	9E		
7								10	17	10E		
8										12	17E	
9											17	
10											2	
11 Lost Tug												
12 Lost Tug												
13 Lost Tug												
14 Lost Tug												
DOD Traffic												
Total Flts	1	6	11	19	17	12	17	17	17	14	18	149
										Lost Missions		+2
DOD Fleet												
Veh. 1	1	6	11	17	3	4	3	14	3	7	2	
2				2	14	8	14	3	14	7	16	
3 Lost Tug												
4 Lost Tug												

	510A-3B/510ADE-3B		KICK STAGE USAGE		
TYPE	501 AKS	505A AKS	503 DKS	504 DKS	505 DKS
NASA Flts.	9	23	12	16	63
KS Deploy	9	23	6	16	62
KS Return			6		33
Refurb			6		33
Production*	9	23	7	16	35
DOD Flts.			20		70
KS Deploy			12		70
KS Return			8		47
Refurb			8		47
Production*			6		31

*DKS PROD = TOTAL DEPLOYS - NO REFURBS + 20% REFURB (AS BACKUP)

FLIGHT ELEMENT REQUIREMENTS — OPTION: 3B (510A/510ADE - 3B)

ITEM			CALENDAR YEAR 80	81	82	83	84	85	86	87	88	89	90	TOTAL
SHUTTLE FLIGHTS		TOTAL	13	15	12	18	22	24	19	22	16	19	18	198
BASIC TUG FLIGHTS	ETR	RECOVERED	13	15	12	15	16	17	14	15	12	12	13	154
		EXPENDABLE					2		1	1		3	1	8
	WTR	RECOVERED				3	4	7	4	6	4	4	4	36
	(TOTAL)		(13)	(15)	(12)	(18)	(22)	(24)	(19)	(22)	(16)	(19)	(18)	(198)
KICK STAGES	KS 501				2		2		3	2		1		9
	KS 502													0
	KS 503		3*			3	3	3						12
	KS 504									8	6	2		16
	KS 505		8**	10	5	7	4	9	6	2	4	2	6	63
	KS 505A		2	1	1	2	3	2	2	2	2	5	4	26
	(TOTAL)		(13)***	(11)	(8)	(12)	(12)	(14)	(11)	(14)	(12)	(9)	(10)	(126)***

* LAUNCHED IN 1979 FOR SUBSEQUENT RETRIEVALS

** INCLUDES 2 KS LAUNCHED IN 1979 FOR SUBSEQUENT RETRIEVALS

*** INCLUDES 5 KS LAUNCHED IN 1979 FOR SUBSEQUENT RETRIEVALS

BAS 9-4-73

NASA TRAFFIC

TABLE 4.5.4.3-5

FLIGHT ELEMENT REQUIREMENTS

OPTION: 3B (510A/510ADE-3B)

ITEM			CALENDAR YEAR 80	81	82	83	84	85	86	87	88	89	90	TOTAL
SHUTTLE FLIGHTS		TOTAL	13	6	11	19	19	12	17	17	17	14	18	163
BASIC TOPS FLIGHTS	ETR	RECOVERED	13	6	11	15	18	10	12	15	15	10	17	142
		EXPENDED												0
	V/TR	RECOVERED				4	1	2	5	2	2	4	1	21
	(TOTAL)		(13)	(6)	(11)	(19)	(19)	(12)	(17)	(17)	(17)	(14)	(18)	(163)
KICK STAGES	KS 501													0
	KS 502													0
	KS 503			2		1	5		1	4	1	1	5	20
	KS 504													0
	KS 505		7*		6	9	9	3	7	8	8	4	9	70
	KS 505A													0
	(TOTAL)		(7)	(2)	(6)	(10)	(14)	(3)	(8)	(12)	(9)	(5)	(14)	(90)

*INCLUDES 1 KS LAUNCHED IN 1979 FOR SUBSEQUENT RETRIEVAL

BAS 9-4-73

DOD TRAFFIC

TABLE A.3.A.3-6

FLIGHT ELEMENT REQUIREMENTS

OPTION: 3B (510A/510ADE - 3B)

ITEM			CALENDAR YEAR 80	81	82	83	84	85	86	87	88	89	90	TOTAL
SHUTTLE FLIGHTS		TOTAL	26	21	23	37	41	36	36	39	33	33	36	361
BASIC TUG FLIGHTS	ETR	RECOVERED	26	21	23	30	34	27	26	30	27	22	30	296
		EXPENDED					2		1	1		3	1	8
	WTR	RECOVERED				7	5	9	9	8	6	8	5	57
	TOTAL		(26)	(21)	(23)	(37)	(41)	(36)	(36)	(39)	(33)	(33)	(36)	(361)
KICK STAGES	KS 501				2		2		3	2				9
	KS 502													0
	KS 503		3*	2		4	8	3	1	4	1	1	5	32
	KS 504									8	6	2		16
	KS 505		15*	10	11	16	13	12	13	10	12	6	15	133
	KS 505A		2	1	1	2	3	2	2	2	2	5	4	26
	(TOTAL)		(20**)	(13)	(14)	(22)	(26)	(17)	(19)	(26)	(21)	(14)	(24)	(216**)

KS'S LAUNCHED IN 1979 FOR SUBSEQUENT RETRIEVALS
* 3
** 6

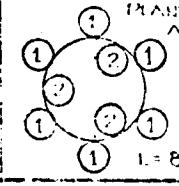
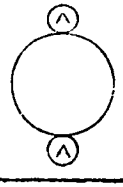
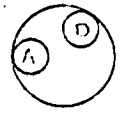
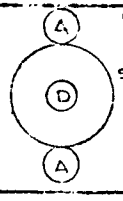
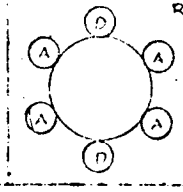
RELIABILITY = ± 4 FLTS

BAC 9-4-73

COMBINED NASA/DOD TRAFFIC

CONCEPT 510A/510ADE-3B

KICK STAGE DEFINITION

KICK STAGE DESIGNATION	GEOMETRY (all stages >10 ft diam. & are 3.5 ft long unless otherwise noted)		PERFORMANCE (geosynch Payload) (lbs)	SRM CHARACTERISTICS INDIVIDUAL WEIGHT (lbs)	NUMBER	TOTAL SRM WEIGHT (lbs)	STAGE INERT WEIGHT (lbs)	TOTAL STAGE WEIGHT (lbs)
KS 501		STAGE 1	5000 lbs to ΔV = 18,400 fps	1742	6	10452	–	10 452
		STAGE 2		1742	3	5226	545	5771
		(TOTAL)						(16223)
KS 502		DOUBLE DEPLOY AKS	3815 (each P/L)	1742	2	3484	516	(4000)
KS 503		AKS	3825	2500	1	2500	–	2500
		DKS		2500	1	2500	804	3304
		(TOTAL)						(5804)
KS 504		AKS	2400 (each P/L)	2500	2	5000	–	5000
		DKS		1400	1	1400	818	2218
		(TOTAL)						(7218)
KS 505		AKS	2385 (each way)	1742	4	6968	–	6968
		DKS		1742	2	3484	864	4348
		(TOTAL)						(11316)

EAS 9-4-23

TABLE 4.3.4.3-8

CONCEPT 510/510ADE-3B

KICK STAGE DEFINITION (cont)

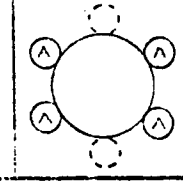
KICK STAGE DESIGNATION	GEOMETRY (all stages >10 ft diam. & are 5.5 ft long unless otherwise noted)	PERFORMANCE (Geosynch Payload) (lbs)	SRM CHARACTERISTICS			STAGE INERT WEIGHT (lbs)	TOTAL STAGE WEIGHT (lbs)
			INDIVIDUAL WEIGHT (lbs)	NUMBER	TOTAL SRM WEIGHT (lbs)		
KS 505A	 AKS Delete 2 DKS from KS 505	6090	1742	4	6968	643	7611

TABLE 4.3.4.3-8 (cont)

FLIGHT	PAYLOAD FLOWN					
	1980	1981	1982	1983	1984	1985
1	D-6	D-2 (KS)	ALL	ALL	D-9	ALL
2	D-17	D-2 (KS)			D-10	
3	D-35	D-3 (KS)			D-18	
4		D-3 (KS)			D-18	
5		D-3 (KS)			D-20 (KS)	
6		D-3 (KS)			D-20 (KS)	
7		D-4 (KS)			D-24 (EXP)	
8		D-7			D-24 (EXP)	
9		D-8 (KS)			R-2 (KS)	
10		D-10			R-2 (KS)	
11		D-11			R-2 (KS)	
12		D1 + D1			R-12	
13		D31 (KS)			R-13	
14		D-31 (KS)			D1 + R1 (KS)	
15		D-34			D3 + R3 (KS)	
16		D-35			D4 + R4 (KS)	
17		D-35			D7 + R4 (KS)	
18		D25 + D25			D8 + R3 (KS)	
19					D8 + R3 (KS)	
20					D14 + R14	
21					D15 + R15	
22					D-28 (KS)	
23					D-28 (KS)	
24					D-31 (KS)	
25					D-31 (KS)	
26					D-31 (KS)	
27					D-31 (KS)	
28					D-34 (KS)	
29					D25 + R25 (KS)	
30					D25 + R25 (KS)	
31					D26 + R26 (KS)	
32					D27 + R27 (KS)	
33					D32 + R32 (KS)	
34					D32 + R32 (KS)	
35					D35 + R35	
36					D35 + R35	
37					D37 + D37 + D37	
38					D39 + D39 + D39	
FLIGHTS FLOWN/SCHED	3/26	18/21	23/23	37/37	38/41	36/36
DEPLOY P/L'S FLOWN/SCHED	3/34	20/23	24/24	47/47	34/37	36/36
RTRV P/L'S FLOWN/SCHED	0/0	0/0	0/0	0/0	24/27	27/27
SORTIES FLOWN/SCHED	0/0	0/0	0/0	1/1	0/0	1/1

CONCEPT 510/510ADE-2B

COSTED FLIGHT BUILD-UP

TABLE 4.3.4.3-9

VI-8.7-9

510A-3B/510ADE-3B FLIGHT OPERATIONS BUILDUP

As in the prior programs the 510A-3B/510ADE-3B flight buildup was defined considering: NASA defined Shuttle/Tug launch constraints, initial and evolved ETR ground crew launch capabilities, and flight mode buildup.

Our recommended flight buildup for 510A-3B/510ADE-3B, including 3 flights in 1980, 18 flights in 1981, and 38 flights in 1984, encompasses 336 total flights through 1990 or 25 less than 100% payload capture traffic.

510A-3B/510ADE-3B FLIGHT OPERATIONS BUILDUP

INPUTS	CY 80	81	82	83	84	85	86	TOTAL FLTS.
	▽ IOC_I				▽ IOC_E			
o 100% PAYLOAD CAPTURE - ETR+WTR FLTS	26	21	23	37	41	36	36	361
ETR FLTS	26	21	23	30	36	27	27	
o SHUTTLE/TUG LAUNCH CONSTRAINT - ETR	3	21						
o INITIAL GND CREW LAUNCH CAPABIL. - ETR	18	22	23					
o EVOLVED IOC GND CREW LAUNCH CAPAB/ETR				30	33	27	27	
o TUG FLIGHT MODE BUILDUP								
SINGLE DEPLOY	3	ALL	ALL	ALL	ALL	ALL	ALL	
SINGLE DEPLOY WITH KICK STAGE	NONE	SOME	ALL	ALL	ALL	ALL	ALL	
MULTI DEPLOY	NONE	SOME	ALL	ALL	ALL	ALL	ALL	
SORTIE	NONE	NONE	NONE	ALL	ALL	ALL	ALL	
RETRIEVE	NONE	NONE	NONE	NONE	ALL	ALL	ALL	
ROUND TRIP	NONE	NONE	NONE	NONE	ALL	ALL	ALL	
ROUND TRIP WITH KICK STAGE	NONE	NONE	NONE	NONE	SOME	ALL	ALL	
RECOMMENDED FLIGHT BUILDUP ETR+WTR	3	18	23	37	38	36	36	336
ETR	3	18	23	30	33	27	27	

BUILDUP RATIONALE

- o SAME AS 310-3A/310RE-3A

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PROGRAMMATIC DATA SUMMARY
STORABLE TUG CONCEPT 510A-3B/510ADE-313

PROJECT HARDWARE UTILIZATION (AUTONOMY IIIA/IIB)

	MAIN STAGE INIT	MAIN STAGE EVOL	ORBITER INTERFACE	AKS 501	AKS 505A	DKS 503	DKS 504	DKS 505
VEHICLE TEST								
PTV	1*	-	-		-			-
STA	1	-	1		-			1
1 AT	1	1	-		1			1
FLT TEST VEH	1*	-	1*		1			1
VEHICLE OPS								
TEST HDWR CONV	*	-	*					-
NATIONAL FLEET	4	10	4	9	23	13	16	66
NASA	3	7	2	9	23	7	16	35
DOD	1	3	2	-	-	6	-	31
TOTAL FLEET	14			32A			95D	

SHUTTLE FLIGHTS

	TEST	OPERATIONS		
	INIT	INIT	EVOL	TOTAL
ETR	1	75	203	278
WTR		7	51	58
COMBINED		82	254	336
NASA		45	140	185
DOD		37	114	151

OPNL YEARS

	INIT	EVOL	TOTAL
ETR	4	7	11
WTR	1	7	8

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8.9 Risk Assessment

In making an assessment of the risk associated with each configuration in each capability option we have considered the type of technology items associated with each vehicle and the impact that it would have on the program if for one reason or another, the item would be unavailable and an alternative solution would be required. The impact is defined, usually, in terms of added weight, lost performance and total program cost increase; in some cases the impact can be decreased weight or reduced cost.

It is assumed that all of the weight increases and all of the cost increases will occur simultaneously without benefit of any offsetting decreases in either weight or cost. For example in configuration 110A-1 we have assumed that the +4 lb. weight impact of abandoning spun aluminum tanks in favor of welded aluminum tanks is combined with a $10.0 million cost increase as a result of abandoning aluminum tanks in favor of titanium tanks due to materials compatibility or fracture mechanics issues.

Taking the summation of all the weight increases, these are converted to costs by using the $75K/lb. figure derived when we were first selecting subsystem options for incorporation with 110A-1. The $75K/lb. number represents the last step (actually the slope of the line) in our subsystems synthesis process which provides a curve of Δ weight versus Δ total program costs as we added lighter and more costly subsystems options to achieve a behicle with 3500 lb. deploy capability. In this manner we arrived at a estimate of the costs expected if we had to recover the weight growth.

In similar fashion we then summed all of the potential cost increases, ignoring any offsetting cost decreases, and added these to the dollars representing the weight increases. The 110A-1 has no projected performance loss since it uses the OME 7.5K engine; the assumption is that the basic OME will have been developed to meet its weight, performance and reusability goals for the Shuttle Orbiter. In the case of configurations which use the Class I engine, for example 410AD-2, we have assumed that a 3 second Isp performance loss is possible. To convert this performance loss to costs we use the payload sensitivity factor to loss in Isp (97 lbs/sec), divide this by the payload sensitivity to inert weight and then multiply by $111/lb. to convert it to costs.

Taking all of the costs and adding them together we get a total low cost risk value of $15.3M for 110A-1 which ranges to a high value of 94.3M for 320A-3A/320AE-3A.

51CA-3B/51OADE-3B RISK ASSESSMENT

TECHNOLOGY ITEM IMPACT	
• SPUN-FORM AL TANK	+4 LB
• PFR TANK	+48 LB
• ADV IMU	+30 LB
• LASER RADAR	COST/SCHED
• SPACE STORABLE SRM	COST/SCHED
• MATERIALS COMPATIBILITY	-13 LB
• FRACTURE MECHANICS	
• HEAT PIPES	SCHED

VEHICLE SENSITIVITY (DEPLOY)	PLAIN	WITH AKS
$\frac{\partial P/L}{\partial W \text{ FIXED}}$ (LB/LB)	-3.52	-2.44
$\frac{\partial P/L}{\partial \text{ ISP}}$ (LB/SEC)	112	92

- TECHNICAL RISK
  - POTENTIAL WT IMPACT: +82 LB ≈ 200 LB OF PAYLOAD (W/AKS)
  - POTENTIAL ISP LOSS: MIN WITH ONE 7.5K ENG
  - OPEN WEIGHT REDUCTION OPTIONS: GRAPHITE COMPOSITE, ADV. FUEL CELL
- SCHEDULE RISK
  - PROPOSED SR&T PROGRAMS (COMPL PRIOR TO ATP) PROTECT AGAINST SCHEDULE SLIP
  - AVAILABILITY OF 621 B SATELLITES
- COST RISK
  - POTENTIAL Δ COST $15.9 M

LOW RISK PROGRAM

510A-3B/510ADE-3B RISK ASSESSMENT

The technology items and their potential impact are shown on the opposite chart. If the Spun-form aluminum tank does not meet its goals, a welded gore aluminum tank adds 4 lbs. to the vehicle, similarly if the prestressed filament reinforced tank is replaced by a 6Al4V titanium tank, 48 lbs. are added. If the advanced (Micron) IMU is unavailable, a Carousel VB IMU plus a rate gyro unit adds 30 lbs. There are no attractive alternatives for the lasar radar and the space storable SRM, hence, they represent both a schedule and cost risk. If materials compatibility or fracture mechanics data indicate the need to change propellant tank material, a change from aluminum to titanium results in a 13 lb. weight reduction but increases costs by $10M. If high heat rejection items are placed on the active loop rather than on heat pipes there are no weight changes. To recover the weight impact on payload capability due to these possible weight increases, graphite composites and the advanced fuel cell remain open options.

The use of the OME 7.5K engine provides high confidence that the weight, performance and reusability goals will be met because the basic engine will have been developed for use in the Shuttle Orbiter. As a result there is no projected potential weight or Isp loss with this engine.

Schedule risk is minimized by the proposed SR & T programs which provide the feasibility of the approach by ATP; however, the availability of the 621B Navigation Satellites remains a schedule risk.

Converting the potential Isp loss and weight increases to a total program cost at a $111K/lb value and adding the potential cost increase items, yields a total cost risk of $15.8M for 510A-3B/510ADE-3B.

RISK ASSESSMENT 510A-3B/510ADE-3B

BASELINE	ALTERNATIVE	WEIGHT, LBS	TOTAL PROGRAM COST, $M
LASER RADAR	RF RADAR PLUS REMOTE TV DOCKING (ALSO A TECHNOLOGY ISSUE) HENCE, NO ALTERNATIVE	-	COST/SCHED RISK
PFR HELIUM TANK	6AL 4V TITANIUM TANK	+48	+0.97
ADVANCED IMU (MICRON)	CAROUSEL VB + RATE GYRO UNIT	+30	-7.8
SPUN-FORM ALUMINUM TANKS	WELDED ALUMINUM, OR TITANIUM TANKS	+4, OR -13	+5.8
SPACE STORABLE SRM	NO ALTERNATIVE	-	COST/SCHED RISK
ALUMINUM TANKS (COMPATIBILITY DATA & FRACTURE MECHANICS DATA)	TITANIUM OR STAINLESS STEEL	(SEE ABOVE)	-
HEAT PIPES	USE ACTIVE LOOP/BYPASS	NONE	NONE

SUMMING HIGHER WEIGHTS & COSTS ONLY---------- 82 LBS $6.77M

CONVERT WEIGHT TO $ at $111K/LB ---------- 9.1

TOTAL COST RISK ----------$15.87M

Section 8.10 Supporting Research and Technology

This section includes a summary matrix chart which identifies all of the SR & T items and where they are applied to each configuration in each capability option.

Following the summary matrix there are individual tables for each configuration which summarize the technology items for that particular configuration and give a very brief synopsis of the type of SR & T program proposed and the estimated funding and schedule requirements. The text following each table is the facing page text prepared for the main presentation.

Following the tables for each configuration, an additional form is filled out for each technology item providing status information, justification for the proposed SR & T program, objectives, technical approach, and a more detailed schedule showing when the proposed program must be completed in order to support the particular configuration.

In dealing with the subject of SR & T we have identified two distinct groups - one where technology is needed and the other where there is no doubt that the technology is available and it is a straightforward engineering task to accumulate data that will preclude making a "false start" where several alternates are under study; we have called the latter group "desired data".

The storable Tug will benefit from the fact that the APOLLO LM program has used similar materials, propellants, equipments and procedures; the Shuttle Orbiter will expand on this data base for the Tug. The low number of identified SR & T items and the modest sums projected are based on the assumption that several existing or planned efforts related to the Shuttle will continue to provide data. These include the planned propellant and materials compatibility testing in support of the Shuttle Orbital Maneuvering Subsystem, its engines, tanks and components both at NASA/WSTF and at the Shuttle contractor's facilities. In addition, we have identified the Air Force funded efforts to develop the advanced Micron IMU for aircraft programs, as an effort which we would build-on rather than to start from scratch.

We have not attempted to detail the SR & T programs required on the Class I engine (with or without the two position nozzle) except to point out the uncertainty associated with the anticipated engine life and the predicted performance of very high expansion ratios within the mixture ratio of interest. The engine contractor will provide the proposed SR & T efforts required on the engine and we will provide comments on same at NASA's request.

The overall "message" which we hope will become obvious to the reader is that there are no real "show-stoppers" among the SR & T items identified.

TECHNOLOGY REQUIREMENTS AND "DESIRED DATA"

		110-A1	410AD-2	310-3A 310RE-3A	320-3A 320AE-3A	310-3B 310ARE-3B	510A-3B 510ADE-3B
S R & T	CLASS I ENGINE, HIGH E PERF		X	X	X	X	
	TWO-POSITION NOZZLE				X		
	LASER RADAR		X	(X)	(X)	(X)	(X)
	PFR HELIUM TANK	X	X	X	X	X	X
	ADVANCED FUEL CELL				X		
	ADVANCED IMU		X	(X)	(X)	(X)	(X)
	GRAPHITE COMPOSITE		X	X	X	X	
	SPUN-FORM ALUM. TANKS	X					X
	LONG TERM SPACE STORABLE SRM		X				(X)
DESIRED DATA	MATERIALS COMPATIBILITY DATA	X	X	X	X	X	X
	FRACTURE MECHANICS DATA	X	X	X	X	X	X
	HEAT PIPE DATA	X	X	X	X	X	X

(X) REQUIRED PRIOR TO GO AHEAD ON EVOLVED TUG CONFIGURATIONS

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510A-3B/510ADE-3B TECHNOLOGY REQUIREMENTS & DESIRABLE DATA

	ITEM	SR&T FUNDS $K	SR&T SCHEDULE MOS.	PROPOSED PROGRAM
SR&T	SPUN-FORM ALUM TANKS	50	6	HIGH ALT. TESTS TO OBTAIN PERF. DATA ON HIGH NOZZLE FOR MIXTURE RATIO RANGE
	LASER RADAR	500	12	FAB & TEST LIGHTWEIGHT, LOW POWER UNIT USING IMPROVED OPTICS & LIGHTER MIRROR DRIVES
	PFR HELIUM TANK	125	12	FAB & TEST 3 TANKS UNDER STATIC & DYNAMIC LOADING: AND ENVIRONMENTAL & COMPATIBILITY TESTS
	ADVANCED IMU	500	18	DEVELOP SOFTWARE FOR REDUNDANCY MGMT AND CALIBRATION OF 2 MULTI-SENSOR TYPE IMU'S
	LONG TERM SPACE STORABLE SRM	100	12	PHYSICAL & BALLISTICS PROPERTIES TESTS ON SAMPLES AFTER VACUUM EXPOSURE
DESIRABLE DATA	MATERIALS COMPATIBILITY DATA	25	6	2219-T87, 2219-T81 & 6Al4VTi; WITH N_2O_4 & MMH UP TO 130°F
	FRACTURE MECHANICS DATA	25	6	2219-T87 & 6Al4VTi; Kic Kth & FLAW GROWTH WITH N_2O_4 & MMH UP TO 130°F
	HEAT PIPES	100	12	FAB & TEST VARIABLE CONDUCTANCE HEAT PIPE RADIATOR & HEADER FOR TURN DOWN RATIO & SHUTOFF HEAT FLUX DATA

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TECHNOLOGY REQUIREMENTS AND DESIRED DATA - 510A-3B/510ADE-3B

The upper part of the facing chart contains the supporting research and technology (SR&T) items required for 510A-3B/510ADE-3B; the lower part of the chart contains what we have termed as "desired data". The distinction between the two is that the "desired data" items do not require technology but are considered straightforward engineering development tasks to produce design data prior to Tug program go-ahead (ATP); this will preclude impacting Tug schedules should the data indicate the desirability of an alternative approach, (vis., titanium propellant tanks rather than aluminum).

The total SR&T funds requested for 510A-3B/510ADE-3B is $1,425 K) to be expended over an 18 month period culminating at Tug ATP or prior to go-ahead on the evolved Tug. The advanced (Micron) IMU is the long lead item (18 months).

410 AD-2, 310RE-3A, 320AE-3A, 310 ARE-3B, 510ADE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Avionics (C&C)
(Discipline)

TITLE Low Weight/Power, (Rendezvous and Docking) Laser Radar

WBS No. 320-03-03-02

STATUS ITT-Gilfillan has been under NASA Contracts since 1964 to design, develop, build, and test various spaceborne laser radar systems. The third generation system will be delivered in late November 1973.

JUSTIFICATION The application of the above developed technology to meet specific space tug rendezvous and docking requirements is desired.

In addition in order to improve the payload capability of the storable tug, low weight Avionics equipments (specifically, low weight/low power laser radar) are required.

OBJECTIVES To design, develop, fabricate, and test a low weight, low power, rendezvous and docking laser radar.

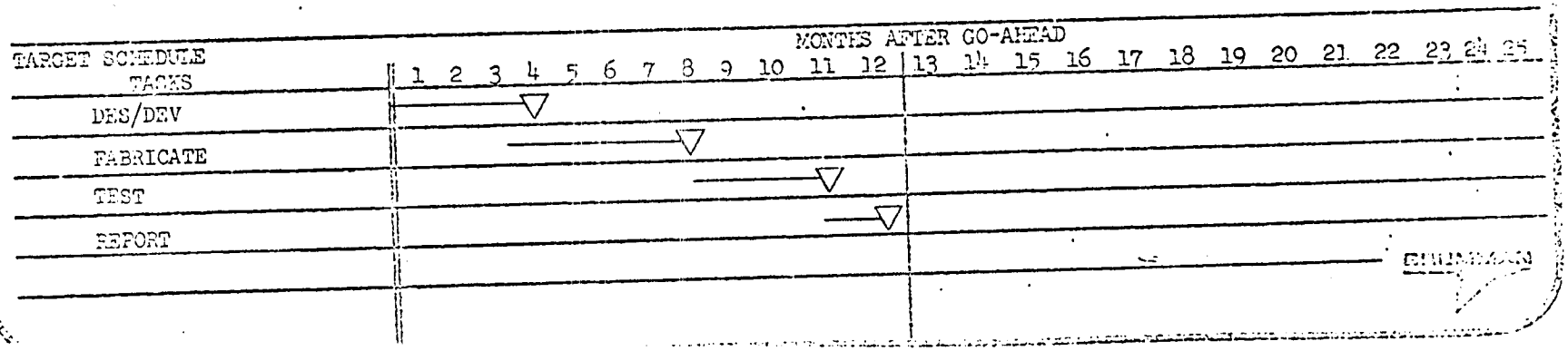
II-88-9

TECHNICAL APPROACH Using Tug requirements, design for light weight, low power by using new components, lighter mirror drives and improved optics

MANPOWER

FUNDING $500 K

SPECIALIZED FACILITIES Development and testing at ITT



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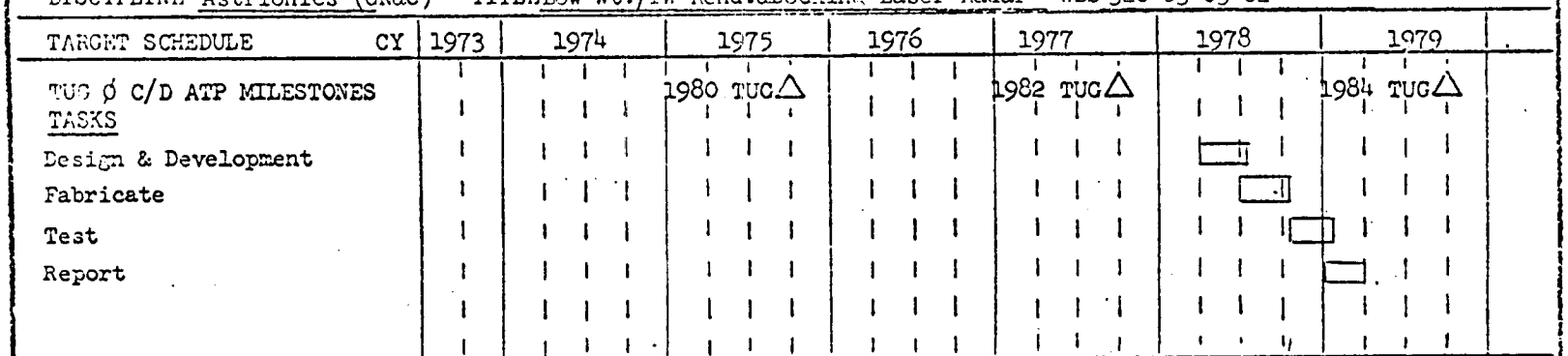
STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE Astrionics (GN&C) TITLE Low Wt./PW Rend.&Docking Laser Radar WBS 320-03-03-02



RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)					4	12	16
FUNDING							
a) DIRECT LABOR					100K	300K	400 K
b) EQUIPMENT & MAT'L					20K	40K	60 K
c) FACILITIES					40K	--	40 K
d) OTHER (SPECIFY)							
TOTAL					160K	340K	500 K

SPECIALIZED FACILITIES	
TYPE/LOCATION/AVAILABILITY	Optics bench, dark rooms, test range
FACILITIES DEV. TIME & COST	

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Main Propulsion
(Discipline)

TITLE Prestressed Filament Reinforced (PFR) Tanks

WBS No. 320-03-04-02

STATUS Structural Composites Industries, Inc. (SCI) and Arde-Portland, Inc. are under contract to LeRC to demonstrate the feasibility of the PFR tanks. This program will result in the construction of a 24 in. diam. Ardeform PFR tank of the type assumed by our study. If successful the basic technology will be proven.

JUSTIFICATION

A PFR ambient helium storage tank is comparable with the weight of a SHe tank and its associated heat exchanger. It provides a simple and less operationally complex system compared to the SHe tank. The PFR tank also provides a leak-before-burst design which results in increased Tug safety.

OBJECTIVES

Design, fabricate, and test 3 to 6 PFR tanks to demonstrate that current manufacturing and quality control techniques are adequate to produce a reliable, low weight tank suitable for containing gaseous helium (or hydrogen and oxygen in the case of fuel cell reactant tanks). The program will resemble a pre-qualification test program which will demonstrate the ability of the PFR tank to undergo the dynamic loading, compatibility, environmental exposure and etc. tests required for acceptance as a flight item.

TECHNICAL APPROACH

Fabricate 3 to 6 tanks and subject them to a pre-qualification test program to demonstrate the maturity of the design.

MANPOWER 2 man years

FUNDING $125,000

SPECIALIZED FACILITIES

Available at tank manufacturers

TARGET SCHEDULE

TASKS	MONTHS AFTER GO-AHEAD 1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Fabricate Tanks		
Test Program		
Analysis and Report		

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BRUNSMAN

ALL EXCEPT 410AD-2

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE MAIN PROPULSION (MPS) TITLE PRESTRESSED FILAMENT REINFORCED (PFR) TANKS WBS 320-03-04-02

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG ∅ C/D ATP MILESTONES			1980 TUG△		1982 TUG△		1984 TUG△
TASKS							
Fabricate Tanks							
Test Program							
Analysis and Report							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)	1	1					
FUNDING							
a) DIRECT LABOR	$ 38,000	$ 37,000					$ 75,000
b) EQUIPMENT & MAT'L	$ 30,000	$ 20,000					$ 50,000
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL	$ 68,000	$ 57,000					$125,000

SPECIALIZED FACILITIES	
TYPE/LOCATION/AVAILABILITY	ARDE, SCI, or Similar
FACILITIES DEV. TIME & COST	None

410AD-2, 310 RE-3A, 320 AE-3A, 310 ARE-3B, 510 ADE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Astrionics (GN&C)
(Discipline) WBS #320-03-03-02

TITLE Advanced (Low Weight) Inertial Measurement Unit for Space Application

STATUS Advanced Lightweight Unit being developed under Air Force Contract. Primarily for aircraft application.

JUSTIFICATION To improve payload capability of a storable tug, low weight Astrionics Equipments are required.

OBJECTIVES To develop the advanced IMU to the point where it can be used in a space application.

TE-8.9-13

TECHNICAL APPROACH
1. Develop software mechanizations for redundancy management.
2. Develop software and procedures for calibration of gyros on the launch pad.
3. Test the software with the hardware in the lab.

MANPOWER

FUNDING $500 K

SPECIALIZED FACILITIES Development and test in subcontractor's facility.

Start Date July 77 Jan 78

TARGET SCHEDULE — MONTHS AFTER GO-AHEAD

TASKS	1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Develop Algorithms	——— ▽	
Program Computer	——— ▽	
Test with Hardware	———	——— ▽
Write Report		——— ▽

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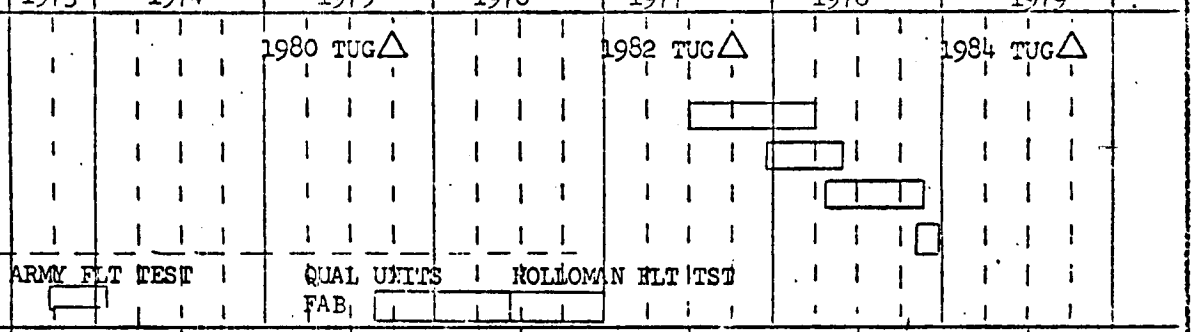
STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE Astrionics (GN&C) TITLE Advanced IMU WBS 320-03-03-02



RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)				4	8		12
FUNDING							
a) DIRECT LABOR				100 K	200 K		300 K
b) EQUIPMENT & MAT'L					100 K		100 K
c) FACILITIES Inertial Test Stand					100 K		100 K
d) OTHER (SPECIFY)							
TOTAL				100 K	100 K		500 K

SPECIALIZED FACILITIES

TYPE/LOCATION/AVAILABILITY

FACILITIES DEV. TIME & COST

Development and test at subcontractor's facility.

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE STRUCTURES TITLE GRAPHITE/EPOXY HONEYCOMB THIN GAGES WBS 320-03-01-03

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG Ø C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS							
o FABRICATE GR/EP HONEYCOMB USING .0025 PLIES to obtain UP TO 0.012 FACE SHEETS.							
o STANDARD TEST SPECIMENS WITH VARIOUS PLY DIRECTIONS TESTED TO OBTAIN DESIGN DATA							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS) ½ MAN YEAR							
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L							
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							
SPECIALIZED FACILITIES TYPE/LOCATION/AVAILABILITY FACILITIES DEV. TIME & COST	—						

110 A-1, 610 A-38/610 ADE-38

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - STRUCTURES
(Discipline)

TITLE SPIN FORMING OF 2219-T 81 DOMES FOR TANKS WBS No. 320-03-01-01-02

STATUS Hot technique of spin forming 2219 is feasible. However, the technique has not been demonstrated nor have design allowables been established.

JUSTIFICATION A weight savings can be achieved if 2219 aluminum alloy can be spun to achieve a temper of at least T81

OBJECTIVES To demonstrate a combination of hot and cold spin forming to achieve a minimum of T81 temper in 2219 spun domes

91-63-IX

TECHNICAL APPROACH Small scale, approximately 5 foot domes will not be hot spun approximately to size. Domes will then be heat treated to the unstable "W" condition and spun cold to size to achieve a T-31 temper. After heat treatment to T81 scale domes will be sectioned for mechanical property evaluation and thickness control.

MANPOWER 3000 MHRS FUNDING

SPECIALIZED FACILITIES NONE

TARGET SCHEDULE

TASKS	MONTHS AFTER GO-AHEAD 1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Spin Form Dome	———	
Evaluate Mech. Properties		
and Thickness Control	—	
Report	▽	

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110 A-1, 510 A-3B/510 ADE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE STRUCTURES TITLE SPIN FORMED 2219-T8 TANK DOMES WBS 520-03-01 = 01/02

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG ∅ C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS							
○ HOT SPIN FORM 8FT DIA. DOMES TO APPROX SIZE							
○ HEAT TREAT TO "W" COND							
○ SPIN FORM COLD TO SIZE TO T-31 TEMPER							
○ HEAT TREAT TO T-81							
○ SECTION TANK TO OBTAIN MATERIAL PROP. & THICKNESSES							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS) 1 ½ MAN YEARS							
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L							
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							

SPECIALIZED FACILITIES
TYPE/LOCATION/AVAILABILITY
FACILITIES DEV. TIME & COST

NONE

510 ADE-5B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Main Propulsion (MPS)
(Discipline)

WBS No. 320-04-8-2, 9-2

TITLE Long-Term SRM Space Storage

STATUS In 1963, Battelle Memorial conducted long-term space storage tests (hard vacuum, thermal and radiation) on SRM propellants, motor components and assembled motors. The testing was performed on PBAA and polyurethane propellants. Some accelerated thermal testing at -160°F has been conducted by UTC on HTPB during the past year.

JUSTIFICATION Some of the Storable Tug missions use deorbit SRM's; these impose a requirement for long-term space storage (3-6 yrs) on SRM's. The effects of hard vacuum and low temperature on the reliability and performance of the SRM must be considered. Radiation is not a consideration because the payloads requiring deorbit kick stages are not exposed to the Van Allen radiation belt for any significant duration.

OBJECTIVES
To demonstrate that long-term exposure to hard vacuum and low temperature will not affect the performance of present day propellants such as CTPB and HTPB.

VI-8,4-18

TECHNICAL APPROACH
Expose propellant tensile bars, propellant burning strands and propellant additives to thermal vacuum conditions and conduct weight/vapor loss, tensile strength, and burning rate tests after exposure.

MANPOWER 2 man years

FUNDING Est. $100,000

SPECIALIZED FACILITIES
Available

TARGET SCHEDULE

TASKS	MONTHS AFTER GO-AHEAD 1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Initial Planning & Fab		
Testing		
Analysis and report		

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510ADE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE MAIN PROPULSION (MPS) TITLE LONG TERM SRM SPACE STORAGE WBS 320-04-8-2,-9-2

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG Ø C/D ATP MILESTONES			1980 TUG△		1982 TUG△		1984 TUG△
TASKS							
Initial Planning & Fab							
Testing							
Analysis and Report							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)					2		
FUNDING							
a) DIRECT LABOR					$ 75,000		$ 75,000
b) EQUIPMENT & MAT'L					$ 25,000		$ 25,000
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL					$100,000		$100,000

SPECIALIZED FACILITIES TYPE/LOCATION/AVAILABILITY	Battelle Memorial Inst., Atlantic Research, or Similar
FACILITIES DEV. TIME & COST	None

ALL TUG VEHICLES

STORABLE SPACE AND SUPPORTING RESEARCH AND TECHNOLOGY - Structures
(Discipline)

TITLE Material Compatibility WBS No. 320-03-01-01-02

STATUS Material compatibility of Ti-6AL-4V STA and 2219-T87 Aluminum alloy in the presence of MMH at temperatures up to 150°F is required. Compatibility of N_2O_4 with 2219-T87 is also required.

JUSTIFICATION Compatibility of propellants with tankage material must be assessed to obtain the reuse life of the tanks under cyclic loads.

OBJECTIVES The objective of the program is to obtain the static and fatigue properties of the tankage parent and weldment materials under cyclic exposure to propellants and load.

VI-8.4-20

TECHNICAL APPROACH Static and fatigue properties of candidate materials specimens will be obtained prior to and after exposure to the propellants. Tests will be performed at R.T. and 150°F.

MANPOWER One man-year FUNDING $ 25 K

SPECIALIZED FACILITIES

TARGET SCHEDULE TASKS	MONTHS AFTER GO-AHEAD 1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Test Plan		
Spec. Fab.		
Test		
Report		

ALL TUG VEHICLES

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE STRUCTURES TITLE MATERIALS COMPATIBILITY DATA WBS 320-03-01

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG Ø C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS o FABRICATE & TEST MATERIAL SPECIMENS OF PARENT MAT'L & WELDMENTS TO OBTAIN COMPATIBILITY DATA FOR N_2O_4 & MMH UP TO 200°F. MATERIALS 6AL-4V, 2219-T87 & T-81							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS) ONE MANYEAR							
FUNDING a) DIRECT LABOR							
b) EQUIPMENT & MAT'L							
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							

SPECIALIZED FACILITIES

TYPE/LOCATION/AVAILABILITY

FACILITIES DEV. TIME & COST

ALL TUG VEHICLES

STORABLE STAGE [illegible] TECHNOLOGY - Structure
(Discipline)

TITLE Fracture Mechanics Test Data WBS No. 320-03-01-01-02

STATUS Fracture mechanics test data for thin gage (.020 to .040) for Titanium 6AL-4V STA and 2219-T87 aluminum alloy exposed to N_2O_4 and MMH at temperatures up to 200°F is not available.

JUSTIFICATION Fracture mechanics data for thin gage tank material are required to assess the fracture mode and life cycle of the tug propellant tanks.

OBJECTIVES The objectives of the program are to obtain K_{ic}, K_{th} and flaw growth data for parent and weldment materials in the induced thermal environment up to 200°F. Data to be obtained prior to and after exposure to the candidate propellants. In addition to fracture mechanics data, NDE techniques are to be employed on the test specimens to assess flaw detection capability.

VI-89-22

TECHNICAL APPROACH Standard fracture elemental specimens are to be employed. Tests are to be employed. Tests are to be conducted at room temperature and at 150 and 200°F. Surface flaws of various sizes are to be used and NDE techniques are to be employed to document size where practical.

MANPOWER One man-year FUNDING $25K

SPECIALIZED FACILITIES

TARGET SCHEDULE — MONTHS AFTER GO-AHEAD

TASKS	1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Test Plan	├─┤	
Spec. Fab.	├─┤	
Test	├──────┤	
Report	▽	

ALL TUG VEHICLES

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE STRUCTURES TITLE FRACTURE MECHANICS DATA WBS 320-03-01 = 01 02

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG ∅ C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS							
o FABRICATE & TEST MAT'L SPECIMENS (Parent metal & weldments) to obtain K_{IC} K_{TH} & FLAW GROWTH DATA FOR INDUCED ENVIRONMENTS INCL. 200°F. ALSO STATIC & FATIGUE DATA. MAT'LS 6AL-4V & 2219-T87 & T81							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)							
ONE MAN YEAR							
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L							
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							

SPECIALIZED FACILITIES

TYPE/LOCATION/AVAILABILITY

FACILITIES DEV. TIME & COST

110 A-1, 410 AD-2, 310-5A/310 RE-3A, 320 A-5A/320 AE-3A, 310-3C/310 ARE-3B, 610 A-3C/610 ADE-3B

STORABLE SPACE TUG SUPPORTING RESEARCH AND TECHNOLOGY - Thermal Control
(Discipline)

TITLE SPACE TUG HEAT PIPES

WBS No. 320-04-02

STATUS

Heat pipes (HP) are currently being used in both ground and space application. The variable conductance heat pipe (VCHP) principle is particularly attractive for Tug application but requires further development.

JUSTIFICATION

The fuel cell and certain high power density avionics units carried on the Space Tug require active cooling. Trade studies which have examined pumped loop radiators, sublimators and various heat pipes have indicated the obvious merits of the variable conductance heat pipe. A VCHP radiator could interface with the pumped loop heat transport system of the fuel cell, eliminating the cost and complexity of a selective stagnation radiator with its associated unreliable automatic bypass valves. A VCHP header, a heat transport device, could provide for high power density avionics heat transport without recourse to the active loop.

VI-5.9-24

OBJECTIVES

Emphasis will be placed on experimentally obtaining the large turn down ratios which appear theoretically achievable and in developing predictive techniques.

TECHNICAL APPROACH

Design, fabricate and test a VCHP radiator and VCHP header and experimentally determine performance with emphasis on turn down ratio and shut off heat flux levels.

MANPOWER 5580 manhours

FUNDING $100K

SPECIALIZED FACILITIES

Grumman Thermal Laboratory

TARGET SCHEDULE

TASKS	MONTHS AFTER GO-AHEAD 1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24 25
Establish Test Plan	-	
Material Procurement	-	
Design & Fab Test Specimens	———	
Conduct Engineering Tests	———	
Analyse Test Results	———	
Final Report	———	

GRUMMAN

STORABLE SPACE TUG SUPPORTING RESEARCH & TECHNOLOGY

DISCIPLINE _____ TITLE _____ WBS _____

TARGET SCHEDULE CY	1973	1974	1975	1976	1977	1978	1979
TUG Ø C/D ATP MILESTONES			1980 TUG △		1982 TUG △		1984 TUG △
TASKS							
TEST PLAN							
DESIGN & FAB TEST SPECIMEN							
CONDUCT TEST							
ANALYSIS & FINAL RPT							

RESOURCE REQUIREMENTS FY	1974	1975	1976	1977	1978	1979	TOTAL
MANPOWER (MAN YEARS)	1.5	1.5					
FUNDING							
a) DIRECT LABOR							
b) EQUIPMENT & MAT'L	100K						
c) FACILITIES							
d) OTHER (SPECIFY)							
TOTAL							

SPECIALIZED FACILITIES
TYPE/LOCATION/AVAILABILITY
FACILITIES DEV. TIME & COST

GRUMMAN THERMAL LAB, BETHPAGE N.Y., AVAILABLE & FULLY DEVELOPED

8.11 SPECIAL COST SENSITIVITIES

REFERENCE:

Due to the size and development of the Special Cost Sensitivities Analysis reference is made herein to Part I, concept 110A-1, paragraph 8.11 of Volume 8.

8.13 ESTIMATING TECHNIQUE APPLIED

WBS ELEMENT	DDT&E	PRODUCTION	OPN
320-01 Proj. Management	CER's Based on IM Experience	Same as DDT&E	Same as DDT&E
320-02 Syst Eng & Integ	Same as 320-01	Same as 320-01	Same as 320-01
320-03-01 Structure	CER's Lower Level Analysis	Same as DDT&E	N/A
320-03-02 Thermal Insul	Same as 320-03-01	Same as 320-03 -01	N/A
320-03-03 Avionics	Vendor Est/Manpower/Wrap-around	Same as DDT&E	N/A
320-03-04 Propulsion	Gov't Est/Vendor Est/Wrap-around	Same as DDT&E	Same as DDT&E
320-03-05 Orbiter Interface	CER's Vendor Est/Wraparound	Same as DDT&E	N/A
320-03-06 Drop Tanks	N/A	N/A	N/A
320-03-07 Final Assy & C/O	Same as 320-01	Same as 320-01	N/A
320-04-01 Structure	Same as 320-03-01	Same as 320-03 -01	N/A
320-04-02 Thermal Insul	Same as 320-03-02	Same as 320-03 -02	N/A
320-04-03 Avionics	Same as 320-03-03	Same as 320-03 -03	N/A
320-04-04 Propulsion	Same as 320-03-04	Same as 320-03 -04	Same as 320-03-04
320-04-05 Interstage Interface	Same as 320-03-01	Same as 320-03 -01	N/A
320-04-06 Drop Tanks	N/A	N/A	N/A
320-04-07 RDM	Gov't est, CER's Vendor Est, wraparound	Same as DDT&E	Same as DDT&E
320-04-08 AKS	Same as 320-04-07	Same as 320-04 -07	Same as 320-04-07
320-04-09 DKS	Same as 320-04-07	Same as 320-04 -07	Same as 320-04-07
320-04-10 Cache Tank	N/A	N/A	N/A
320-04-11 Final Assy & C/O	Same as 320-03-07	Same as 320-03 -07	N/A
320-05 Logistics	CER's	Same as DDT&E	Same as DDT&E
320-06 Facilities	CER's	Same as DDT&E	Same as DDT&E
320-07 GSE	CER's, and End-item analysis	Same as DDT&E	Same as DDT&E
320-08 Vehicle Test	CER's, Manpower Loading	N/A	N/A
320-09 Launch Ops WTR	N/A	N/A	Manpower Loading
320-10 Launch Ops ETR	N/A	N/A	Manpower Loading

WBS ELEMENT	DDT&E	PRODUCTION	OPN
320-11 Flt Ops DOD	CER's & Manpower Loading	N/A	Same as DDT&E
320-12 Flt Ops NASA	Same as 320-11	N/A	Same as DDT&E
320-13 Ref & Int, 1st TR	N/A	N/A	Manpower Loading
320-14 Ref & Int, 2nd TR	N/A	N/A	Manpower Loading

COST = A (BASE)^B	PROGRAM BASIS	BASE	A DDT&E	A PROD	B DDT&E	B PROD
PROJECT MGMT.	LM	VEH COST	.1	.09	1	1
	LM	LESS ENG.				
SE & E	LM	VEH COST	.13	.08	1	1
		LESS ENG.				
STRUCTURE	LM	WEIGHT				
SPUN AL. TANKS			124	15	.71	.61
TI TANKS			140	24.3	.71	.61
BODY SHELL			25	2.8	.71	.61
THRUST STRUCTURE			5.5	0.4	1	1
METEOROID SHIELD			5.5	.47	1	1
PAYLOAD INTERFACE			37.2	3.4	1	1
PROPULSION						
ACPS THRUSTERS		VENDOR COST	2	1.66	.7	.7
ACPS SUPPORT		VENDOR COST	2.4	1.84		
EPS WIRING	LM	(WEIGHT)	39.7	7	.7	.7
ORBITER INTERFACE, STRUCTURE	LM	WEIGHT	5.5	.4	1	1
FINAL ASSY & C/O	LM	VEH COST	.54	.18	1	1