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T-70-00625

BURNER II IMPROVED CENTAUR

Integration Study

D2-116103

JANUARY 1970

Volume II — Costs and Schedules

AEROSPACE GROUP ■ SPACECRAFT BRANCH

THE BOEING COMPANY

SEATTLE, WASHINGTON

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BURNER II/IMPROVED CENTAUR INTEGRATION STUDY

FINAL REPORT - VOLUME II

D2-116103

SUBMITTED TO:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LEWIS RESEARCH CENTER

IN COMPLIANCE WITH

NASA CONTRACT NAS 3-11803

JANUARY 1970

AEROSPACE GROUP - SPACECRAFT BRANCH
THE BOEING COMPANY
SEATTLE, WASHINGTON

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ABBREVIATIONS & ACRONYMS

AFETR	Air Force Eastern Test Range
AFWTR	Air Force Western Test Range
AGE	Aerospace Ground Equipment
AVE	Airborne Vehicle Equipment
CEI	Contract End Item
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESA	Explosive Safe Area
ETR	Eastern Test Range
GFE	Government Furnished Equipment
GSE	Ground Support Equipment
ICD	Interface Control Drawing
ITL	Integrate, Transfer & Launch (Facility)
KSC	Kennedy Space Center
LeRC	Lewis Research Center
LCCE	Launch Control & Checkout Equipment
RCS	Reaction Control Subsystem
RCSSE	Reaction Control Subsystem Servicing Equipment
RF	Radio Frequency
S&EA	Structure & Equipment Assembly (Burner II Stage less rocket motor)
SMAB	Solid Motor Assembly Building
ULO	Unmanned Launch Operations
WTR	Western Test Range
W_P	Weight of Propellant

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1.0 INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

This report presents the results of a Centaur/Burner II integration study conducted for NASA under the technical direction of Lewis Research Center, Contract NAS3-11802. The objectives of the integration study were:

1. Develop conceptual engineering designs to integrate efficiently the Burner II with the Centaur launch vehicle.

2. Determine the integration requirements of Burner II Ground Support Equipment (GSE) into the launch complex and evaluate the resulting interface requirements with the launch vehicle GSE.

3. Perform preliminary mission studies to establish performance of Centaur/Burner II with Titan IIIB and Titan IIID boosters for planetary and synchronous equatorial type missions.

4. Establish planning level costs and a program schedule for incorporating the Burner II on the Titan/Centaur launch vehicles.

The results of the study are contained in two volumes. This document, Volume II, contains the schedule and cost data as well as the integration plan which was originally released and transmitted to NASA as a seperate document, D2-116082-5.

Planning level costs segregated to Level 3 of the Work Breakdown Structure are presented and a summary schedule depicting the timing of planned activities is provided. The ground rules and assumptions which provide the basis for both the costs and schedule are also presented.

D2-116103, Volume I, the companion to this document, contains the technical description of the integration tasks which form a part of the overall basis for the cost and schedule planning. Additional definition is provided in the Integration Plan which is included as an appendix to this document.

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1.2 SUMMARY

A summary of the technical document, Volume I of D2-116103, as well as this document, Volume II, is presented in the following section.

1.2.1 Background

NASA mission planning reflects the need for an upper stage on the Centaur launch vehicle. Specific studies of the Centaur/Burner II for high energy and synchronous equatorial missions have illustrated the value of the Burner II velocity increment, guidance accuracy and attitude stabilization capability. Forthcoming missions to the outer planets will rely on the Jupiter swingby gravity assist. The potential of the Titan IIID/Centaur/Burner II is shown to be compatible with 1600 - 1700 pound spacecraft for this mission. In addition the Atlas SLV-3C or a Titan IIIB/Centaur/Burner II could send a 1200 - 1800 pound spacecraft around Venus or go direct to Mercury with an 800 - 900 pound spacecraft.

The ability of the Burner II to provide the 5.5 hour coast required for synchronous equatorial missions allows either the Atlas SLV-3C or the Titan IIIB/Centaur to place 1300 - 1400 pound spacecraft in synchronous orbit. Spacecraft of this size are compatible with data relay satellite systems. Burner II eliminates the need for apogee motors and transfer coast attitude control systems in the spacecraft. Thus the spacecraft in orbit is not required to either jettison the spent injection motors or provide sufficient control authority to retain them with the spacecraft. Payloads of up to 2700 pounds can be placed in synchronous equatorial orbit with the Titan IIID/Improved Centaur/Burner II vehicle.

The Centaur/Burner II integration provides a significant step in the process of integrating Burner II with Centaur for future NASA missions.

1.2.2 Scope

The Centaur/Burner II integration study was divided into eleven tasks to cover the broad aspects of the study objectives. The study pursued each of the tasks to the depth required to produce conceptual designs, program documentation visibility, and operational concepts that could be priced to a planning estimate level. The objectives, ground rules, and magnitude of the study effort established the depth at which each of eleven tasks of the study were pursued. The study, of six month duration, included an initial performance evaluation of (2) boosters (Titan IIIB/Centaur and Titan IIID/Centaur), (7) Burner II configurations, and two types of missions for a 28 point performance matrix. Two Burner II configurations were selected for further study involving preliminary designs of a Burner II-to-Centaur adapter and Burner II-to-payload structure and related interface details. The structural design details established were strongly influenced by the ground rule payload weight of 2800 pounds. Integration of the Burner II flight stage with the Improved Centaur and integration of the Burner II GSE into the Titan ITL complex were analyzed. An integration plan was developed to provide the basis for the pricing and schedule outputs of the study. The shroud used in the

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study was conceptual and does not necessarily represent the final configuration. The Centaur was the "E" version with 60 minute coast capability.

1.2.3 Summary of Study Results

A summary by task of the study output reveals the following:

1.2.3.1 The 28 point performance matrix analysis indicated that while a significant performance improvement was achieved by integrating a Burner II with the Titan IIID/Centaur and the Titan IIIB/Centaur it made little difference which Burner II configuration was used. With this in mind a selection was made of the Standard Burner II and a growth motor Burner II as the configurations for the detailed integration and performance analysis. It also became apparent that designing for 2800 pound synchronous equatorial payload capability would penalize the lighter weight lower cg planetary payloads by up to 100 pounds. Consequently a separate weight estimate was made for the adapter to be used with 1200 to 1500 pound planetary payloads for the final payload vs. velocity plots.

1.2.3.2 The mechanical design of the Centaur-to-Burner II adapter and Burner II-to-payload support structure as well as the structural modifications to Burner II were completed to meet the loads and stiffness criteria imposed by the study ground rules. The resulting adapter design is a semi-monocoque two piece structure. Both sections of the adapter are used for the growth motor Burner II while only one section is used for the shorter Standard Burner II. The structural modifications required for the Burner II stage are primarily gauge changes in the existing design to react the additional loads. The payload support structure provides a bolt circle at the payload interface that is the same as the bolt circle at the top (Sta. 2491.80) of the Improved Centaur. This payload interface definition was selected because of the lack of a specific spacecraft to integrate with and because this approach would allow the spacecraft to be flown on the Improved Centaur with or without Burner II depending on the mission requirements. The weight of the Centaur/Burner II adapter is strongly influenced by the payload weight and cg location. Weight data was developed for both a 50 percent cg and 25 percent cg location for the 2800 pound ground rule payload. The adapter design included a separation analysis to verify adequate clearance during in-flight separation of the Burner II from the Centaur.

1.2.3.3 Electrical integration of the Burner II with the Improved Centaur was analyzed in terms of wiring interfaces, signal functional interfaces, power distribution and RF performance. All 12 Burner II-to-Centaur interface wires can be carried through one in-flight separation connector. Trade studies of the routing of payload umbilical wires through Burner II indicate that a second Burner II-to-Centaur connector would be required to get the payload umbilical down to the Centaur umbilical island. An RF link analysis for Burner II and specified ground facilities indicated that the Burner II Telemetry System could be modified for adequate performance at synchronous altitude by an increase in transmitter power from 5 watts to

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12 watts and other minor system changes. Burner II Telemetry transmission prior to shroud jettison can be handled by RF slots in the shroud located in relation to the Burner II S-Band antenna to provide an acceptable re-radiated antenna pattern.

1.2.3.4 The intentional destruction of Burner II by either range safety command or from premature separation of the Burner II from the Centaur is provided for with the Burner II destruct system mounted in the Burner II-to-Centaur adapter. The command destruct signal comes to Burner II by way of the Centaur command destruct receivers.

1.2.3.5 The Burner II/Centaur guidance system error analysis revealed that the predominant error associated with Burner II integration with Centaur was the attitude transfer error of 1.0° (all axis) associated with transferring the attitude reference of the Centaur to the Burner II during Burner II gyro uncage. Methods to reduce the attitude transfer error were explored. It has been determined that a reduction in attitude transfer error to .44° is obtained if the Burner II gyros are uncaged during a 30 to 50 second non-guidance-steering segment of the Centaur second burn. Lateral accelerometers added to the Burner II strapped down guidance system sense cross-axis accelerations due to attitude misalignment with the thrust vector during the reference period that Centaur is thrusting along a preprogrammed inertial vector. Corrections are computed in Burner II from the sensed cross-axis accelerations so that the Burner II pitch and yaw gyros can be torqued to be aligned with the established Centaur inertial reference. Centaur modifications for this concept are limited to software. Burner II changes required involve the addition of accelerometers and some computing circuitry.

1.2.3.6 The electromagnetic interference aspect of integrating the Burner II with the Improved Centaur was analyzed in terms of interface signals, grounding, and RF coupling. The latching type relays used on Burner II for signal interfaces are highly insensitive to EMI and sufficient testing has been done on Burner II with EMI environment in excess of the Centaur/Burner II predicted levels to verify a satisfactory signal interface. The grounding philosophies of the Burner II (single point ground) and the Centaur (single point except for the igniters and recirculating pump) are different but analysis of the specific circuits involved indicate that no adverse effects will occur. The destruct ordnance initiate circuit is not involved in the grounding differences because no ground exists on the Burner II side of the interface for this circuit.

1.2.3.7 Field operations for processing the Burner II at the ETR were studied and detailed functional flow diagrams prepared. The flow diagrams were used as a basis for establishing ETR and Seattle requirements for ground support equipment, services, and facilities. A primary consideration was environmental control of the payload. A concept of payload encapsulation within the nose shroud was developed to provide environmental control of the payload from the time it is encapsulated in a clean room until vehicle launch. Equipment required to support this concept includes a transporter assembly with suitable positioning hardware to independently support the shroud and the Burner II/Payload combination. The only new

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electrical GSE identified are minor items such as suitcase size Centaur signal simulator, cables, etc. The major new mechanical GSE identified is the transporter mentioned above.

1.2.3.8 The facility requirements for integrating Burner II with the Centaur at K.S.C. include a high bay, explosive safe, clean room for the assembly of the Spacecraft/Burner II/Shroud combination with the spacecraft encapsulation concept. Service tower modifications are minor involving the removal or modifications of some of the folding work platforms.

1.2.3.9 The reliability of the Burner II for a Titan/Centaur/Bumner II synchronous equatorial mission is estimated to be .955. This is considered a valid estimate for the first flight of the above vehicle since the Burner II is a mature flight system. This maturity is based on eight successful Thor/Burner II missions out of eight launches and also on the flight experience of the Burner II system components on other vehicles, such as Scout, and Thor/Delta. Consideration of the effects of the Van Allen belt radiation exposure for the synchronous equatorial mission profile have been included in the estimated reliability of the Burner II electronic components. The safety analysis of the integration of Burner II with the Titan/Centaur vehicle, including the interfacing with the shroud, the launch facility and the GSE, indicates that the hazards encountered are typical of current missiles and space systems involving ordnance devices, solid and liquid propellants and pressurized systems. The integration can be performed within the normally acceptable risk limits for unmanned space systems.

1.2.3.10 The task of integrating Burner II with the Centaur for a specific mission involves interfaces with the booster, Centaur, shroud, launch facilities and payload contractors as well as the various NASA agencies. These program interfaces were reviewed and an integration plan was established to account for all of the tasks to be performed in the integration of Burner II with Centaur for an ETR launch on the Titan booster. The integration plan provided visibility in terms of Design, Analysis, Testing and Documentation for the Boeing tasks as well as an approximation of the Boeing tasks relative to the other contractor's and to first Burner II delivery for a Titan/Centaur mission at ETR. Pricing ground rules were established to provide further program scope to the pricing effort.

Recurring unit cost for the Burner II vehicle including payload support and Centaur adapter is approximately $500,000 excluding the motor which is GFE. A detailed breakdown of nonrecurring and complete recurring costs is presented in Figures 3-1 and 3-2.

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2.0 GROUND RULES

The following costing ground rules were used to generate the cost data summarized on Figure 3-1 for a seventeen (17) vehicle program.

2.1 SCHEDULE

a. First launch May 1974, second launch October 1974, three launches per year in 1975 through 1979. Total launches - 17.

b. First AVE delivery to ETR required 9 weeks prior to launch.

c. GSE required at ETR 11 weeks prior to first launch.

d. Assume Titan/Centaur already integrated and Titan/Centaur tests and payload checkout at pad can be performed in parallel with Burner II checkout.

e. AVE deliveries at the rate of one every two months.

f. Delivery schedule is essentially the same for both configuration options and for both mission options.

g. A Burner II launch crew is assumed required during the booster integrated test period prior to launch (3 weeks for first launch, 1 week for second and on launches)

2.2 CONFIGURATION

a. Burner II, payload support and Centaur adapter configuration per Section 2.2 of the Final Study Report, D2-116103, Volume I.

- Standard Burner II (1440 lbs Wp), quantity of 17
- Growth Burner II (2300 lbs Wp), quantity of 17

b. Payload weight is 2800 pound for Synchronous Equatorial missions and 1200 pounds for Escape Missions with cg location 1/2 height at payload, centrally located.

c. Boeing designs and builds the adapter and payload support.

d. Payload wire bundle (50 wires) routed through Burner II. Burner II provides payload separation signal to the payload electrical connector.

2.3 MISSION

a. Easterly launch from ETR.

b. Earth Escape Missions and Synchronous Equatorial Missions.

c. On Earth Escape Missions, extended coast capability not required.

d. Recurring launches are priced as if all missions and payloads are identical.

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2.4 GENERAL

a. A complete set of Burner II spares will be provided at ETR.

b. Price is presented to Level 3 of the Program Breakdown Structure shown on Figure 3-3.

c. 1970 pricing rates have been used to price the entire effort.

d. Recurring and nonrecurring costs are priced separately.

e. Assume a continuing contracted Burner II program during the 1974-1979 time period.

f. Pricing for the Boeing encapsulation is segregated as an identifiable package. It is assumed that payload encapsulation must be performed whether or not Boeing is responsible. If Boeing is not responsible, the shroud will not be required in Seattle for the physical integration test. In either case, Boeing will design and build the Burner II peculiar handling equipment including the transporter.

g. Rocket Motors are costed as GFE.

h. Nonrecurring costs include design and development test, first set of GSE and tooling.

2.5 EQUIPMENT, SERVICES AND GFE

a. Government Furnished Equipment (GFE)

Equipment which is known to be available from federal stock or at the launch site or equipment which would normally be provided by other contractors such as payload handling slings or shroud segment handling equipment, is listed as GFE and not priced.

b. Government Furnished Services

Services which are known to be available from the government at ETR or which would normally be provided by other contractors such as facility modification, is listed as government furnished and not priced.

c. Government Furnished Facilities

All facilities required at ETR are considered government furnished and not priced.

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d. Documentation

The integration of all program documentation is considered governmented furnished. Boeing has priced inputs to the program documents and preparation of all Burner II unique documentation.

e. Ground Support Equipment (GSE)

Price includes Boeing providing all GSE other than the GFE for accomplishment of Boeing's job at Seattle and ETR. Quantities of equipment are as follows:

- One set of handling and transportation equipment will be provided. Equipment will be utilized in Seattle during integration testing and then shipped to ETR.
- Three sets of permanently installed Launch Control and Checkout Equipment (LCCE) will be provided. Two for ETR and one for Seattle.
- Two sets of portable LCCE will be provided; one for Seattle and one for ETR.
- One set of Reaction Control Subsystem Servicing Equipment (RCSSE) will be provided for ETR.
- One Launch Facility Mod Kit will be provided for ETR.

The costs of the above noted 2 sets of permanent LCCE and single set of portable LCCE is shown under recurring costs on Figure 3-1 since this equipment would be permanently located at the ETR site to support a 17 launch program.

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3.0 COSTS

This section contains the planning (±20%) cost estimate for the performance of the subject program in accordance with the specific ground rules contained in Section 2.0 of this document.

Costs and related information have been segregated and presented as follows in Figure 3-1.

- o Costs for each Level 3 Task for each selected configuration.
- o Manhours for engineering and manufacturing for each configuration for each Level 3 Task.
- o Recurring and nonrecurring costs for each selected configuration.
- o Encapsulation costs - recurring and nonrecurring.

The Program Breakdown Structure which provides the framework for this estimate is also included in this section in Figure 3-3.

Included in this section, Figure 3-2, is a cost summary for a varying program level; a single Burner II unit, three units, and six units. The 17 unit figures are also repeated here for reference. Ground rules for the 1, 3, and 6 unit programs are the same as those given in Section 2.0 with the following speiific exceptions:

- All units are delivered prior to the first launch.
- C. one set of GSE is required and is included in non-recurring costs. This set of GSE will be used for integration testing and checkout in Seattle and delivered to ETR eleven weeks prior to the first launch.
- The necessary "launch out plant" costs assume that for 6 launches at a rate of two per year the key people are sustained between launches. For 3 launches at a rate of one per year a new crew is trained for each launch. For a single Burner II, the Seattle checkout crew will be the launch crew.
- Spares support includes only the initial set. Component failure will require refurbishment or GFE replacement to maintain spares inventory.

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BURNER II CENTAUR INTEGRATION
EARTH ESCAPE MISSION

TOTAL - COST SUMMARY - 17 VEHICLES
(HRS & $ IN THOUSANDS)

	TE-M-364-2	TE-M-364-4
NONRECURRING		
DESIGN & TEST	$ 2,780	$ 2,780
GSE	310	310
TOOLING	140	140
ENCAPSULATION	50	50
RECURRING		
SPARES	700	700
AVE**	8,110	8,340
LAUNCH OUTPLANT	3,610	3,610
ENCAPSULATION	490	490
GSE	550	550
TOTAL NONRECURRING & RECURRING	$16,740	$16,970

- EQUIP. ETR SITE
- BUILD AND DELIVER 17 B-II UNITS
- LAUNCH 3/YR.

LEVEL 3 TASK	TE-M-364-2 CONFIG			TE-M-364-4 CONFIG		
	MANHOURS*			MANHOURS*		
	ENG	MFG	DOLLARS*	ENG	MFG	DOLLARS*
AVE	30	233	10,060	30	248	10,290
GSE	6	32	990	6	32	990
SYST INTEG & TEST	39	8	1,030	39	8	1,030
FLIGHT SUPPORT	83	88	4,310	83	88	4,310
PROGRAM MGMT	16	0	350	16	0	350
TOTAL	173	361	16,740	173	376	16,970

* NOTE - MANHOURS ARE NOT EQUIVALENT TO DOLLARS SINCE DOLLARS INCLUDE OTHER COSTS. (MATERIAL, TRAVEL, ETC.)

** - ROCKET MOTORS ASSUMED GFE

FIGURE 3-1

EARTH ESCAPE MISSION

(TE-M-364-2)

COST SUMMARY

TOTAL DOLLARS IN THOUSANDS

	17 BII UNITS LAUNCH 3/YR	6 BII UNITS LAUNCH 2/YR	3 BII UNITS LAUNCH 1/YR	1 BII UNIT LAUNCHED
NON-RECURRING				
DESIGN - TEST	2,780	2,780	2,780	2,780
GSE	310	310	310	310
TOOLING	140	140	140	140
ENCAPSULATION	50	50	50	50
RECURRING				
SPARES	700	*200	*200	*200
AGE **	8,110	2,880	1,740	620
LAUNCH OUT PLANT	3,610	1,632	1,032	230
ENCAPSULATION	490	168	114	48
GSE ***	550	-	-	-
TOTAL NON-RECURRING-RECURRING	16,740	8,160	6,366	4,378

* INITIAL SPARES SUPPORT (FAILURE WILL REQUIRE REFURBISH OR GFE REPLACEMENT)
** ROCKET MOTORS ARE GFE
*** FOR 1,3, AND 6 UNITS, IN-PLANT GSE DELIVERED TO ETR FOR LAUNCH SUPPORT

FIGURE 3-2

CENTAUR/BURNER II PROGRAM BREAKDOWN STRUCTURE

						ENGINEERING & DEVELOPMENTAL									PR..	.C	MANUFACTURING						FAC	FIN	MATERIEL						
						ELECTRONICS	MECH SYSTEMS	PROPULSION	SYSTEM INTEG & TEST	SYST ASSURANCE	SYSTEM TEST	GND BOARD DATA MGMT	PROG CONTROL		PROD PLANNING	QUAL CONTROL	FABRICATION	SUB ASSEMBLY & TEST	SYSTEM ASSY & TEST	REWORK	TOOLING	MFG SUPPORT	FACILITIES	FINANCE	TOOLING	PRODUCTION	PURCH EQUIP	OUTSIDE PRODUCTION	ENGINEERING SUPT		
TOTAL MISSION SYSTEM	BURNER II SPACE BOOSTER SYSTEM	AVE	SSEA	STRUCTURE & EQUIPT SUPPORT	01																										
				REACTION CONTROL	02																										
				GUIDANCE & CONTROL	03																										
				POWER & DISTRIBUTION	04																										
				TELEMETRY	05																										
				ORDNANCE	16																										
				PAYLOAD SUPPORT STRUCT	42																										
				SSEA A/T & DEL	09																										
			ROCKET MOTOR		13																										
			CENTAUR ADAPTER		41																										
		GSE	LAUNCH CONTROL & CHECKOUT EQUIPT		15																										
			HANDLING & TRANSP EQUIPT		16																										
			TEST FIXTURES		17																										
			R/C SERV EQUIPT		18																										
			LAUNCH FACIL MOD		19																										
		SYST INTEG INTER-FACES & TESTING	STRUCT & ENVIRON ANALYSIS		20																										
			SYST INTEG/SP. & DOCUMENTATION		21																										
			WEIGHTS & BALANCE		22																										
			PERF & ERROR ANAL		23																										
			FLIGHT DYNAMICS ANAL		24																										
			STATIC TEST		25																										
			EMI TEST		26																										
			POST FLIGHT ANALYSIS		27																										
			INTEGRATION TEST - INPLANT		28																										
			INTEGRATION TEST - OUTPLANT		29																										
		FLIGHT SUPPORT	FLD PROC/PLANS & REPORTS		30																										
			LAUNCH OPER/ OUTPLANT		31																										
			LAUNCH OPER/ INPLT SUPPORT		32																										
			FLIGHT READINESS REVIEW		33																										
		SYSTEM PROGRAM MGMT	RELIAB & SAFETY		34																										
			CONFIGURATION MGMT		35																										
			SPARES		36																										
			MAINTAINABILITY		37																										
			CHANGE BOARD		38																										
			DELIV READINESS REVIEW		39																										
			PROGRAM CONTROL		40																										

FIGURE 3-3

SHEET 3-4

4.0 SCHEDULES

Figure 4-1 is the summary schedule for performing the integration of Burner II with the Centaur/Titan launch vehicle in accordance with the ground rules contained in Section 2.0 of this document. The gross timing for each of the major elements of planned activity is reflected.

Figure 4-2 is a more detailed depiction of the planned integration testing.

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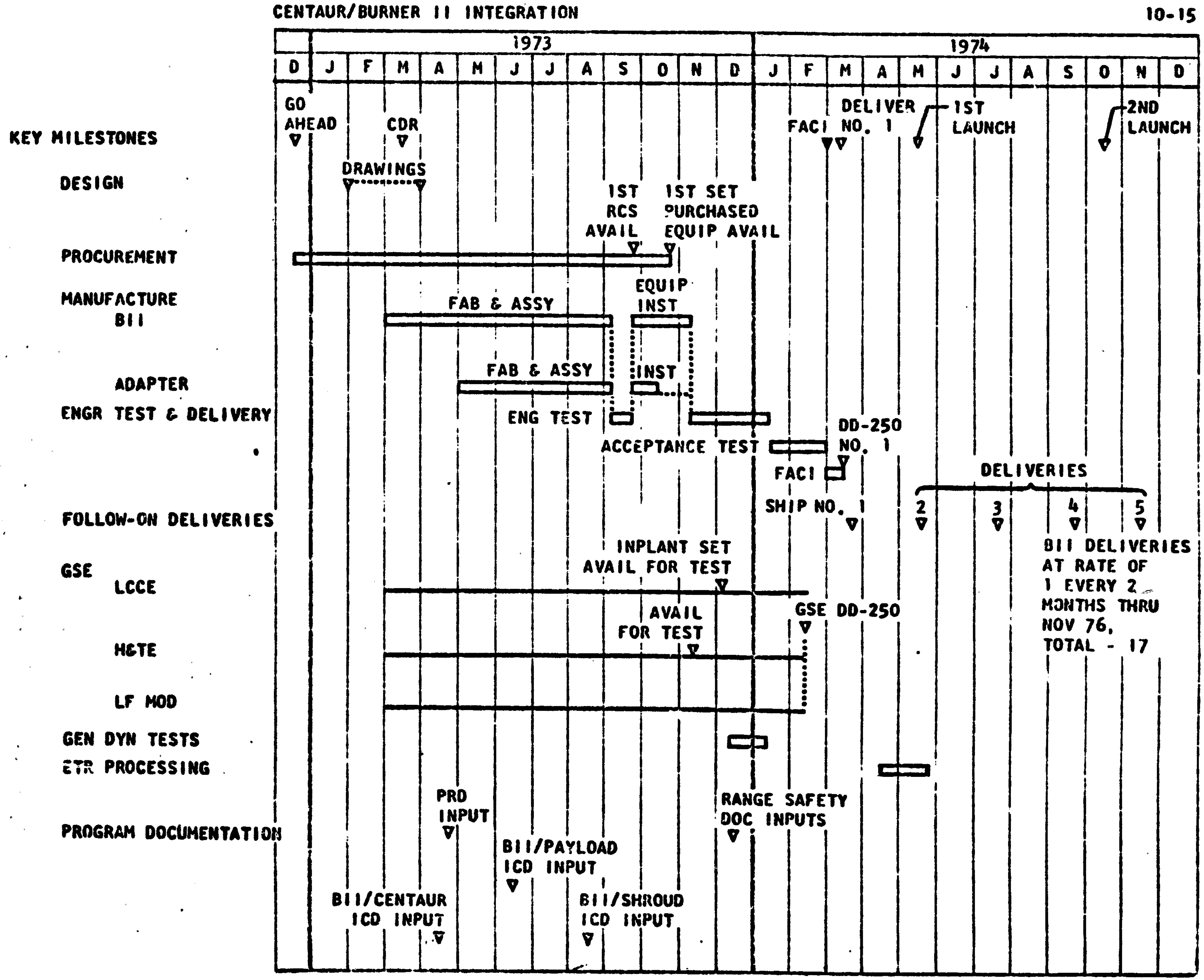

CENTAUR/BURNER II INTEGRATION
10-15
1973
1974
D J F M A M J J A S O N D J F M A M J J A S O N D
KEY MILESTONES
GO AHEAD
CDR
FACI
DELIVER NO. 1
1ST LAUNCH
2ND LAUNCH
DESIGN
DRAWINGS
1ST RCS AVAIL
1ST SET PURCHASED EQUIP AVAIL
PROCUREMENT
MANUFACTURE BII
FAB & ASSY
EQUIP INST
ADAPTER
FAB & ASSY
INST
ENGR TEST & DELIVERY
ENG TEST
ACCEPTANCE TEST
DD-250 NO. 1
FACI
SHIP NO. 1
DELIVERIES
2
3
4
5
FOLLOW-ON DELIVERIES
BII DELIVERIES AT RATE OF 1 EVERY 2 MONTHS THRU NOV 76, TOTAL - 17
GSE
LCCE
INPLANT SET AVAIL FOR TEST
H&TE
AVAIL FOR TEST
GSE DD-250
LF MOD
GEN DYN TESTS
ETR PROCESSING
PROGRAM DOCUMENTATION
PRD INPUT
BII/PAYLOAD ICD INPUT
BII/CENTAUR ICD INPUT
BII/SHROUD ICD INPUT
RANGE SAFETY DOC INPUTS

FIGURE 4-1

CENTAUR/BURNER II INTEGRATION
INTEGRATION TESTING

10-15

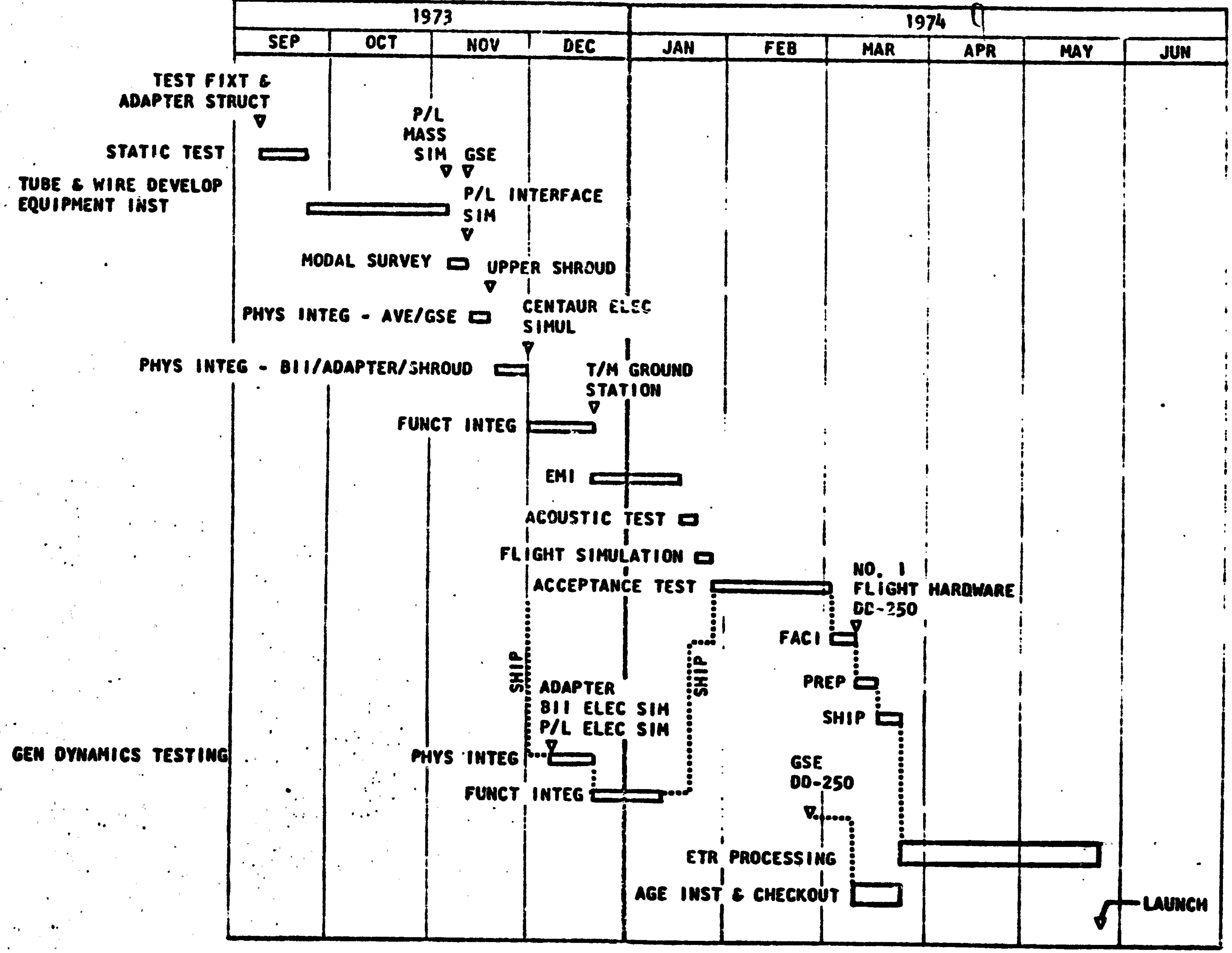

FIGURE 4-2

Appendix to D2-116103 - Volume II

Integration Plan - Burner II/Centaur Integration Study.

NOTE: **This information was previously submitted to NASA as Section I of D2-116082-5. Minor revisions and clarifications have been incorporated based on NASA comments at the 2nd Study Progress Review in early September. Revisions are noted with an "R" in the right margin.**

INTRODUCTION

In compliance with the Burner II Integration Study Contract NAS 3-11802, Exhibit "A", Statement of Work 111.K, Task 11, Item I, Study Plan, The Boeing Company has prepared in this document the Integration Plan as described in Task 10 of Document D2-116082-3, "Study Plan".

This Integration Plan presents the overall picture of the tasks required to actually accomplish the Burner II/Centaur integration for a generalized mission from the Titan complex at the Kennedy Space Center.

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INTEGRATION PLAN

GENERAL

The material presented in the Integration Plan is arranged to describe the Burner II to Centaur Integration. The tasks and responsibilities of the participants other than Boeing are treated in general terms while the Boeing tasks are treated in sufficient detail to provide a basis for cost estimation.

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1.0 MISSION DESCRIPTION

1.1 MISSIONS

a. Earth Escape Mission

b. Synchronous Equatorial Mission

1.2 GROUND RULES

a. On Earth Escape missions the Burner II fires immediately after the Centaur and an extended coast capability is not required.

b. For Synchronous Equatorial Missions the Burner II will have extended coast capability for the 5.5 hour coast to synchronous altitude. Burner II will provide the injection velocity for orbit circularization and plane change. Burner II will provide the attitude stabilization and required thermal maneuvers during coast to synchronous apogee.

2.0 RESPONSIBILITIES

The Boeing Company responsibilities will include:

- Responsibility for the Burner II Flight Stage including payload support;
- Responsibility for the Centaur to Burner II Adapter
- Responsibility for integration of the Spacecraft with Burner II
- Responsibility for Burner II AGE
- Providing Burner II Installation and Checkout Procedures
- Providing Burner II-to-Shroud Interface requirements to the Shroud Contractor.
- Providing the Burner II only Range Safety Documentation.

Interface coordination and participation in total program integration is defined in Section 3.

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3.0 INTEGRATION TASK SUMMARY

The tasks required to accomplish integration of the Burner II with the Titan/Centaur vehicle are summarized in this section. Primary emphasis is given to identification of interfaces between elements of the system and the contractor coordination through Lewis Research Center necessary to complete the tasks.

With operational status assumed for the Titan/Centaur/Shroud/ITL Complex, integration tasks for these elements are limited to providing or verifying compatibility with Burner II and the intended range of payloads and missions. The Boeing approach to integration is to make maximum utilization of existing Titan/Centaur hardware and software and minimize their modification. Thus, it is intended that existing interfaces will be preserved and, to the extent possible, that modifications to the Titan/Centaur system be limited to mission and payload requirements. Figures 3-1 and 3-2 reflect the elements of the integration task and the general operational concept.

3.1 TRAJECTORY AND GUIDANCE DEVELOPMENT

The steps that are required for trajectory and guidance development are shown in Figure 3-3. The organization responsibility for performing each step is indicated by the coding on each block in the diagram. Trajectory and guidance development will commence with a definition of the spacecraft and its mission requirements. Using performance weight statements and propulsion models of the launch vehicle trajectory optimization trades will be performed to establish the mission flight profile. The launch vehicle flight profile will be analyzed in two phases; 1) The Titan/Centaur flight using Centaur guidance, and 2) The Burner II flight having a separate guidance mode. For synchronous orbit missions the Titan/Centaur will be targeted to the Centaur burnout point at the perigee of the transfer ellipse. For escape missions the Titan/Centaur will be targeted to the Burner II startburn point. In each instance the Burner II will be targeted to the desired spacecraft trajectory. The mission sequence of events will define Centaur and Burner II coast times and any necessary modification requirements for extended coast.

A Titan/Centaur trajectory analysis will be performed to identify the general trajectory guidance programming required for each booster and any modifications to their guidance systems. A Titan/Centaur error analysis will be performed, followed by guidance equation development and a trajectory targeting analysis. The output of this analysis will be a Titan/Centaur covariance error matrix, the Burner II startburn window, constraints on the launch window, Range Safety tapes and final Titan/Centaur guidance constants.

The analyses of Burner II separation from Centaur and the spacecraft will define the separation control modes and their Guidance and Reaction Control system (RCS) requirements. The Burner II trajectory analysis will define the duration of the Burner II coast mode, the burnout vernier correction mode, if used, and injection timing. From these RCS, Guidance, Telemetry and power system design modification requirements will be identified as well as any consequent GSE design modifications. From the resulting Burner II design a final Burner II

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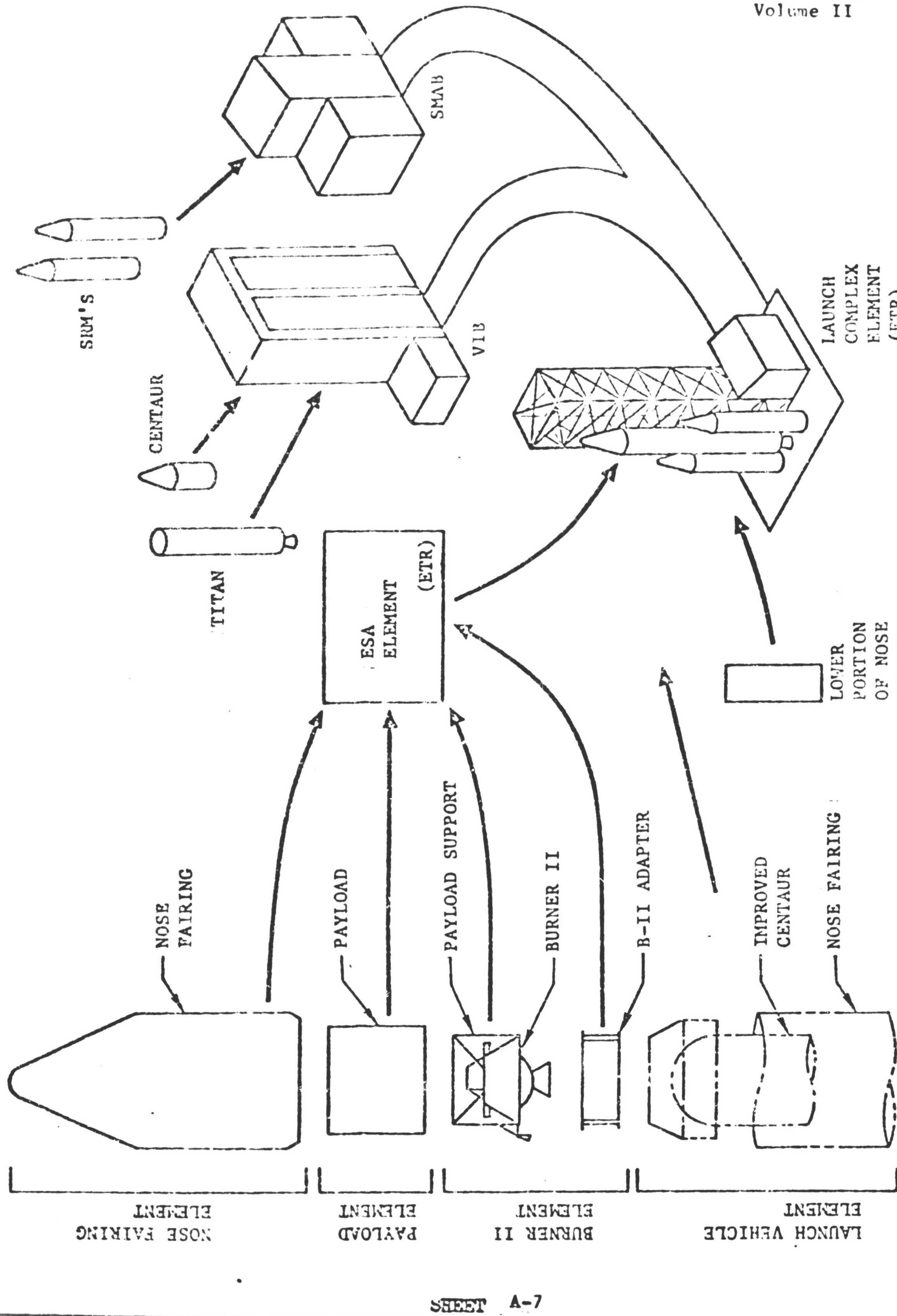

Figure 3-1 ELEMENTS of BII/CENTAUR/TITAN SYSTEM

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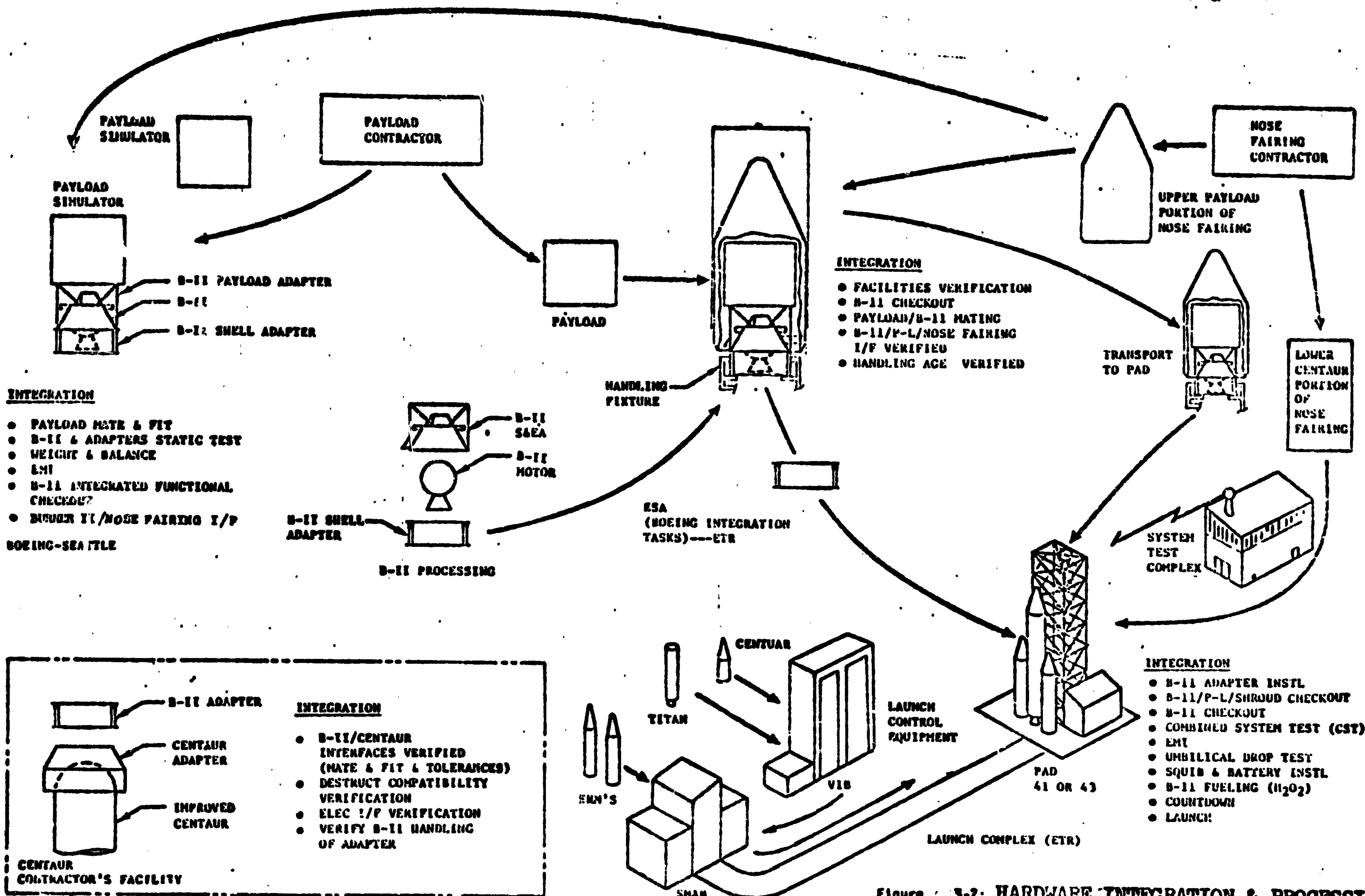

Figure 3-2: HARDWARE INTEGRATION & PROCESSING

weight and velocity model will be developed for the Titan/Centaur targeting analysis. A Burner II guidance equation development and targeting analysis will establish the final Burner II guidance constants and the spacecraft trajectory and its dispersions.

3.2 VEHICLE COMPATIBILITY VERIFICATION

As shown in Figure 3-4, verification of the structural integrity and control stability of the Titan/Centaur/Burner II vehicle during boost will require the combined effort of the vehicle contractors coordinated through Lewis Research Center. Burner II structural design will proceed from a preliminary estimate of boost loads and stiffness requirements for the Adapter/Burner II/payload structure.

A total vehicle bending modes analysis will be performed using a preliminary estimate of adapter/Burner II/payload structure mass and stiffness. The bending mode analysis will support a dynamic flight loads analysis and a Titan flight control stability analysis. The dynamic loads analysis will consider vehicle launch availability and be included in a total vehicle loads analysis which will establish structural requirements for each of the vehicle stages.

The bending modes analysis and the vehicle loads analysis will define the final adapter/Burner II/payload stiffness and loads requirements. These requirements will be verified with a static proof test and a modal survey test.

Design modification requirements for the upper portion of the shroud will be identified for Burner II and the payload and incorporated on the shroud Interface Control Drawing (ICD). Burner II and payload interfaces will be incorporated on the Centaur/Burner II ICD. The Centaur forward mechanical interface will be duplicated on the Burner II forward interface to maintain a common Centaur/payload interface with or without Burner II.

3.3 INTEGRATION TESTING.

Test activity to support integration of Burner II with the Titan/Centaur vehicle is shown in Figure 3-5, tests to be performed by Boeing in Seattle will include verifications of adapter/Burner II/payload structural strength and stiffness; general physical and functional integration testing of Burner II AVE and GSE design modifications and interfaces between the shroud, payload and Burner II; EMI testing and a complete flight simulation test of the Burner II; and a weight and balance test of the Burner II. The Burner II/Centaur adapter will be shipped to General Dynamics for physical and functional integration tests with the Centaur using Burner II/Centaur and payload/Centaur GSE simulators. These tests are described in Section 4 of the Integration Plan.

Integration testing at Kennedy Space Center will include Burner II/payload/upper shroud assembly and checkout in the Explosive Safe Area and total vehicle assembly, checkout and combined system compatibility testing on the launch pad. These tests will be described under the Study Tasks 7 and 8 and are summarized in Figure 3-5.

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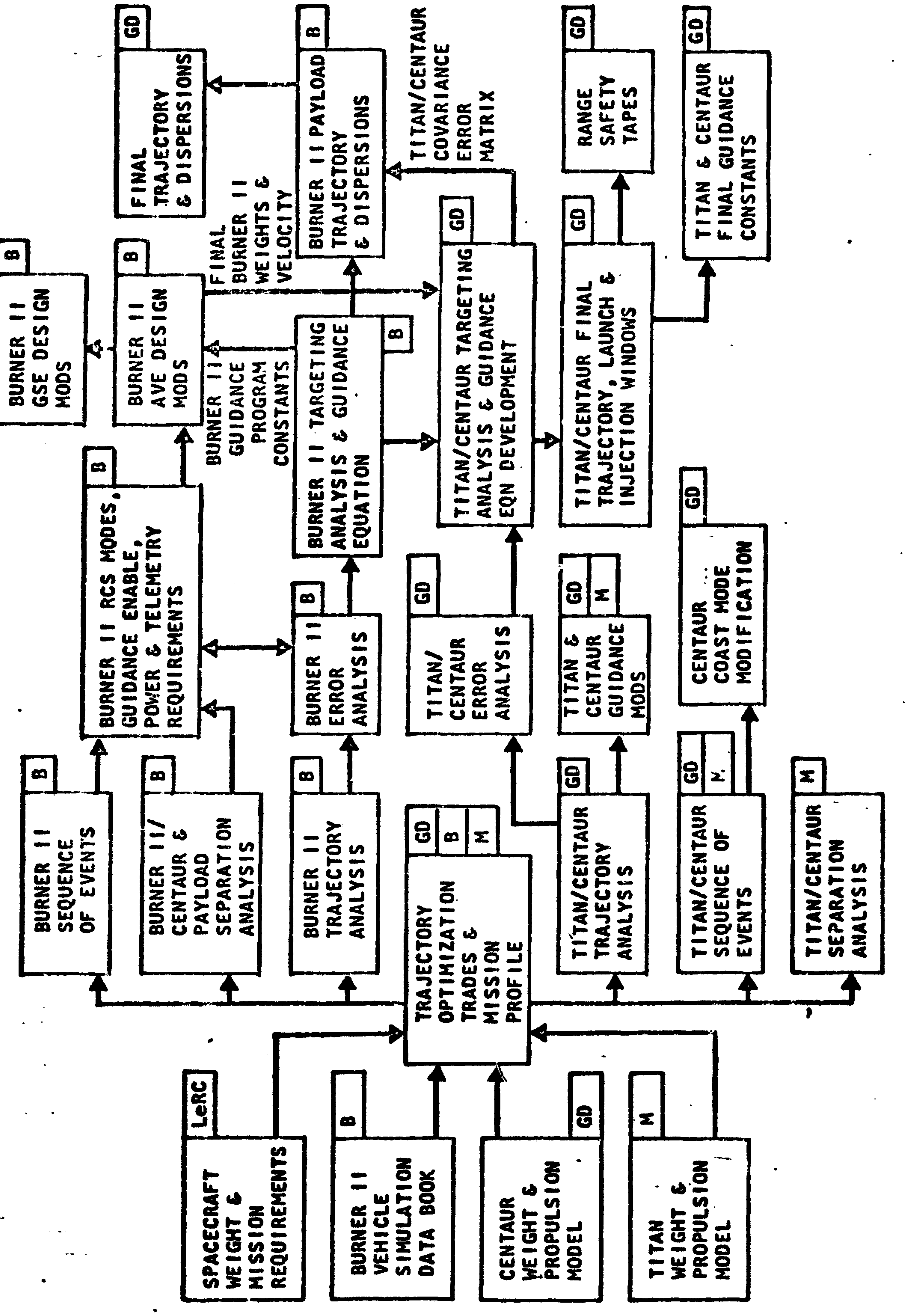

FIGURE 3-3: TRAJECTORY AND GUIDANCE DEVELOPMENT

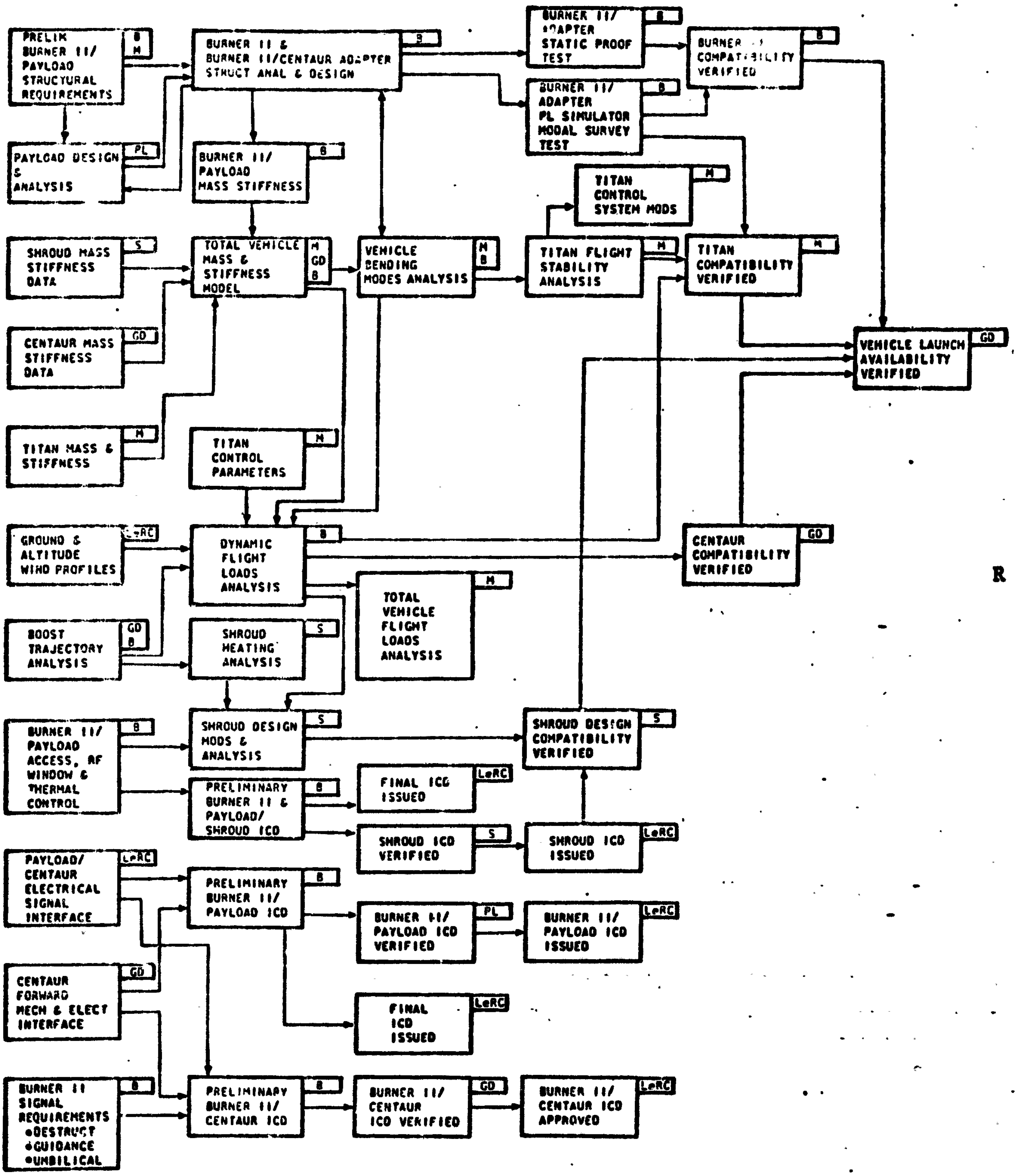

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FIGURE 3-4
LAUNCH VEHICLE STRUCTURAL INTEGRITY AND COMPATIBILITY VERIFICATION

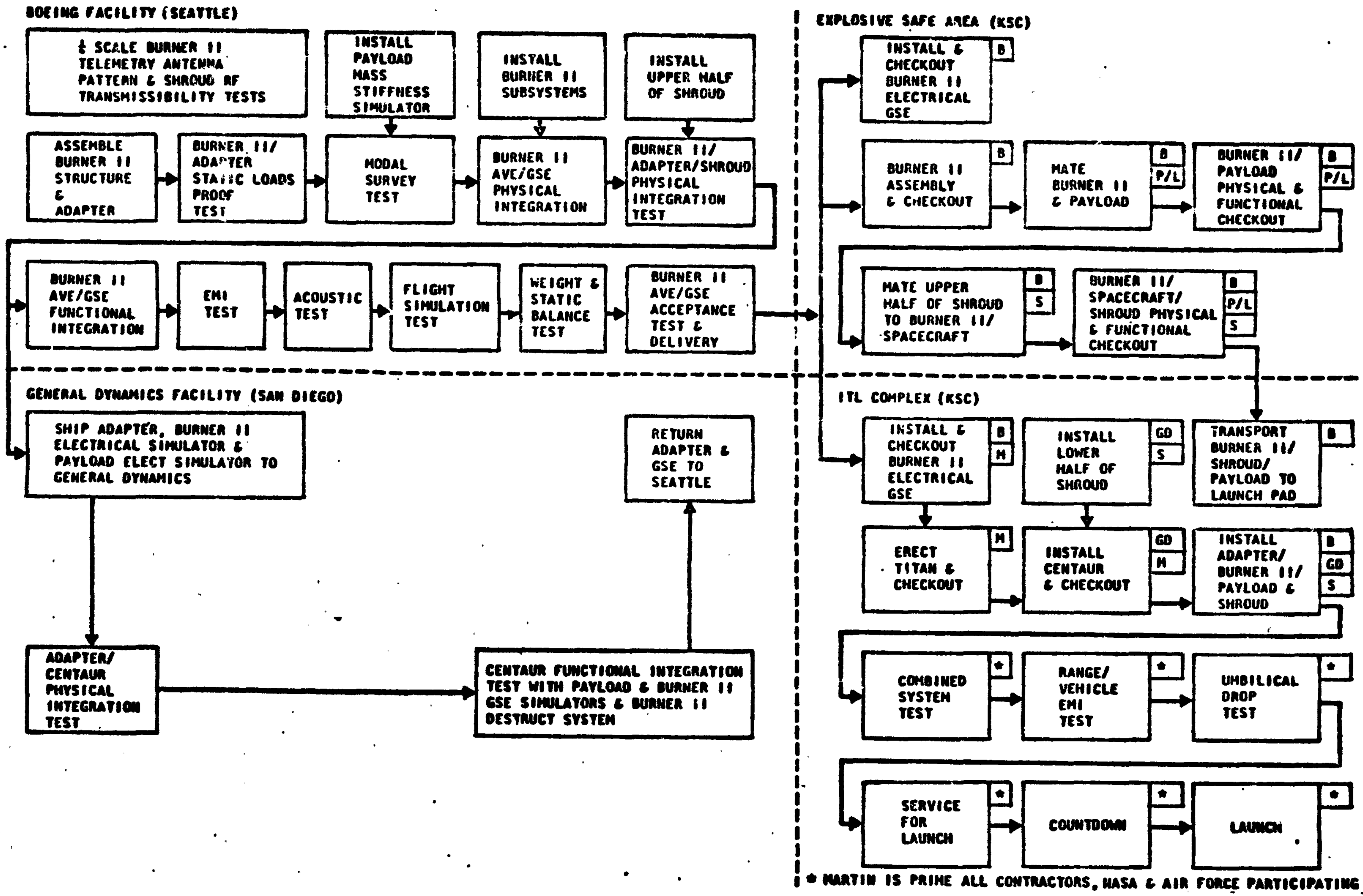

FIGURE 3-5: INTEGRATION TESTING (IDENTIFICATION OF BURNER II INTERFACES)

3.4 LAUNCH COMPLEX INTEGRATION

The launch complex integration task is summarized in Figure 3-6. Physical integration of Burner II with the ITL Complex will require definition and allotment of facilities to support Burner II GSE and operations. Items to be considered for physical integration include equipment installations, cable runs, umbilicals, work platforms, utilities, assembly and test areas, safety provisions and on-pad air conditioning. Launch facility interface requirements and interface and installation drawings will be entered into the ITL Complex configuration accounting system.

Integration of Burner II with the launch complex operations will be accomplished through working group meetings chaired by the NASA Launch Working Group at Kennedy Space Center. Through these meetings all field activities of launch vehicle contractors, NASA and the Air Force will be coordinated, integrated and scheduled. R

3.5 PROGRAM DOCUMENTATION

Basic Burner II program documentation has been developed for use at the AFWTR. This documentation, with revisions to reflect Centaur/Burner II integration design modifications, will generally satisfy the AFETR Documentation System and the Kennedy Space Center Documentation System requirements. The documentation required for a specific launch will be assembled by the launch vehicle contractor, General Dynamics, and submitted to the Air Force at ETR through KSC/ULO. Program documentation required to support a launch at ETR is indicated in Figure 3-7.

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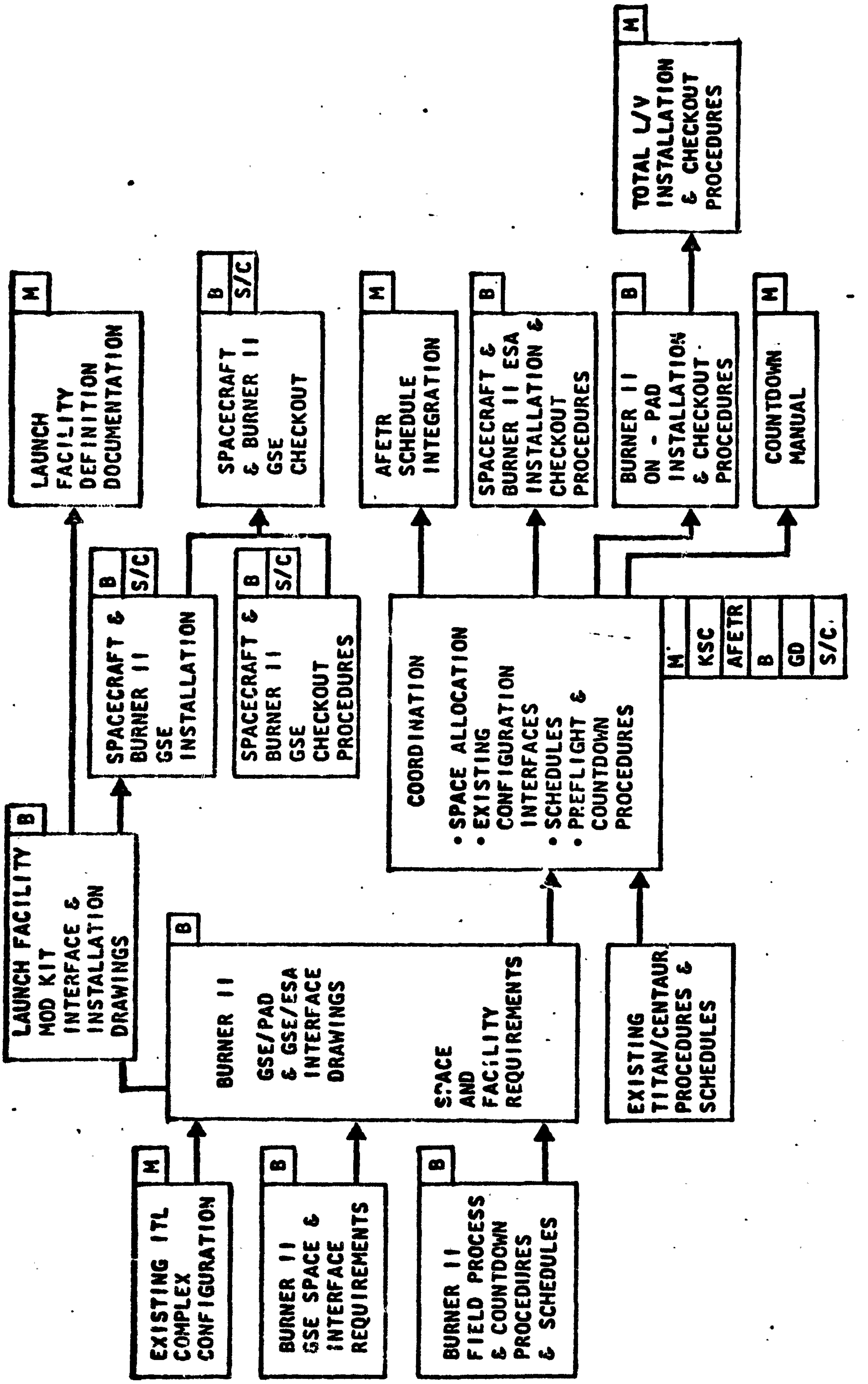

FIGURE 3-6: LAUNCH COMPLEX INTEGRATION

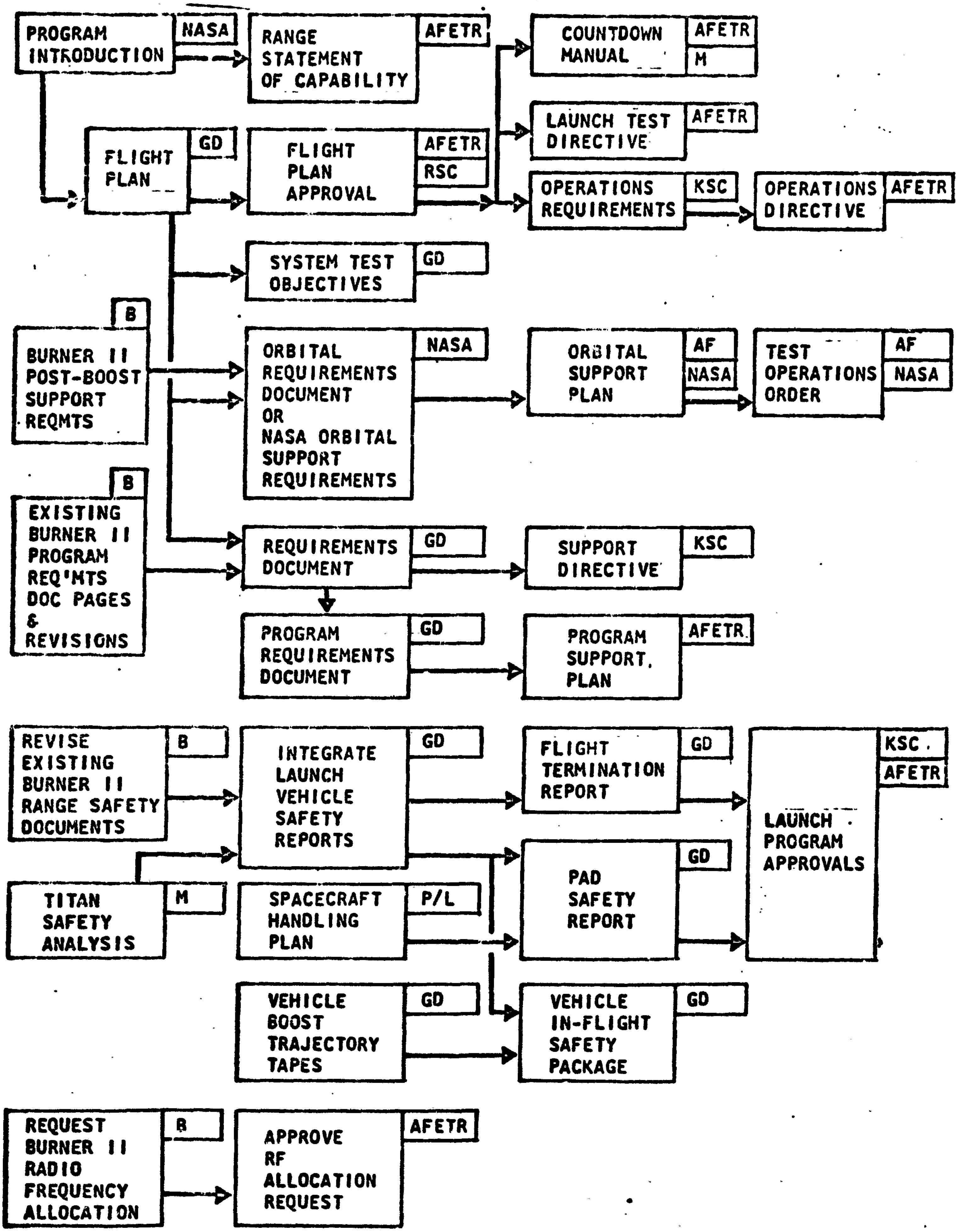

FIGURE 3-7: PROGRAM DOCUMENTATION

4.0 BOEING DESIGN ANALYSIS AND TESTING

This section will deal with the specific tasks that Boeing will accomplish for the integration of Burner II with the Improved Centaur. The tasks are described under the four headings of Design, Analysis, Testing, and Program Documentation.

4.1 DESIGN

The following hardware and/or systems will be designed to meet the requirements imposed by integrating Burner II with the Improved Centaur for Synchronous Equatorial and Planetary Missions.

4.1.1 Centaur to Burner II Adapter.

Boeing will design and fabricate an adapter combination similar in concept to that shown in Figure 4-1. The adapter will be capable of accommodating either the TE-364-2 Burner II or the TE-364-4 Burner II. The adapter will contain the Burner II destruct system, the Burner II separation system, and appropriate wiring. The adapter will be of semi-monocoque construction with aluminum and magnesium panels, ring stiffners, and 3 tapered longerons.

4.1.2 Burner II Stage Modifications

The design changes required in the Burner II flight stage involve flight systems and payload support structure. The flight systems requiring design changes are:

a. Electrical Power System:

- Add batteries to provide for 6 hour mission duration;
- Provide appropriate wiring for Centaur to Spacecraft and Burner II to spacecraft signals and appropriate interface connectors.

b. Telemetry System:

- Replace existing Telemetry transmitter with a higher power unit for synchronous altitude range
- Provide appropriate wiring

Burner II structural design modifications are required to accommodate a 2800 pound payload. A payload support concept similar to that shown in Figure 4-2 will be designed and fabricated to mate with the payload interface and provide adequate stiffness and load carrying capability. The inflight separation system for the payload shall not be part of the Boeing payload support structure.

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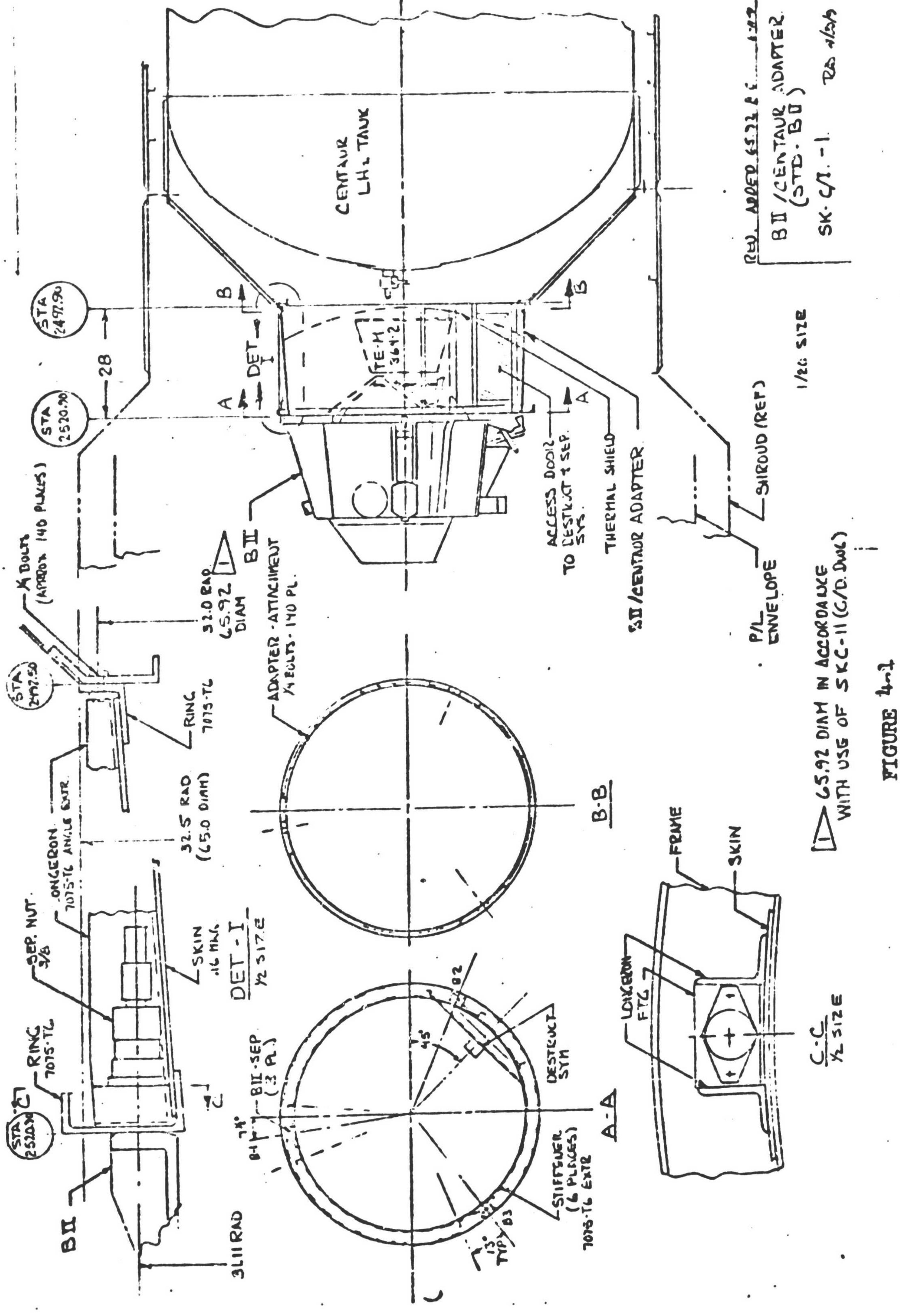

FIGURE 4-1

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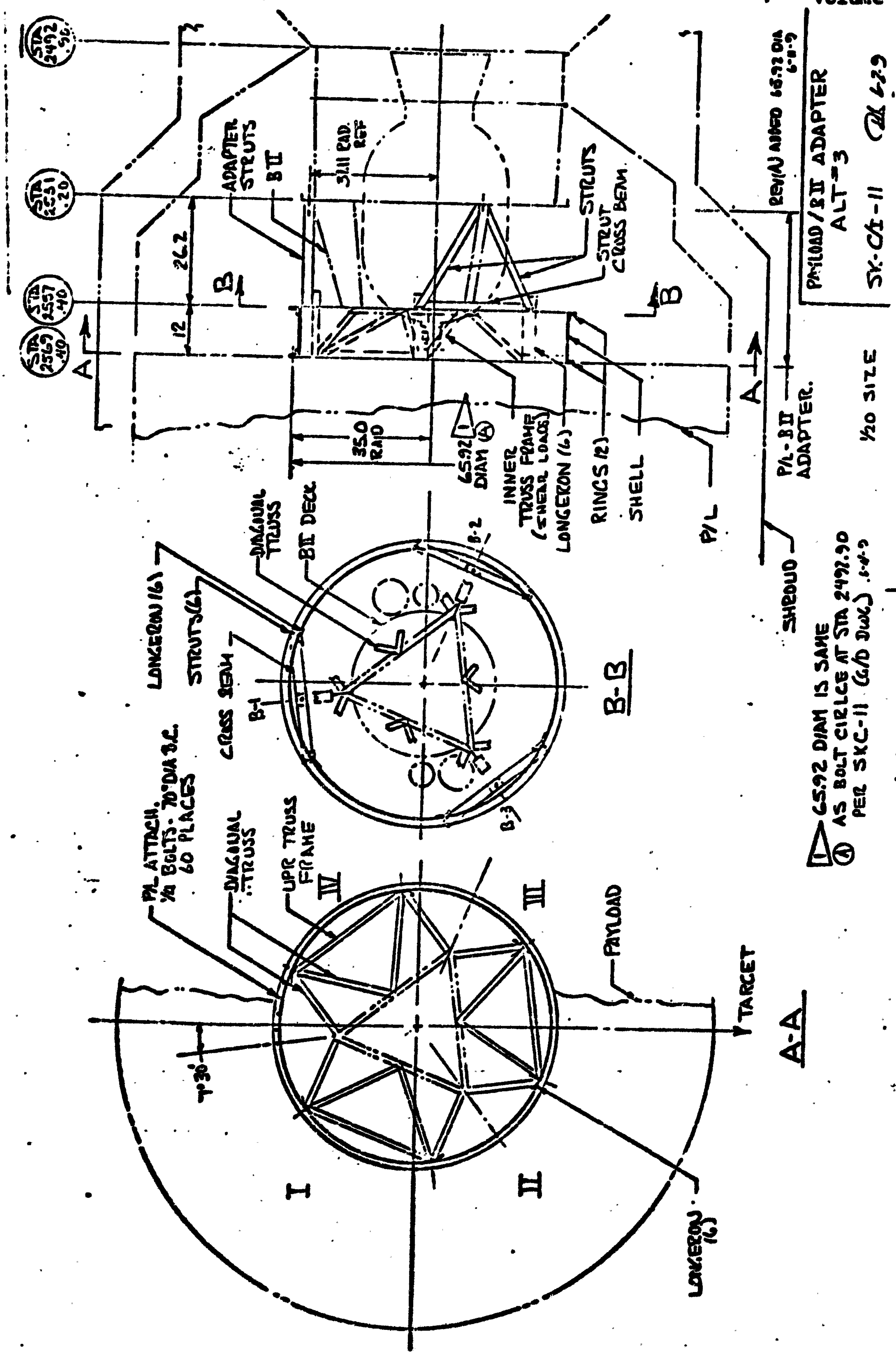
STA 2492.90
STA 2531.20
STA 2557.40
STA 2569.40
31.11 RAD. REF
ADAPTER STRUTS
B II
26.2
12
STRUTS
STRUT CROSS BEAM
REV(A) ADDED 65.92 DIA
PAYLOAD / B II ADAPTER
ALT-3
SK-CA-11
35.0 RAD
65.92 DIAM (A)
INNER TRUSS FRAME (SHEAR LOADS)
LONGERON (6)
RINGS (2)
SHELL
P/L
P/L - B II ADAPTER.
1/20 SIZE
SHROUD
B II DECK
DIAGONAL TRUSS
LONGERON (6)
STRUTS (6)
CROSS BEAM
B-1
B-2
B-3
B-B
P/L ATTACH. 1/2 BOLTS - 70" DIA B.C. 60 PLACES
DIAGONAL TRUSS
UPR TRUSS FRAME
PAYLOAD
TARGET
7°30'
I
II
III
IV
A-A
LONGERON (6)
(A) 65.92 DIAM IS SAME AS BOLT CIRCLE AT STA 2492.90 PER SKC-11 (G/D DWG.)

FIGURE 4-2

4.1.3 Burner II Mechanical AGE.

Additional Burner II mechanical AGE will be required for the processing operations associated with the payload encapsulation concept shown in Figure 4-3. The new mechanical AGE to de designed includes:

a. Shroud/Burner II/Payload handling sling with spreader bar;

b. Shroud/Burner II/Payload handling ring;

c. Shroud/Burner II/Payload transportater

d. Burner II/Clean Room cover;

e. Lift cable assemblies;

f. Miscellaneous Slings, hand tools, work platforms, and dollies.

4.1.4 Burner II Electrical AGE.

Additional Electrical AGE to be designed includes*:

a. A cable set;

b. Burner II/Centaur simulator;

c. Payload Simulator;

d. Squib simulator.

*NOTE: These items will be similar to existing Burner II AGE.

4.2 ENGINEERING ANALYSIS

The Engineering Analysis associated with integrating the Burner II with the Improved Centaur and a Spacecraft Payload are described here to provide scope, purpose and sufficient description for cost estimation.

4.2.1 Burner II Performance Analysis.

This analysis shall include all work done to identify the Burner II contribution to the mission payload capability and accuracy. A trajectory analysis will be conducted, within the mission constraints, to optimize and define the payload capability, determine the flight sequence-of-events, define Tital Mission accuracy and indicate any Range Safety inputs.

Payload capability will be defined with the aid of Centaur parametric performance data, at Burner II separation, that covers the range of mission alternatives. Mission alternatives include all the implications of the selected mission launch window.

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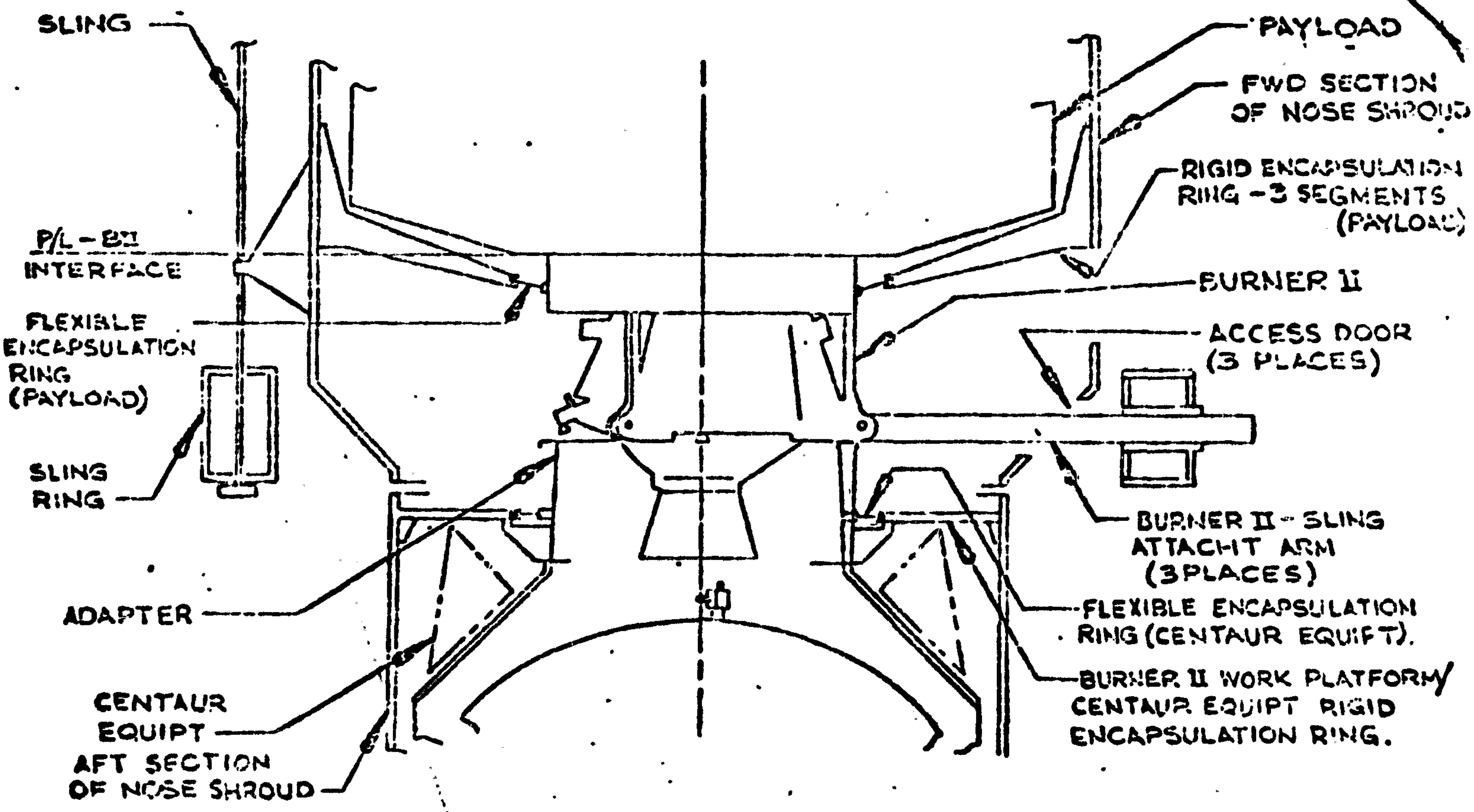
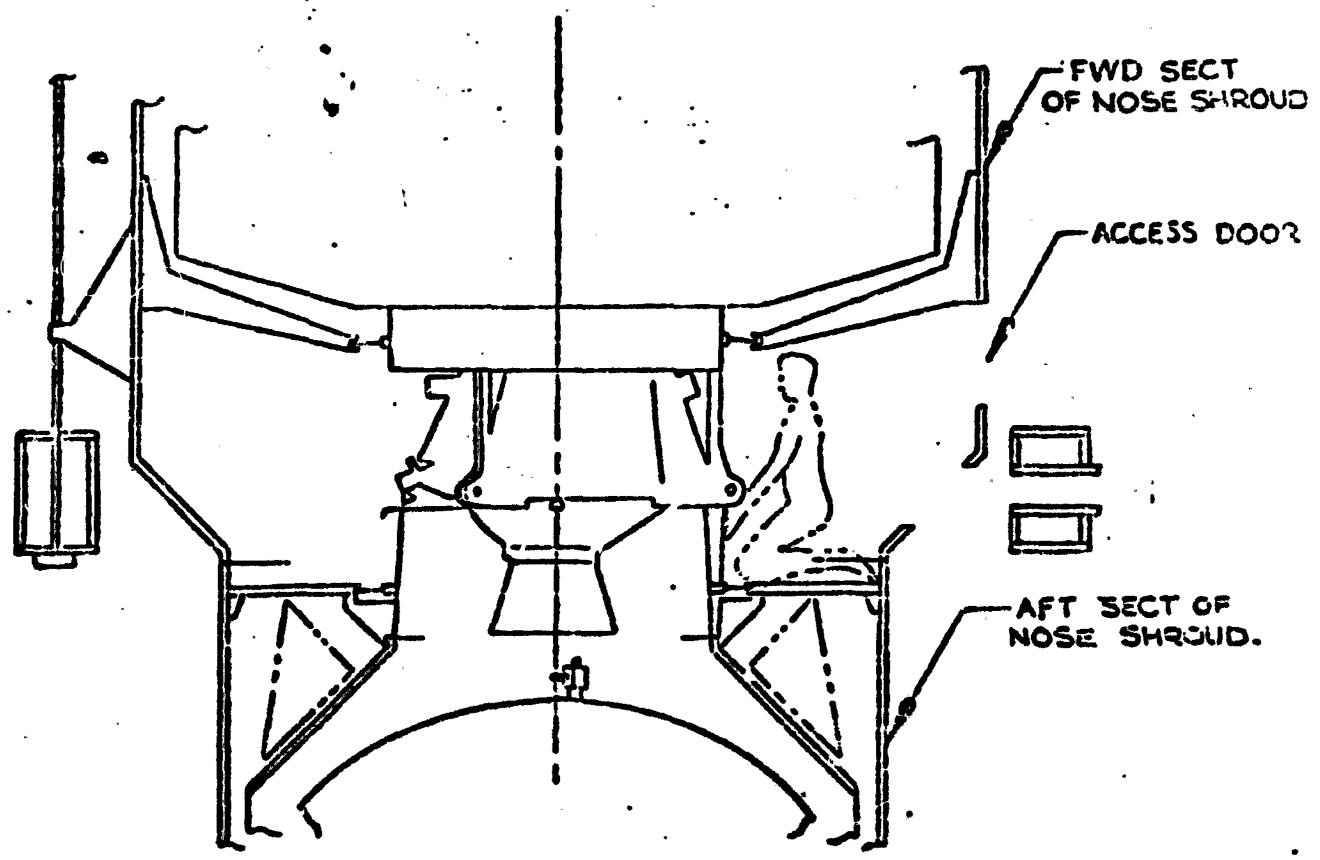


BURNER II AND PAYLOAD ATTACHED TO ADAPTER.
FWD SECT OF NOSE SHROUD SUSPENDED UNATTACHED.



BURNER II AND PAYLOAD ATTACHED TO ADAPTER.
FWD AND AFT SECTS OF NOSE SHROUD ATTACHED.

ENCAPSULATION CONCEPT — BURNER II WITH STD MTR (TE-M-364-2)

FIGURE 4-3

4.2.1 Burner II Performance Analysis (Continued)

The flight sequence-of-events will be defined to cover all events prior to and after Burner II separation that relate to the Burner II portion of the mission. Mission accuracy analyses will be developed for all mission alternatives with the aid of Centaur burnout position, velocity and attitude covariance matrices. These data will be combined with the Burner II errors to provide a state vector error covariance matrix at spacecraft separation.

The impact of the Burner II on Range Safety will be evaluated. This analysis will include all possible malfunction modes such as premature ignition or separation and the effect of destruct action.

Completion of these analyses are predicated on the adequate availability of necessary input data such as:

1. Booster performance during mission launch window;

2. Flight sequence-of-events for pre-Burner II portion of mission;

3. All accuracy analysis data for the boost stages that has implications on the mission accuracy.

4.2.2 Structural Analysis

The Structural Analysis for the integration of Burner II with the Improved Centaur will include the following:

a. Perform detailed strength and stiffness analysis of the payload support structure, Burner II structure, and the adapter structure.

b. Evaluate vibration environments for the payload and Burner II stage, and establish qualifying requirements for equipment components.

c. Perform Structural Analysis of ground handling equipment.

d. Verify qualification of equipment components.

e. Perform weight, cg, and inertia analysis.

f. Provide appropriate mass and stiffness data for the Payload/Burner II/ Adapter combination to the Launch Vehicle Integration Contractor for the Total Launch Vehicle Loads Analysis.

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4.2.3 Electrical System Analysis

An electrical load analysis will be performed for the Burner II vehicle when the mission time line analysis or total sequence-of-events becomes available. The analysis results will be used to select the size of the main battery and also the Telemetry battery from available space qualified cells and battery cases. Burner II operating time for specific missions i.e., six hours for the Synchronous Equatorial Mission or 1/2 hour for the Planetary Mission will have a direct and predominate effect on battery weight and vehicle weight and balance results.

An RF link analysis will be performed to provide requirements for the Telemetry transmitter power and antenna details. Specific ground tracking and communication facilities will be identified for the RF link analysis as appropriate for the mission involved.

An electromagnetic environment analysis will be made to determine sensitivity of Burner II Systems to the Launch Vehicle. This will be accomplished by RF coupling analysis, Burner II/Centaur Interface Signals Analysis, and a Grounding Analysis. The coupling data will be used to establish RF signal strength (at Burner II) which will be compared with previous Burner II EMI sensitivity data. The interface signal and grounding analysis will be used to locate potential compatibility problems and provide electrical interface design data.

4.2.4 Burner II Flight Dynamics Analysis

Analysis will be conducted to verify all aspects of flight dynamics for the Burner II/Payload combination. These analyses will include:

a. Separation Analysis of the Burner II/Centaur separation. This will be used to verify the separation clearances and separation rates as well as establish inputs to the mission accuracy analysis.

b. Separation Analysis of the Payload/Burner II separation. This analysis will verify the status of the payload in terms of attitude position, attitude rates, and separation environment.

c. Burner II Control System Analysis. This will verify the control system stability and performance for reaction control system requirements. The adequacy of thrust levels and of Flight Control Electronics compensation to provide stability margins and control during long coast periods will also be verified. This analysis will include a detailed evaluation of the "slow roll" technique as proposed for gyro drift cancellation during extended coast missions. Roll rates selected will be compatible with the thermal maneuver requirements as well as the gyro drift cancellation requirements.

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4.2.5 Burner II Thermal Analysis

A thermal analysis will be conducted to verify the Burner flight systems ability to operate during the six hour coast requirement for the Synchronous Equatorial Mission. The diurnal and seasonal variations inherent in the possible range of launch times, as well as the extended exposure times result in a more severe range of equipment environments. Continuous roll of the vehicle as proposed for guidance accuracy improvements will be particularly advantagious to the Thermal environment of the Burner II equipment.
No test program is anticipated and all thermal design support will be accomplished analytically. The existing analytical thermal model of Burner II will require updating to the proposed vehicle configuration. Roll rates for the "slow roll" during coast will be determined for best thermal results since the accuracy requirements for the "slow roll" maneuver can be achieved over a wide range of roll rates.

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4.3 TESTING

4.3.1 Introduction. The objectives of integration testing are as follows:

- Demonstrate compliance of AVE and GSE hardware with the quality assurance provisions of the System and CEI Specifications;
- Verify compatibility of Burner II subsystems with each other and compatibility of the Burner II system with its interfacing system;
- Verify, by test, the design and engineering analyses used to develop the Burner II AVE;
- Validate the Burner II Acceptance Test and field processing procedures;
- Integrate and checkout the total launch vehicle/payload/Range system to a point of readiness for countdown and launch.

All testing will be conducted on flight hardware. No qualification testing will be done on non-structural components unless such components have not been qualified by prior use, similarity, etc. No reliability testing will be done for the purpose of measuring or improving system reliability; however, any test malfunctions or failures will be evaluated for possible implications to system reliability.

To the maximum extent possible, integration testing will be conducted in series with normal assembly of the Burner II stage. This approach has the following advantages:

- Hardware assemblies will be tested as soon as they become available, providing a maximum of time for any required retest or corrective action;
- Engineering and evaluation test set-up and tear-down will be minimized for a low cost test program.

4.3.2 Boeing Phase I Testing. The following tests will be accomplished at the Boeing Space Center, Seattle:

4.3.2.1 Static Loads Test. A proof load test of the combined Burner II Structure and Equipment Assembly and adapter structure will be performed to demonstrate its structural integrity and verify its stiffness. The adapter will be mounted on a base support test fixture and loads will be applied through the Structure and Equipment Assembly payload support interfaces and rocket motor through loading fixtures. The loads will be applied at 110 percent of the predicted maximum about two perpendicular axes for critical lateral load conditions and for the critical combination of axial and lateral acceleration conditions. Instrumentation will be installed to define stresses at critical locations and to accurately define the structural deflection characteristics.

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4.3.2.2 Modal Survey Test. Since the Titan/Centaur/Burner II vehicle is expected to carry payloads having a variety of structural characteristics a precise knowledge of the Burner II Structure and Equipment Assembly/adapter structural stiffness parameters and major resonances would be valuable for defining total vehicle structure - control system dynamic coupling limitations. The modal survey test will provide this knowledge through measurement of structural mode shapes and frequencies. Structure and Equipment assembly and adapter used in the static load test will be mounted on the static test base support fixture and small shakers will be used to excite the test article. Actual equipment components or mass simulated components will be installed on the S&EA and a payload simulator, having the largest, highest center-of-gravity mass anticipated, will be attached to the Structure and Equipment Assembly payload support. The structure will be instrumented with accelerometers so that when the vibrator sweeps through the natural structural frequencies the mode shapes can be determined.

4.3.2.3 Physical Integration Test. A test will be performed to verify the physical compatibility of new and existing Burner II AVE and GSE, the adapter, the payload interface, the payload-to-Centaur cable and the upper portion of the shroud. The test will also be used to validate in-plant and field assembly and processing procedures. Equipment required will include the Burner II AVE, GSE for handling and transportation (H&T) and Launch Control and Checkout (LCCE), the adapter, the upper portion of the shroud, the base support test fixture and payload structural interface simulator used will be inspected for fit. The shroud interfaces will be tested for encapsulation fit, shroud clearances and accessibility through doors. Electrical connectors will be mated for fit check.

4.3.2.4 Functional Integration Test. Following the physical integration test the shroud will be removed and tests will be performed to verify functional interfaces between the Burner II AVE, the adapter and the Burner II electrical GSE. Success of this test requires that all Burner II subsystems perform all modes of operation when operating concurrently with all other subsystems. All instrumentation requirements are contained in the Burner II electrical GSE which will be calibrated before the test. The GSE will include a Centaur interface electrical simulator. No reaction control fluids or ordnance devices will be used.

4.3.2.5 EMI Test. A Burner II System Level Test will be performed to verify (1) Electromagnetic Compatibility (EMC) of AVE and GSE subsystems, (2) Interference introducted by the payload, Centaur, the payload-to-Centaur cable and the Range is within acceptable limits, and (3) EMC of the new Burner II telemetry subsystem. The test configuration will be the same as for the Functional Integration test except that a telemetry ground station will also be required and electrical simulators to operate the payload-to-Centaur cable. Instrumentation will include oscilloscopes and tape recorders to monitor and identify the nature of interference signals and equipment to simulate the signals a higher noise level. The interference signature at critical test points will be recorded and reinjected into the Burner II at a six decibel higher level. The Burner II AVE will be required to operate without unacceptable response or malfunction through all flight functions in the simulated environment. The known payload, Centaur and Range RF environments will be simulated during this test.

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4.3.2.6 Flight Control Simulation Test. A test will be performed on the Burner II Guidance and Control (G&C) subsystem to verify attitude control stability and reaction control subsystem nitrogen capacity. An analog simulation of vehicle control dynamics will be used to operate the G&C subsystem in a closed loop test for compatibility and stability. An analog computer will be required to input signals developed from an analog flight control simulation analysis. All modes of Burner II flight will be simulated.

4.3.2.7 Antenna Test. Quarter scale tests will be performed on the Burner II telemetry system to establish optimum antenna location, determine antenna radiation patterns and verify the location and sizing of RF window slots in the vehicle shroud. A shroud simulator and RF radiation measuring instrumentation will be required in addition to a telemetry system RF output simulator.

4.3.2.8 Acoustic Test. An acoustic test will be performed on the Burner II stage to ensure the equipment will withstand the Titan sound pressure levels. R
A Burner II stage will be placed in a reverberation chamber and subjected to the 145 db overall qualification spectrum. Vibration response of equipment will be measured and compared to qualification levels.

4.3.2.9 Acceptance Test. Acceptance tests will be conducted on Burner II AVE and GSE to show compliance with the quality assurance provisions of the applicable CEI Specifications. These tests will include a flight simulation test and a weight and balance test to determine flight weight and verify center of gravity and interface concentricity and parallelism.

4.3.3 General Dynamics Phase I Testing. The following tests will be accomplished at General Dynamics/Convair, San Diego:

4.3.3.1 Physical Integration Test. A test will be performed to verify the physical compatibility of the Burner II/Centaur Adapter with the Centaur forward interface, the Burner II/Centaur interface electrical connectors and the payload-to-Centaur cable electrical connectors. The adapter, Burner II electrical simulator and payload electrical simulator will be shipped to General Dynamics from Boeing.

4.3.3.2 Functional Integration Testing. Following the physical integration test, Centaur electrical signal interfaces with Burner II and the payload will be conducted using Burner II and payload electrical simulators hooked up with the Centaur interface connectors. The Burner II destruct subsystem interface with the Centaur Command Destruct Subsystem will be verified with an inert destruct subsystem in the adapter. The test support equipment will be returned to Boeing after completion of the test.

4.3.4 Installation and Checkout Testing. The Installation and Checkout type testing to be required at the launch facility is summarized in Figure 3-5. Details of this testing will be developed in Task 7 and 3 of the Integration Study. Overall field processing sequences will be developed to identify the space, equipment and test materials required.

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4.4 PROGRAM DOCUMENTATION

The following paragraphs describe documentation that will be developed by Boeing to support the Centaur/Burner II integration effort. A large part of this documentation will consist of revisions to existing Burner II documentation to reflect changes in Burner II design and interfaces and to reflect NASA requirements. These existing documents have been identified in parenthesis as appropriate.

4.4.1 Range Documentation. A complete set of Burner II system Range documentation has been prepared to support AFWTR launch programs. Over thirty pages of the Program Requirements Document will require Burner II system inputs. Range Safety documentation will be revised to reflect changes in Burner II design, particularly as related to the Burner II/Centaur Command destruct interface. Existing Burner II Range Safety documentation is contained in the following documents:

- Flight Termination System Report (D2-82675-3)
- Missile In-Flight Safety Report (D2-82675-2)
- Pad Safety Report (D2-82675-1)

Appropriate Air Force or NASA documentation will be required for Burner II telemetry data recovery beyond the confines of the AFETR telemetry receiving stations.

4.4.2 Field Procedures. A series of Burner II documents (D2-82659) have been prepared containing the Installation and Checkout (I&C) and Countdown procedures for field processing of the Burner II system. This document series describes the following Burner II activities.

- GSE Installation and Checkout
- Off-Pad Installation and Checkout
- On-Pad Installation and Checkout
- Countdown Manual Inputs

These documents will be revised as necessary for compatibility with total Titan/Centaur/Spacecraft/ITL Complex operations. Boeing responsibility for integration of the Spacecraft with Burner II will require integration of Burner II and Spacecraft plans and procedures for ESA I&C activities.

4.4.3 Specifications. The acquisiton of a new hardware system by NASA would ordinarily include development of new System and CEI Specifications. However, since a complete set of Burner II specifications have been prepared in accordance with AFSCM 375-1 and because of the similarities of the NASA NPC 500-1 to AFSCM 375-1 it is considered most cost effective to revise the existing specifications.

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4.4.4 Interface Control Drawings. Burner II system ICD's with Centaur, the shroud and the payload will include all pertinent physical and functional interfaces including, as applicable, alignment, attachment, separation, electrical, EMI, environmental, performance and clearance provisions and responsibilities The development of this type of ICD requires coordination with and approval from associate contractors and the corresponding NASA organizations.

The Burner II GSE ICD with the launch facility will include installed electrical equipment space, protection and utility requirements, cable installations, service tower break-out box locations and air conditioning requirements.

4.4.5 Quality Assurance Plan. The Quality Assurance Plan currently followed for the Burner II/Burner IIA Program contained in the Technical Proposal D2-116099-3, will be used for the Burner II/Centaur Program. This plan has been reviewed for compliance with the requirements and provisions of the NASA publication NPC-200-2, "Quality Program Provisions for Space System Subcontractors and it has been determined that it complies with the requirements and intent of NPC-200-2, with one exception: The Burner II Quality Assurance Plan does not provide for traceability to the extent specified in NPC-200-2, as it has not been an Air Force requirement. However, Boeing has provided Traceability, in compliance with NPC-200-2, on other NASA Programs, and has the capability to provide it for Burner II, per the Boeing Integrated Record System.

Traceability to the extent specified in NPC-200-2 is not considered cost effective for the Burner II/Centaur Program. The Burner II procedure provides traceability at the equipment level, i.e., assembly records provide equipment serialized records. These manufacturing records will be used in determining the hardware affected by Suspect Material Deficiencies. R

4.4.6 Reliability Plan. The Reliability Program Plan currently used for the Burner II/Burner IIA Progrem (Document D2-82600-24) will be used for the Burner II/Centaur Program, with no proposed major change in scope. A revision to the document will be required, to provide for possible differences in customer reporting requirements, for contract documentation and other reference changes, and for changes in reliability numerical requirements due to design, interfaces, environment and mission profile differences.

The Burner II/Burner IIA Reliability Program Plan has been reviewed for compliance with the requirements and provisions of the NASA's Publication NPC-250-1, "Reliability Program Provisions for Space System Subcontractors", and it has been determined that it complies with the requirements and intent of NPC-250-1, with the following few exceptions:

A. Section 2.5 *"Reliability Indoctrination and Training". The Burner II Program has currently no formal provisions for this training, as the program has been in existence over four years, and the personnel participating in the program are skilled in the reliability assurance procedures employed by The Boeing Company, which comply with the NASA requirements.

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*All sections references are of NPC-250-1

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4.4.6 (Continued)

B. Section 3.0, "Parts and Materials Program"
As Burner II is a mature system, with equipment flight proven during eight successful flights, and from other programs, a complete parts and materials selection program is not applicable; however, parts and materials application and control will be implemented for any required design modifications, in accordance with the Reliability Program Plan.

C. Section 3.10 "Equipment Logs"
Current Burner II requirements do not include Equipment Logs for all equipment, below the Spacecraft level. It is noted, however, that the principal elements of this section are included in the data packages for all CEI level equipment, and that The Boeing Company's "Integrated Records System", can accommodate the requirements of Section 3.10 if they are found desirable for Burner II. At present, the need for detailed equipment logs is not envisioned.

D. Section 4.0 "Test and Evaluation"
All elements of this section, except the Reliability Demonstration Test (RDT) are currently required on the Burner II program. As Burner II is a flight proven system, no RDT is planned for the Burner II/Centaur Program.

E. Section 5.0 "Documentation"
Current Burner II reliability reporting requirements, include a monthly report of status of failures and corrective actions, and a quarterly report of reliability program element implementation status. The extent of this reporting is considered consistent with the magnitude and scope of the Burner II/Centaur Program, and weekly Summary Reports, as required by NPC-250-1, are not presently proposed.

It is noted that Boeing has successfully participated in other NASA Space Programs and has complied with all NASA reliability requirements. Compliance with NPC-250-1 in the Burner II/Centaur Program will be as defined in the revised Reliability Program Plan.

4.4.7 Safety Plan. The System Safety Engineering Plan currently used for the Burner II/Burner IIA Program (Document D2-82600-16) will be used for the Burner II/Centaur Program, revised for an increase in scope to include Safety consideration for Boeing personnel operations at ETR and changes for differences in Test Range Safety requirements (AFETR vs AFWTR).

The Safety Plan will also require minor revisions to references of contractual and USAF Safety documentation, for concurrence with the Burner II/Centaur Program. The current scope of the Safety Analyses specified in the Safety Plan, which include a System Hazard and an Operating Safety Analysis, broadened to encompass the Boeing Integration Task, is considered adequate for the Burner II/Centaur Program.

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4.4.8 Maintenance Plan. The maintenance concept will be similar to that for the basic Air Force Burner II Program, except that all maintenance will be performed by the Contractor. Field-level maintenance will be limited to "remove-and-replace" of individual units. Component repair will be performed at the Contractor's plant. A complete set of spares will be supplied at ETR. Repair cost pricing will be based on Burner II experience at WTR. A Maintenance Plan will be prepared.

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