

university of alabama in huntsville
saturn history
10 | 3 | 68

CREW BRIEFING IU STAGE

SATURN HISTORY DOCUMENT
University of Alabama in Huntsville
History of Science & Technology Group
Date: _____

XIII.4
1968



OCT 3 1968

CREW BRIEFING
INSTRUMENT UNIT STAGE PRESENTATION

— IBM
Huntsville

INTRODUCTION

INSTRUMENT UNIT

GUIDANCE

ATTITUDE CONTROL

INSTRUMENTATION, TRACKING & COMMAND

ELECTRICAL

ENVIRONMENTAL CONTROL

STRUCTURAL

IU TEST HISTORY AND STATUS

IU RELIABILITY

IU CHANGE STATUS & SCHEDULE

IU EXPECTED LIFETIME

ORBITAL "SAFING" STATUS UPDATE

VEHICLE INTERLOCKS

GROUND REQUEST ABORT LOOP

PRELAUNCH

C. H. GRACE

E. W. SMYTHE

G. V. DOOLITTLE

F. G. KILMER

L. M. OVERHULTZ

J. E. LUNDBERG

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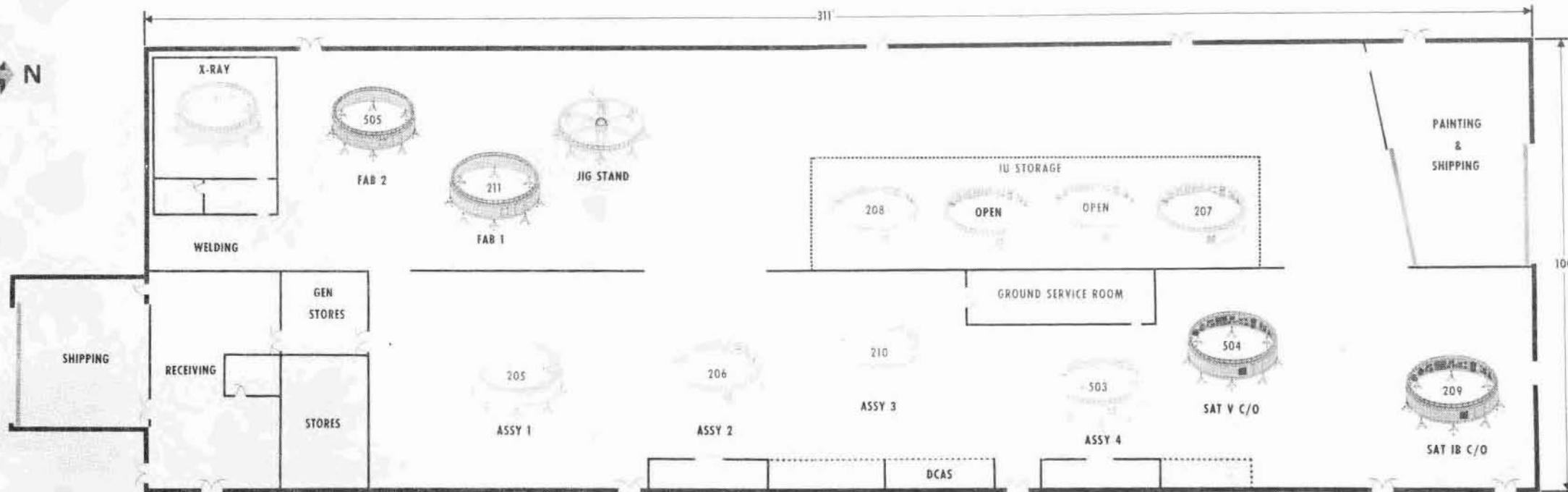
J. W. GLASS

C. C. HAGOOD

OPEN DISCUSSION

SATURN HISTORY DOCUMENT
University of Alabama Research Institute
History of Science & Technology Group
Date: _____ Doc # _____

INSTRUMENT UNIT



FAB STAND 1 VERTICAL INTERFACE PREPARATION

ALIGN, DRILL, ROUT, INSTALL INSERTS, POT.

ANTENNA HOLE PREPARATION

LOCATE, DRILL, ROUT, INSTALL INSERTS, POT.

ST-124 MOUNTING FRAME AND ACCELEROMETER PADS

OPTICALLY ALIGN, MACHINE, INSTALL EPOXY PAD AND VIBRATION DAMPENERS.

FORWARD INTERFACE PREPARATION

DRILL, ROUT, POT, INSTALL FORWARD PROTECTIVE RING

FAB STAND 2 AFT INTERFACE PREPARATION

DRILL, ROUT, POT, PAINT TOUCHUP, INSTALL AFT PROTECTIVE RING.

ASSEMBLY STANDS - IU ASSEMBLY SHIPMENT/STORAGE PREPARATION

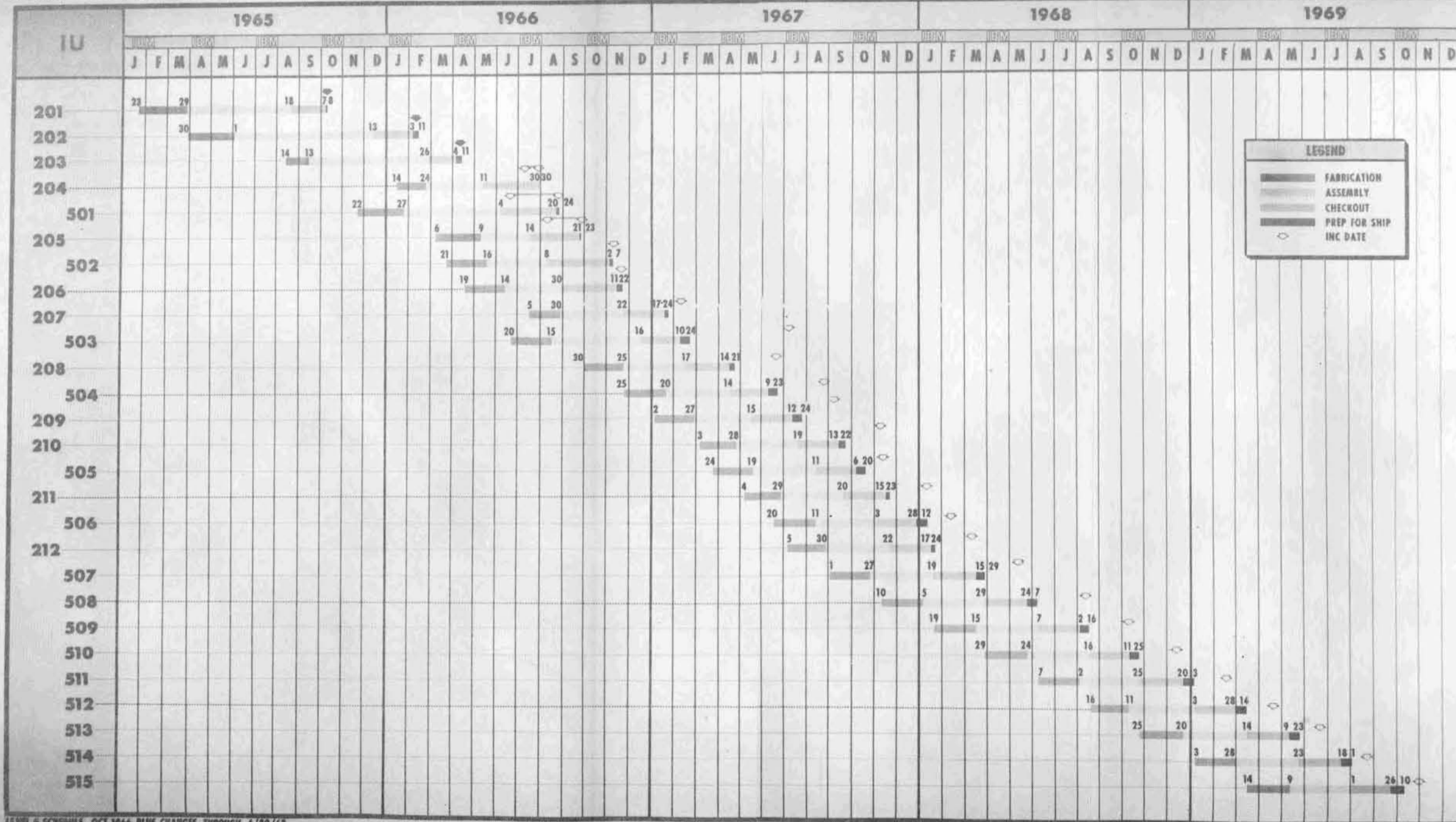
INSTALL CABLE TRAY, MANIFOLDS, COLD PLATES, COMPONENTS, CABLES. PERFORM MEGGER, END ITEM THRU UMBILICAL, AND PRELIMINARY W/M SYSTEM LEAK TEST.

CHECKOUT STANDS - LEAK AND SYSTEM TESTING

RUN W/M AND GN₂ SYSTEM LEAK TESTS. PERFORM SYSTEMS TEST ACTIVITIES

IBM INSTRUMENT UNIT MASTER PHASING SCHEDULE

C. H. GRACE PROGRAM MANAGER

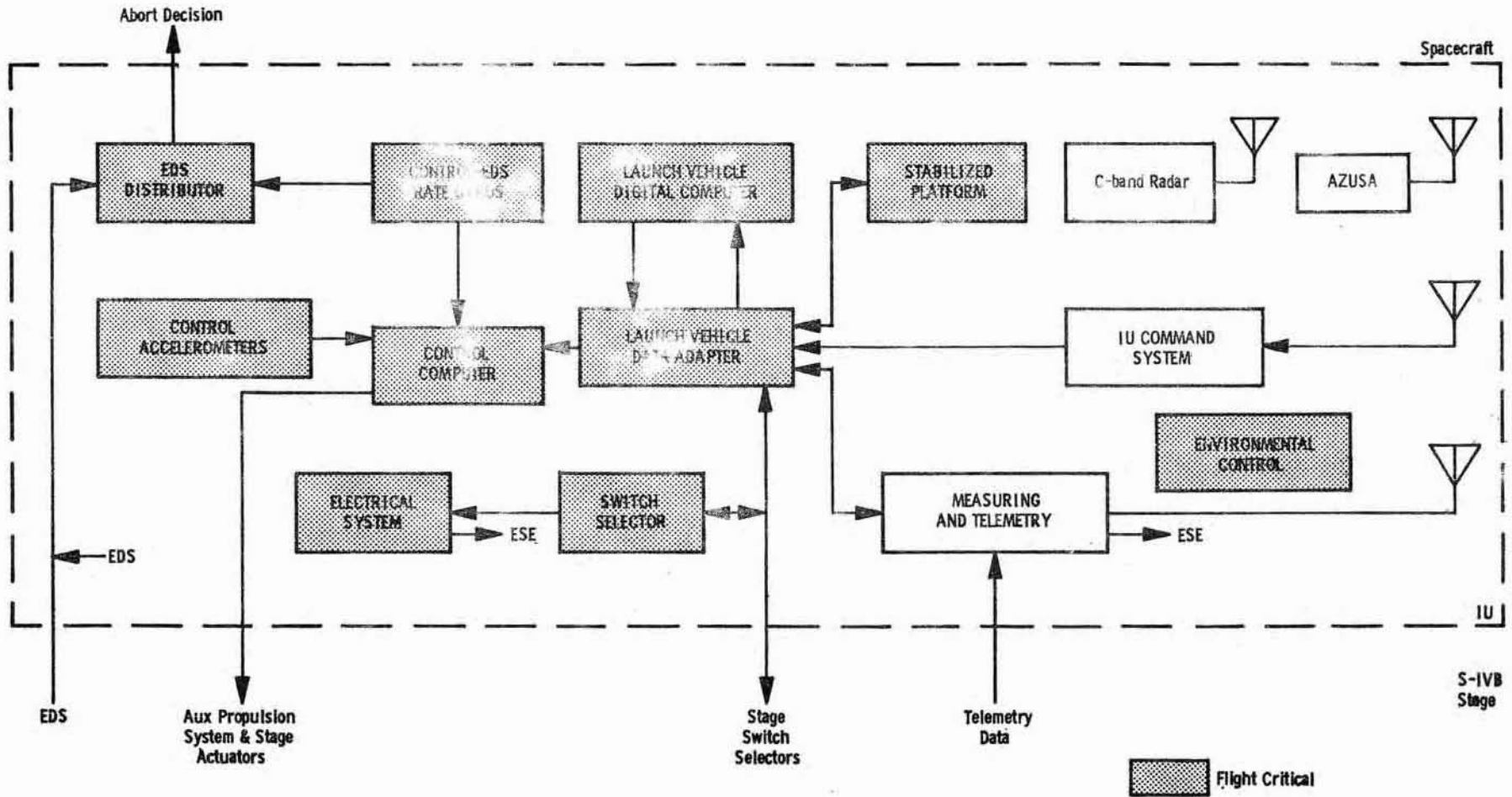


LEVEL 4 SCHEDULE OCT 1966 PLUS CHANGES THROUGH 6/30/67

IU REQUIREMENTS

- **Guidance And Control**
- **Load Bearing**
- **Monitor And Originate Vehicle Events**
- **Self Sustained**
- **Range Safety And Orbit Determination**
- **Ground Communications**
- **Reliability**
- **Hardware Commonality (IB And V)**

S-IU-205



203/205 MAJOR COMPONENT DIFFERENCES

S-IU-203

S-IU-205

GENERAL

2 MEASURING DISTRIBUTORS

1 MEASURING DISTRIBUTOR

9 MEASURING RACKS

4 MEASURING RACKS

2 EXPERIMENTS (MSC, LOW-G)

NO EXPERIMENTS

1 C-BAND TRANSPONDER

2 C-BAND TRANSPONDERS

CONTINUOUS COOLANT TEMP CONTROL

DISCRETE CONTROL

203/205 MAJOR COMPONENT DIFFERENCES

203

TELEMETRY

- 1 SINGLE SIDEBAND/FM
- 2 FM/FM (ANALOG)
- 2 S-BAND TV TRANSMITTER WITH CONTROL UNIT
- 1 410 MUX & 1 RDSM MUX FOR PCM
- 2 270 MUX's - ONE FOR FM/FM (ANALOG) AND ONE FOR PCM
- 1 TAPE RECORDER

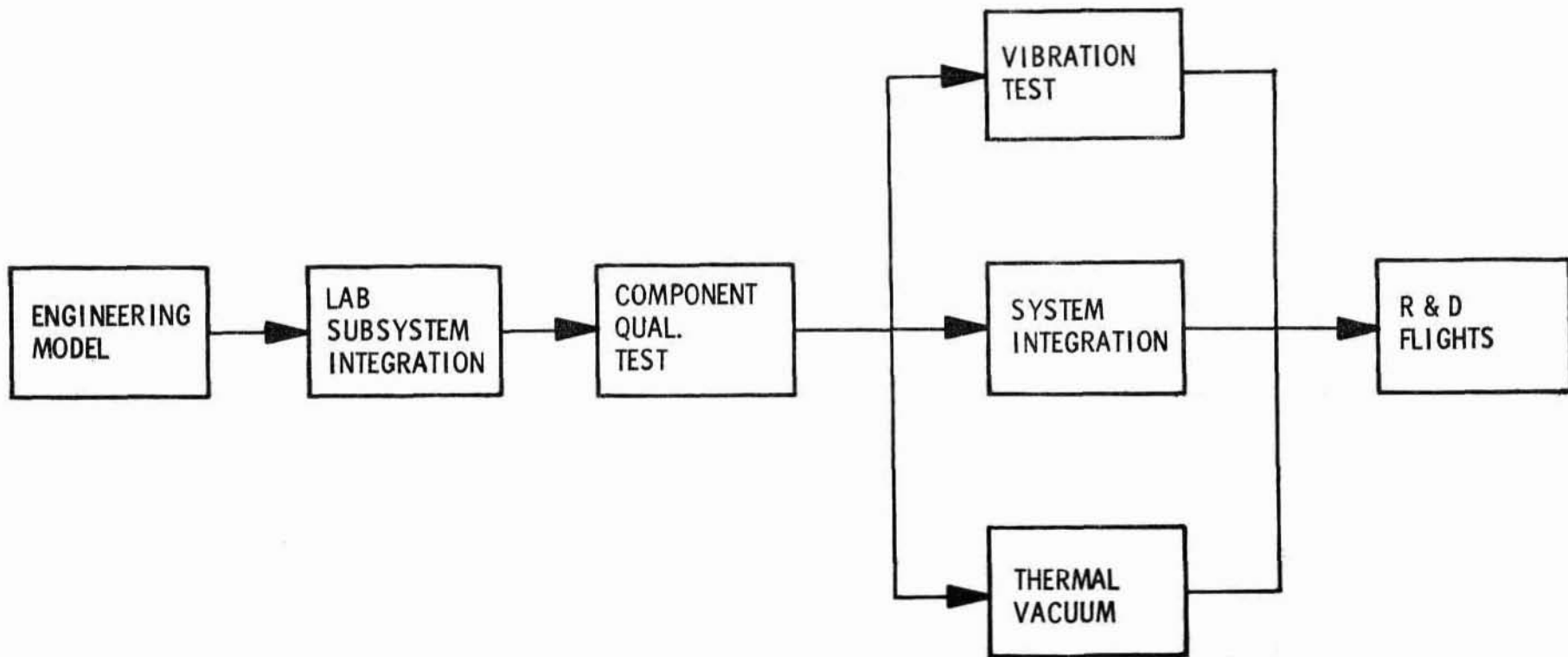
NO CROSSOVER OF S-IVB AND IU PCM TELEMETRY

205

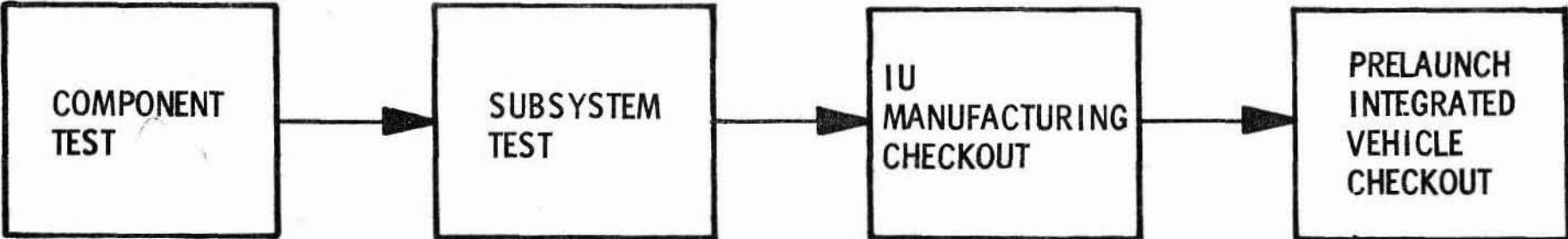
- NO SINGLE SIDEBAND/FM
- 1 FM/FM (ANALOG)
- NO S-BAND TV XMTR's NOR CONTROL UNIT
- 2 410 MUX's FOR PCM, NO RDSM MUX
- 2 270 MUX's - BOTH FOR PCM
- NO TAPE RECORDER

CROSSOVER OF S-IVB AND IU PCM TELEMETRY

IU TESTS-DESIGN VERIFICATION



PRODUCTION TESTING



S-IU-205

RELIABILITY GOAL	0.992
PREDICTED DESIGN RELIABILITY	0.991
ESTIMATED LOWER BOUND	0.975

GUIDANCE

GUIDANCE SYSTEM

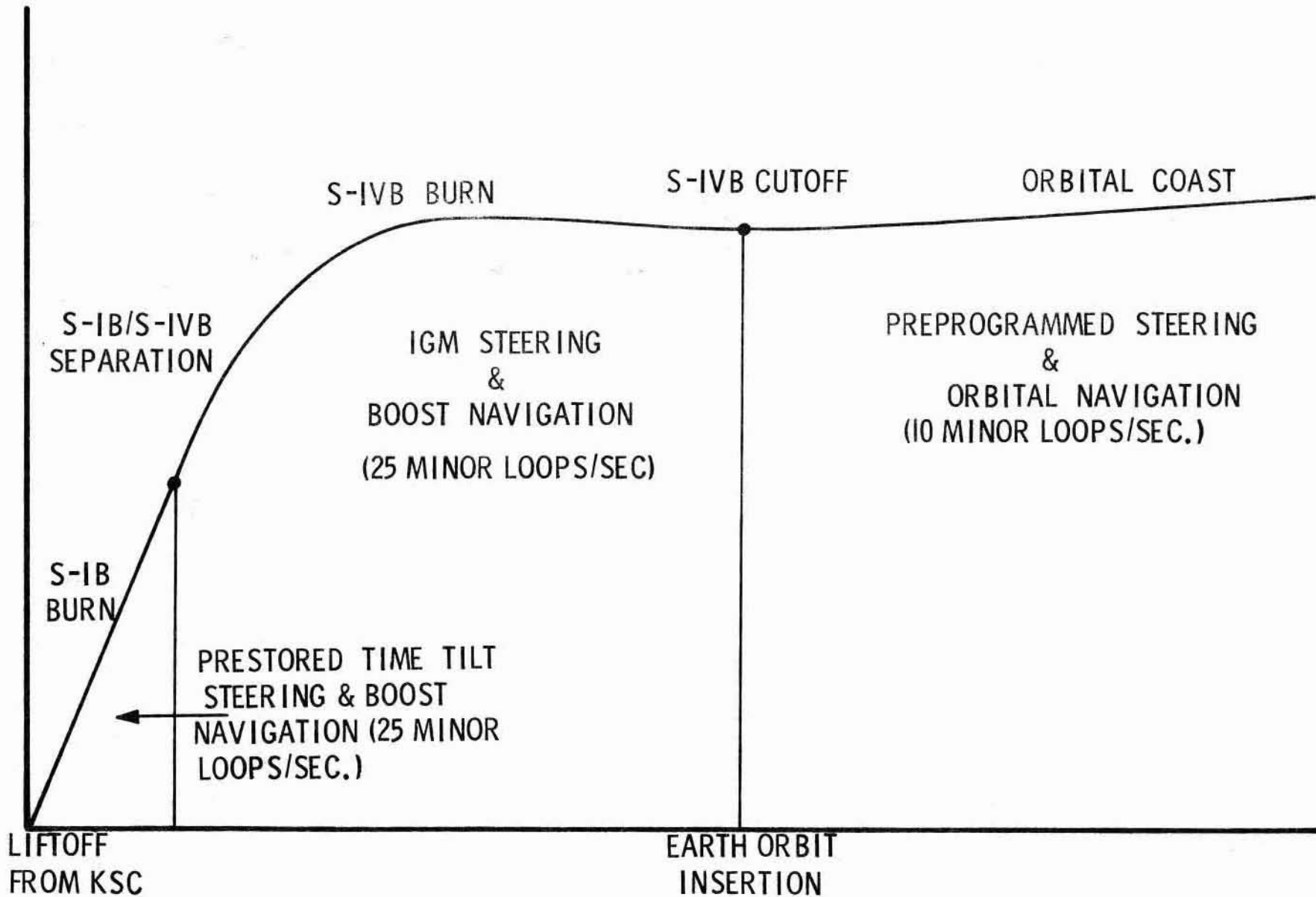
- DESIGN REQUIREMENTS

- Direct Acceleration Vector To Meet End Conditions
- Direct Acceleration Vector To Maximize Payload
- Orient Vehicle During Coast
- Determine Position During Coast

- INSERTION ACCURACIES

- Velocity ± 2.6 m/sec (± 8.6 FT/s)
- Path Angle $\pm 0.025^\circ$
- Altitude ± 1 Km (± 3281 FT)

GUIDANCE MODES



PERFORMANCE

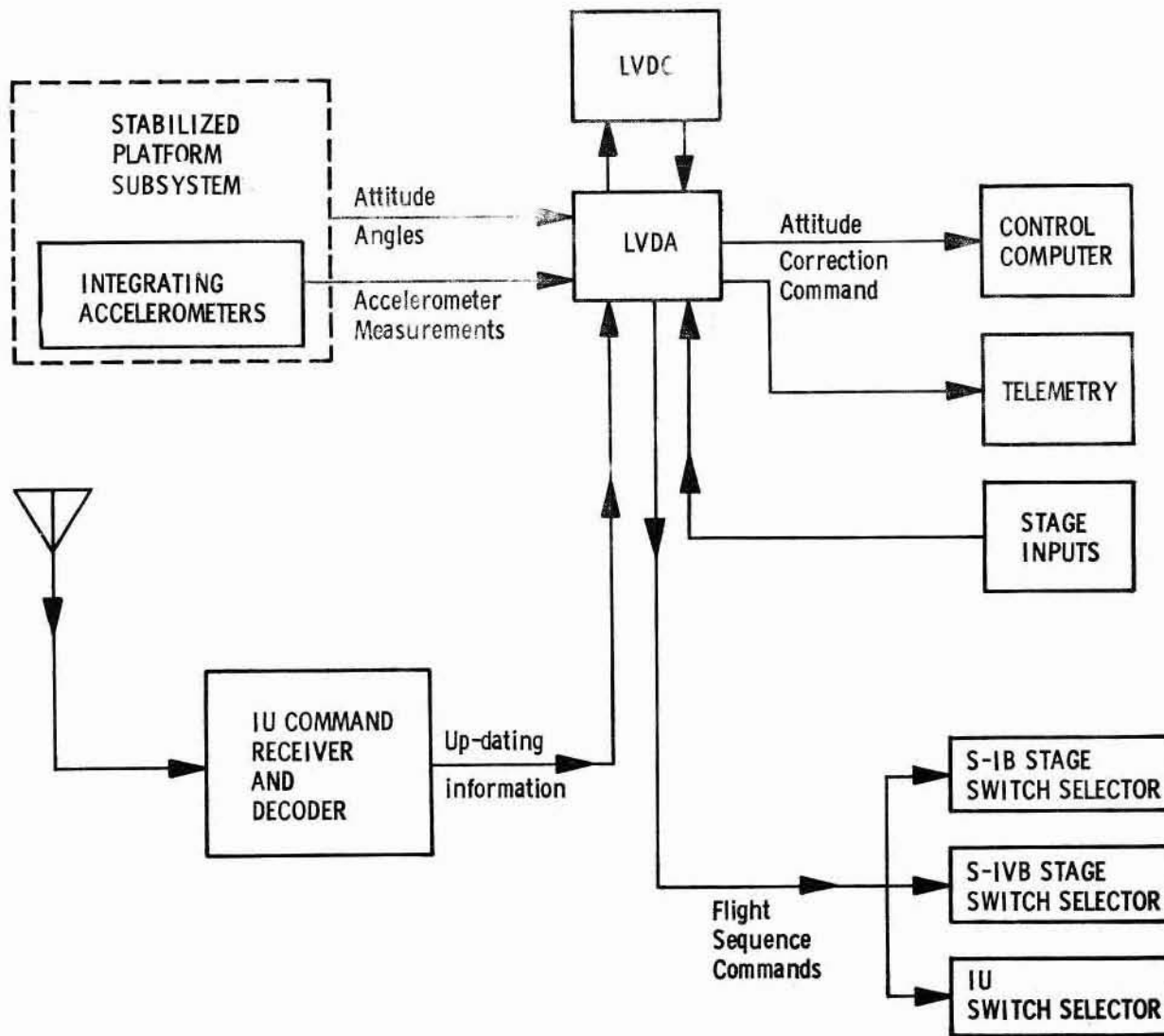
	ΔV (ft/S)	ΔR (ft)	$\Delta \Theta$ (deg.)
SA - 8	2.36	-69	- 0.008
SA - 9	1.48	1011	- 0.014
SA - 10	1.51	157	- 0.013
AS - 201	1.54	125	- 0.0007
AS - 202	0.876	-682	- 0.008
AS - 203	2.34	92	+ 0.0097
AS - 205 *	± 8.6	3281	± 0.025

* REQUIRED PERFORMANCE

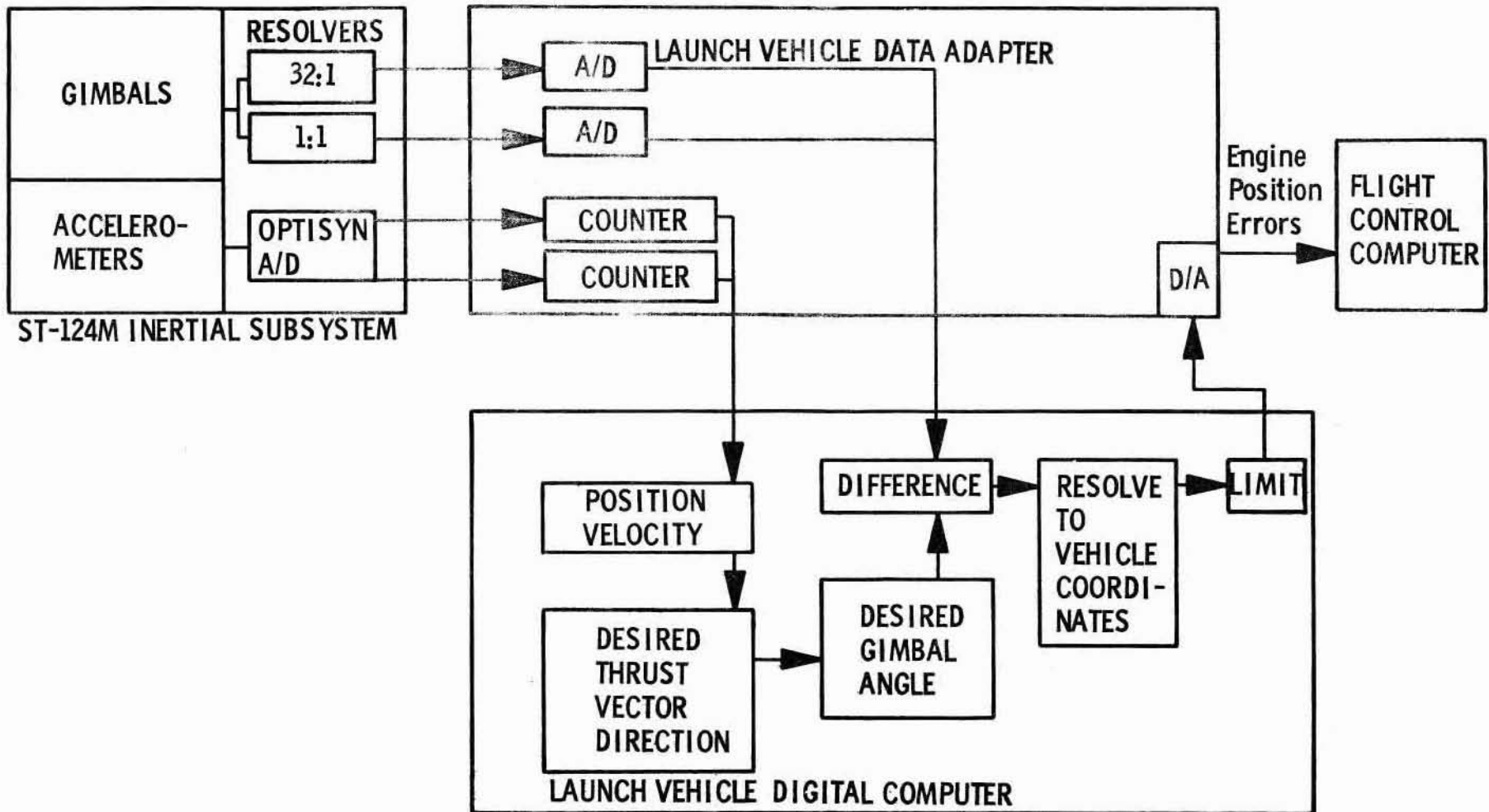
TYPICAL ORBITAL EVENTS

- o ORBITAL PITCH RATE
- o ORBITAL SAFING OF THE S-IVB
- o 20° PITCH DOWN WITH ORBITAL PITCH RATE
- o ASTRONAUT CONTROL OF THE IU/S-IVB
- o CSM/S-IVB SEPARATION (INERTIAL HOLD WITH ASTRONAUTS
"HEADS UP")
- o RENDEZVOUS OF CSM & S-IVB

BLOCK DIAGRAM OF SATURN GUIDANCE SYSTEM



ATTITUDE COMMAND SIGNAL FLOW



PROGRAMMED TESTS

- (1) ATTITUDES
 - o Zero Input
 - o Excessive Rate

- (2) ACCELEROMETER
 - o Zero Inputs
 - o Excessive Rate (Reasonableness)
 - o Disagreement

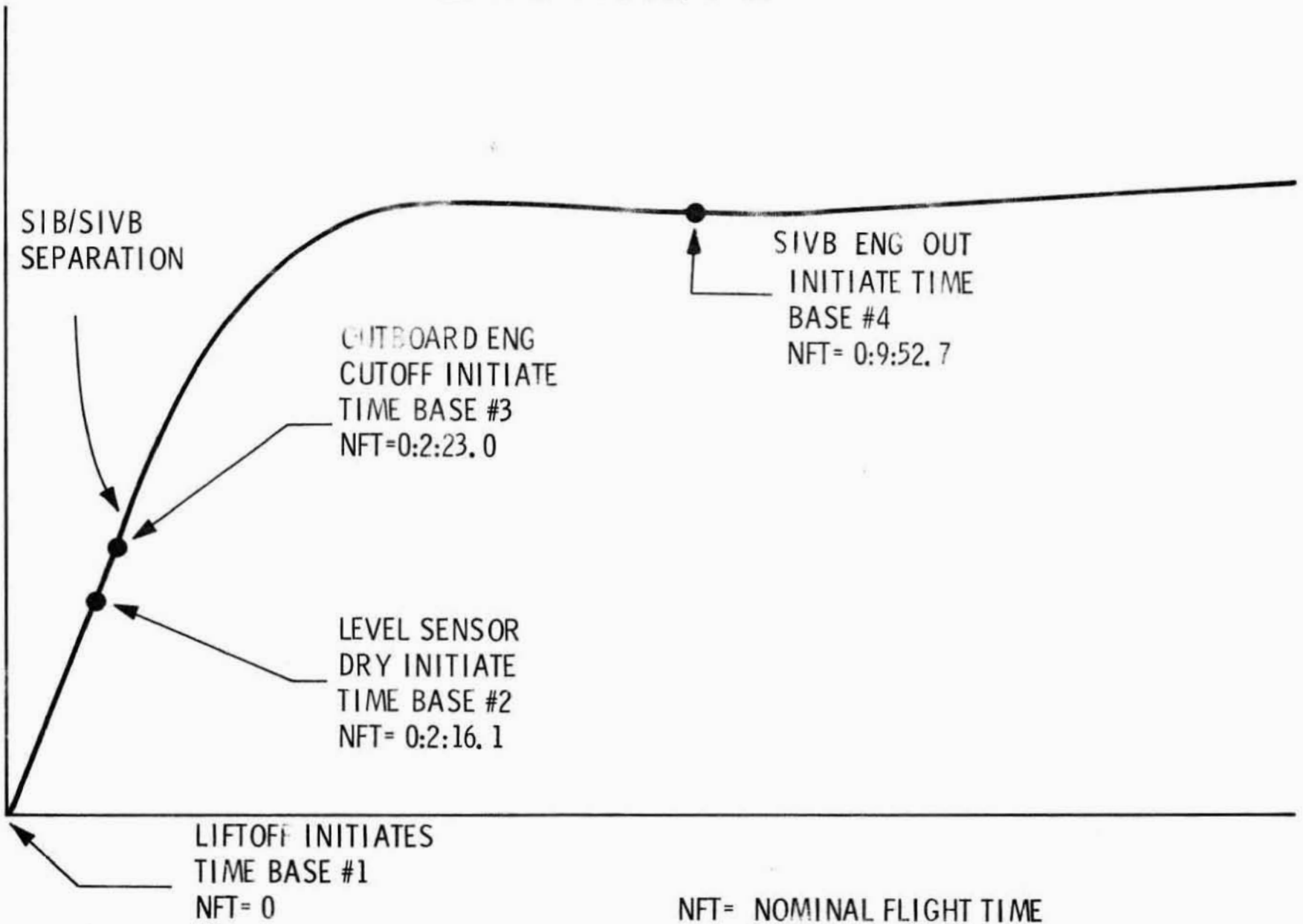
- (3) ATTITUDE ERROR
 - o Rate Limiting
 - o Magnitude Limiting

SEQUENCING SYSTEM FUNCTIONAL REQUIREMENTS

- o DISCRETE OUTPUTS (HIGH AND LOW SPEED)
- o PRESTORED TIME SEQUENCE (4 TIME BASES)
 1. Liftoff (TB 1)
 2. SIB Low Level Sense
 3. SIB Outboard Engine Cutoff
 4. S-IVB Engine Cutoff
- o CALCULATED FUNCTIONS

ALL TIME BASE INITIATION BACKED-UP BY SOFTWARE

PRESTORED TIME SEQUENCE



SEQUENCING

SWITCH SELECTOR

- Triple Modular In Computer And Data Adapter
- Quad Redundant In Decoding
- Feedback And Software Create Duplex Operation In Input Side

LVDC OPERATIONS FOR COMMAND SYSTEM

- Backup To Preprogrammed Operations
- Receive Data From Decoder
- Verify Received Data
 - Verify Proper Redundant Data Format
 - Verify Valid Mode Command
 - Verify Proper Sequence Of Commands For A Given Routine
- Execute Commanded Routine

DIGITAL COMMAND SYSTEM (DCS)

TYPICAL DCS COMMANDS

- o MANEUVER INHIBITS
- o MANEUVER UPDATES
- o TIME BASE UPDATES
- o NAVIGATION UPDATES
- o GENERALIZED SWITCH SELECTOR
- o MEMORY SECTOR DUMPS
- o SINGLE MEMORY LOCATION DUMP
- o MANEUVER EXECUTES
- o RETURN TO TIMED MANEUVER SEQUENCE
- o TERMINATE

TELEMETRY LVDC/LVDA

- Requirement For Mission Control And Postflight
- Two Hundred Words/Second
- Simplex
- Error Detection
 - Parity
 - Validity

GUIDANCE SYSTEM VERIFICATION

- **Systems Development Facility**
- **S-IU-500FS Testing**
- **IU Manufacturing Checkout Testing (Huntsville)**
- **Prelaunch Tests (KSC)**
- **Flight Testing**

FLIGHT PROGRAM DIFFERENCES - 203/205

MISSION CHANGES

- VENTS
- SEQUENCE
- PITCH PROFILE

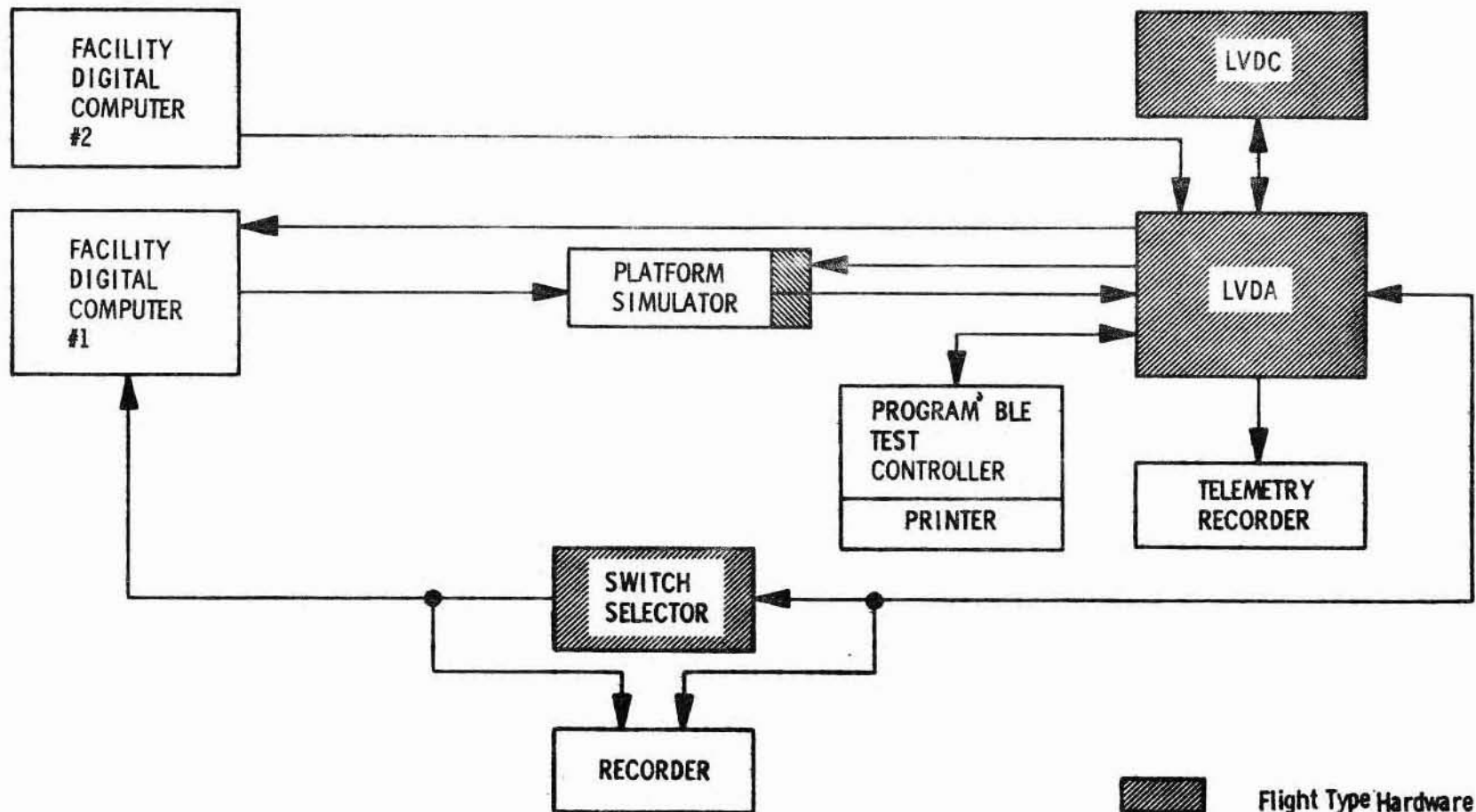
INCREASED CAPABILITY

- MANEUVERS
- COMMANDS
- ORBITAL TIME BASE INITIATE
- FAST CUTOFF LOOP

SOFTWARE VERIFICATION

- Closed Loop Digital Simulation
- Closed Loop Hybrid Simulation
- Flight Hardware Checkout Simulation (Huntsville)
- Flight Hardware Checkout Simulation (KSC)

IBM PROGRAM VERIFICATION FACILITY

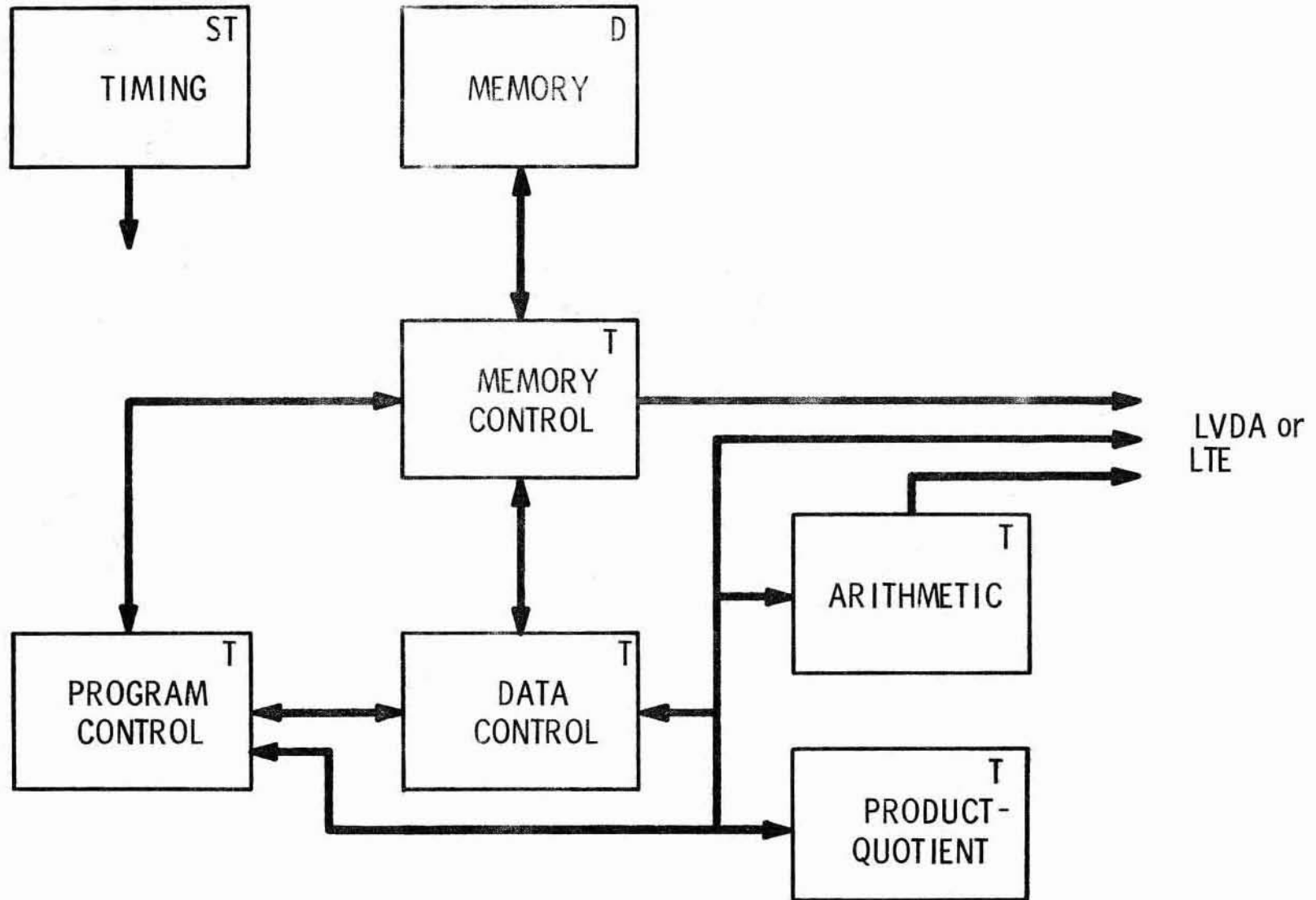


OPEN ITEMS

COMPLETE FLIGHT PROGRAM VERIFICATION

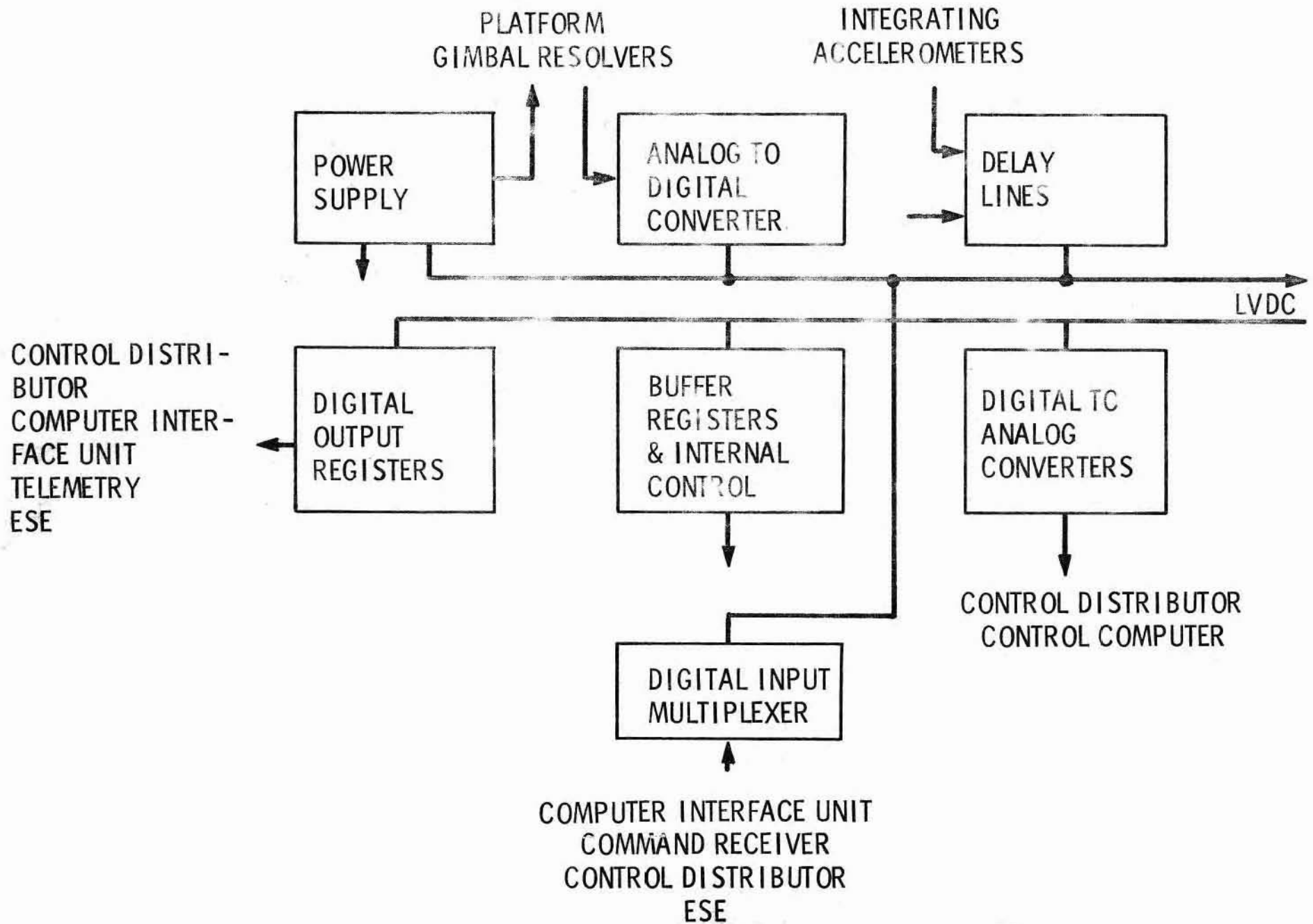
**DIGITAL
COMPUTER
SUBSYSTEM**

LAUNCH VEHICLE DIGITAL COMPUTER
BLOCK DIAGRAM

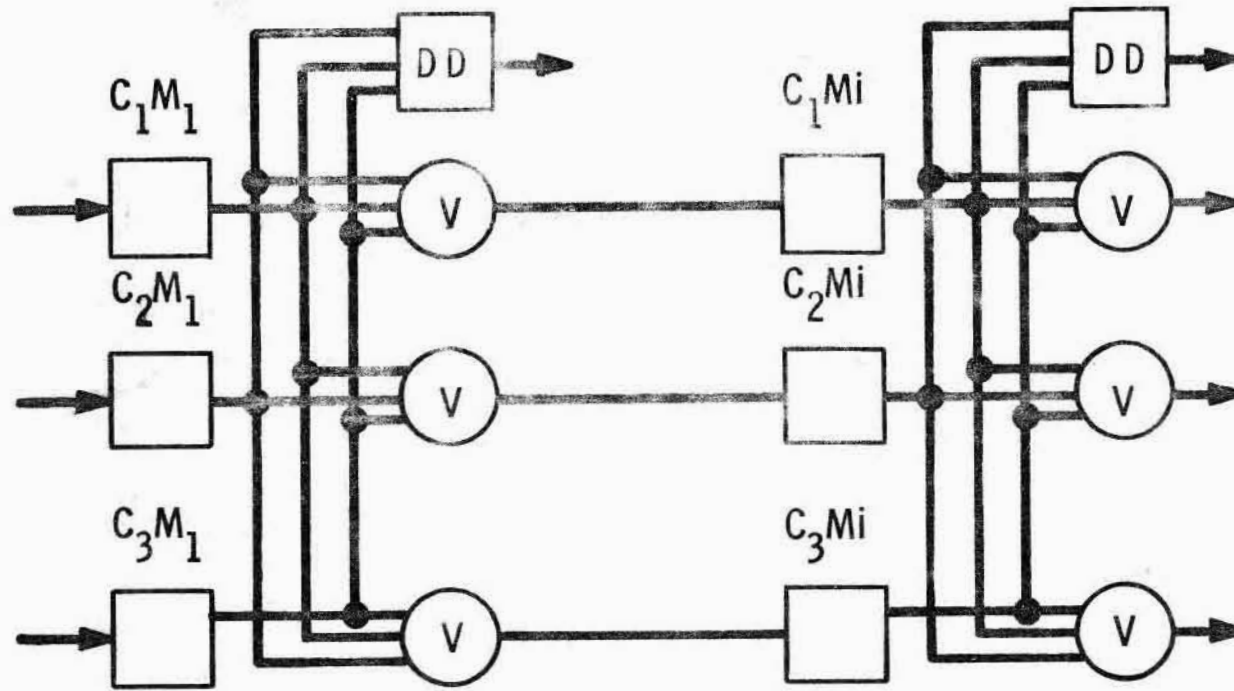


LAUNCH VEHICLE DATA ADAPTER

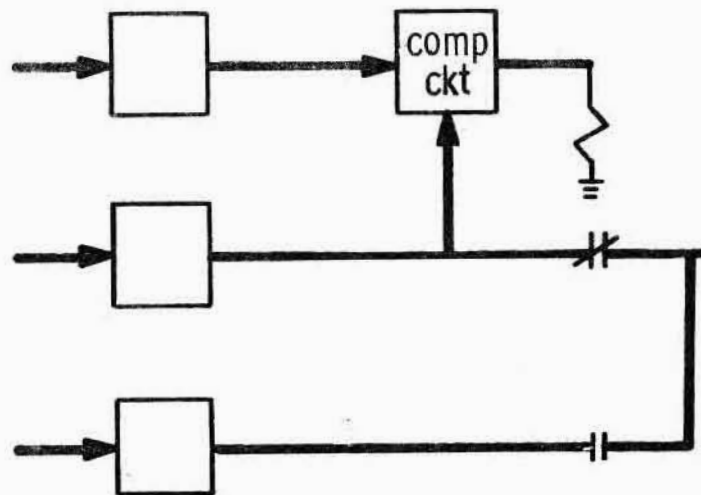
BLOCK DIAGRAM



TRIPLE MODULAR REDUNDANCY
(MAJORITY VOTING)



TRIPLE REDUNDANCY (PAIR AND SPARE)



DESIGN VERIFICATION

- **Worst Case Circuit Analysis**
- **Prototype Evaluation**
- **Component Qualification**
- **System Qualification Program**
- **Field Experience**

QUALIFICATION ENVIRONMENTS

Impact Shock

Temperature Altitude

Operational

Non-Operational

Constant Acceleration

Vibration

Isolated

Hard Mount

RFI

Explosive Atmosphere

Humidity

Orbital Simulation

Acoustic Noise

Salt Fog

Coolant Tests

Pressure

Pressure Drop

Leak

LVDC/LVDA DIFFERENCES FROM S-IU-203

LVDC

NOISE SUPPRESSION
NEW PRESSURE RELEASE VALVES

LVDA

DUPLEX VOLTAGE INPUTS TO SWITCH SELECTOR REGISTER
MINOR RELIABILITY INCREASES
NEW PRESSURE RELEASE VALVES
REPLACING TEFLON COOLANT HOSE

LAUNCH VEHICLE DIGITAL COMPUTER REQUIREMENTS

Type: Stored program, general purpose, serial, fixed point, binary

Timing: 2.048 Mc clock, 4 clocks per bit, 512 kilobits per second
3 phases per computation cycle
Each phase = 14 bits
Phase A instruction read/Phases B & C. Instruction execution (DATA)

Computation Speed: Add or subtract and multiply or divide concurrently.

Time Accuracy

Add	82 usec, 26 bit
Multiply	328 usec, 24 bit
Mult-Hold	410 usec, 24 bit
Divide Time	656 usec, 24 bit

Memory: Random access toroidal core

Storage Capacity: Up to a maximum of 32,768 28-bit words in 4,096-word modules

Word Length: Memory word 28 bits; two instructions may be stored in one memory word.

Data: 26 bits plus 2 parity bits

Instruction: 13 bits plus 1 parity bit

Input/Output: External: Computer-programmed interrogation
T/O Control: External interrupt provided

LAUNCH VEHICLE DATA ADAPTER REQUIREMENTS

ITEM	DESCRIPTION
Computer Input/Output Rate Power Supplies Discretes	<ul style="list-style-type: none"> ● 512-kc serial ● 6 pairs of duplexed supplies ● 8-bit input register ● 15-bit output register ● 7 interrupt inputs ● 13 discrete outputs ● 32 discrete inputs
Buffer Register Tag Register Mode Register Digital-to-Analog Converter	<ul style="list-style-type: none"> ● 26 bits } provides communication with ● 9 bits } the Ground Control Computer ● 6 bits } and telemetry system ● 8 bits plus sign, 2-millisecond operation, three attitude commands, and two spare outputs
Analog-to-Digital Converter Platform Spares	<ul style="list-style-type: none"> ● Equivalent of 17 bits from a two-speed resolver ● 4 two-speed gimbal angle resolver inputs ● 10 resolver inputs
Telemetry Command Receiver Data Transmitter	<ul style="list-style-type: none"> ● 14 bits for input data ● 38 data and identification bits plus validity bit and parity bit
Telemetry Multiplexer	<ul style="list-style-type: none"> ● 15 bits address plus validity bit for output data, 10 bits for input data
Ground Control Computer Frequency Source	<ul style="list-style-type: none"> ● 41 data identifier bits plus interrupt - output data ● 14 bits for input data plus interrupt ● 2-1016 cps frequency source

ATTITUDE CONTROL SYSTEM

AS-205 ATTITUDE CONTROL SYSTEM

FUNCTION

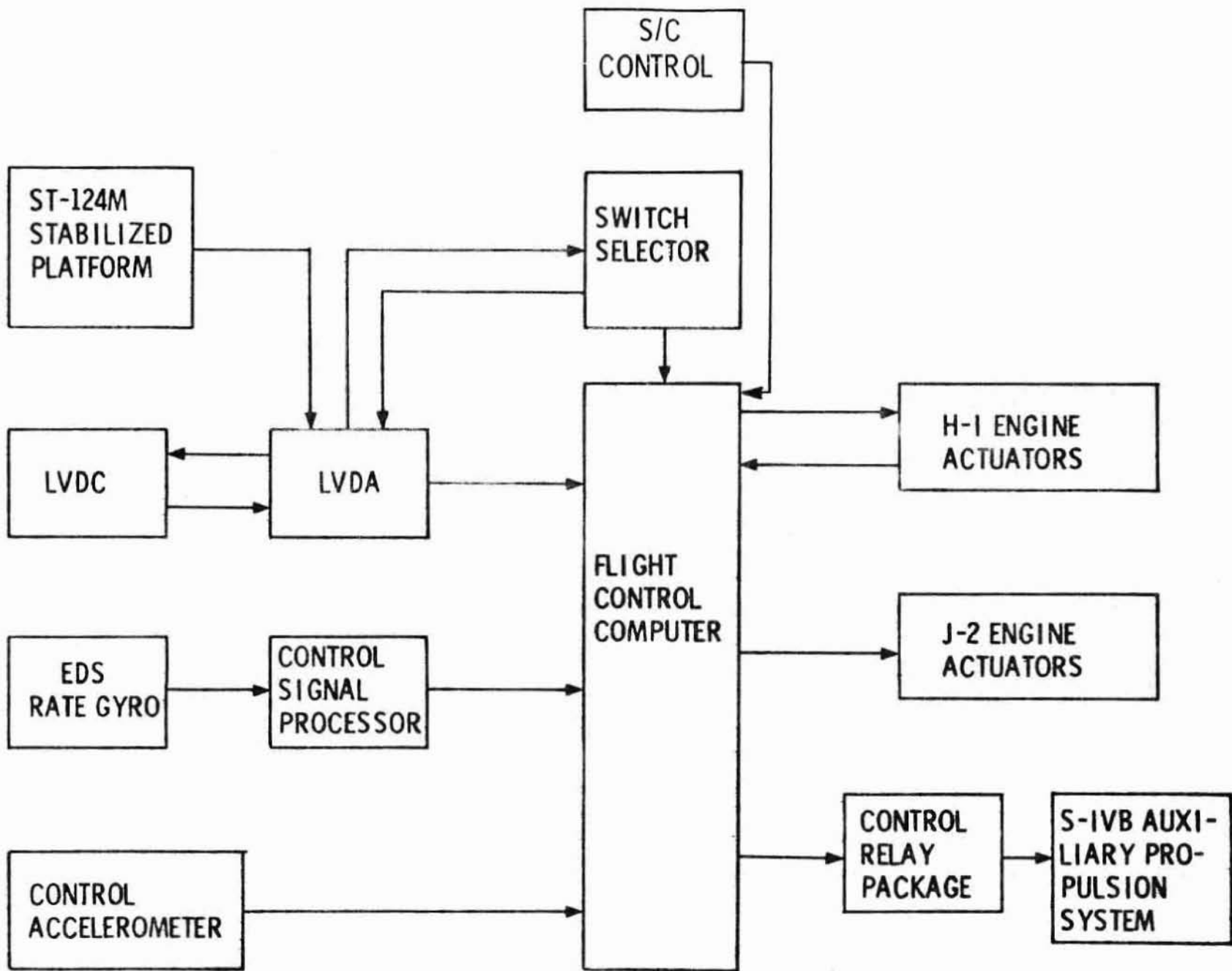
MAINTAIN VEHICLE ORIENTATION

- o TO GUIDANCE COMMANDS
- o IN THE PRESENCE OF ENVIRONMENTAL DISTURBANCES,
I. E. , WINDS

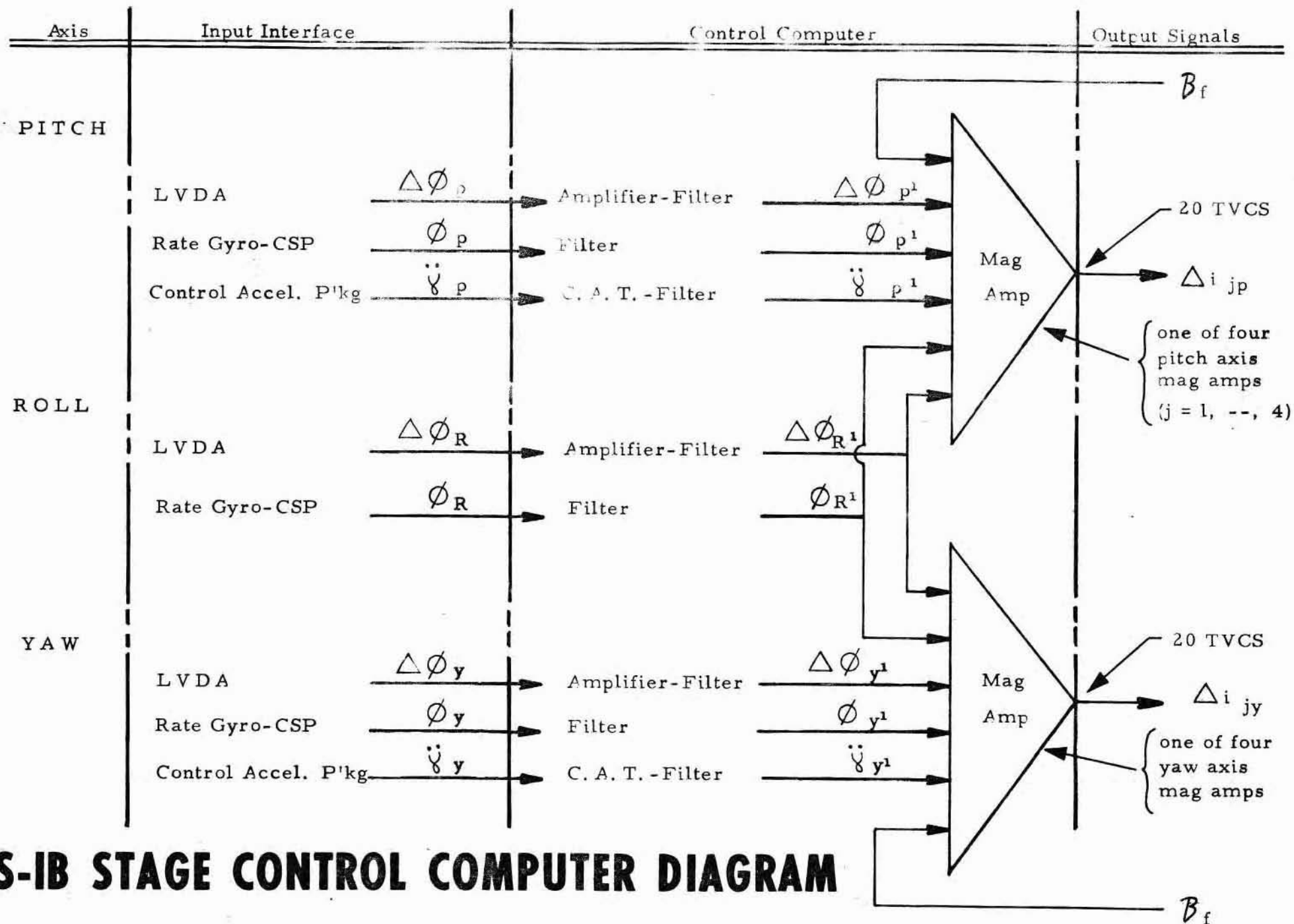
REQUIREMENTS

PROVIDE VEHICLE STABILITY & RESPONSE CHARACTERISTICS

- o TO MAINTAIN ADEQUATE STABILITY MARGINS
- o TO MAINTAIN LINEAR-RANGE ACTUATOR CONTROL
- o TO PROVIDE NECESSARY RELIEF OF VEHICLE BENDING
MOMENTS
- o TO REGAIN CONTROL AFTER STAGE-SEPARATION
- o TO PROVIDE ORBITAL FLIGHT CAPABILITY

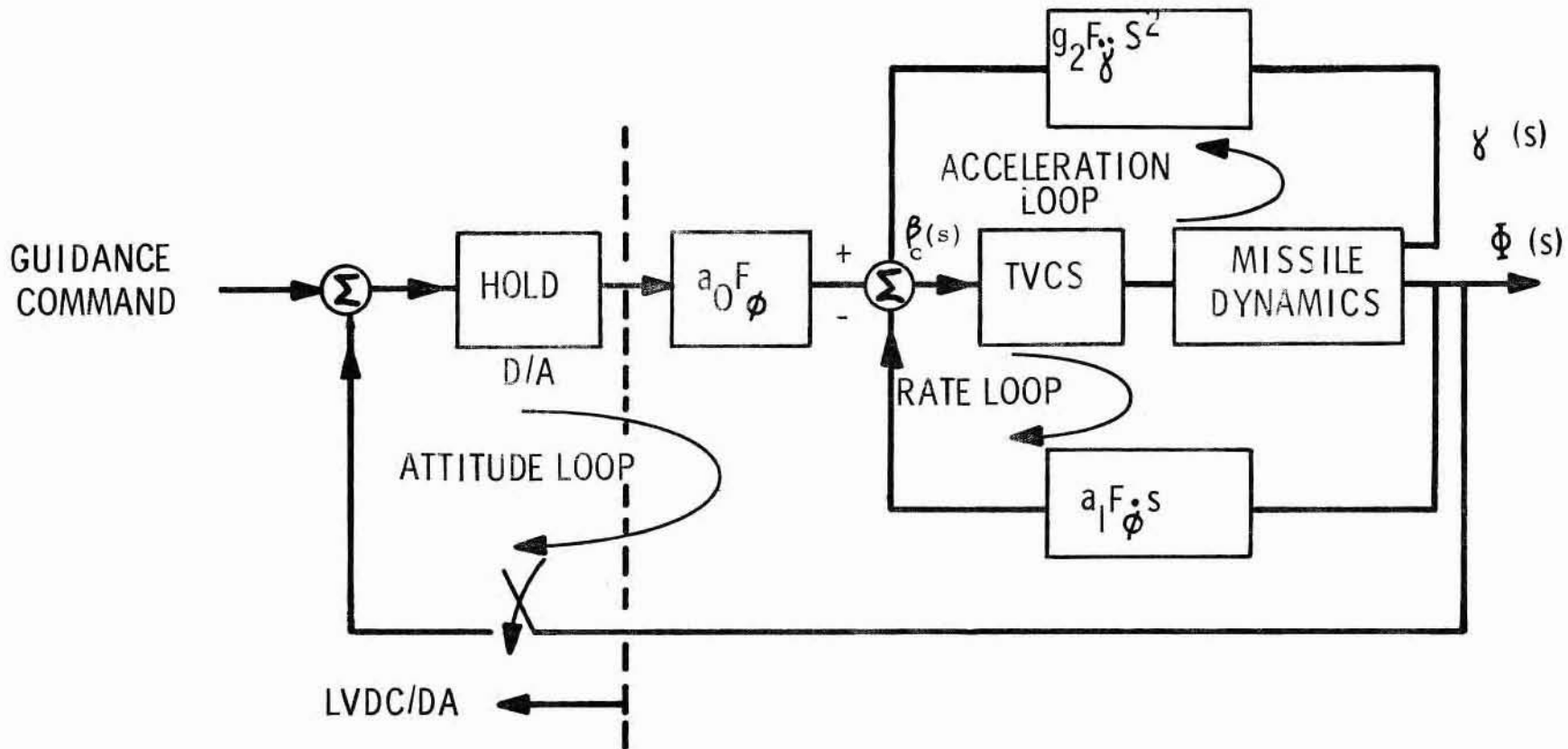


AS-205 ATTITUDE CONTROL SYSTEM BLOCK DIAGRAM



S-IB STAGE CONTROL COMPUTER DIAGRAM

FUNCTIONAL BLOCK DIAGRAM OF S-IB ATTITUDE CONTROL SYSTEM



- o a_0 and a_1 ARE PIECEWISE CONSTANT GAINS
- o g_2 IS RAMPED-IN, HELD, AND RAMPED-OUT DURING 30 TO 110 SECONDS OF S-IB FLIGHT
- o F_ϕ , $F_\dot{\phi}$ AND $F_{\ddot{\gamma}}$ ARE STABILIZATION FILTERS
- o MISSILE DYNAMICS INCLUDE RIGID BODY, ELASTIC BODY AND FUEL SLOSH MODELS

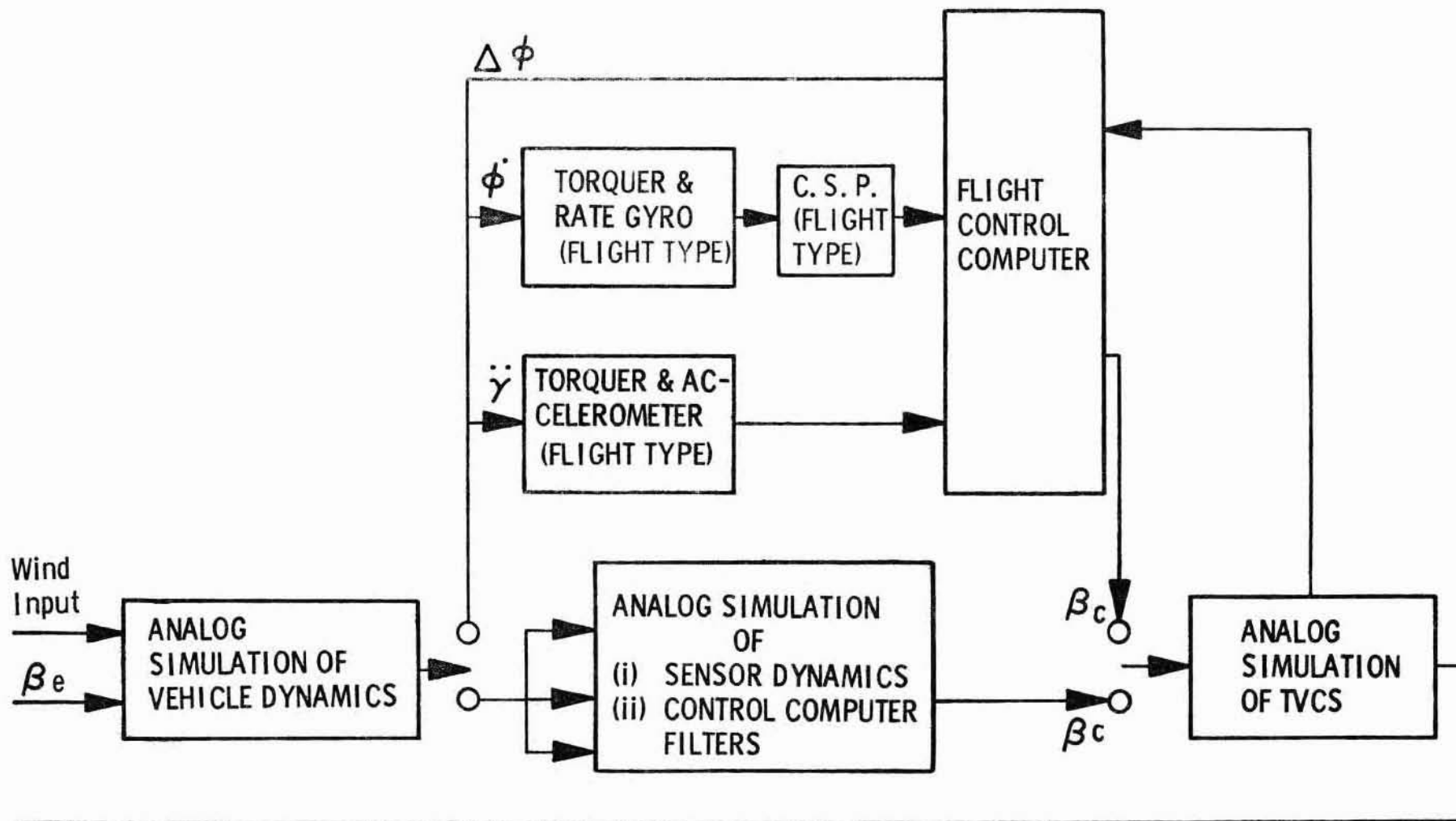
ORBITAL ATTITUDE CONTROL

- o During Attitude-Hold (Steady State) Operation, APS provides
 - (1) Attitude Error ≤ 1 deg
 - (2) Body Rates $\leq .05$ deg/sec
- o For Spacecraft Control, FCC limiters constrain attitude error \leq
 - 2.5 deg, pitch and yaw
 - 3.5 deg, roll
- o The Comparators for Pair-Spare Redundancy of APS Spatial Amplifiers have a threshold of 50% duty cycle

ADDITIONAL ACS DESIGN FEATURES

- o Launch Escape Tower Jettison
 - Requires manual input; S-IVB rate filters automatically switch at $T_3 + 42$ seconds
- o Capability for spacecraft control (Attitude error commands) during S-IVB flight.

FLIGHT CONTROL COMPUTER VALIDATION TEST BLOCK DIAGRAM



SIGNIFICANT ATTITUDE CONTROL SYSTEM IMPLEMENTATION CHANGES
AS-201 THROUGH AS-205

<u>Component</u>	<u>Modification</u>	<u>Effectivity</u>
(a) Control Signal Processor (CSP)	Implement a dual-rate switch	AS-202 and subsequent.
(b) CSP	Addition of filter to the Emergency Detection System -(EDS) Rate Switch	AS-202 and subsequent.
(c) S-IVB stage attitude error D. C. amplifiers	Spacecraft D. C. Gain compatibility implementation	AS-205 and subsequent CSM's
(d) Auxiliary Propulsion System (APS) spatial amplifiers	Synchronization of APS roll engine firing during S-IVB burn	AS-202 and subsequent
(e) 12 ma. magnetic amplifiers	Addition of redundant inverter	AS-202 and subsequent
(f) Flight Control Computer FCC	Elimination of undesirable signal paths.	

ALL ATTITUDE CONTROL SYSTEM COMPONENTS HAVE BEEN QUALIFIED

INSTRUMENTATION
TRACKING AND COMMAND

TELEMETRY SYSTEM

COMPUTER DATA STREAM

FLIGHT CONTROL DISCRETES

ENGR DISCRETES

ESE DISCRETES

ESE ANALOGS

FLIGHT CONTROL ANALOGS

ENGR ANALOGS

410 MUX (K)

410 MUX (J)

270 MUX CAO

270 MUX DAO

301 PCM/DDAS

DDAS OUTPUT

CIU

PCM XMTR (VHF)

TO ANTENNA SYSTEM

FM/FM

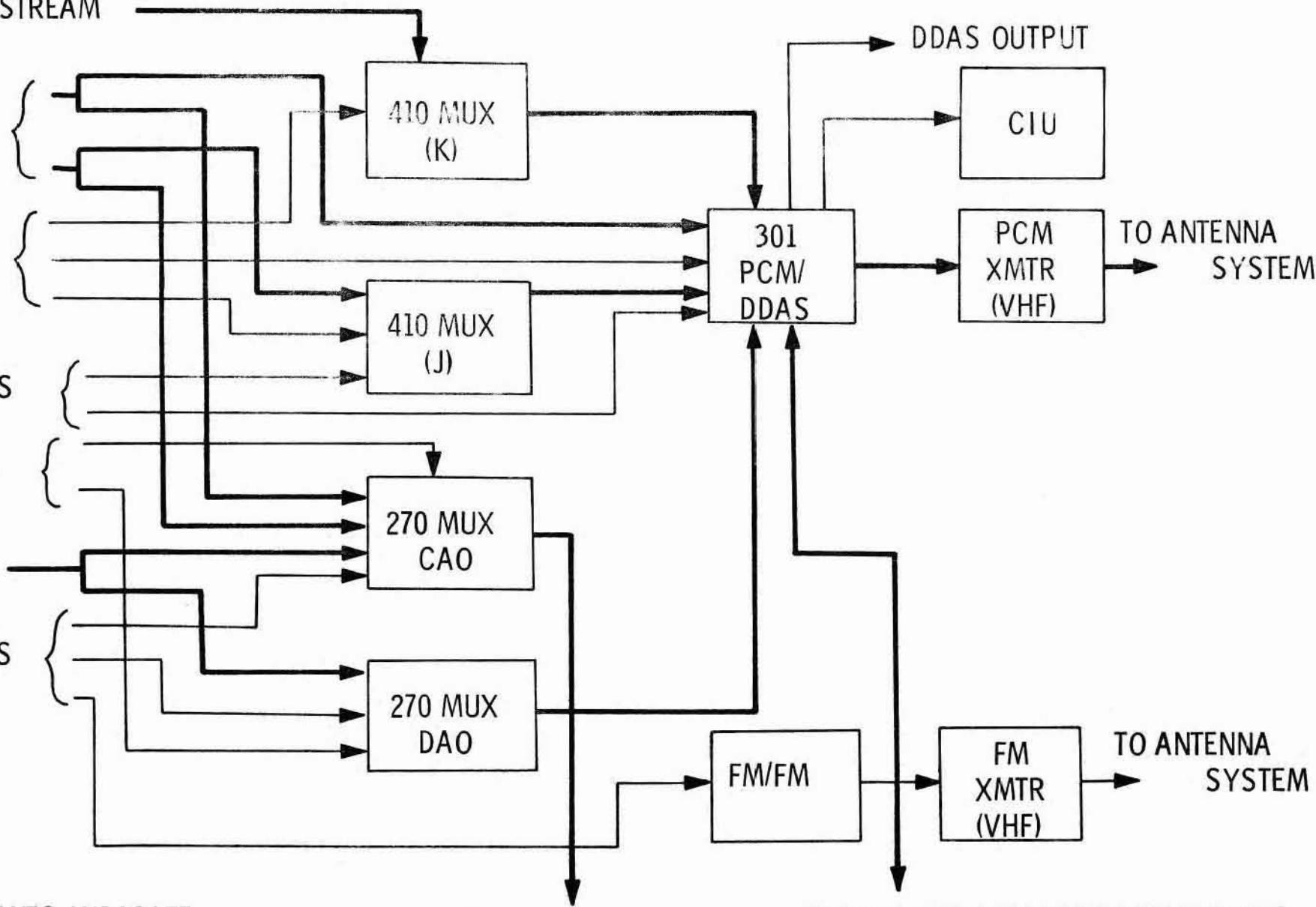
FM XMTR (VHF)

TO ANTENNA SYSTEM

NOTE: HEAVY LINES INDICATE FLIGHT CONTROL DATA

TO S-IVB PCM/DDAS ASSY AO TIME SLOT

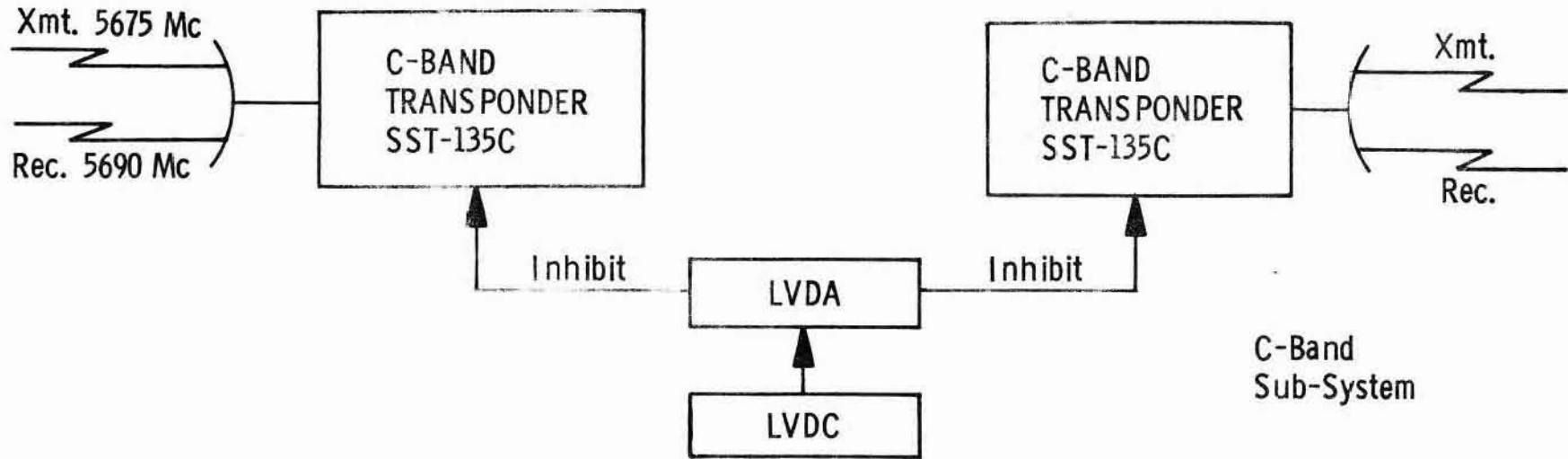
FROM S-IVB 270 MUX BO TIME SLOTS (ALL S-IVB FLIGHT CONTROL DATA)



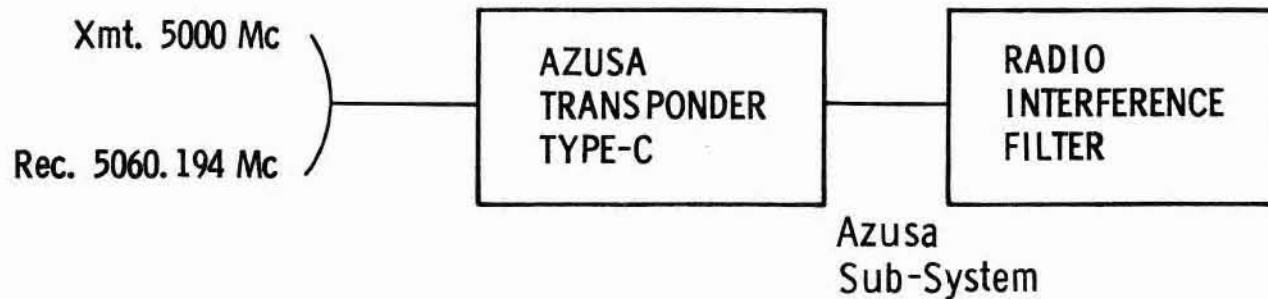
INSTRUMENTATION

MULTIPLEX TECHNIQUES	CAPABILITIES ACCURACY	FREQ. RESPONSE	PARAMETERS
FM/FM	3%	0 - 1050 CPS	ACCELER- ATION, FLOW RATE, 400 CPS FREQ.
FM/FM/FM	3%	0 - 40 CPS	NONE ON 205
PCM/FM	0.8%	12 SPS (2.4 CPS)	ALL TEMP, PRESS. VOLTAGES
		120 SPS (24 CPS)	ACT POSITION GYRO ANGLES ACCELERATION
		240 SPS	LVDC DIGITAL WORD

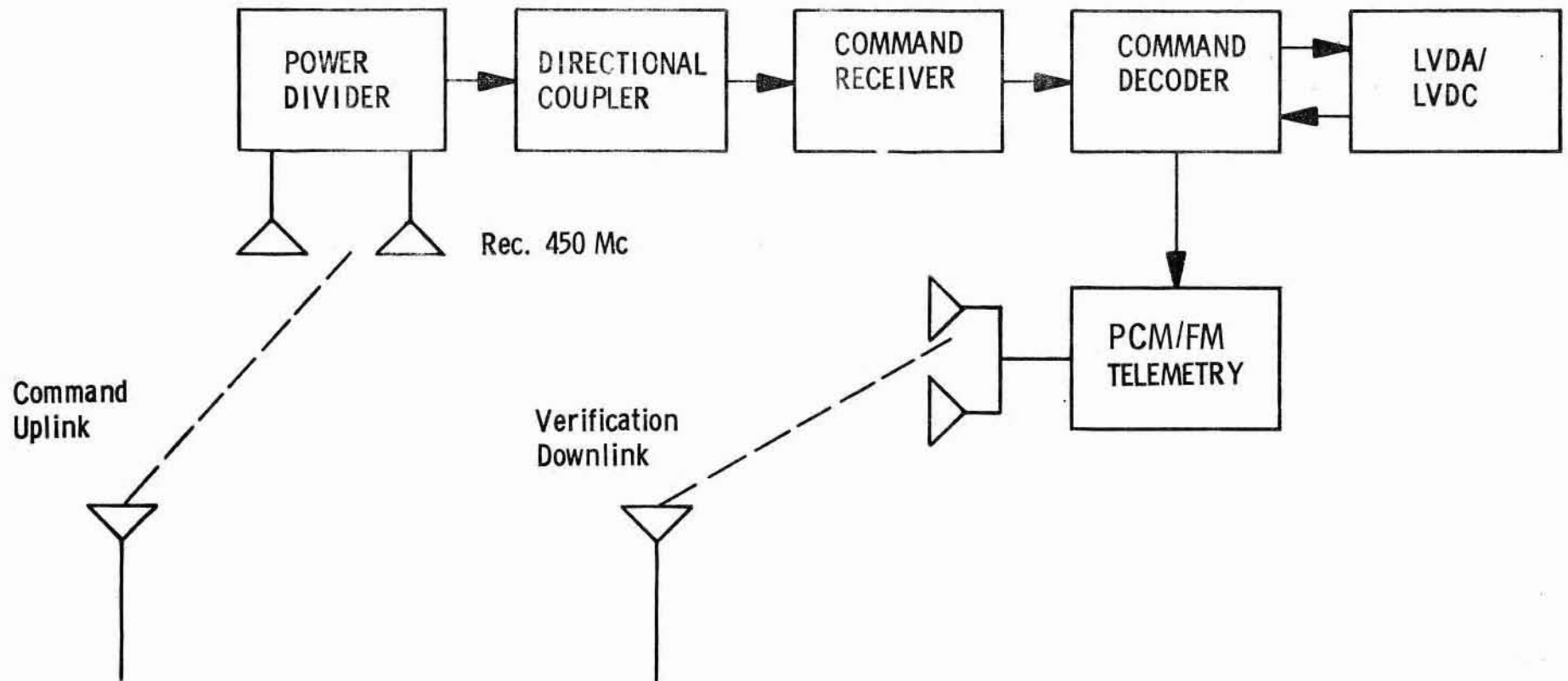
TRACKING SYSTEM



Both C-Band Transponders Operate At Same Frequency



COMMAND SYSTEM



Ground Station - Each Message Verified
Before Transmission Of
A New Command.

PROBLEMS AND CORRECTIVE ACTION

C-BAND COVERAGE

DESIGNED DUAL C-BAND
COMPUTER INHIBITED

FAILURE OF RF CONNECTOR

ESTABLISHED PROCEDURE
TO ELIMINATE FAILURE

QUALIFICATION STATUS

37 UNITS (28 UNIQUE)

ALL QUALIFIED

20 TRANSDUCERS (13 UNIQUE)

11 QUALIFIED

UNQUALIFIED TRANSDUCERS

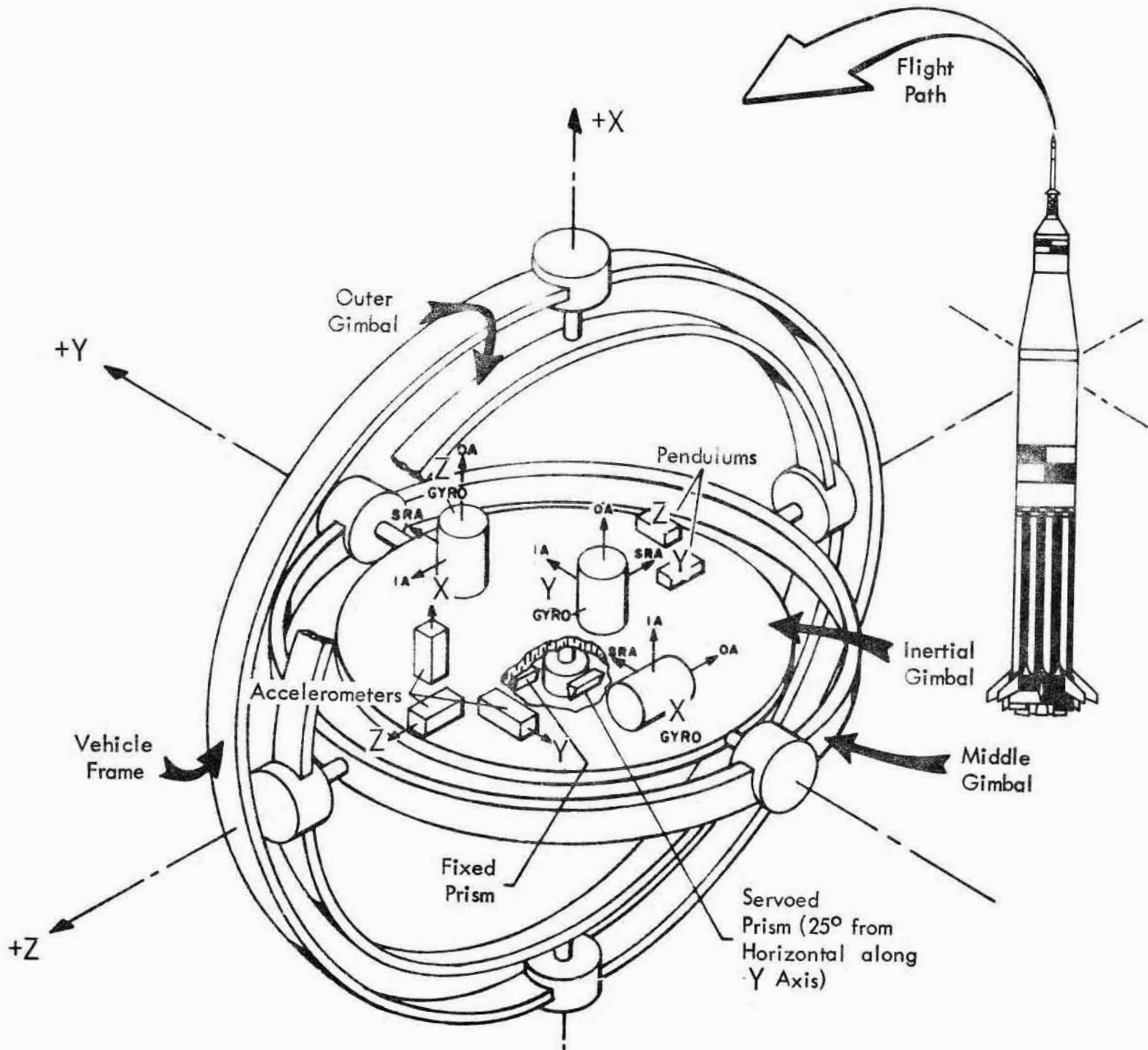
F-1 FLOWMETER

QUALIFIED BY NOV. 15, 1967

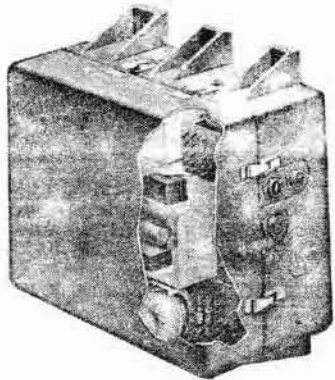
0-3 PSI PRESSURE GAGE

QUALIFIED BY FEB. 15, 1968

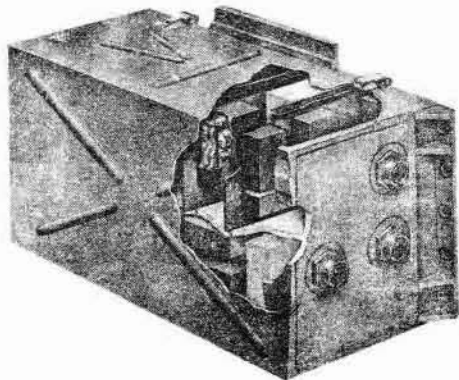
PLATFORM SYSTEM



INERTIAL STABILIZED PLATFORM SYSTEM SATURN V&IB



AC POWER SUPPLY



PLATFORM SERVO AMPLIFIER



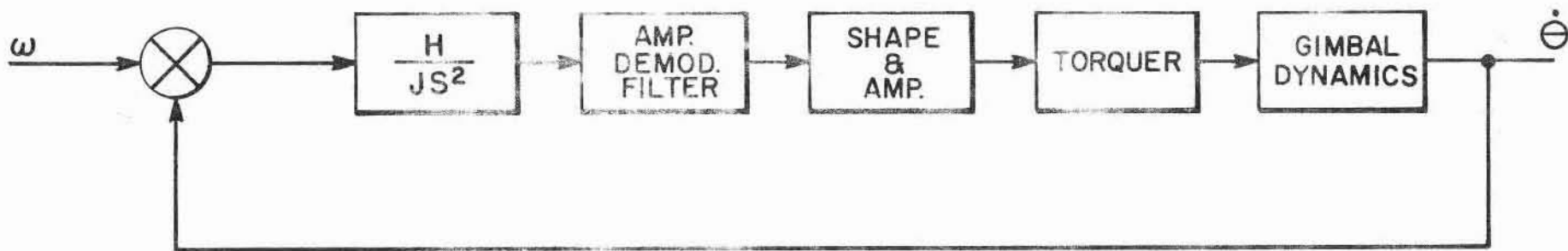
**ST-124 M
STABLE PLATFORM**



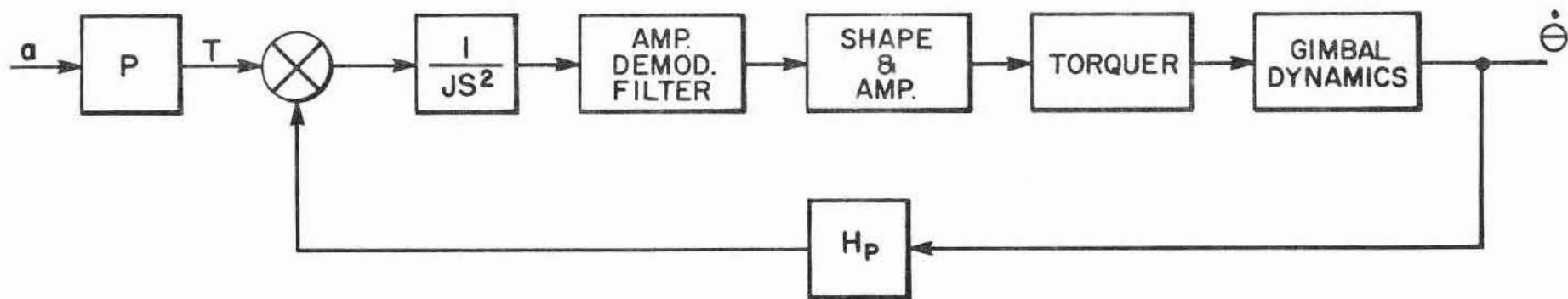
**ACCELEROMETER SIGNAL
CONDITIONER**

SYSTEM FUNCTIONS

- A. ACCELERATION SENSING AND REFERENCE.
- B. VEHICLE ATTITUDE AND PROGRAMING.
- C. GUIDANCE REFERENCE COORDINATES.
- D. EARTH REFERENCE COORDINATES UNTIL GRR.



TYPICAL GIMBAL SERVO BLOCK DIAGRAM



TYPICAL ACCELEROMETER SERVO BLOCK DIAGRAM

TYPICAL PLATFORM PERFORMANCE SPECIFICATIONS

Gyro Drift 0.075°/hr/g and 0.075°/hr

Accelerometer Bias 2×10^{-5} g

Accelerometer Scale Factor 2×10^{-5} g/g

Accelerometer Orthogonality 5 arc sec

Azimuth Position 20 arc sec

Alignment To Local Gravity 12 arc sec

NOTE:

All Values

±3 σ

32:1 Multispeed Resolvers

32 Speed (Fine) 10 arc sec resolution

10 arc mechanical accuracy

20 arc sec

Single Speed (Coarse) 30 arc min

PLATFORM SYSTEM DIFFERENCES
IU-203 - IU-205

CHANGE	PURPOSE
1. GYRO MOTORS - MONEL TO ELKONITE	INCREASE RELIABILITY
2. ACCEL. STOPS - 3 ⁰ to 6 ⁰	ELIMINATE POSSIBLE ERRONEOUS PULSES AT LIFTOFF

VERIFICATION PROGRAM

- o DEVELOPMENT TESTING
- o QUALIFICATION TESTING
- o ROCKET SLED TEST
- o FLIGHT TEST
- o IU 500 FS TEST
- o ACCEPTANCE TEST
 - o VENDORS
 - o HUNTSVILLE
- o SYSTEM TEST

ELECTRICAL

ELECTRICAL SYSTEM FUNCTIONS

PROVIDE POWER

CONTROL POWER

DISTRIBUTE POWER & SIGNALS

CONDITION POWER

PERFORM E.D.S. LOGIC

PRINCIPLE DESIGN REQUIREMENTS

PRIMARY BATTERIES - 80% OF CAPACITY

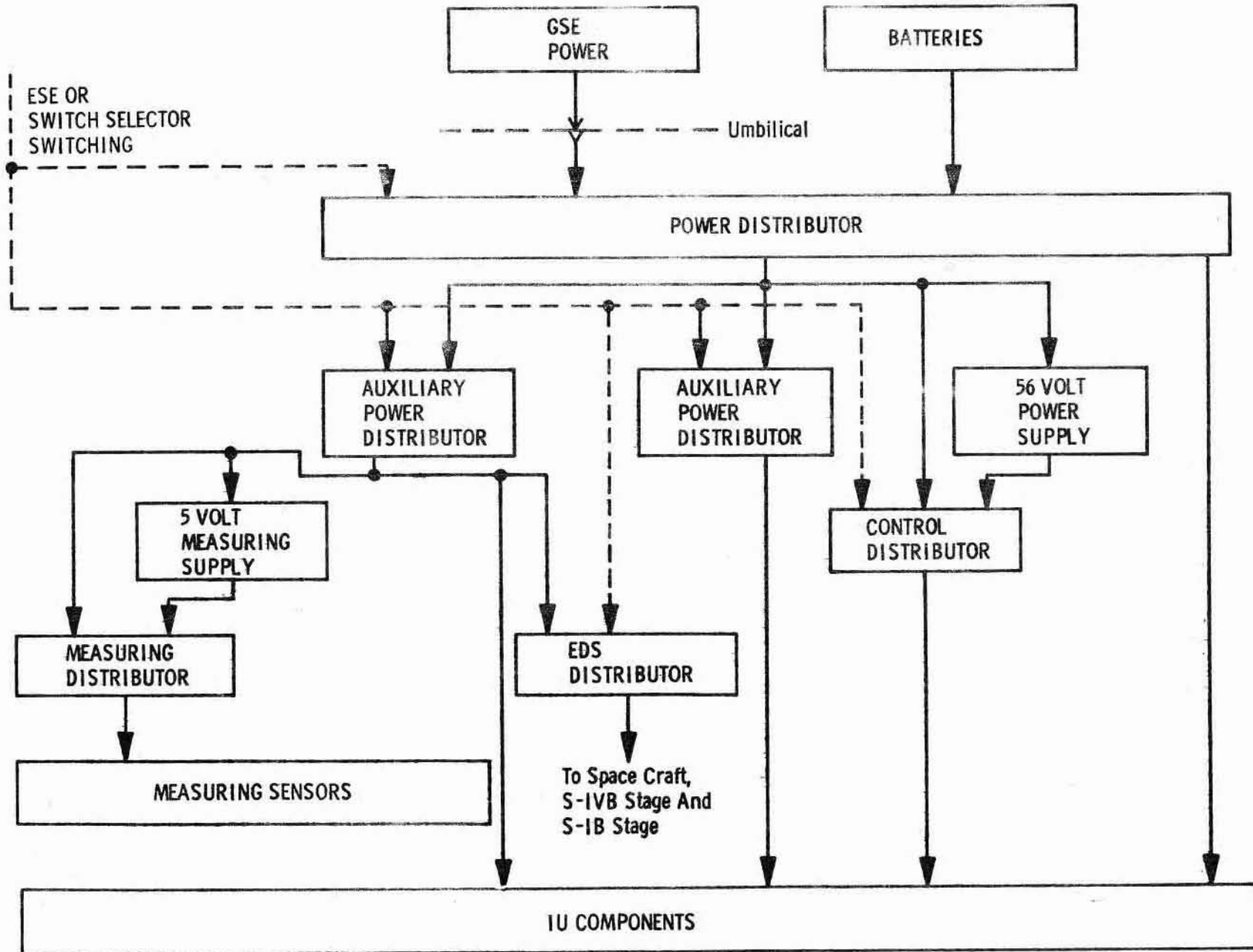
CABLING AND WIRING SAFETY FACTOR OF 2

MIN WIRE - AWG 24

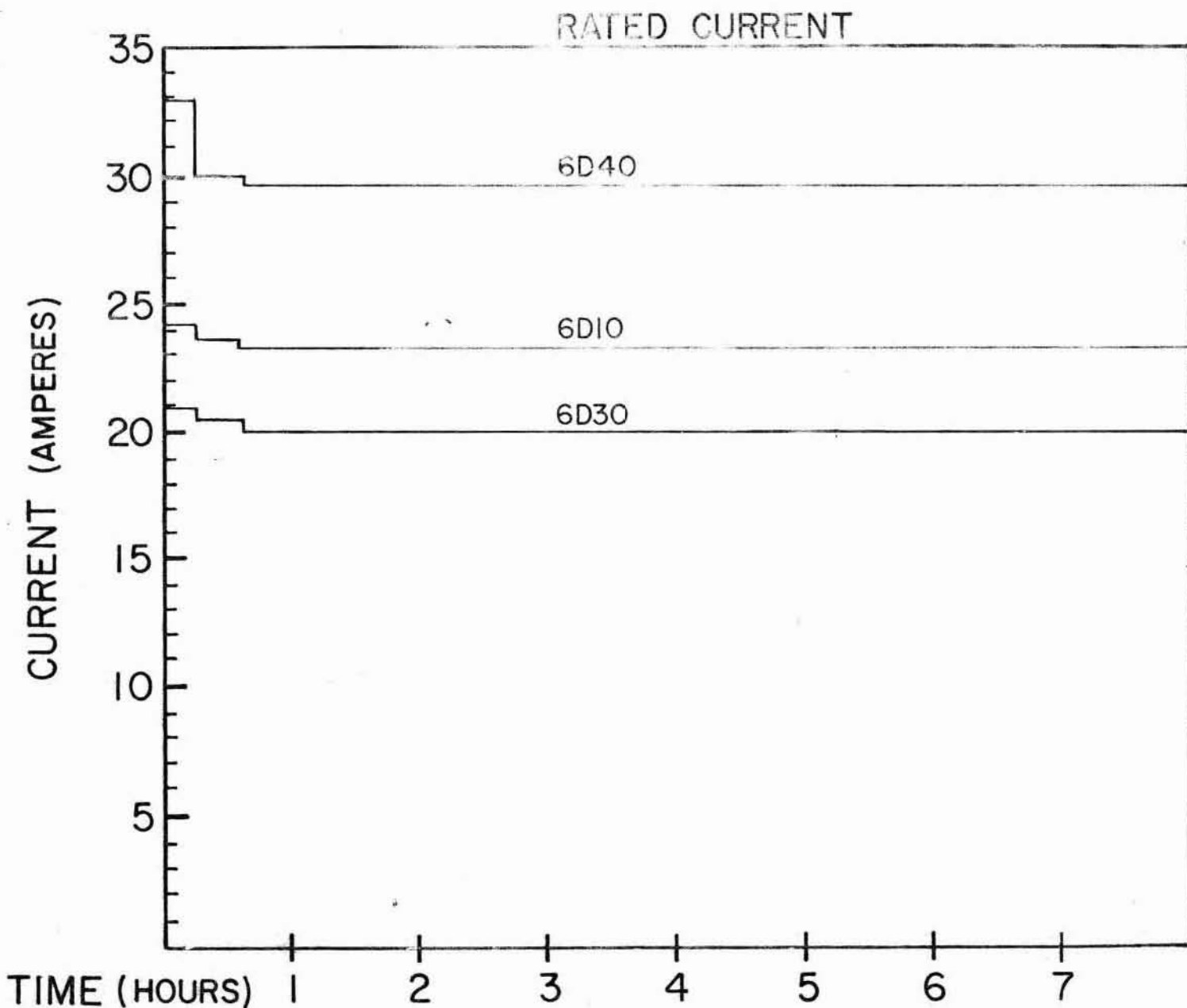
CABLING VOLTAGE DROP - 2V MAX.

MEAS. POWER SUPPLY - 5V \pm 0.1%

ELECTRICAL SYSTEM BLOCK DIAGRAM



205 BATTERY LOAD PROFILE



DISCHARGE DEPTH
-6.8 HRS.

D40 — 58 %
D30 — 40 %
D10 — 45.7 %

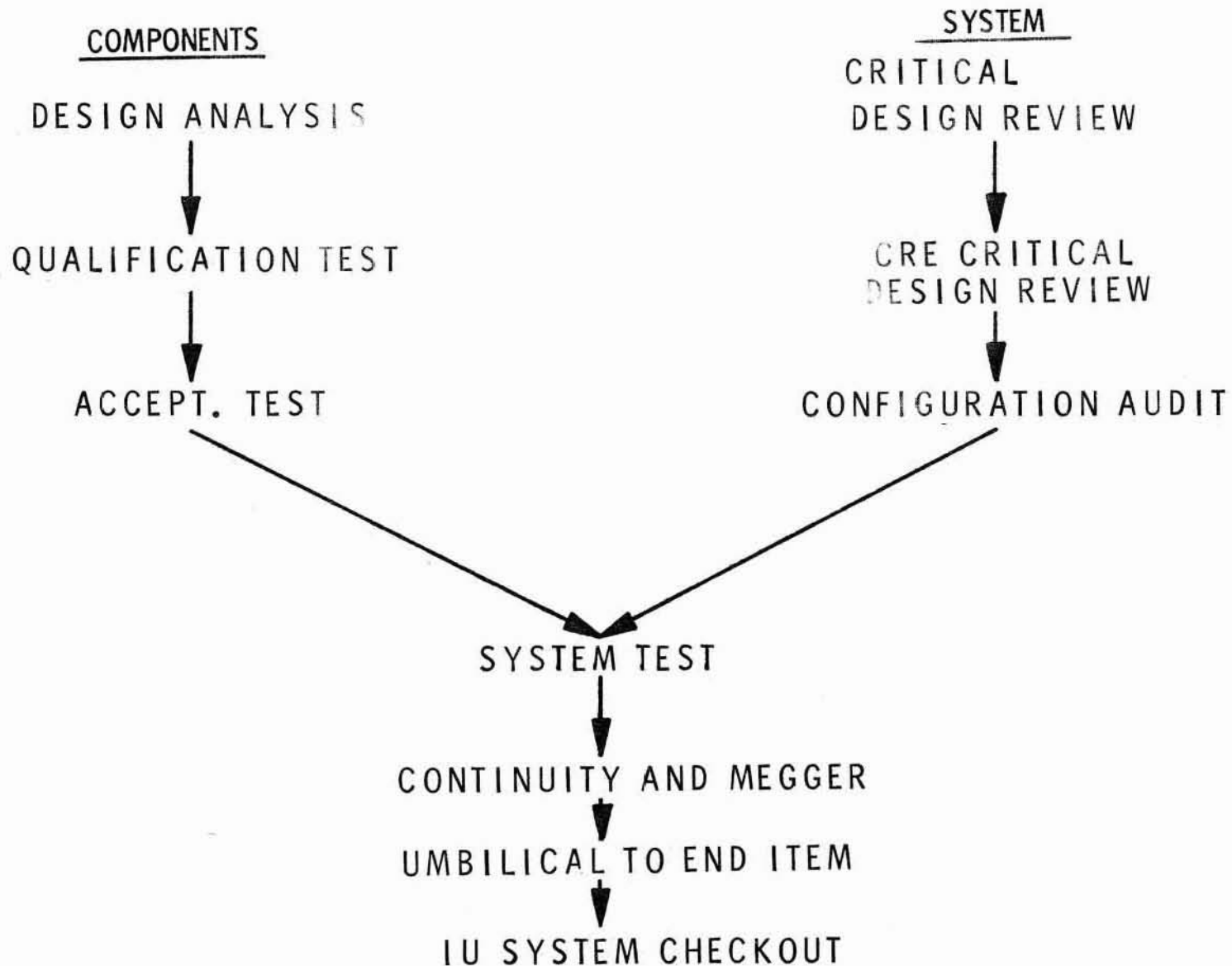
IU-205

ELECTRICAL SYSTEM DIFFERENCES
IU-203 - IU-205

PURPOSE: REDUCED MEASUREMENTS 362 to 202 AND ELIMINATE
MEASUREMENT RACKS
SUPPORT OTHER SUBSYSTEM CHANGES

HARDWARE CHANGES: ELIMINATE ONE MEASURING DISTR.
REDUCE BATTERIES FROM 4 TO 3
CABLES REDUCED FROM 190 TO 115

VERIFICATION PROGRAM



**EMERGENCY
DETECTION
SYSTEM**

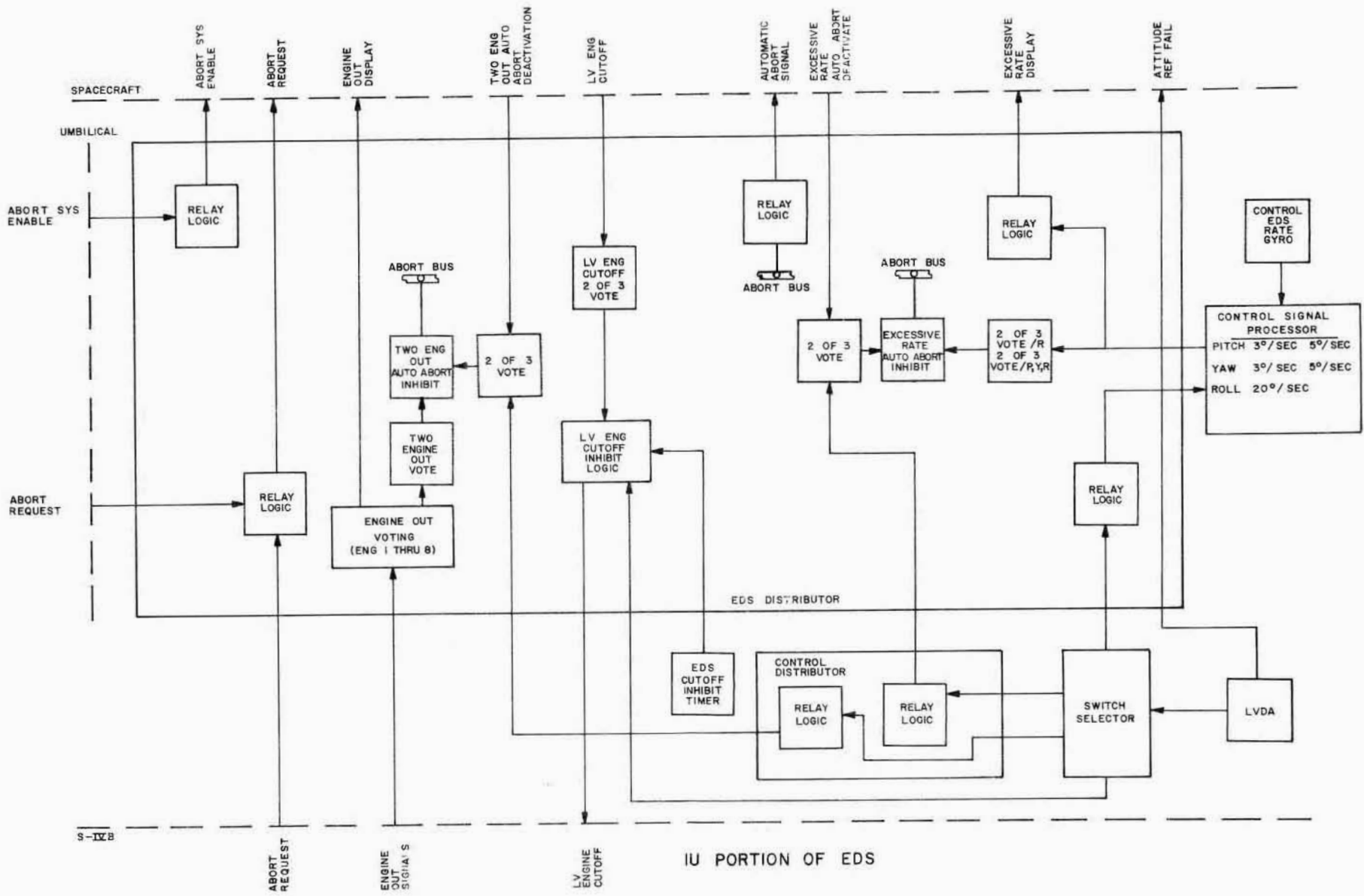
EMERGENCY DETECTION SYSTEM FUNCTIONS

SENSE AND ACT ON EMERGENCY SITUATIONS DURING BOOST.

PROTECT APOLLO CREW AGAINST VEHICLE FAILURE.

IU EDS FUNCTIONS

- 0 SENSE EXCESSIVE ANGULAR RATE
- 0 RATE LIMIT CHANGE
- 0 MAJORITY VOTE
 - 0 EXCESSIVE ANGULAR RATE
 - 0 ENGINE THRUST
- 0 INHIBIT ENGINES OUT ABORT. 135.8 SEC. AFTER LIFT OFF
- 0 INHIBIT EXCESSIVE RATE ABORT 135.4 SEC AFTER LIFTOFF
- 0 IDENTIFY ATTITUDE REFERENCE FAILURE
- 0 RESPOND TO CREW INHIBIT REQUEST AND LIFT OFF ENABLE
- 0 PREVENT ENGINE CUT OFF FOR 40 SEC.
- 0 PROVIDE SIVB ENGINE STATUS



S-IV B

IU PORTION OF EDS

EDS DIFFERENCES 203 - 205

EDS ENGINE CUTOFF INHIBITED ON S-IU 203

26 EDS MEASUREMENTS ON S-IU 203

- 16 ENGINE OUT (2 PER ENGINE)
- 2 LAUNCH VEHICLE EXCESSIVE RATE
- 2 LAUNCH VEHICLE ATTITUDE REFERENCE FAIL
- 1 ABORT REQUEST
- 2 EDS LIFTOFF
- 3 AUTO ABORT

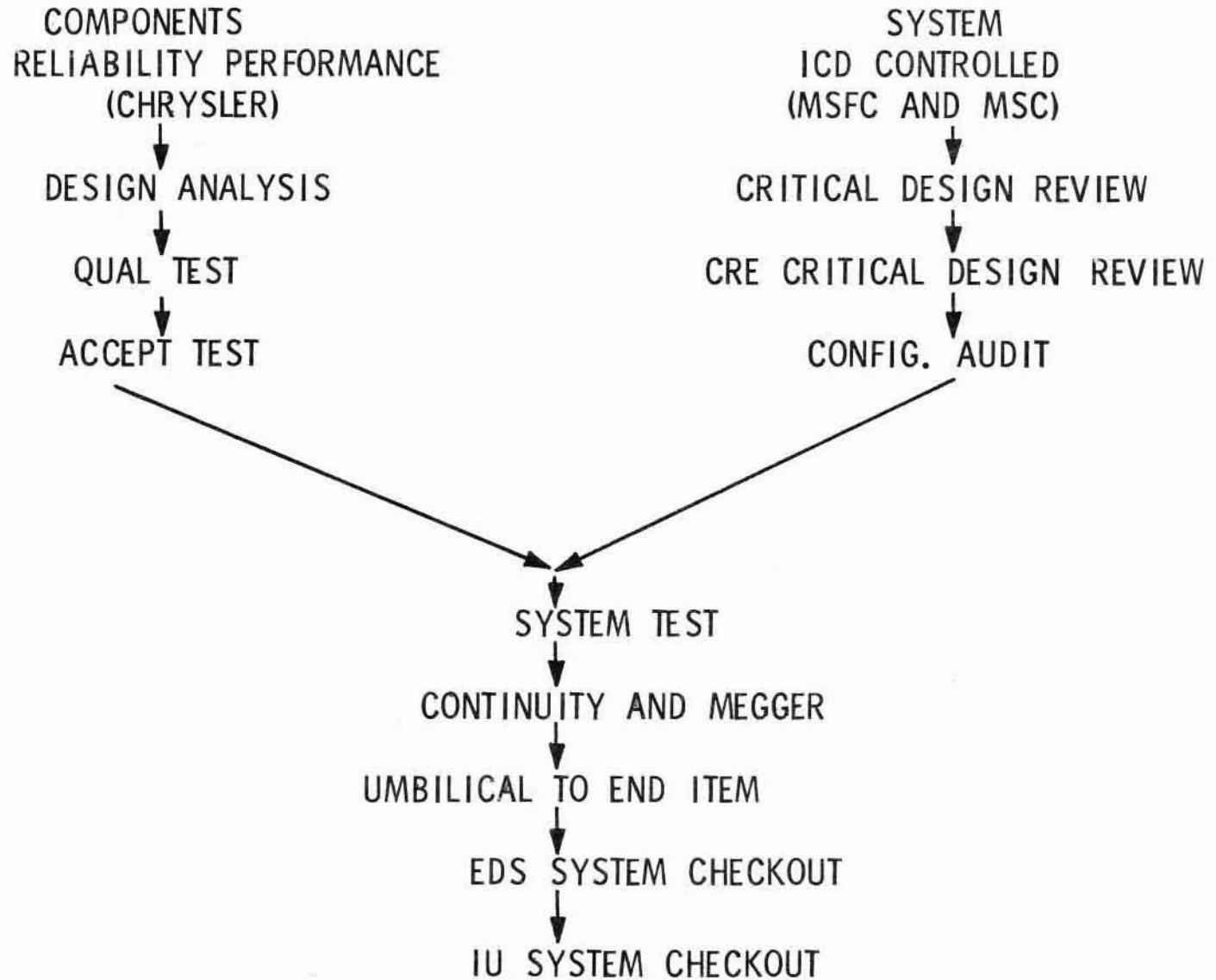
ON S-IU 205 ABOVE SIGNALS GO DIRECTLY TO SPACECRAFT.

S-IU 205 EDS SYSTEM CHANGED TO ACCOMMODATE SPACECRAFT 101 (BLOCK 11).

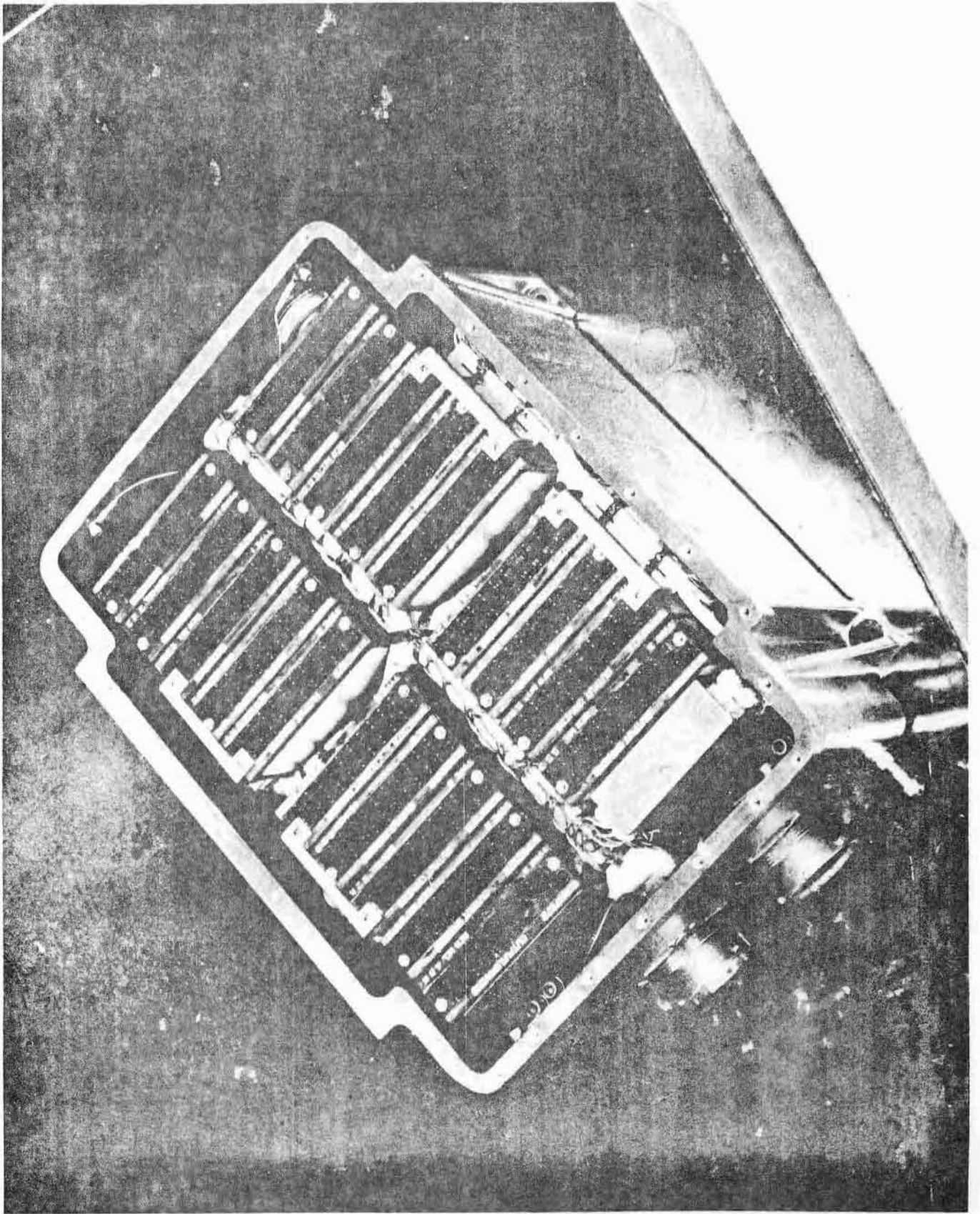
ELIMINATED 20 SECOND TIMER - SWITCH SELECTOR PERFORMS EXCESSIVE RATE SWITCH - IMPROVED RELIABILITY.

CIRCUIT ADDED TO PREVENT LAUNCH VEHICLE CUTOFF AT $T_0 + 40$ SECONDS IF AN ABORT OCCURS PRIOR TO 40 SECONDS.

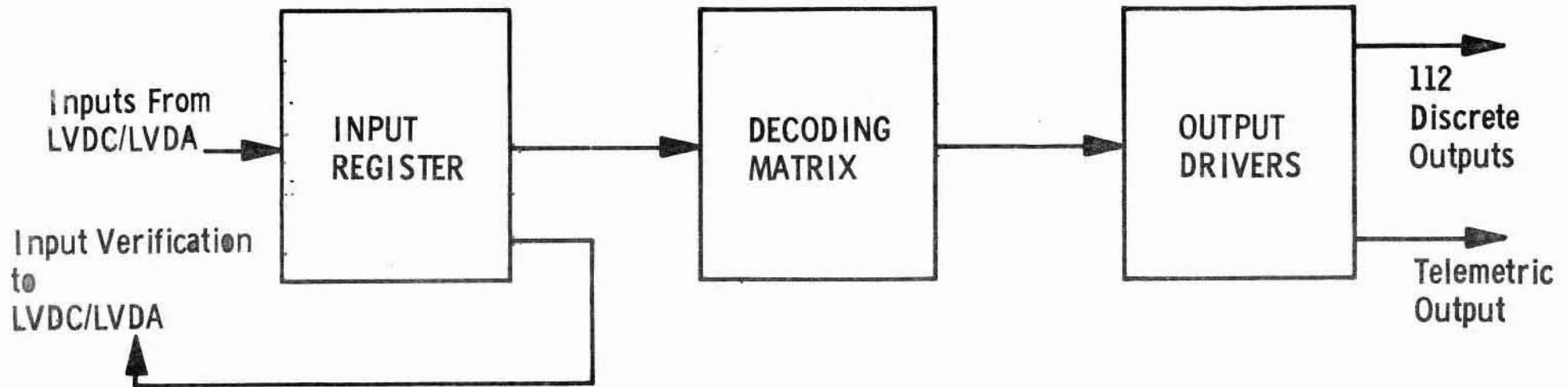
VERIFICATION PROGRAM



SWITCH SELECTOR



SWITCH SELECTOR BLOCK DIAGRAM



Design Features:

- Quad Redundant Circuits
- Dual Redundancy in Register
- Triple Redundant Command Functions
- Dual Electrical Connectors

DESIGN GROUND RULES

REQUIREMENTS	IMPLEMENTATION
AUTO ABORT	
2 OR MORE ENGINES LOSE THRUST	2 OUT OF 3 VOTE FOR EACH ENGINE
EXCESSIVE VEHICLE ANGULAR RATE	2 OUT OF 3 VOTE FOR EACH AXIS
MANUAL ABORT	
ENGINE STATUS (SIB)	2 OUT OF 3 VOTE FOR EACH ENGINE LIGHT INDICATION REDUNDANT
ENGINE STATUS (SIVB)	LIGHT INDICATION REDUNDANT
EXCESSIVE VEHICLE ANGULAR RATES	LIGHT INDICATION REDUNDANT
LV ATTITUDE REFERENCE FAIL	LIGHT INDICATION REDUNDANT
ABORT REQUEST	LIGHT INDICATION REDUNDANT
GENERAL	
NO SINGLE POINT FAILURE SHALL CAUSE AN ABORT	TRIPLE REDUNDANT CIRCUITS FOR AUTO ABORT WITH DUAL REDUNDANT CIRCUITS FOR MANUAL ABORT. REDUNDANT SIGNALS ARE ROUTED THROUGH SEPARATE CABLES, CONNECTORS AND P.W. BOARDS.
BATTERIES ARE ELECTRICALLY ISOLATED FROM EACH OTHER	3 BUS SYSTEM (EDS NO 1, NO 2, NO 3)

VERIFICATION PROGRAM



Design Analysis



Qualification Test



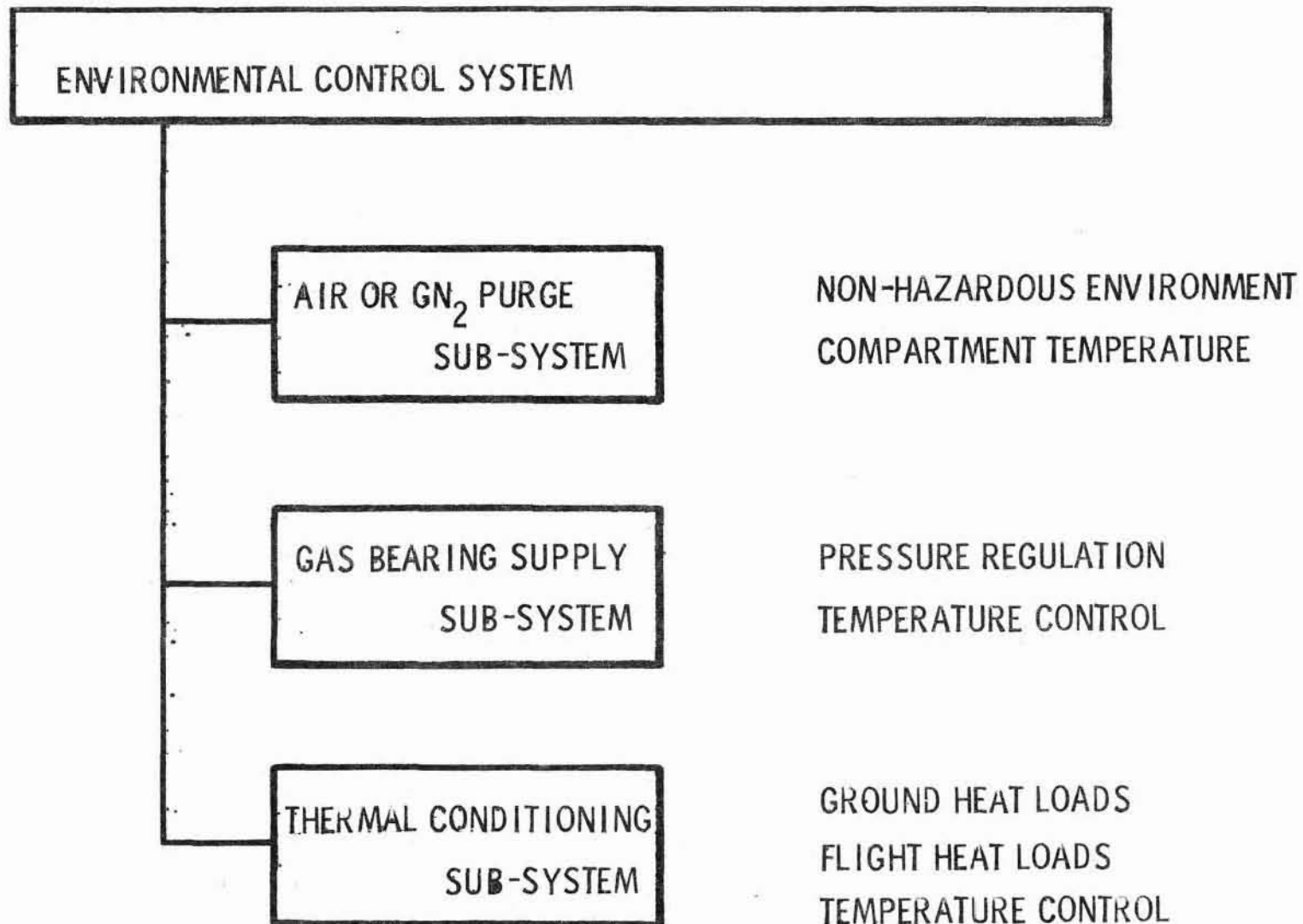
Pre-acceptance Test



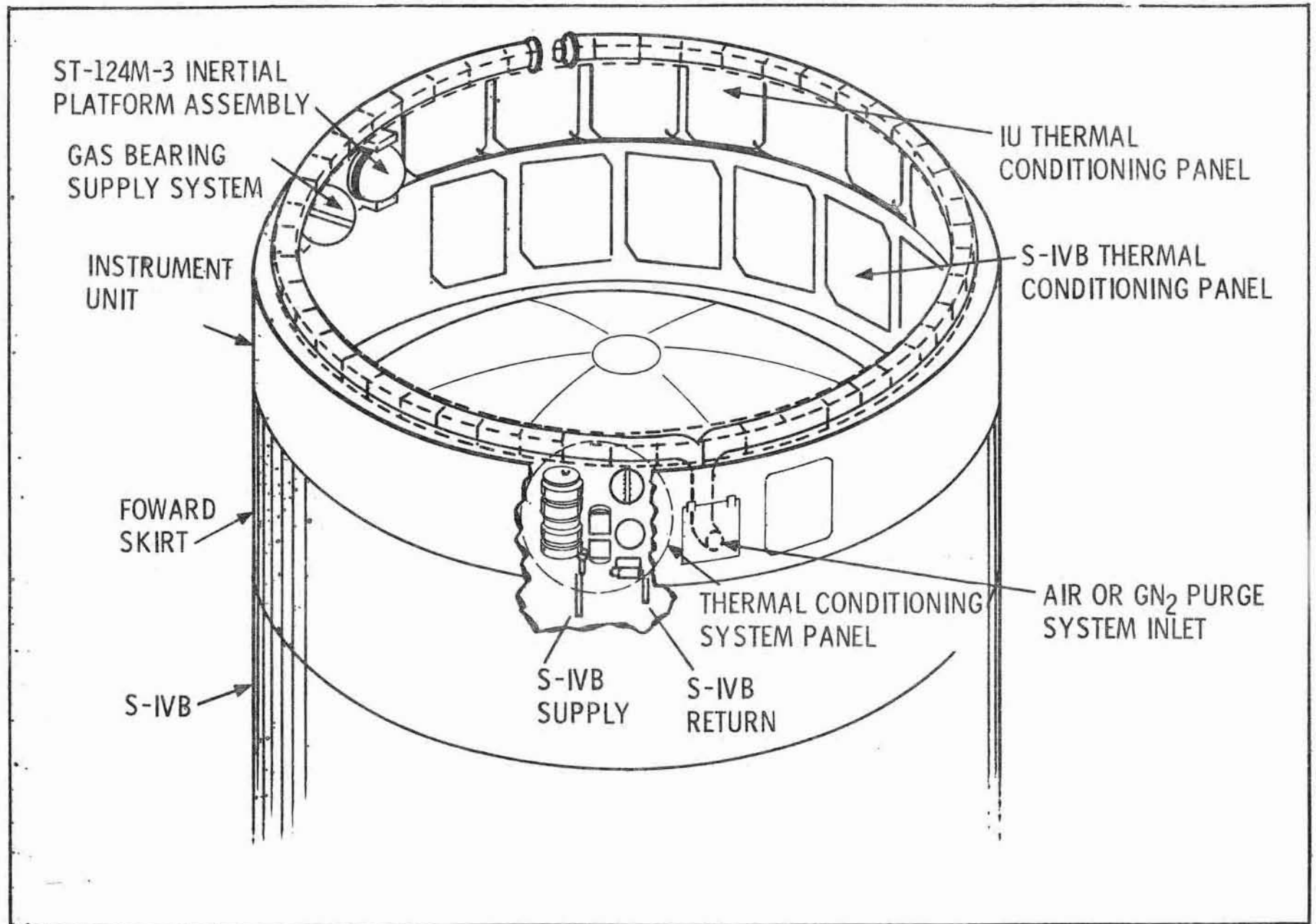
Acceptance Test

ENVIRONMENTAL CONTROL

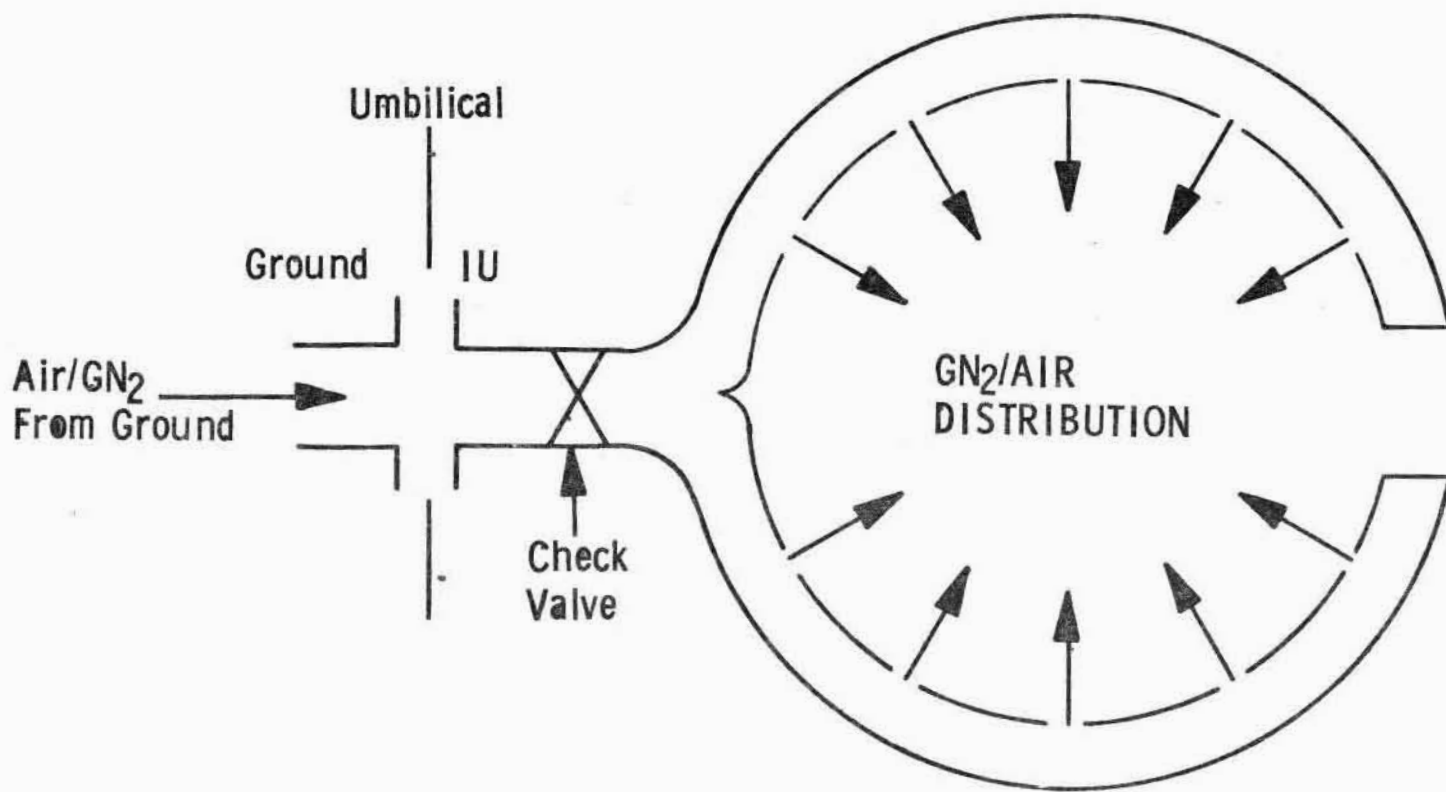
DESIGN REQUIREMENTS



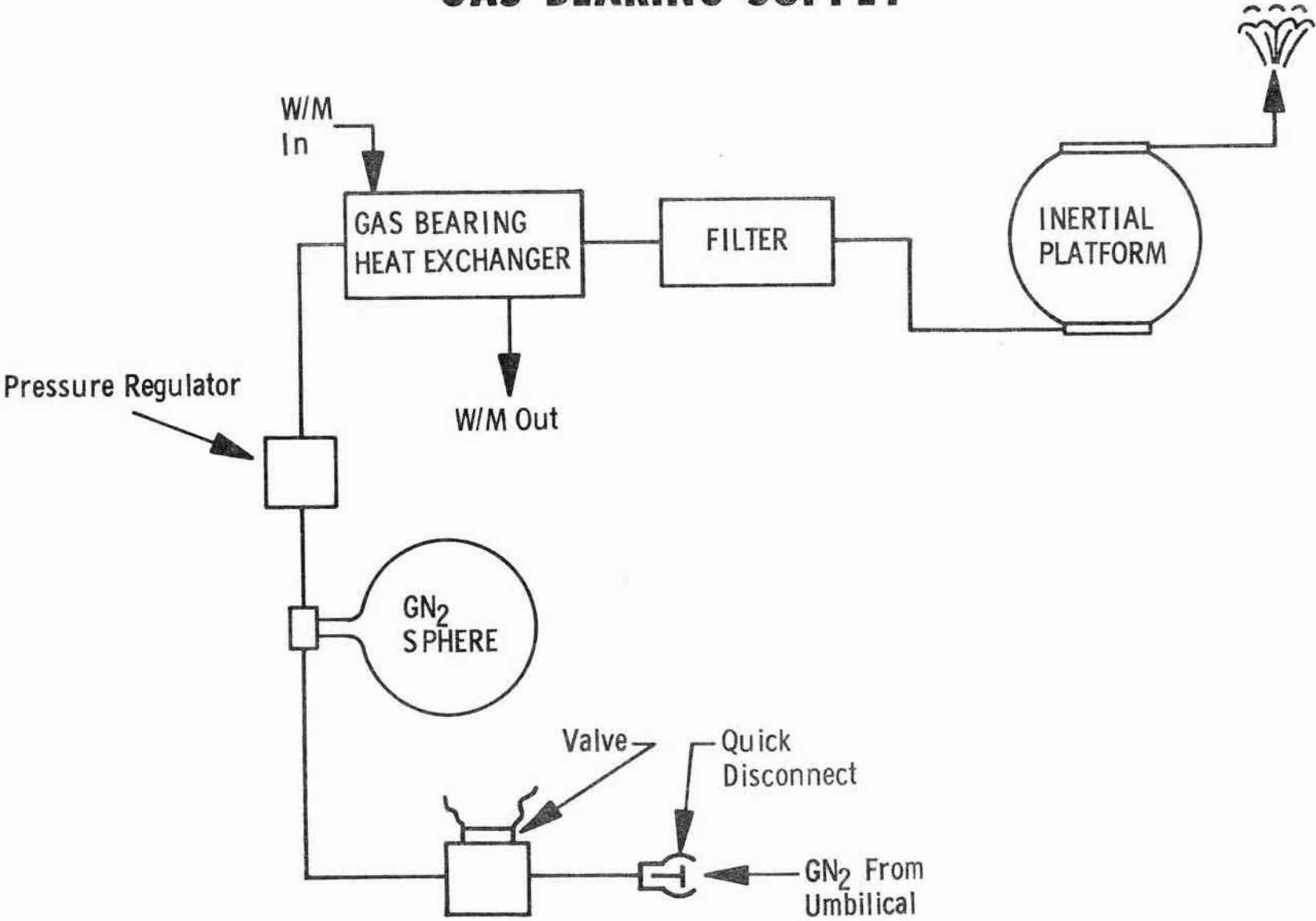
Environmental Control System

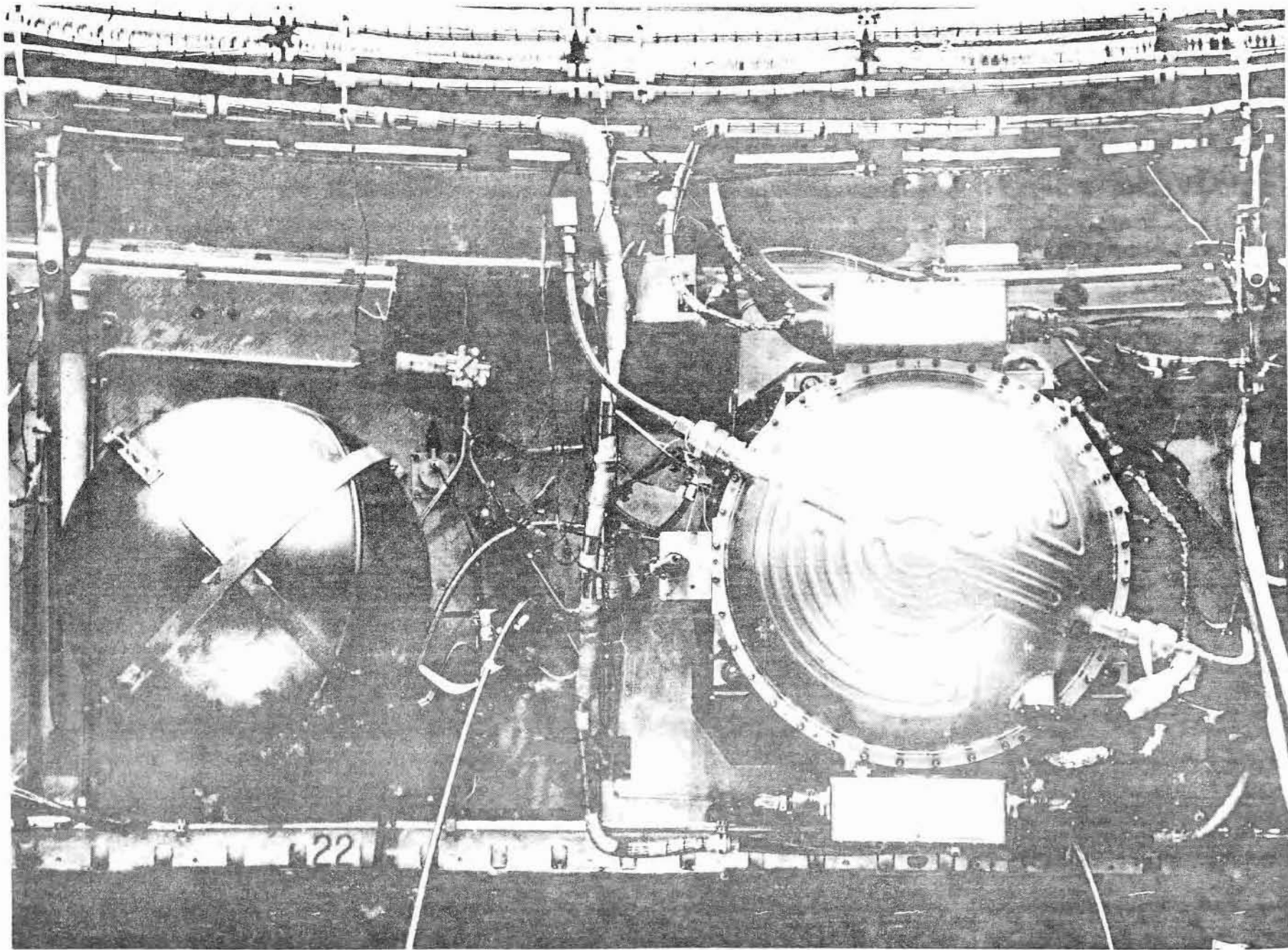


PURGE DUCT SYSTEM

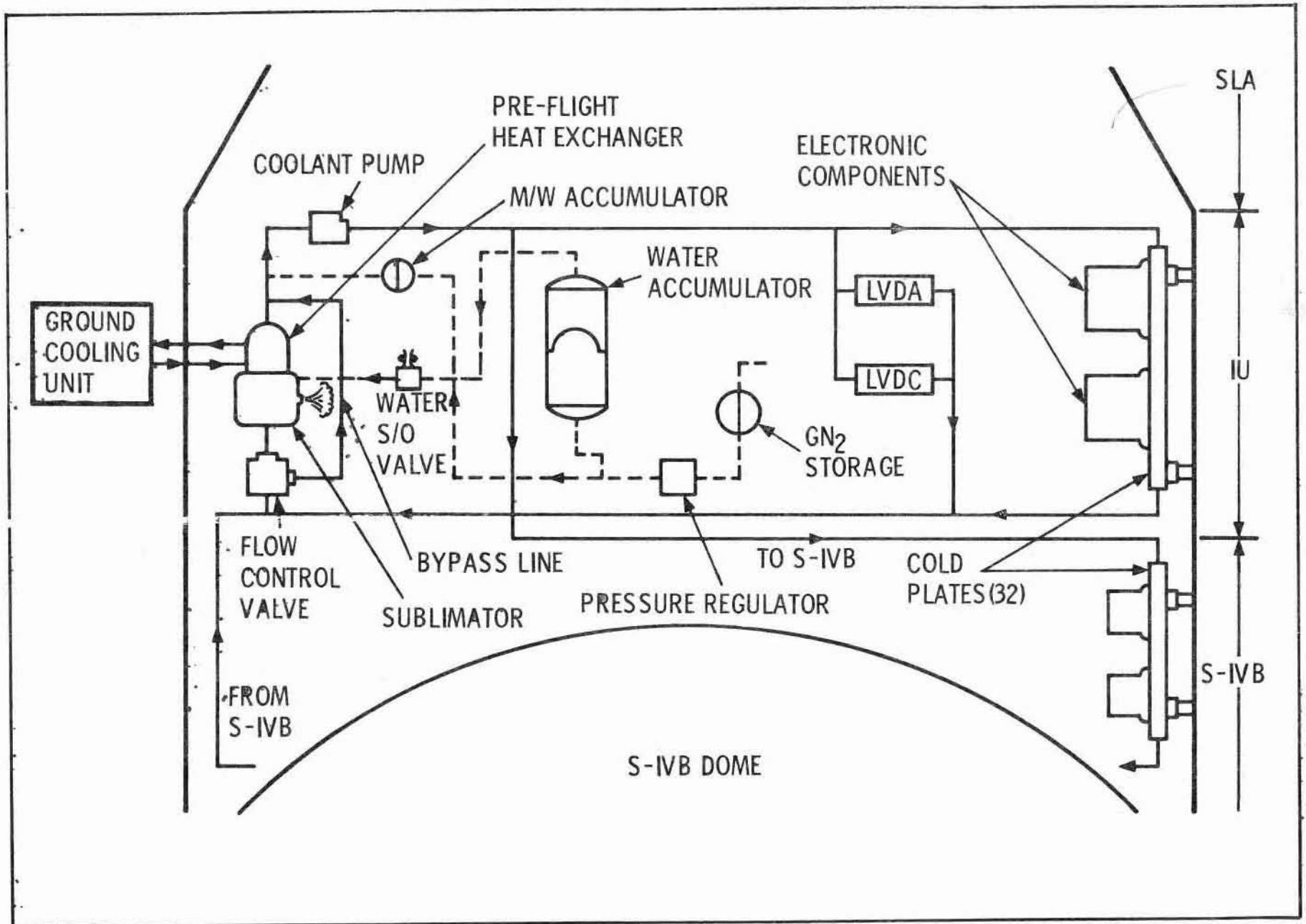


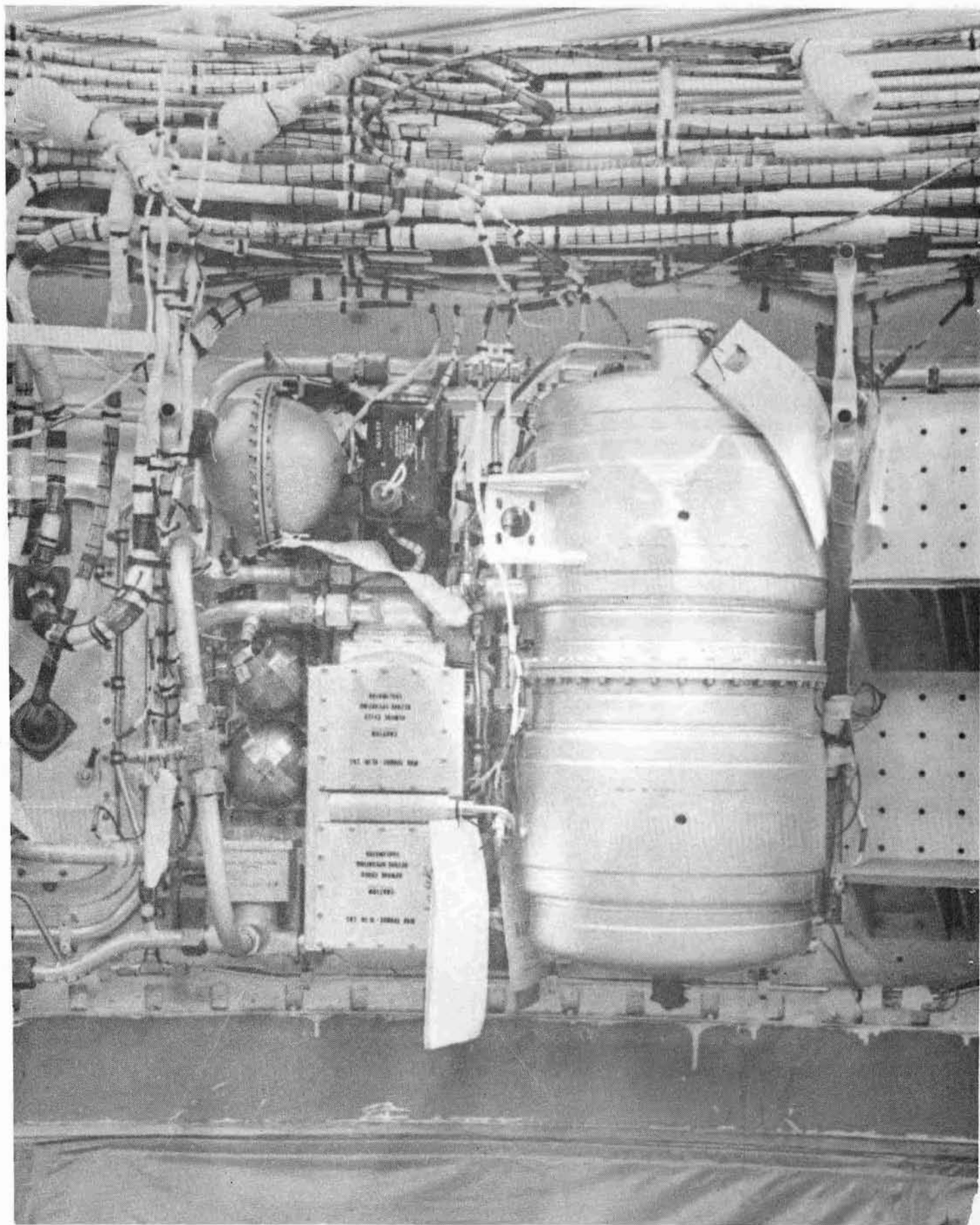
GAS BEARING SUPPLY



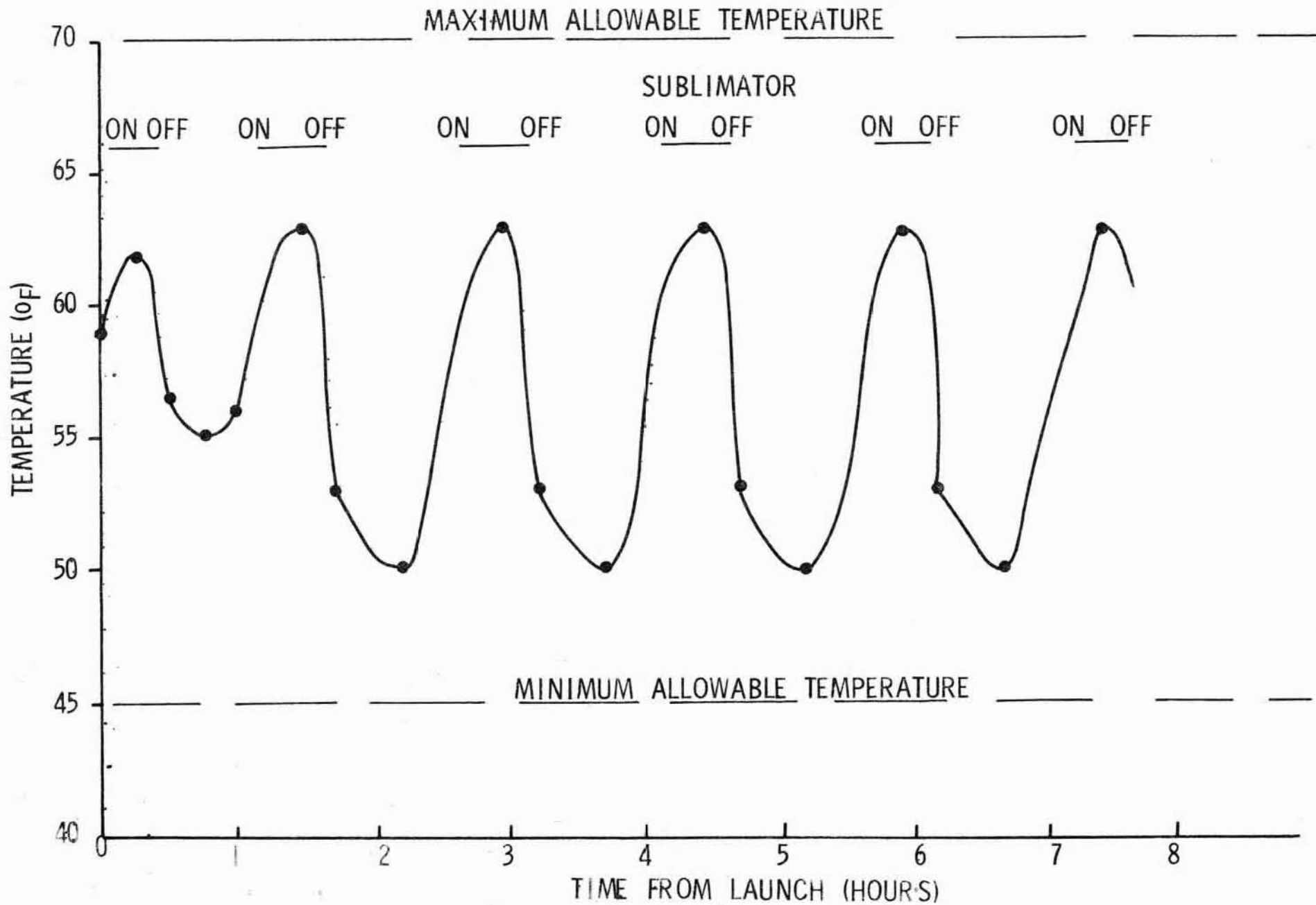


Thermal Conditioning System

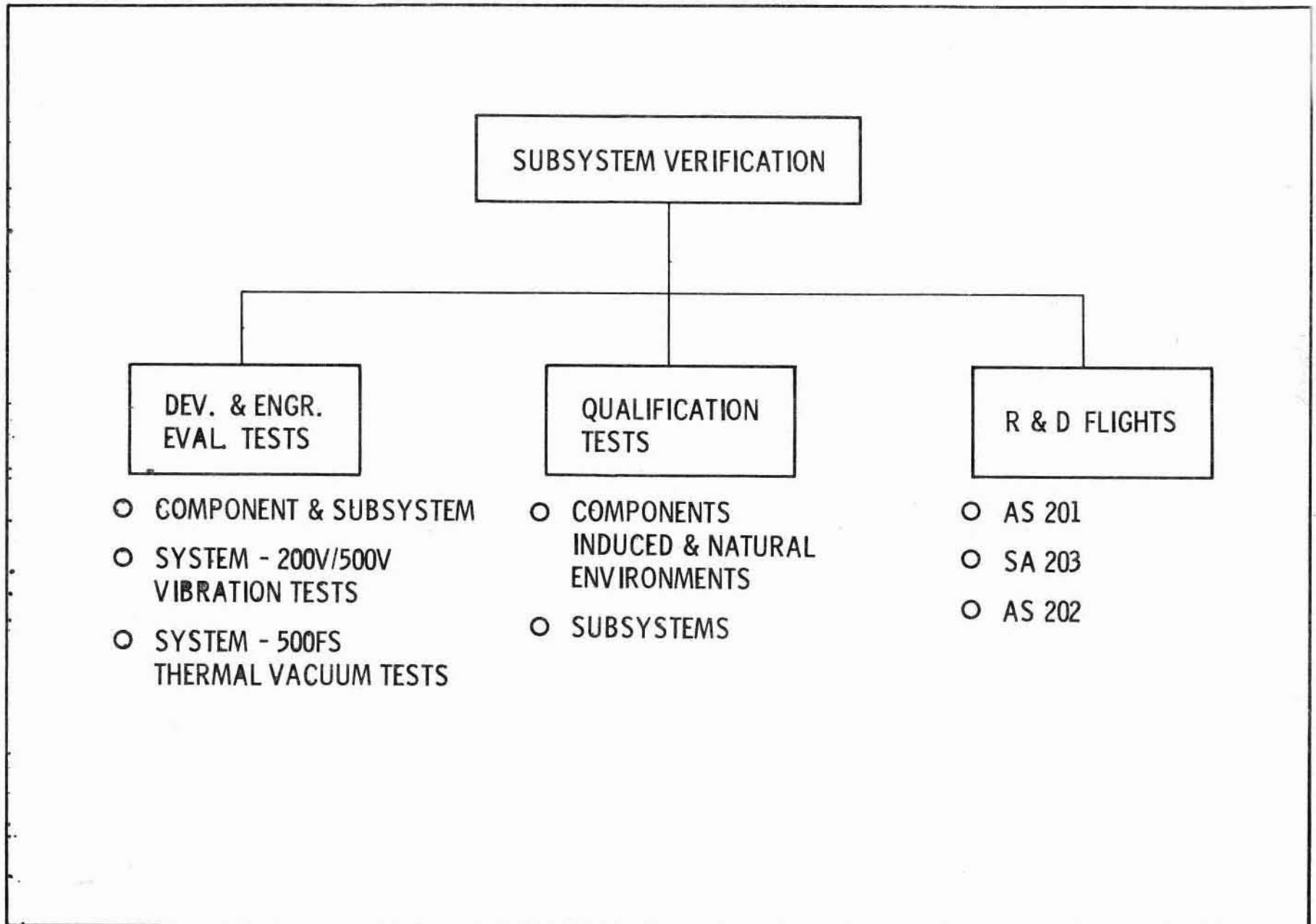




AS 205 M/W TEMPERATURE PREDICTIONS



Test Verification Program



SAFETY CONSIDERATIONS

1. GN₂ PURGE - INERT ENVIRONMENT DURING & AFTER PROPELLANT LOADING
2. W/M LEAKAGE - MAX. LEAKAGE .01% OF AMT. REQ'D FOR COMBUSTION
3. THERMAL SHROUDS - REPLACED WITH NON FLAMMABLE ALUMINUM TAPE
4. PROTECTIVE COVERS - PROTECT IU AGAINST PROPELLANT SPILLAGE
5. SYSTEM PROCEDURE REVIEW - INSURE COMPATABILITY WITH SAFETY REQUIREMENTS

ECS FACTORS OF SAFETY

1. EXPENDABLES:

- o PLATFORM GN₂ SUPPLY 200% OF REQ'D* CAPACITY
 - o W/M GN₂ PRESSURIZATION 115% OF REQ'D* CAPACITY
 - o SUBLIMATOR WATER 225% OF REQ'D* CAPACITY
- * REQ'D MISSION TIME 6.8 HRS.

2. THERMAL LAG (500 FS):

- o HOT CONDITIONS (NO W/M CIRCULATION) 20 MIN. TO COMPONENT RED LINE - PLATFORM
2 1/2 HRS. TO FAILURE - LVDC
- o COLD CONDITIONS (SUBLIMATOR FULL ON) 20 MIN. TO COMPONENT RED LINE
LVDC & PLATFORM
REACH STEADY STATE 30⁰F - NO FAILURES

STRUCTURES

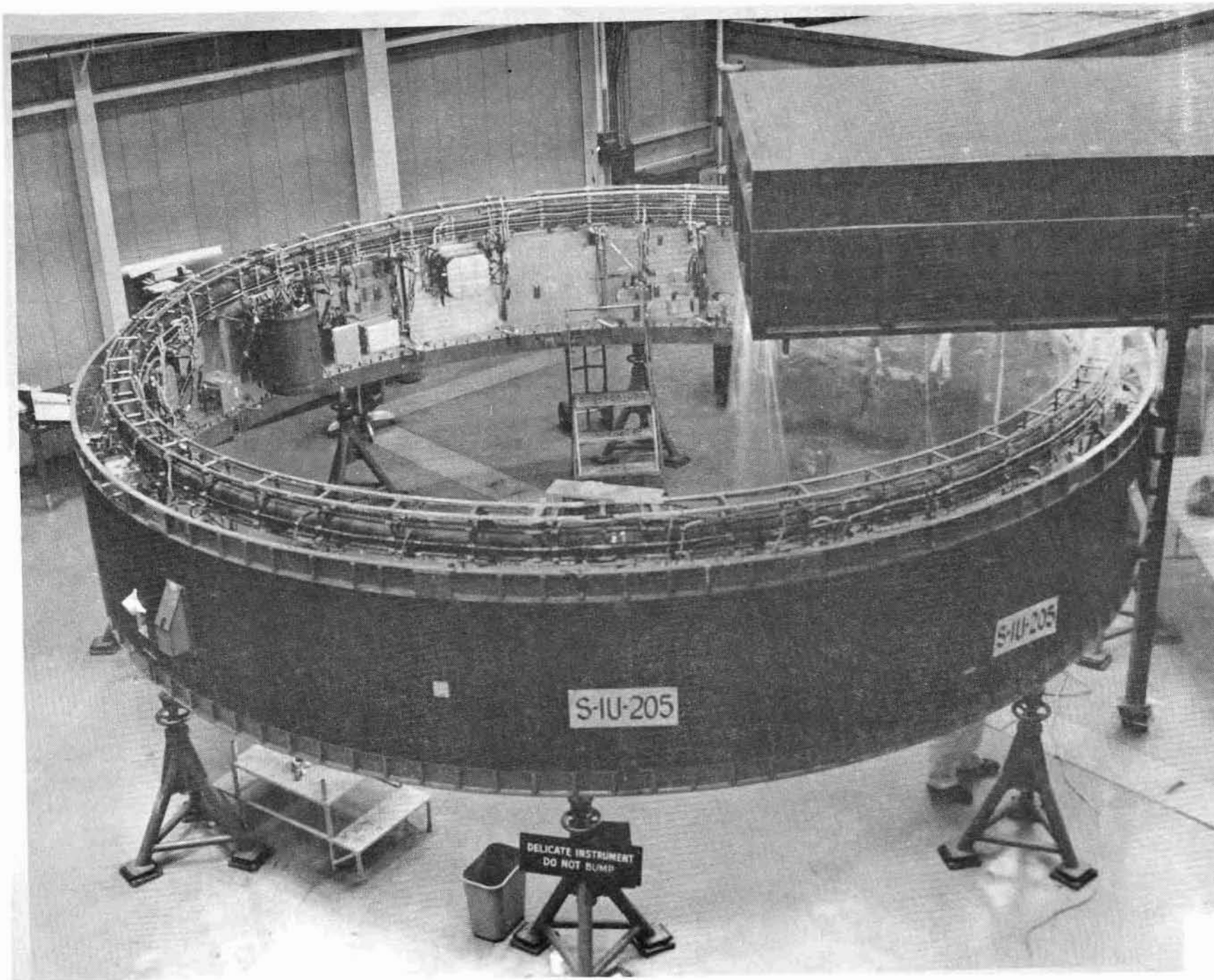
STRUCTURE SUBSYSTEM IU DESIGN REQUIREMENTS

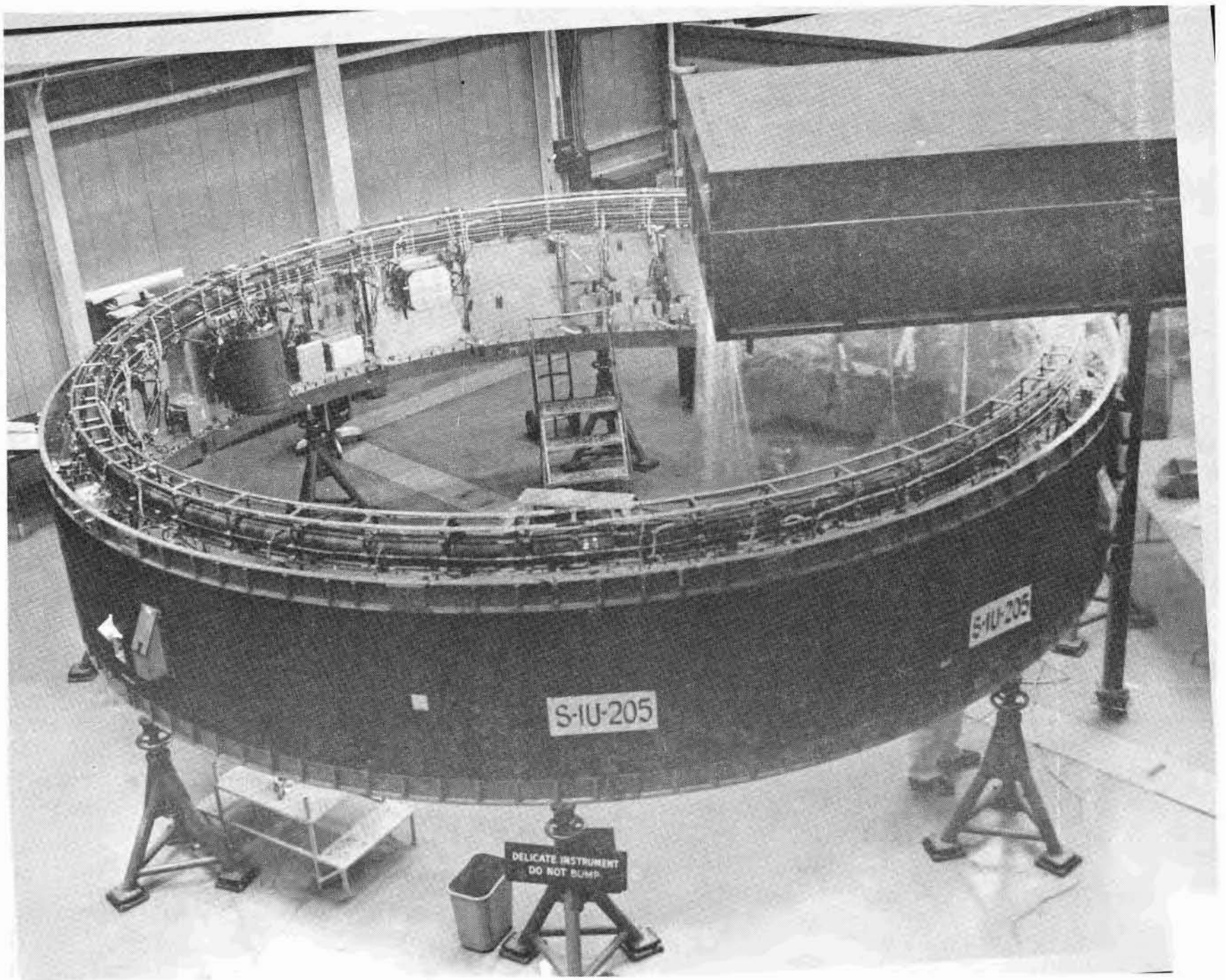
PRIMARY

- **Transfer Load Between The S-IVB And SLA**
- **Provide Mount For Equipment**

SECONDARY

- **Provide Personnel Access Door**
- **Provide Umbilical Plate For Ground Checkout**
- **Provide Cable And Purge Duct Tray**

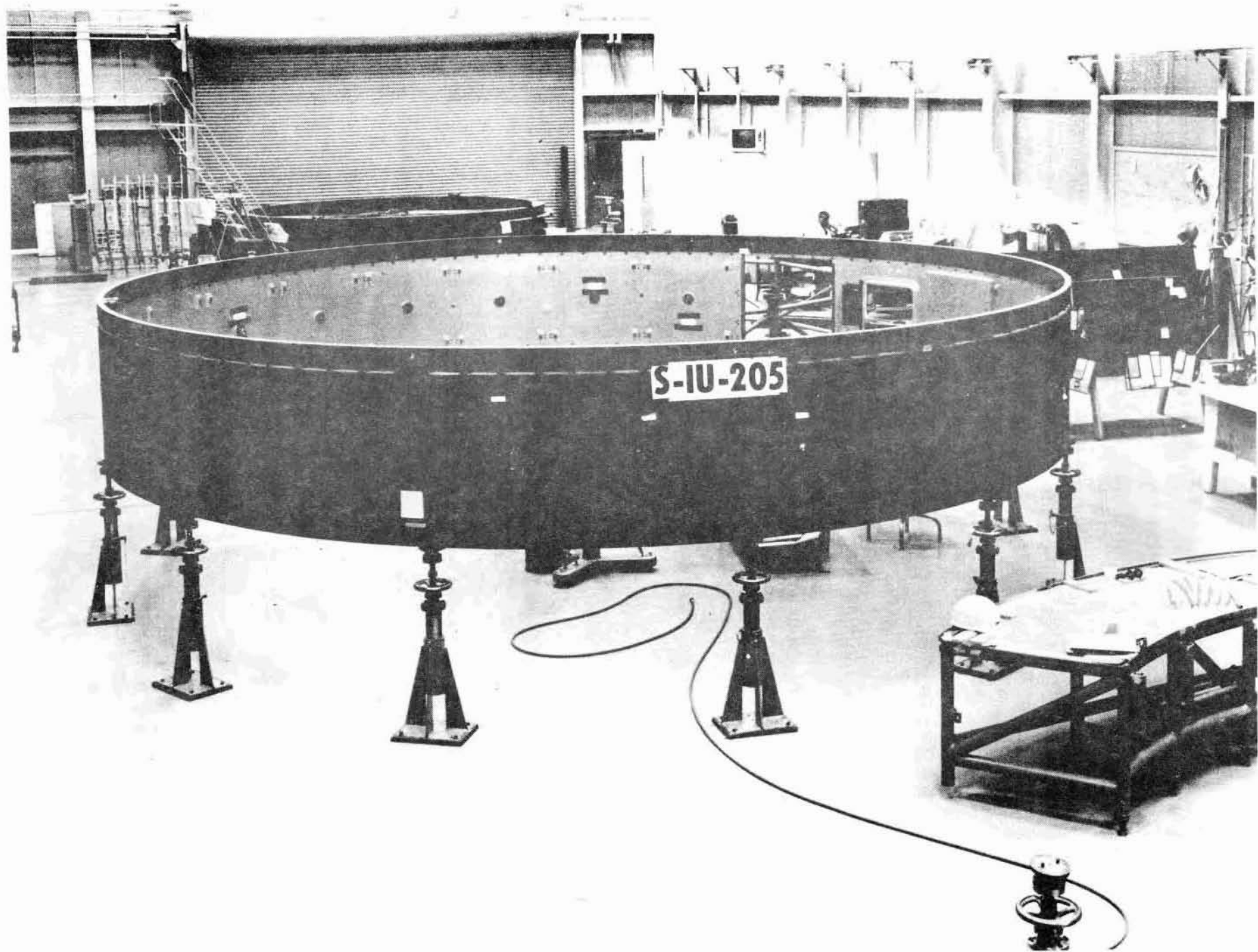




S-IU-205

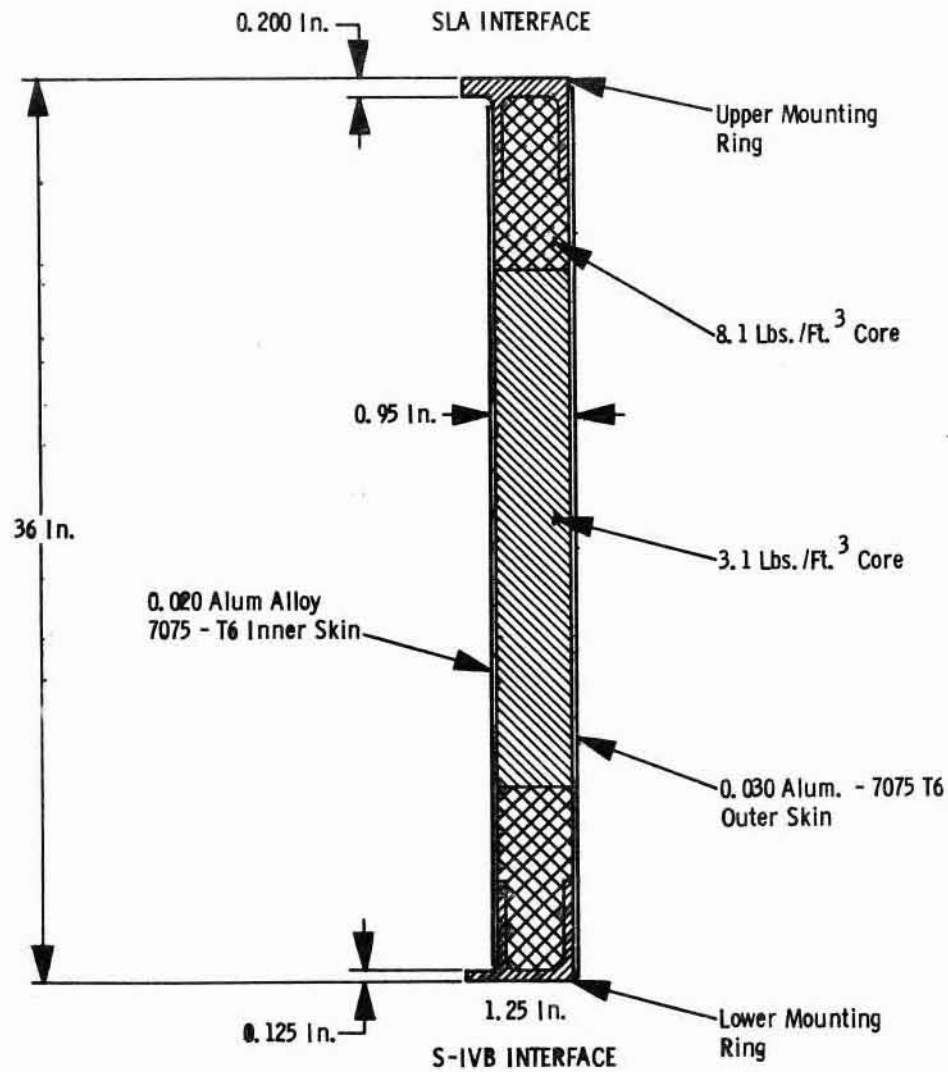
S-IU-205

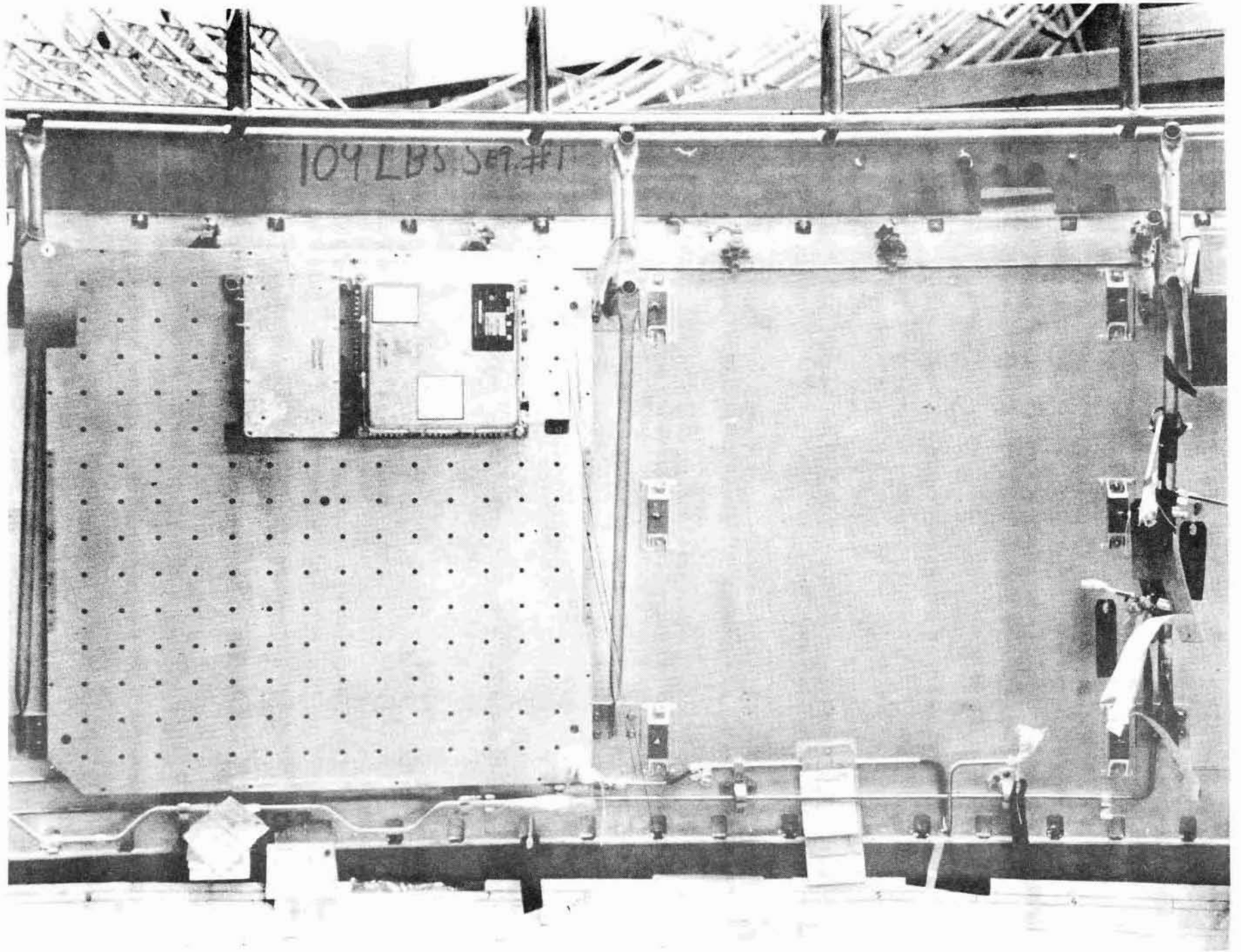
DELICATE INSTRUMENT
DO NOT BUMP

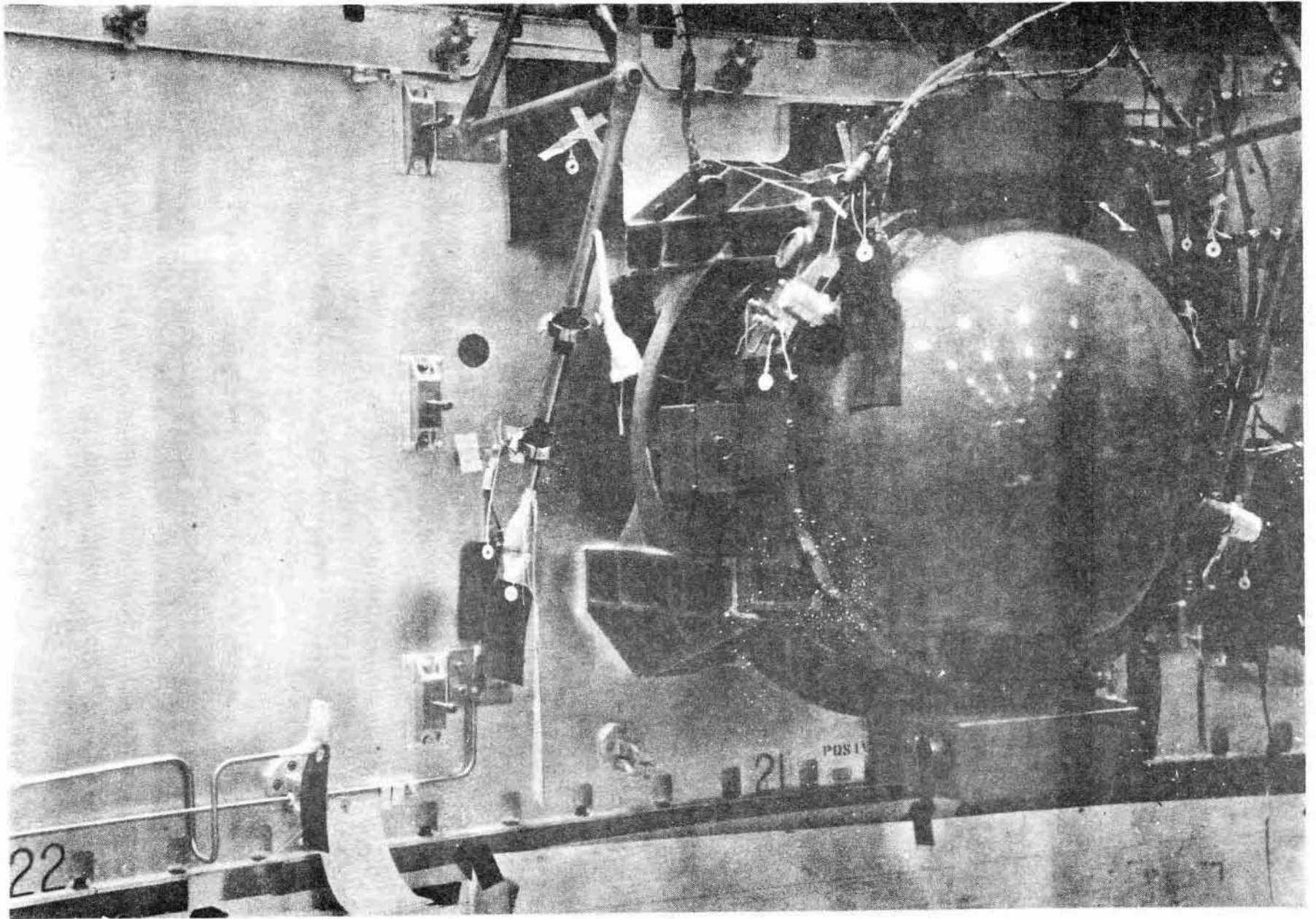


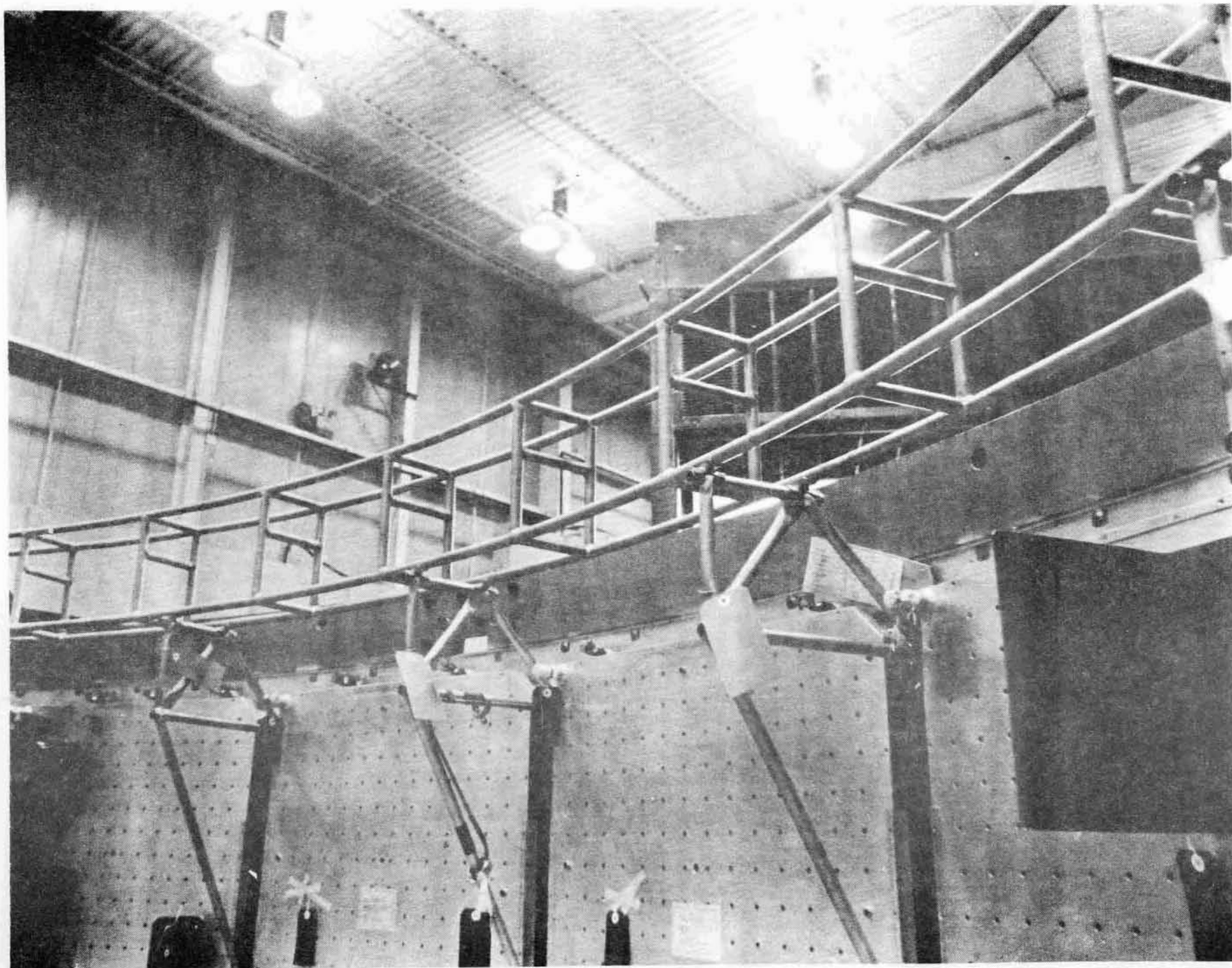
S-IU-205

TYPICAL SECTION OF HONEYCOMB SANDWICH FOR INSTRUMENT UNITS









QUALITY ASSURANCE PROGRAM

NON-DESTRUCTIVE MEASUREMENTS

Dimensional

Ultrasonic

Portashear

Proof Load

Radiographic

Bonded Assemblies
Welds & Castings

DESTRUCTIVE TESTS

Confirmation Test

Segment

Bonded And Tested To Destruction Prior To Production And After Each 15th Segment

Test Tab

Bonded With Each Segment And Specimens Tested

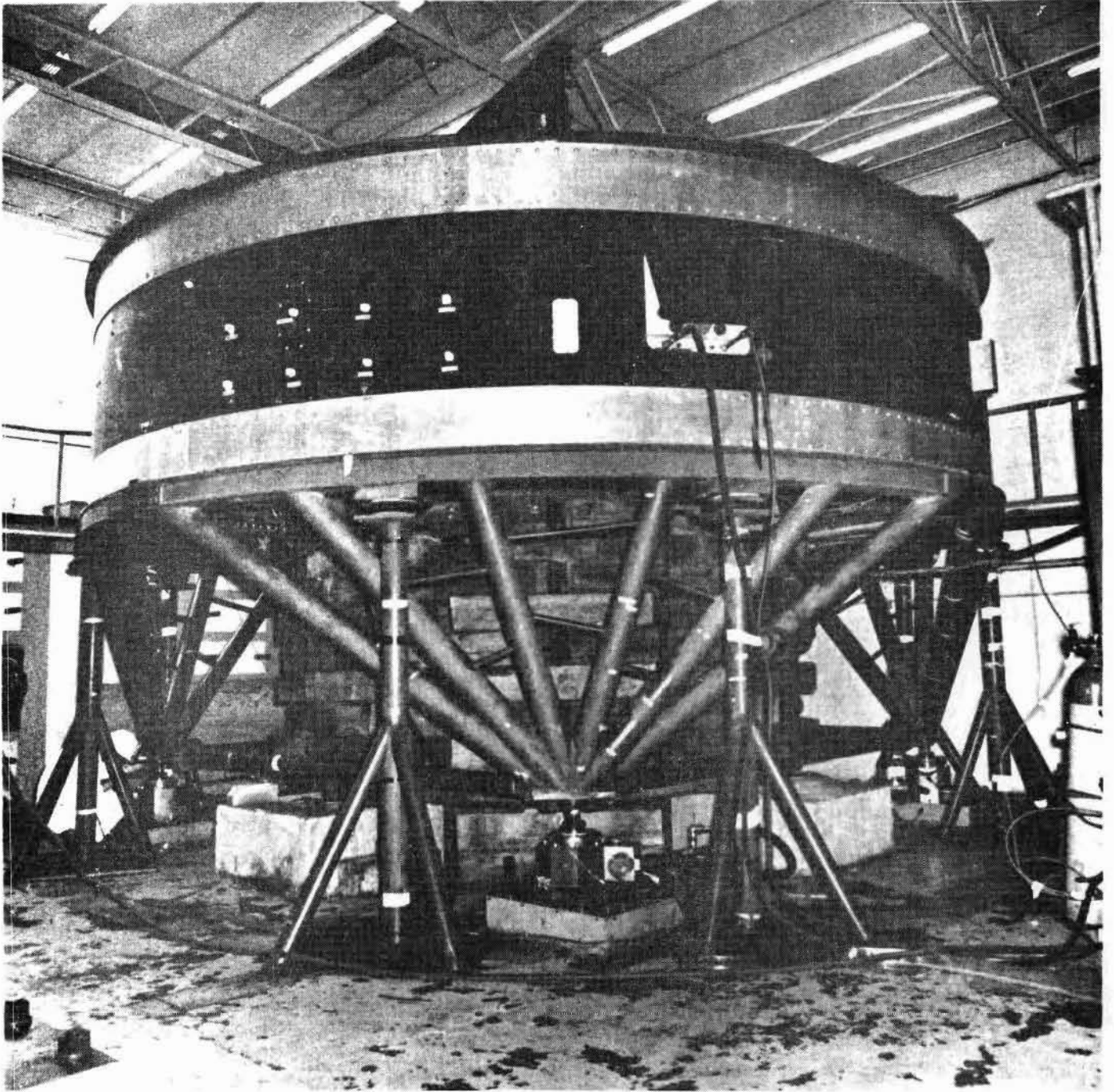
FLIGHT LOAD REQUIREMENTS

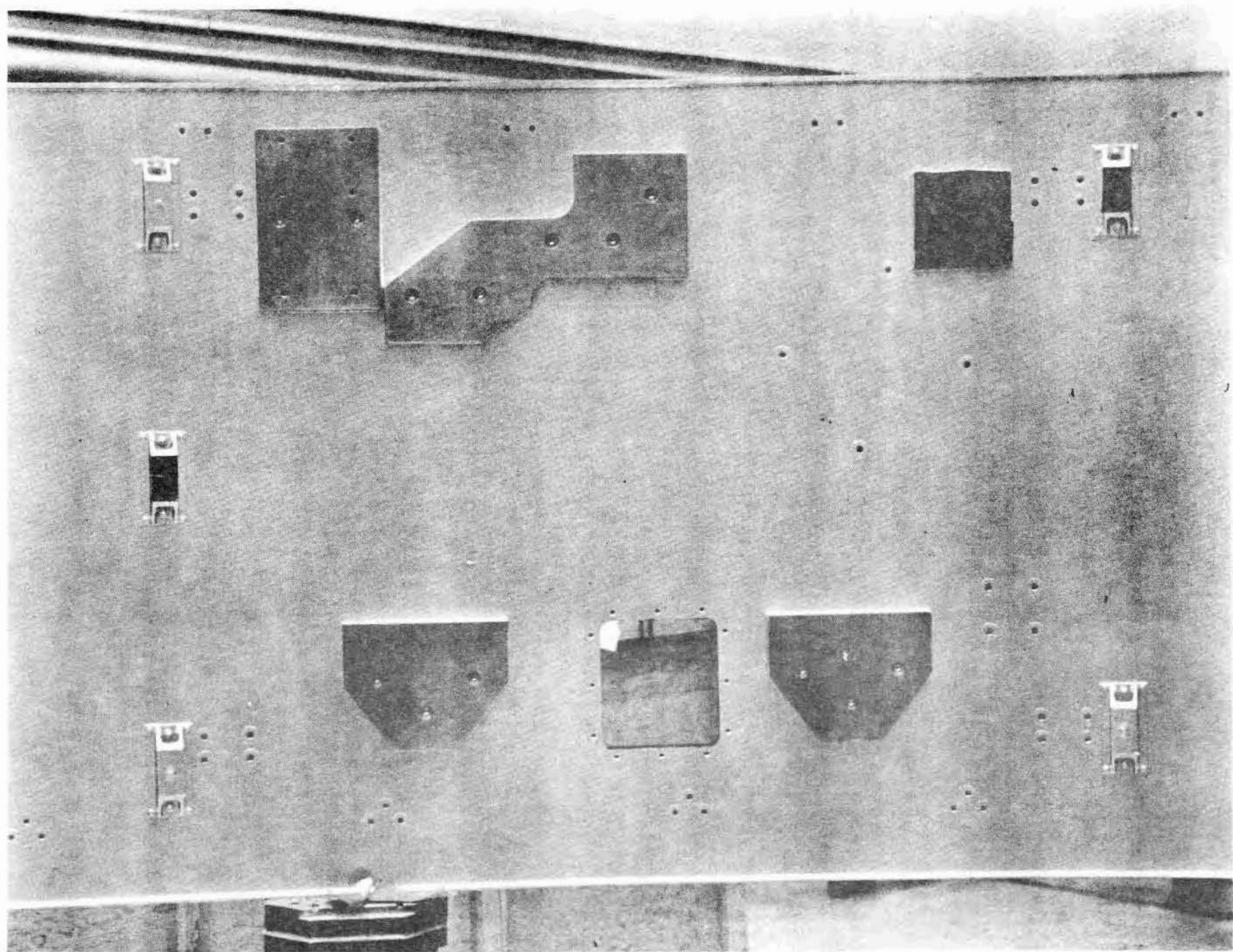
VEHICLE	LIMIT LOAD (LBS/IN)	FACTOR OF SAFETY
SATURN V TENSION COMPRESSION	608 987	1.4 * 1.4 *
SATURN IB TENSION COMPRESSION	394 640	> 2.2 > 2.2

* IU DESIGN TO SATURN V LOADS DEMONSTRATED BY TEST RESULTS

IU STRUCTURAL QUALIFICATION TESTS

	STATIC		DYNAMIC	
Test Vehicle	200/500S	200/500S-II	500V	500V-II
Purpose	Qualify Design	Qualify New Structure Source	Qualify Design	Qualify New Source
Environment	Loads Greater Than Saturn IB Ultimate	Saturn V Ultimate Loads	Saturn V Multi Axis Sine Sweep And Random	Saturn V Flight Axis Sine Sweep & Random
Results	Design Qualified	New Structure Source Qualified	Design Qualified	New Structure Source Qualified





STATIC LOADING TEST STAND

SWING ARM TEST STAND

IU TEST HISTORY & STATUS

INSTRUMENT UNIT 205 LIFE HISTORY

3/5/66



FABRICATION AND ASSEMBLY

9/19/66

POST MFG.
CHECKOUT



STORAGE AT MSFC



11/4/66

MOD KIT INST. & MISSION RECONFIG



2/20/67

RETEST 205X



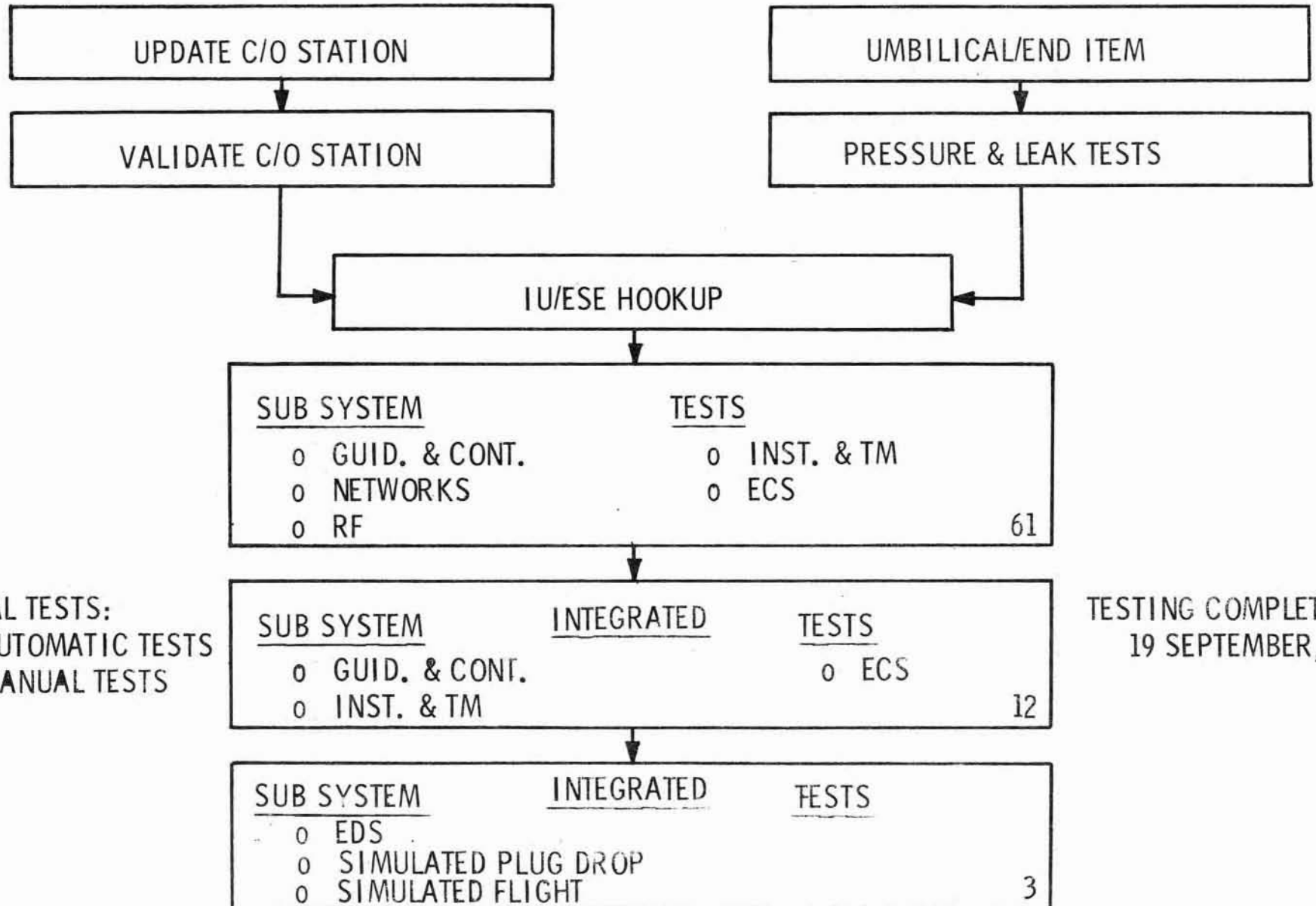
3/10/67

STORAGE: IBM-HVL



9/67 (present)

POST MANUFACTURING CHECKOUT
SIMPLIFIED FLOW DIAGRAM UPDATED SATURN I INSTRUMENT UNIT



76 TOTAL TESTS:
34 AUTOMATIC TESTS
42 MANUAL TESTS

TESTING COMPLETED:
19 SEPTEMBER, 1966

UPDATE C/O STATION

VALIDATE C/O STATION

IU/ESE HOOKUP

MOD KIT INSTALLATION & INSPECTION

PRESSURE & LEAK TESTS

SUBSYSTEM TESTS

- o GUID. & CONT.
- o NETWORKS
- o INST. & TM
- o ECS
- o RF

INTEGRATED SUBSYSTEM TESTS

- o GUID. & CONT.
- o INST. & TM
- o ECS

INTEGRATED SYSTEM TESTS

- o EDS
- o SIMULATED PLUG DROP
- o SIMULATED FLIGHT

TOTAL NUMBER OF TESTS		
Post Mfg. C/O	1st Retest	2nd Retest*
61	18	41
12	4	6
3	1	2
76	23	49

S-IU-205

0	RELIABILITY GOAL	0.992
0	PREDICTED DESIGN RELIABILITY	0.991
0	ESTIMATED LOWER BOUND	0.975

PERCENT CONTRIBUTION TO IU FAILURE
RISK

0	INERTIAL SUBSYSTEM GAS BEARING SUPPLY BATTERY D10 56 VOLT POWER SUPPLY	62 %
0	THERMAL CONDITIONING SUBSYSTEM BATTERY D40	27 %
0	ALL OTHER COMPONENTS	11 %
		<hr/>
		100 %

HISTORY OF SINGLE POINT FAILURES IN CRITICAL COMPONENTS

- 0 FLIGHT CONTROL COMPUTER
- 0 ST-I24M INERTIAL PLATFORM
- 0 AUX POWER DISTRIBUTOR
- 0 FIRST STAGE PRESSURE REGULATOR
- 0 K-SEAL LEAKAGE
- 0 BATTERY
- 0 LVDA

ANALYSIS OF POSSIBLE FLIGHT CRITICAL FAILURES

CREW LOSS -

NO SINGLE POINT FAILURES

POSSIBLE MISSION LOSS -

53 COMPONENTS CONTAIN SINGLE POINT FAILURE
MODES

INSTRUMENT UNIT 205 CHANGE ACTIVITY

MOD KIT INSTALLATION

205X

TOTAL = 23

- o INST. & TM - 7
- o NETWORKS - 7
- o ECS - 3
- o RF - 2
- o MECH. - 4

MAJOR CHANGES:

- o ELIMINATE SINGLE POINT FAILURE FOR INDICATION OF J2 ENGINE SHUTDOWN.
- o D.C. AMPLIFIER CHANGE TO NON-POLARIZED CAPACITORS
- o "FIX" FOR QUALIFICATION TEST FAILURES (TM UNITS)

205

TOTAL = 30

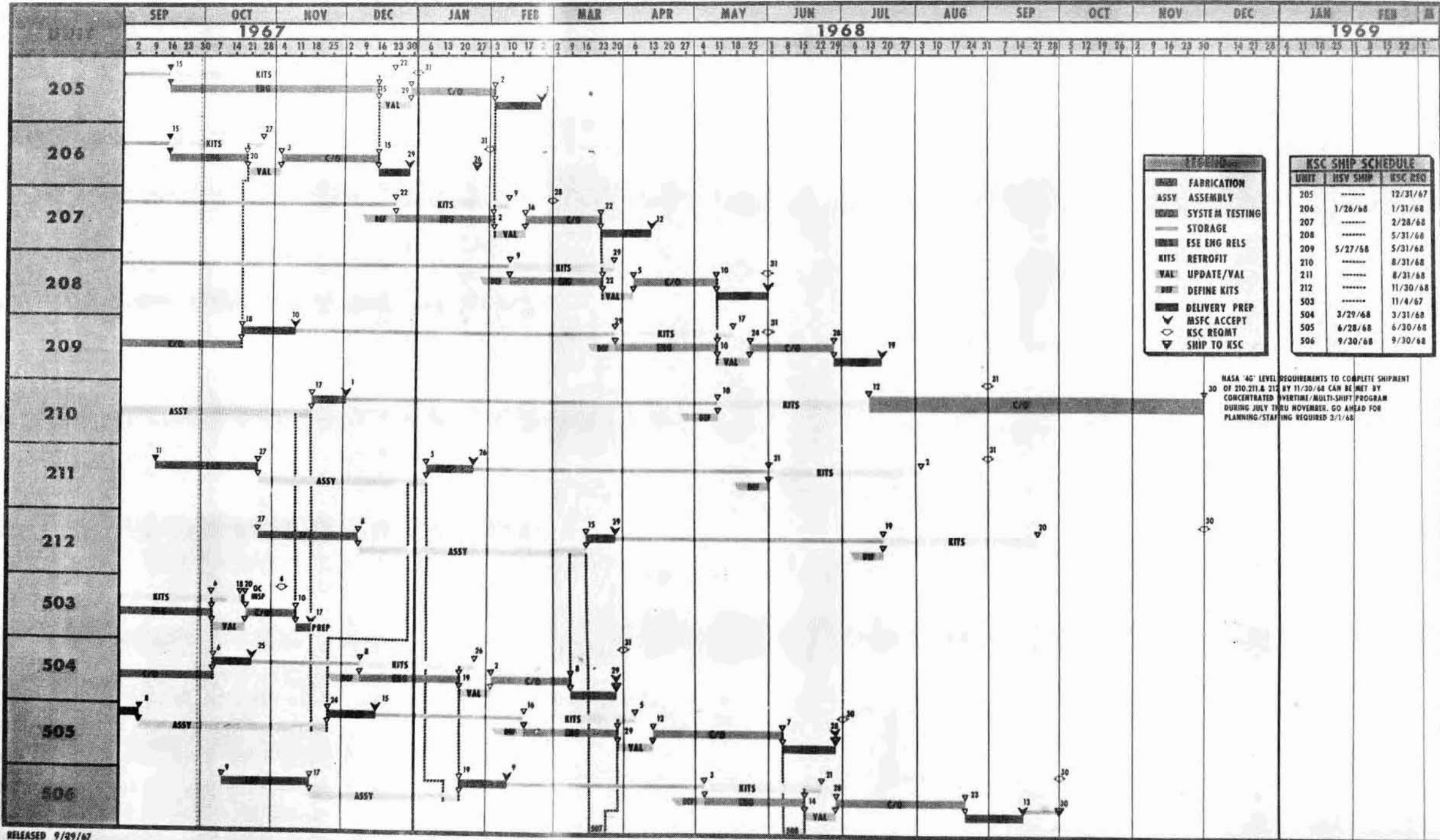
- o INST. & TM - 5
- o NETWORKS - 8
- o ECS - 6
- o RF - 3
- o MECH. - 8

MAJOR CHANGES:

- o TEMPERATURE CONTROL BY REGULATION OF SUBLIMATOR WATER FLOW.
- o REDESIGNED WATER/METHANOL ACCUMULATOR
- o MODIFY EDS DISTRIBUTOR TO PREVENT AUTOMATIC CUTOFF OF BOOSTER ENGINES IF AN ABORT OCCURS PRIOR TO EDS ENGINE CUTOFF TIME.

SATURN IB/V COMPOSITE SCHEDULE TO LEVEL H MASTER PHASING SCHEDULE

C.H. GRACE PROGRAM MANAGER
L.A. WOLFF PROGRAM CONTROL



**IU CHANGE
STATUS & SCHEDULE**

IU 205 MODIFICATION KIT STATUS

TOTAL DIRECTED SINCE LAST SYSTEMS TEST	-	35
ALREADY INSTALLED	-	2
TO BE INSTALLED PRIOR TO RETEST	-	32
TO BE KITTED TO KSC	-	1*

* Spotfacing of Control Signal Processor. Flight Unit Being Recycled To Vendor; Change Will Be In CSP When It Arrives At KSC.

IU

EXPECTED LIFE TIME

S-IU-205 ACTIVE LIFETIME

REQUIRED	-	4.5 HOURS
DESIGN GOAL	-	6.8 HOURS
END	-	10 HOURS (EST)
C-BAND TRANSPONDER	-	EXTENDED (1-2 DAYS)

PRELIMINARY ESTIMATES OF RESIDUAL IU/S-IVB RATES

FAILURE MODE	EFFECT	RESULTANT RATE*
LVDA LOW VOLTAGE, EDS RATE GYROS NOT RUNNING	LADDER OUTPUTS FULL ON, NO RATE COMPENSATION	3 TO 6 ⁰ /SEC-p, y ** 15 TO 30 ⁰ /SEC-R
ST-124M GYROS AND EDS GYROS FAIL	ATTITUDE ERROR INCREASES TO LIMIT OF 2.5 ⁰ , NO RATE COMPENSATION	3 TO 6 ⁰ /SEC-P, Y ^{**} 15 TO 30 ⁰ /SEC-R ^{**}
ST-124M GYRO FAILURE	ATTITUDE ERROR INCREASES TO LIMIT OF 2.5 ⁰	0.5 TO 1.0 ⁰ /SEC-P, Y, R
LVDC/DA FAILURE	LADDER OUTPUTS FULL ON	3 ⁰ /SEC-P, Y, R

*ESTIMATED MAXIMUM RATE BUILD UP WHICH MAY OCCUR WITHIN 60 SEC.

**DEPLETION OF FUEL GOVERNS MAXIMUM RATE REACHED.

IU/SC INTERFACE

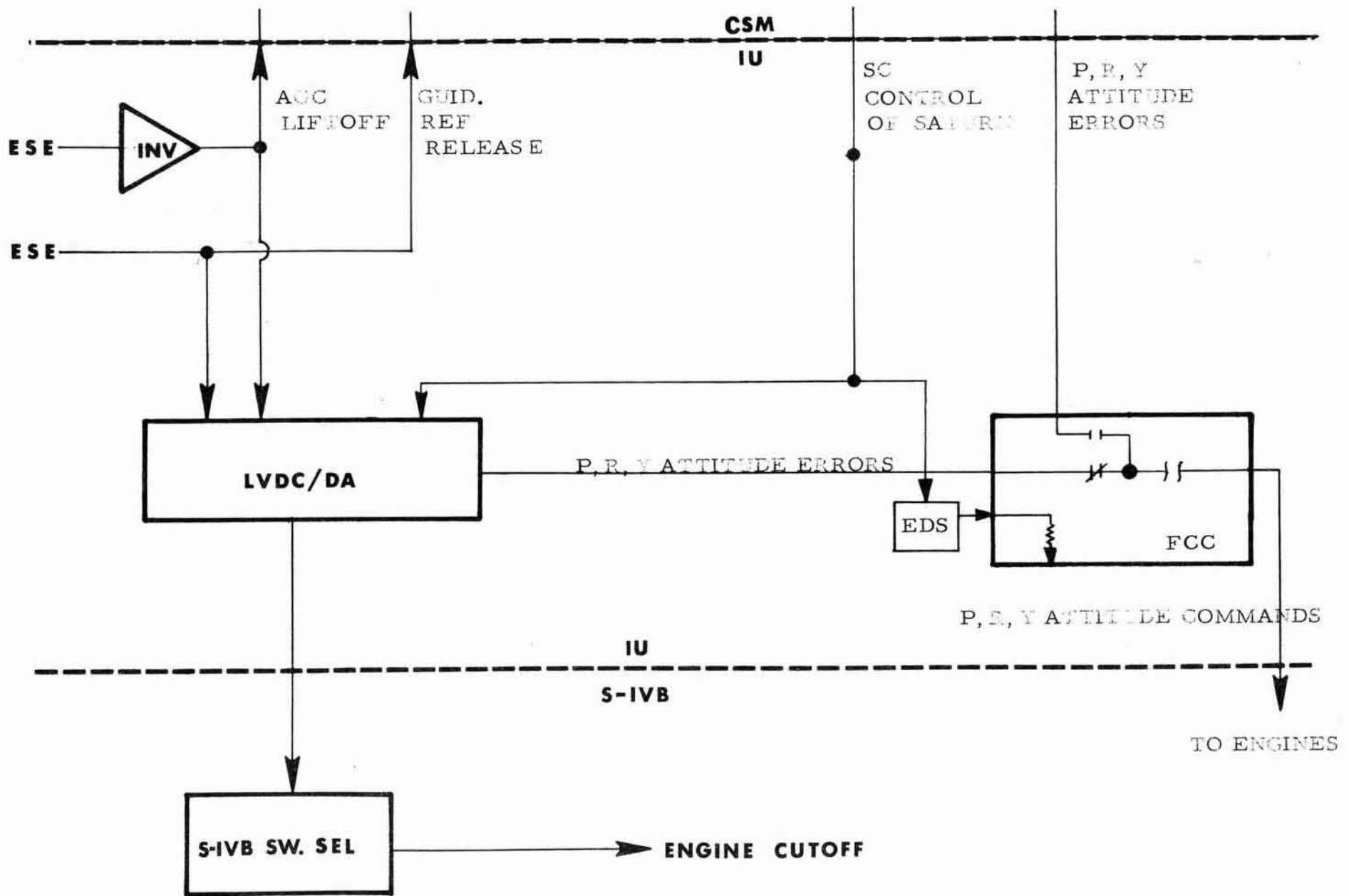
FUNCTIONS OF THE IU/SC INTERFACE
(EDS FUNCTIONS COVERED UNDER ELECTRICAL SYSTEM)

Q-BALL

POWERED FROM IU
DIFFERENTIAL PRESSURES (P&Y) }
INTERNAL TEMPERATURE } TM FROM IU

SC DISPLAYS

- 0 LV ATTITUDE REFERENCE FAIL
LVDC HAS DETERMINED UNREASONABLE ONE OR MORE OF THE
BACK-UP PLATFORM RESOLVER READINGS.
- 0 GUIDANCE REFERENCE RELEASE
INDICATES TO AGC THAT THE PLATFORM HAS BEEN RELEASED.
OCCURS 5 SECONDS PRIOR TO LIFTOFF
- 0 AGC LIFTOFF
INDICATES LIFTOFF. GENERATED BY IU UMBILICAL RELEASE.



IU/SC INTERFACE

205 ORBITAL SAFING FOR
S-IVB AND SPACECRAFT
CLOSE PROXIMITY RENDEZVOUS

GROUND RULES

ALL LIQUID MUST BE OUT OF PROPELLANT TANKS WITHIN
4 1/2 HOURS AFTER ORBITAL INSERTION

COLD HELIUM AND HYDROGEN BOTTLES MUST BE STABILIZED
OR DECREASING AT 1000 PSIA OR LESS WITHIN 4 1/2 HOURS
AFTER ORBITAL INSERTION

AMBIENT HELIUM BOTTLES NEED NOT BE DUMPED BUT WILL
BE DUNPED TO 1000 PSIA OR LESS WITHIN 4 1/2 HOURS AFTER
ORBITAL INSERTION IF NO HARDWARE MODIFICATIONS ARE
REQUIRED

MODIFICATIONS FOR ORBITAL SAFING KIT

FUEL VENT LINE

ADDITION OF:

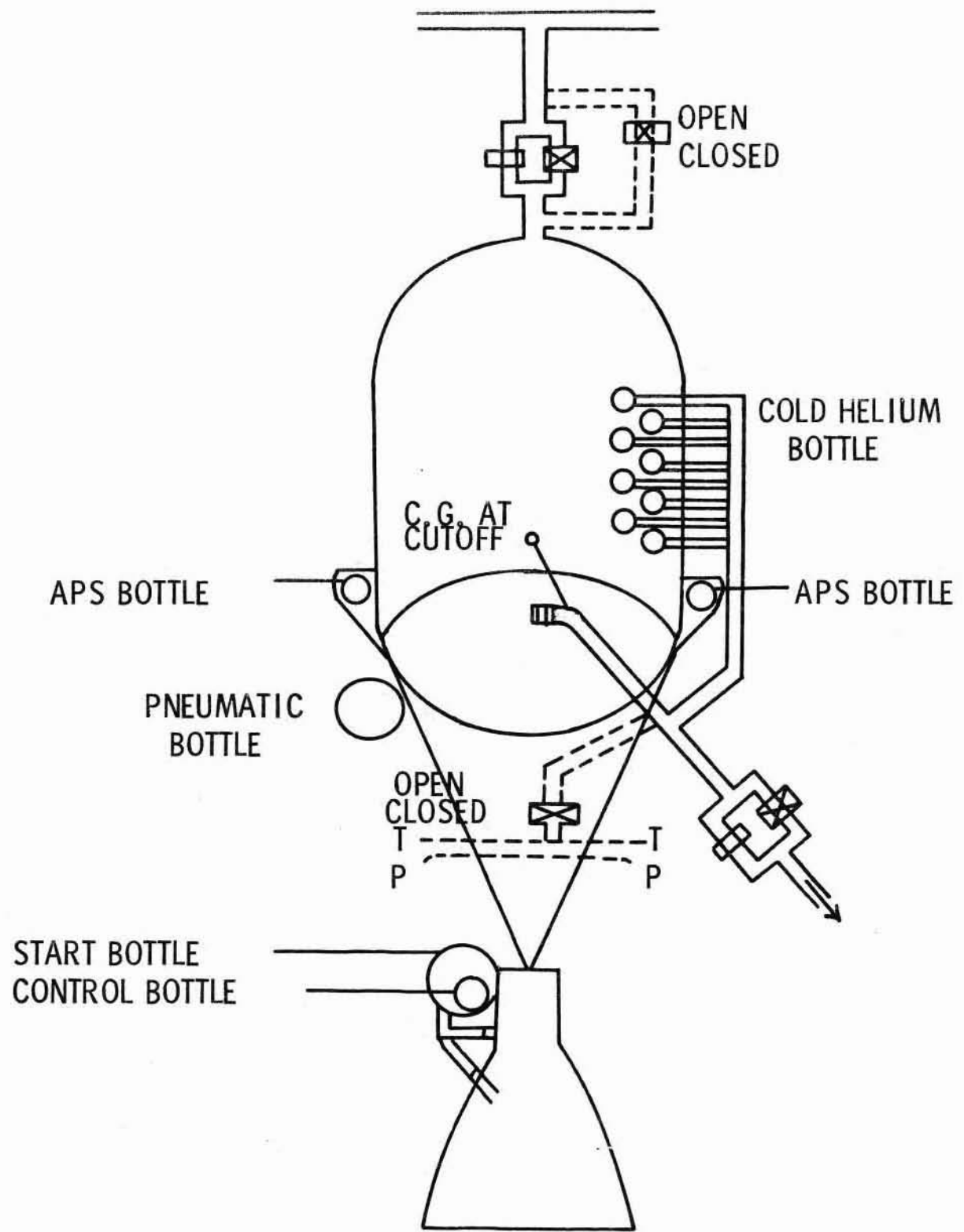
ONE PNEUMATIC VALVE
PNEUMATIC CONTROL MODULE
TWO SWITCH SELECTOR FUNCTIONS
A ONE-INCH LINE
OPEN AND CLOSE TM INDICATIONS FOR VALVE

LOX VENT LINE

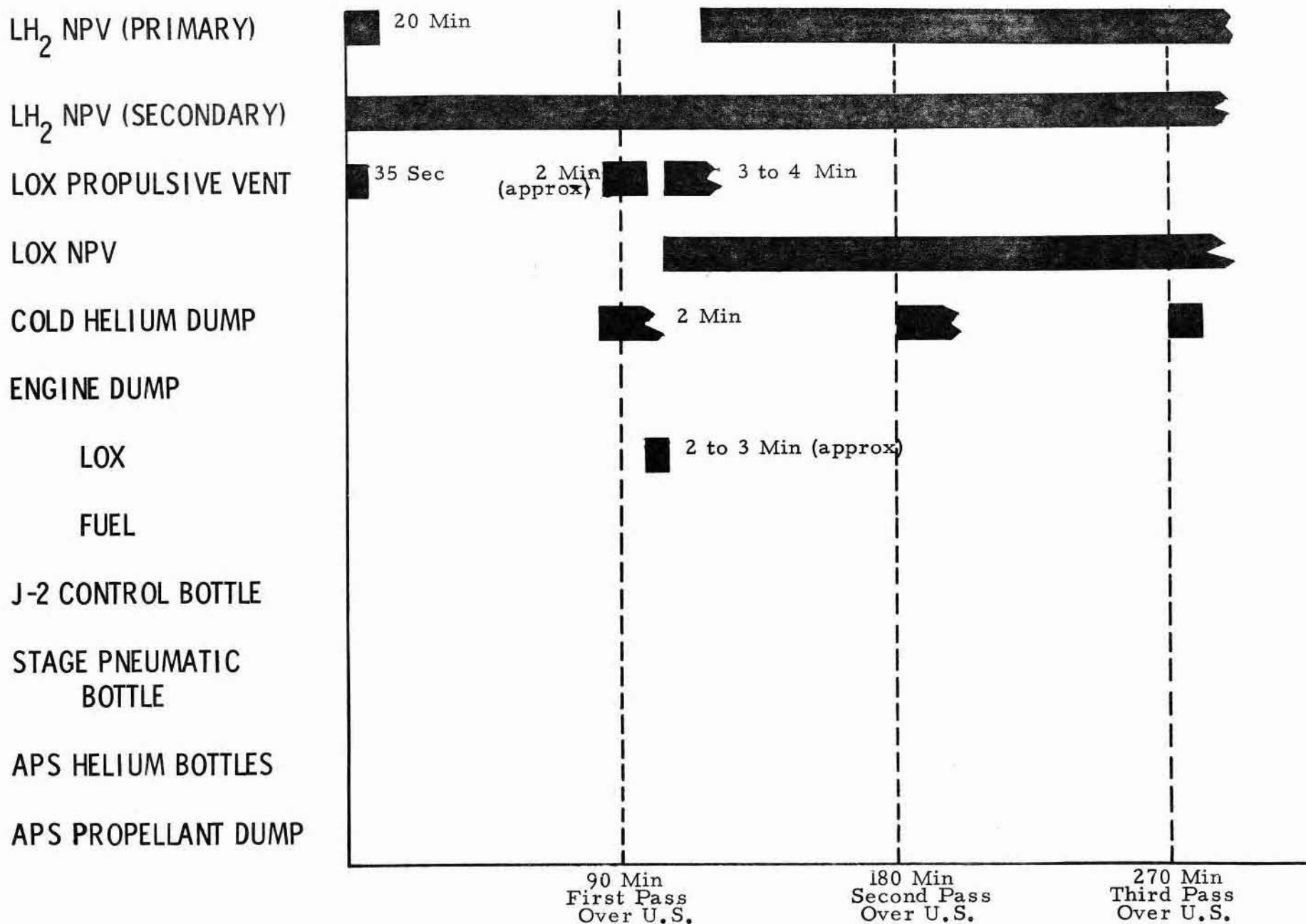
ADDITION OF:

ONE PNEUMATIC VALVE
PNEUMATIC CONTROL MODULE
TWO SWITCH SELECTOR FUNCTIONS
A ONE-INCH LINE WHICH RUNS 180 DEGREES AROUND STAGE
OPEN AND CLOSE TM INDICATIONS FOR VALVE
TEMPERATURE & PRESSURE MEASUREMENTS IN EACH
NOZZEL OF NEW LINE

- | | |
|-----------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| o COLD HELIUM BOTTLE
NO MODIFICATIONS | o ENGINE CONTROL BOTTLE
NO MODIFICATIONS |
| o PNEUMATIC BOTTLE
NO MODIFICATIONS | o DUMP LOX & FUEL THROUGH ENGINE
ELECTRICAL MODIFICATIONS -
EIGHT SWITCH SELECTOR
FUNCTIONS |
| o ENGINE START BOTTLE
ADD BLANKING FLANGES IN RECHARGE LINES | |
| o APS BOTTLES
NO MODIFICATIONS REQUIRED | |



PRELIMINARY 205 ORBITAL TIMELINE



VEHICLE INTERLOCKS

(SEPARATE HANDOUT PROVIDED)

GROUND REQUEST
ABORT LOOP

(SEPARATE HANDOUT PROVIDED)

PRELAUNCH SEQUENCE

(OPEN DISCUSSION)