

# STS-1 Symposium

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Presentation Material

June 11, 1981



National Aeronautics and  
Space Administration

**Lyndon B. Johnson Space Center**  
Houston, Texas



AGENDA  
STS-1 SYMPOSIUM  
BUILDING 2 AUDITORIUM  
JUNE 11, 1981

8:00 - 8:05	Film	
8:05 - 8:10	Welcoming Remarks	Dr. C. C. Kraft, Jr.
8:10 - 8:15	Program Introduction	W. R. Kelly
8:15 - 8:45	Prelaunch, Launch, SRB, SSME, ET	R. Kohrs
8:45 - 9:45	Ascent, Trajectory, and Entry Performance	A. Bordano/J. Garman/ E. Schiesser/C. Graves
9:45 - 10:00	Acoustic Environment	M. Coody
10:00 - 10:15	Break	
10:15 - 10:30	Medical Operations	S. Pool
10:30 - 11:00	Flight Control	T. Holloway
11:00 - 11:30	Crew Activity	E. Pavelka
11:30 - 12:45	Lunch	
12:45 - 1:00	Systems Performance Summary	S. Owens
1:00 - 1:15	Tracking and Communications	D. Travis
1:15 - 2:00	Avionics Systems	H. Smith/W. Swingle
2:00 - 2:30	Propulsion and Power	H. Brasseaux
2:30 - 2:45	Break	
2:45 - 3:30	Veh. Perf., Aero., Sep. Sys., Debris Assess.	B. Redd
3:30 - 3:45	Mechanical Systems	J. McCullough
3:45 - 3:50	Vehicle Contamination	L. Leger
3:50 - 4:05	Structures	P. Glynn
4:05 - 4:30	Thermal	J. Smith
4:30 - 5:00	Questions/Answers	All Speakers



NASA-S-81-11187

JOHNSON SPACE CENTER  
**STS-1 SYMPOSIUM**  
**SHUTTLE SYSTEM INTEGRATION**

JUNE 11, 1981

R. H. KOHRS



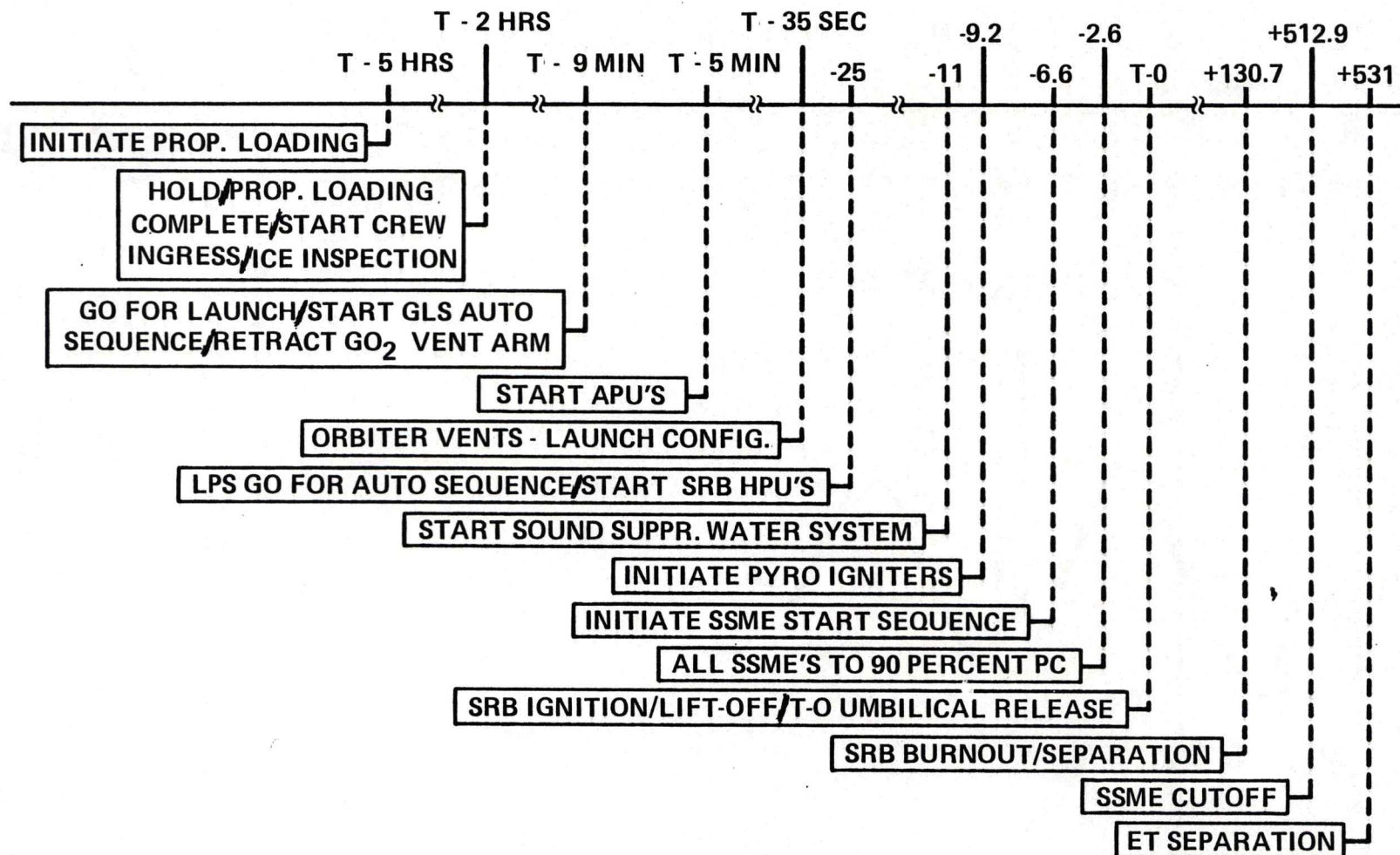
# SHUTTLE SYSTEM INTEGRATION

## AGENDA

- PRELAUNCH
- LIFTOFF/ASCENT
- SSME PERFORMANCE
- SRB PERFORMANCE/RECOVERY
- ET PERFORMANCE/ENTRY



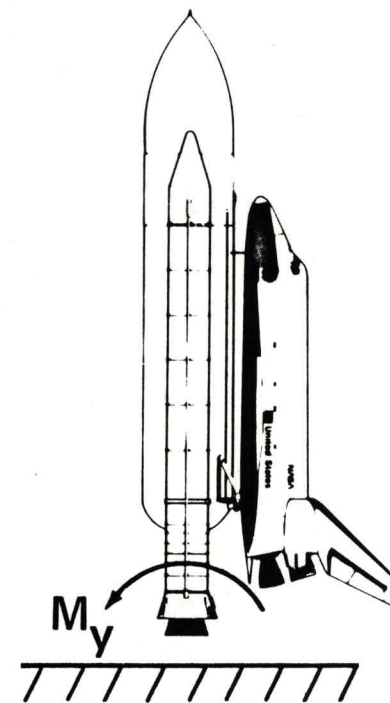
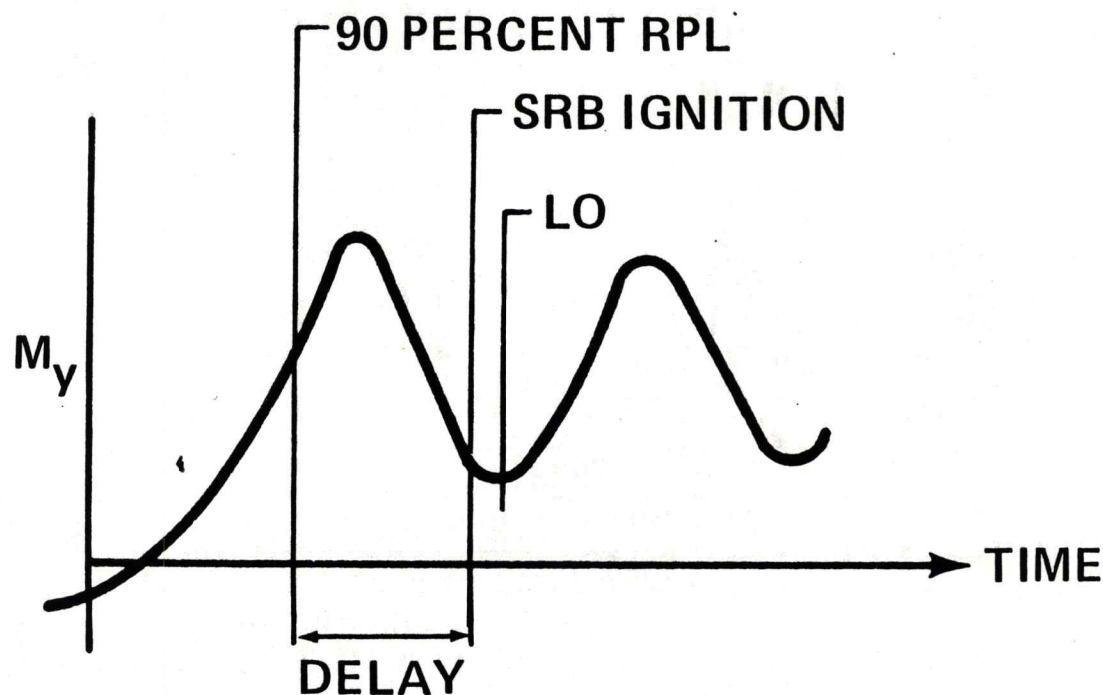
# STS-1 PRELAUNCH - ASCENT TIMELINE SUMMARY





## LIFT OFF LOADS DYNAMICS

- LIFT-OFF LOADS DEPENDENT ON BASE BENDING MOMENT ( $M_y$ )
- SRB IGNITION DELAY TIME OF 2.64 SEC FROM SSME 90 PERCENT RPL DETERMINED TO MINIMIZE  $M_y$  AT LIFT-OFF

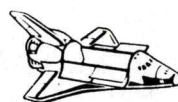


- ANALYTICAL DELAY TIME CONFIRMED BY FRF
- OBSERVATION OF STS-1 FILM INDICATES DELAY AT OR NEAR OPTIMUM. PRELIMINARY LOADS DATA CONFIRM MARGIN



# SPACE SHUTTLE NOMINAL MISSION PROFILE FOR STS-1

**NOMINAL ORBIT** 150/150 n. mi.  
Inclination 40.3°  
Duration 54.5 hours



**ON-ORBIT  
OPERATIONS**



**DEORBIT** (53:27:52)  
2/149 n. mi.  
(over Indian Ocean)  
40° S 63° E

**OMS-4** (7:05:31) 150/150 n. mi.

**OMS-3** (6:21:41) 130/150 n. mi.

**OMS-2** (0:44:00) 130/130 n. mi.  
88 sec, 163 fps

**OMS-1** (0:10:32) 57 / 130 n. mi.  
(perigee/apogee)  
76 sec, 137 fps

**ET SEP** (00:08:50)

**MECO** (0:08:32)  
383,000 ft. 740.5 n. mi.

**SRB SEP**  
(0:02:12)  
163,000 ft. 24.9 n. mi.

**Max Dyn. Pressure**  
(0:00:53)  
573 psf nom

**LIFT-OFF**

KSC

78° W 30° N  
137 n. mi.

**SRB Landing**  
(0:07:13)

**ET Impact**  
Indian Ocean

31° S 93° E

62 n. mi.

2100 n. mi.

Centered 10,500 n. mi.

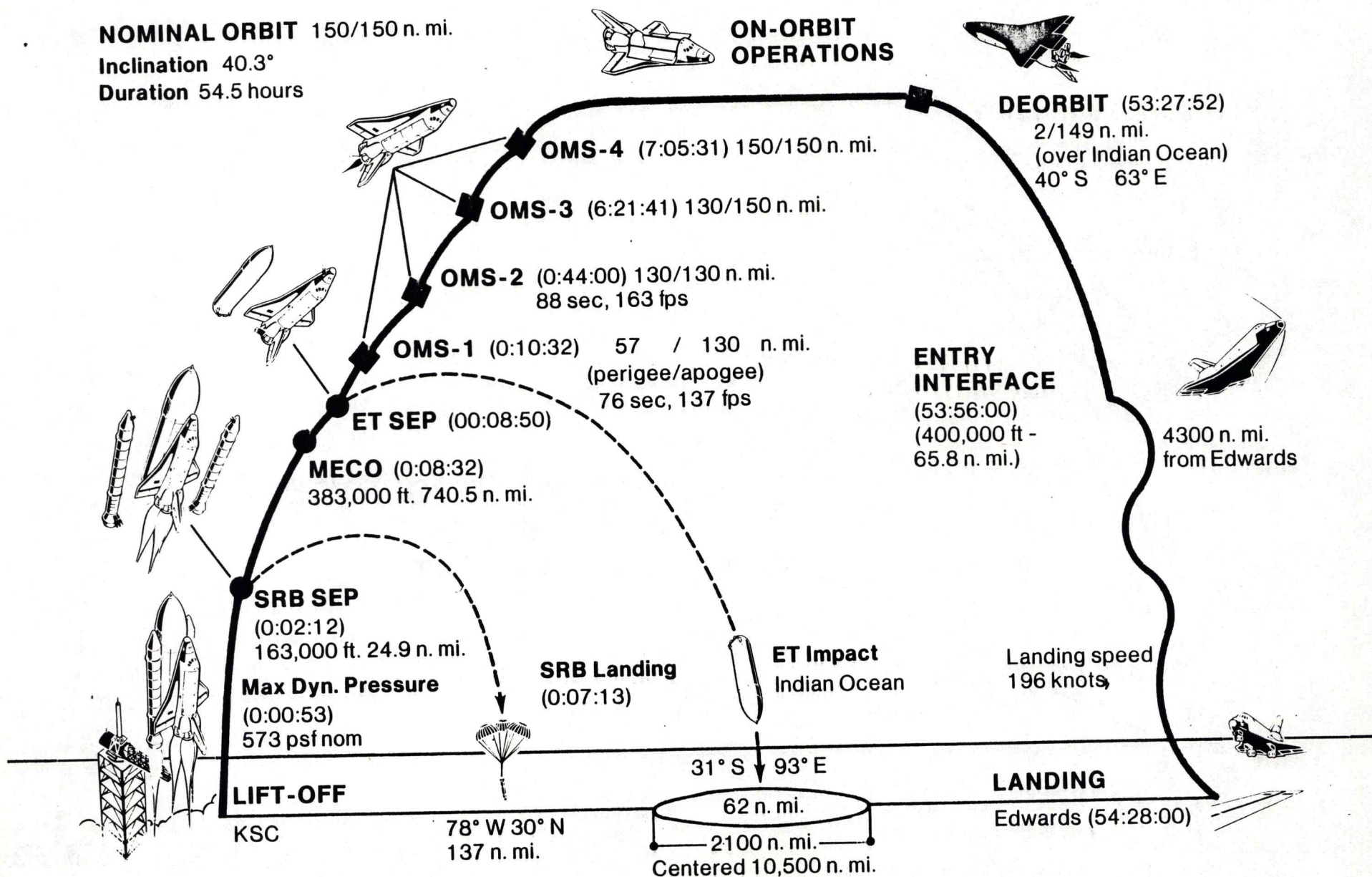
**ENTRY  
INTERFACE**  
(53:56:00)  
(400,000 ft -  
65.8 n. mi.)

4300 n. mi.  
from Edwards

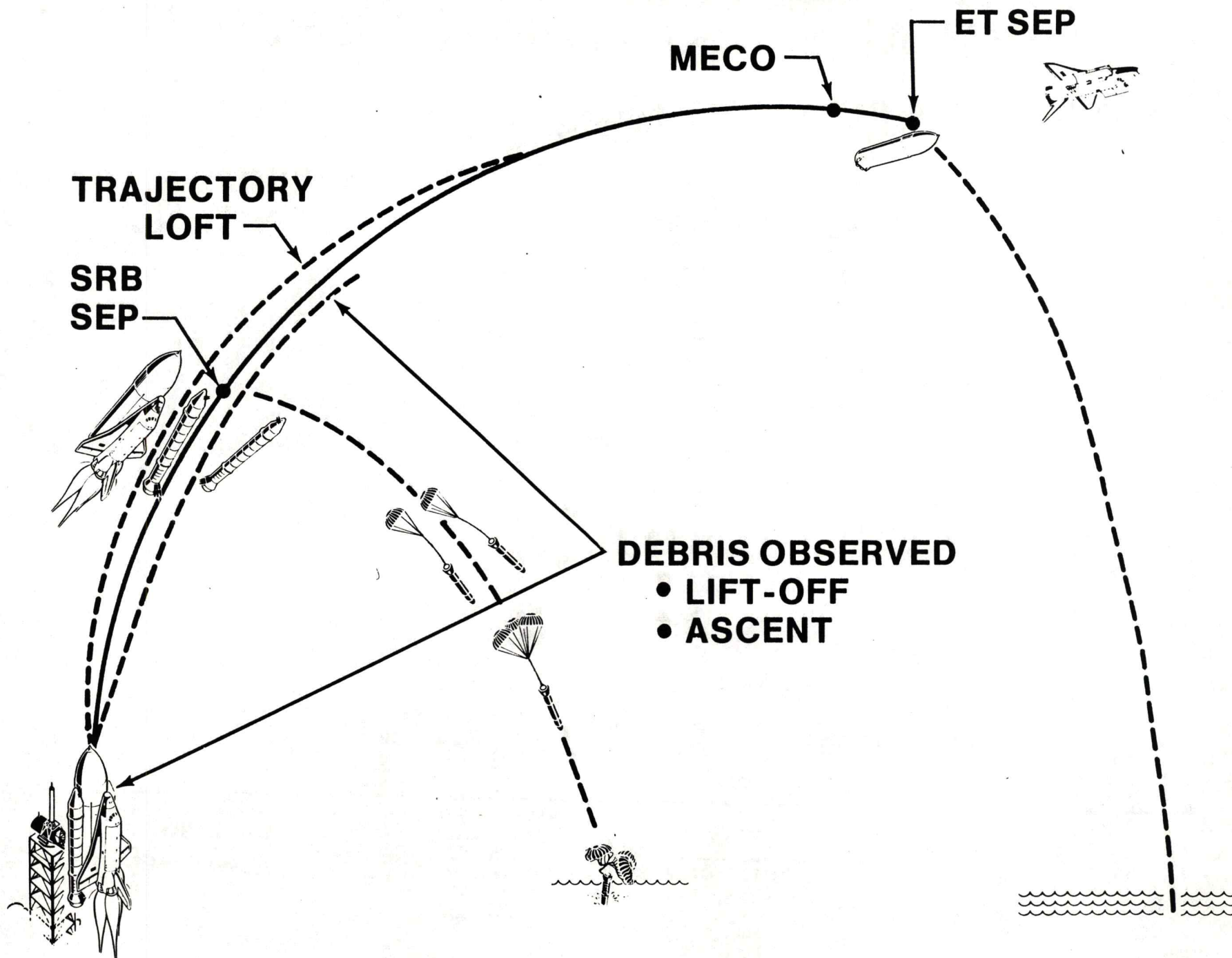
Landing speed  
196 knots

**LANDING**

Edwards (54:28:00)

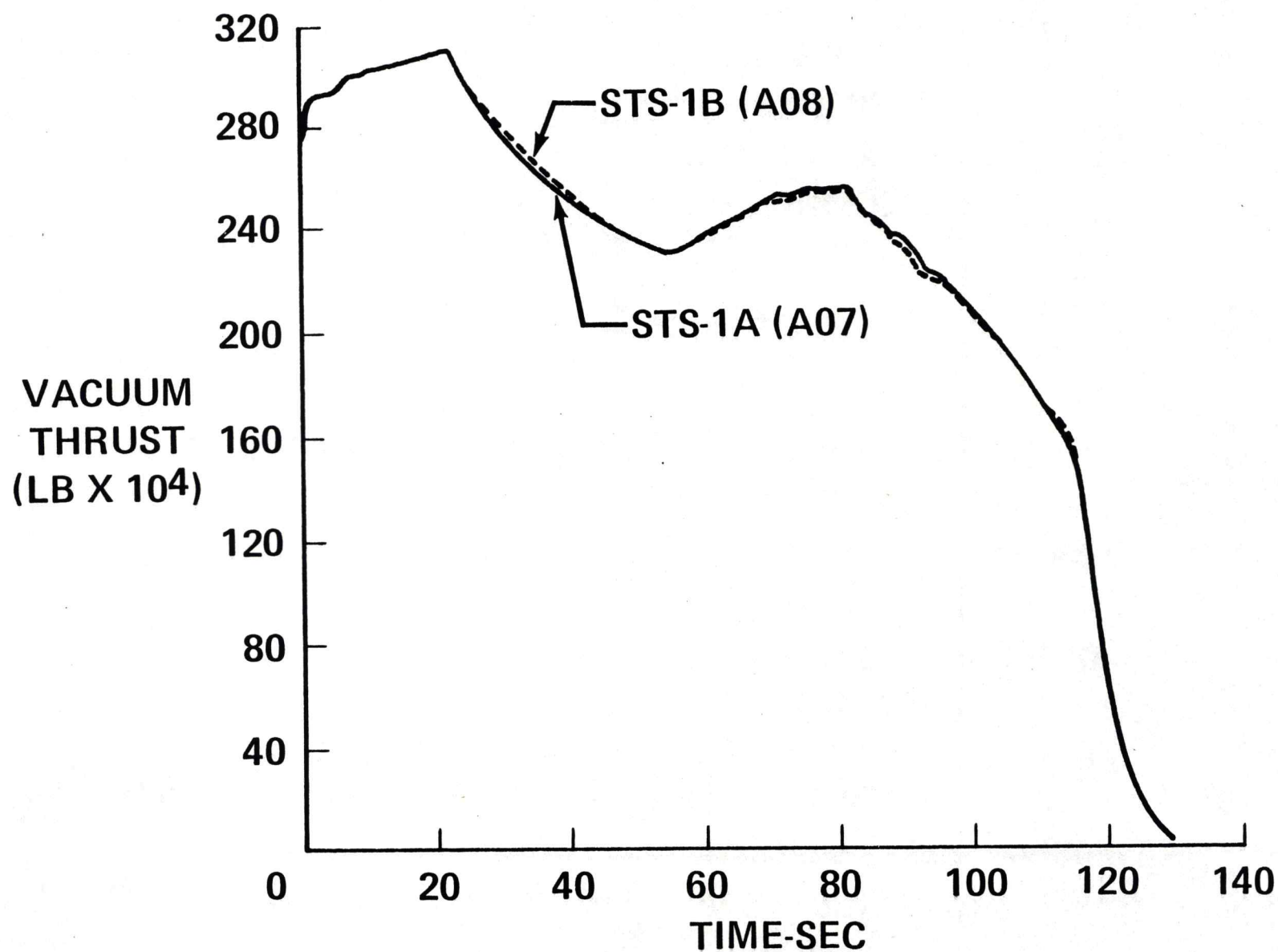


# STS-1 TRAJECTORY

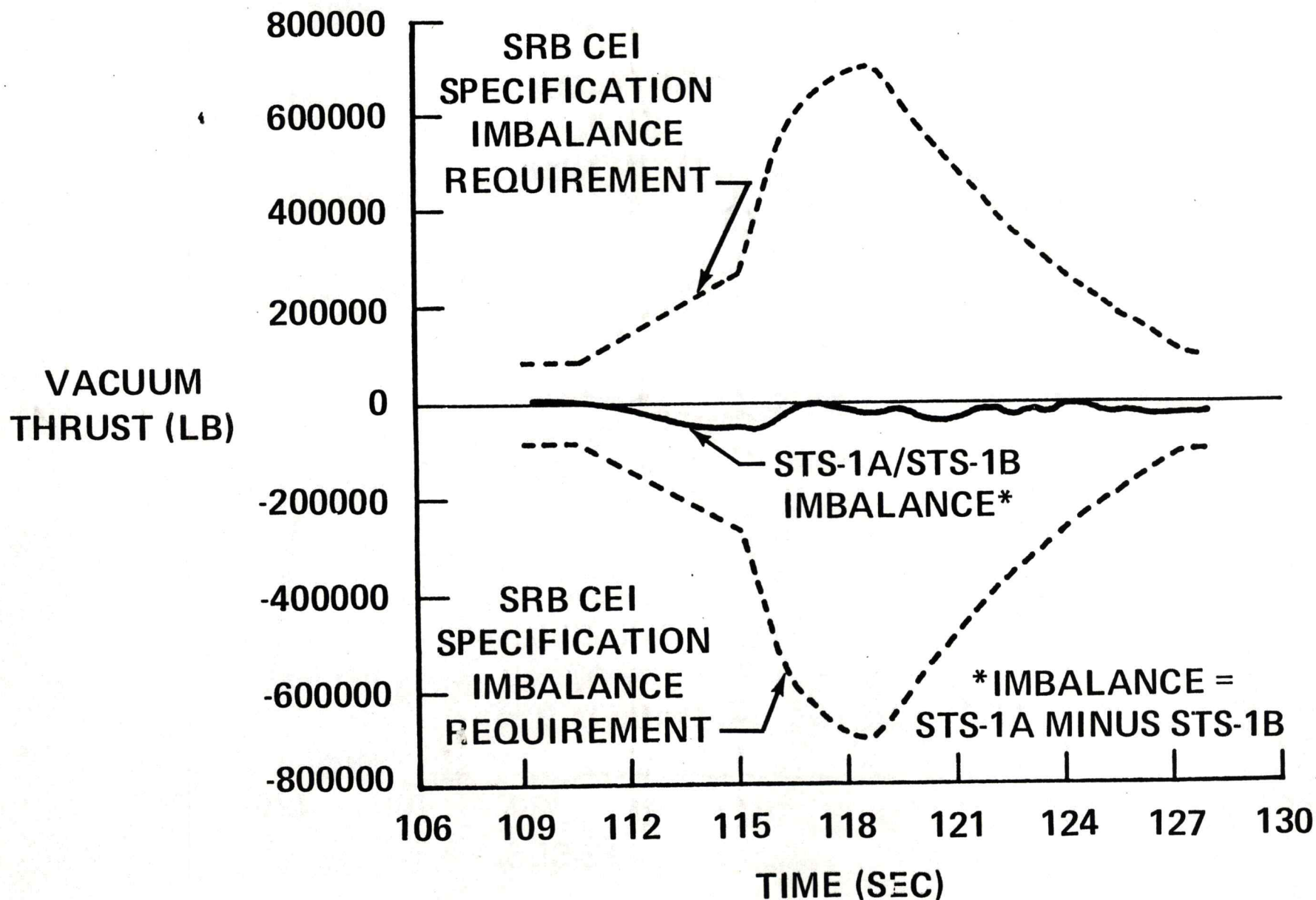




## COMPARISON OF SRM STS-1A AND STS-1B VACUUM THRUST



# COMPARISON OF THE SRM STS-1A/STS-1B TAILOFF THRUST IMBALANCE



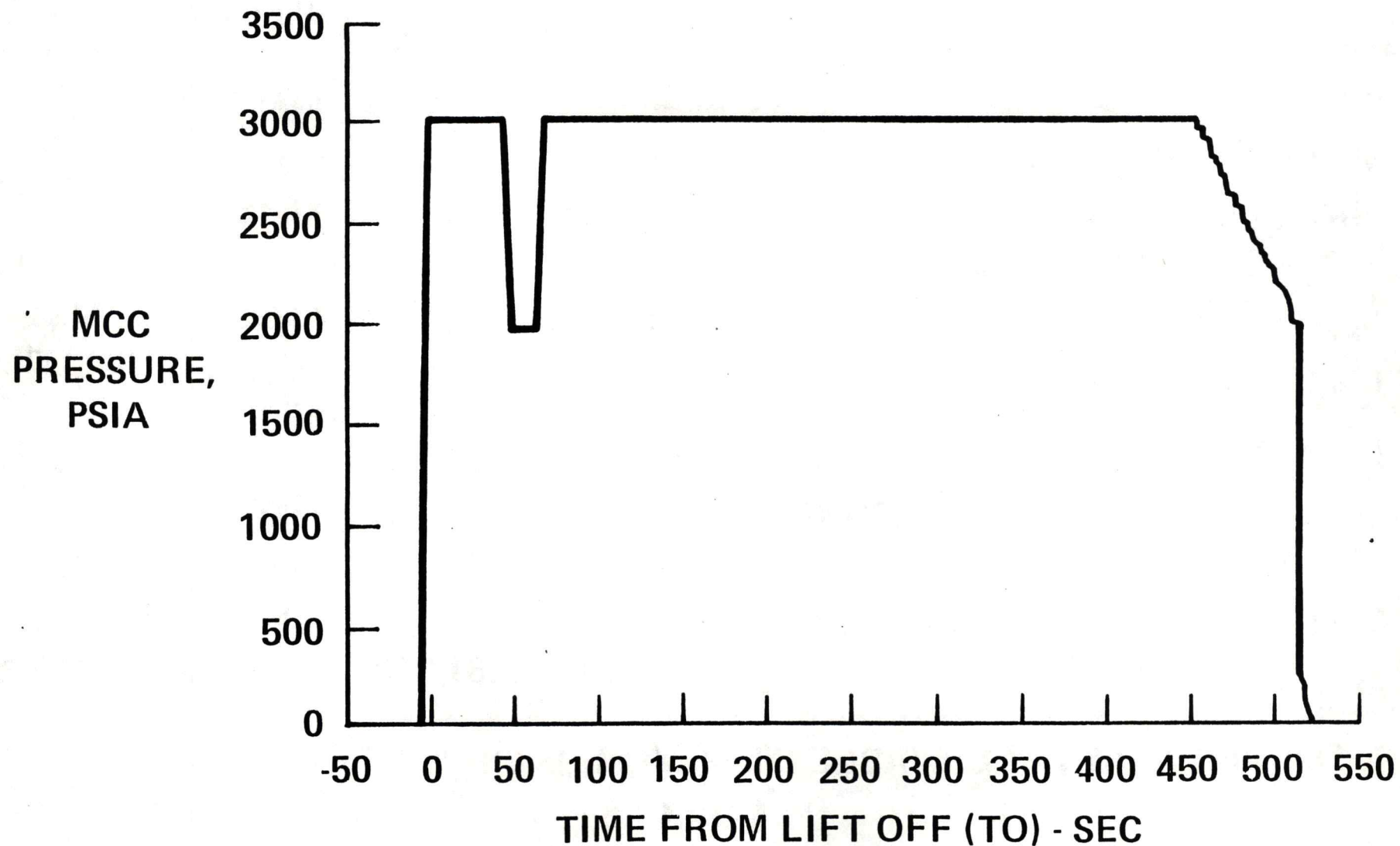


## STS-1 SRM PERFORMANCE

	STS-1A (A07)	STS-1B (A08)	STS-1A (A07)	STS-1B (A08)
PMBT (°F)	68	68	68	68
MAXIMUM PRESSURE (PSIA)	839	843	850	848
PROPELLANT BURN RATE AT $P_c = 625$ PSIA AND $60^\circ$ F (IPS)	.356	.357	.359	.359
$I_{20}$ ( $10^6$ LB-SEC)	58.7	59.0	59.5	59.5
$I_{60}$ ( $10^6$ LB-SEC)	161.1	161.8	162.8	163.3
$I_{AT}$ ( $10^6$ LB-SEC)	294.0	294.4	294.0	294.4
MAXIMUM AVERAGE PRESSURE RISE RATE (PSI/IOMS)	92.5	92.5	86 <sup>1</sup>	90 <sup>1</sup>
MAXIMUM AVERAGE THRUST RISE RATE (LB/10 MS)	261,600	261,600	250,000	279,000

1 SPECIFICATION ALLOWABLE (MAXIMUM) IS 109 PSI/10 MS

## STS-1 SSME PERFORMANCE

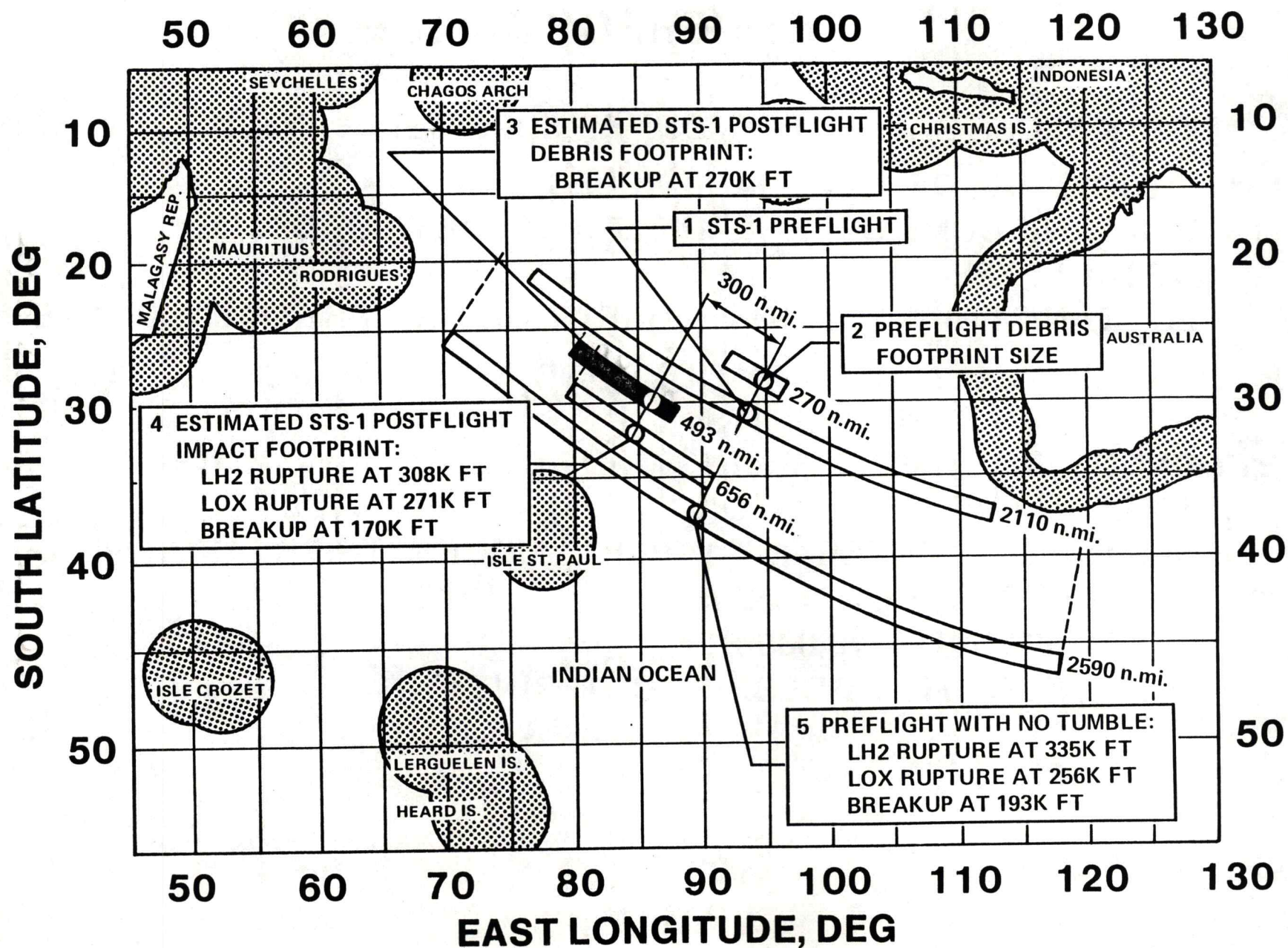




## STS-1 ET PERFORMANCE

- LO<sub>2</sub> TANK SLOSH BAFFLE PERFORMED SUCCESSFULLY
- NO STRUCTURAL DESIGN LOAD EXCEEDANCES
  - LO<sub>2</sub> TANK DOME BULKHEAD OSCILLATORY LOADS HIGHER THAN EXPECTED
  - LH<sub>2</sub> TANK FORWARD DOME VIBRATION HIGHER THAN EXPECTED
- PRELAUNCH THERMAL CONDITIONS AND ASCENT AEROHEATING WERE WITHIN DESIGN LIMITS
- ET DID NOT ENTER IN TUMBLING MODE DUE TO FAILURE OF TUMBLE VALVE
  - DESIGNED TO ENTER IN TUMBLING MODE WITH BREAKUP AT  $\approx$  193000 FT, ALTITUDE
  - BREAKUP WAS  $\approx$  270,000 FT
  - INCREASED IMPACT DEBRIS FOOTPRINT

# STS-1 ET IMPACT FOOTPRINTS





**STS-1 POST FLIGHT  
ASCENT PERFORMANCE**

## **STS-1 POST FLIGHT - ASCENT PERFORMANCE**

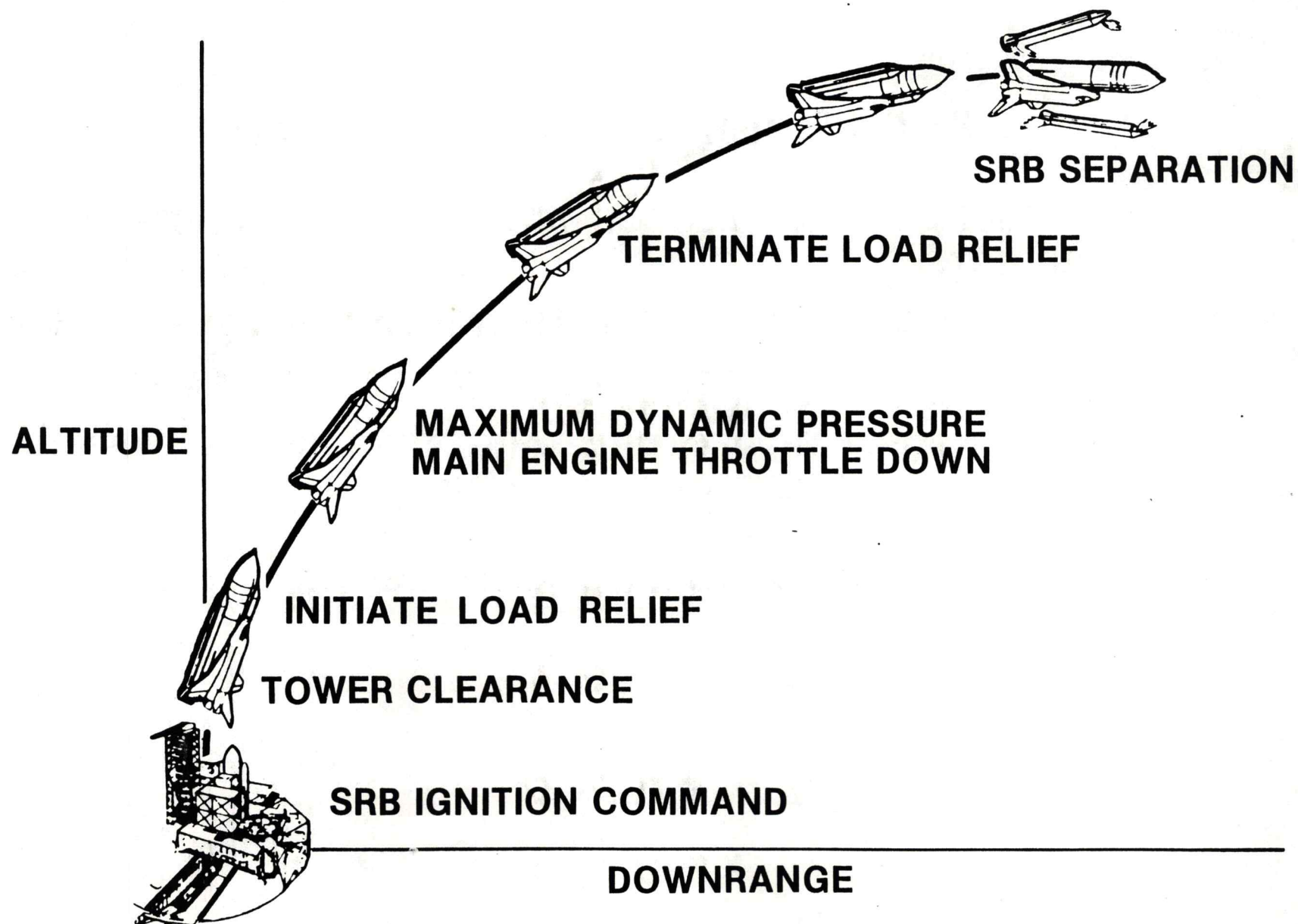
- **ASCENT PERFORMANCE SUMMARY**
- **FIRST STAGE**
  - **SUMMARY**
  - **LOFTING EFFECTS**
  - **LOFTING RECONSTRUCTION STATUS**
- **SECOND STAGE**
  - **SUMMARY**
  - **SSME PERFORMANCE RECONSTRUCTION STATUS**
- **OMS-1 AND OMS-2 MANEUVERS**
  - **SUMMARY**
  - **OMS ENGINE PRIMARY ACTUATOR FAILURE**
- **CONCLUDING REMARKS**

## **ASCENT PERFORMANCE SUMMARY**

- **STS-1 ASCENT FLIGHT PERFORMANCE WAS VERY CLOSE TO PREDICTED**
  - **NO HARDWARE PROBLEMS THAT IMPACTED PERFORMANCE**
  - **ALL ONBOARD SOFTWARE FUNCTIONS PERFORMED WELL**
  - **ALL ASCENT TRAJECTORY TARGETS WERE ACHIEVED WITHIN ACCEPTABLE TOLERANCES**
- **RECONSTRUCTION OF THE ASCENT TRAJECTORY IS STILL IN PROGRESS**



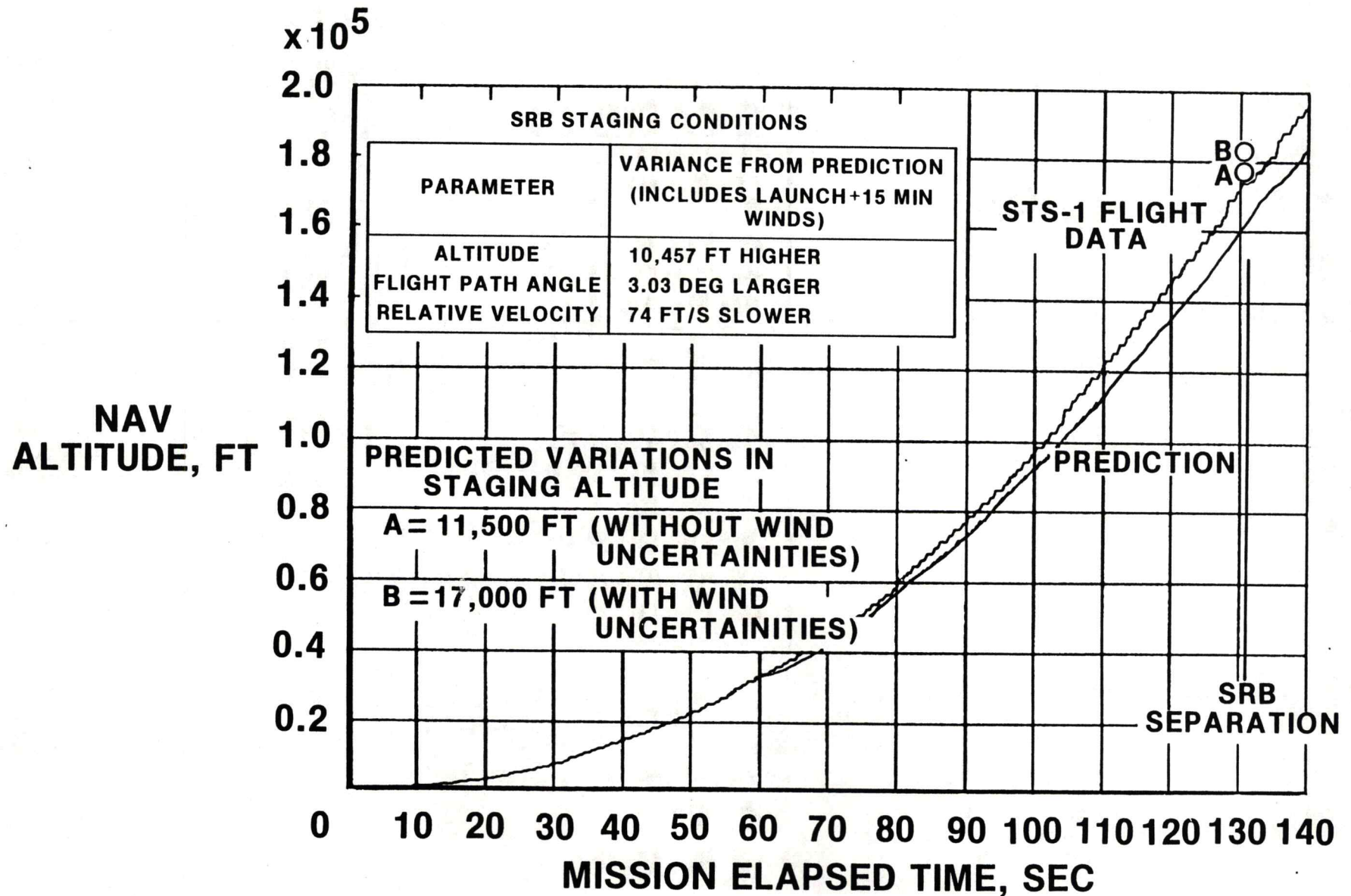
# TYPICAL FIRST-STAGE ASCENT



## FIRST STAGE SUMMARY

- TOWER CLEARANCE — 150 FEET OF VERTICAL CLEARANCE
- AERODYNAMIC LOAD RELIEF — MAXIMUM DYNAMIC PRESSURE WAS APPROXIMATELY 14 PSF HIGHER THAN PREDICTED (BASED ON NAVIGATION DATA)
- MAIN ENGINE THROTTLE DOWN — 0.9 SECONDS EARLY DUE TO HIGH PERFORMANCE SOLID ROCKET MOTORS
- SRB STAGING CONDITIONS — TRAJECTORY WAS HIGH IN ALTITUDE AND SLOW IN VELOCITY DUE TO LOFTING

# FIRST STAGE LOFTING EFFECTS

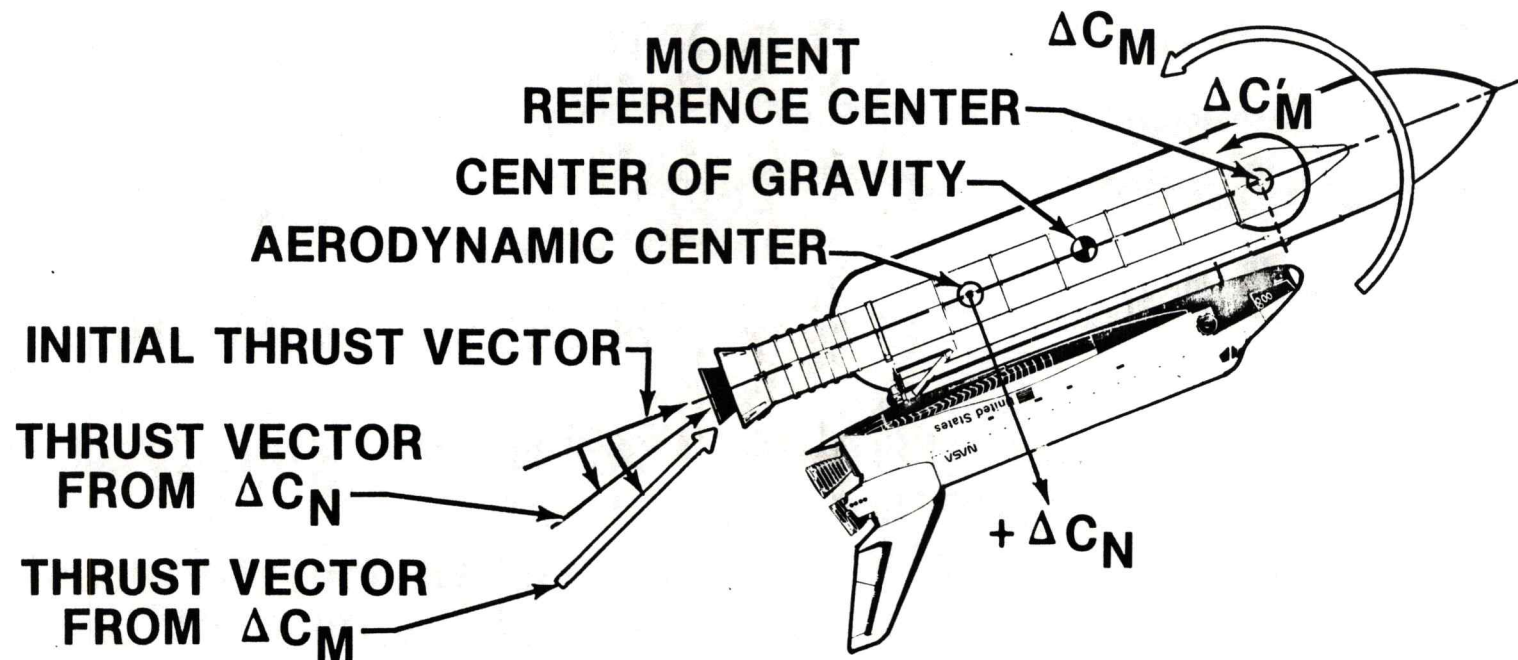




## **FIRST STAGE LOFTING RECONSTRUCTION STATUS (PRELIMINARY)**

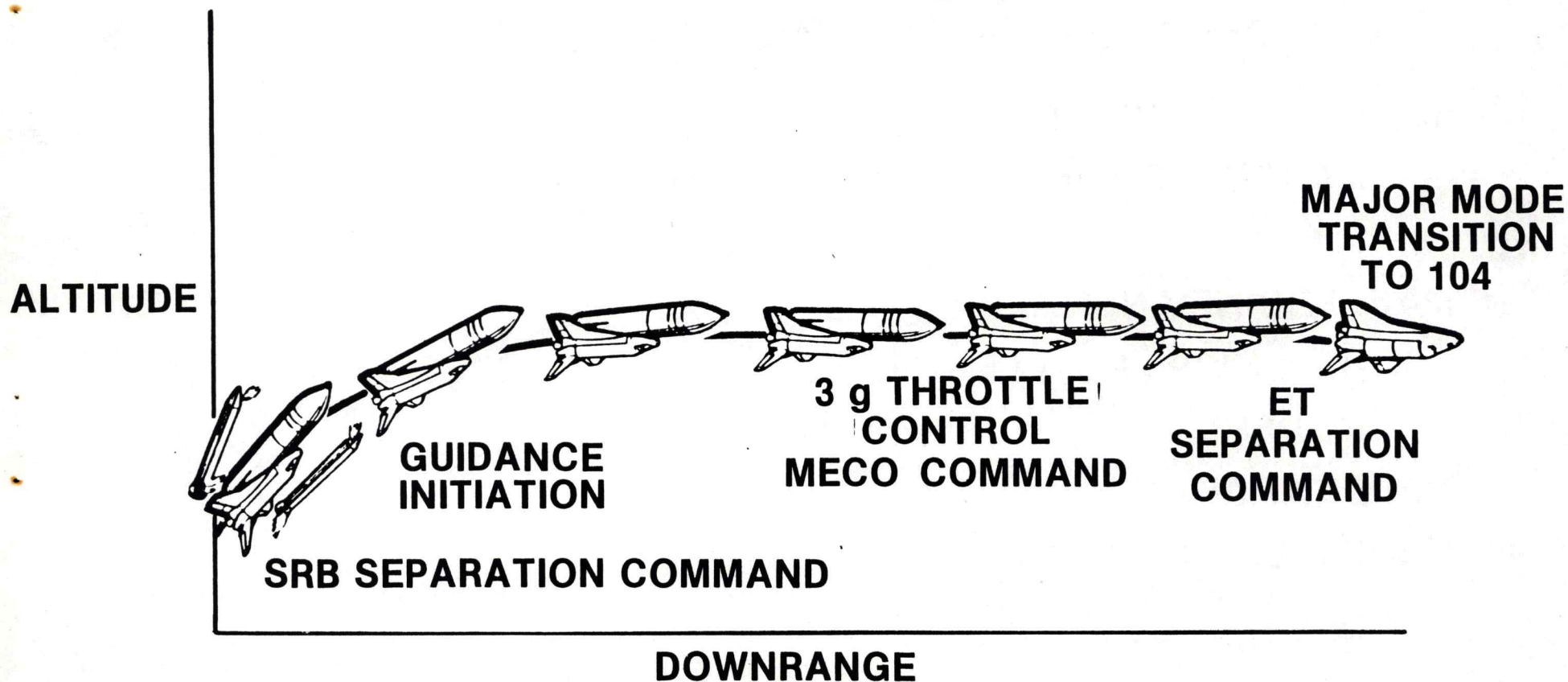
- **KNOWN DIFFERENCES FROM PRE-FLIGHT TRAJECTORY**
  - **LAUNCH + 15 MINUTES WIND DATA**
  - **LAUNCH TIME ATMOSPHERE DATA**
  - **MSFC PRELIMINARY SRB PERFORMANCE DATA**
  - **INCREASED SSME THRUST LEVEL**
- **ASSUMED DIFFERENCES TO PRODUCE TRAJECTOR MATCH**
  - **CM**
    - **AERODYNAMIC PITCHING MOMENT COEFFICIENT INCREASED ( $\Delta c_m$ ) IN THE NEGATIVE DIRECTION**
    - **CM WAS INCREASED FROM 0 TO 0.6 OF THE PREMISSION DEFINED VARIATION LEVELS (FUNCTION OF MACH NUMBER)**
  - **CN**
    - **AERODYNAMIC NORMAL FORCE COEFFICIENT INCREASED ( $\Delta C_N$ ) IN THE POSITIVE DIRECTION**
    - **CN WAS INCREASED FROM 0 TO 1.0 OF THE PREMISSION DEFINED VARIATION LEVELS (FUNCTION OF MACH NUMBER)**
- **POWER ON BASE FORCE - REDUCED BY 30 PERCENT**

# EFFECT OF INCREMENTAL NEGATIVE PITCHING MOMENT ( $\Delta C_M$ ) AND POSITIVE NORMAL FORCE ( $\Delta C_N$ ) ON FIRST STAGE LOFTING



- ADDITIONAL NEGATIVE PITCHING MOMENT ( $\Delta C_M$ ) CAUSES VEHICLE ATTITUDE TO BE MORE VERTICAL AND INDUCES LOFTING
- ADDITIONAL POSITIVE NORMAL FORCE ( $\Delta C_N$ ) INDUCES ADDITIONAL NEGATIVE PITCHING MOMENT ( $\Delta C'_M$ ) AND LOFTING
- POWER ON BASE FORCE DISPERSION IS ANALOGOUS TO ADJUSTING THRUST LEVELS

## TYPICAL SECOND-STAGE ASCENT



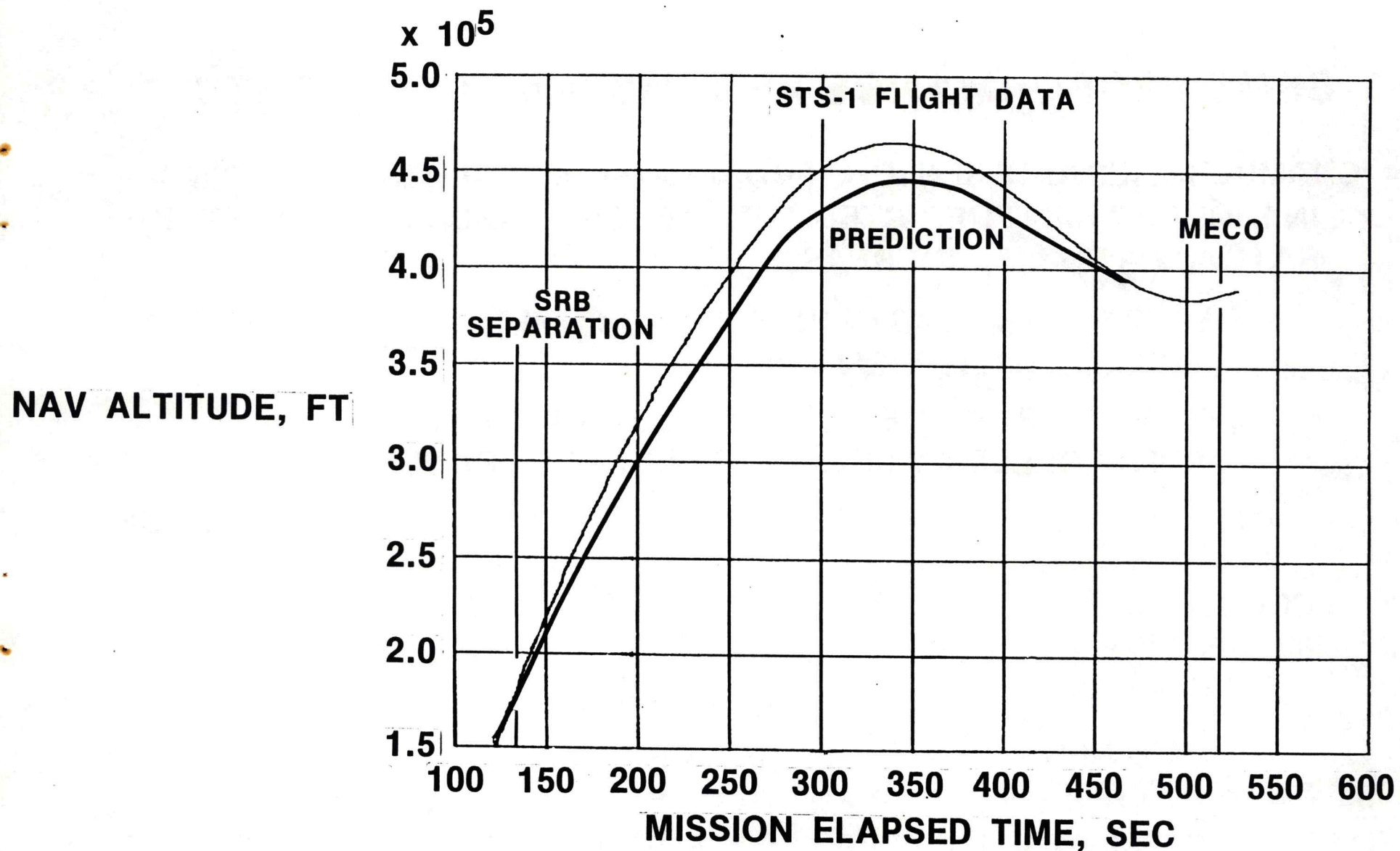


## SECOND STAGE ASCENT SUMMARY

- GUIDANCE INITIATE
  - GUIDANCE CONVERGED PROPERLY AND WAS STABLE THROUGHOUT SECOND STAGE
- 3G THROTTLE CONTROL
  - MAINTAINED VEHICLE ACCELERATION TO LESS THAN 2.97 G's
- MAIN ENGINE ANOMALIES
  - NO MAJOR PROBLEMS, PERFORMANCE DIFFERED FROM PREDICTED VALUES, e.g. ISP.
- MECO TARGETS
  - EXCELLENT TARGET ACHIEVEMENT

— ALTITUDE	- 467	FEET MISS (HIGH)
— VELOCITY	- 3	FEET/SEC MISS (LOW)
— FLIGHT PATH ANGLE	- 0.0052	DEGREE MISS (LOW)

# SECOND STAGE RECOVERY FROM FIRST STAGE LOFTING

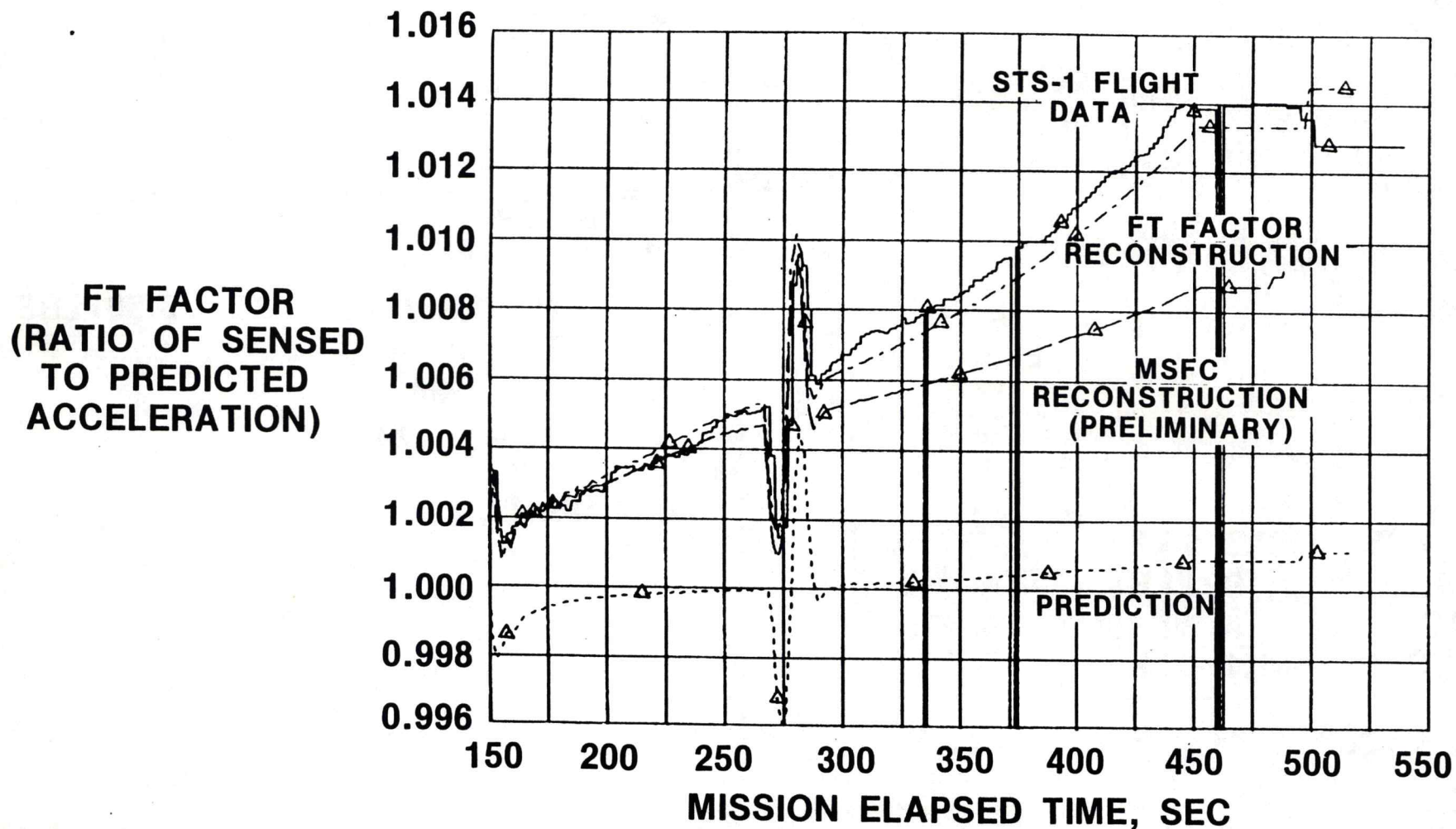


## **SSME PERFORMANCE RECONSTRUCTION STATUS**

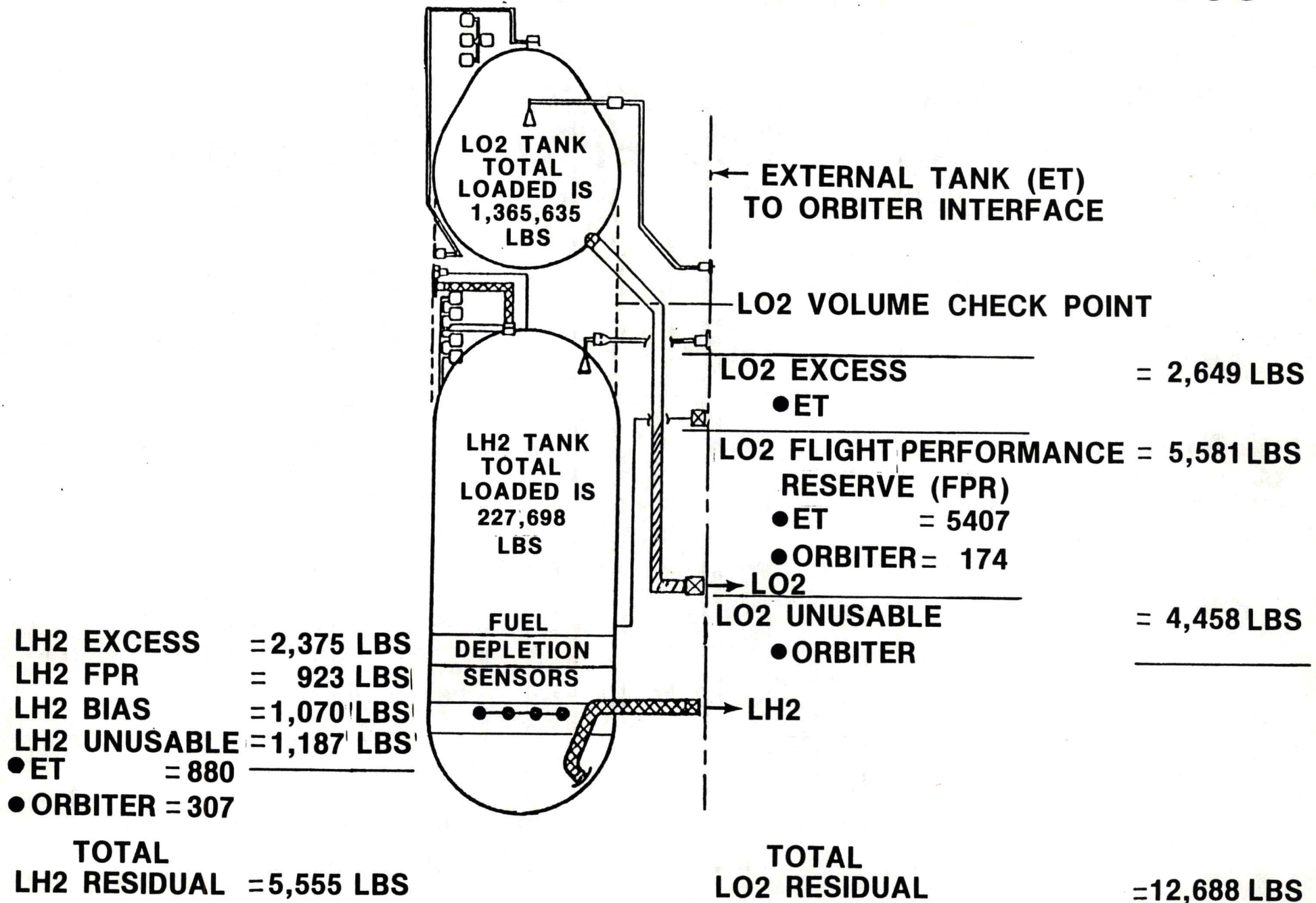
- CHAMBER PRESSURE SENSORS PRODUCED LOW VALUES, RESULTING IN HIGHER THAN PREDICTED THRUST LEVEL AND ENGINE MIXTURE RATIO ( $\text{LO}_2$  TO  $\text{LH}_2$ ) INCREASES
  - THRUST LEVEL WAS INCREASED TO COMPENSATE FOR SENSED LOW CHAMBER PRESSURE
  - CHAMBER PRESSURE AND RESULTING THRUST LEVEL IS CONTROLLED BY MODIFYING  $\text{LO}_2$  FLOWRATE
  - SENSOR HEATING IS THE SUSPECTED CAUSE OF THE LOW VALUES
- RECONSTRUCTION TRAJECTORIES INDICATE A SHIFT OCCURRED IN SPECIFIC IMPULSE (ISP)
  - FT\_FACTOR IS THE RATIO OF SENSED TO PREDICTED ACCELERATION
  - TO MATCH STS-1 FT\_FACTOR DATA, A SPECIFIC IMPULSE REDUCTION MUST BE ASSUMED (WITH CURRENT THRUST DATA)



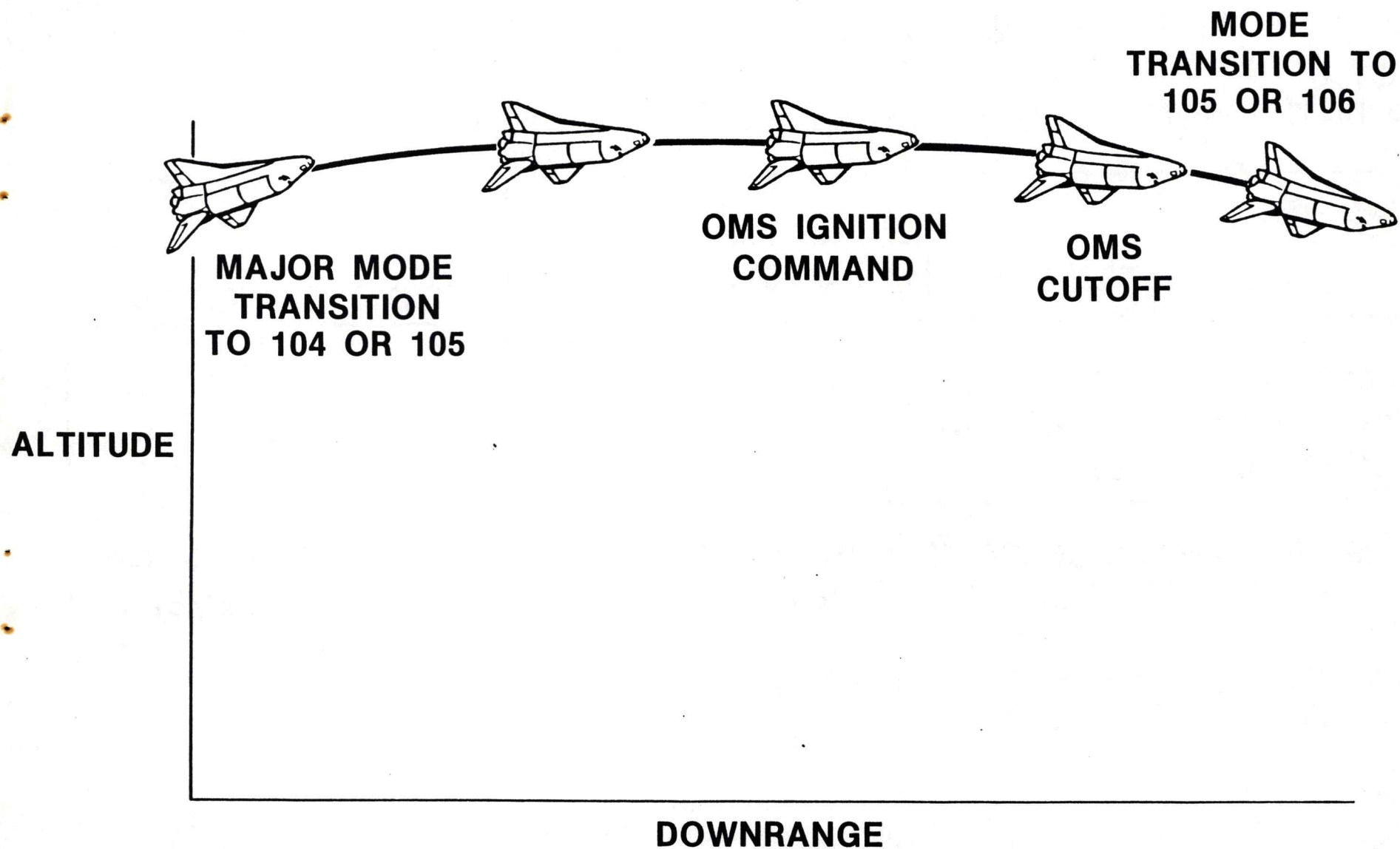
# SSME PERFORMANCE RECONSTRUCTION STATUS ACCELERATION HISTORY MATCHUP



# SSME PROPELLANT RECONSTRUCTION STATUS



# TYPICAL ASCENT OMS-1 AND OMS-2





## OMS-1 AND OMS-2 MANEUVER SUMMARY

- BOTH OMS MANEUVERS WERE CLOSE TO PREDICTED

PARAMETER	OMS-1		OMS-2	
	PREDICTED	ACTUAL	PREDICTED	ACTUAL
APOGEE ALTITUDE (NMI)	130.4	130.0	130.8	130.9
PERIGEE ALTITUDE (NMI)	49.0	54.9	128.4	130.0
BURN TIME (SEC)	85.5	86.2	85.7	74.7

- MAIN PROPULSION SYSTEM PROPELLANT VENTING HAD HIGHER INITIAL THRUST LEVELS AND A LONGER TAIL-OFF AT LOW THRUST LEVELS
- PRIMARY PITCH ACTUATOR FAILED TO RESPOND TO COMMANDS FOR THE RIGHT OMS DURING THE OMS-2 MANEUVER

## **CONCLUDING REMARKS**

- **PRESENTED STS-1 FLIGHT ANOMALIES DID NOT SIGNIFICANTLY IMPACT ASCENT PERFORMANCE**
- **THE STS-1 FLIGHT PROVIDED VALUABLE VERIFICATION OF ASCENT FLIGHT PLANNING TECHNIQUES AND VEHICLE PERFORMANCE**
- **THE RECONSTRUCTION EFFORT RESULTS WILL PROVIDE A DATA POINT FOR "FINE TUNING" THE ASCENT FLIGHT PLANNING**
- **STS-1 FLIGHT ANOMALIES SHOULD NOT IMPACT STS-2 FLIGHT SCHEDULES**

**NASA-S-81-11016**

# **STS-1 ONORBIT DRAG EFFECTS**

**RICHARD OSBURN**

**JSC/FM8**

**HEAD, GROUND NAVIGATION SECTION**



## **FACTORS WHICH EFFECT DRAG**

- **FRONTAL AREA AND WEIGHT OF VEHICLE**
- **ALTITUDE**
- **SOLAR ACTIVITY**

## **REVIEW OF DRAG EFFECTS**

- **OVER 200 N.MI. ALTITUDES**
  - **VERY SMALL EFFECTS FOR SHORT PERIODS (< 10 DAYS)**
- **150 N.MI. (SHUTTLE ORBIT)**
  - **RETARDS TRAJECTORY BY UP TO 50 MILES PER DAY**
- **100 N.MI.**
  - **RETARDS TRAJECTORY BY UP TO 500 MILES PER DAY**
  - **CAUSES REENTRY WITHIN 60 HOURS**

## SHUTTLE DRAG MODEL

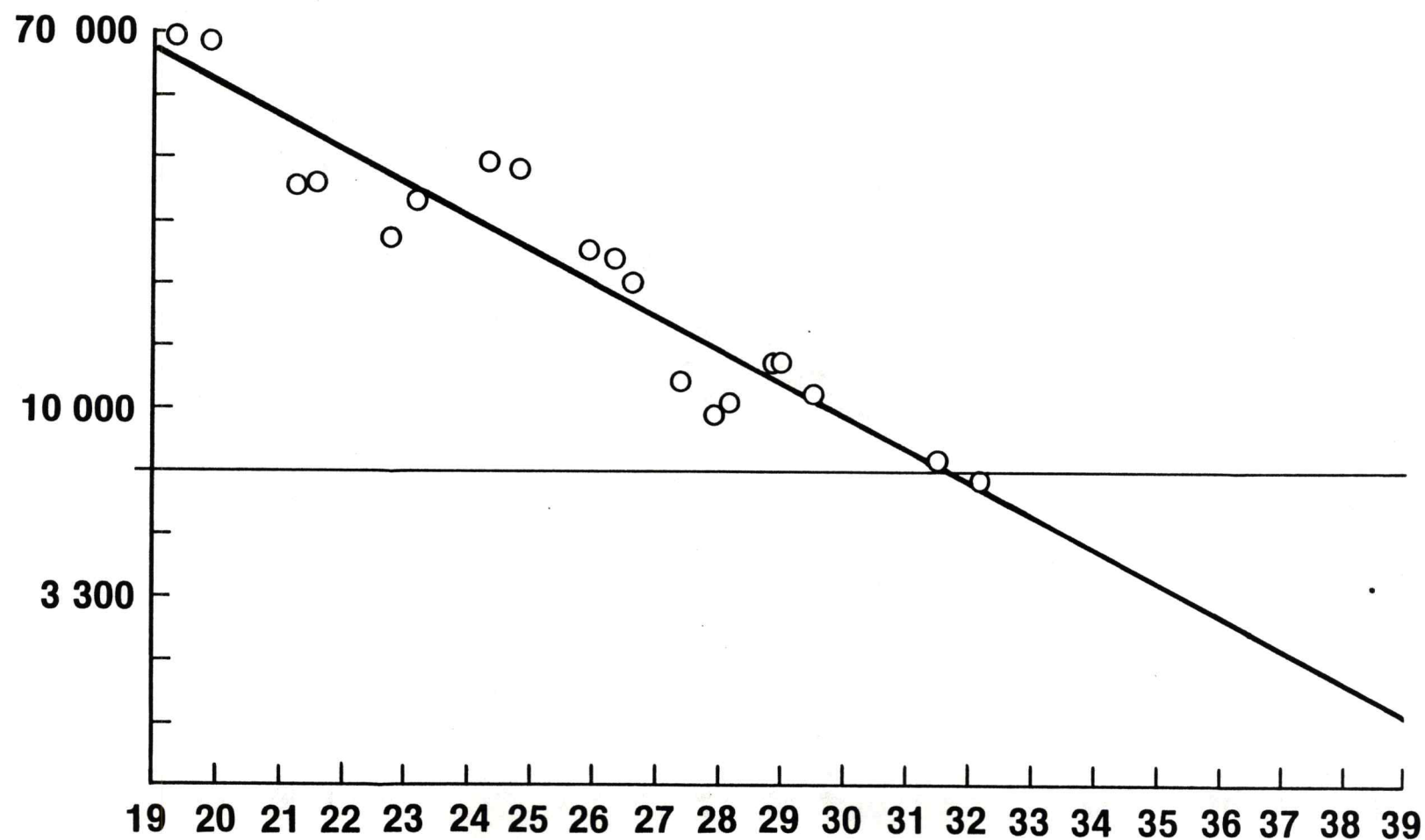
- VARIABLE AREA
  - DOORS OPEN/DOORS CLOSED
- ALTITUDE VARIATIONS CONSIDERED
- USES MEAN VALUES FOR "NOMINAL" SOLAR ACTIVITY



## **STS-1 RESULTS**

- **LARGE SOLAR FLARE ON 4/10/81 (TWO DAYS PRIOR TO LAUNCH)**
- **DRAG EFFECTS WERE 1.9 TIMES PREDICTED**
- **DEVIATION FROM THE PLANNED TRAJECTORY DURING THE FIRST NIGHT WAS 15-20 N. MI.**
- **CORRECTED DURING DAY 2**

## DAY 1 DOWNTRACK PREDICTION ERROR (FT)



**NASA-S-81-11224 A**

**STS-1 ATMOSPHERIC DESCENT  
GUIDANCE AND ENERGY MANAGEMENT**

**C. GRAVES  
JUNE 11, 1981**



## INTRODUCTION

- **ATMOSPHERIC DESCENT**
  - **ENTRY**
  - **TAEM**
  - **APPROACH AND LANDING**
- **SYSTEMS STATUS**
  - **WEIGHT AND BALANCE NOMINAL**
  - **ALL AFT RCS JETS OPERATIONAL WITH SUFFICIENT PROPELLANT**
  - **ALL APU'S OPERATIONAL WITH SUFFICIENT PROPELLANT**
  - **EXCELLENT IMU'S AND NAVIGATION IN GENERAL**
- **ENVIRONMENT**
  - **WINDS BELOW 130K FT ALTITUDE VERY LOW MAGNITUDE**
  - **VERY LOW ATMOSPHERIC TURBULENCE LEVEL**

## APPROACH AND LANDING PERFORMANCE

- STS-1 SPEED BRAKE DEFLECTION ON STEEP GLIDESLOPE 68  
PERCENT COMPARED TO 67.8 PERCENT PREFLIGHT
- LANDING WAS ABOUT 3100 FT LONG AT 183 KTS EAS
  - ENVIRONMENT/MASS 425 FT
  - AERODYNAMIC EFFECTS 1175
    - CDO
    - SPEEDBRAKE EFFECTIVENESS
    - GROUND EFFECTS?
  - OTHER 1450
    - SPEED AT PREFLARE
    - POSITION AT PREFLARE
    - SPEEDBRAKE DEFLECTION
    - LANDING GEAR DEPLOYMENT
    - TOUCHDOWN SPEED
- TOTAL 3050 FT

## APPROACH AND LANDING PERFORMANCE (CONCLUDED)

- ROLLOUT

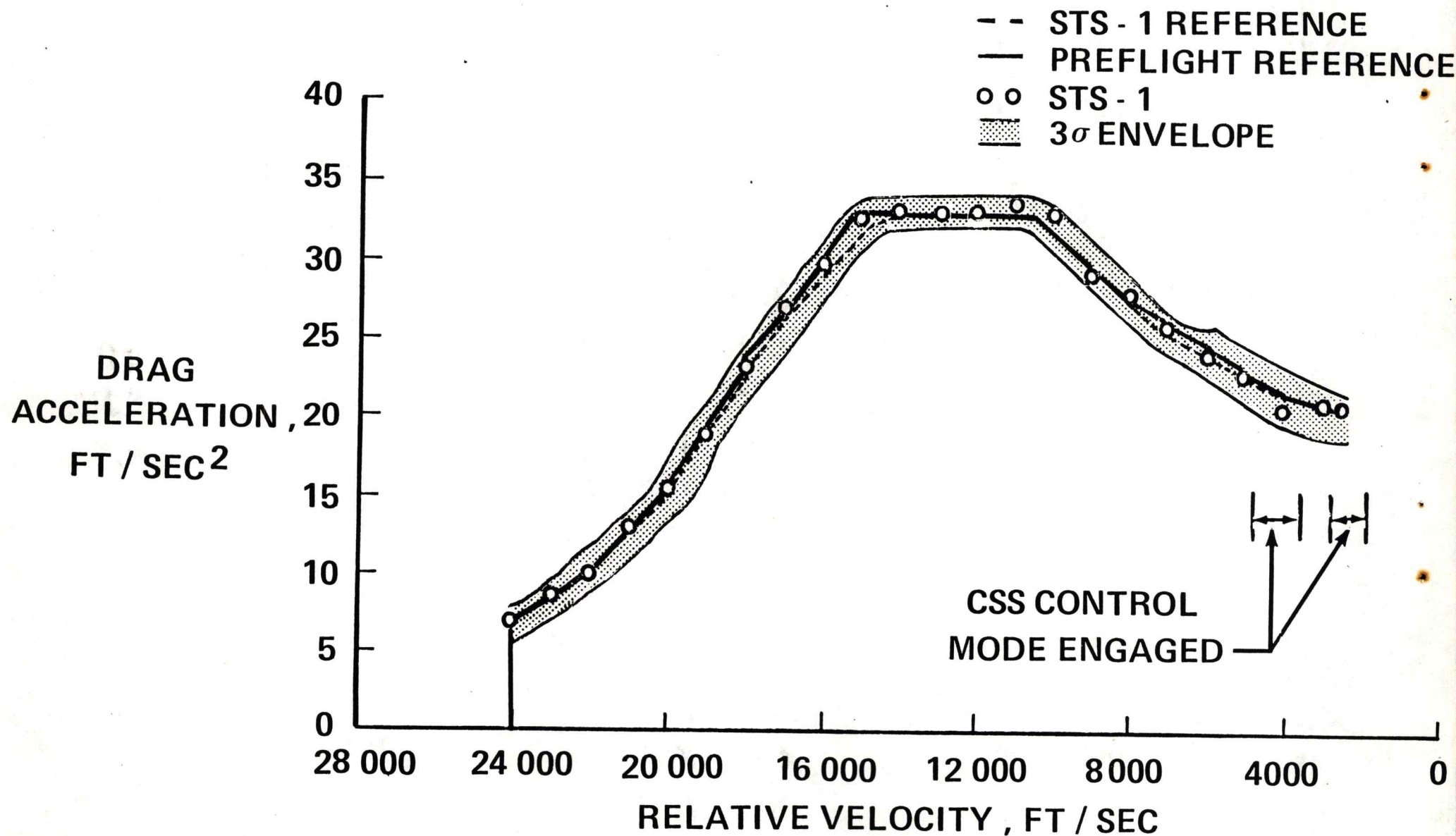
- NOSE GEAR PITCHDOWN  $\approx$  10 KTS SLOW
- NOSE GEAR  $\dot{H} \approx$  5.6 FPS
- BRAKING INITIATED  $\approx$  12000 FT FROM THRESHOLD
- WHEELS STOP AT 15046 FT FROM THRESHOLD
- PREDICTED STOPPING CAPABILITY
  - MODERATE BRAKING – 12500 FT FROM THRESHOLD
  - HEAVY BRAKING – 10000 FT FROM THRESHOLD



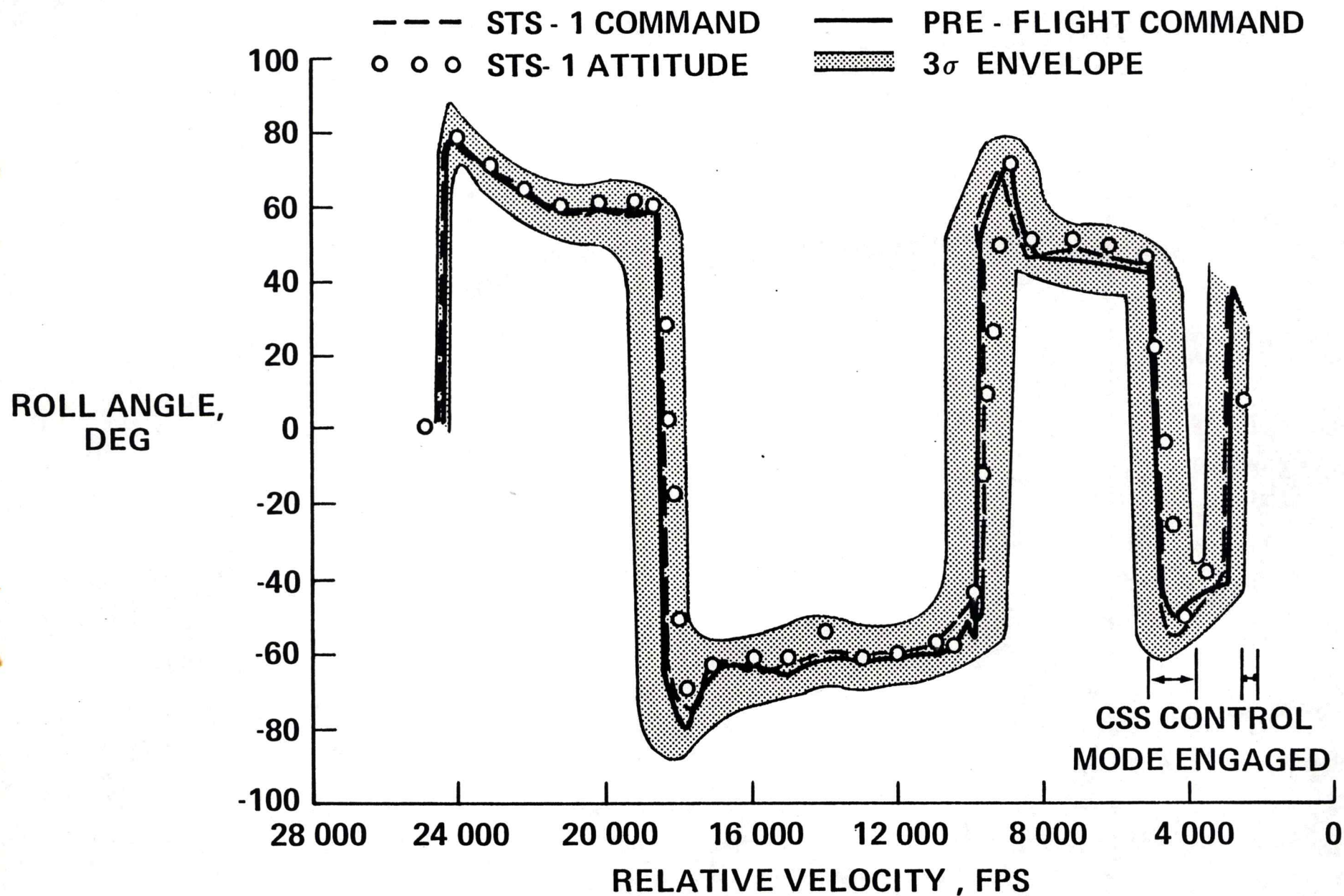
## **SUMMARY**

- **OVERALL DESCENT GUIDANCE AND ENERGY MANAGEMENT PERFORMANCE WAS EXCELLENT**
- **ANOMALIES/POTENTIAL RESOLUTION**
  - **BODY FLAP DEFLECTION —→ REVISED ELEVON SCHEDULE**
  - **ENERGY AT R/W THRESHOLD —→ REVISED APPROACH AND LANDING PROFILE**

## ENTRY DRAG ACCELERATION

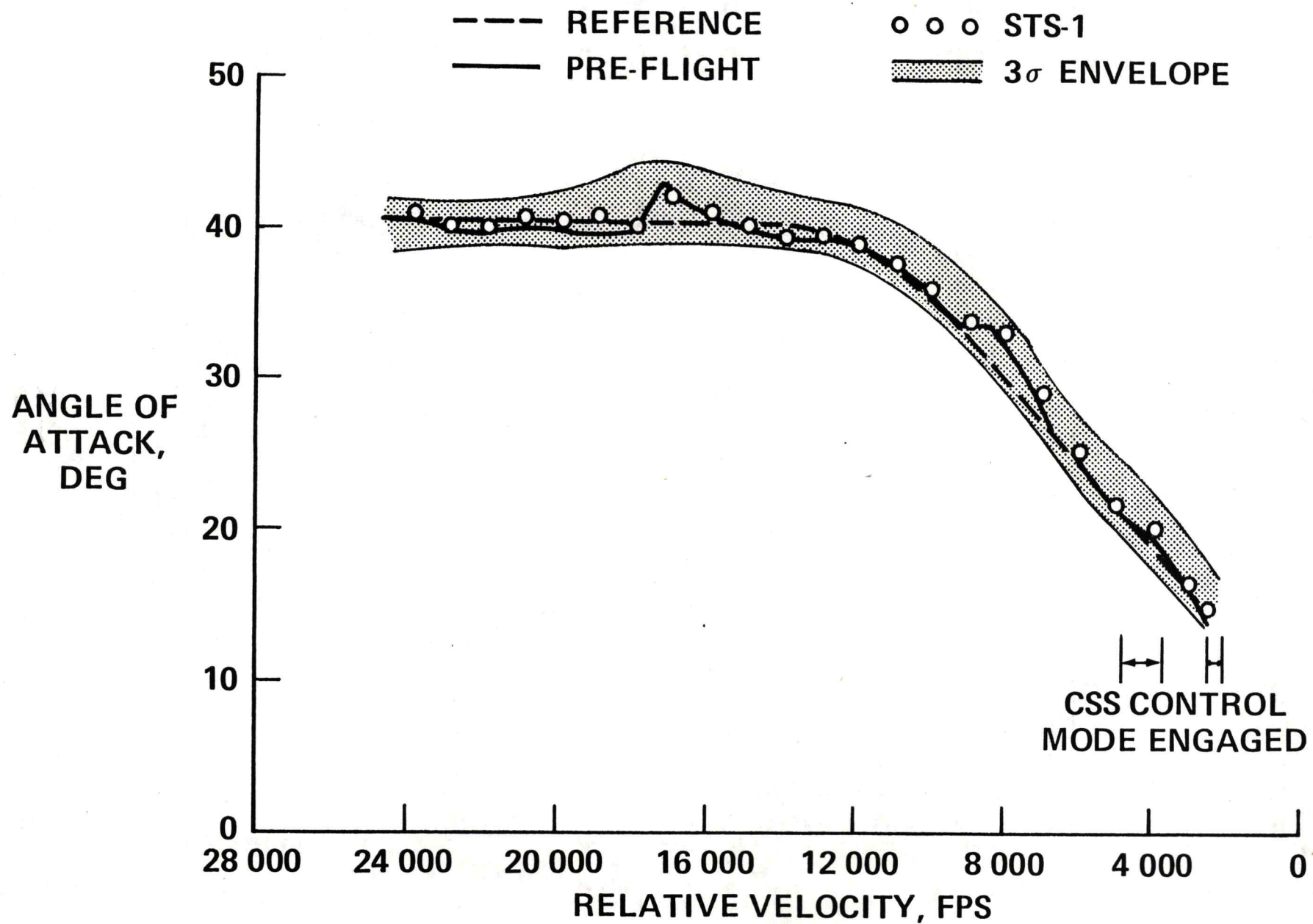


## ENTRY ROLL PERFORMANCE

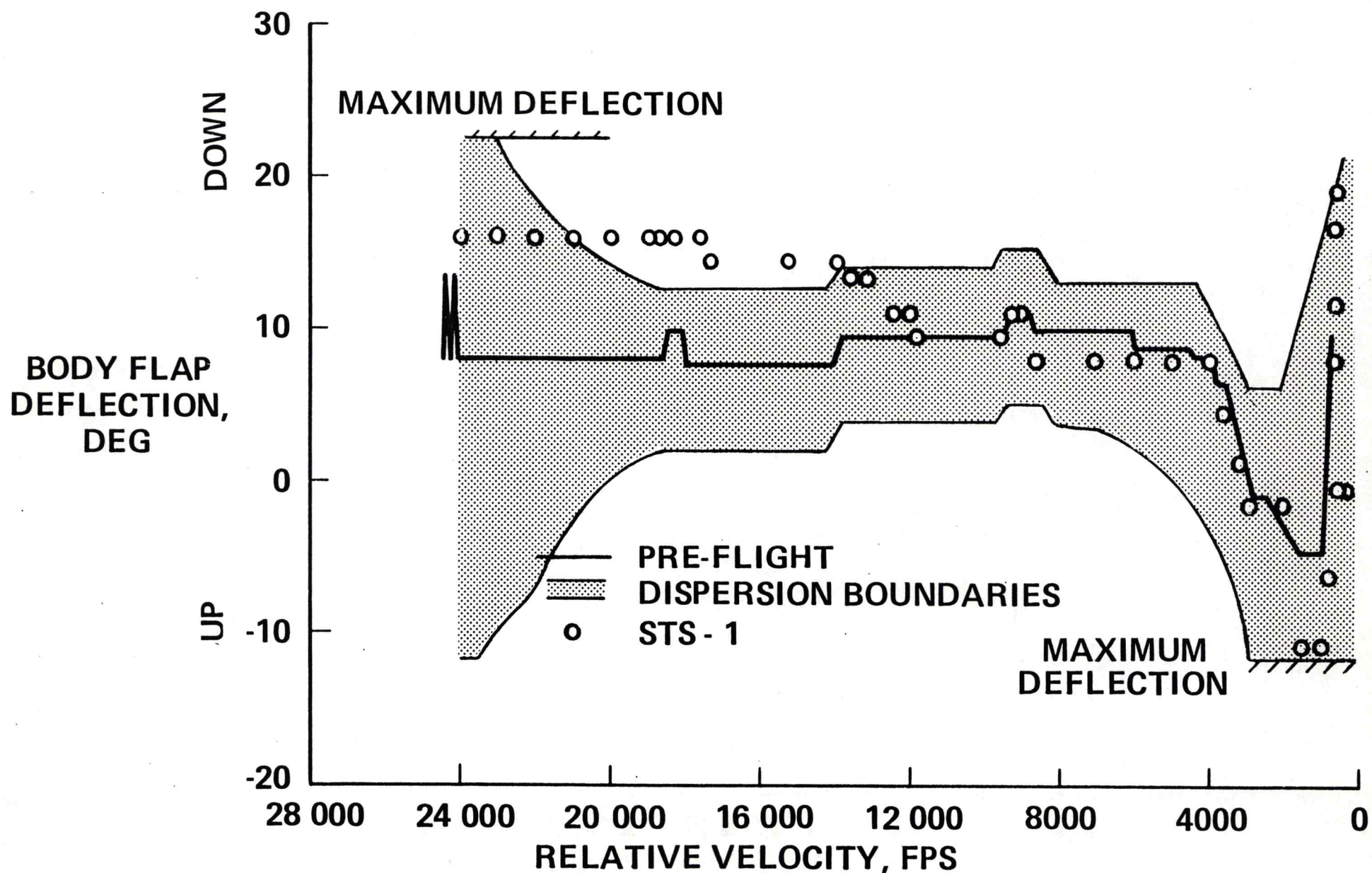




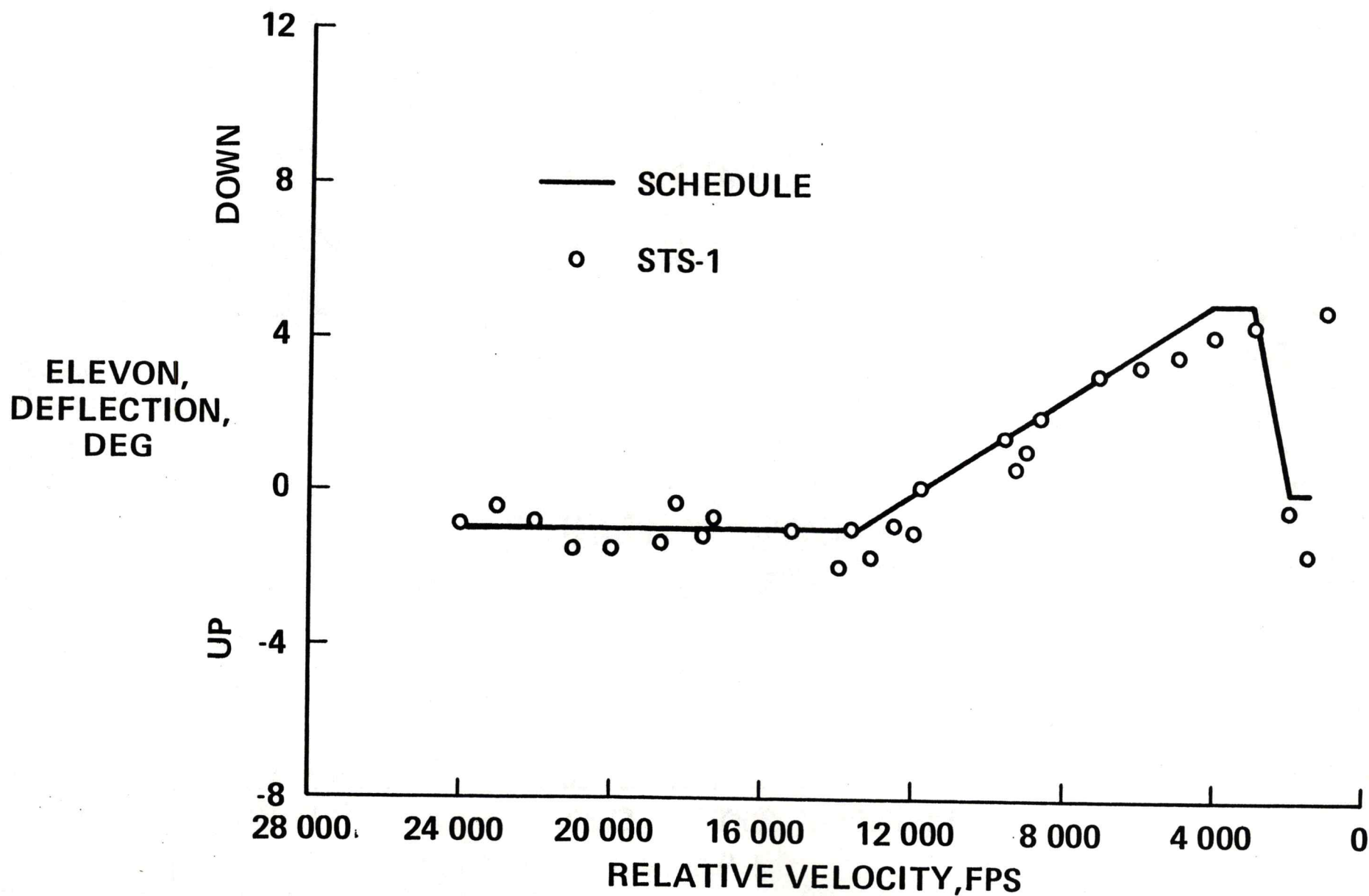
## ENTRY ANGLE - OF - ATTACK PERFORMANCE



# ENTRY/TAEM BODY FLAP DEFLECTION

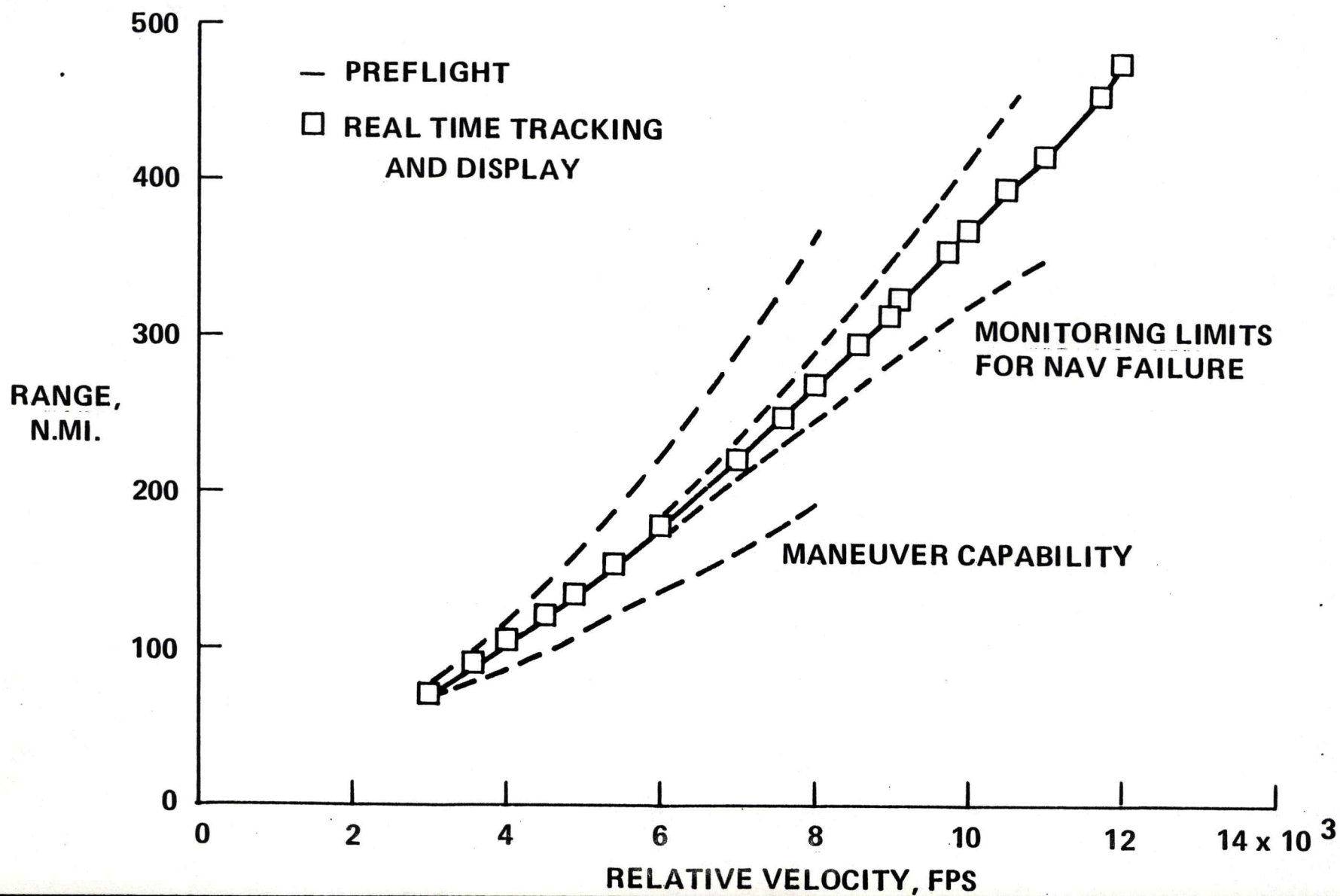


# ENTRY ELEVON DEFLECTION

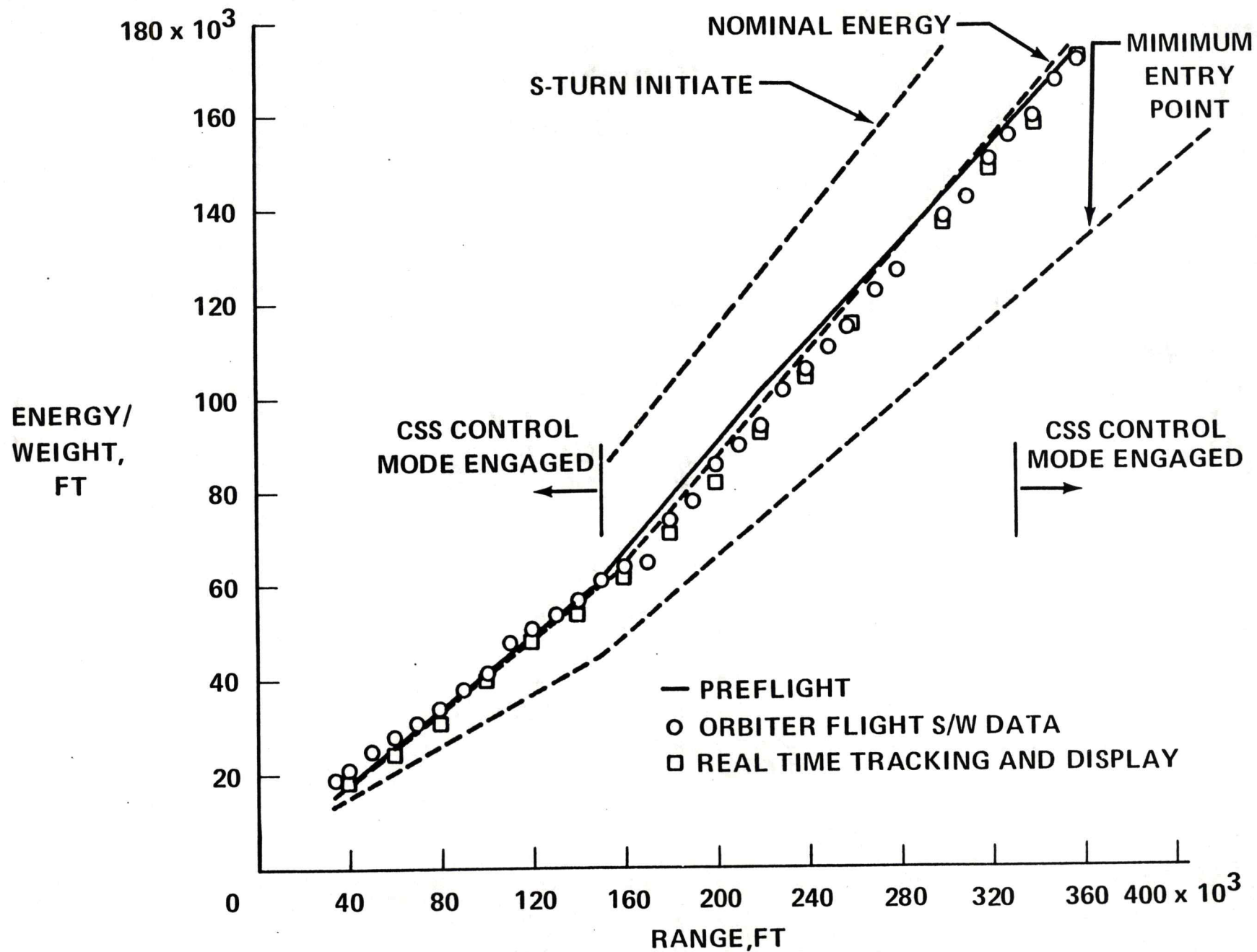




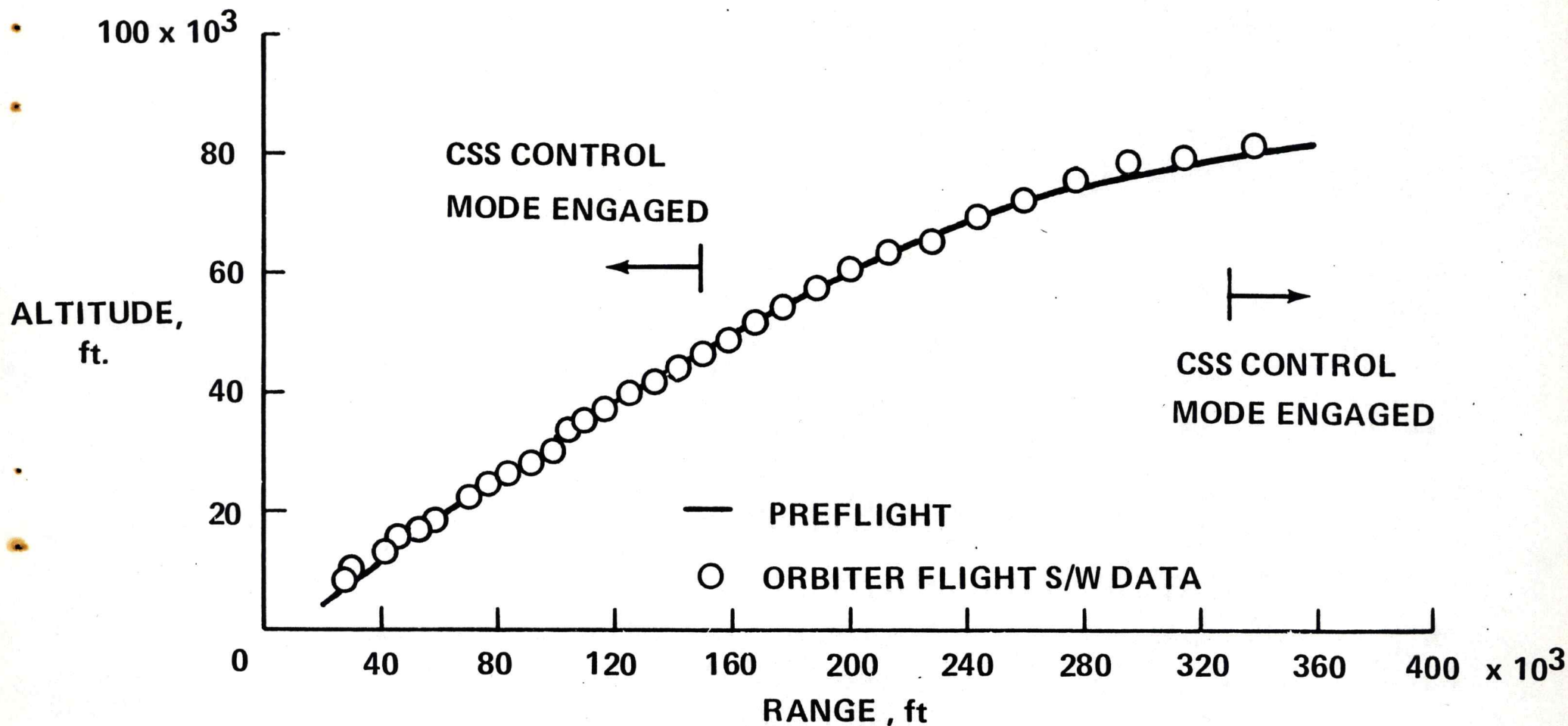
# LATE ENTRY ENERGY MANAGEMENT



## TAEM ENERGY MANAGEMENT

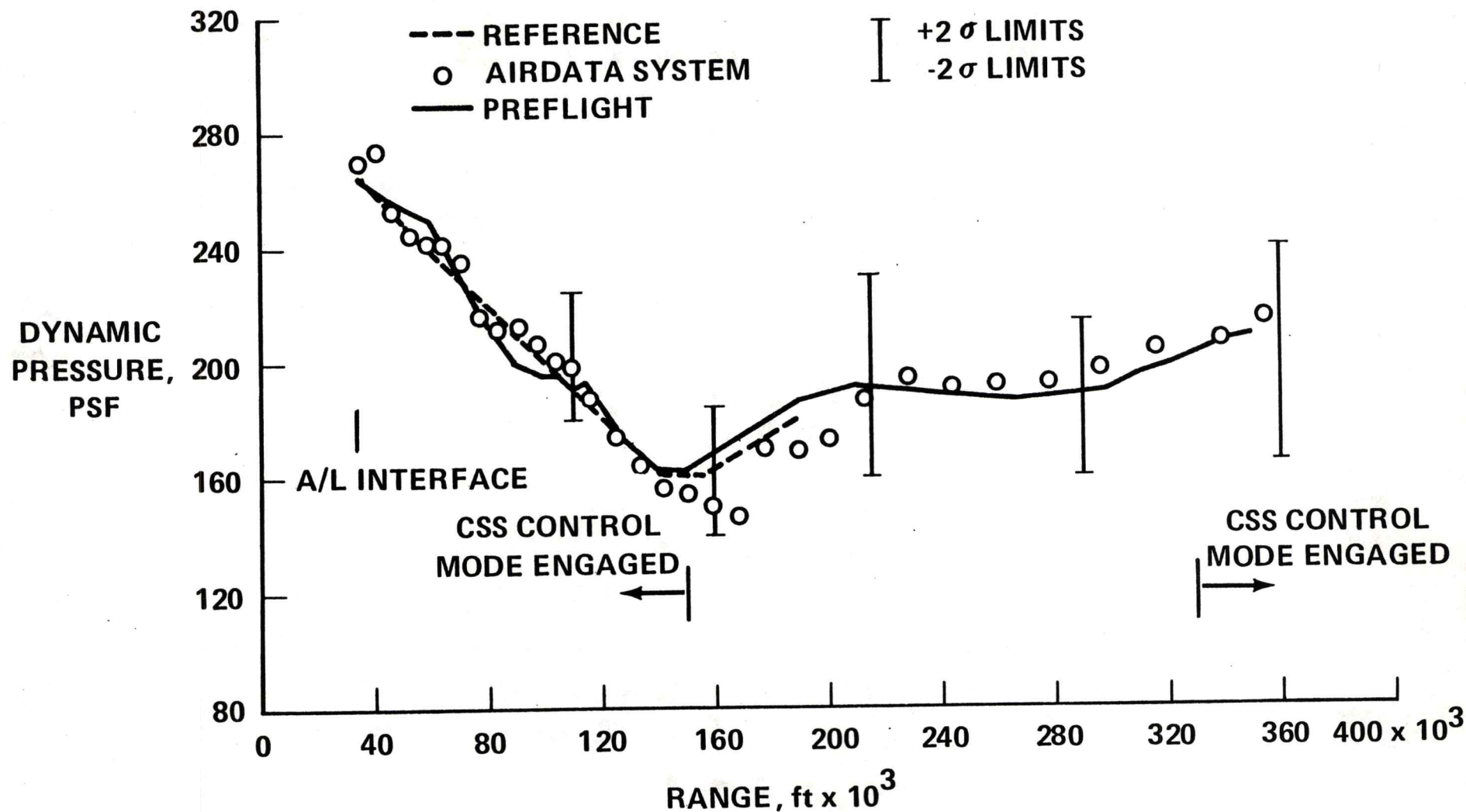


# TAEM ALTITUDE / RANGE PROFILE

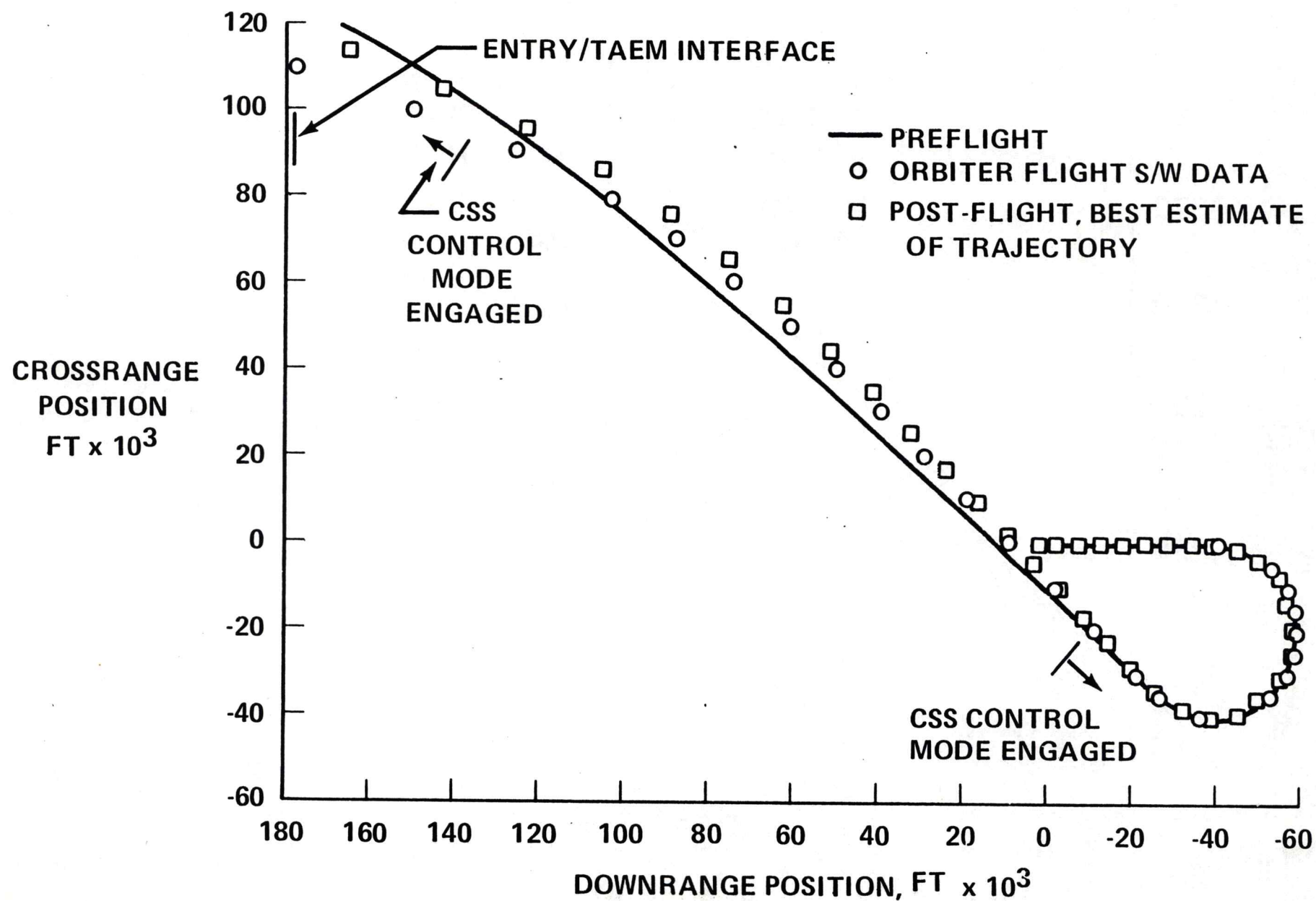




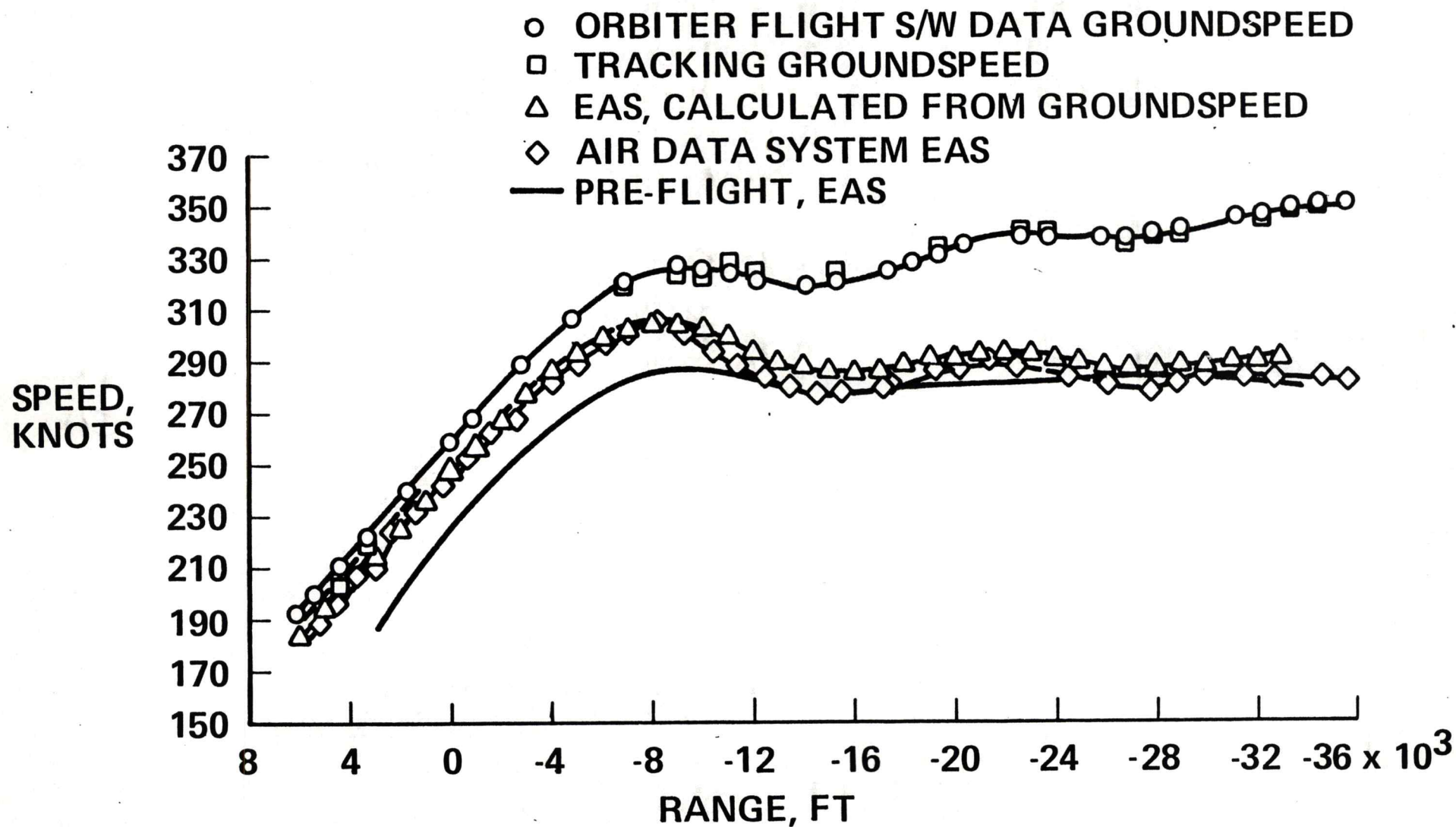
# TAEM DYNAMIC PRESSURE VS. RANGE



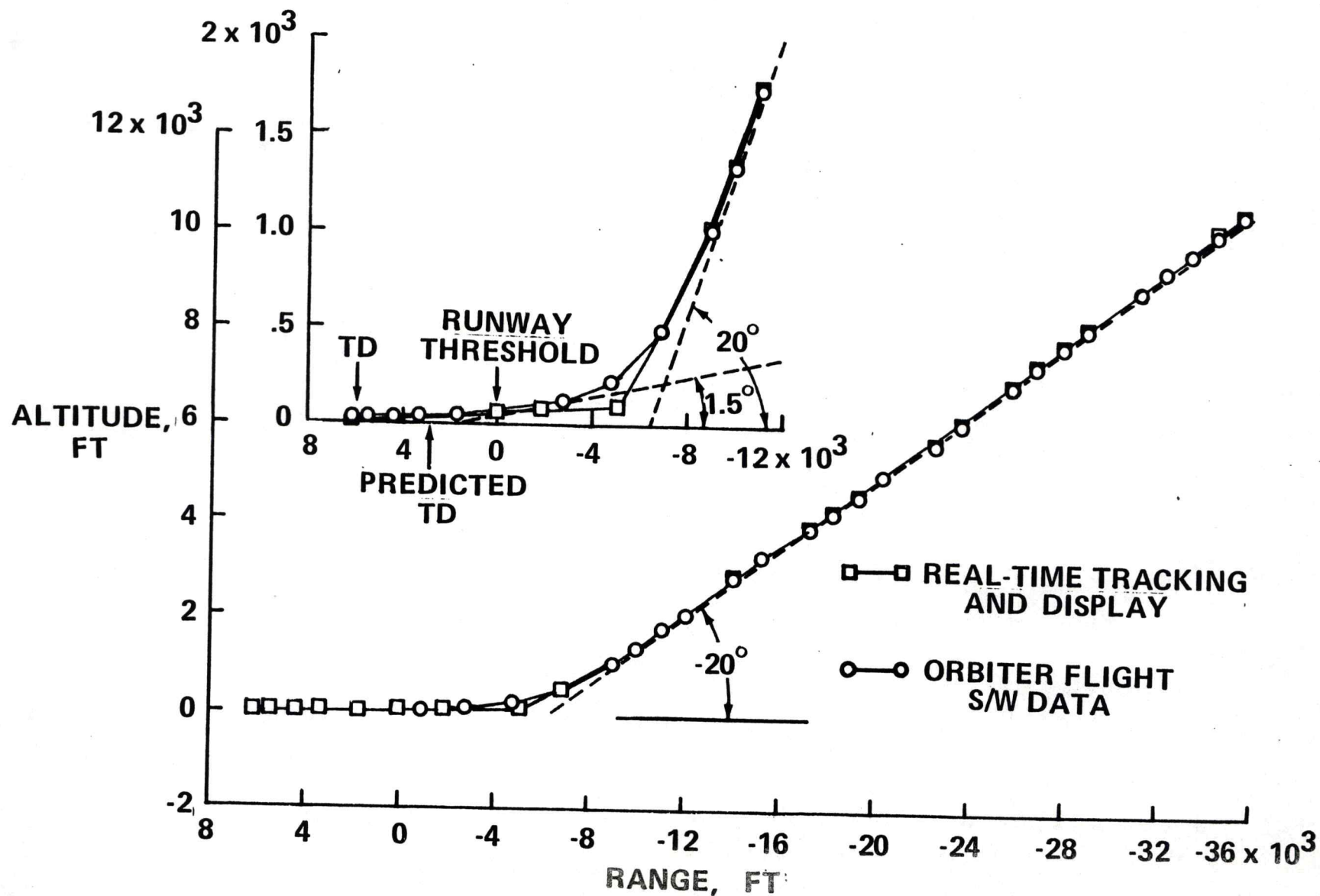
## TAEM/A &amp; L GROUNDTRACKING



# APPROACH AND LANDING SPEED/RANGE PROFILE



# APPROACH AND LANDING ALTITUDE/RANGE PROFILE





NASA-S-81-11088

# **STS-1 SYMPOSIUM ACOUSTIC ENVIRONMENT**

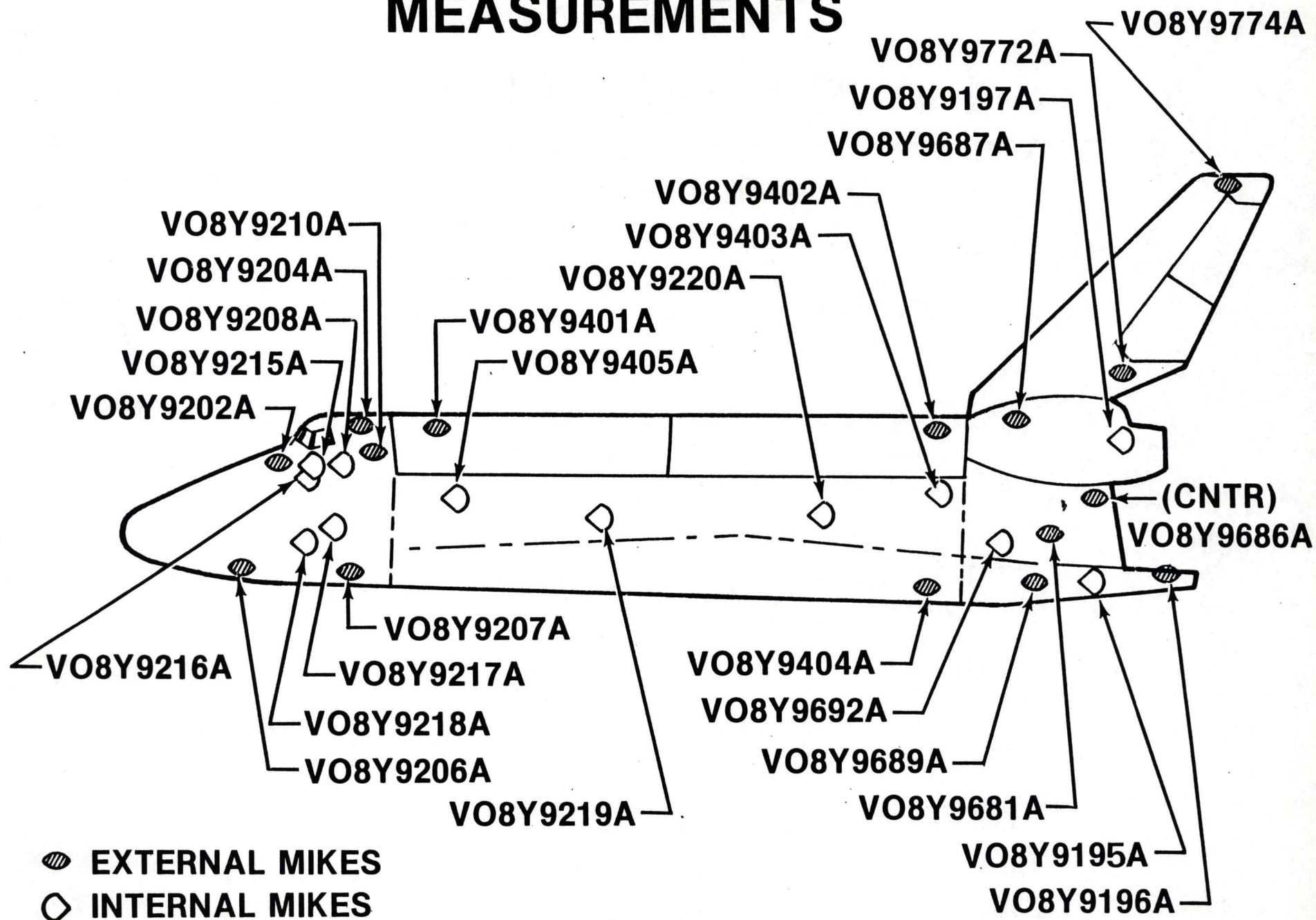
**JUNE 11, 1981**

**PRESENTER: M. C. COODY**

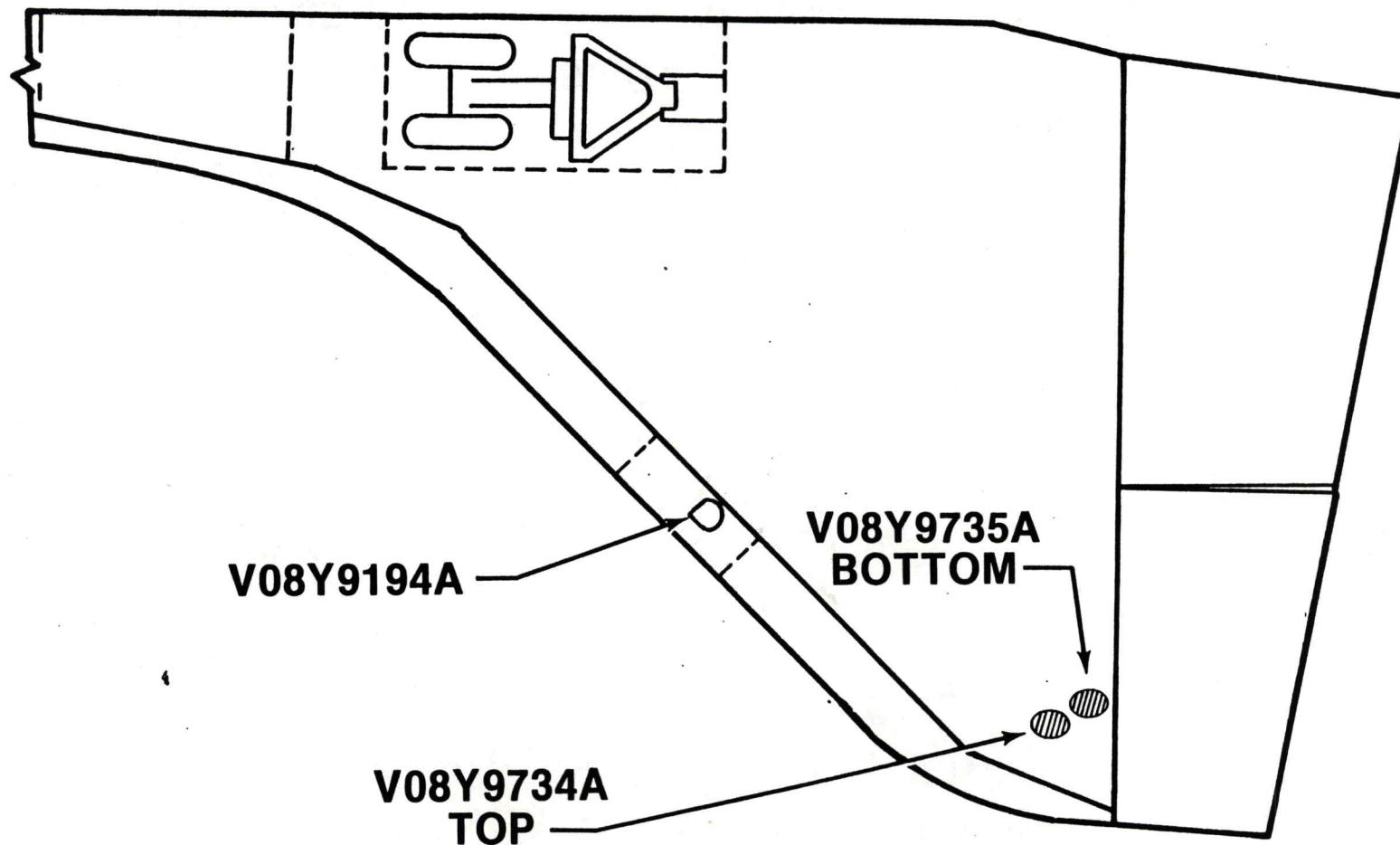
## **STS-1 ACOUSTIC ENVIRONMENT**

- **NOISE LEVELS MEASURED ON 17 EXTERNAL MIKES AND 13 INTERNAL MIKES MOUNTED ON THE ORBITER**
- **SPECIFICATION CRITERIA DERIVED FROM 6.4 PERCENT SCALE MODEL TESTS AND IS-2 WIND TUNNEL TEST**
- **TEST DATA FROM MPT AND FRF WAS USED TO AFFIRM THE NOISE LEVELS FOR FULL SCALE**

# STS-1 ACOUSTIC MEASUREMENTS

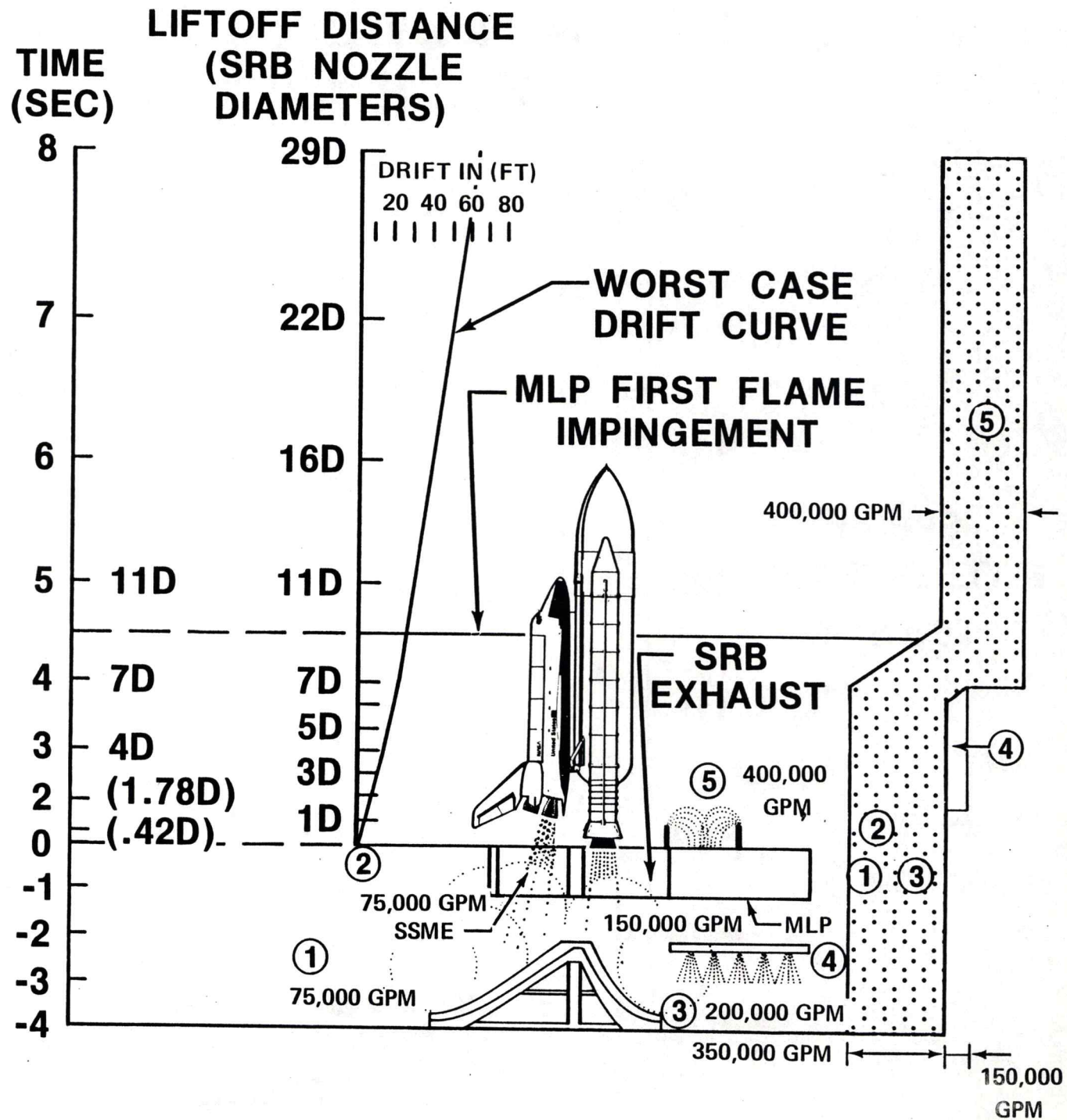


# STS-1 ACOUSTIC MEASUREMENTS

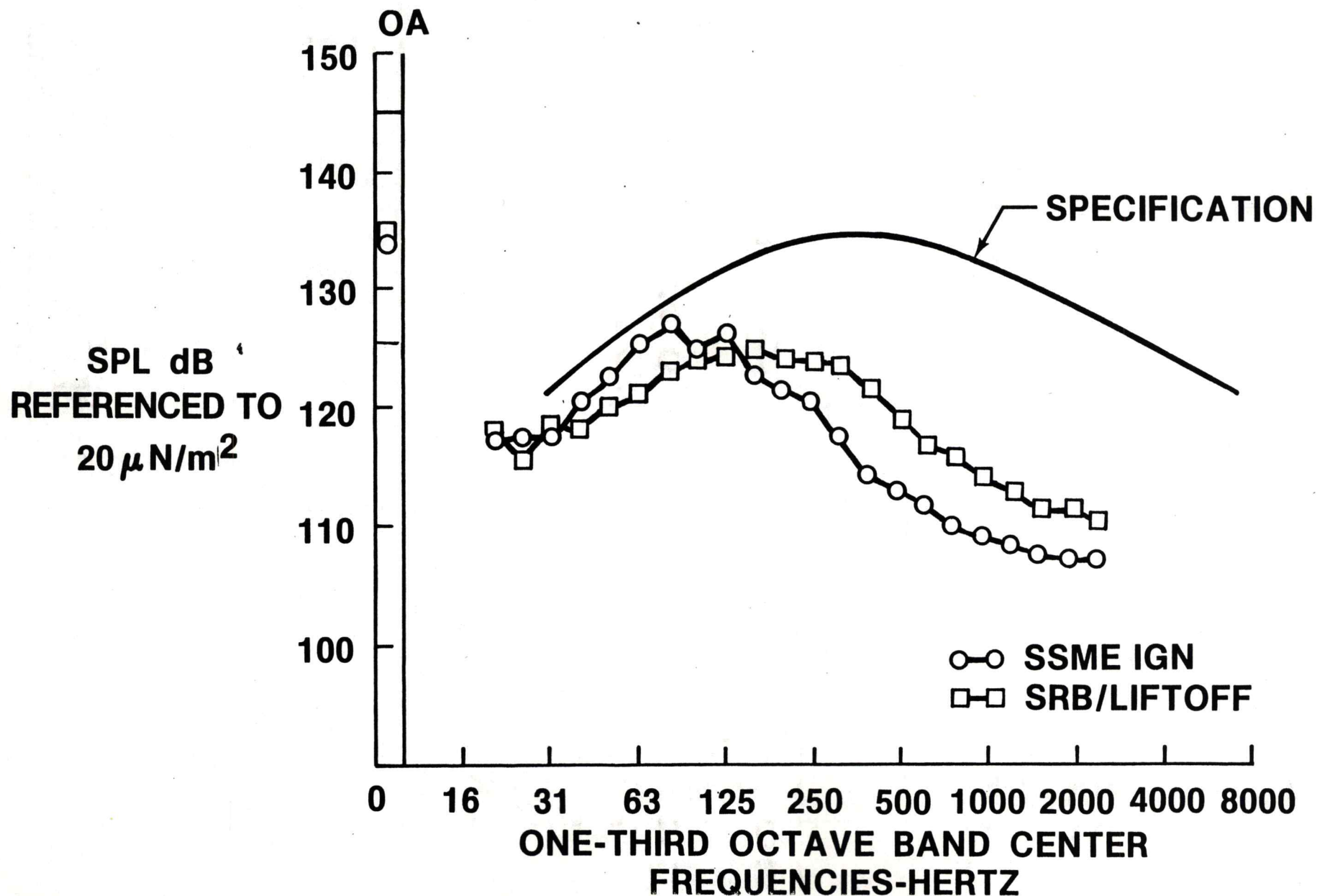




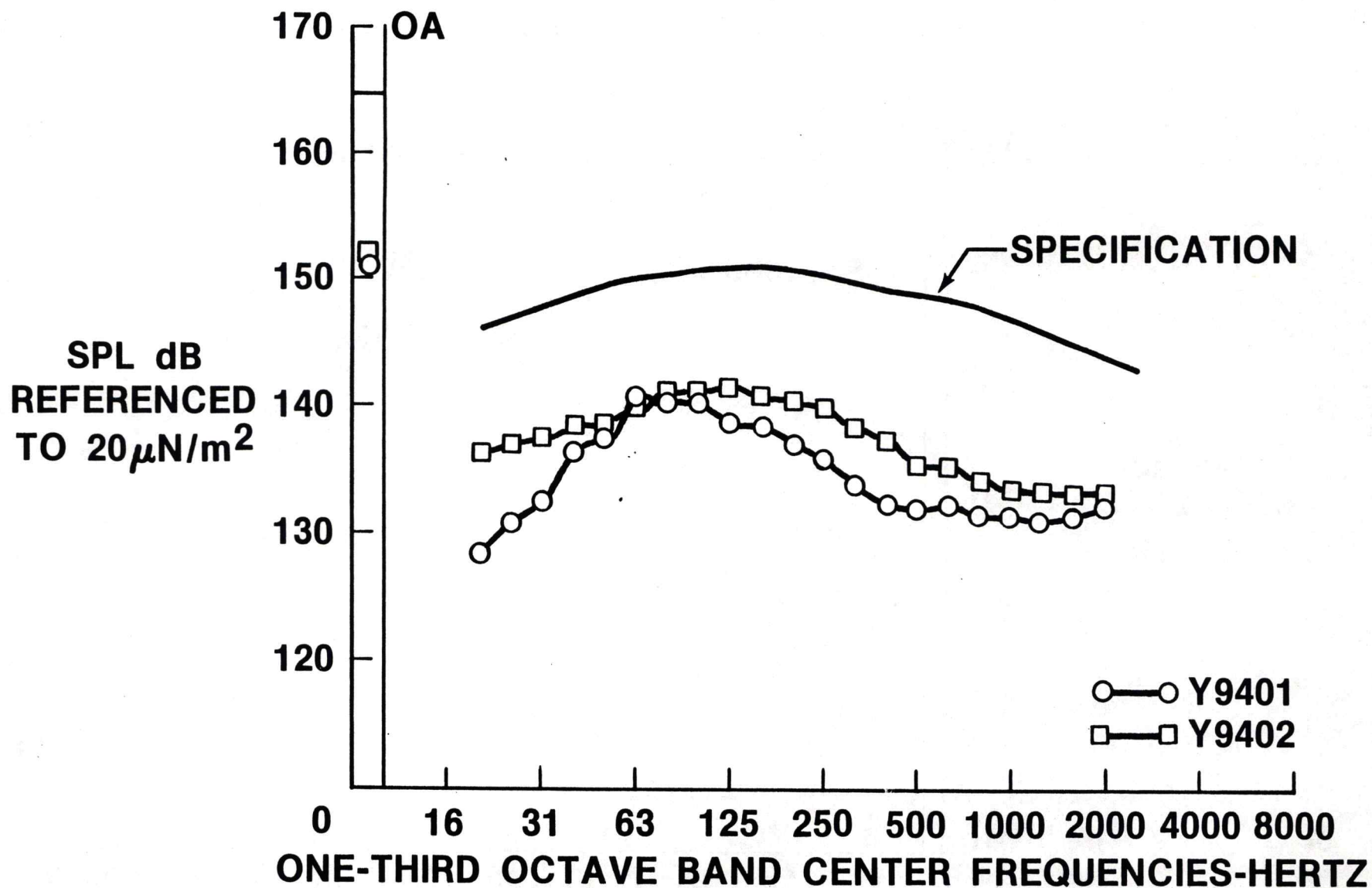
# **PAD SOUND SUPPRESSION SCHEME PLOT OF FLOW/DRIFT VS TIME**



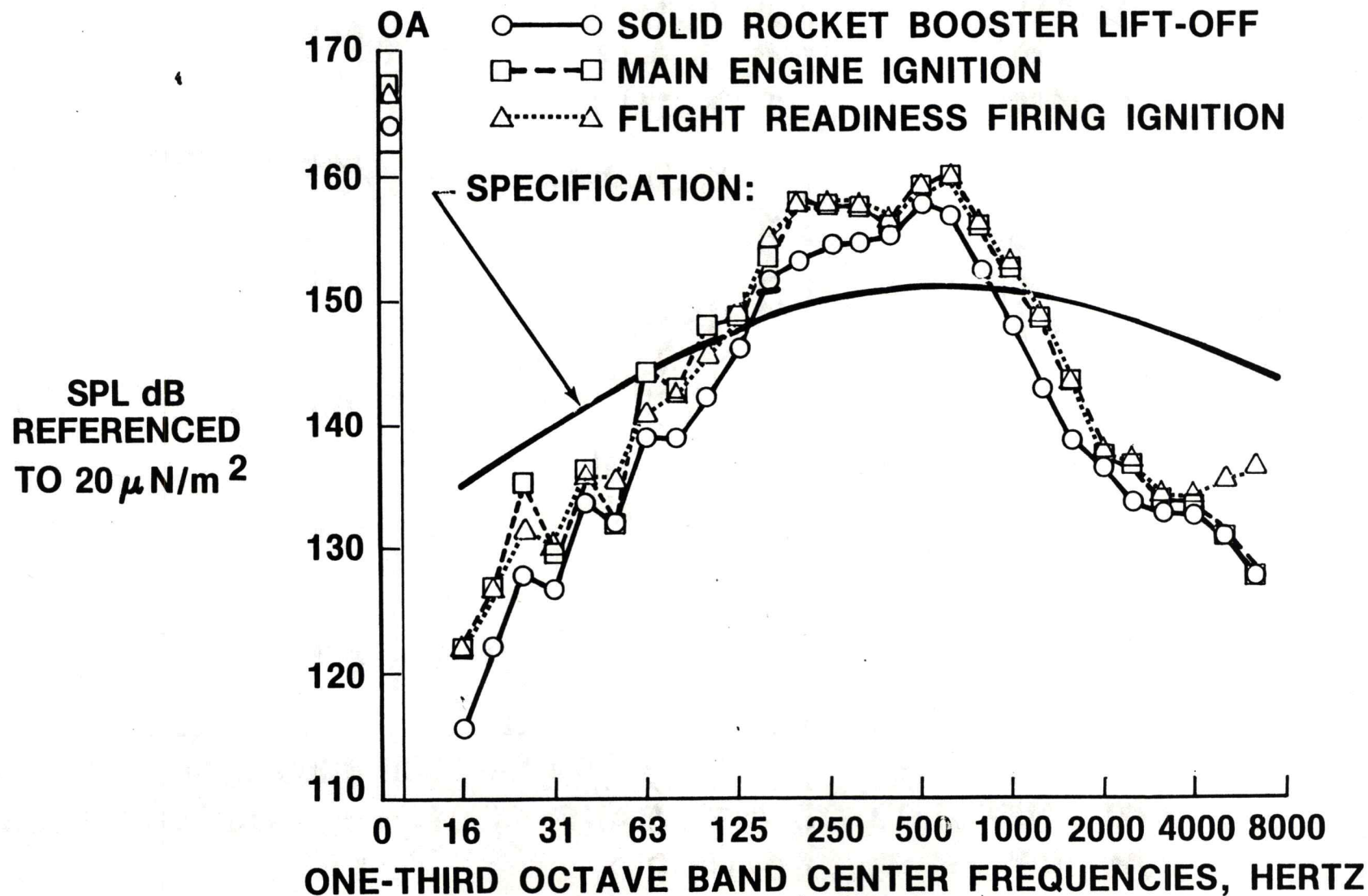
# STS-1 PAYLOAD BAY INTERIOR SPACE AVERAGE



# STS-1 PAYLOAD BAY EXTERIOR AERODYNAMICS

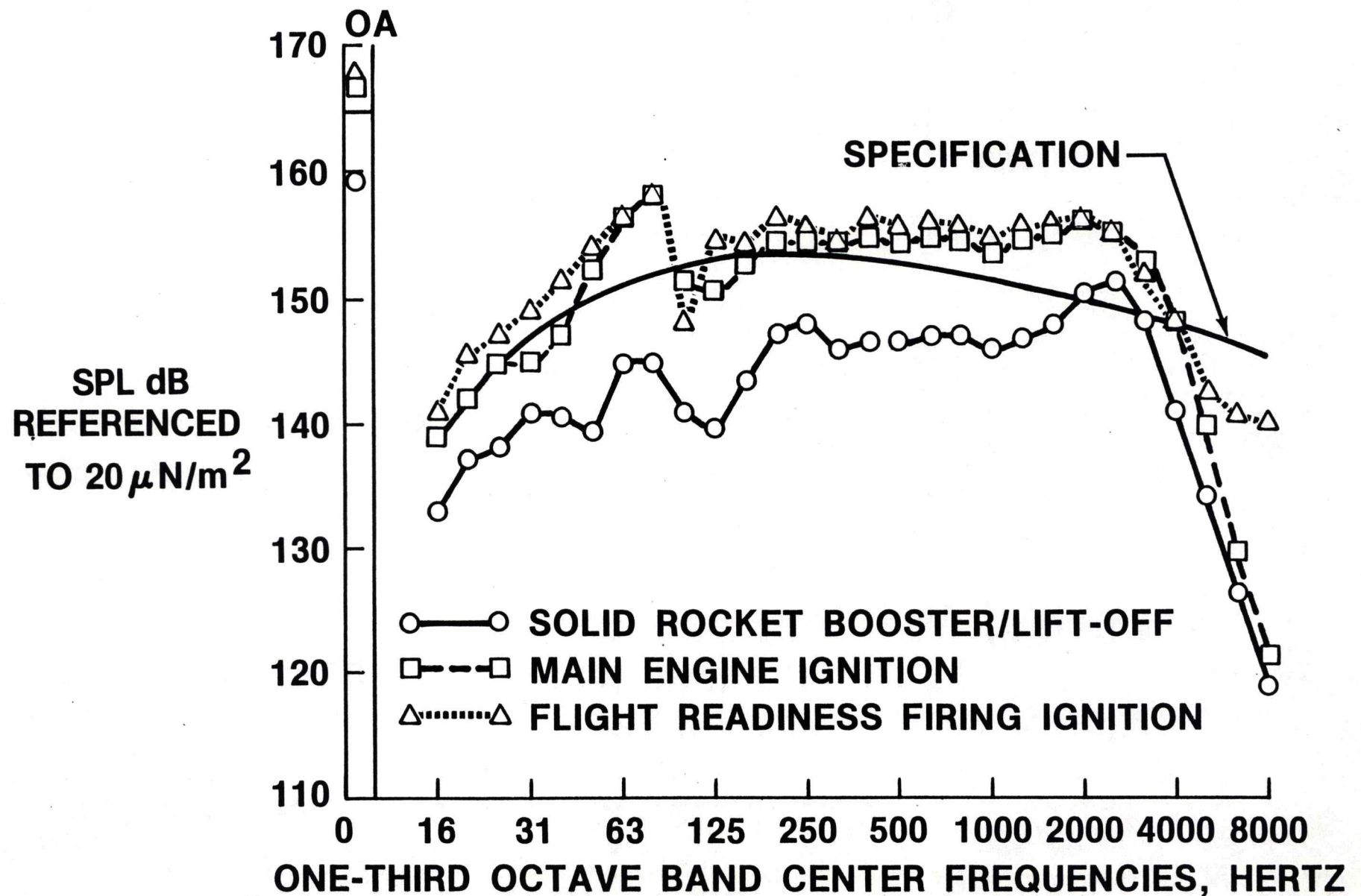


# COMPARISON OF LAUNCH PHASE NOISE LEVEL MEASUREMENTS AT THE TIP OF THE VERTICAL TAIL

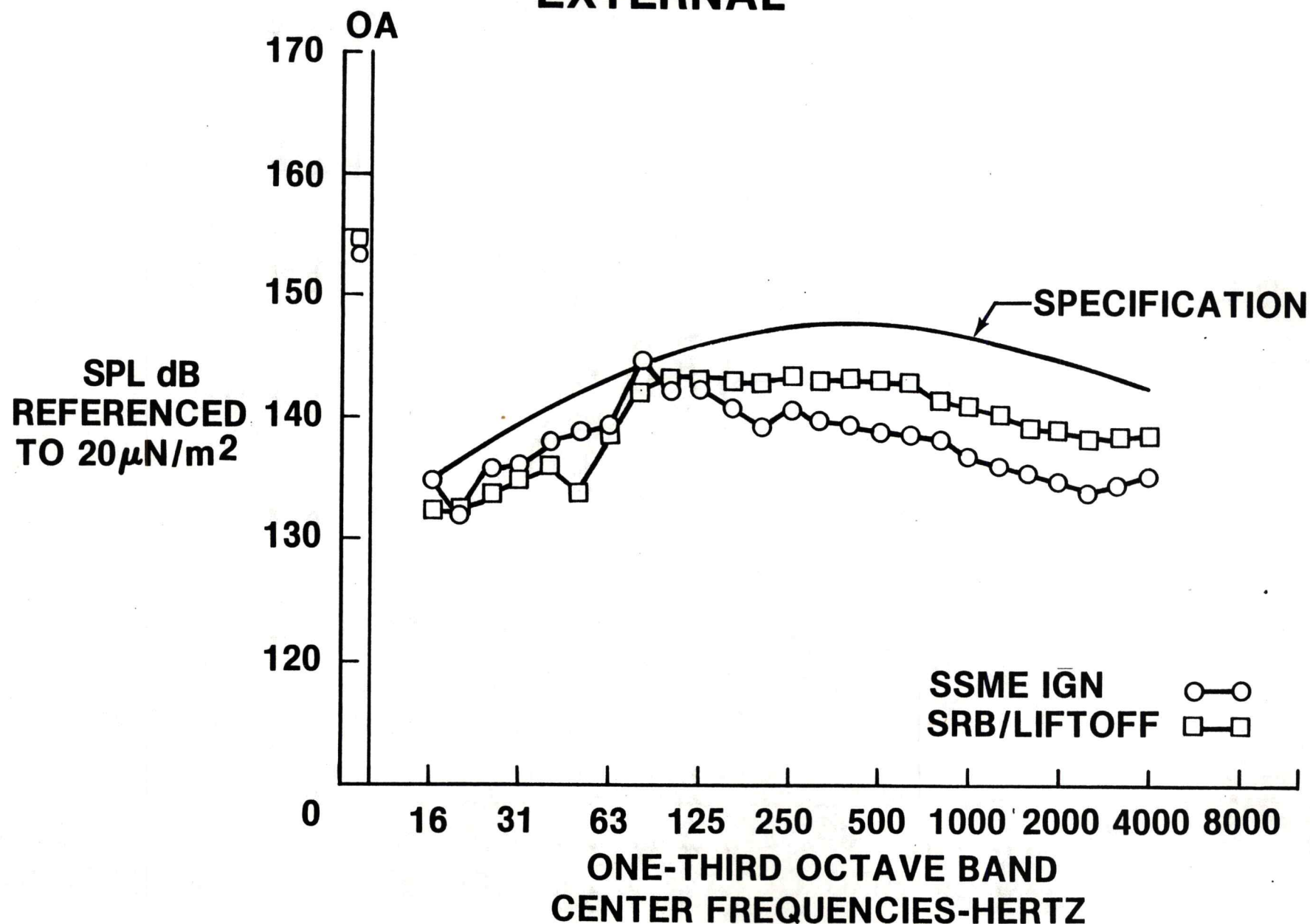




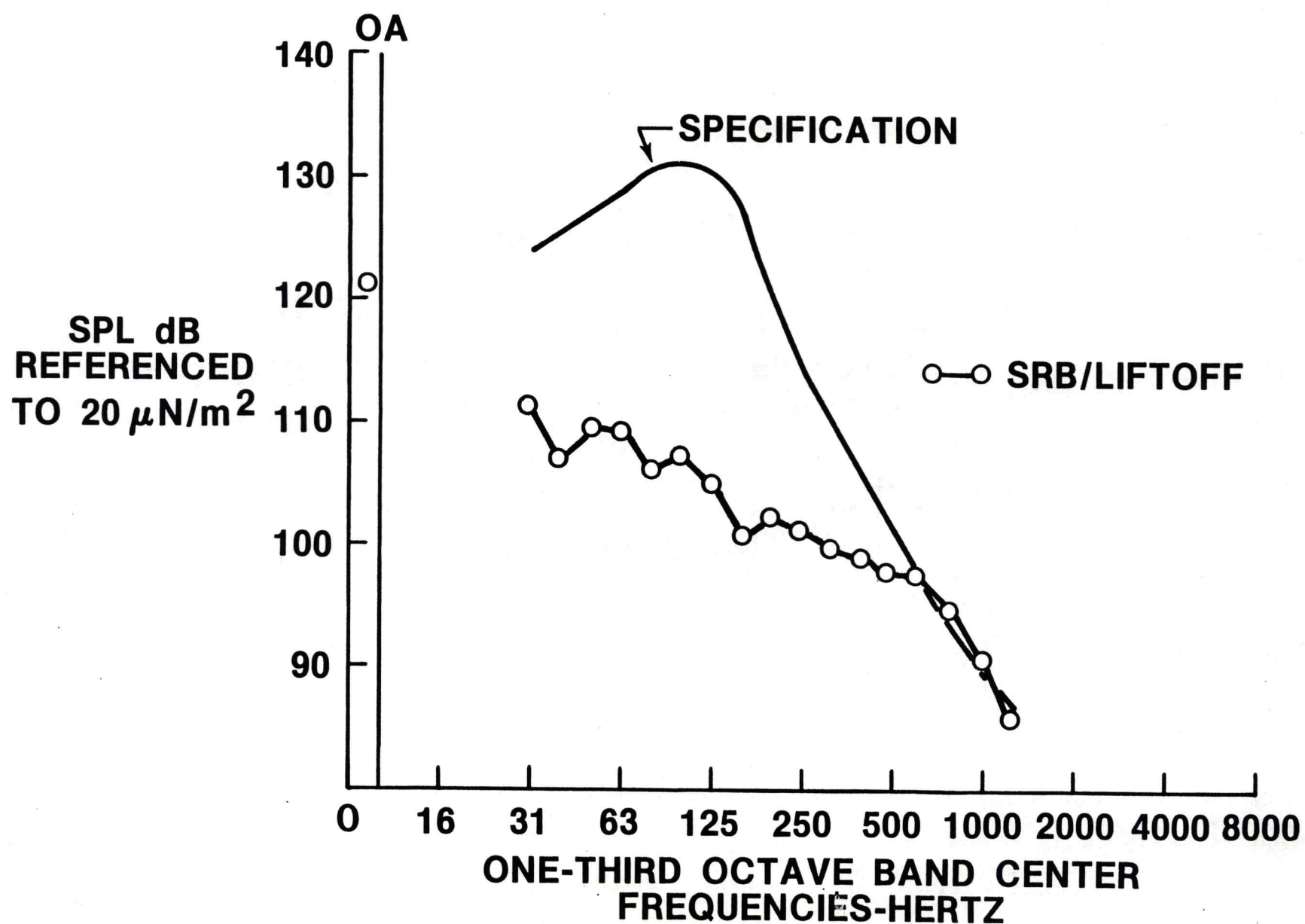
# COMPARISON OF LAUNCH PHASE NOISE LEVEL AT TOP OF BODY FLAP



# STS-1 OMS POD X-1340, Z-470 EXTERNAL



# STS-1 CREW MODULE NOISE LEVELS



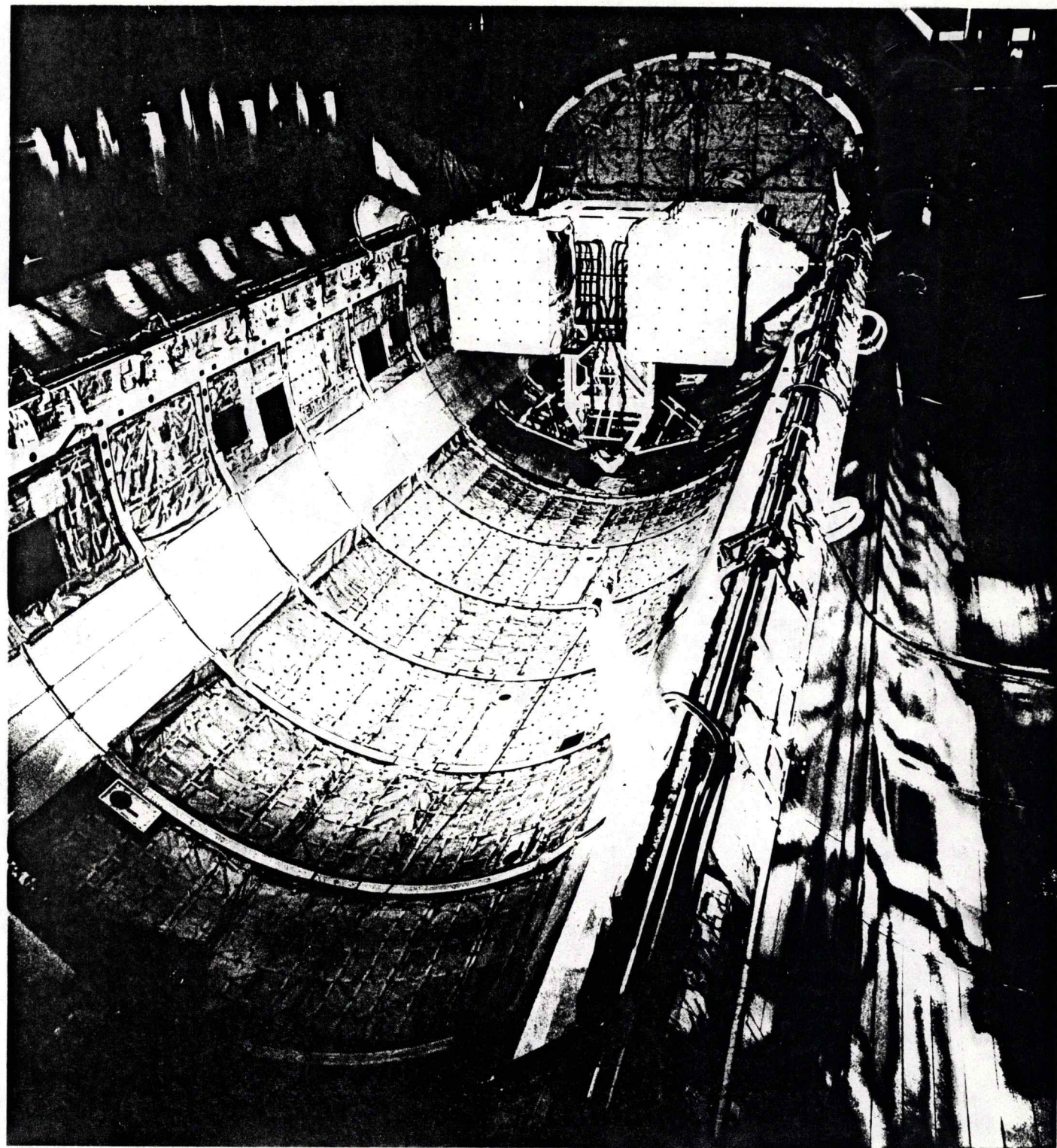
## **CONCLUSIONS**

- **MEASURED NOISE LEVELS WERE AS EXPECTED  
FROM 6.4 PERCENT SCALE ENGINE NOISE TESTS  
AND IS-2 WIND TUNNEL TEST**
- **MEASURED NOISE LEVELS GENERALLY BELOW  
SPECIFICATION CRITERIA**



NASA-S-81-11097

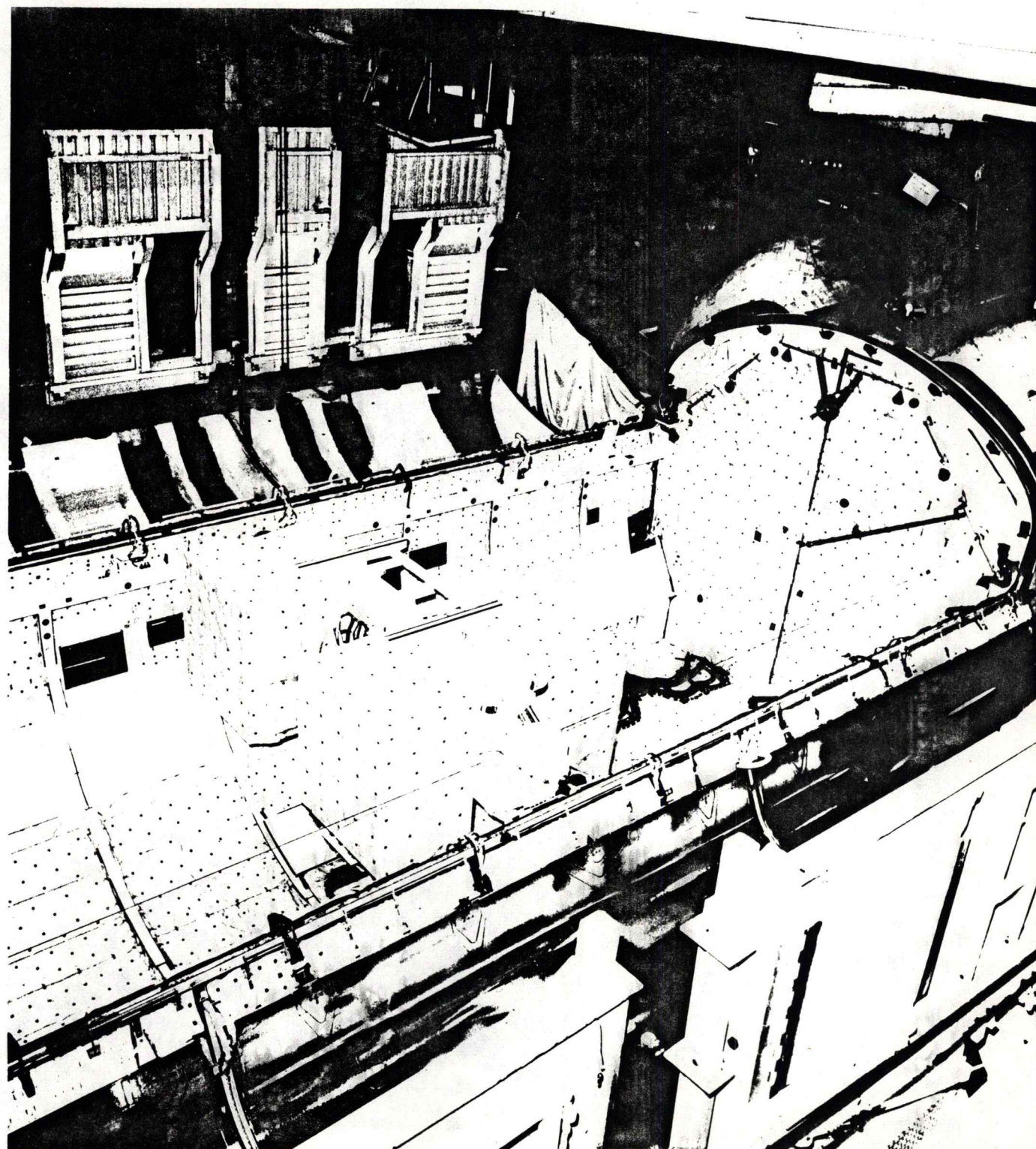
# STS-1 PAYLOAD BAY





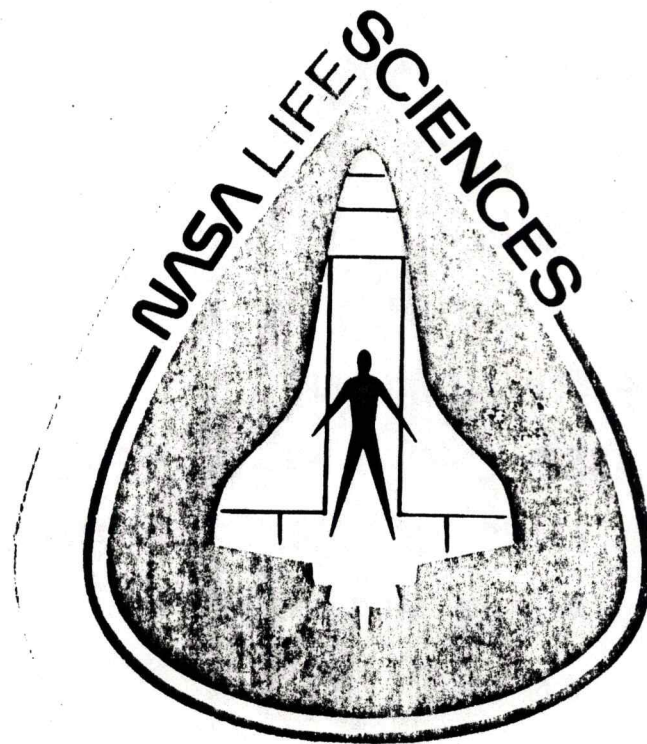
NASA-S-81-11098

# STS-1 PAYLOAD BAY



NASA-S-81-11173

# MEDICAL OPERATIONS





# **MEDICAL OPERATIONS**

## **STS-1**

- EVALUATION OF CREW HEALTH
- HEALTH STABILIZATION
- EMERGENCY MEDICAL SERVICES
- TOXICOLOGY
- RADIATION
- SPACECRAFT NOISE ASSESSMENT
- MOTION SICKNESS PROPHYLAXIS
- BIOINSTRUMENTATION
- ANTI-G SUIT
- MEDICAL KIT



# EVALUATION OF CREW HEALTH

## STS-1

	MARCH 3	MARCH 31	APRIL 8
EXAM SCHEDULE	F-30 DAYS	F-10 DAYS	F-2 DAYS
LOCATION	JSC	JSC	JSC
DURATION (ACTUAL)	1:15	1:55	0:15
EXAM COMPONENTS	LAB PHYSICAL DENTAL VISUAL TONOMETRY	LAB TREADMILL PHYSICAL AUDIO	LAB

## EVALUATION OF CREW HEALTH (CONT)

STS-1

	APRIL 10 APRIL 12	APRIL 14	APRIL 17	
EXAM SCHEDULE	F-0	L+0	L+3 DAYS	L+3 TO L+7 DAYS
LOCATION	KSC	DFRC	JSC	JSC
DURATION (ACTUAL)	0:10	0:40	1:45	
EXAM COMPONENTS	PHYSICAL	LAB STAND TEST - WEIGHT PHYSICAL	TREADMILL DENTAL VISUAL TONOMETRY AUDIO PHYSICAL	T-38 CHECKOUT

## **HEALTH STABILIZATION**

### **STS-1**

- PROBLEMS WITH INFECTIOUS DISEASE DURING CRITICAL MISSION TIMES FROM APOLLO 7 TO APOLLO 13
- HEALTH STABILIZATION STARTED WITH APOLLO 14
- NO ILLNESSES OCCURRED DURING CRITICAL MISSION TIMES FOR APOLLO 14 THROUGH APOLLO 17, ASTP, SKYLAB 2, 3, 4, AND STS-1

# HEALTH STABILIZATION

## STS-1

- PRIMARY CONTACT NUMBER, TYPE, AND LOCATION

<u>TYPE</u>	<u>JSC</u>	<u>KSC</u>	<u>DFRC</u>	<u>ARC</u>	<u>HQ</u>	<u>SUBTOTAL</u>
NASA	216	35	7	1	5	264
CONTRACTOR	643	42	12	0	0	697
OTHERS	<u>10</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>11</u>
SUBTOTAL	869	78	19	1	5	<span style="border: 1px solid black;">972</span>

- NUMBER AND LOCATION OF PRIMARY CONTACT ILLNESS

<u>REPORT</u>	<u>JSC</u>	<u>KSC</u>	<u>DFRC</u>	<u>OTHER</u>	<u>TOTAL</u>
ILLNESS	31	4	3	0	38
CONTACT ILLNESS	6	2	0	0	8

- UPPER RESPIRATORY INFECTION MOST COMMON ILLNESS



# **EMERGENCY MEDICAL SERVICES**

## **STS-1**

- PROVIDE RAPID ACCESS TO HEALTH CARE
- PRIMARY MODE OF TRANSPORTATION, HELICOPTER
- CONFIGURATION OF ALL PRIMARY SITES IS THE SAME
  - MCC SURGEON COORDINATOR
  - PATIENT/RESCUE
  - HELICOPTER - PARAJUMPERS/PHYSICIAN
  - FLIGHT LINE CLINIC
  - STABILIZATION HOSPITAL
  - DEFINITIVE CARE HOSPITAL

**TOXICOLOGY****STS-1**

	<b>MATCO</b>	<b>OV-102</b>	<b>OV-102</b>	<b>SPACECRAFT</b>
		<b>6 HR. TEST</b>	<b>INFLIGHT</b>	<b>MAXIMUM</b>
	<b><u>(MG/M<sup>3</sup>)</u></b>	<b><u>(MG/M<sup>3</sup>)</u></b>	<b><u>(MG/M<sup>3</sup>)</u></b>	<b>ALLOWABLE</b>
				<b>CONCENTRATION</b>
				<b><u>MAC (MG/M<sup>3</sup>)</u></b>
<b>CARBON MONOXIDE</b>	<b>408.80</b>	<b>&lt;0.60</b>	<b>1.02</b>	<b>29</b>
<b>METHANE</b>	<b>3.36</b>	<b>1.43</b>	<b>18.38</b>	<b>1755</b>
<b>FREON 113</b>	<b>.0004</b>	<b>81.81</b>	<b>5.70</b>	<b>383</b>
<b>PROPANOL</b>		<b>0.02</b>	<b>0.08</b>	<b>0.10</b>
<b>2-PROPANONE</b>		<b>0.26</b>	<b>0.17</b>	<b>70</b>
<b>N-BUTANOL</b>	<b>0.21</b>	<b>0.20</b>	<b>0.09</b>	<b>117</b>
<b>2-BUTANONE</b>		<b>0.45</b>	<b>0.04</b>	<b>58</b>
<b>2-PROPANOL</b>	<b>0.32</b>	<b>0.80</b>	<b>0.13</b>	<b>102</b>
<b>BENZENE</b>	<b>14.84</b>	<b>0.004</b>	<b>0.003</b>	<b>0.10</b>
<b>TOLUENE</b>	<b>597.02</b>	<b>0.44</b>	<b>0.06</b>	<b>76</b>

# RADIATION

## STS-1

### PREFLIGHT PROJECTION

### ACTUAL MEASURED\*

- CREW DOSE 12 MILLIRAD 20 MILLIRAD
- ORBIT BELOW RADIATION BELTS,  
13 PASSES THROUGH SOUTH ATLANTIC ANOMALY
- SOLAR FLARE IN PROGRESS AT LAUNCH, APRIL 10, 1981
  - SPACECRAFT PROTECTED BY MAGNETOSPHERE (x2/38) PEAK  
NUMBER OF RADIATION PARTICLES =  $50/\text{cm}^2 \cdot \text{SEC} \cdot \text{STERADIAN}$  AT GEOSYNCHRONOUS ALTITUDE. HORN  
ELECTRONS BRIEFLY MOVED TO LATITUDES BELOW  $40^\circ$   
FLUX OBSERVED  $220 \text{ ERGS}/\text{cm}^2/\text{SEC}$
- ANOMALY
  - CREW PASSIVE DOSIMETERS (INCLUDING NON-FLIGHT CONTROLS)  
GAVE READINGS 362-596 MILLIRAD INDICATING DURING  
COMMERCIAL SHIPMENT TO CONTRACTOR THEY WERE EXPOSED  
TO RADIATION SOURCE
- CORRECTIVE ACTION
  - COURIER OR SHIP EXPRESS MAIL

\*POCKET DOSIMETERS (LOW RANGE)

# **SPACECRAFT NOISE ASSESSMENT**

## **STS-1**

- **HISTORICAL BACKGROUND**
  - **JSC DESIGN AND PROCEDURAL STANDARD FOR NOISE EXPOSURE IN SPACECRAFT ESTABLISHED IN 1972 APPLIED TO STS-1**
    - **NC 50 (55 DBA) ADOPTED AS HABITABILITY SPECIFICATION FOR EXTENDED EXPOSURES**
- **DTO 161: CABIN ACOUSTICAL NOISE**
  - **TO VERIFY STS CABIN ACOUSTICAL NOISE ON-ORBIT IS WITHIN ACCEPTABLE LEVELS AND TO VERIFY OFT AND POST-OFT NOISE SUPPRESSION PLANS**
- **INFLIGHT DATA**
  - **HAND-HELD SOUND LEVEL METER USED TO CONDUCT ACOUSTIC NOISE SURVEY DURING SCHEDULED PERIOD ON MISSION DAY 1**



## SPACECRAFT NOISE ASSESSMENT

### STS-1

- RESULTS (INCLUDING PREFLIGHT TESTS)

	HZ:	<u>63</u>	<u>125</u>	<u>250</u>	<u>500</u>	<u>1K</u>	<u>2K</u>	<u>4K</u>	<u>8K</u>	<u>DBA</u>
STD 145		73	66	60	55	52.5	50	48	47.5	55
KSC TEST										
(MID DECK)		59.5	61	60	60.5	62	62.5	55	50	67.5
(FLT DECK)		64.5	58	56	56	58	56	52	45	63.5
STS-1										
(MID DECK)		61	61	63	58	61	61	58	53	67
(FLT DECK)		64	58	55	55	58	53	48	42	60

- CONCLUSIONS

- EFFORTS SHOULD BE CONTINUED TO LOWER NOISE TO REQUIREMENTS

# **MOTION SICKNESS PROPHYLAXIS**

## **STS-1**

- **OBJECTIVES**

- **PROVIDE MOTION SICKNESS PROPHYLAXIS**
- **TO COLLECT DATA**

- **ACCOMPLISHMENTS**

- **PREFLIGHT**

- **CREW MOTION SICKNESS EXPERIENCE EVALUATED**
- **MOTION SICKNESS SUSCEPTIBILITY TEST COMPLETED**
- **SIDE EFFECTS AND EFFICACY OF ANTI-MOTION SICKNESS DRUGS EVALUATED**

- **INFLIGHT**

- **MICROCASSETTE RECORDER**
- **ONE SCOPLOMINE/DEXEDRINE USED BY PILOT PER TIMELINE**
- **NO SYMPTOMS REPORTED BY COMMANDER AND PILOT**

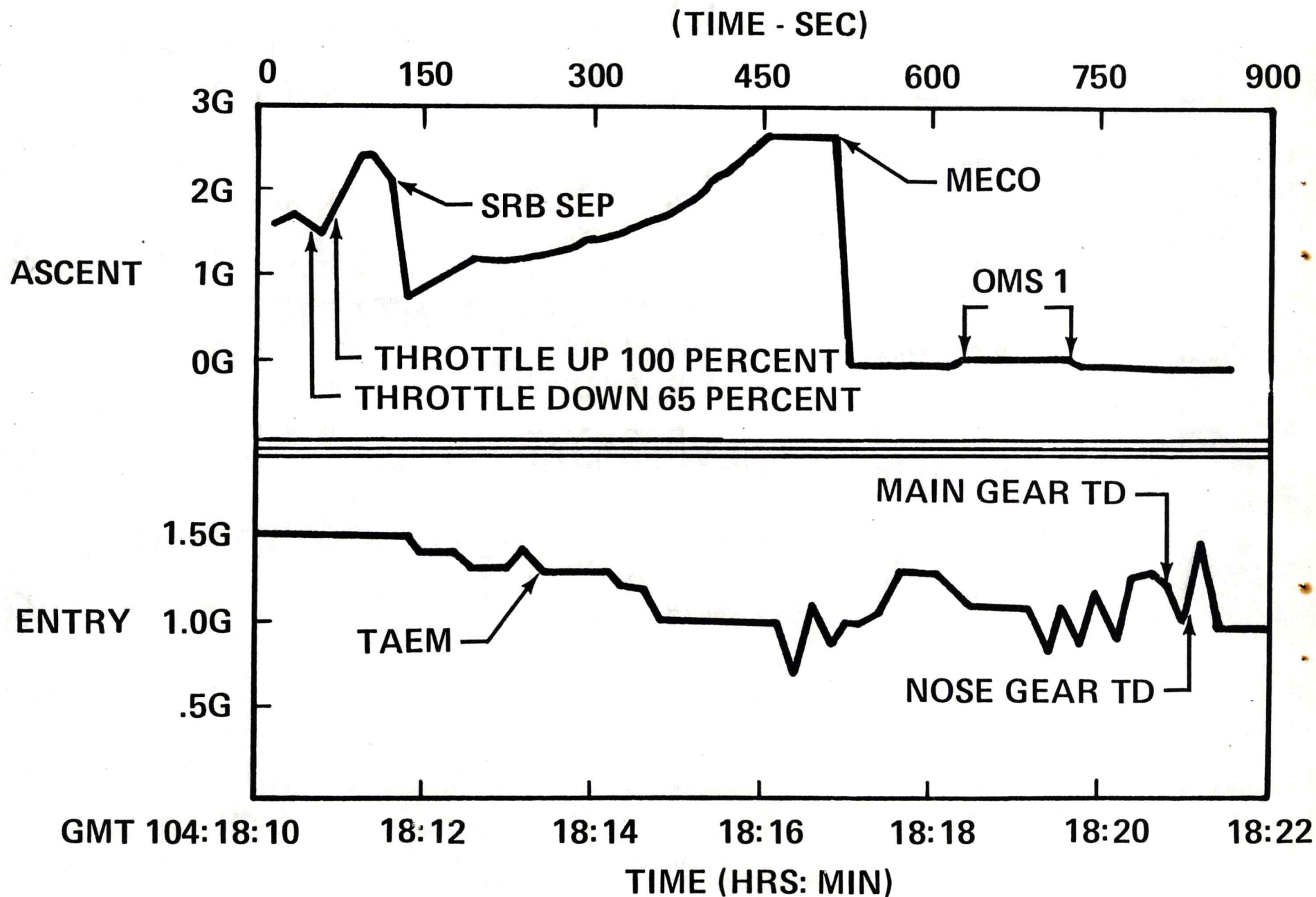
- **POSTFLIGHT**

- **NO MOTION SICKNESS, DISORIENTATION OR POSTURAL DYSEQUILIBRIUM REPORTED**

# **BIOINSTRUMENTATION**

## **STS-1**

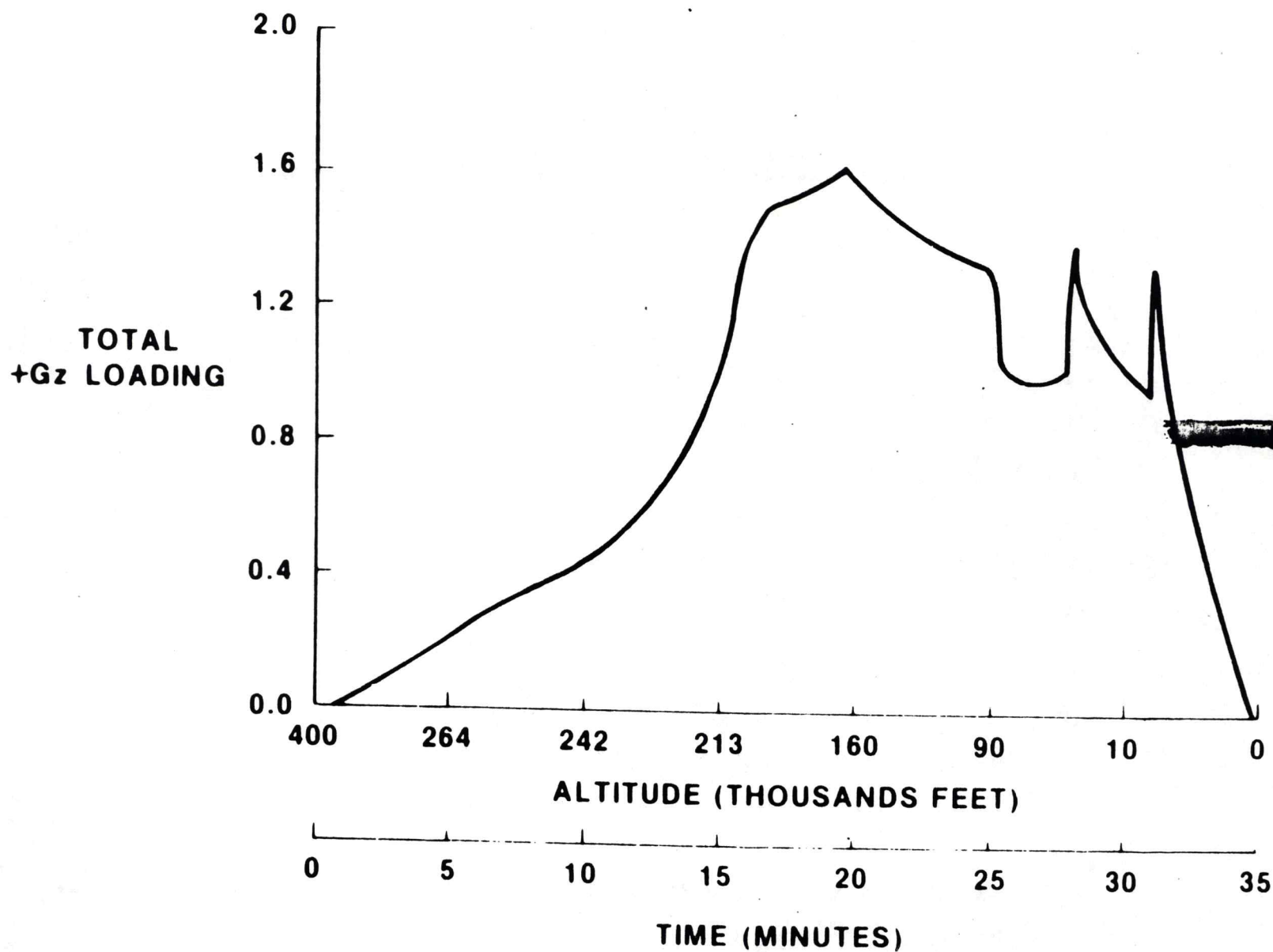
- **EQUIPMENT FUNCTIONED WELL**
- **HEART RATE DATA WITHIN EXPECTED LIMITS**





NASA S 80 10881

## SHUTTLE-ORBITER ENTRY PROFILE



NASA-S-81-11199

# TOXICOLOGY

## STS-1

### SHUTTLE OUTGASING TEST HISTORY

VEHICLE	PREDICTED (MG/M <sup>3</sup> )		FOUND (MG/M <sup>3</sup> )	
	CO	ORGANICS	CO	ORGANICS
1. OV-101 (PREFLIGHT)	--	--	<0.06	<0.08
2. OV-101 (POSTFLIGHT)	<0.60 (PREFLIGHT)	0.08 (PREFLIGHT)	<0.60	<0.80
3. OV-102 (6-HR TEST)	300 (MATCO)	4000 (MATCO)	<0.60	90
4. OV-102 (56-HR MISSION)	<0.60* (6-HR TEST)	800* (6-HR TEST)	1.0	26

\* DOES NOT CONSIDER ACTION OF ECLSS CONTAMINANT  
REMOVAL SYSTEM

NASA-S-81-11175

# **EVALUATION OF CREW HEALTH**

## **STS-1**

- **PRIME AND BACKUP CREW - EXCELLENT HEALTH**
- **NO MEDICATION EXCEPT FOR MOTION SICKNESS  
PROPHYLAXIS INFLIGHT**
- **SLEEP**
- **FOOD**
- **WATER**

NASA-S-81-11186

# TOXICOLOGY

## STS-1

### SHUTTLE OUTGASING TEST HISTORY

#### TEST LOCATION

#### DATE

- H. L. DRYDEN FLIGHT RESEARCH CENTER
  - 4-HOUR PREFLIGHT OUTGASING TEST
  - WHOLE GAS SAMPLES FROM CABIN
  - FOR ORBITER OV-101 (ENTERPRISE)
- H.L. DRYDEN FLIGHT RESEARCH CENTER
  - POSTFLIGHT OUTGASING TEST
  - WHOLE GAS SAMPLES FROM CABIN
  - FOR ORBITER OV-101 (ENTERPRISE)
- WHITE SANDS TESTING FACILITY
  - SHUTTLE MATERIALS TESTING PROGRAM
  - MATERIALS ACCOUNTABILITY TRACKING AND CONTROL (MATCO)
  - FOR ORBITER OV-102 (COLUMBIA)

MAY 1977

JULY 1977

SEPTEMBER 1979  
TO  
NOVEMBER 1980



NASA-S-81-11198

## **TOXICOLOGY (CONT)**

### **STS-1**

#### **SHUTTLE OUTGASING TEST HISTORY (CONT)**

- **KENNEDY SPACE CENTER**

**MAY 1980**

- **6-HOUR PREFLIGHT OUTGASING TEST**
- **WHOLE AND ADSORBED GAS SAMPLES FROM CABIN**
- **FOR ORBITER OV-102 (COLUMBIA)**

- **KENNEDY SPACE CENTER**

**APRIL 1981**

- **INFLIGHT 56-HOUR SAMPLE ACQUISITION**
- **WHOLE AND ADSORBED GAS SAMPLE FROM CABIN**
- **FOR ORBITER OV-102 (COLUMBIA)**





National Aeronautics and  
Space Administration

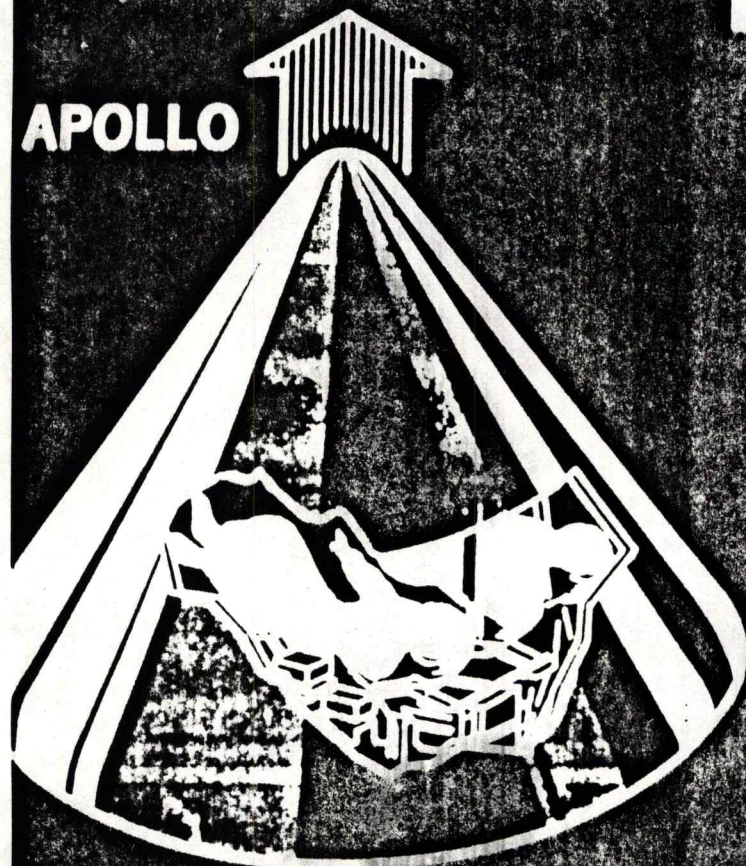
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Lyndon B. Johnson Space Center  
Houston, Texas 77058

# REENTRY G

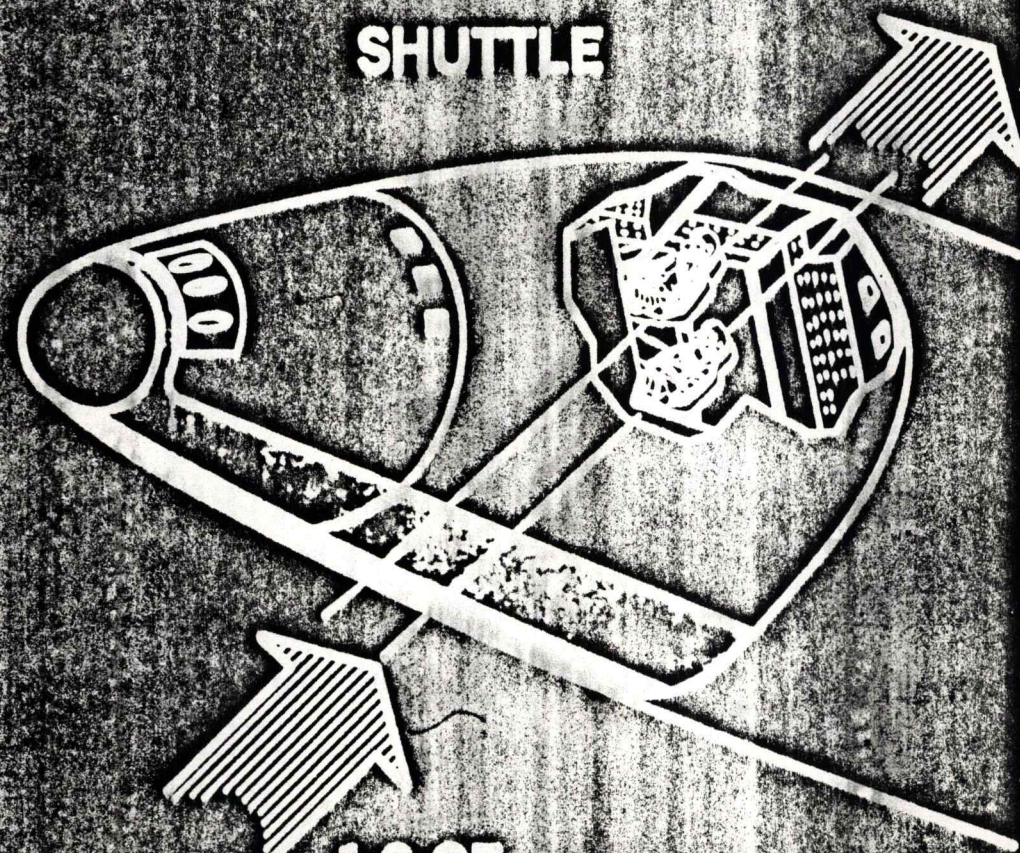
NASA  
*Life Sciences*

APOLLO



7.19 GX  
(1 MIN)

SHUTTLE



1.2 GZ  
(17 MIN)

8875-11-003





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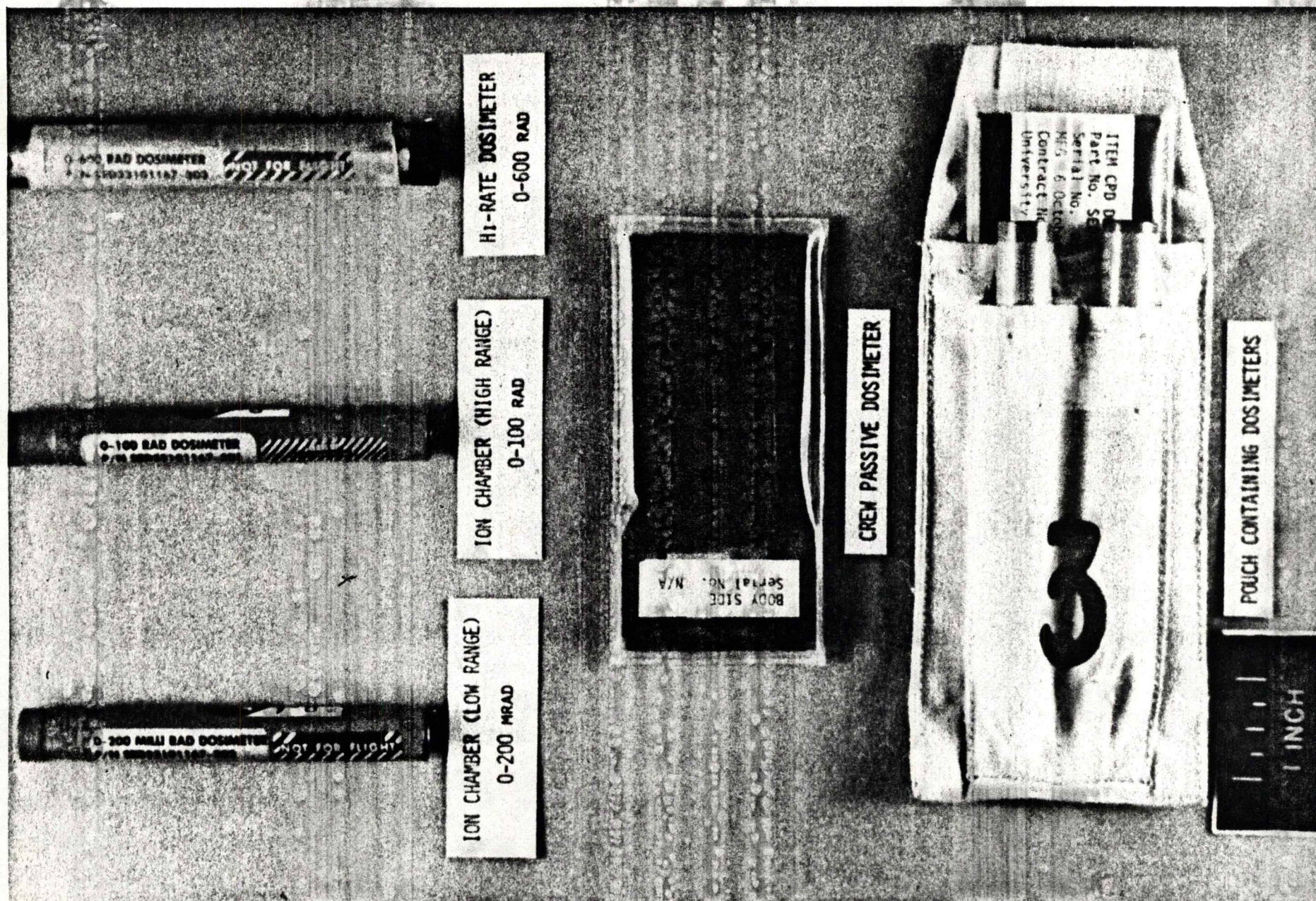




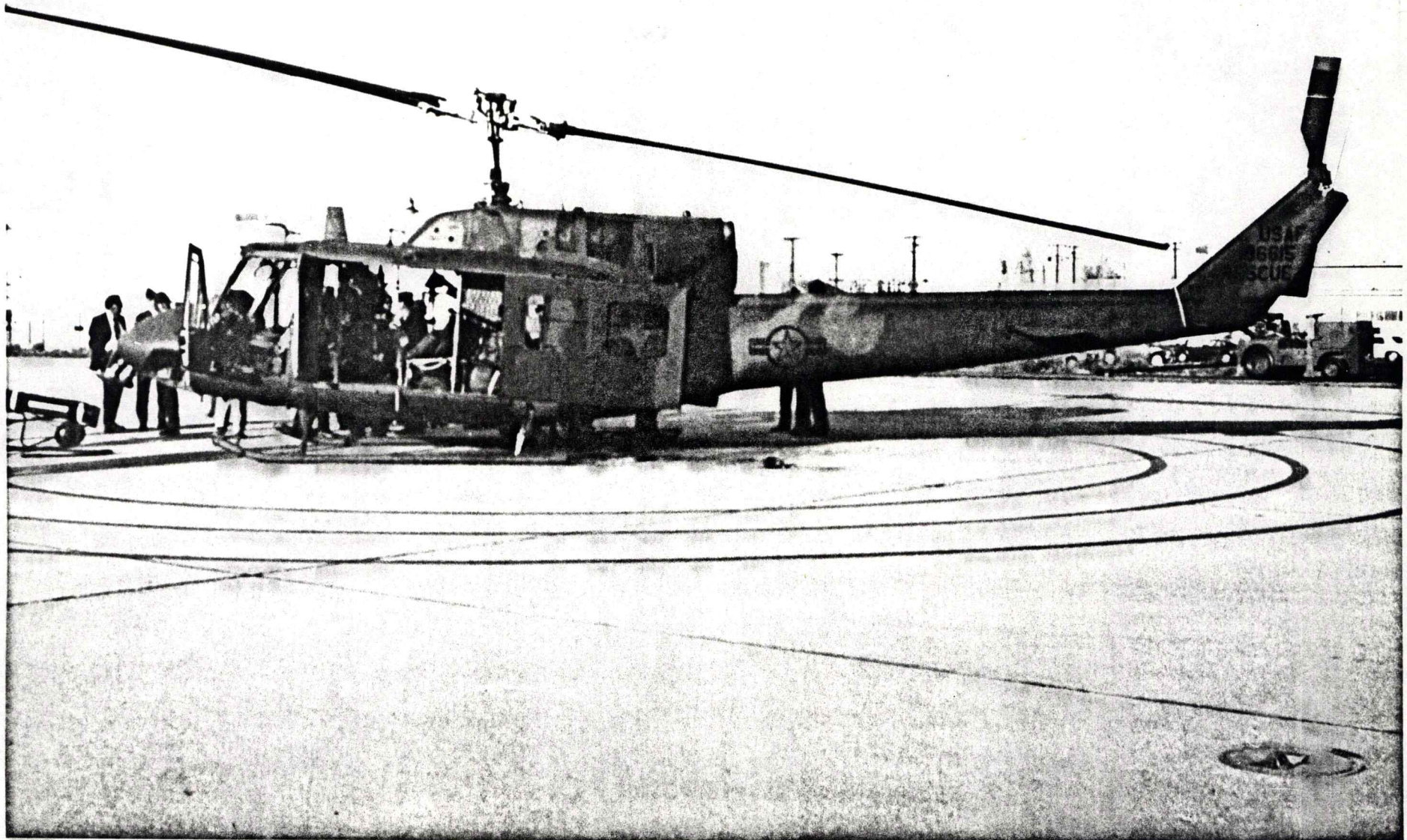
National Aeronautics and  
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SR1-33354

Lyndon B. Johnson Space Center  
Houston, Texas 77058







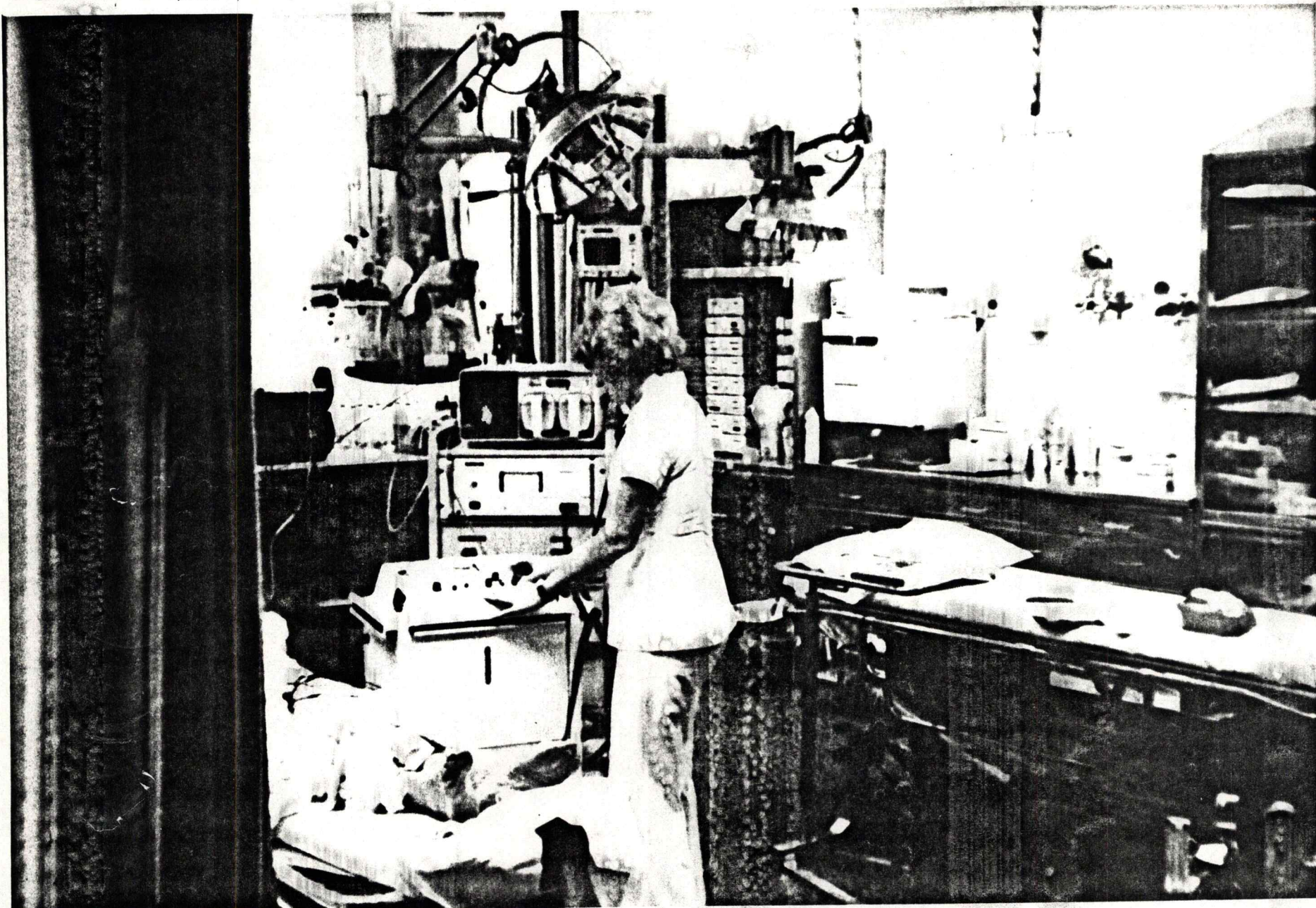


**NASA**

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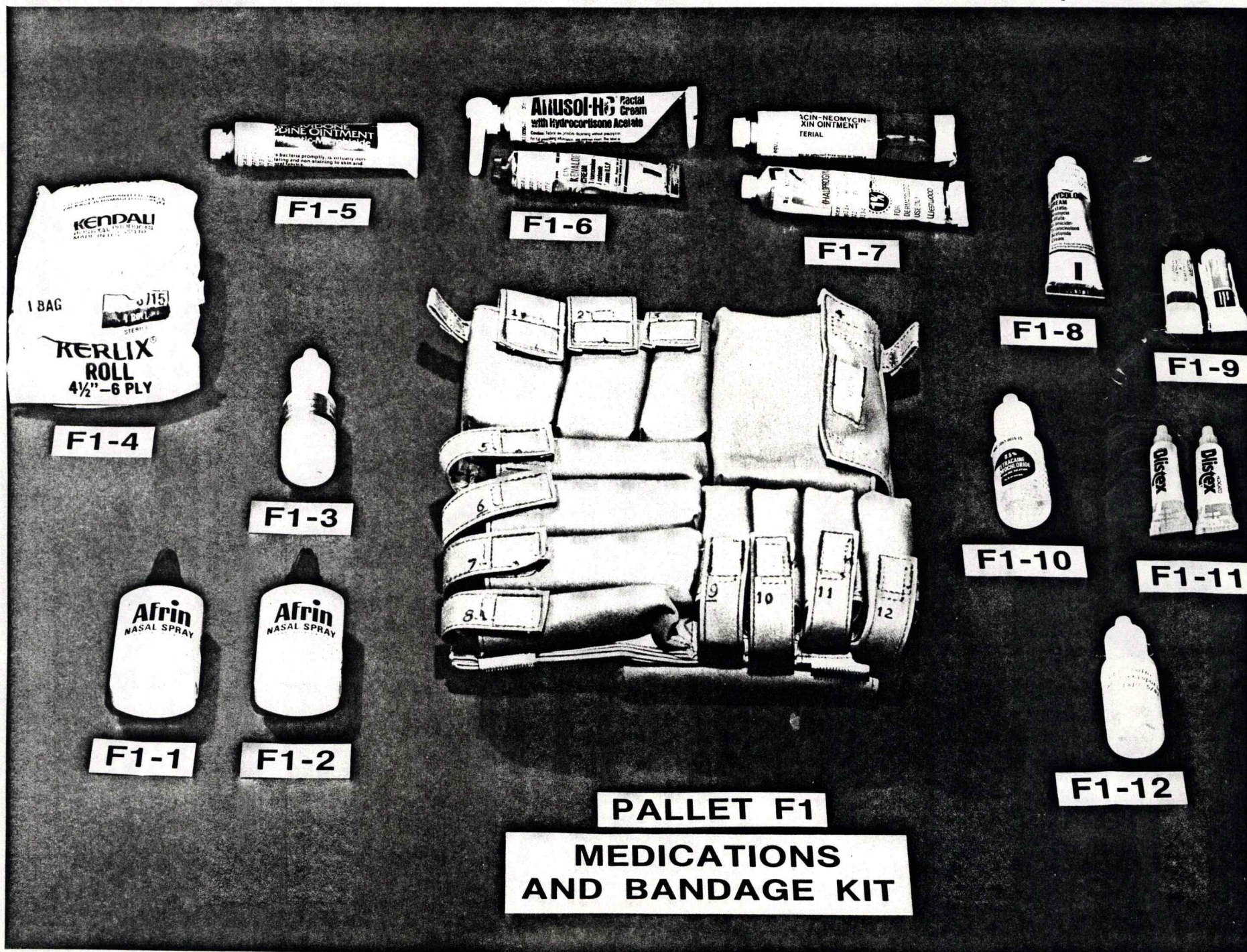




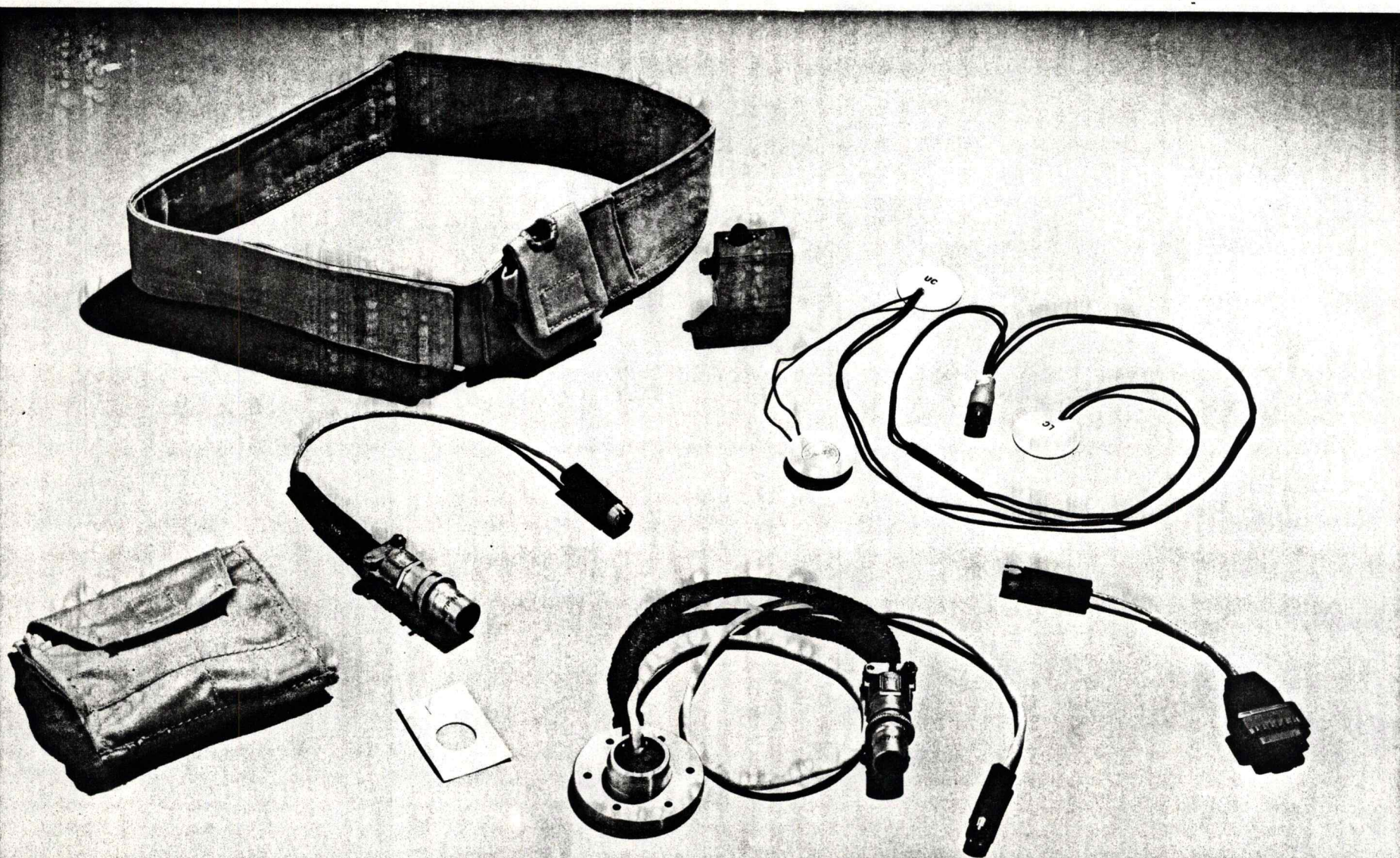
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580-37870

Lyndon B. Johnson Space Center  
Houston, Texas 77058







# Operational Bioinstrumentation System

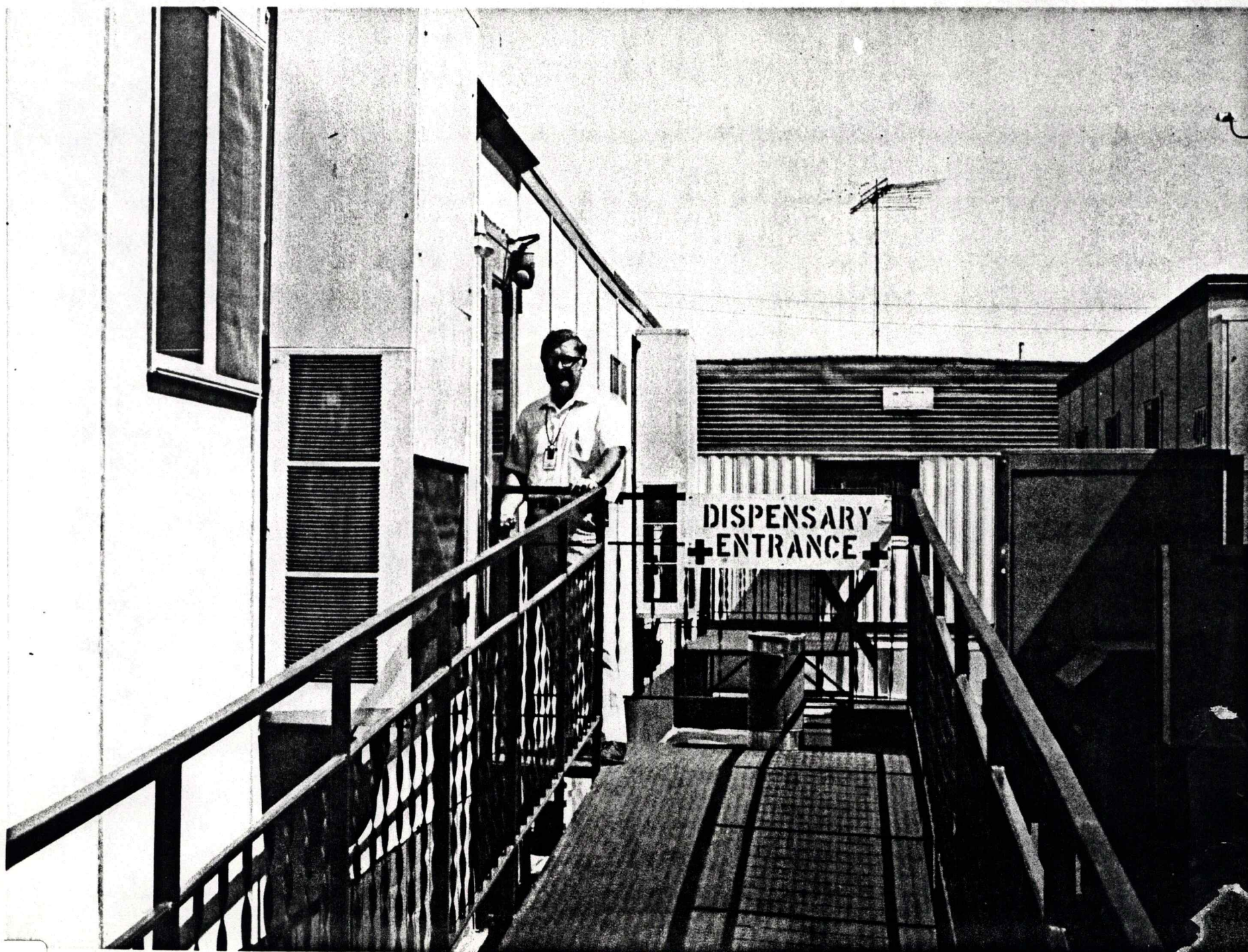




National Aeronautics and  
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8- 78- 30839

Lyndon B. Johnson Space Center  
Houston, Texas 77058







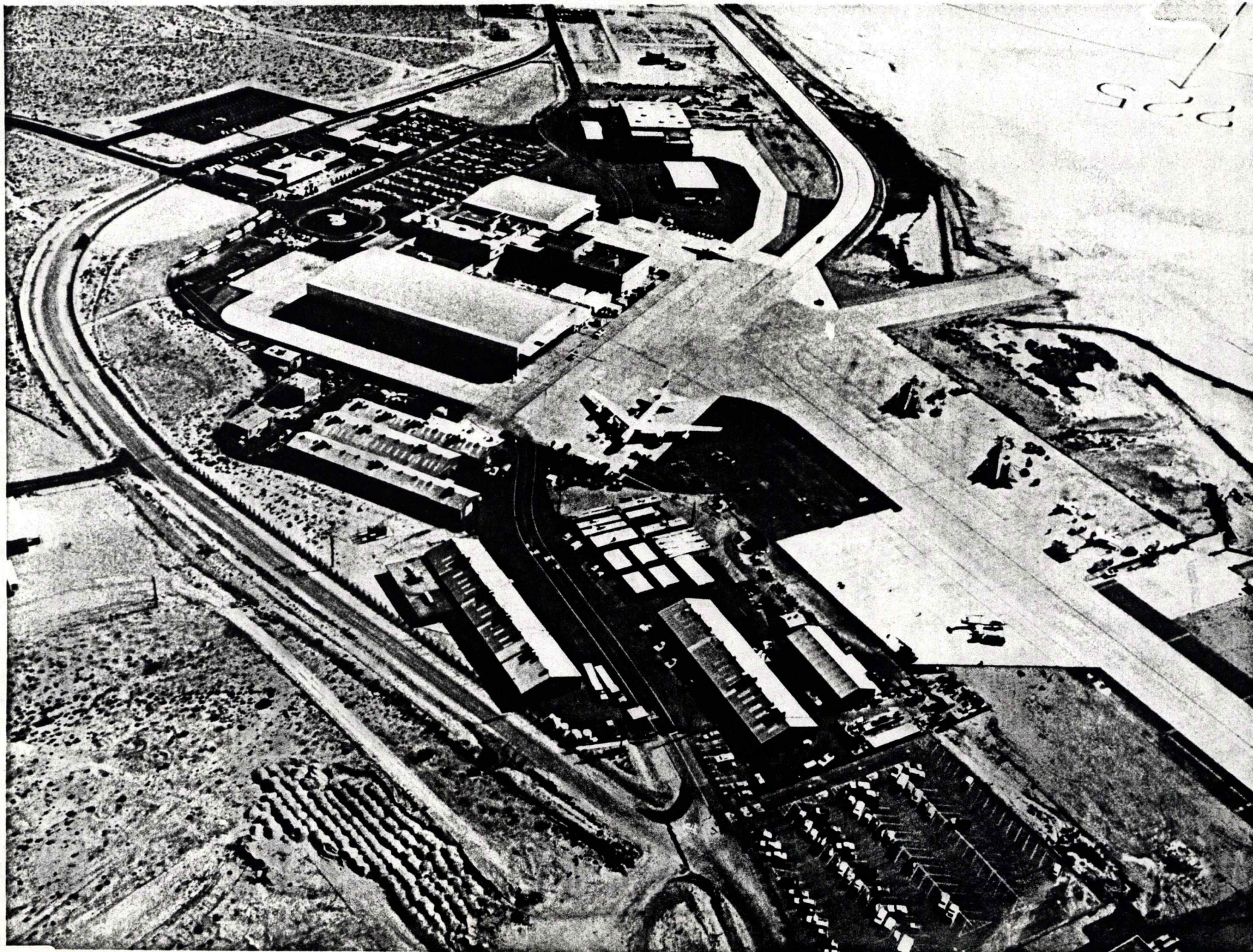




National Aeronautics and  
Space Administration

581-25539

Lyndon B. Johnson Space Center  
Houston, Texas 77058







National Aeronautics and  
Space Administration

8- 78- 30029

Lyndon B. Johnson Space Center  
Houston, Texas 77058



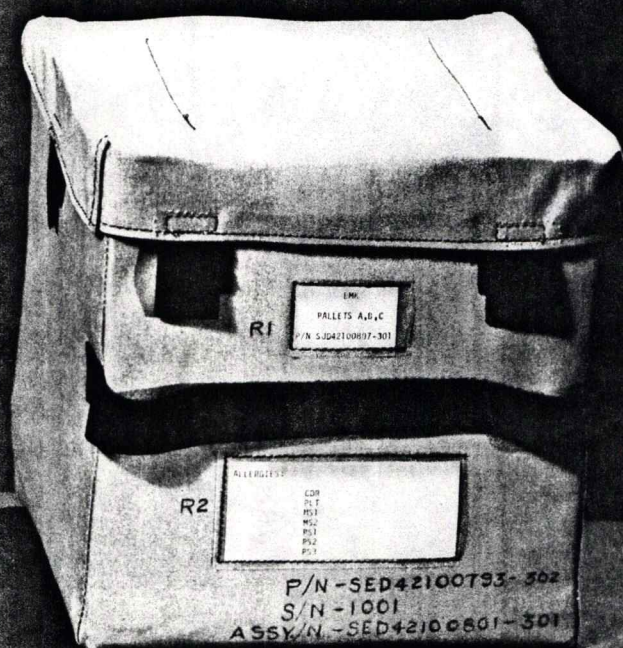
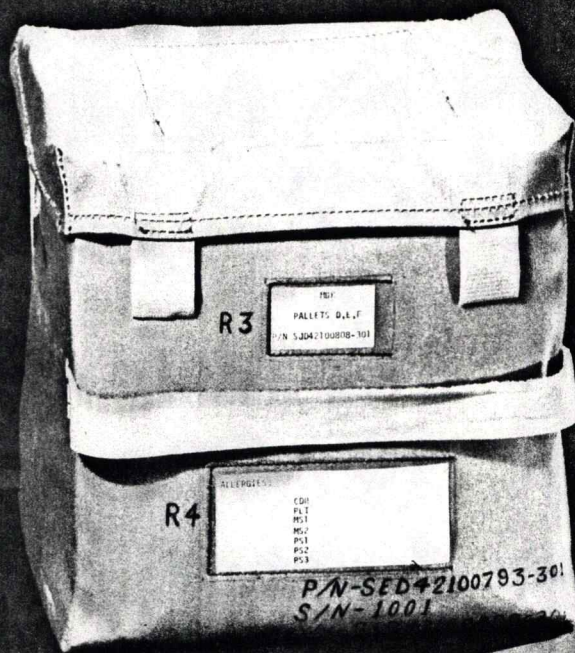




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# SHUTTLE ORBITER MEDICAL SYSTEM

## SOMS-A

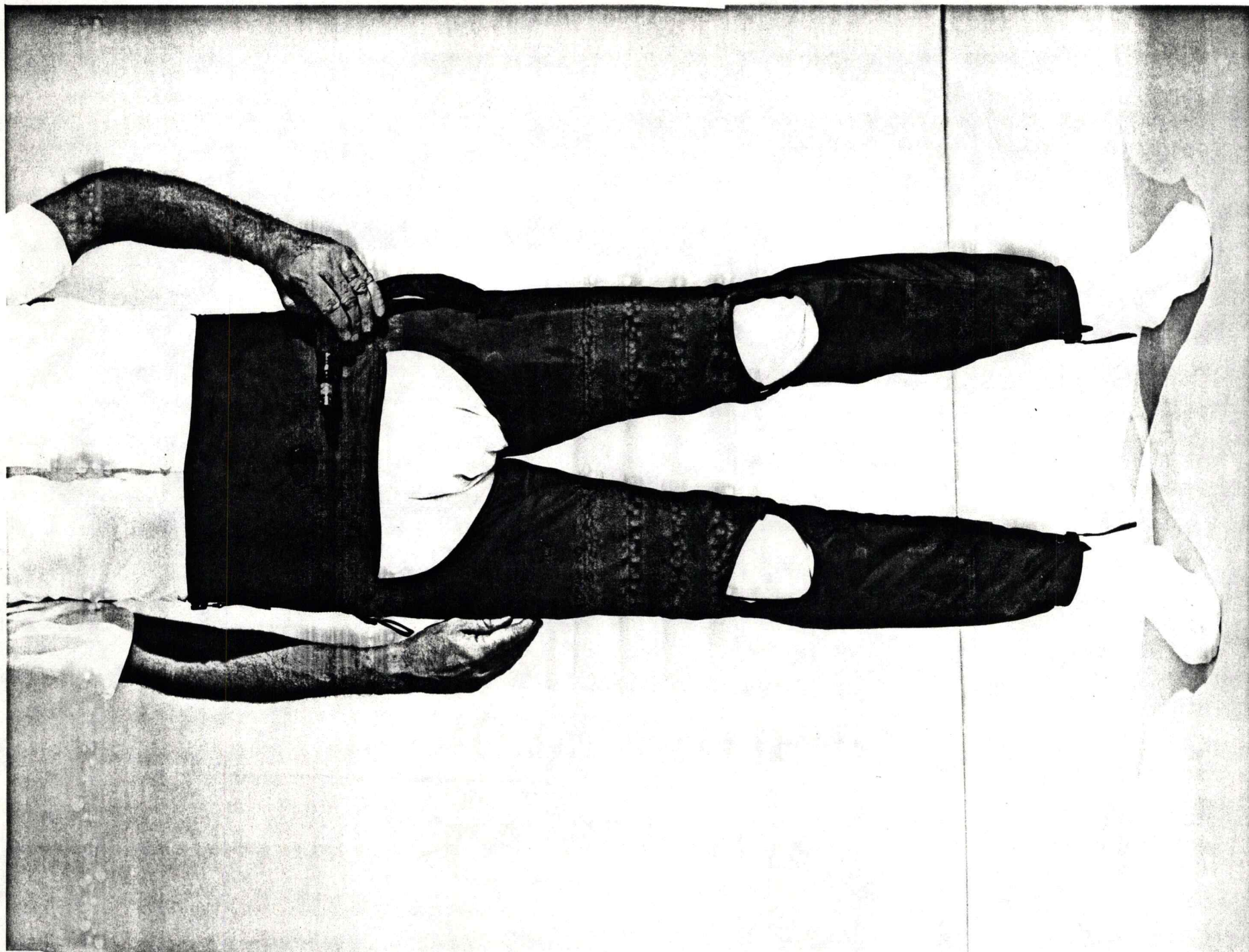




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Space Administration

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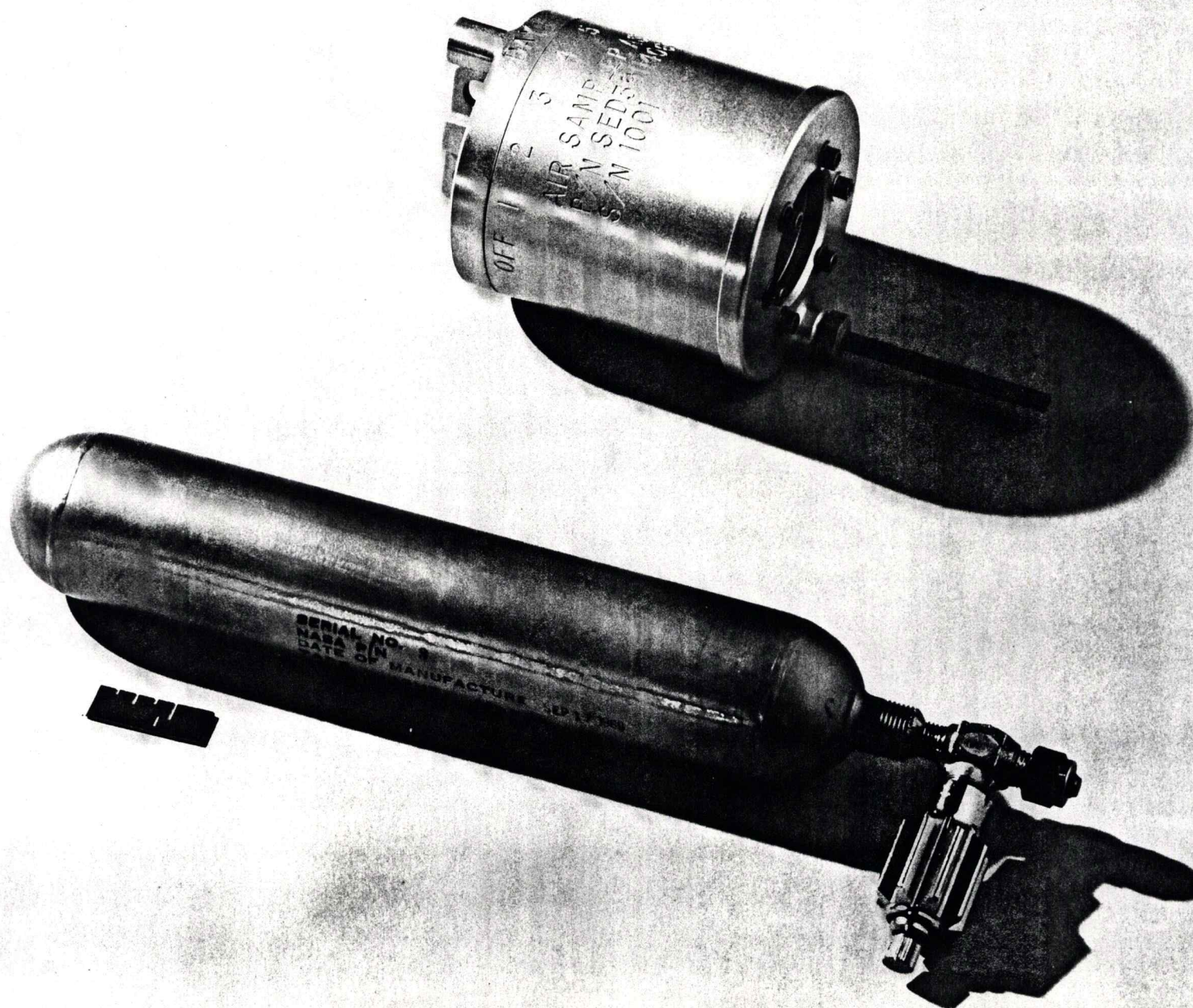




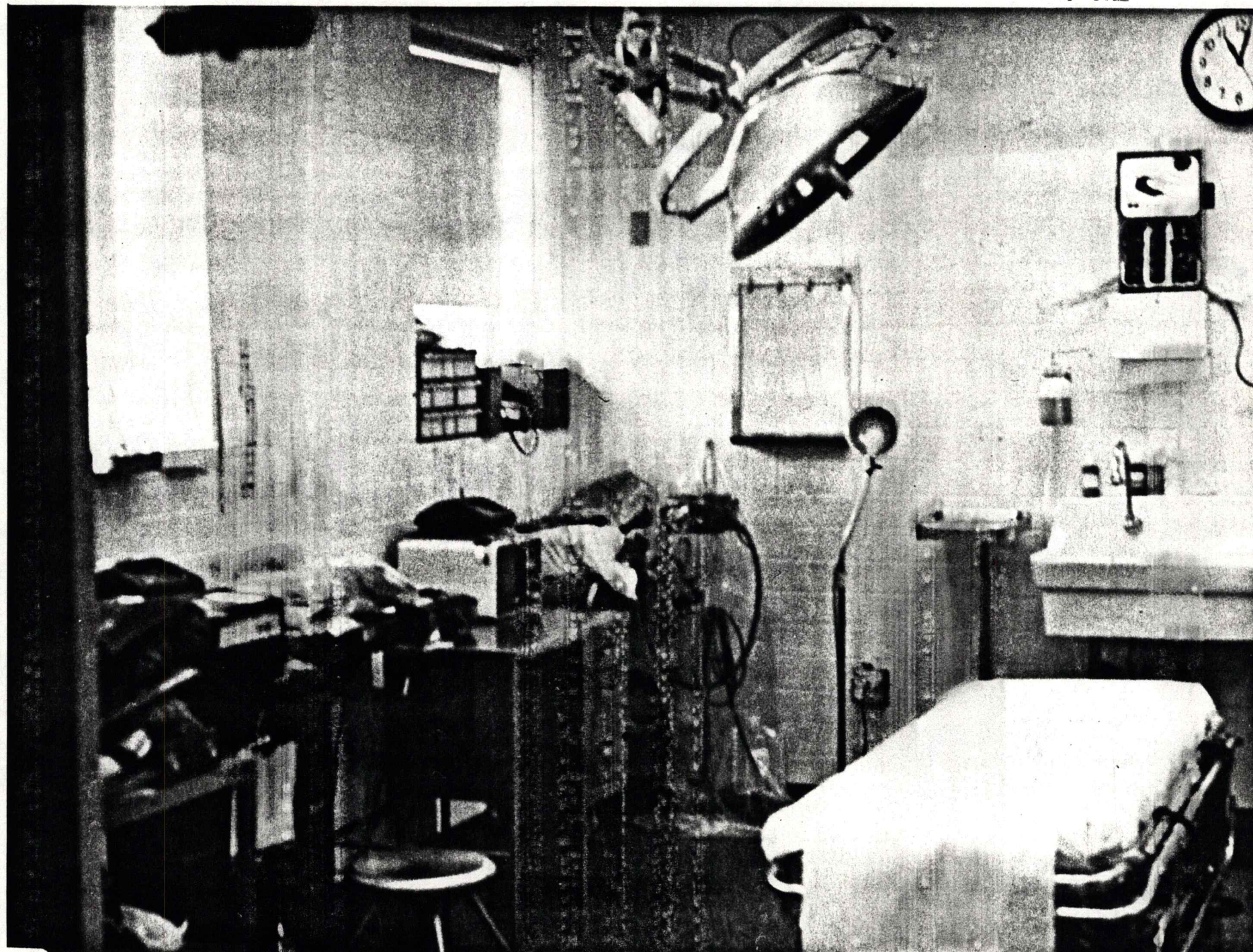
National Aeronautics and  
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Lyndon B. Johnson Space Center  
Houston, Texas 77058







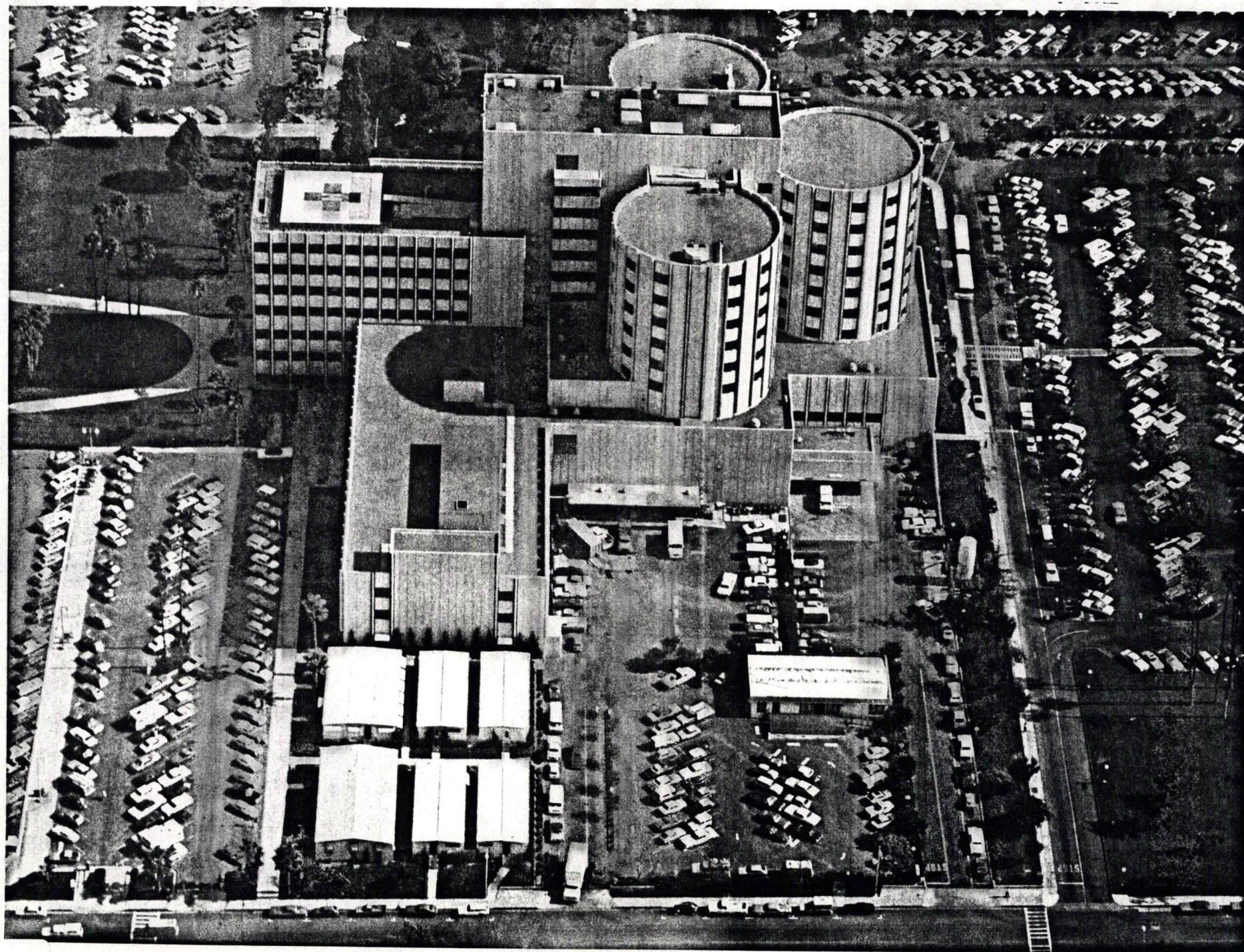




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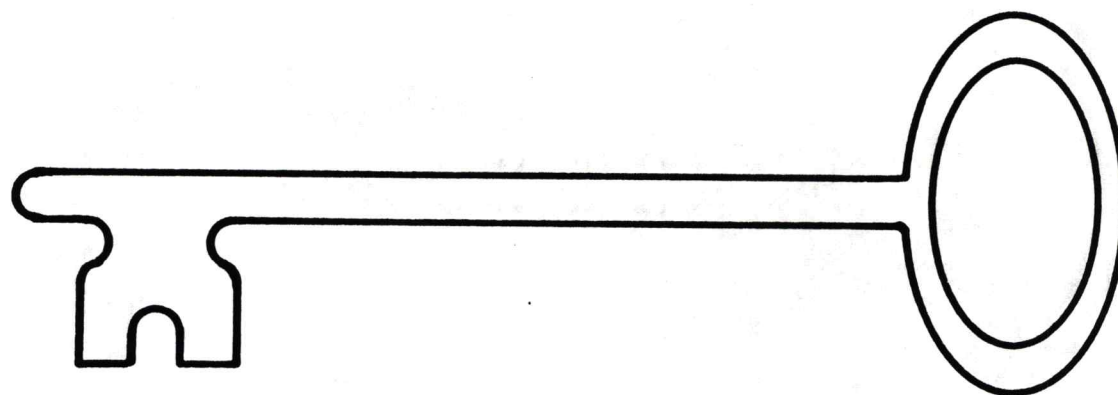




**STS-1**

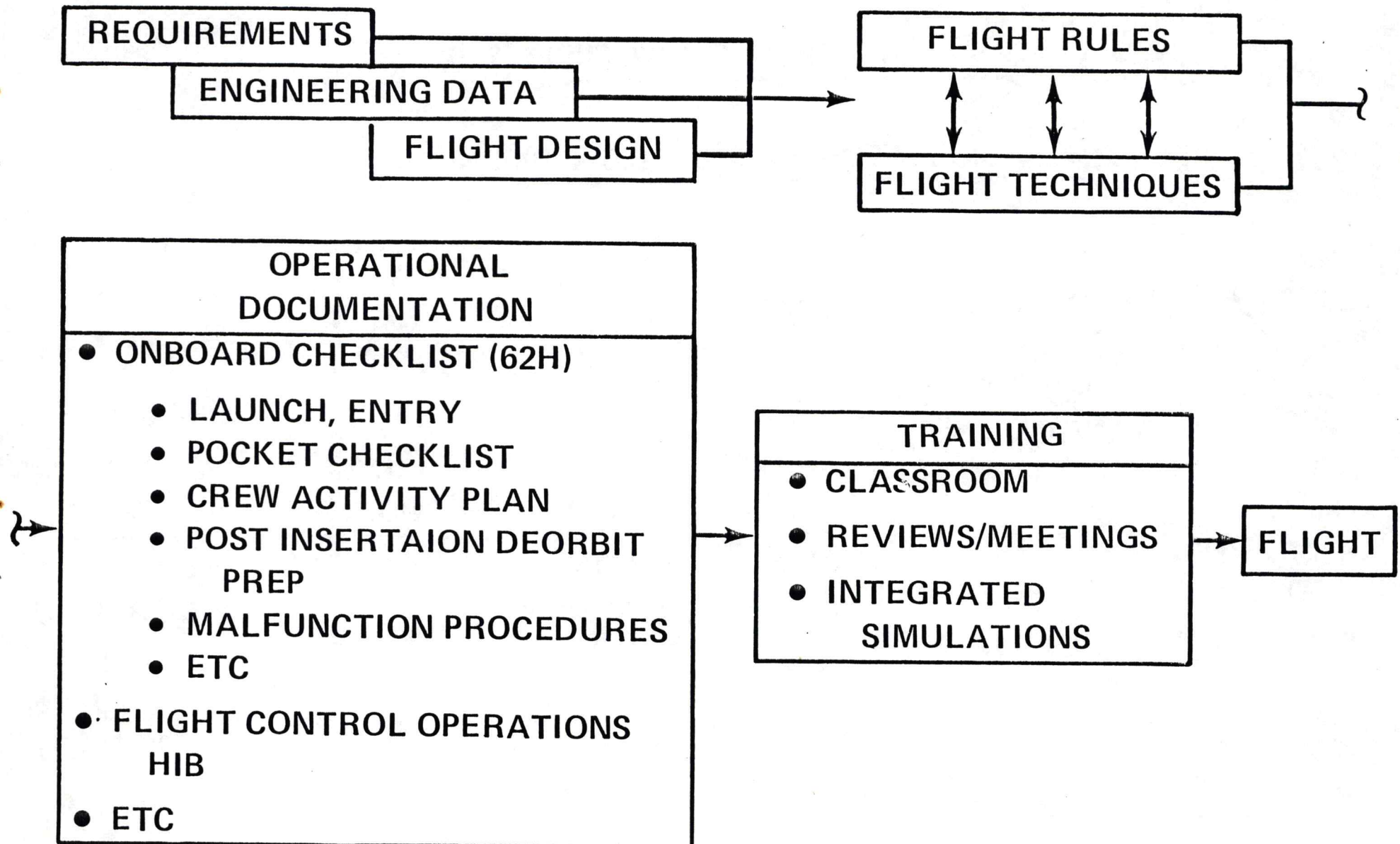
**FLIGHT CONTROL  
OPERATIONS**

## THE KEY PREPARATION

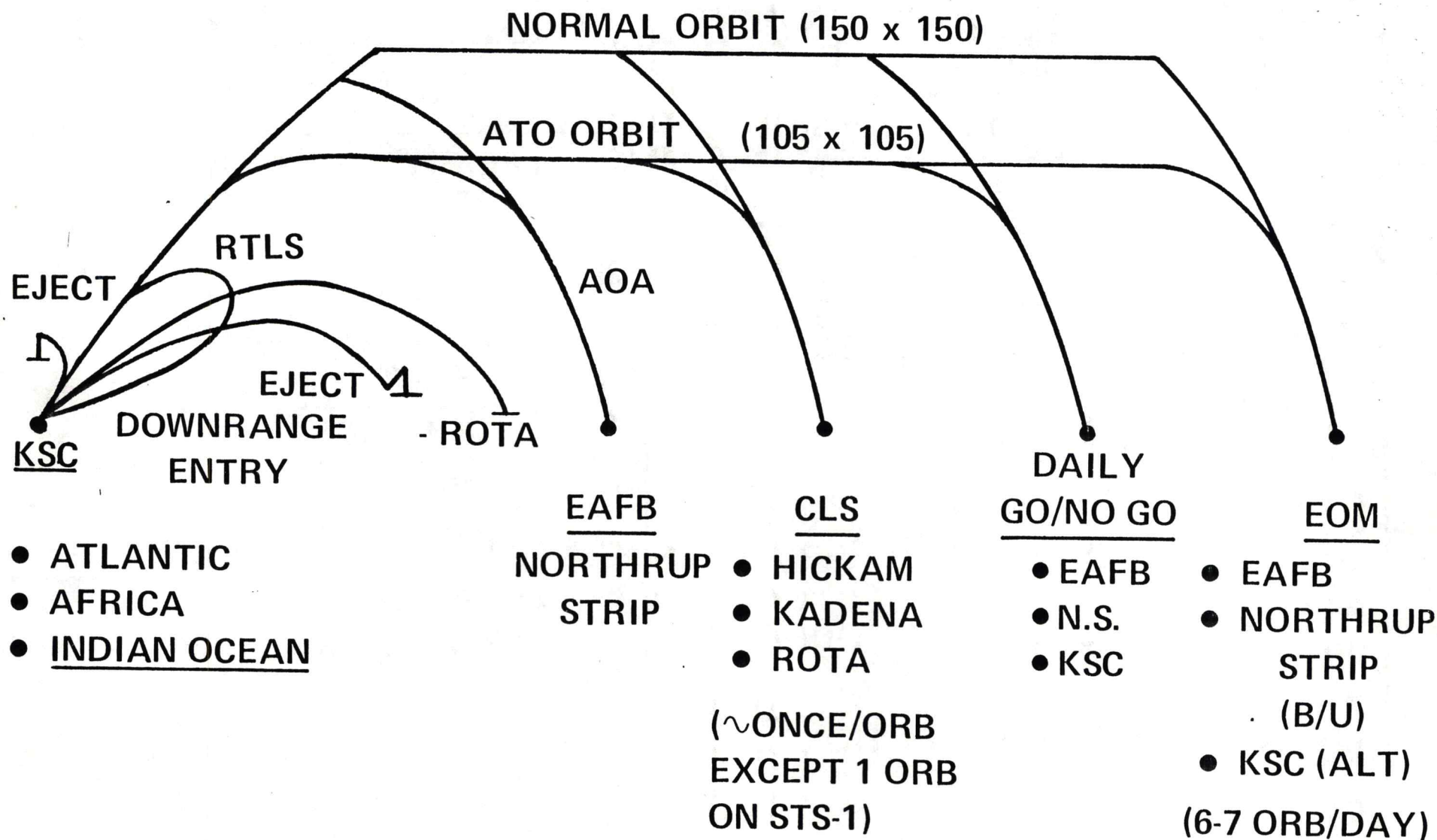




# PREFLIGHT FLIGHT CONTROL DEVELOPMENT



# ABORT SUMMARY





**STS-1 OPERATIONS**

NORMAL FLIGHT										
SYSTEMS CHECKOUTS/GO-NO GO's/FLIGHT TEST OBJECTIVES										
<b>ASCENT ABORTS</b>  • RTLS • AOA • ATO • ROTA • CONT  • 2 SSME FAIL • 3 SSME FAIL			  • ORBIT 5 DE-ORBIT • CONTINGENCY LANDING SITE DE-ORBIT				  • DAY 2 ENTRY			
SYSTEMS OPERATIONS										
GNC	DDS	ELEC	OMS	RCS	ECLS	APU	HYD	PBD	MPS	COMM
FAILURE CASES										
<b>ASC/ON-ORBIT/ENTRY</b>  • LOSS OF 1 FUEL CELL/ELECT BUSSES • LOSS OF 1 FREON LOOP • LOSS OF TOPPING EVAP • LOSS OF HIGH LOAD EVAP			<b>ASC/ON-ORBIT/ENTRY</b>  • LOSS OF CABIN PRESSURE • LOSS OF 2 FUEL CELLS • LOSS OF 2 FREON LOOPS • LOSS OF 2 WATER LOOPS • LOSS OF BOTH EVAPS • LOSS OF BOTH CABIN FANS				<b>ORBIT</b>  • EVA TO CLOSE PBD's. • EMERGENCY D/O			

ASC PCL - 106 PGS

ORB PCL - 104 PGS

ENT PCL - 106 PGS

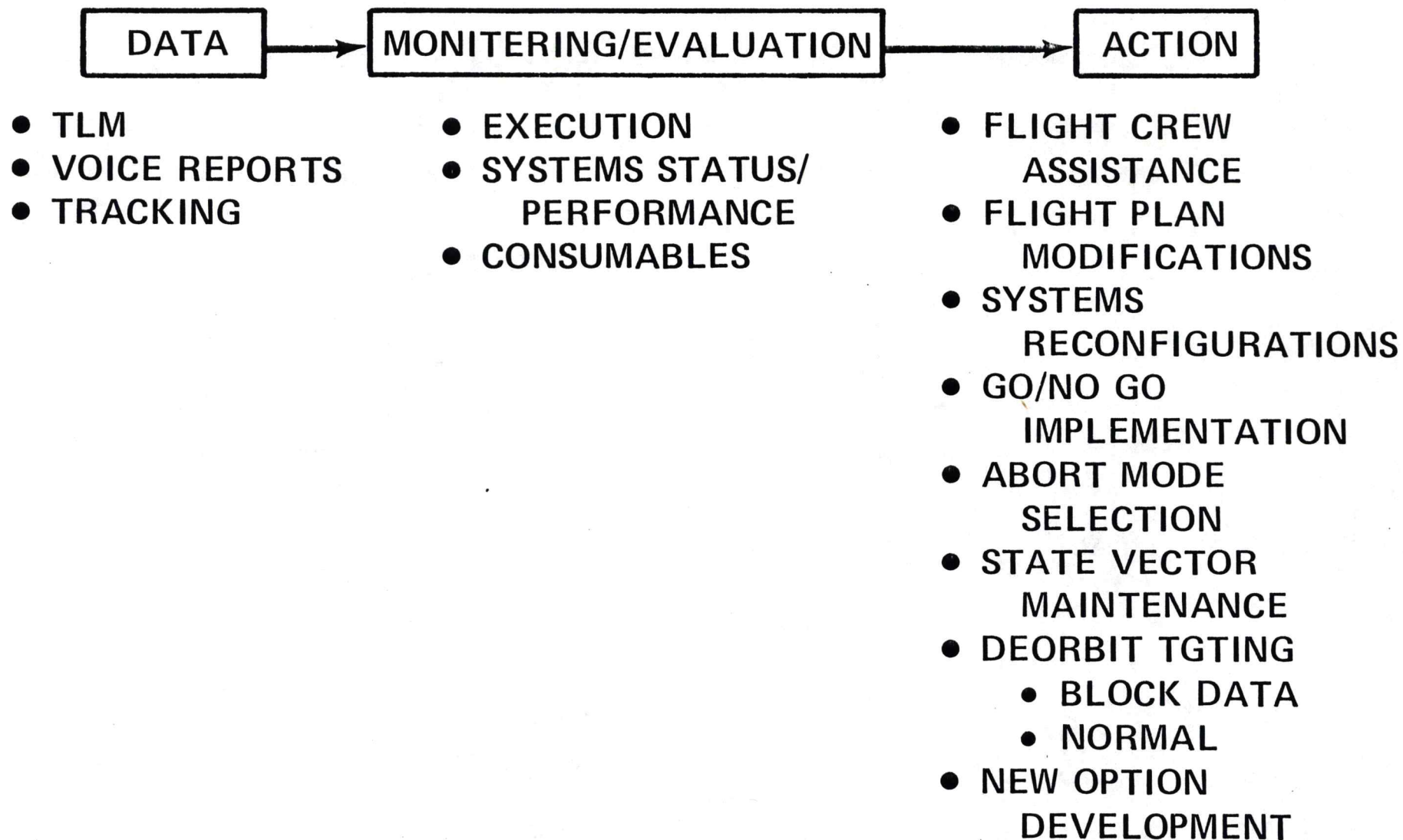
MALF PROC - 688 PGS

## **TEAM STRUCTURE PREPARATION**

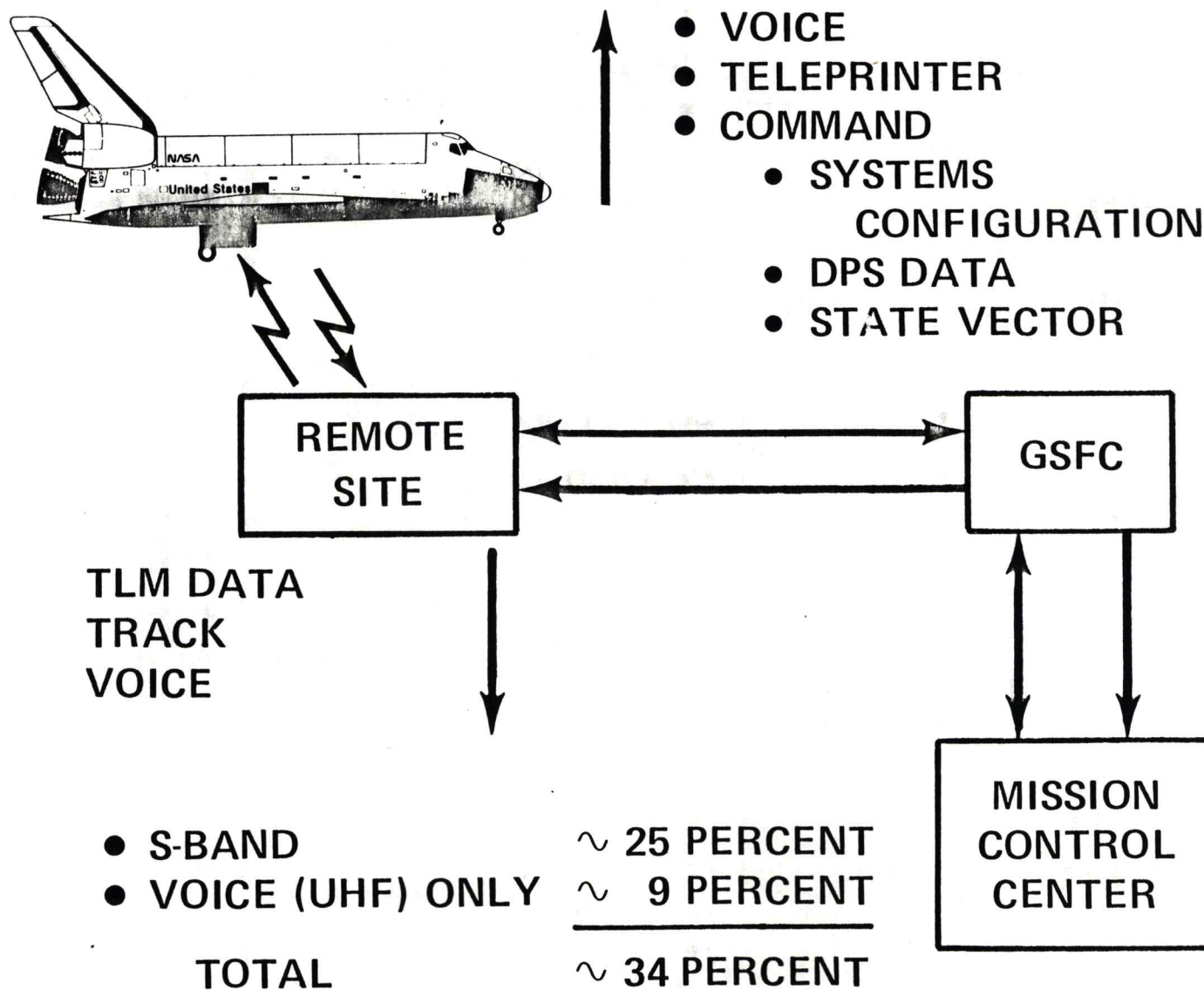
- **INTEGRATED TRAINING T (STARTED 27 MARCH 1979)**
  - **ASCENT - 544 HOURS**
  - **ON-ORBIT - 515 HOURS**
  - **ENTRY - 377 HOURS**
- **LONG DURATION SIMULATIONS**
  - **7 - FULL DURATION**
  - **1 - 30 HOUR**
- **FORMAL TECHNIQUES MEETINGS (STARTED AUGUST 1977)**
  - **ASCENT - 62**
  - **ON-ORBIT - 74**
  - **ENTRY - 49**
- **FLIGHT RULES REVIEWS**
- **FLIGHT TEST OPERATIONS CONFERENCE - JUNE 6 AND 7, 1978**



## FLIGHT CONTROL FLOW

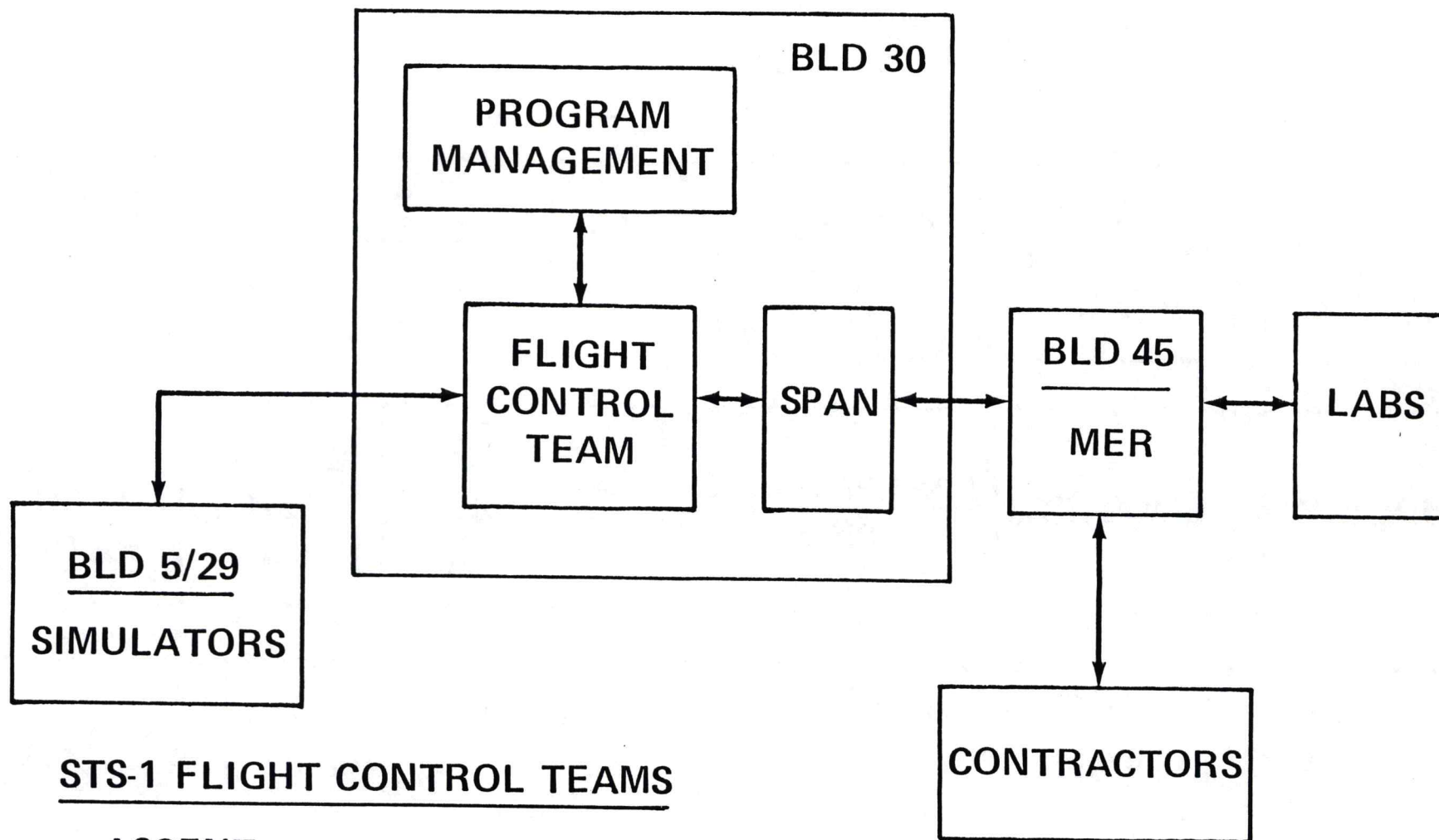


# REALTIME DATA FLOW





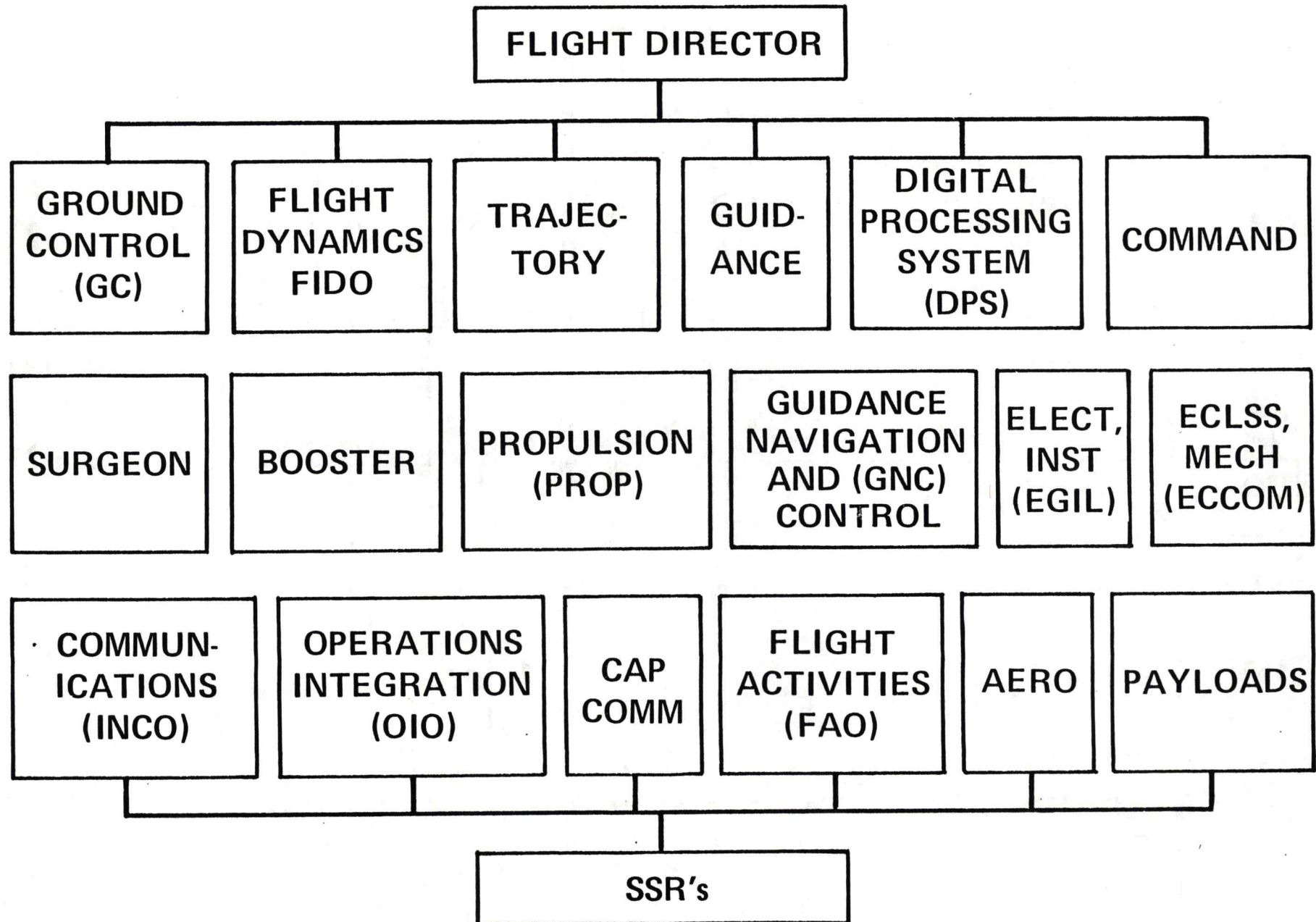
## REALTIME SUPPORT



### STS-1 FLIGHT CONTROL TEAMS

ASCENT  
ON-ORBIT  
ENTRY  
BACKUP

# FLIGHT CONTROL TEAM

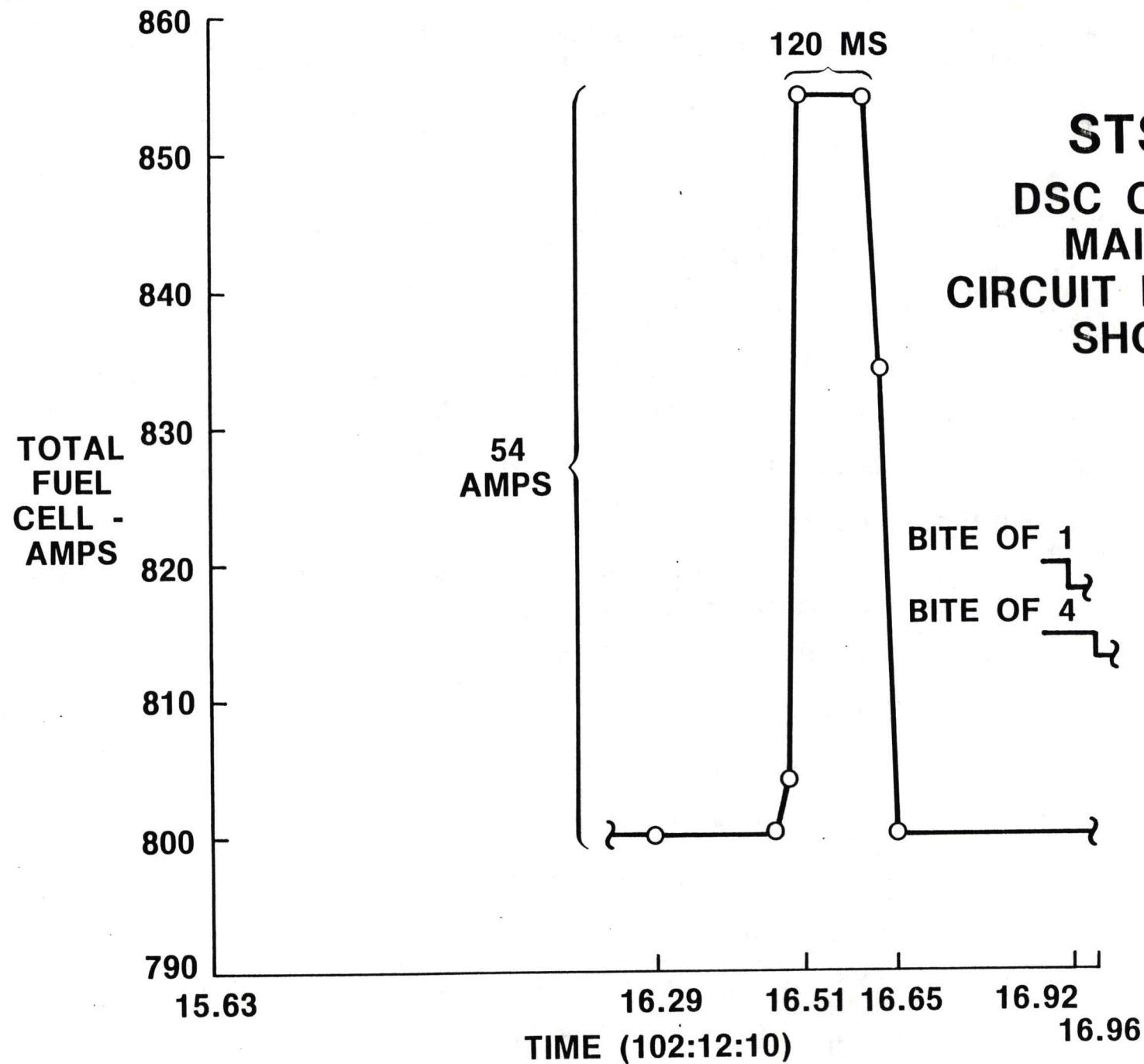




# STS-1 TELEPRINTER MESSAGE

01 MSG NO. 006 - REQUEST CCTV PICTURES OF OMS PODS AND VERTICAL TAIL  
02 PAGE 1 OF 1, 50 LINES THIS PAGE  
03  
04  
05 AT APPROX 11:55 MET MNVR TO ATT R60.7 P330.7 Y283.5 (DAP: B/AUTO/VERN)  
06 FOR LIGHTING FOR VISUAL OPS AND TV  
07  
08 1. LIMIT VTR COVERAGE TO LESS THAN 5 MIN  
09  
10 2. RECORD VOICE ON OPS RCRD  
11  
12 3. ACTIVATE FWD BAY CAMR AND VTR PER TV OPS CUE CARD  
13  
14 4. INSTALL NEW VTR CASSETTE  
15  
16 5. USE BINOCULARS TO SCAN PODS AND TAIL  
17  
18 6. SET UP VTR TO RECORD FULL VIEW CCTV PICTURES OF OMS PODS AND TAIL.  
19 B&W CAMR PREFERRED, IF NO OTHER FACTOR  
20  
21 7. ZOOM IN ON POINTS OF INTEREST (YOUR JUDGMENT ON PRIORITY). WE ARE  
22 PRIMARILY INTERESTED IN STABILIZER BUT THIS IS BASED ON OUR  
23 LIMITED DATA - YOUR CALL  
24  
25 8. ZOOM BACK OUT TO GIVE REFERENCE LOCATION AND GO TO NEXT POINT OF INTEREST  
26  
27 9. REWIND TAPE  
28  
29 CAUTION: AVOID CCTV LOOKING DIRECTLY INTO THE SUN  
30  
31 10. AT APPROX 12:20 MET PERFORM VTR PLAYBACK  
32  
33 A. MCC WILL SET UP S-BAND LINK FOR VTR DUMP  
34  
35 B. ON MCC CUE, VTR - PLAY  
36

NASA-S-81-11064





**NASA-S-81-11073**

# **STS-1 CREW ACTIVITIES**

**ED PAVELKA**

## **CREW ACTIVITIES ARE A REFLECTION OF:**

- **VEHICLE COMPLEXITY AND PERFORMANCE**
- **TRAINING FIT**
- **COMPLEXITY OF MISSION OBJECTIVES**
- **CREW ACTIVITY TIMELINE - PLANNED VS ACTUAL**



**NASA-S-81-10974**

# **STS-1SUMMARY**

**SHELBY L. OWENS**

## **SUMMARY**

- ALL MAJOR FLIGHT OBJECTIVES ACCOMPLISHED
- PERFORMANCE OF SUBSYSTEMS EXCELLENT
- NO MAJOR HARDWARE FAILURE OR ANOMALIES
  - OMS POD DELAMINATION?
- THERMAL PROTECTION SYSTEM DAMAGE IS READILY REPAIRABLE
- FLIGHT CREW REPORTS ARE VERY COMPLIMENTARY WITH SPECIAL EMPHASIS ON FLYING QUALITIES



## **FLIGHT CONTROL/AERO**

- **FLIGHT CONTROL PERFORMANCE - EXCELLENT**
- **ASCENT PERFORMANCE OK - (SOME LOFTING)**
- **NO POGO**
- **ON-ORBIT PERFORMANCE - EXCELLENT**
- **ENTRY PERFORMANCE - NEAR NOMINAL**
- **BOTH PRIMARY AND BACK-UP FLIGHT CONTROL  
PERFORMANCE DURING ALL MISSION PHASES - EXCELENT**
- **ACIP DATA ARE OF EXCELLENT QUALITY**

## **DPS/COMM/NAV/INSTR**

- ALL PLANNED FTR'S WERE ACCOMPLISHED
- DATA PROCESSING SYSTEM PERFORMED NORMALLY
- COMMUNICATIONS AND TRACKING SYSTEMS PERFORMANCE - EXCELLENT
- NAVIGATIONAL SYSTEMS PERFORMANCE NOMINAL
- IMU PERFORMANCE WAS EXCELLENT
- ALL RECORDERS EXCEPT DFI PCM RECORDER PERFORMED NORMALLY
  - DFI RECORDER JAMMED ~ 32 MINUTES AFTER LIFT OFF



## PROPULSION/POWER/HYDRAULICS

- ALL PLANNED FTR'S ON ALL PPD SUBSYSTEMS ACCOMPLISHED
- MAIN PROPULSION SYSTEM PERFORMED NORMALLY
- REACTION CONTROL SYSTEM PERFORMANCE WAS NOMINAL
- ORBITAL MANUEVERING SYSTEM PERFORMANCE WAS SATISFACTORY
- AFT FUSELAGE GAS SAMPLER ANALYSIS SHOW PRESENCE OF  $H_2$  AND  $H_E$ 
  - ALL SIX SAMPLES WERE WELL BELOW EXPLOSIVE LIMITS
- AUXILIARY POWER UNIT PERFORMANCE WAS NOMINAL
- POWER GENERATION SUBSYSTEM PERFORMANCE WAS NOMINAL
  - ASCENT POWER LEVELS - 2 kW LOWER THAN PREDICTED
  - ON-ORBIT POWER LEVELS - 2 kW LOWER THAN PREDICTED
  - ENTRY POWER LEVELS - 3 kW LOWER THAN PREDICTED
- HYDRAULIC SYSTEM PERFORMANCE NOMINAL
- NO ISSUES WITH MISSION CONSUMABLES

## **ENVIRONMENTAL CONTROL/ LIFE SUPPORT/CREW EQUIPMENT**

- ALL PLANNED FTR'S ACCOMPLISHED
- ACTIVE THERMAL CONTROL SYSTEM PERFORMANCE - NORMAL
  - RADIATORS PROVIDED ALL ON-ORBIT COOLING - TOPPING EVAPORATOR WAS NOT REQUIRED TO FUNCTION ON-ORBIT
- ATMOSPHERIC REVITALIZATION SYSTEM PERFORMANCE - ACCEPTABLE
  - CABIN TEMPERATURE CONTROL REQUIRED CREW PARTICIPATION
- CREW PERSONAL ITEMS PERFORMED SATISFACTORILY
- ET AND SRB SEPARATION CAMERAS OBTAINED EXCELLENT DATA
- ON-BOARD TV CAMERA PERFORMED NORMALLY



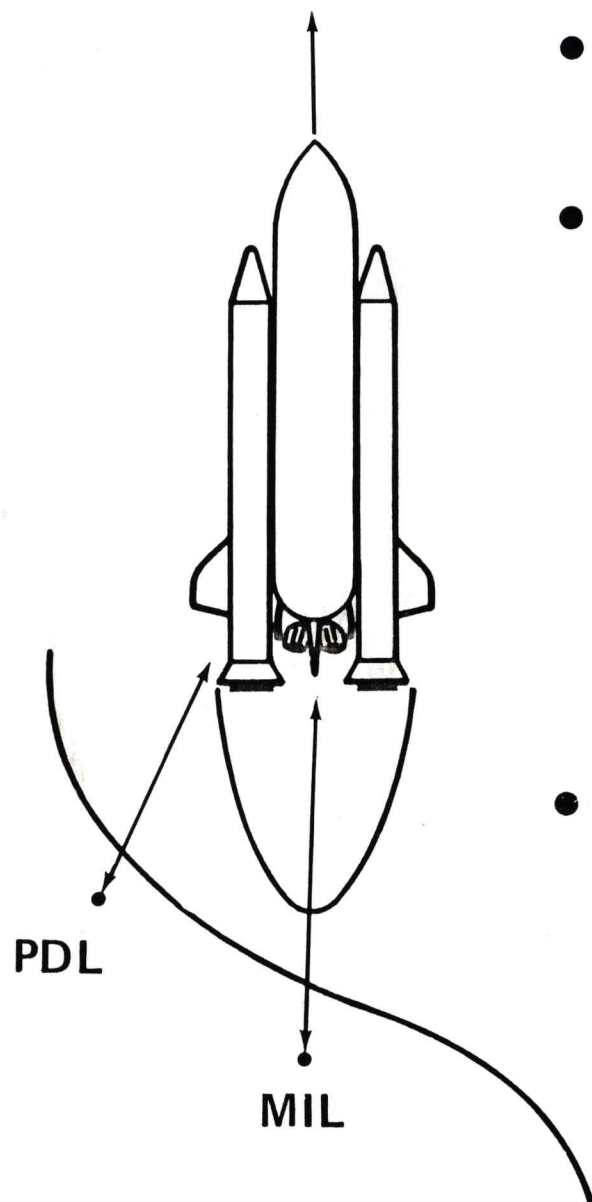
## **THERMAL/STRUCTURAL/MECHANICAL**

- ALL MECHANISMS, DOORS, AND SEPARATION DEVICES FUNCTIONED NORMALLY
- PURGE, VENT AND DRAIN SYSTEM PERFORMED NORMALLY
- THERMAL PROTECTION SYSTEM PERFORMED ACCEPTABLY
  - SOME TILE DAMAGE ON ASCENT CAUSED BY DEBRIS
  - BONDLINE TEMPERATURES WERE 75°F TO 100°F BELOW ALLOWABLE LIMIT
  - TILE REPLACEMENT REQUIREMENTS ARE MINIMAL  
(-500 FOR DENSIFICATION AND - 100 FOR LOSS OR DAMAGE)
- THERMAL CONTROL SYSTEM PERFORMED NORMALLY
  - HEATER ANOMALIES TO BE DISCUSSED

## **COMMUNICATIONS AND TRACKING**

- **OVERALL PERFORMANCE EXCELLENT**
- **REVIEW FOLLOWING**
  - **S-BAND COMMUNICATIONS DURING ASCENT**
  - **UHF COMMUNICATIONS COVERAGE**
  - **ENTANGLED COMMUNICATIONS UMBILICALS**
  - **TACAN BEARING DATA DESELECTED**
  - **RADAR ALTIMETER DROPOUT**

## S-BAND COMMUNICATIONS DURING ASCENT



- PROBLEM - S-BAND COMMUNICATIONS UNUSABLE FROM 1:40 TO 2:15 ELAPSED TIME
- ASSESSMENT
  - SRB EXHAUST PLUME CAUSED
    - LOSS UPLINK FRAME SYNCHRONIZATION
    - LOSS NIL RECEIVER LOCK
  - GOOD DATA RECEIVED AT PDL
  - GROUND PROCESSING PROBLEMS CAUSED LOSS OF MCC DISPLAY DATA
- CORRECTIVE ACTION
  - CONTINUE ANALYSIS OF MIL PROCESSING
  - DETERMINE EFFECTS OF MCC VALIDATION CRITERIM
  - REOPEN QUESTION OF HANDOVER TO PDL



## UHF COMMUNICATIONS COVERAGE

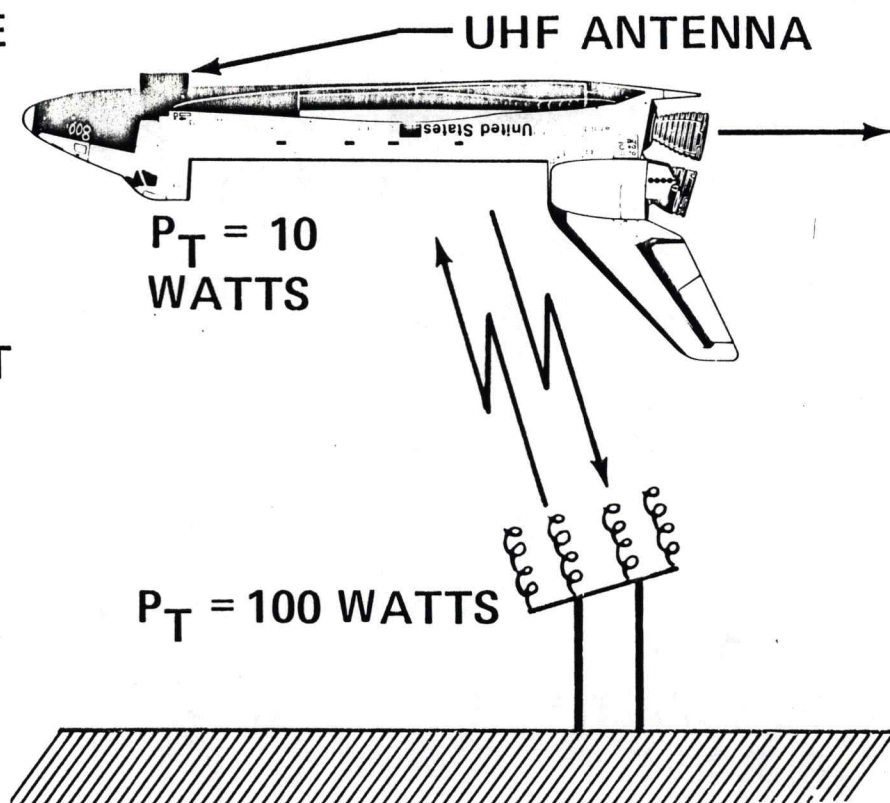
- PROBLEM - DOWNLINK PERFORMANCE NOT AS GOOD AS UPLINK

- ASSESSMENT

- PERFORMANCE SHOULD HAVE BEEN EQUAL.
  - GROUND RECEIVER SQUELCH SET TOO HIGH
  - POSSIBLE LOW ORBITER TRANSMITTER MODULATION

### PERFORMANCE DIFFERENCES (UPLINK - DOWNLINK)

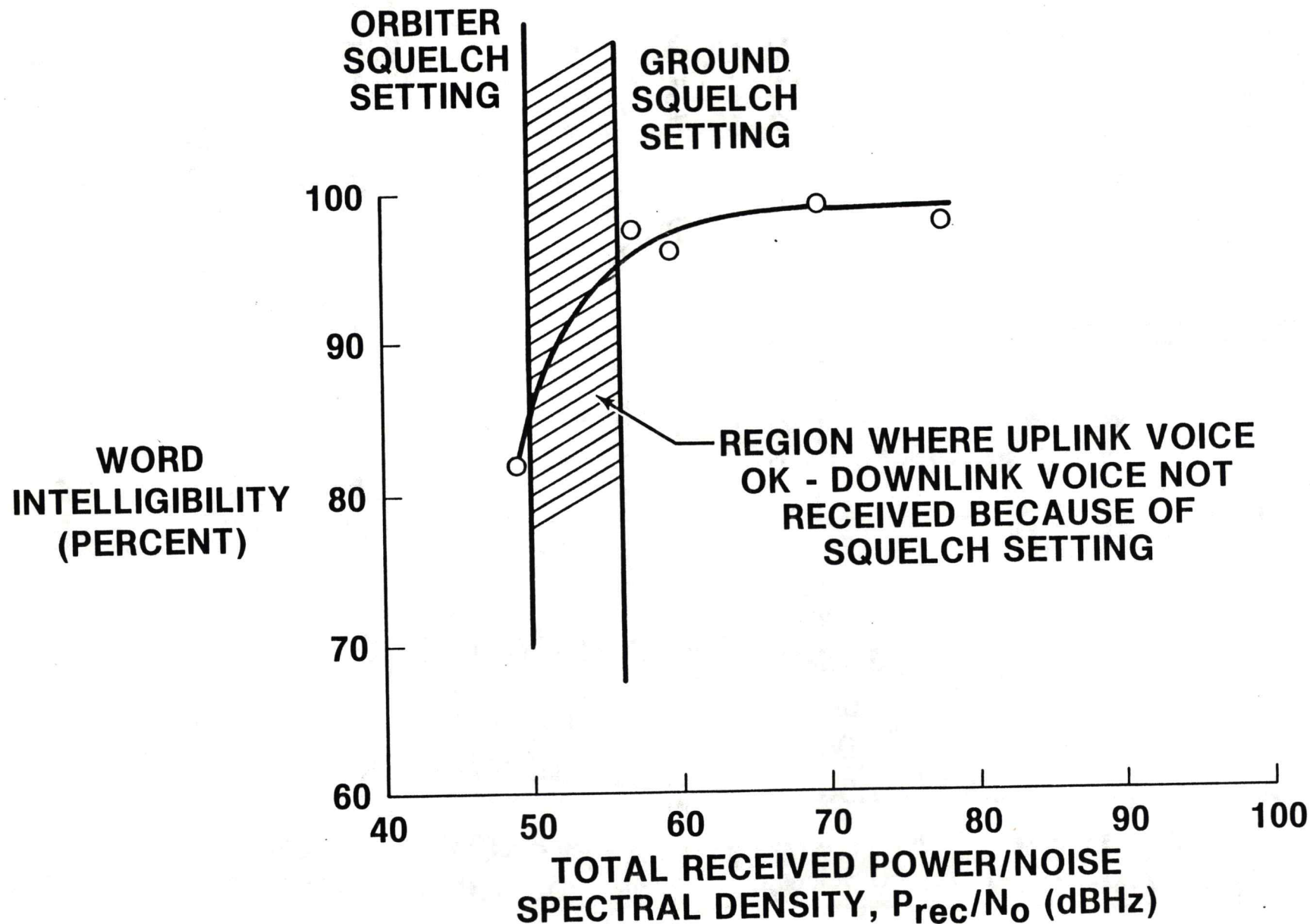
PARAMETER	$\Delta$
TRANS. PWR	+ 10dB
GND ANT. GAIN.	- 2.1dB
SPACE LOSS	0dB
ORB. ANT. GAIN	0dB
RECEIVER NOISE TEMP	- 7.6dB
TOTAL	+0.3dB



- CORRECTIVE ACTION

- DEFINE OPTIMUM GROUND RECEIVER SQUELCH SETTING
  - VERIFY ORBITER MODULATION LEVEL

# EFFECTS OF SQUELCH SETTING

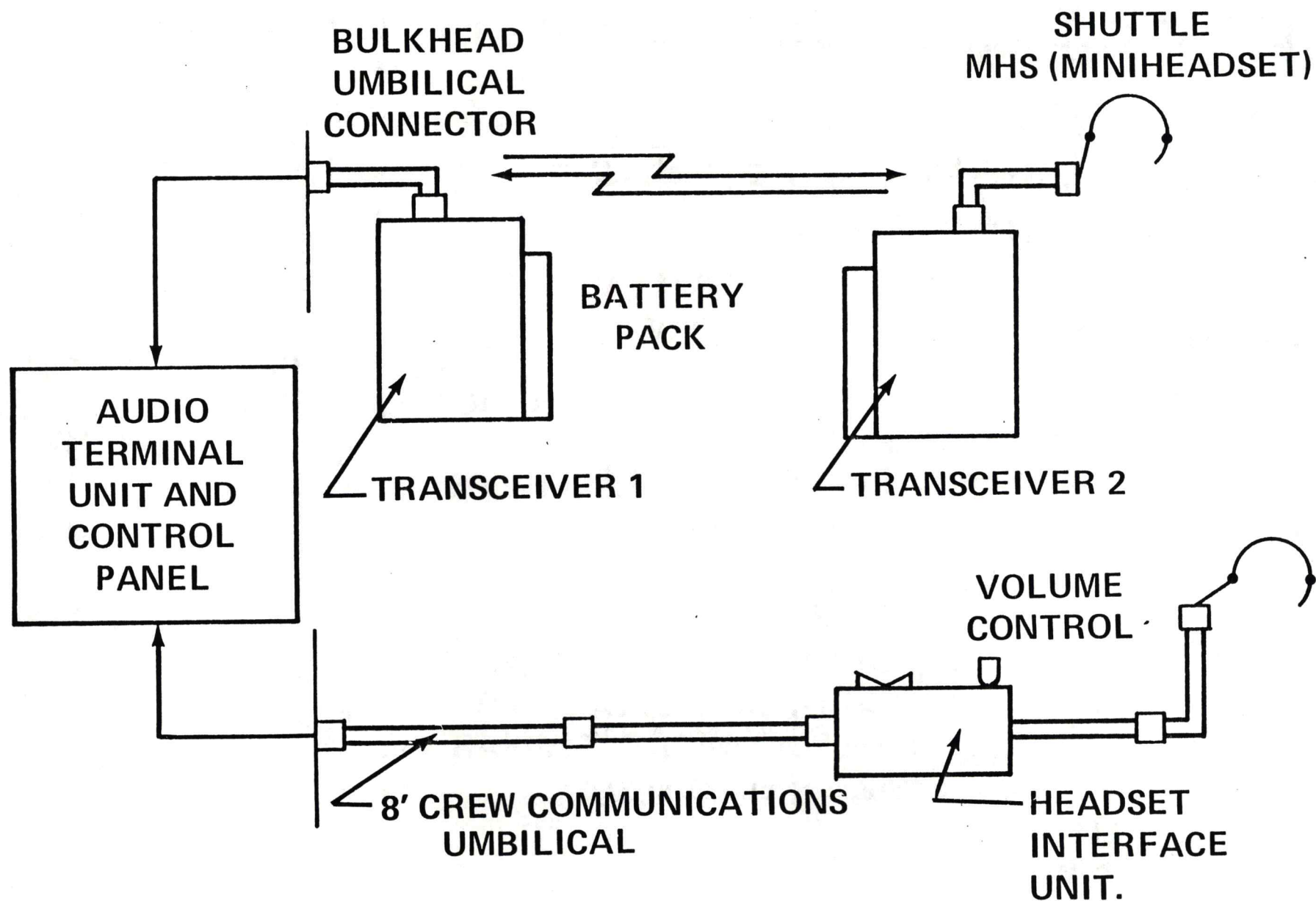


## ENTANGLED CREW COMMUNICATIONS UMBILICALS

- PROBLEM - UMBILICALS
  - LIMIT MOBILITY
  - BECOME ENTANGLED
  - PULL HEADSETS OFF
- CORRECTIVE ACTION
  - IMPLEMENT WIRELESS CREW COMMUNICATIONS FOR EVALUATION
    - BUY OFF-THE-SHELF TRANSCEIVERS
    - MODIFY IN-HOUSE
      - NEW CASE
      - ADD KEYING
      - MAKE AUDIO COMPATIBLE WITH HEADSET AND AUDIO TERMINAL UNIT
    - "TIGER TEAM" OPERATION SIMILAR TO TELEPRINTER
    - GOAL - STS-2 EFFECTIVITY

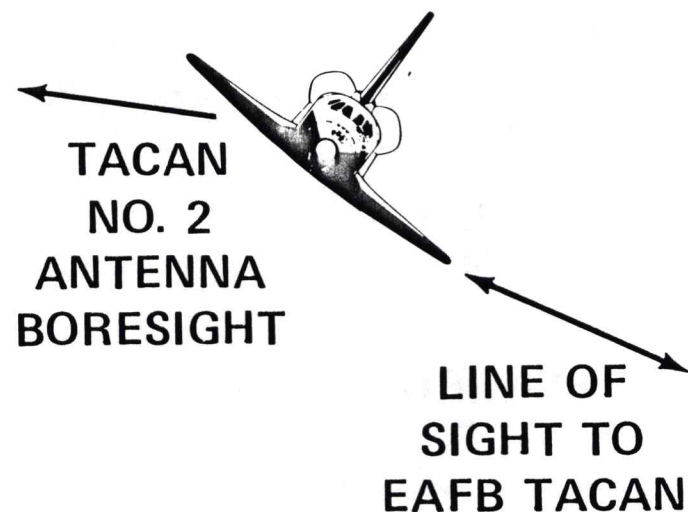


## WIRELESS CREW COMMUNICATIONS



## TACAN BEARING DATA

PROBLEM - TACAN NO. 2 BEARING DATA DESELECTED AT 104:18:14:12



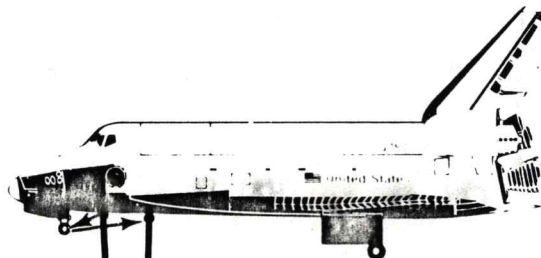
- ASSESSMENT

- ORBITER'S TURN AND BANKING ANGLES RESULTED IN POOR LOOK ANGLES TO EAFB TACAN
- 40° ERROR MULTIPLES ENCOUNTERED TEN CONSECUTIVE SAMPLES - LOW SIGNAL STRENGTH
- TACAN NO. 2. BEARING DATA USABLE REMAINDER OF FLIGHT

- CORRECTIVE ACTION

- NONE REQUIRED

## RADAR ALTIMETER



- PROBLEM

- RADAR ALTIMETER BROKE LOCK DURING LANDING GEAR DEPLOYMENT
- SUBSEQUENT DATA NOT VALID

- ASSESSMENT

- REFLECTED ENERGY OFF NOSE GEAR/ DOORS CAUSED ALTIMETER TO BREAK LOCK
- ALTIMETER TRACK ALTERNATED/ AVERAGED BETWEEN NOSE GEAR AND GROUND
- SIMILAR TO ALT FF4 PROBLEM-ANTENNAS RELOCATED FOR OFT

- CORRECTIVE ACTION

- USE HIGH FIDELITY MOCKUP TO DETERMINE DECREASE IN ANTENNA GAIN (TOWARD NOSE GEAR) REQUIRED
- ANALYZE IMPACT ON ANTENNA DESIGN



**NASA-S-81-11222**

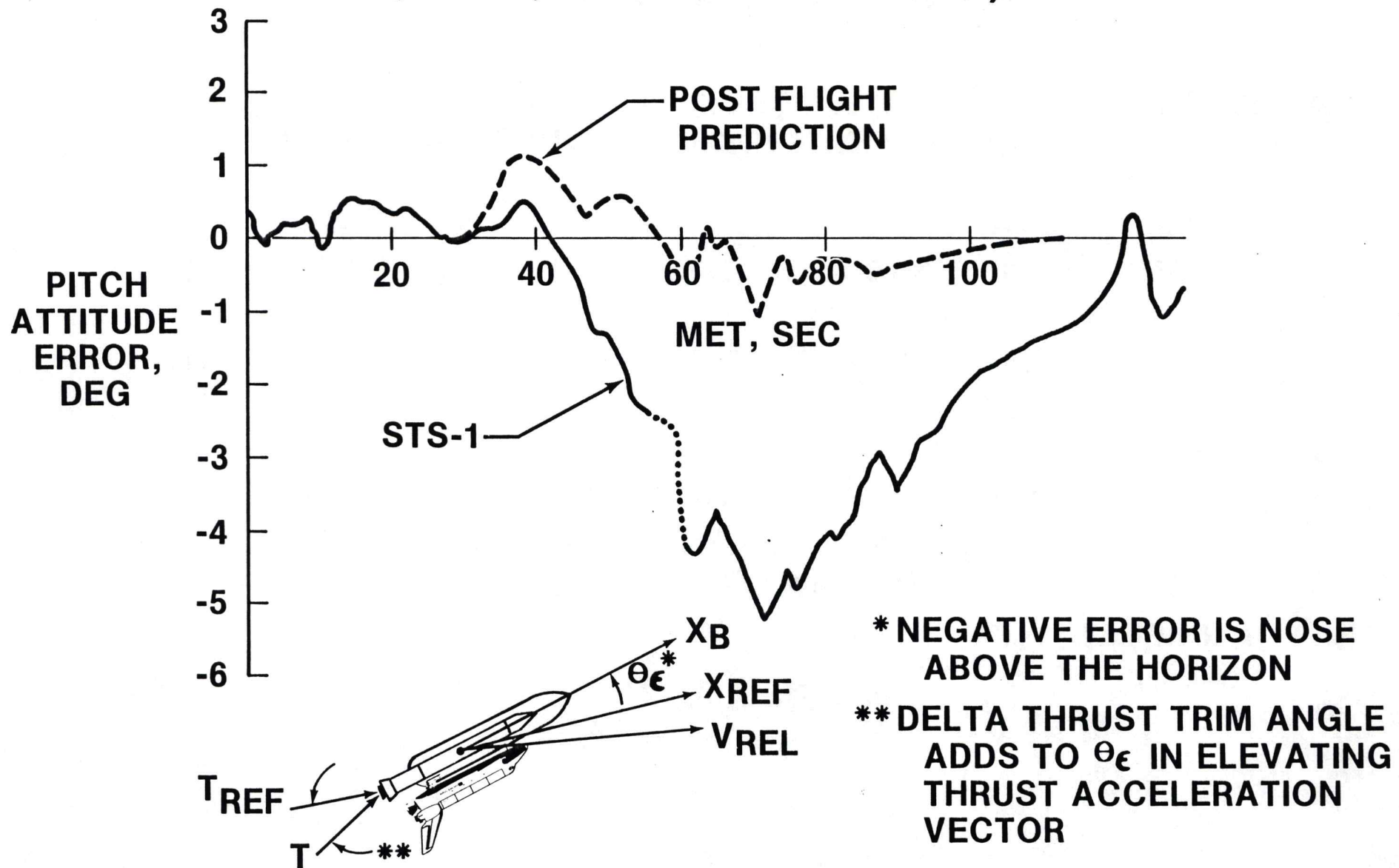
**STS-1 SYMPOSIUM**  
**GN&C SYSTEMS AND AVIONICS**  
**EQUIPMENT PERFORMANCE**

**E. SMITH**

## ASCENT GN&C - STS-1

- TECHNICAL FINDING
  - ALL ASCENT GN&C FUNCTIONS PERFORMED AS PLANNED
- TECHNICAL FINDING
  - TVC DUTY CYCLE DUE TO LOX SLOSH ACTIVITY MUCH LESS THAN ANTICIPATED
- TECHNICAL FINDING
  - TRAJECTORY LOFTING OCCURRED
    - NON-NOMINAL AERODYNAMIC MOMENT (AND/OR THRUST MISALIGNMENT) REQUIRED SUBSTANTIAL ATTITUDE ERROR TO PRODUCE MOMENT BALANCE
    - ABOUT 10,000 FT. HIGH AT SRB SEPARATION
- RECOMMENDATION FOR FUTURE
  - CONTINUE ANALYSIS AND OFFLINE SIMULATION, POTENTIAL I-LOAD CHANGES TO SRB TRIM TABLES

# STS-1 FIRST STAGE FLIGHT LOFTING DUE PRIMARILY TO CENTER OF PRESSURE ESTIMATION ERRORS (FORE, AFT AND NORMAL)



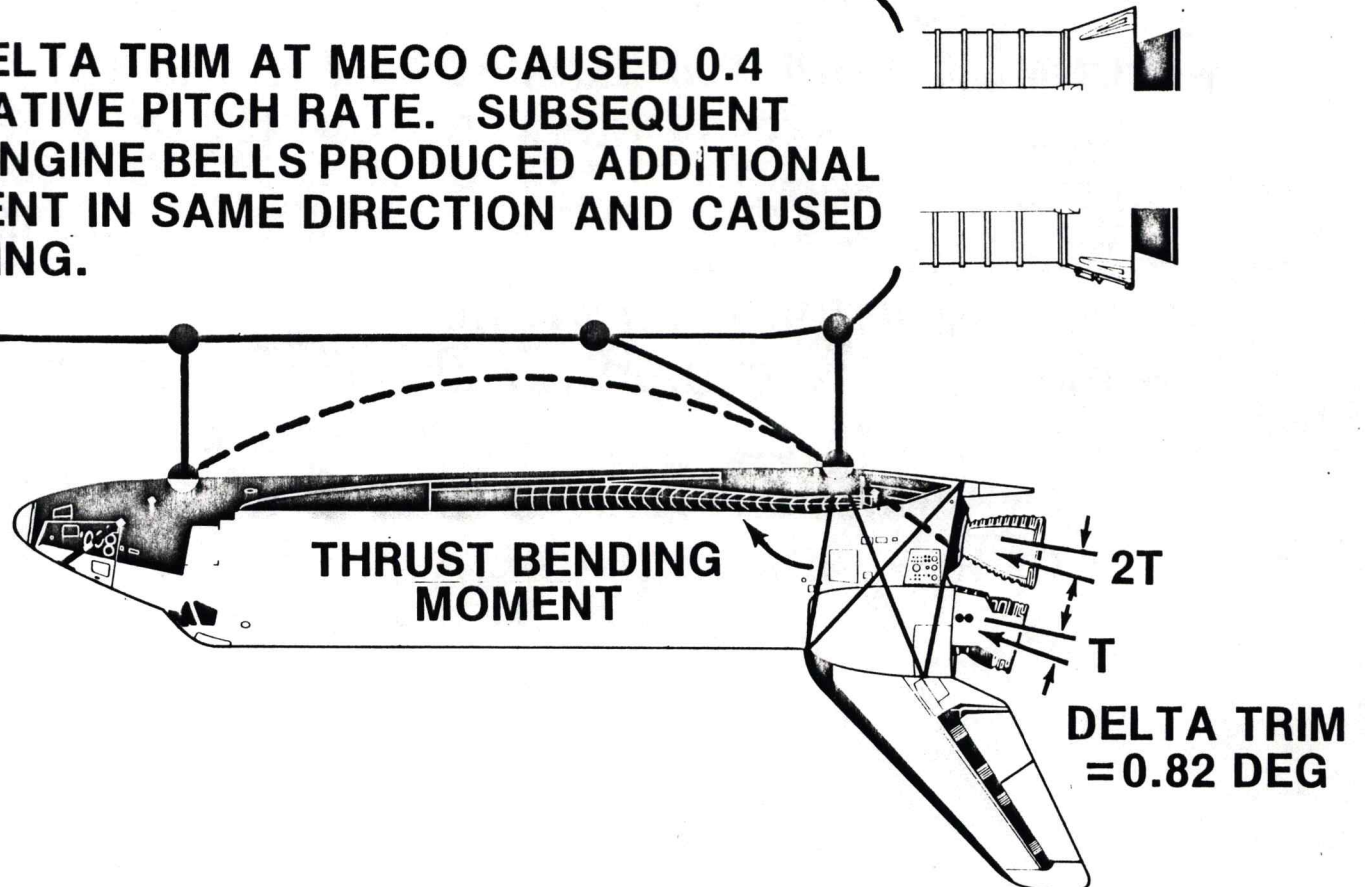


## ON-ORBIT AND TRANSITION GN&C - STS-1

- TECHNICAL FINDING
  - SSME SLEWING TO STOW POSITION CAUSED UNEXPECTED THRUSTER FIRINGS
- RECOMMENDATION FOR FUTURE
  - LONG-RANGE FIX IS TO MODIFY SOFTWARE BY REDUCING SIZE OF SLEWING COMMAND STEPS. SHORT-RANGE PROCEDURAL OPTION IS TO ENGAGE PULSE MODE DURING THE SLEW TO STOW POSITION
- TECHNICAL FINDING
  - ROLL OSCILLATION AMPLITUDE DURING PASSIVE GRAVITY GRADIENT TEST LARGER THAN PREDICTED
- RECOMMENDATION FOR FUTURE
  - REPEAT PASSIVE GRAVITY GRADIENT TEST ON STS-2

## ILLUSTRATION OF ORBITER THRUST MISALIGNMENT AND EFFECT ON PITCHING RATE AT MECO

REMOVAL OF DELTA TRIM AT MECO CAUSED 0.4  
DEG/SEC NEGATIVE PITCH RATE. SUBSEQUENT  
SLEWING OF ENGINE BELLS PRODUCED ADDITIONAL  
RATE INCREMENT IN SAME DIRECTION AND CAUSED  
THRUSTER FIRING.



## ON-ORBIT AND TRANSITION GN&C - STS-1 (CONT)

- TECHNICAL FINDING
  - SSME DUMP TRANSIENT DURING OMS-1 PRODUCED MORE THAN EXPECTED ROLL THAN YAW DISTURBANCE
- RECOMMENDATION FOR FUTURE
  - UPDATE VENTING MODELS BASED ON FLIGHT RESULTS
- TECHNICAL FINDING
  - PRIMARY JET FIRINGS WERE NOISY TO THE CREW
- RECOMMENDATION FOR FUTURE
  - REFINE PASSIVE GRAVITY GRADIENT MODE FOR USE DURING SLEEP PERIODS IF VERNIERS FAIL. MAKE INPUTS TO "ORBITER ENHANCEMENT" ACTIVITIES TO ACCELERATE AVAILABILITY OF REDUNDANT VERNIERS



## ENTRY FLIGHT CONTROL

- ENTRY FLIGHT CONTROL WAS SUBSTANTIALLY  
NOMINAL WITH BETTER THAN EXPECTED  
OVERALL PERFORMANCE
- SOME ANOMALIES DID OCCUR, HOWEVER,  
AND THE IMPLICATIONS FOR STS-2  
WILL BE DISCUSSED

## MANEUVER PERFORMANCE

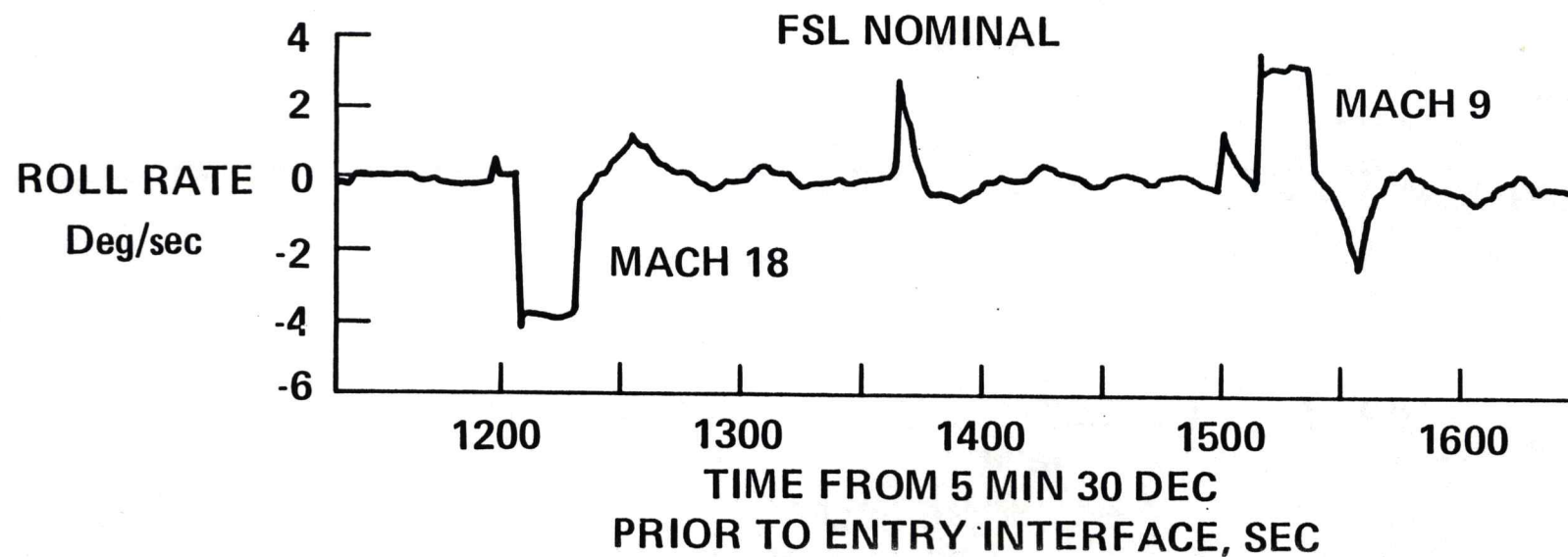
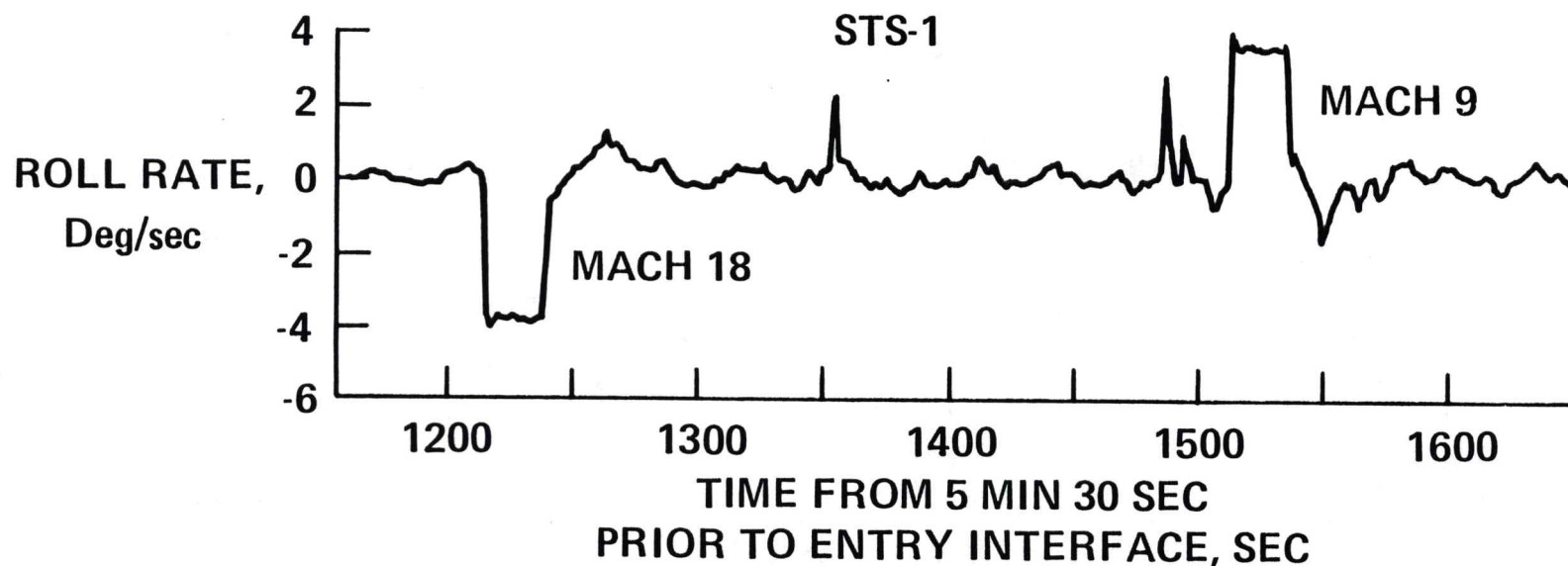
### LATERAL DIRECTIONAL PERFORMANCE

- ROLL MANEUVERS - AT MACH 18 AND 9
  - PERFORMED IN AUTO
  - BOTH WERE CRISP, PRECISE, AND WELL COORDINATED
    - NO SIGNIFICANT TRANSIENTS OR OVERSHOOTS NOTED
- ROLL MANEUVERS AT MACH 5 AND 3
  - INITIATED IN AUTO, COMPLETED MANUALLY
  - INITIAL AUTO RESPONSE WAS CLOSE TO NOMINAL
  - RESPONSE TO STICK COMMANDS APPEARED GOOD
- THE SUBSONIC MANUAL ROLL MANEUVER AT THE HEADING ALIGNMENT CYLINDER WAS ALSO GOOD

### LONGITUDINAL PERFORMANCE

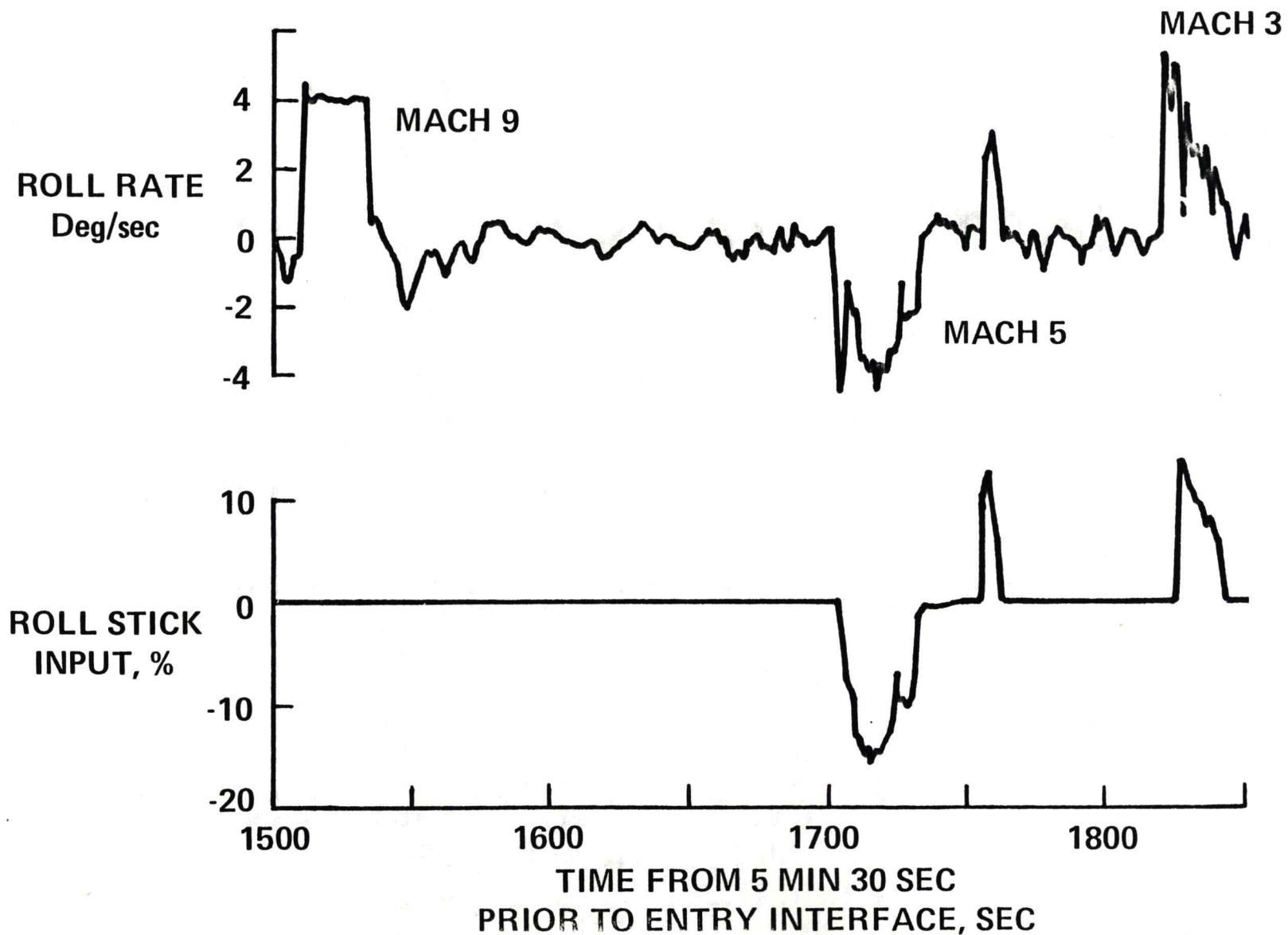
- AUTOMATIC ANGLE OF ATTACK TRACKING WAS PRECISE AND SMOOTH THROUGH MOST OF THE TRAJECTORY
- MANUAL PITCH CONTROL WAS INITIATED BELOW MACH 0.9
- ELEVATOR AND PITCH RATE ACTIVITY WAS MODERATE THROUGHOUT THE ENTRY
- SPEEDBRAKE OPERATION WAS BASICALLY NOMINAL

## ROLL RATE COMPARISON





## PILOT'S ROLL STICK INPUTS AND ROLL RATE FOLLOWING



## ENTRY GN&C - STS-1

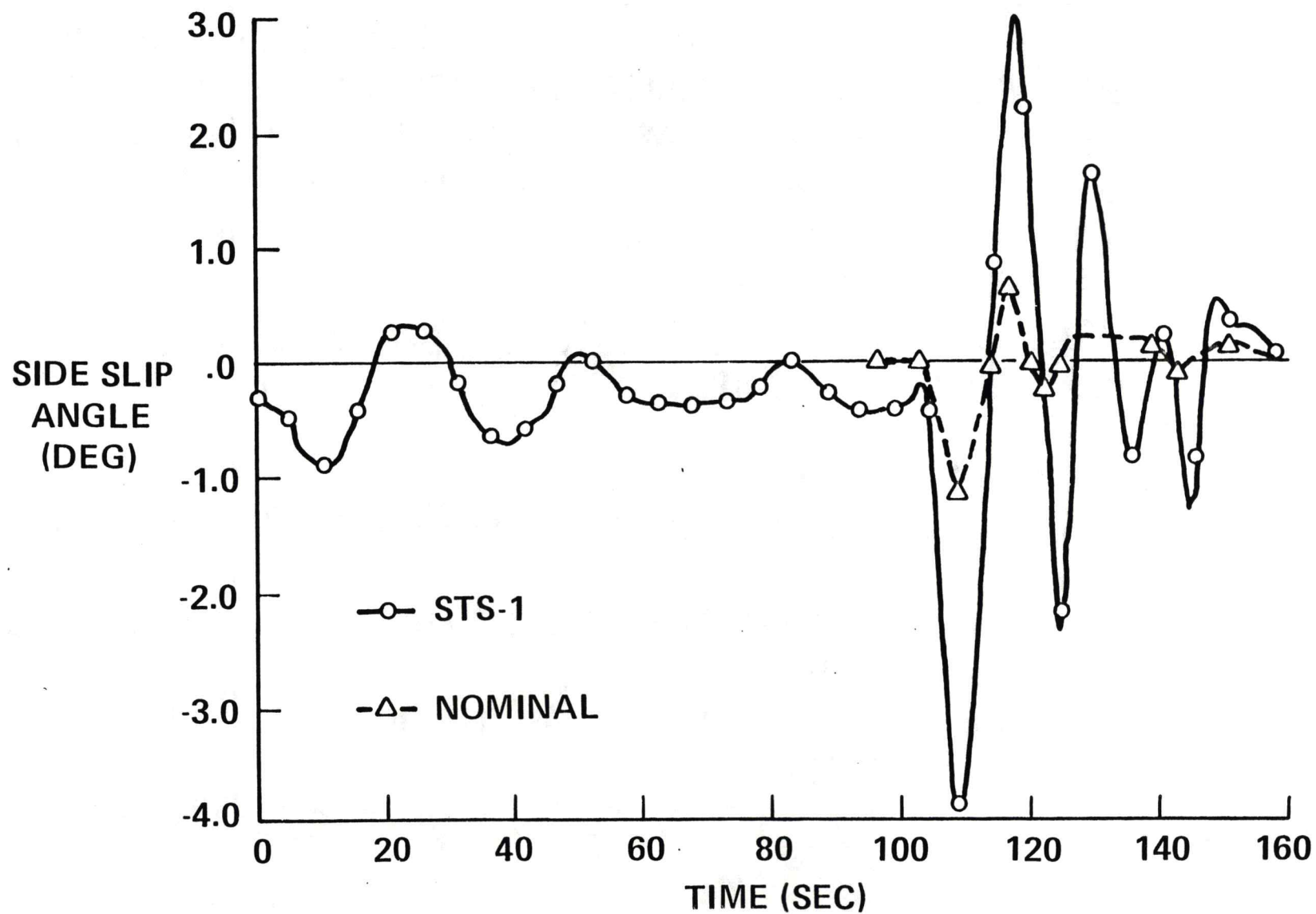
- TECHNICAL FINDING

- LATERAL OSCILLATION AT FIRST ROLL MANEUVER ( $\bar{q} \approx 12.4$  PSF)
  - VEHICLE RESPONSE TO INITIAL ROLL COMMAND WAS POOR
  - POORLY DAMPED ROLL/YAW OSCILLATION WITH A MAXIMUM PEAK-TO-PEAK BETA OF  $7^\circ$  AND A PERIOD OF APPROXIMATELY 13 SECONDS
  - MOTION DAMPED AFTER 4 CYCLES
  - PROBABLE CAUSE - YAW JET ROLL TORQUE UNCERTAINTIES GREATER THAN EXPECTED

- TECHNICAL FINDING

- BODY FLAP/ELEVONS OFF SCHEDULE
  - BODY FLAP WAS MORE DOWN THAN EXPECTED IN HEATING REGION
  - BODY FLAP AND ELEVATORS WERE MORE UP THAN EXPECTED IN  $2 > M > 1$  REGION
  - PROBABLE CAUSE - PITCHING MOMENT OUTSIDE EXPECTED UNCERTAINTIES

## SIDE SLIP COMPARISON OF STS-1 AND PRE-FLIGHT NOMINAL





## ENTRY GN&C - STS-1 (CONT)

- TECHNICAL FINDING
  - LATERAL OSCILLATION AT  $M \approx 1.6$ 
    - ROLL/YAW OSCILLATION WITH A PEAK-TO-PEAK ROLL RATE OF 4 DEG/SEC AND A PERIOD OF 4 SEC
    - PROBABLE CAUSE - DECREASED AILERON AND INCREASED RUDDER ROLLING MOMENTS OUTSIDE EXPECTED UNCERTAINTIES

## ENTRY GN&C - STS-1 (CONT)

- TECHNICAL FINDING
  - STS-1 TOUCHDOWN WAS 3093 FEET BEYOND PREDICTED
    - CONTRIBUTING FACTORS
      - SLOW T/D VELOCITY
      - HEAVIER WEIGHT
      - TAILWINDS
      - LOWER ALTITUDE PROFILE
      - PREMATURE SPEEDBRAKE RETRACTION
      - AIR DATA ERROR
      - LOW FREQUENCY TRAJECTORY OSCILLATION
      - AERO DRAG (TILE ROUGHNESS EFFECT)
- RECOMMENDATION FOR FUTURE
  - CONTINUING STUDIES AT JSC, ROCKWELL, SPERRY, AND AMES
  - POSSIBLE MODS TO AERO DATA, AND/OR PILOT PROCEDURES

## ENTRY GN&C - STS-1 (CONT'D)

### RECOMMENDATIONS FOR FUTURE

- PRELIMINARY ANALYSIS HAS BEEN COMPLETED AND THE FOLLOWING RECOMMENDATIONS MADE FOR STS-2
  - PERFORM FIRST ROLL MANEUVER MANUALLY (CSS)
  - REDUCE MAGNITUDE OF AERO DATA EXTRACTION MANEUVERS BELOW MACH 4
  - MAKE NO ADDITIONAL SYSTEM MODIFICATIONS
- ADDITIONAL STUDIES ARE CURRENTLY IN WORK TO FURTHER UNDERSTAND THE PROBLEMS NOTED
  - MAN-IN-THE-LOOP WORK ON SPS AND FSL
  - LINEAR STABILITY ANALYSIS AT HI/RIC/JSC
  - TIME DOMAIN WORK AT HI/RIC/JSC TO MATCH TRAJECTORY



## **STS-1**

### **GN&C EQUIPMENT**

- **ANOMALIES**
- **PERFORMANCE TRENDS**

## STS-1 INSTRUMENTATION FAILURES

<u>ITEM</u>	<u>ASSESSMENT</u>	<u>FORWARD ACTION</u>
SIGNAL CONDITIONER POWER SUPPLY (REDUNDANT)	PAPER CLIP	REPLACE FAILED EQMT
AFT BUS C CURRENT SENSOR	INCOMPLETE	REPLACE FAILED EQMT VENDOR ANALYSIS
ME 2 GASEOUS HYDROGEN PRESSURE AND TEMP	EXCESSIVE VIBRATION, EXPECT INTERNAL LEAD BREAKAGE	REPLACE FAILED EQMT RELOCATE PRESSURE SENSOR STS-3

## STS-1 HSI COMPASS CARD FAILURE

### PROBLEM

- COMMANDER'S HORIZONTAL SITUATION INDICATOR COMPASS CARD FAILURE DETECTED DURING ON-ORBIT CHECKOUT, RECURRENT FAIL DURING ENTRY

### ASSESSMENT

- PROBABLE MECHANICAL RESTRICTION, PRELIMINARY FINDINGS SHOW CONTAMINATION OF GEAR LUBRICATION

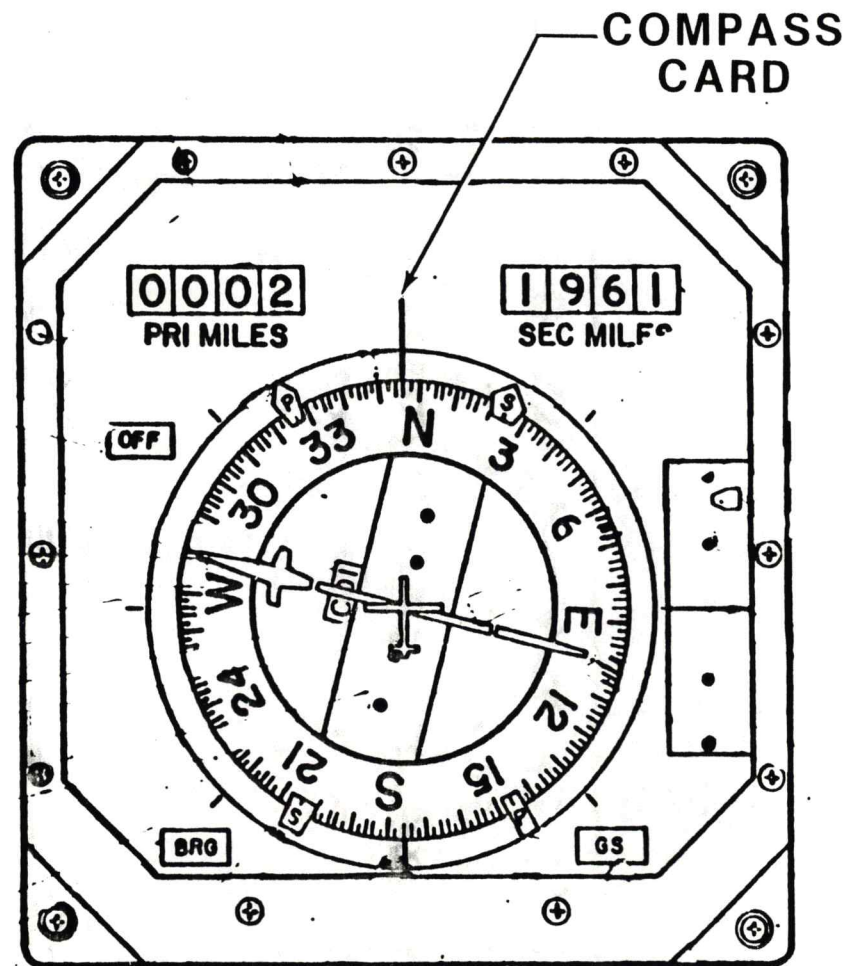
### FORWARD ACTION

- REPLACE IN VEHICLE
- COMPLETE VENDOR FAILURE ANALYSIS AND REPAIR



NASA-S-81-11271

# HORIZONTAL SITUATION INDICATOR



## STS-1 OMS ACTUATOR FAILURE

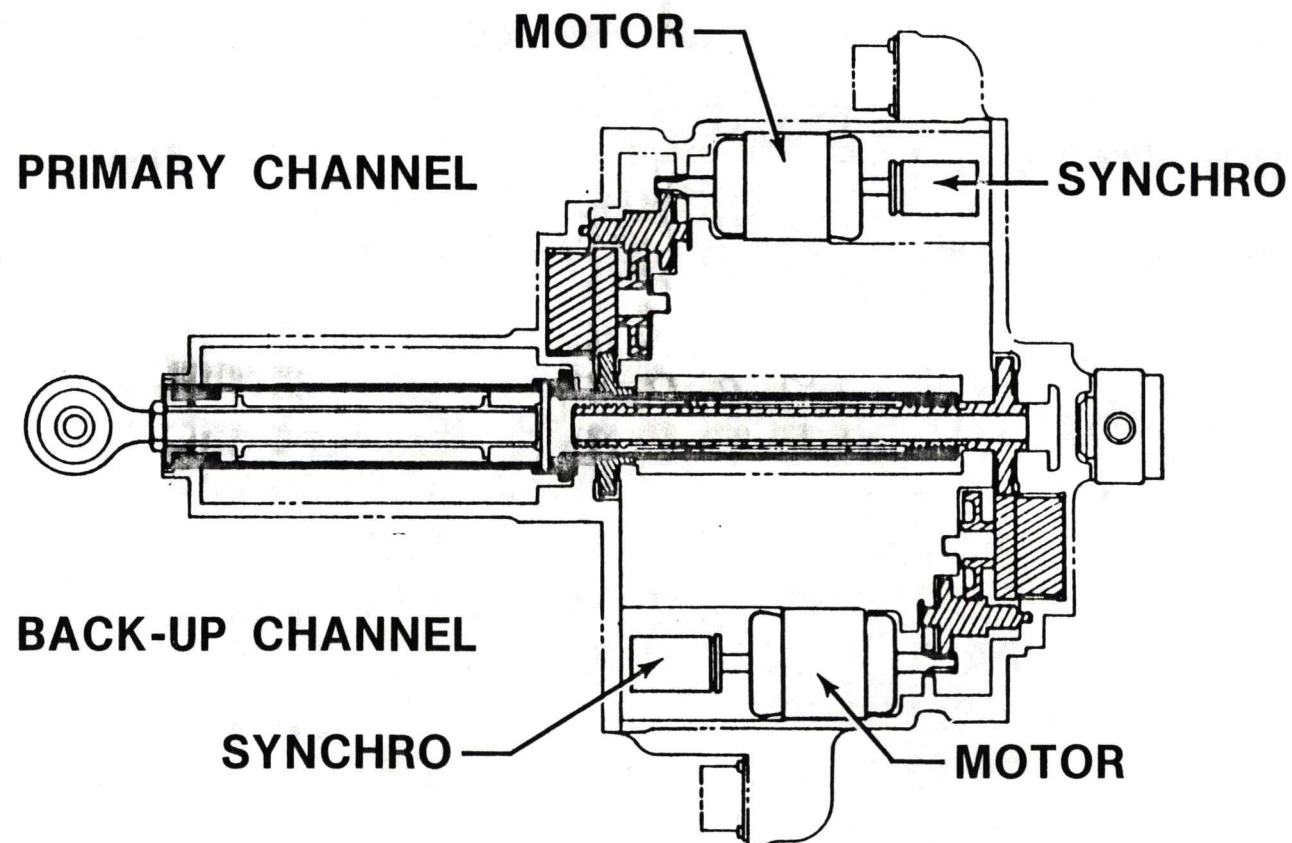
- PROBLEM

- FAILURE OF THE RIGHT PRIMARY PITCH OMS ACTUATOR
  - DETECTED DURING SLEW TEST JUST PRIOR TO OMS 3 BURN
  - DATA SHOWED FAILURE TO DRIVE ACTUALLY OCCURRED DURING OMS 2 BURN BUT ERROR ( $\sim 2^\circ$ ) DID NOT EXCEED FAULT DETECTION ERROR THRESHOLD
  - BACKUP CHANNEL USED FOR OMS 4 AND SUBSEQUENT BURNS

- ASSESSMENT

- FAILURES DID NOT AFFECT STS-1 TRAJECTORY ADJUSTMENTS
- MAIN EFFECT OF FAILURE OR LOSS IS TO USE EXTRA RCS FUEL FOR ATTITUDE CONTROL DURING OMS BURNS
- BETWEEN 2 AND 5 CHANNEL FAILURES ARE TOLERABLE BEFORE RCS FUEL IMPACT. CAN RETURN SAFELY WITHOUT OMS
- FAILURE ANALYSIS IN PROCESS
  - MOTOR POSITION SYNCHRO ROTATED ON ITS SHAFT DUE TO BOND FAILURE
  - EVIDENCE OF ROTOR TO STATOR CONTACT, EXTERNAL STRESS TO THE SYNCHRO SHAFT, AND SYNCHRO DIMENSIONAL. ANOMALIES

# OMS ACTUATOR





## **STS-1 STAR TRACKER SHUTTER LATCH CLOSE ANOMALY**

- **PROBLEM**

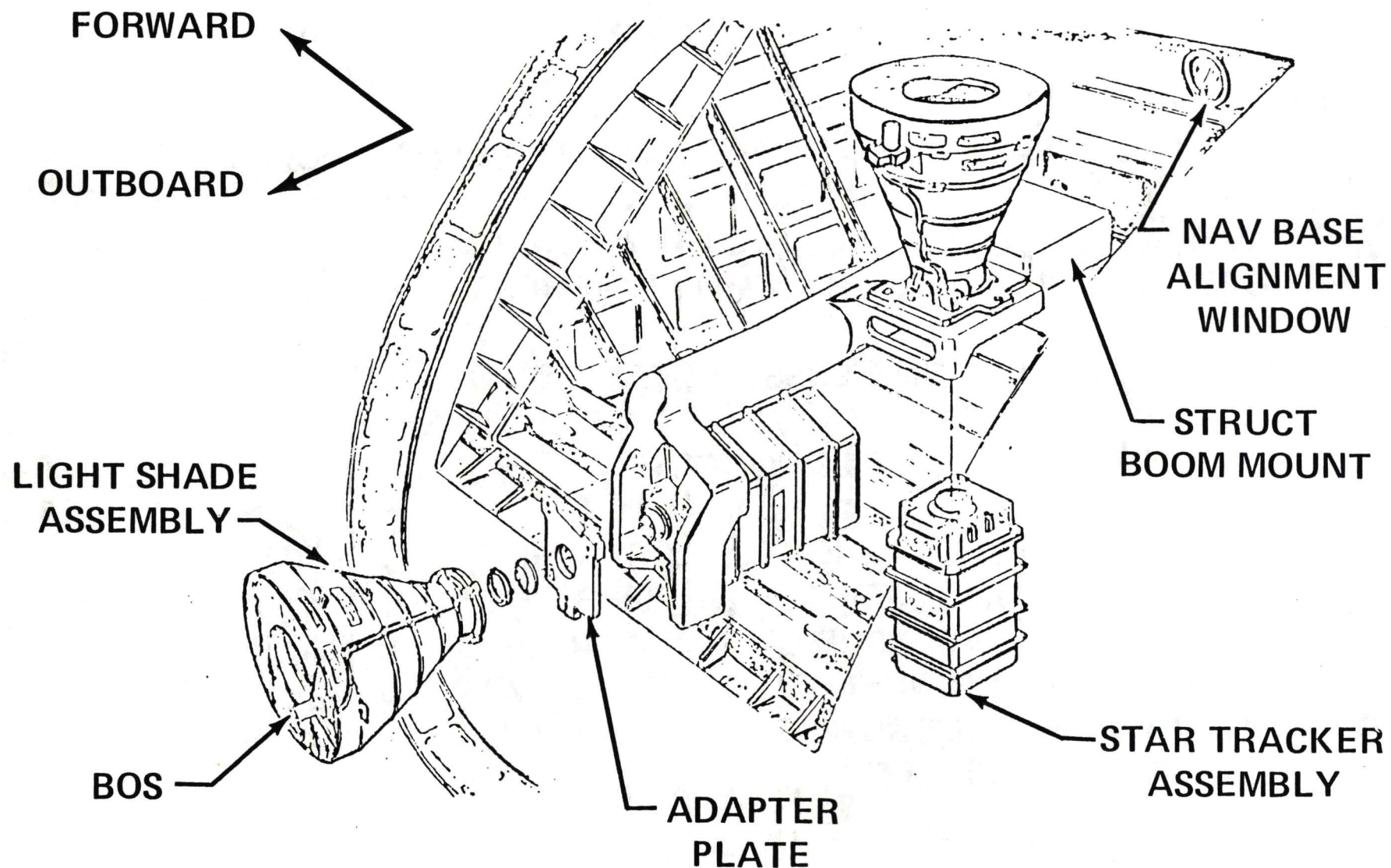
- THE STAR TRACKER PROTECTIVE SHUTTER CLOSED AND LATCHED FREQUENTLY DURING STS-1 WHEN CROSSING THE EARTH'S LIMB. KEYBOARD ENTRY REQUIRED TO UNLATCH
- DOES NOT AFFECT EXPLICIT IMU ALINEMENT PROCESS USED FOR OFT
- IT DID RESULT IN SOME LOSS OF STAR'S OF OPPORTUNITY ALINEMENT ASSESSMENT GOALS. IT MIGHT AFFECT OPTICAL RENDEZVOUS TARGET TRACKING

- **ASSESSMENT**

- PRELIMINARY DATA INDICATES EARTH LIMB AWAY FROM THE SUB-SOLAR POINT IS NOT ALWAYS BRIGHT ENOUGH TO TRIGGER BRIGHT OBJECT SENSOR ON THE OUTSIDE OF SHUTTER. IT IS BRIGHT ENOUGH WHEN IN ST FIELD-OF-VIEW TO TRIGGER THE TRACKER TARGET SUPPRESS CIRCUIT WHICH CLOSSES AND LATCHES THE SHUTTER

# STAR TRACKER/LIGHT SHADE INSTALLATION

## VIEW LOOKING INTO STAR TRACKER CAVITY



## **STS-1 HARDWARE PERFORMANCE DATA**

- **TVC/AERO ACTUATOR SECONDARY  $\Delta$  PRESSURE**
  - **CONCERN LEVEL IS 1200 PSIA**
  - **GROUND AND FLIGHT TEST SHOWED 300-400 PSIA, TYPICAL**
  - **NO. 1 TVC PITCH ACTUATOR SHOWED 900 PSIA LEVELS.**  
**WILL BE MONITORED AND ASSESSED DURING TURN-AROUND TESTING AT KSC**
- **FLIGHT CONTROL SENSORS**
  - **SRB RGA'S, ORBITER RGA'S, AND AA'S DATA TRACKED CLOSELY WITHIN THEIR SETS. MAX  $\Delta$  WITHIN SET WAS LESS 40 PERCENT OF RM FAULT DETECT THRESHOLD, EVEN DURING LIFTOFF TWANG AND MAX Q DURING ASCENT**



## STS-1 HARDWARE TREND DATA (CONT)

- FLIGHT CONTROL SENSORS
  - SRB RGA'S, ORBITER RGA'S, AND AA'S DATA TRACKED CLOSELY WITHIN THEIR SETS. MAX  $\Delta$  WITHIN SET WAS LESS 40 PERCENT OF RM FAULT DETECT THRESHOLD, EVEN DURING LIFTOFF TWANG AND MAX  $\bar{Q}$  DURING ASCENT
- IMU
  - PREFLIGHT CAL PARAMETER REPEATABILITY (22 PER IMU)
    - 5 OF 66, .5 TO 1.0 SIGMA
    - 61 WERE LESS THAN .5 SIGMA
    - AVERAGE IS .3 SIGMA
  - GROUND ALINE GOODNESS TEST (ALL IMU'S) REPEATED PREVIOUS DATA BASE BY
    - 2 ARC SECONDS IN TILT
    - 25 ARC SECONDS IN AZIMUTH

## STS-1 HARDWARE TREND DATA (COND)

### STAR TRACKER

- FIRST ALINEMENT TORQUING ANGLES AVERAGE .7 SIGMA
- IMU ALINEMENT REPEATABILITY ABOUT AS EXPECTED  
AVE OF .02 DEG
- STAR ANGLE SEPARATION CHECKS USUALLY WITHIN .01 DEG

### COAS

- FWD STATION COAS TO NAV BASE BIAS ALINEMENT OF .27 DEGREES, AND STABLE THROUGHOUT MISSION
- ABOUT EQUIVALENT TO STAR TRACKER FOR ORBIT ALINE ACCURACY

# **HIGHLIGHTS FROM PROPULSION AND POWER DIVISION SUBSYSTEMS STS-1 PERFORMANCE PROBLEMS/ANOMALIES/FUNNIES**

- **MAIN PROPULSION SYSTEM (MPS)**
- **ORBITAL MANEUVERING SYSTEM (OMS)**
- **REACTION CONTROL SYSTEM (RCS)**
- **AUXILIARY POWER SYSTEM (APUS)**
- **HYDRAULIC SYSTEM (HYDRAULICS)**
- **PYROTECHNIC SYSTEM (PYROS)**
- **CRYOGENICS STORAGE SYSTEM (PRSD)**
- **FUEL CELLS (EPG)**

**PRESENTOR: HUBERT J. BRASSEAU**



# **MAIN PROPULSION SUBSYSTEM (MPS)**

## **STS-1 PERFORMANCE PROBLEMS/ANOMALIES/FUNNIES**

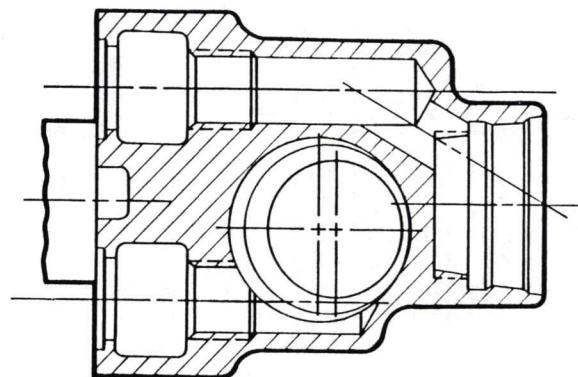
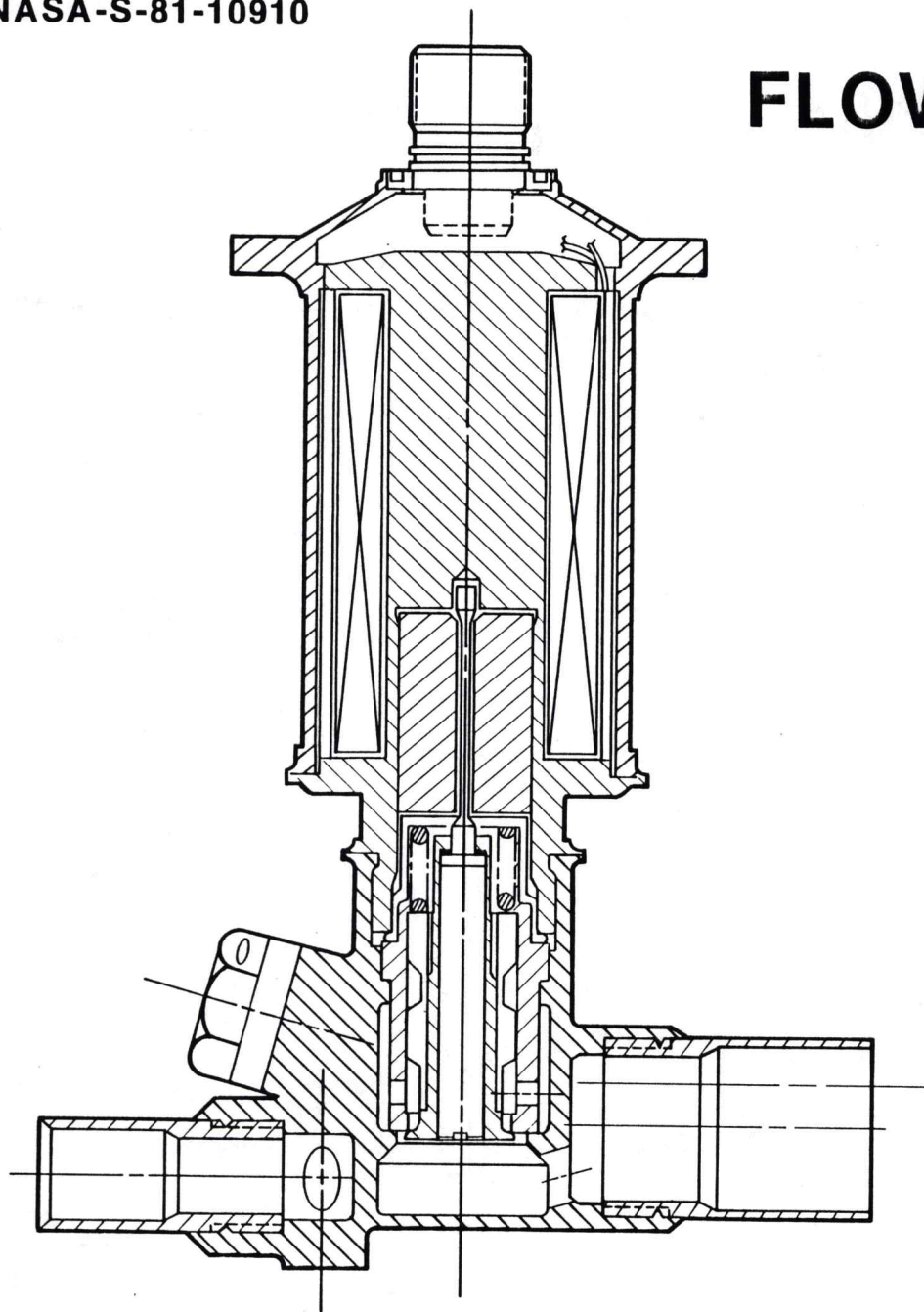
### **● INFLIGHT**

- SYSTEM NO.1 GO<sub>2</sub> PRESSURIZATION FLOWRATE LOWER THAN NOMINAL (ALSO OCCURRED DURING FRF STILL UNDER INVESTIGATION)**
- GH<sub>2</sub> SYSTEM NO. 2 PRESSURE AND TEMPERATURE TRANSDUCERS FAILED (ALSO FAILED DURING TESTS AT MPT)**
- HYDROGEN REPLENISH VALVE CLOSED SLOW POSTDUMP (SUSPECT MICROSWITCH TEMPERATURE PROBLEM - OCCURRED DURING MPT TESTING)**
- MIXTURE RATIO HIGH - CAUSED FROM CHAMBER PRESSURE TRANSDUCER SHIFT**

NASA-S-81-10910

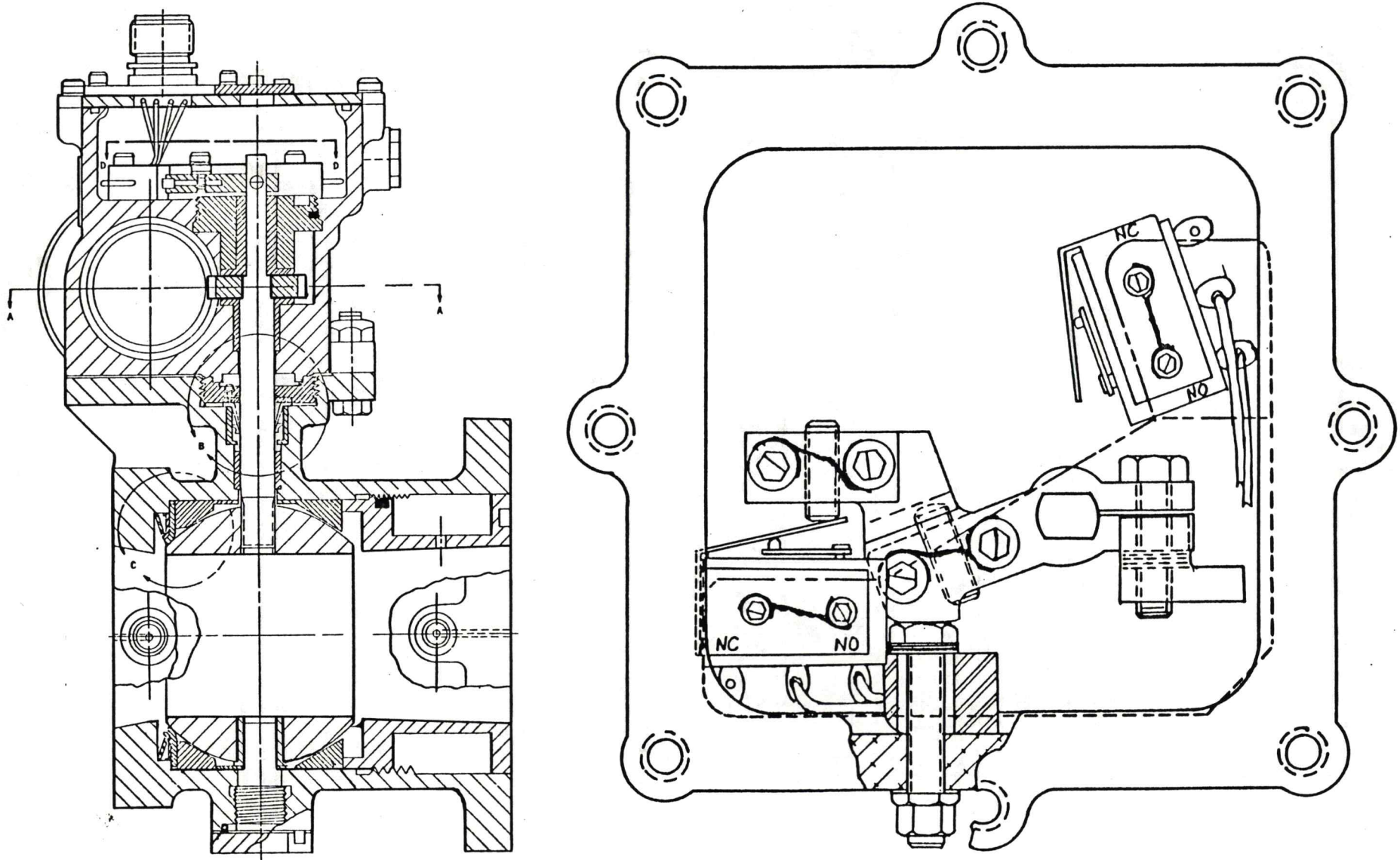
# FLOW CONTROL VALVE

MC-280-0017



# BALL VALVE

## TYPE I VALVE SWITCH CONFIGURATION

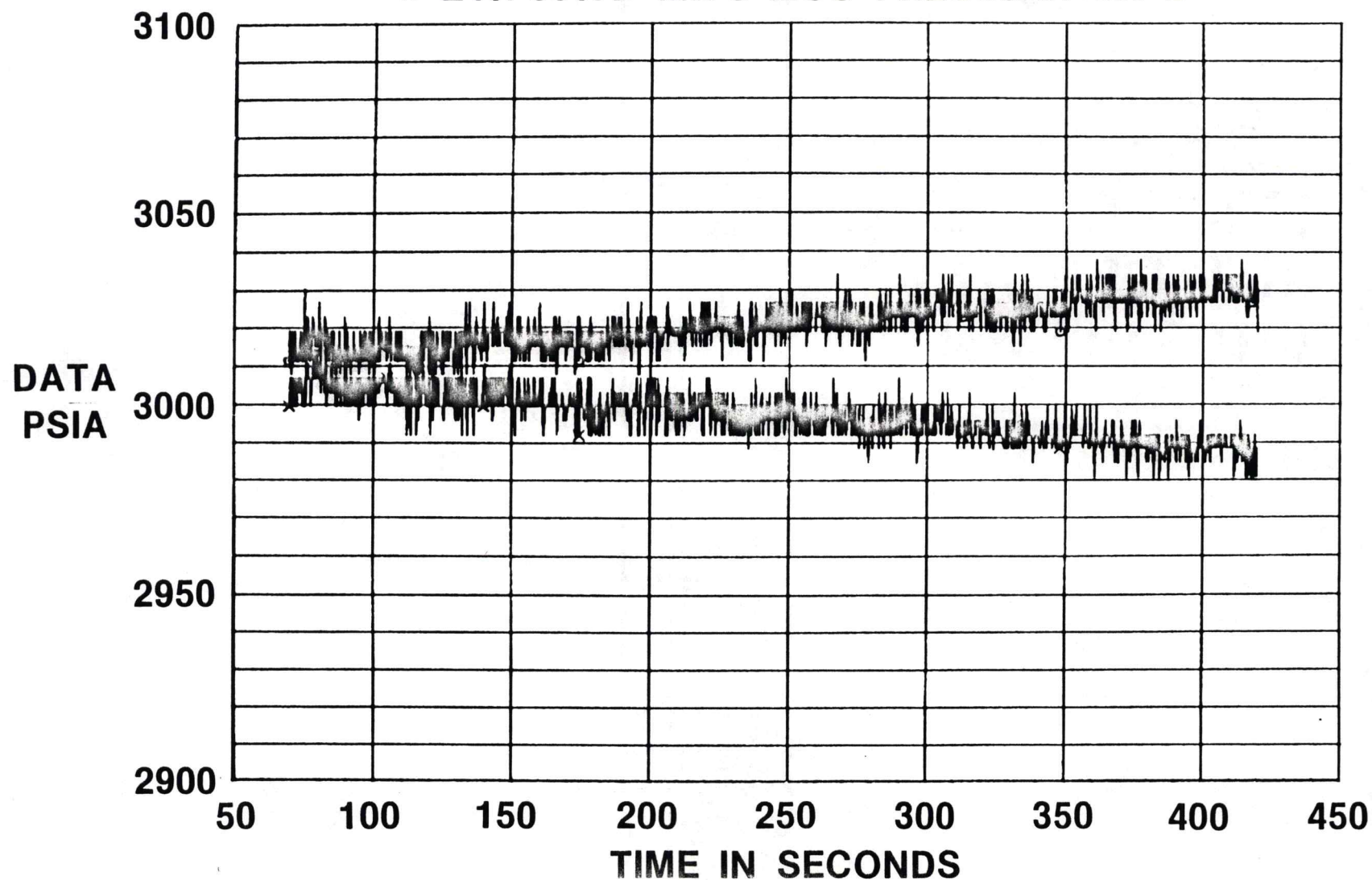




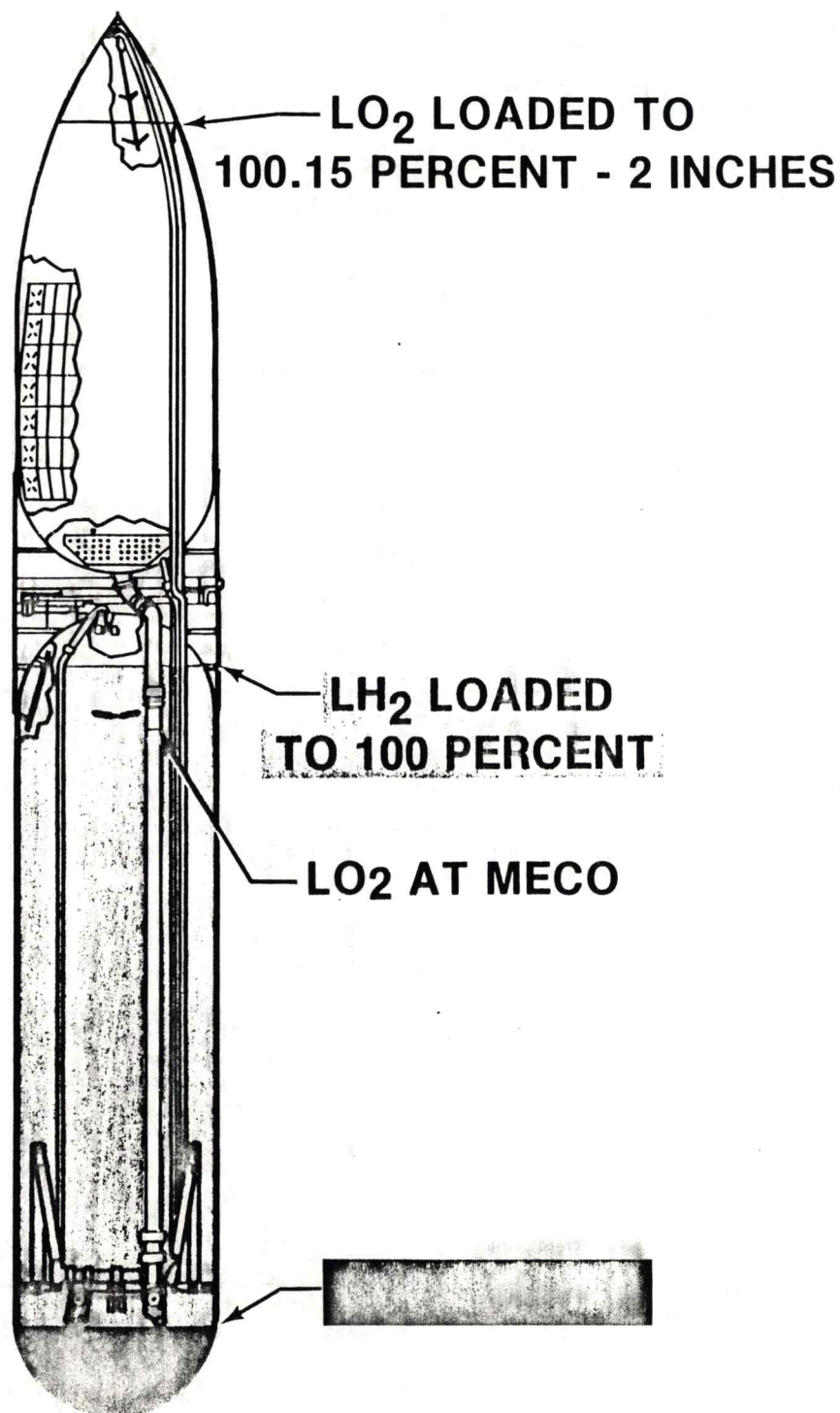
## SSME CHAMBER PRESSURE

○ E41P3016D ME-3 MCC PRESSURE CH A

× E41P3017D ME-3 MCC PRESSURE CH B



# MPS LOADED CUT-OFF AND PROPELLANT LEVELS



# **ORBITAL MANEUVERING SUBSYSTEM (OMS) STS-1 PERFORMANCE PROBLEMS/ANOMALIES/FUNNIES**

## **● INFLIGHT**

- RT OME OXIDIZER FLOW DROPPED DURING OMS - 1 BURN AND  
SUBSEQUENT BURNS (UNDER INVESTIGATION)**
- OMS FUEL AND OXIDIZER QUANTITY GAGES DID NOT RESPOND  
ACCURATELY**

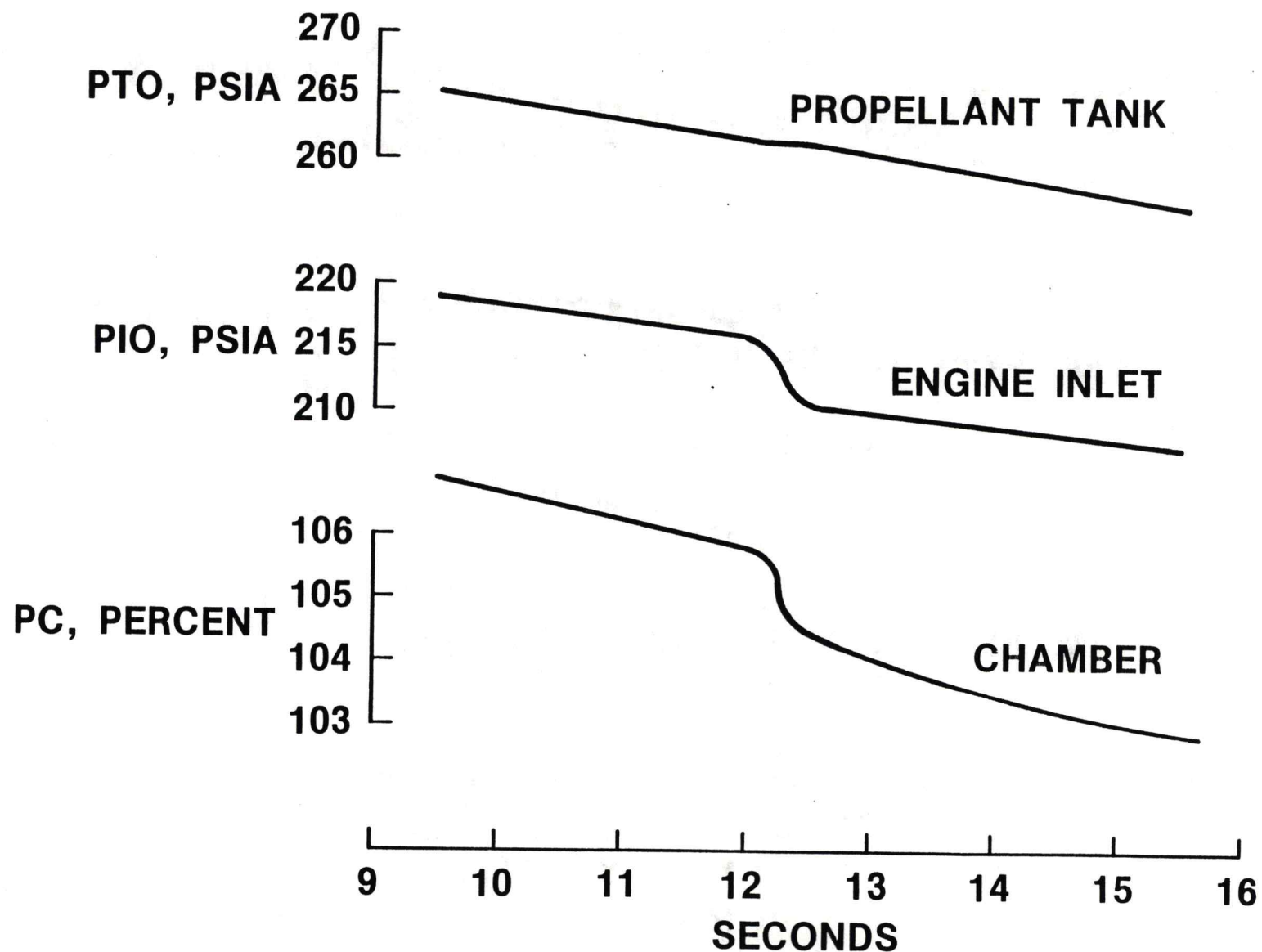
## **● POSTFLIGHT**

- OME NOZZLE DFI TEMPERATURES EXCEEDED LIMITS DURING  
ASCENT**
- RT FUEL GAGE INOPERATIVE - SUSPECT BELLOWS FAILURE -  
FAILED DURING GROUND TEST**

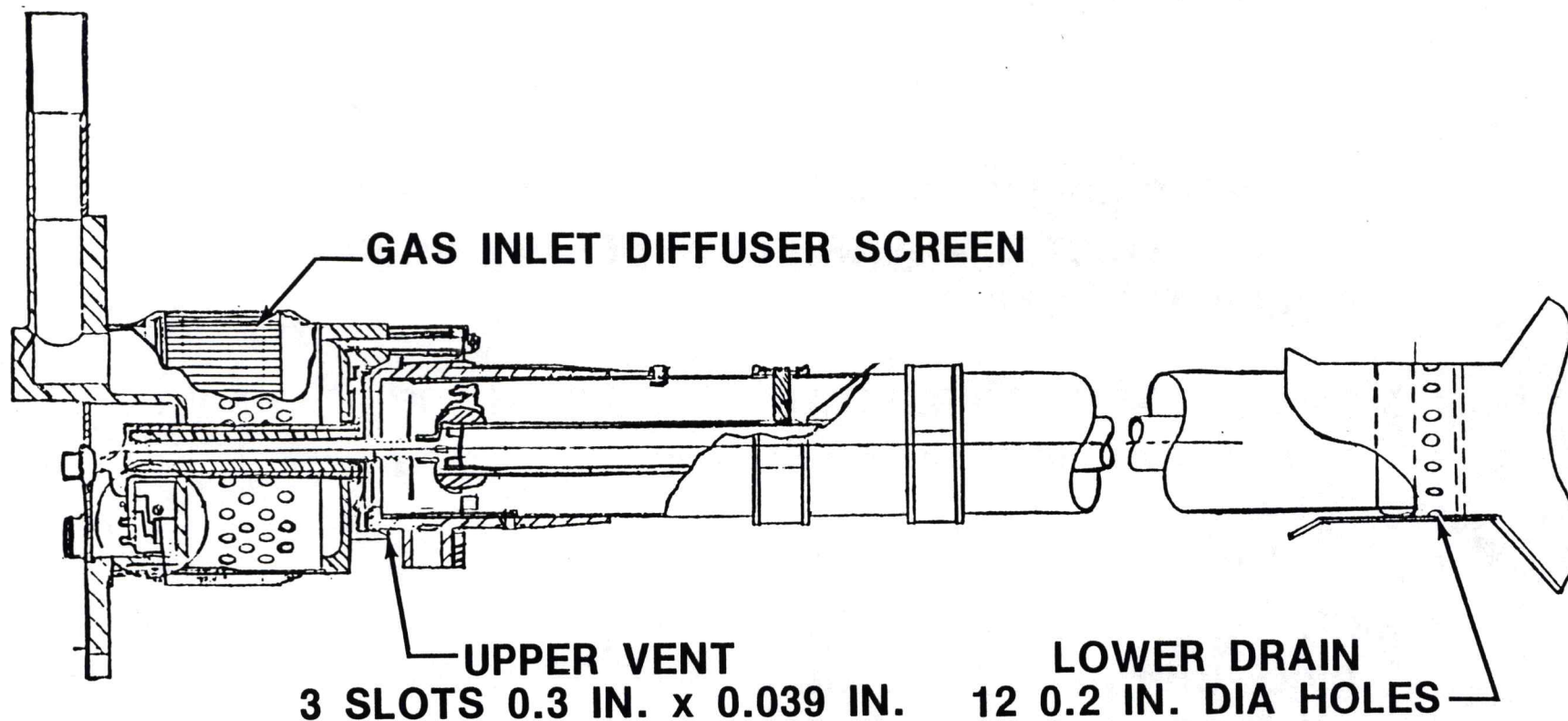


# OMS SYSTEM PRESSURES

## RIGHT OMS-1 BURN



# OMS PROPELLANT QUANTITY GAGING FORWARD FUEL PROBE



# **REACTION CONTROL SUBSYSTEM (RCS) STS-1 PERFORMANCE PROBLEMS/ANOMALIES/FUNNIES**

## **● INFLIGHT**

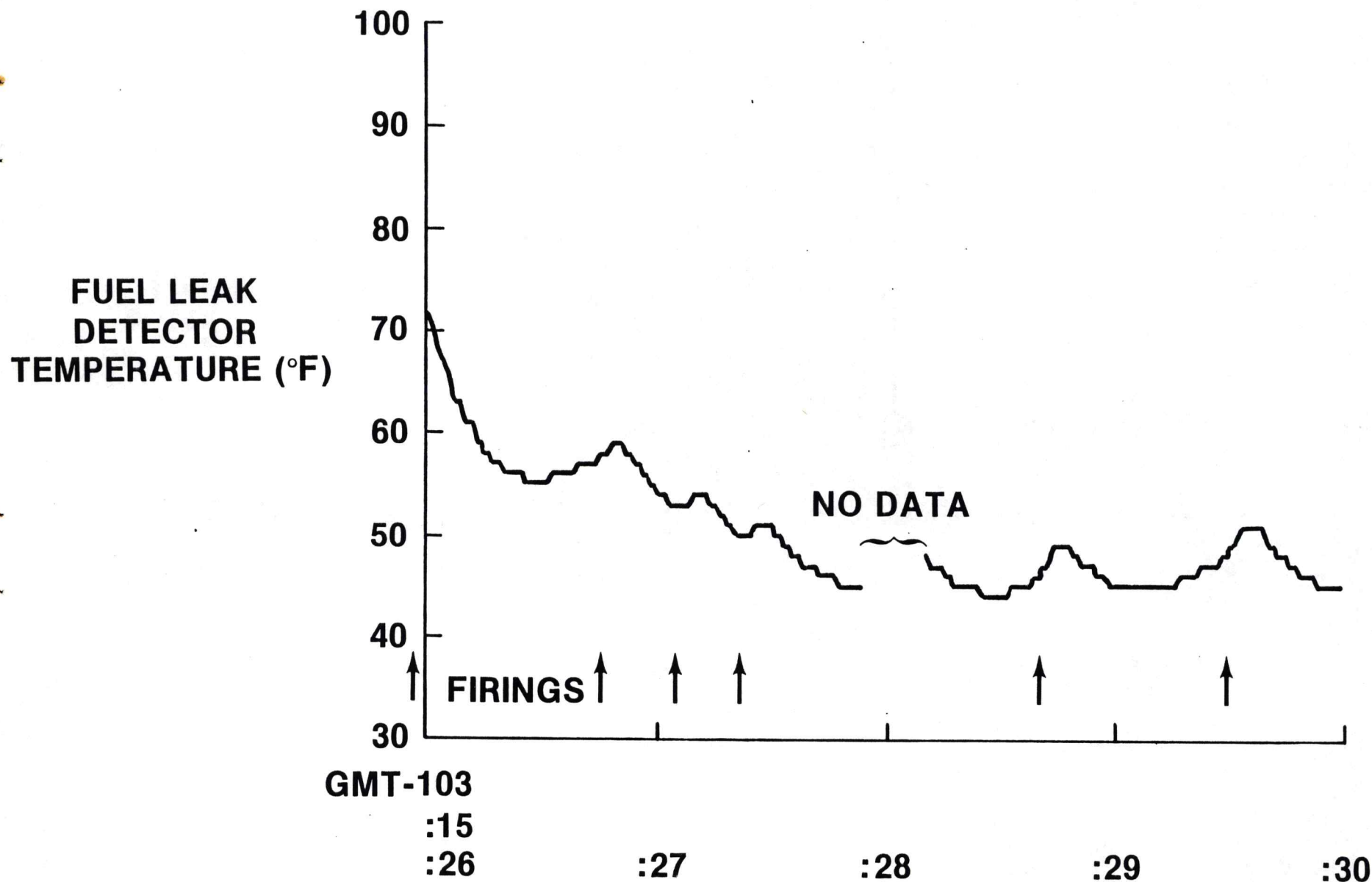
- FUEL SIDE DRIBBLE VOLUME EVAPORATIVE COOLING GREATER THAN PREDICTED - SENSOR USED FOR LEAK DETECTION COULD TRIP C&W**
- MCA DID NOT REMOVE POWER FROM RIGHT RCS TANK ISO VALVE MOTOR AFTER OPENING**

## **● POSTFLIGHT**

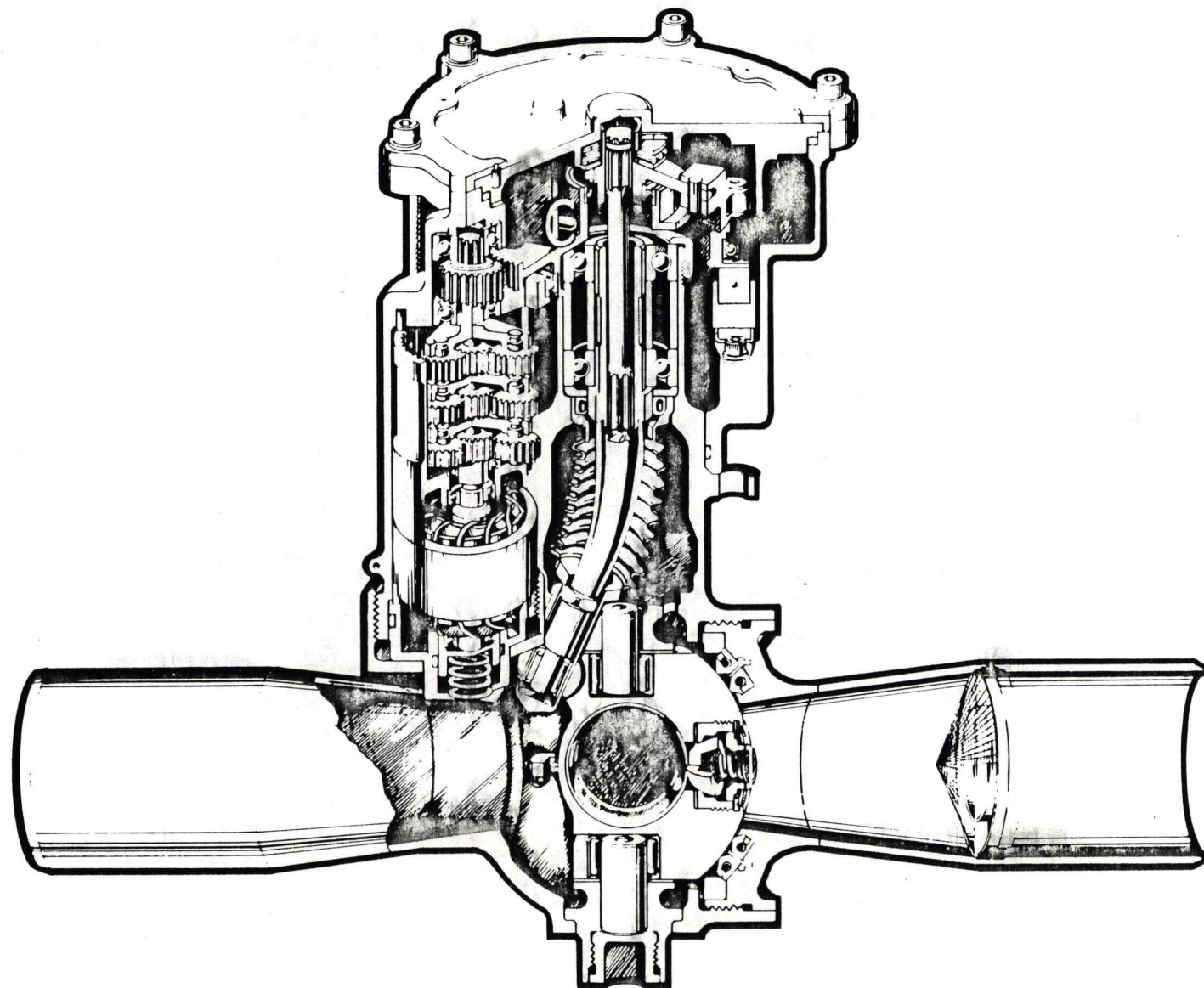
- RIGHT RCS TANK ISO VALVE FAILED OPEN DURING DESERVICING (WILL CHANGE ALL REMAINING ACTUATORS WITH NYLON GEARS TO STEEL GEARS)**



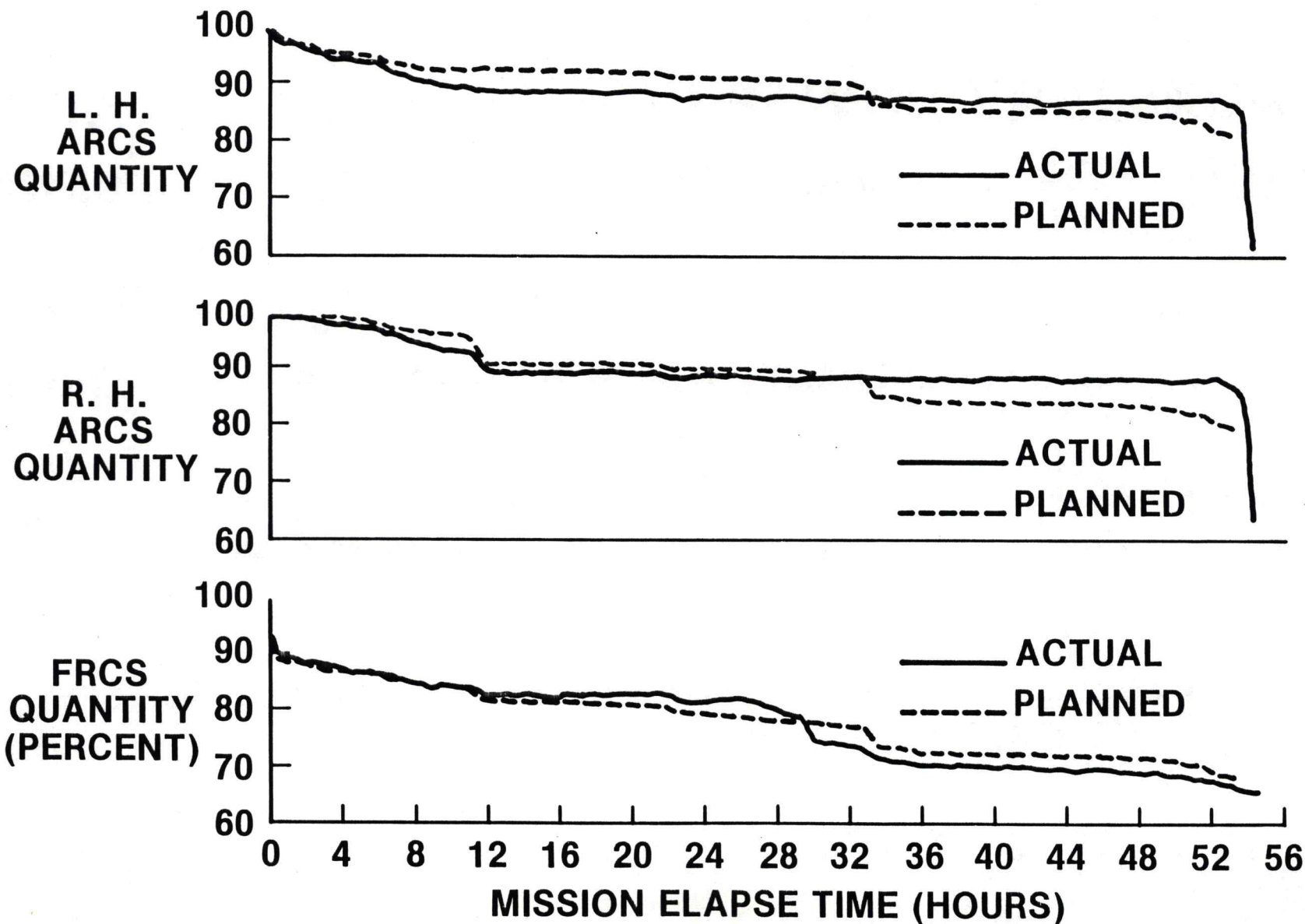
# L4D FUEL LEAK DETECTOR TEMP



# AC MOTOR VALVE



# RCS PROPELLANT CONSUMPTION





# **AUXILIARY POWER UNIT SUBSYSTEM (APUS) STS-1 PERFORMANCE PROBLEMS/ANOMALIES/FUNNIES**

## **● INFLIGHT**

- A & B GAS GENERATOR HEATER SYSTEMS FAILED ON APU NO. 2  
(UNDER INVESTIGATION)**
- APU NO. 1 HAD LOW PC DURING ON-ORBIT AND NO. 1 AND NO. 3  
DURING ENTRY START-UP (UNDER INVESTIGATION)**

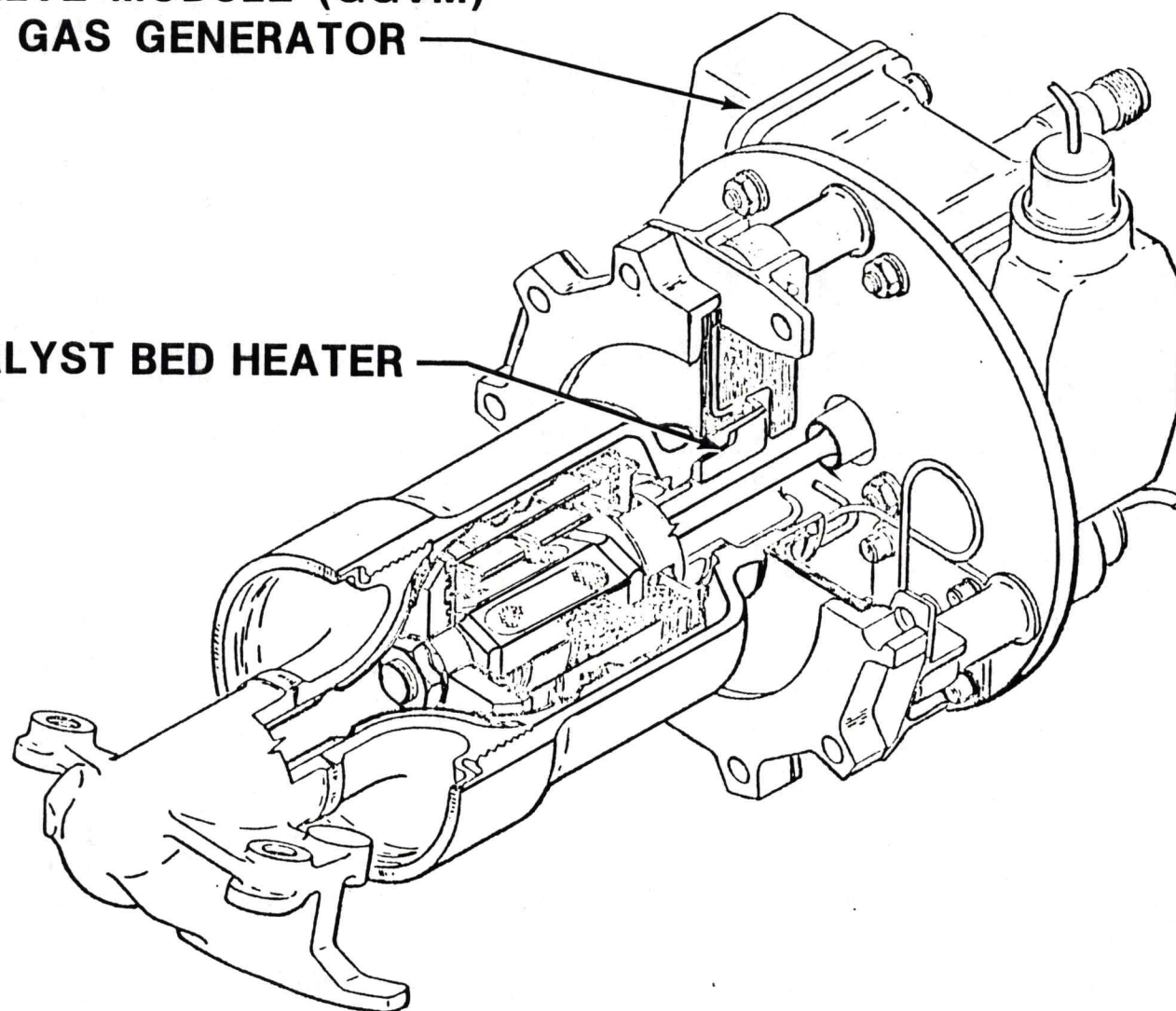
## **● POSTFLIGHT**

- SEAL CAVITY DRAIN RELIEF VALVES CRACKING OUT OF SPEC -  
13 PSIG TO 21 + PSIG**

# GAS GENERATOR SUBASSEMBLY

VALVE MODULE (GGVM)  
GAS GENERATOR

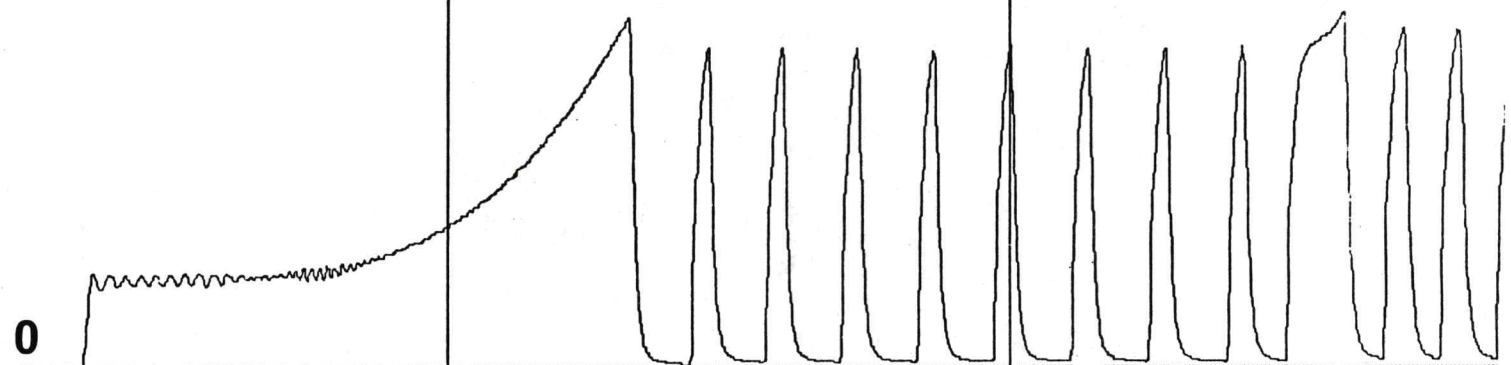
CATALYST BED HEATER



# APU

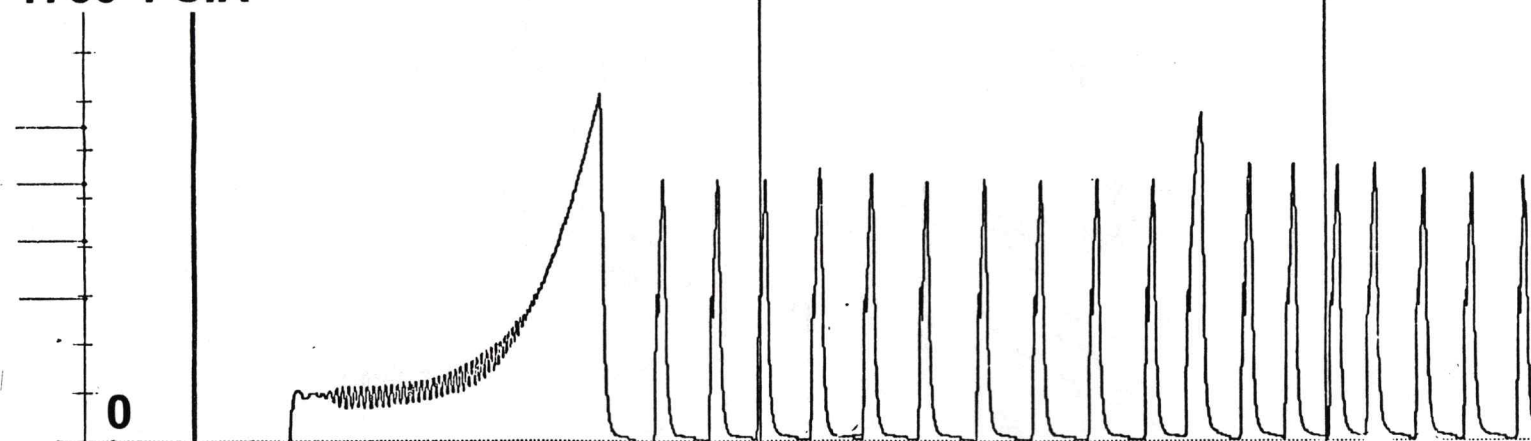
NORMAL  $P_c$

1750 PSIA



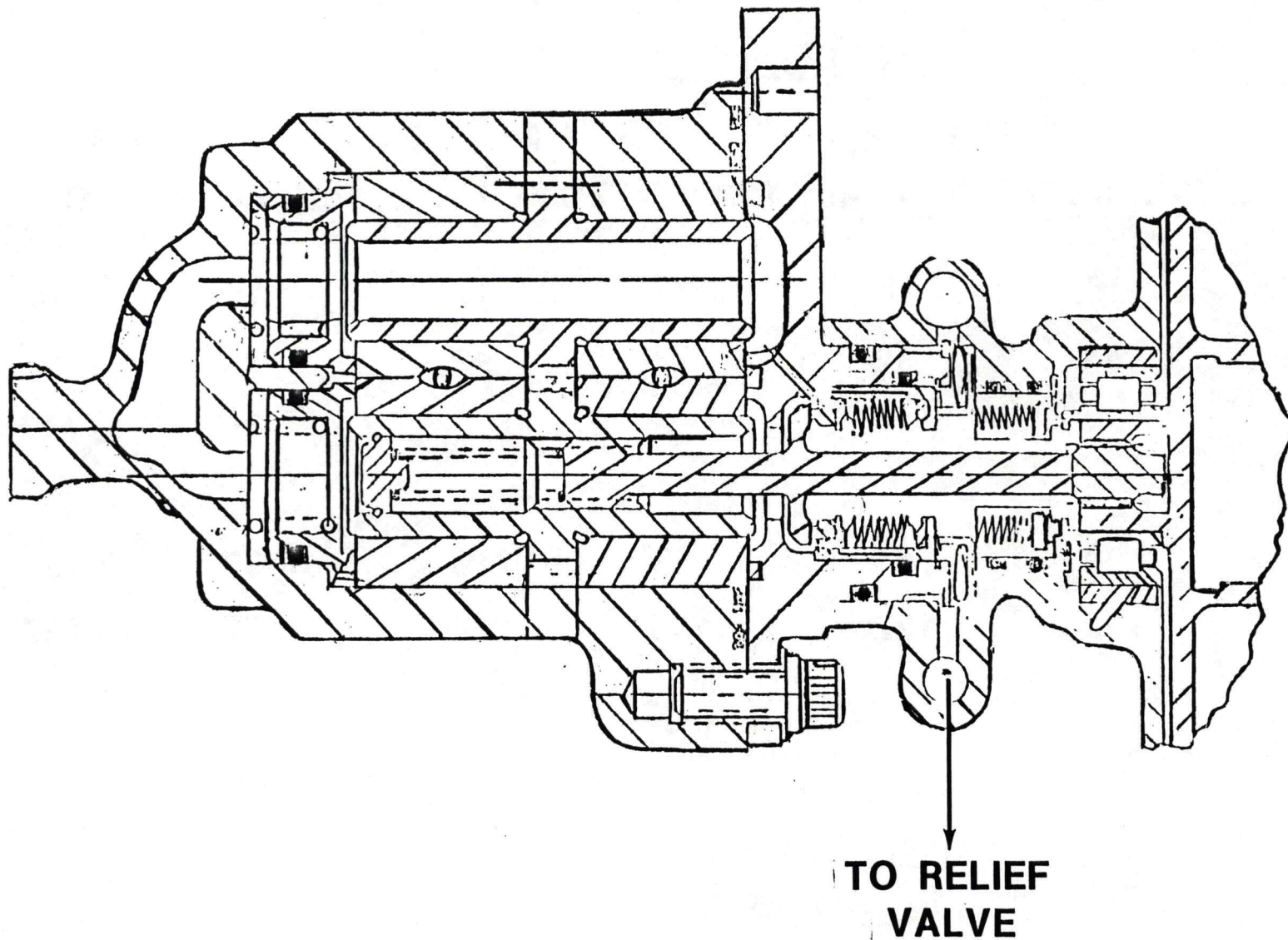
LOW  $P_c$

1750 PSIA





# SPACE SHUTTLE APU FUEL PUMP



# APU STS-1 CONSUMABLES

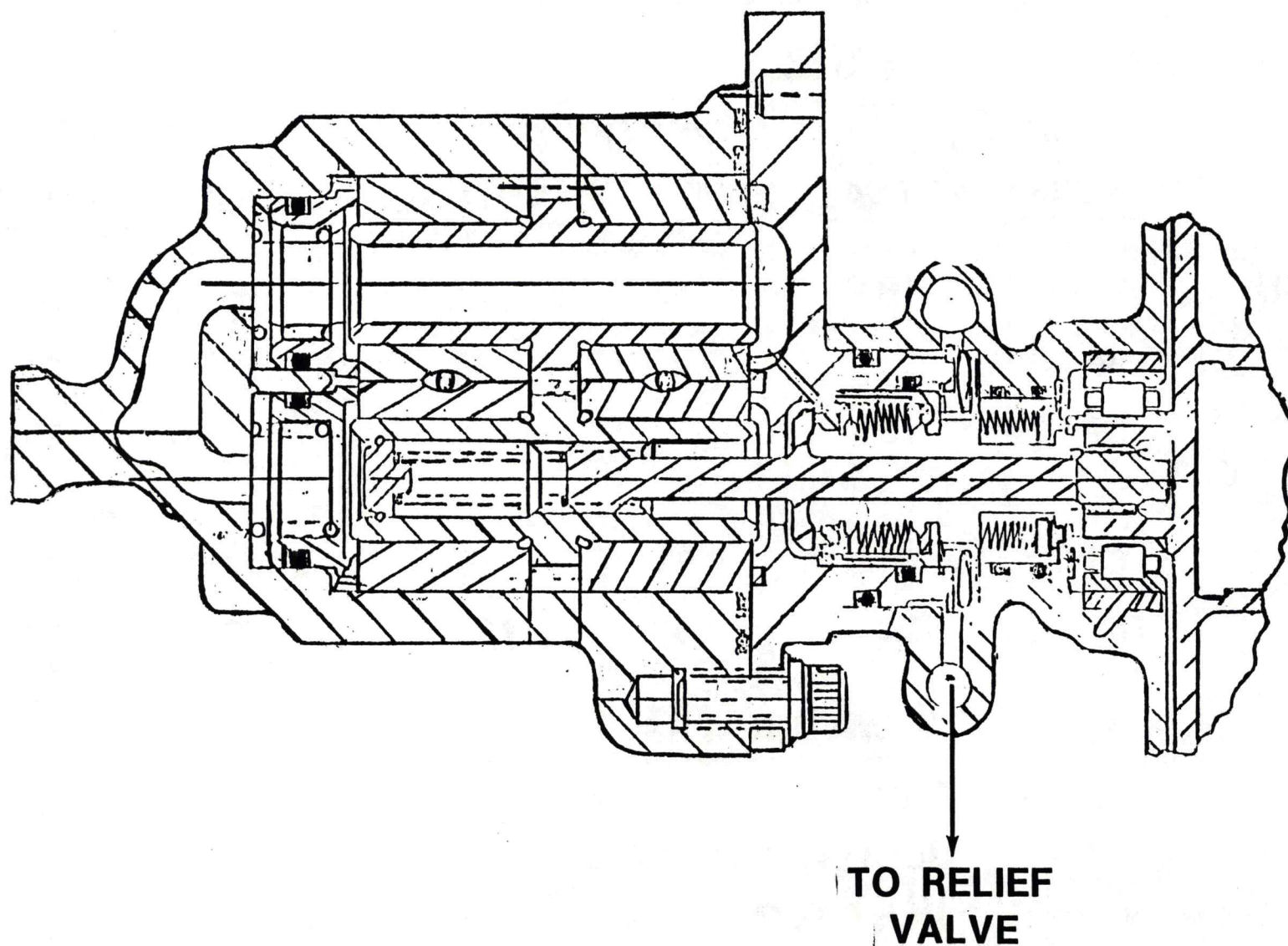
## FUEL, LBS

	APU 1		APU 2		APU 3	
	<u>PREDICTED</u>	<u>ACTUAL</u>	<u>PREDICTED</u>	<u>ACTUAL</u>	<u>PREDICTED</u>	<u>ACTUAL</u>
PRELAUNCH	18	18	17	17	16	16
ASCENT	44	32	41	33	39	34
ON-ORBIT CHECKOUT	7	8				
ENTRY	64	64	98	116	97	107
TOTAL	133	122	156	166	152	157

## WATER, LBS

PRIMARY	4.7
SECONDARY	1.6
INJECTOR	1.5

# SPACE SHUTTLE APU FUEL PUMP





# APU STS-1 CONSUMABLES

## FUEL, LBS

	APU 1		APU 2		APU 3	
	<u>PREDICTED</u>	<u>ACTUAL</u>	<u>PREDICTED</u>	<u>ACTUAL</u>	<u>PREDICTED</u>	<u>ACTUAL</u>
PRELAUNCH	18	18	17	17	16	16
ASCENT	44	32	41	33	39	34
ON-ORBIT CHECKOUT	7	8				
ENTRY	64	64	98	116	97	107
TOTAL	133	122	156	166	152	157

## WATER, LBS

PRIMARY	4.7
SECONDARY	1.6
INJECTOR	1.5

# HYDRAULICS

## STS-1 PERFORMANCE PROBLEMS/ANOMALIES/FUNNIES

### ● PREFLIGHT

- SYSTEM NO. 3 CIRCULATION PUMP START TIME NOW 43 SECONDS - WAS 21 SECONDS FOR FRF - SHOULD START 0.3 SECONDS - (SUSPECT MOTOR ELECTRONICS)

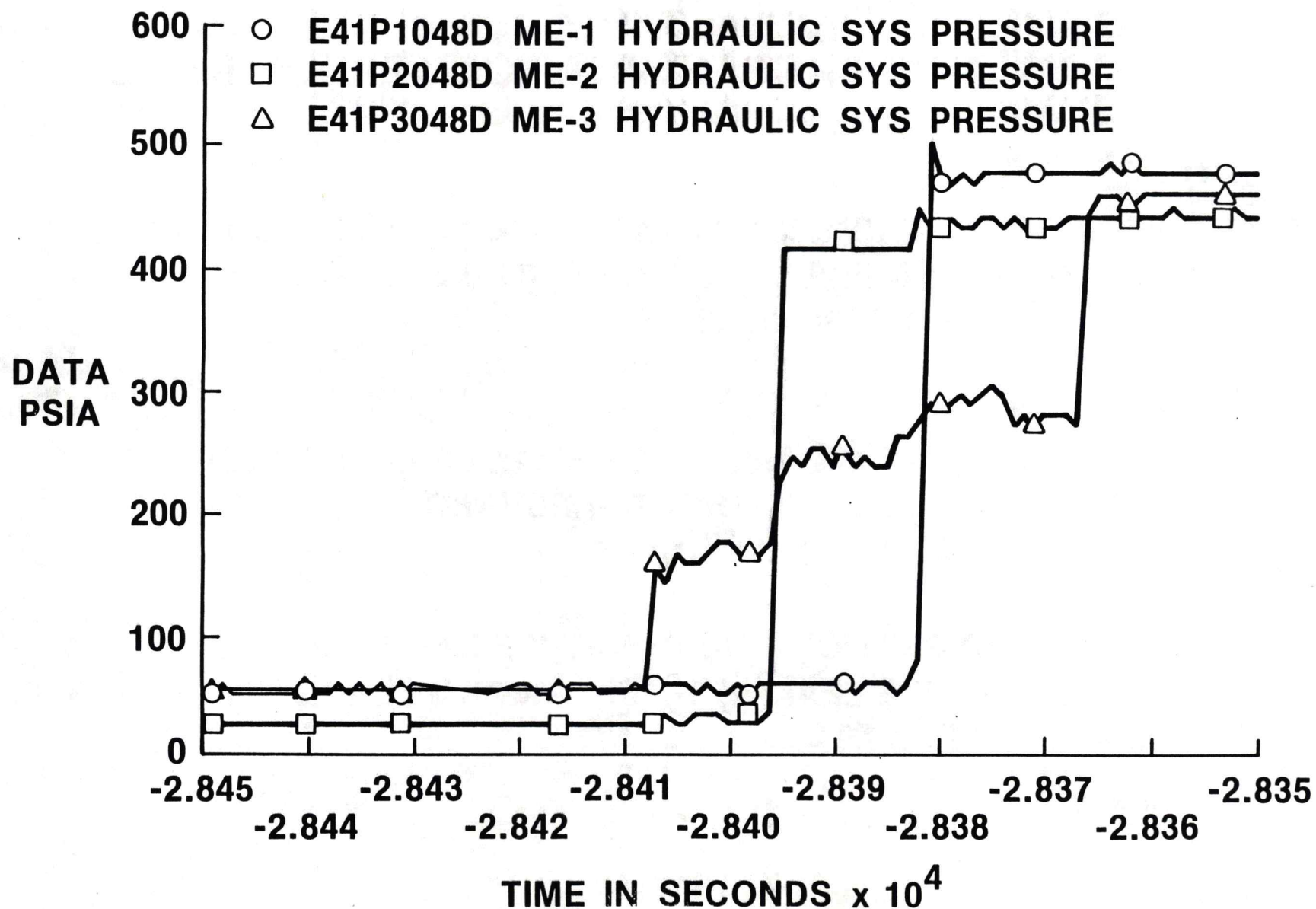
### ● INFLIGHT

- PRECHARGE POOL FROZE ON ALL THREE WATER SPRAY BOILERS - QUAL WAS ACCOMPLISHED WITHOUT PRECHARGE

### ● POSTFLIGHT

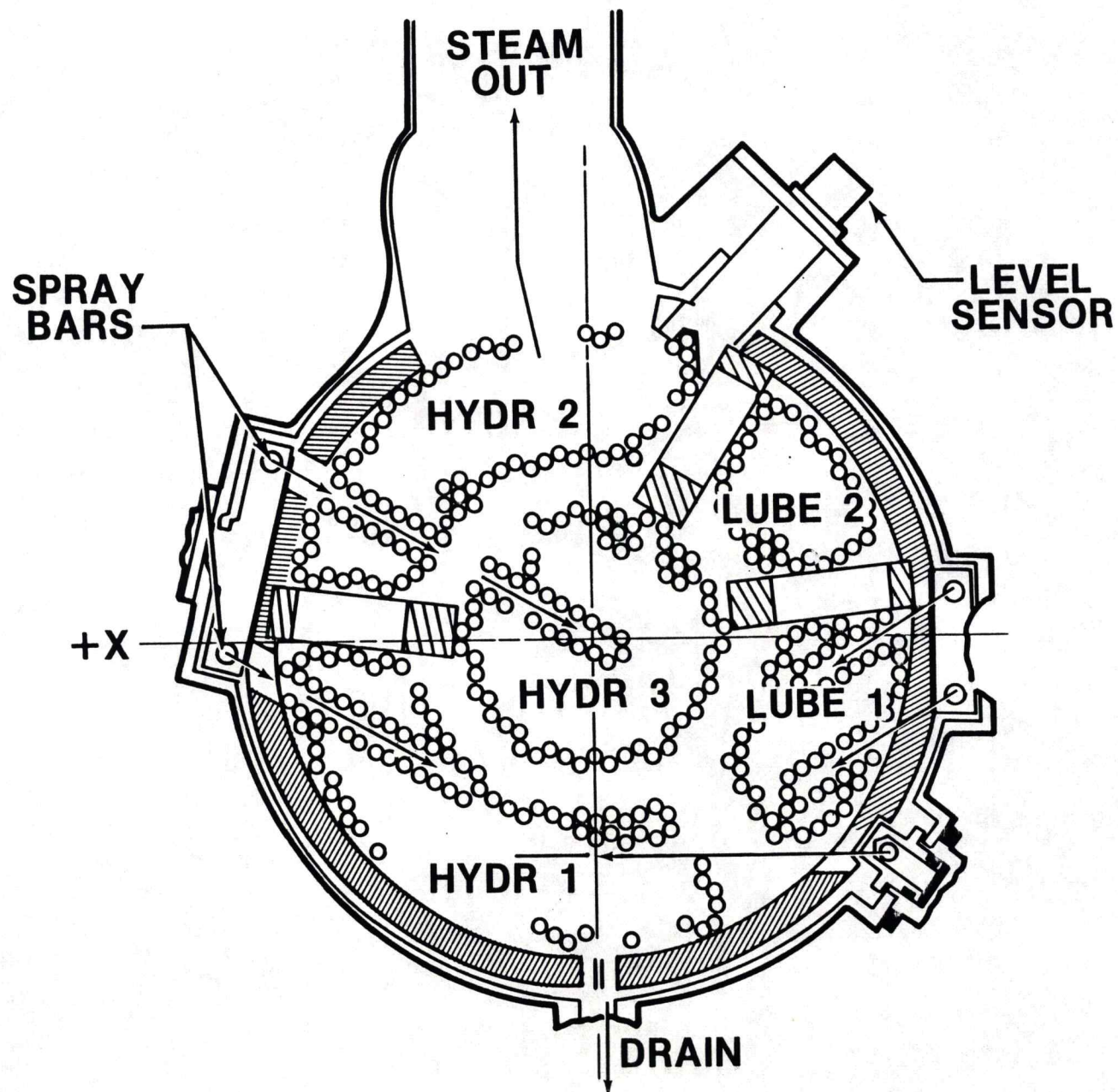
- SYSTEM NO. 1 PUMP SUCTION LINE DYNATUBE HAD LARGE LEAK - RETORQUED DYNATUBE LEAK STOPPED - RECOMMEND LOCK WIRING, PUMP DYNATUBES FOR STS-2

# PRELAUNCH CIRC PUMP START STS-1



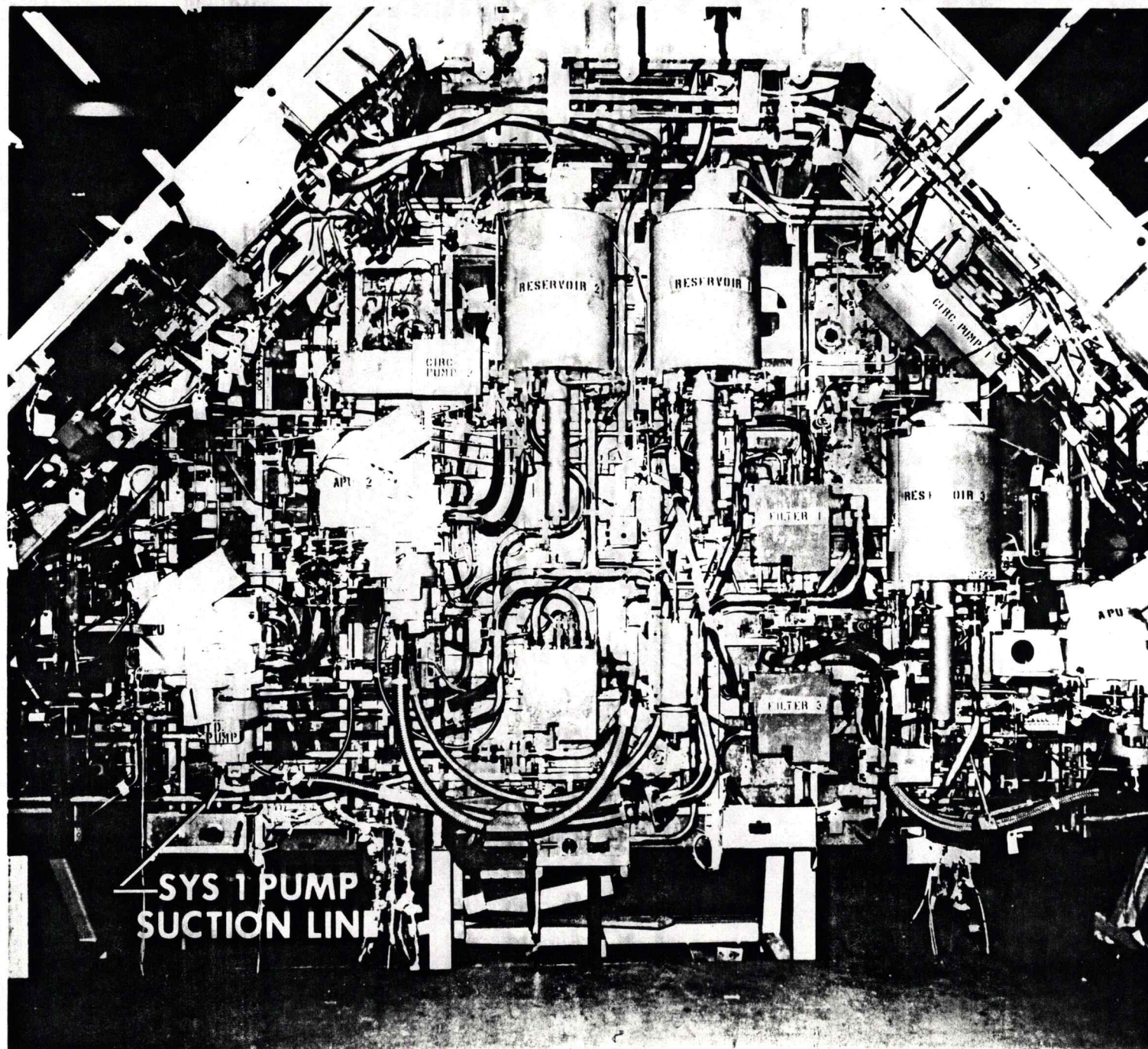


# WATER BOILER





# MANUFACTURING AID SHOWS HYDRAULIC INSTL ON 1307 BULKHEAD



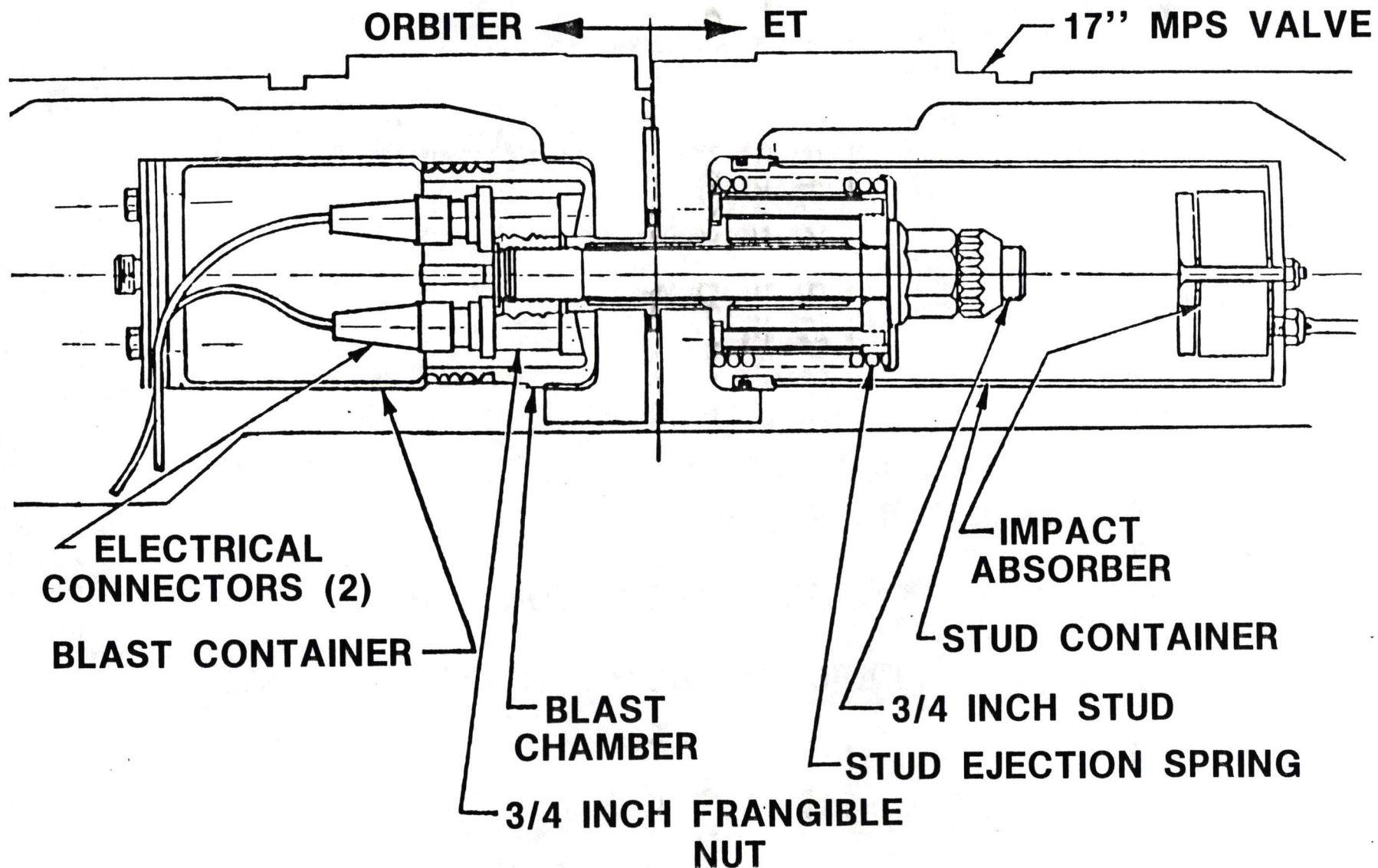
# **PYROTECHNICS**

## **STS-1 PERFORMANCE PROBLEMS/ANOMALIES/FUNNIES**

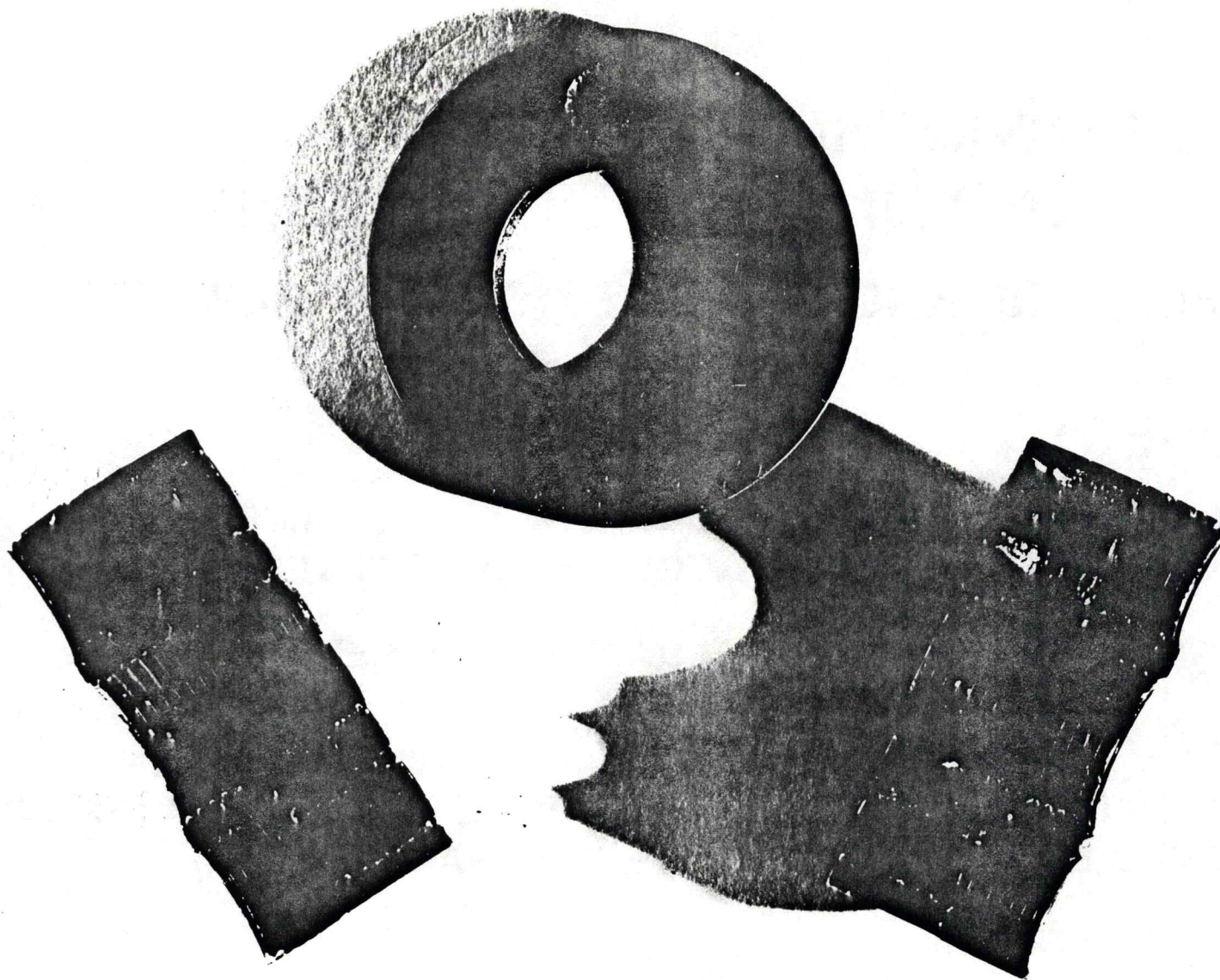
- **INFLIGHT**
  - **NONE**
- **POSTFLIGHT**
  - **REDUNDANT PYRO NOT FIRED IN ONE RELEASE NUT FOR ET UMBILICAL CARRIER PLATE**
  - **ET TUMBLE VALVE FAILED - USES NSI/DETONATOR**
    - **ACCEL DATA INDICATES DETONATOR FUNCTIONED**



# ORBITER/ET UMBILICAL RETENTION/RELEASE DESIGN CONFIGURATION



# LEFT AFT (H<sub>2</sub>) - STS-1



LEFT AFT (H<sub>2</sub>) STS - 1

MC. 114-0018-0003 L/N WCP S/N 13

# **POWER REACTANT STORAGE AND DISTRIBUTION (PRSD)**

## **STS-1 PERFORMANCE PROBLEMS/ANOMALIES/FUNNIES**

### **● PREFLIGHT**

- PRELAUNCH HEAT LEAKS ABOUT TWICE EIAT VALUES (O<sub>2</sub> AND H<sub>2</sub>) (SERVICING VS. ACCEPTANCE TEST TECHNIQUE)**
- PURGE SAMPLES FAILED PRELOADING - PROCEDURE**

### **● INFLIGHT**

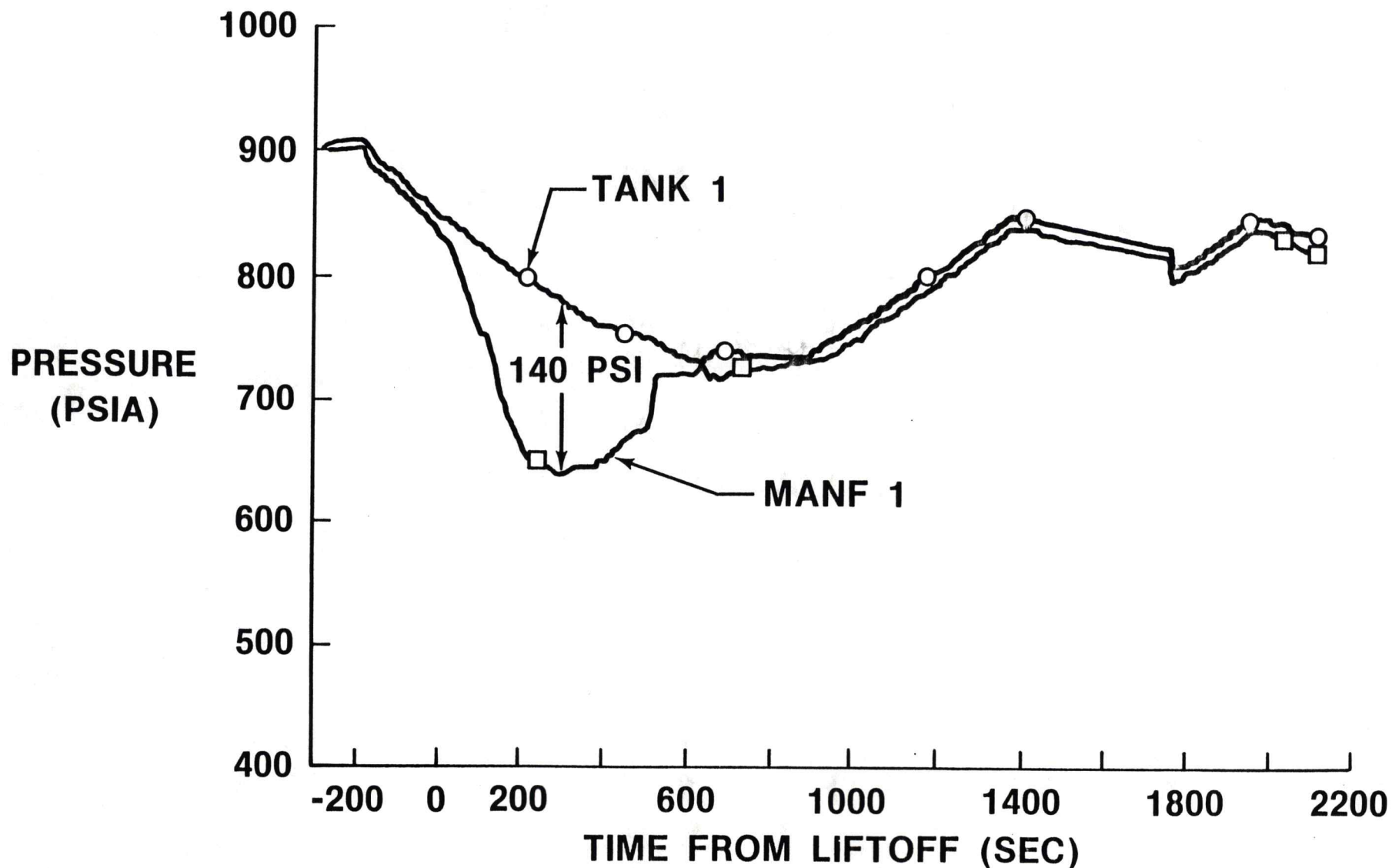
- BOTH O<sub>2</sub> MANIFOLD PRESSURES DROPPED BELOW TANK PRESSURES DURING BOOST - (TRANSDUCER THERMAL PROBLEM)**



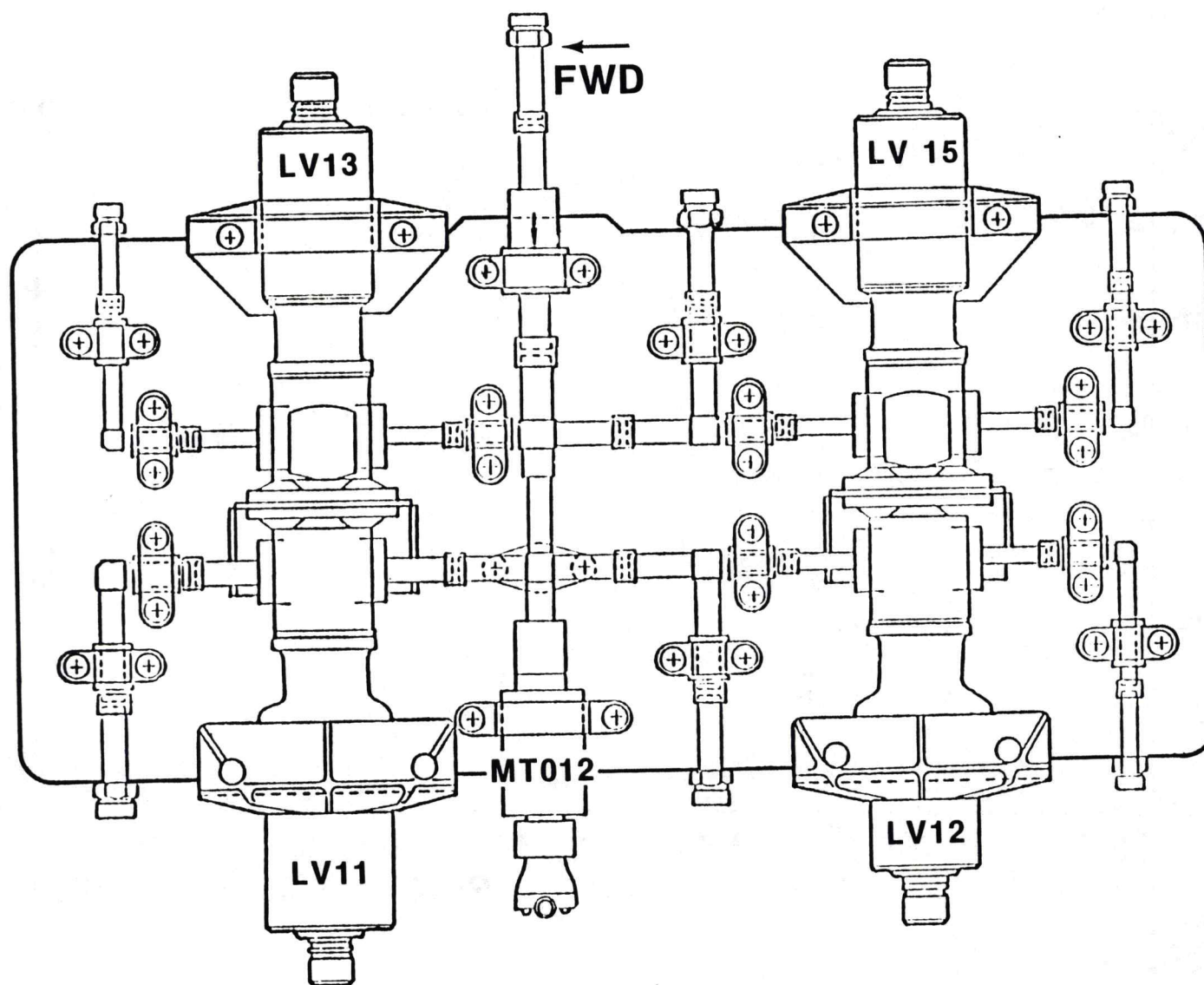
# PRSD CRYO TANK HEAT LEAK DURING STANDBY

	END ITEM ACCEPTANCE TEST (LB/HR)	STANDBY (LB/HR)
O <sub>2</sub> TANK 1	0.163	0.277
O <sub>2</sub> TANK 2	0.126	0.277
H <sub>2</sub> TANK 1	0.061	0.084
H <sub>2</sub> TANK 2	0.054	0.094

# O<sub>2</sub> PRSD PRESSURES DURING STS-1 ASCENT

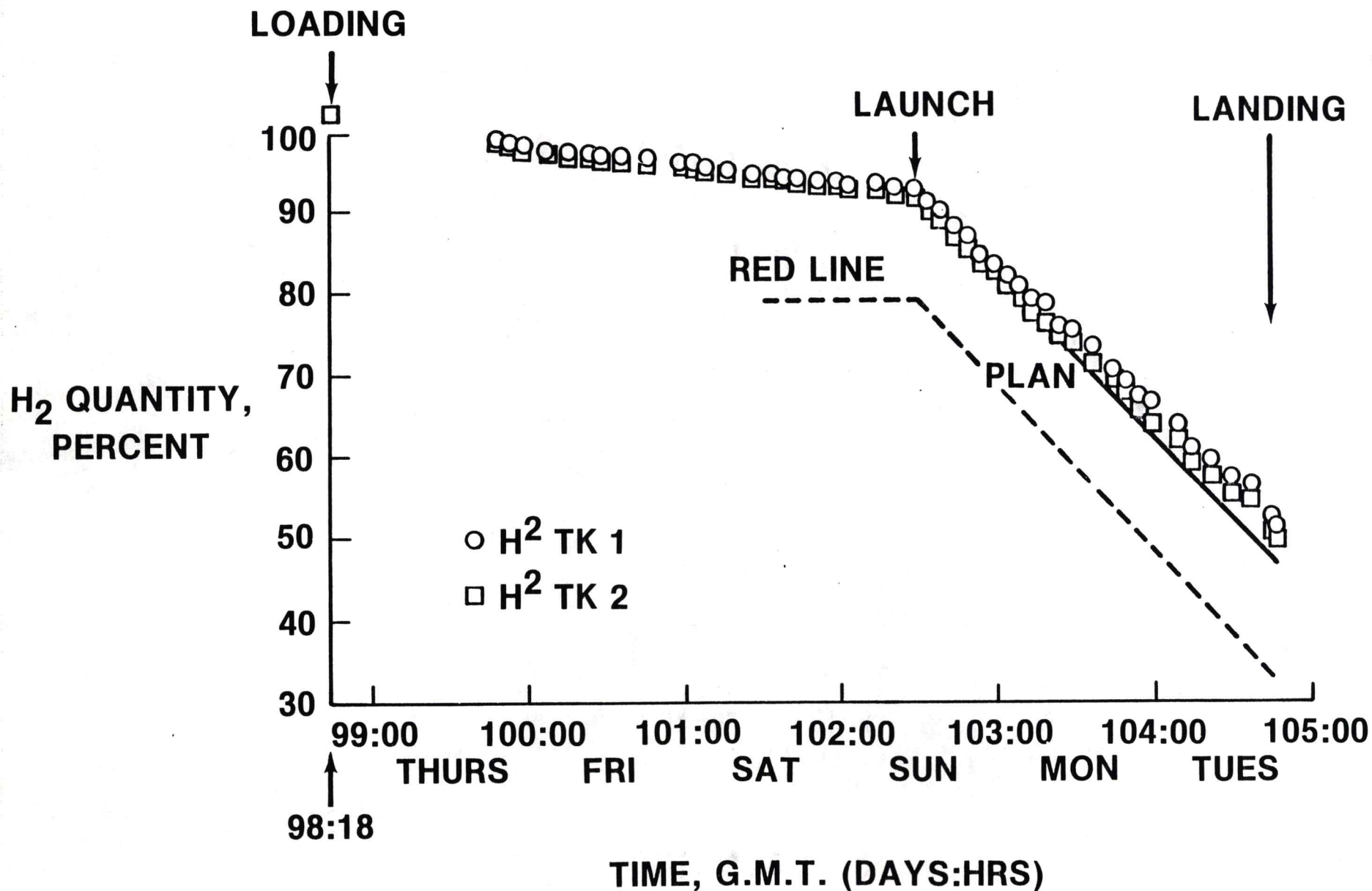


# PRSD O<sub>2</sub> MANIFOLD

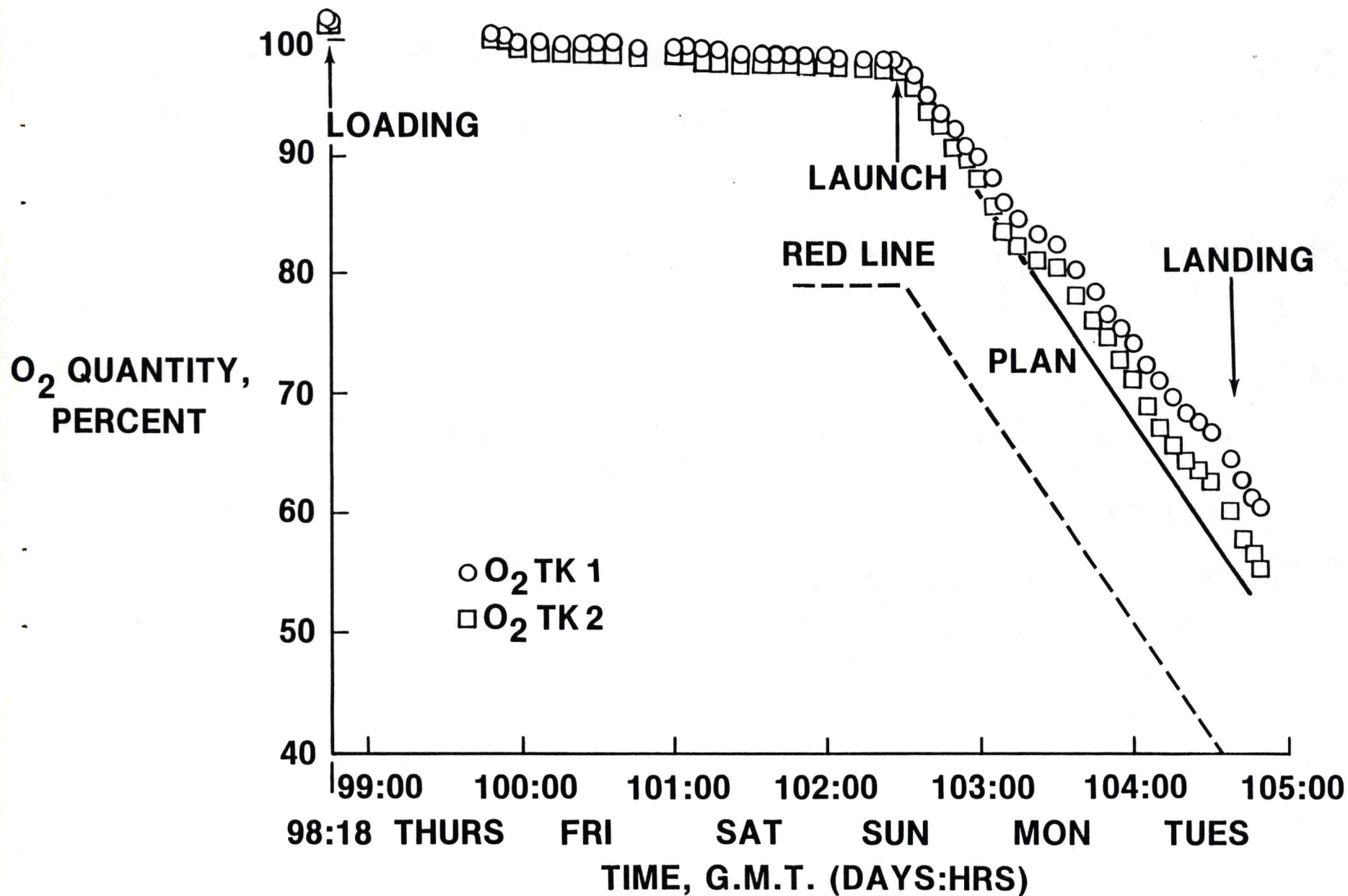




# HYDROGEN QUANTITY



# OXYGEN QUANTITY



# **ELECTRICAL POWER GENERATION (EPG)**

## **STS-1 PERFORMANCE PROBLEMS/ANOMALIES/FUNNIES**

- **PREFLIGHT**

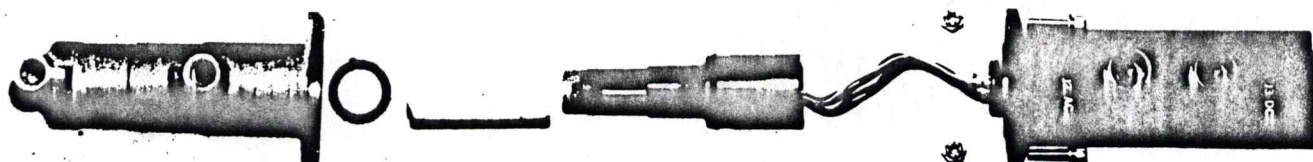
- **OUT OF LIMIT pH INDICATION**

- **INFLIGHT**

- **WATER RELIEF VALVE UNEXPECTEDLY VENTED ON-ORBIT  
AT 7:05 HRS MET - UNEXPLAINED (ALSO OCCURRED  
DURING FRF)**
- **AUTOMATIC FUEL CELL PURGE FAILED - KNOWN PREFLIGHT -  
FLOW METER CALIBRATION PROBLEMS - FLOW METER  
FEEDBACK BEING ELIMINATED BY SOFTWARE CHANGE**



# WATER PURITY MONITOR



HOUSING

SENSING PROBE

SIGNAL  
CONDITIONER

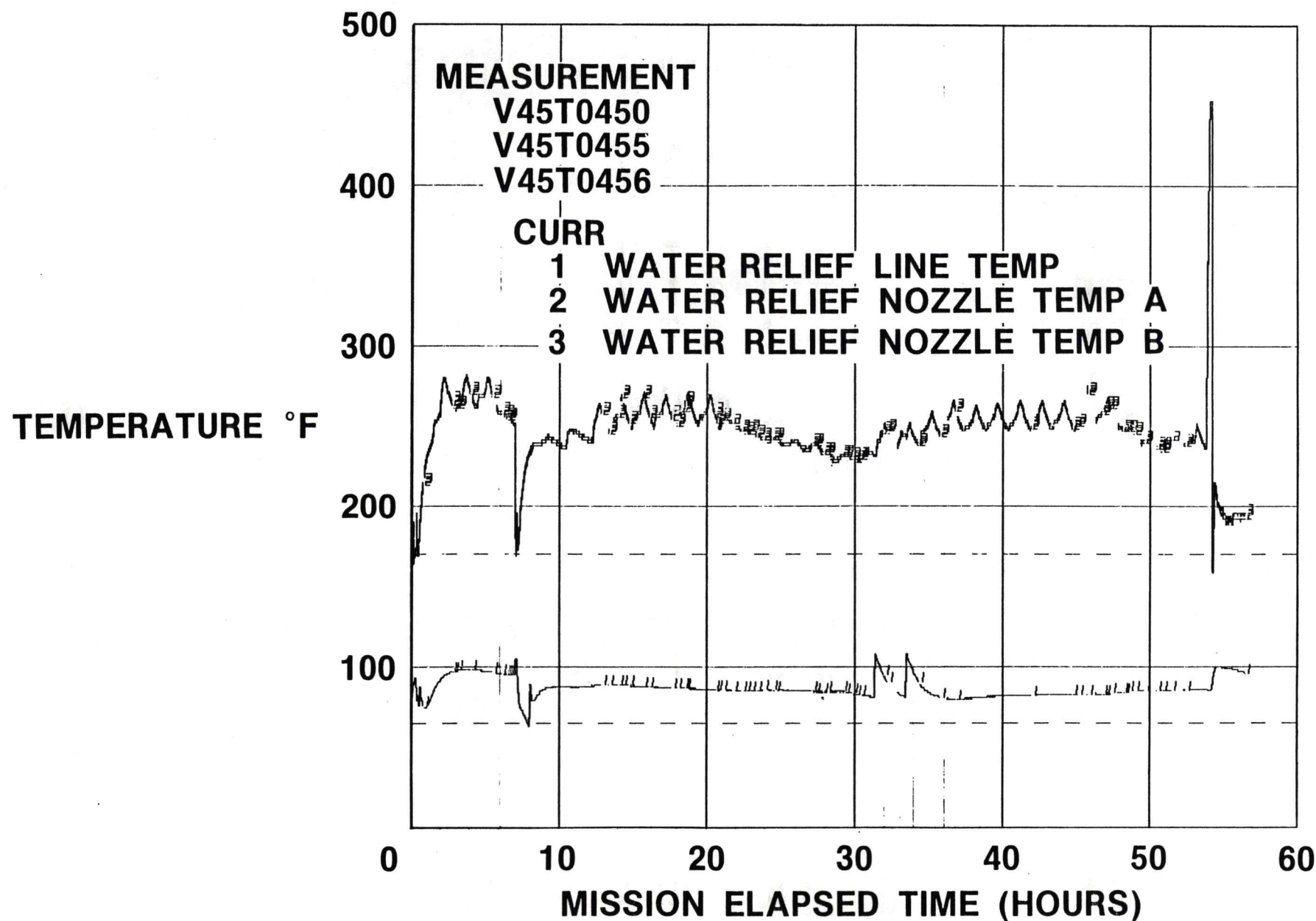
- **FUNCTION**

- CONTINUOUSLY MONITOR CONDUCTIVITY OF WATER PRODUCED BY POWERPLANT

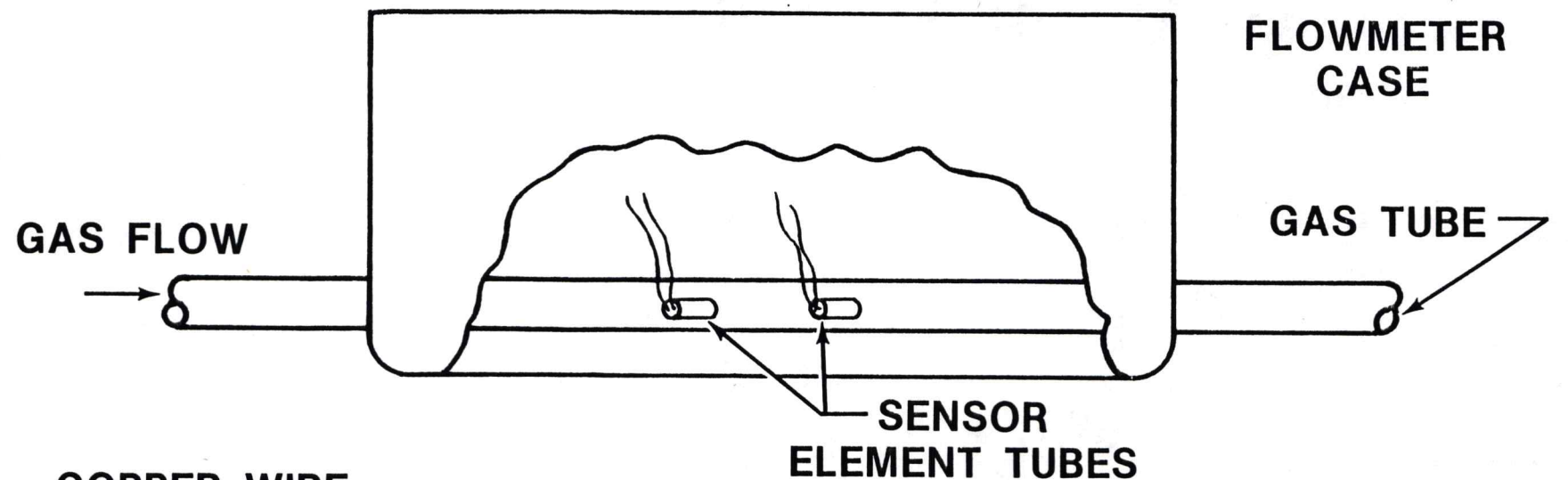
- **RANGE**

- PROVIDE SIGNAL IF CONDUCTIVITY OF WATER IS OUTSIDE RANGE EQUIVALENT TO pH OF 6-8

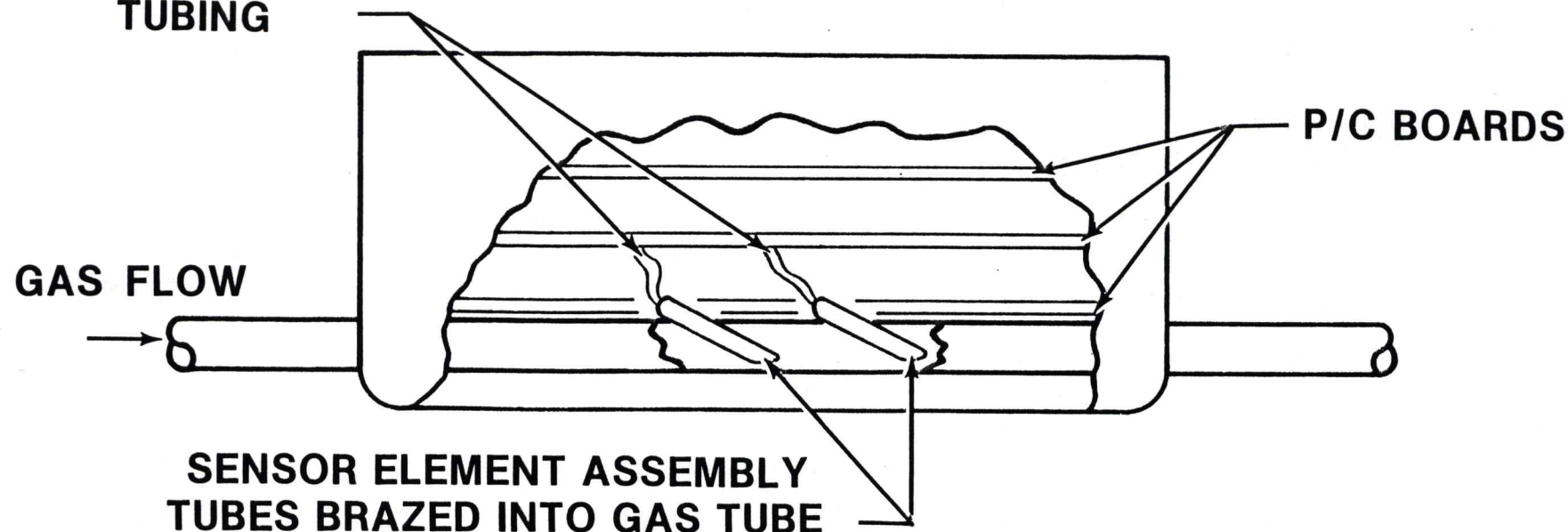
# EPG - WATER RELIEF NOZZLE TEMPERATURE



# REACTANT GAS MASS FLOWMETER

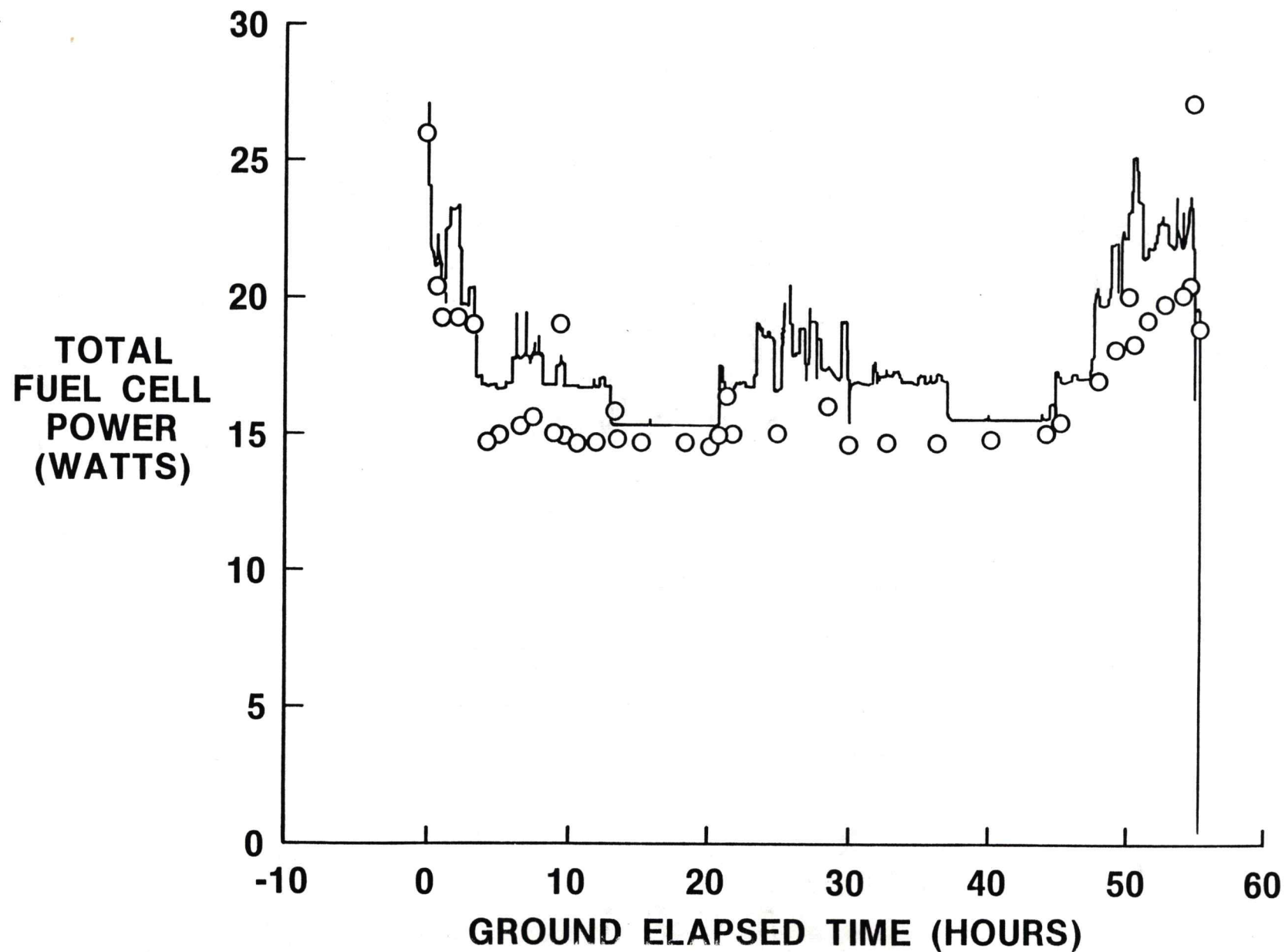


**COPPER WIRE  
WITH VARGLOSS  
TUBING**





# TOTAL FUEL CELL POWER



NASA-S-81-11027

**STS-1 ASSESSMENT OF TPS TILE  
DAMAGE CAUSED BY  
LAUNCH/ASCENT DEBRIS**

- ASCENT PERFORMANCE
  - PROPELLANT REMAINING
  - PITCH ATTITUDE ERROR
- SEPARATION - E/T TUMBLE VALUE
- ASCENT DEBRIS
- ENTRY
  - $\beta$  OSCILLATION
  - BODY FLAP DOWN
  - LOW TRANSONIC DAMPING
  - LANDING L/D



## ASCENT PERFORMANCE STATUS

- PREFLIGHT PREDICTIONS

- L-24 ATMOSPHERE
- L+15 MINUTE WIND
- 68° SRB

- LO<sub>2</sub>

16,024 LBS LOX REMAINING PREDICTED

12,668 LBS LOX REMAINING BASED ON ROCKWELL-MPS  
RECONSTRUCTION

3,356 EXCESS LOX CONSUMED

- LH<sub>2</sub>

4,169 LBS H<sub>2</sub> REMAINING PREDICTED

5,555 LBS H<sub>2</sub> REMAINING FROM FLOW METER DATA

1,386 EXCESS H<sub>2</sub> REMAINING

- PERFORMANCE STATUS

18,223 LOX + H<sub>2</sub> REMAINING FROM POST FLIGHT PROPULSION  
RECONSTRUCTION

- 20,193 LPX + H<sub>2</sub> PREDICTED TO BE REMAINING

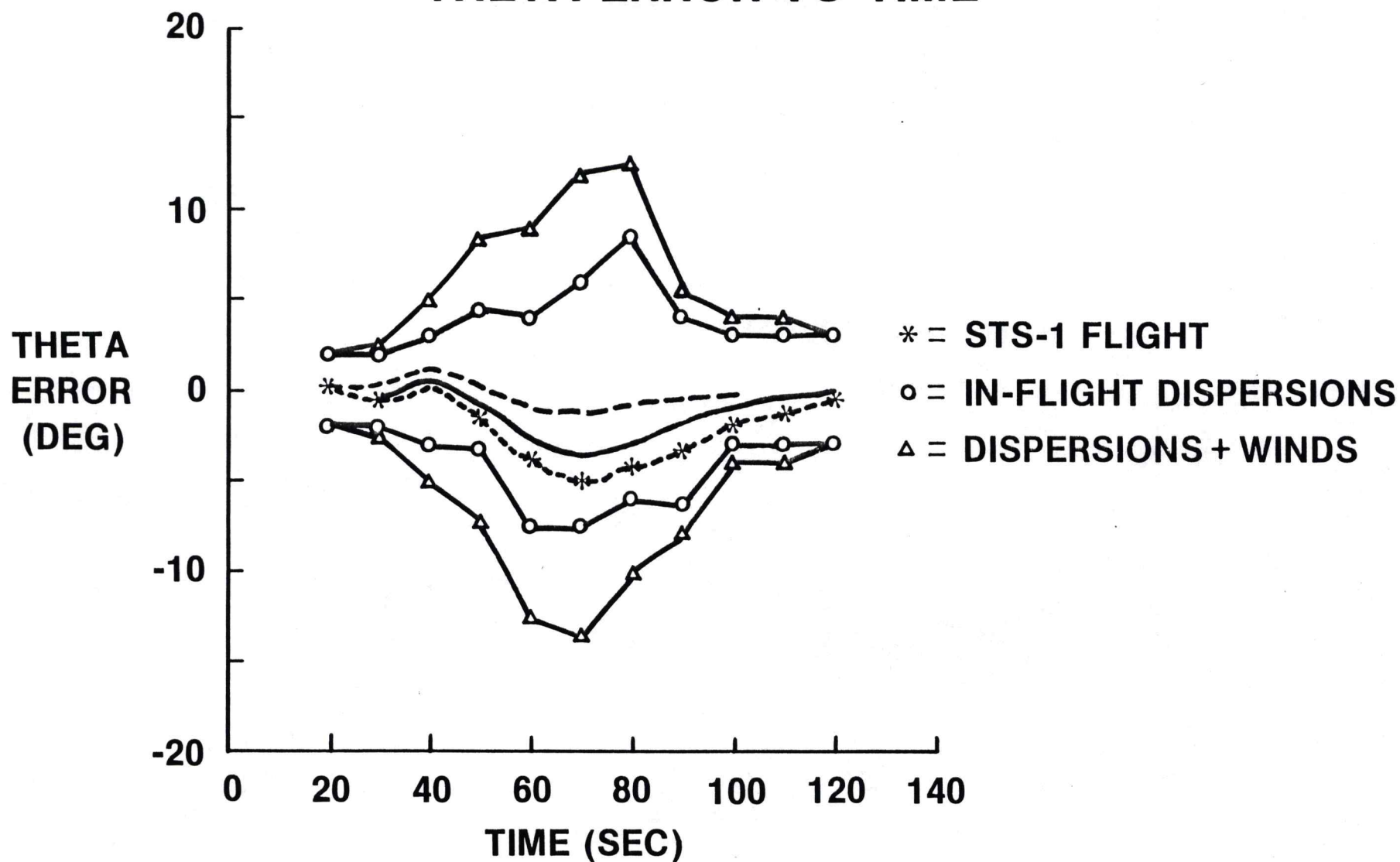
- 1,970 LBS Δ PROPELLANTS (LOW PERFORMANCE)

## ASCENT PERFORMANCE STATUS (CONT)

- TRAJECTORY RECONSTRUCTION PROPELLANT ACCOUNTING
  - 2,300 LBS DUE TO LOFTING
  - 700 LBS DUE TO SSME MODEL
  - + 850 LBS DUE TO HOT SRB
  - + 1,300 LBS DUE TO REDUCED BASE FORCE
  - 850 LBS TOTAL LOSSES ACCOUNTED FOR TO DATE
- - 1970 LBS PROPELLANT ( LOW PERFORMANCE)
  - 850 LBS PROPELLANT ACCOUNTED FOR TO DATE
  - 1120 LBS PROPELLANT REMAINING TO BE FOUND FROM  
OTHER SOURCES
- TRAJECTORY RECONSTRUCTION AND ITERATION WITH PROPULSION  
FOR COMPLETE PERFORMANCE RESOLUTION UNDERWAY

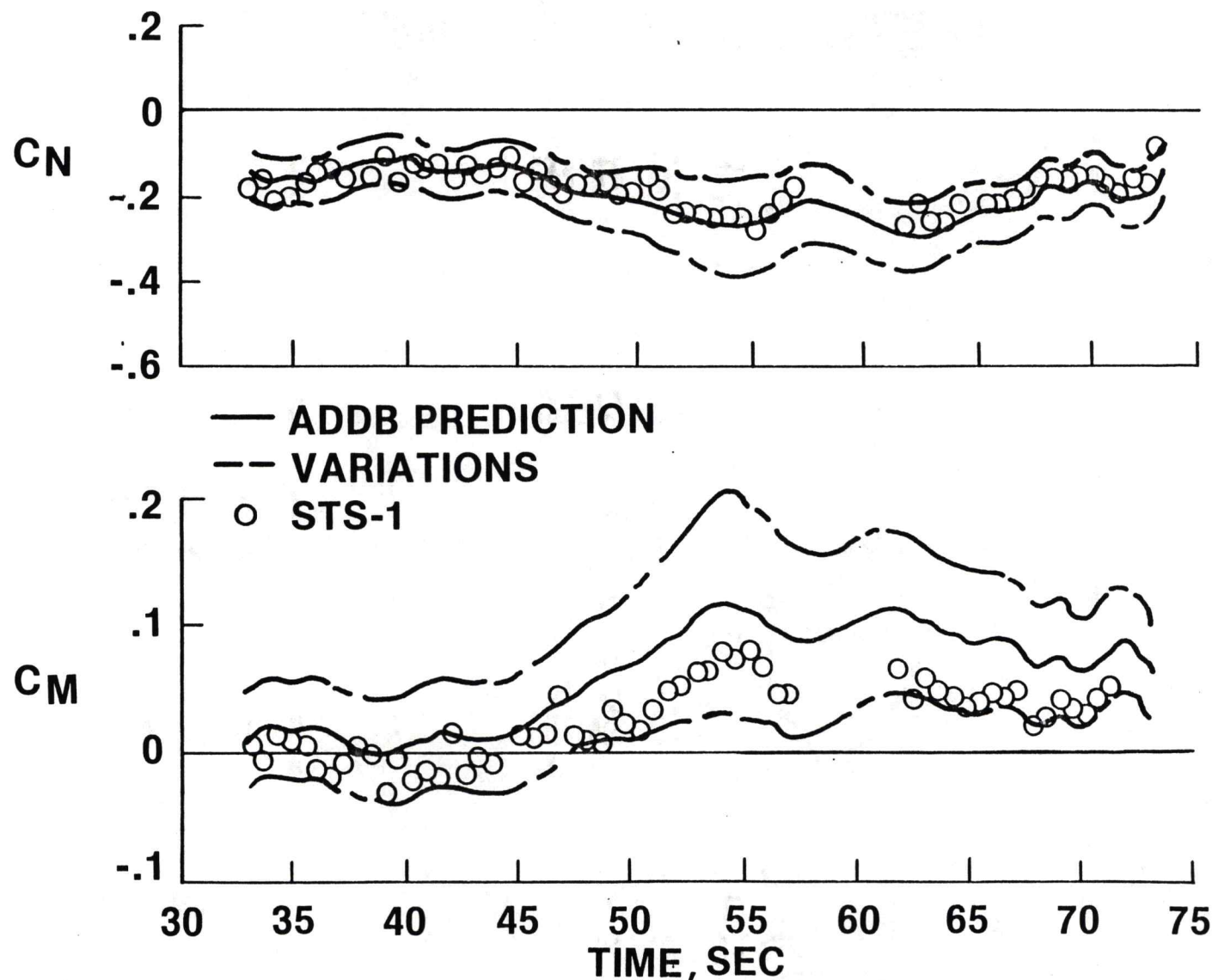
# PITCH ATTITUDE ERROR/STS-1

## THETA ERROR VS TIME

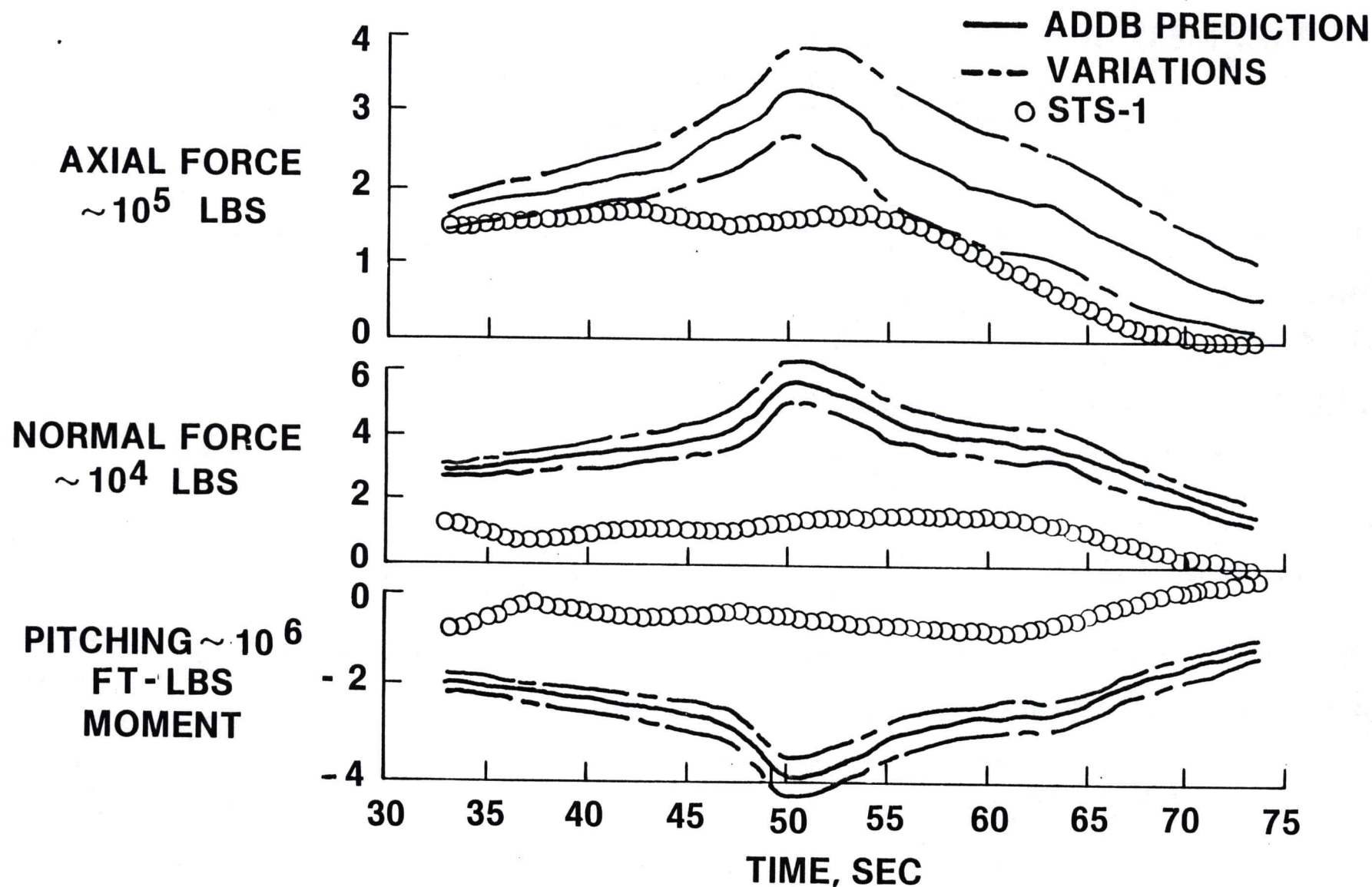




# PRELIMINARY ESTIMATE OF STS-1 MATED VEHICLE AERODYNAMICS



# PRELIMINARY ESTIMATE OF STS-1 MATED VEHICLE POWER ON BASE EFFECTS



## RECONSTRUCTION

<u>PARAMETER</u>	<u>PREDICTED AT L-3 HRS</u>	EX <u>RECON- STRUCTION*</u>	<u>FLIGHT DATA</u>
QMAX	594	606	605
$\alpha$ MAX	-4.0	-5.5	-4.5
$\beta$ MAX	-1.0	-1.0	-1.0
STAGING ALTITUDE	163,957	173,541	174,44
STAGING VELOCITY	4,175	4,157	4,112
MAX PITCH			
ATTITUDE ERROR	$\pm 1.0$	-3.8	-5.2

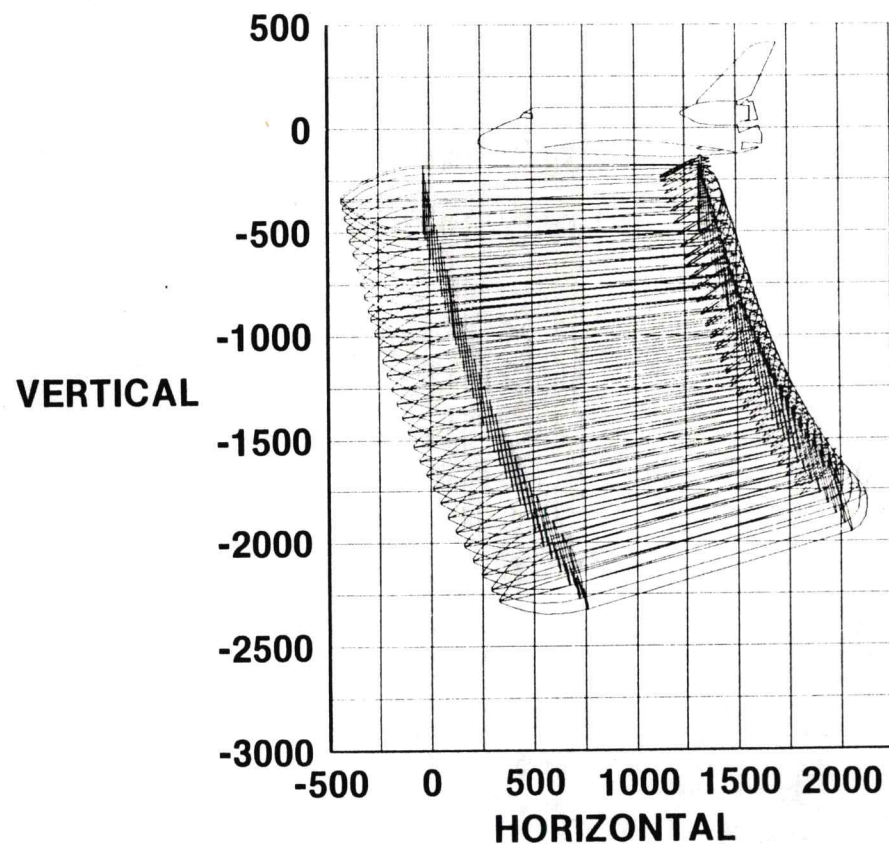
\*SIMULATION INCLUDES: MET DATA, QUICK-LOOK SRB, QUICK-LOOK SSME, ELEVON POSITION BIAS, QUICK-LOOK AERO



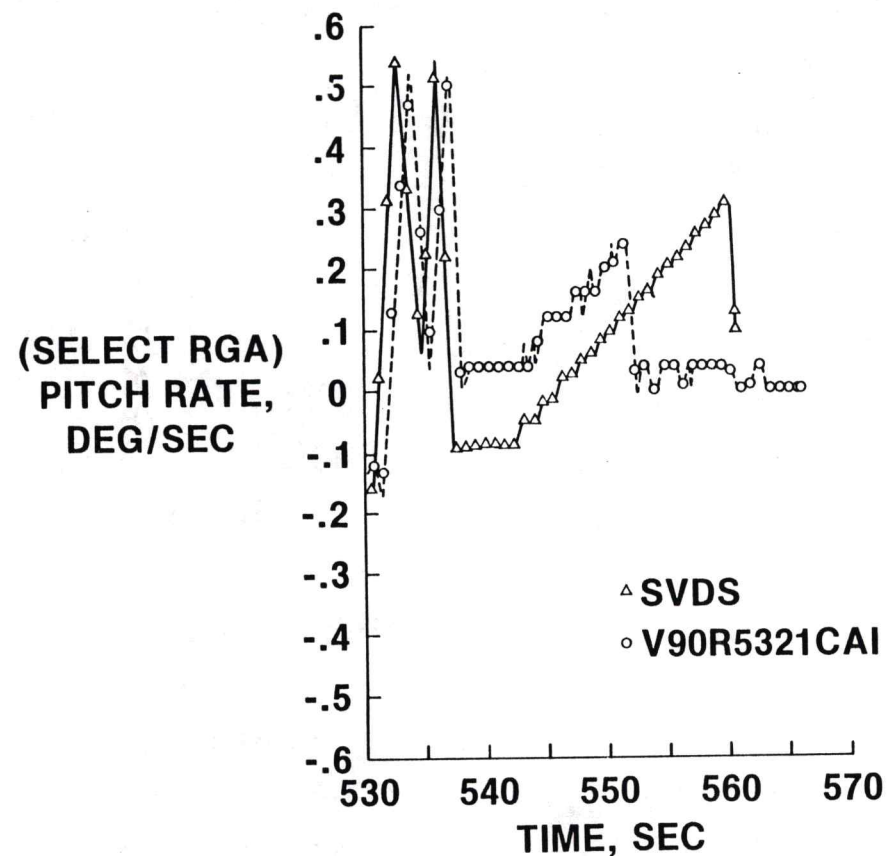
## **ET SEPARATION; COMPARISON, FLIGHT AND ANALYSIS**

- SEPARATION WAS NOT AS PREDICTED: INSUFFICIENT RELATIVE PITCH ANGLE
- ASSUMED TUMBLE VALVE NOT FUNCTIONAL, THEN COMPARISONS ARE "EXACT"
  - TIMING AND RGA BIAS NOT PRECISELY MATCHED, CONTINUING ANALYSIS WILL IMPROVE
  - ERROR IN DATA REDUCTION CAUSES APPARENT SHIFT IN RELATIVE DISPLACEMENT
- MODELS VERIFIED:
  - FLIGHT CONTROL SYSTEM
  - SOFTWARE FUNCTIONAL MODELING
  - RCS FORCES AND MOMENTS
  - RCS PLUME IMPINGEMENT TO ORBITER AND EXTERNAL TANK
  - 2-BODY, 6 DOF EQUATIONS OF MOTION
  - SEQUENCING FUNCTIONAL MODELING
- DEMONSTRATED HIGH CONFIDENCE IN ABILITY TO PREDICT RELATIVE TRAJECTORIES FOR FUTURE MISSIONS
- DEMONSTRATED SAFE SEPARATION WITH NO RECONTACT
- OPEN WORK:
  - ASSESS TUMBLE VALVE FAILURE
  - ADDITIONAL DATA ON STS-2, 3, AND 4

# ET SEPARATION; COMPARISON, FLIGHT AND ANALYSIS

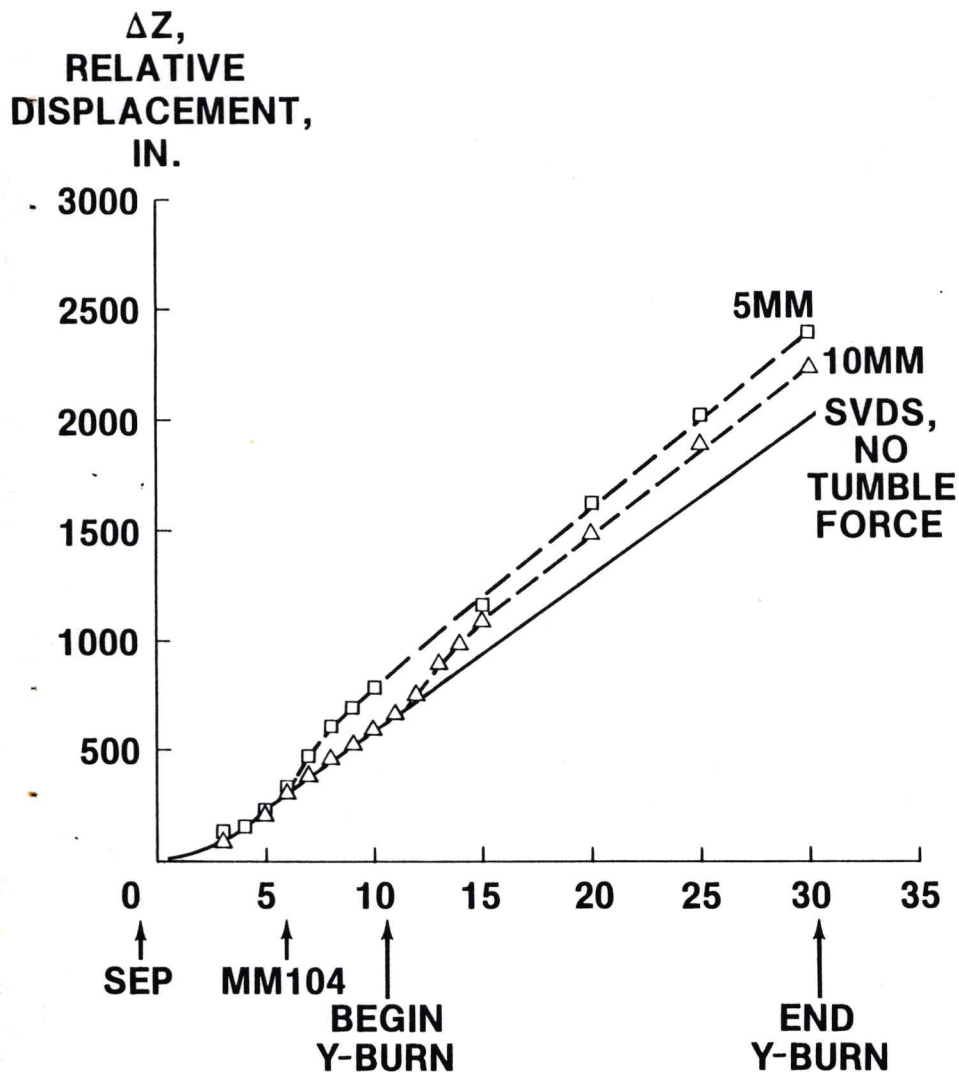


ORBITER ET 3 VIEW

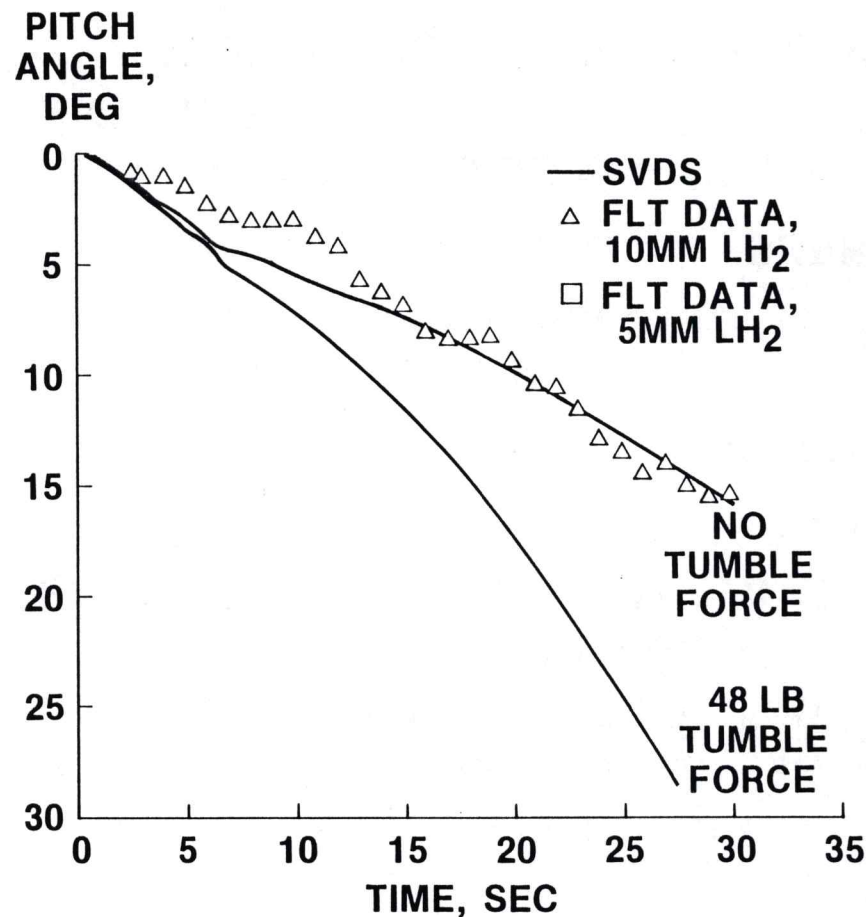


● ORBITER PERFORMANCE COMPARISON

# ET SEPERATION; COMPARISON, FLIGHT AND ANALYSIS (CONT)



● RELATIVE DISPLACEMENT



● RELATIVE ATTITUDE



## **STS-1 DEBRIS ASSESSMENT TEAM**

**OBJECTIVE** - IDENTIFY SOURCES OF DEBRIS WHICH CAUSED DAMAGE TO THE ORBITER DURING STS-1 AND WHICH HAVE SAFETY OF FLIGHT IMPLICATIONS FOR STS-2

**MEMBERS** - BASS REDD - LEADER (JSC)      GEORGE STROUHAL (JSC)  
JIM SISSON (MSFC)      BILL FROHOFF (RI)  
MARK CRAIG (JSC)      RUSS RHODES (KSC)

### **APPROACH**

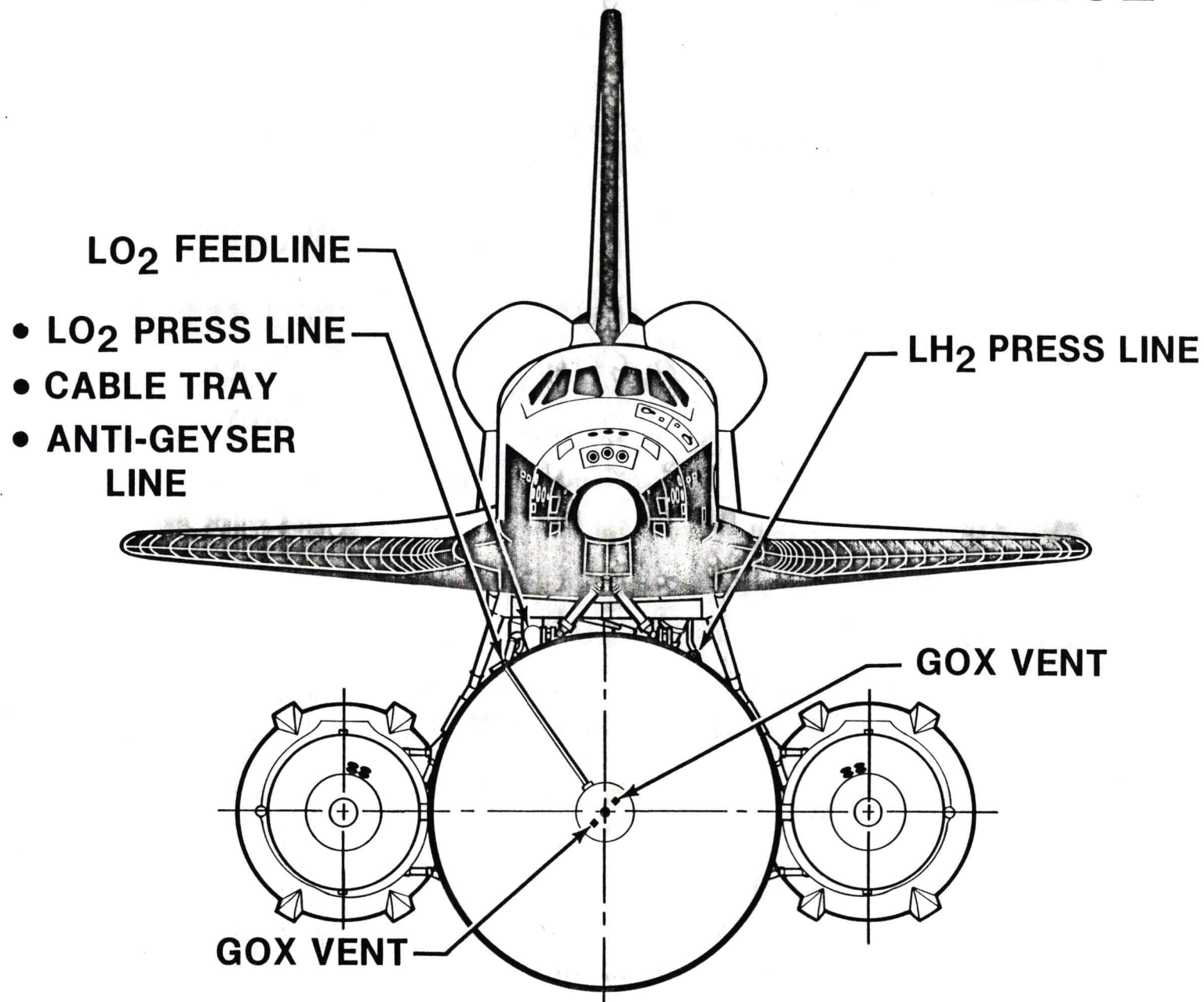
- REVIEW PRE-LAUNCH, LAUNCH, AND FLIGHT FILMS AND VIDEO TO IDENTIFY POTENTIAL DEBRIS SOURCES (COMPARE TO WAIVED DEBRIS LIST)
- INSPECT ORBITER TO ESTABLISH DAMAGE PATTERNS
- REVIEW TPS ASSESSMENT TEAM RESULTS (CHEMICAL ANALYSIS, DAMAGE MAPS)

## **STS-1 DEBRIS ASSESSMENT TEAM (CONT)**

### **APPROACH (CONT)**

- **SELECT FOR FURTHER STUDY DAMAGE LOCATIONS SIGNIFICANT IN TERMS OF EITHER SAFETY OR TRANSPORT PHENOMENA**
- **IDENTIFY DEBRIS CAPABLE OF CAUSING SELECTED DAMAGE**
- **PERFORM REPRESENTATIVE BALLISTIC TRANSPORT ANALYSES TO ESTABLISH FEASIBILITY OF PROPOSED DEBRIS/DAMAGE CORRELATION**
- **LIST FEASIBLE DEBRIS SOURCES AND TRANSPORT PHENOMENA FOR EACH SELECTED DAMAGE LOCATION**
- **FORMULATE RECOMMENDATIONS TO REDUCE ORBITER TPS DEBRIS DAMAGE AND TO IMPROVE FUTURE DEBRIS DAMAGE ASSESSMENTS**

# ET/ORBITER GEOMETRY REFERENCE





## STS-1 ELEMENT DEBRIS SUMMARY

	<u>HIGH DENSITY</u>	<u>MEDIUM DENSITY</u>	<u>LOW DENSITY</u>
ORBITER	<ul style="list-style-type: none"> <li>• TILE INSTALL. SHIMS (4" x 1" x 0")</li> </ul>	<ul style="list-style-type: none"> <li>• CANOPY TILE FRAGMENT (2" x 2" x 1/2")</li> </ul>	<ul style="list-style-type: none"> <li>• CRYOGEN ICE (3")</li> </ul>
ET	<ul style="list-style-type: none"> <li>• LIGHTNING BAND (4" x 30/1000")</li> <li>• (ICE)</li> <li>• PAINT FLAKES</li> <li>• CABLE TRAY SPACERS* (3" x 2" x 3/10")</li> </ul>	<ul style="list-style-type: none"> <li>• FROST</li> <li>• FRL PAINT + SOFI</li> </ul>	<ul style="list-style-type: none"> <li>• PAL RAMP FRAGMENTS (18" x 12" x 6")</li> <li>• SOFI POPCORN (2")</li> <li>• TUMBLE VALVE COVER</li> </ul>
SRB	<ul style="list-style-type: none"> <li>• (AFT CONNECTOR FRAGMENTS)</li> <li>• FRUSTRUM PAINT FLAKES</li> </ul>		<ul style="list-style-type: none"> <li>• THERMAL CURTAIN FILM</li> </ul>
LAUNCH PAD	<ul style="list-style-type: none"> <li>• ICE</li> <li>• HARD HAT</li> </ul>	<ul style="list-style-type: none"> <li>• FROST</li> </ul>	<ul style="list-style-type: none"> <li>• HOLD-DOWN IN- SULATION</li> </ul>

\*NO CONCLUSIVE EVIDENCE THAT DEBRIS OF THIS COMPOSITION EXISTED  
( ) = WAIVED; NOTE THAT ICE ON THE ET IS WAIVED AFT OF STA 1106

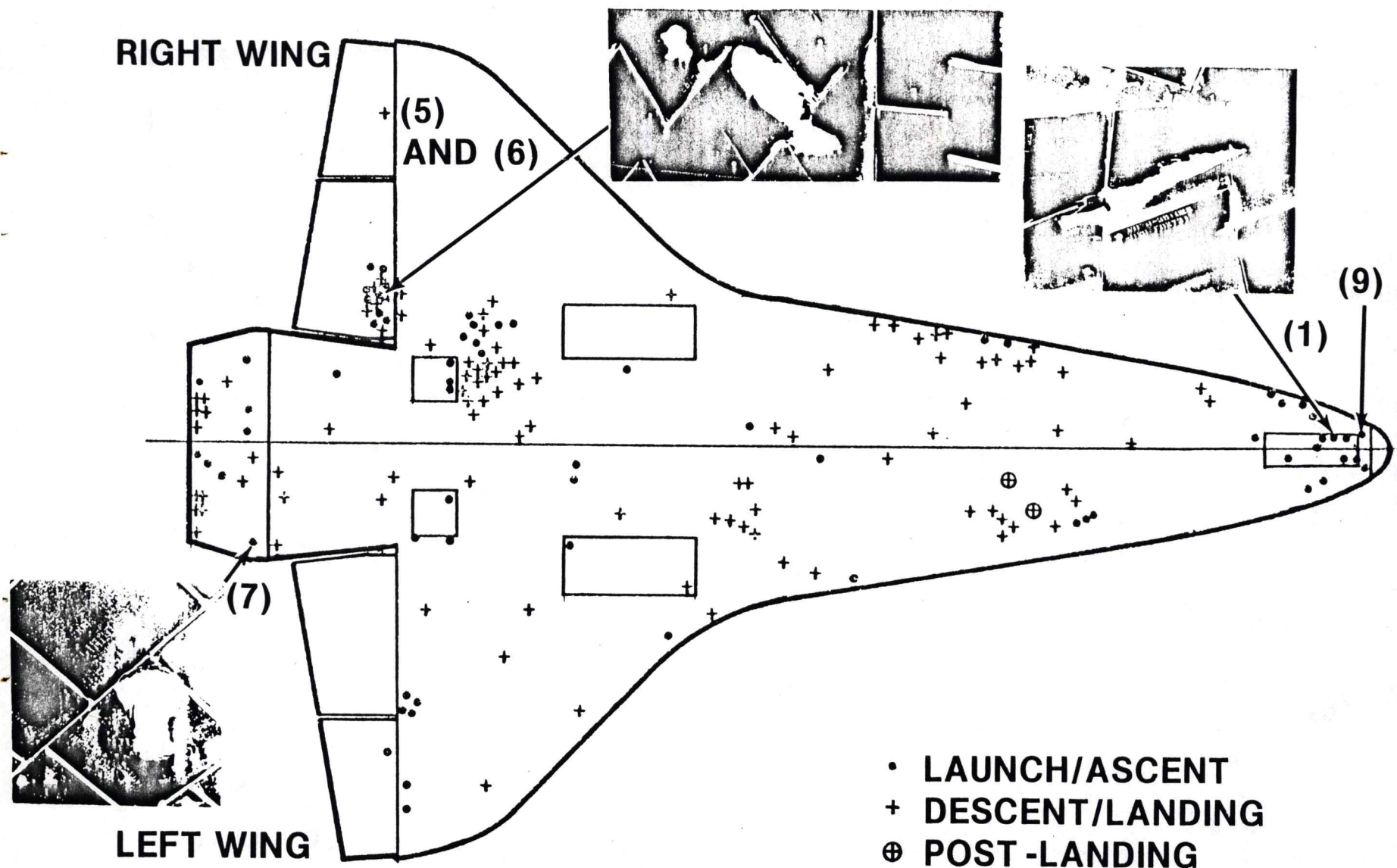
**DAMAGE**

<u>NO.</u>	<u>LOCATION</u>	<u>SIZE (LxWxD)</u>	<u>CHEMICAL ANALYSIS</u>	<u>SIGNIFICANCE</u>
1.	RH NOSE GEAR DOOR	8" x 1" x 1"	--	SAFETY
2.	LH TOP OF NOSE	2" x 3/4" x 1/8"	NONE	TRANSPORT
3.	RH SIDE OF FUSELAGE	12" x 1" x 1/4"	NONE	TRANSPORT
4.	RH OMS POD	2" x 1" x 1/2" 3" x 1" x 1/4"	NONE	TRANSPORT
5.	RH WING/ELEVON (LOWER SURFACE)	4" x 1/2" x 1/8" 4" x 1/2" x 1/8" 3" x 1" x 1/8" 6" x 1/2" x 1/8"	NONE	TRANSPORT
6.	RH INB. ELEVON	6" x 3" x 1/4"	Si, Ti, B, Zn, Cu, Sb, (23, 25)	SAFETY
7.	BODY FLAP (LH LOWER SURFACE)	3" x 2" x 2"	--	SAFETY
8.	RH AFT RCS POD	1/2" x 1/2"	NONE	TRANSPORT
9.	NOSE CAP BORDER (LOWER SURFACE)	3/4" x 3/4" x 1/8"	NONE	SAFETY
10.	RH WING GLOVE	1" x 1/2" x 1/8"	PVA/PVC (22)	TRANSPORT

**POTENTIAL DAMAGE AGENTS**

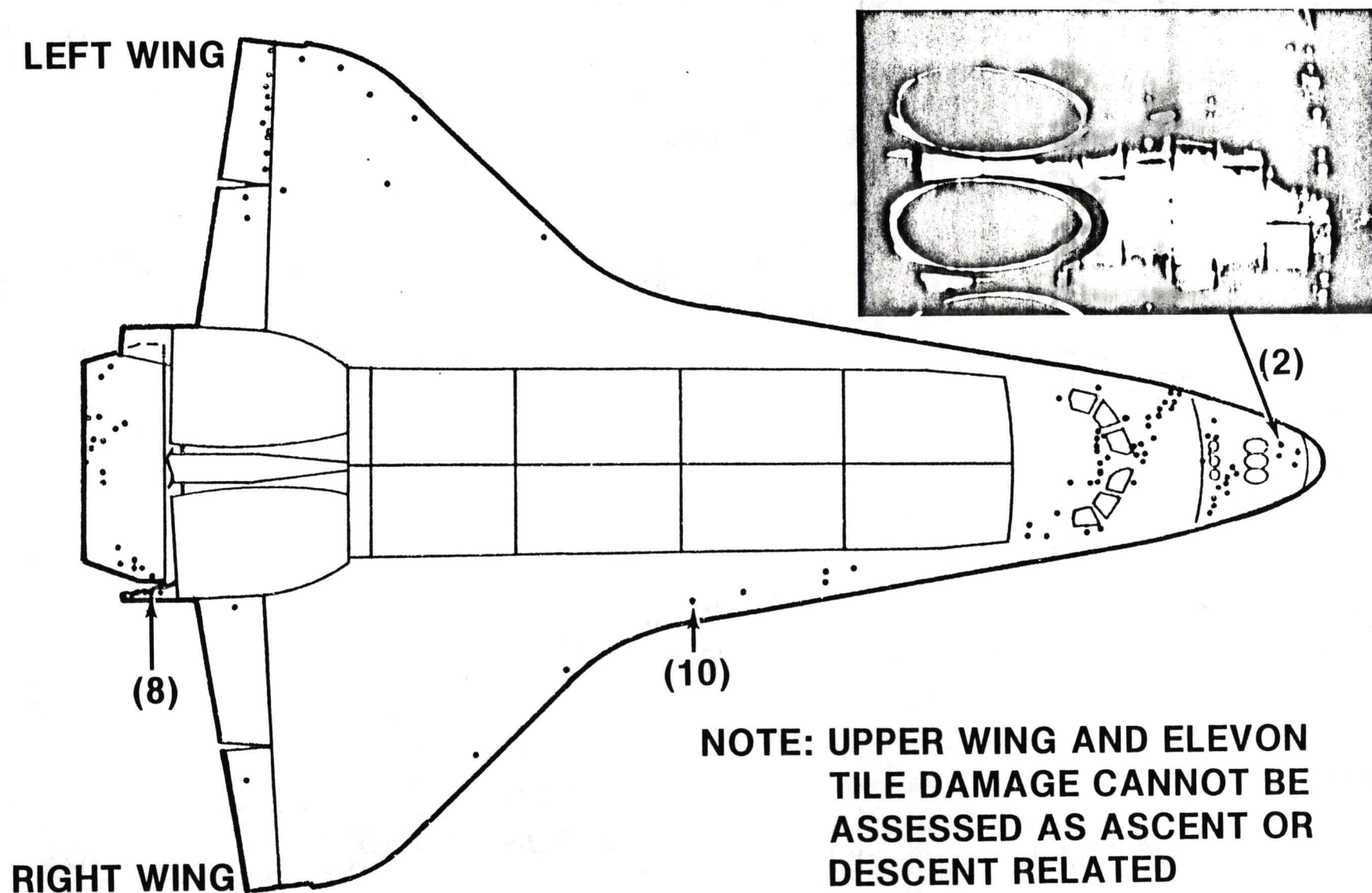
<u>TRANSPORT MECHANISM</u>	<u>SOURCE STATION</u>	<u>MATERIAL</u>	<u>CONSTRAINTS</u>
AERO	ET ≤ 700	HI <sub>ρ</sub>	V <sub>IMP</sub> ≥ 400 fps
AERO	ET ≤ 700	ANY <sub>ρ</sub>	M ≥ 0.5
AERO THRUST	ET ≤ 1100 ET ≈ 900	HI <sub>ρ</sub> HI <sub>ρ</sub>	0.9 ≤ M ≤ 1.5 V <sub>IMP</sub> ≤ 98 fps
AERO AERO THRUST	ORB=475 ET ≤ 700 ET ≈ 900	LRSI LO <sub>ρ</sub> LO <sub>ρ</sub>	V <sub>IMP</sub> ≤ 145 fps
AERO	ET ≤ 1700	ICE	
AERO RICOHET	ET ≤ 1700 ET ≤ 1700	LO <sub>ρ</sub> ICE	LARGE DEBRIS
AERO	ET ≤ 2100	ANY <sub>ρ</sub>	LOW ANGLE
RECIRC	PAD	HI <sub>ρ</sub>	AT LIFT-OFF
AERO	ET ≤ 700	ANY <sub>ρ</sub>	
AERO	ORB ≤ 950	TILE SHIM	

# STS-1 TILE DAMAGE - LOWER SURFACE

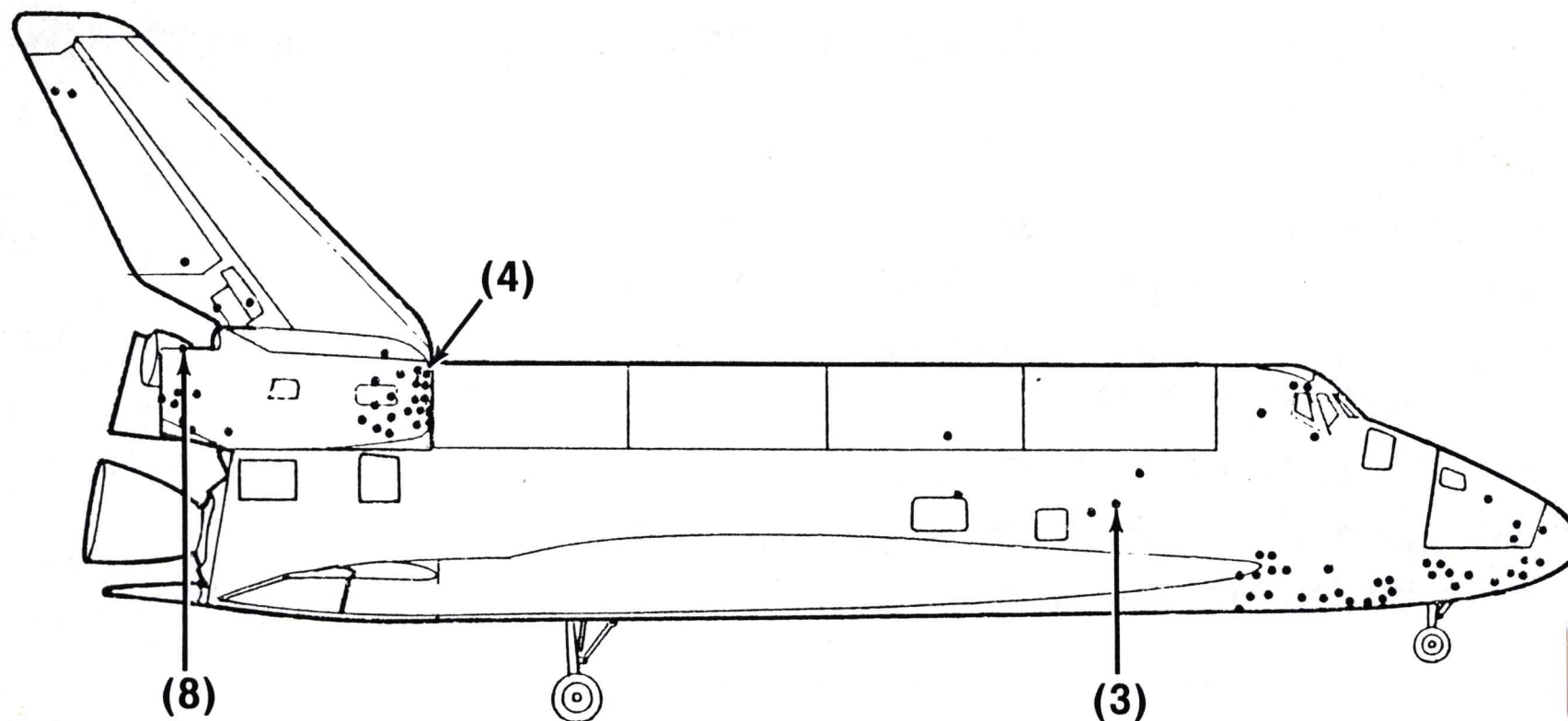




# STS-1 ASCENT TILE DAMAGE UPPER SURFACE



## STS-1 ASCENT TILE DAMAGE - RIGHT SIDE



## **RECOMMENDED ACTIONS**

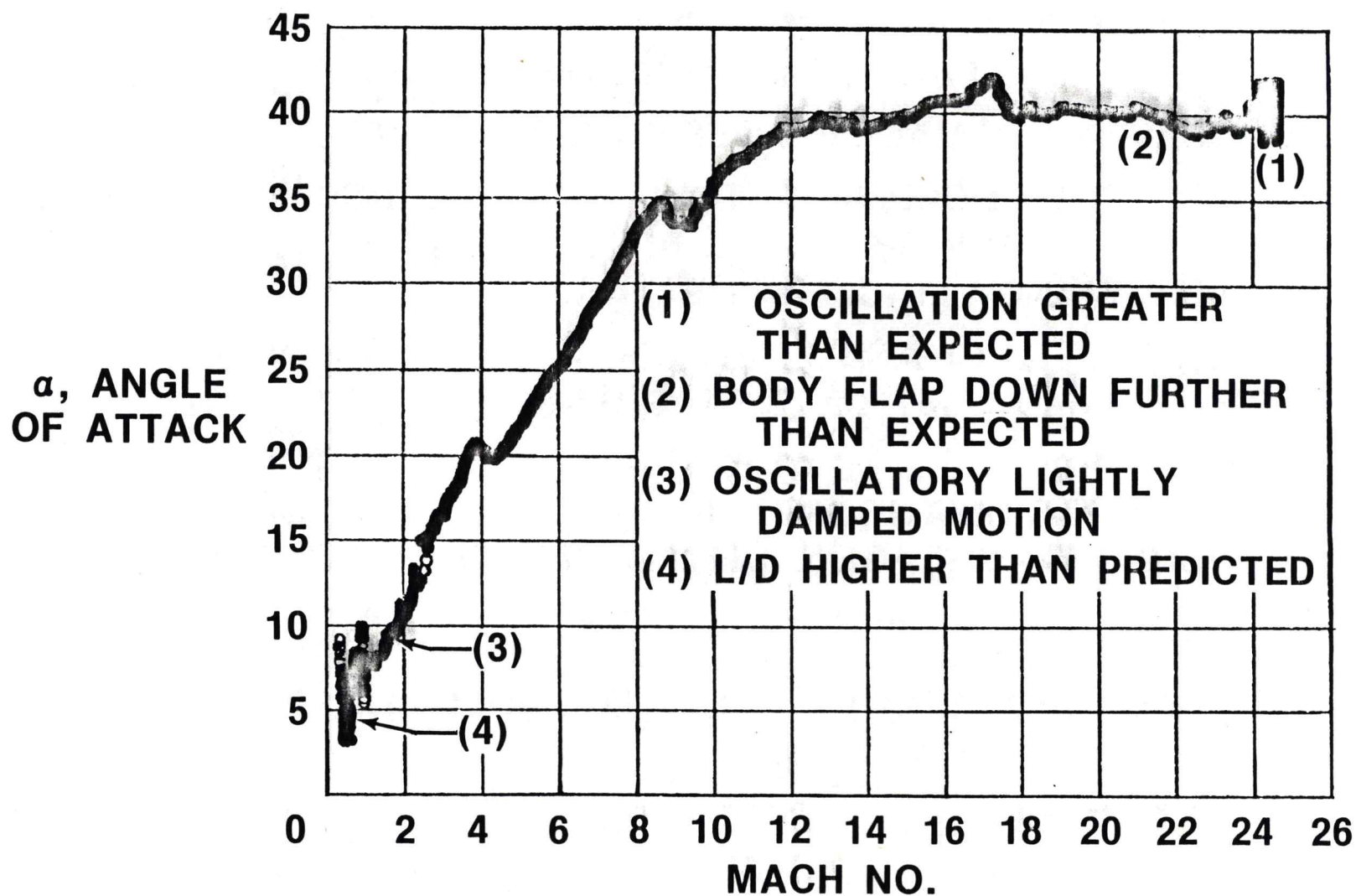
- **TO SIGNIFICANTLY REDUCE DAMAGE TO THE ORBITER TPS FOR STS-2**
  - **PREVENT ICE/FROST FORMATION ON THE ET OGIVE FORWARD OF STATION 700**
  - **ELIMINATE PAL RAMP FRAGMENTATION**
  - **REDESIGN LIGHTNING BANDS TO RESPOND TO THERMAL ENVIRONMENT WITHOUT GENERATING DEBRIS**
  - **ASSURE THAT ET CABLE TRAY PHENOLIC SPACERS CANNOT BE DISLODGED IN FLIGHT**
  - **ELIMINATE LAUNCH PAD DEBRIS**
  - **ESTABLISH PROCEDURES TO ASSURE REMOVAL OF TPS SPACER SHIMS PRIOR TO LAUNCH**
- **TO FURTHER REDUCE DAMAGE TO THE ORBITER TPS**
  - **MINIMIZE ICE/FROST FORMATION ON THE ET FORWARD OF STATION 2058 (AFT ATTACH)**
  - **ESTABLISH MANUFACTURING TECHNIQUES WHICH MINIMIZE THE POTENTIAL OF SOFI "POPCORNING"**



## **RECOMMENDED ACTIONS (CONT)**

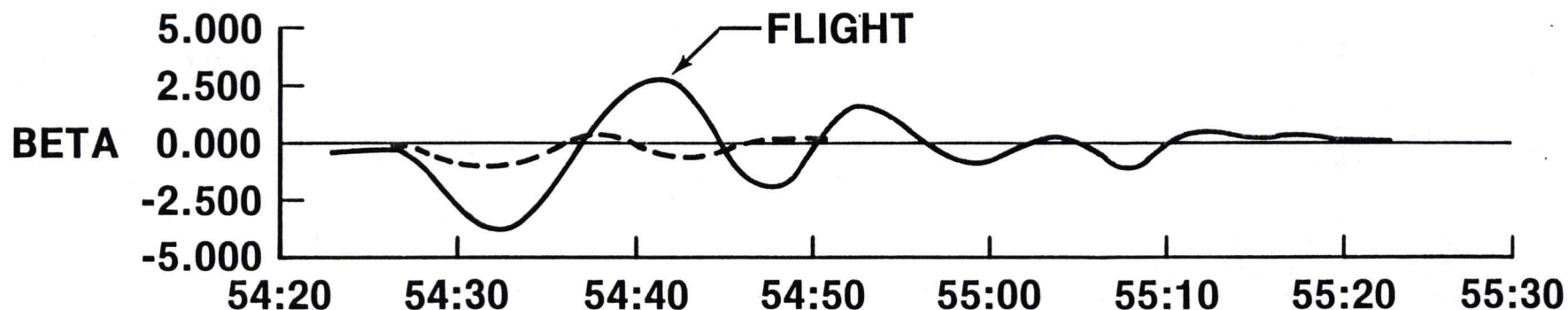
- **TO ENHANCE CAPABILITY TO DETERMINE TPS DAMAGE SOURCES**
  - **CONTINUE STS-1 DAMAGE SAMPLE CHEMICAL ANALYSIS**
  - **PROVIDE BETTER DOCUMENTATION OF ET ICE/FROST CONDITIONS AT LAUNCH THROUGH HIGHER RESOLUTION PHOTO/VIDEO COVERAGE AND VEHICLE INSPECTIONS**
  - **TURN ON BOTH LEFT AND RIGHT COCKPIT WINDOW CAMERAS DURING ASCENT; SET TO THE HIGHEST POSSIBLE SHUTTER SPEED**
  - **PLACE CAMERAS ON THE SRB'S TO VIEW THE FOLLOWING THROUGHOUT 1st STAGE (LISTED IN DECREASING ORDER OF IMPORTANCE):**
    - **ORBITER NOSE**
    - **ORBITER MID AND AFT FUSELAGE UNDERSIDE**
    - **ET INTERSTAGE AND LINES**
    - **ET OGIVE**

# PRELIMINARY STS-1 FLIGHT DATA RESULTS

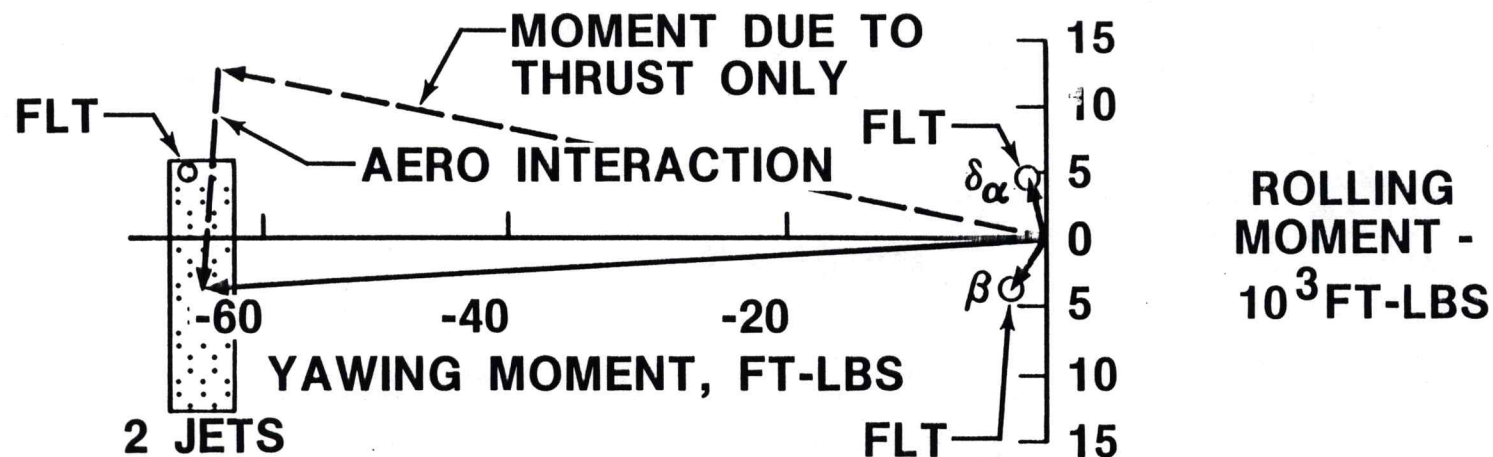


# $\beta$ OSCILLATIONS GREATER THAN PREDICTED

## ● MOTION COMPARISON

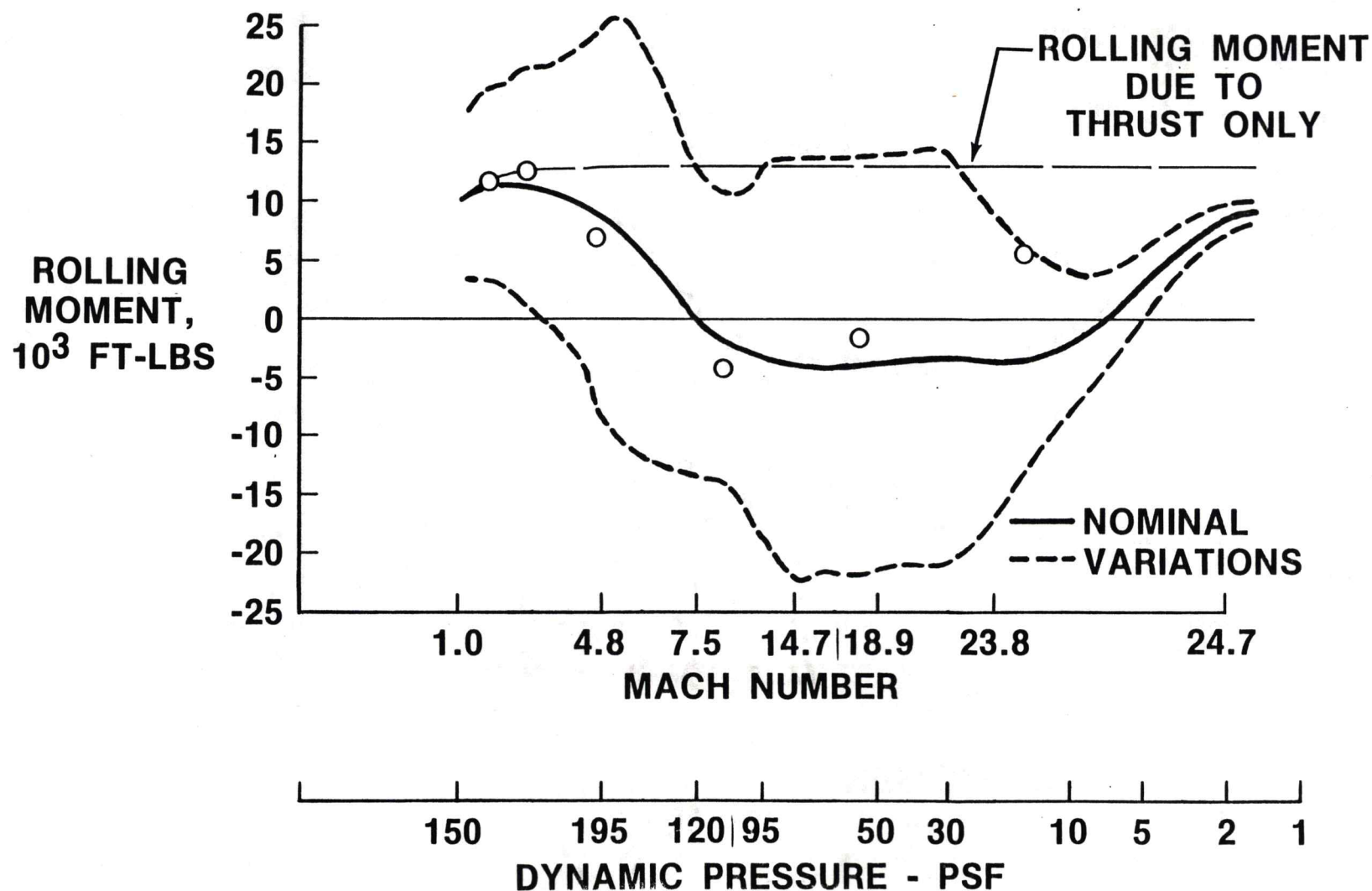


## ● FLIGHT EXTRACTED TO PREDICTED AERODYNAMIC CONTROL EFFECTOR COMPARISON

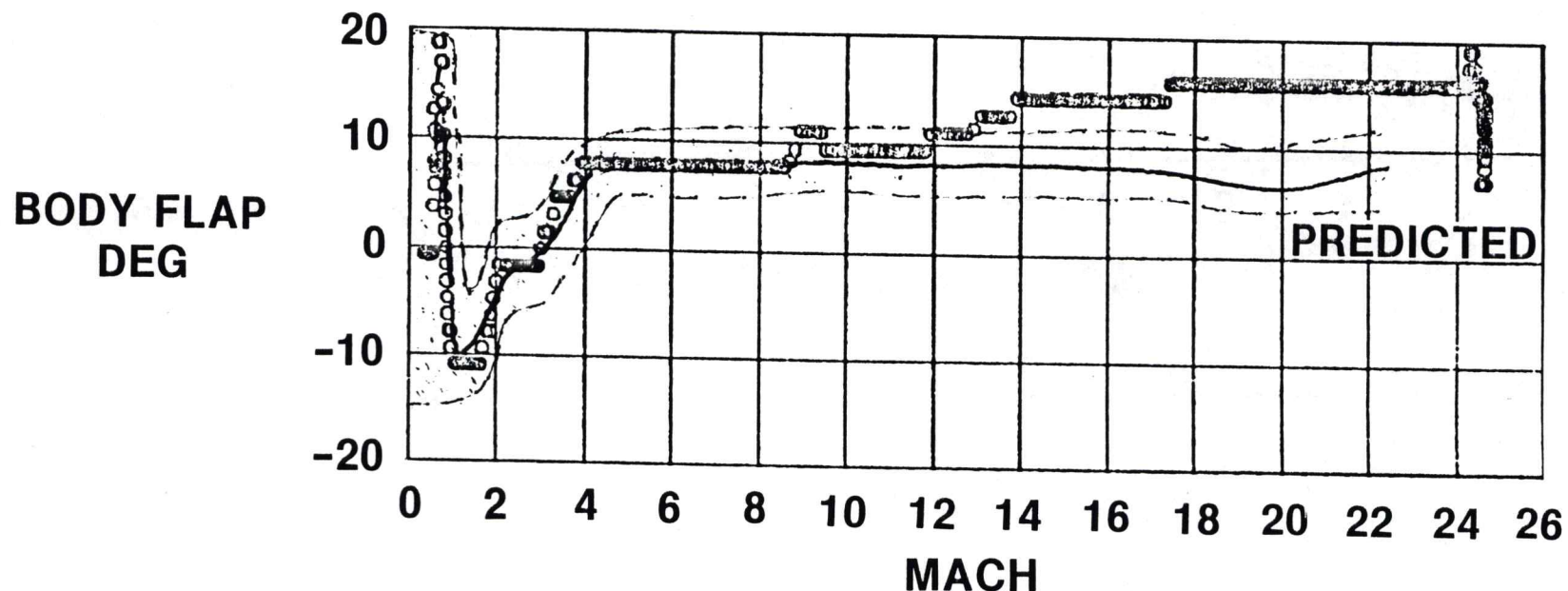




# ROLLING MOMENT DUE TO THE LEFT HAND YAW JETS

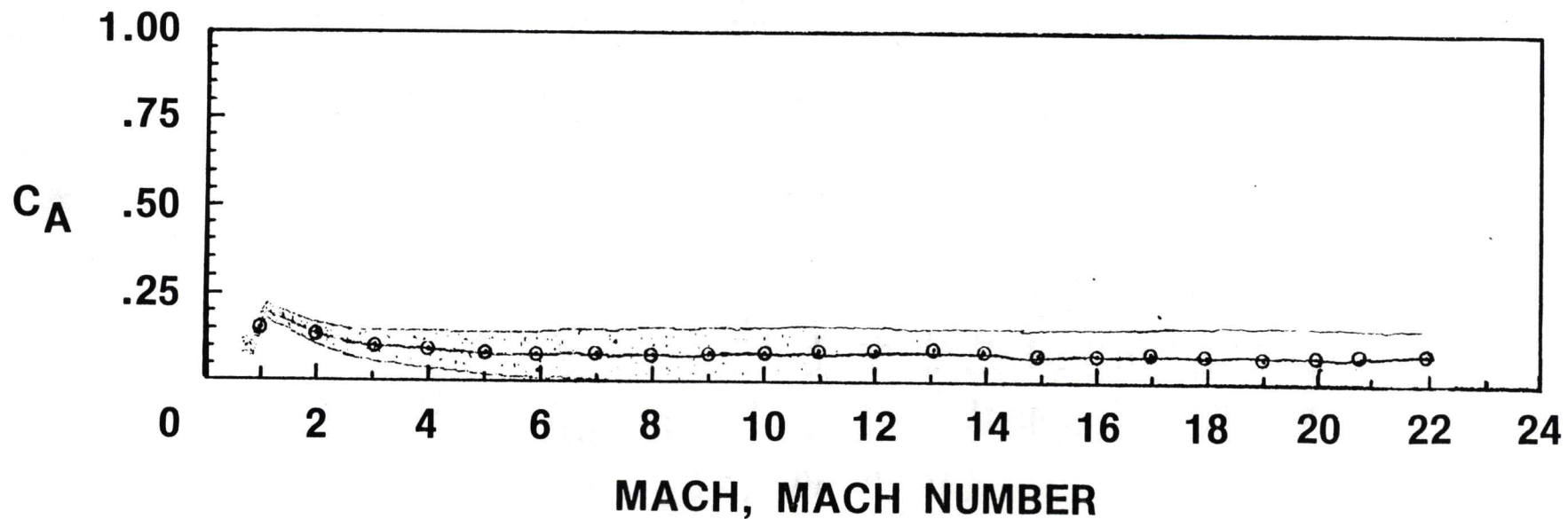
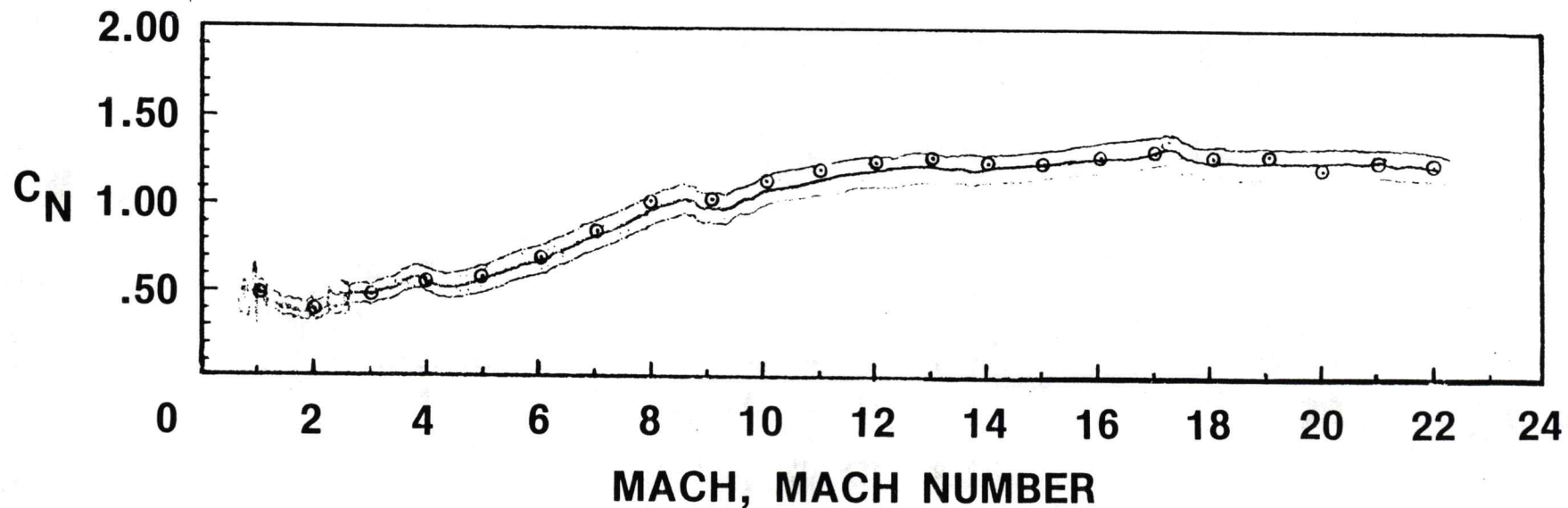


## BODY FLAP DOWN FURTHER THAN PREDICTED



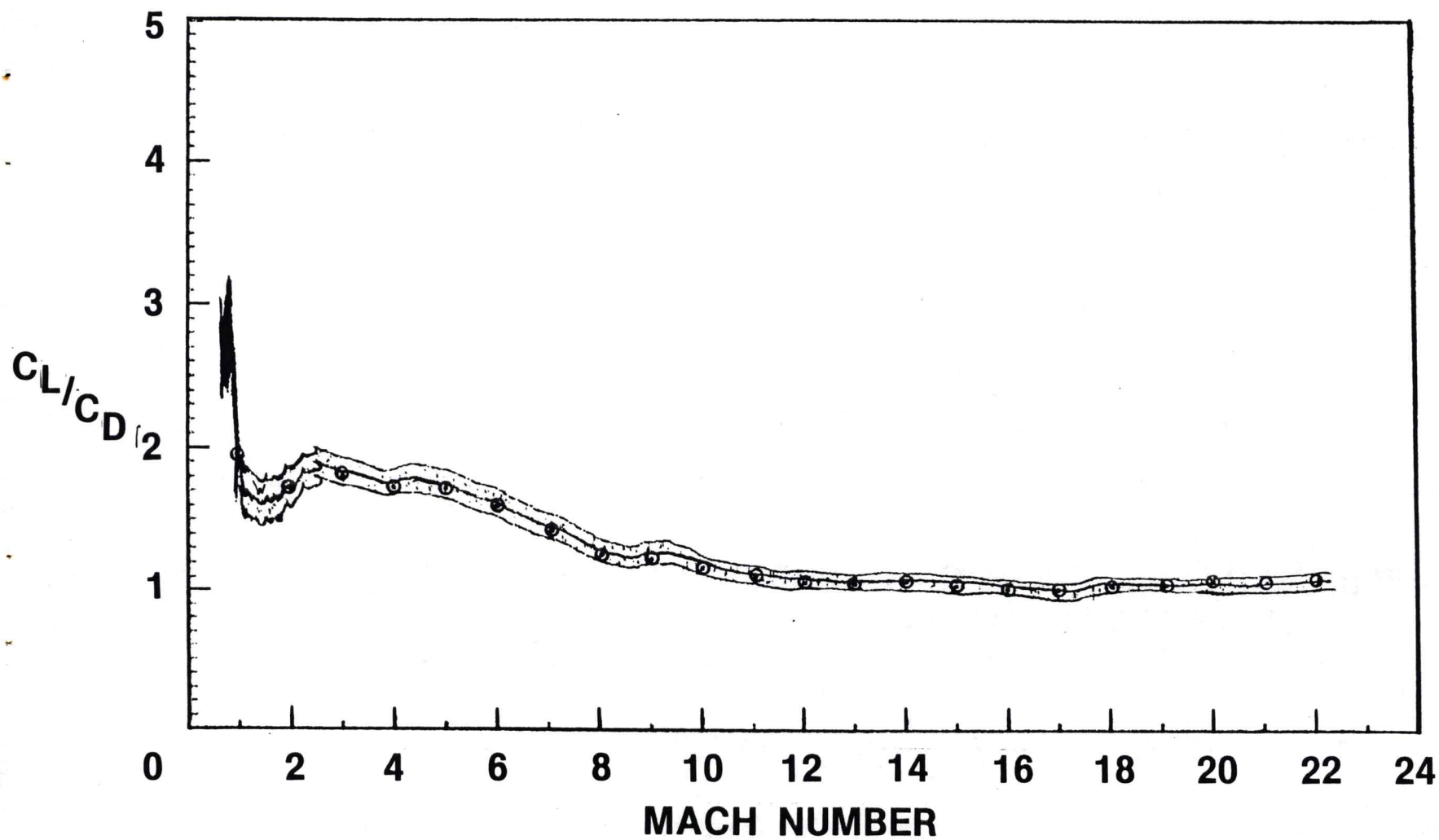
- REAL GAS EFFECT
- VISCOUS INTERACTION
- OTHER LONGITUDINAL AERODYNAMIC NOMINAL

# LONGITUDINAL EFFECTIVENESS



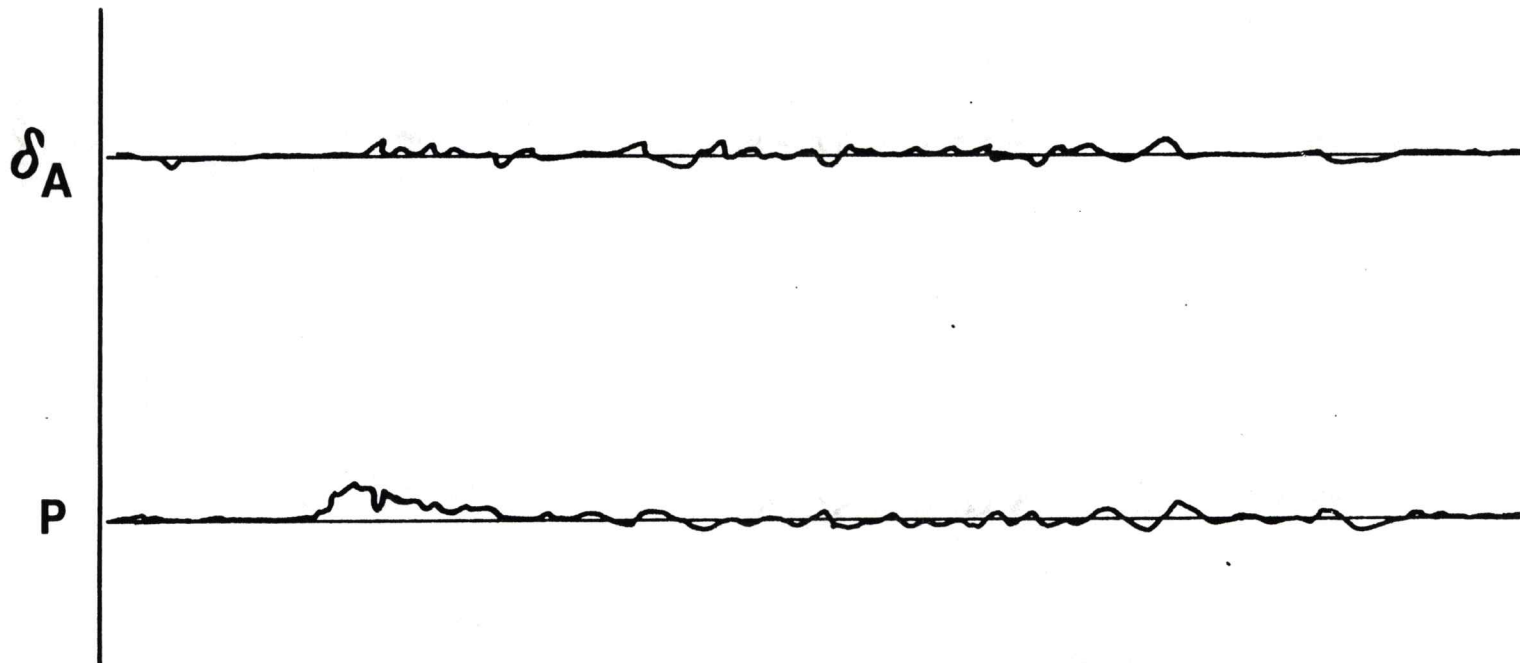


# LIFT TO DRAG RATIO



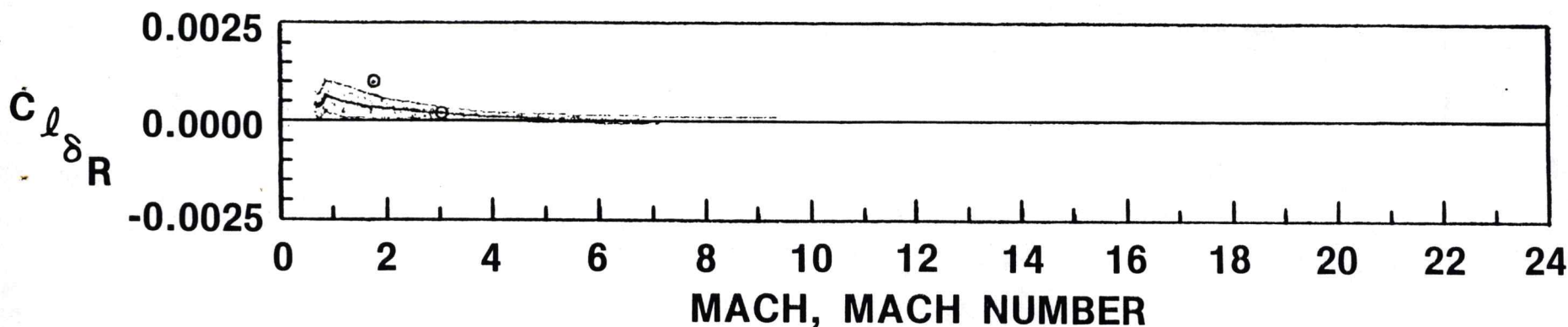
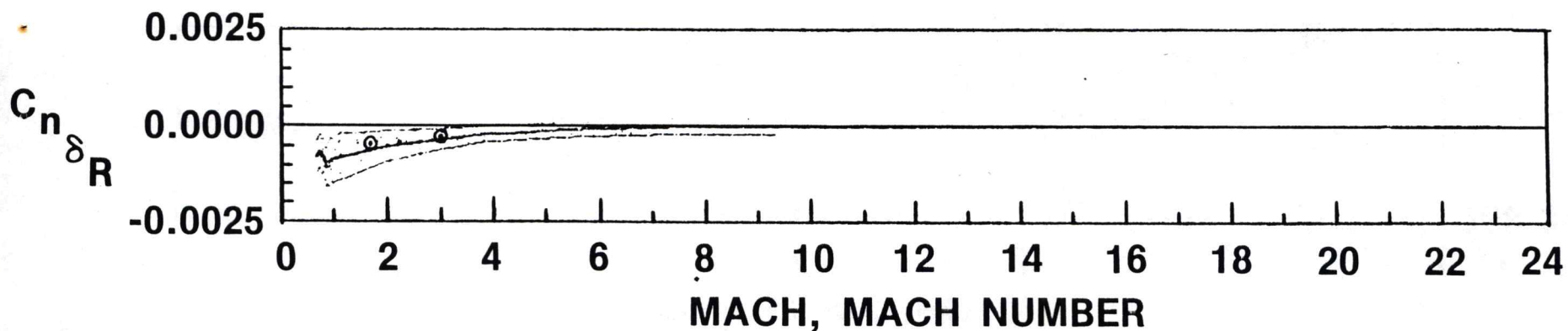
# LOW DAMPED OSCILLATORY MOTION

- VEHICLE MOTION 1/4 HERTZ AT MACH 1.6



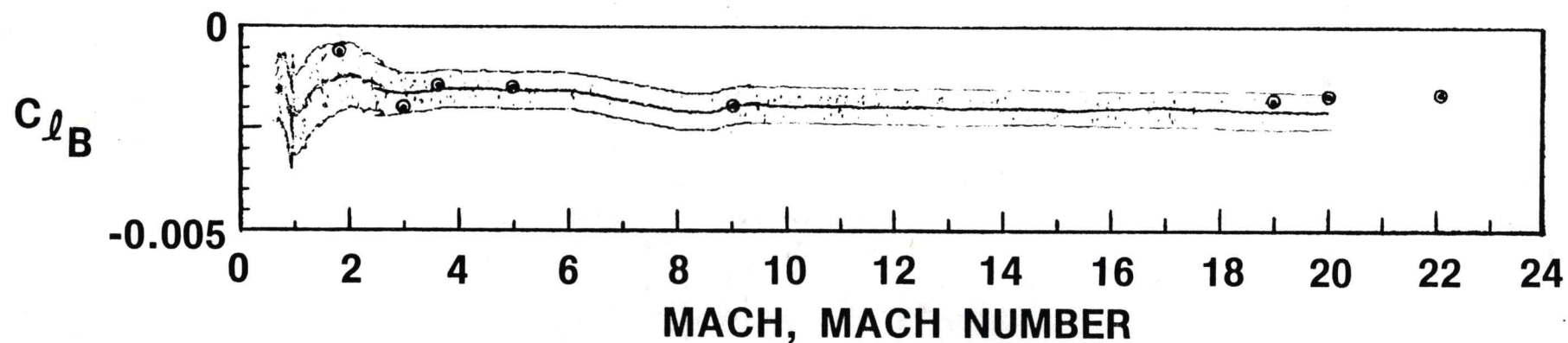
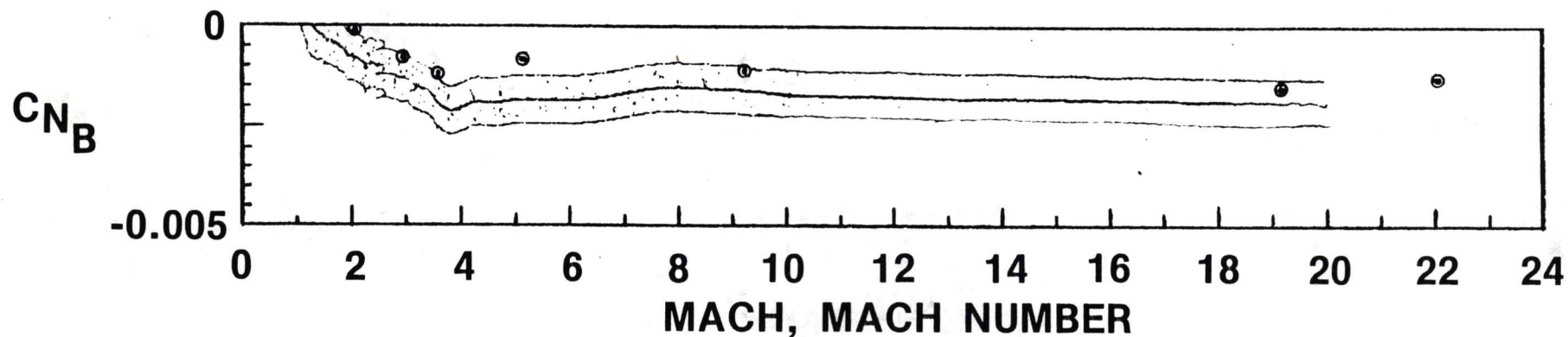
- PRELIMINARY EVALUATION - CAUSED BY  $C_{l_{\xi z}}$
- 6 DOF EXTRACTION IN WORK
- $C_{\eta \beta}$  ALTHOUGH UNCERTAIN, APPEARS TO BE + VARIATION
- $C_{l_{\xi A}}$  LESS EFFECTIVE AT MACH 3 TO 1.6
- ALL AERODYNAMIC EVALUATION MADE ON POOR MANEUVER FOR DATA EXTRACTION, THEREFORE, RESULTS ARE UNCERTAIN

# RUDDER EFFECTIVENESS

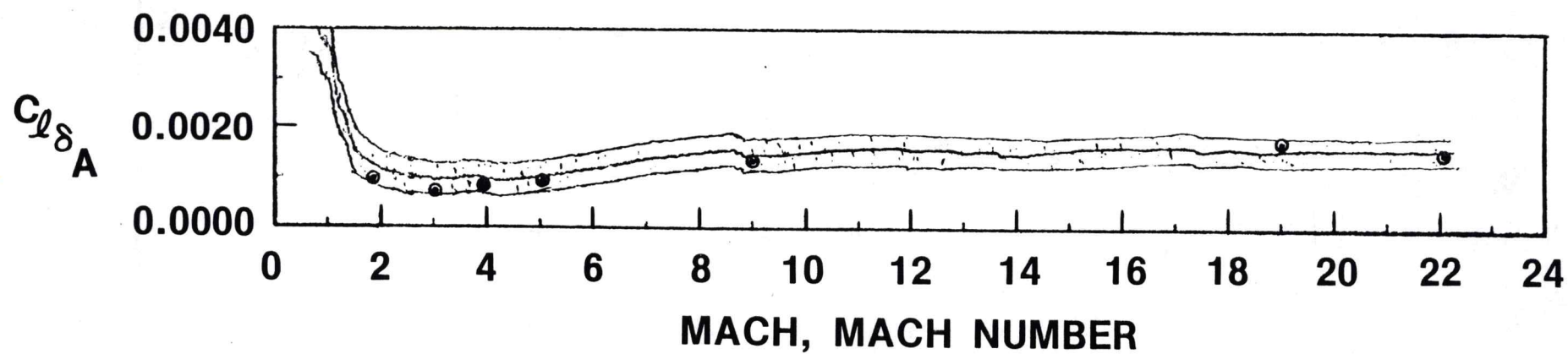
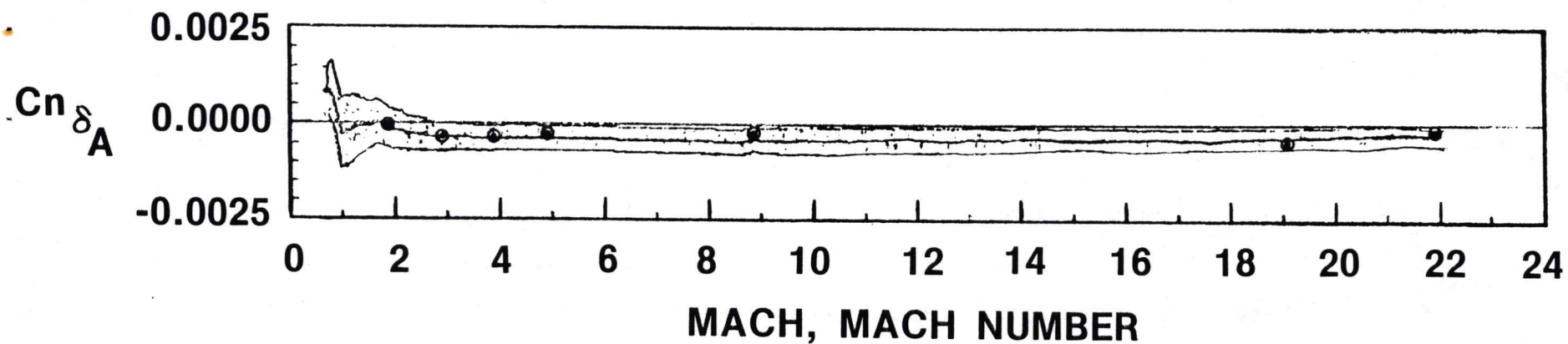




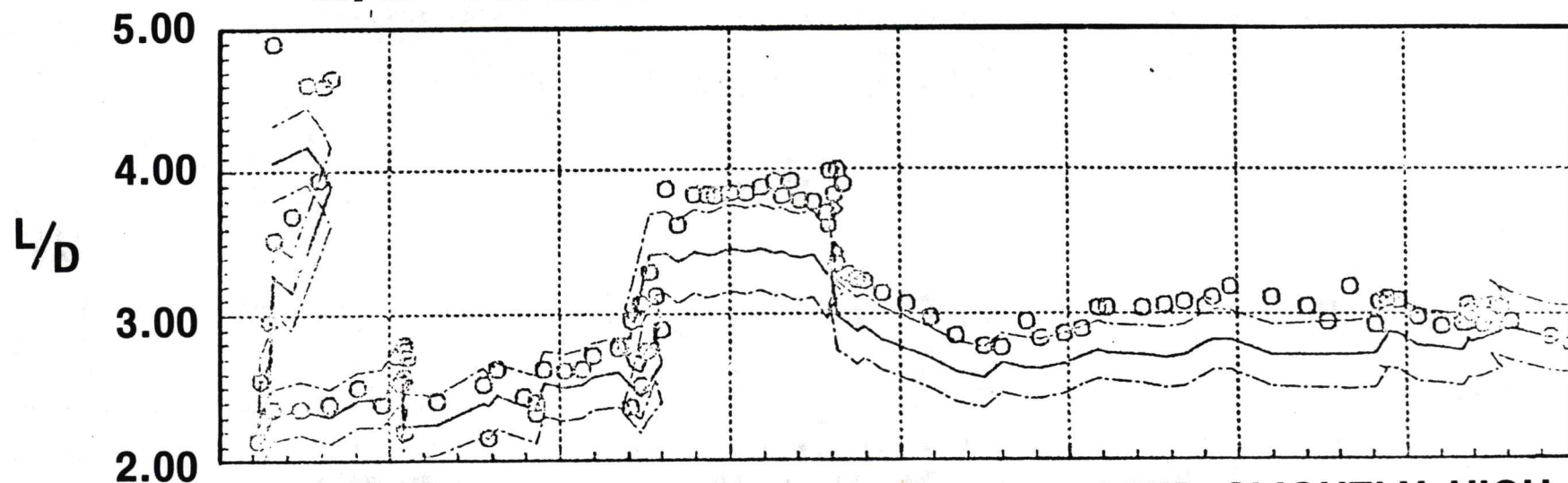
# LATERAL DIRECTIONAL EFFECTIVENESS



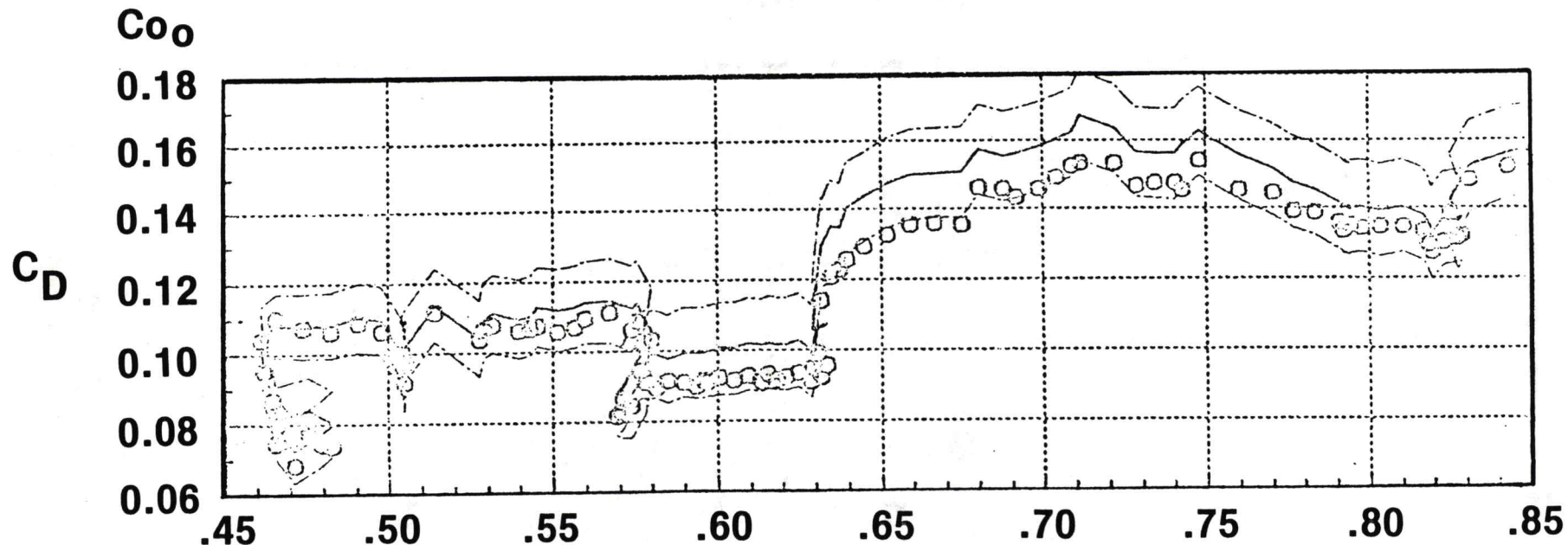
# AILERON EFFECTIVENESS



# L/D HIGHER THAN EXPECTED



● SUBSONIC LIFT TO DRAG RATIO PREDICTED SLIGHTLY HIGH



● TOO HIGH BY 50 CTS - OVER ESTIMATE OF TILE DRAG

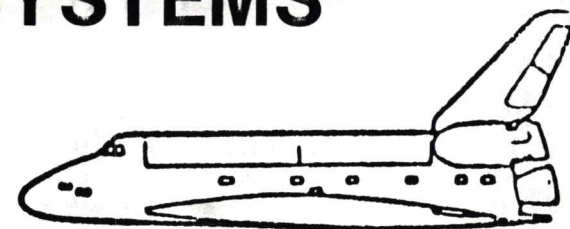


**NASA-S-81-10945**

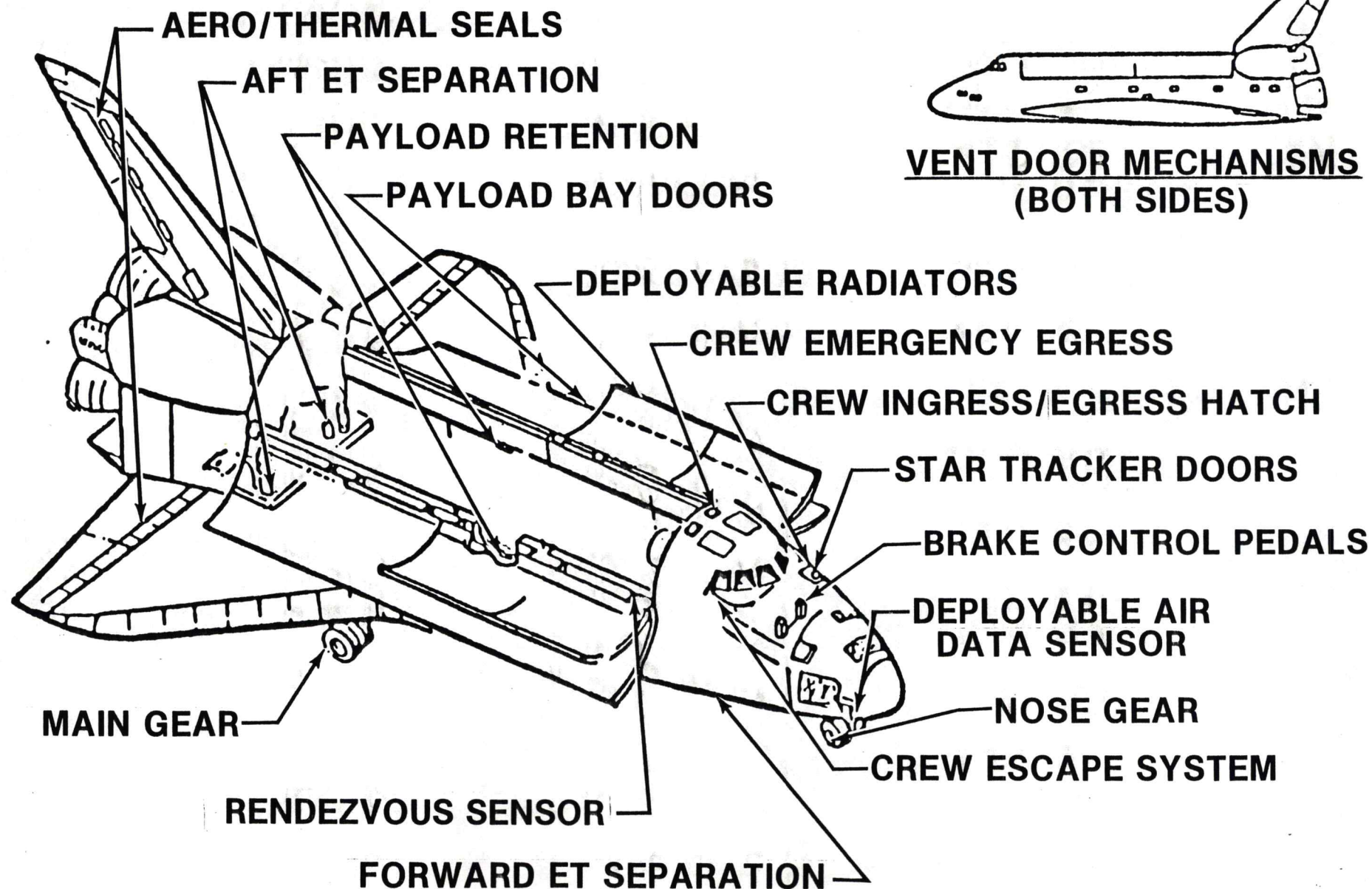
# **STS-1 MECHANICAL SYSTEMS PERFORMANCE ASSESSMENT**

**J. McCULLOUGH  
SPACECRAFT DESIGN DIVISION**

# ORBITER MECHANICAL SYSTEMS



VENT DOOR MECHANISMS  
(BOTH SIDES)



## STS-1 MECHANICAL SYSTEM PERFORMANCE

- ACTUATION MECHANISMS
- ALL PERFORMED AS DESIGNED - ACTUATION WITHIN SPECIFICATION

	<u>MOTORS</u>	<u>SWITCHES</u>
PAYLOAD BAY DOORS	20	56
RADIATORS	12	24
VENT DOORS	12	64
ET UMBILICAL DOORS	12	30
STAR TRACKER	4	8
AIR DATA PROBE	4	8
CREW HATCHES	-	2
TOTAL	<hr/> 64	<hr/> 192

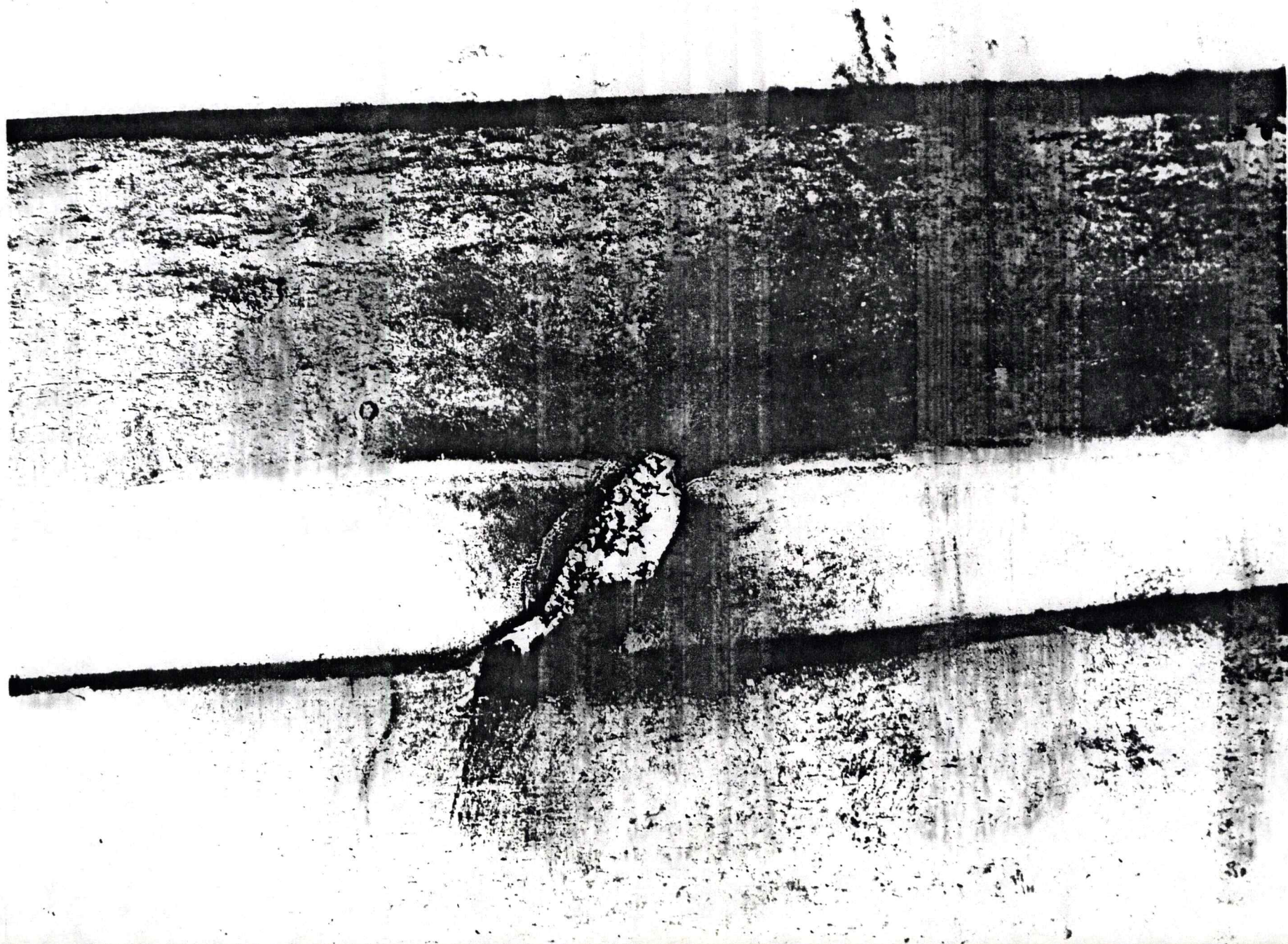


# **STS-1 MECHANICAL SYSTEM PERFORMANCE ASSESSMENT LANDING DECELERATION SYSTEM**

- **ANOMALIES**
  - **LEFT MAIN TIRE CUT**
  - **UPLOCK ROLLER FAILURE**
  - **ABNORMAL PRESSURE ON R. H. INBOARD BRAKE**

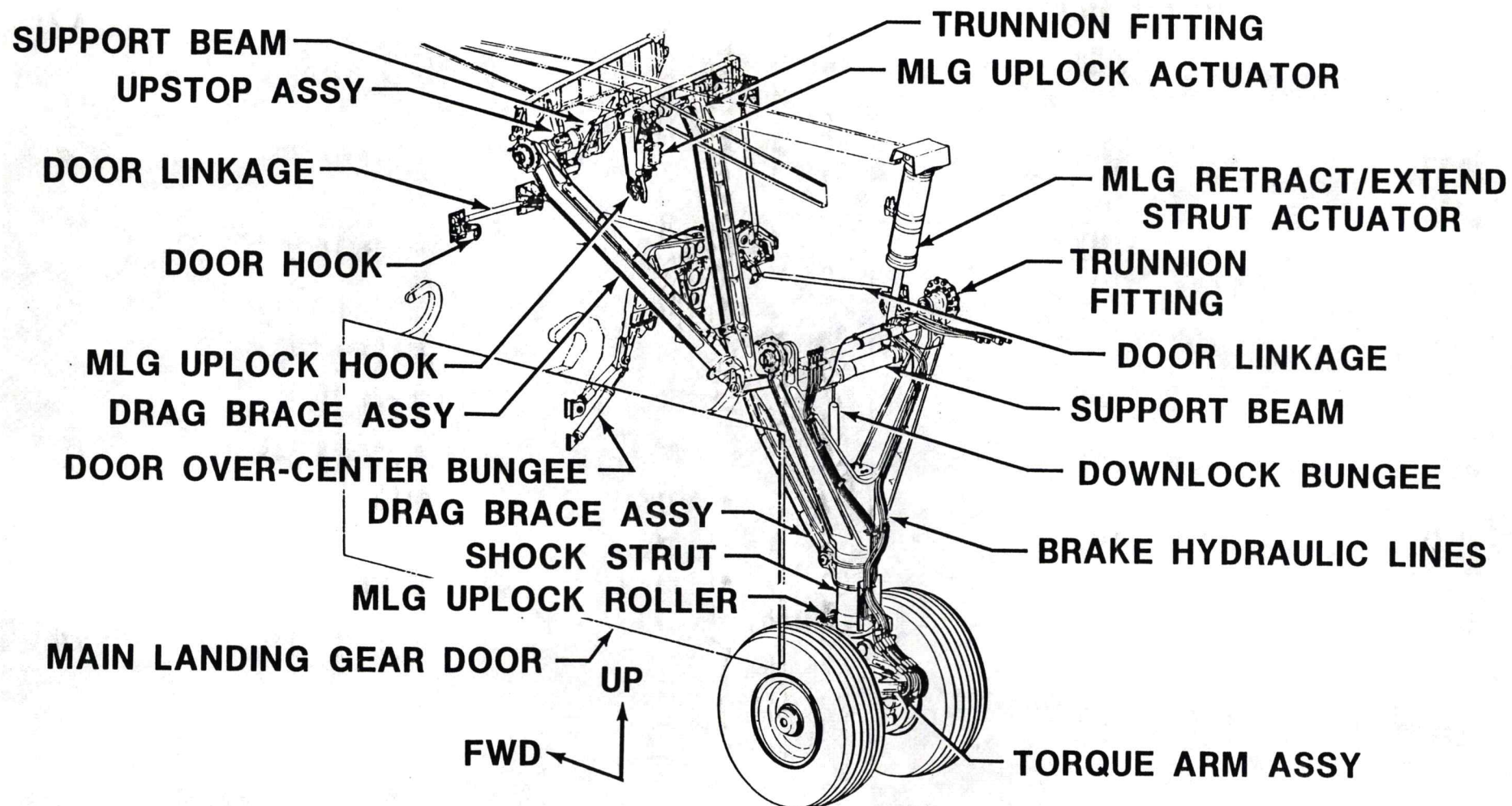
NASA-S-81-10947

# STS-1 CUT - LHOB TIRE





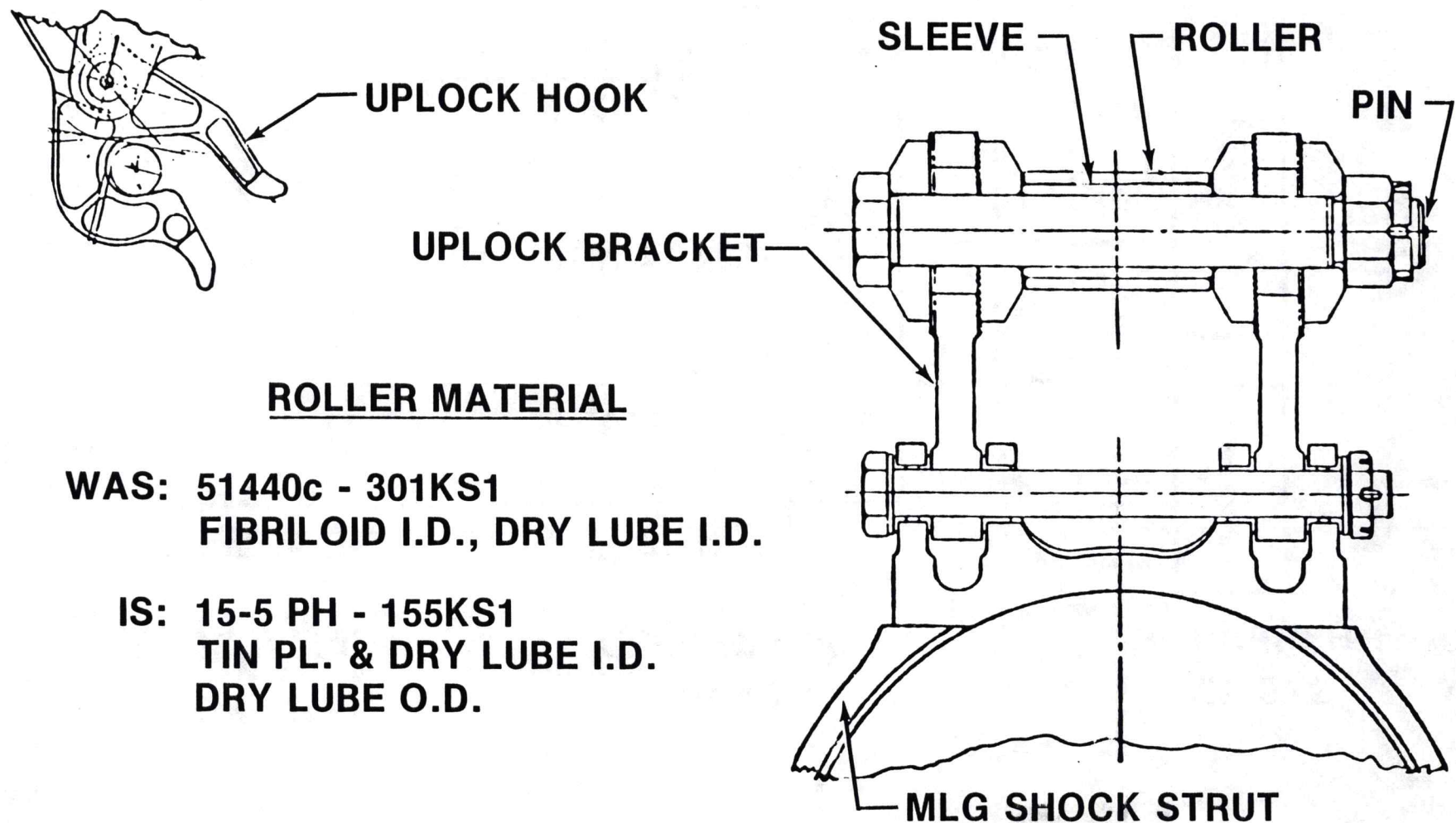
# MAIN LANDING GEAR



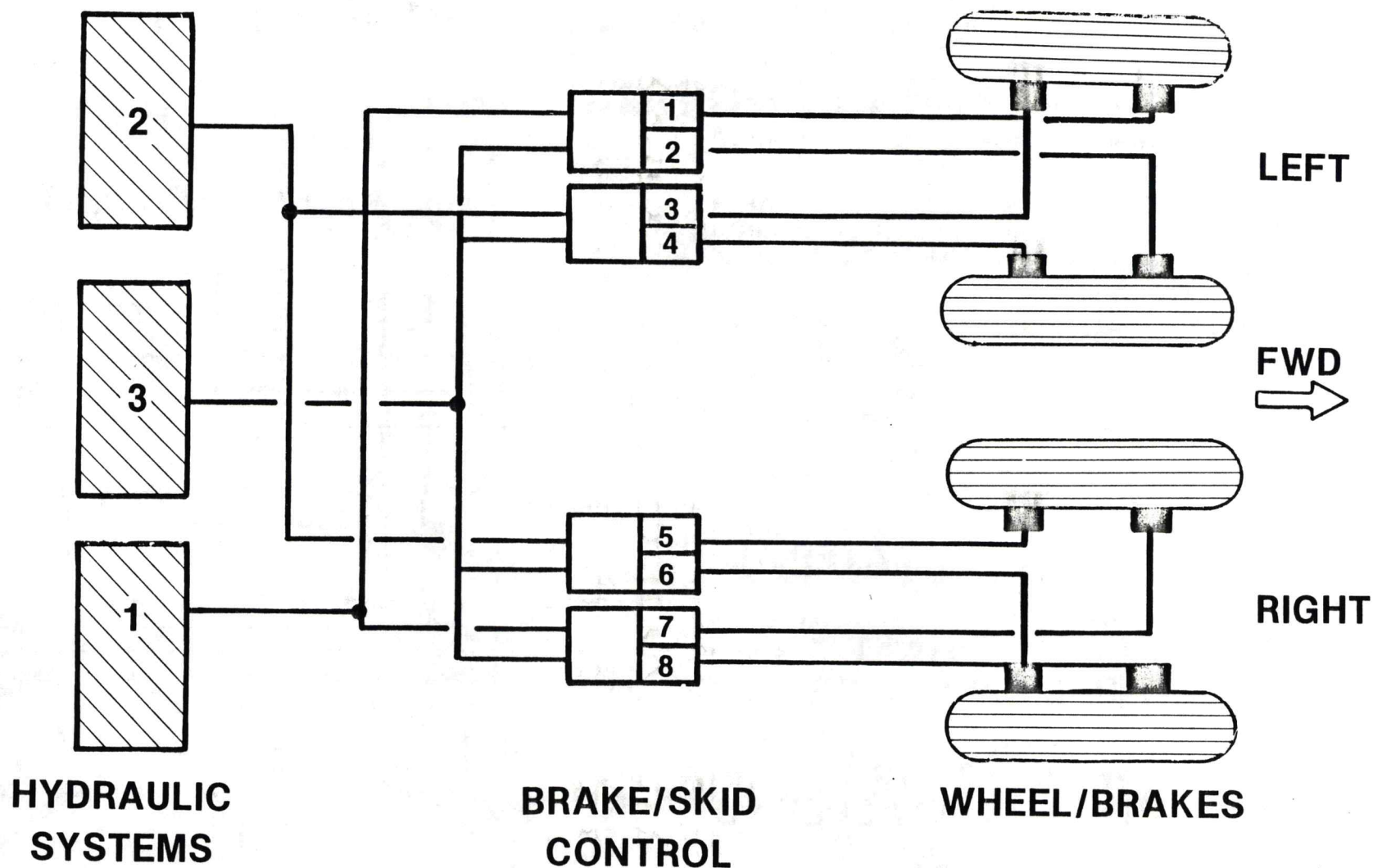


# STS-1 MECHANICAL SYSTEM PERFORMANCE ASSESSMENT

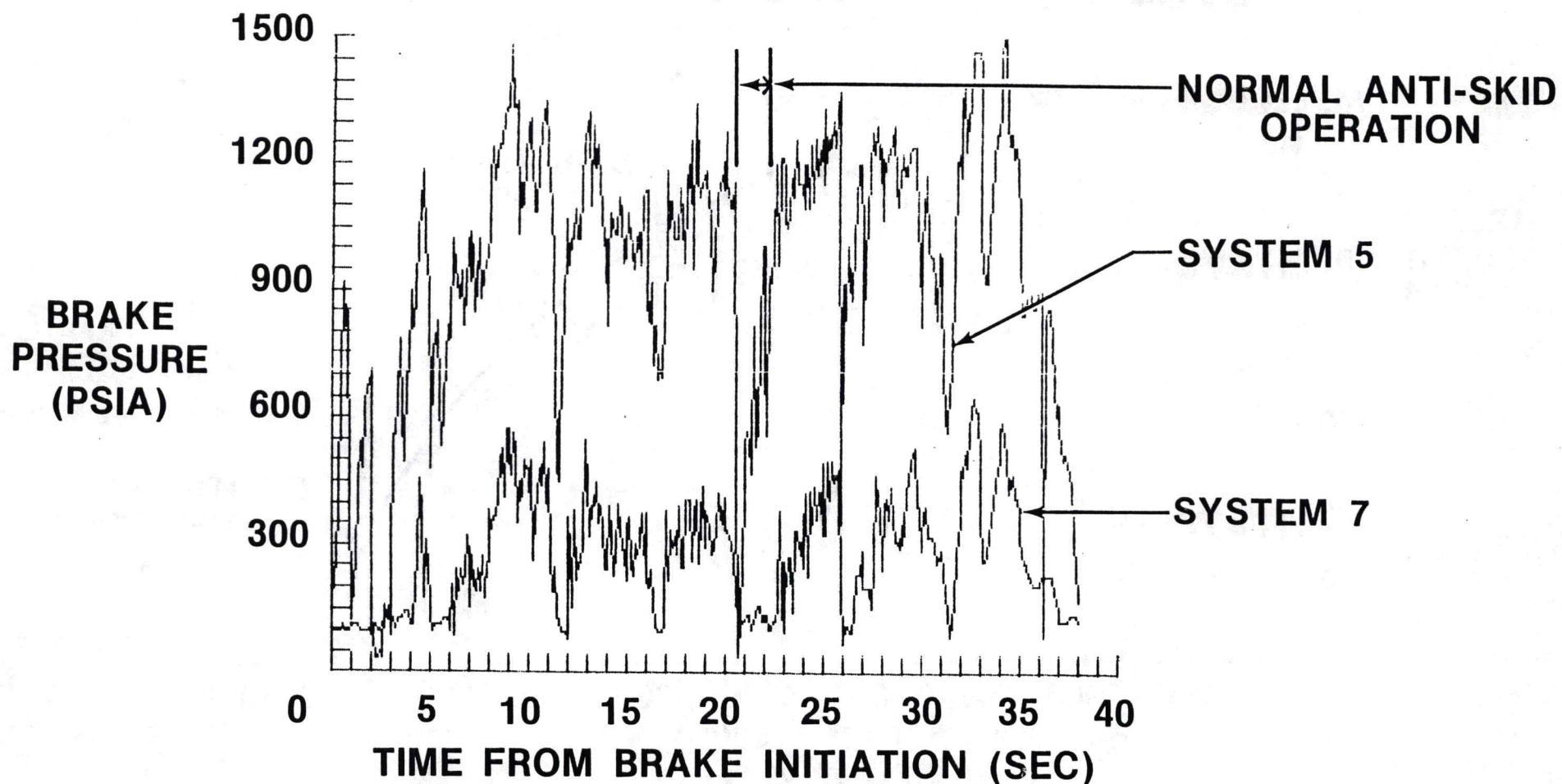
## MAIN LANDING GEAR UPLOCK



# BRAKE HYDRAULIC SCHEMATIC

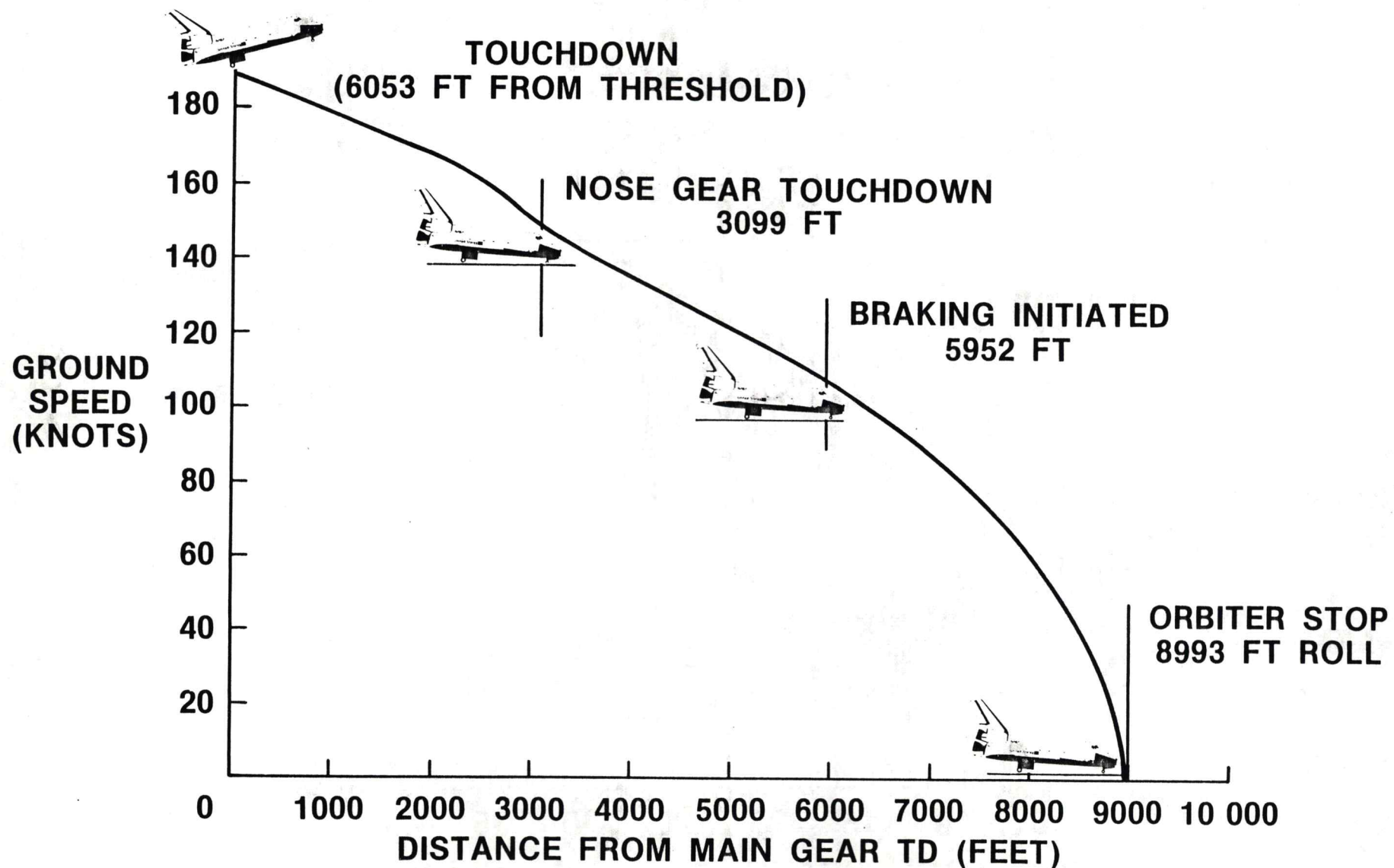


# STS-1 MECHANICAL SYSTEM PERFORMANCE ASSESSMENT RIGHT INBOARD BRAKE PRESSURES





# STS-1 LANDING



# **STS-1 MECHANICAL SYSTEM PERFORMANCE ASSESSMENT EMERGENCY CREW ESCAPE SYSTEM**

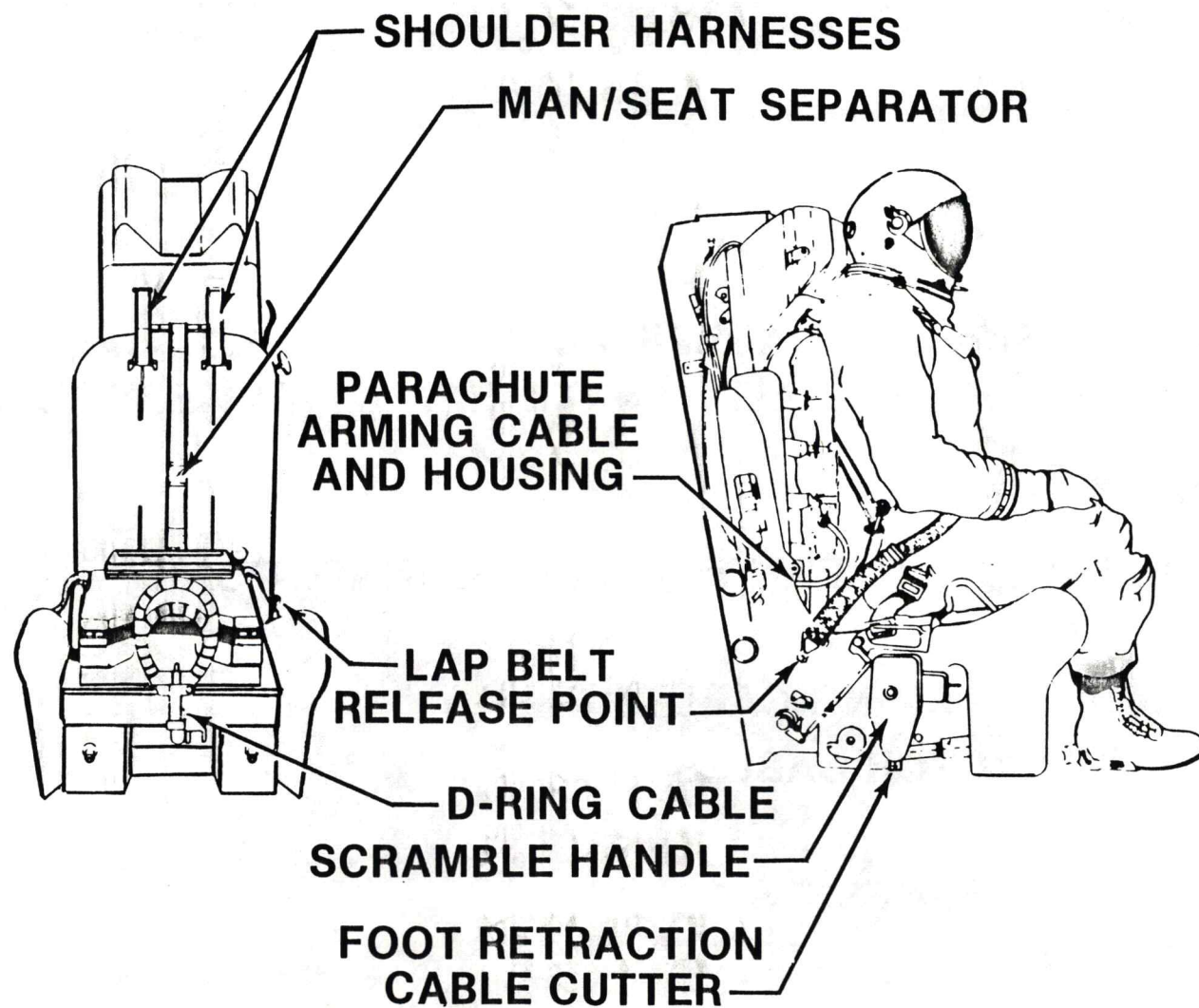
## **● ANOMALY**

- SCRAMBLE HANDLE(S) INADVERTENTLY UNLOCKED - SAFETY CLIPS  
COULD NOT BE REINSTALLED UNTIL HANDLE(S) WERE PUSHED DOWN**

## **● FUNCTION**

- QUICK RELEASE OF CREW FROM SEAT CONNECTIONS**
  - LAP BELTS**
  - PARACHUTE ARMING CABLES**
  - FOOT RETRACTOR CABLES**
  - D-RING CABLES**
  - SHOULDER HARNESSSES**
  - INERTIA REELS**
- SYSTEM REDUNDANCE - BALL DETENT LOCK AND SAFETY WIRE**

# EMERGENCY CREW ESCAPE SYSTEM

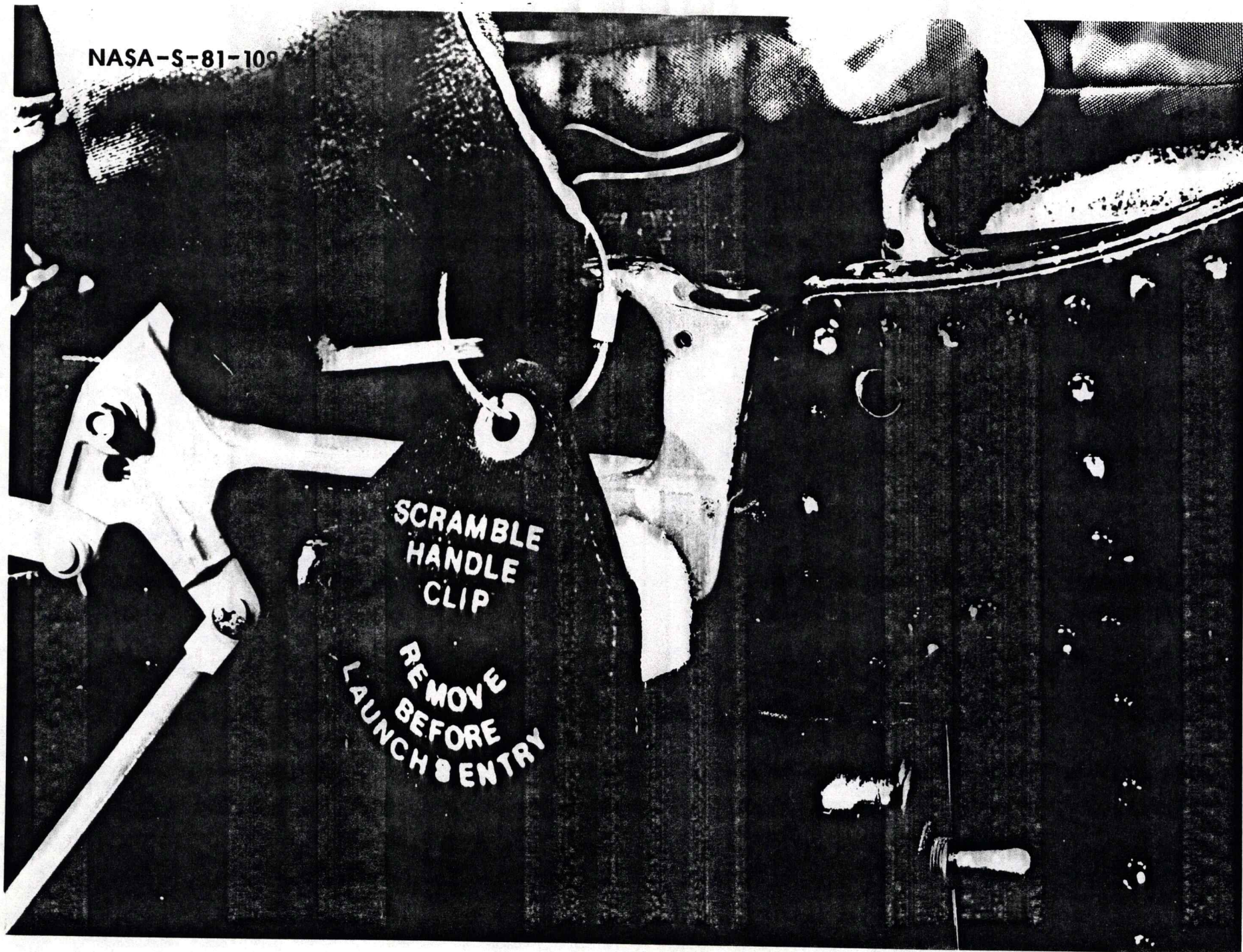




NASA-S-81-109

SCRAMBLE  
HANDLE  
CLIP

REMOVE  
BEFORE  
LAUNCH & ENTRY



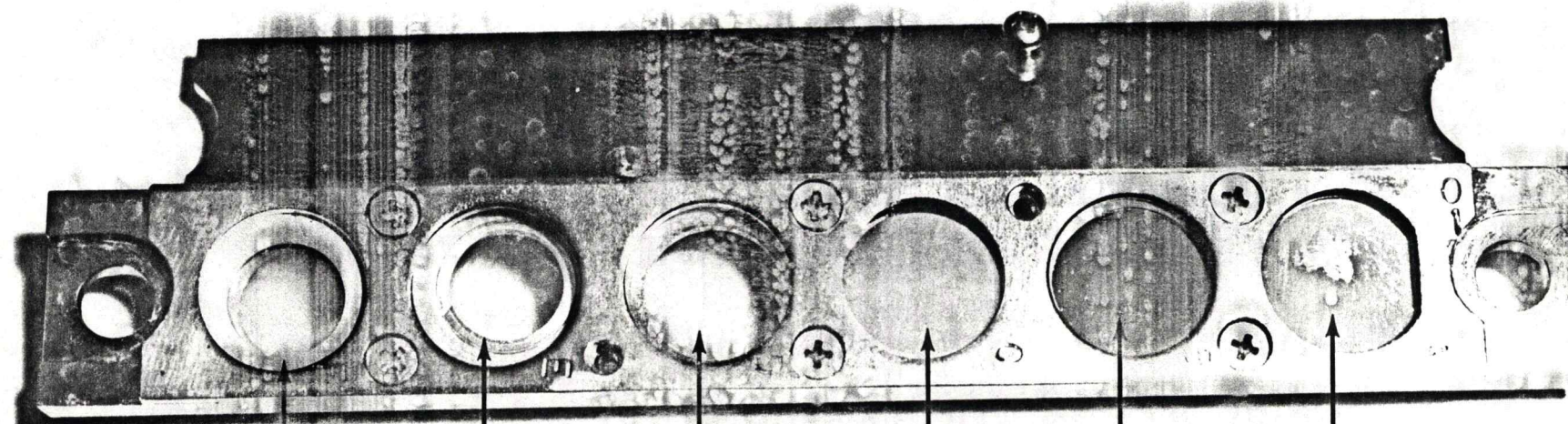


# **STS-1 CONTAMINATION ASSESSMENT**

- **DEBRIS DURING FLIGHT**
  - **VIDEO TAPE**
  - **CREW COMMENTS**
- **VEHICLE EXAMINATION**
  - **INTERIOR BAY**
    - **FILM DEPOSITS FOUND ONLY ON ONE TV CAMERA**
    - **PARTICULATES FOUND IN SOME LOCAL REGIONS OF BAY**
    - **SAMPLES REMOVED FOR FURTHER ANALYSIS**
  - **WINDOWS**
    - **GENERALLY IN GOOD SHAPE**
    - **EXTERIOR PANES HAVE "SMOKEY" DEPOSIT, OK FOR FLIGHT**
    - **NO INTERIOR DEPOSITS**
- **PASSIVE SAMPLES EXPOSED IN BAY DURING FLIGHT**
- **QUANTITATIVE RESULTS WILL BE OBTAINED ON STS-2 AND STS-3**

NASA-S-81-11100

# POSA-DFI



ELECTRET

CaF<sub>2</sub>  
OVER  
ELECTRET

CaF<sub>2</sub>

1810 Å  
FILTER

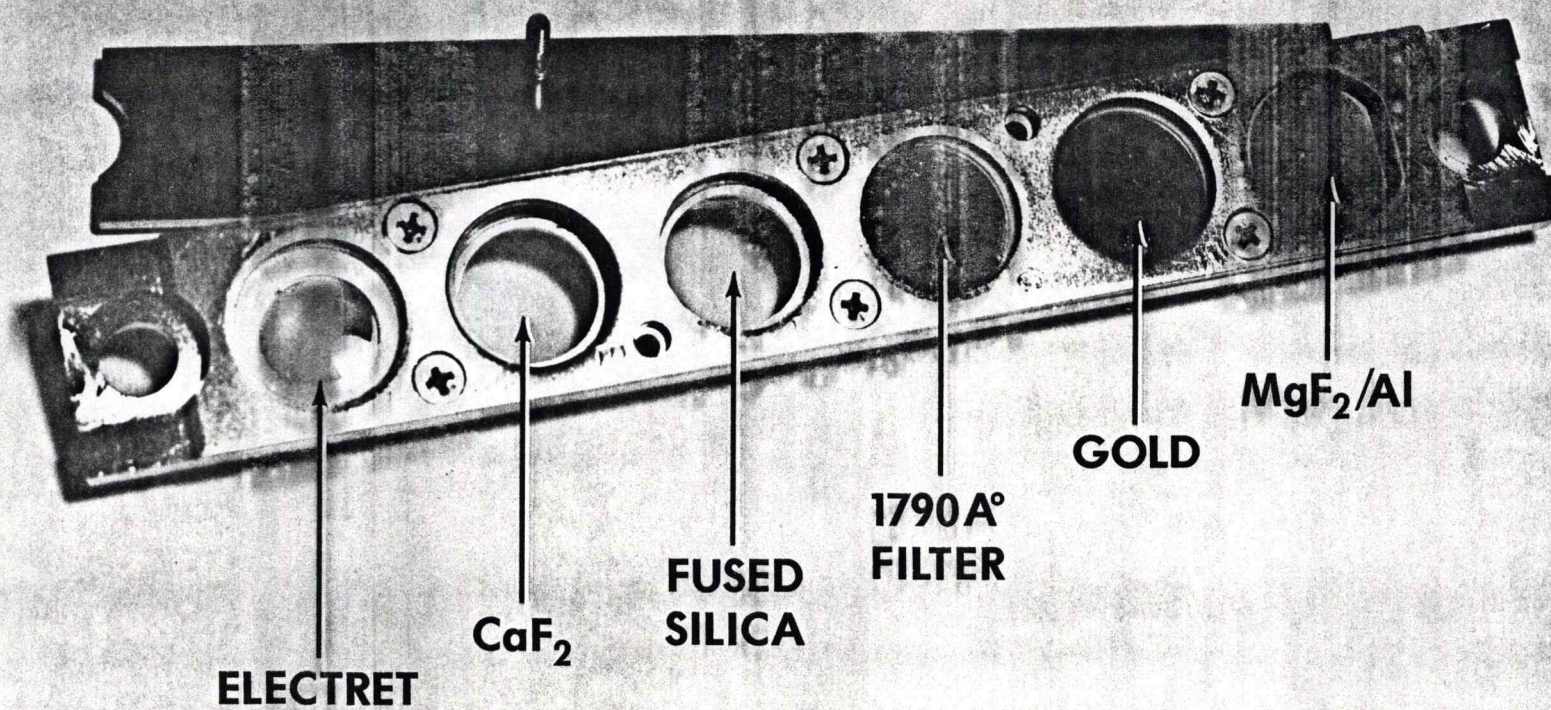
GOLD

MgF<sub>2</sub>/Al



NASA-S-81-11099

# POSA-FERRY FLIGHT



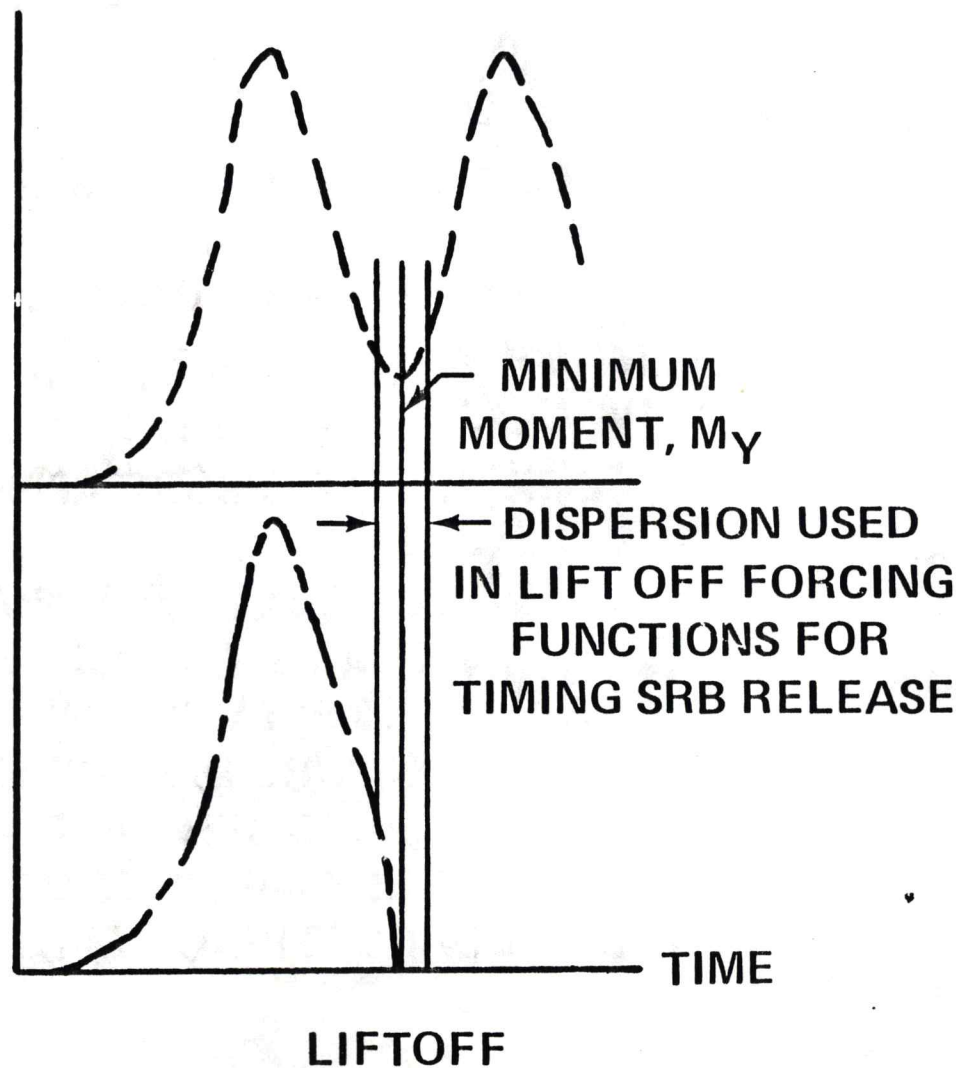
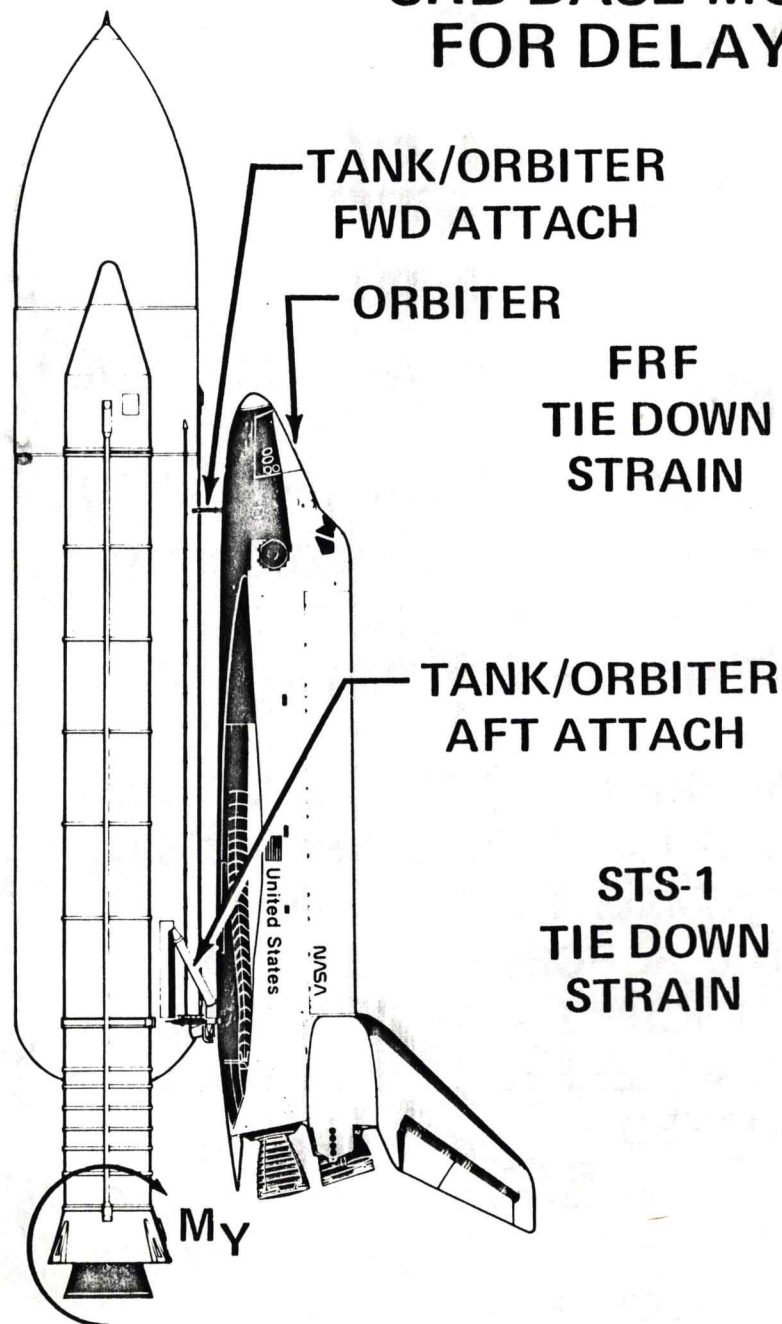


## STS-1 FLIGHT TEST RESULTS - LOADS

- LIFT-OFF LOADS

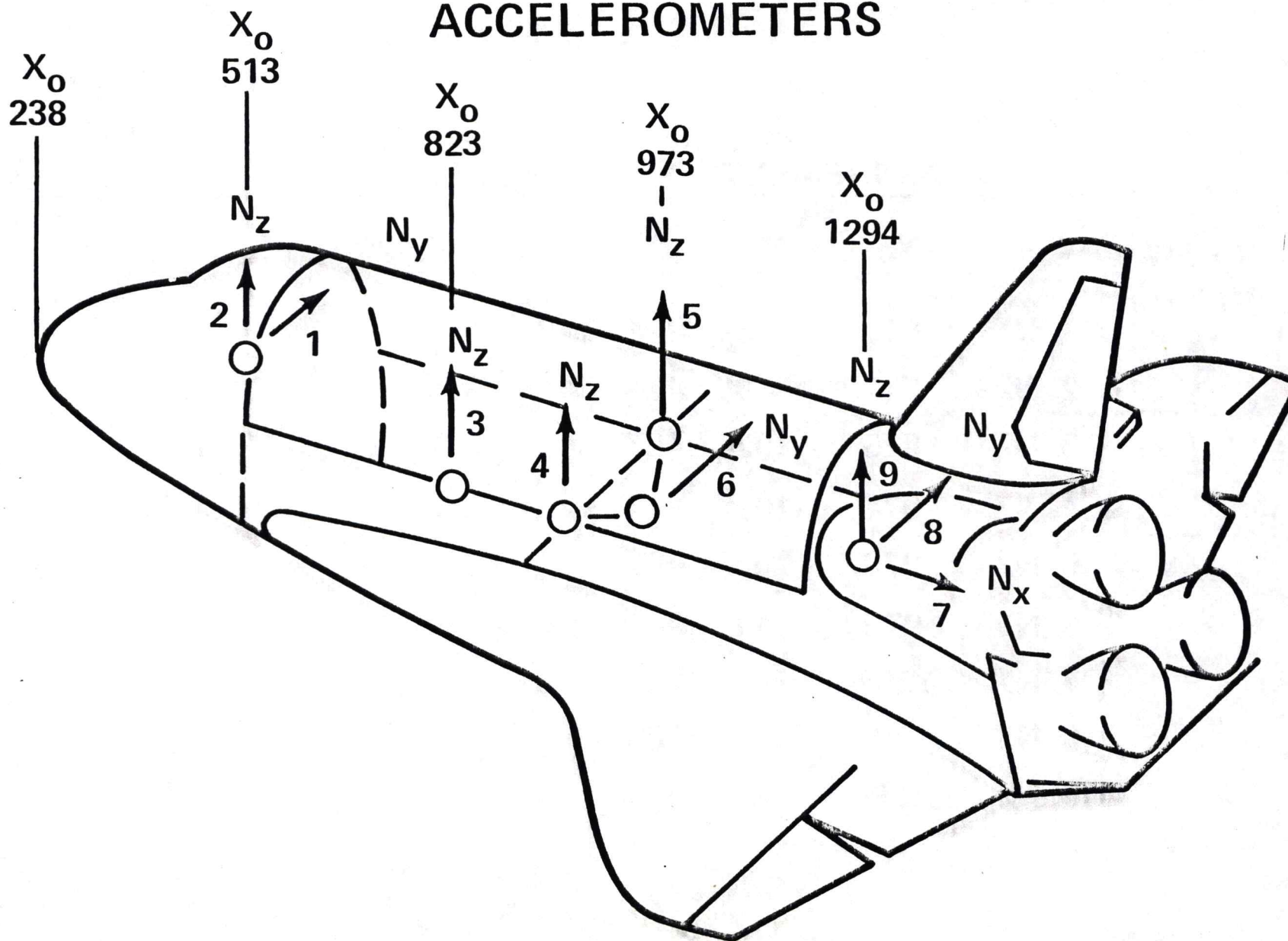
- RELEASE TIMING TO MINIMIZE BASE MOMENT AT RELEASE AS PREDICTED
- ORBITER  $N_z$  APPROXIMATELY TWICE AS HIGH AS PREDICTED
  - $\sim 3.5$  g's MEASURED IN CREW MODULE (1.8 PREDICTED) AND FORWARD PAYLOAD BAY AT LIFT-OFF
- LIFT-OFF OVERPRESSURE APPROXIMATELY 4 TIMES AS HIGH AS PREDICTED:
  - APPROXIMATELY 2 PSI MEASURED ON ORBITER AFT HEAT SHIELD VS. 1.32 PSI DESIGN AND 0.5 PSI PREDICTED
  - TRANSIENT ELEVON HINGE MOMENTS NEAR LIMIT
  - OVERPRESSURE DISTRIBUTED FORCES FOR LIFT-OFF DYNAMIC RESPONSE ANTICIPATED TO BE APPROXIMATELY 4-6 TIMES DESIGN. EFFECT ON LIFT-OFF LOADS IS BEING EVALUATED

# SRB BASE MOMENT AND TIMING FOR DELAYED SRB IGNITION





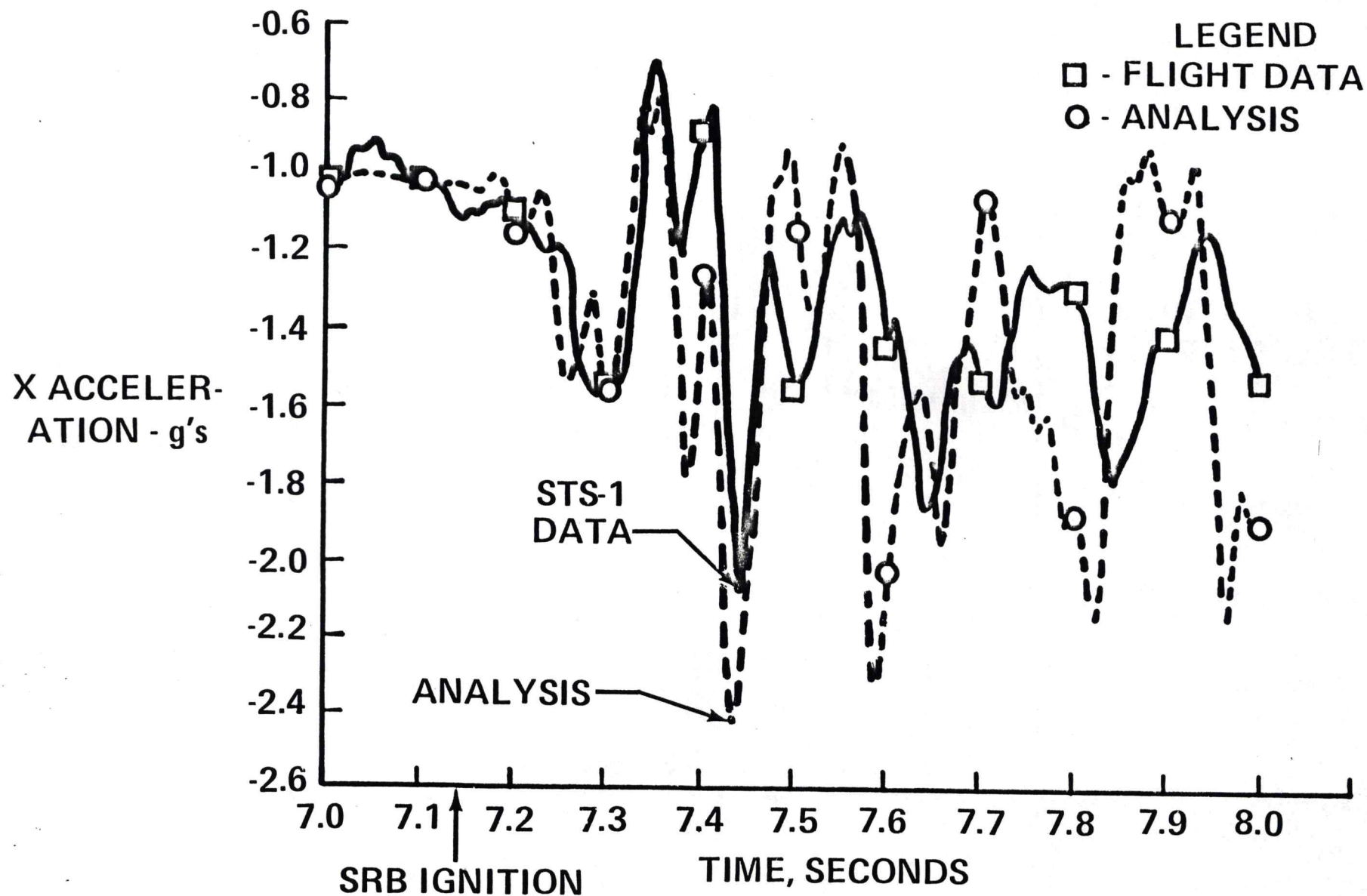
# ORBITER LOW FREQUENCY ACCELEROMETERS



# ORBITER ACCELERATIONS ~ STS-1 LIFTOFF

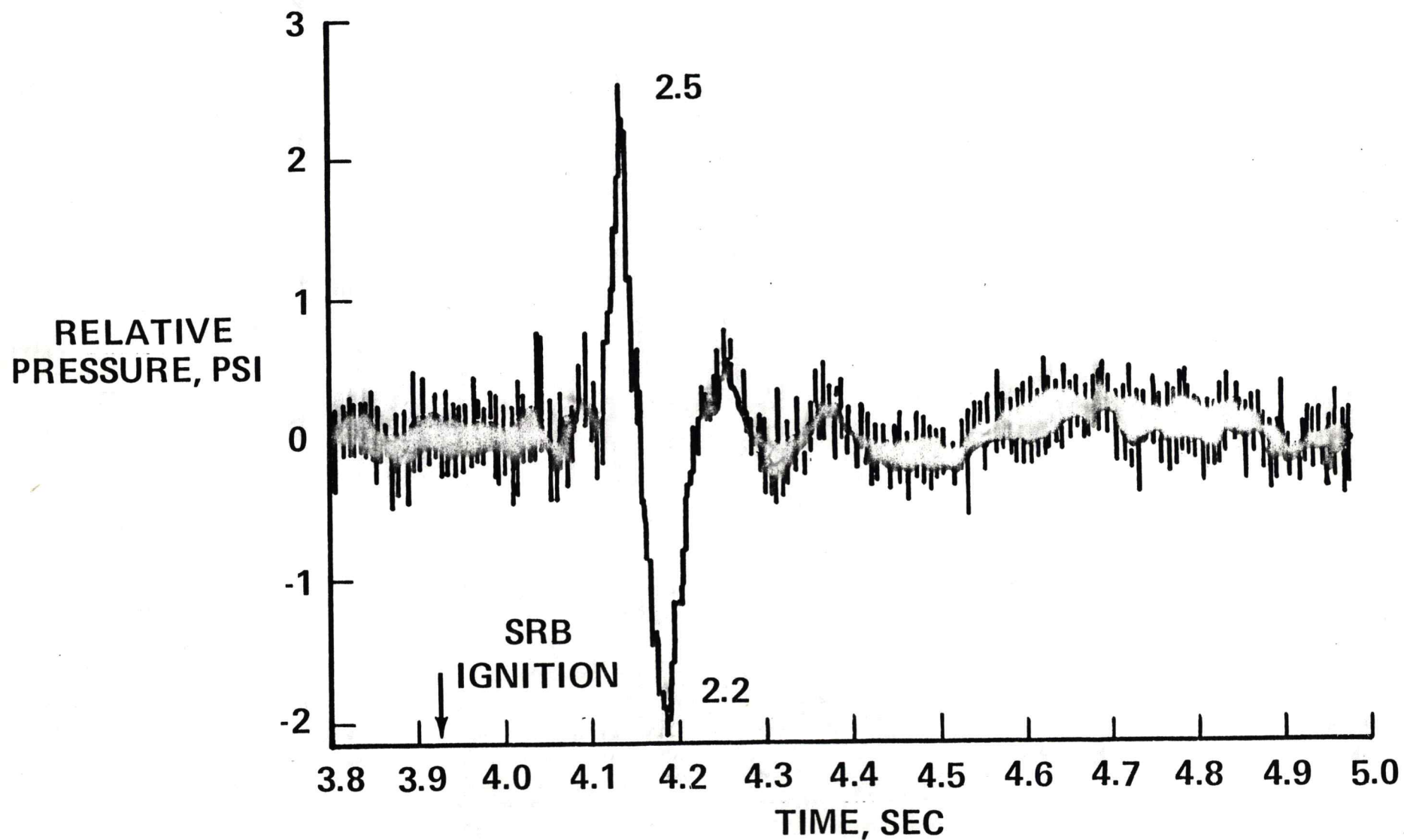
		<u>MEASUREMENT</u>			<u>STS-1 MEASURED</u>	<u>PRE-FLIGHT DESIGN LIMITS</u>
		<u>X<sub>o</sub></u>	<u>Y<sub>o</sub></u>	<u>Z<sub>o</sub></u>	<u>G's</u>	<u>G's</u>
<div> <div>CREW MODULE</div> <div>↑</div> <div>↓</div> <div>PAYLOAD BAY</div> </div>	1. NY	511	3	424	.19	.87
	2. NZ	511	0	424	3.5	1.43
	3. NZ	825	-102	407	2.8	1.85
	4. NZ	974	102	407	2.9	1.75
	5. NZ	973	-103	407	2.9	1.83
	6. NY	979	-11	302	.40	-.45
	7. NX	1294	-2	297	-2.10	-2.41
	8. NY	1294	-2	300	.25	-.66
	9. NZ	1294	-2	289	-1.25	-.95

# COMPARISON OF X ACCELERATION AT 1307

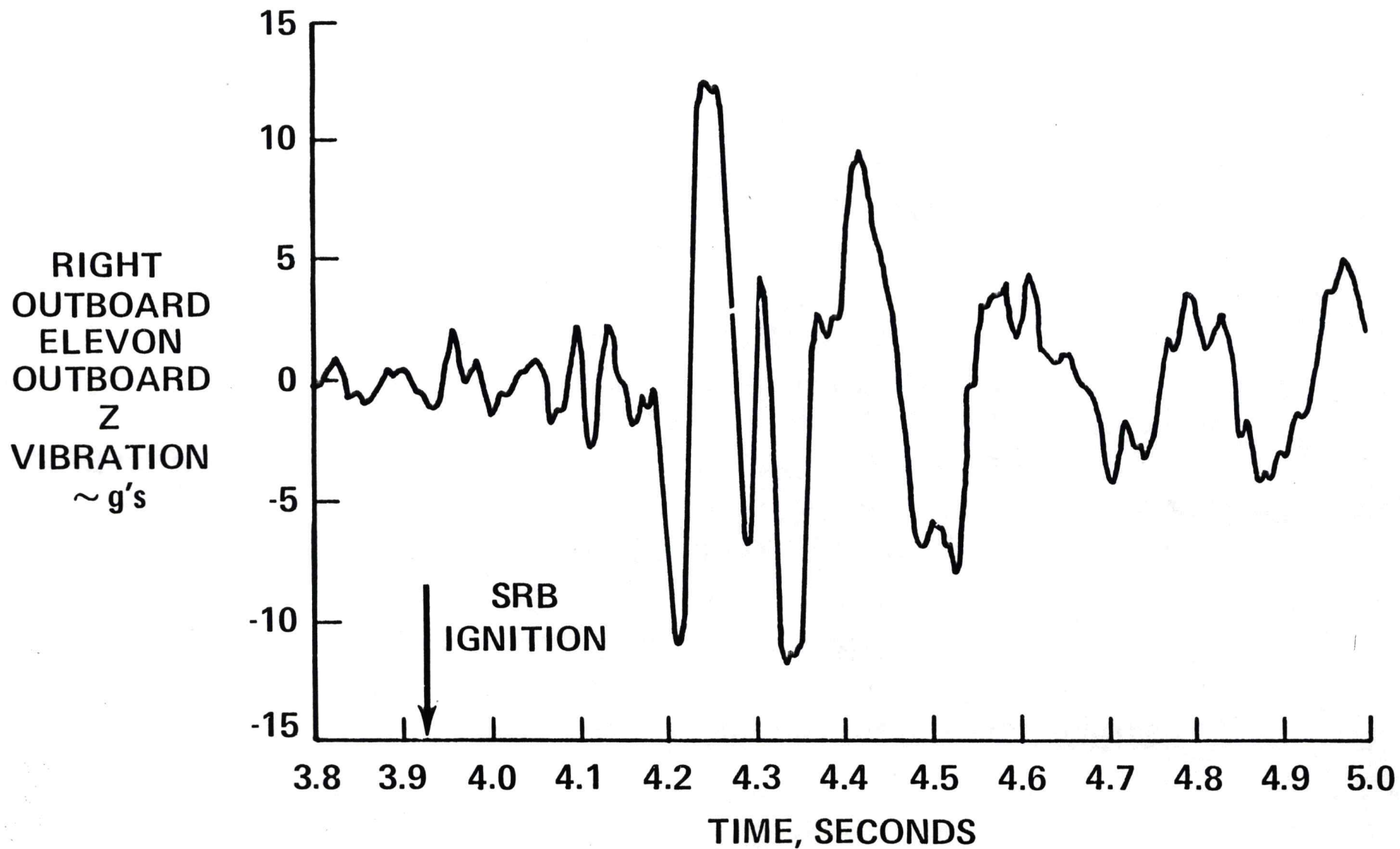




# PRESSURE ON UPPER SIDE OF BODY FLAP



## ELEVON OVERPRESSURE RESPONSE



## STS-1 FLIGHT TEST RESULTS - LOADS (CONT)

- ASCENT

- INTERFACE STRUT STRAINS APPROXIMATELY AS PREDICTED AND WITHIN DESIGN LIMITS
- COMPARTMENT DIFFERENTIAL PRESSURES WITHIN LIMITS BUT COMPARISON WITH PREDICTED MIXED
- QUASI-STATIC LOAD FACTORS LESS THAN DESIGN LIMITS
- MINIMAL RESPONSE OF ORBITER ACCELERATIONS TO SRB AND SSME THRUST OSCILLATIONS
  - ET LOX TANK BOTTOM OSCILLATING PRESSURES  $< 1.0$  PSI VS. 5.0 PSI DESIGN ALLOWABLE
- MEASURED AERO PRESSURES AND SHOCK STRENGTHS LOOK REASONABLE. DATA BASE COMPARISON IS BEING PERFORMED

- DESCENT

- QUASI-STATIC LOAD FACTORS LESS THAN DESIGN LIMITS
- MAX  $N_z$  DURING FLARE MANEUVER 1.6 VS PLACARD LIMIT OF 2.0
- LANDING MAIN GEAR  $\sim 1$  FPS VS PLACARD LIMIT OF 6 FPS
- NOSE GEAR CONTACT AT 5.7 FPS VS DESIGN LIMIT 11 FPS  
(CREW MODULE  $N_z = 1.8$  VS 4.1 DESIGN)



## **STS-1 FLIGHT TEST RESULTS - STRUCTURAL DYNAMICS**

- **ORBITER FIRST BODY BENDING MODE RESPONSE OF 5.2 HZ MEASURED WHEN SSME'S STOWED FOLLOWING MECO ~ AGREES WELL WITH VALUE PREDICTED BY ORBITER MATH MODEL**
- **NO EVIDENCE OF SYSTEM POGO. (PRESSURE OSCILLATIONS UPSTREAM SUBSTANTIALLY SUPPRESSED - GIMBAL AND ACCELEROMETERS RESPONDED ONLY TO THE TRANSIENTS.)**
- **NO ORBITER AEROSURFACE FLUTTER OR BUZZ INDICATED. CONTROL SURFACE LOW LEVEL BUFFET WAS DETECTED IN THE TRANSONIC REGION DURING ASCENT AND ENTRY. ( $\pm 5g$ 's WING/FIN TIP ASCENT)**
- **ACOUSTIC AND AERONOISE MEASURED ENVIRONMENTS WITHIN EXPECTED LEVELS. PAYLOAD BAY ENVIRONMENT 16 db LESS THAN EXTERNAL ENVIRONMENT OVERALL. HIGH FREQUENCY ATTENUATION GREATER THAN PREDICTED**

## **STS-1 FLIGHT TEST RESULTS - AIRFRAME STRUCTURE**

- **ASCENT AND ENTRY DATA HAVE BEEN REVIEWED. NO ABNORMAL STRAIN RESPONSE NOTED. DATA BASE COMPARISON IS BEING PERFORMED**
- **BONDLINE TEMPERATURES BELOW DESIGN LIMITS. GRADIENT COMPARISON AND THERMAL STRESS EXTRACTION ARE BEING PERFORMED**
- **ASCENT LOAD CALIBRATION OF WING COMPLICATED BY EFFECT OF FUSELAGE BENDING MOMENT AND THUS HAS BEEN DELAYED. DESCENT LOAD CALIBRATION REQUIRES EXTRACTION OF THERMAL STRESS**

## **THERMAL TECHNOLOGY BRANCH STS-1 FLIGHT TEST RESULTS**

- ENTRY HEATING AND TPS
- LEADING EDGE STRUCTURAL SUBSYSTEM (LESS)
- THERMAL CONTROL SYSTEM



## ENTRY HEATING AND TPS PERFORMANCE

- BACKGROUND
  - AEROTHERMAL AND TPS HISTORICALLY IMPLIED TO BE OVERLY CONSERVATIVE
    - APOLLO HEAT SHIELD DESIGN BASED ON HIGH HEAT RATE AND HIGH HEAT LOAD TRAJECTORIES BUT ALWAYS FLOWN TO NOMINAL (WIND TUNNEL AND MATERIAL PROPERTY DATA COVERED WORST CASE)
  - AUGUST 1974 REDUCED TPS WEIGHT BY 2776 LBS BASED ON NOMINAL HEATING, NOMINAL TRAJECTORY AND NOMINAL TPS PERFORMANCE. ASSUMED STS-1 BENIGN BUT ASSESSED TO DISPERSIONS FOR CERTIFICATION
  - SUBSEQUENT STS-1 RSS ANALYSIS SHOWED CLOSE TO OR GREATER THAN NOMINAL DESIGN, REQUIRING EXTENSIVE TESTING AND ANALYSIS FOR CERTIFICATION

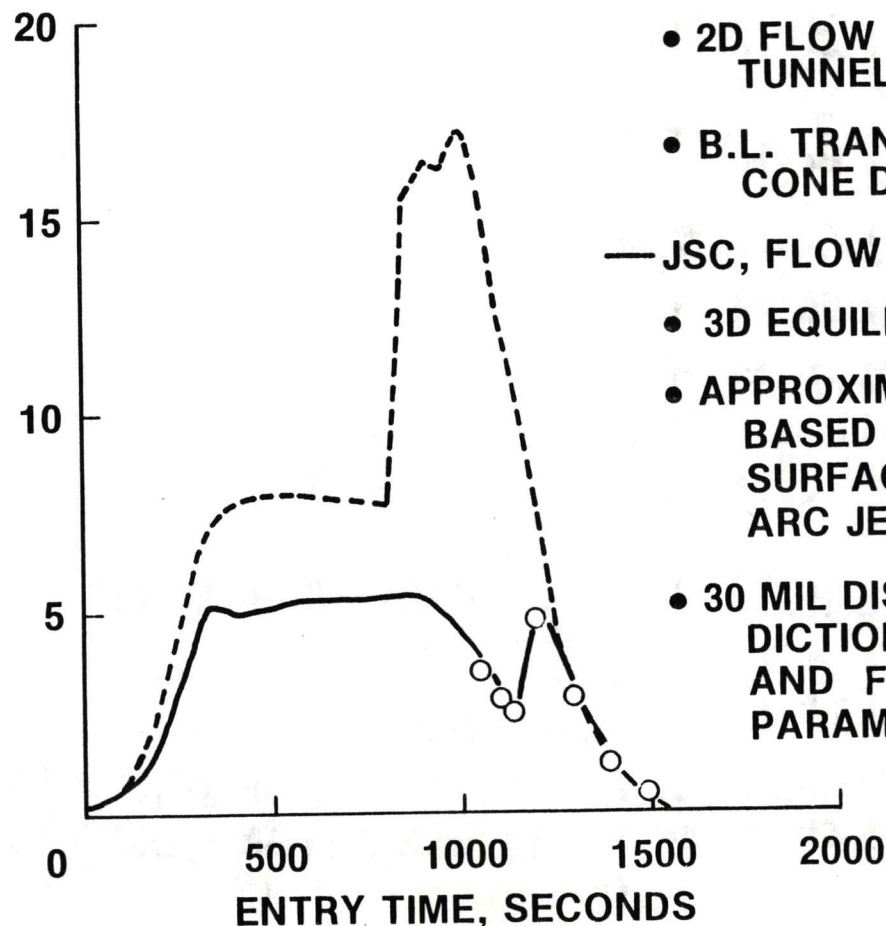
## ENTRY HEATING AND TPS PERFORMANCE (CONT)

- STS-1
  - LOSS OF DFI RECORDED DATA DURING PEAK HEATING LIMITS A DIRECT CORRELATION OF PREDICTED VS ACTUAL HEATING RATES AND TPS PERFORMANCE
  - SUFFICIENT DATA WAS AVAILABLE TO CORRELATE MAGNITUDE AND RESPONSE FOR SURFACE HEATING AND TPS PERFORMANCE BASED ON HEATING PREDICTIONS AND SHOWED:
    - WINDWARD LAMINAR HEATING AND BOUNDARY LAYER TRANSITION DATA AGREES WITH THE JSC PREDICTED HEATING FOR 30 MIL DISTRIBUTED ROUGHNESS AND WITH ROCKWELL SMOOTH BODY PREDICTED HEATING WHEN REDUCED BY 20 PERCENT
    - LIMITED DATA ON LEESIDE HEATING INDICATES NO CONSERVATISM IN DESIGN
  - MPAD TRAJECTORY SHAPING (WITH HEATING CONSTRAINTS), EARLY NOSE RESHAPING, AND "AS BUILT" TPS HAS BEEN SUCCESSFUL IN ACHIEVING A LAMINAR VEHICLE: (TRANSITION NOMINAL)

# STS-1 ENTRY HEATING DATA AND PREFLIGHT PREDICTIONS

WINDWARD @  $\frac{X}{L} = .4$

HEATING RATE,  
BTU/FT<sup>2</sup> - SEC



● DATA

--- RI, PREFLIGHT ASSESSMENT STATE-OF-THE-ART

- 2D FLOW MODELS CALIBRATED BY WIND TUNNEL DATA

- B.L. TRANSITION BASED ON GENERIC CONE DATA FOR SINGLE POINT ROUGHNESS

— JSC, FLOW FIELD CALIBRATED

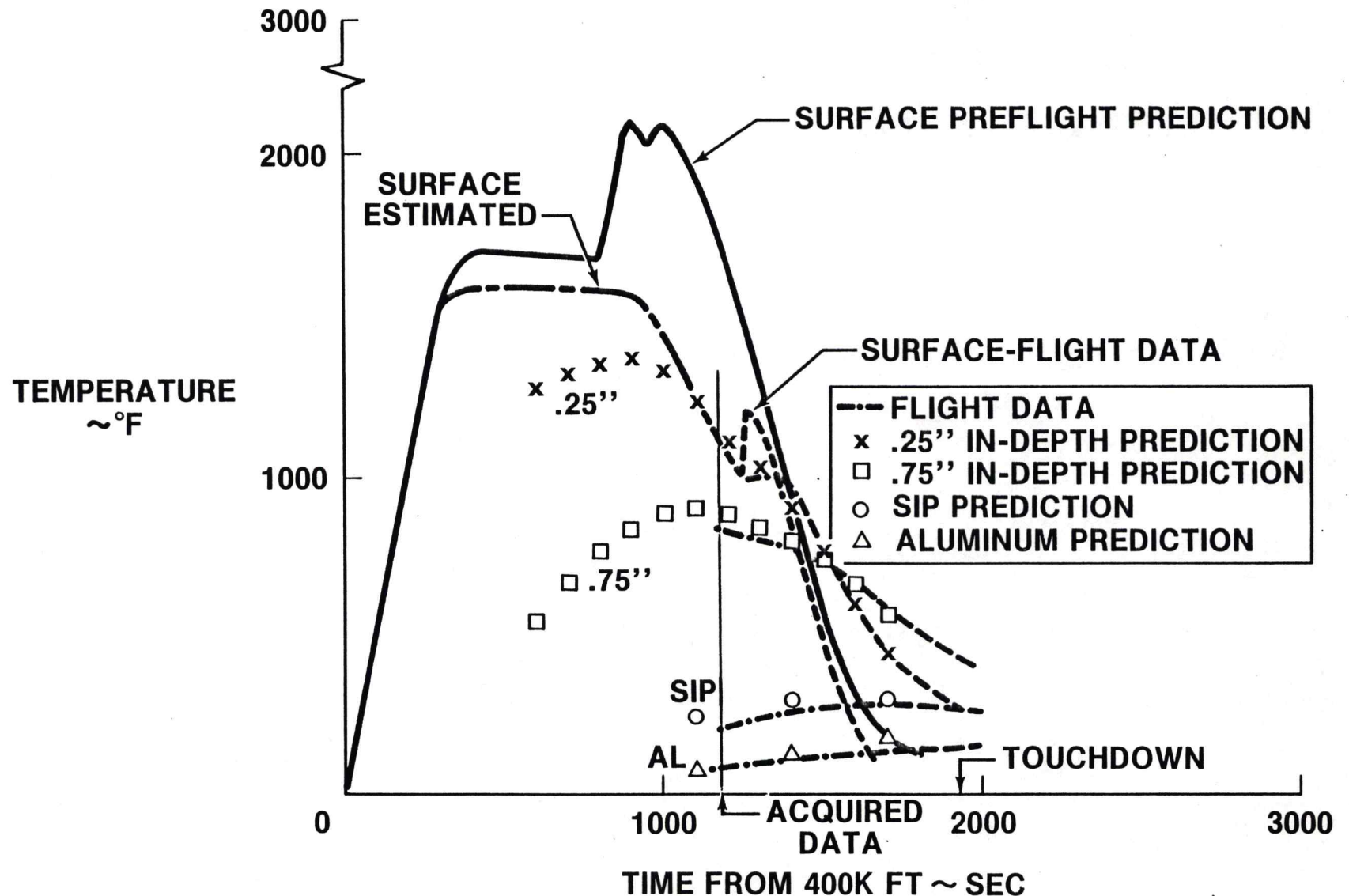
- 3D EQUILIBRIUM FLOW FIELD

- APPROXIMATE SURFACE CATALYSIS BASED ON 3D REACTING FLOW FIELD AND SURFACE RATES INFERRED FROM ARC JET

- 30 MIL DISTRIBUTED ROUGHNESS PREDICTIONS BASED ON SIMILITUDE TESTING AND FLOW FIELD EXTRAPOLATION PARAMETERS ( $Re_k$ ),  $Re_\theta/M$

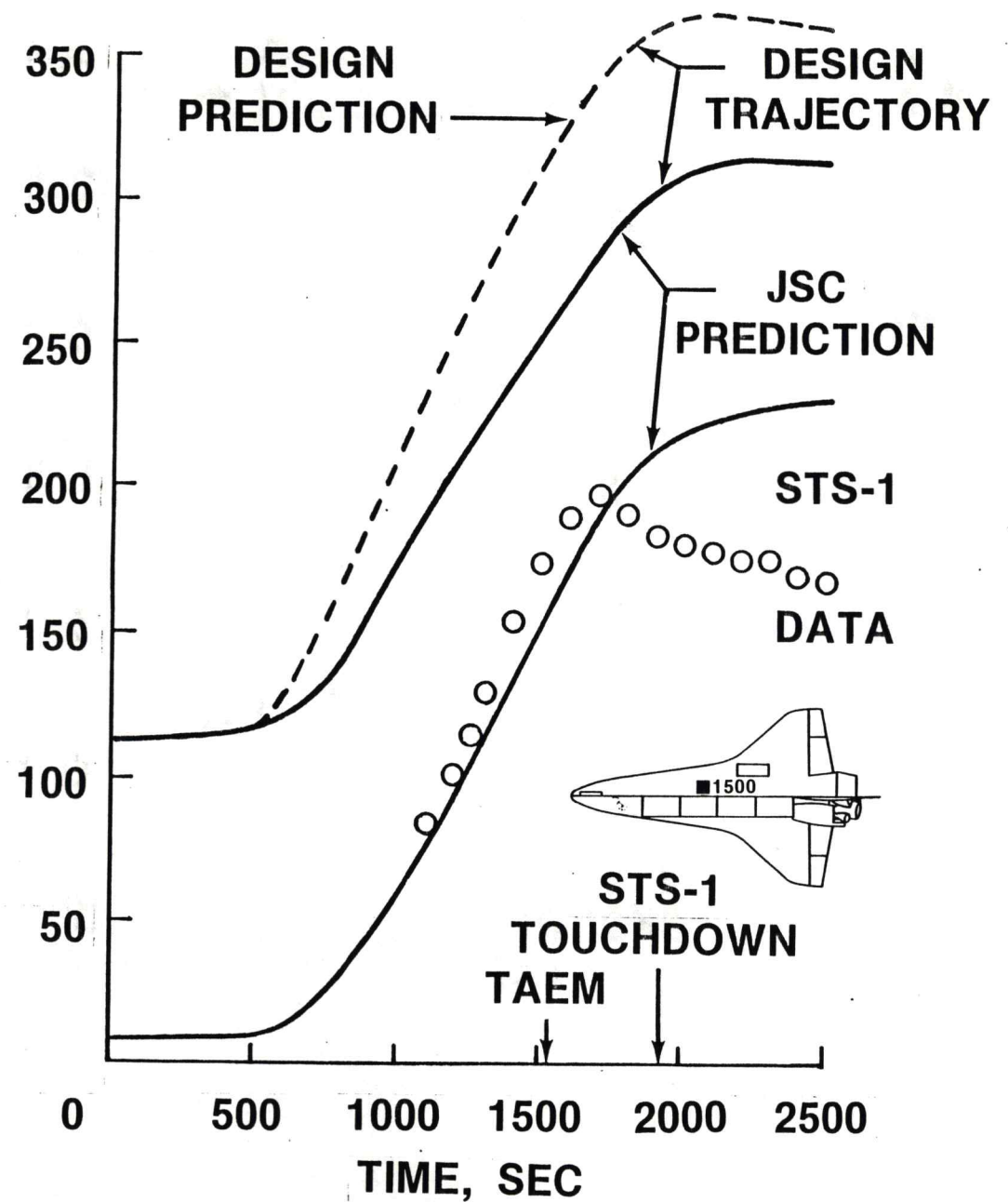


# STS-1 ENTRY TPS IN DEPTH TEMPERATURE RESPONSE



# ENTRY BONDLINE THERMAL RESPONSE, MIDBODY WINDWARD

TEMPERATURE,  
°F



## **TPS POST-FLIGHT INSPECTION SUMMARY - RSI**

- **SURFACE IMPACT DAMAGE**
  - **303 DING AND GOUGES IN TILE OML  
(80 PERCENT OCCURRED DURING ASCENT)**
  - **98 TILE COATING CHIPS**
  - **MORE TOLERANT TO DAMAGE (DUE TO LOWER  
SURFACE TEMPERATURES, NOMINAL VS RSS)**
  - **ONLY 12 REQUIRE REPLACEMENT**
  - **REMAINDER REPAIRABLE**

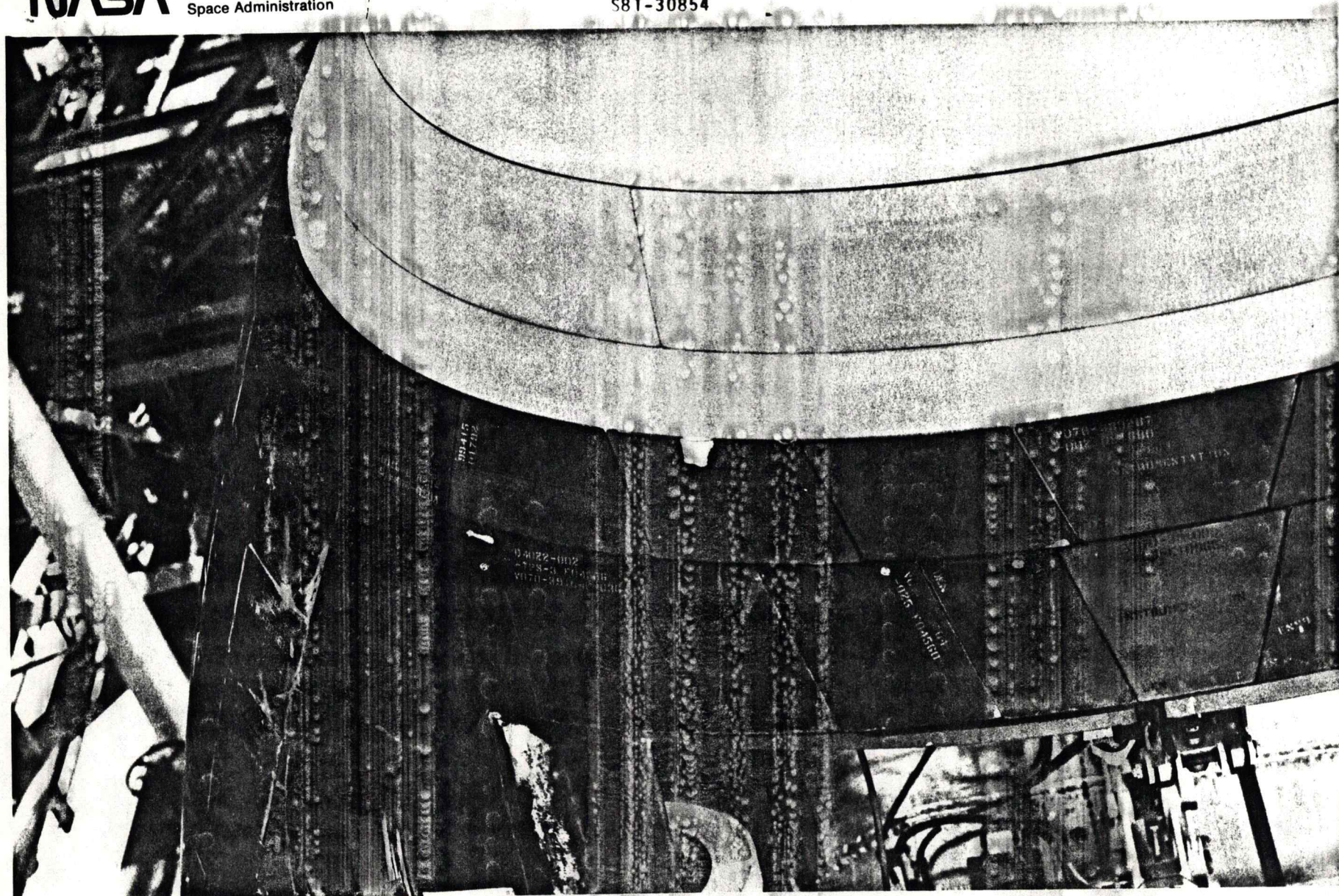




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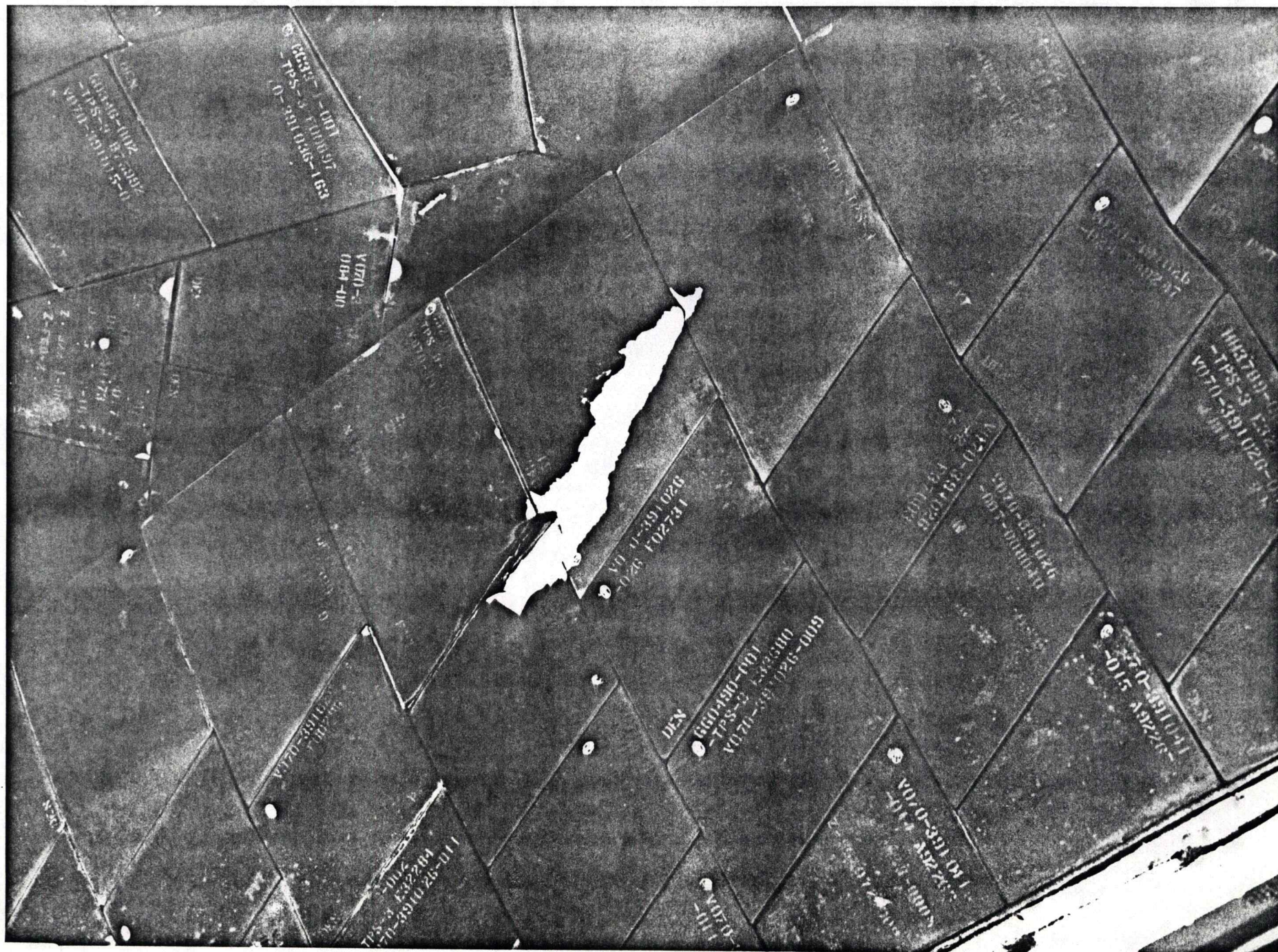
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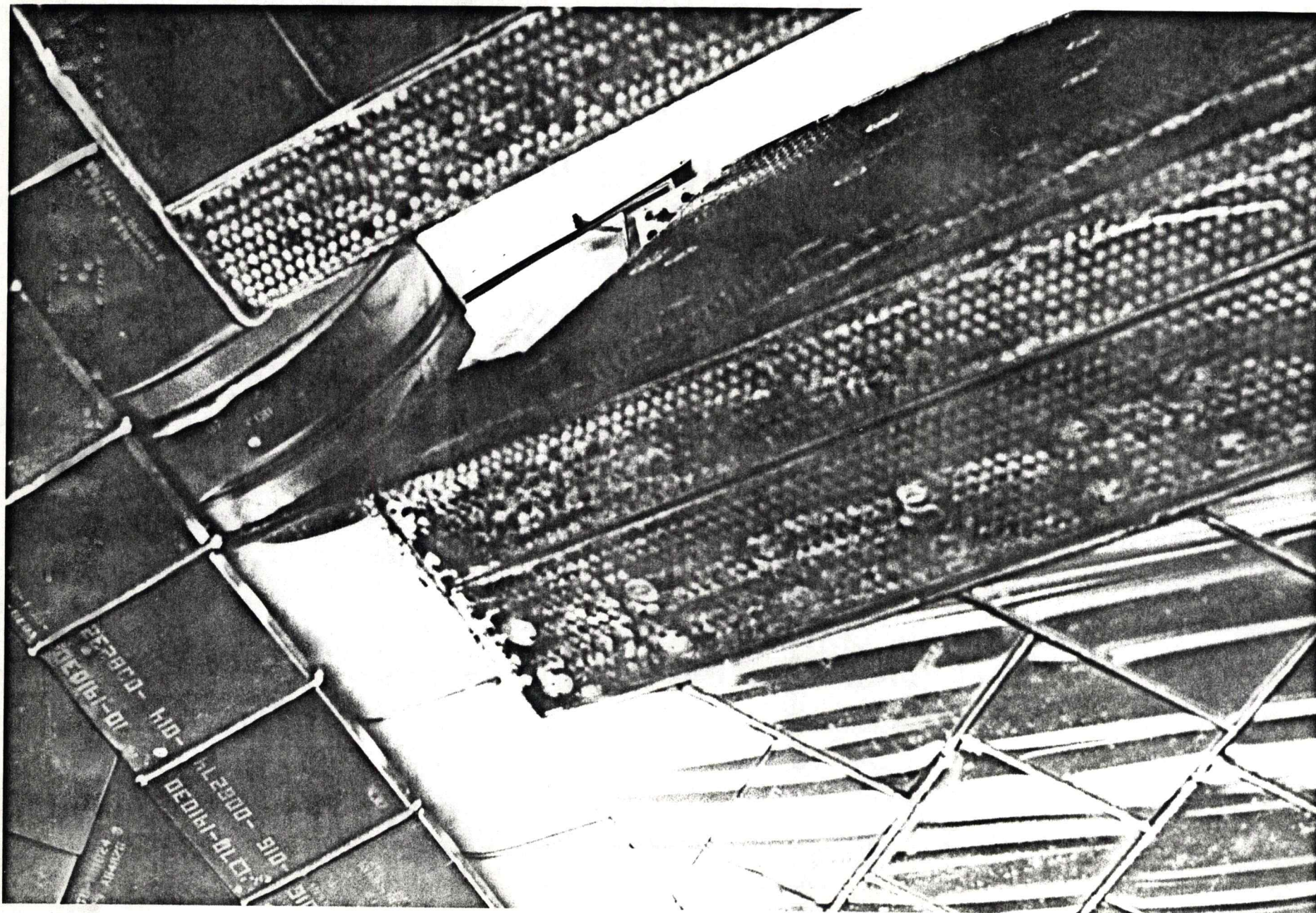




## TPS POST-FLIGHT INSPECTION SUMMARY - RSI (CONT)

- CONTAMINATION OF TPS SURFACE
  - RTV 577 FILLED GAPS DEPOSITED CALCIUM AND ZINC OXIDE ON DOWNSTREAM TILE SURFACES
  - ACOUSTIC SENSORS (LWR FWD) DEPOSITED Ni, Cr, AND  $\text{FeO}_2$  ON DOWNSTREAM TILE SURFACES
  - SRB'S DEPOSITED AL  $\text{O}_2$  ON TILE OML IN AFT REGIONS
  - UNKNOWN CONTAMINANT REACTED WITH WHITE TILE (LRSI) COATING ON SIDE OF MID-FUSELAGE
  - CONTAMINANTS WILL BE CLEAN FROM SURFACE OF TPS
  - DEPOSITS NOT CLEANABLE WILL BE DEMONSTRATED ACCEPTABLE BY GROUND TEST







## TPS POST-FLIGHT INSPECTION SUMMARY - RSI (CONT)

- EXCESSIVE TILE TO TILE GAP HEATING
  - LH NOSE GEAR DOOR THERMAL BARRIER BREACH AND TILE SIDEWALL SHRINKAGE
  - RH MAIN LANDING GEAR DOOR SEVERE TILE SIDEWALL SHRINKAGE, FILLER BAR CHARRING AND SLIGHT ALUMINUM DOOR STRUCTURE BUCKLE
  - APPROXIMATELY 250 OTHER LESS SEVERE DIS-COLORED/BURNED FILLER BARS IN BOTTOM OF TILE TO TILE GAPS (PARAMETERS AFFECTING CONDITIONS ARE: FWD FACING STEPS, LARGE GAPS, LOCAL PRESSURE GRADIENT, TILE TO FILLER BAR GAPS, AND SOFT SIP)
  - LH NLGD THERMAL BARRIER BEING REDESIGNED
  - RH MLGD BUCKLE BEING RAPAIRED/TILES BEING RE-INSTALLED
  - MODERATELY CHARRED FILLER BAR LOCATIONS BEING FIXED BY ADDITION OF A GAP FILLER; BADLY CHARRED AREA REQUIRE TILE REMOVAL FILLER BAR REPAIR AND RE-INSTALLATION

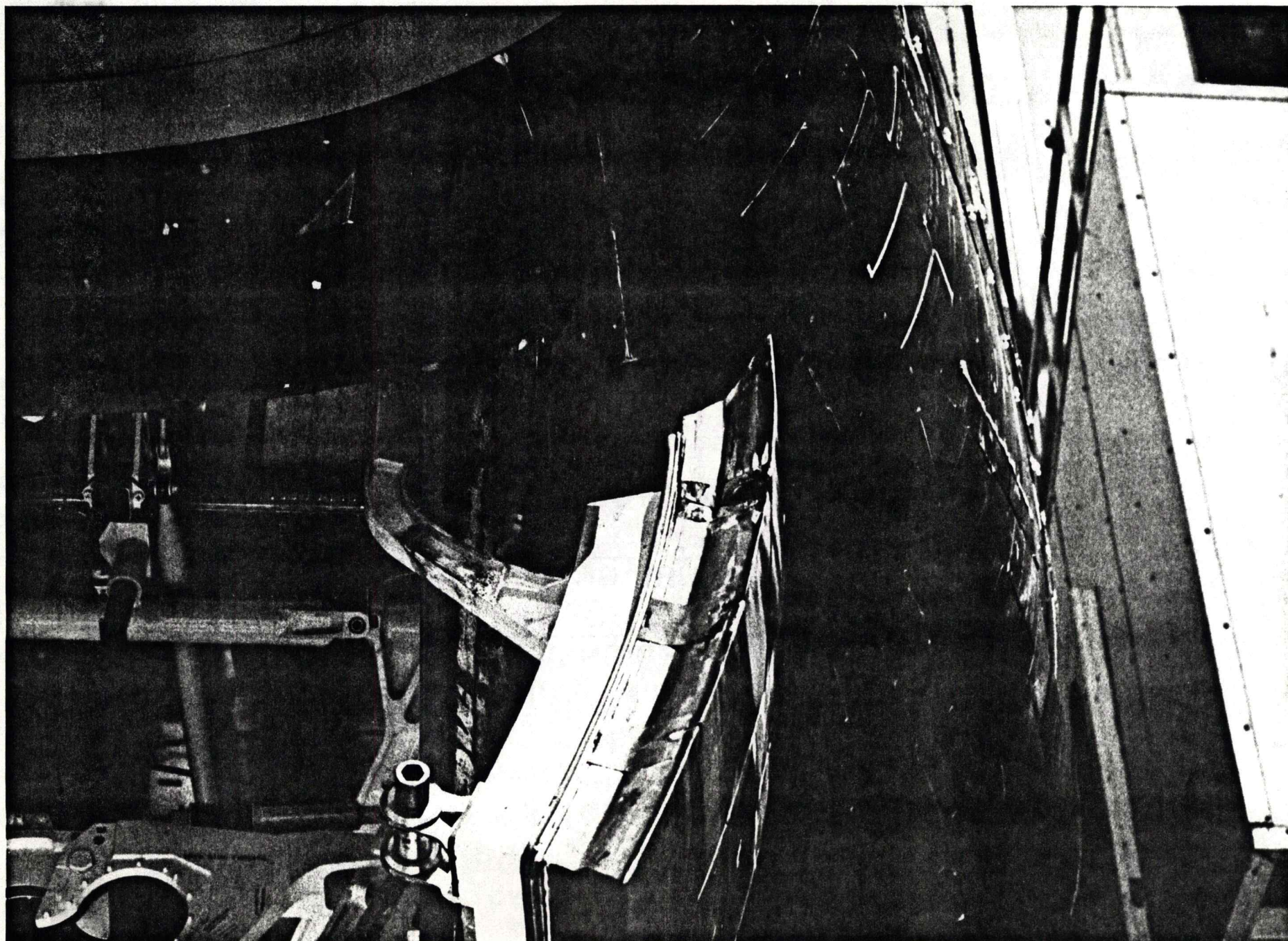




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## **TPS POST-FLIGHT INSPECTION SUMMARY - RSI (CONT)**

- **EXCESSIVE ELEVON COVE HEATING**
  - **FLOW LEAKAGE UNDER WING TRAILING EDGE TILE CARRIER PLATES INTO COVE**
  - **SPANWISE FLOW ENTERING COVE NEAR WING TIP AND FLOWING INBOARD**
  - **SEVERE DEGRADATION OF RTV AND FRSI IN COVE**
  - **FLOW RESTRICTORS BEING ADDED**
  - **FRSI BEING REPLACED WITH AB312 BLANKETS**



## **TPS POST-FLIGHT INSPECTION SUMMARY - RSI (CONT)**

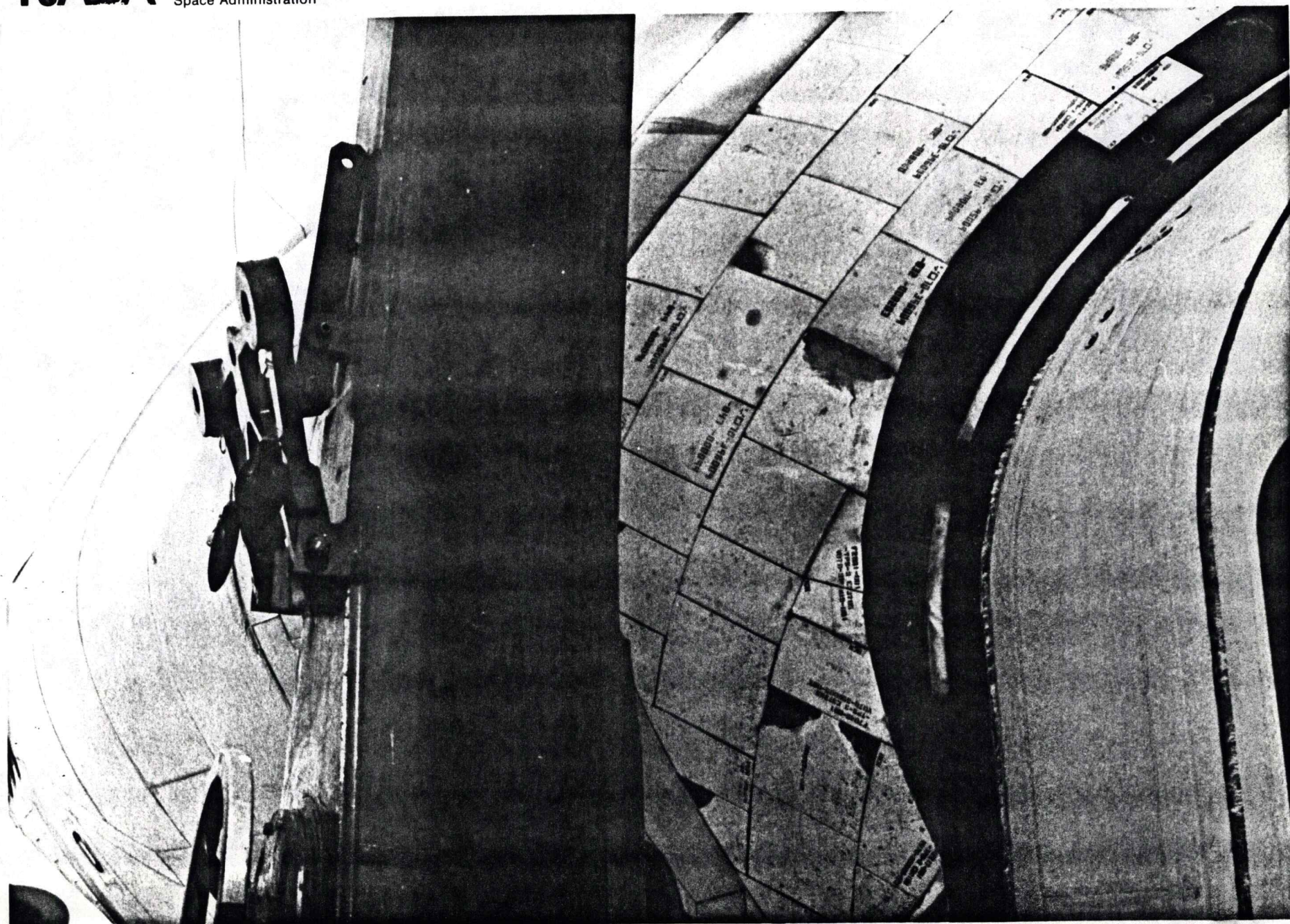
- **OMS POD ANOMALIES**
  - **FWD. REGION LOST TILES/PIECES (16)  
RESULTED IN:**
    - **RT POD 7 LOCAL HCB CORE  
DELAMINATIONS**
    - **LT POD 3 LOCAL HCB CORE  
DELAMINATIONS**
  - **FWD. REGION FRSI SURFACE OVER-  
TEMPERATURE:**
    - **HIGHER HEATING MAY REQUIRE SMALL  
INCREASE IN TILE AREA FOR STS-4  
AND DESIGN MISSION**
  - **DENSIFIED DICED LRSI TILES BONDED TO  
THE FILLER BAR WILL REPLACE  
UNDENSIFIED TILES IN THIS AREA**
  - **FRSI WILL BE CLEANED AND RE-COATED IN  
PLACE**





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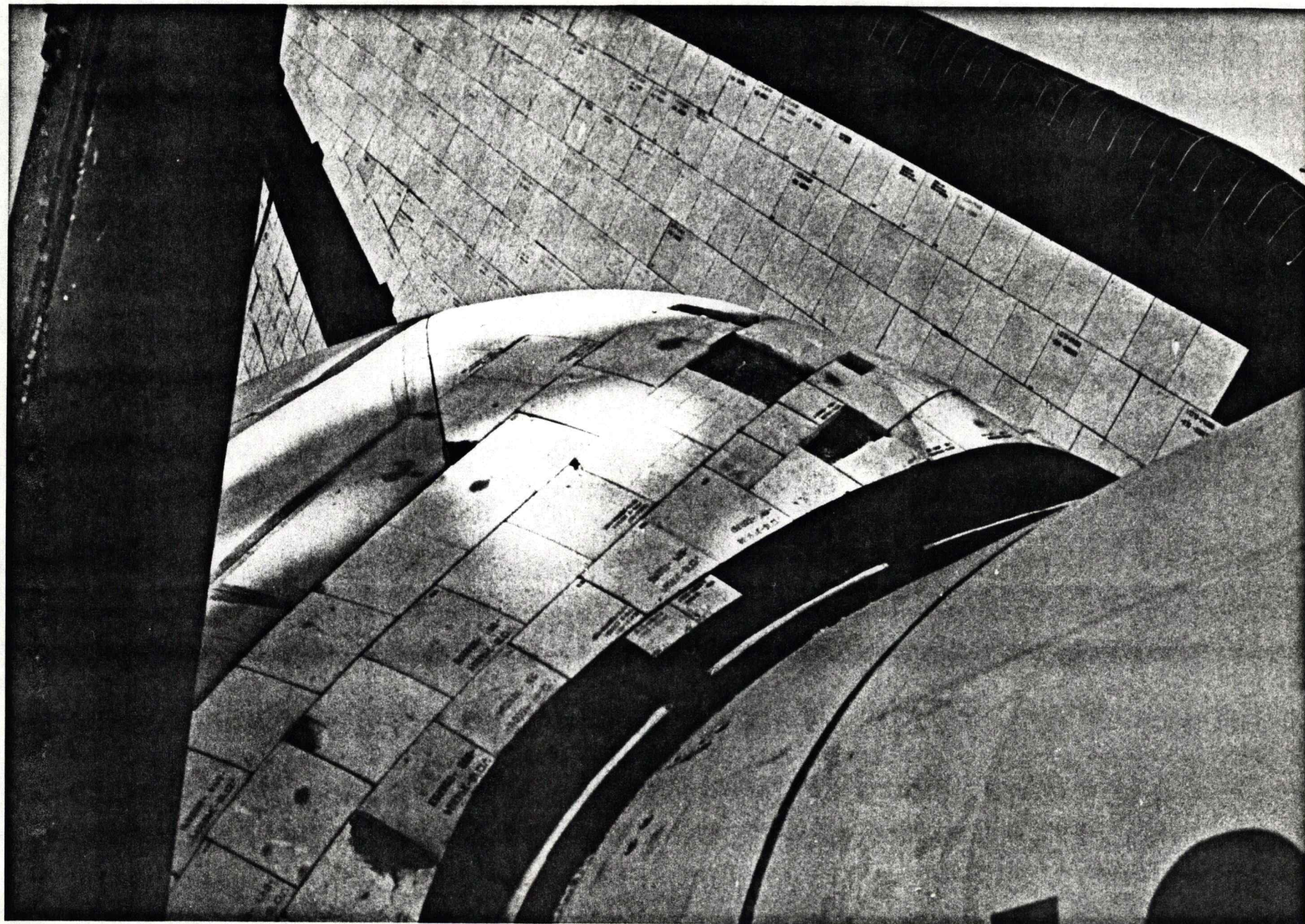






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## **TPS POST-FLIGHT INSPECTION SUMMARY - RSI (COND)**

- **AFT LOWER SIDES OF PODS EXPERIENCED EXCESSIVE SURFACE HEATING. SEVERE FRSI DEGRADATION AND HCB CORE DELAMINATION OCCURRED. FRSI DEGRADATION APPEARS CAUSED BY HIGH TEMPERATURE SHORT TERM SPIKE (  $\approx 1600$  °F FOR 5 SEC.)**
- **FRSI WILL BE REPLACED BY  $\approx 25$  TILES ON EACH SIDE OF THE OMS POD**

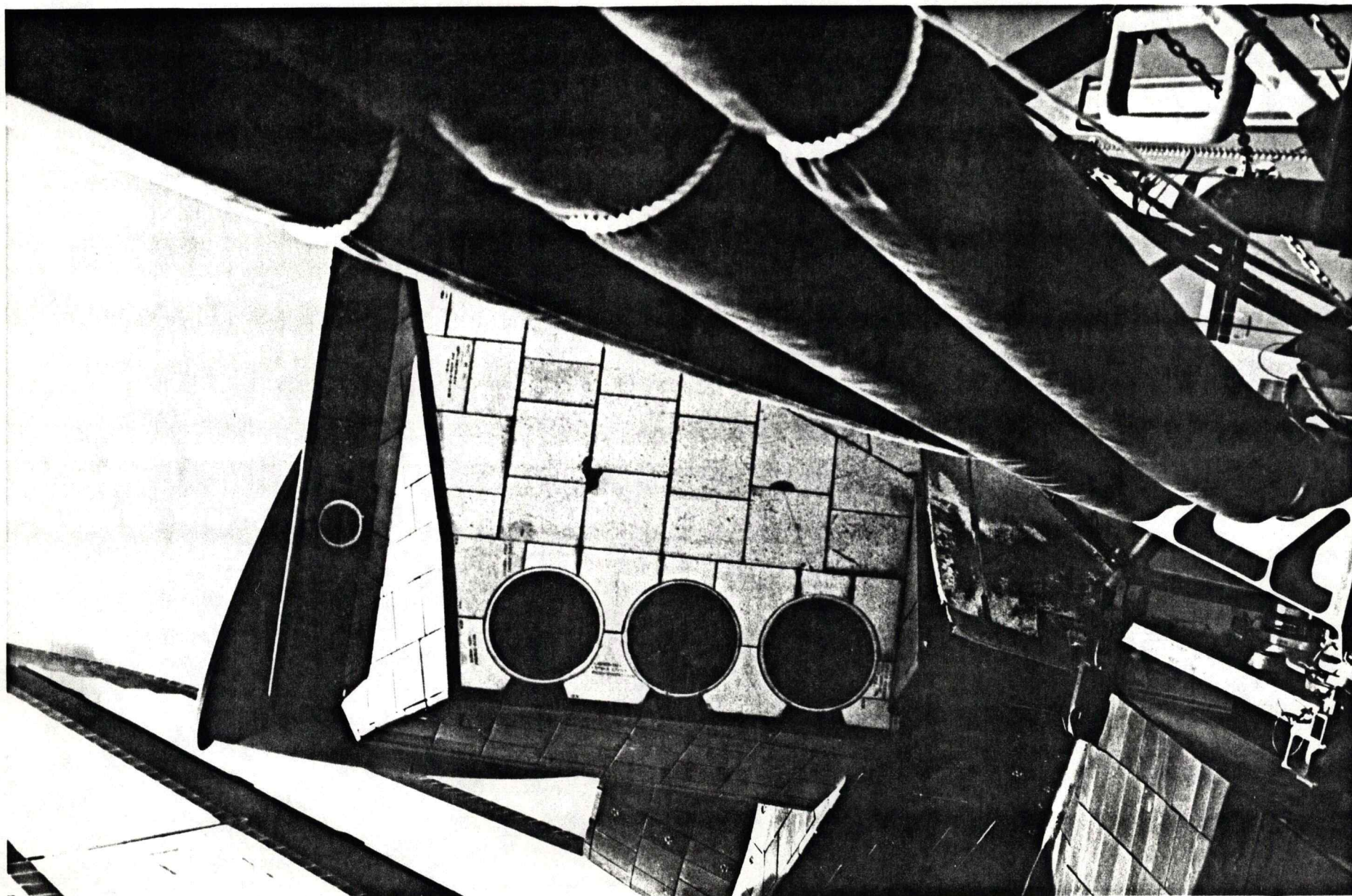




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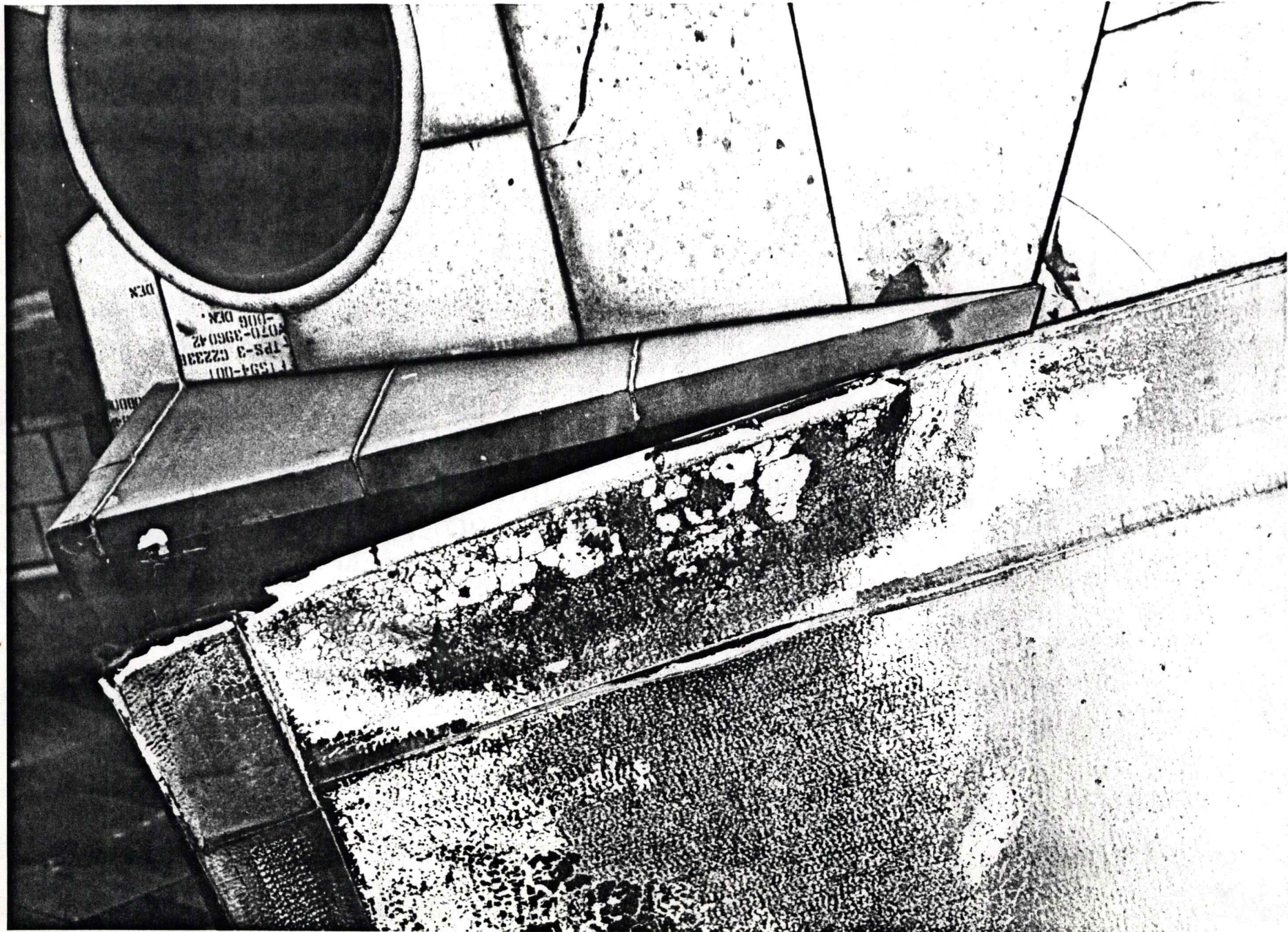




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# LEADING EDGE STRUCTURAL SUBSYSTEM (LESS)

## STS-1 FLIGHT TEST RESULTS

- POST FLIGHT INSPECTION AT KSC
  - NO SIGNIFICANT ANOMALIES FOR THE LESS, ABLATORS AND WINDOWS WERE NOTED FROM THE STS-1 FLIGHT
- STS-1 DFI DATA
  - NOSE CAP
    - RADIOMETER TEMPERATURES APPROXIMATELY 600-800° F LOWER THAN PREDICTED
    - PEAK NOSE CAP TEMPERATURE  $\approx 2400^{\circ}$  F; ESTIMATED USING; FLIGHT DATA, PRE-FLIGHT PREDICTIONS AND T-5 TEST DATA
  - RCC ATTACHMENT TEMPERATURES
    - LOWER CENTERLINE FORWARD BOLT
      - AGREES WITH PRE-FLIGHT PREDICTION
    - LOWER CENTERLINE AFT BOLT
      - $\approx 220^{\circ}$  F HOTTER THAN PRE-FLIGHT PREDICTION
    - UPPER CENTERLINE FORWARD BOLT
      - $\approx 120^{\circ}$  F COOLER THAN PRE-FLIGHT PREDICTION

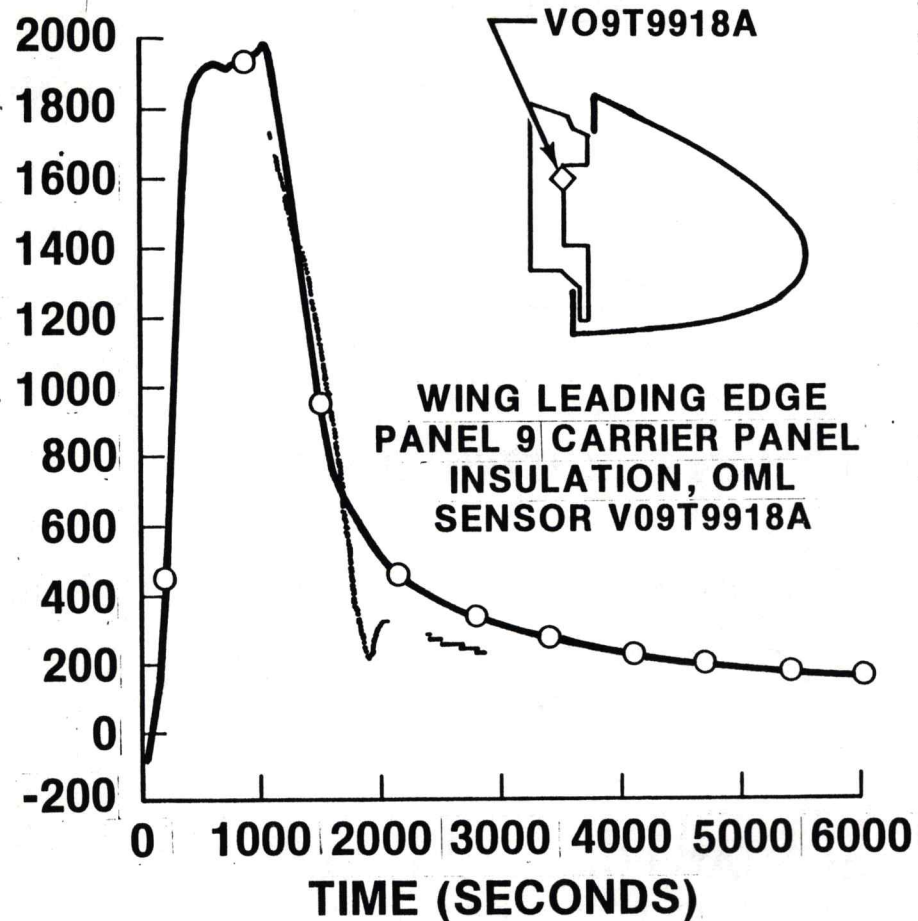


## LESS STS-1 FLIGHT RESULTS (CONT)

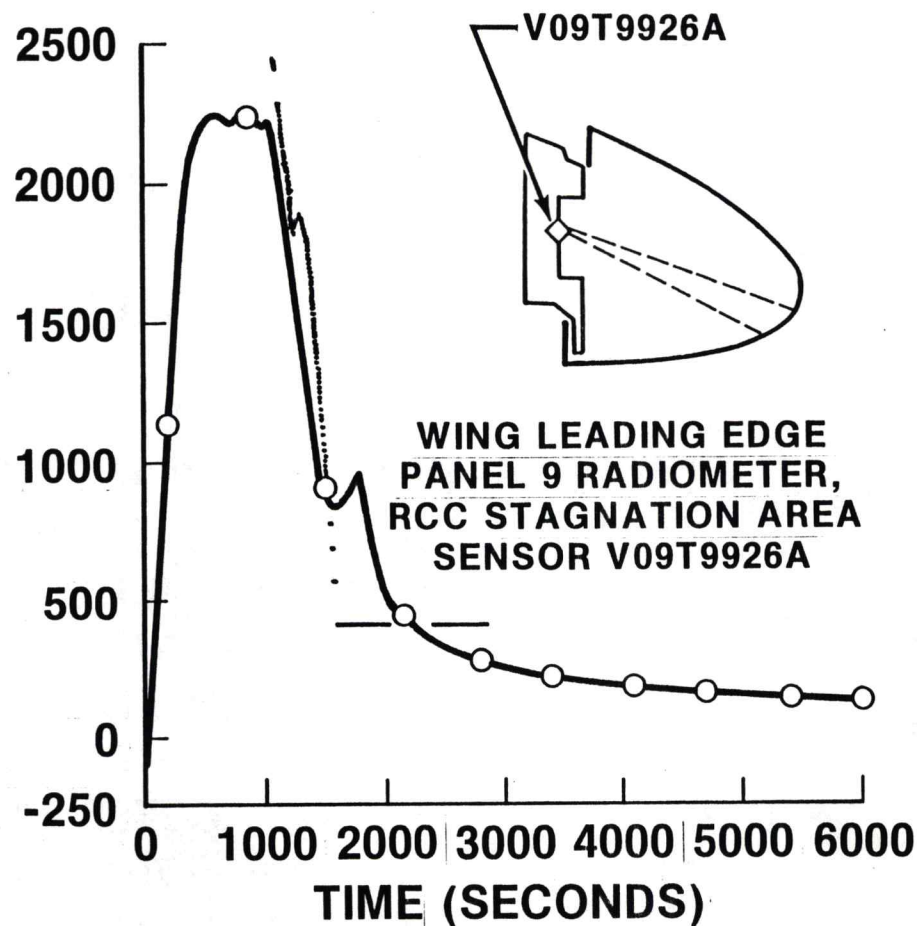
- WING LEADING EDGE
  - RADIOMETER MEASUREMENTS IN EXCELLENT AGREEMENT WITH PREDICTIONS
    - PANEL 9 -  $T_{MAX} \approx 2460^{\circ}F$
    - PANEL 16 -  $T_{MAX} \approx 2000^{\circ}F$
  - INTERNAL INCONEL/DYNAFLEX INSULATION TEMPERATURE IN GOOD AGREEMENT WITH PRE-FLIGHT PREDICTIONS
    - VISUALLY INCOFLEX PANEL 8 HOTTER THAN INCOFLEX PANEL 9
  - RCC INCONEL CLEVIS FITTINGS
    - LOWER CLEVIS -  $190 - 230^{\circ}F$  LOWER THAN FLIGHT PREDICTION
  - RCC SPAR FITTINGS (A-286 STEEL)
    - LOWER FITTINGS: PANEL 9 - PEAK TEMPERATURE IN GOOD AGREEMENT WITH PRE-FLIGHT PREDICTION
    - UPPER FITTINGS: PANEL 16 - PEAK TEMPERATURE  $\sim 80^{\circ}F$  HOTTER THAN PRE-FLIGHT PREDICTION
  - RCC/HRSI INTERFACE ACCESS PANEL
    - LOWER ALUM TUBE,  $\sim 70^{\circ}F$  COOLER THAN PRE-FLIGHT PREDICTION
    - UPPER ALUM HONEYCOMB,  $\sim 25^{\circ}F$  HOTTER THAN PRE-FLIGHT PREDICTION

.... FLIGHT DATA  
 ○ PREDICTED DATA

TEMPERATURE  
 (DEG F)



TEMPERATURE  
 (DEG F)



## **LESS STS-1 FLIGHT RESULTS (COND)**

- **ELEVON/ELEVON ABLATOR**
  - **NO DATA MEASUREMENTS**
  - **VISUAL OBSERVATIONS**
    - **SIMILAR IN APPEARANCE TO QUAL TEST ARTICLE**
    - **ESTIMATED CHAR THICKNESS MUCH LESS THAN PREDICTED**
  - **ABLATOR CORE SECTIONS REQUIRED FOR HEATING/THERMAL PERFORMANCE EVALUATION**
- **RCC FORWARD ET ATTACHMENT**
  - **NO DATA MEASUREMENT**
  - **VISUAL OBSERVATION INDICATES NO ANOMALIES**
- **WINDOWS - THERMAL PANES**
  - **DEPOSIT (SILICON DIOXIDE) ON 5 WINDSHIELD THERMAL PANES AND SIDE HATCH THERMAL PANE**
  - **THERMAL RESPONSE OF WINDOW STRUCTURE INDICATES AEROHEATING SIGNIFICANTLY LOWER THAN PREDICTED**

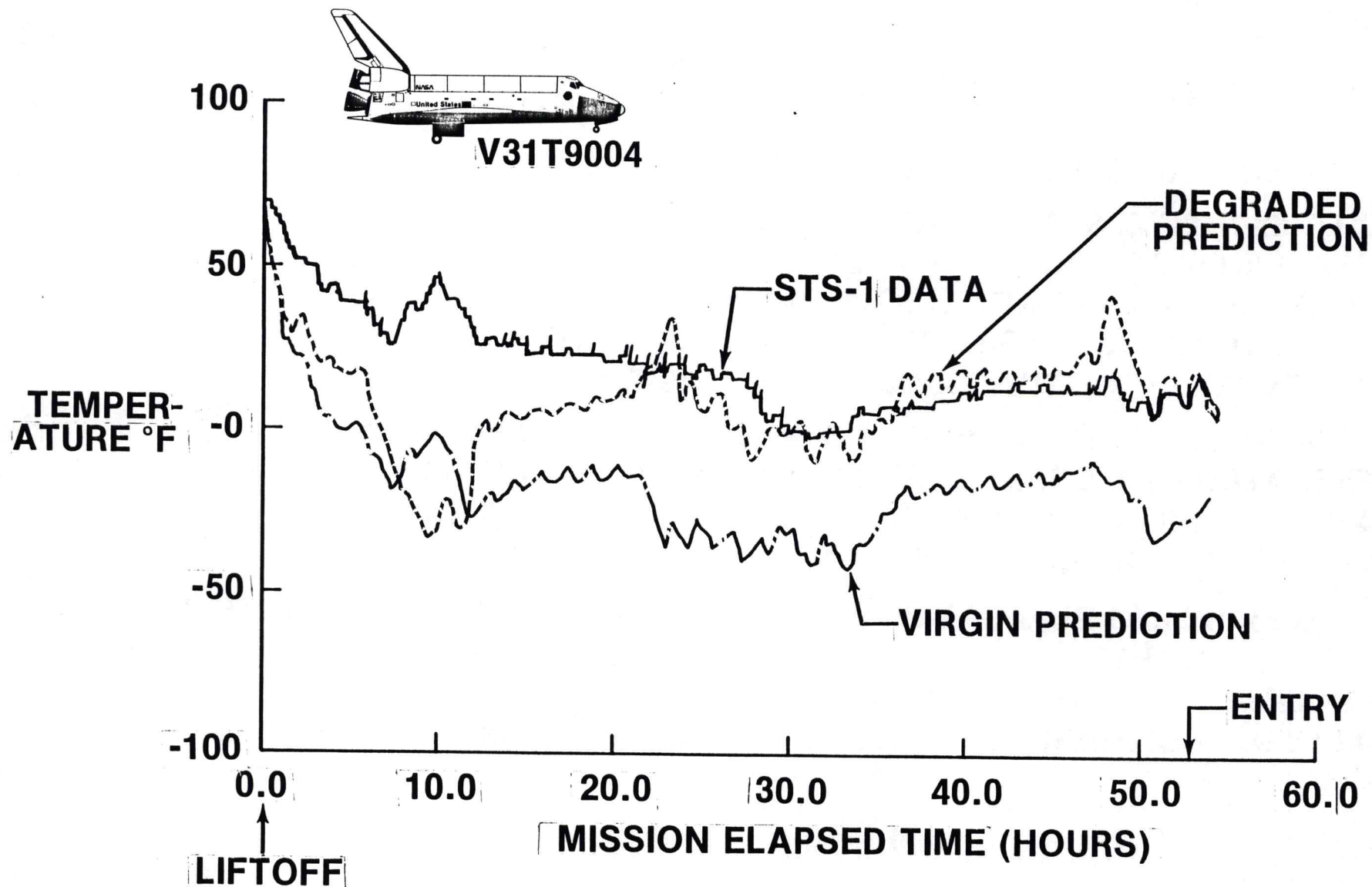


## **STS-1 TCS TEST FLIGHT EVALUATION**

### **● GENERAL OBSERVATIONS**

- APPROXIMATELY 80 PERCENT OF ENABLED HEATERS CYCLED DURING THE MISSION
- FORWARD AND AFT RCS ENGINE HEATERS DUTY CYCLES (40 TO 50 PERCENT) WERE IN GENERAL 2 TO 3 TIMES HIGHER THAN PREDICTED
- MID BODY FES LINES HEATER DUTY CYCLES HIGHER THAN PREDICTED (30 PERCENT AS COMPARED TO 10 TO 15 PERCENT)
- OMS CROSSFEED HIGH POINT AND LOW POINT DRAIN LINES HEATERS DUTY CYCLES WERE AS MUCH AS 2 TIMES THE PREDICTED VALUES
- ON-ORBIT STRUCTURE/BONDLINE TEMPERATURES WERE WARM BIASED TO LEVELS REPRESENTATIVE OF DEGRADED TPS SURFACE PROPERTIES
  - HRSI, 5 °F TO 20 °F HIGHER THAN "VIRGIN" PREDICTIONS
  - LRSI/FRSI, 20 TO 35 °F HIGHER THAN "VIRGIN" PREDICTIONS
- ON-ORBIT STRUCTURE COOL DOWN RATES AND RESPONSE TO ATTITUDE CHANGES SLOWER THAN PREDICTED
  - IMPLIES REDEFINITION OF 6/3 ATTITUDE CONSTRAINT AND PRE-ENTRY THERMAL CONDITIONING REQUIREMENTS

# STS-1 STRUCTURE TEMPERATURE RESPONSE FWD STB SIDE FUSLEAGE

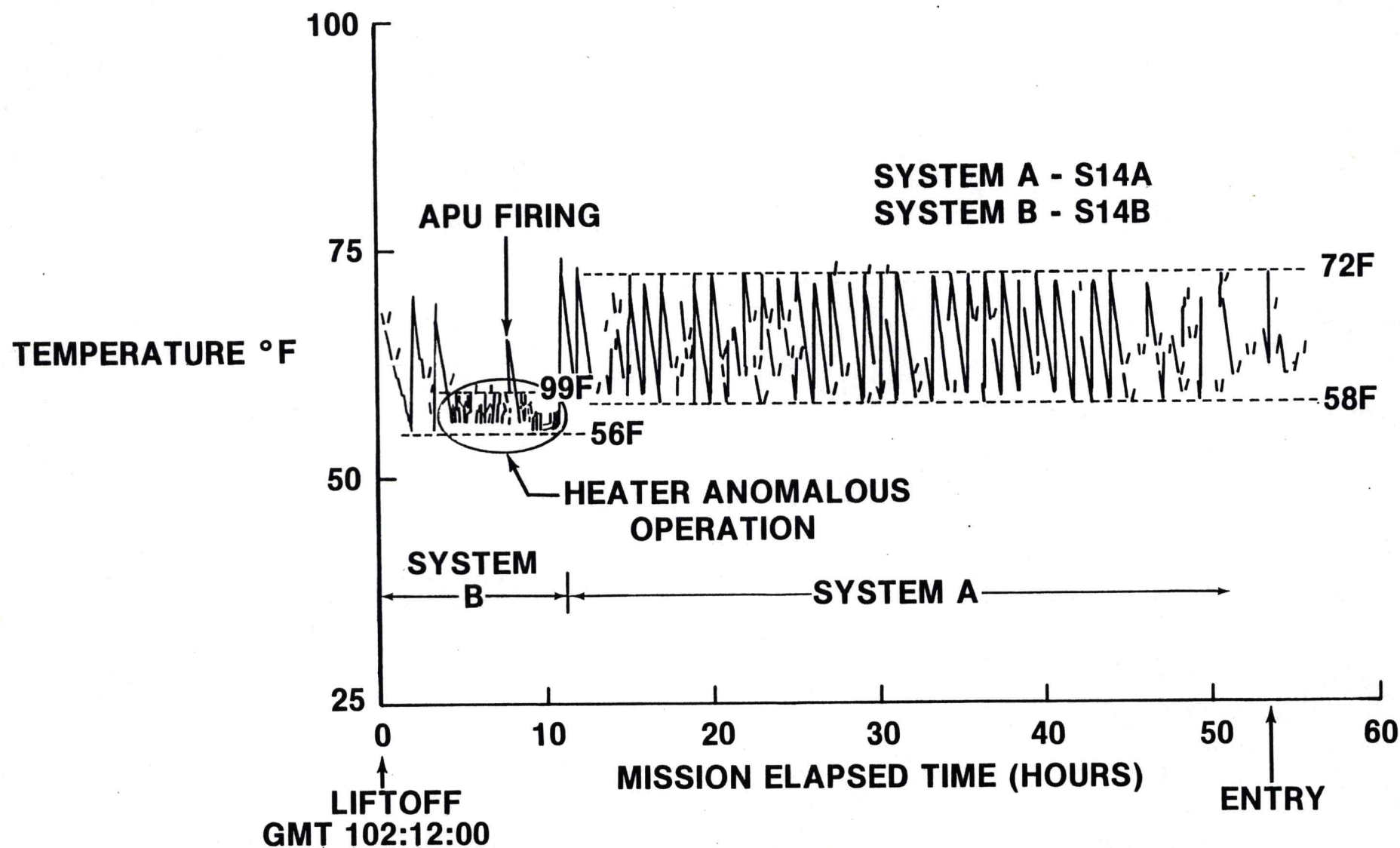


## STS-1 TCS POST FLIGHT EVALUATION

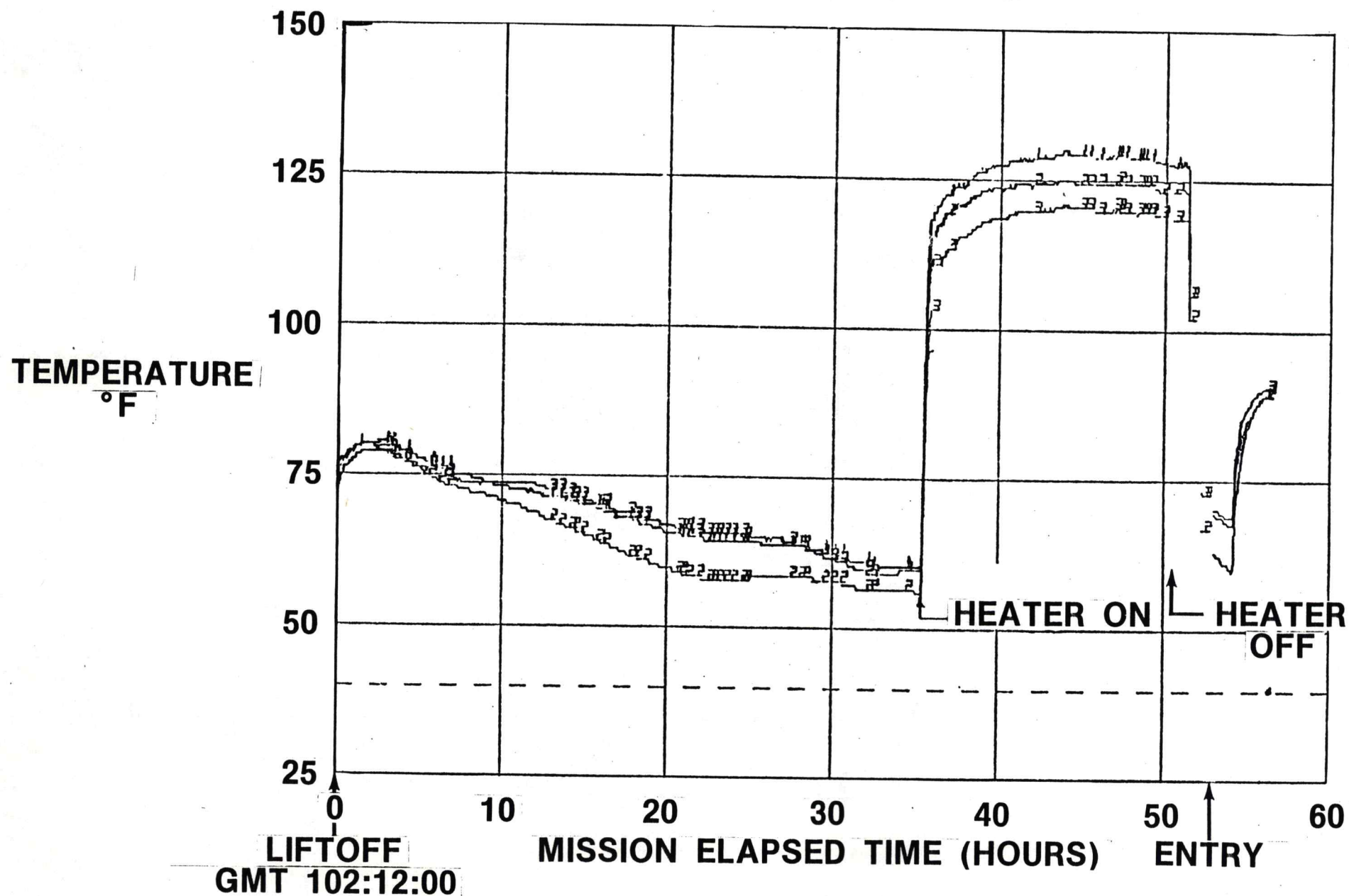
- ANOMALOUS/UNEXPECTED PERFORMANCE
  - EIGHT (8) THERMOSTAT LOCATIONS IN THE FLASH EVAPORATOR FEEDLINES, APU FUEL FEED AND WATER COOLING SYSTEM, OMS CROSSFEED LINES AND ECLSS POTABLE WATER DUMP LINE EXHIBITED "CREEP" OR "DITHER" CHARACTERISTICS AND THREE (3) TEMPERATURE TRANSDUCERS ARE SUSPECT
  - FORWARD RCS COMPARTMENT PORT HEATERS UNEXPECTEDLY OPERATED AT 100 PERCENT DUTY CYCLE (25 PERCENT PREDICTED) AND HEATER PANEL TEMPERATURES RANGED FROM 115 °F TO 130 °F (132 °F TO 153 °F PREDICTED)
  - $\Delta P$  GAGE V07P9083 READ MAXIMUM  $\Delta P$  OF 0.312 PSID (AT APPROXIMATELY GMT 102:12:01:12) DURING ASCENT BETWEEN FORWARD LOWER EQUIPMENT BAY AND PAYLOAD BAY
    - LINER AND LINER LEVEL INSULATION LIMIT PRESSURE IS 0.10 PSID



# APU NO.1 FUEL FEEDLINE



# STS-1 FWD RCS COMPARTMENT PORT HEATER PANEL TEMPERATURES



## **STS-1 TCS POST FLIGHT EVALUATION (CONT)**

- **ANOMALOUS/UNEXPECTED PERFORMANCE (CONT)**
  - **TROUBLE SHOOTING PLANS IN WORK**
    - **VERIFY INSULATION/HEATER INSTALLATIONS ON ALL SUSPECT THERMOSTAT/TRANSDUCERS PROBLEM AREAS**
    - **REPLACE SUSPECT THERMOSTATS AND RETURN TO ROCKWELL FOR FAILURE INVESTIGATION**
    - **VERIFY INSTRUMENTATION AND INSTALLATION CONFIGURATION**
    - **VERIFY FORWARD RCS COMPARTMENT INTERFACE VOLTAGE AND HEATER RESISTANCE AND T/S BRACKET INSTALLATION PER PRINT AND PERFORM THERMOSTAT/HEATER INSTALLATION CHECKOUT**
    - **VERIFY CALIBRATION OF  $\Delta P$  GAGE V07P9083**