THE ORBITER EXPERIMENTS (OEX) PROGRAM

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NASA/DOD Flight Experiments
Technical Interchange Meeting

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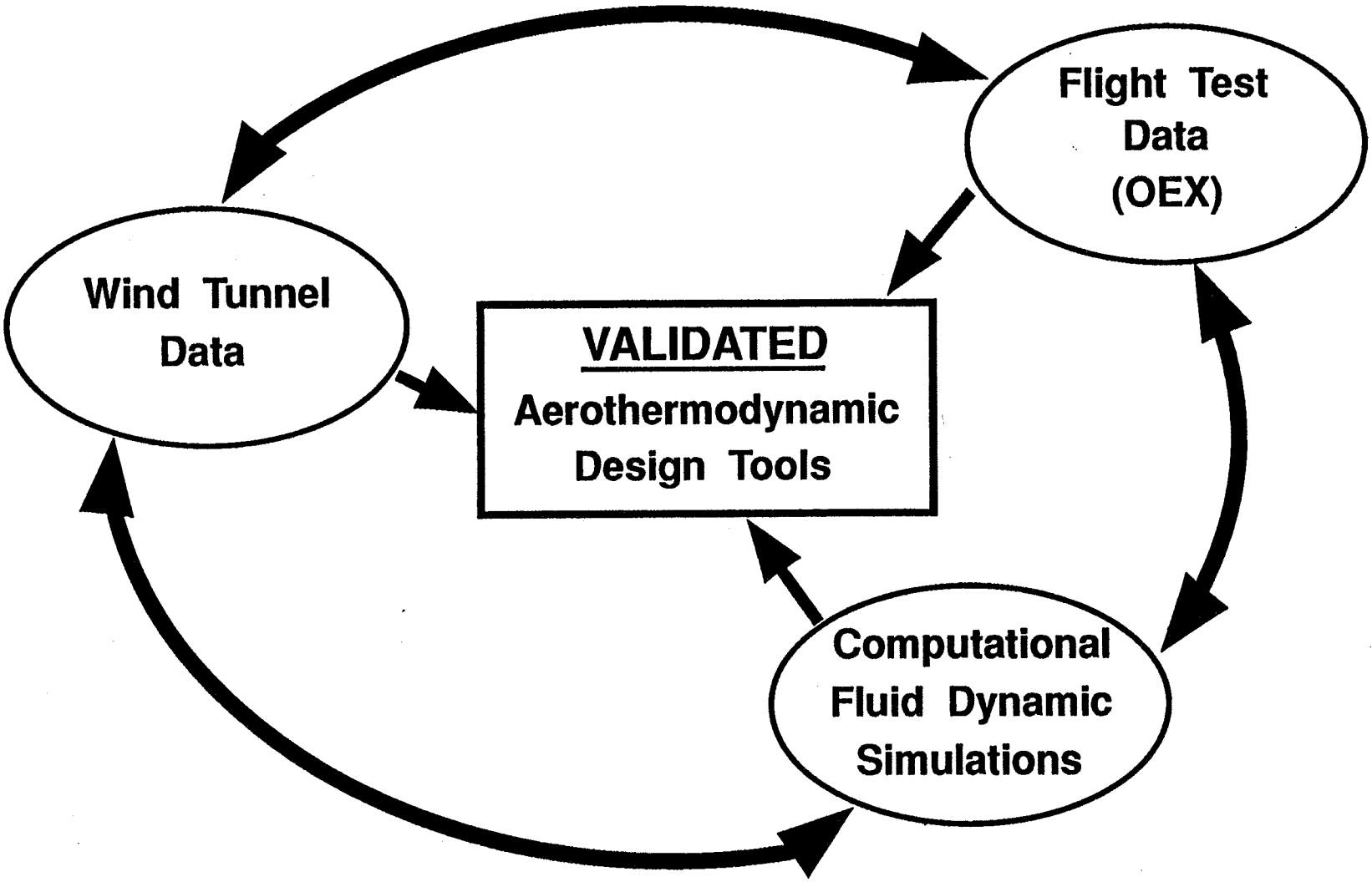
Monterey, CA

OEX PROGRAM OBJECTIVE

". . . . to obtain research quality flight data for augmentation and advancement of space transportation technologies. This includes the validation and advancement of analytical theories and of ground-test methods and techniques."

OEX Project Plan

AEROTHERMODYNAMIC DESIGN TOOL DEVELOPMENT AND VALIDATION



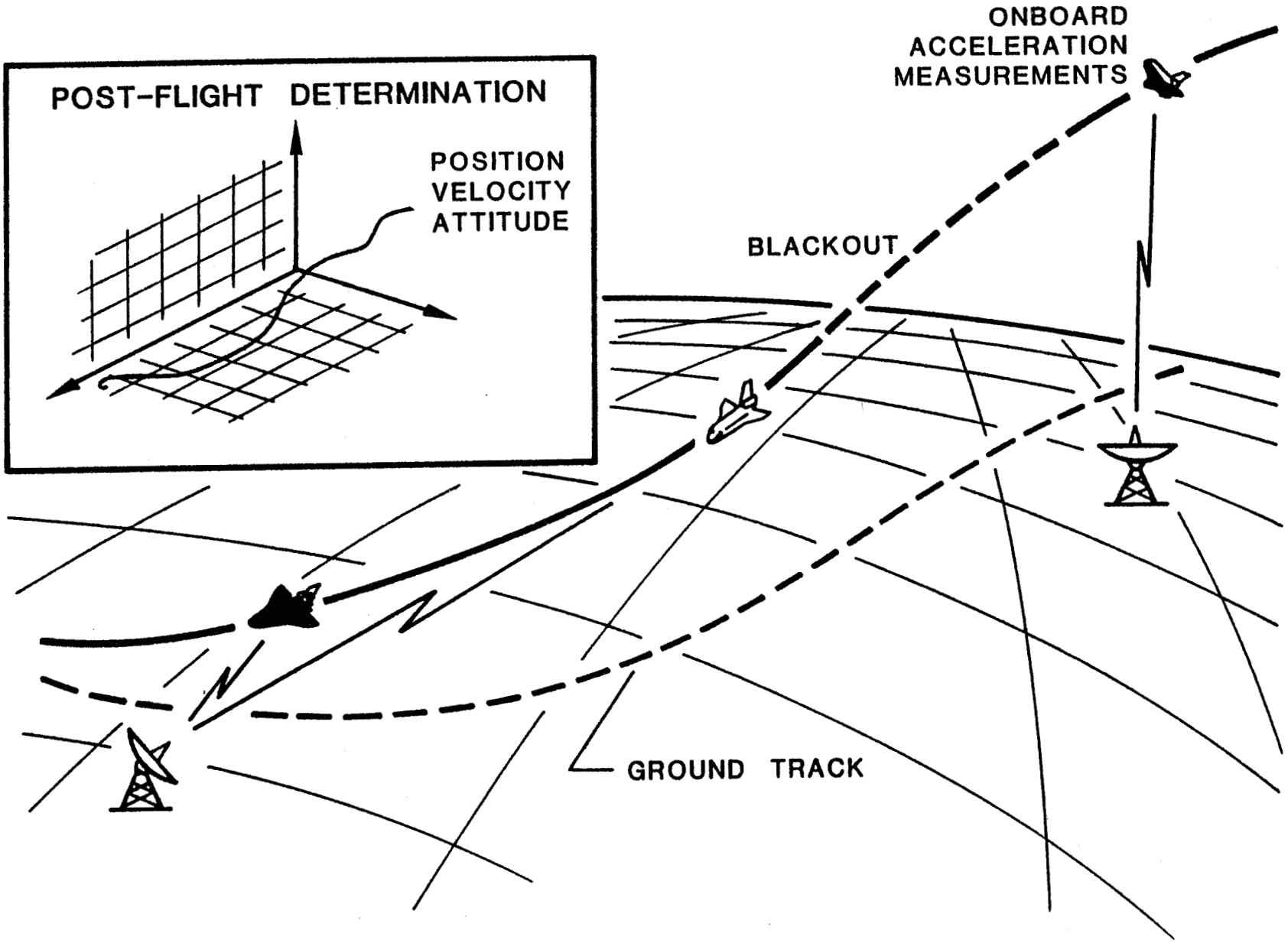
AEROTHERMODYNAMIC FLIGHT RESEARCH DATA REQUIREMENTS

- Freestream Environment (Including Vehicle Attitude)
- Aerodynamic Forces and Moments
- Surface Pressure and Heat Transfer

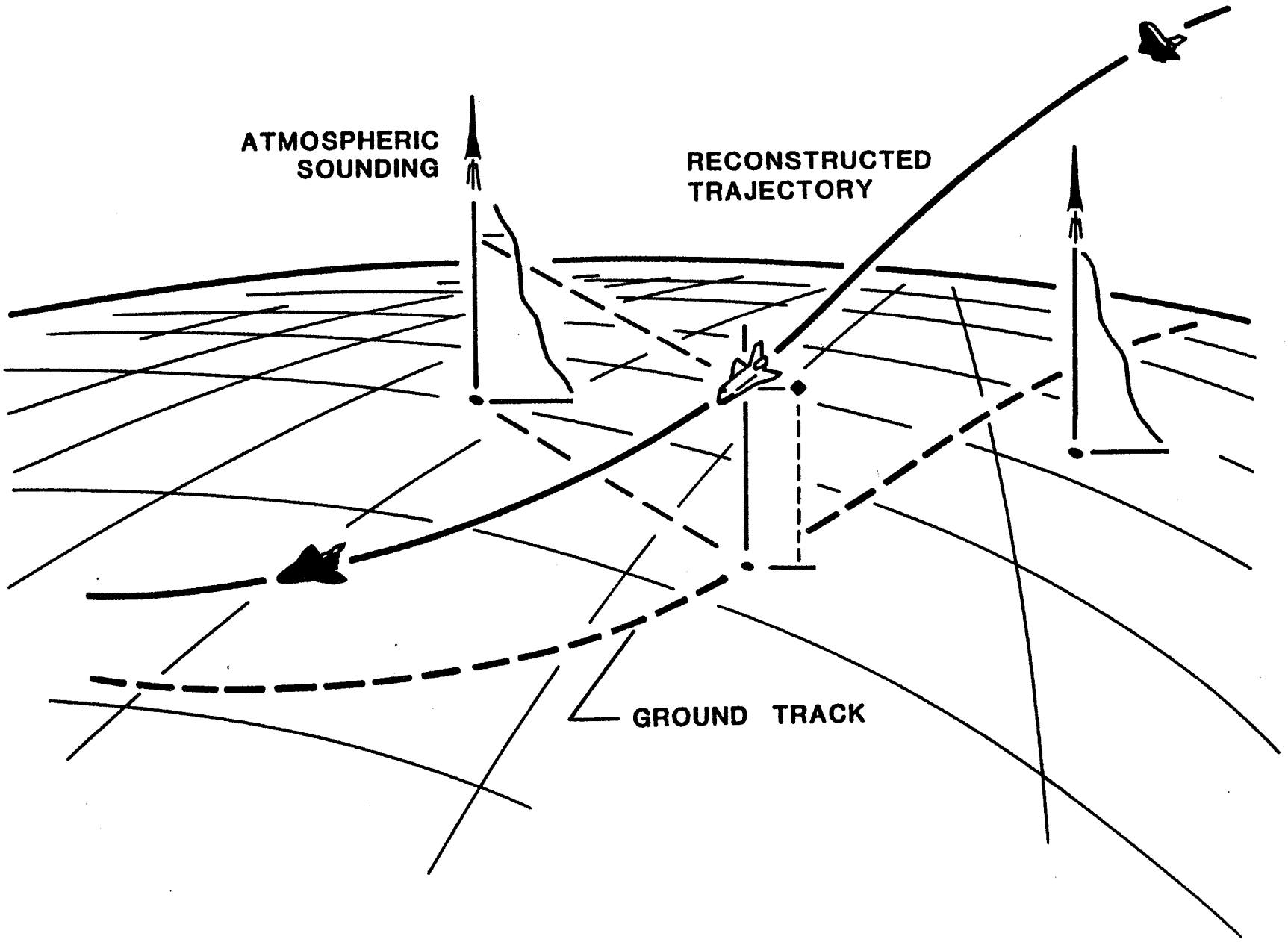
FREESTREAM ENVIRONMENT

- Best Estimate of Trajectory
- Shuttle Entry Air Data System (SEADS)
- Shuttle Upper Atmosphere Mass Spectrometer (SUMS)

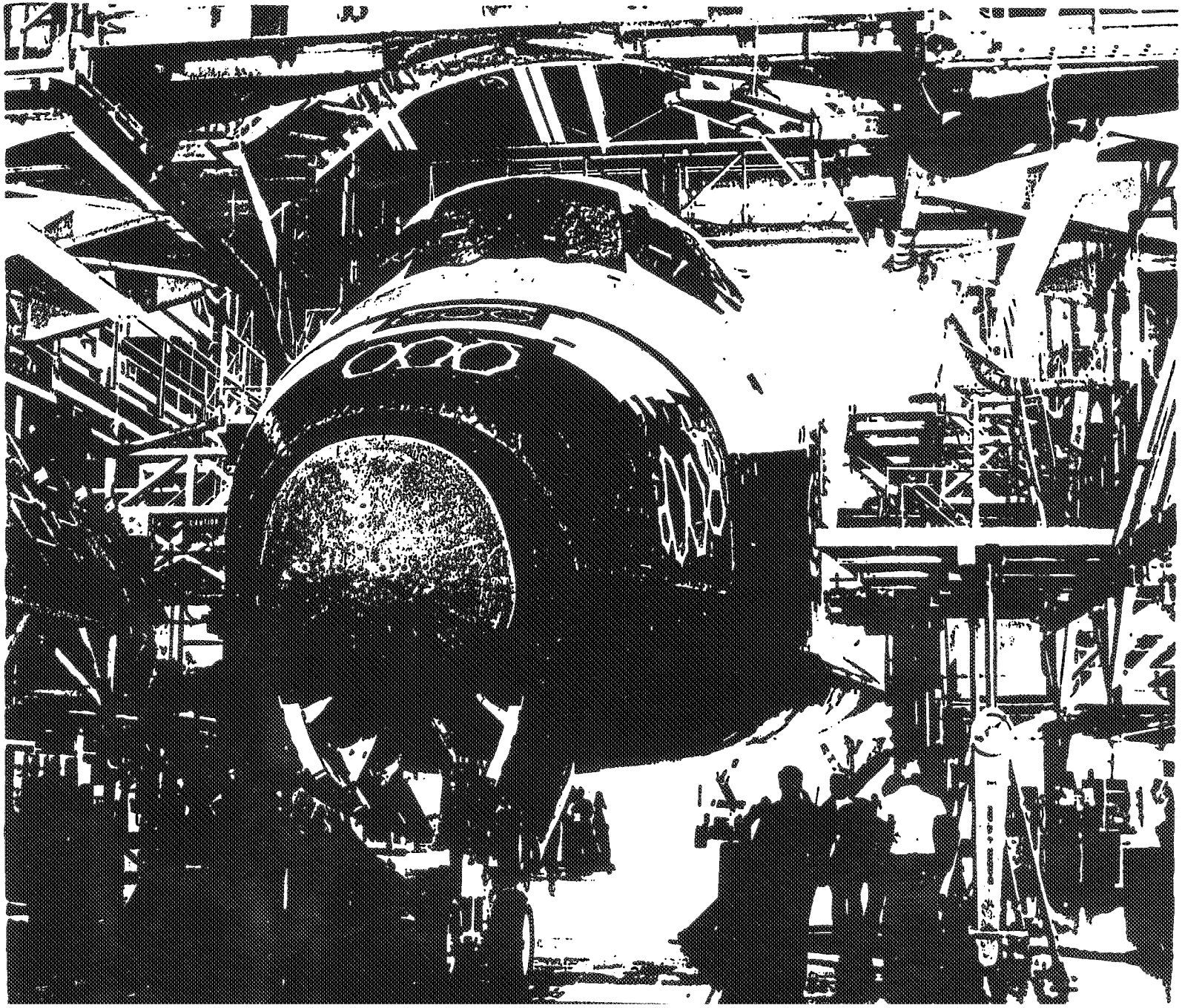
TRAJECTORY RECONSTRUCTION



ATMOSPHERIC RECONSTRUCTION

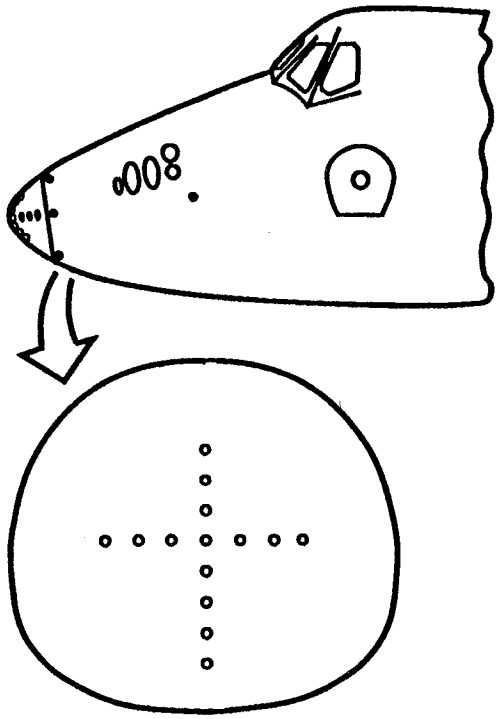


SHUTTLE ENTRY AIR DATA SYSTEM (SEADS)

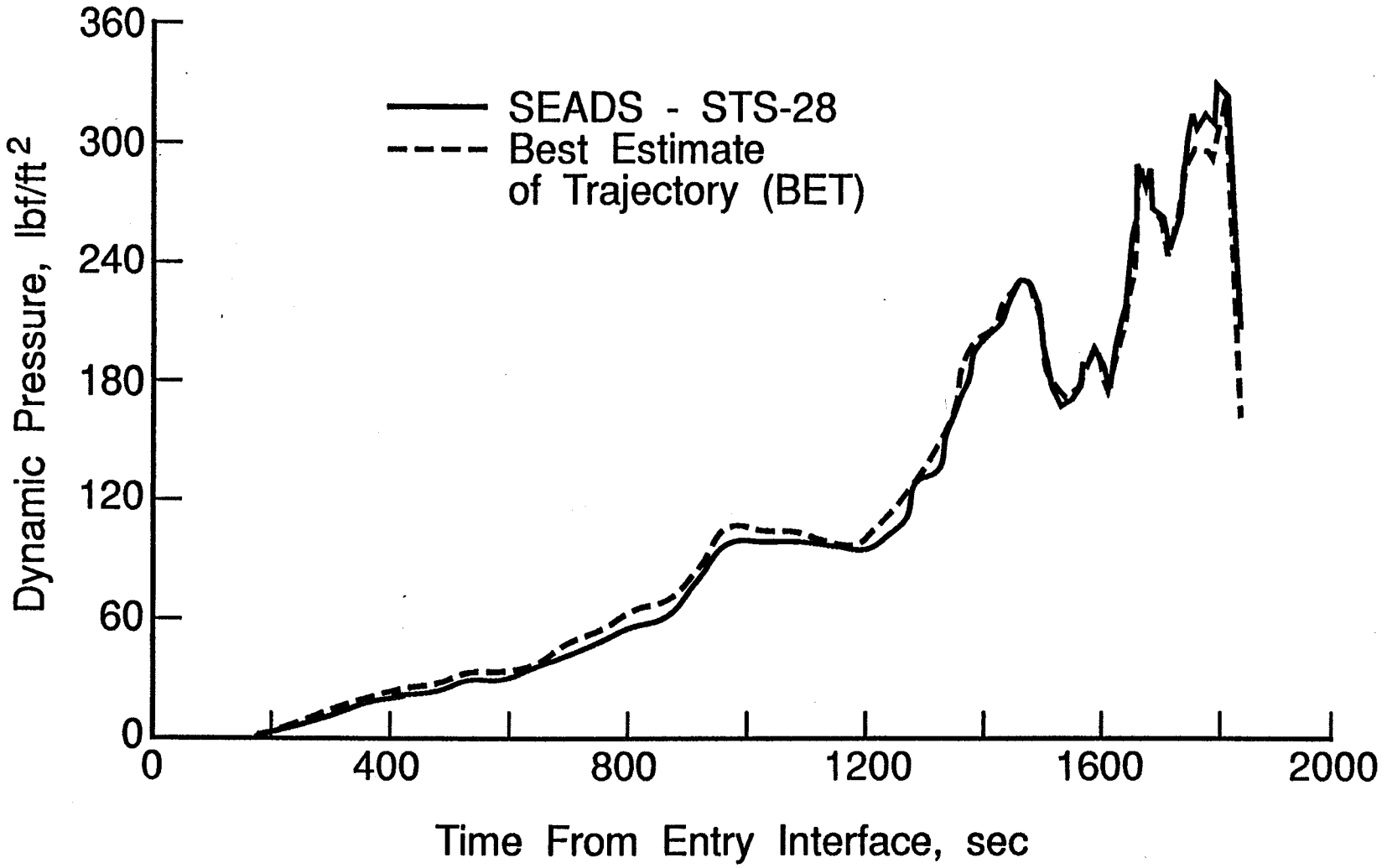


SHUTTLE ENTRY AIR DATA SYSTEM SCHEMATIC

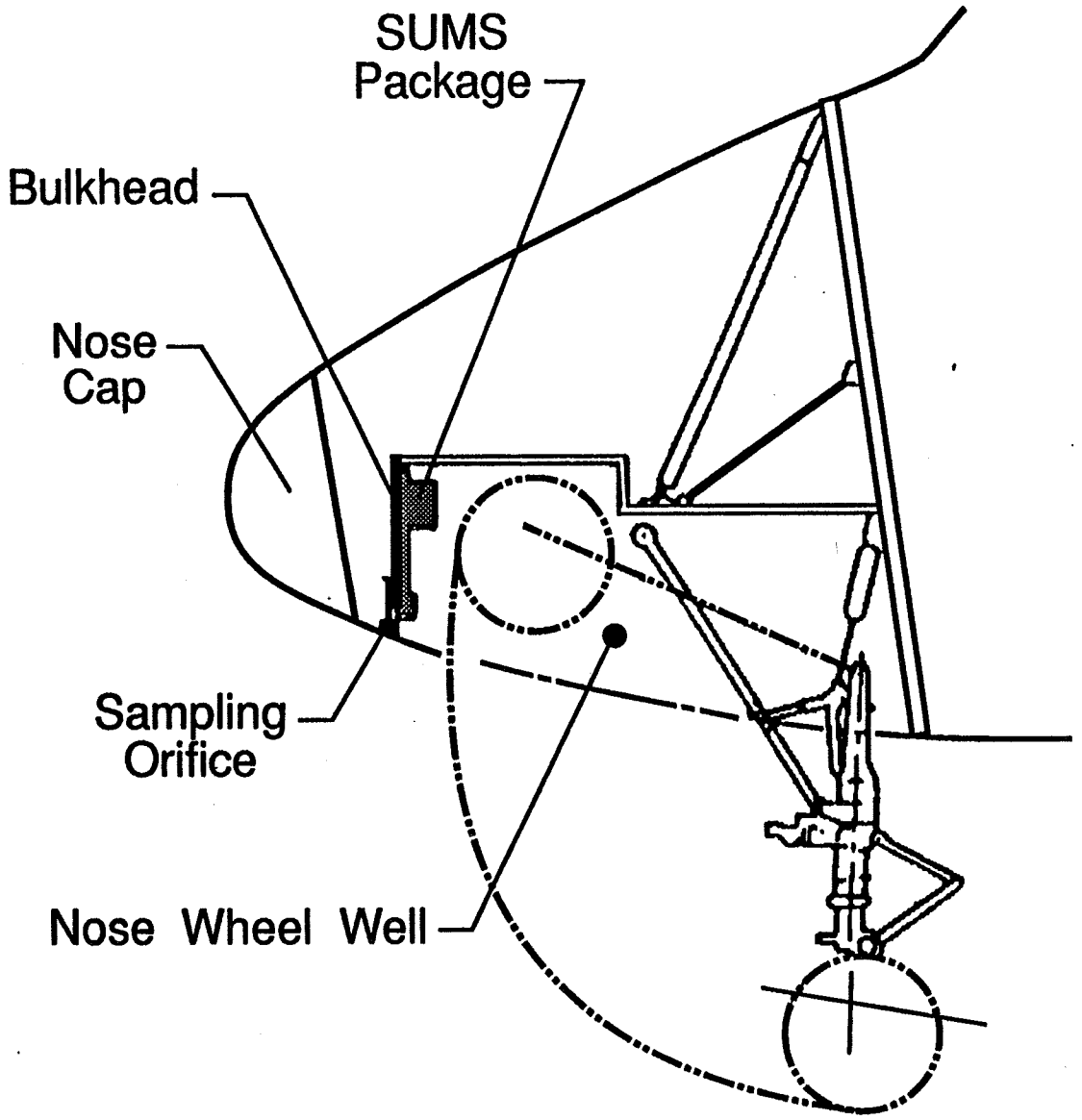
- Nosecap Orifices (14)
- "Static" Orifices (6)



SEADS RESULTS CONFIRM ACCURACY OF BEST ESTIMATE OF TRAJECTORY (BET)



LOCATION OF SUMS ON THE SHUTTLE ORBITER



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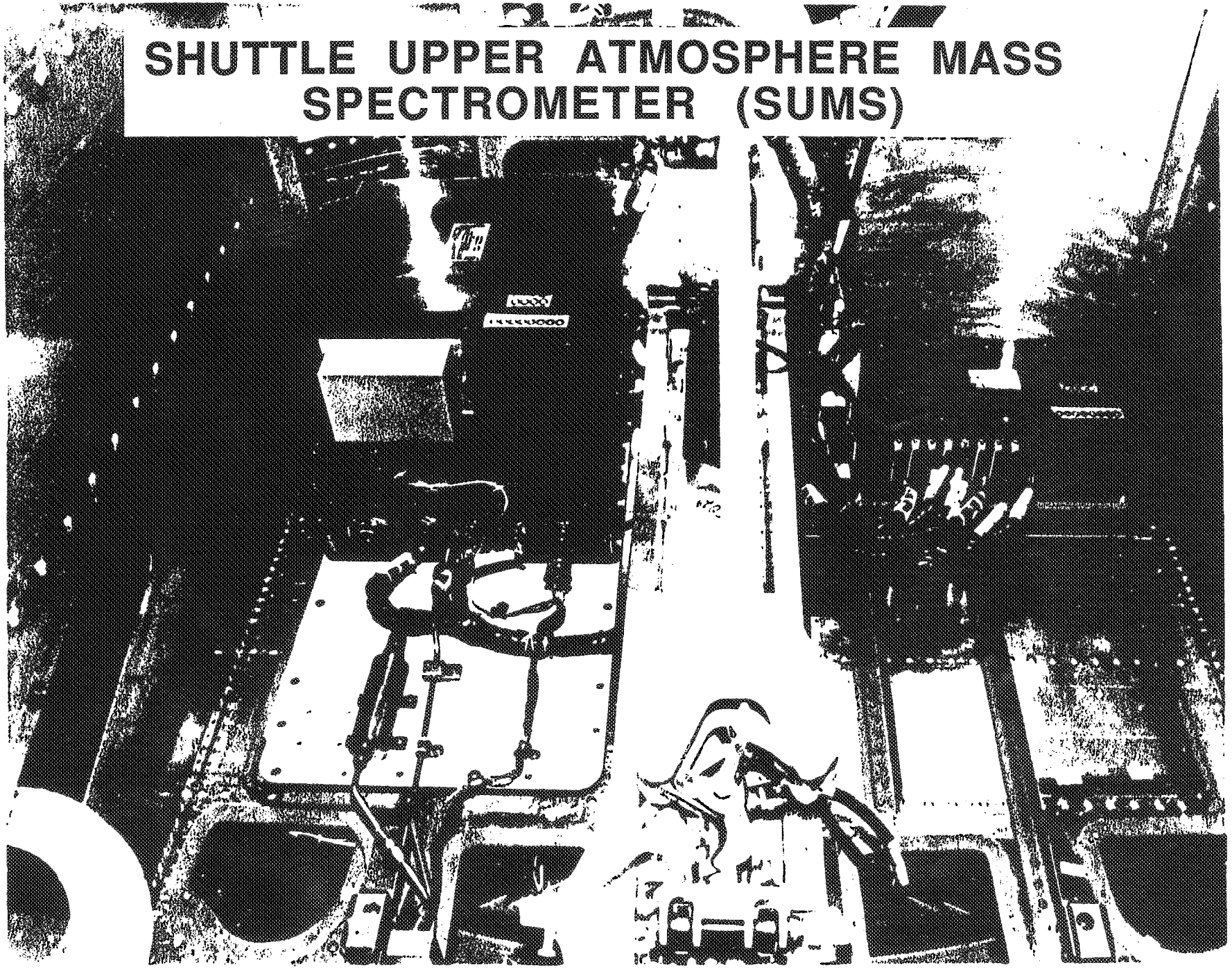
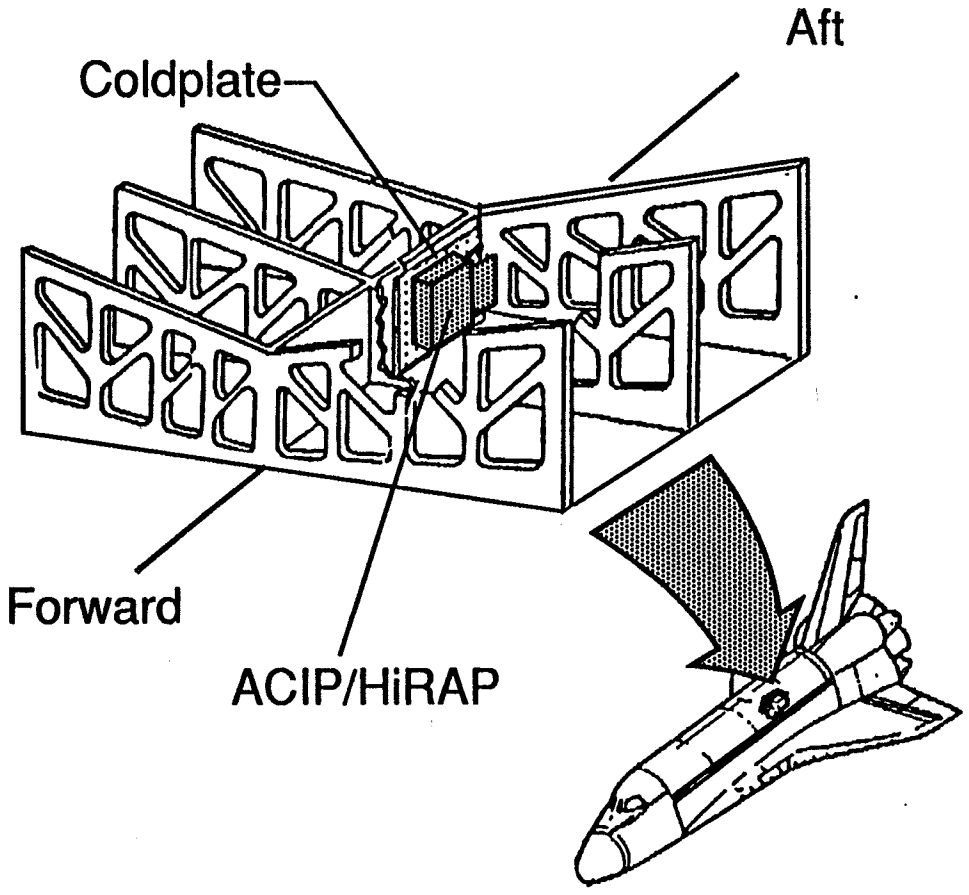
SHUTTLE UPPER ATMOSPHERE MASS SPECTROMETER (SUMS)



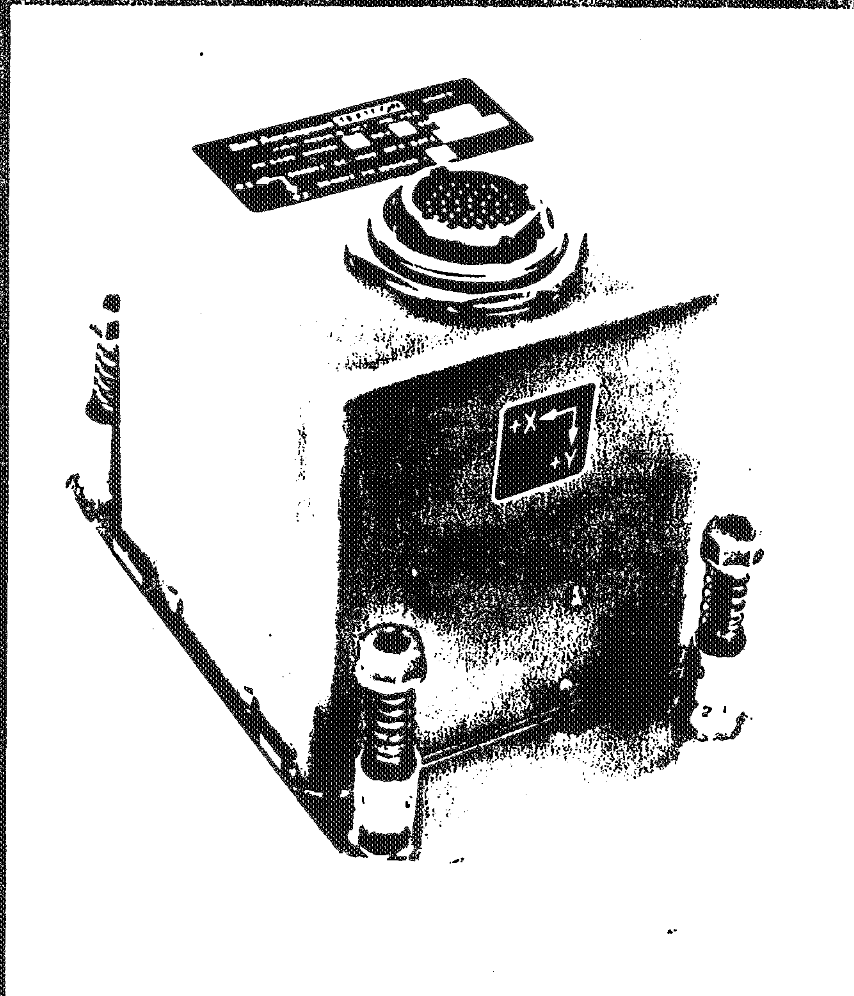
AERODYNAMIC FORCES AND MOMENTS

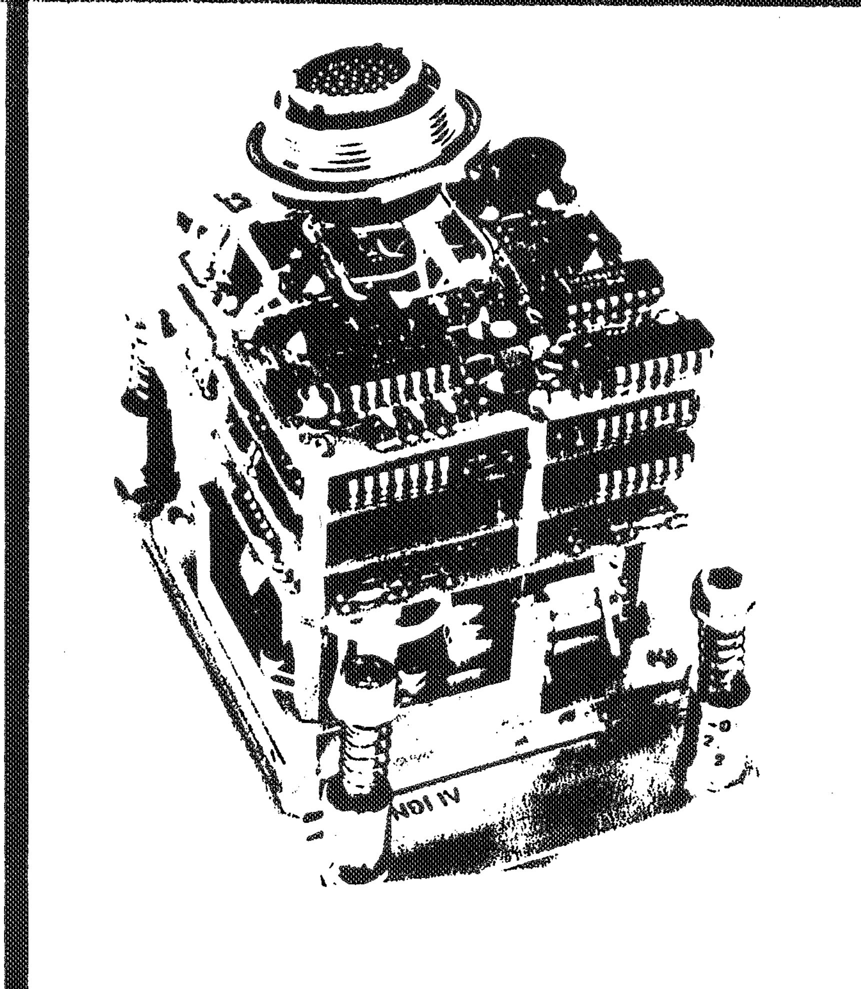
- Inertial Measurement Units
- Aerodynamic Coefficient Identification Package (ACIP)
- High-Resolution Accelerometer Package (HiRAP)
- Orbital Acceleration Research Experiment (OARE)

ACIP AND HiRAP LOCATION WITHIN SHUTTLE ORBITER

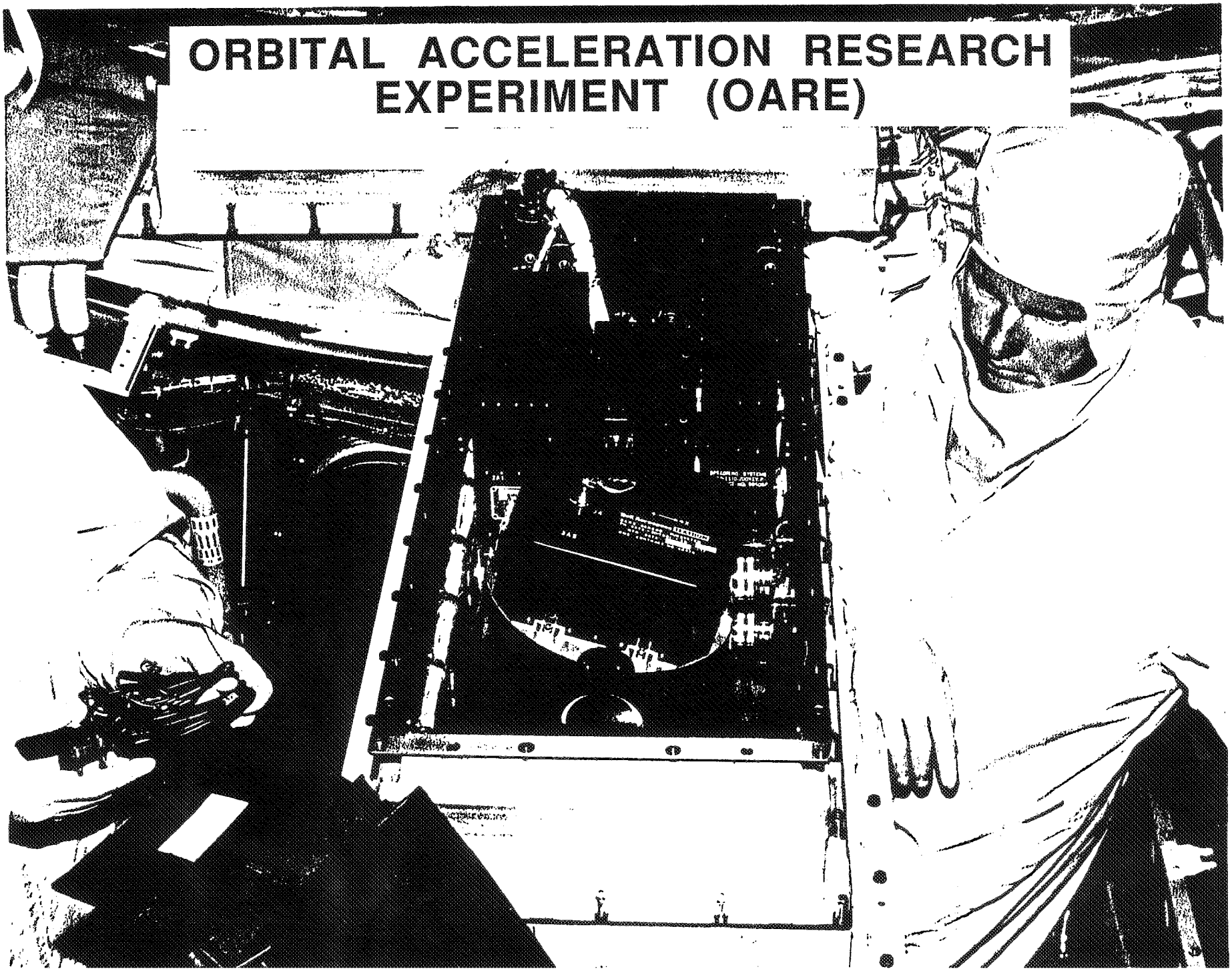


HiRAP FLIGHT UNIT: SN 002





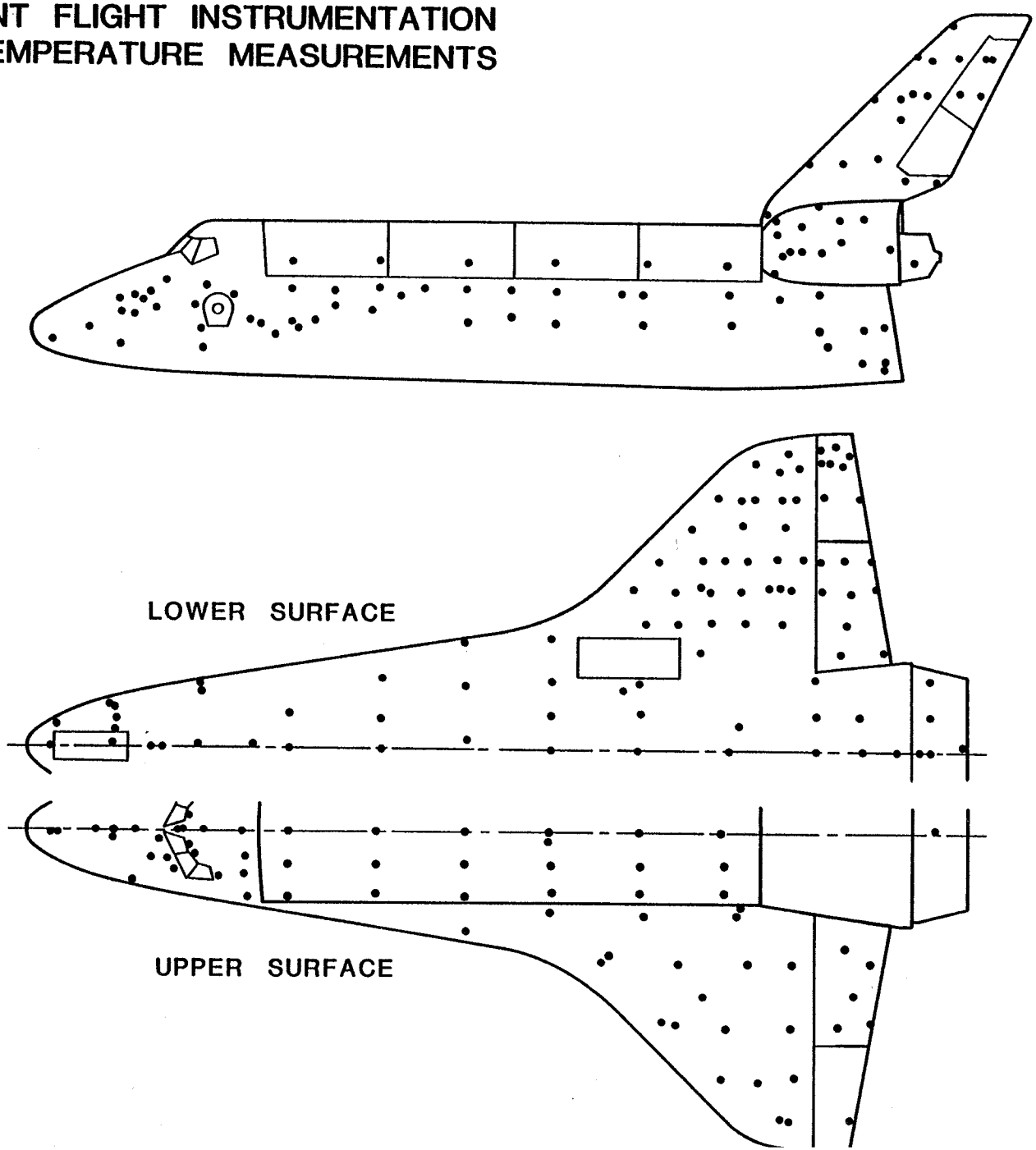
ORBITAL ACCELERATION RESEARCH EXPERIMENT (OARE)



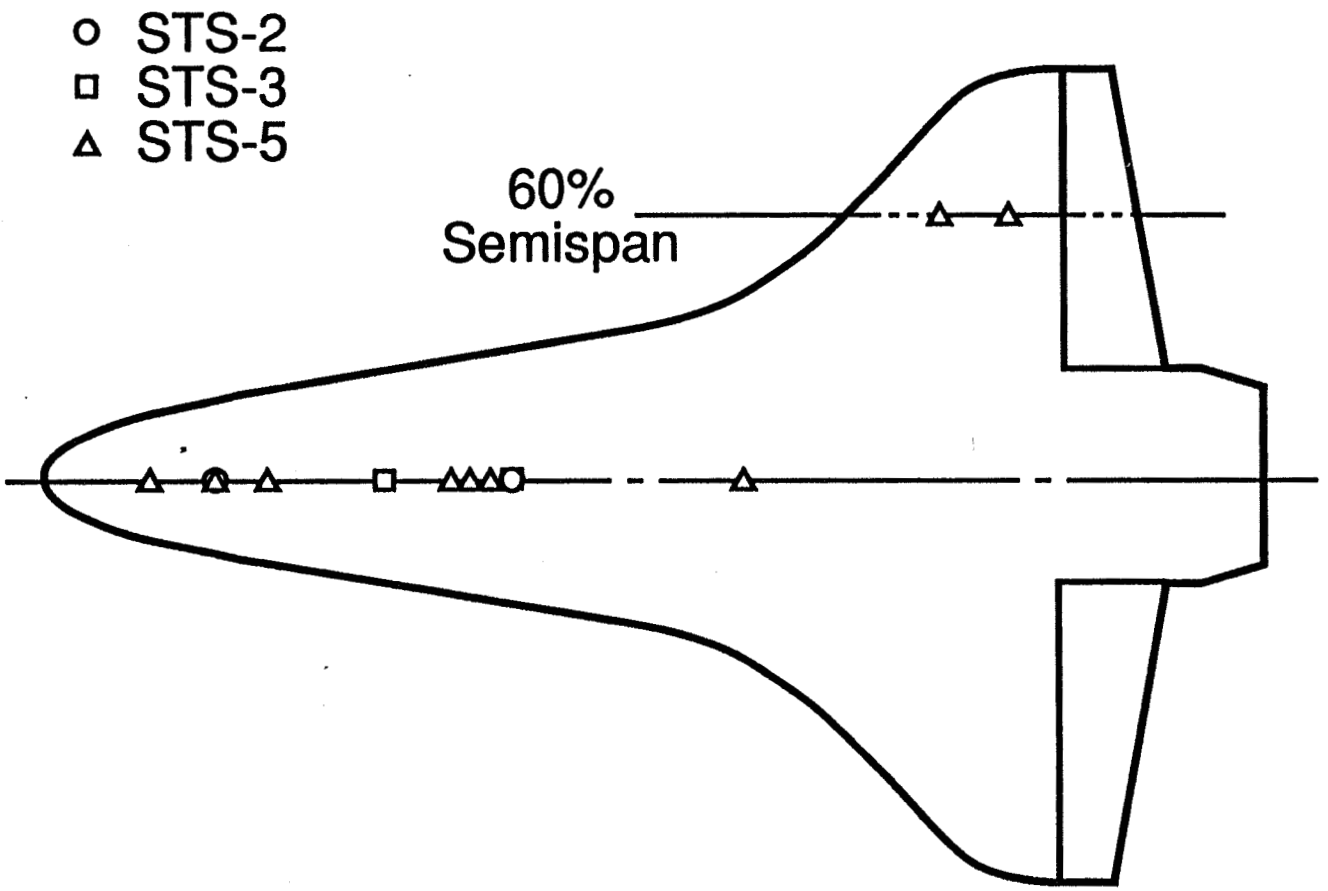
SURFACE PRESSURE AND HEAT TRANSFER

- Development Flight Instrumentation (DFI)
- Tile Gap Heating (TGH)
- Catalytic Surface Effects (CSE)
- Infrared Imagery of Shuttle (IRIS)
- Shuttle Infrared Leeside Temperature Sensing (SILTS)
- Aerothermal Instrumentation Package (AIP)

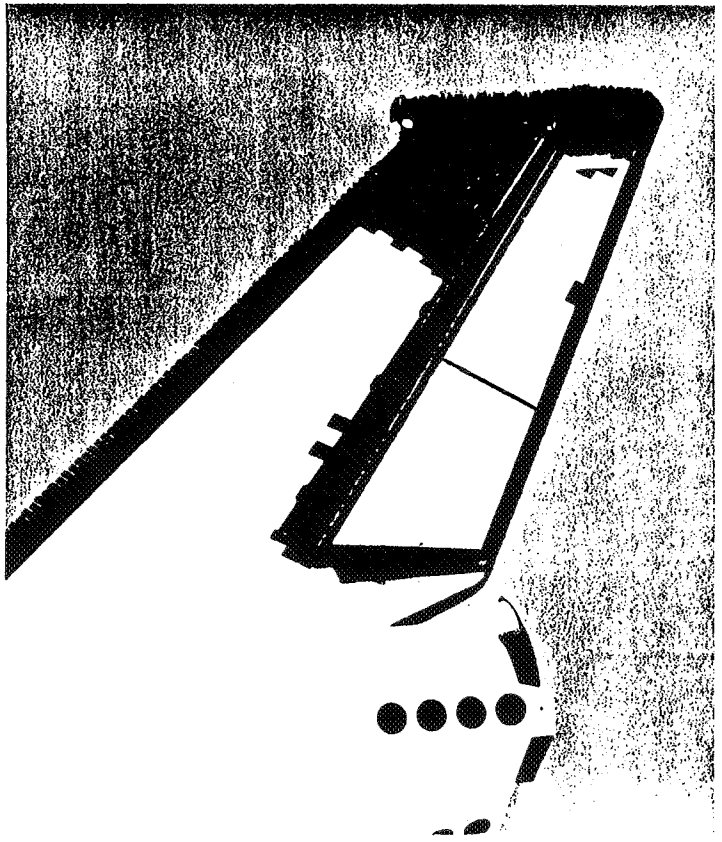
DEVELOPMENT FLIGHT INSTRUMENTATION
SURFACE TEMPERATURE MEASUREMENTS



CSE EXPERIMENT MEASUREMENT LOCATIONS

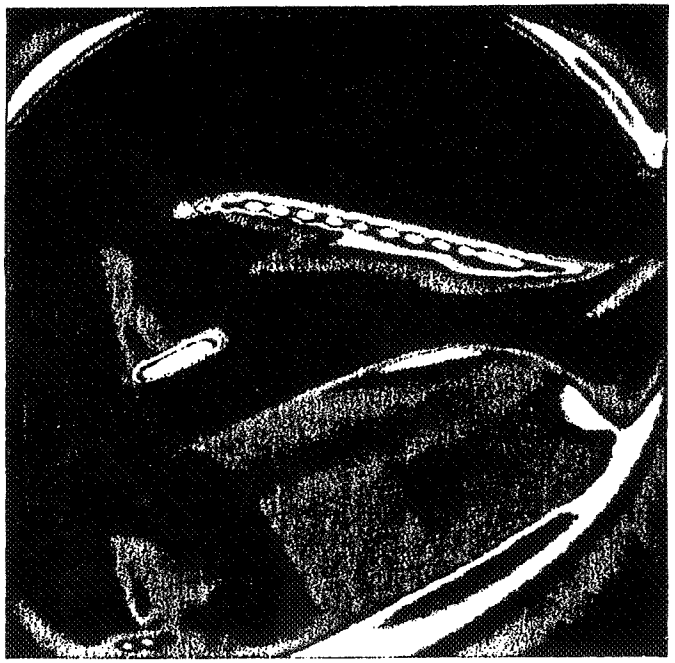


SILTS MODIFICATION TO ORBITER COLUMBIA

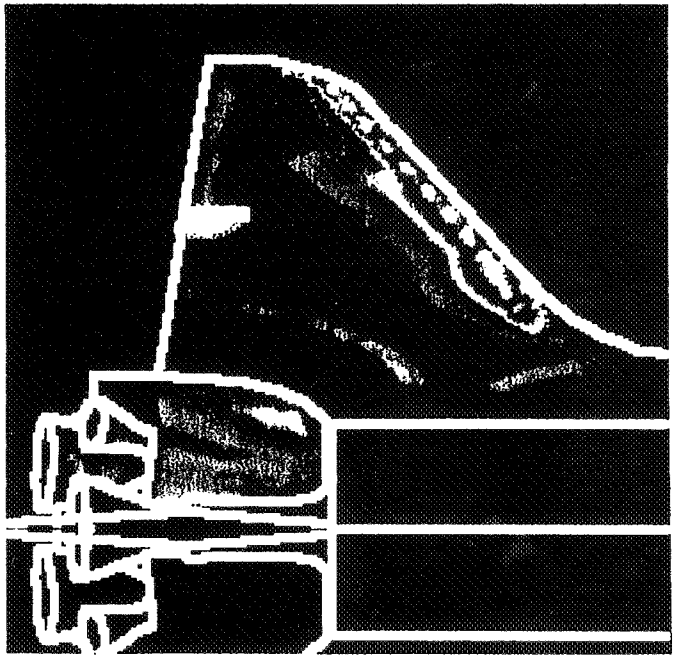


TYPICAL SILTS IMAGE DATA FROM STS-28

Increasing Temperature



Camera View



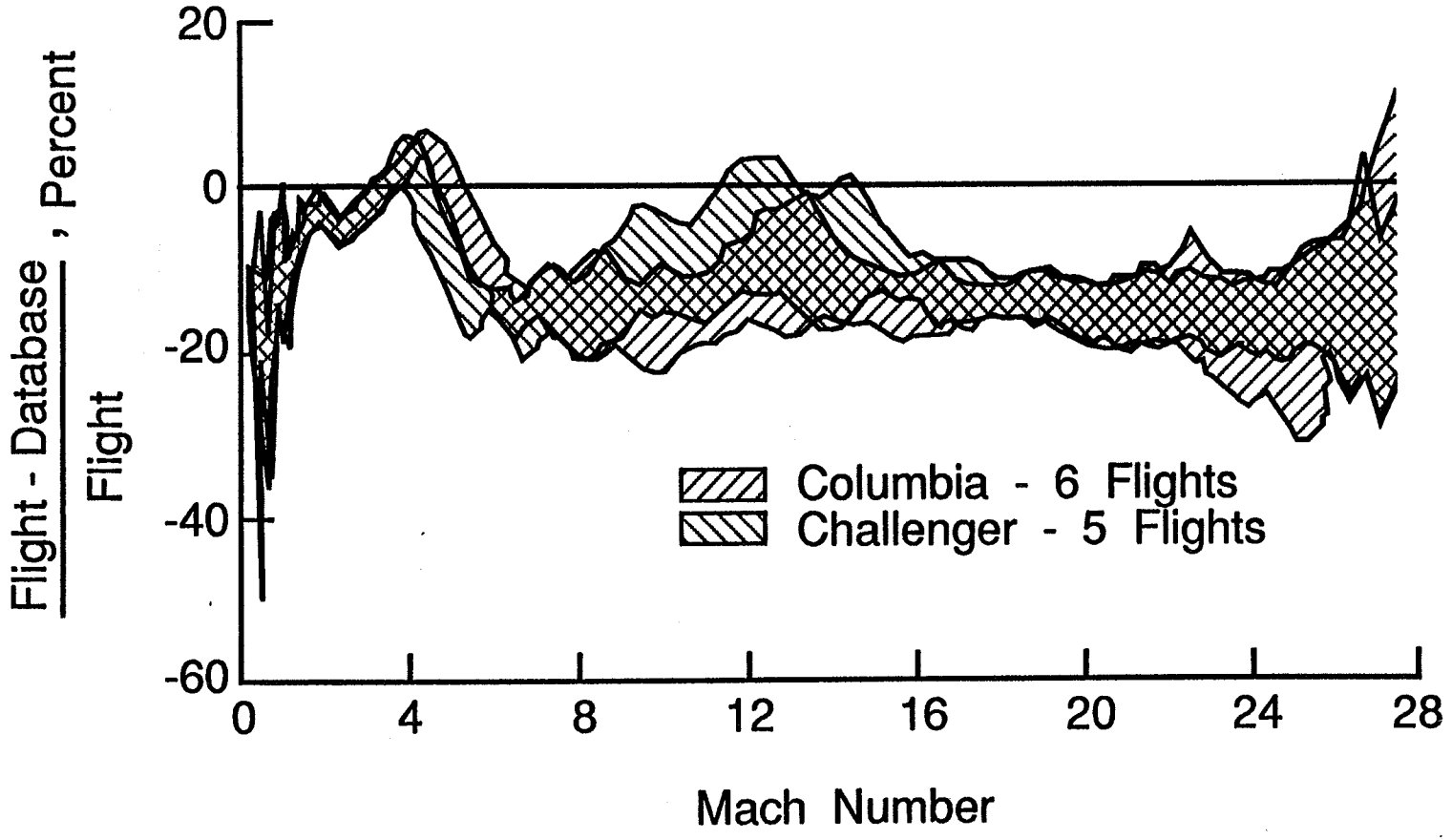
Projection to Planview

NON-AEROTHERMODYNAMIC EXPERIMENTS

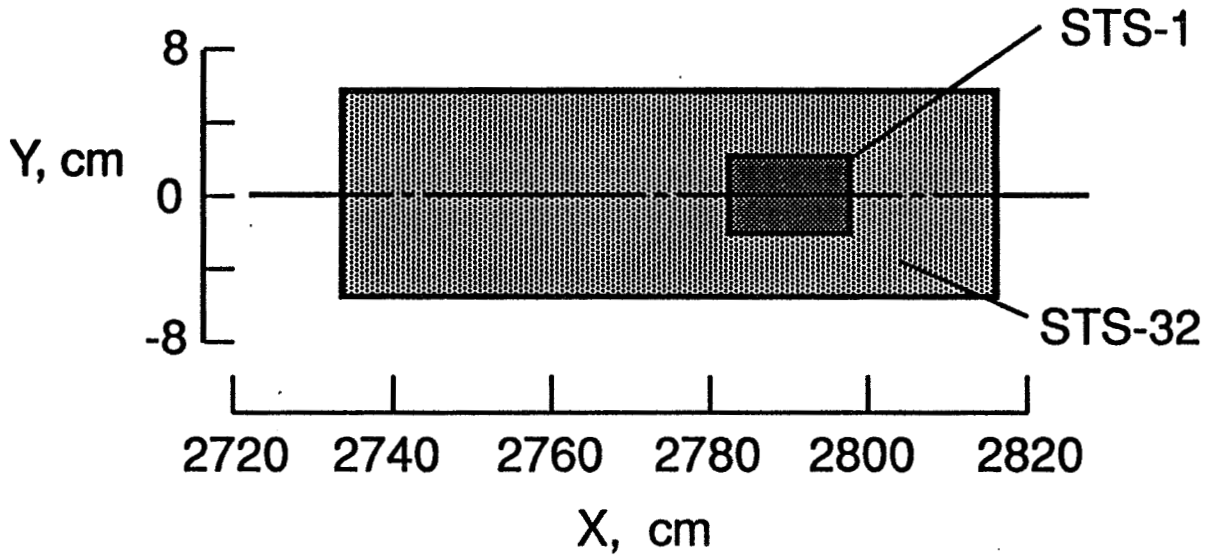
- Dynamic, Acoustic, and Thermal Environments (DATE)
- OEX Autonomous Supporting Instrumentation System (OASIS)
- Advanced Autopilot Experiment (AAPE)
- Advanced Flexible Reusable Surface Insulation (AFRSI)

OEX FLIGHT DATA UTILIZATION EXAMPLES

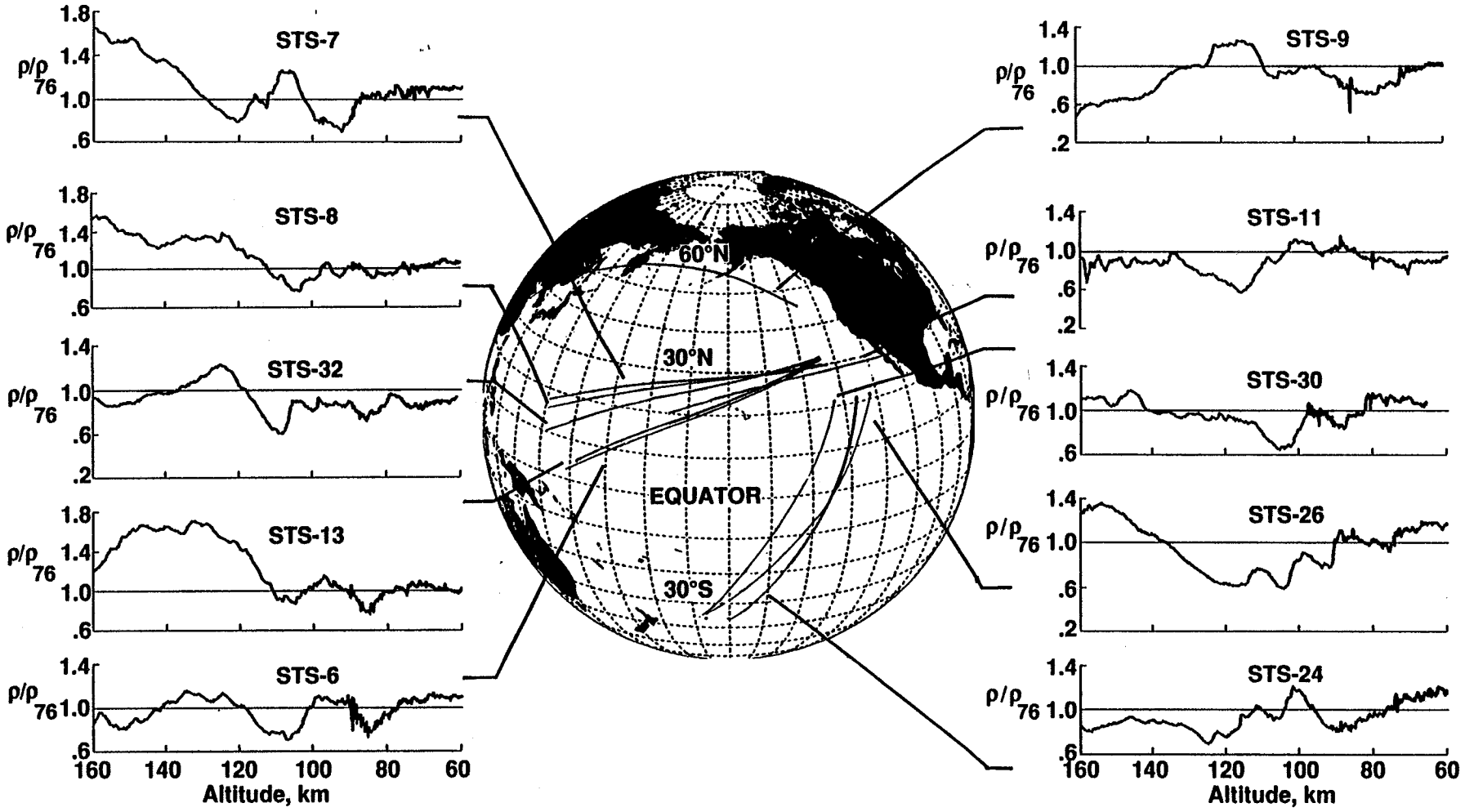
TYPICAL FLIGHT / WIND TUNNEL DATABASE COMPARISON
Axial Force Coefficient



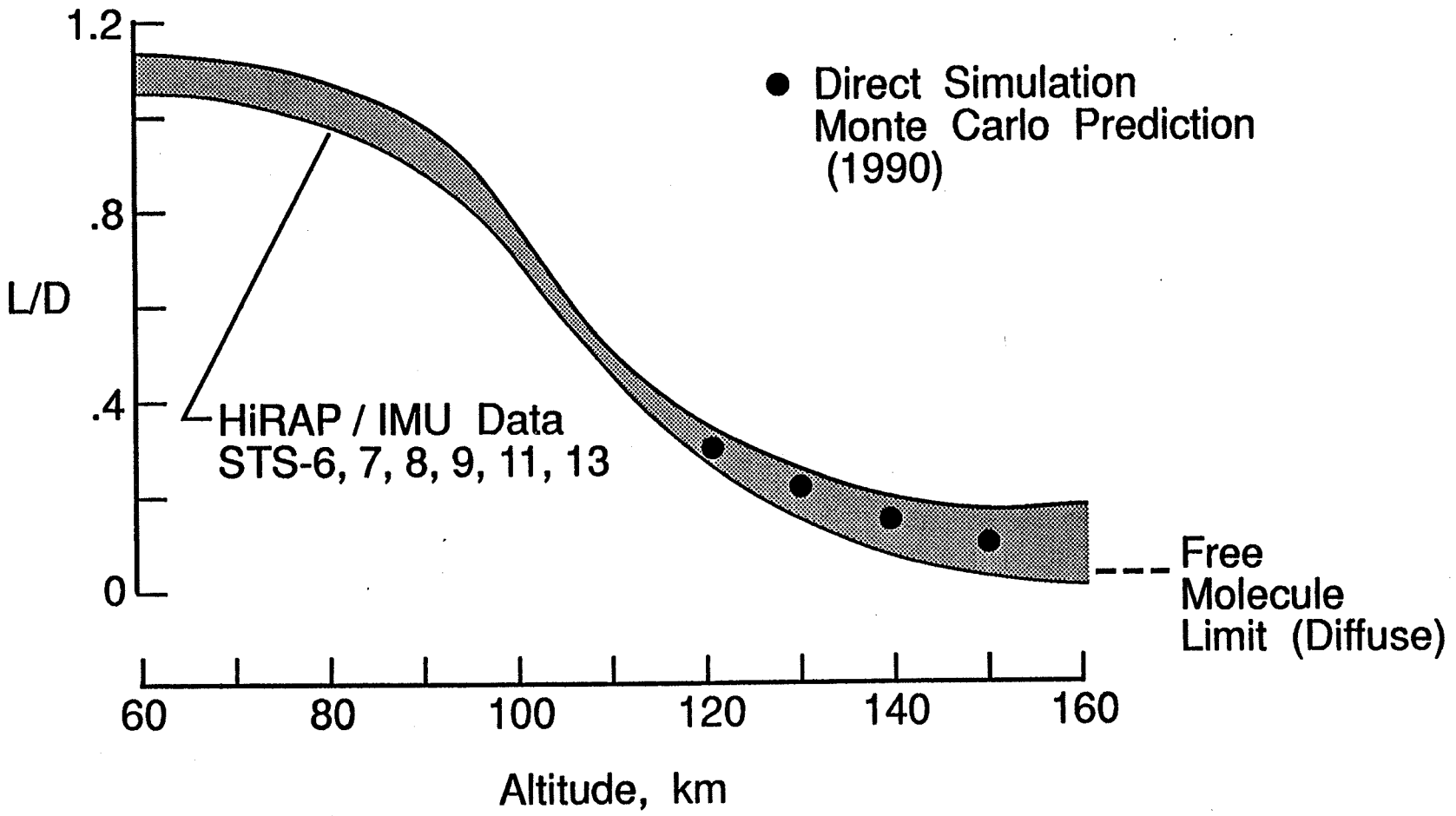
ACIP DATA ENABLED EXPANSION OF ALLOWABLE ORBITER C. G. ENVELOPE



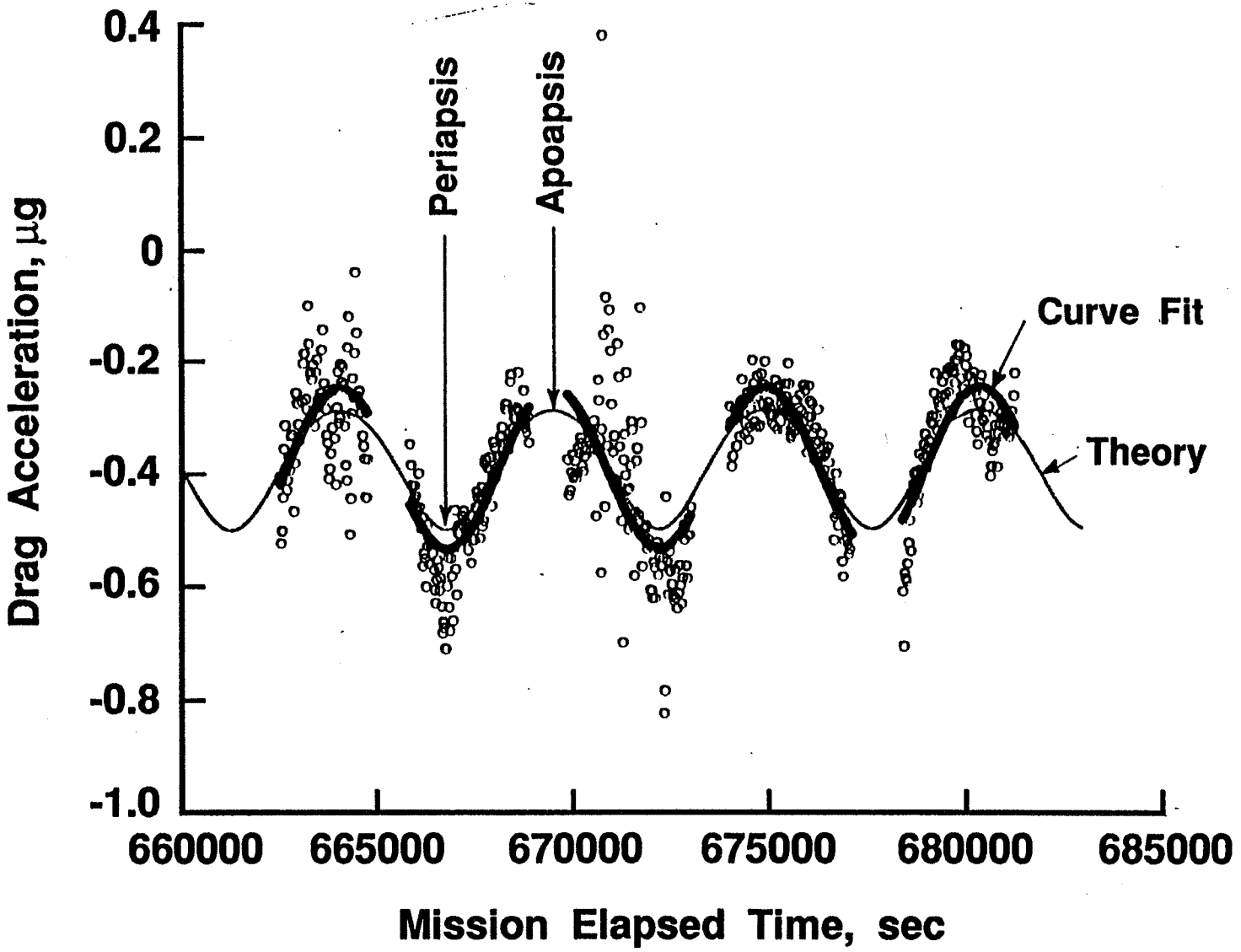
HiRAP/ IMU DENSITY DATA LED TO MODIFICATION OF GLOBAL REFERENCE ATMOSPHERE MODEL (GRAM)



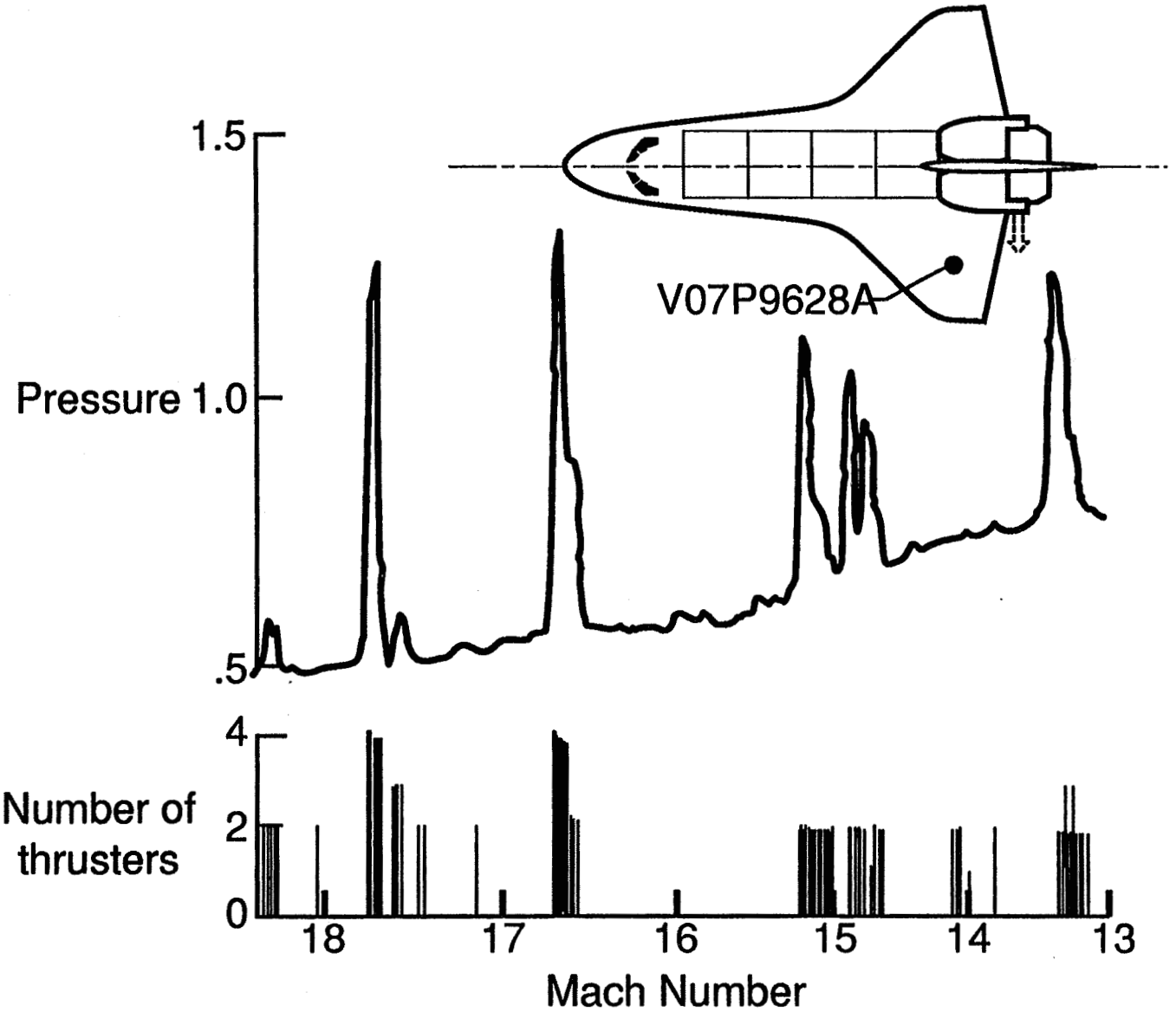
HiRAP PROVIDES VALIDATION DATA FOR RAREFIED FLOW COMPUTATIONAL TOOLS



OARE SENSES PERIODIC ORBITAL DRAG VARIATION

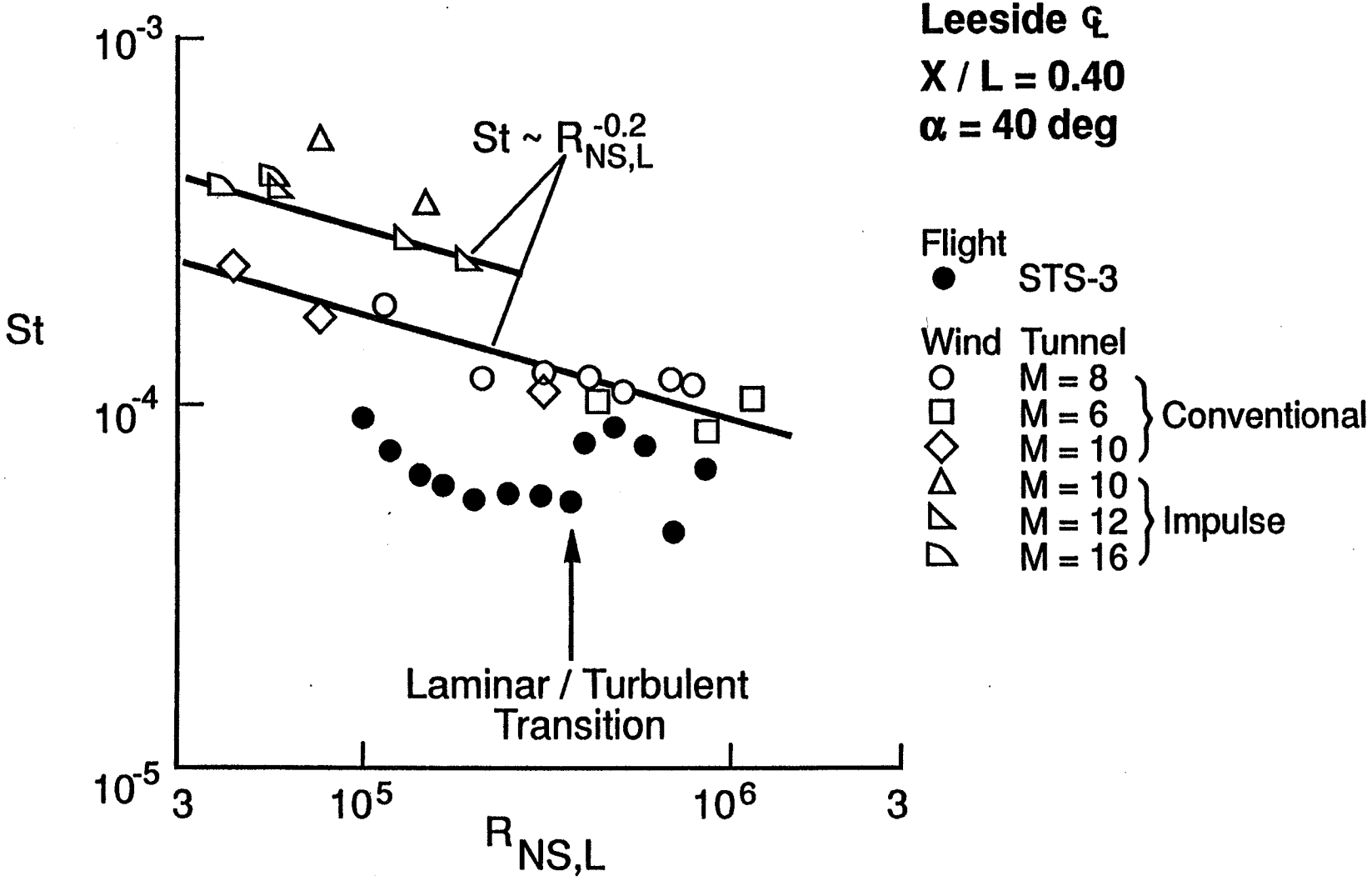


STS-3 CORRELATION OF PRESSURE CHANGES ON LEEWARD SURFACE OF WING WITH RCS FIRINGS

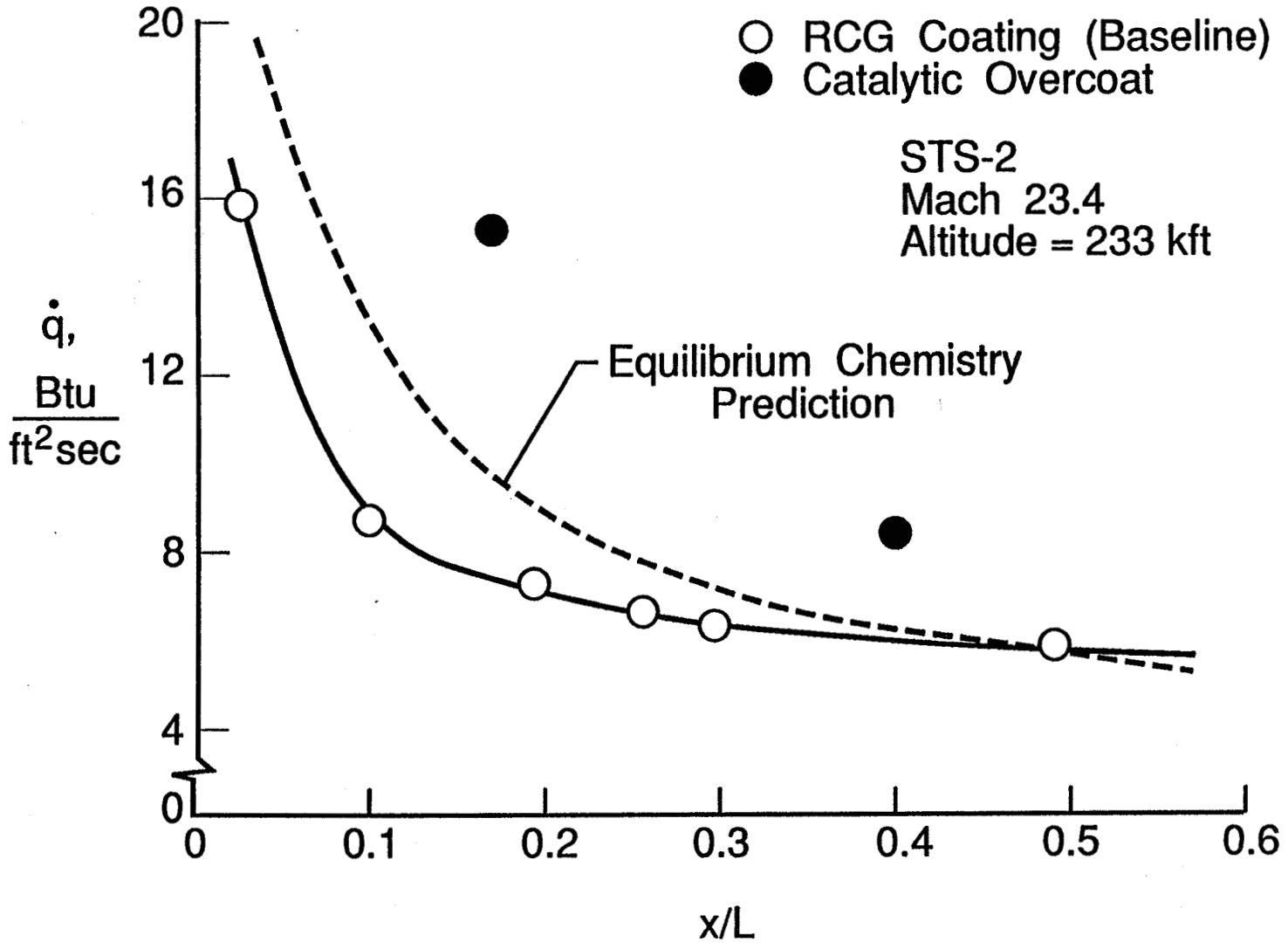


WIND TUNNEL DATA OVERPREDICT LEESIDE HEAT TRANSFER

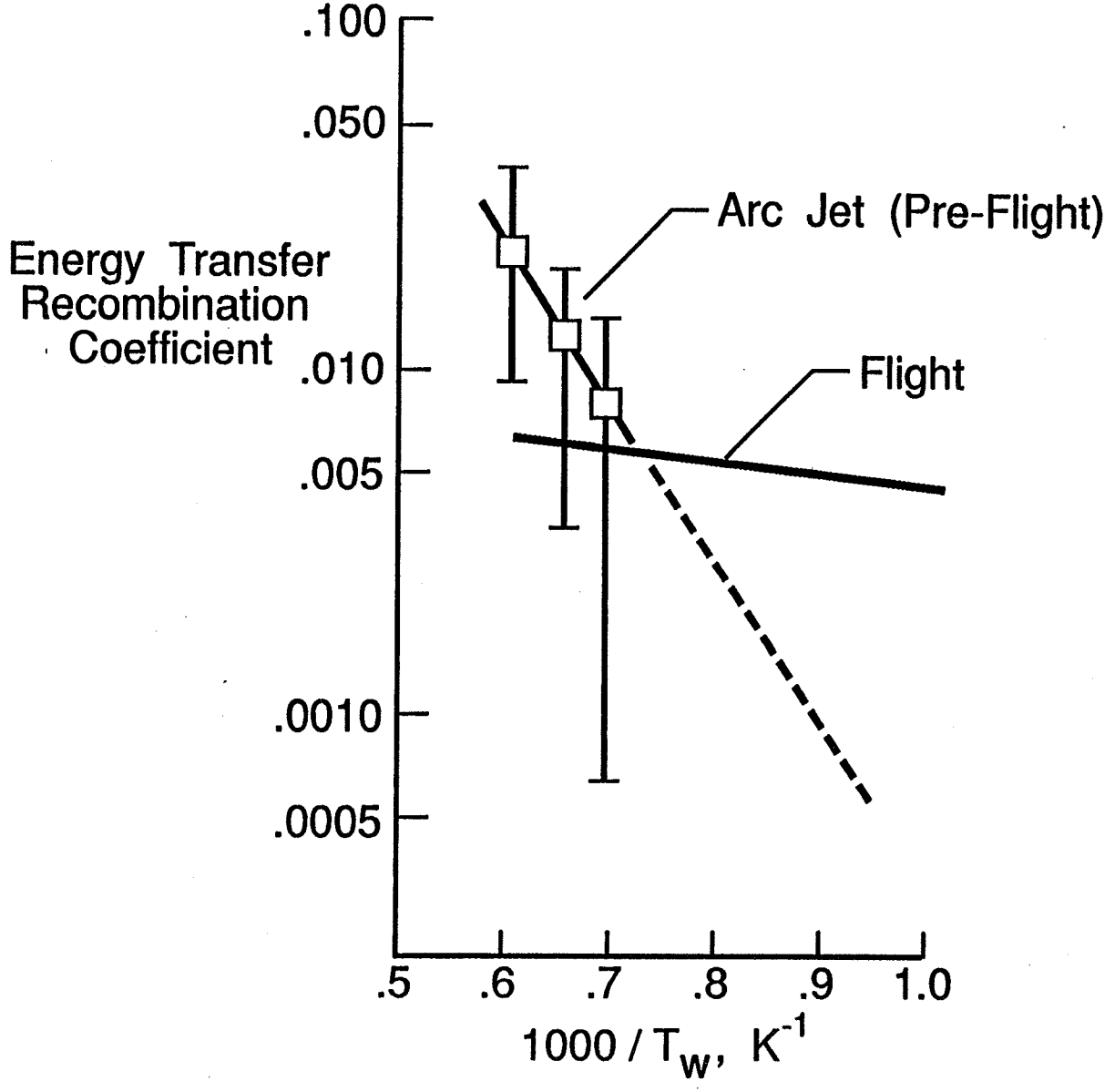
(LAMINAR VS TURBULENT LEESIDE FLOWFIELD)



CSE EXPERIMENT CONFIRMS NON-CATALYTIC BENEFIT OF GLASS TILE COATING IN FLIGHT ENVIRONMENT

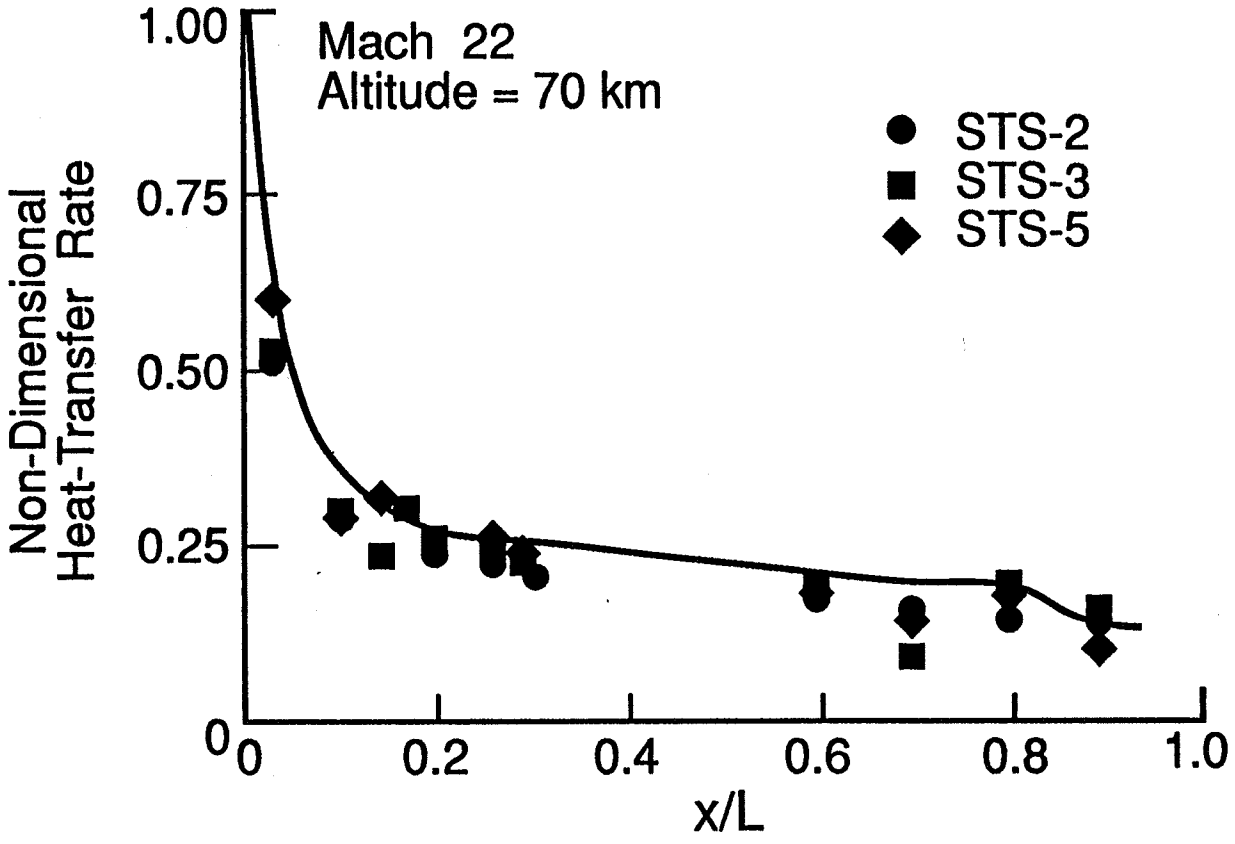


FLIGHT DATA ENABLE DETERMINATION OF TPS SURFACE CATALYTIC EFFICIENCY

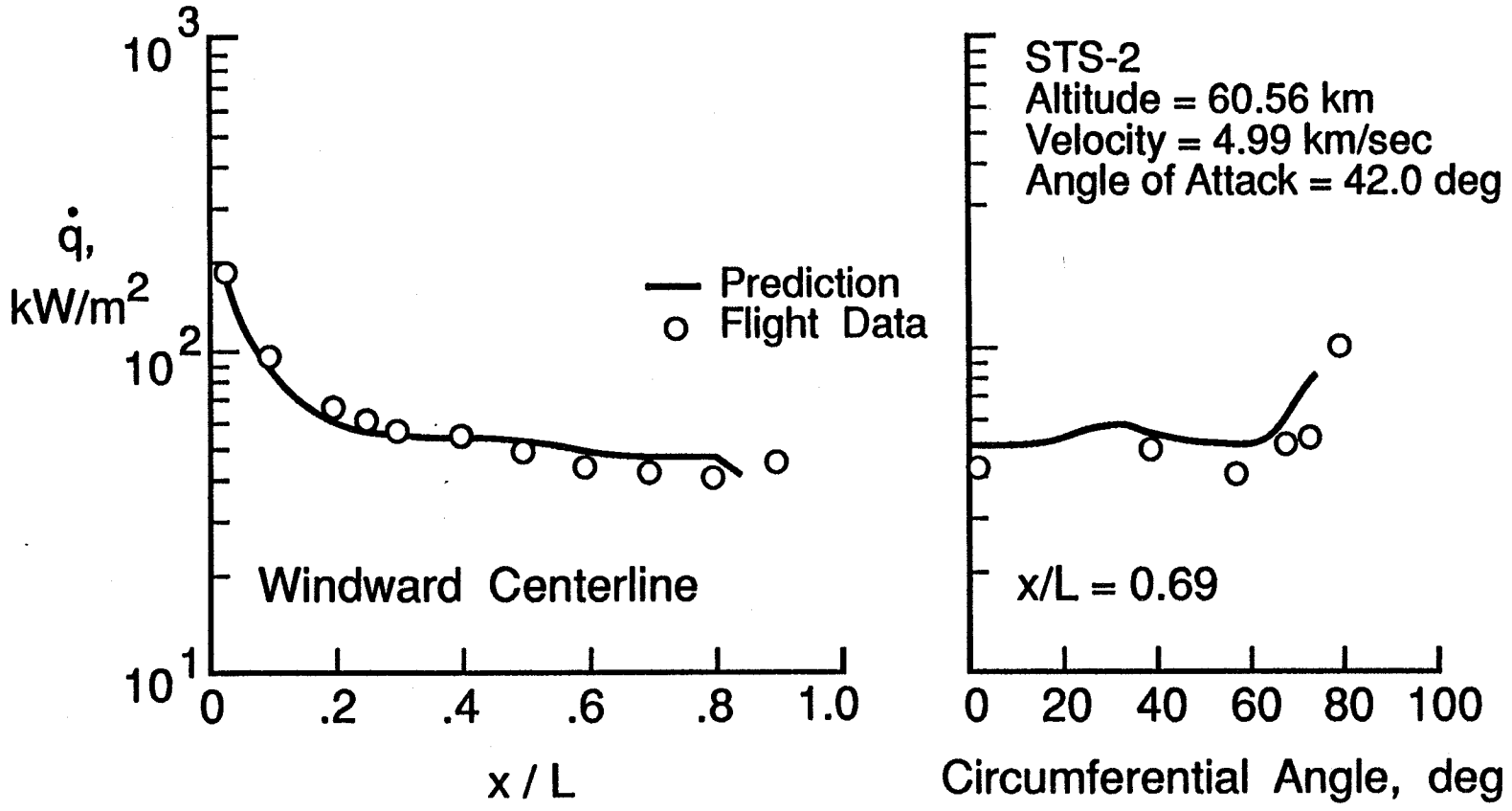


8-17

COMPARISON OF FLIGHT DATA WITH 3-DIMENSIONAL NAVIER STOKES SOLUTION

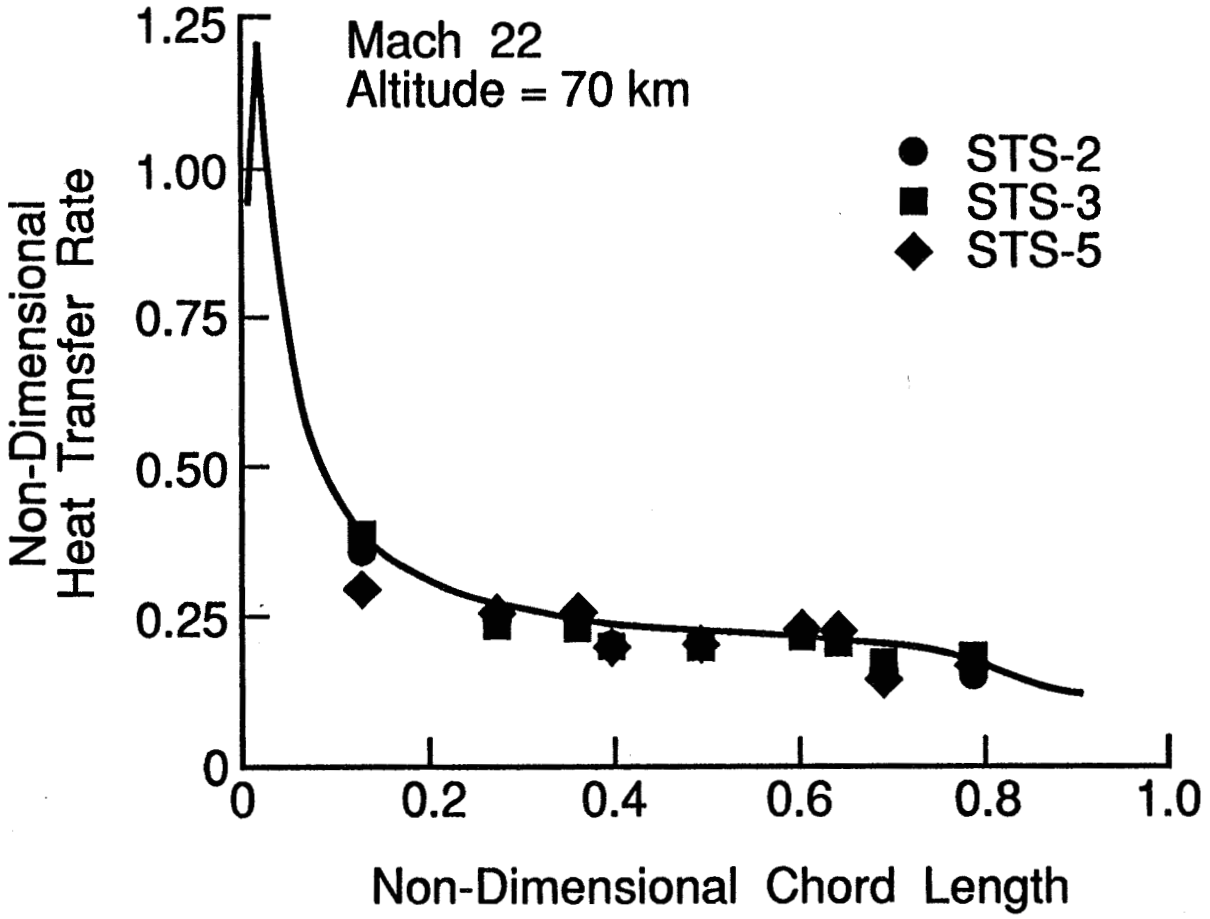


COMPARISON OF FLIGHT DATA WITH 3-DIMENSIONAL VISCOUS SHOCK LAYER SOLUTION

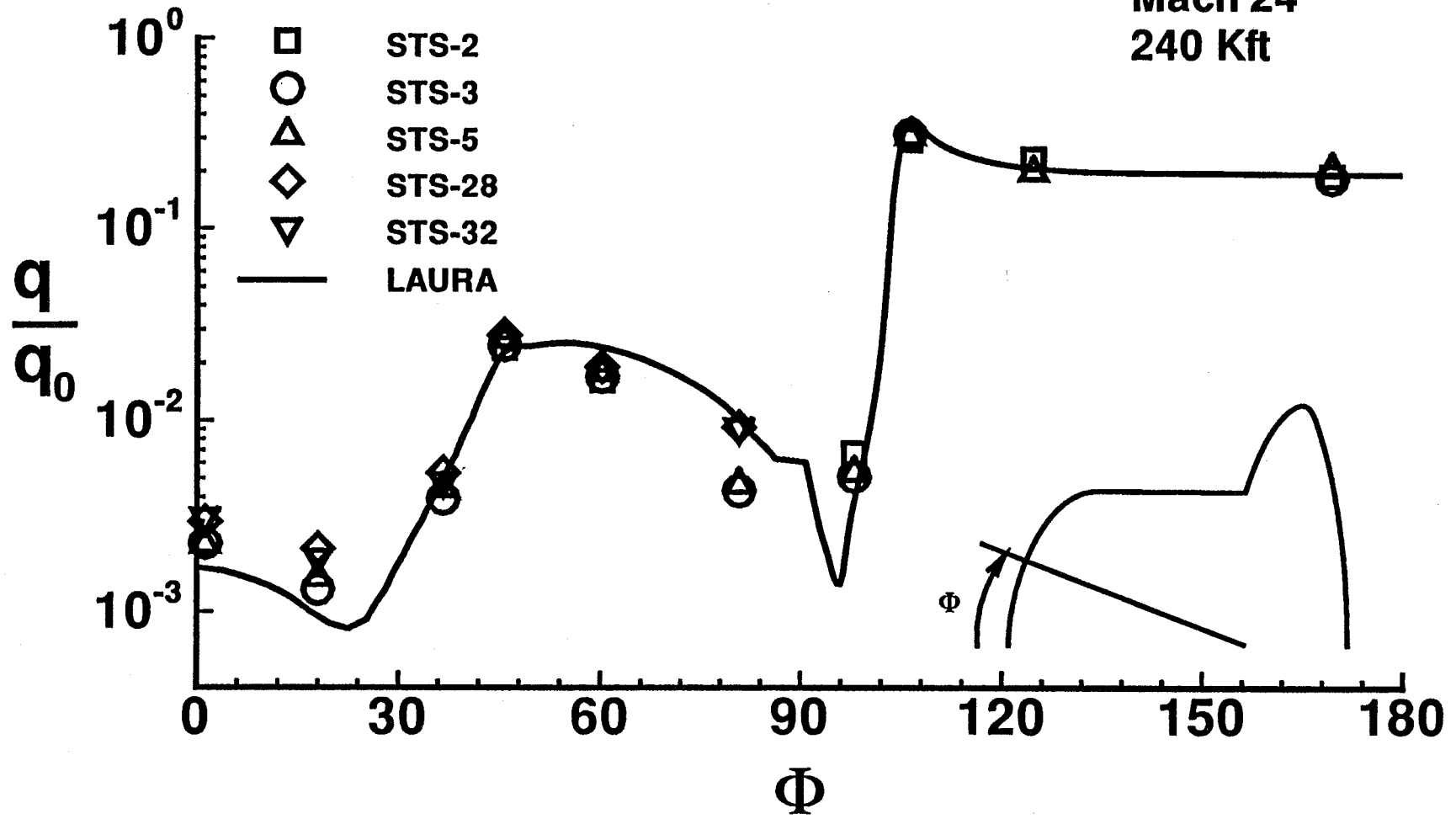


COMPARISON OF FLIGHT DATA WITH 3-DIMENSIONAL NAVIER STOKES SOLUTION

(50 PERCENT SEMISPAN)



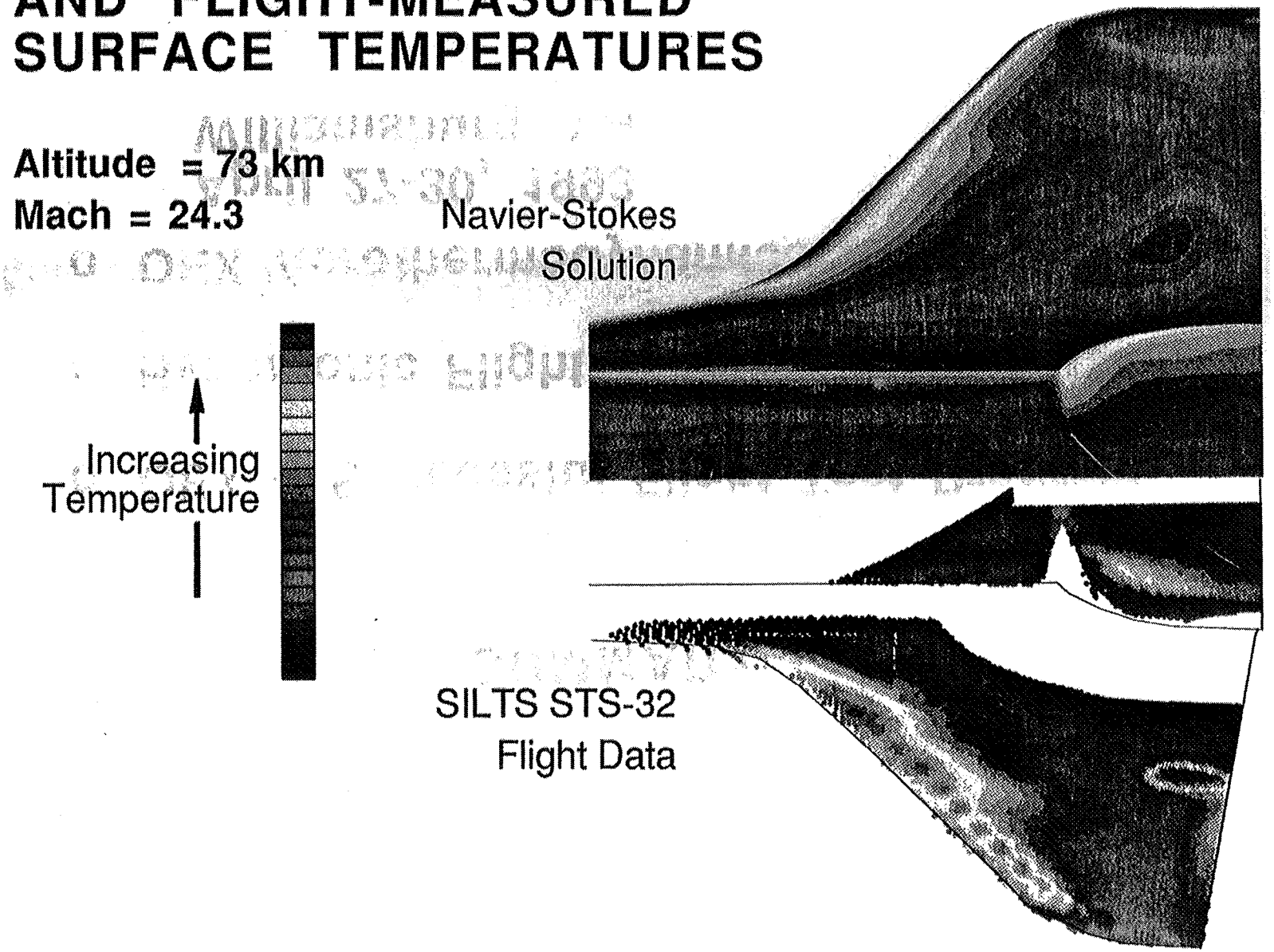
Comparison of Predicted and Flight-Measured Heat-Transfer Rates (X/L=0.50)



COMPARISON OF PREDICTED AND FLIGHT-MEASURED SURFACE TEMPERATURES

Altitude = 73 km

Mach = 24.3



SUMMARY

- OEX -- Successful Flight Test Program
- Hypersonic Flight Test Lessons Learned
- OEX Aerothermodynamics Symposium

  April 27-30, 1993
  Williamsburg, VA