LESSONS LEARNT FROM 11 GAS PAYLOADS FLOWN ON 5 SHUTTLE MISSIONS

Dr. H. Stolze and Dr. P. Vits
MBB-ERNO
Bremen, FRG

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MBB–ERNO'S INVOLVEMENT IN THE GAS PROGRAM

- INDUSTRIAL CONTRACTOR FOR THE MAUS–PROJECT (MATERIAL SCIENCE EXPERIMENTS)
  - PHASE A/B STUDY (PARALLEL STUDIES)
  - PHASE C/D PROJECT
  - 10 UNITS FOR 5 FLIGHTS EACH
  - 10 PAYLOADS FLOWN ON 5 MISSIONS (STS 5, 7, 11, 51G)

- RELATED STUDY PERFORMANCES
  - MAUS CLUSTER
  - MAUS ON HITCHHIKER

- COMPANY FUNDED GAS–PAYLOAD
  - EMTE I SURFACE TENSION TANK EXPERIMENT (STS 51G)
  - EMTE II REFLIGHT WITH NEW EXPERIMENT–PROFILE
  - BIOLOGY EXPERIMENT QUALIFICATION (BIO–MAUS)

- COMMERCIAL GAS PAYLOAD SUPPORT SYSTEM PASS
  - HARDWARE LEASING
  - PAYLOAD INTEGRATION AND MISSION SUPPORT

LESSONS LEARNT

- SELECTED HINTS DERIVED FROM 5 YEARS EXPERIENCE IN:
  - EXPERIMENT HARDWARE DESIGN
  - HARDWARE QUALIFICATION
  - SAFETY PROVISIONS
  - EXPERIMENT TESTING
  - PAYLOAD INTEGRATION
  - FLIGHT PREPARATION
  - BATTERY TRANSPORT
  - POST–MISSION CHECK–OUT

- THIS IS NOT A PRESENTATION OF A COMPLETE DESIGN PHILOSOPHY, BUT ONLY SELECTED HINTS FOR FUTURE GAS–USERS

- BASIC RULE
  „MAKE IT SIMPLE AND OVERSIZED"

OVERVIEW OF MAUS–SYSTEMS

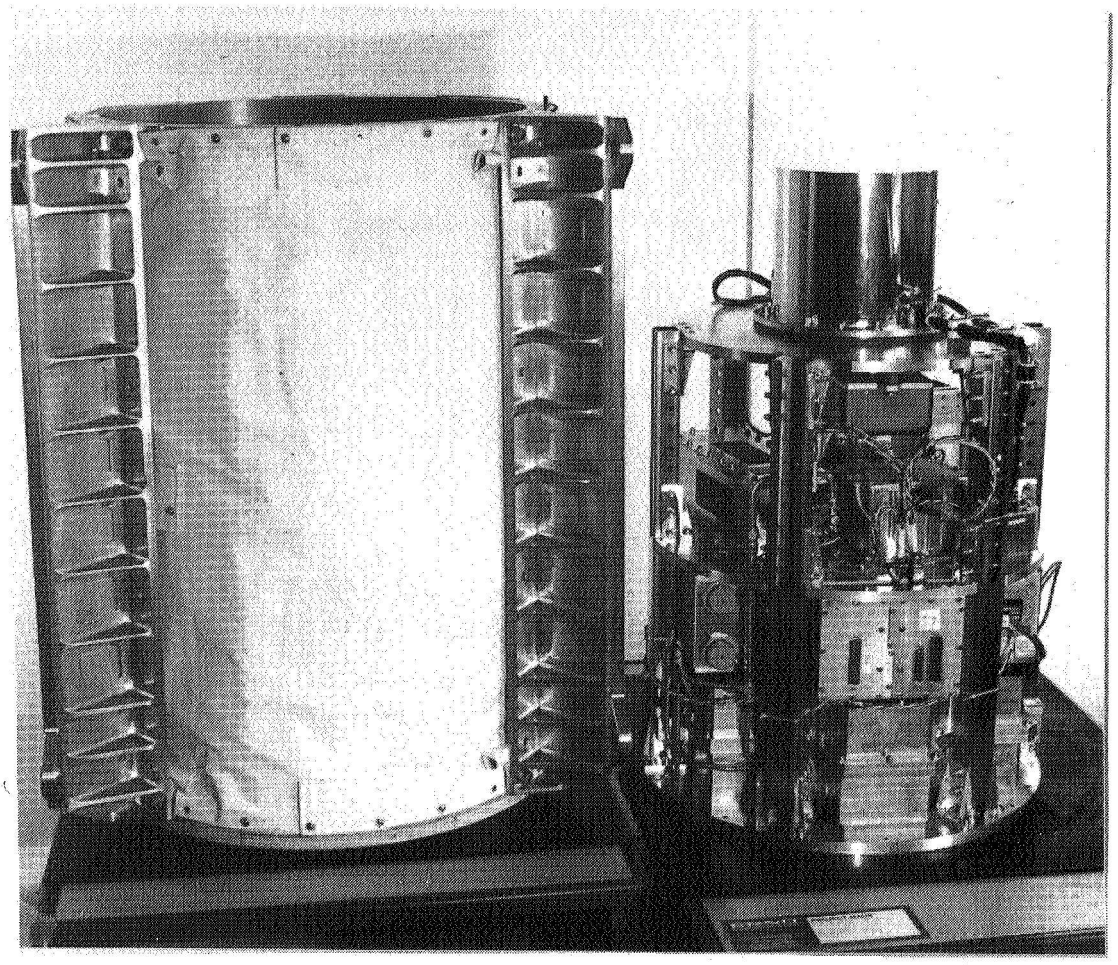
(IN ORDER TO UNDERSTAND THE LESSONS LEARNT)

- MAUS–CONCEPT — VIEWGRAPH 1

- SUBSYSTEMS — VIEWGRAPH 2

- PAYLOADS
  - MAUS DG–XXX — VIEWGRAPH 3
  - EMTE I — VIEWGRAPH 4

- MAUS–MISSIONS
  - GAS — VIEWGRAPH 5
  - SPAS — VIEWGRAPH 6
  - OSTA II — VIEWGRAPH 7
  - D1/NAVEX — VIEWGRAPH 8



PAYLOAD

- o VOLUME 140 l
- o ENERGY 2 kWh
- o WEIGHT 91 kg

EXPERIMENT

- o VOLUME 70 l
- o ENERGY 1,8 kWh
- o WEIGHT 20 kg

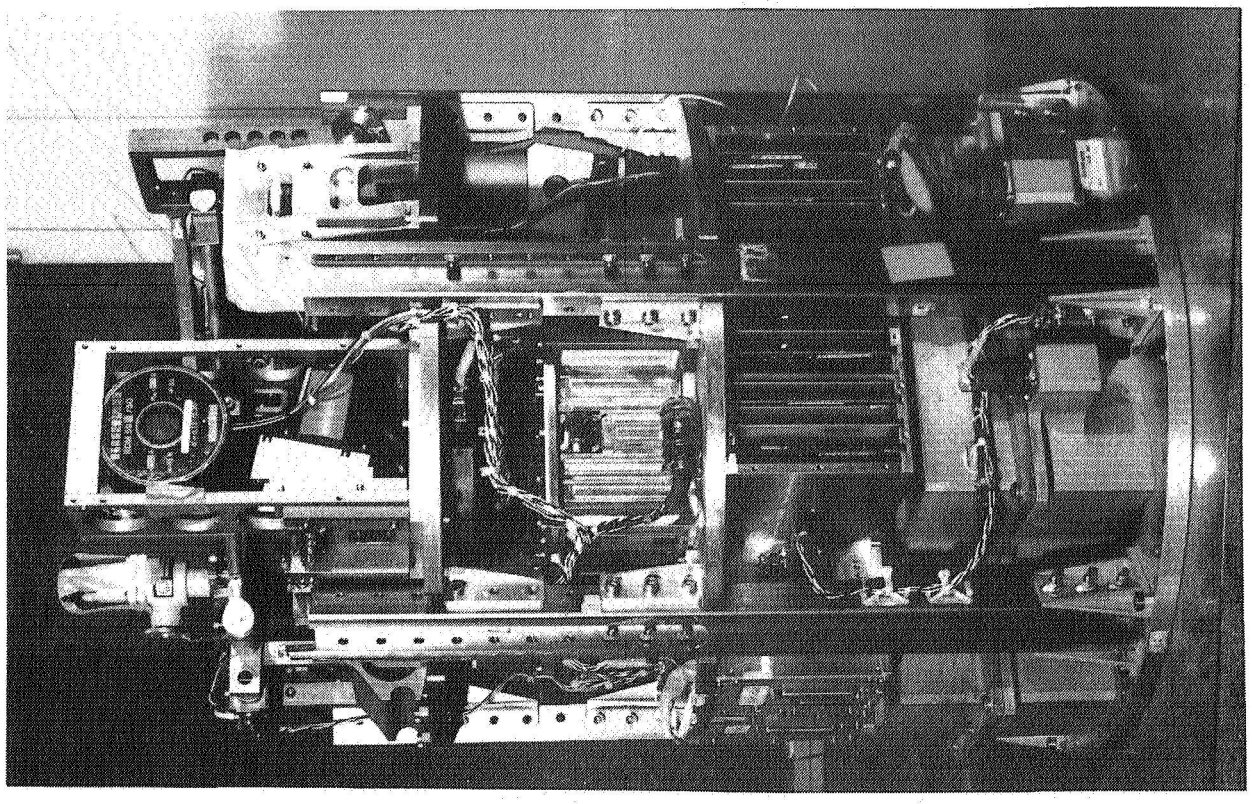
SERVICE MODULE

- o EXPERIMENT CONTROL
- o DATA ACQUISITION
- o DATA STORAGE
- o SIGNAL CONDITIONING
- o POWER CONDITIONING
- o POWER SUPPLY
  - – ELECTRONICS
  - – EXPERIMENT
- o GSE–INTERFACE
- o EXPERIMENT MOUNTING STRUCTURE
- o HOUSEKEEPING SYSTEM
  - – PRESSURE
    - –– CONTAINER
    - –– BATTERIES
  - – TEMPERATURE
  - – BATTERY – VOLTAGES
  - – ACCELERATION (3–AXIS)

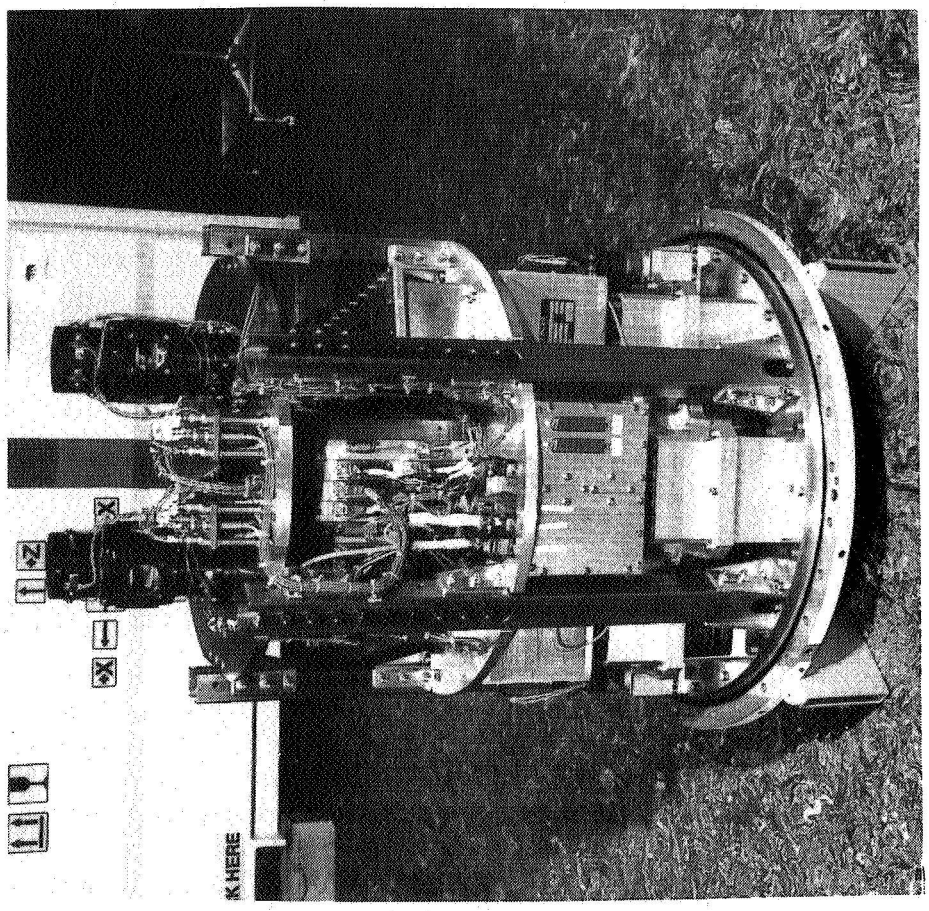
AND

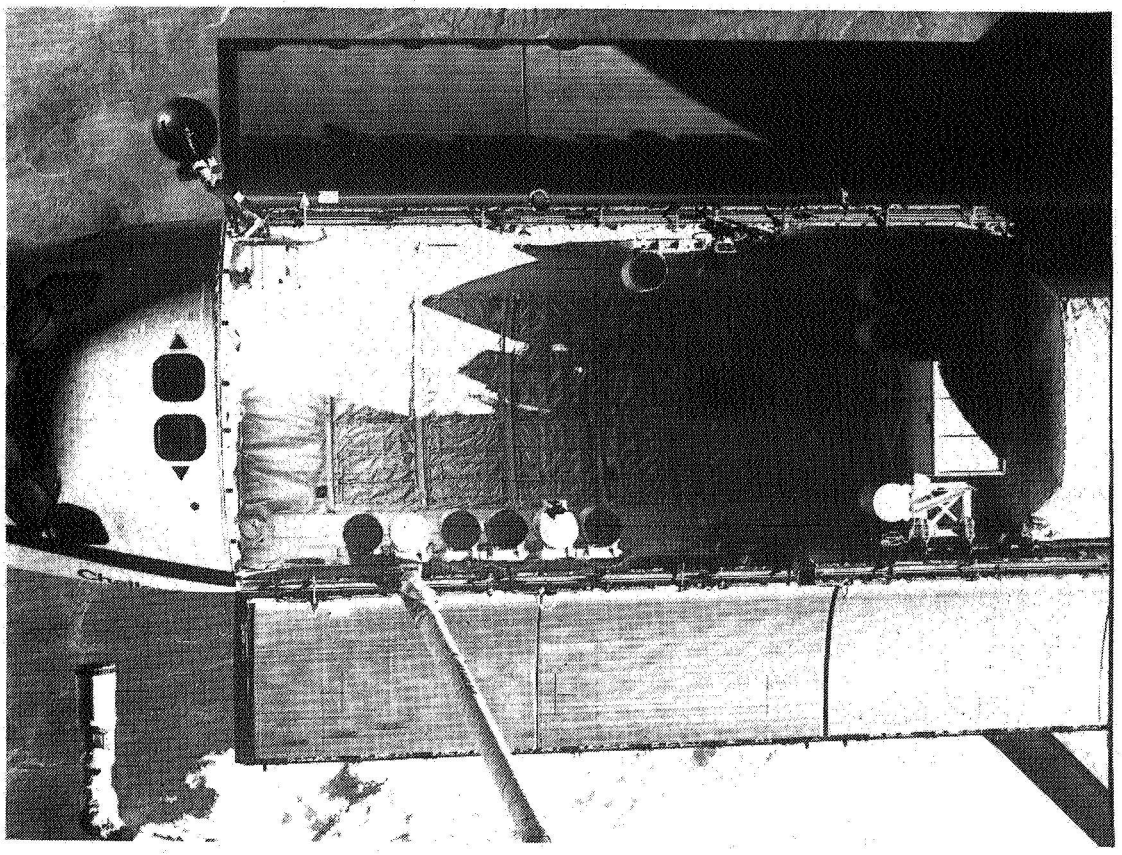
CONTAINER, ON/OFF–INTERFACE, ADAPTER BRACKET, MGSE, EGSE

MAUS-Concept and Subsystem Definition

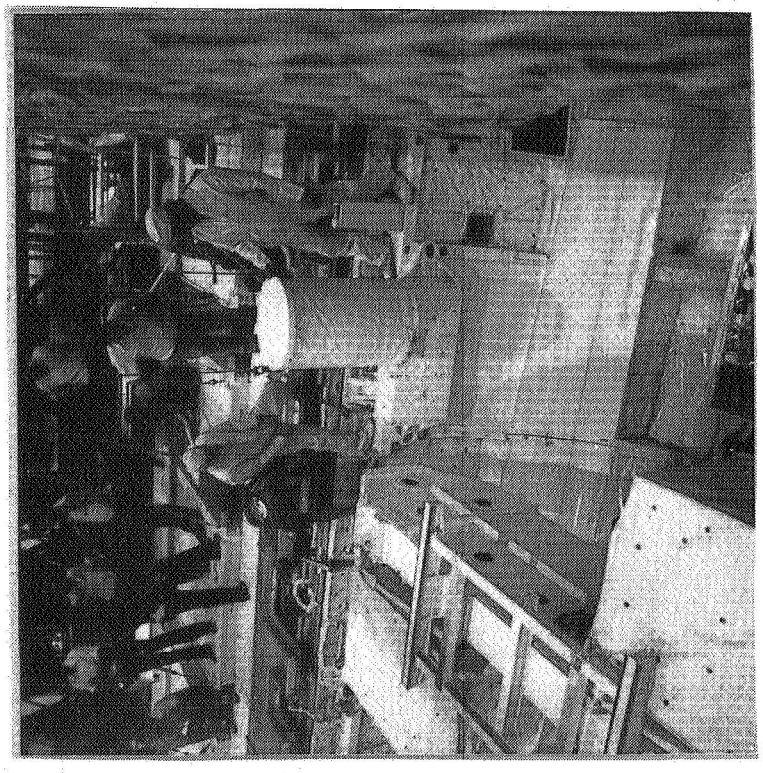


MAUS Internal Payloads

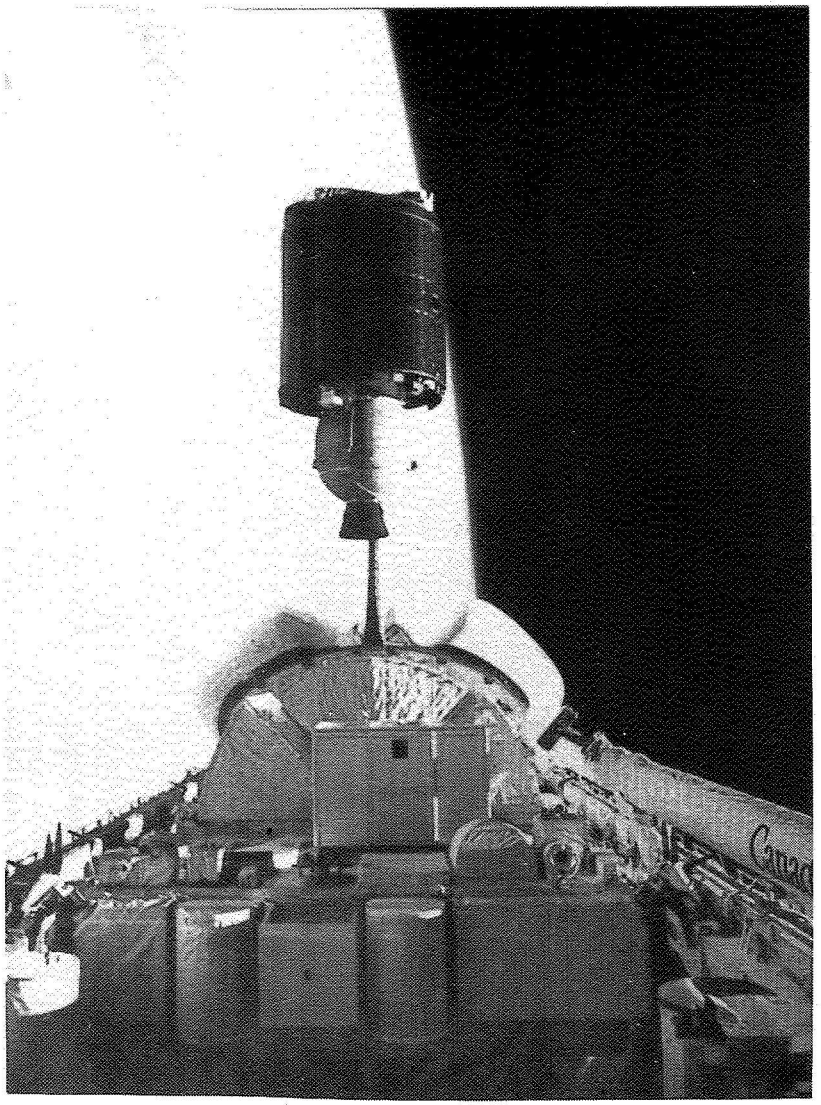




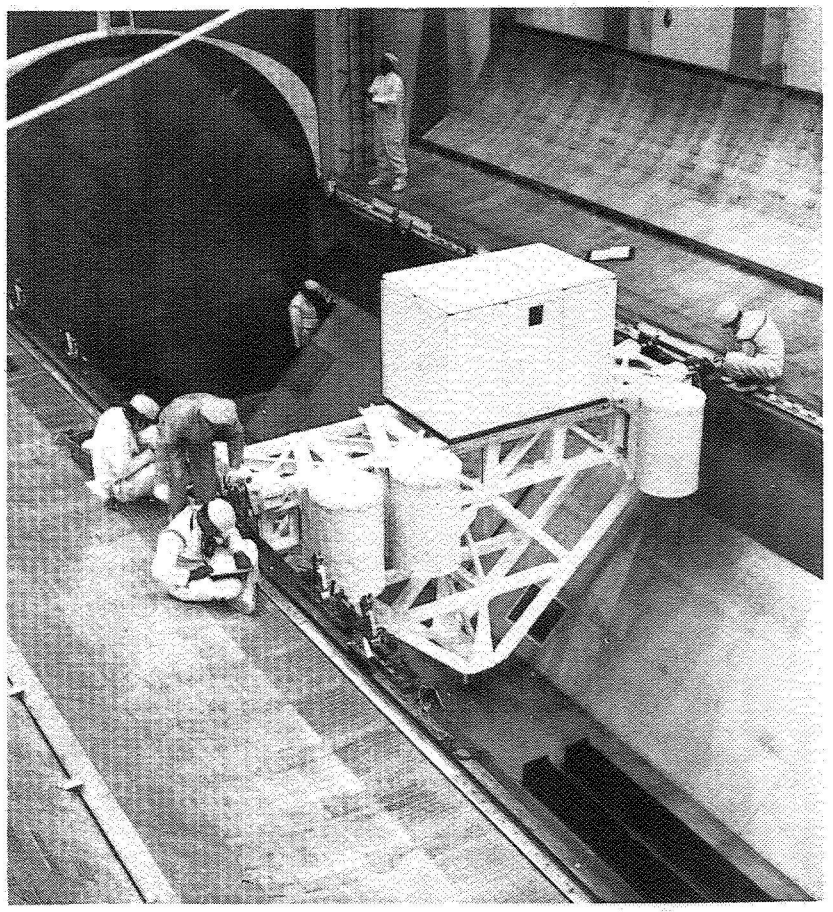
GAS-Configuration STS-7



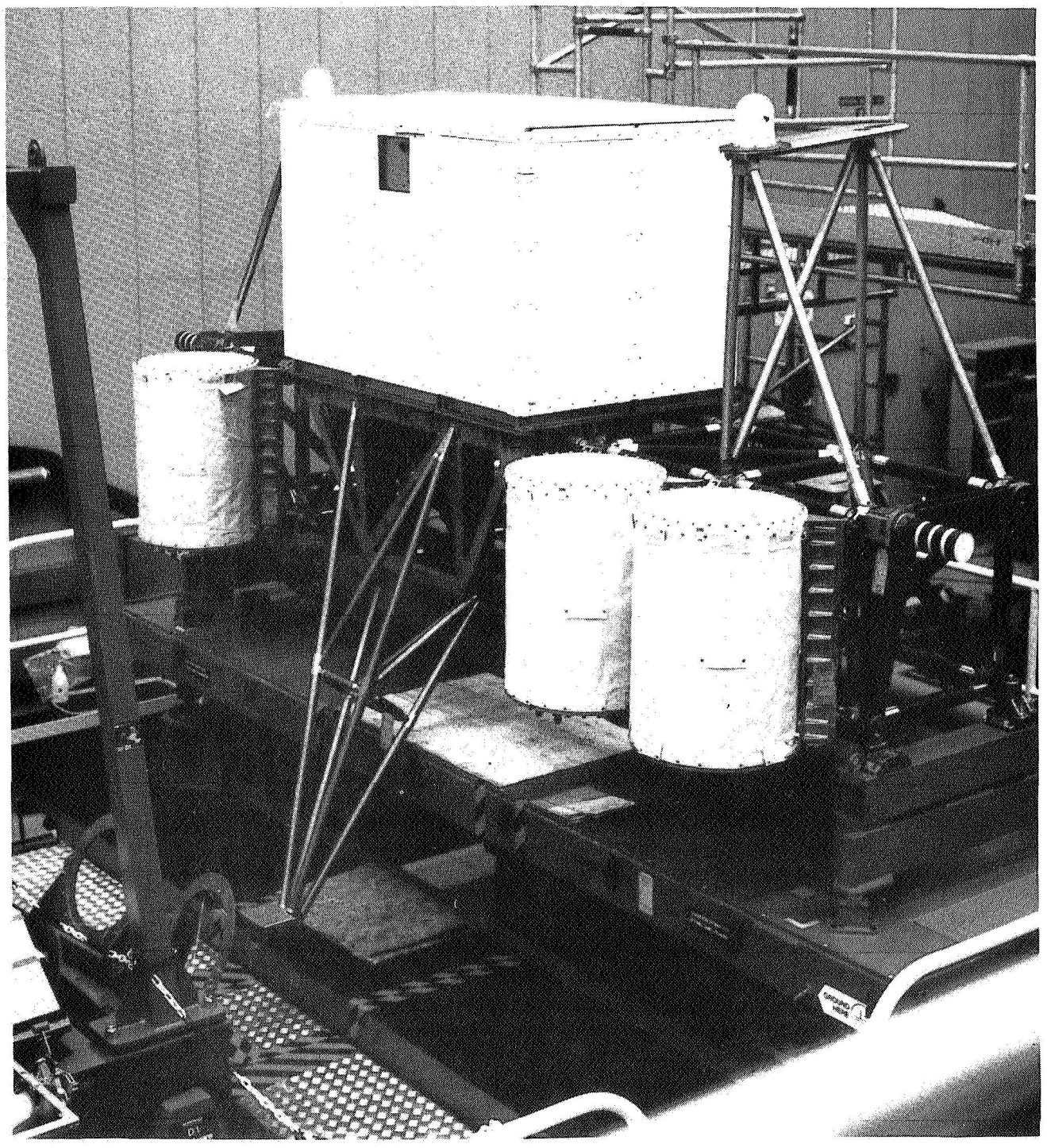
GAS-Configuration STS-5



MAUS-Payloads on SPAS-01



MAUS-Payloads on OSTA 2



NAVEX/D1-Configuration

LESSONS LEARNT (I)

1. ENSURE, YOUR EXPERIMENT RUNS DURING SLEEPING PERIOD OF CREW TO MINIMIZE DISTURBANCES CAUSED BY CREW MOVEMENTS AND ORBITER OPERATIONS

2. TEST THE INFLUENCE OF YOUR OWN EXPERIMENT ON THE μ–G ENVIRONMENT (CAMERA WINDOWS, SHUTTER, MOTORS, ETC.)

3. USE A 3–AXIS ACCELEROMETER AND RECORD THE OUTPUT TO PROVE YOUR EXPERIMENT IS TURNED ON IN SPACE AND NOT ON THE GROUND, AND TO VERIFY THE QUALITY OF THE μ–G ENVIRONMENT

4. SELECT OFF–THE–SHELF HARDWARE, BUT VERIFY AT LEAST
   - VIBRATION (QUALIFICATION LEVEL)
   - TEMPERATURE RANGE

5. PREPARE A LOGICAL QUALIFICATION PHILOSOPHY
   - PROTOTYPE SYSTEM QUALIFICATION
   - COMPONENT QUALIFICATION
   - INTEGRATED SYSTEM QUALIFICATION

LESSONS LEARNT (II)

6. CONSIDER THE CONSEQUENCES OF PRESSURE CHANGES DURING LEAKAGE TESTS AND/OR PURGING (FOAM, TIGHT BOXES, INTEGRATED CIRCUITS, RELAYS, ETC.)

7. SILVER/ZINC BATTERY EXPERIENCE
   - VERIFY ALL BATTERY SAFETY PROVISIONS (PRESSURE SWITCH OFF, UNDER VOLTAGE SWITCH OFF, FUSES, PRESSURE RELIEF VALVE FUNCTION, LEAKAGE)
   - TRANSPORT THE FILLED (HOT) BATTERY ONLY BY „CARGO ONLY AIRPLANES" OR BY „COOLED TRUCK" IN WOODEN BOXES
   - BE PREPARED FOR EXCHANGE OF WEAK CELLS
   - TEST YOUR BATTERY PACK FOR LEAKAGE IN ALL 3 AXES BEFORE INTEGRATION
   - SEAL THE POLE–BOLTS WITH INSULATING PAINT

8. TAKE INTO ACCOUNT THE EXTREME CAPACITY LOSS OF NiCd–BATTERIES BEFORE LAUNCH UNDER WORST CASE CONDITIONS (TIME, TEMPERATURE, ALL DATA TOLERANCES)

LESSONS LEARNT (III)

9. EMERGENCY SWITCH–OFF–FUNCTIONS (TEMP.–INCREASE, PRESSURE LOSS, BATTERY UNDER VOLTAGE, PRESSURE RISE, ETC.)

   - DETECT SEVERAL„OUT OF LIMITS" BEFORE INTRODUCING ANY ACTION IN ORDER TO AVOID EXP. SHUT–OFF BY VOLTAGE PEAKS

   - THINK ABOUT PARTIAL SWITCH–OFF FUNCTIONS (E.G. WITHIN A PAYLOAD CONSISTING OF SEVERAL FURNACES)

   - THINK ABOUT GIVING YOUR μ–PROCESSOR THE POSSIBILITY TO
     - –– JUMP INTO SUBPROGRAMS DUE TO SPECIAL EVENTS (MODIFIED EXP.–PROFILE)
     - –– JUMP INTO DEDICATED SWITCH–OFF PROCEDURES (E.G. MAGNETIC COILS)

   - THINK ABOUT DATA REGISTRATION BEFORE ABNORMAL SWITCH–OFF FOR FAILURE DIAGNOSIS AFTER MISSION

10. VERIFY SENSOR CALIBRATION AT KSC BEFORE AND AFTER MISSION IN ORDER TO ELIMINATE TRANSPORT EFFECTS

LESSONS LEARNT (IV)

11. RUN COMPLETE EXPERIMENT BEFORE AND AFTER MISSION AT KSC AS REFERENCE EXPERIMENT FOR COMPARISON AND FOR DETECTION OF ANOMALIES

12. RUN REFERENCE EXPERIMENTS WITH BATTERY POWER SUPPLY AND NOT WITH EXTERNAL POWER SUPPLY

13. THINK ABOUT PROGRAMMING YOUR μ–PROCESSOR TO INCLUDE AUTOMATIC TEST RUNS AND SELF–CONTAINED FAILURE DIAGNOSTIC CAPABILITY

14. CONSIDER THE CONSEQUENCES THAT EVERY COMPONENT OR PART WITHIN YOUR EXPERIMENT MIGHT FAIL

15. USE SIMPLE TEMPERATURE SENSING STRIPS (COLOUR CHANGING MATERIAL) FOR
    - TEMPERATURE CONTROL OF SELECTED COMPONENTS
    - ENVIRONMENTAL CONTROL (MISSION DEPENDENT ENVIRONMENT)
    - QUICK–LOOK DIAGNOSIS AFTER FLIGHT