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CONTAINERLESS EXPERIMENTATION IN MICROGRAVITY WORKSHOP

GROUND-BASED AND MICROGRAVITY CONTAINERLESS POSITIONING TECHNOLOGIES AND FACILITIES

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PRESENTATION OUTLINE

- CONTAINERLESS EXPERIMENTS
- UNIQUENESS OF MICROGRAVITY
- MICROGRAVITY EXPERIMENTS
- CONTAINERLESS PROGRAM DEVELOPMENT
  - SCIENTIST PARTICIPATION
- ACCOMMODATING MICROGRAVITY EXPERIMENTS
  - POSITIONING APPROACHES
  - SPACE FLIGHT FACILITIES
  - GROUND-BASED FACILITIES AND TECHNOLOGY DEVELOPMENT
  - SPACE STATION FACILITIES

CONTAINERLESS EXPERIMENTS

- SAMPLE IN FREE SUSPENSION IN A FLUID OR VACUUM
- SINGLE OR MULTI-PHASED MATERIAL (LIQUID, SOLID, PHASE TRANSFORMATION)
- NON-CONTACT MEASUREMENT TECHNIQUES
- MINIMUM SAMPLE PERTURBATION (STABILITY)
- HIGH PURITY ENVIRONMENT - MINIMIZES CRUCIBLE CONTAMINATION
- EXTREME ENVIRONMENTS (HIGH TEMPERATURE, PRESSURE, OR VACUUM)

UNIQUENESS OF MICROGRAVITY

- GRAVITY PERTURBS PHENOMENA (CONVECTION, SEDIMENTATION, SMALL FORCES OVERWHELMED BY GRAVITATIONAL ACCELERATION)

- EXPERIMENT NOT OPTIMUM IN GRAVITY FIELD (LEVITATION OF GLASSES, CERAMICS)

- HIGH INTENSITY LEVITATION FIELDS MASK OR PERTURB PHENOMENA - (SHAPE DEFORMATION, LARGE EDDY CURRENT OR CHARGE DENSITY EFFECTS, DYNAMIC NUCLEATION)

- LONG DURATION QUIESCENT ENVIRONMENT (REDUCED FLUID FLOWS)

- EXCELLENT VIBRATION ISOLATION POSSIBLE (CRYSTAL GROWTH - PROTEIN CRYSTALS)

MICROGRAVITY EXPERIMENTS

- REQUIRES EXTENSIVE GROUND-BASED EXPERIMENTATION
- CONSIDERATION OF PAST FLIGHT EXPERIENCE, UNDERSTANDING OF CURRENT CAPABILITIES, AND LONG RANGE PLANNING
- STRONG INTERACTION BETWEEN CURRENT AND FUTURE SCIENTISTS AND FACILITY BUILDER
- LONG LEAD TIME FOR DEVELOPMENT - SHORT PERFORMANCE TIME
- EXPENSIVE - GENERALLY ACCOMMODATED BY MULTI-USER FACILITY
- COMPLEX TO PERFORM - REMOTE OR AUTOMATED OPERATIONS AND RESTRICTED ACCESS - SAFETY CONCERNS
- EVOLUTIONARY PROCESS : FIRST - SIMPLE EXPERIMENTS, LATER - MORE PRECISE EXPERIMENTS WITH ADVANCED CAPABILITIES AS EQUIPMENT MATURES
- UNIQUE ENVIRONMENT - ORBITAL LABORATORY IS A VALUABLE RESOURCE

CONTAINERLESS PROGRAM DEVELOPMENT

SCIENTIST PARTICIPATION

- EVALUATE PRESENT SCIENTIFIC CAPABILITIES OF FACILITIES AND SUGGEST ENHANCEMENTS
- PROPOSE NOVEL EXPERIMENTS TO MATCH CURRENT FACILITIES
- DOCUMENT CURRENT AND POTENTIAL NEW SCIENCE REQUIREMENTS
- PARTICIPATE IN GROUND BASED RESEARCH AND DEVELOPMENT PROGRAM (PROPOSALS, AO, NRA)
- **RESPOND TO SURVEY ON CONTAINERLESS EXPERIMENTATION SCIENCE CAPABILITIES**

ACCOMMODATING MICROGRAVITY EXPERIMENTS

POSITIONING APPROACHES

- DEVELOPMENT OF DIFFERENT POSITIONING APPROACHES
  - ACOUSTIC - HIGH INTENSITY SOUND FIELDS
    FLUID MEDIUM, ANY MATERIAL,
    STATIC METHOD
  - ELECTROMAGNETIC - INDUCED EDDY CURRENTS
    FLUID OR VACUUM MEDIA,
    CONDUCTING MATERIAL,
    STATIC METHOD
  - ELECTROSTATIC - FORCES BETWEEN OPPOSITE CHARGES, FLUID OR VACUUM MEDIA, SURFACE CHARGES, DYNAMIC METHOD
  - GAS FILM - PRESSURE DROP ASSOCIATED WITH THIN LAYER OF FLOWING GAS
  - FREE FLOAT - NO EXTERNAL FORCES

EARLY NASA SPACE FLIGHTS

- ACOUSTIC CONTAINERLESS EXPERIMENTAL SYSTEM - **ACES** (STS 11, 1984)

- DROP DYNAMICS MODULE - **DDM** (SPACE LAB 3, 1985)

- TRIPLE AXIS ACOUSTIC LEVITATOR - **3AAL** (STS 24, 1986)

- ELECTROMAGNETIC LEVITATOR - **EML** (STS 24, 1986)

- SINGLE AXIS ACOUSTIC LEVITATOR - **SAAL** (STS 7, 1983 - STS 61A, 1985)

EARLY NASA SPACE FLIGHTS

LESSONS LEARNED

- LOW BUDGET, HIGH RISK FLIGHTS PROVIDE SPARSE SCIENTIFIC RETURNS

- TOTALLY AUTOMATED POSITIONERS REQUIRE MORE THAN ONE SHORT DURATION (2 HOUR) FLIGHT TO BECOME OPERATIONAL

- ASTRONAUT OPERATED POSITIONERS INCREASE PROBABILITY OF SUCCESS

- PRE-FLIGHT IMPROVEMENTS
  - IMPROVED GROUND-BASED CALIBRATION
  - PRECURSOR FLIGHT EXPERIMENTS (KC-135, ROCKET FLIGHTS)
  - SCIENCE EVALUATION OF POSITIONERS

ACCOMMODATING MICROGRAVITY EXPERIMENTS

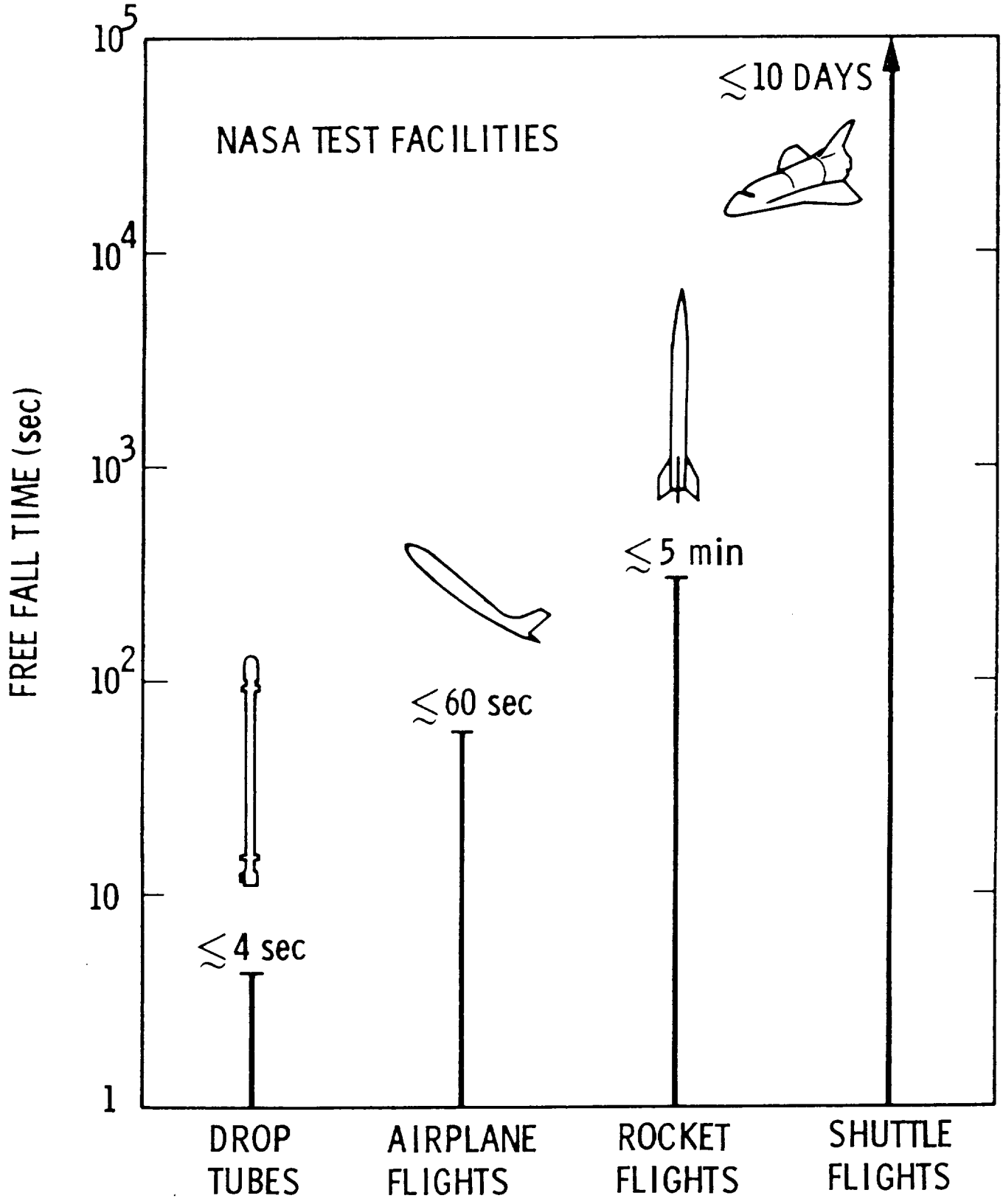
GROUND-BASED FACILITIES

- INDIVIDUAL INVESTIGATORS FACILITIES (ELECTROMAGNETIC, ACOUSTIC, ELECTROSTATIC, AERODYNAMIC, GAS FILM, ...)

- DROP TUBE FACILITIES (NASA LRC, MSFC)

- NASA KC-135 / ESA CARAVELLE FACILITIES

- ROCKET FLIGHTS (TEXUS, PRIVATE COMPANIES)


NASA TEST FACILITIES
FREE FALL TIME (sec)
10^5
10^4
10^3
10^2
10
1
≲10 DAYS
≲5 min
≲60 sec
≲4 sec
DROP TUBES
AIRPLANE FLIGHTS
ROCKET FLIGHTS
SHUTTLE FLIGHTS

ACCOMMODATING MICROGRAVITY EXPERIMENTS

SPACE FLIGHT FACILITIES

- PAST FLIGHT EQUIPMENT (SAAL, ACES, DDM, 3AAL, EML)

- CURRENT FACILITIES

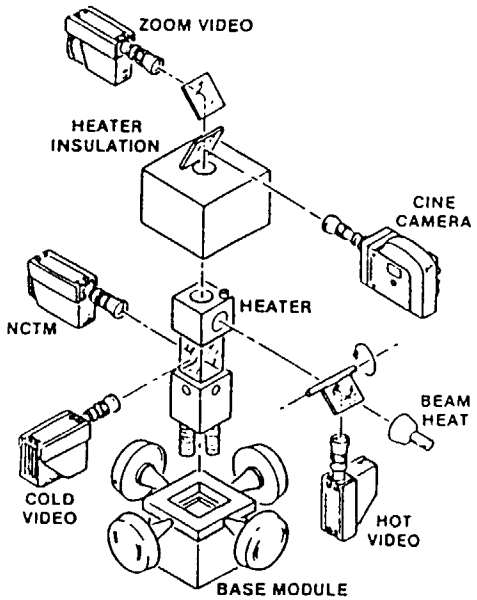
  - DROP PHYSICS MODULE - **DPM** (NASA JPL ACOUSTIC POSITIONER)

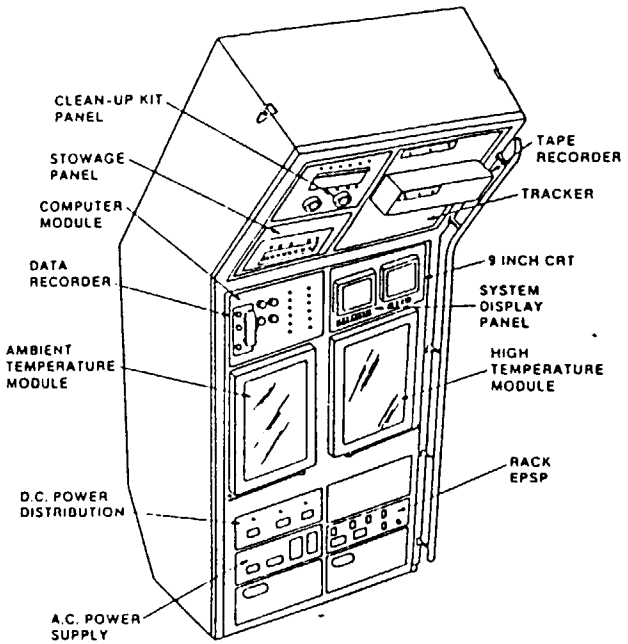
    - UNITED STATES MICROGRAVITY LABORATORY - **USML** SERIES **USML-1** (1992), **USML-2** (1994)

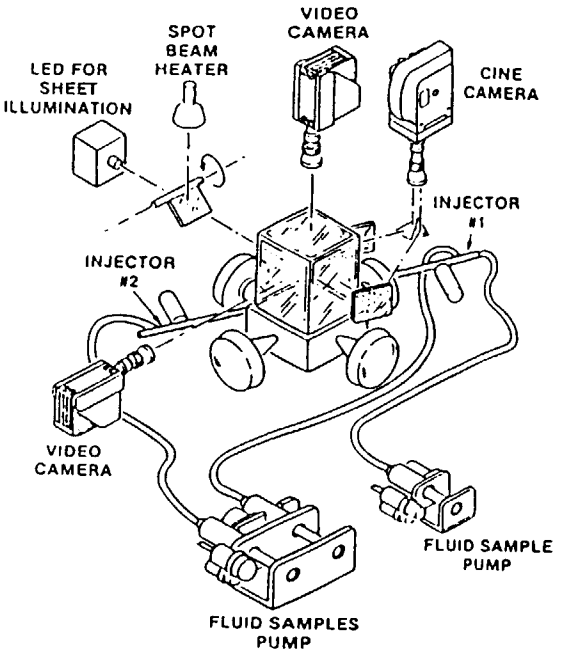
  - TEMPUS (GERMAN ELECTROMAGNETIC POSITIONER)

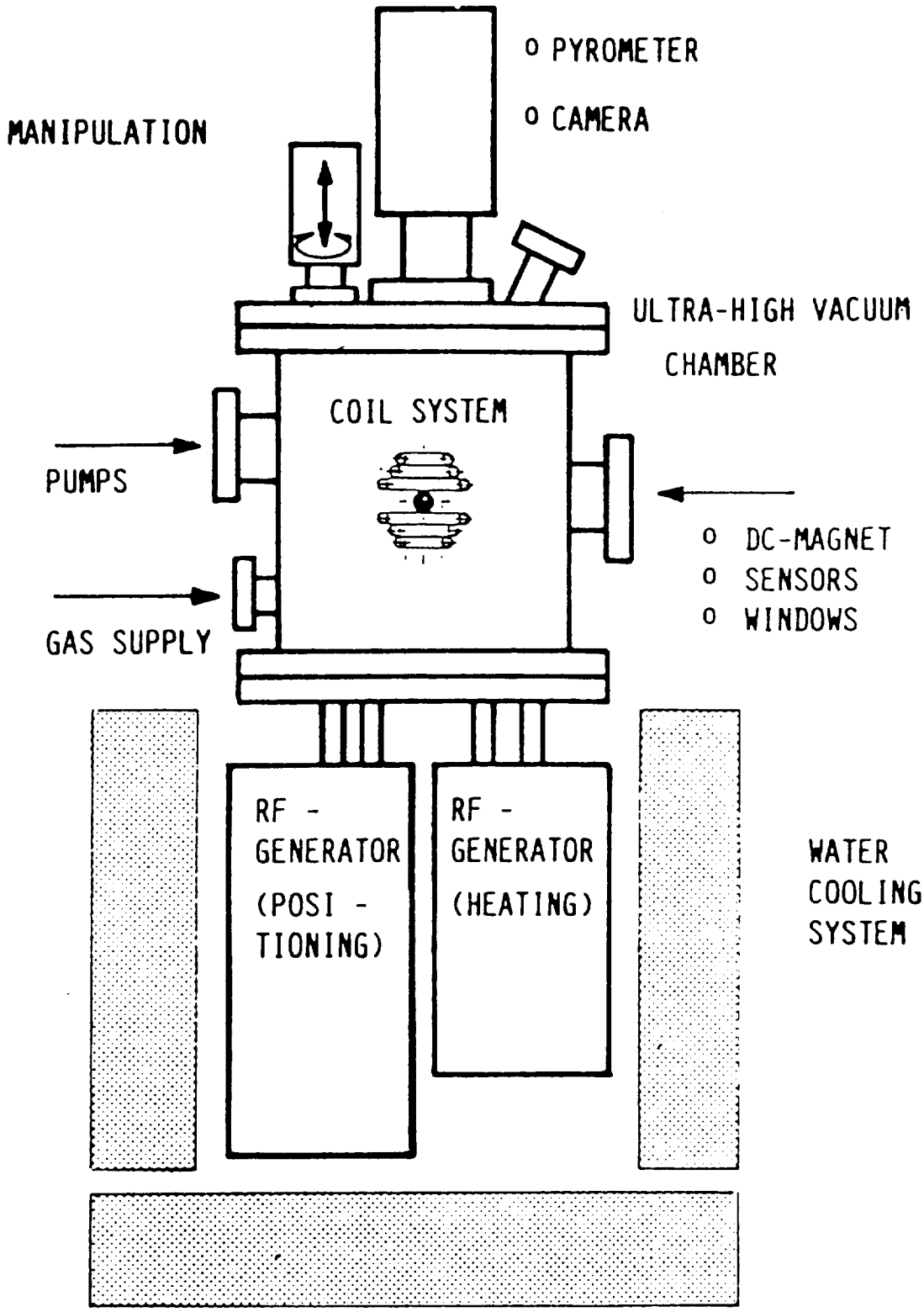
    - INTERNATIONAL MICROGRAVITY LABORATORY (**IML-2**) (LATE 1992)

- INTERNATIONAL COOPERATION (AMERICAN, EUROPEAN, AND JAPANESE PROGRAMS)


ZOOM VIDEO
HEATER INSULATION
CINE CAMERA
HEATER
NCTM
BEAM HEAT
COLD VIDEO
HOT VIDEO
BASE MODULE


CLEAN-UP KIT PANEL
STOWAGE PANEL
COMPUTER MODULE
DATA RECORDER
AMBIENT TEMPERATURE MODULE
D.C. POWER DISTRIBUTION
A.C. POWER SUPPLY
TAPE RECORDER
TRACKER
9 INCH CRT
SYSTEM DISPLAY PANEL
HIGH TEMPERATURE MODULE
RACK EPSP


LED FOR SHEET ILLUMINATION
SPOT BEAM HEATER
VIDEO CAMERA
CINE CAMERA
INJECTOR #1
INJECTOR #2
VIDEO CAMERA
FLUID SAMPLE PUMP
FLUID SAMPLES PUMP


o PYROMETER
o CAMERA
MANIPULATION
ULTRA-HIGH VACUUM
CHAMBER
COIL SYSTEM
PUMPS
o DC-MAGNET
o SENSORS
o WINDOWS
GAS SUPPLY
RF -
GENERATOR
(POSI -
TIONING)
RF -
GENERATOR
(HEATING)
WATER
COOLING
SYSTEM

ACCOMMODATING MICROGRAVITY EXPERIMENTS

TECHNOLOGY DEVELOPMENT

- POTENTIAL FUTURE FACILITIES (DEVELOPING TECHNOLOGIES)
  - ACOUSTIC LEVITATION FURNACES
    - ISOTHERMAL, BEAM HEATING
  - MODULAR ELECTROMAGNETIC LEVITATOR
  - STABILIZED ELECTROMAGNETIC LEVITATOR
  - ELECTROSTATIC TETRAHEDRAL POSITIONERS
  - GAS LAYER LEVITATOR
  - MICROWAVE/ACOUSTIC HYBRID POSITIONER
- NON-CONTACT PARAMETER MEASUREMENTS
  - TEMPERATURE

ACCOMMODATING MICROGRAVITY EXPERIMENTS

SPACE STATION FREEDOM

- MODULAR CONTAINERLESS PROCESSING FACILITY - **MCPF**
  - FACILITY CONCEPT FOR SPACE STATION
  - SCIENCE COMMUNITY INPUT NEEDED
- MULTIPLE POSITIONING MODULES
  - ACOUSTIC
  - ELECTROMAGNETIC
  - ELECTROSTATIC
  - HYBRIDS

Modular Containerless Processing Facility (MCPF)

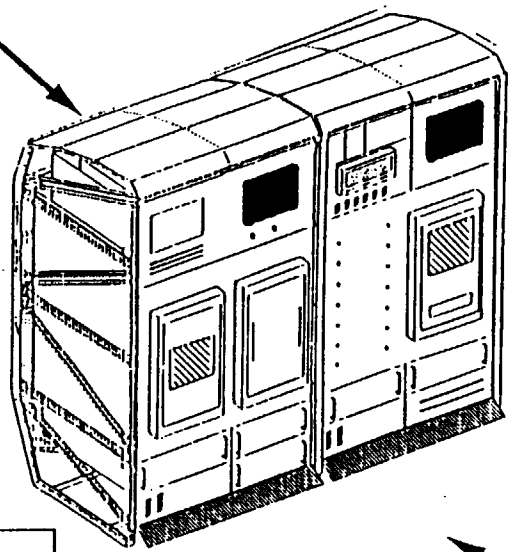
Provides 4 kinds of experimental facilities on Space Station Freedom

ACOUSTIC POSITIONING FACILITY

Fundamental Fluid Physics
Interfacial Phenomena
Interparticle Dynamics
Geophysical Fluid Dynamics
Glasses and Ceramics Processing
Phase Transition Phenomena

ELECTROSTATIC POSITIONING FACILITY

Protein Crystal Growth
High Temperature/
high vacuum chemistry
Charged fluid/particle dynamics
High temperature materials



ELECTROMAGNETIC POSITIONING FACILITY

Metals and Alloys Processing
Very High Temperature Chemistry
Metastable Structures Formation
Homogeneous Nucleation
Advanced Materials Structures

EXOBIOLOGY FACILITY

Aerosol Physics
Fractals Dynamics
Interparticle Dynamics
Atmospheric Chemistry

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