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STIG Flight Experiments
Technical Interchange Meeting

OPM

The Optical Properties Monitor (OPM)
A Multipurpose Optical Laboratory In Space

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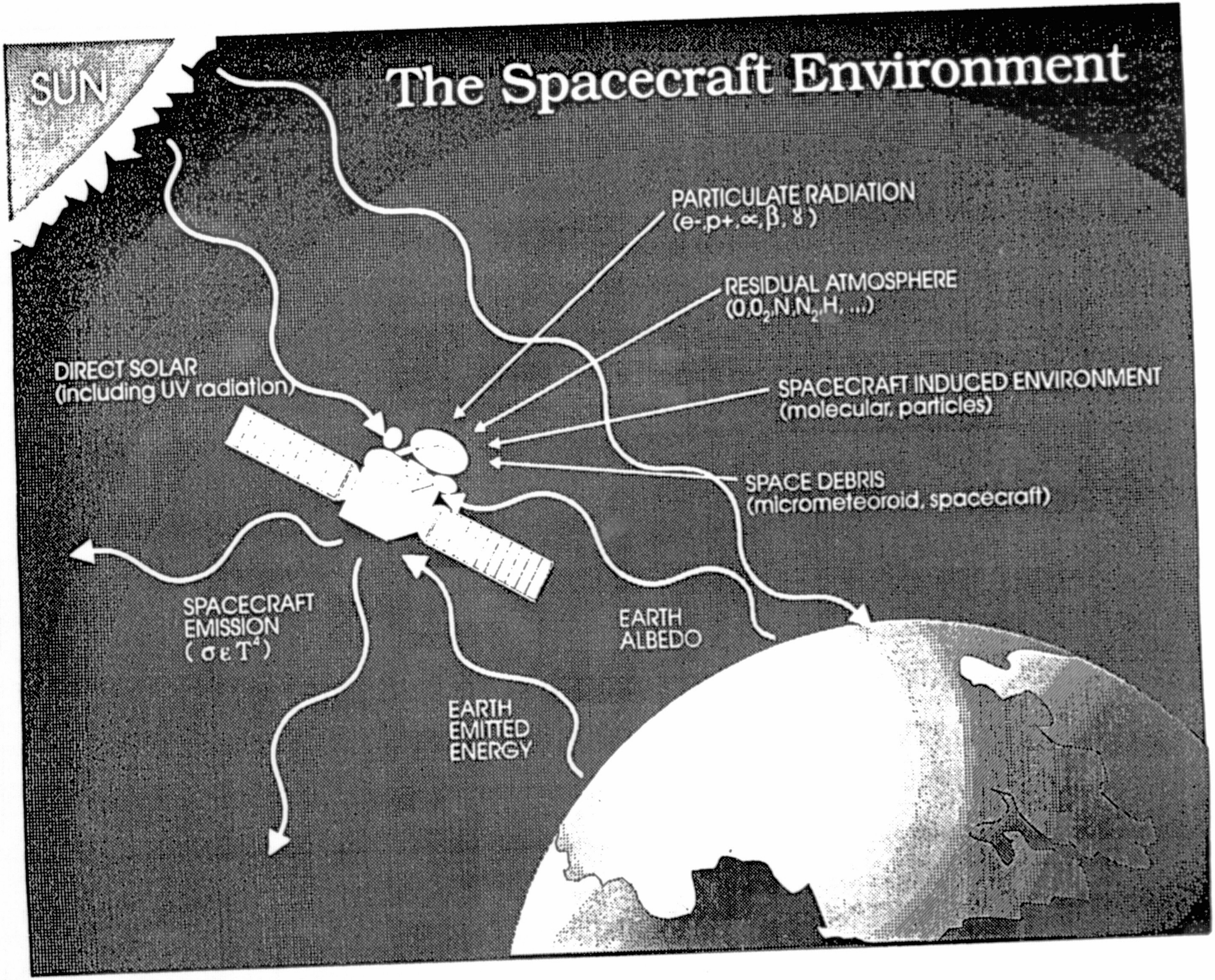

The Spacecraft Environment
SUN
PARTICULATE RADIATION
(e-, p+, ∝, β, γ)
RESIDUAL ATMOSPHERE
(O, O_2, N, N_2, H, ...)
DIRECT SOLAR
(including UV radiation)
SPACECRAFT INDUCED ENVIRONMENT
(molecular, particles)
SPACE DEBRIS
(micrometeoroid, spacecraft)
SPACECRAFT
EMISSION
($\sigma\varepsilon T^4$)
EARTH
ALBEDO
EARTH
EMITTED
ENERGY

Technical Background

- The natural and induced space environment can damage spacecraft and instrument materials
- Space environmental effects and damage mechanisms are not well understood
- The space environment cannot be fully simulated in the laboratory
- There have been only limited in-space optical measurements of material properties
- Analytical lifetime prediction models are limited due to lack of time vs. effects flight data

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Technology Need

- Longer duration, and more complex missions, such as Space Station Freedom, require better materials and improved materials performance characterization

- A better understanding of space environmental damage mechanisms will lead to:
  - More stable materials and coatings
  - More accurate ground simulation testing
  - Lifetime prediction models for materials in the space environment

- Improved materials and better material performance characterization will lead to more cost effective, lower weight, higher performance, maintainable space systems designs

Need for an In-Space Experiment

- Time dependent flight data is required to understand the non-linear nature of materials degradation.

- Some effects of the space environment on materials are reversible when returned to the terrestrial environment.

- The space environment cannot be fully simulated in the laboratory.

- There is significant disagreement between flight and laboratory simulation testing of materials.

- Flight tests of new and improved materials are required before full acceptance of these materials by space hardware designers.

OPM Experiment Objectives

To study the effects of the space environment, both natural and induced, on optical, thermal control, solar array and other materials.

- Determine the effects and damage mechanisms of the space environment on materials.
- Provide data to validate lifetime prediction models.
- Perform flight testing of critical spacecraft and instrument materials.
- Provide data to validate space simulation test facilities and techniques.
- Develop a reusable multifunctional flight instrument for optical studies.

OPM Experiment Concept

- The OPM is a multifunction in-flight laboratory for in-situ optical studies of materials.
- Many independent and related studies can be carried out on EURECA with the OPM instruments to address the experiment objectives.
- Test Samples will be selected to address the materials and issues of the greatest interest to NASA, ESA, DoD, and the aerospace community. A Sample Selection Advisory Committee (SSAC) will be formed and chaired by the OPM PI and MSFC Project Scientist.

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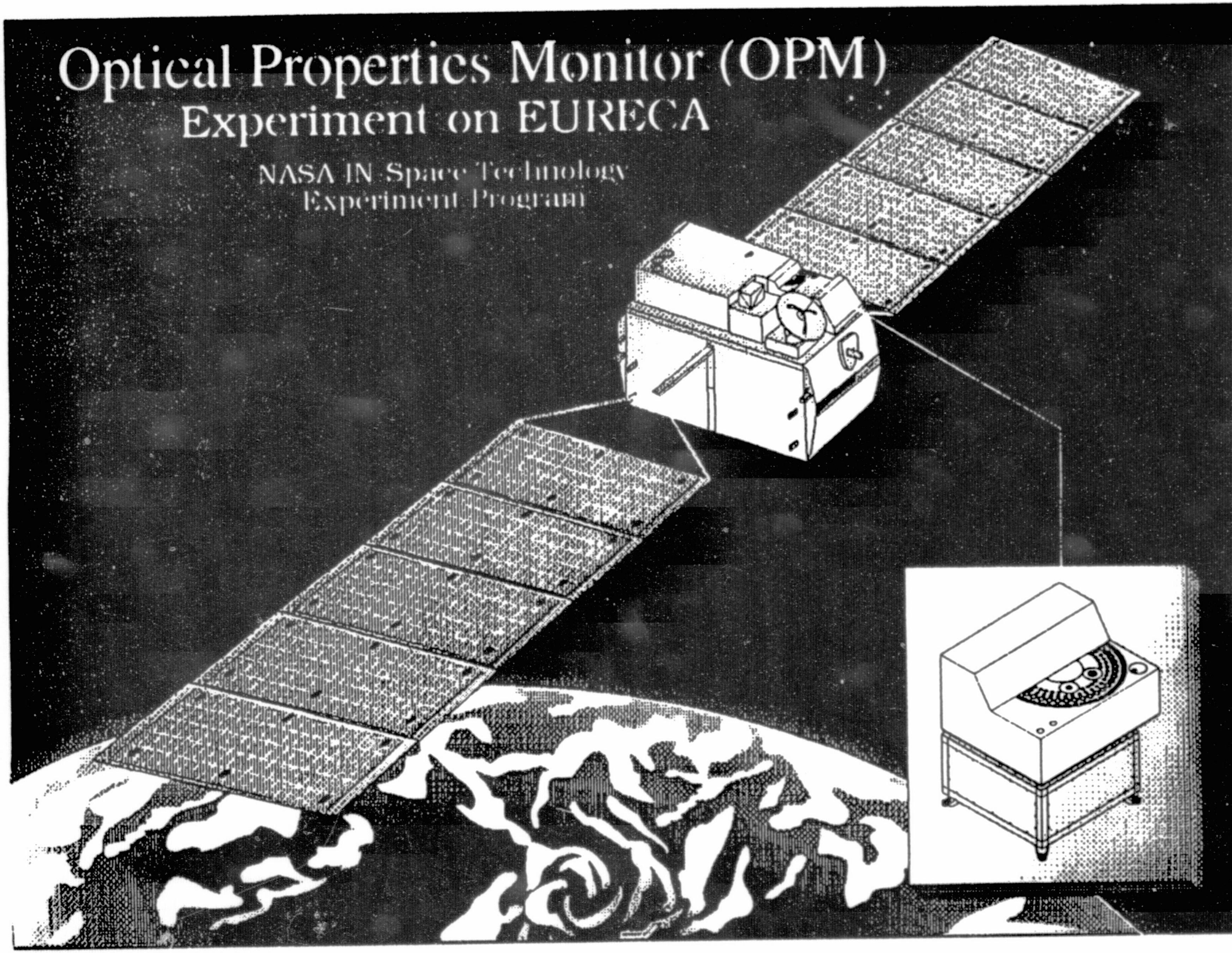
Experiment Summary

Selected materials will be exposed to the low earth orbit space and EURECA environment and their effects measured through in-situ measurements and post-flight analyses.

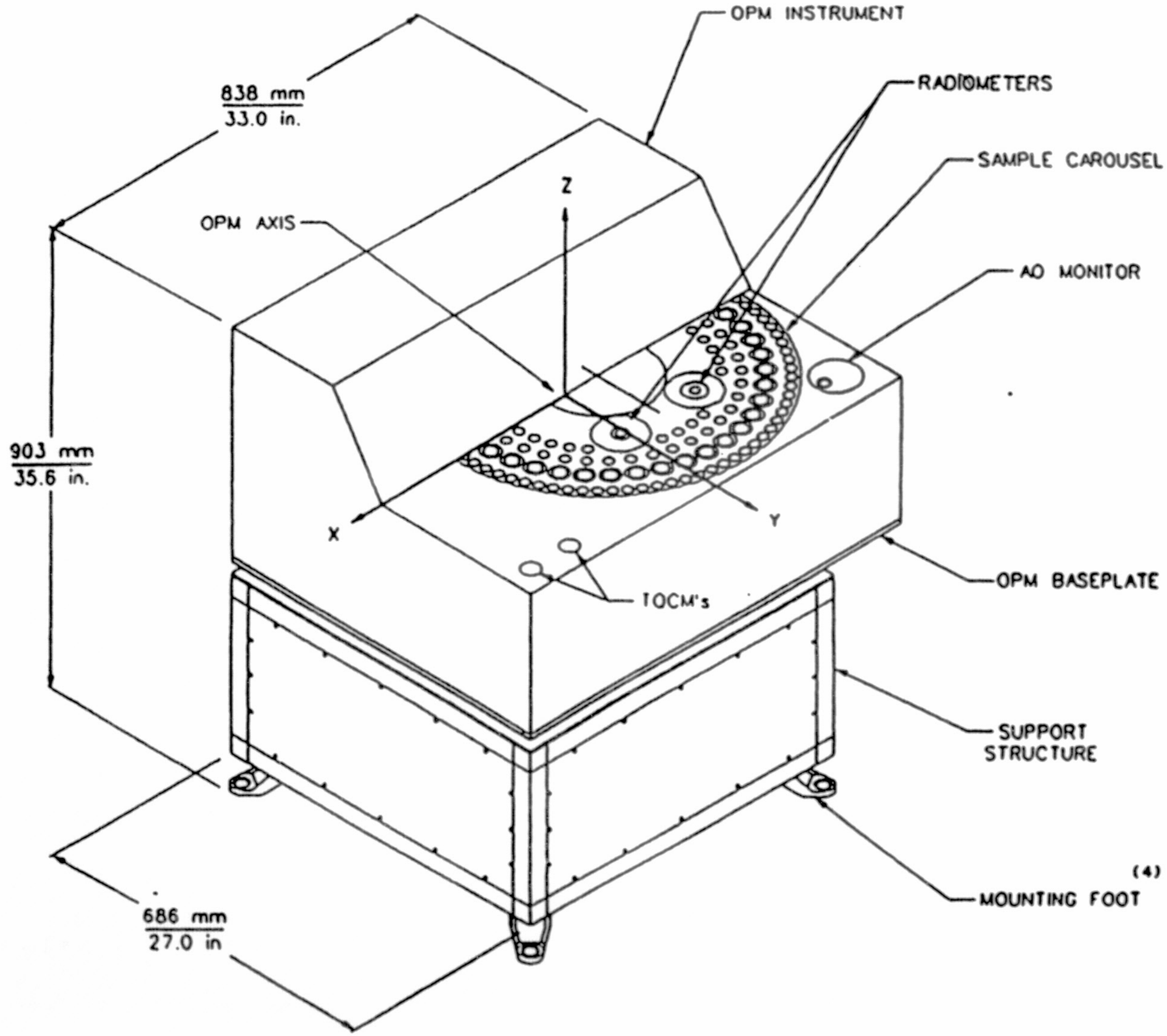
- Optical and thermal properties are measured by in-situ measurement subsystems
  - Spectral total hemispherical reflectance
  - Total Integrated Scatter (TIS)
  - Vacuum Ultraviolet (VUV) reflectance/transmittance
  - Total emittance
- Environmental monitors measure selected components of the exposure environment
  - Solar/earth irradiance
  - Molecular contamination
  - Atomic oxygen
- Detailed optical and thermal properties, surface degradation, and contamination are determined by post-flight analysis.

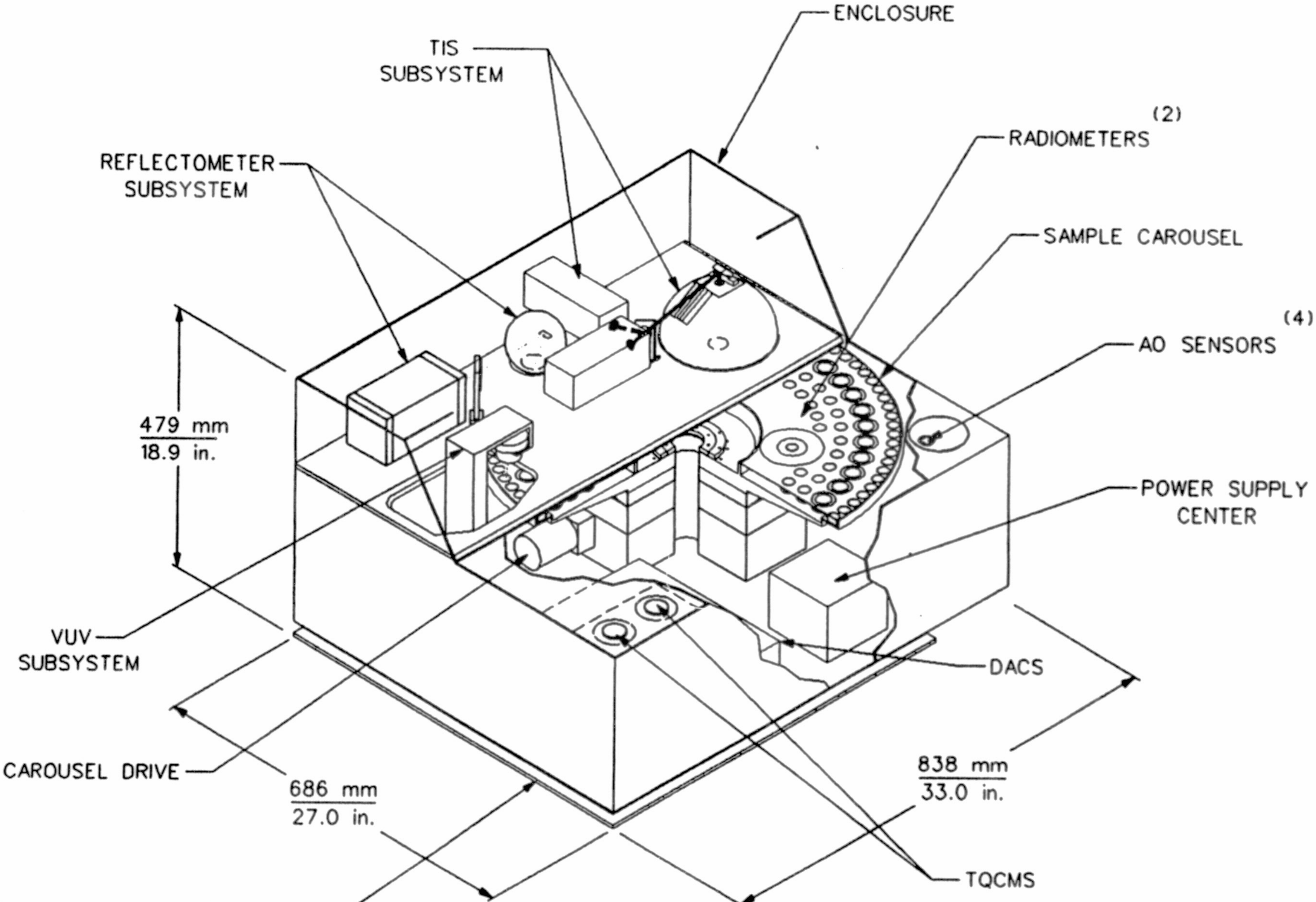
- Experiment results will be disseminated to the aerospace community through IN-STEP conferences, technical conferences and publications, space materials handbooks, and materials databases.



Optical Properties Monitor (OPM)
Experiment on EURECA
NASA IN-Space Technology
Experiment Program

OPM Instrument and Support Structure





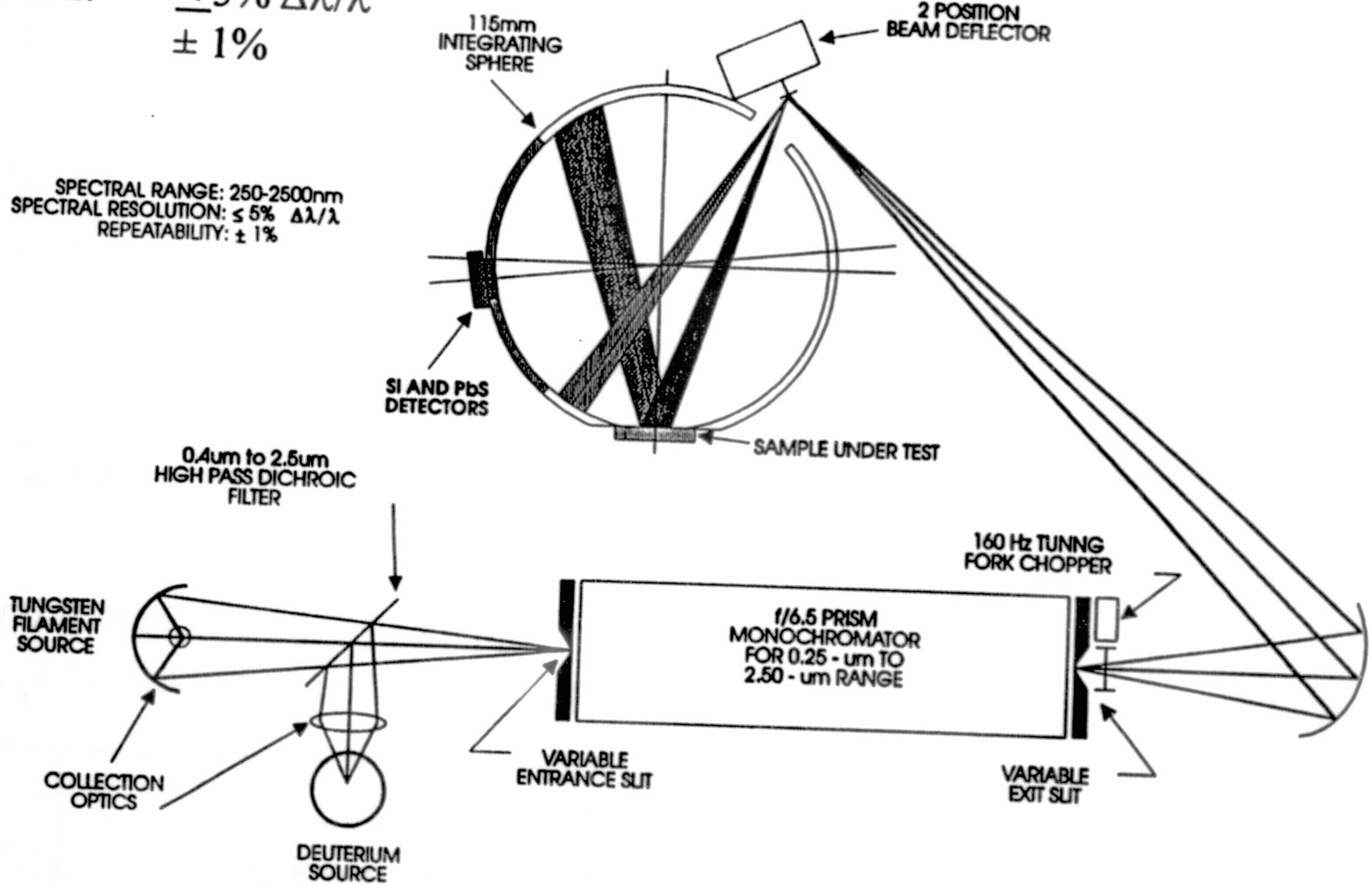
OPM ASSEMBLY

OPM Hardware Summary

Size	686mm x 838mm x 903mm (27" x 33" x 35.6")
Mass	127 Kg (279 lbs)
Number of Test Samples	188
Power Source	28VDC S/C Power
Power - Average	43 watts
- Peak	258 watts
Command/Data Interface	EURECA RAU (Serial)
Data Rate - Average	5 bps
- Peak	50 bps

Reflectometer Optical Schematic

Spectral Range: 250 - 2500 nm
Spectral Resolution: $\leq 5\% \; \Delta\lambda/\lambda$
Repeatability: ± 1%



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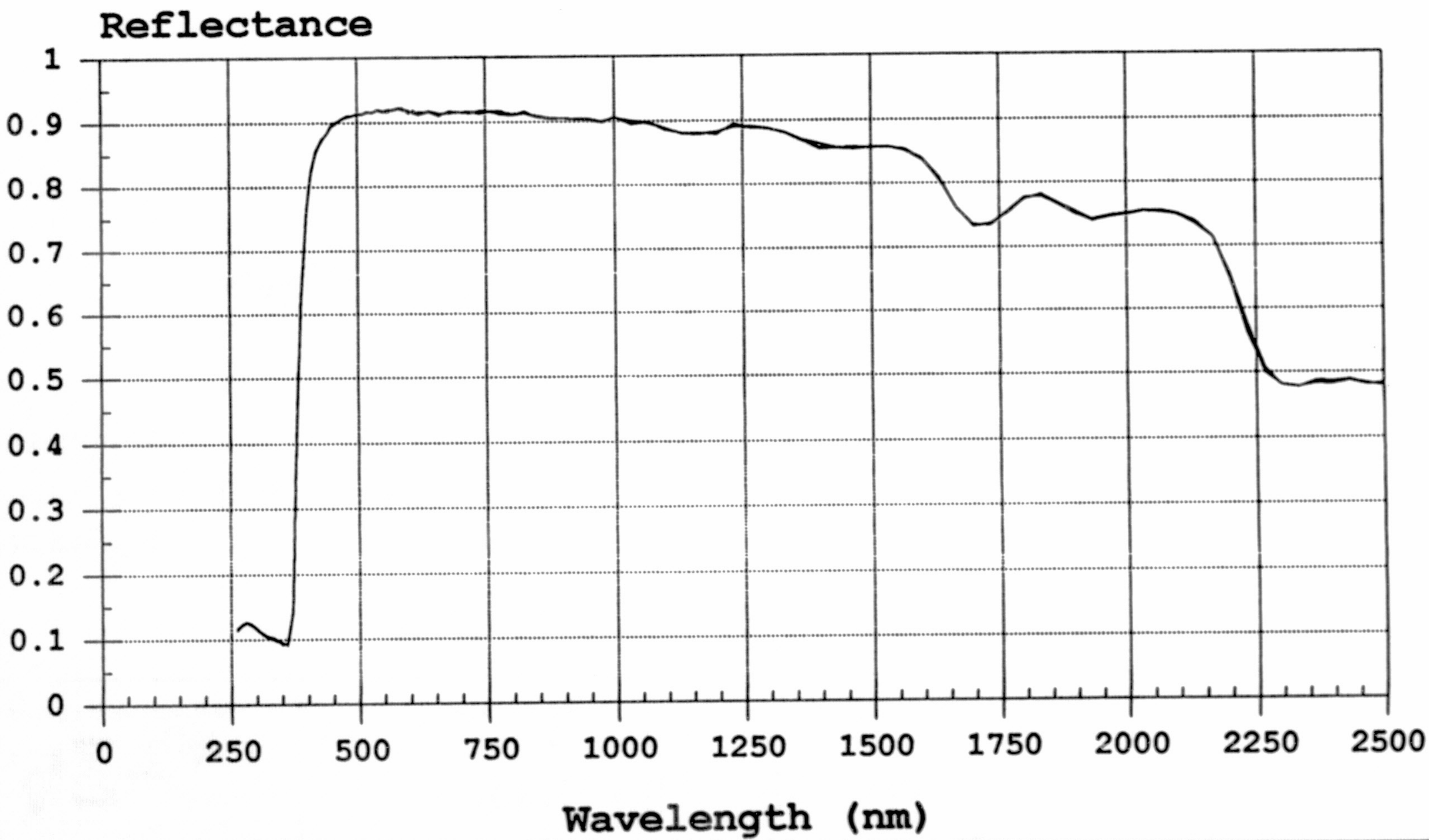
Performance of the updated reflectometer design is demonstrated in this plot of three separate measurements of S13G/LO white paint.



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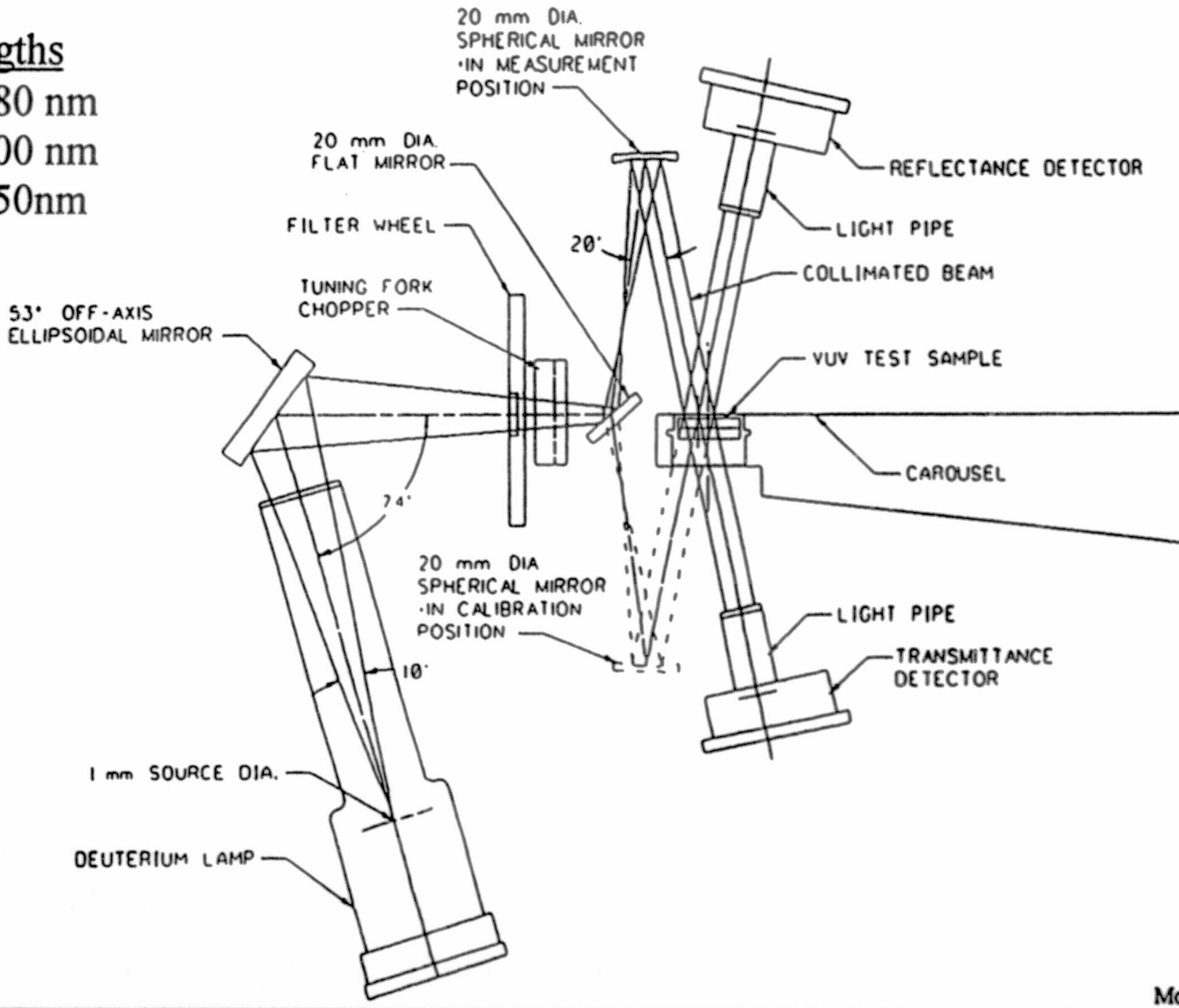
VUV Spectrometer Design

Measurement Wavelengths

- 121.6 nm	-180 nm
- 160.6 nm	-200 nm
- 170 nm	-250nm

Accuracy: ± 5%
Repeatability: ± 2%



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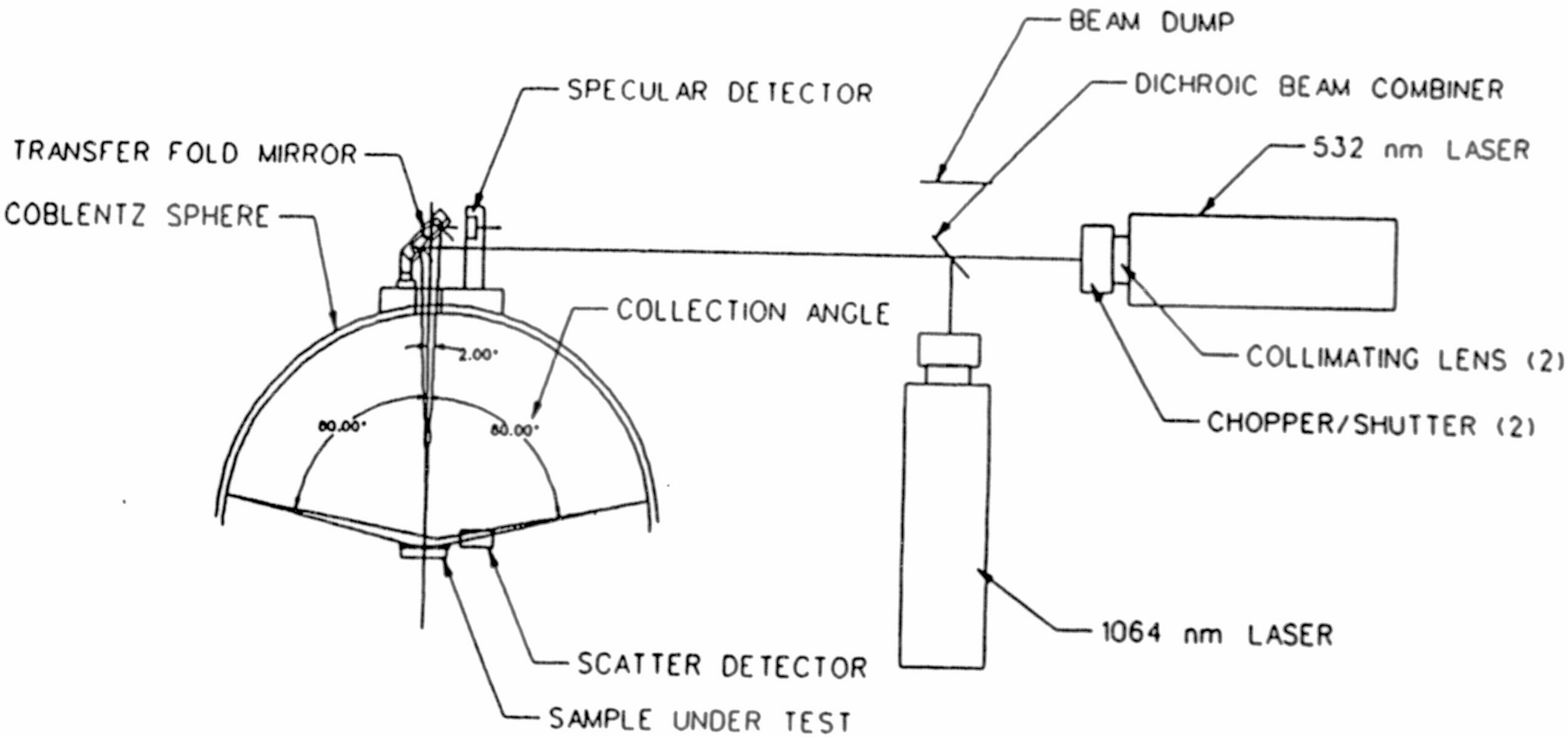
TIS Optical Schematic



TIS = $V_{scattered}/V_{specular}$ RMS = $(\lambda/4\pi)(TIS)^{1/2}$

Scatter Collection Angle: 2.5° to 80°

Accuracy : ± 10%

Repeatability : ± 2%

RMS Measurement Range: 5 - 500 Å

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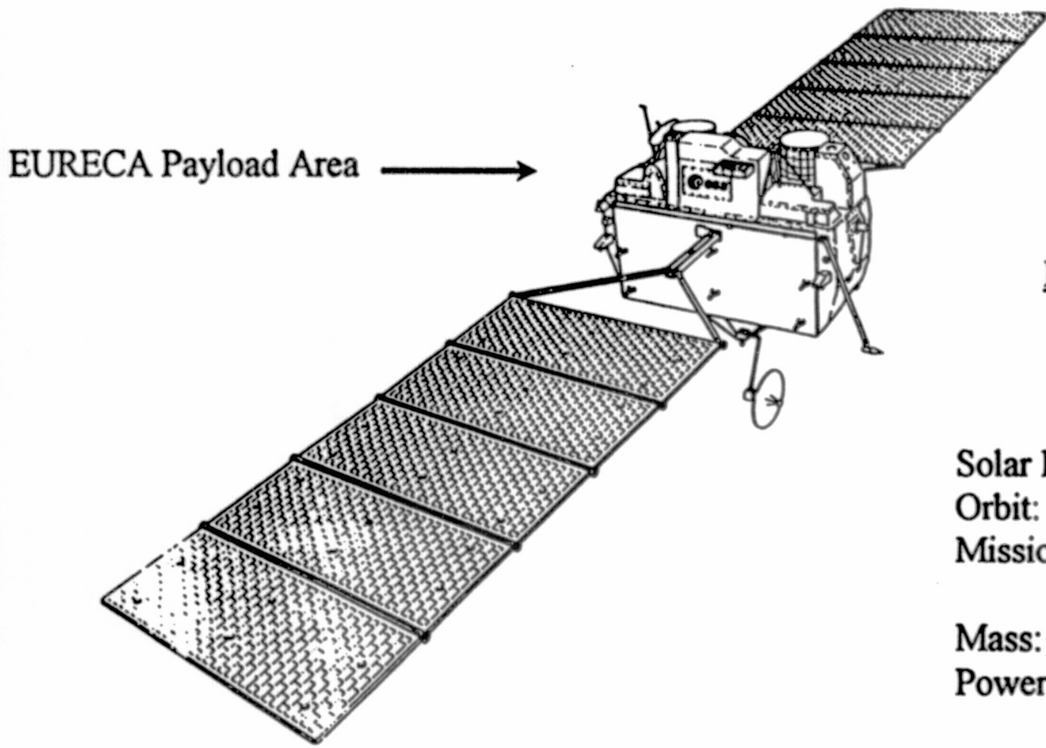
EURECA Summary

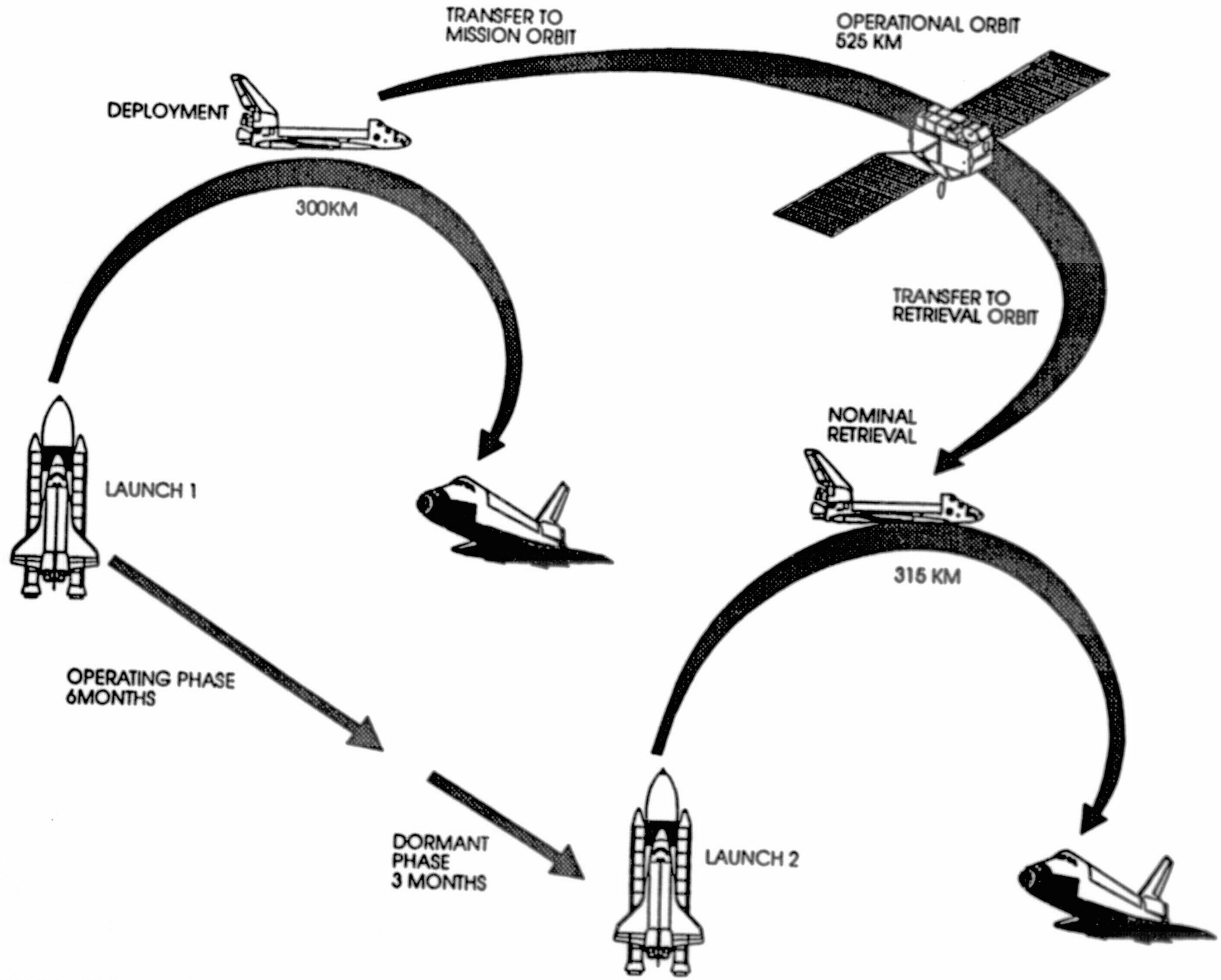


EURECA

EUropean REtrievable CArrier

Solar Pointing Shuttle Launched Free Flier
Orbit: 525 km at 28.5° inclination
Mission Duration: 6 Months Operational (Nominal)
3 Months Dormant
Mass: Total: 4500 kg
Power: Available to Payload: 1000 W
Peak: 1500 W
Thermal Control: Passive or Liquid Freon Loop (1000 W)
Data: High Speed Down-Link: 256 kbps
Low Speed Down-Link: 2 kbps
Solar Pointing Accuracy: 1°
Microgravity: 10^{-5}g < 1 Hz
10^{-3}g > 100 Hz

EURECA Flight Scenario



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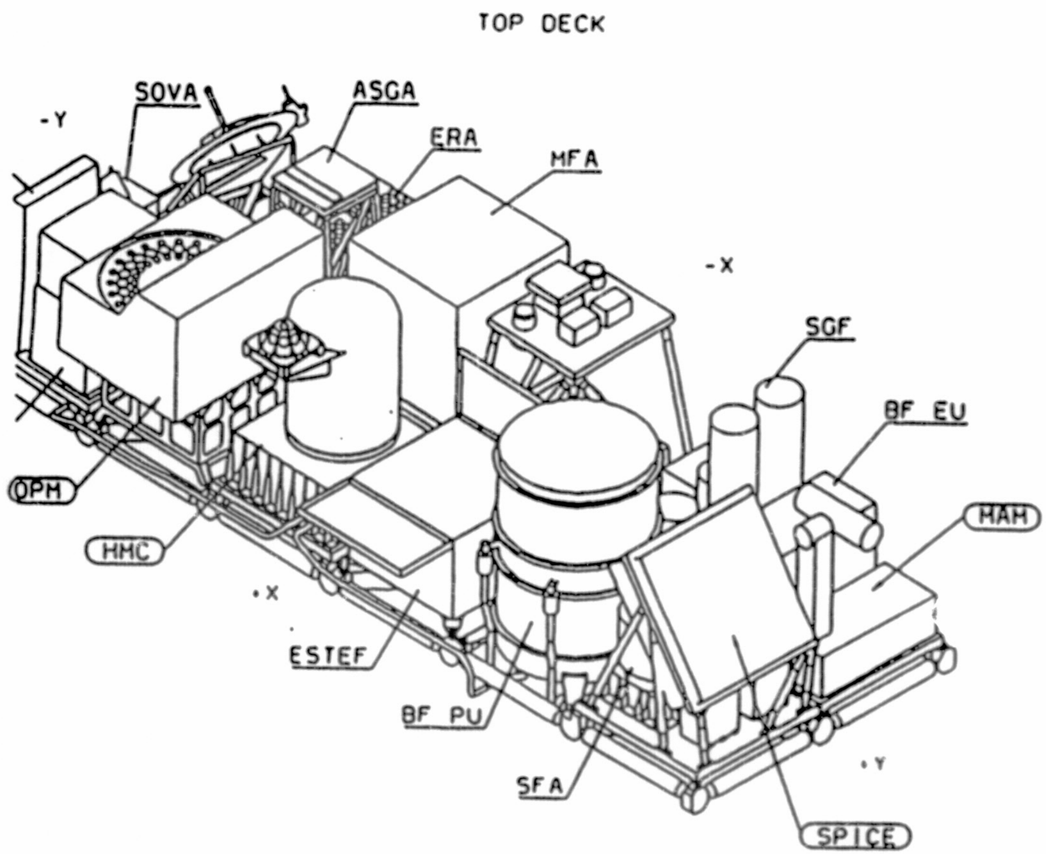
OPM Accommodation on EURECA Payload Deck



EURECA Payload Exposure Environment

Operational Orbit (525 km)

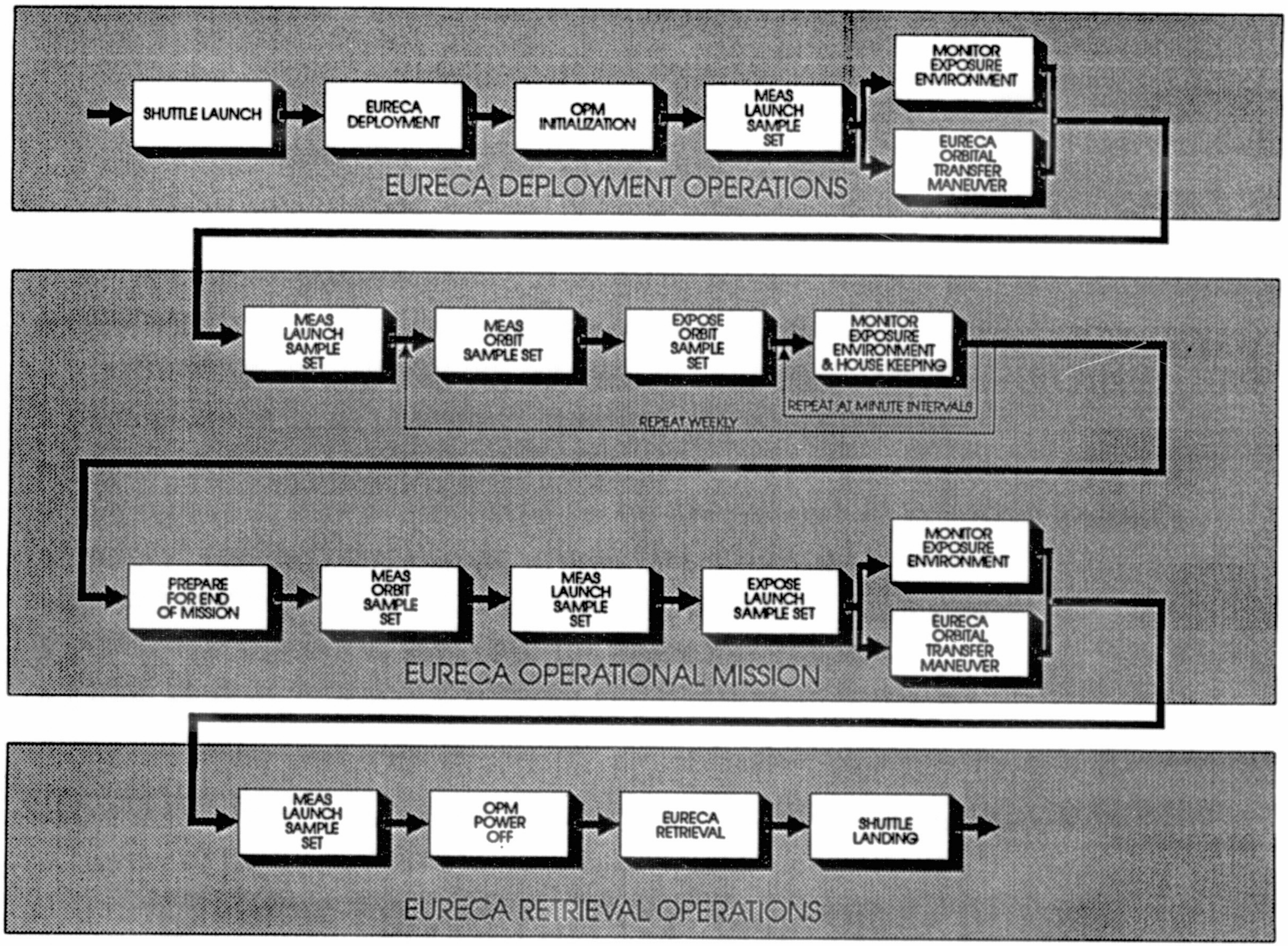
- Six months total exposure
- Solar exposure: ~3,000 direct sun hours (Equivalent to 3.3 x exposure of non-solar oriented vehicle such as the Space Station or 1.7 years)
- Atomic Oxygen Fluence: ~10^{20} atoms/cm^2

Parking Orbit (300 km)

- Approximately one month exposure
- Solar exposure: ~ 150 direct sun hours
- Atomic Oxygen: ~ 10^{20} atoms/cm^2

Boost/De-Boost

- Monopropellant hydrazine residue contamination - EURECA offers the additional opportunity to study the in-situ effects of boost/deboost operations



OPM Mission Operations

Example OPM/EURECA Technology Studies

Many different technical studies can be carried out on the OPM/EURECA mission.

- Flight tests of selected spacecraft and instrument materials
- Sensitivity of optical scatter to the space environment
- Synergistic effects of the contituents of the space environment
- Launch, retrieval and orbital manueuver effects on materials
- The effects of processing variables on the stability of anodized coatings
- Effectiveness of AO protective coatings
- Effectiveness of AO cleaning of molecular contamination
- Performance of different adhesives and application methods for silver Teflon
- Characterize the environment of a Shuttle launched free-flier

OPM Milestones

Preliminary Design Review	August, 1992
Non-Advocate Review	September, 1992
Critical Design Review	December, 1993
OPM Flight Hardware Delivery	March, 1996
EURECA Launch	September, 1997
EURECA Retrieval	March, 1998
OPM Quick Look Report	June, 1998
OPM Final Report	March, 1999