Update on the European Technology exposure Facility

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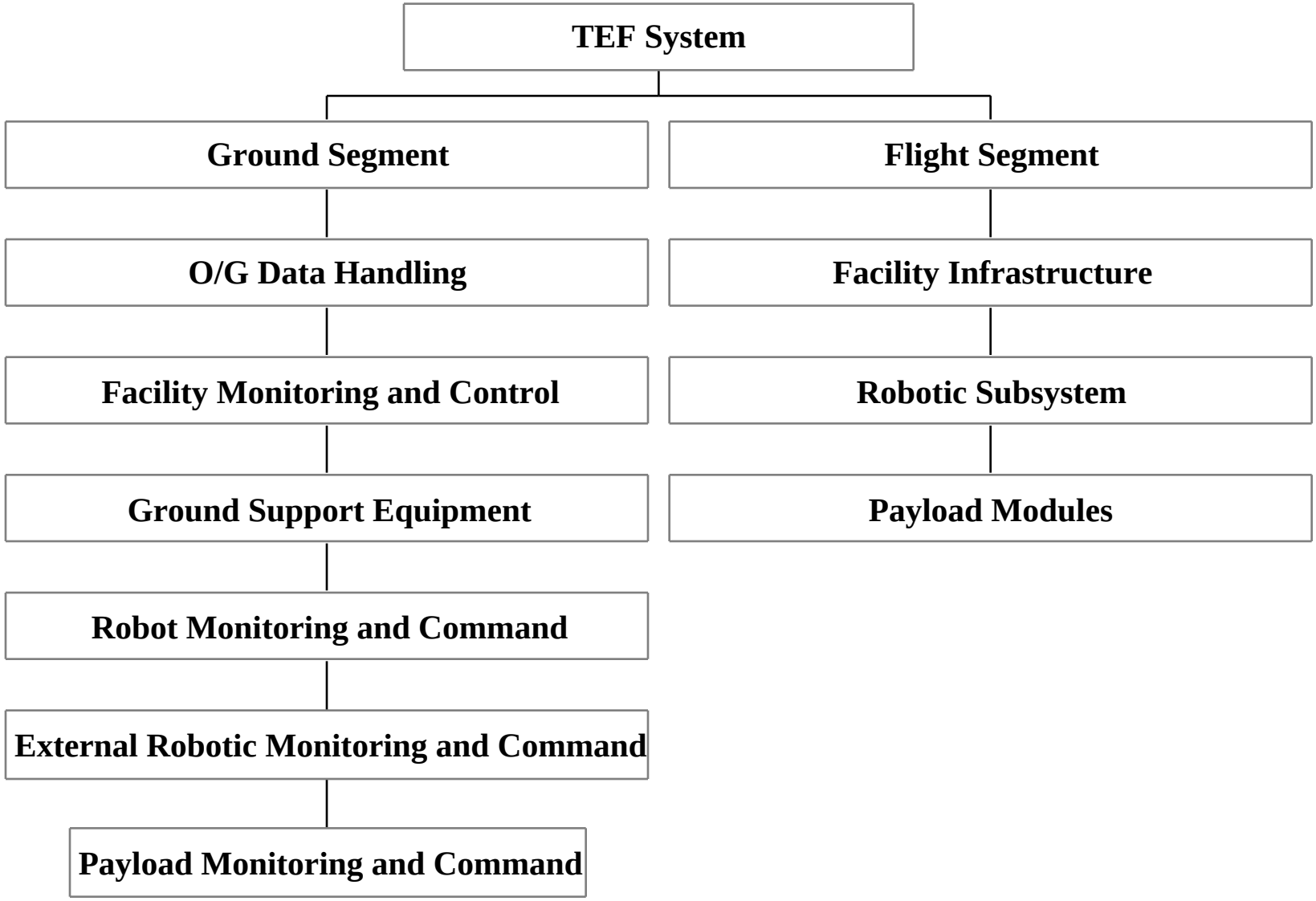
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Payload Monitoring and Command

Ground Segment

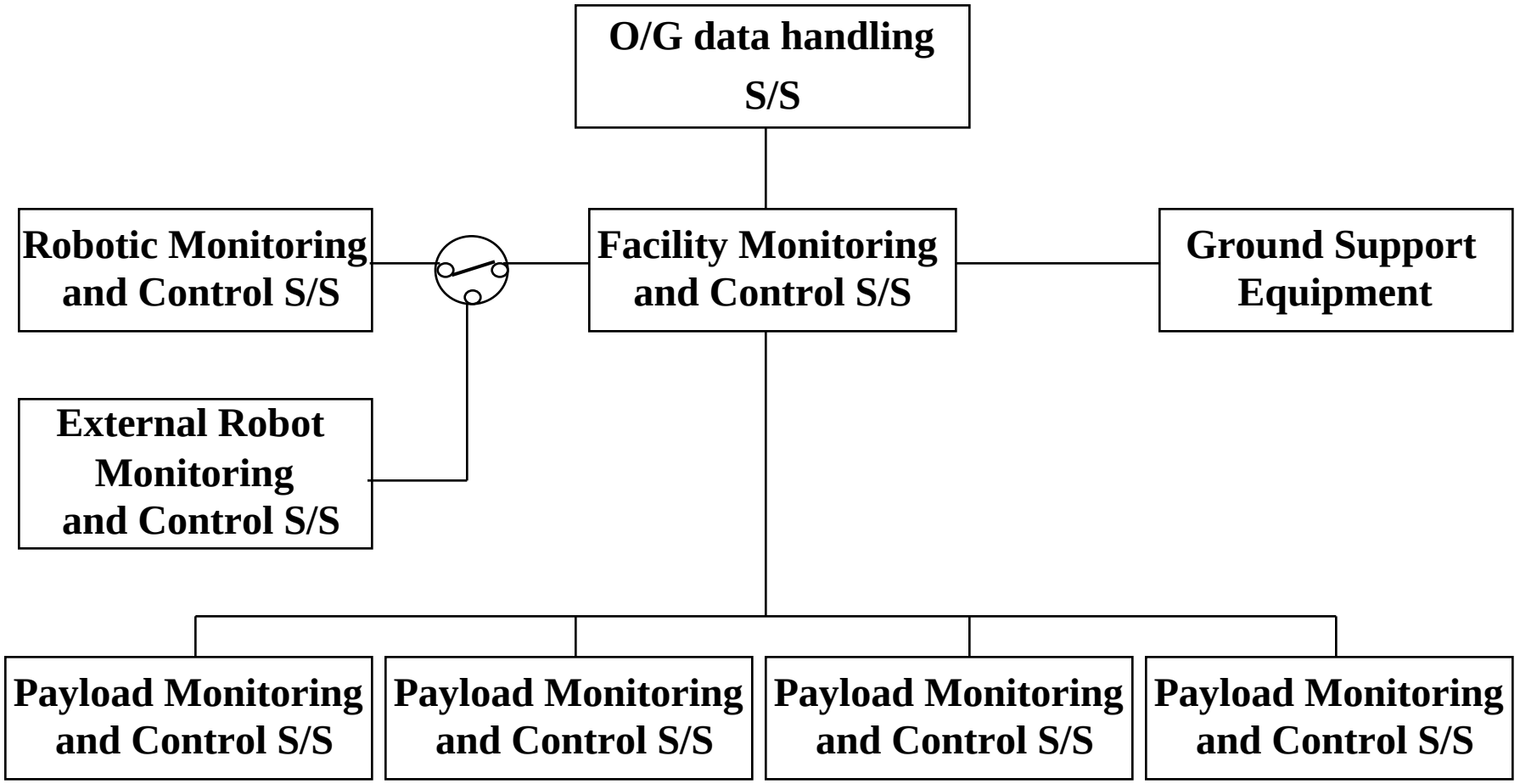
Pre-launch phase

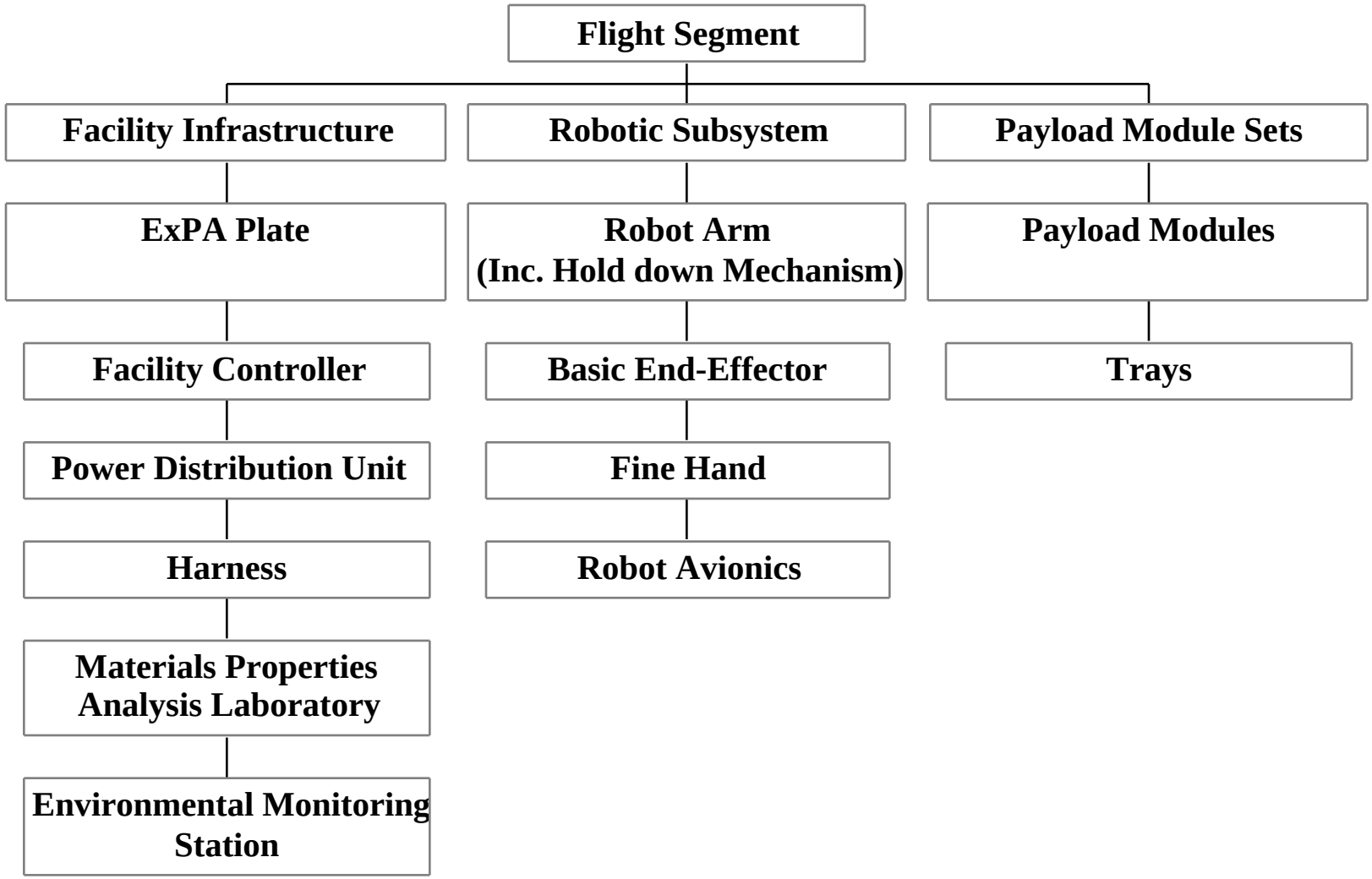
- **Integration of payloads into TEF**
- **Preparation of payload operation**
- **Training of TEF users and operators**

Operational phase

- **Communication between TEF flight segment and TEF users**
- **Management of TEF and scheduling of operations**
- **Management of resources available to TEF and their timely allocation to TEF users**

Ground Segment (cont. 1)




Flight Segment
Facility Infrastructure
Robotic Subsystem
Payload Module Sets
ExPA Plate
Robot Arm
(Inc. Hold down Mechanism)
Payload Modules
Facility Controller
Basic End-Effector
Trays
Power Distribution Unit
Fine Hand
Harness
Robot Avionics
Materials Properties
Analysis Laboratory
Environmental Monitoring
Station

Facility Infrastructure

Express Pallet Adapter Plate

- **Provided through the ISS Express Pallet Integration Contract.**
- **All TEF components will be mounted on it.**

Facility Infrastructure (cont. 1)

Facility Controller

- **Subsystem in charge of control & data handling of whole TEF (Payload + robot)**

- **Basic SPLC-set H/W & S/W elements to interface with ExPA data network**

- **H/W to control and interface to other TEF elements**

- **Controller S/W, allows automation of TEF**

  i.e. Actions & parameters of controlled PM & Robot Arm + control of correct execution of these actions

Facility Infrastructure (cont. 2)

Power Distribution Unit

- **Conversion and distribution of power to the TEF subsystems.**
- **Commanded through the Facility Controller (e.g. switch on/off output lines).**

Harness

- **Includes all electrical cables, interconnecting the different elements of TEF.**
- **All cables are rigidly fixed. The robot does not move any cable.**

Facility Infrastructure (cont. 3)

Materials Property Laboratory

- Provides measurement of thermo-optical properties of material samples (in specially adapted trays)
- Transport from exposure or storage location is performed using the robotic arm

Environment Monitoring Station

- Range of instruments providing centralised measurement capabilities for plasma, radiation, M&D, AO, and contamination

Robotic Subsystem

Robotic Arm

- **Is the means by which all TEF subjects may be moved.**
- **Mounted on the ExPA base and connected to the Facility Controller and the Robot Avionics**
- **Equipped with a hold-down mechanism to lock the arm firmly during launch**

Basic End-Effector (BEE)

- **Permanently attached to the Robot arm tool-flange.**
- **Mechanical and electrical interfaces are compatible with the Standard Grasp Interface (SGI) (available on all TEF subjects)**
- **Actions include grasp, move and release**
- **Sensors include camera system for scene and close up visual inspection**

Robotic Subsystem (cont. 1)

Fine Hand

- **Will be grasped by the BEE**
- **Provides dextrous capability for grasping and manipulating objects not equipped with a SGI.**

Robot Avionics

- **Servo Control Unit**
- **Servo Amplifier Unit**
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Payload Module Sets

Payload Module (PM)

- **All TEF payloads will be accommodated inside the Payload Modules. Can be relocated and arranged by the Robot arm.**
- **Each PM has individual power and data interfaces, which remains connected even when manipulated by the Robot arm.**
- **Base dimensions and mechanical/electrical I/F are identical on all PM.**

Trays

- **Used for smaller subjects with a limited exposure time requested.**
- **Robot arm will slide out/in a tray from a PM for exposure.**
- **Tray can be fully extracted and moved independently from PM.**

Payload Module Sets (cont. 1)

- **Plasma Contactor Electron Gun Payload**

- **High Temperature Super Conductors Demonstrator for Satellite Communications**

- **Measurement of Atomic Oxygen Flux**

- **Passive Material Exposure Tray; Effect of Space Exposure of Materials on their Thermo-optical, Optical and Mechanical Properties**

- **Monitoring and Detection of Micrometeoroids and Space Debris**

- **Dynamic Measurement of the Degradation of Thermo-optical Properties/ Calorimetric Measurement of the Degradation of Thermo-optical Properties**

Payload Module Sets (cont. 2)

- **Effects of Contamination/Radiation on Optical Surfaces/Effect of Contamination/Radiation on ISS Optical Surfaces**
- **Atomic Oxygen Experiment**
- **Manipulator System Identification and Dynamic Model Validation**
- **Intelligent Axis for Automation and Robotics**
- **Tactile Sensor based Robot Control**
- **Active Meteoroid/Debris Impact Detector**

Payload Module Sets (cont. 3)

- **Robot Inspection and Measurement of the Effects of the Low Earth Orbit Environment on Solar Cells**
- **A Teleoperated Intelligent Gripper for Handling Tasks**
- **Columbus Radiation Environment and Effects Package**
- **Heat-Pipe/Thermal Energy Storage Receiver Element for Solar Dynamic Space Power Systems**
- **Tribometer Facility for Generic Space Mechanism Lubricant Testing/ Fluid Lubricant Experiment on Test and Verification of Labyrinth Seal and Vent Design**
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Material experiments

Main Objectives

1. Evaluate the effects of the complex space environment on optical,thermo-optical and mechanical properties of materials currently being considered for utilisation on spacecraft in LEO. It includes the passive exposure of materials, mounted in exposure trays, that can e.g. be analysed in the Material Properties Laboratory (MPL).

2. Assessment of the effects of the ISSA environment on optical windows.

3. Investigation of microparticle and debris fluxes (and more exactly, their variation as a function of time and space exposure) and, after retrieval, the origin of debris and the detectors behavior. Active flux measurements will be performed using so-called MOS-detectors.

For the passive collection trays two types of collecting material will be used: high purity metals either as thick surfaces or multilayers and silica aerogels.

Material experiments

Active experiments

Sub-Experiment A (calorimeters):

Basically two types of calorimeters will be employed:

a) micro-calorimeters

b) "THERME" calorimeters

Sub-Experiment B (spectrometer)

The experiment makes use of a polychromator system involving optical quartz fibers, two polychromators, two optical detectors and a number of transparent optical windows on a rotating sample wheel.

Sub-Experiment C (MOS detectors)

Basically, two types of detectors will be employed:

- detectors with 1 µm dielectric thickness

- detectors with 1.4 µm dielectric thickness

Material experiments

Passive Experiment

Two kinds of passive modules are envisaged:

– MPL-drawers compatible with the Materials Properties Lab, enabling in situ visual microscopic inspection and measurement of the spectral reflection.

– Passive trays only used for ground inspection/analyses before and after flight.

- **Samples mounted by means of a standardised fixation interface.**
- **Will be protected during the launch and transportation phase**
- **Will be exposed to space for given time intervals.**
- **At the end of mission, the sample-holder modules will be protected, retrieved and carried back to ground for laboratory investigation.**
- **The trays will have re-usable (protective) covers to protect them from accidental contamination during e.g. high external activity phases.**

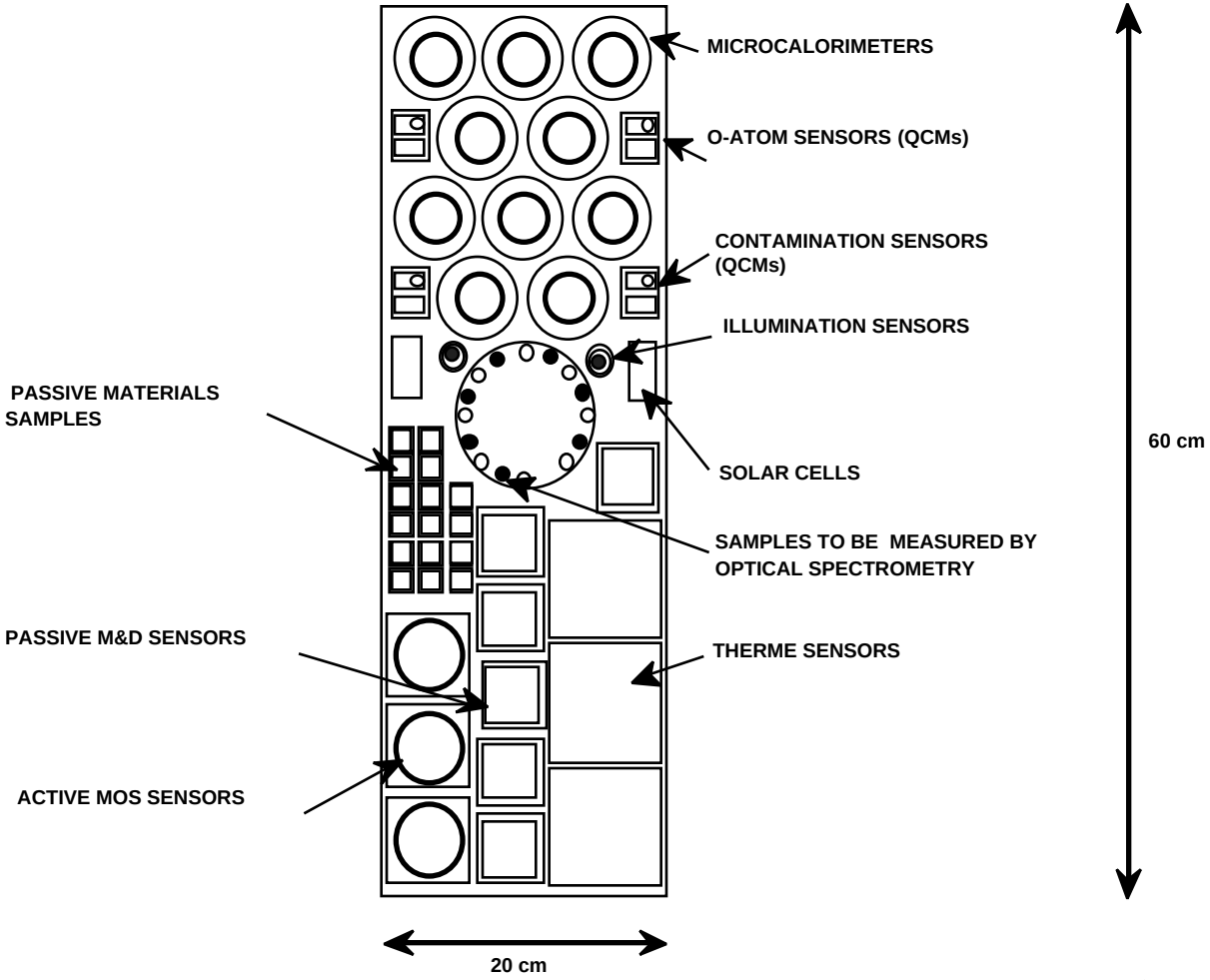
Material experiments

Sub-module Micrometeoroids and Debris in order to be able to study secondary impacts: close to "walls" (for instance in a geometry corresponding to a hollow cube corner, close to the apex).

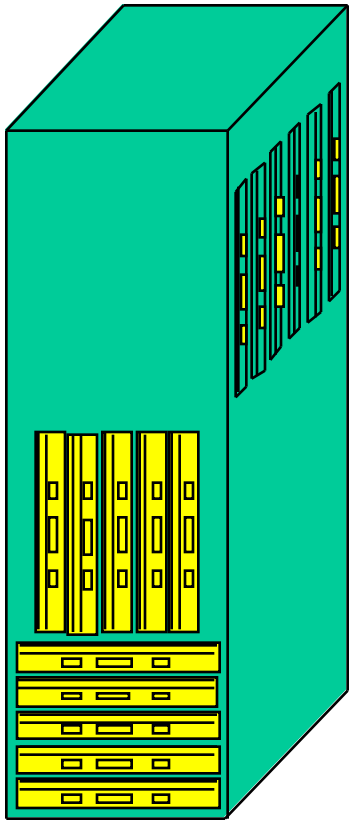
The Multilayer Sensors experiment uses a combination of thick metallic targets and succession of thin metallic films.

The metals (aluminium, gold and nickel) have a surface and a purity state sufficient for detecting small particles and the identification of the impact residues.

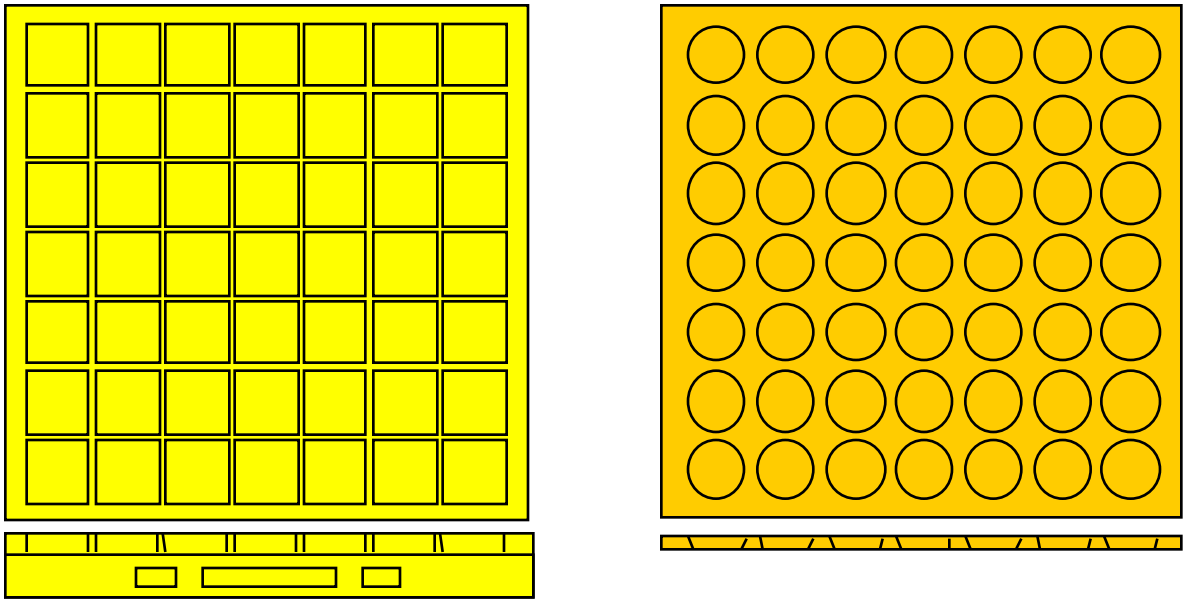
Materials Exposure and Degradation Experiments
CNES/DESP/ESA



Materials Exposure and Degradation Experiments
Passive Material Exposure PM for MPL



Materials Exposure and Degradation Experiments
Passive Exposure Tray for MPL

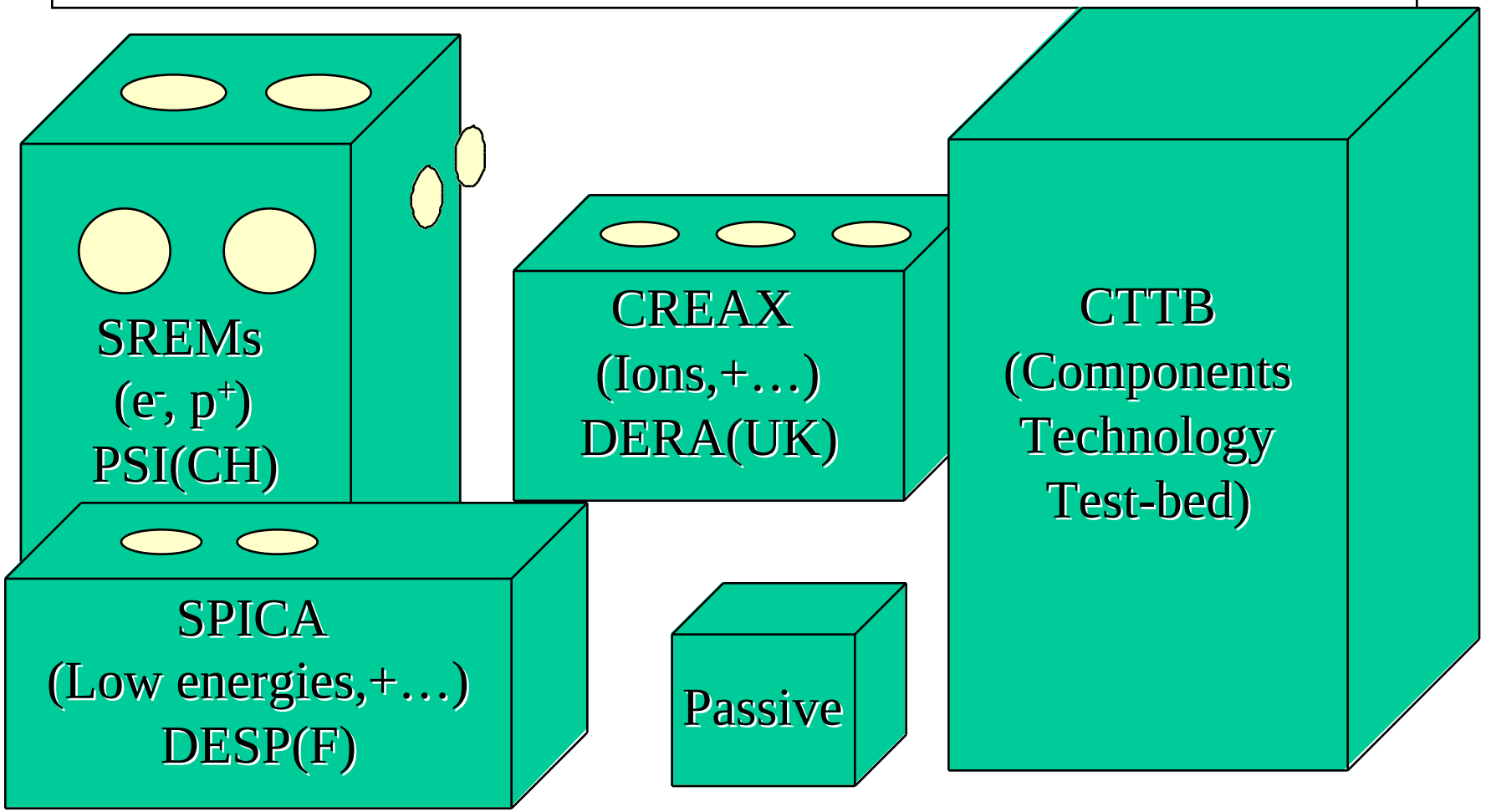


Environment Monitoring Station
Columbus Radiation Environments and Effects Package

SREM (x3)*	Directional electrons and protons (radiation belt, solar energetic particles)	0.5 MeV< E_e <10 MeV 10MeV < E_p< 300 MeV
CREAX*	Ions, protons, nuclear interactions, activation studies	1.5 < LET < 10^5 MeV.cm^2/g
SPICA*	Low energy electrons and protons for materials studies	0.05 MeV < E_e 3 MeV < E_p
CTTB	Sub-experiments for technology research / demonstration / test	Digital, analog, photonic, ...
Ground	• Comprehensive calibrat'n & simulat'n • CTTB technology pre- & post-flight evaluation; • Data analysis & dissemination	-European proton (PSI), ion (various), ele (various) beams; - open data policy (except commercial) - real-time & near real-time data

* overlapping capabilities exploited for validation

Environment Monitoring Station
Columbus Radiation Environments and Effects Package



Environment Monitoring Station
In-Situ Standard Impact Detector [DEBIE]

Overview

DEBIE shall monitor in-situ the sub-millimetre size meteoroid/debris population in space and its variation with time and position

Common design for easy adaptation to different spacecraft and orbits

Up to 4 sensors on different spacecraft surfaces

Information on mass and velocity of impactors

Active detector: impact data by telemetry near real time

Environment Monitoring Station
In-Situ Standard Impact Detector [DEBIE]

Properties

Based on prototype developed by Univ. of Kent

Combination of impact ionisation, momentum and foil penetration detection

For 3 complete sensors: mass +/- 2.8 kg; power +/- 3.3 W

Sensitivity: mass > 10^{-15} g (velocity dependent)

On-board classification of events

Environment Monitoring Station
In-Situ Standard Impact Detector [DEBIE]

Flight Opportunities

PROBA (Project for On-Board Autonomy); a small technology demonstration satellite in Polar orbit. Launch: mid 2000 (DEBIE with 2 sensors)

ISSA exposure facility (TEF) during early utilisation phase. Launch: mid 2002. DEBIE (with 3 sensors) included in baseline detector set.

Other, preferentially high altitude missions (several flight opportunities offered)

Environment Monitoring Station
Pressure, Atomic Oxygen and Contamination,

Pressure

- **Penning gauge based on commercially available design**
- **Pressure range 10^{-4} - 10^{-9} mbar**

Atomic Oxygen

- **Baseline : Carbon coated QCM**

Contamination

- **Baseline : QCM**

Materials Properties Laboratory [MPL]

Aim

- **Measuring of optical properties of materials over the solar region of the spectrum**

Configuration

- **shall be accommodated in a standard PM**
- **MPL module can be relocated in orbit**
- **operational in a number of positions, subject to thermal and robotic access restraints**
- **shall make use of BEE for tray transportation and measurement aperture scanning**

Materials Properties Laboratory [MPL]

Elements

- Space reflectometer and controller subsystem
- Optical microscope
- Sample tray, guide and position sensor
- Interfacing hardware with TEF
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