# Matroshka

## Measuring Radiation Hazards for Spacewalkers

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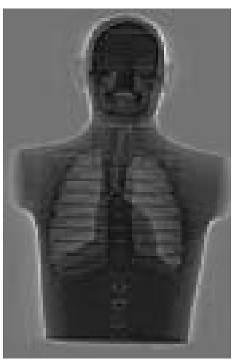
### Introduction

Matroshka will measure the radiation doses that astronauts face during spacewalks. Surprisingly, these are still not well known. Knowing the doses suffered by sensitive body organs is crucial for assessing the hazards from cosmic radiation. Mounted outside Russia's Zvezda module on the ISS for a year, the multi-user Matroshka will record the radiation doses at different depths in a human mannequin on a simulated EVA. It provides:

*Matroshka will help to make spacewalks safer for astronauts ...*

- simulation of the human body and organs with respect to size, shape, position, mass density and nuclear interactions;
- chemical and physical stability of tissue substitutes in the vacuum of space;
- mounting of passive and active detectors in the body and spacesuit elements;
- temperature monitoring and control;
- atmospheric pressure monitoring;
- experiment and housekeeping data acquisition, temporary storage and transfer to the onboard data management system;
- delivery of telemetry data to the Payload Data Control Server for facility monitoring by Mission Control Center-Moscow;
- mechanical, electrical, thermal, pressure and data interfaces to Zvezda;
- disassembly/assembly to exchange the passive experiments inside Zvezda.



*Simulated organs and real bone are seen in this tomographic image.*

### Components of Matroshka

Matroshka is housed in a container with a total height of 1100 mm; mass is 68 kg. The facility requires 40 W of power. The protective canister, of carbon fibre reinforced plastic with an atmosphere of oxygen, to some extent simulates a spacesuit.

### The Phantom

The Phantom is designed of natural bone and material equivalent to human tissue. Lower-density material simulates the lungs. The Phantom is sliced into layers 25 mm thick and stacked around a mandrel for stability. The slices carry most of the sensors to measure the radiation doses at organ sites such as stomach, lungs, kidney, colon and eyes. In addition, the Phantom carries a coat of multi-layer insulation (MLI) equipped with Thermo-Luminescence Dosimeters (TLDs) to measure the skin dose. One Dosimetric Telescope (DOSTEL) is mounted on the head and the Tissue Equivalent Proportional Counter (TEPC) in front. The passive sensors must be returned to Earth for evaluation.

The base structure contains the electronics for the experiments and data-handling systems to communicate with Zvezda.

### Dosimeters

Measuring the complex radiation field calls for a range of detectors. Active detectors will measure single particles and deliver their data to Zvezda, while the passive detectors will accumulate the particle data for evaluation on the ground after the year's exposure time.

*DOSTEL (Dosimetric Telescope):* a charged-particle telescope using three sandwiched silicon detectors to monitor the particle flux, dose-rate and linear energy transfer (LET) spectra of radiation from the Van Allen belts, deep space and the Sun.

*TEPC (Tissue Equivalent Proportional Counter):* a low-pressure ionisation chamber surrounded by 1.9 mm of tissue-equivalent material (A-100). All types of radiation will be measured. It is able to record a LET-spectrum every minute.

*HiLRS (High-LET Radiation Spectrometer):* solid-state microelectronics measuring the deposition of energy in p-n junctions with dimensions similar to a biological cell. The pulse height of the signal is proportional to the particle LET. It measures preferentially the high-LET particles.

*SSD (Silicon Scintillator Device):* a plastic scintillator cube covered by silicon detectors. The light output is proportional to the radiation dose. This dosimeter discriminates against charged particles and therefore measures the neutron dose.

*TLD (Thermo-Luminescence Dosimeter):* electrons are trapped in lattice imperfections in the TLD crystal under the impact of the radiation. When heated, the luminescence signal is proportional to the radiation dose. The dosimeters are distributed every 2.5 cm to give a depth-dose profile within the Phantom.

*PNTD (Plastic Nuclear Track Detector):* particle radiation produces latent tracks which can be made visible by an etching process. From these, we can generate LET spectra, and particle fluxes and spectra.

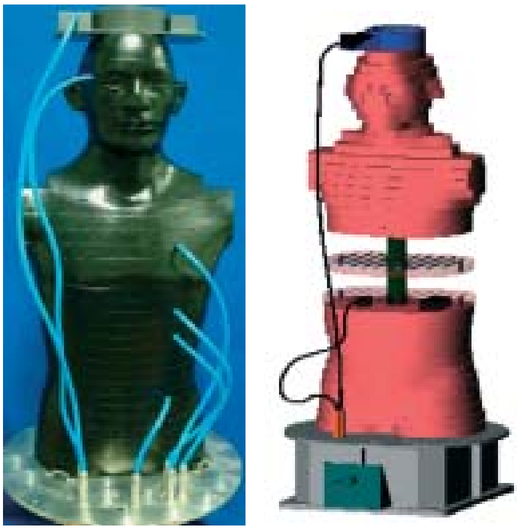
## Operation and Status of Matroshka

Several Matroshka models will be delivered to RKK-Energia for cosmonaut training and tests:

- Training Model 1 for EVA training (water tank);
- Training Model 2 for ISS internal training;
- Engineering Model for Complex Integration Tests;
- Flight Model.

Training Model 1 was successfully tested in the Neutral Buoyancy Laboratory of the European Astronaut Centre in Cologne in 2002. The EM will be delivered to RKK-Energia in June 2003. The FM is being built now; delivery and final acceptance are planned for November 2003.

Matroshka will be launched aboard a Progress unmanned ferry in January 2004 and transferred into the Russian Segment. The crew will perform an EVA to mount it outside Zvezda on a 'Universal Working Platform', produced by RKK-Energia. Matroshka will remain there for a year, until an EVA returns it inside. The MLI surrounding the canister and its embedded passive sensors will be removed during the EVA



*Matroshka consists of 25 mm-thick slices.*

and packed into a special bag for return to Earth. Inside the Station, the container will be opened and the slices slid out one by one to remove the TLDs for bagging and delivery to ground. Accurate analysis requires no more than 2 months' total storage time in orbit.

## Participating Industry

The ESA facility is under the project leadership of the German Aerospace Centre (DLR). Facility assembly, integration and test, Phantom preparation, experiment integration and processing are also the responsibility of DLR. The container and base structure are being built by DTM Technologies (Modena, I). Electronics and software development are by Kayser Italia (Livorno, I).