From LEO to Lunar
Exploring Deep Space Medical Capabilities

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Introduction:

New medical solutions that exploit validated medical technologies and state-of-the-art knowledge must be developed and integrated into a single system, to ensure crew safety during deep space missions. The ESA Space Medicine Team has initiated the development of an ESA Exploration Medical System (ExMS) concept. Although this system is being developed for Artemis mission utilisation, it could be also applicable to other types of extreme medicine. The system exploits ESA expertise acquired from ISS operations. The ExMS aims at dual applicability of concepts and technologies to space and terrestrial medicine so it can also benefit citizens on Earth.

Key Requirements:

Modularity: Allows for enhanced flexibility of the system and enables scalability, portability, upgradeability, adaptability, and training and simulation features.

Scalability: Allows for optimisation of medical system functionalities to mission requirements and mission profiles.

Portability: Enables mobility of the ESA ExMS across the whole exploration vehicles stack.

Upgradeability: Allows for resolution of software bugs, optimisation of software in response to operational experience and installation of enhancements in response to evolving medical requirements.

Connectivity: Allows for the integration of medical data from different sources and integration into the spacecraft architecture.

Adaptability: Enables changes in medical inputs, mission scenario changes, available resources, contingencies and environmental factors.

Data Management: Enables adequate distribution of data to the required operational teams and users (on a need-to-know basis) while preserving the privacy of the crewmember.

Telemedicine: Allows for remote diagnosis and medical management of medical conditions.

Training: Allows knowledge retention and adequate medical provision performance of crewmembers.

Terrestrial Applications:

Microgravity Exercise Devices: The MoLo, E4D, and LBNP are all devices specifically designed to countermeasure musculoskeletal decline during space missions. With sacropenia/frailty affecting many elderly folks and patients on bedrest, these devices can provide an effective way to counteract muscle and bone loss.

Health Monitoring: Terrestrial use of EveryWear and Tempus can allow for monitoring health of patients in remote locations and in clinics, easing the pressure on hospitals.

Diagnostics: Miniatured devices for automatic blood analysis, such as Hemocue, and ultrasounds using augmented reality and AI, such as EchoFinder, can facilitate diagnosis in clinics and remote locations with minimal training required.

Sample Medical Capabilities:

Everywear

Everywear is a database integrating different types of medical data, enabling communication with a surgeon and providing a user interface. The system is already in use on ISS in a basic form; however, it still gives scope for expansion to gather more data directly (touch screen, camera) and indirectly (from other iPad Apps, and wired and wireless connections).

HiFi

Jumping was proven to be a comprehensive and highly effective plyometric exercise during bed rest studies. It gives the best results against musculoskeletal and cardiopulmonary decline. HiFi is a device enabling weighted jumping in microgravity. The ISS technological demonstration is currently being prepared to perform submaximal hops on the T2 treadmill.
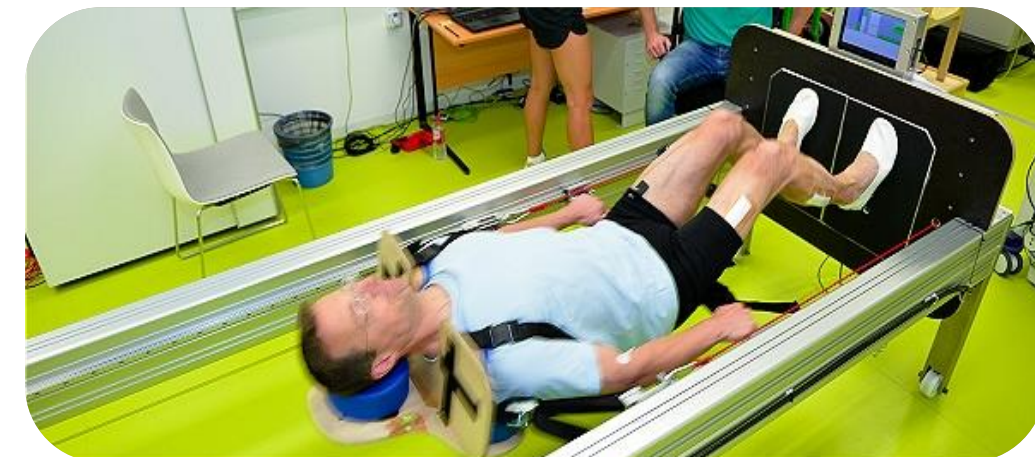
Tempus

The current ISS standard for vital signs monitoring consists of separate devices. Lack of integration creates a risk of data attrition. Tempus is an Integrated vital signs monitor with AED module and possibility to connect Ultrasound and Laryngoscope, as well as with a training and telemetry module. It is currently in the process of flight certification and ISS technological demonstration.
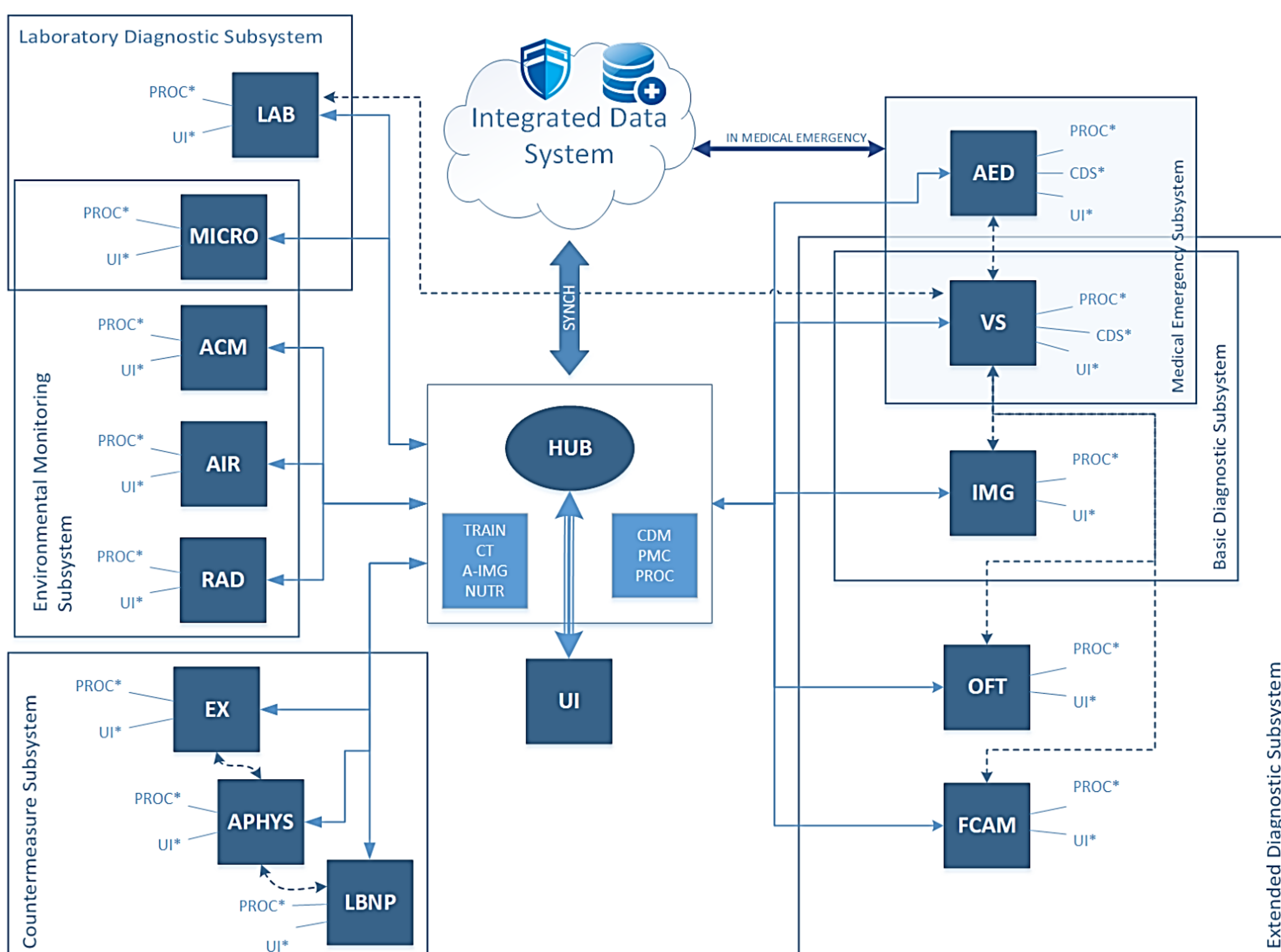
AED	Semi-Automatic Defibrillator / Pacer Module	EX	Advanced Exercise Module	OFT	Advanced Ophthalmology Imaging Module
A-IMG	Autonomous Diagnostic Module for Medical Imaging	FCAM	Flexible Camera Module	PMC	Private Medical Communications Module
AIR	Air Contamination Monitoring Module	IMG	Medical Imaging Module	PROC	Advanced Medical Procedure Module
APHYS	Advanced Physiological Parameter Measurement Module	LAB	Blood and Urine Analysis Module	RAD	Personal Radiation Dosimetry Module
CAN	Acoustic Monitoring Module	LBNP	Lower Body Negative Pressure Module	TRAIN	Medical Competence Maintenance Module
CDM	Clinical Decision Module	MICRO	Microbiology Identification and Quantification Module	UI	User Interface and Data Input Module
CT	Consumables Tracking and Stock Management Module	NUTR	Nutrition Assessment Module	VS	Vital Signs Module