

Panel: BENEFITS, LIMITATIONS, AND FEASIBILITY OF MINIATURE X-RAY IN SPACE

ABSTRACT 3: EVALUATING THE VIABILITY OF COMPACT AND PORTABLE X-RAY SYSTEMS FOR AN EXPLORATION MEDICAL SYSTEM IN A GROUND DEMONSTRATION

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MOTIVATION FOR INCLUDING X-RAY CAPABILITIES

For upcoming exploration missions, the need for enhanced medical care becomes critical due to extended mission durations, significant communication delays, and minimal evacuation opportunities. Previous evidence by our team has revealed that among the 119 medical conditions targeted for management during spaceflight within NASA Exploration Medical Capability's IMPACT Condition List, at least 36 could benefit from radiography (XR). Utilizing XR for diagnosis and management is hypothesized to significantly improve management of crew health by enabling the immediate evaluation and confirmation of potential injuries or illnesses. Beyond clinical applications, XR also holds potential for non-destructive testing (NDT). This includes applications such as assessing the structural integrity of the spacecraft, analyzing surface and meteorite samples, and inspecting onboard electronics.

THREE CANDIDATE X-RAY SYSTEMS CHOSEN FOR GROUND DEMONSTRATION

The Exploration Medical Capability Element (ExMC) and the Exploration Medical Integrated Product Team (XMIPT) of the Mars Campaign Office initiated early background work for ground demonstrations. In FY21, ExMC published a Concept of Operations to guide requirements development. By FY23, XMIPT and yet2, a technology scouting and open innovation consulting firm, had completed a market survey and trade study to identify potential miniature XR systems. Selection criteria included commercial-off-the-shelf availability, low mass and volume, and regulatory compliance. The top three candidate devices—Remedi REMEX-KA6, MinXray Impact, and FujiFilm Xair—were acquired to characterize the requirements and capabilities of each device. To facilitate testing, phantoms, and radiographic personal protective equipment (PPE) were purchased, and a dedicated space was designated for XRS usage at Glenn Research Center. During this presentation, the mass, volume, and power requirements for each of the three piloted devices are revealed, as well as information regarding the detector, mA, and kV of the devices.

GOAL AND OBJECTIVES OF A MINI XRS GROUND DEMONSTRATION

The primary goal of ExMC/XMIPT technology demonstrations is to bridge the gap in available, flight-ready medical device technology by flight-testing diagnostic and treatment technologies essential for managing medical conditions during exploration missions. These technologies must adhere to vehicle constraints such as mass, volume, power, and data requirements, integrate seamlessly with medical decision-support tools, and support increasingly Earth-independent operations. There are three main objectives for the future ground demonstration of these three devices. First, we aim to determine the full capabilities of these three miniature XR systems within the context of the spaceflight environment. While medical applications are the primary focus for the miniature XR, a comprehensive exploration of non-medical uses has been initiated by an XMIPT-sponsored NASA SPARK campaign to identify collaborators. Second, we plan to establish criteria and to use insights gained from evaluating each miniature XR against those criteria to select the most suitable system among the three candidates. Third, we intend to evaluate their suitability for flight certification, which includes assessing its durability for launch, reentry, and exposure to

high background radiation, as well as its compatibility with existing data architecture systems. Numerous subject matter experts from NASA and partner institutions will support these objectives.