

## **EARTH INDEPENDENT MEDICAL OPERATIONS (EIMO) DATASCOPE: CHALLENGES AND POTENTIAL SOLUTIONS**

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Data flows and storage/retrieval capacity are severely constrained during missions in space and challenges will become even greater during exploration class missions. There is a need for an artificial intelligence (AI)-based clinical decision support system (CDSS) to monitor and analyze data to provide real-time consultative support for crew medical officer (CMO) decision-making. EIMO is defined as the gradual transition of medical care and decision making from terrestrial to space-based assets, enabling support of astronaut health and performance and reducing overall mission risk. While a hallmark of this paradigm shift from low-earth orbit is that on-board care will increasingly become the responsibility of the astronauts for primary management and decision making, terrestrial assets will continue to be paramount in pre-mission screening and planning, as well as prevention, health maintenance and long-term care contingencies. New capabilities and systems that enable progressively more robust and resilient systems and crews will be necessary to reduce risk and increase probability of deep space exploration mission success. An aspiration for EIMO is to develop AI-enhanced solutions for analysis of crew health & performance data and to facilitate clinical decision support for autonomous medical operations.

A “system of systems” approach is envisioned whereby EIMO will deploy AI-supported natural language processing and machine learning (ML) techniques to utilize embedded reference databases and real-time data streams [input vectors] from multiple data sources. Constituent input vectors may include environmental controls, countermeasures data, behavioral data, physiologic wearables, point-of-care laboratory tests, personalized medical records, inventory trade space risk assessments, COTS medical databases, and ground support inputs. An ideal AI capability would possess trained fusion algorithms to cross reference input vectors with medical ‘knowledge’ [cultivated database] to stratify relevant data streams for predictive and actionable capabilities. In addition, EIMO will feature mobility, in that it can be accessed and can push/pull data within and between multiple vehicles/habitats.

Large amounts and variable sources of data can be leveraged to diagnose, inform treatment strategies, and potentially predict medical events and performance decrements. Inclusion of advanced training tools using extended reality will enable increasingly autonomous medical care to aid a CMO when ground support is unavailable or time-delayed beyond required action window, e.g., emergent medical situations. EIMO CDSS would require very large datasets to train pre-flight and significant amounts of data are needed to support ML via in-flight CDSS operations. An additional challenge will be to find sufficient data to train a model relevant to astronaut demographics. The rapid, accelerating evolution of this field creates a propitious solution space to leverage multi-modal AI through public-private partnership(s).

The status of multi-modal AI systems today would preclude their use for long duration missions as they remain unreliable and are subject to “digital hallucinations” and other errors that could pose operational risk. A federated labs structure is being considered to test and optimize data flow from the multiple input vectors leading to field testing in suitable ground/flight analogs. Critical to the success of an EIMO CDSS will be integration and interoperability and success will be defined by a system that can serve as an in-flight medical consult for the CMO providing critical support during medical contingencies. Benefits to terrestrial medicine may be significant as an outflow of the EIMO medical system, particularly for remote areas and communities lacking significant infrastructure, personnel and resources.