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

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Expanding the Boundaries of Space Medicine and Technology

BACKGROUND

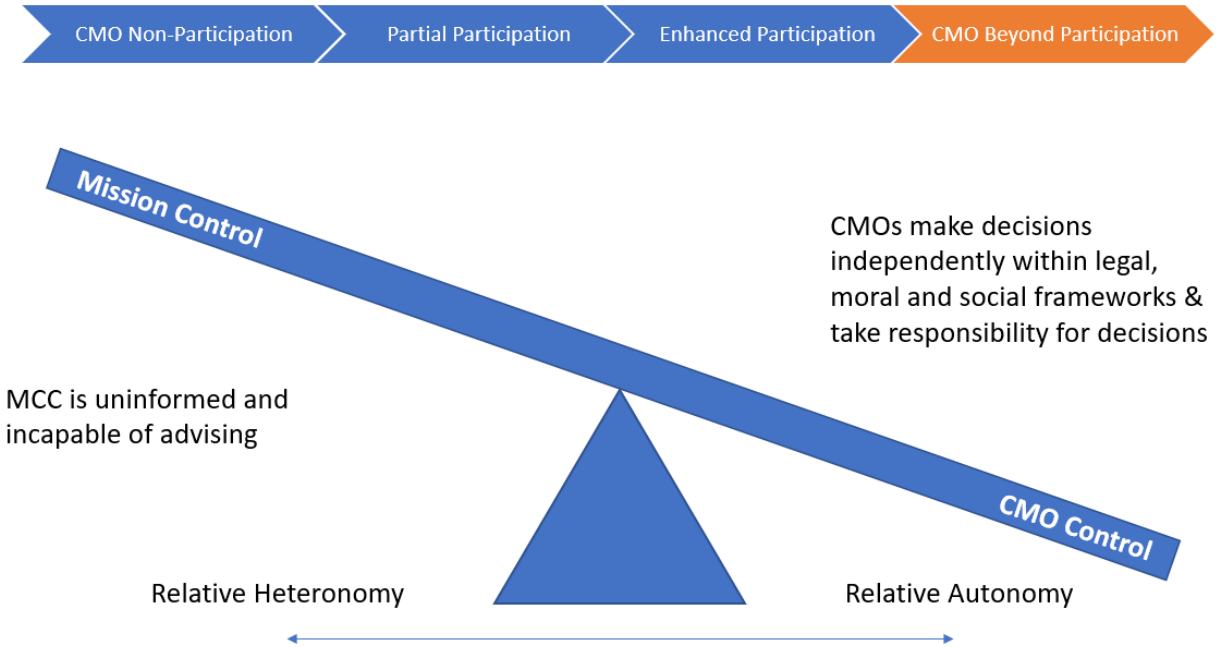
- **NASA Leadership Technical Interchange Meeting (TIM) on 10 January 2023:**
  - Pre-mission planning
  - Acute and prolonged medical decision making
  - Supply & resource management
  - Task load management

- **Additional EIMO TIM's:**
  - Datascope: 21 August 2023
  - CMO Training: 26 October 2023
  - Medical Supply & Resource Management: 27 February 2024
  - Task Load Management: TBD April 2024
  - Multi-modal AI Clinical Decision Support System: TBD June 2024

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.

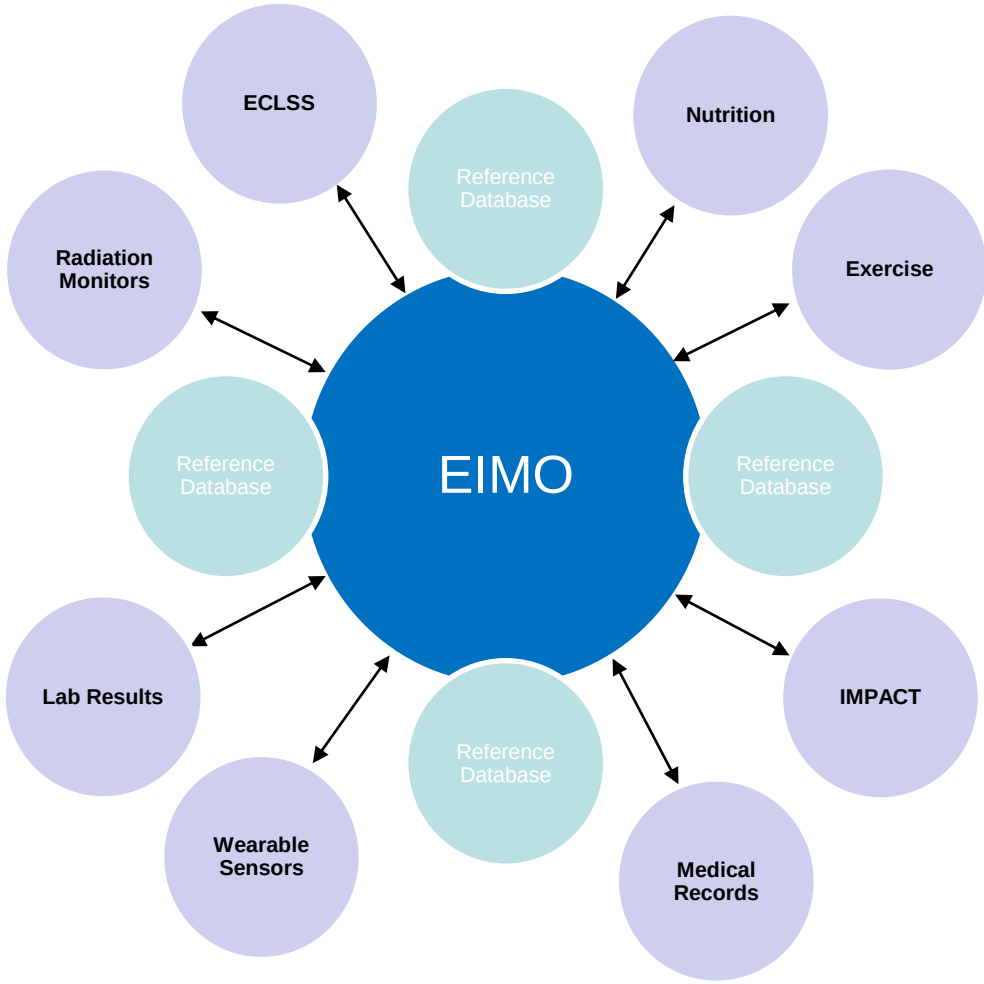
Why DATASCOPE TIM?

- **On-board Care Will Increasingly Become Crew Responsibility**
  - Communication delays
  - Limited transmission bandwidth
  - Baseline knowledge, skills & abilities



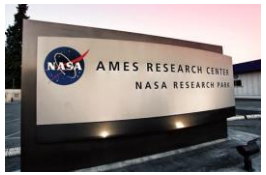
What is the Solution?

- **New Tools & Capabilities**
  - Data intensive technologies
  - Significant on-board resources
  - “System of systems” approach
  - Artificial Intelligence enhanced capability



DATASCOPE TIM Subject Matter Experts

- **NASA SME's**
  - Johnson Space Center
    - Human Research Program
    - Space Medicine Operations
    - Human Health and Performance Directorate
  - Ames Research Center
  - Glenn Research Center
  - Langley Research Center
  - Marshall Space Flight Center



- **External SME's**
  - Hewlett Packard Enterprise
  - Microsoft
  - IBM
  - WoltersKluwer (UpToDate)

Hewlett Packard Enterprise

Microsoft

IBM

UpToDate®

DATASCOPE TOPIC #1

Is generative AI the 'way to go' when considering operating systems and for spaceflight IDA?

- **Pros**
  - Excellent at summarizing large amount of information quickly and answering specific questions and Large Language Models (LLM) are deployable today
  - Rapidly evolving technology may ultimately be deployable in zero-tolerance setting
- **Cons**
  - Currently unreliable for Clinical Decision Support
  - Lacks symbolic reasoning critical for plan synthesis and tracking plan execution
  - Inaccurate on net new content
  - Appropriate guardrails are necessary

DATASCOPE TOPIC #2

To what degree could dedicated, terrestrial LLM 'training' use cultivated datasets to bridge the gap in AI data requirements? Given the sparsity of data (and unknowns) in the space environment, what other considerations exist regarding training models with limited data sets?

- Data sparsity in the "SIM to Real" gap has highlighted data synthesis methods ("fuzz sensors")
- Caution regarding overfitting the models
- Training data should exclusively employ spaceflight data
- Domain specific LLMs do not outperform general purpose LLMs in healthcare
- Retrieval Augmented Generation (dynamic presentation with real-time iteration)
- Meta prompts (system level) critical guardrails
- Trade-offs related to on-board computational capacity and data flow/bandwidth are inevitable

DATASCOPE TOPIC #3

What would a ground test environment [lab] look like? Metrics of success in integrating input vectors into a full-fledged integrated data architecture [IDA] that can both pull and push information to the end users? What skillsets and levels of expertise should direct this work? What AI modalities should be tested?

- Ideal test environment should mimic as closely as possible the mission environment
- Phased approach is essential
- Testing driven by schedule not milestones
- System of Systems approach with Federated Lab architecture
- Build and break model (Chaos Monkey, etc.) or build back from the right
- Emulation of anticipated processing and storage constraints would be value added

DATASCOPE TOPIC #4

Future EIMO TIMs will focus on crew training, supplies & resource management, and task off-loading. What else should we consider re: this Datascope in meeting these other EIMO requirement domains?

- **Additional TIM's for consideration:**
  - Shelf-life of medical resources (pharmaceutical, sterile water/saline for injection, syringes, etc. may be compromised due to length of mission and the plan to "pre-deploy" some materials well in advance (several years)
  - AI modalities especially in the setting of limited on-board resources
  - User Interface
  - Hierarchy of needs related to CDSS (most common diseases, most serious)
  - COTS medical devices, interoperability and integration
  - Autonomous mission operations, crew telemetry, equipment/supplies, cadence of monitoring

DATASCOPE TOPIC #5

We seek innovative solutions from industry to make sure we're capturing the cutting-edge ideas and technologies of today, to build systems that will fly over a decade from now. To that end, what does this group think are the most effective ways to engage with thought leaders and innovators? RFI's? Targeted conferences? Interactive solution activities, i.e., Hack-a-thons?

- EIMO well aligned with healthcare industry interests & public/private partnerships could accelerate development to close technology gaps
- Interoperability is paramount and NASA could take the lead in establishing standards for space medicine that could transform terrestrial medicine
- Decadal survey from National Academies of Science
- Healthcare Information Management Systems Society Annual Meeting
- Development of a roadmap for EIMO

DATASCOPE TIM TAKEAWAYS

- **Multi-modal Artificial Intelligence (AI) Solution**
  - No single AI modality is sufficient
- **Trust Gap**
  - Generative AI currently susceptible to “hallucinations”, safeguards needed
- **Build or break**
  - Testing with integration of multiple input vectors via Federated Labs structure
  - Multimodal AI combinations, best practices inform Concept of Operations and Requirements
- **Public-Private Partnerships**
  - Landscape evolution eclipsing Moore’s Law, obsolescence measured in months vs. years
- **More deliberations**
  - How to deploy AI in data/computing resource constrained environments; optimal user interfaces; medical device interoperability and integration
- **Achievable**
  - Consensus that palpable solutions were possible for this challenge

Thank you to our SME Contributors

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