CUSTOM INTEGRATION OF MULTIPLE MEDICAL FUNCTIONALITIES

B. E. Lewandowski[1*], C. A. Haddix[2], A. A. Nelson[1], C. M. Schkurko[1]

[1]NASA Glenn Research Center, 21000 Brookpark Rd., Cleveland, OH 44135.

[2]HX5, 21000 Brookpark Rd., Cleveland, OH 44135.

*Beth.E.Lewandowski@nasa.gov

INTRODUCTION

- NASA roadmaps identify technical capability gaps necessary for successful exploration missions.
- The Exploration Medical Integrated Product Team's (XMIPT) Medical Imaging, Diagnostics, and Treatment Technologies Roadmap (Fig. 1) highlights the need for flight-tested medical devices for effectively managing medical conditions that meet vehicle constraints, integrate with decision support tools, and enable Earth-independent operations [1].
- The NASA Human System Risk Board identified the need to increase inflight medical capabilities and identify new capabilities that a) maximize benefit and/or b) reduce resource costs associated with the human system, mission, or vehicle [2].
- Technology demonstration efforts performed by the Human Research Program (HRP) and Mars Campaign Office (MCO) help close these human health related technology gaps.

Figure 1. XMIPT Medical Imaging, Diagnostics, and Treatment Technologies Roadmap

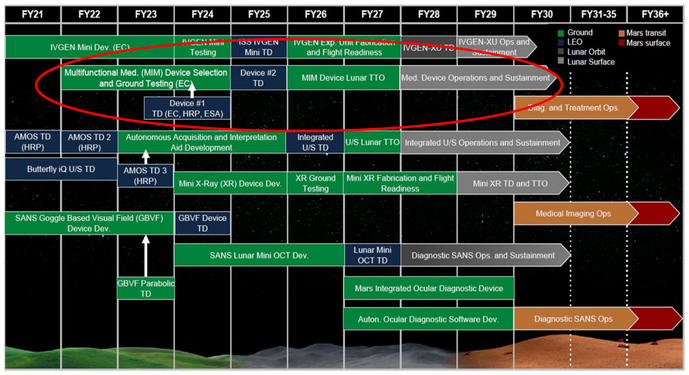

Figure 2. The Tempus Pro™ and its Peripherals

Figure 3. The LifeBot® and its Peripherals

EVALUATION OF COMMERCIALLY AVAILABLE MIM DEVICES

- Multi-functional Integrated Medical (MIM) device selection and ground testing is a roadmap activity (Fig 1.) and is of interest to HRP and the NASA medical community.
- The Tempus Pro™ (Fig. 2) (Remote Diagnostic Technologies, Ltd., Philips Corp., Farnborough, UK) and the LifeBot® (Fig. 3) (LifeBot Health, Chicago, IL, USA) were evaluated.
- Details of the MIM device evaluations of these MIM are presented elsewhere [3], with an evaluation summary within Table 1.

Table 1. Key Findings from MIM Evaluations

Evaluation Criteria	Key Findings from MIM Evaluations
Provide optimal medical capabilities for prevention, diagnosis, treatment, rehabilitation, and risk minimization	Both devices integrate key medical capabilities, such as vital sign measurements, scopes, and ultrasound, but also include capabilities that are not likely to be required during exploration missions.
Meets mass, volume and power constraints	Tempus Pro mass = 3.5 kg, volume = 5.6 L; LifeBot mass = 3.9 kg, volume = 10.75 L.
Provide accurate results, reliability, and robustness within the spaceflight environment	Both devices produced accurate vital sign readings against a biomedical simulator, but the clinical usability of the ultrasound capability was lower than expected. Both devices tolerated exposure to exploration atmospheres. The Tempus Pro was flight certified and worked nominally after cabin depressurization and re-pressurization. Device software issues were uncovered and required some reboots during the evaluations.
Includes or can easily integrate with electronic health records, procedural guidance, and decision support tools	Basic training and general procedural guidance were adequate for instructing novice users through vital sign collection. Users desired more instruction on performing and interpreting ultrasound imaging. Both devices include patient electronic health records.
Data from the device can integrate with a central data architecture	The devices have cloud-based telemedicine capabilities. LifeBot contained an outdated API and Tempus Pro uses manual PDF file transfer.

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CHP-ICT CONCEPT FORMULATION

- *The limitations of the MIM devices are overcome by introducing the **Crew Health and Performance – Integrated Customized Technology (CHP-ICT)** Project.*
- The vision for medical systems for late Artemis and future Mars missions exist within various documents (Table 2).
- Device selection for early Artemis missions has been based on user preference, commercial availability, ability to spaceflight certify, and device robustness.
- *CHP-ICT aims to bridge near-term device selection practices with long-term medical system visions, striving to infuse desirable long-term characteristics into near-term selections.*

Table 2. Documents with Exploration Medical System Requirements

Documents Containing Exploration Medical System Requirements
Medical System ConOps for Mars Exploration Mission (JSC-67070)
EIMO ConOps for Mars Exploration Missions
Evidence Library Capabilities and Resources
Moon to Mars Architecture Document
CHP-IDSP Interface Design Document
AROWG Clinical and Research Ultrasound Functional Needs and Operational Considerations
ECLSS-CHP SCLT Roadmaps
ExMC LDLOLS Medical Foundation
NASA-STD-3001 V1 & V2
HLS-REQT-001

KEY COMPONENTS OF CHP-ICT

- Integration of multiple devices and capabilities that optimally reduce medical risk
- Flexibility to adapt to changing requirements within different vehicles and/or missions
- Use of devices that easily connect to an independent data architecture and third-party visualization software
- Inclusion of higher quality ultrasound imaging capabilities
- Integration of devices with procedural guidance and decision support tools

CHP-ICT WORK PLAN

- Understand the current state of requirements for future exploration medical systems.
- Participate in Artemis device down select and flight certification processes.
- Identify medical devices that can meet near- and long-term requirements.
- Evaluate devices in collaboration with data integration projects, spaceflight analog missions, and/or various spaceflight platforms. for performance, usability, and integration compatibility (Table 3).
- Provide information about candidate devices to decision makers, requirements writers, and medical system designers.

Table 3. Tentative CHP-ICT Collaborations and Outcome Objectives

Collaboration	Outcome Objectives
MEDPRAT/IMPACT/ IMM/CHP-PRA	Understand medical system capability needs. Obtain optimal capabilities lists and risk quantification
Orion and HLS Med Kit Integrators	Understand Artemis med kit down select, CoFR, and operational processes; contribute evaluation results
CHP-IDSP/xEHR	Integrate medical devices within data architecture, make device data available to software storage and analysis packages
Clinical Science Team	Determine clinical usability of medical device output (i.e., clinical relevance and quality of images). Develop clinically relevant medical scenarios
SIO Digital Engineering Team	Understand near and long-term medical system and CHP system requirements
CHAPEA and/or other analogs	Perform EIMO medical scenarios, collect information about what EIMO assistance is needed when performing scenarios. Test out different types of procedural guidance. Collect user experience information.

CONCLUSIONS

- Investigation of customized integrated medical technology provides a method for better understanding the needs of Earth-independent exploration spaceflight medical systems.
- Optimized, streamlined medical systems, containing necessary functionality and supporting information, while fitting within mission and vehicle constraints, will help to maintain crew health and performance, which is necessary for achieving mission success.

REFERENCES

[1] M. Thompson et al., Identifying and Closing Medical Capability Gaps for Human Spaceflight Missions Beyond Low Earth Orbit. *Aerospace Medicine and Human Performance* 94 (4): 237, 2023.

[2] E. Antonsen et al., Estimating medical risk in human spaceflight. *npj Microgravity* 8 (1), 2022.

[3] C. Haddix et al, Evaluating multi-functional integrated medical devices: insights from ground demonstrations, NASA HRP IWS, Galveston, TX, 2025.