Medical Data Architecture
Capabilities and Design

C. Middour\textsuperscript{1}, M. Krihak\textsuperscript{2}, A. Lindsey\textsuperscript{3}, N. Marker\textsuperscript{4}, S. Wolfe\textsuperscript{3}, S. Winther\textsuperscript{5}, K. Ronzano\textsuperscript{5}, D. Bolles\textsuperscript{3}, W. Toscano\textsuperscript{3}, and T. Shaw\textsuperscript{3}

\textsuperscript{1}Millennium Engineering and Integration Co, NASA Ames Research Center, Moffett Field, CA
\textsuperscript{2}Universities Space Research Association, NASA Ames Research Center, Moffett Field, CA
\textsuperscript{3}NASA Ames Research Center, Moffett Field, CA
\textsuperscript{4}SGT Inc., NASA Ames Research Center, Moffett Field, CA
\textsuperscript{5}Wyle Laboratories, NASA Ames Research Center, Moffett Field, CA

2017 NASA Human Research Program Investigators’ Workshop

24 January 2017
Overview

- Project Background
- Objectives/Challenges
- System Overview
- Integrated Devices
- Current Status/Next Steps
Project Background

ExMC Element Risk
Risk of Adverse Health Outcomes & Decrement in Performance due to Inflight Medical Conditions

MDA Need
ExMC Gap Med07: We do not have the capability to comprehensively process medical-relevant information to support medical operations during exploration missions.

MDA Goal
The MDA project will develop capabilities that support autonomous data collection, and necessary functionality and challenges in executing a self-contained medical system that approaches crew health care delivery without assistance from ground support.
MDA Project Objectives

• Develop a system to comprehensively manage and process medically-relevant information to support medical operations during exploration missions

• Build a series of test beds that incrementally add capability

• The system will provide the data architecture foundation to:
  – Facilitate autonomous data collection
  – Promote seamless communication with medical and non-medical devices
  – Accommodate data streams in varying formats
  – Provide data management capability for medical operations
Challenges

• Implement NASA Space Flight Human-System Standard NASA-STD-3001
  – Level of Care V: “A high level of potential risk exists that personnel may experience medical problems on orbit at some time during the mission.”
  – Increasing levels of autonomous care

• Limited Resources
  – Medical knowledge and skills (Integrated data/knowledge management)
  – Supplies and equipment
  – No resupply

• Autonomous Crew Medical Operations
  – Delayed communications
  – No ability for medical evacuation

• Accommodate future technologies
Test Bed 1 Overview

Test Bed 1 Objectives

- Demonstrate data flow autonomy
- Establish data architecture foundation
- Develop a scalable data management system
- Utilize modular design and standardized interfaces

Collect Data
- Astroskin
- Cardiax
- Dose tracker
- CMO data input

Store Data
- Database population
- Medical history
- Biosensors’ measurements
- Medication consumption

Provide Information
- Display patient medical record
- Display vital signs

Demo
MDA Test Bed 1 Functional Block Diagram

- Modular design
  - Layers allow for organization of code and components
  - Biosensor device adapters are modular
- Subsystems separated by interfaces
  - Drop-in replacements of systems in later versions (upgrades, etc)
Software Layers

• **User Equipment Layer**
  - Standard web browser (Laptop/Tablet) - Complete
  - ECG monitor (CARDIAx) - Complete
  - Wearable biosensor vest for vital signs (Astroskin) - Complete
  - iPad application currently onboard ISS (Dose Tracker) - Future Work

• **User Interface Layer**
  - Electronic Medical Records (OpenEMR) - In Progress
  - Search and display of biosensor data - In Progress

• **Analytical Layer**
  - Data reduction: reduce streams of heart beat events to a single number - In Progress
Software Layers

- **Storage Layer**
  - Data API - Complete
    - Stores/retrieves biosensor data
    - Backed by relational and time series databases (MySQL, OpenTSDB, HBASE)

- **Data Sources Layer**
  - Software supporting
    - CARDIAX - In Progress
    - Astroskin - Complete
    - Dose Tracker - 1.1 Release
    - Crew Data Importer - In Progress

- **Infrastructure Layer**
  - Server(s) - Complete

- **Discovery and Analytics Layer**
  - No components in Test Bed 1
System Overview

• Integrates biomedical devices with medical records system
  – “Vitals” and ECG data are automatically populated into EMR

• Software deployment options for development, laboratory and analog testing
  – Hardware (stand-alone servers, “cloud” systems, laptops)
  – Operating System (UNIX, Mac, Windows)

• Automated software build
  – Pre-configures with a standard load of patient data
  – Reduces manual data entry

• Uses open-source components

• NASA Class C software and process
Medical Records System

- Lightly modified open source Electronic Medical Records system “OpenEMR”
  - Integration with biosensor data for auto-populating and plotting data
  - Remove links to insurance billing

Screen captures of patient data entry demonstration

Ultrasound of lumbar spine
**Devices**

**Astroskin**
- Wearable garment-based monitoring system
- Sensors: Accelerometers, 3-lead ECG, respiration, \( \text{SpO}_2 \), Systolic Blood pressure, skin temperature

**CARDIAAX**
- Wireless, 12-Lead ECG
- ECG Glove: Built-In lead wires attached to pre-positioned electrodes

**Dose Tracker**
- Collects ISS crewmember medication
  - Usage, dosage, frequency
  - Side effects
Current Status

• Passed gate reviews
  – System Requirements Review (SRR)
  – Preliminary Design Review (PDR) / Critical Design Review (CDR)
  – From the final PDR/CDR board report:
    • “As detailed in the 'Review Success Criteria Assessment’ section of this report, the project has met, as ‘successful’, all ToR-defined review success criteria.”
    • “ExMC MDA continues to employ a robust incremental phased approach to the Test Beds 1-4, and has documented its technical architecture and allocation of requirements, developed in conjunction with customer’s requirements.”
  – Currently in implementation phase
Test Bed 1 in the Lab

ExMC staff execute demonstration at ARC

ExMC staff execute demonstration at ARC
Next Steps

• Scoping potential “Test Bed 1.5” (not baselined)
  – Operate in cooperation with habitat evaluations
    • Integrate exercise device(s)
    • Provide biosensor “telemetry” to spacecraft simulators
• Test Bed 1 Demo – April 2017
• Test Bed 1.0 Release – June 2017
  – Patch Release 1.1 – August 2017 (with Dose Tracker)
• Test Bed 2.0 Scope Completion – July 2017
• Test Bed 2.0 SRR – August 2017