Medical Data Architecture
Capabilities and Design

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Overview

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

ExMC Element Risk
Risk of Adverse Health Outcomes & Decrements 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

Data Collection

- Astroskin
- Cardiax
- Dose tracker
- CMO data input

Data Storage

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

Data Display

- 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 (CARDIA) - 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, SpO₂, Systolic Blood pressure, skin temperature

CARDIAX
- 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