



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

Collect Data

- Astroskin
- Cardiax
- Dose Tracker
- CMO Data Input

Store Data

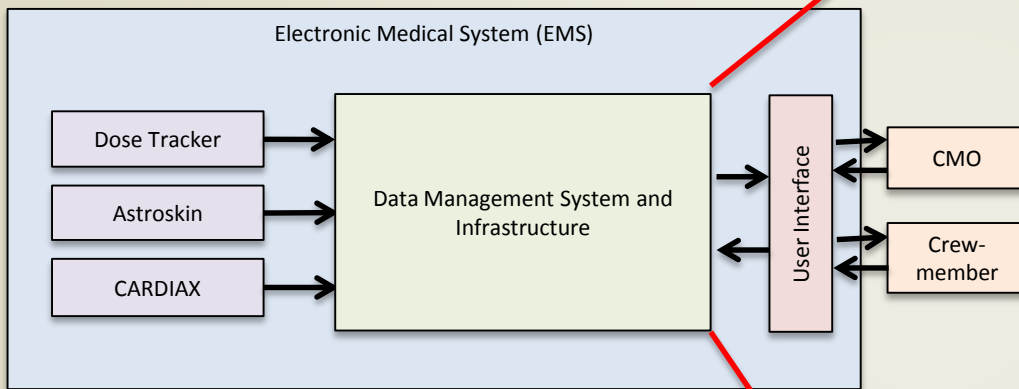
- Database Population
 - Medical History
 - Biosensors' measurements
 - Medication consumption

Provide Information

- Display Patient Medical record
- Display Vital Signs

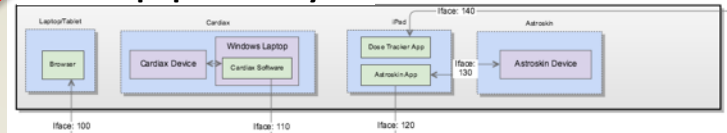
Demo

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)

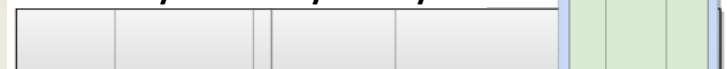
User Equipment Layer



User Interface Layer



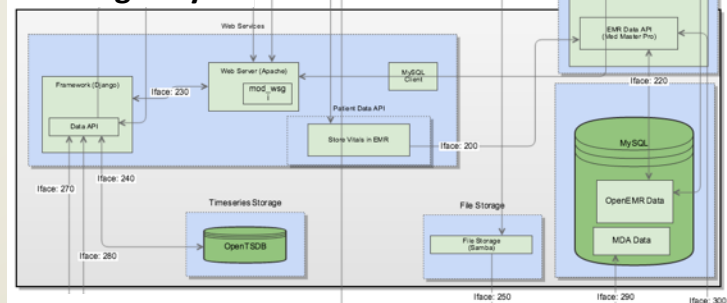
Discovery and Analytics Layer



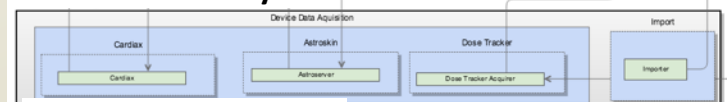
Analytical Layer



Storage Layer



Data Sources Layer



Infrastructure Layer



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**

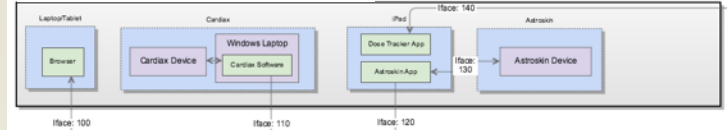
• User Interface Layer

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

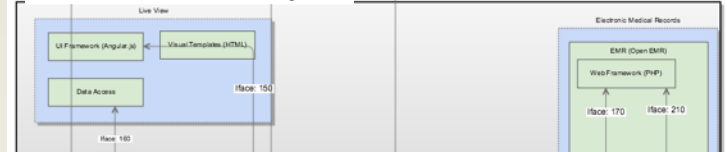
• Analytical Layer

- Data reduction: reduce streams of heart beat events to a single number - **In Progress**

User Equipment Layer



User Interface Layer



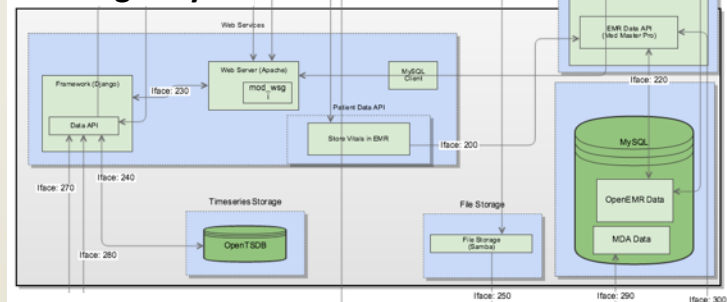
Discovery and Analytics Layer



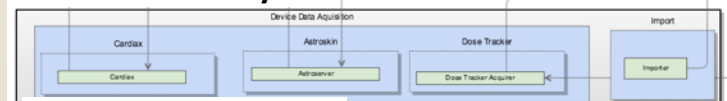
Analytical Layer



Storage Layer



Data Sources Layer



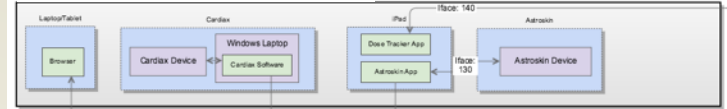
Infrastructure Layer



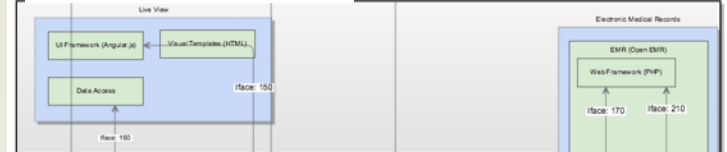
Software Layers

- **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

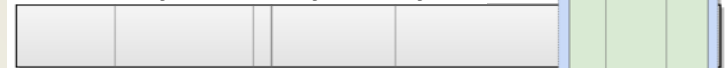
User Equipment Layer



User Interface Layer



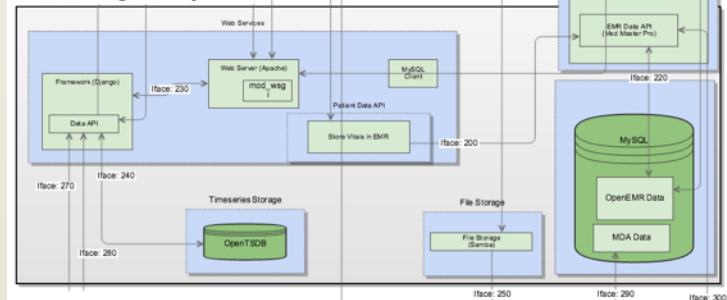
Discovery and Analytics Layer



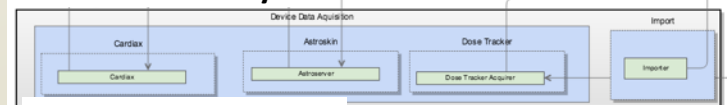
Analytical Layer



Storage Layer



Data Sources Layer



Infrastructure Layer



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

NEW PATIENT | Patient: Jared Smith (1) | Encounter History | Selected Encounter: 2016-12-01 (202)

Smith, Jared | Delete | Reset Onsite Portal Credentials

History | Report | Documents | Transactions | Issues

Edit Demographics (collapse)

Who | Contact | Choices | Employer | Stats | Misc

Name: Dr. Jared A Smith | External ID: 1
 DOB: 1961-11-26 | Sex: Male
 S.S.: 351389233 | License/ID:

Marital Status: Married
 User Defined: Jerry Smith

Edit Delete SOAP by Administrator (Collapse)

Subjective: Sub: Patient experiencing some pain and discomforting in anterior region of right shoulder. Occur when using HULK for daily exercise routine. First occurrence was three days prior. Patient describes as a low level of pain that can be felt with increased movement.

Objective: Obj: Patient's vitals are all within normal, healthy limits. Based on assessment, no major issues found. Likely a mild case of bursitis.

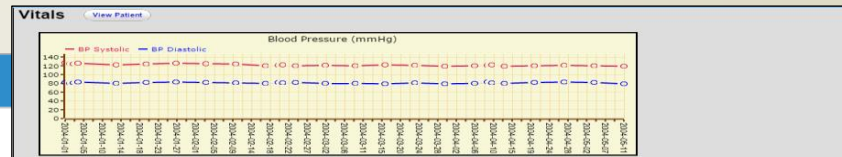
Assessment: Ass: Palpation of anterior region shows mild tenderness, but range of motion, strength, and stability are not affected.

Plan: Plan: 400mg of Naproxen for pain and inflammation twice a day for five days. Reduce level of efforts during exercise. Evaluate exercise routine. Follow up after five days.

Edit Delete Patient Encounter by Administrator (Collapse)

Reason: Scheduled private medical conference. Patient has recently completed daily exercise routine. Patient is experiencing low level shoulder pain after using HULK during exercise routine. No other complaints or concerns.

Facility: Prometheus Service

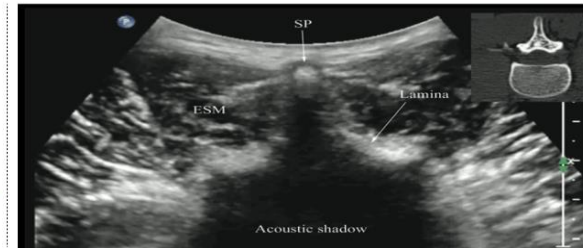


ID	Name	Unit	2004-05-11	2004-05-04	2004-04-27	2004-04-20	2004-04-13	2004-04-10	2004-04-09	2004-04-06	2004-03-30	2004-03-23
	Weight	lbs	118.00	119.00	118.00	120.00	119.00	118.00	118.00	119.00	121.00	120.00
	Weight	kg	53.52	53.98	53.52	54.43	53.98	53.52	53.52	53.98	54.88	54.43
	Height	in	62.10	62.10	61.60	61.60	61.60	61.65	61.65	61.65	61.70	61.70
	Height	cm	157.73	157.73	156.46	156.46	156.46	156.59	156.59	156.59	156.72	156.72
	BP Systolic	mmHg	119	120	121	120	119	122	121	120	119	121
	BP Diastolic	mmHg	79	82	83	82	80	81	83	80	79	81
	Pulse	per min	50	51	50	51	50	51	52	51	50	50
	Respiration	per min	20	19	19	19	18	18	18	18	19	18
	Temperature	F	98.80	98.70	98.60	98.70	98.70	98.60	98.80	98.70	98.60	98.50
	Temperature	C	37.11	37.06	37.00	37.06	37.06	37.00	37.11	37.06	37.00	36.96
	Temp Location		Oral	Oral	Axillary	Oral	Axillary	Oral	Oral	Oral	Oral	Axillary
	Oxygen Saturation	%	23	24	22	23	23	22	23	22	23	22

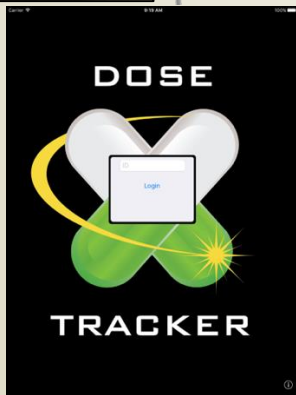
Documents

Categories (Collapse all)

- Advance Directive
- CCD
- CCR
- Lab Report
- Medical Record
- Patient Information
 - Patient ID card
 - Patient Photograph
- 2004_April
- 2004_February
- 2004_January
 - 2004_January_01
 - 2004-01-01 Keratitis
 - 2004-01-01 Lumbar_Spine
 - 2004_January_20
- 2004_March



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