



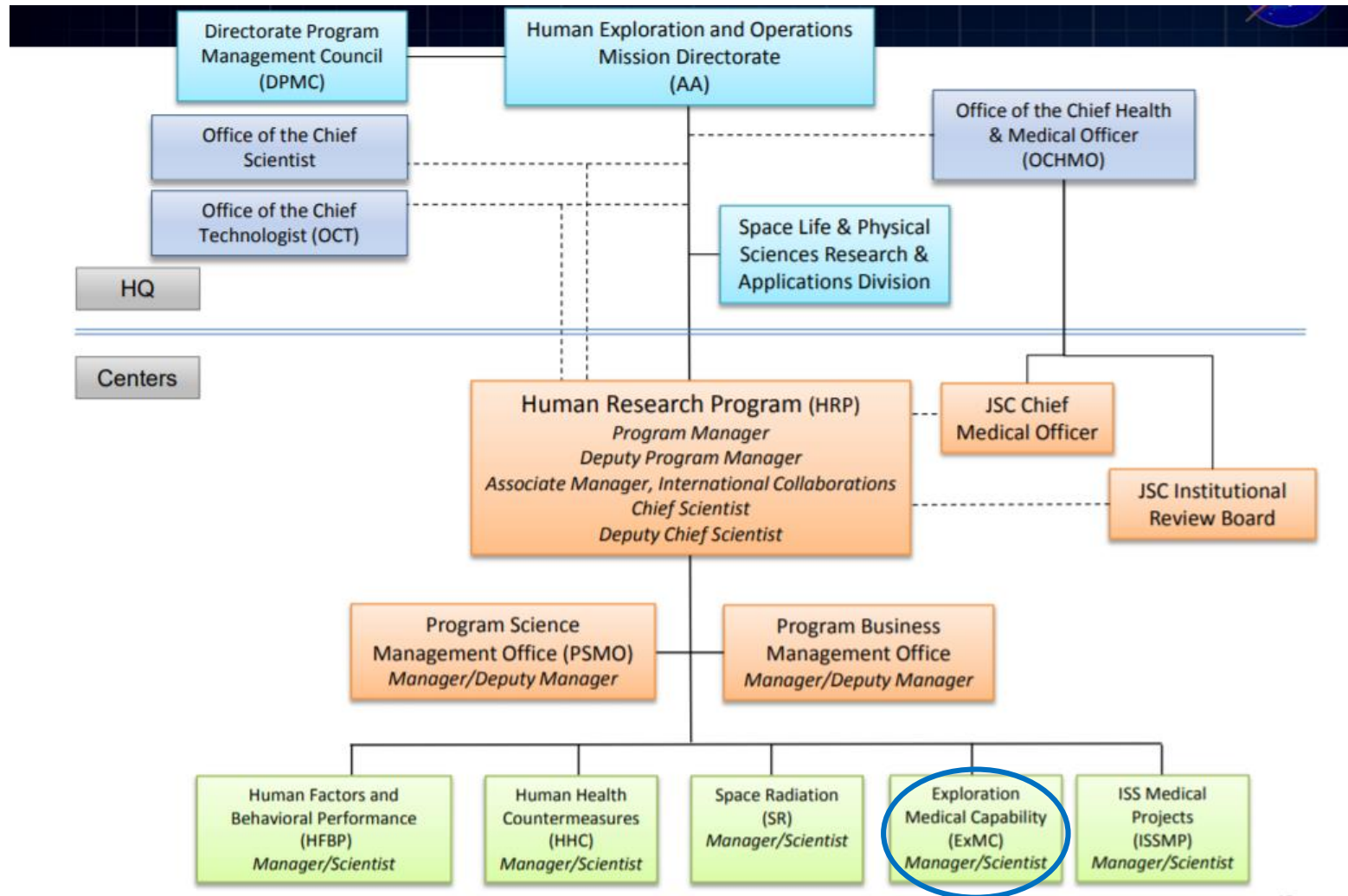
On-Astronaut Wireless Sensor System (OAWSS) to Support Crew Health Monitoring for Exploration Missions

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- **Human Research Program – Structure and Mission**
- **Exploration Medical Capabilities Element**
- **Biosensor Technologies - Past & Current**
- **Emerging Technologies – Tech Watch**
- **Biosensor Needs for Exploration Missions**
- **Commercial Biosensor Technologies**
- **OAWSS – Measures and Advantages**
- **Medical Data Architecture – Capabilities and Components**
- **OAWSS – Technology Demonstration**

Human Research Program Structure



To enable space exploration beyond Low Earth Orbit (LEO) by investigating the specific **risks to astronaut health & performance.**

Objectives:

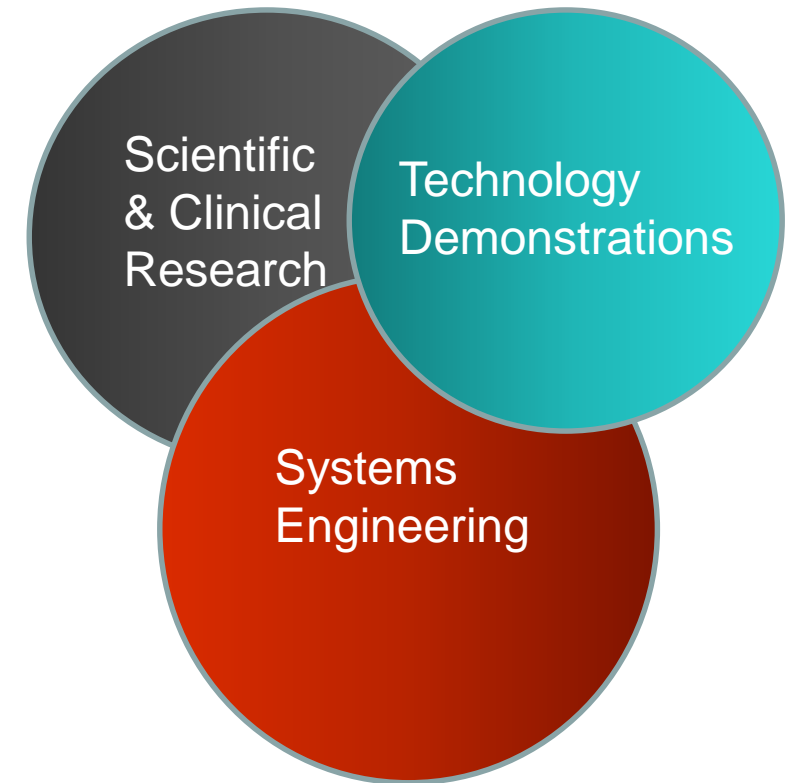
- 1. Develop necessary countermeasures and technologies** in support of human space exploration, focusing on mitigating the highest risks to crew health and performance.
- 2. Develop technologies to reduce medical and environmental risks**, to reduce human systems resource requirements (mass, volume, power, data, etc.), and to ensure effective human-system integration across exploration systems.
- 3. Maintain core competencies necessary to enable risk reduction** in the following areas: space medicine, physiological and behavioral effects of long-duration spaceflight, space environmental effects on health and performance; and space human factors.

Exploration Medical Capabilities (ExMC) Element



Goal: To establish methods of monitoring and maintaining astronaut health and advancing technologies that identify, prevent, and treat any health threats that may occur during exploration missions

- **Scientific & Clinical Research** to update standards and develop medical system requirements
 - Radiation Risk
 - Renal Risk
 - Bone Fracture Risk
- **Tech Demos** to validate medical system requirements & inform specifications
 - Imaging-Flexible Ultrasound
 - Biosensors for Medical System
 - Medical Data Architecture
- **Systems Engineering** to create & trace medical system requirements & specifications
 - Human System Concept of Operations
 - Crew Health & Performance Con Ops and Functional Requirements
 - Medical System Con Ops and Functional Requirements



Biosensors - Past and Current

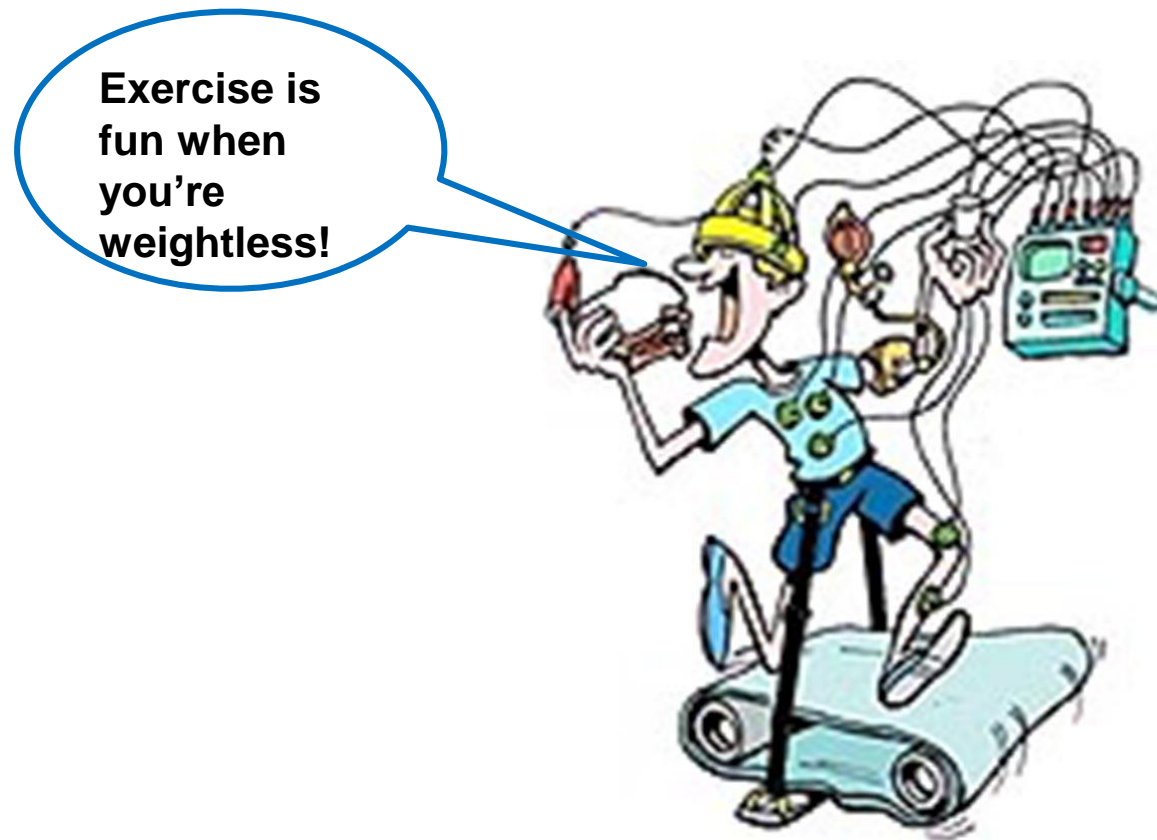


Shuttle

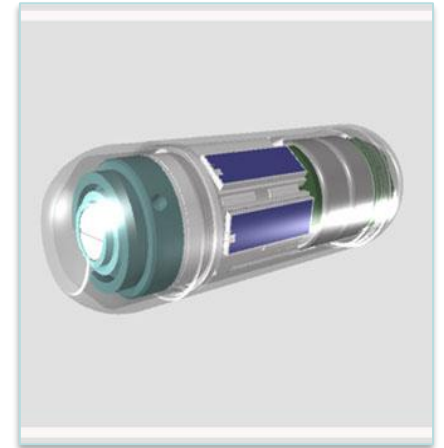
ISS



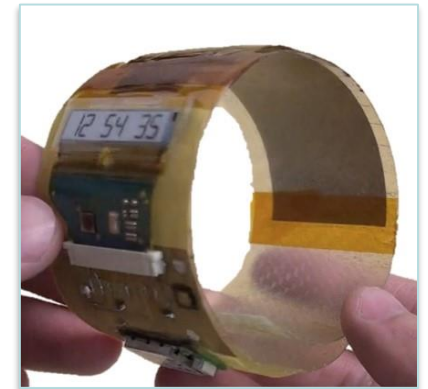
Crew Fitness Evaluation



- textiles with embedded sensors
- stretchable biosensor platform (electrochemical tattoo)
- swallowable capsule (3D images of GI tract)
- wearable watch devices
- point of care devices
- **wireless patch sensors**



- MEMS nano-sensors
- body area networks
- flexible rechargeable batteries
- piezoelectric generator



Biosensor Needs for Exploration Missions



- accurate
- non-invasive
- requires low amount of consumables
- compact /low mass
- long battery life
- multifunctional (includes all key parameters)
- **mobile/wireless**
- can be worn and operated by single user
- can measure, store and transmit data

Recent trend is to utilize commercially available devices as much as possible.

Intra-Vehicle Activity (IVA)

- ***Electrocardiogram***
- ***Heart Rate***
- ***Blood Pressure***
- ***Pulse Oximetry***
- Respiration Rate
- Body Temperature
- Accelerometry (activity)

Extra-Vehicle Activity (EVA)

- ***Heart Rate*** > metabolic rate
- Body Temperature

parameters measured on ISS with four separate devices

Commercial Biosensor Devices



Omron Wrist Cuff

Measures: pulse rate, diastolic & systolic blood pressure

- 3 readings in 10 minutes
- syncs with smartphone



Pulse O2

Measures: heart rate, blood oxygen, accelerometry

- two week battery life
- syncs with smartphone



Dash Ear Buds

Measures: heart rate, blood oxygen, body temperature

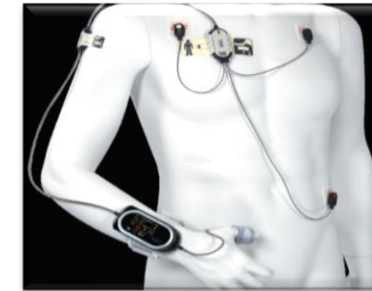
- 4GB internal storage
- syncs with smartphone



Equival

Measures: ECG, heart rate, respiration rate, blood oxygen, skin temperature, accelerometry

- syncs with smartphone



ViSiMobile

Measures: ECG, heart rate, respiration rate, blood oxygen, skin temperature, accelerometry, systolic BP

- syncs with smartphone



Astroskin

Measures: ECG, heart rate, respiration rate, blood oxygen, skin temperature, accelerometry, systolic BP

- syncs with smartphone

Commercial Wireless Skin Patch Sensors



IsanSys Lifetouch

Measures: ECG (single lead), heart rate, respiration rate

- 4-day wear duration
- 24-hour storage on sensor



Vital Connect Vital Patch

Measures: ECG (single lead), heart rate, respiration rate, skin temperature, accelerometry

- 5-day wear duration
- 10-hours storage on sensor

Benefits:

- greater freedom of movement
- eliminates signal loss from cable detachment
- eliminates need to fit garment or harness
- enhance comfort
- long-term monitoring
- minimize interference in performance of tasks

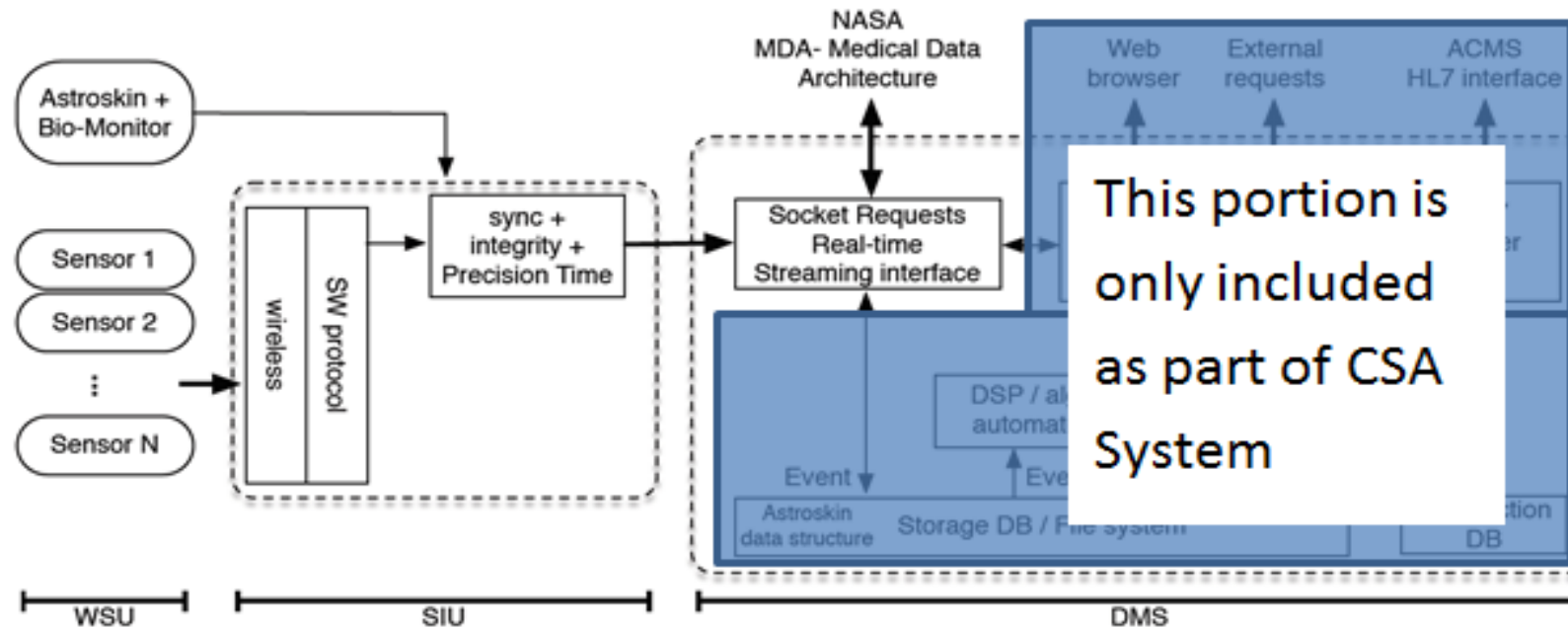
Interoperability & Integration Concerns



- **variety of physiological monitor classes**
 - cardiac, hemodynamic, respiratory, blood glucose
- **each device contains sensors, processing component, display unit, communication link**
- **demonstrated interoperability of cardiac and respiratory monitoring**
- **dedicated DSP display unit is needed**
 - small, portable, multi-parameter continuous monitoring

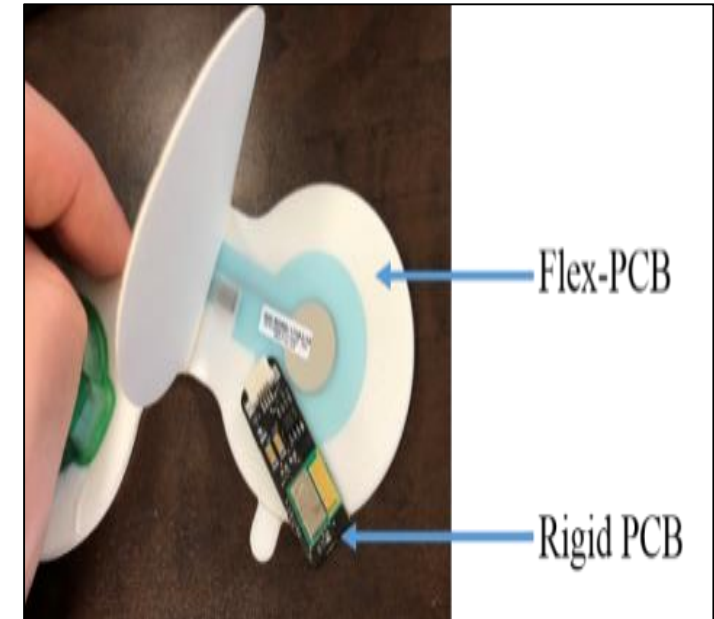
System includes:

- a set of biosensors (WSU) attached to the body
- sensors powered by lithium coin cell
- electronic circuit encapsulated to protect from moisture ingress
- sensor data communicated to sensor interface unit (SIU) via Bluetooth LE
- mobile app enables real-time data transfer to medical data system



Source: Courtesy of Carre Technologies

| Sensor | Parameter | Location on body |
|--------|---------------------------|------------------------|
| 1 | ECG – Heart Rate | Left side subcostal |
| 2 | O ² Saturation | Behind ear or forehead |
| 3 | Galvanic Skin Response | Wrist |
| 4 | Body Movement | TBD |
| 5 | Skin Temperature | TBD |
| 6 | Respiration Rate | Side subcostal |



Wireless Skin Patch Sensor

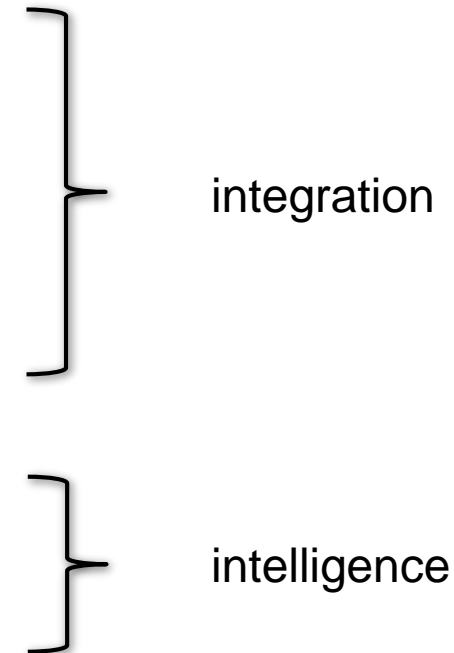
- wireless miniaturized skin patches
- plug and play add-on sensors
- transmit **real-time** multiple physiological parameters
- approx. shelf-life 3-years
- acquires data continuously for 7 days
- no skin irritations
- can wear inside space suit (EVA)
- dynamic and flexible user interface (smartphone or tablet)
- track and trend heart rate during critical mission tasks
- **integrates with a medical data system**

What is Medical Data Architecture (MDA)?



Integrated medical data system that will *assist CMO* in the provision of medical care to astronauts on future exploration missions. MDA under development at NASA Ames Research Center

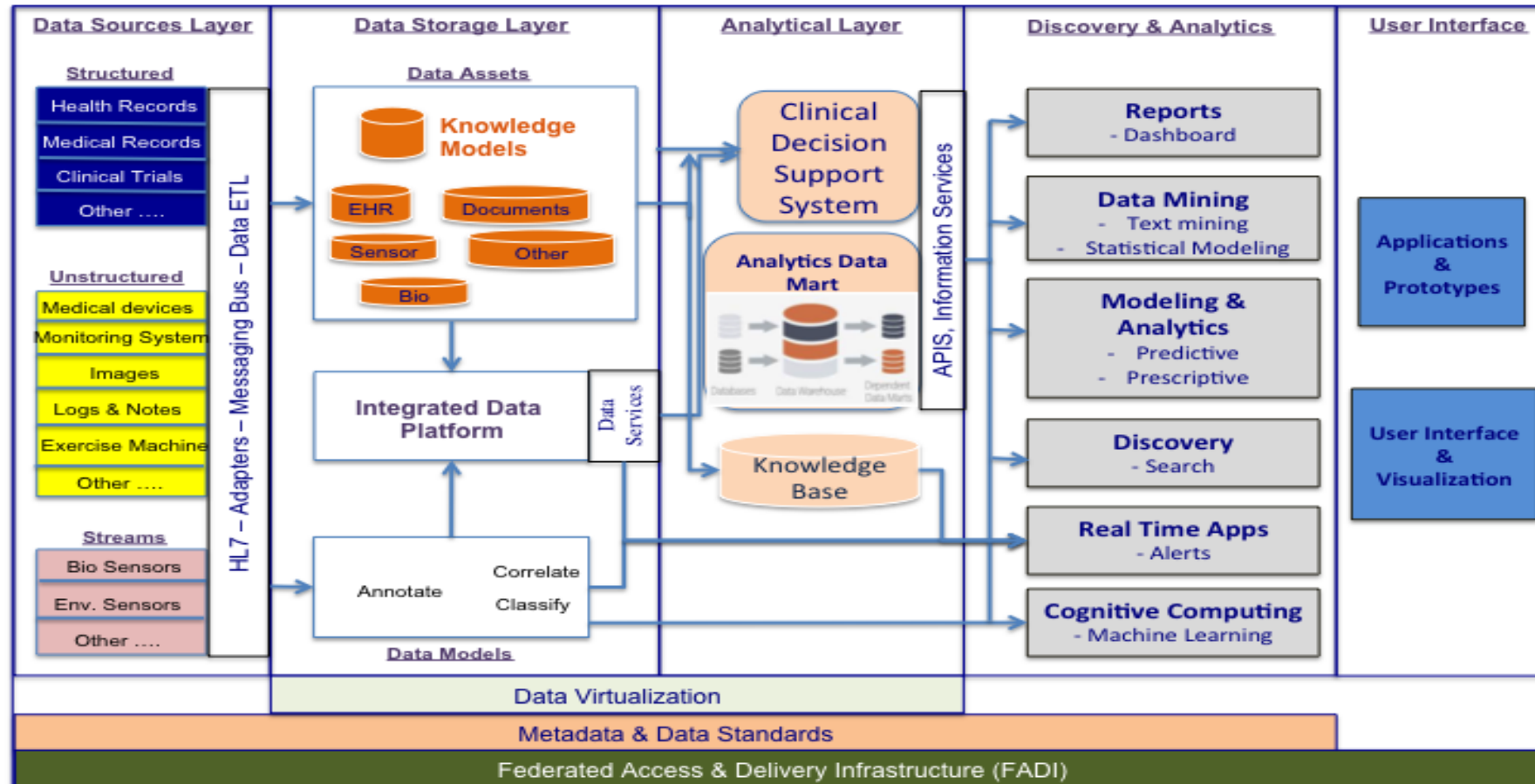
- Acquire health data from medical devices
- Provide central management of health data
 - Automate data collection, management and communication tasks
 - Reduce time to access and manipulate data
 - Allows for scalability and interoperability
- Provide for more efficient decision making
 - Reduced time for diagnosis and treatment
- Determine potential diagnosis/treatments
- Health monitoring and early onset detection
- Manage medical consumables



MDA System Components



MDA is a modular collection of software components, and networking and storage equipment designed to perform data computation tasks that are integrated to function as a system.



Goals:

- advance biosensor monitoring capabilities to support crew health and performance during future exploration-class missions
- provide critical biosensor data for diagnosis and treatment of medical conditions
- facilitate evaluations of crew fitness, health and readiness for mission operations

Specific Aims:

- evaluate OAWSS performance during simulated exploration activities
 - exercise
 - EVA tasks
 - spatial disorientation simulator
- integrate OAWSS measures with MDA
- validate OAWSS signal quality relative to gold standard measures
- assess OAWSS user operability and comfort

Thank you

