NASA, We have a data problem! ExMC and Bioinformatics

EVA Technology Workshop 2017

October 17, 2017
Marlei Walton, PhD, MSE
Exploration Medical Capabilities
What are our mission and goals

International Space Station

Orion Capsule

Gateway Missions
ExMC – Mission

Minimize mission medical risk through medical system design and integration into overall mission and vehicle design
1) Research
2) Risks
3) Design/techs
4) Standards
Types of Telemedicine Care

- Live remote guidance
- Live monitoring
- Store and forward
- Autonomous
Exploration EVA

Current ISS Ops

Live monitoring: reliant on ground

Mission tasks

Exploration

Live monitoring → space-based expertise

Mission tasks
Bioadvisory information
Navigation
Consumables tracking
Medical Capabilities

- Biomonitoring
- Radiation Monitoring
- Sleep Monitoring
- Flexible Ultrasound
- Pharmaceutical stability
- Laboratory Analysis
- Medical Training Platforms
- Medical Data Architecture
- Medical Systems Development
- Medical Risk Assessment
Translating to Engineering

Flight System

Crew Health and Performance

Medical

Ground System

Structures  C&DH  GN&C  Comm & Tracking  Power  etc.

Crew as Physician

Crew as Explorer or Patient
Translating to Engineering

Flight System

: Crew Health and Performance System

: Medical System

: Medical Supplies

: Reusable Supplies

: Single-use Supplies

: Medical Devices

: Imagers

: Medication Dispenser

: Lab Analysis

: Medical Oxygen Delivery

: Medical Suction

: Bio-sensors

: etc...

: Crew Health & Performance Data System

: Data Handling

: Data Storage

: Data Analytics & Decision Support

: Health and Wellness System

: Exercise System

: Behavioral Health System

: Food System

: Physiological Countermeasures (non-exercise)

: Mission Task Performance Support System

: Procedures

: Training

: User Interfaces

: Structures

: C&DH

: GNC

: Comm & Tracking

: Propulsion

: Power

: Crew Disp. & Controls

: ECLSS

: EVA Support

: Maint. & Repair

Etc...

Ground System

: Pre and Post-Flight Medical Appliances

: Ground Health and Wellness System

ExMC Scope

Researcher

Analyst

MCC

ASCR

FOD Trainer

Flight Surgeon
What are the early entry vehicle and mission medical integration needs?

- Data Architecture
- Training and Skills
- Ground Support Model Dev
- Data System Maturation
- System Integration with Vehicle
- System Testing
- Ground Support Initial Ops
- System Validation
- Ground Support Mature Ops
- Validated Flight System
- Validated Ground Support Ops
- Fully Integrated Human System
Human System Integration

From “System Engineering at JPL” training course material, June 1991.
Moving Towards Mars: Intuitive, Usable

Notional Human System Interface

Medical

Developing Decision Aids to Enable Human Spaceflight Autonomy

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Jeremy D. Frank, Kerry McGuire, Haifa R. Moses, Jerri Stephenson
NASA, because of its mission and history, has tended to be an insular organization dominated by traditional engineering. Because of the engineering problems associated with early space endeavors, the historical approach to solving problems has been that of engineering. Long duration space travel will require a different approach, one requiring wider participation of those with expertise in divergent, emerging, and evolving fields. NASA has only recently begun to recognize this insufficiency and to reach out to communities, both domestic and international, to gain expertise on how to remedy it.
ExMC – Risks

• Pharmaceutical Stability Risk
• Renal Stone Risk
• Acute Bone Fracture Risk
• Celestial dust Exposure Risk

• Medical Risk
<table>
<thead>
<tr>
<th>Med01</th>
<th>We do not have a concept of operations for medical care during exploration missions.</th>
<th>ConOps</th>
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</thead>
<tbody>
<tr>
<td>Med02</td>
<td>We do not have the capability to provide a safe and effective pharmacy for exploration missions.</td>
<td>Pharmacy</td>
</tr>
<tr>
<td>Med03</td>
<td>We do not know how we are going to apply personalized medicine to reduce health risk for a selected crew.</td>
<td>Personalized Medicine</td>
</tr>
<tr>
<td>Med05</td>
<td>We do not know how to train crew for medical decision making or to perform diagnostic and therapeutic medical procedures to enable extended mission or autonomous operations.</td>
<td>Training for Autonomy</td>
</tr>
<tr>
<td>Med07</td>
<td>We do not have the capability to comprehensively process medically-relevant information to support medical operations during exploration missions.</td>
<td>Real-time Comprehensive Data Processing</td>
</tr>
<tr>
<td>Med08</td>
<td>We do not have quantified knowledge bases and modeling to estimate medical risk incurred on exploration missions.</td>
<td>Databases and Modeling</td>
</tr>
<tr>
<td>Med10</td>
<td>We do not have the capability to provide computed medical decision support during exploration missions.</td>
<td>Real-time Decision Support</td>
</tr>
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Biosensor Integration Development
ExMC/Canadian Space Agency Collaboration

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

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- \textit{2017 NASA Human Research Program Investigators’ Workshop}