Operations to Research: Communication of Lessons Learned

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Human/System Integration Process

1. **Research**
   - *How can we do better?*

2. **Requirements Development**

3. **Operations**
   - *Lessons learned!*

4. **Verification**
   - *Were requirements met?*

5. **Requirements Integration**
   - *Negotiating project buy-in*

6. **Design**
   - *Hands-on architectural involvement*
Human Spaceflight Experience:
The Long and the Short of it…

- Characteristics of the Vehicle
- Habitat Environment
- Partial Gravity Exposure
- Countermeasure Availability
- Physiological, Medical, Environmental Data

<table>
<thead>
<tr>
<th>Flight Duration</th>
<th>Number of individual exposures</th>
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<tbody>
<tr>
<td>1 day or less</td>
<td>0</td>
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<tr>
<td>1 week</td>
<td>0</td>
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<tr>
<td>1-2 weeks</td>
<td>450</td>
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<tr>
<td>2.3 weeks</td>
<td>400</td>
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<tr>
<td>3 wk-1 mo.</td>
<td>350</td>
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<tr>
<td>1-2 months</td>
<td>300</td>
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<tr>
<td>2-3 months</td>
<td>250</td>
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<tr>
<td>3-4 months</td>
<td>200</td>
</tr>
<tr>
<td>4-5 months</td>
<td>150</td>
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<td>5-6 months</td>
<td>100</td>
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<td>6-7 months</td>
<td>50</td>
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<td>7-8 months</td>
<td>0</td>
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<td>8-9 months</td>
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<td>9-10 months</td>
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<td>13-14 months</td>
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<td>14-15 months</td>
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Operational Approach

Selection and Retention Standards

Pre-, In-, and Post-flight Monitoring

Prevention, Mitigation, or Treatment

Reconditioning, Recovery, and Reassignment
Selection and Retention Standards
Screening for disease, medical history, preventive strategies

Pre-, In-, and Post-flight Monitoring
Establish degree of bone loss, skeletal muscle loss, magnitude of cardiovascular deconditioning, medical conditions, etc

Prevention, Mitigation, or Treatment
In-flight countermeasures (exercise, nutrition, pharmaceuticals)

Reconditioning, Recovery, and Reassignment
Post-flight training regimen, return to pre-flight baseline, and flight assignment

What do we mean by that?
Apollo Program

• Health Stabilization Program
• Video monitoring
• Biosensor harness
  – $O_2$ and $CO_2$ levels
  – Temperature
  – Vital statistics
• Metabolic expenditure during EVA
Skylab Program

- Data down-linking (12-24 hours after experiment)
- Real-time biomedical research meetings
- In-flight medical unit
Shuttle Program

- Cardiovascular
- Neuroscience
- Musculoskeletal
- Radiation
- Nutrition
- Exercise
Shuttle-Mir

• 975 days on Mir, 7 astronauts
  – Norman Thagard – 115
  – Shannon Lucid – 188
  – John Blaha – 128
  – Jerry Linenger - 132
  – Mike Foale – 134
  – David Wolf – 145
  – Andy Thomas – 128
International Space Station
Data can be used to assess the individual or the population
International Space Station

ISS Exercise Hardware Availability Timeline

Constraints: Time; Money; Mass; Power; Volume
Orion Support to ISS Missions

- Transport up to 6 crew members on Orion for crew rotation
- 210 day stay time
- Emergency lifeboat for entire ISS crew
- Deliver pressurized cargo for ISS resupply
Orion Missions
More questions than answers

• How do we use previous experience to prepare for future exploration?
• Can we simply extrapolate or is the future more complex than that?
• What types of analogs are appropriate?