Laboratory Analysis Capability for the
International Space Station and
Future Space Exploration Missions

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Space Environment

- Reduced or micro-gravity
- Radiation
- Limited mass, volume and power
- Limited resources - water, air, food
- Communication lags or blackouts (isolation)
In-Flight Laboratory Analysis

Goals

• Perform Research on the ISS
• Demonstrate operations and research capability for Exploration Missions
  • Novel paradigm for flight surgeons and researchers
• Ensure astronaut health and safety due to injury or illness on extended (>30 days) human exploration missions.
• Provide biomedical diagnostics capability to facilitate the recognition and treatment of several medical conditions.
• Provide analysis capability of biological fluids (i.e. blood, urine, saliva, sweat) in any habitable location
In-Flight Laboratory Analysis

Specifications

• Minimize the equipment's mass, volume, consumables, reagents and power.
• Ease of operation; minimal training.
• Ideally, should have FDA approval, or have gone through the rigors of FDA approval type validation.
• As mission duration lengthens, an analyzer’s capability should be readily expanded through software, reagents, dipsticks and/or microfluidic cartridges.
• Short start-up time
• 3- to 5-year shelf life
In-Flight Laboratory Analysis

Operational Requirements

1. Basic Metabolic Panel
2. Blood Gases Panel
3. Hematology - complete blood cell count with 4-part differential
4. Cardiac Panel
5. Liver/Renal Panel
6. Urinalysis + urates

ALT - Alanine aminotransferase
AST - Aspartate aminotransferase
ALP - Alkaline phosphotase
# In-Flight Laboratory Analysis

## Human Research Requirements

<table>
<thead>
<tr>
<th>Analyte Class</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ions (Na, Cl, etc)</td>
<td>Na, Cl, K,…</td>
</tr>
<tr>
<td>Blood Gases</td>
<td>pH, pO₂, pCO₂, BUN,…</td>
</tr>
<tr>
<td>Small Molecules</td>
<td>Glucose, lactate,…</td>
</tr>
<tr>
<td>Amino acids</td>
<td>3-methylhistidine, GABA,…</td>
</tr>
<tr>
<td>Proteins</td>
<td>II-1, leptin, transferrin, troponin,…</td>
</tr>
<tr>
<td>Peptides</td>
<td>BNP, helical peptide P, insulin,…</td>
</tr>
<tr>
<td>Enzymes</td>
<td>ALT, AST, CK-MB,…</td>
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<tr>
<td>Fatty Acids</td>
<td>Triglycerides,…</td>
</tr>
<tr>
<td>Minerals</td>
<td>Fe, Zn, Se, Cu, Mg, P,…</td>
</tr>
<tr>
<td>Vitamins</td>
<td>Retinol, b-carotene, folic acid,…</td>
</tr>
<tr>
<td>Steroids</td>
<td>Cortisol, estradiol, DHEA,…</td>
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<tr>
<td>Lipids</td>
<td>Cholesterol, LDL, HDL,…</td>
</tr>
<tr>
<td>Metabolites</td>
<td>Bilirubin, creatinine,…</td>
</tr>
<tr>
<td>Cell Type</td>
<td>Leukocyte, WBC, hematocrit,…</td>
</tr>
<tr>
<td>Cell Markers</td>
<td>P-selectin, CD4,…</td>
</tr>
</tbody>
</table>
Near future needs for –omics research

DNA Microarray analysis
Northern blot tests
SAGE analysis (serial analysis of gene expression)
RT-PCR (reverse transcription polymerase chain reaction)
**Abbott i-STAT 1**
*Electrochemistry/immunoassay-based blood analyzer*

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
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<tbody>
<tr>
<td>• Self-calibrated, multiplexed assays</td>
<td>• Cartridges for specific panels (not necessarily those required by NASA)</td>
</tr>
<tr>
<td>• Lightweight, portable analyzer</td>
<td>• Cartridge stowage volume/refrigeration</td>
</tr>
<tr>
<td>• Small blood sample (venous or capillary), no preparation</td>
<td>• Expensive new assay development</td>
</tr>
<tr>
<td>• Space flight certified (PCBA version)</td>
<td>• Short shelf-life (up to 4 months)</td>
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<tr>
<td>• Blood gas, CHEM8, and cardio panels</td>
<td>• Results for certain measurements are inconsistent (reliability)</td>
</tr>
<tr>
<td>• CLIA, FDA approved</td>
<td>• Does not support hematology or liver panel measurements</td>
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<tr>
<td>• Wireless approved</td>
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</tbody>
</table>

*Earlier version (PCBA) iSTAT on ISS*
Current ISS Operations

1. Blood Drawn on ISS
2. Sample is centrifuged
3. Sample is frozen to wait for return
4. Samples are returned on SpaceX
5. Samples arrive back at JSC
6. Samples analyzed and results documented.
Point of Care Platforms and Multiplexing Cartridges being Evaluated at NASA/JSC in March 2013
None were successful in a blind test

DNA Medicine Institute

McDevitt Laboratory

OPKO (Claros)

DeVenCI funded

Nanomix

DeVenCI funded
Additional Technologies we are currently evaluating

**Theranos**

*Finally, a lab test that asks less of you.*

**Luminex**

![MAGPIX Layout](image)