Suborbital Research and Development Opportunities
2011 Next-Generation Suborbital Researchers Conference

March 1, 2011

Jeffrey R. Davis, MD
Director, Space Life Sciences, NASA
Novel Strategies for Problem Solving

• Discussion Topics
  – Space Life Sciences Overview
  – Strategic Initiatives
    • Visioning Workshop
    • Space Life Sciences Strategic Plan
    • Alliances Benchmark
    • Harvard Business School open collaboration/innovation
  – New Business Model
  – Opportunities for Suborbital Research
Space Life Sciences Overview

• Human health and performance in the space environment
  – Space medicine – health care and medical systems
    • Physiological and behavioral effects of spaceflight
  – R&TD on weightlessness, isolation
  – Space environmental monitoring
    • Radiation, air/water, microbiology/toxicology, food systems
  – Human Factors
    • Human centered design, ergonomics, biomechanics, food systems
• Human-centered risk assessment and risk mitigation
• Space Flight Human System standards and requirements
• Host of the ESMD/Human Research Program Office
• Strategy formulation and innovation management
2006 Visioning Workshop

HQ lead office for life sciences
- Assumption:
  - Low likelihood of returning in next 10 years
- Characteristics
  - Central budget, Fundamental research, NRA’s, grants
  - NASA funded partnerships
  - Some institutional costs provided by program

Current state
- Assumptions
  - Current resources, no growth
- Characteristics
  - Focused R+D on TRL/CRL 4-6
  - Inflation, escalation erode content
  - Little low TRL/CRL work

Minimum necessary services
- Assumptions
  - Program need to reduce costs
  - Program buy it by the yard
- Characteristics
  - Outsourcing
  - Minimal R&D
  - Few partners

Partner/shared services model
- Assumptions
  - Core capabilities not funded by institution
  - Rapid external pace of change
- Characteristics
  - Consulting, high-end expertise, Partners fill in low CRL/TRL work
  - Leverage with partners
2006 Visioning Workshop Outcome:

- Need to shift from traditional strategies and philosophies to partnerships and collaboration to achieve goals
- Break out session discussions provided basis for key strategies and goals in strategic plan

Partner/shared services model

- Assumptions
  - Core capabilities not funded by institution
  - Rapid external pace of change
- Characteristics
  - Consulting, high-end expertise,
  - Partners fill in low CRL/TRL work
  - Leverage with partners
Strategic Initiatives

• 2007 SLSD Strategic Plan

  – Mission Statement
    “To optimize human health and productivity for space exploration”

  – Vision Statement
    “To become the recognized world leader in human health, performance and productivity for space exploration”

  – Strategic Goals
    o Manage balanced internal/external portfolio
    o Drive health innovations
    o Drive human system integration innovations
    o Educate and inspire
Strategic Initiatives

• SLSD Strategic Plan 2007
  • Key strategies for driving innovation
    o Develop/implement an improved business model (collaborative approaches and tools)
    o **Establish strategic alliances/collaborative efforts**
    o **Adopt an integrated human system risk management approach**
    o Enhance internal and external communications
    o **Establish a virtual center to achieve vision**
Strategic Initiatives

• 2008-2010 Alliances Benchmark
  – Developed benchmark process to assess best practices for identifying, establishing, and managing alliances and collaborations
  – 20 organizations interviewed
    • Government agencies
    • Industry
    • Academia
Strategic Initiatives

• 2008-2010 Alliances Benchmark (cont.)
  – Responses: Why Collaborate?
    • 100% response: critical to innovate
    • Enhance portfolios by supplementing internal core capabilities with external capabilities
    • Find innovative solutions quickly and efficiently in a rapidly changing environment
  – Critical Success Factors
    • 100% response: address cultural issues: “Not invented here”
    • Unifying vision, alignment with strategy, clearly defined objectives
    • Annual planning/gap analysis
Strategic Initiatives

• Summary
  • Visioning exercise and strategic plan
  • Alliances benchmark 2008-2010
  • HBS collaborative innovation models and collaborative projects 2008-2010
  • Open innovation pilot project 2008-2010
  • Virtual center for collaboration established 2010: NASA Human Health and Performance center
  • Pursue collaborative research models 2011
  • Develop Strategic Framework for Innovation 2011
New Business Model

• A new business model is required to infuse open collaboration/innovation tools into existing models for research, development and operations (research announcements, procurements, SBIR/STTR etc)

• Components of a new model
  – Strategic visioning and planning with annual review
  – Portfolio definition – what work are you trying to achieve?
  – Portfolio analysis to determine when to collaborate and the optimal collaborative strategy
  – Establish decision framework for using novel and established approaches (tools)
  – Evaluate with metrics / reassess on an annual basis
  – Organize to fully implement collaborative model – NASA Human Health and Performance Center (NHHPC)
Portfolio Definition

• Human System risks for space flight (our portfolio of work)
  • Evidence based risk management system
    • Space Flight Human System Standards
    • 65 human system risks
    • Human System Risk Board formed April 2008—integrates research and operations—decisions made by one entity
  • Developed Risk Management Analysis Tool (RMAT)
    • Captures vertical “standards to deliverables” process
    • Links risks for common elements (e.g. low vitamin D levels common to several risks)
  • Subject matter experts (risk owners) identify gaps in their research and technology portfolio
  • Gaps became opportunities for open collaborative solutions
Portfolio Analysis

- Portfolio mapping – Dr. Gary Pisano, Harvard Business School (HBS)

- Workshop conducted by Dr. Pisano with NASA – Wyle leadership team July 2009
  - Analyzed 12 gaps for collaborative opportunity, those that mapped to open innovation quadrant selected for pilot projects
Portfolio Analysis: Mapping - Models of Collaboration

The Four Ways to Collaborate

There are two basic issues that executives should consider when deciding how to collaborate on a given innovation project: Should membership in a network be open or closed? And, should the network’s governance structure for selecting problems and solutions be flat or hierarchical? This framework reveals four basic modes of collaboration.

<table>
<thead>
<tr>
<th>Innovation Mall</th>
<th>Innovation Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>A place where a company can post a problem, anyone can propose solutions, and the company chooses the solutions it likes best</td>
<td></td>
</tr>
<tr>
<td>Example: innoCentive.com website, where companies can post scientific problems</td>
<td></td>
</tr>
<tr>
<td>A network where anybody can propose problems, offer solutions, and decide which solutions to use</td>
<td></td>
</tr>
<tr>
<td>Example: Linux open-source software community</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Elite Circle</th>
<th>Consortium</th>
</tr>
</thead>
<tbody>
<tr>
<td>A select group of participants chosen by a company that also defines the problem and picks the solutions</td>
<td></td>
</tr>
<tr>
<td>Example: Alessi’s handpicked group of 200-plus design experts, who develop new concepts for home products</td>
<td></td>
</tr>
<tr>
<td>A private group of participants that jointly select problems, decide how to conduct work, and choose solutions</td>
<td></td>
</tr>
<tr>
<td>Example: IBM’s partnerships with select companies to jointly develop semiconductor technologies</td>
<td></td>
</tr>
</tbody>
</table>

From Gary Pisano, Harvard Business School

Space Life Sciences
Exploring Space | Enhancing Life
Suborbital Research and Development Opportunities

• Physiological characterization of first few minutes of space flight
  • Early changes may be important to chronic changes
    • Cardiology
    • Intracranial pressure
  • Wider range of medical conditions
    • Better inform medical guidelines and standards for government programs
  • Easier access – allows physiological monitoring equipment to be worn
  • These first few minutes represent a data gap in government programs
Suborbital Research and Development Opportunities

• Environmental monitoring

• ISS will fly until 2020 and next generation environmental monitoring equipment will be needed
  • Small, portable, reliable, replaceable
  • Air, water, microbiology, toxicology
  • Suborbital vehicle could serve as an initial testbed for these devices
Suborbital Research and Development Opportunities

• Shared database
  • Centralized database for various data elements
    • Non-attributable medical data
    • Physiologic responses to flight
    • Medical issues during flight
  • Why?
    • Standardized data collection benefits risk management for suborbital operators
    • Similar database not available in commercial aviation
    • Inform medical standards of government operators
• Novel problem solving techniques and collaboration
  • Public – private partnerships for prizes
  • Can facilitate open innovation prizes among partners
  • Will briefly discuss results of open innovation challenges at NASA

• NASA Human Health and Performance Center
  • Opportunity for new members to participate in knowledge sharing, best practices, collaborative projects
  • Will briefly discuss
  • No fees or agreements to participate
Open Innovation

- Open innovation and collaboration– four pilot projects
  - **InnoCentive** - posts individual challenges/gaps to their established network of solvers (200,000)
    - financial award if the solution is found viable by the posting entity
  - **Yet2.com** - acts as an actual technology scout bringing together buyers and sellers of technologies
    - Option to develop partnerships
  - **TopCoder** - open innovation software company with a large network of solvers (200,000)
    - variety of skill-based software coding competitions
  - **NASA@work** - internal collaboration platform leveraging expertise found across NASA’s 10 centers
Welcome to the **NASA Innovation Pavilion**, which provides Solvers the opportunity to develop innovative solutions to the unique challenges faced by NASA in achieving its mission to pioneer the future of space exploration, scientific discovery, and aeronautics research. Solutions to these challenges will not only benefit space exploration, but may also further the development of commercial products and services in the fields of health and medicine, industry, consumer goods, transportation, public safety, computer technology, and environmental resources.

**Centers Participating in the NASA Innovation Pavilion**

**Johnson Space Center**

The Johnson Space Center has been home to all U.S. human space flight programs. Our scientists and engineers are engaged in research and technology development projects encompassing human health and performance, life sciences, and aerodynamics, mechanical, electrical, industrial, propulsion, chemical, and computer engineering. We are seeking new and creative ideas to enable our success as we venture beyond low Earth orbit and further explore the universe.
2900 Solvers – 80 countries
# InnoCentive Pilot: Challenge Data and Statistics

<table>
<thead>
<tr>
<th>Challenge Title</th>
<th>Ctr</th>
<th>Posted</th>
<th>Deadline</th>
<th>Proj Rms</th>
<th>Sub</th>
<th>Award Date</th>
<th>Award Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical Consumables Tracking</td>
<td>GRC</td>
<td>5/17/2010</td>
<td>7/27/2010</td>
<td>365</td>
<td>56</td>
<td>in progress</td>
<td>$15,000 (3)</td>
</tr>
</tbody>
</table>
Yet2.com

- NASA technical needs chosen based on portfolio mapping exercise
- Yet2 works with NASA technical need owner to develop statements and facilitate initial communication with contacts
- 6 technical needs in process
  - Phase 1
    - Bone Imaging
      - A clinically-useful technology with enough sensitivity to assess the microstructure of "spongy" bone that is found in the marrow cavities of whole bones.
  
  - Water Monitoring (2 components)
    - Preventing growth of and removing microorganisms and bio-films from a potable water system
    - Real-time analysis and reporting of water-borne microorganisms

- Radioprotectants for humans exposed to chronic and acute radiation
  - Biological, pharmaceutical, or dietary countermeasures to act as radioprotectants for humans exposed to higher doses of radiation, both chronic and acute
**Bone Imaging Contacts**

- **Germany**: 6
- **Austria**: 1
- **Japan**: 7
- **Canada**: 1
- **France**: 6
- **Israel**: 1
- **Australia**: 3
- **Belgium**: 1
- **UK**: 5
- **Switzerland**: 4
- **Sweden**: 1
- **USA**: 15

**Total**: 51

**Description**

**OVERVIEW**

We are seeking a clinically useful technology with high sensitivity to assess the microstructure of “spongy” bone that is found in the marrow cavities of whole bones. However, the technology must be scalable to large populations. Technological advances in the field of bone imaging, particularly in the areas of cross-sectional imaging and advanced radio-contrast agents, hold promise for making bone imaging routines a standard part of routine radiological practice. However, the assessment of trabecular bone microarchitecture is crucial, since bone tissue interferes with conventional imaging and using a more accessible area—such as the vertebrae or the elbow as a proxy for the less accessible skeletal regions—will not be accurate. A non-radioactive technology is strongly preferred.

**BACKGROUND**

The structural arrangement of tiny bones (the trabecular microarchitecture) that are found in the marrow cavities of whole bones is difficult to image. Trying to image the trabecular microarchitecture can be complicated by the presence of soft tissue. Techniques for imaging bone have been developed to assess the extent of bone mineral loss in the body, but are limited to the affected skeletal areas—such as the spine and hip in particular. In other words, measurements conducted at a site at the periphery of the skeleton may not reflect changes at a site located more centrally in the skeleton.

The recent development of cross-sectional imaging techniques, such as those used in advanced MRI and X-ray scans, has allowed for detailed visualization of bone microarchitecture. These new imaging methods, however, are limited to lesions in skeletal sites that are closer to the surface and the signal can be detected better (greater “signal to noise”) than for bones surrounded by layers of soft tissue. A similar issue...
Open Innovation- TopCoder

- Opportunity presented to NASA by Harvard Business School
  - Research project to compare outcomes of collaborative and competitive teams
  - NASA provided the problem statement
    - Optimize algorithm that supports medical kit design
- Competition began on 11/04/2009 and lasted approximately 10 days
  - 2800 solutions were submitted by 480 individuals
  - Useful algorithm developed and incorporated into NASA model
- Team felt this process was more efficient than internal development
- Next steps – SOMD (Jason Crusan) has formed a Tournament Lab with HBS and TopCoder to seek many novel optimization algorithms for ISS
**If and When Life Is Discovered on Mars, How Can We Determine If It is Truly Indigenous Mars Life?**

Challenge Award: $200 USD  
Challenge 429  
Challenge Owner: Levine, Joel S. (LARC-E303) - [Edit This Challenge](#)

Proposals are requested for protocols that would increase the certainty that any life discovered during missions to Mars is indigenous to Mars and does not result from man’s exploration of the planet surface (‘Forward Contamination’). Input from biologists and experts in habitability and planetary protection is particularly welcome.

[Read Details](#)  
[Discuss Challenge](#)
## NASA@Work Center Participation

<table>
<thead>
<tr>
<th>Center</th>
<th>Challenges Posted</th>
<th>Registered Solvers</th>
<th>Discussion Posts</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ames</td>
<td>3</td>
<td>310</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>Dryden</td>
<td>0</td>
<td>146</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Glenn</td>
<td>1</td>
<td>467</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Goddard</td>
<td>2</td>
<td>564</td>
<td>101</td>
<td>13</td>
</tr>
<tr>
<td>Jet Propulsion Lab</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Johnson</td>
<td>3</td>
<td>1380</td>
<td>46</td>
<td>29</td>
</tr>
<tr>
<td>Kennedy</td>
<td>2</td>
<td>1067</td>
<td>73</td>
<td>39</td>
</tr>
<tr>
<td>Langley</td>
<td>4</td>
<td>425</td>
<td>31</td>
<td>12</td>
</tr>
<tr>
<td>Marshall</td>
<td>0</td>
<td>700</td>
<td>23</td>
<td>14</td>
</tr>
<tr>
<td>Stennis</td>
<td>2</td>
<td>148</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td>Headquarters</td>
<td>1</td>
<td>267</td>
<td>15</td>
<td>9</td>
</tr>
</tbody>
</table>
JSC Challenges

397-Temperature Mgmt During Lunar Night
411-Non-Invasive Means Detect Internal Leak
432-Nonflam Stowage Bags
• Early Findings
  • Connected 10 NASA centers horizontally (peer to peer)
  • Connected areas of expertise previously untapped
  • Enthusiasm for the pilot and willingness to use again
  • Positive comments about NASA trying a new business model
  • Solid solutions for some technical problems
• Established October 18, 2010 – overarching goals:
  – Integrate human health and performance efforts across NASA and with member organizations
  – Advance human system research and technology, process, and practice innovations
  – Facilitate collaborative projects that enable and advance human spaceflight capabilities, and address national and global human health and performance needs
  – Resource for integration and coordination of NASA proposals, risk assessments, and requirements to inform the human exploration missions and technology needs
NASA Human Health and Performance Center

• Membership
  – 70 + members:  http://nhhpc.nasa.gov
  – Seven NASA Centers
  – International Space Station partners:  JAXA, DLR
  – Government orgs: FAA, GSA, USAF Research Labs,  two NIH Centers, FDA,  USAID
  – Academia:  FAA COE (Stanford), MIT, UTMB, Tufts, Clemson
  – Corporate:  Philips, Johnson & Johnson, Procter & Gamble, General Mills, Nike, GE, InnoCentive, Yet2.com, Cazneau, Pitney Bowes, UnitedHealth Group
  – Nonprofits:  Mozilla, Southwest Research Institute, National Center for Human Performance, San Diego Zoo, Draper Lab

• First Workshop January 19, 2011 – Collaborative Innovation: Strategies and Best Practices