Battelle
The Business of Innovation

Future Remote Sensing Opportunities

JUSTSAP 2009

Christopher J. Pestak
Battelle Memorial Institute
pestakc@battelle.org

What is the Battelle Memorial Institute?

- Non-profit, charitable trust and independent non-profit R&D corp., started operations in 1929
- Global enterprise applying science and technology to real-world problems in:
  - Energy
  - Environment
  - Health & Life Sciences
  - National Security
- Managing machinery of scientific discovery and innovation

  ORNL PNNL LLNL

  BNL INL NREL
- Bringing new technologies to international marketplace
- Promote STEM education for preparation of the future workforce

- Generates $5.2 billion annually in global R&D
- Oversees over 20,000 employees in 130 locations worldwide

Battelle's Interests in Space

Application of Space-Based Remote Sensing to Major Societal Issues

- Agriculture and Fisheries Management
- Water Resources Management
- Community Infrastructure Planning
- Disease Vector Tracking/Modeling
- Improving Energy Efficiency
- Air Quality Monitoring
- Climate Change Monitoring
- Greenhouse Gas Monitoring
- Environmental Clean Up
- Disaster Prediction and Response

Enabling Space Exploration

- Human and Robotic Lunar Exploration
- Lunar Energy Architectures
- In Situ Resource Utilization on Moon/Mars
- Closed Loop Life Support

Future Energy Solutions

- Terrestrial Applications of Space Technology

STEM Education

- Space Science and Space Technology as a vehicle to promote STEM education

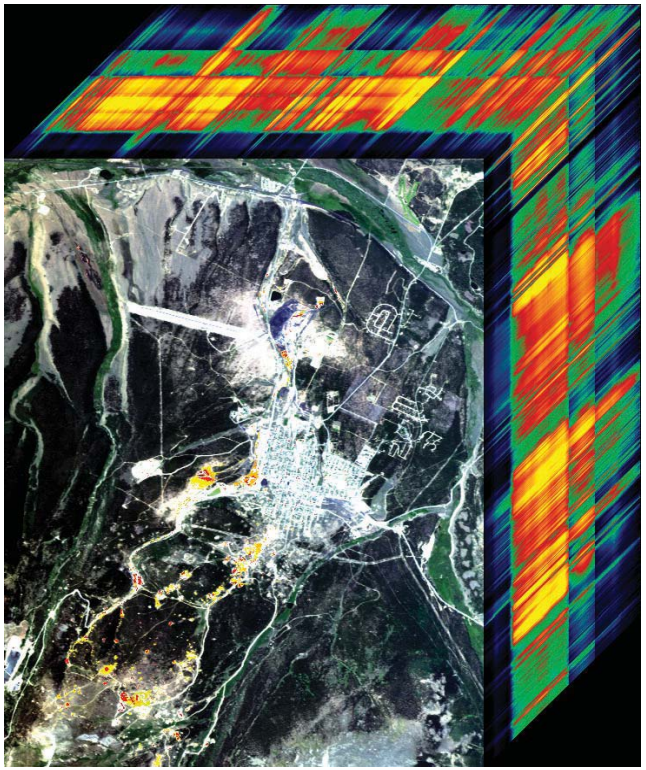
Space-Based Hyperspectral Remote Sensing

Why Pursue Hyperspectral Remote Sensing?

- **Hyperspectral is the future of remote sensing.**

- **Multispectral imagers dominate the remote sensing arena, measuring reflectance of Earth's surface material at a few wide wavelength bands.**
  - **ETM+ (Landsat 7): 8 spectral bands**
  - **MODIS (Terra & Aqua): 36 spectral bands**

- **Hyperspectral imagers measure reflected radiation in narrow and contiguous wavelength bands, providing <u>much more</u> information.**
  - **Combines information on the spatial characteristics of objects (e.g., shape, location, texture) with detailed information about their material characteristics (e.g., composition, abundance, state of matter).**



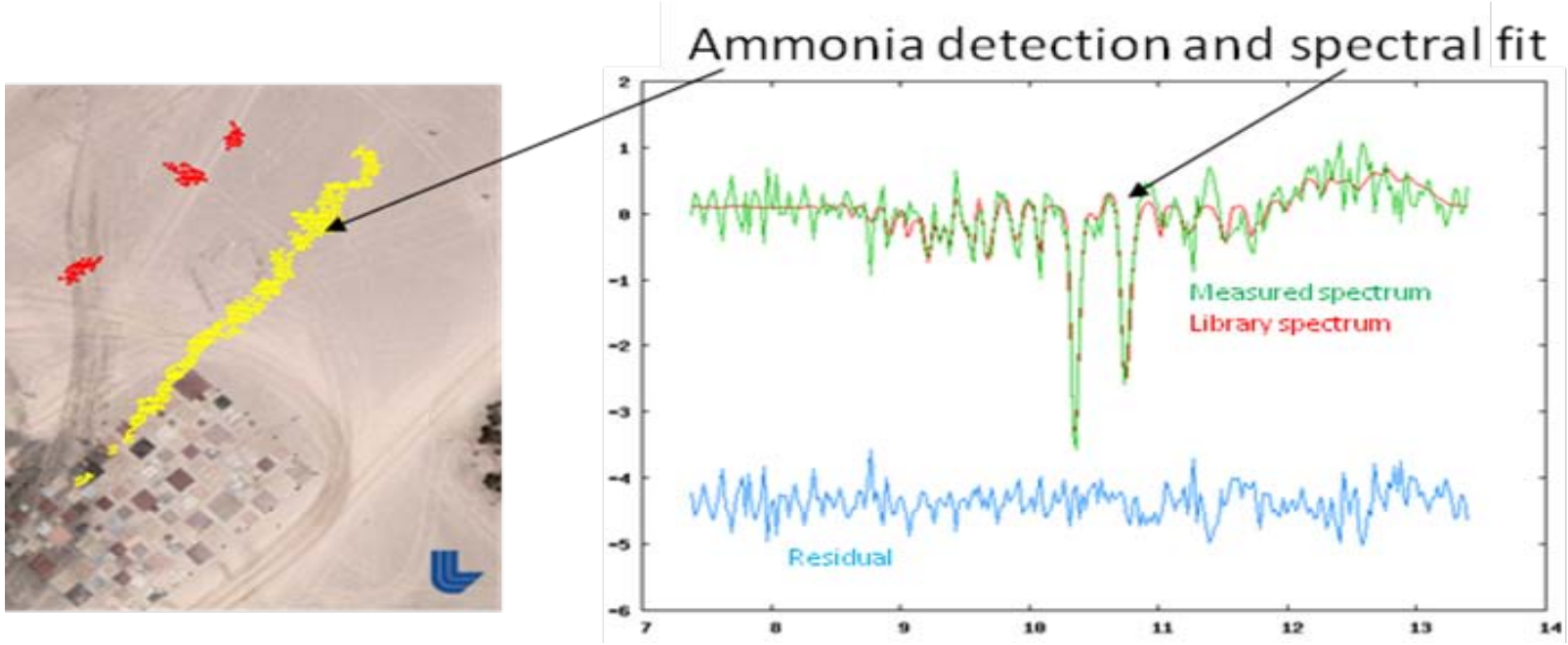
Hyperspectral representation of mining district in Leadville, CO showing acid mine drainage in Arkansas River watershed.

- **Space-based hyperspectral remote sensing is in the early stages of adoption. We've only scratched the surface on what can be achieved in the hyperspectral domain.**

- **Geospatial marketplace is growing. Hyperspectral domain is next logical expansion.**

Why Pursue Hyperspectral Remote Sensing?

- **By combining the spatial and material composition characteristics of objects, overlayed with geospatial information, hyperspectral systems can provide detailed information on what is occurring at a specific location.**



Gas Detection and Identification – False color gas plumes (left, red and yellow) overlaid onto high resolution visible image for context. Yellow plume is positively identified as ammonia gas, as evidenced by the spectral fit of the measured data compared to library spectrum.

Hyperspectral Testbed and Operational Platform (HyTOP)

Battelle
The Business of Innovation

What is HyTOP?

HyTOP is a Battelle concept for a state-of-the-art hyperspectral imaging suite and associated support equipment, located on the International Space Station (ISS).

- **Three hyperspectral imaging spectrometers fed through a common optic:**
  - **0.4 – 2.5 um: Visible and Near Infrared/Short Wavelength Infrared (VNIR/SWIR)**
  - **3.0 – 5.0 um: Medium Wavelength Infrared (MWIR)**
  - **7.5 – 13.5 um: Long Wavelength Infrared (LWIR)**
- **High data rate downlink system independent of ISS telemetry downlink**

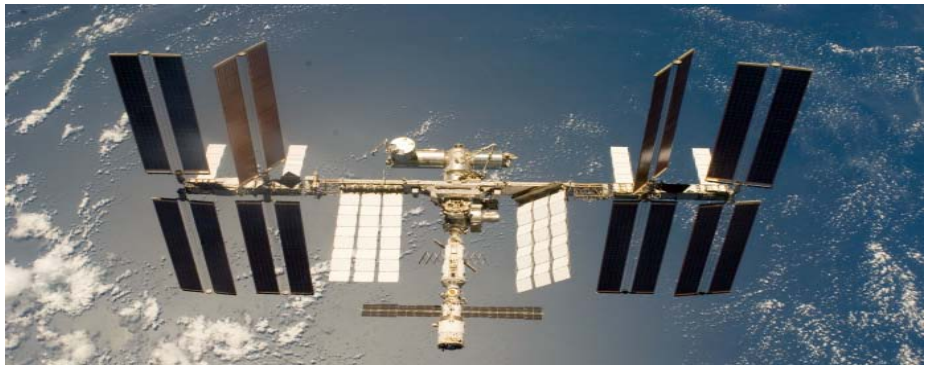
- **HyTOP can deliver 765 narrow (10-20nm) <u>co-registered</u> spectral bands**
  - **More co-registered spectral bands than have ever been available**
  - **covers all of the spectral "atmospheric windows" to image Earth from space**
  - **senses absorption bands of gases important to industry and environmental monitoring related to water quality and climate change**
- **Unique spatial resolution capability**
  - **40m Ground Sampling Distance (GSD) and 1km GSD**

Hyperspectral Testbed and Operational Platform (HyTOP)

Battelle
The Business of Innovation

Why Use the ISS?

- International Space Station (ISS) is a good platform for Earth observation
  - 220 mile altitude between +/- 52^0
  - can cover large % of Earth population
  - power and cooling provided
  - hardware can be changed out if needed
- NASA encouraging use of ISS as a National Laboratory and offering major incentives
- International cooperation on ISS is already the established way of doing business



Battelle
The Business of Innovation

What is the value of HyTOP?

As an Operational Remote Sensing System

HyTOP provides a hyperspectral Earth observing capability that currently does not exist, allowing Battelle and our partners to develop special-purpose, high-value data products for government and commercial clients in a wide range of areas.

- Agriculture, Forestry, and Fisheries
- Energy Exploration and Mining
- Inland and Coastal Water Resources
- Community Infrastructure Planning
- Disease Vector Tracking/Modeling
- Climate Change Monitoring
- Environmental Clean Up
- Disaster Prediction
- Disaster Response
- Greenhouse Gas Monitoring

For example, HyTOP would enable leadership in global climate change assessment, water resource management, and special-purpose Earth science and geospatial analyses.

As a Testbed

HyTOP could be an international asset on the ISS, facilitating the development of advanced algorithms for specific remote sensing.

HyTOP could also serve as the training ground for the next generation of Earth scientists.

Hyperspectral Testbed and Operational Platform (HyTOP)

Battelle
The Business of Innovation

Business Challenge - Where do we find $ to build and deploy HyTOP?

Viable technical and business concept.

Next step is to focus in detail on the issue of lining up investors/sponsors for the project.

- **Need better understanding of the value chain of the geospatial market for both Govt. and commercial users.**
  - **Tie specific types of applications and/or data products to specific clients**
  - **Identify and target department/persons in govt. agencies and industry who would have interest and funding authority for:**
    - **investment in HyTOP**
    - **purchase of data products that result from HyTOP**
- **Marketplace is moving from geospatial technologies to information services.**
- **Geospatial technologies and capabilities are merging into the IT industry.**

Battelle
The Business of Innovation

Business Challenge - Where do we find $ for HyTOP?

- Must establish a business model that will attract clients by delivering value and attract investors by delivering a good Return On Investment (ROI).

- Business Model 1: Consortium of govt. agencies to split the cost of dev. and ops.
  - Multi-agency approach has cost benefits to each user, but also much effort to coordinate.
- Business Model 2: Single Govt. investor
- Business Model 3: Commercial investor from the growing geospatial marketplace
  - Google and Microsoft are vying for supremacy in open-source geospatial information arena.
  - SAS is growing its line of decision support system products that utilize geospatial information
  - HyTOP has great potential appeal to these IT giants in terms of:
    - the information capabilities it could bring them
    - the notoriety/branding it could provide
    - the STEM education potential (Google & Microsoft)

Other Possible Remote Sensing Opportunities

HyTOP is one example of an advanced remote sensing concept that JUSTSAP could pursue.

What are your thoughts on other potential projects in the remote sensing area?