2005 Director's Discretionary Fund Proposal

Principal Investigator: John Bolton/420
Co-Investigators:
Proposal Title: An Autonomous Mapping and Exploration System (AMES)

Background:

Using currently available optical remote sensing instrument technology it is possible to build a compact system that can provide both digital terrain maps and spectral analysis. The advantage of having one system with common optics that can perform both mapping and remote sensing functions is that the data acquired will be co-registered. This solves the common problem of post-processing to overlay terrain and remotely sensed information. The system would be modular so that capabilities such as spectral range and spatial resolution could be changed and added as required.

This proposal seeks to investigate the feasibility of applying existing technology in an innovative way to pre-process, transmit, and extract information from large image sets and from full-spectral, remotely sensed data. The key to this approach is that only information that is collected, rather then all of the raw bytes of data, will be transmitted and saved. As an extension to this phase of the project, the possibility to extract topographic features photogrammetrically, and extract spectral features using proven techniques as a way of further reducing the data volume, would be investigated. If successful, this would allow the production of real-time topographic maps and overlaying these maps with spectrometric features. The possibility to include a low duty-cycle LIDAR ranging system for an absolute elevation reference will also be investigated. An image correlation tracking system could be added if pointing stabilization is needed.

The tools currently available for handling and processing topographic and full-spectral data will be evaluated. Techniques for handling the data in the form of spectral curves or for 3D compression of the "hypercube" will be researched and developed. The tools of information theory will be used to minimize the number of bytes required while at the same time losing none of the information content. We will see how the information obtained from an orbiting system can be most efficiently transmitted and utilized to most effectively produce the standard mapping and remote sensing data products.

Assistance on this project will be obtained from colleagues with whom I have been working on various projects related to FSI, and who I have worked with on the development of commercial hyperspectral and imaging systems. This work will be reviewed by colleagues here at Goddard, notably the participants in the EO-1 Program who have the best understanding of hyperspectral imaging. The work on mapping will be reviewed by colleagues outside Goddard who are specialists in topography and photogrammetry.

We expect that the most basic application of the Full Spectral Imaging (FSI) will reduce remotely sensed data transmission and storage requirements by at least an order of magnitude. Real-time compression of the topographic data would reduce that data volume by an order of magnitude as well. Refinement of the principles and supplementing FSI using Spectro-Spatial Compression (SSC) could produce another order of magnitude reduction. Topographic and spectral feature extraction could reduce the data volume by still another order of magnitude.

Objectives:

1) Catalog and benchmark existing topographic and hyperspectral system capabilities
2) Evaluate existing photogrammetric and full-spectral data acquisition, transmission, and processing technologies
3) Investigate currently available alternative data handling and processing systems
4) Explore and develop new photogrammetric and full-spectral concepts
5) Model photogrammetric and full-spectral systems

6) Evaluate capabilities of full spectral systems and spectro-spatial compression
7) Evaluate capabilities for topographic and spectral feature extraction
8) Develop "strawman" system design
9) Assess advantages of new and alternative systems

Research and Development Plan:

1) Define current topographic and hyperspectral state-of-the-art and data products (1 month)
2) Define current mapping and full-spectral systems state-of-the-art (1 month)
3) Research alternative pre-processing, transmission, and processing systems (5 months)
4) Develop "strawman" mapping and full-spectral evaluation systems (2 months)
5) Compare and evaluate new technology systems (2 months)
6) Compile information and prepare report on findings (1 month)

Context:

This proposed project is definitely innovative and also high risk. The risk is not primarily in the availability of technology and applications, but in the acceptance of this approach by the mapping and remote sensing communities. This DDF would allow the PI to demonstrate the feasibility and utility of full spectral imaging and on-the-fly topographic mapping, and prepare for further investigations to develop the principles. This research would be a follow-up to the well-received paper I presented at the 10th international Symposium on Remote Sensing sponsored by the SPIE entitled, "Full Spectral Imaging; A Revisited Approach to Remote Sensing". The work on topographic mapping would be a follow-up to a DDF on active stabilization of mapping systems using image correlation tracking.

The project fits perfectly with Goddard's Mission as it seeks to develop an innovative technology for Lunar and Planetary science measurements from space that will help "develop and maintain advanced information systems for the display, analysis, archiving and distribution of space and Earth science data". In addition this research could lead to advanced technologies that could help to "develop National Oceanic and Atmospheric Administration (NOAA) satellite systems that provide environmental data for forecasting and research".

Innovation Summary:

FSI is the next step beyond hyperspectral imaging. It can open the doors to major advances in passive optical remote sensing technology, in which significant advances have not been made in more then ten years. Developing FSI would put Goddard at the forefront of the development of the most widely used type of remote sensing. The technology to build a FSI system is currently available "off-the-shelf". This project will be successful if the mapping and remote sensing communities see and accept the value of on-the-fly topographic mapping and of FSI. The risk is that the community will not be willing to give up, much less change, the approaches to mapping and remote sensing that has been used for the past 30 years.

Budget:

• Analytical Software	$4,500
• Supplemental Hardware and associated Software	$3,000
• Travel	2,500
• Contractor Support	5,000
• Total	$15,000

PI Time 0.25 man-years