N91-25473

Title: **End-to-End Remote Sensing at the Science and Technology Laboratory of John C. Stennis Space Center**

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Discipline: **Land and Oceans**

The Science and Technology Laboratory (STL) of Stennis Space Center (SSC) has been developing an expertise in remote sensing for more than a decade. Capabilities at SSC/STL include all major areas of the field. STL includes: the Sensor Development Laboratory (SDL), Image Processing Center, a Learjet 23 flight platform and on staff scientific investigators.

Sensor Development - The Sensor Development Laboratory (SDL) at SSC/STL is responsible for research, development, maintenance and calibration of multispectral scanners used in remote sensing. In the area of airborne sensors the SDL has designed and developed the Calibrated Airborne Multispectral Scanner (CAMS), the Airborne Multispectral Pushbroome Scanner (AMPS), and the Airborne Bathymetric Scanner (ABS). Also, the Thermal Infrared Multispectral Scanner (TIMS) and the Thematic Mapper Simulator (TMS) were modified at the SDL to the current state of operation. The SDL also develops ground based sensor systems. The Shuttle Thermal Imager (STI) was conceived and integrated at SSC using off the shelf technology. Currently, there are seven STI units installed at KSC with eight more to be installed in the next fiscal year. It is projected more units will follow. As a follow on to the STI an Ice Detection System (IDS) has been developed and is currently being tested. The IDS will be used along with the STI to monitor conditions on the Space Shuttle prior to commit to launch.

Data Acquisition - STL maintains a Learjet 23 (LJ23) for acquiring airborne remotely sensed data. The aircraft is equipped with instrumentation necessary to provide the housekeeping information for locational and attitude data used in the analysis of the images acquired. Basic operating parameters for the aircraft are altitudes from 3,000 to 41,000 FT ASL, range approximately 1,000 nautical miles and speeds up to 400 knots. The sensor system is installed in an open bay area of the aircraft and is accompanied by a Zeiss 9in square format aerial photographic camera. With the sensor systems available on this platform data has been acquired with resolutions from 2.5 to 30 meters. The LJ23 has been deployed to acquire data throughout the USA, Canada, Central and South America. Data acquired by STL is decomutated and processed on the in house computer systems. Key to STL's data acquisition program is the rapid response status in which the LJ23 is operated. In the past mission have been requested scheduled and flown in less than 24 hours. Secondly, because of the low cost to operate the LJ23, STL has the unique capability to stay deployed on target and wait for optimal weather conditions and accomplish the mission.

Data Analysis - To meet research objectives STL has developed ELAS, an image processing software package. Originally created to process digital images acquired by the Multi-Spectral Scanner (Landsat MSS) for NASA, ELAS developed into a very flexible, general purpose tool. ELAS has been used to process data from satellite and aircraft images, images of Egyptian tomb paintings, fish scales and turtle flippers, Magnetic Resonance Imaging (MRI) images of the human head, breast and heart, aerial photographs, soil maps, gravity potential fields, topographic data, and submarine sonar images. It has been used to extract information for studies on topics such as wetlands productivity, forest stress due to drought, thermal response of forests, remote analysis of rock's silica content, compiled geographic information system/data base applications at a wide range of scales for many sites, relationship of mychorrizal involvement and the health of pine trees, and the transport of sediment in the near shore marine environment. This flexibility is inherent in the design and creation of the ELAS software.

STL has found the concept and execution of ELAS so successful and useful that over a period of more than 7 years approximately 140 man-years of programmer effort has been expended in its continuing development. Today more than 100 other organizations, federal, state, academic and private, now use the software. Also at least four companies utilize it as the basis of their commercially available image processing software.

ELAS is designed primarily to process data sets which form two or three dimensional arrays. Although there are no limitations in the software that make this a basic premise, it is convenient to conceive of these arrays as forming images or pictures. The package also has extensive ability to define and manipulate data defined in a vector format (polygons, line segments, points). There are several elements in the design of ELAS that are key to understanding its flexibility and general utility. Major features include utilization of FORTRAN for all application programs, a standard library of subroutines and single set of routines which all application programs must use to interface with the host computer, a master and slave task structure, a single format interface for the storage of almost all data, retention of intermediate results and process for the storage of almost all data, retention of intermediate results and process control information in user accessible files, and a directive and parameter driven user interface. All application programs, referred to as modules, are accomplished by single functions. Only when practical utilization of the module's primary function so requires are multiple functions placed within a single module. The modules are also order independent. In a real sense one can consider ELAS to be a very high level programming language which is designed to process arrays (images) of data.

FORTRAN is used for the application modules because of its wide spread availability and the transportability of code from one machine to another. While not perfect, FORTRAN has demonstrated longevity. To implement ELAS on a new type of computer requires creation of programs which act as the interface between the operating system and the application code. These interface programs will handle the actual I/O. These programs, which form the master task, are machine specific and should be written in a form that maximizes speed. The remainder of ELAS, which is over 99% of the software, is therefore shielded from machine variations and can be transferred on to the new computer with minimal difficulty.