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# THE ALEXIS DATA PROCESSING PACKAGE: AN IDL-BASED SYSTEM

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## INTRODUCTION

The ALEXIS experiment (Array of Low Energy X-ray Imaging Sensors; Priedhorsky et al., 1990) is a mini-satellite containing six wide angle EUV/ultrasoft x-ray telescopes. Its purpose is to map out the sky in three narrow (5%) bandpasses around 66, 71, and 93 eV. The 66 and 71 eV bandpasses are centered on intense Fe emission lines which are characteristic of million-degree plasmas such as the one thought to produce the soft x-ray background. The 93 eV bandpass is not near any strong emission lines and is more sensitive to continuum sources. The mission will be launched on the Pegasus Air-Launched Vehicle in the first quarter of 1992 into a 400-nautical-mile, high-inclination orbit and will be controlled entirely from a small ground station located at Los Alamos. The project is a collaborative effort between Los Alamos National Laboratory, Sandia National Laboratory, and the University of California-Berkeley Space Sciences Laboratory.

The six telescopes are arranged in three pairs. As the satellite spins twice a minute they scan the entire anti-solar hemisphere. Each f/1 telescope consists of a spherical, multilayer-coated mirror with a curved, microchannel plate detector located at the prime focus. The multilayer coatings determine the bandpasses of the telescopes. The field of view of each telescope is 30 degrees with a spatial resolution of 0.5 degree, limited by spherical aberration.

The data processing requirements for ALEXIS are large. Each event in one of the six telescopes is telemetered to the ground with its time of arrival and position on the detector. This information must be folded with the aspect solution for the satellite to reconstruct the direction on the sky from which the photon came. Because of the way the six telescopes scan the sky, the effective exposure calculation is also very compute-intensive. ALEXIS may generate up to 100 megabytes of raw data per day, which are converted into a gigabyte per day of processed data. The entire analysis system is built on a set of SPARCstation platforms.

## SOFTWARE OVERVIEW

While the processing job for ALEXIS is sizable, the programming staff is small. To maximize programming efficiency, and to make the best use of tools available in the public domain, we chose Research Systems Incorporated's IDL package as our software development platform. IDL was used from the start of instrument development through flight. We use IDL as a top-level executive for the processing tasks (replacing Unix shell scripts), as a device-independent graphics engine, as a database manager, and as a final data manipulator. IDL routines spawn special-purpose C programs to perform detailed telemetry deconvolution and other specialized functions.

### ALEXIS Data Streams and the End-to-End Philosophy

Early in the ALEXIS project, a uniform standard for all binary data files and streams was adopted. This standard, a self-describing record format called General Data Format or GDF, was applied to ground as well as flight software. The data streams are made up of variable-length records, each consisting of a header section comprised of three 16-bit integer words followed by a data section consisting of a variable number of bytes. The three words in the header contain a record ID, a data type, and the number of bytes in the data section, respectively. The record ID indicates the source of data. As an example it might identify with which of the six ALEXIS telescopes a record of photon data originated. The data type indicates the structure or type of data found in the data section of the record. Examples of this include: an array of integers or real numbers, or a heterogeneous data structure. The last of the three integers indicates the actual length of the data section of the record, in bytes. This record format allows heterogeneous record streams to be read by software that may not know about all of the records in the stream and can therefore pick out only those records of interest, skipping over the rest.

This uniform data standard allowed us to adopt an end-to-end system test and development philosophy. Simulation software for the ALEXIS instrument produced GDF data streams just as the flight system does. When we tested individual ALEXIS telescopes in the laboratory, the ground test equipment (GSE) also generated GDF data streams that looked as they would in flight. In this way, software developed to analyze experiment simulations could later be used for instrument testing, and then for flight operations, with little or no modifications. This aided our software development efforts a great deal. We did not have to re-write existing software to match new data formats that could have arisen at each phase of experiment planning and integration.

### Use of IDL

The ALEXIS experiment will generate up to 100 Megabytes of data per day that must be automatically processed and reduced. At the program's start, we began writing software for the project from the bottom up, writing, in the C language, Unix "filter" programs first that read gdf streams from standard input and write new ones to standard output. We debated for quite some time as to how to tie all the programs together into an automated system for processing, archiving, and plotting the flight data. Our initial choice was to write Unix shell scripts, and use a plotting package such as MONGO for graphics. After a demonstration of the IDL data processing/graphics package, we obtained a license and began experimenting with it. Considering IDL's operating system access and process-spawning capabilities, we came to the conclusion that IDL could exceed shell scripts in versatility and provide a device independent graphics capability as well. IDL would also provide a high-level, array-oriented, data manipulation functionality. Another advantage of IDL was an existing library of astronomy routines that was available from the UIT project at Goddard Spaceflight Center, an effort funded by the NASA Astrophysics Data Program.

Currently, our software design has control, or "Glue," routines in IDL at the top level. These, in turn, call specialized IDL functions which perform specific data processing tasks. These functions in turn spawn Unix pipelines of C-language data filters to do the majority of the telemetry data manipulation. Temporary files produced by these Unix filters, or the direct Unix-pipe output of the spawned processes, can be accessed easily within IDL to obtain transformed data for final results. In the next section we will discuss how the Glue routines interact with an IDL database package for production analysis control.

## Databases

All the ALEXIS database work is built on the UIT IDL astronomy library database routines. We realized that if we used a database to control the flow of production processing we could gain a great deal of efficiency in managing the data. All of the Glue routines interact with IDL databases that keep track of what has been done to each file as well as record specific characteristics of each archived telemetry file. For off-line data processing, the IDL database inquiry routines then allow easy recall of the names of specific files that match any user specified characteristics.

An example is the IDL Glue procedure to control routine full processing of flight data. The procedure receives as input a parameter file setting a number of flags, the path names of the raw telemetry file and the aspect file, and the locations where output files may be placed. The database is queried for information on which, if any, of the functions have already been performed on the designated telemetry file. Sky coverage in the file is entered into the database if it has not been entered previously. Appropriate sub-procedures are started to tag all counts with their origin in sky coordinates and to add them to cumulative sky maps. Point sources that are covered in the file are extracted from the database, and sub-procedures are started to extract count data from sky locations on or near these sources. At the end of processing, an entry is made in the database registering the tasks completed.

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