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SPACELAB DATA PROCESSING FACILITY (SLPDF) QUALITY ASSURANCE EXPERT SYSTEMS DEVELOPMENT

Lisa Basile (NASA/GSFC/Code 564)
Angelita C. Kelly (NASA/GSFC/Code 564)

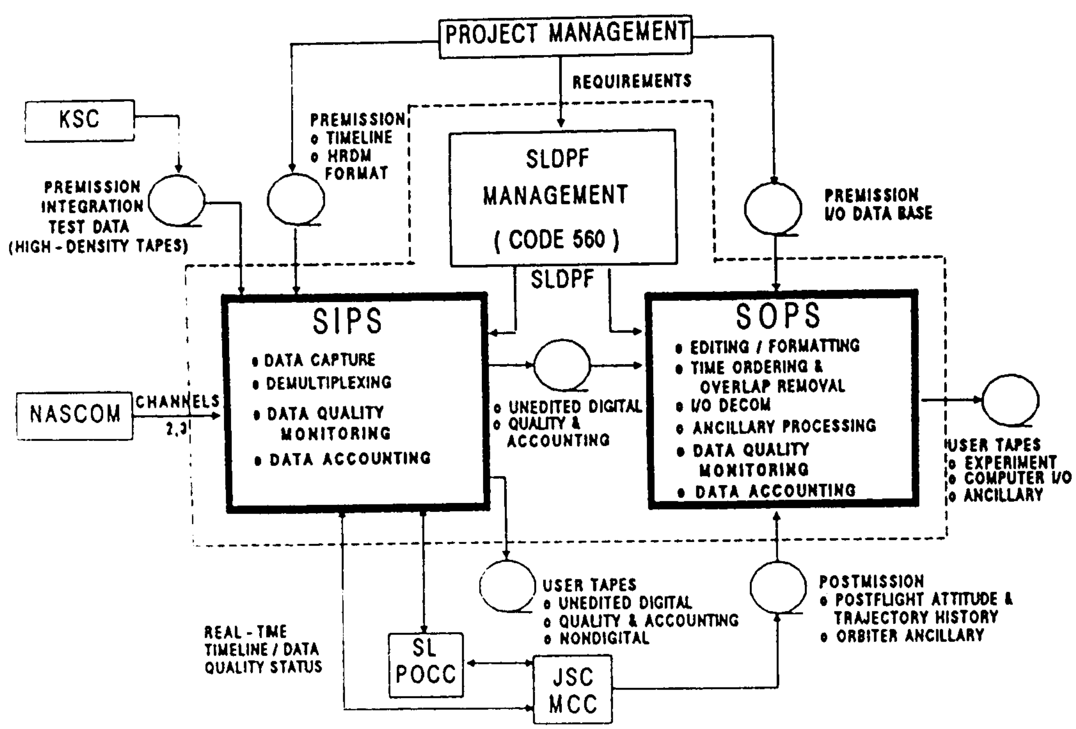
Goddard Space Flight Center
Greenbelt, MD 20771

ABSTRACT

The Spacelab Data Processing Facility (SLDPF) is an integral part of the Space Shuttle data network for missions that involve attached scientific payloads. The SLDPF has developed expert system prototypes to aid in the performance of the quality assurance (QA) function of Spacelab and/or Attached Shuttle Payloads (ASP) processed telemetry data. The SLDPF functions include the capturing, quality monitoring, processing, accounting, and forwarding of data from Spacelab and ASP missions to various user facilities. The SLDPF consists of two functional elements: the Spacelab Input Processing System (SIPS) and the Spacelab Output Processing System (SOPS). The two expert system prototypes were developed to determine their feasibility and potential in the quality assurance of processed telemetry data. The SIPS expert system, Knowledge System Prototype, (KSP), uses an IBM PC/AT with the commercial expert system shell OPS5+. Expert knowledge (from SIPS experts) emulating the duties of quality assurance analysts was implemented. In an interactive mode, a SIPS analyst responds to queries resulting in instructions and decisions governing the reprocessing, releasing or further analysis/troubleshooting of data. Released data is forwarded for further processing on the SOPS Sperry 1100/82. The data are edited, time ordered with overlapping data removed, decommutated, and quality checked before release to the user. The SOPS QA analysts isolate problems and select the appropriate action: either accept the data or request the data to be reprocessed. The SOPS expert system emulates this process by utilizing an expert system shell, CLIPS, and the Macintosh personal computer. To date, these prototypes indicate potential beneficial results; e,g., increase analyst productivity, decrease the burden of tedious manual analysis, provide consistent evaluations of data, provide concise historical records, provide training for new analysts, and expedite the operational training of Spacelab analysts. The logic implemented in the prototypes, the limitations of the personal computers utilized, and the degree of accessibility to input data have led to an operational configuration to be implemented on a SUN 3/160 Workstation. This configuration is currently under development and on completion will enhance the efficiency, both in time and quality, of releasing Spacelab/ASP data.

INTRODUCTION:

The SLDPF processes payload data from Spacelab and ASP missions. The SLDPF functions include the capture, quality monitoring, processing, accounting, and shipping of data to users. The SLDPF is composed of two functional elements: the SIPS and the SOPS. In SIPS, Ku-band channel 2 and/or channel 3 data are captured onto high-density tapes (HDTs). The primary functions of SIPS are the realtime capture, the monitoring of data for quality and status coordination with the Spacelab external interfaces such as the Spacelab Payload Operations Control Center (POCC), the Mission Control Center (MCC), and the Network elements. See Figure below. The data captured, including playback and direct access channel data, are processed to produce Spacelab Experiment Data Tapes (SEDTs) and/or Spacelab Input/Output Data Tapes (SIDTs). To assure completeness and high quality of SIPS processing, analysts currently perform quality assurance and data accounting (QA/DA) analysis by the manual evaluation of Spacelab Quality and Accounting Records (SQARs) aided with information from Spacelab reports and logs. The results of the QA analysis determine the release of SEDTs, SIDTs and Spacelab Quality and Accounting Tapes (SQATs) to the SOPS or to other users. Additional data processing is performed by the SOPS. The data are edited, time ordered with overlap removed, decommutated, quality checked, and shipped to users. The QA/DA analysis is a manual process of evaluating and correlating information from various reports and logs to determine the quality of the data and its status: release or reprocess.



SLDPF INTERFACES

Expert system applications in the Information Processing Division were first considered for their potential to expedite the SLDPF operations, in particular, the QA/DA analyst functions of both the SIPS and the SOPS. The extremely large volume of data from one mission and the short turnaround requirement for delivery to users often makes the QA/DA task demanding and tediously repetitive. The objective of the operational expert systems is to assist the analyst by making decisions and suggesting logical analysis paths based on given data quality information. The strategy formulated to accomplish the prototypes was to use commercial expert system shells, code the QA/DA knowledge bases within the shells and implement them on personal computers. The SIPS KSP uses the OPS5+ Development System with a C language interface installed on an IBM PC/AT. The SOPS Expert System (ES) prototype was implemented with the expert system building tool CLIPS and an in-house-written interface on an Apple Macintosh.

SIPS KSP:

The SIPS KSP is designed to emulate the performance of experienced SIPS QA/DA analysts in the evaluation of Spacelab data quality and accounting information. This function is currently performed through the examination of data quality and accounting reports.

The first task was to gather the analysis expertise of the QA/DA analysts to determine that this area was a practical application for an expert system. The scope of the initial effort was restricted due to the extensiveness of the application and the limitations of the prototype hardware and software configuration. Three stages of analysis were established: initial data evaluation, comparison of initial and redo processing run data, and data trends. Each can stand alone logically but need access to the data and decisions of the others. The use of a database to store data quality and accounting information as well as the decisions of each stage allows the expert system to be divided into independent modules which run with the available memory of the prototype configuration. As each module runs, pertinent data and decisions are written to report files from which database updates and printed summary reports are generated. The code for database control, the Front End module, grew to include database creation and loading, data validation, data maintenance, data selection, expert system module selection, and expert system report selection.

The rule-based expert system tool OPS5+ was used to develop the knowledge base for the KSP. The knowledge elements (rules) are in the form "IF <condition(s)> THEN <action(s)>." The KSP Stage 1: Initial Data Evaluation knowledge base consists of 201 rules; Stage 2: Comparison of Initial and Redo Processing Runs, 130 rules. Completion of Stage 3: Data Trends has been deferred to direct the use of resources to the operational system requirements definition.

The Front End interfaces with the user in the form of selection and input screens. Required responses are limited to one-keystroke if default values are selected. Page forward and backward options are provided. Data input/viewing screens are provided to allow input and data maintenance. Stage 1 interfaces with the user in the form of a running dialog. It is initiated by loading and initializing the evaluation program after entering the OPS5+ environment. Data not directly downloaded is obtained by user-query; responses are limited to one keystroke. Stage 1 generates a summary report printed on user request. The Stage 2 program, after being loaded and initialized, operates without intervention from the user; both a summary report and a detailed report are created and printed on user request.

SOPS ES PROTOTYPE:

The knowledge base for the SOPS ES prototype was developed using the rule-based expert system language CLIPS. All knowledge elements are represented in the form "IF <condition(s)> THEN <action(s)>." The knowledge base can be logically divided into sets called knowledge islands consisting of rules to diagnose a problem, drive the user interface, and to retrieve data specific to that knowledge island. A knowledge island can be modified or replaced to reflect a procedural change in SOPS without affecting the other knowledge islands; this simplifies the modification process. The prototype consists of four knowledge islands: Run Stopped Early, Data Gap Between Files, Data Coverage, and Data Quality. Each was implemented only to the detail required to realistically demonstrate the feasibility of an operational SOPS ES. The knowledge islands will be expanded for future implementation to include particulars uncovered by this prototype.

The SOPS ES prototype uses many of the standard features for applications running on the Apple Macintosh. The features include the use of multiple windows, pull-down menus, and dialog boxes. Dialog boxes and windows may contain buttons, scroll bars, or space for the analyst to type in additional information called a text field. Whenever possible, the ES will set a default value for the text fields; if the analyst changes the value of a text field, the ES performs a consistency check to prevent the entering of unacceptable values. The primary windows viewed by the analyst are the Transcript, Timeline, and Conclusion windows. The Transcript window maintains a log of the ES session containing all questions asked by the ES, the analyst's responses, all recommendations from the ES, and any analyst-added comments. The Timeline window displays the run in a graphical format with the ES's current focus of attention flagged. The Conclusion window displays the conclusions reached (rules fired) by the ES. All windows can be printed upon completion of the ES session.

CONCLUSIONS:

The prototypes show that the expert systems offer many benefits. They are fast. They are consistent. The expertise of the most experienced staff members is now made available to all. The prototypes can act as training tools when refined to a detailed level. Throughout development, ways in which current procedures could be further automated to increase accessibility to information, to improve processing speed, and to decrease the monotony of repetitious tasks were identified. Also, areas in the expert systems' own operation will be streamlined to make the expert system concept not only workable but operationally practical.

The goal of the expert system prototypes was to define the design and configuration of expert systems in the mission environment. These new operational systems will be larger, more efficient, and more automatic, incorporating the capabilities indicated by, but not present in the prototypes. Both the SIPS and SOPS operational expert system configurations will use the same hardware, the SUN 3/160 workstation, and software, CLIPS with C language interfaces, for consistency and maintainability. Network interfaces will be established to automatically transfer necessary information from the existing SIPS and SOPS mainframes to the workstations for the expert systems' analysis. It is planned that this configuration will be operational by December 1988, in time to support ASTRO-1, the first of several scheduled SLDPF missions in the post-Challenger period.

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