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The University of Alabama in Huntsville

Technical Report 5-33055
Contract No. NAS8-38609
Delivery Order No. 51
UAH Research Report No.

VALIDATION
OF
AUTOMATED PAYLOAD EXPERIMENT TOOL
(5-33055)

Final Technical Report for Period
11 September 1992 through 30 July 1995

Prepared by

Gary A. Maddux
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Huntsville, AL 35899

Prepared for

George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Marshall Space Flight Center, AL 35812

Attn: JA81 (Mr. David Jex)

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Mr. David Jex,

This report will be submitted through proper channels on 15 Aug 95. Please review and sign the statement below if it meets with your approval.

Gary A Maddux PI

8 Aug 95 Date

I have reviewed this report for technical and security purposes.

David Jex 9 Aug 95

PREFACE

This technical report was prepared by the staff of the Research Institute, The University of Alabama in Huntsville. The purpose of this report is to provide documentation of the work performed and results obtained under delivery order 51 of Marshall Space Flight Center (MSFC) Contract No. NAS8- 38609. Mr. Gary A. Maddux was Principal Investigator for this three year level of effort. Mr. David Jex of the Microgravity Experiment Projects Office provided technical coordination.

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official NASA position, policy, or decision unless so designated by other official documentation.

I have reviewed this report, dated 8 Aug 95 and the report contains no classified information.

Gary A Maddux

Principal Investigator

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1.0 INTRODUCTION

The System Management and Production Laboratory, Research Institute, The University of Alabama in Huntsville (UAH), was tasked by the Microgravity Experiment Projects (MEP) Office of the Payload Projects Office (PPO) at Marshall Space Flight Center (MSFC) to conduct research in the current methods of written documentation control and retrieval. The goals of this research were to determine the logical interrelationships within selected NASA documentation, and to expand on a previously developed prototype system to deliver a distributable, electronic knowledge-based system. This computer application would then be used to provide a "paperless" interface between the appropriate parties for the required NASA documentation.

2.0 BACKGROUND AND OBJECTIVES

The Microgravity Projects Office (MPO) of the Space Systems Office at MSFC is currently responsible for collecting and coordinating experiment/facility specifications and requirements between NASA personnel and various colleges, universities, research centers, and other public- and private-sector organizations that are selected or are requesting to fly their respective experiments on space flights. This coordination involves the communication of flight hardware requirements and the preparation and review of all documentation transpiring between NASA and the research groups. To assist and accommodate these customers of NASA, an effort was undertaken to research, analyze, and evaluate the current procedures involved in the information gathering activities associated with experiment development.

The MPO identified a need to develop a software package that will lead experiment developers through the development planning process, obtain necessary information, establish an electronic data exchange avenue and allow easy manipulation/reformation of the collected information. A MS-DOS compatible software package called the Automated Payload Experiment Tool (APET) has been developed and delivered. The APET system was designed to assist in the preparation of several NASA documentation packages including: Science Requirements Document (SRD), Experiment Requirements Document (ERD), Science Requirements Envelope Document, PPO Payload Safety Implementation Approach, and MSAD Project Plan. Several of these APET software modules were field tested with different teams from the research groups and their suggestions/comments were documented.

The objective of this task was to expand on the results of APET work previously performed by UAH and provide a modified version of the Project Plan to include the requirements of the MSFC Project Plan. The software will assist the scientist or engineer in generating the appropriate documentation on a computer platform in which they are familiar.

3.0 CURRENT ENVIRONMENT

The current environment of manual data gathering and information dissemination is excessively reliant on paper as the primary medium of transfer. This reliance on a static media adds exponentially to the complexity of a process that by its nature is elaborate. Changes to a document stored on an information media that requires physical manipulations are costly and burdensome. With no method in place to ensure that changes are incorporated throughout follow-on documents, (other than manual verification), modifications to science, experiment, safety, and other documents are more susceptible to human error than necessary.

The design, development and preparation of an experiment to fly in space are time consuming tasks demanding a great deal of technical and disciplinary knowledge. Reducing the time required to prepare an experiment and its supporting documentation is of vital interest to the Microgravity Science Applications Division (MSAD). Methods of developing and utilizing state of the art information technologies are of prime concern in simplifying the critical Principal Investigator (PI)/Payload Element Developer (PED) interface.

4.0 ACTIVITIES

The validation of the APET system began after the completion of two software modules, the Science Requirements Document (SRD) and the Experiments Requirements Document (ERD). The validation process required members of the software development team at UAH to demonstrate the software to proposed Principal Investigators (PIs), assist the PIs in using the software to create the documents and then interviewing the PIs about the quality and ease of use of the software.

4.1 Validation of the APET Software

The first phase of this contract was from September 92 through September 93. During this phase several demonstrations and interviews were conducted. A software team of three members provided several presentations of the APET system at different locations. The demonstrations were conducted at Lewis Research Center, Cleveland, OH; Marshall Space Flight Center, Huntsville, AL; and NASA Headquarters in Washington DC.

Several SRD software packages and a few ERD software packages were distributed during these presentations. A number of positive comments were received at the presentations, but there has been little feedback since these initial efforts. Follow-up attempts were made to contact these PIs, but because of flight delays, funding fluctuations, etc., few suggestions have been forthcoming. None of the members have requested help with the software. From the comments provided on the SRD software, several issues were addressed. Some dealt with the MSAD outline and some were user guide and software issues. All issues were addressed and in some cases used to improve the APET system.

At the end of the initial contract period of performance no additional suggestions or comments were returned to the UAH software team. None of the PIs were at the stage of experiment development where an ERD was required so no information about the ERD software had been received. Due to the lack of response, contracted funds were still available so a request to extend (at no additional cost) the contract until March 10, 1994 was made. This began the second phase of the contract.

During the second phase, requests were made for the development of the Science Requirements Envelope Document, the MSAD Project Plan and the Safety Data software packages. These packages are mainly used by Program and Project Managers. The demonstration of these packages opened up a new level of users. Several presentations were conducted at MSFC to demonstrate the use of these packages and to distribute copies. Possible users were contacted but most of them were more familiar with the Macintosh platform and did not show an interest in learning to use the APET system.

In January of 1994 a second request for a no cost contract extension was made for September of 1994. This is considered phase three. In February a third request was made for an extension through July 30, 1995, with additional funds for further software development. Under this fourth phase the request was made for the Project Plan software to be updated to include the MSFC MMI 7120.1 version of a Project Plan. During the development of the updated version it was requested that the NHB 7120.5 version of a Project Plan also be included. The finished updated version includes the MSAD 100-0 version, the MMI 7120.1 version and the NHB 7120.5 version. It was completed and ready for distribution in mid July 1995.

4.2 Update of APET Project Plan Software

A Project Plan is the basic planning document that describes the overall plan for proceeding with a project. Project Plans are unique to each project and the format and level of detail vary with the size, complexity, sensitivity and other characteristics of the project. The Project Plan covers the project to completion, including operational and data analysis periods.

The original version of the APET Project Plan completed answers for just the MSAD 110-0 version that is required by MSAD, however, several Project and Program Managers were asked to complete one of the other two versions as well. Therefore, a request that the software include the capability to complete the other versions would be of great help. A description of the different versions is included in the following sections. All the versions are similar in development because they require narrative answers to a specific list of questions. However, each version of the Project Plan has a different outline and requires different levels of information about the project. For example, the answer for *Safety* in the NHB 7120.5 version is broken down into subheadings, in the MSAD version it is a single answer, and in the MMI 7120.1 version it is grouped together with *Reliability and Quality Assurance*.

In response to the difference in answers, the software will maintain separate files for each answer, but will allow the user to incorporate answers from one version into another for editing. This allows the user to modify the text as needed for each version, however, the user will not have to start from scratch when completing a different version. Each version uses an outline format that allows the user to select a main heading (*Safety*), and then if applicable a subheading (*Industrial Safety*), to complete the answers. The outline approach provides the user with control over which sections they select to complete. When the user feels the document is complete, there is an option that allows the user to inquire whether all the sections have been completed and then view or print the document.

4.2.1 MSAD 100-0 Project Plan

The Microgravity Science and Applications Division (MSAD) requires that a MSAD Project Plan be submitted and approved prior to making a major commitment of resources to an MSAD project. MSAD Project Plans are to be prepared in final draft form for the Requirements Definition Review (RDR).

Plans are prepared and submitted for all flight experiments. Project Plans are reissued, modified, or amended for reflights depending on the complexity of the task. *A plan's preparation is the responsibility of the designated Project Manager at the responsible NASA center.* The Project Manager will sign the MSAD Project Plan as the preparer; the Project Scientist and the Principal Investigator will sign as concurring. The MSAD Project Plan will be signed off at the NASA center prior to submission to Headquarters by the appropriate center's authorities. When the Program Scientist and Program Manager sign to register their concurrence, the MSAD Project Plan will be submitted to the MSAD Director for approval.

The Project Manager is responsible for updating the MSAD Project Plan when significant changes occur (such as changes in scope, organization, or roles and responsibilities). This does not apply to resources, schedules or manpower, which are updated through normal budgeting and project monitoring activities. The Project Manager will establish a change control process for maintaining the MSAD Project Plan and other project documentation.

4.2.2 MMI 7120.1 Project Plan

This document contains the guidelines for preparation of MSFC Space Flight Project Plans. This instruction applies to all organizational elements of MSFC involved in the planning, definition, and preliminary design of space flight programs/projects.

Major MSFC research and development projects will be undertaken only on the basis of plans and analyses that clearly define the need and work to be done; set forth progammatic, managerial, resources and schedule implications; and provide assurance that the required technology can be made available. Project Plans will be the systematic approach to the planning, review, approval and conduct of MSFC research and development projects.

4.2.3 NHB 7120.5 Project Plan

This document is prepared by the field installation that establishes the overall plan for implementation of the project. The Project Plan emphasizes the management and programmatic aspects of the project rather than technical information, and establishes the agreement(s) between the Program Associate Administrator (PAA) and the involved FID(s) (Single Field Installation Programs), or between the Program Manager at the Host Field Installation (HFI) and the field installation project managers (Multiple Field Installation Programs).

4.3 Listing of Other APET Software

Over the course of this contract several software packages have been developed for the use of PIs and PEDs. A review of each of the packages is provided here to give a reference to the total effort provided under this contract.

4.3.1 Science Requirements Document

According to the MSAD Management Plan, "The Science Requirements Document (SRD) is the basic document which levies the science requirements on the hardware. As such, the document must first provide adequate justification for conducting the experiment in space and then delineate and justify the individual science requirements. The science requirements include the observational and environmental data requirements necessary to meet the science objectives."

The SRD is the first documentation requirement to be met by the Principal Investigator. It was also the logical beginning for the APET software. The previous version of the SRD contained 52 questions, however, the MSAD has since reviewed the questions and now the SRD section of APET consists of a query of 35 questions concerning the description of the experiment, the limitations of non-space testing, and the potential benefits from the space environment.

The answers to the 35 questions are narrative in form (other parts of APET have fill-in-the-blank or answers chosen from a list). The user has the option of answering these questions sequentially or randomly. An option also exists to answer only the unaddressed questions, so that at any time, the user can see how many questions remain. There are a number of options available to the user to make the documentation process more efficient. An example of a more efficient option is during the question/answer session, when the user has the option of viewing/editing related answers on selected questions. This adds to the consistency of the material, and provides an easier data retrieval method for the user.

4.3.2 Experiment Requirements Document

The Experiment Requirements Document (ERD) is used by the payload element developer and/or the principal investigator to define experiment requirements to be accommodated by the Space Transportation System (STS) for a given mission. The ERD is the logical follow-on document to the SRD. While the SRD justifies the need for a space environment and generally describes experiment requirements, the ERD expands on these generalities and requires specific experiment specifications.

Because of the more exacting nature of the ERD, the user faces more demands to respond to questions with exact numbers rather than narrative descriptions. Therefore, the ERD user prompts will often ask for a number or word to be selected from a limited list of appropriate answers, or supply a short (one or two word) answer to the software query. Because of the more demanding requirements of the ERD, the software has a much deeper level of complexity. Questions with a limited number of answers or questions that require logical responses (YES/NO) can be checked against previous answers to ensure that conflicting or mutually exclusive responses are not accepted. This built-in "expertise" adds much to the integrity of the user supplied data, and thus makes the information contained in the ERD more consistent and useful.

The ERD section of APET is a great deal larger than the SRD. There are twelve sections of the ERD, several of which taken separately would be as large as the SRD in its entirety. However, based on the requirements of the experiment, complete sections of the ERD can be eliminated. The ERD is also more technically complex than the SRD, containing far more terminology, acronyms, etc., than the other APET modules. Therefore, the uses of hypertext definitions, examples, graphics and hypertext reference sections are more widely used in the ERD.

The most critical of the ERD sections is the first, which deals with the experiment's functional objectives. Each experiment contains one or more functional objectives, which in turn are composed of one or more steps. Follow-on sections in the ERD refer back to and are based on the answers given in ERD Section One. The APET software helps the user by requiring that Section One be completed before these follow-on sections, and also aids by ensuring that if a functional objective is deleted, that the follow-on sections that refer to that deleted functional objective will also be deleted. Again this adds to the consistency of the material, and provides an easier documentation method for the user.

Because of the additional size and operability of the ERD the system requirements for this software package are somewhat larger than the other packages within the APET system. The ERD requires the use of at least a 486 PC with 14M (megabytes) of space on the hard drive for the software and another 1M for the data files that will be created. Of course the amount of space needed for the data files depends on the size and complexity of the project being defined.

4.3.3 Science Requirements Envelope Document

The Science Requirements Envelope Document provides an envelope or volume of science requirements for a type of experimentation that is intended to encompass the science requirements generated by individual experiments of that type. The primary purpose of the document is to provide science requirements against which hardware can be conceptualized such that later, when specific PIs are chosen, their individual requirements will fall within the requirements originally stated in the Science Requirements Envelope Document.

The Science Requirements Envelope Document is very similar to the SRD. The primary difference is not the questions, but in the user responses, where a range of values are given for a capacity rather than a discreet measurement for an experiment. To complete the Science Requirements Envelope Document, questions were taken directly from the MSAD Management Plan.

4.3.4 PPO Payload Safety Implementation Approach

The PPO Payload Safety Implementation Approach designates the safety-related activities and documentation required of individual Payload Element Developers (PED). This document is applicable to all MSFC Payload Project Office managed Space Transportation Systems (STS) attached payload missions and to all of the PEDs for those missions. STS attached payloads include Spacelab dedicated missions, middeck payloads, and partial-payload missions. A partial-payload mission is a flight that is not a Spacelab dedicated (unique) mission and is shared with other payloads. Such missions are also referred to as mixed cargo missions. Partial payloads are defined as those payloads that do not require a Spacelab module or the Spacelab igloo.

The PPO Payload Safety Implementation Approach requirements include the information required in the safety certification of instruments, facilities, Mission-Peculiar Equipment (MPE), and Instrument Ground Support Equipment (IGSE) that constitute a STS payload or payload complement for which the PPO has management and integration responsibility. This information is documented in a PED Safety Compliance Data Package and is reviewed by the Payload Mission Manager (PMM) to ensure overall payload safety. Data packages are completed for both flight hardware and ground hardware. These data packages are provided at a series of progressive reviews that require current updated and scaled data to reflect the maturity of the hardware.

Each data package has different requirements but the user's response is either to complete a narrative answer, fill in the blank or select the answer from a list. The size of the document depends on the type of experiment and the amount of detail required to fully describe the functionality and emergency procedures. The APET software provides for the variation in content.

5.0 APET SOFTWARE COMMENTS

The most valuable comments made about the APET software are not the compliments, but the criticisms. Without the customer's inputs of what is still required in the system, it would be difficult to determine the improvements necessary to make it a valuable tool for the PI and/or PED. We have looked forward to comments or suggestions that the PIs and/or PEDs would provide about all the APET software packages, but not many were received. From those that were received many have been incorporated into the specific software packages and the overall system. One of the main improvements brought about by the use of the SRD was the reduction in the number of questions. This was caused by the use of redundant answers to many of the questions, which became more evident after using the software.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Considering the preliminary comments of the users who have taken part in the distribution of the APET software, APET fills a need to automate the documentation process. However, more work needs to be done to enhance the APET system and improve user acceptance.

It is recommended that the findings of this research be used to examine the documentation requirements placed on the PI. There are instructions in the NASA-supplied hardcopy documentation that offer little information as to the amount of detail required to adequately answer the questions. These questions cause problems for the PI, and add unneeded complexity to the overall task. It has been suggested that the software be modified to include examples of what is expected from the user, specially in terms of the Project Plan's graphic examples. Example answers could further be developed to provide the users a model that could be used as a base answer, then customized for individual responses.

It is realized that many people are reluctant to learn a new software package if it is not mandatory or if they feel it is not worth the effort. The PPO and UAH have tried to make using the APET software as easy as possible by providing free instruction and assistance to anyone who requires it. However, there has been little response from the PIs who have received copies and even less response from project managers/scientists who might use the software themselves or advise PIs about its availability. The main emphasis of the APET software is the reusability of supplied answers and the cross reference of the information. If users have the understanding that the SRD is a one time only document and the only one they must prepare, they tend to be even more reluctant to spend the time learning the software. It is recommended that a stronger emphasis be used by the project managers/scientists to support the use of the APET in gathering information about projects. The information gathered can be reused in other support documentation, such as the Project Plan or the PPO Payload Safety Implementation Approach.