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SPACE SHUTTLE LIFE SCIENCES REQUIREMENTS DEVELOPMENT AND DOCUMENTATION

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GENERAL ELECTRIC COMPANY
SPACE DIVISION
HOUSTON OPERATIONS
LIFE SCIENCES PROJECTS

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APOLLO SYSTEMS DEPARTMENT
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SUBJECT: FINAL REPORT FOR CONTRACT NAS9-14973 - SPACE SHUTTLE LIFE SCIENCES REQUIREMENTS DEVELOPMENT AND DOCUMENTATION

The attached Final Report is submitted in response to Contract NAS9-14973 - DRL-MA 649T. This report summarizes the results of all work done under this contract and references the respective reports satisfying each task item specified in the contract.

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1.0 INTRODUCTION AND SUMMARY

This final report documents the completion of work and summarizes the accomplishments of a 1 1/2 year contract, NAS9-14973. The work done under each major task item is briefly discussed in Section 2.0, but the referenced documents must be referred to for specific technical information. Section 3.0 of this report contains the conclusions derived from this effort and Section 4.0 contains recommendations for future activities. Sections 3 and 4 are concerned only with payloads planning for the Space Shuttle which is the subject of all but the first of the requirements documents delivered under this contract.

One definition is needed for the user of this report to understand the task and document descriptions. For purposes of these requirement analyses, Level II requirements are management related; are usually applicable across the board to an entire program such as the type of requirements imposed by a Level II program office; and also can include requirements imposed by a higher authority. Level III requirements are those applicable to the implementation of a function and can vary considerably each time the function is performed, depending on the project or hardware involved.

There have been other documents prepared on the subject of requirements for Life Sciences payloads and it is important to understand the differences. Each document has a different point of view and serves a useful purpose and this comparison is not meant to be derogatory. One published document looks at requirements from a hardware point of view, and lists the R&QA requirements, design review requirements, etc. Another document identifies many required functions and estimates the time required for each implementation of the functions, again from the hardware point of view. Still another document looks at the requirements for the facility, including space and equipment.

In contrast to the above documents, the requirements identified in this GE study covers a much wider range of functions including management plans, payload planning, optimization and analysis, flight and mission planning, and mission reporting, as well as all the design, integration and test functions that are hardware oriented. Some of the above functions would be done only once for the entire program, others would be done once for each payload, and others are applicable to each of the many experiments or end items in each payload.

2.0 ACCOMPLISHMENTS

The description of accomplishments is essentially a description of each document submitted to NASA. Tasks 2.3 and 2.6, review and coordination support to NASA, are not described separately since they are an inherent part of the other tasks.

2.1 PROGRAM PLAN (Task 2.1)

The first task undertaken was the preparation of the Program Plan. This plan described the technical approach to be followed during the reporting period. Standardized formats that were developed as part of the Program Plan were used for preliminary reports which preceded submittals of the ALT Level II Requirements Document and the OFT Level II Requirements Document. Also, these formats were adopted by other contractors for documenting requirements for their studies in the Life Sciences payloads area.

2.2 WORK BREAKDOWN STRUCTURE

A detailed durvey of the Space Shuttle Work Breakdown Structure was undertaken to identify areas affecting the Life Sciences Directorate, either as the Lead Organization or as a principal supporting organization. Also identified were WBS elements that impacted LSD and where LSD might consider making an input. All Space Shuttle panels were listed for LSD management use.

2.3 SPACE SHUTTLE PROGRAM DEFINITION AND REQUIREMENTS BASELINE DOCUMENT (Task 2.2)

This document was prepared to provide an overview of specific Space Transportation System (STS) elements which are relevant to Life Sciences' STS roles and responsibilities. Eight major topics were covered including: (1) Program Management and Control; (2) Program Work Breakdown Structure; (3) Mission Descriptions, including ALT, OFT, and operational missions; (4) Space Shuttle Natural Environment for payloads; (5) Space Shuttle Vehicle Description, including cabin environment, induced environments, crew accommodations and payload accommodations; (6) Flight Operations, (7) Ground Operations and (8) Life Sciences areas of concern. This document was based on official documentation including much of the JSC-07700 series, the Spacelab Accommodations Handbook, the OFT Payload Requirements and Constraints Document and others. All paragraphs in the baseline document contained source references so that the user could go to the original documents for further details and revisions that might be issued after our research (Ref. DE-S-STS-056).

2.4 ALT LIFE SCIENCES REQUIREMENTS DOCUMENT (Task 2.4 and 2.5)

The ALT Requirements Document covers the ALT program description, ALT management, general requirements and specific Medical Support Requirements for preflight and for emergency medical care. The preliminary draft had much background information on the ALT project. Each requirement was described with impact statements on forms comparable to PRCB Change Request forms. Each requirement was reviewed and approved by LSD management. The final draft was edited to include the requirements only without the supporting information. This shorter document was approved by LSD management, but the ALT Project Office requested further changes before giving its approval. The changes requested included deleting all internal LSD requirements not directly affecting the interface with the ALT Project Office, the flight crew and flight team. The requirements section was rewritten to accommodate these requests and the document was resubmitted (Ref. DE-S-ALT-057) and subsequently approved by the ALT Project Office.

2.5 OFT BASELINE PROGRAM SUMMARY (Task 2.3 and 2.4)

A summary of the Orbital Flight Test (OFT) program was prepared and presented to the Life Sciences Requirements Working Group. This overview was intended to furnish the impetus for drafting LSD OFT project support requirements.

2.6 OFT LIFE SCIENCES LEVEL II REQUIREMENTS DOCUMENT FOR PAYLOADS (Task 2.4)

This document had been specified by the Technical Monitor to contain two basic requirements sections: Medical Operations Requirements and Payload Development and Operations requirements. The requirements were to originate from the Life Science Requirements Working Group assisted by supporting contractors and coordinated/integrated by GE. At the beginning of the OFT requirements development task, the Technical Monitor redirected GE to prepare the payloads section of the requirements document and to incorporate Medical Operations requirements which would be furnished by NASA into the final document. Change action was initiated to reflect the redirection together with similar redirection for Level III OFT documentation and all STS documentation in the GE contract.

The Te .nical Monitor designated a Carry-on Laboratory (COL) as the baseline LSD payload for OFT. The first task was payload requirements identification. This was performed after a COL Functional Flow diagram was developed and approved by the Technical Monitor. The diagram was divided into four layers. Three layers were designated as

functional elements of the Life Sciences Directorate. These are Science, Engineering, and Operations. The top layer designated "Higher Authority" includes NASA Headquarters, the Space Shuttle Project Office, and higher level integration centers which have OFT carry-on lab management roles. Requirement identification forms were compiled for each event on the functional flow diagram. The forms contain descriptive information for general management, technical management, and resource management and cover items such as the responsible organization, product, and impact if not approved. A preliminary OFT Level II Requirements Document was submitted and reviewed with LSD representatives from Science, Engineering, and Operations.

The decision was then made to shorten and simplify the final document to reflect the complexity of a carry-on laboratory which has only structural interfaces with the Orbiter. A new approach to formatting technical requirements evolved. This tabular format emphasized the objectives and the Level II requirements, and omitted some items on the earlier forms considered non-essential by the LSD review groups. The revised document was submitted at the end of the reporting period for LSD review and approval. It was later decided that the OFT Life Sciences payloads program was so limited that formal NASA approval and publication would not be necessary. (Ref. DE-S-OFT-058)

At the direction of the Technical Monitor, the final document was issued with only payload requirements, since the Medical Operations requirements to be supplied to GE did not support our contract delivery dates.

2.7 OFT LIFE SCIENCES LEVEL III REQUIREMENTS IDENTIFICATION (Task 2.5)

The approach to this task was to prepare a Level III functional flow chart for each Level II element on a Level II functional flow diagram. This systematic approach helped bring out requirements which otherwise might be overlooked. However, this approach assumed each element was self-contained with little continuity or momemtum from previous elements and resulted in too many self-evident and elementary implementation requirements. A format similar to that used for the Level II requirement identification was adopted and a draft document submitted to NASA. Another format change was requested as a result of the NASA review whereby each functional element was considered under eleven areas of interest, plus the objective and constraints applicable to the element. This enhanced the usefulness of the document to an individual interested in only one aspect of a payload such as R&QA, logistics, etc.

2.8 STS LEVEL II LIFE SCIENCES PAYLOAD REQUIREMENTS (Task 2.4)

The STS requirements identification, the most significant output of this task, was a major expansion of the OFT task, since, as noted in Para. 2.6, the OFT task was simplified by the assumption of a carry-on lab with no functional interfaces with the vehicle. Another major conflicting factor is that the OFT task was concerned with only one experiment while the operational phase analysis involved all phases of establishing a payload program; designing, optimizing, procuring, integrating and testing payloads as well as multiple experiments. One measure of the expansion is that the functional flow diagram for the operational phase payloads required four sheets compared to one for the OFT payload. The diagram organization was similar to that for OFT but included three extra "layers"; one each for Procurement and Resources Management, Program Control Management, and Configuration Management. The format used for the requirement identification sheets was revised somewhat from the OFT format as a result of discussions with NASA. The most significant change was that the major section of the form was changed to "Implementation Requirements" from "Level II Requirements." This made it easier to document the functions that were Level III in nature according to our definition. After a preliminary review of the Level II document by the Technical Monitor, it was decided that the Level II document contained a far greater amount of information than was anticipated and the need for a separate Level III documentation would not add significantly to the study. As a result, the contract was amended to delete the Level III document.

The preliminary Level II document was delivered to NASA on April 15, but due to the high NASA workload concerned with a major Life Sciences activity (the SMD III test), no formal reviews could be scheduled until early in June. The agenda for the NASA reviews were formatted according to the levels of the functional flow diagrams. These reviews were extended over a very long period, partly due to the resignation of the Technical Monitor and partly due to increased activity in the payload planning area. As a result, it was no longer possible to comply with the contractual plan of submitting another draft for NASA review and then prepare a final document. Instead, the red-lined changes to the document were reviewed by the (new) Technical Monitor and a final version was produced.

The front part of the document deserves mention because it is much more than an introduction to the requirements identification. It is a comprehensive, although somewhat philosophical, discussion of the following areas: STS Payloads Description and Assumptions, Payload Project

Management, Program Control and Analysis, Resource Management, Configuration Management, and Information Management. This portion of the report is intended to stimulate discussion of the Level II requirements considered desirable for all NASA funded space investigations, in the context of the NASA desire to promote a low cost space program in the Shuttle era. Much of this portion of the report has not received a critical review by NASA but was retained in the final report because of its original approach.

3.0 CONCLUSIONS

Several conclusions can be stated concerning the work as a whole that may put this report in the proper perspective. One is that the payload program is still in a state of flux with some areas not yet resolved. An example of this is the area of training, both for Mission Specialists and for Payload Specialists, including training responsibility, duration, facilities needed, etc.. Another area that is still not well defined is the role to be played by the various program offices involved in the Shuttle program.

One consideration that should be kept in mind when reviewing the requirements documents or when such documents are prepared in the future is that they will be overly comprehensive for any one particular payload or experiment. Not all the requirements will be applicable to all experiments. For example, some experiments do not involve specimens which show up in several elements of the functional flow diagram; not all experiments have real time data; not all experiments require crew training, etc. This has an unavoidable effect of making such a document appear to be an overkill when it is just a natural result of its generality. However, a bonus consideration that follows from the comprehensive nature of the documents is that the functional elements and the associated requirement statements can be applied to payloads in any discipline, not just Life Sciences, with very little change other than organization name changes.

4.0 RECOMMENDATIONS

Several recommendations are presented here to assist NASA in planning future effort in this area or in applying the documentation to their payload program.

4.1 The Life Sciences Payload Requirements Document should be periodically reviewed and updated. Reasons for this include: new program policy definition, organization incompatibilities, nomenclature changes, program maturity, and program simplification for selected payloads.

4.2 Such a review could be one of the tasks performed by the ILSEE contractor, when selected, as part of the transition phase from government to contractor operation. This could be a good means of orientation training while getting up to speed. Obviously, this contractor will have a responsibility to make his efforts compatible with the requirements for the real payload and any incompatibilities should be reconciled early in the program.

4.3 A means of factoring experience gained from previous programs into the Life Sciences payloads program needs to be developed. This experience can be found in Lessons Learned documents, crew debriefings, mission reports, etc., for Skylab, ASSESS II, SMS I, SMS II, and SMD III.

4.4 In addition to the above recommendations, the following list of follow-on actions are submitted. While it is felt that action items are most meaningful if a priority is assigned to them, these action priorities are in order of importance, not time prioritized. It is quite possible that some of these may already be in progress.

1. Prepare and publish the Organization and Charter for the Life Sciences Program Office.
2. Clarify relationships, interfaces, and responsibilities for working with other program offices involved in the Shuttle program.
3. Clarify crew training concepts and organization responsibilities, both for Payload Specialists and Mission Specialists.
4. Review plans for the Science Committee(s) (peer groups) in light of Presidential/Executive Office initiatives to reduce the number of committees.

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