NASA LaRC FREEDOM

OPERATIONS MODELING FOR SSF EVOLUTION

SPACE STATION EVOLUTION

Beyond the Baseline

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Background

The operations required to support the on-orbit Space Station Freedom activities planned or being studied will be complex. Operational capability to perform tasks will be dependent on many factors such as manpower availability, logistics, other tasks being worked, and Space Station configuration. This effort uses information available about these and other factors to perform operations analysis for given missions and determine the feasibility of target configuration concepts to support those missions.

Studies have been conducted to determine processing requirements for a number of potential evolutionary missions on the Space Station Freedom. These studies have identified the need for growth of the Space Station in various ways. Some of the studies have dealt with the operational needs for the particular mission that they are concerned with, but none have looked at the total evolutionary operations requirement.

In order to pursue the subject of overall on-orbit operations to any appreciable level of detail, data bases of operational on-orbit tasks need to be compiled, and an analysis tool is needed to assist the analyst. A number of existing operations tools have been reviewed, and none have been found to satisfactorily perform the functions needed to analyze integrated operations requirements for the evolutionary Space Station Freedom. However, during the tool review, some existing applications were found to provide subsets of the required functionality, and these are being considered for incorporation into the analysis tool.

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Background

- In order to determine the feasibility of configuration concepts for evolution of the Space Station Freedom, analysis of on-board operations to accomplish the tasks to be carried out are required.
- Relevant supporting study activity in FY87 – FY89
  - KSC/MDAC Ground-to-Space Based Operations Task Definition Studies
  - LARC/CTA Ops Analysis Model Survey And Model Data Base Development Study
  - LARC/MDAC Multi-discipline Mission Accommodation Analysis
  - LARC/PRC Manned Mars And Lunar Base Missions Studies
  - KSC/MDAC Advanced Automation And Robotics For In-space Vehicle Processing
  - MSFC Space-based Transfer Vehicle Requirements And Accommodations
  - JSC EVA Systems Evolution Analysis
  - JPL Advanced Robotics for In-space Vehicle Processing
- Analyses of the on-board operations will draw on these studies but will require data bases of operational on-orbit tasks and an analysis tool(s) to assess operational capabilities of any given configuration

Vehicle Processing Operations Data base (VPOD)

One of the uses of the Space Station Freedom may be to perform the assembly and refurbishment of Planetary Exploration Space Transfer Vehicles. The Vehicle Processing Operations Data base (VPOD) is designed to provide a repository for the data that is being compiled relating to the on-orbit operations that will be required to accomplish those tasks. The VPOD can be used to derive estimates of requirements for; Crew Personnel, Equipment usage, Resource Requirements, and Required processing time. These estimates will then need to be integrated with all other operations that will be occurring at that time to determine overall Space Station operations requirements.

The VPOD has the capability to allow the vehicle processing operations to be specified to any desired level of detail. During the early phases of mission definition, when very little information is known about the mission, the VPOD can be used to provide preliminary estimates, and as more information is developed and entered into the data base, the estimates become more realistic.

VPOD three main tables of information relating to the operations required to assemble or refurbish a planetary vehicle on orbit. The first is the Events table which contains descriptions of the individual events needed and the Crew, Assemblies, Equipment, Resource, and Time requirements for performing the event. Next is the Assemblies table. This table contains the necessary information about the various pieces of the vehicle being worked on such as mass, dimensions, resource and test requirements. Finally the Equipment table contains a record of the various pieces of Orbital Support Equipment (OSE) needed to perform the various events.

The VPOD can be used to provide a base of information that will be used by an Operations Analysis and Simulation tool. Once the details of a vehicle assembly or refurbishment mission are specified in the VPOD, the analyst will be able to specify the mission by name, along with missions from a sibling data base for parallel Science efforts, and Space Station housekeeping and maintenance operations. The Analysis tool will then perform scheduling of all the required operations, and simulate their execution, keeping track of the resources used.

VPOD internal analysis can be used to generate summation reports and graphs showing mission specific information such as; Estimated Crew Time, OSE requirements, Station Resource requirements, and total required processing time.

VPOD can also be used to generate data files that can be used by other external tools such as spreadsheets, graphics generators, and word processors.

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Vehicle Processing Operations Data Base (VPOD)

- Systematic, automated tool set to define operations tasks for on-orbit processing of planetary vehicles and derive estimates of
  - Crew personnel
  - Equipment usage
  - Resource requirements
  - Required processing time
- Model vehicle processing operations to any desired level of detail
- Contains generic events, assemblies, and equipment
- Base of information for use by other mission analysis tools
- Generate summation Reports and Graphs
- Generate data files to be used by other tools

Vehicle Processing Operations Data base (VPOD)

This chart shows a functional flow diagram for the VPOD. The Assemblies Data Base, and The Equipment Data Base are both used by the Events Data Base. The Assemblies Data Base contains descriptive records of the various parts of a vehicle that must be assembled or refurbished. The Equipment Data Base contains a list of the various OSE that is needed to perform the Events that put the assemblies together. The Events Data Base describes the individual operations required to perform the mission. The Mission Scenario uses data from the Events Data Base and from the analyst to define the order of processing of events that comprise a Planetary Exploration Vehicle assembly or refurbishment.

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Vehicle Processing Operations Data Base (VPOD)

Assemblies Data Base

Defines parts of the Exploration Vehicles to be assembled or refurbished On-Orbit

Equipment Data Base

Defines support equipment needed to assemble or refurbish an Exploration Vehicle On-Orbit

Events Data Base

Defines the activities needed for assembly or refurbishment of Exploration Vehicles On-Orbit

Mission Scenario

Defines the order of processing for the events comprising an Exploration Vehicle mission

Vehicle Processing Operations Data base (VPOD)

The VPOD supports two user groups and two file types. The Data base manager can maintain the permanent data base files by updating the information in existing records, or incorporating data from Temporary data base files into the permanent data base. Write access to the permanent data base is controlled by the data base managers password.

The Mission Analyst can read information from the permanent data base files, create temporary data base files, and add or update information in his temporary data base files. The Mission Analyst can also create a mission scenario using the mission editor, and initiate the generation of the summary reports desired for a defined scenario. Data records in the temporary data base files can supersede the information in the permanent data base files. This is accomplished by searching the specified temporary data base files before proceeding with the search of the permanent data base for a piece of information needed by the mission scenario. If a record or set of records needed by the Mission Analyst from the permanent data base for a mission scenario is incorrect or must be changed, he can copy that record into his temporary data base file then make the updates required.

The VPOD user interface is designed for the operations analyst. No programming experience is needed to perform any of the functions. The user is presented with either a menu or help line on each of the information screens, and may receive further context sensitive help by using the help function key at any time.

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Vehicle Processing Operations Data Base (VPOD) continued

- Support Two user groups
  - Mission Analysts
  - Data Base Managers
- Support Two file types
  - Permanent data base file
  - Temporary data base files
- User Interface designed for Operations Analyst

Vehicle Processing Operations Data base (VPOD)

The VPOD user interface consists of six functional areas which are: the operations concept editor, the mission editor, the events editor, the equipment data base editor, the assemblies data base editor, and the report generator. The operations concept editor is used to update and modify a set of generic vehicle processing operations flows defined in Task Description Language (TDL) files. The resulting operations concept is used as a template for defining missions using the mission editor. The mission editor is used to define the logical sequence of events that are required to perform the operations needed for a vehicle processing mission. The events, assemblies, and equipment editors are used to create, modify, or delete records in the respective data base data base. The report generator is used to specify the mission to be reported, the specific reports desired, and the level of detail to be reported.

The reports available from VPOD consist of Waterfall charts showing the events sequence and overall timeline, Transition tables showing on-orbit crew crew skill and time requirements, tables of OSE and assemblies needed to perform the mission, and requirements for Space Station supplied resources such as power, communications, thermal, and fluids. A time ordered table of the materials needed can be generated to aid in determining Earth to Orbit Transportation manifesting.

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Vehicle Processing Operations Data Base (VPOD) continued

- User interface consists of six functional areas
  - Operations Concept editor
  - Mission editor
  - Events editor
  - Equipment data base editor
  - Assemblies data base editor
  - Report Generator.
- Outputs include
  - Waterfall charts
  - Mission Manifesting information
  - Resource Usage
  - Equipment and Assembly use
  - Crew Requirements

VPOD Events Hierarchy Example

The Events, Assemblies, and Equipment data bases in the VPOD are structured in a hierarchical manner. At the top level (level 1), events are defined as entire missions, an assembly would be the entire mission vehicle, and a level 1 Equipment record would represent a stand-alone piece of equipment. As the level increases, more detail about the element is available.

In this example, the on-orbit assembly of the Phobos Gateway Mission Vehicle is used to illustrate how the hierarchy works for events. The level one event is the entire vehicle assembly process. At the next level down, the major subsystems such as; Aerobrake receiving, assembly, and test, and Piloted vehicle stacking events are stored. The example then shows Piloted vehicle stacking detailed to the next level which consists of; Mars Descent Vehicle (MDV) off-load from the Earth to orbit launch vehicle and transfer to the Space Station assembly hanger, then MDV receiving inspection, and indicates that other operations follow at this level. These hierarchical levels can be taken to any desired level of detail (currently limited to about ten levels due to the size of the ID field).

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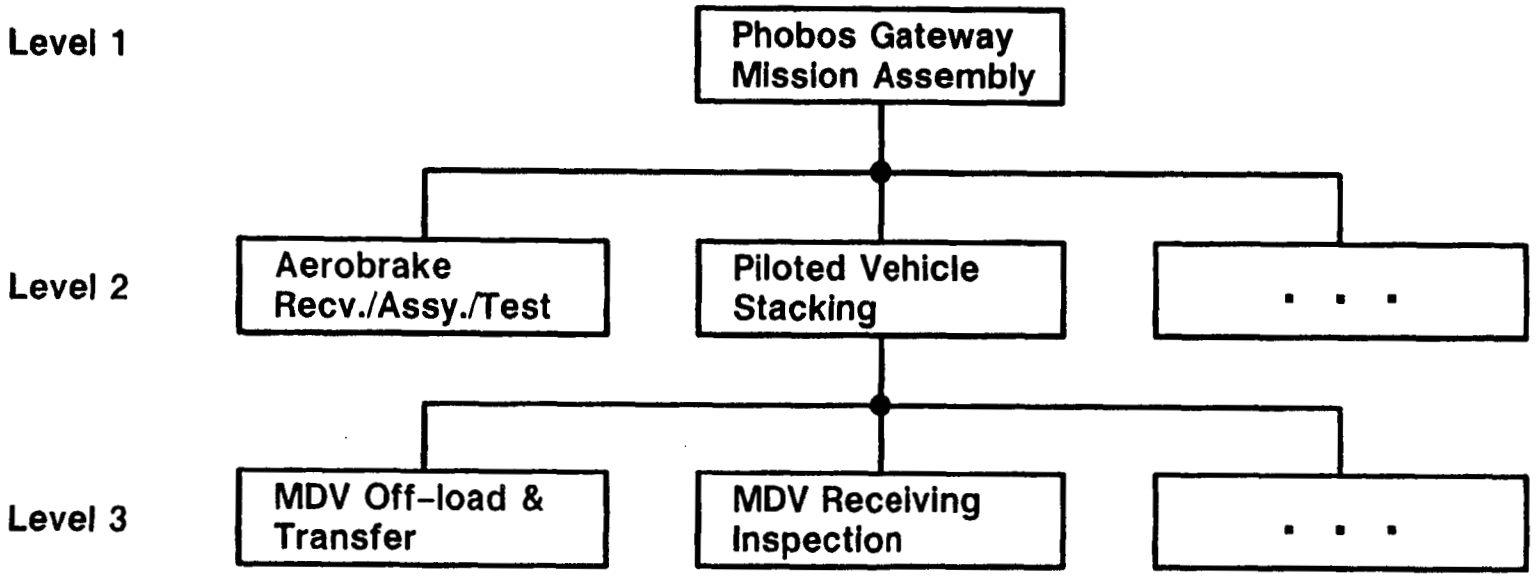
VPOD Events Hierarchy Example



VPOD Events Hierarchy Example

This chart shows how the VPOD can support trade studies of EVA versus Tele-operated or Automated operations. At some level in the events hierarchy, a kernel operation is defined that may be performed by one of a number of methods. At the next level, all of the methods to be studied are defined, with any additional detail desired in successive levels below. Then when the mission analysis is performed the analyst will specify what the preferred type of operation is, and any exceptions that may be needed. By performing the analysis multiple times, and specifying a different preferred type of operation each time, compatible results for the different types of operations available can be generated.

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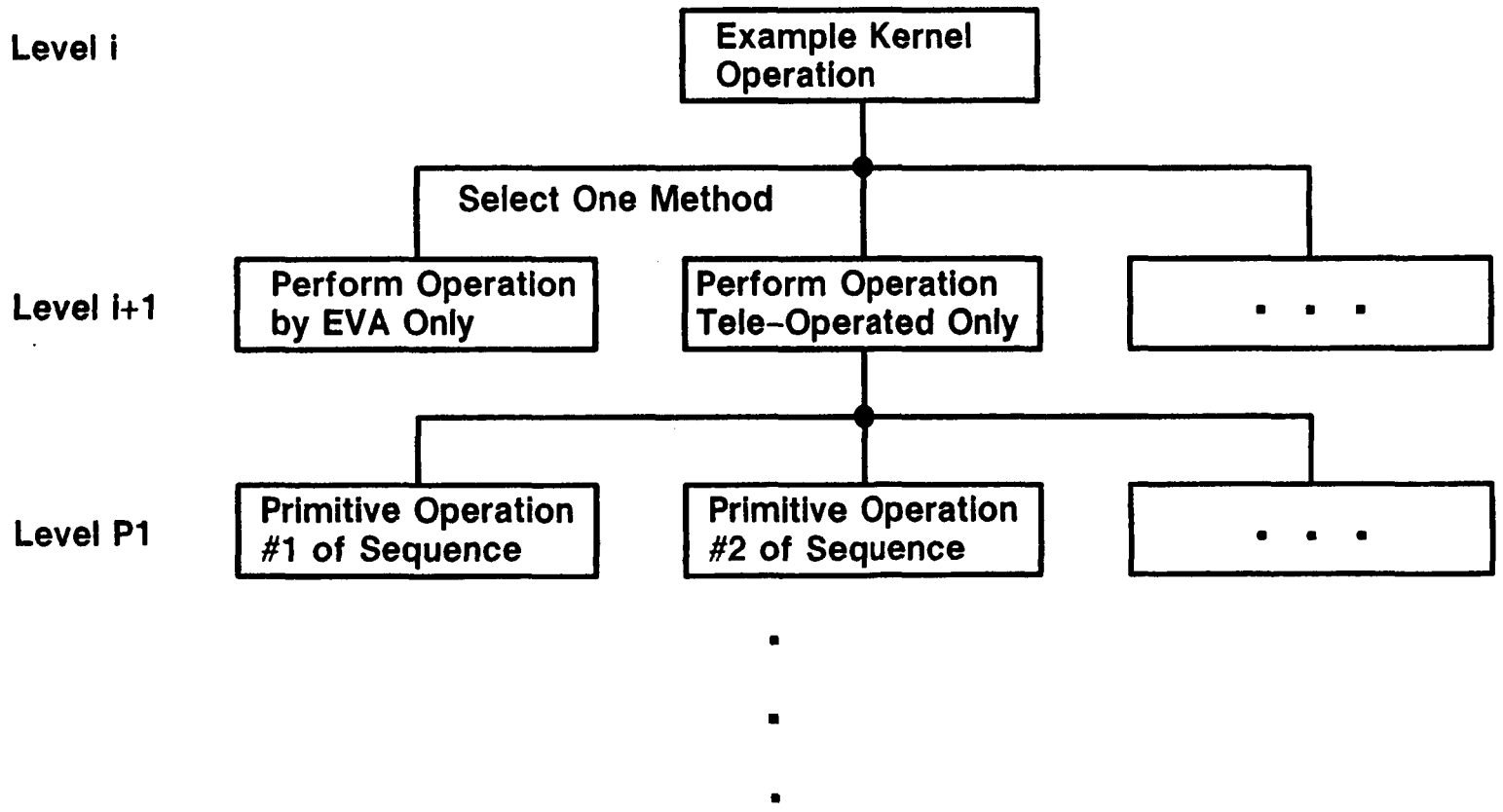
VPOD Events Hierarchy Example (Continued)



Advanced Analysis and Simulations Requirements

The main purpose of the VPOD is to act as a data repository for an Operations Analysis and Simulation tool that is currently in the requirements definition phase. This tool is needed to assist with the operations analysis that is needed to determine the feasibility of evolutionary Space Station Freedom configurations. These analysis will require the integration of operations that support Space Transfer Vehicle (STV) assembly and refurbishment, Scientific Research Projects, and New Technology Testing and Verification.

In order for the tool to support the integration of such a diverse set of operations needs, it will have to be able to interface to a number of different data bases. These data bases will consist of the VPOD which has been the subject of this report, a Science Missions Operations Data base (SMOD), a Space Station Housekeeping and Maintenance Operations Data base, and a Space Station Configurations Data base.

Multiple Space Station evolution concepts are being developed to support various types of missions. Using the Analysis and simulation tool, the user will select the mission to be evaluated, and the particular Space Station configuration that the mission is to be evaluated on, so that various evolution concepts may be evaluated to determine their capability to support the desired mission operations.

The analysis and simulation tool will also be able to support trade studies of manual versus Automation and Robotics (A&R) options for performing on-orbit operations at the Space Station. Targeted operations for the trade study can be analyzed using a variety of methods and the results can then be compared.

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Requirements Defined for Advanced Analysis and Simulation

- Tool for Operations Modeling and Analysis in Space (TOMAS)
- Integrate vehicle processing and Research Operations
- Interface to multiple data bases
- Support multiple Space Station Configurations
- Provide support for development of concepts for Space Station evolution
- Support study of both manual and A&R options for performing operations

Advanced Analysis and Simulations Requirements

The Advanced Analysis and Simulation tool will be a complex computer application, but the development can be minimized by using the proper commercially available programming tools. The data base requirements are being met using a standard data base language (Oracle SQL). The simulation portion of the application will be written using a standard simulation tool (CACI's Simscript II.5). The interface code required will be developed using the C programming language (Proposed ANSI Standard). C code will be used only as necessary to minimize the total programming effort.

By using the application development tools mentioned above, a high degree of portability between different computing environments can be achieved. The final application will be capable of being ported from the MS-DOS initial development environment to environments such as UNIX, VAX VMS, and IBM Mainframes.

All data sources used by the simulation will be traceable to their source. This is being accomplished by providing a traceability field in each record of the various data bases. Detailed analysis reports can then incorporate this information.

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Advanced Analysis and Simulation Requirements Continued

- Will be built using High Level System Development tools
  - Standard data base Language
  - Standard Simulation Language
  - Traditional programming languages used only as necessary
- Must be portable to multiple computing environments
  - MS-DOS
  - UNIX
  - VAX VMS
  - Mainframe
- Provide for data traceability

Advanced Analysis and Simulations Requirements

This chart shows the typical flow of operations data through the analysis tool. Required data from the individual data bases is collected by the analysis application. This data is then processed to provide the desired reports in support of the operations requirements for various NASA organizations. The Analysis outputs may also be useful as an input source for a Space Station Freedom Increment Planning and Scheduling Tool.

IN SPACE OPERATIONS MODELING FOR SSF