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SIMULATOR REQUIREMENTS IDENTIFIED

Introduction

The discussion below is intended to identify those simulator requirements adjudged to be significant in the MOL operational proficiency area and further, to explain the particular function of the simulator in each of the areas so identified. Emphasis is placed on those requirements steming from the need to simulate the acquisition, processing and use of the data derived from the on-board tape recorder. This particular area requires emphasis not only because it provides a major impact on the software processing system, the time dynamics of information retrieval, and the proficiency training of orbital support personnel, but also because it is absent from the present baseline.

Discussion

Four logical categories of MOL functional elements have been identified. They are:

1. Software
2. Hardware
3. People/Procedures
4. Operational Support

The elements included in each group are discussed in the following paragraphs.

Software

1. Command loading - Exercise of the command loading software routines cannot be accomplished without providing the accept/reject feedback to close the command loop. The simulator must provide both hardware and software accept/reject telemetry at their normal repetition rates and contain all the on-board logic employed to assure proper command and block formats, parity, authentication, etc.

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2. Tracking Data Acquisition - Though some arguments are offered to the contrary, it is seen as a requirement to produce simulated tracking data for exercise of the ephemeris prediction software. When orbit adjusts are performed, nominal and non-nominal, the real time rehearsal cannot be considered valid unless the orbit parameters are perturbed in accordance with the actual OA.

3. Telemetry Response Generation - This simulation application needs little explanation. It concerns, of course, the generation of proper telemetry responses to commanded changed in vehicle state. These commanded changes include not only those seen in real time but also those stored and on-board generated commands responses which must be placed on the tape recorder. Without correct responses to generated commands, the rehearsal becomes a sham with little meaning. Included in this group ~~or~~ of responses which must be generated are those modeled parameters which denote expendable consumption in response to either command activity (film) or normal usage (power, attitude control gas, etc.)

4. Telemetry Processing - The remote station data processing software can be verified to some extent by playing AGE signature tapes through the RTS. However, for rehearsal purposes, canned tapes cannot, ~~of course~~, provide a true simulation of the "vehicle". It will be required, over the span of several rehearsals to generate non-nominal values in practically all parameters for instance. This must be accomplished to verify that flag generation algorithms of the telemetry modes are functional and that corresponding displays are adequate for their purpose. The simulator can be used to generate these non-nominal responses by introducing erroneous data base models for those parameters to be shown as anomalous.

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In addition, the simulator becomes a necessary tool in the generation of the recorded telemetry profile, actually providing the responses to simulated on-board generated payload commands, storing of the executed command list and edge data buffer information. The simulator output would be recorded on a tape recorder during the 'real time payload pass' period and played back at the next station to exercise the many telemetry modes required to extract and process the payload data. The data so generated must be meaningful if the vehicle image/status update function is to be thoroughly checked. Likewise, the target information derived from the tape recorder edge data must be valid if the mission correlation programs are to be exercised with any degree of realism.

5. Target Summary Generation and MCD Activity - The target summary is the compilation of voting logic and related target information placed in the on-board computer memory during the real time payload pass and dumped to telemetry during the real time station pass by command - either real or stored. For ~~this~~ the same reasons given above for the recorded edge data, the real time target summary data must be generated precisely as it would occur; with the astronaut inputs being stored in the buffer until the real time dump is commanded. Once again, the mission correlation function would not be exercised without a target summary corresponding to the known target list sent to the vehicle. The simulator is the only route by which this summary can be produced.

6. Simulate LGA data - The present operating concept of the LGA provides an uplink predict of LGA output. The downlink LGA telemetry is based on the difference between this predict and the actual drag experienced. To make this data meaningful to the ephemeris software which will use it, the data placed in the LGA storage buffer (which is dumped during the pass) should

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be meaningful. It is proposed that an earth drag model (different from AOES model) be placed in the simulator to generate these deltas for the LGA summary. A canned summary could be used to exercise the data extraction software at the RTS but would not suffice for providing a reheaseable input to the ephemeris program.

7. Orbit Determination Studies - To adequately exercise the orbit prediction software and personnel, a simulator must be used to model the vehicle configuration during a simulated burn, modeling such parameters as thrust variation, change in the c.g. during burn, ~~and~~ misalignments, expendable consumption resulting from the burn, etc.

8. Consumables Management - Expendable supplies on-board must be modeled by the simulator to provide realistic inputs to the limit checking algorithms ~~stated~~ stated for use in real time telemetry modes. The simulator will also be called upon to provide anomalous data in the expendables area - exercising orbit analysts in responding to unusual behavior singatures. Though most of the consumables are DACO responsibilities, film quantities, both primary and secondary, would require modeling.

9. Performance Evaluation and Trend Analysis - Performance evaluation is construed to mean the verification of payload operational health. Rigorous ground software programs are being devised to measure the degree of performance of the on-board computation and drive systems. Without responsive data these analysis programs cannot be exercised, nor can the people who must interpret their output. In a true simulation of an on-board problem, selection of malfunction telemetry modes would normally follow problem identification, allowing problem isolation activity to proceed. Without the opportunity to demonstrate the adequacy of the malfunction mode design, the proficiency of the system analyst is neglected.

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Trend analysis of non-commandable parameters is another area suitable for worthwhile application of computer modeling. Ground test significant parameter profiles will be extracted from test histories and stored at the contractor support facility. During operations these same performance parameters will be periodically inspected to determine any unusual trending - i.e. sluggish servo response, abnormally high currents, unusual temperature profiles, etc. The unique software accessing of this comparison data from a test history library as well as the actual analysis effort itself needs rehearsing. Generation of normal and abnormal trends in prime data points would provide an excellent training tool.

10. Vehicle Image/Status Update - To conduct a true simulation of system operation, it is necessary to exercise all of the normal image and update routines which provide printouts of the current vehicle.command and data image and the vehicle status at the load time of the update message. This command image cannot be maintained without simulator concurrence ascertaining the loading of a message or portion of a message. Likewise the status update cannot be maintained without proper telemetry response indications of commanded vehicle status. Also, the executed command profile cannot be maintained without a simulation of the ECL buffer contents dumped to the on-board recorder. Without the ability to reconstruct current vehicle image and status, the command generation software is not working with its normal input thereby possibly aborting the operation of the conflict resolution logic and other routines which use status as an input.

11. Prepass Message Generation - The prepass message sent to the RTS contains among other things an acquisition message and any changes in the telemetry limits being used by the RTS telemetry processing modes. As the acquisition message is generated from the ephemeris base which will be

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perturbed by orbit adjusts it will be necessary to provide the tracking data from the simulator for the ephemeris update. The telemetry limits at the RTS hopefully reflect the predicted condition of each telemetry point to be interrogated. Since the limits are only as good as the known commanded vehicle status, and vehicle command status is in turn a function of having the ECL, numerous data flags will unnecessarily conplicate both the real time and post pass telemetry mode analysis if current vehicle status is unknown. This ECL generation can only be provided from a simulator.

12. Display Adequacy - The adequacy of any functional element can only be demonstrated when it is being used in its normal operational environment. As CRT displays are considered the system baseline display, each and every format option as well as each selected data group within that format must be exercised under normal and malfunction conditions. Analysis type displays must be shown effective in presenting data flags accurately and timely - and further, that the aggregated data of a given display is suitable for the purpose for which it was designed. The simulator capability is very much required to produce the meaningful data necessary to conduct this evaluation. Running an AGE signature tape from the RTS to demonstrate display adequacy falls short for several reasons; the two prime reasons being that: Y/)

    1. Without the simulator it would be difficult if not impossible to generate anomalous data for every parameter to insure that the data flag was presented properly on the display.
    2. Without a true simulation of data, the analysis personnel are not given the opportunity to exercise their judgement in determining data validity, the composite data picture (i.e. are all the flags

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in one subsystem), and how to apply the deductive reasoning required to call for back up displays or chart a course of action.

The many rehearsals conducted in the past on other satellite hardware have shown an extreme weakness in this precise area - that is, providing data to the system from old flight tapes to merely exercise the hardware and software systems with little regard for the analyst who becomes disinterested, unchallenged and exercised not at all in the job he will be called upon to perform with hopeful proficiency. The best training has always come from actual flights, and will continue to be true - but MOL with its dearer than dear investment of lives and dollars cannot afford the learning curve to start at a mediocre level at lift off time. The simulator must be employed to the maximum extent possible to smooth the operational wrinkles long before launch.

13. Data Base Maintenance and Corrector Generation - The requirement for a simulator to generate correctors for revising the on-board data base needs little discussion. It would be hard to imagine that it could be done in another manner without considerable risk involved.

Data base maintenance - The changing of parameter entries in the MOL system MPES tables, will be occasioned for numerous reasons:

1. Changes in hardware configuration
2. Software/hardware limitations changes
3. Operational constraints
4. Malfunction impacts

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For whatever reason the data base is modified the changes must be verified when the possibility of on-board conflicts, hardware damage or unknown complications may result. Before subjecting the flight hardware to possible damage, improper or non-optimum operation, the new quantities should be checked in the simulator in all modes where the new quantity impacts.

14. Generation of New TM Modes - On those infrequent occasions when a telemetry mode must be altered to provide a new mode, the simulator can be used to exercise the new software contained in the mode design. It is unlikely that wholesale changes will be made in any mode - since the only basic reason for changing a mode is to respond to a contingency operational mode. It is ~~conceivable however~~ reasonable to assume that abnormal parameter values would be required from the simulator to insure proper algorithm and display processing of these flagged values.

HARDWARE

1. SOC Operation - The SOC console at the RTS will perform, among other functions, the back up command loading function. In order to exercise this one function for hardware compatibility assurance, the simulator must provide the accept/reject logic in precisely the same manner as needed for verification of the command loading software. Other functions driven from data derived from the PCM ~~list~~ bit stream will undoubtedly be included in the console design. All displays so driven must be driven with valid time coordinated inputs to assure hardware integrity.

2. MCC Display Adequacy - To assure that MCC displays other than telemetry data are adequate for their proposed usage, it will be necessary to conduct training exercises and rehearsals of each prime control console. For instance, the Command Generation Console will be used by the Master Generator to

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initiate the generation of a message, follow its progress, observe the conflicts which are unresolved, take appropriate action, display the formatted contents of the message and otherwise control the entire procedure.

To allow a real time rehearsing of this procedure, the data base, the command image and the vehicle status must be input to the generation program. Without these inputs furnished by the simulator as discussed above, the control console display adequacy cannot be verified. Similarly, test controller displays will no doubt be driven by simulated tracking data to provide the realism of actual time constraints.

3. Microwave Link/Contractor Support Facility - The microwave link will provide full bandwidth data to the CSF for the proposed malfunction investigations resulting from special tests conducted over the Cook station - as well as numerous other critical response data for trend comparisons. Proving the integrity of the MWL can be accomplished without the simulator; the data which it carries, however, must be simulated. The effectiveness of the CSF analysis procedures can only be proven adequate when a simulated malfunction condition is presented in the data. The indepth malfunction isolation software must be developed from increasing knowledge gained from early rehearsals. Without the simulator providing a realistic data input, this software development will never get a chance to evolve.

PEOPLE/PROCEDURES

1. Flight Documentation Adequacy - In the course of the pre-flight rehearsals, the collection of crew, flight director, test controller and analyst handbook's must be implemented to familiarize the operating team with their contents and to prove their worth as reference material.

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To conduct this evaluation without a reasonable operating vehicle simulation would drastically reduce operator training and the effectiveness of document evaluation. On the other hand, repeated use of these documents to solving problems as they are presented in a real life type of rehearsal will promote capabilities and vastly decrease the time required to mount the learning curve.

2. Exercise of the Decision Making Process - The descision making process will necessarily be an involved affair requiring many briefings, a shakedown of valid inputs, weighing tradeoffs, and coordinating with the many agencies involved. This whole procedure must flow smoothly and in haste. This it cannot do without repeated trail runs of one contingency after another as programmed by well thought out rehearsals. The prime mover in this decision making exercise is always the data. Realistic exercises cannot be accomplished without a believeable profile of vehicle status as painted by the simulator.

3. Time Dynamics/Resource Allocation - Post pass RTS time scheduling of equipment will be governed largely by the amount of data to be stripped from the tape recorder and number of modes which must be played to the STC to complete the data requirements list. This data stripping procedure is strictly a function of how long the read in record is, how many targets were taken, how rapidly the tape recorder can be played without overloading the computer buffers, etc.. Exercises of this nature where time is a basic parameter need a full simulation of what the on-board tape recorder contains. The source of this simulated data is logically the payload simulation module of the MMSE.

Likewise, resource allocation of equipment at the STC (3800's) can only be realistically patterned when the data inputs to the command and control update and analysis programs are typical of a simulated mission.

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Since by far the largest task of command profile update and performance evaluation concerns the data extracted from the on-board tape recorder, it is considered mandatory that these data inputs truly reflect the loading expected and thereby produce reasonable equipment and personnel time loading factors.

4. Crew/Hardware/Software/Analyst Interface Familiarization - The simulator is an absolute must in rehearsing the crew/system/controller/analyst interface. Without the simulator producing the proper stimuli to each of the elements and personnel involved, the close knit communication and ~~understanding response needed for verbal explanation of symtoms and observations~~ appreciation for how the system must work cannot be established.

OPERATIONS SUPPORT

1. Malfunction Analysis - After the book learning phase of an orbit support analyst's training is completed, the real 'getting up to speed' portion of his training is accomplished in the normal operational habitat, working with the tools provided, understanding system lingo, and learning unique answers to his unique questions. Only a 50% job can be accomplished in this area if his questions are never stimulated - and they never will be without putting him through the self same rituals which he must follow in a real operation. Past programs has suffered serious loss - to and including loss of an entire vehicle because an analyst misinterpreted data being presented to him and responded in error. The proficiency normally gained on the first few flights of a program must be gained before flight on the MOL program. To this end, the dollars invested on MOL simulation equipment represent an investment which just has to produce results.

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2. Verify Accuracy of Data Base Changes and Validity of New Sequences - Satisfying the accuracy of data base changes was discussed under software. The new sequence validation requirement ~~items~~ stems from the on-orbit circumstance where a malfunction has caused revision of the normal sequences. To insure that the altered sequence produces the desired response in an anomaly configured system, the simulator can be used to first duplicate the conjectured anomaly and then operate on the new sequence to ascertain its compatibility. This type of insurance becomes extremely important where data base paramters such as drive limitations are ~~entered~~ altered. Altering of these parameters can produce physical damage to the MPSS equipment and should always be verified prior to use.