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NOVEMBER 1977

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GENERALIZED ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM COMPUTER PROGRAM (G189A) CONFIGURATION CONTROL

PHASE II FINAL REPORT

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

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JOHNSON SPACE CENTER, HOUSTON, TEXAS, UNDER CONTRACT NAS9-14877

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-WEST

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FOREWORD

The work described in this report was performed by the Biotechnology Department of the Vehicle, Energy and Biotechnology Subdivision, Engineering Division, McDonnell Douglas Astronautics Company - Huntington Beach, California. mr. J. R. Jaax of the Crew Systems Division, National Aeronautics and Space Administration, Johnson Space Center, Houston, Texas, was the contract monitor. S. W. Nicol was the project manager for McDonnell Douglas at Huntington Beach. The G189A computer program configuration control effort was performed on-site at NASA/JSC by R. E. McEnulty.

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SUMMARY

This final report documents the work performed during Phase II of contract NAS9-14877, Generalized Environmental Control and Life Support System Computer Program (G189A) Configuration Control. Phase II of this contract covers the period from 1 December 1976 to 30 November 1977. During this period the following items of significance were accomplished:

1. The G189A simulation of the Shuttle Orbiter ECLSS was upgraded in the following areas:

   (a) The Shuttle simulation was modified to accept Shuttle Electrical and Environmental Requirements (SHEER) tapes for processing.

   (b) The IMU configuration was changed from a closed circulation system to an open system. The schematic print subroutine ARSGAS was updated to show this change.

   (c) The H_2O tank dump and fill logic was changed to represent the latest configuration.

   (d) The capability was added to post-process a data tape generated during a Shuttle simulation run to produce a summary comparison table of phase averaged data in the event of an aborted run.

   (e) Avionic Bays cabin components were replaced with Thermal Analyzer components (Section 3, Reference 12) to decrease computer time requirements.

   (f) The O_2-N_2 controller logic has been reworked and upgraded to the latest configuration for OFT and OV103 missions.

(g) Dual Freon Loop simulation has been added to the program and the freon loop schematic has been updated.

2. All simulation library versions and simulation models were converted from the EXEC2 to the EXEC8 computer system this contract period (Section 3, Reference 12).

3. A new program, G189PL, was added to the combination master program library. The program permits the post-plotting of up to 100 frames of plot data over any time interval of a G189 simulation run (Section 3, Reference 12).

4. The overlay structure of the G189A simulations were restructured for the purpose of conserving computer core requirements and minimizing run time requirements.

1.0 INTRODUCTION

The G189 Generalized Environmental Control and Life Support System Computer was initially conceived and developed by MDAC-Huntington Beach in 1964. An initial version of the program was delivered to NASA/JSC in 1965 under contract NAS9-4090. Since 1965 a number of program additions, revisions, and new developments have occurred as a result of in-house work and subsequent NASA contracts. The Crew Systems Division (CSD) of NASA/JSC has been instrumental in developing this program into a valuable ECLSS simulation analysis tool. This contract, NAS9-14877 - Generalized Environmental Control and Life Support System Computer Program (G189A) Configuration Control, provides NASA/JSC with Houston based personnel who can maintain, update, and utilize the G189A computer program effectively and efficiently. The contract effort also includes: (1) providing instruction and consultation services for others regarding the use and application of the G189A program, (2) developing new subroutines or modifying existing subroutines to provide additional capabilities required for current or new simulations, (3) maintaining and improving existing G189A simulation models developed for Shuttle ECLSS and payload ECLSS analyses, (4) developing new simulation models as required, and (5) supporting special study analyses requested by CSD. This contract continues the effort begun in April 1973 under contract NAS9-13404. The following section describes in detail the progress made under the various tasks described in the Phase II portion of contract NAS9-14877.

2.0 REPORT OF PHASE II PROGRESS

The Phase II progress on tasks 1-10 as described in contract NAS9-14877 is reported below.

2.1 Task 1 - Formulate Master Programs

G189A EXEC2 Master Programs were maintained and updated during this contract period according to the method described in paragraph 2.1 of Reference 15.

The G189 EXEC8 master program was incorporated into the computer system this contract period. This program has been checked out and is available for general use. The master program can be accessed by using either a combination master program Library Tape or a system secure file (G189A) which contains all program elements.

The element NAME/VERSIØN remains the same as described in Reference 12. The FLAG parameter of the EXEC2 system is no longer required. Each version of the program is executed by modifying the loader map to perform the same function as the flag parameters.

A new program, G189PL, described in Reference 13 has been incorporated into the master program library. This program permits post plotting of up to 100 plots/per case and multiple subcases under two different plot parameter specification formats.

An off line program to process a data tape and print out a run summary table has been developed. The program is described in Reference 10. This program has been incorporated into the master program library.

2.2 Task 2, Maintain Tape Library

Seven EXEC2 and four EXEC8 G189 master program librarys were generated this contract year.

Copies of MPAD electrical load data for ØFT1 through ØFT6 missions were made and saved. Data tapes, post plotting plot tapes and Table 1 summary table tapes were made and saved as required. Table 1 shows the present tape status.

2.3 Task 3, Provide Recommendations

Contact has been maintained between J. P. Kenney, LEC; Karl Houck, NASA/JSC; Ernie Smith, HSD; and Stuart Nicol, MDAC-Huntington Beach during this report period to provide them with recommendations regarding the use of master program library tapes, the use of simulation model tapes, the modification

of program subroutines to perform specific tasks, and peculiarities and limitations of selected subroutines. These personnel were the only identified active users of the G189A program during this contract period.

2.4 Task 4, Provide Instruction

Consultation services have been provided for the on-site users of the G189A program and telephone communications have been maintained with the off-site users to provide them with information regarding new program features and options, subroutine revisions, and program manual revisions.

2.5 Task 5, Provide Program Modifications

During this report period modifications were made to 23 of the subroutines that are used by all of the library versions, to 11 of the subroutines that are used in the standard library version, and to 35 of the subroutines used for the Shuttle library versions. The modifications made to each subroutine have been documented in the monthly progress reports and are referenced below for each subroutine name/version.

Subroutine NAME/VERSION	Reference Document Reference No. (Section)
ADSØRB	4(1.5)
ARSGAS/S	3(1.5), 4(1.6), 6(1.6)
ARSH2Ø/S	1(1.4), 3(1.5), 4(1.6), 6(1.6)
ARST/S	1(1.4), 3(1.4), 5(1.4), 7(1.4)
ATCST/S	1(1.4), 5(1.4), 7(1.4), 8(1.4)
BASDAT	2(1.5)
CABINT/A	6(1.5)
CABINT/S	5(1.4)
CASDAT	2(1.5), 7(1.4)
CNDNSR/A	10(1.5)
COMSØL/A	1(1.4)
ECLST/A	1(1.4), 2(1.5), 5(1.4), 6(1.5)

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ECLST/S  1(1.4), 2(1.5), 3(1.4), 5(1.4), 6(1.5), 7(1.4), 8(1.4), 9(1.5)
ELCØØL  5(1.4)
ELINT/M  8(1.4), 9(1.5)
ELINT/Q  6(1.5)
ELØAD/M  9(1.4), 9(1.5)
ELØAD/Q  6(1.5)
FAN  2(1.5)
FCL/S  3(1.5), 4(1.6), 6(1.6)
FLØWØR  10(1.5)
F21/S  8(1.4)
GPØLY1/M  1(1.4), 2(1.5), 3(1.4), 4(1.5), 5(1.4), 6(1.5), 7(1.4), 8(1.4),
          9(1.5), 10(1.5)
GPØLY1/Q  1(1.4), 2(1.5), 3(1.4), 4(1.5), 5(1.4), 6(1.5), 7(1.4)
GPØLY2/M  1(1.4), 2(1.5), 3(1.4), 4(1.5), 5(1.4), 6(1.5), 7(1.4), 8(1.4)
          10(1.5)
GPØLY2/Q  1(1.4), 2(1.5), 3(1.4), 4(1.5), 5(1.4), 6(1.5), 7(1.4)
G189PL/P  5(1.4), 7(1.4)
G189  2(1.5)
HBALNC  4(1.5)
HTSINK/A  2(1.5)
HTCAPC/A  2(1.5)
IEDIT  1(1.4), 2(1.5)
IVBLØK  2(1.5)
MAINPL/G  2(1.5), 7(1.4)
MAINPL/P  5(1.4), 7(1.4)
MERGEC  2(1.5)
PIPETL  1(1.4)
PLEDIT/G  2(1.5), 4(1.5)
PLEDIT/P  6(1.5), 10(1.5)
PLØNLY/P  5(1.4), 10(1.5)
PLØT89  2(1.5)
PREP/G  2(1.5), 8(1.4), 10(1.5)
PREP/P  9(1.4), 10(1.5)
PRØP/A  9(1.5)
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Subroutine NAME/VERSIØN	Reference Document Reference No. (Section)
PRØP/S	9(1.5)
PUMP	2(1.5)
QLØAD/M	1(1.4), 3(1.4), 4(1.5), 5(1.4), 6(1.5), 7(1.4), 8(1.4), 9(1.5), 10(1.5)
QLØAD/Q	6(1.5)
QPHAVG/S	1(1.4), 5(1.4), 7(1.4), 8(1.4), 9(1.6)
QTAPE/M	3(1.4), 5(1.4), 8(1.4), 9(1.5)
QTAPE/Q	6(1.5)
QTAVG/S	3(1.4), 4(1.5), 6(1.5), 8(1.4), 9(1.5)
REDDER/S	1(1.4), 5(1.4)
RITER/S	1(1.4), 4(1.5), 5(1.4), 7(1.4)
SEGPRG/A	6(1.5)
SEGPRG/S	6(1.5), 8(1.4)
SERVØ/A	1(1.4)
SØRBT/A	8(1.4), 9(1.5)
SØRT	2(1.5)
SSRAD	8(1.4)
STØPIT	2(1.5), 3(1.4), 4(1.5)
STØPIT/A	4(1.5), 8(1.4)
STØPIT/S	4(1.5), 8(1.4)
SUITS/A	9(1.5)
TANKG	5(1.4), 6(1.5)
TAPEIT	1(1.4), 2(1.5)
THERMG	5(1.4), 7(1.4)
VALUE	3(1.4)
VARPRT	1(1.4)
VERTHM	2(1.5)

2.6 Task 6, Establish System Schematics

Specific G189A program system configurations are generally prepared for each G189A simulation model. These configurations consist of a master program library tape; a simulation basic case data tape; and, in the case of Shuttle Orbiter ECLSS simulations, special purpose data tapes such as the MPAD power profile data tapes, phase averaged heat load and temperature comparison tapes, and post plotting data tapes for post plotting routines. The system configurations currently maintained under this contract are listed in Table 1.

2.7 Task 7, Provide Digital Computer Program Requirements

Program listings of the G189A master program library tapes and EXEC8 secure file as well as card decks for the execution of current simulation models are maintained at NASA/JSC, building 7A, CSD. The master program library tapes, simulation model data tapes, MPAD electrical power profile data tapes, phase averaged comparison data tapes and post-plotting tapes are stored in the NASA/JSC Institutional Data Systems Division (IDSD) magnetic tape library in building 12. The G189A ETC/LSS program manual (Reference 13) updates, prepared during this contract effort, are included as Attachment A of this report.

2.8 Task 8, Support Special Analyses

The following special study analyses were supported during this contract period by generating input data, developing special logic and making the runs:

1. Single Failure Tolerance 14.7 PSIA Cabin
2. Single Failure Tolerant 8.0 PSIA Cabin
3. Single Failure Tolerant Failed Ascent/Entry Flash Evaporator
4. Single Failure Tolerant Single Freon Loop
5. Single Failure Tolerant Failed Ascent/Entry F/E 5 Minute Pwr Down
6. Single Failure Tolerant Failed Ascent/Entry F/E 20 Minute Pwr Down
7. Single String 14.7 PSIA Cabin
8. Single String 8.0 PSIA Cabin
9. Single String Failed Ascent/Entry Flash Evaporator

10. Single String Single Freon Loop
11. Single String Descent Failed Ascent/Entry F/E 10 Minute Pwr Down
12. Single String Descent Failed Ascent/Entry F/E 20 Minute Pwr Down
13. Single String Descent Failed Ascent/Entry F/E 30 Minute Pwr Down
14. ØFT1 through ØFT6 Missions
15. ØFT1 8 PSIA Failed Radiatior Door Latches
16. ØFT1 (2 Day) Mission
17. NASA PSMP SEPS
18. NASA PSMP SHEER
19. ØFT1 (2 Day) Descent .45 inch hole in cabin

2.9 Task 9, Provide Monthly Progress Report

Eleven monthly Progress Reports (References 1-11) were provided under this contract effort.

2.10 Task 10, Furnish Final Report

This document is furnished to satisfy the requirements of Task 10.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The G189A program configuration control contract has proved to be an efficient method of organizing and controlling the use and modification of the G189A program and the G189A simulation models. The program users have been identified and communications have been maintained with these users to provide consultation, determine program errors and deficiencies, identify new requirements, and define system configurations to be used for specific problem solutions. This effort has resulted in the orderly development of the G189A program and has established a central authority who can assess proposed program changes and their effects upon the program's generalized applications. Specific simulation model requirements are accommodated by creating special versions of the standard G189A master program library (Section 2.1). As these modifications are checked out and used and if they are determined to be applicable to other simulations or to the standard master program library their solutions are

prepared as generalized logic blocks which can be added to other library versions and/or to the standard library version. A technique was developed during the latter portion of the Phase I contract period whereby all of the various master program library versions are placed on and accessed from a single master program combination library tape or EXEC8 secure file (Section 2.1).

The G189A Shuttle Orbiter ECLSS simulation models developed under Phase I of the previous contract (Reference 12) were modified and upgraded to provide the new simulation model configurations required for the studies supported under this contract (Section 2.8). A simulation model log was developed (Table 1) which identifies the various simulation model configurations developed and their current status. This log provides a convenient method of assessing the current G189A Shuttle ECLSS analysis capability.

Since 1975 the G189 ECLSS program has had the capability to read and process the MPAD generated Shuttle Electrical Power System (SEPS) tapes. This has permitted the ECLSS simulation program to compute realistic transient thermal analyses.

The SEPS program was developed by MPAD primarily to perform consumable analyses and although it provides excellent transient data the program requires a large amount of time for data preparation and execution. MPAD began a parallel development effort in 1975 to create a simplified program which would require less time for data preparation and execution, but still yield adequate data for consumable analysis purposes. The Shuttle Electrical and Environmental Requirements (SHEER) computer program was developed for this purpose. Recently MPAD restricted its use of the SEPS program in favor of the SHEER program. Therefore, the G189 ECLSS thermal analysis programs were modified to provide the option of inputting electrical power profile data generated with the SHEER program.

The SHEER program differs from the SEPS program in that it computes the average power requirements for each component used within an activity block and groups the power dissipations into predefined ECLSS heat load locations while the SEPS program computes instantaneous power data for each component and the user is free to group the component power dissipations to match his program requirements. The SHEER programs activity block averaging and component grouping techniques have not been compared with the SEPS instantaneous power data to verify the fidelity of the SHEER ECLSS simulation. MPAD has been requested to furnish SEPS tapes of ØFT2 and ØFT-4 missions so that the adequacy and/or limitations of the SHEER data analysis can be determined.

Three steps have been taken this contract period to speed up the computer run time. The Avionic Bays Cabin components have been replaced by thermal analyzer components, the overlays have been restructured and the on-orbit time step has been increased to 600 seconds. The simulated mission time to computer execution time ratio is now at 20/1. Compared to the EXEC II simulation, this is very slow and is caused by excessive input output time on the EXEC VIII system. The central processor to real time ratio is 48/1 on the present ECLSS simulation.

The G189A Shuttle simulation models have proven to be a cost effective method of studying overall ECLSS performance under a variety of conditions. Problem areas can be quickly identified and determinations can be made as to the necessity of performing additional analyses requiring the use of the detailed thermal analyzer models which are prepared and maintained by RI. The ease and speed with which special ECLSS reconfigurations, failure modes, and/or boundary conditions can be incorporated in the various models has been thoroughly demonstrated. The present set of G189A Shuttle Orbiter ECLSS simulation models provides a varied data base which can easily be upgraded and/or modified to accept hardware development and acceptance test data as they become available.

The following recommendations are made with regard to desired improvements for the G189A program and the Shuttle simulation models.

1. A new subroutine should be developed that allows a component's K array data to be printed out. (The G189A library currently contains subroutines which print out component A, B, R, and V array data.) This routine would be useful for model debugging.

2. All obsolete, undocumented and unused subroutines should be eliminated from the Master Program Library and their documentation should be deleted from the program manual.

3. The thermal mass, heat transfer conductance, fluid line size and length data incorporated into the Shuttle Orbiter ECLSS models last year should be updated and, if possible, the predicted transient responses of the water and freon loops should be verified by test data.

4.0 REFERENCES

1. Twelfth Monthly Progress Report, Generalized Environmental Control and Life Support System Computer Program (G189A) Configuration Control, Contract NAS9-14877, January 1977.

2. Thirteenth Monthly Progress Report, G189A Configuration Control, NAS9-14877, February 1977.

3. Fourteenth Monthly Progress Report, G189A Configuration Control, NAS9-14877, March 1977.

4. Fifteenth Monthly Progress Report, G189A Configuration Control, NAS9-14877, March 1977.

5. Sixteenth Monthly Progress Report, G189A Configuration Control, NAS9-14877, April 1977.

6. Seventeenth Monthly Progress Report, G189A Configuration Control, NAS9-14877, May 1977.

7. Eighteenth Monthly Progress Report, G189A Configuration Control, NAS9-14877, June 1977.

8. Twentieth Monthly Progress Report, G189A Configuration Control, NAS9-14877, August 1977.

9. Nineteenth Monthly Progress Report, G189A Configuration Control, NAS9-14877, July 1977.

10. Twenty-First Monthly Progress Report, G189A Configuration Control, NAS9-14877, September 1977.

11. Twenty-Second Monthly Progress Report, G189A Configuration Control, NAS9-14877, October 1977.

12. Phase I Final Report - Generalized Environmental Control and Life Support System Computer Program (G189A) Configuration Control, MDAC Report No. MDC G0598, November 1976.

13. G189A Generalized Environmental/Thermal Control and Life Support Systems Program - Program Manual, R. L. Blakely, et. al., MDAC Report No. MDC-G2444, September 1971.

14. IDSD Procedures Manual, JSC-09609, Part 19, Exec II System, Rev. 4B, May 1976.

15. Exhibit B - Request for Proposal 9-BC 73-27-6-M8P, NASA/JSC, 21 October 1975.

TABLE 1 - SHUTTLE ORBITER ECLSS MODELS

Item No.	Simulation Model Description	MASTER PROGRAM LIBRARY Tape No.	Oper. Date	Drop Date	SIMULATION DATA Tape No.	Oper. Date	Drop Date	SEPS POWER DATA Tape No.	Oper. Date	Drop Date
1	ØFT1 Ph 1-2	X08540 X09821	3-15-77		X21003	3-21-77		X19923		
2	ØFT1 Ph 1-14	X09821 X08540	3-15-77		X21003	3-21-77	X19036	3-11-77		
3	ØFT1 Ph 1-8	X09821 X08540	3-15-77		X19336	3-23-77	X15886	MPAD Tape		
4	ØFT2 Ph 9-13	X09821 X08540	3-15-77		X11032			X18651	3-18-77	
5	ØFT3 Ph 1-13	X09541 X21953	4-14-77		X09848	4-14-77		X05388	MPAD TAPE	
6	ØFT4 Ph 1-19	X09541 X21953	4-14-77		X20421	4-18-77		X18232	3-21-77	
7	ØFT5 Ph 1-13	X09541 X21953	4-14-77		X21257	4-18-77		X12789	4-11-77	
8	ØFT6 Ph 1-14	X09541 X21953	4-14-77		X03683	4-18-77		X21281	3-18-77	
9	SFT Ph 1-12	X20018 X21834	5-19-77		X03683	4-18-77		N/A		
10	SFT Ph 18-31 14.7 PSIA	X20018 X21834	5-19-77		X23396	5-31-77		N/A		
11	SFT Ph 18-31 8.0 PSIA	X20018 X21834	5-19-77		X21167	5-31-77		N/A		
12	SFT Ph 18-31 One F21 Loop	X20018 X21834	5-19-77		X15638	6-7-77		N/A		
13	SFT Ph 18-31 Failed F/E	X20018 X21834	5-19-77		X13125	6-11-77		N/A		
14	S/L1 Ph 1-5 Ascent	X20018 X21834	5-19-77		X05549	6-7-77		X13271	8-4-76	

Revised 3-1-77; Revised 4-1-77;
Revised 5-1-77; Revised 7-1-77

TABLE 1 - SHUTTLE ORBITER ECLSS MODELS

Item No.	Simulation Model Description	MASTER PROGRAM LIBRARY Tape No.	Oper. Date	Drop Date	SIMULATION DATA Tape No.	Oper. Date	Drop Date	SEPS POWER DATA Tape No.	Oper. Date	Drop Date
15	NASA PSMP SEPS	X19853 X14143	7/20		X22970	7/29		X05626		
16	NASA PSMP SHEER	X18612 X02358	6/23		X12476	7/9		X20650		
17	ØFT1 (2 Day)	X14143 X19853	7/20		X18033	8/20		X11652		
18	ØFT1 (2 Day)	X14077 X17664	8/9		X09012	9/6		X11652		
19	ØFT1 (2 Day) Hole in Cabin Ascent on Orbit	G189A	8/10		X09012	9/6		X11652		
20	ØFT1 (2 Day) Hole in Cabin Descent	G189A	8/10		X13500	9/6		X11652		
21	ØFT1 (2 Day) 1 F/E HYD Heat Load Prob.	X23768	10/21		X23221	10/25		X11652		
22	OFT1 (2 Day) 2 F/E's HYD Heat Load Prob.	X23768	10/21		X02520	10/26		X11652		
23	S/L1 Ascent with Monkeys and Rats	G189A	10/19		X03169	11/1		X07989		
24	S/L1 Ascent Baseline	G189A	10/19		X06319	11/2		X07989		
25	S/L1 Descent with Monkeys and Rats	X23768	10/21		X21356	11/8		X07989		