TECHNICAL MEMORANDUM

(TM Series)

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Improvements to Information Management

Systems Simulator

Final Report

. DRL Item No. 4

by

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ABSTRACT

This document summarizes the results of efforts conducted by System Development Corporation for the Flight Support Division of NASA's Manned Spacecraft Center under NASA contract NAS 9-12871, "Improvements to Information Management System Simulator." This contract extended the original work performed by SDC in the design, development, and installation of the IMSIM simulation model for the analysis of computer-based information management systems performed under NASA contract NAS 9-11211. Contained in this report is a summary of IMSIM capabilities at the beginning of the contract, a summary of efforts applied to contract tasks (including obtained results), current model capabilities, and recommendations for further efforts.

This report satisfies DRL number 4 requirements for contract NAS 9-12871.

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1.0 INTRODUCTION

This document summarizes the performance of System Development Corporation
personnel in the augmentation and improvement of the interactive IMSIM
information management system simulation model, originally developed for NASA/
MSC under contract NAS 9-11211. With this augmented model, NASA now has even
greater capabilities for the simulation of computer system configurations, data
processing loads imposed on these configurations, and executive software to
control system operations. Through these simulations, NASA has an extremely
cost-effective capability for the design and analysis of computer-based data
management systems.

These efforts have been performed for the Flight Support Division of MSC under
contract NAS 9-12871. This contract commenced on 27 June 1972, and technical
and documentation efforts concluded on 17 November 1972. A training course is
tentatively scheduled for the week of 27 November to complete this contract.

Key personnel involved in this effort are as follows:

MSC

John C. Lyon   - NASA Technical Monitor, Guidance Programming Section,
                    Flight Support Division

SDC

Richard W. Bilek - SDC Project Leader, Systems Analysis Center

Jerry J. Peterka - IMSIM and MODLIT redesign and checkout; anomaly
                    corrections

Larry E. Imel   - MODLIT recompilations; RTOS adaptation; development
                    of augmented interactive capabilities

Jack J. Lagas   - Anomaly corrections

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The objectives of this contract can best be described by the following work
summary as abstracted from the contractual statement of work:

> The IMSIM program was developed to provide a simulation capability for
> large-scale computing complexes with maximum "usability." The actual
> determination of this "usability" was not feasible until implementation
> and exercise of the IMSIM program. A number of features of the basic
> IMSIM have been identified which could profitably be modified to enhance
> its capability, to establish more extensive applications for the
> program, and to allow a more natural representation of computing
> system architecture from the standpoint of the analyst.
>
> The objectives of this study, then, are improvements and modest
> extensions to the existing IMSIM program which will establish the
> IMSIM as an appropriate, cost-effective vehicle for performance evaluation
> of computing complexes. The specific areas of improvement and modifications
> required to satisfy these objectives are detailed in the following tasks:
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In the performance of the program-related tasks, SDC was directed to use the
interactive MODLIT simulation language that was used to construct the initial
IMSIM. Revisions and additions to IMSIM were to be implemented for ultimate
compilation on the IBM 360/75 system under the RTOS operating system at MSC's
RTCC. To accomplish this, the computer resources at SDC's Santa Monica facility
were to be employed, as well as those of MSC.

The remainder of this report is organized as follows: Section 2.0 presents
the status of the IMSIM capabilities at the beginning of the contract
(including known limitations), orienting these capabilities to the detailed
customer requirements and the work statement. Section 3.0 summarizes the effort
applied to these tasks, the intents of these efforts, and the obtained results.
Section 4.0 describes the present IMSIM capabilities that resulted from these
efforts, while Section 5.0 outlines recommendations for further work. Section
6.0 presents a summary of this report, and Appendix A lists all documentation
produced by SDC during this contract.

2.0   IMSIM-1 CAPABILITIES

The capabilities of the IMSIM model at the beginning of the contract were basically those that existed at the conclusion of the original IMSIM contract (NAS 9-11211) which concluded on 13 August 1971. These capabilities were augmented by informal exchanges of information that occurred between SDC and MSC during the period of 14 August 1971 through 26 June 1972. A summary of system capabilities that existed at the close of the original effort appeared in SDC document TM(L)-4769/000/00, "Information Managment System Design for Future Missions - Phase B Final Report," 30 July 1971.

On 26-27 July 1972, R. W. Bilek of SDC and J. C. Lyon of MSC met to discuss the contractual statement of work, and to cover task priorities. A summary of these areas of study, listed by the task categories outlined in the work statement, is as follows (included in this list are known program limitations):

1.   Modifications/Improvements Task

1.1   Process Representation

a)   Message/element interrelationships should be investigated to incorporate the following changes:

1.   The "Computation Time" fields should be removed from the Type 5 Message input form and added to the Type 3 Routine input form.

2.   A "Predecessor" field should be added to the Type 3 input form to sequence the execution of routines, similar to what is now done for job-steps in form 1.

3.   For each routine prototype, a set of fields should be used to generate an "execution" probability. These fields could be an "Fn" entry followed by parameters "A" - "D", as are now used for computation time, interarrival time, etc. Each time a task calls for a routine, the distribution function indicated by these fields would be evaluated, and the resulting value would be tested against a random number. Based on this test, the routine may or may not be executed on that task iteration.

This capability can be expanded by using different distribution functions for different copies of a particular routine, depending on the task(s) to which a routine is assigned. Thus, a "task" field would have to be added to form 3 to identify which routine/

distribution functions apply to which tasks. (If the
same distribution function for a routine applies to all
tasks, an entry of "0" can be used to indicate this.)
These changes would permit dynamic control over the
execution of routines on a probabalistic basis. Studies
might also be made into manual selection and control
over the execution of routines at specific times (i.e.,
for discrete occurrences of selected tasks). Also, if
such changes can be implemented, consideration might be
given to deleting or modifying the current "GO/NO GO"
field associated with form 1 (job-step inputs).

Note that these changes might require _two_ variable length
entries in form 3 - one for routine predecessors and one
for applicable tasks.

b) Cyclic or recurring functions: An entry should be added to
    form 1 (job-step inputs) to provide a start time interval
    for continued executions of a job.

c) Expenditures of time in process performance: IMSIM apparently
    computes and uses a new access time each time a page is
    extracted from auxiliary storage. Only _one_ seek time should
    be used for each memory transfer, regardless of page size or
    number of pages required.

    Also, we should investigate logic changes to transfer in
    only the environments needed, and not full pages (especially
    if swapping is not being performed).

d) Memory maps: It would be desirable to output physical memory
    maps and auxiliary storage maps, as is now done for virtual
    memory.

1.2 Execution Time

a) Study the possibility of only loading physical memory, and
    not virtual memory, if the user does not desire a simulated
    virtual memory capability.

b) Study automatic means for detection and bypassing of unneces-
    sary program logic; e.g., not scanning tables or deques for
    multiple processors if only one processor or virtual machine
    is specified in a run.

    c) Check all deque-spinning to see if some of these spins can
       be eliminated to save time.

    d) Investigate the possibility of a non-interpretive version of
       MODLIT that could be used for speedier batch runs of IMSIM.

1.3 Model Capacities

The following capabilities shall be included in the final
delivered version of IMSIM:

Reports:	50
Report lines:	200
Blocks:	about 200 block margin after all design changes are incorporated.
Savex cells:	about 500 cell margin after all design changes are incorporated.
Variables:	margin will depend on the nature of the changes that can be incorporated under 1.1 (a) above.

1.4 Executive Program Representation

The user should have direct control over the IMSIM executive, as
is done now for "applications" workloads. The user should be
able to establish JOB 1, TASKS 1-5, etc. as he desires. If the
changes in 1.1 (a) can be incorporated, these should also apply
to the executive.

1.5 Interaction

It may be possible to do a "reload" from the 2260 without using
the card reader by some simple procedural changes and minor
changes to MODLIT. These changes can be partially checked out
in batch mode in Santa Monica. Prospective changes will permit
revisions to input forms 3-13, additions or replacements (but
not deletions) of forms 1 and 2, and the insertion of a new job
schedule. SDC will investigate the possibility of storing an
initial job script in a savex table for simpler modification.

1.6 Coordination

SDC will communicate frequently with MSC to transmit IMSIM
revisions and preliminary change pages to manuals.

2. Maintenance Task

    2.1 Program Maintenance

         SDC will maintain MODLIT and IMSIM capabilities for the IBM
         360/75 operating under RTOS at MSC.

    2.2 Program Anomalies

         The following anomalies will be resolved:

         a) The MODLIT storage tables only allow for 50 data sets
             (storages 1-50), while system capacities are 100 data sets.
             The storage table should be modified to place 100 data sets
             in storages 151-250 (leaving storages 1-50 unused), without
             changing the rest of the storage organization.

         b) The necessity for defining unique data blocks to avoid
             problems in overlapping jobs and tasks should be investigated.

         c) Total storage access time and eventual transfer into virtual
             and physical memory appear to be taking longer than required.
             SDC should run some controlled test cases and compare with
             hand-calculated values to verify timing associated with the
             current logic.

         d) The use of page size, as documented for form 7 (memory speci-
             fications) should work as specified. Page sizes must now be
             input for each virtual machine via savex cells 571-6.

    2.3 Recompilations

         It may not be necessary for SDC to deliver and install a final
         version of IMSIM-1A at MSC, if tapes can be compiled in Santa
         Monica and transmitted to MSC.

         The final delivery of IMSIM-1A is tentatively scheduled for
         3 November 1972.

3. Training Task

    A one week training course is tentatively scheduled for some time
    between late September and mid October 1972. An assessment will be
    made of IMSIM design changes around 1 September to permit announce-
    ments and coordination of this course.

4. <u>Documentation Task</u>

SDC will expand the "set/use" listings in the Program Description
Manual, and will also look into expansion of the Transaction parameters
listed in section 3.4.2 of that document. Where feasible, transaction
parameter tables will be incorporated onto applicable flowchart pages
for reader convenience.

User input form descriptions will be expanded for clarity in the User's
Manual. However, the forms will generally be described in simplified
form, with explanatory comments reserved for backup pages.

Other areas that may be studied as time permits are as follows:

● Expansion of Report 12 to include a wider range of possible IMSIM
error conditions;

● Use of a "conversational" mode of entry of input forms and schedules
from the 2260 console, where alphabetic inputs could be used in
addition to numerics;

● Generation of a new "summary" report that would list the equipments,
configuration (and possibly workload specifics) used in a run. This
might possibly be tied in with some of the speedup changes suggested
earlier (e.g., checking the number of processors, virtual machines,
etc.).

3.0 SUMMARY OF EFFORTS APPLIED TO TASKS

At the 26-27 July meetings between MSC and SDC, MSC listed the following
subtasks as high priority items:

1. Rectification of program anomalies;

2. Message/element interrelationship redesign;

3. Reduction of execution time.

SDC was already engaged in items 1 and 3 at that time, and proceeded to
investigate item 2. While these initial tasks were underway, SDC generated
preliminary estimates of the efforts to do the actual development required
for all SOW subtasks described in section 2.0. These estimates were then
discussed with MSC to refine the scope of the redesign and development that
could reasonably be performed under this contract. Some of the candidate
efforts, such as the compilation of a non-interpretive version of MODLIT
to speed up batch runs, were clearly out of the scope of this contract, and
were tabled for possible future effort. The remaining tasks which appeared
feasible under the present contract were then to be addressed by SDC, with
particular emphasis on the above three high priority subtasks.

It was acknowledged that a considerable amount of logic redesign and checkout
would be required to implement the changes required under item 2 above. In
essence, these changes would alter the operating philosophy of IMSIM so as to
associate task computation times with routines (input form 3), rather than
accumulating processing times solely as a function of message transmission
(input form 5). Messages would still be used as triggers to signal the
accumulation of "computing units," but this would now be done via user-
specified relationships between the routines and messages that make up task
environments. These relationships would generally be specified via MODLIT
variables that would have to be assembled by the user to characterize these
relationships. Although this would impose a greater effort on the model
user, the capability would then exist for much greater flexibility in the
execution of specific routines in the performance of selected tasks (either
deterministically or statistically), and would be a closer counterpart of
real-world situations.

SDC analyzed the impact of these changes and presented design approach
recommendations to MSC in an SDC letter of 11 August 1972 entitled "IMSIM
Modification Plan." (Also included in this letter was a set of recommenda-
tions for the design and use of a new input form 14 for the description of
virtual machine characteristics.) MSC subsequently approved this plan and
directed SDC to proceed with the suggested modifications.

A summary of SDC efforts in the major task and subtask areas is as follows:

1. Modifications/Improvements Task

    In the "process representation" area, the desired message/routine
    logic changes were developed and checked out. These changes consti-
    tuted by far the major portion of this subtask, and a significant
    portion of the entire contract. Some study was made of ways to
    implement cyclic jobs, possibly via input form 1 changes, but logic
    changes to IMSIM were not made. It may be convenient for the user
    to employ short transactions using GENERATE blocks for job scheduling,
    rather than a discrete card input schedule. (See page 192 of the
    IMSIM User's Manual.) Analysis was also made of the process used to
    simulate times required for the transfer of successive pages from
    virtual memory, and it was concluded that the logic is working
    correctly as designed. Finally, attention was given to the genera-
    tion of maps for physical memory and auxiliary storage. It was
    determined that auxiliary storage maps could not be conveniently
    produced without a major overhaul to MODLIT and IMSIM, since dynamic
    location statistics on auxiliary storage elements are not maintained.
    Changes could be implemented to map physical memory, but resources
    did not permit this feature under the current contract.

    In the "execution time" area, it was concluded that the model logic
    in essence does not perform separate loads of physical and virtual
    memory; thus, no savings in execution time could be realized by
    "eliminating" the simulation of virtual memory loads. Refining of
    improvements to MODLIT's pushdown stack logic were made, and permitted
    some execution time reductions in the design of the new routine/
    message logic. Greater potential exists for modifying pushdown stack
    operations in other areas of IMSIM. Other specific time-saving
    features that were implemented are as follows:

    a) Extra tests in MODLIT for evaluation of variables in order to
        speed up the evaluations of some types of arguments.

    b) Changes to MODLIT to permit selective printing of blocks; i.e.,
        printing of those having throughput and/or current content,
        instead of all blocks.

    c) Elimination of IMSIM deque spinning to determine addressable
        physical memory for task execution.

    d) Elimination of IMSIM deque spinning to determine source for a
        response message.

Studies were also made of the possibility of a non-interpretive
version of MODLIT to be compiled for batch mode operation. Although
such a version might reduce execution time by as much as a factor
of 5, the required development of a meta-compiler and the attendant
changes to MODLIT were far more than could be performed in this
effort. If frequent batch operation is a strong possibility, however,
SDC recommends that strong consideration be given to this feature
(see Section 5.0).

Model capacities were increased as desired by MSC. Allowable report
capacities were augmented as part of the recompilation effort, and
capacities for blocks, savex cells, and variables were increased
after the design and checkout of the final logic changes to IMSIM.
As directed by MSC, the intent was to allow the user maximum avail-
ability of MODLIT resources within an allowable operating memory
requirement of 500K bytes for the MODLIT/IMSIM package (MODLIT/IMSIM
required approximately 410K bytes of storage under the design con-
figuration that existed at the beginning of the contract).

Studies were made into the area of executive program representation,
and the following conclusions were reached: In general, the model
user is more concerned with the specific characteristics of "appli-
cations" programs and their environments, and often does not require
the added burden of specifying executive functions. For this reason,
the model does not provide for the same kind of facility in manipulat-
ing the executive job, its five tasks, its elements, or its messages.
This kind of flexibility (similar to what is now provided for other
jobs, tasks 6 and above, etc.) would require major changes to IMSIM.
However, the user can alter several executive characteristics by
changing appropriate savex table entries prior to a RUNTIL request;
e.g., the user can index via the first five cells of the ROUTINE
table to modify executive routines, the first five entries of the
message table for executive message characteristics, and so on.
Where other specialized changes to the executive are desired, these
can be made via REVISE statements.

In the "interaction" area, SDC performed several recompilations of
MODLIT and executed test cases in batch mode to implement a new
"rerun" procedure using the DISCARD command. This change would
permit repeated runs of IMSIM by modifications to input form parameters
and to the job schedule from the 2260 console, without reading from
the card reader. Tapes containing modified versions of MODLIT and
IMSIM were delivered to MSC for final checkout under the RTOS/2260
environment.

Throughout these activities, SDC coordinated with MSC to resolve design
questions and exchange information regarding suspected anomalies and
interim program fixes.

2. <u>Maintenance Task</u>

Numerous recompilations of MODLIT under JOVIAL and reassemblies of
IMSIM were performed in Santa Monica to generate loadable versions
of the simulation package for MSC's 360/75 computers. Some problems
occurred because of errors in the current JOVIAL compiler and in the
compatibility of the present compiler with the current versions of
the OS operating system, but these were resolved in time for com-
pletion of the contract.

Several anomalies were investigated during this effort. The MODLIT
storage table was restructured through redefined variables that
generate and index this table, thus permitting the use of the correct
complement of simulated data sets. Studies were also made to investi-
gate the necessity of using a unique element (e.g., a data block) for
each task when allocation problems might occur in tasks that overlap
in time. Since such interference is an actual counterpart of what
could happen when job overlap in the real world, IMSIM redesign was
not attempted in this area.

Other possible anomalies included incorrect IMSIM computations for
storage access and transfer times. Controlled test cases simulating
a variety of conditions were constructed and executed, and the results
analyzed. In checking the results of these tests, all times appear
to be in agreement with the access times, transfer rates, line rates,
and message/page sizes. Previously observed erroneous results may
have been in conjunction with the computation time errors described
at the end of this section, for which correctors have been implemented.

Also, the initial "page size" entry on input form 7 (memory units) was
not being interpreted by IMSIM, requiring user setting of savex cells.
The necessity for this entry was eliminated in conjunction with the
newly designed input form 14 for the description of virtual machine
characteristics. In addition, IMSIM synchronization errors were
detected that under some conditions would cause memory "0" to be
addressed. The net effect of this incorrect indexing would be that
incorrect computation times would be calculated, since the processor(s)
rates would now be compared to the nominal memory transfer rate of a
fictitious memory, resulting in improper calculation of compute times
and task durations. Correctors were devised and sample test cases
were set up and executed for verification.

As noted above, a new input form 14 was designed to specify the
executive memory unit and the virtual memory characteristics for
the six virtual machines. Test cases were also devised to simulate
conditions using these input forms to verify the changes to the model.

In addition to recompiling MODLIT for compatibility with current
versions of OS, MODLIT recompilations were required for several
other reasons. Capacity changes for reports and storage tables
necessitated recompilation, as did changes to MODLIT to permit the
new DISCARD option for restarting an entire model from the 2260
console. MODLIT was also recompiled to enable the new pushdown stack
logic (POP and SAVE blocks), and other MODLIT changes to speed up
execution time. In addition, changes were made to improve the
simulator's ability to detect and process abnormal end conditions.

3. Training Task

The timing and structure of a one-week training course was discussed
by MSC and SDC, and it was mutually agreed that the course should be
conducted after the 20-week period of the original contract, at no
additional cost to the government. (The course was originally
scheduled for no later than the 18th week of the contract.) This
would permit greater attention to the IMSIM redesign effort, and
would also permit the generation of final NASA-approved manuals for
use in the course. It was also agreed that although on-line class
experience with the 2260 terminal would be desirable, heavy RTOS
schedules of use of MSC's 360/75 computers would probably not permit
this aspect of training.

4. Documentation

During the course of the contract, several discussions between MSC
and SDC were held to agree on feasible approaches to the production
of project documentation. Draft and final versions of the reports
required in the CDRL list were provided in accordance with CDRL
instructions. These deliverables were:

        CDRL item no. 1:   Program Description Manual Change Pages

        CDRL item no. 2:   User's Manual Change Pages

        CDRL item no. 3:   Monthly Progress Reports

        CDRL item no. 4:   Final Report

        CDRL item no. 5:   Classroom Handout Documents

A complete list of all project documentation appears in Appendix A.

Tapes comprising the program deliverables were delivered to MSC at
various times throughout the contract. On 5 October, interim new
versions of MODLIT and IMSIM were installed by SDC under RTOS at MSC,
containing several of the required new features. However, attempts
at execution were not successful, due to problems in the use of
partitioned data sets. Revised versions were again assembled in
Santa Monica. Checks were made to ensure that tapes could be
successfully read from disk to tape, then reread onto disk and
properly executed. A new tape, accompanied by job control language
cards and instructions, was sent to MSC on 18 October. (Several
problems were encountered by SDC in Santa Monica during this process
through the use of the utility program IEHMOVE, mainly due to
ambiguous documentation concerning the use of this program.)
Eventually, a final tape containing an upgraded MODLIT load module
and a complete IMSIM source file was transmitted to MSC on 17 Nov. 1972.

A summary of the task and subtask resources applied to this contract
by SDC appears in Table 1.

TABLE 1. MANPOWER AND RESOURCE SUMMARY**

TASK	PROFESSIONAL MANPOWER (HRS)		370/155 COMPUTER TIME (CHARGE UNITS)
	SUBTASK	TASK	
1. MODIFICATIONS/IMPROVEMENTS		247.0	
1.1 PROCESS REPRESENTATION	192.0		
1.2 EXECUTION TIME	25.0		
1.3 MODEL CAPACITIES	7.0		
1.4 EXEC. PROGRAM PRESENTATION	7.0		
1.5 INTERACTION	16.0		62.516
2. MAINTENANCE		646.0	
2.1 RTCC, RTOS COMPATIBILITY	16.0		
2.2 ANOMALY RECTIFICATIONS	364.5		402.447
2.3 RECOMPILATIONS	265.5		1031.911
3. TRAINING			
4. DOCUMENTATION		137.0	
4.1 MONTHLY PROG. REPTS (3)*	20.0		
4.2 PROGRAM DESCRIP. MAN. REVISIONS (1)	19.0		
4.3 USER'S MANUAL REVISIONS (2)	42.0		
4.4 FINAL REPORT (4)	19.0		
4.5 CLASSROOM HANDOUTS (5)	37.0		
TOTALS		1030.0	1496.874

*"(x)" indicates CDRL line item no.
** This chart represents totals through-19 November 1972.

4.0   IMSIM-1A CAPABILITIES

The new capabilities of IMSIM developed under this effort have been indicated
in the preceding section.   Detailed characteristics of these changes (new
input forms, operational techniques, logic changes, table expansion, etc.)
appear in the change pages that have been issued for the User's Manual and
Program Description Manual.   A summary of the major new capabilities of IMSIM
are as follows:

1. Process Representation

   To implement the desired changes for routine/message interrelation-
   ships, the user can now associate "compute times" directly with task
   routines while retaining the capability for message triggering of the
   processing times.   This provides the user with vast flexibility in
   the scheduling of routines and the determination of their compute
   times.   Through the use of MODLIT variables, the user can now define
   a limitless variety of compute time dependencies (e.g., functions of
   message lengths, sources of sinks, current time or iteration, etc.
   on discrete or probabalistic bases) that are truer approximations to
   actual data system situations.

2. Execution Time

   Numerous changes to MODLIT and IMSIM have been incorporated to stream-
   line program execution time.   The MODLIT changes can be more valuable
   to IMSIM if other sections of the model are changed to make use of
   the modified pushdown stack logic, and completely new sections of
   IMSIM (or other totally new MODLIT models) could be similarly
   enhanced.

   It was not practical in SDC's 370/155 batch environment to determine
   discrete reductions in operating times due to several individual fixes
   to MODLIT and IMSIM, especially since multiple features were often
   being checked out in single runs.   The best way to assess actual
   reductions in execution times will be to execute the new IMSIM under
   RTOS on MSC's 360/75, using 2260 consoles and previously executed test
   cases.

3. Model Capacities

   The major new capacities that are available in the upgraded versions
   of MODLIT and IMSIM are as follows:

     Total required operating environment: 470K bytes

     MODLIT prototype reports: 50

Lines available for prototype reports: 200
MODLIT blocks —

Current IMSIM: 1905 blocks

Allowable capacity: 2150 (145 block margin)

Savex cells —

Current IMSIM: utilizes savex cells in the range of 1-6201*

Allowable capacity: 6701 cells (500 cell margin)

Variables —

Current IMSIM: 321 variables

Allowable capacity: 501 variables (180 variable margin)

4. Interaction

Complete restarts of a model are now possible from the 2260 console,
including the capability for modifying the model parameters (input
forms 1-12) and/or the job schedule, without a reload from the card
reader. The user can, by using the redesigned DISCARD option in
conjunction with other operating procedures, input images of new
input forms 1-12, and can modify parameters of forms 3-12 that
appear in the original card deck. The user cannot delete existing
images for forms 3-12, but changes in many cases can be made to
effectively eliminate their usage; e.g., deleting a data set by
making its initial and maximum size equal to 0. Existing forms 1
and 2 (job and tasks, resp.) cannot be deleted by "overlays," since
these are stored as transactions, but new job and tasks can be added.

5. Program Anomalies

Several logic errors were corrected as part of this effort, resulting
in more reliable model operation. Correctors were developed and
verified to correctly establish and index the MODLIT storage table
and to properly index correct memory units when comparing memory
access times with processor computation times.

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*See TM-(L)-4713/000/01 (including revision A), "IMSIM Program Description
Manual"

6. <u>Recompilations</u>

Several recompilations of MODLIT and reassemblies of IMSIM were
performed in the course of the contract. In recompiling MODLIT for
compatibility with the current version fo RTOS, SDC also provided
the new report and data base capabilities, numerous speedup changes,
modifications to abnormal end processing, and changes to the DISCARD
command. In reassembling IMSIM-1 to produce IMSIM-1A, a clean source
file was generated to incorporate all logic changes, including new
reports, error correctors, and new IMSIM features, such as the
modified routine/message logic. Future changes to the IMSIM-1A
should now be made with reference to this new version.

5.0   RECOMMENDATIONS FOR FUTURE EFFORT

Although the capabilities of IMSIM-1A are significant improvements over the
IMSIM-1 package, there are several other areas in which design and support
effort is recommended to even further enhance the utility of this modeling
tool. These areas are as follows:

1.   Modifications/Improvements

    1.1   Process Representation

        a)   Cyclic or recurring function capability

           Studies should be made into the feasibility of making jobs
           repetitive with a user-specified time interval, similar to
           what is now done for message transmissions. This would
           provide for a simple way to re-execute jobs, and would be
           an easy way to alter a job execution sequence without
           changing the job schedule deck for modifying "job generator"
           transactions.

        b)   Physical memory map

           Changes should be made to list the contents of specified
           physical memory units, similar to the virtual memory map
           that is now produced. This would aid the user in determining
           memory allocation algorithms to reduce processor-memory
           interference.

    1.2   Execution Time

        a)   Bypassing of unnecessary logic

           In addition to the speedup changes now incorporated, time
           can be saved by directing the model to scan user inputs so
           as to bypass execution of unnecessary sections of IMSIM
           whenever possible.

        b)   Revised pushdown stack operations

           To take advantage of the new POP and SAVE blocks in MODLIT,
           all sections of IMSIM should be inspected to eliminate
           applicable portions of code where these modified blocks can
           be implemented. Such logic changes will not only save
           execution time, but the elimination of several POP and SAVE
           blocks will provide a greater block margin for future changes
           to IMSIM.

c)   Non-interpretive batch MODLIT

Batch runs of MODLIT can be speeded up by as much as a factor
of 5 if a non-interpretive version of MODLIT is developed for
non-interactive runs. This would entail the development of
some fairly significant meta-compiler techniques and changes
to the MODLIT structure, but the efforts would be well justi-
fied if a major amount of production runs is anticipated.

1.3   Executive Program Representation

Greater flexibility can be built into IMSIM to permit the user
to manipulate the characteristics of the simulated executive
operations. This would permit more accurate representations of
executives, and could provide the user with more meaningful
statistics concerning overhead characteristics of simulated
operating systems.

1.4   Extended User Support

a)   Error message expansion

Consideration should be given to an expansion of Report 12
to output a much greater range of error conditions for the
user. Although many errors are now detected and output by
this report, most error checks are inherent to MODLIT, and
do not reflect the IMSIM logic. A broader spectrum of error
checks and anomalous conditions (e.g., resource confiscation,
message loss, etc.) could be very useful to operating
personnel and analysts.

b)   "Conversational" mode of input form entry

Changes should be studied to use a conversational mode of
entry of input forms and job schedules from the 2260, using
alphabetics as well as numerics. This would be most beneficial
to a new user, and would aid greatly in bookkeeping sequences
of user inputs.

c)   Expanded report capabilities

New reports should be designed to give more concise descriptions
of model inputs and periodic, tabulations of status, and statis-
tical summaries. Coupled with appropriate changes to the logic,
these reports would aid greatly in the analysis of model
behavior.

2. Maintenance

2.1 Generalized Maintenance and Loading Capabilities

Updates and improvements to MODLIT should be incorporated as
they are developed by SDC. In addition, the feasibility of a
scatter-load capability should be studied and implemented, if
practical. This would permit the loading of MODLIT/IMSIM into
non-contiguous areas of memory of the 360/75 under RTOS, and
would permit more efficient execution of IMSIM in foreground/
background operation with other users.

2.2 Recompilations

SDC should maintain the MODLIT simulator for use under RTOS by
recompiling MODLIT (under JOVIAL) whenever necessary, so as to
maintain compatibility between the OS and RTOS operating
systems.

2.3 Implementation on Other Systems

Studies should be made of the feasibility of implementing MODLIT/
IMSIM on other computers, if the use of these computers can be
beneficial to MSC. Thus, if the continued heavy use of the 360/
75 computers at MSC presents scheduling problems for IMSIM, the
simulation package could be recompiled for use on alternate
computers if workloads on those machines will permit greater
use of IMSIM in batch or interactive environments.

3. Documentation

A significant amount of documentation has been generated in the course
of this contract, especially in the updating of the user's manual and
the program description manual. These efforts should be continued to
take full advantage of the extended development work that will be
pursued by SDC and MSC in model development. Complete reissues of
the above manuals are recommended, and consideration should be given
to the production of an Operating Guide to present a more useful
orientation to prospective users.

4. Model Construction and Analysis Support

Although comprehensive manuals have been produced by SDC, IMSIM
requires a reasonable amount of user effort to build, execute, and
analyze model runs. It is recommended that SDC assist MSC as
much as possible in these areas, so that the most cost-effective

approach may be obtained for using this tool. This assistance can be
especially cost-effective when changes to the model logic itself are
contemplated. SDC, through its intimate knowledge of the model
structure and operating characteristics, is in an excellent position
to support MSC in working with MODLIT and IMSIM in the analysis of
information management system applications.

6.0   SUMMARY

System Development Corporation has been involved in a significant support effort
for the Flight Support Division of NASA's Manned Spacecraft Center.   In this
effort, SDC has augmented the capabilities of the IMSIM information management
system simulator, developed by SDC under an earlier contract for MSC.   These
upgraded capabilities offer a wide range of possibilities for the IMSIM user,
and provide an even more cost-effective tool for the interactive execution of
simulation models for the design and analysis of information management systems.

Early in the contract period, MSC and SDC discussed the details of potential
subtasks that might effectively be accomplished during the 20-week development
period of this effort.   These various subtasks were categorized into the fol-
lowing major task areas:

1.   Model modifications and improvements

2.   Model maintenance

3.   Training

4.   Documentation

The subtasks were costed out as to estimated required effort and a reasonable
set of activities was begun that could be accommodated within the contract
scope.   Primary attention was directed towards the following three subtasks:

1.   Rectification of program anomalies

2.   Modified process representation logic (changes to the methodology
     for computing processing times as functions of message/routine
     interrelationships)

3.   Reductions in program execution time

As work proceeded in these and other statement of work areas, an interim
delivery of the new model - IMSIM-1A - was delivered to MSC.   This prelimi-
nary version contained several speed up changes, logic changes, and correctors.
A final version of the new IMSIM model and a recompiled version of the MODLIT
interpreter was delivered to MSC at the end of the development period.

By mutual agreement, the MSC training course was postponed till after the
original 20-week period of the contract, so as to provide more attention to
model deliverables and project documentation.

Contract documentation was quite extensive, and included:

1. Change pages to IMSIM Program Description Manual

2. Change pages to IMSIM User's Manual

3. Monthly progress reports

4. Final report

5. Classroom handouts

Each CDRL item (with the exception of monthly progress reports) was submitted in draft form for MSC approval prior to final publication.

Some of the major IMSIM capabilities provided in this activity include:

1. **Process Representation**

   Capabilities of form 3 inputs (simulated routines) and form 5 inputs (simulated messages) were modified to associate task "computation times" with routines through user-specified variables that link message transmissions with the executions of selected routines.

2. **Execution Time**

   Several features were recompiled into MODLIT and reassembled into IMSIM to streamline model operating time.

3. **Model Capacities**

   User capabilities were augmented by expanding the capacities of reports, blocks, savex cells, and variables, using the MSC guideline of keeping the total MODLIT/IMSIM environment less than 500K bytes.

4. **Interaction**

   The user now has the capability to re-execute IMSIM runs directly from the 2260 console. He can now modify desired portions of the inputs specification forms and/or the job schedule from the console without re-reading extensive input decks for each iteration.

5. **Program Anomalies**

   Several model discrepancies (incorrect storage table structure, improper addressing of memory units, etc.) were corrected and implemented.

6. <u>Recompilations</u>

Numerous recompilations of MODLIT were made with the JOVIAL compiler
(MODLIT is written in JOVIAL) to incorporate the above capabilities
and to maintain compatibility with the RTOS operating system. IMSIM
was also reassembled to incorporate all model-specific logic changes,
thus providing an updated MODLIT/IMSIM package for system simulation.

Although IMSIM is now significantly augmented from its initial capabilities,
extended development work would even further enhance the usefulness of this
tool. Detailed recommendations appear in section 5.0, and are summarized as
follows:

1. <u>Modifications and Improvements</u>

   a)   Cyclic (recurring) function capabilities

   b)   Generation of physical memory maps

   c)   Additional automatic sensing and bypassing of unnecessary logic
        to reduce execution time

   d)   Revised transaction pushdown stack operations

   e)   Development of non-interpretive MODLIT for more rapid batch runs

   f)   Expanded representation of simulated executive logic

   g)   Expanded error message capabilities

   h)   "Conversational" mode for input form entries

   i)   Expanded IMSIM reports

2. <u>Maintenance</u>

   a)   Implementation of scatter-load capabilities

   b)   Recompilations with upgraded versions of MODLIT, maintaining
        compatibility with RTOS

   c)   Implementation of MODLIT/IMSIM on other computer systems

3. <u>Documentation</u>

Continued maintenance of program documentation and generation of more
illustrative user-oriented manuals.

4. <u>Model Construction and Analysis Support</u>

   Assistance in the construction, execution, and analysis of specific
   configurations, including the implementation of interim logic fixes
   to IMSIM as desired by MSC.

Through the augmentation of IMSIM in these tasks, MSC will be assured of an
even more effective simulation model for the preliminary design and assessment
of large scale information management systems.

APPENDIX A - Project Documentation

1.   CDRL Item 1 - Program Description Manual change pages

        TM-(L)-4713/000/01A Draft: 20 October 1972
        TM-(L)-4713/000/01A Final: 10 November 1972

2.   CDRL Item 2 - User's Manual change pages

        TM-(L)-4712/001/01A Draft: 20 October 1972
        TM-(L)-4712/001/01A Final: 10 November 1972

3.   CDRL Item 3 - Monthly Progress Reports

        TM-4966/001/00: 7 August 1972
        TM-4966/002/00: 7 September 1972
        TM-4966/003/00: 7 October 1972
        TM-4966/004/00: 7 November 1972

4.   CDRL Item 4 - Final Report

        TM-5019/000/00 Draft: 20 October 1972
        TM-5019/000/00 Final: 10 November 1972

5.   CDRL Item 5 - Classroom Handout Documents

        TM-5011/000/00 Draft: 16 October 1972
        TM-5011/000/00 Final: 10 November 1972

6.   Project Correspondence

     a) SDC letter of 11 August 1972, entitled "IMSIM Modification Plan,"
         by J. J. Peterka.

     b) SDC letter of 13 October 1972, entitled "Extension of Period of
         Performance for Current IMSIM Contract," by R.W. Bilek.

         (Letters of transmittal also accompanied SDC deliveries of CDRL
         items 1, 2, 4, and 5.)

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