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FEDERAL COMPUTER PERFORMANCE EVALUATION AND SIMULATION CENTER



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PREFACE

This report is based on a detailed analysis of the Information Processing System Simulator (IPSS), DIMUI, and the Extendable Computer System Simulator (ECSS). The results address the specific problem of evaluating the capabilities of the above for the modeling and performance evaluation of data base management systems and their computer system environments. Questions related to the subject of this report or to the possibility of extending the stated conclusions should be addressed to its author at the Federal Computer Performance Evaluation and Simulation Center (FEDSIM).

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ABSTRACT

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This report presents the results of FEDSIM's evaluation of the Information Processing System Simulator (IPSS), the Extendable Computer System Simulator (ECSS), and DIMUI--A Performance Evaluation System for Data Base Management with respect to their data base management system/computer system modeling capabilities, modeling support facilities, and program product qualities.

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TABLE

I. INTRODUCTION

This report presents the results of FEDSIM's evaluation of the Information Processing System Simulator (IPSS), ',' the Extendable Computer System Simulator (ECSS), and DIMUI₄₋₅ Performance Evaluation System for Data Base Management. The objective of the evaluation is to assess the Data Base System (DBS) modeling capabilities, modeling support facilities, and program product qualities of each simulator.

¹T. G. DeLutis, "A Methodology for the Performance Evaluation of Information Processing Systems," Final Report to the National Science Foundation, Office of Science Information Services, Grant No. GN 36622.

²T. G. DeLutis, "Information Processing System Simulator (IPSS): Syntax and Semantics," working document to NSF Grant No. GN 36622.

³D. W. Kosy, <u>The ECSS II LANGUAGE for Simulating Computer</u> Systems (The Rand Corporation, 1975).

⁴A. Reiter and B. Finkel, "Simulating a Virtual Data Machine," NTIS Document No. AD-A027 894, May 1976.

⁵A. Reiter, "DIMUI - IDMS User Manual, Version 1.2," Technical Report No. 101, Israel Institute of Technology, June 1977.

⁶"Data Base System" is used here to mean data base management system and its computer system environment.

II. METHODOLOGY

In order to establish a perspective from which to view and evaluate a DBS simulator, a structured set of evaluation criteria was developed. An evaluation technique was then developed to provide a means to specify the degree to which a simulator's facilities and qualities satisfy the criteria, and to facilitate a comparative evaluation of IPSS, DIMUI, and ECSS.

A. EVALUATION CRITERIA

The DBS simulator evaluation criteria are organized into three major categories: (1) modeling capabilities, (2) modeling support facilities, and (3) program product qualities.

1. Modeling Capabilities

DBS simulation imposes a need for modeling capabilities oriented specifically toward DBMS's and computer systems, in addition to those capabilities required for simulation in general. DBS simulator's modeling facilities can be evaluated by the extent that the simulator supports the modeling of the items listed in Table II-1.

2. Modeling Support Facilities

The overall utility of a DBS simulator is determined by its support of the entire simulation modeling process, as well as by the actual modeling facilities it provides. The support capabilities specified in Table II-2, which benefit all stages of the DBS simulation modeling process, are used to evaluate each DBS simulator's modeling support facilities.

3. Program Product Qualities

Aside from the functional and technical issues associated with DBS simulation modeling, a DBS simulator should also be evaluated as a program product. Table II-3 identifies the criteria used to evaluate the DBS simulator as program product.

B. EVALUATION TECHNIQUE

The foregoing categories of evaluation criteria establish the perspectives from which a DBS simulator is viewed and

OATA BASE MANAGEMENT SYSTEM (DBMS)

- DBMS buffers
 - Description
 - Management algorithms
 - Management
 - Management/use operations
 - Buffer-data base access interaction
 - Utilization statistics collection
 - Queueing statistics collection
- Data base access control mechanisms
- Data base access scheduling algorithms
- Data base access management
- Request scheduling algorithms
- Data base management utility functions
- DBMS overhead
- Request processing statistics collection
- Request queueing statistics collection
- Data base access statistics collection
- Data base access locality statistics collection
- Data base access queueing statistics collection
- DBMS overhead statistics collection
- Data manipulation language (DML) operation statistics collection

MODELING CAPABILITIES: EVALUATION CRITERIA

TABLE II-1

OPERATING SYSTEM

- Resource management strategies
- Resource management
- Separation from application program behavior
- Supervisory overhead
- Supervisory overhead statistics collection
- TELEPROCESSING RESOURCES
 - Transmission control units
 - Communications lines
 - Terminal I/O devices
 - Terminal control units
 - TP device connectivity
 - Message transmission operations
 - Computation of message transmission time
 - Message management strategies
 - Message management
 - Line control

MODELING CAPABILITIES: EVALUATION CRITERIA

TABLE II-1 (Cont'd)

4

• PROCESSOR RESOURCES

- Definition
- Execution rate
- Execution rate degradation due to primary memory contention
- Different execution rates for different instruction types
- Multiprocessor configurations
- Processor management strategies
- Processor management
- Priority-based interrupts
- Execution bursts
- Virtual memory reference patterns associated with execution bursts
- Multiprocessor management strategies
- Multiprocessor management
- Processes which implicitly require allocation of a processor
- Utilization statistics collection
- Queueing statistics collection
- Utilization-by-process statistics collection

MODELING CAPABILITIES: EVALUATION CRITERIA

- STORAGE RESOURCES: PRIMARY MEMORY
 - Definition
 - Memory management strategies
 - Memory management
 - Allocation/deallocation requests
 - Capacity utilization statistics collection
 - Capacity queueing statistics collection
- * STORAGE RESOURCES: VIRTUAL MEMORY
 - Definition
 - Mapping to secondary storage
 - Mapping to primary memory
 - Page reference
 - Page transfer
 - Management strategies
 - Management
 - Page fault statistics collection
 - Utilization statistics collection
 - Queueing statistics collection

- * STORAGE RESOURCES: SECONDARY STORAGE, DIRECT ACCESS
 - Definition
 - Capacity
 - Physical organization
 - Space overhead
 - Space management strategies
 - Space management
 - Space allocation/deallocation requests
 - Space utilization statistics collection
 - Space queueing statistics collection
- STORAGE RESOURCES: SECONDARY STORAGE, TAPE
 - Definition
 - Capacity
 - Space overhead

- I/O RESOURCES: DIRECT-ACCESS STORAGE DEVICES
 - Definition
 - Transfer rate
 - Latency
 - Cylinder access time
 - Computation of cylinder access time
 - Computation of data transfer time
 - Read/write operations
 - Seek operation
 - Search operation
 - Computation of search time
 - Seek statistics collection
 - Read/write statistics collection
 - Search statistics collection
 - Utilization statistics collection
 - Queueing statistics collection

TABLE II-1 (Cont'd)

8

- ° I/O RESOURCES: TAPE DEVICES
 - Definition
 - Transfer rate
 - Rewind rate
 - Latency
 - Computation of data transfer time
 - Computation of rewind time
 - Read/write operations
 - Rewind operation
 - Utilization statistics collection
 - Queueing statistics collection
 - Read/write statistics collection
 - Rewind statistics collection
- I/O RESOURCES: UNIT RECORD DEVICES
 - Definition
 - Transfer rate
 - Latency
 - Computation of data transfer time
 - Read/write operations
 - Utilization statistics collection
 - Queueing statistics collection

- I/O RESOURCES: CONTROL UNITS
 - Definition
 - Transfer rate
 - Message capacity
 - Utilization statistics collection

.

- Queueing statistics collection
- I/O RESOURCES: CHANNELS
 - Definition
 - Transfer rate
 - Message capacity
 - Utilization statistics collection
 - Queueing statistics collection

• I/O RESOURCES: OTHER I/O DEVICES

- Definition
- Transfer rate
- Computation of data transfer time
- Read/write operations
- Utilization statistics collection
- Queueing statistics collection
- Read/write statistics collection

MODELING CAPABILITIES: EVALUATION CRITERIA

- I/O RESOURCES: DEVICE CONNECTIVITY
 - Definition
 - Dynamic path selection
 - Path management strategies
 - Path allocation/deallocation
 - Path management
 - Computation of effective path data transfer rate based on current states of all I/O devices on a path
 - Critical device statistics collection
 - Path utilization statistics collection
 - Path queueing statistics collection
- I/O RESOURCES: BUFFERS
 - Definition
 - Management strategies
 - Buffer management
 - Buffer allocation/deallocation requests
 - Buffer-I/O interaction
 - Utilization statistics collection
 - Queuing statistics collection

TABLE II-1 (Cont'd)

11

- * DATA RESOURCES: FILES/FILE STRUCTURES
 - Definition
 - Record characteristics
 - Space allocations
 - Access methods
 - Record-to-space allocation mappings
 - Space allocation-to-physical storage media mappings
 - Translation of file access into I/O activity
 - File access requests
 - Dynamic file creation/deletion
 - Dynamic file space allocation
 - File management strategies
 - File management
 - Access statistics collection
 - Queueing statistics collection
 - Utilization statistics collection

° DATA RESOURCES: DATA BASE

- Data structure (DS) representation
- Multiple DS's
- DS-to-DS mappings
- DS access/traversal operations
- Translation of access/traversal operations into processing time and physical I/O activity
- DS-to-secondary storage media mapping
- DS-to-virtual storage mapping
- DS-to-file (structure) mapping
- DML command characterization
- DML command invocation
- DS access paths
- Dynamic access path selection
- Access path statistics collection
- Data structure accessing statistics collection
- ° SOFTWARE RESOURCES
 - Definition
 - Management strategies
 - Management
 - Allocation/deallocation requests
 - Utilization statistics collection
 - Queueing statistics collection

MODELING CAPABILITIES: EVALUATION CRITERIA

PROCESSES

- Definition/characterization
- Implicit processor requirement
- Time delays
- Initiation
- Termination
- Synchronization/communication/suspension
 - Wait for sub-process
 - Wait/post mechanism
 - Wait for I/O
 - Inter-process message passing
- Initialization, saving, and restoring of local process variables
- Process lists
- Process list entry discipline
- Process list operations
- Occurrence statistics collection
- Processor utilization statistics collection
- Processor queueing statistics collection
- Resource utilization statistics collection
- Resource queueing statistics collection
- I/O statistics collection

MODELING CAPABILITIES: EVALUATION CRITERIA

· WORKLOAD

- Workload element representation
- Workload element arrival pattern specification
- Workload element processing statistics collection

GENERAL-PURPOSE SIMULACRA

- Events

- Definition
- Internal events
- External events
- Recurring events
- Event scheduling operations
- List data structures
 - Definition
 - Dynamic creation
 - List elements
 - Definition
 - Data aggregates
 - Dynamic creation/deletion
 - List processing operations
- Random number generator
- Probability distribution functions
- Empirical distributions
- Event and clock management
- Recursive routines
- Basic computational facilities

MODELING CAPABILITIES: EVALUATION CRITERIA

TABLE II-1 (Cont'd)

15

- STATISTICS COLLECTION CONTROL
 - Suppression/resumption
 - Selective suppression
 - Selective omission
 - Reset
 - Cumulative collection
 - Collection of statistics for specified time intervals
- STATISTICS REPORTING
 - Automatic generation of reports in pre-defined formats
 - Selective report generation
 - Report generation scheduling
 - End-of-simulation
 - Periodically
 - Via external events
- SUPPLEMENTAL STATISTICS COLLECTION AND REPORTING
- MODEL BEHAVIOR TRACING
 - Statement-execution level trace
 - Change-of-state level trace
 - Tracing control
 - Selective change-of-state tracing
 - Limited-range statement-execution tracing
 - Event-based scheduling of tracing activity

MODELING SUPPORT FACILITIES: EVALUATION CRITERIA

TABLE II-2

POST SIMULATION PROCESSING

- Selective saving of raw statistics data
- Graphical display of statistics data
- Generation of standard statistics reports from raw statistics data
- MODEL SYNTHESIS
 - Model source component library facilities
 - On-line interactive prompting/help facility for model source input
 - On-line model source editing
 - Macro processing

^o MODEL VERIFICATION AND VALIDATION

- Run-time diagnostic facilities
- Model debugging facilities
 - Tracing
 - Formatted dumps
 - Behavior statistics
 - Routine traceback
 - Snapshot
- Diagnostics at model source statement level as well as at base language level
- On-line, interactive debugging facilities
- Supplemental debugging facilities

MODELING SUPPORT FACILITIES: EVALUATION CRITERIA

^o MODEL INITIALIZATION AND MODIFICATION

- Pre-simulation input of model initialization data
 - System-defined capability for parameter value entry
 - Modeler-programmable parameter value entry and storage
- Modification with minimal or no model source reprocessing
 - Assigning new values to model parameters
 - Hardware reconfiguration
 - Routine replacement

MODEL PROCESSING

- Model source syntax checking
- Library facilities for the storage and retrieval of object/load modules
- Diagnostics at each step of model processing
- Conditional termination of model processing at any step due to error(s) in a previous step
- Operating system-independent control language to initiate and control model processing
- Inclusion of previously-processed model components

MODELING SUPPORT FACILITIES: EVALUATION CRITERIA

MODEL EXECUTION

- Run-time diagnostic facilities
- Checkpoint/restart
- Simulation termination control
 - Simulated-time based
 - Event-occurrence based
 - Error-occurrence based
 - Run-time based
- Operating system independent language to initiate and control model execution
- Run-time monitor providing on-line interaction with a model during execution
- Multiple simulations during a single run

MODEL OPTIMIZATION

- Main storage space requirements
 - Program overlay
 - Deletion of unneeded data structures
 - Release of initialization and other routines not required after start of simulation
 - Omission of unneeded statistics collection
- Executional efficiency
 - Optimizing compiler
 - Suppression/omission of collection of unneeded statistics

MODELING SUPPORT FACILITIES: EVALUATION CRITERIA

- ACQUISITION COSTS
 - Simulator
 - Other software products
- MAINTENANCE
 - Costs
 - Probability of continuing, long-term support
- RESOURCE REQUIREMENTS
 - Specific computer systems and/or operating systems
 - Main memory space
 - Language compiler(s), assemblers
 - Other software products
- ° PORTABILITY

STABILITY/RELIABILITY

PROGRAM PRODUCT QUALITIES: EVALUATION CRITERIA

TABLE II-3

DOCUMENTATION

- User's manual
- Language reference manual
- Program logic manual
- Texts, tutorials
- Descriptions of:
 - Default algorithms
 - System-defined data structures

 - Random number generator algorithms
 Probability distribution function algorithms
 - Timing routine
 - Event management
 - Process management
 - System-defined subprogram communication conventions

° TRAINING

- Courses
- Consultation

PROGRAM PRODUCT QUALITIES: EVALUATION CRITERIA

evaluated. Depending on the category, an evaluation technique ranging from qualitative assessment to quasi-quantitative measurement is used, as described below.

1. Modeling Facilities

Depending on the richness of a language's modeling constructs and features, a desired capability may be achievable with or without there being an explicit feature for it. Thus, it is not sufficient to simply state that a simulator "has" a particular capability or does not have it. To objectively evaluate a simulator's true modeling capabilities, a more quantitative measurement scale is needed. Such a measurement scale will also facilitate the comparison of languages with both similar and diverse features for satisfying the same set of requirements.

To achieve a desired modeling capability, a certain amount of modeling effort is required on the part of a modeler; and the amount of effort will vary depending on the features of the simulator being used. The degree to which a simulator supports a desired modeling capability can be "measured" in terms of the <u>level of modeling effort</u> required to achieve the capability using the simulator's modeling facilities. Thus, the quasi-quantitative measurement scale to be used for evaluating a DBS simulator's modeling capabilities will have level of modeling effort as a metric.

Specifically, the evaluation technique will, for each modeling capability, specify the following:

a. Whether or not the capability is explicitly provided (a measure of the richness of a simulator's modeling constructs).

b. The level of modeling effort required, encoded as one of the following:

- NONE: Capability is provided automatically/ implicitly
- * DCL: Capability is achieved via a declarative
- STMT: Capability is achieved via one or very few in-line (high-level) statement(s)

- ROUTINE: Capability is achieved via a single (process) routine or a relatively small number of in-line statements
- MODULE: Capability is achieved via two or more routines and/or many in-line low-level statements
- MODULE+: Capability is achieved via two or more routines and/or many in-line low-level statements, plus new data structure(s)
- MODULE++: Capability is achieved via two or more routines and/or many in-line low-level statements, plus new data structure(s) and substantial modifications to system-defined data structures and/or system routines

c. Qualifying remarks regarding how the capability is achieved, limitations, etc.

2. Modeling Support Facilities

The modeling support facilities of a simulator are appraised using a qualitative assessment technique. For each support requirement, the following is specified:

a. An indication (YES or NO) of the availability of the modeling support facility.

b. If the support facility is provided, an appraisal of its comprehensiveness and/or limitations, if appropriate.

3. Program Product Qualities

A qualitative assessment is made of the qualities of each simulator as a program product per the specified evaluation criteria.

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III. ASSUMPTIONS AND CONSTRAINTS

The results of the evaluation are based on (1) a review of all available documentation on IPSS, DIMUI, and ECSS; (2) FEDSIM's experiences with ECSS and IPSS; and (3) limited discussions with the developers of IPSS and DIMUI.

Additional insight into the capabilities and usability of each simulator for DBS modeling could be obtained by benchmark studies, involving the application of each simulator to a set of representative DBS modeling problems. Such studies are, however, beyond the scope of this project.

The developmental nature of IPSS and DIMUI is recognized and every effort has been made to represent as accurately as possible the capabilities of each. Capabilities which are inadequately documented or undocumented may not be accurately represented.

IV. FINDINGS AND RESULTS

A. IPSS

The results of the evaluation of IPSS with respect to its modeling capabilities, modeling support facilities, and program product qualities are presented below. Detailed evaluation results are presented in tabular format in Appendix A.

1. Modeling Capabilities

IPSS modeling constructs are embodied in a modeling language comprised of a large number of declarative and executable statements. Due to the large number of statement types and the often large number of parameters per statement, the IPSS language is not an easy language to learn. Learning the language is, however, facilitated by the natural way in which many of the statements correspond to components and operations within the DBS being modeled.

DBMS Modeling. IPSS provides facilities for modeling DBMS-related application programs, DBMS software, and DBMS buffer management. Built-in features facilitate characterizing data manipulation operations, modeling data structure traversal, and simulating data base access. All DBMS application programs, scheduling algorithms, utility functions, data manipulation operations, and other software strategies must be procedurally characterized. There is no implicit mechanism for modeling data base access management or DBMS request management. Statistics on data base accessing, DBMS request processing, and DBMS software execution are automatically collected and reported.

Operating System Modeling. IPSS does not represent the supervisory software of a computer system as a distinct model component. Resource management functions must be procedurally characterized. Supervisory overhead is not represented explicitly and is not reported as a separate component of resource utilization. IPSS does provide certain capabilities which will facilitate the characterization of resource management strategies, including the automatic association of a queue with each defined resource, queues and queue management, and process suspension and synchronization.

Teleprocessing Subsystem Modeling. IPSS does not provide explicit facilities for modeling teleprocessing (TP) environments. Certain IPSS definitional facilities can be adapted to describe TP hardware configurations and characterize TP message transmission; but extensive supplemental coding is required for modeling line control, message management, etc.

Processor Resource Modeling. Other than the capabilities to define a CENTRAL PROCESSOR or an INPUT OUTPUT PROCESSOR facility and to represent time delays within processes, IPSS provides no special support for simulating processors, interrupts, processor management, and processor usage.

Storage Resource Modeling. Primary memory is represented explicitly and may be characterized either as simply having a capacity or as consisting of some number of partitions, each of which has a capacity. Procedural operations for effecting memory allocation/deallocation are provided. No implicit memory management capability is provided. Memory utilization statistics are collected automatically in response to memory allocation/deallocation operations.

IPSS provides no explicit facilities for the representation of virtual memory, virtual memory management, or virtual memory usage.

Facilities are provided for the description of secondary storage devices, including direct-access and tape devices, and for the representation of secondary storage for space management purposes. No implicit secondary storage space management capability is provided.

<u>I/O Resource Modeling</u>. IPSS provides explicit capabilities for the description of secondary storage I/O devices, control units, channels, and other peripheral I/O devices, and the representation of I/O device configurations. I/O statistics are collected automatically for all I/O devices.

IPSS allows the description of buffer pools and provides built-in buffer allocation/deallocation operations. Buffer utilization statistics are collected automatically in response to those operations. There is no implicit buffer management capability.

Data Resource Modeling. IPSS provides extensive facilities for the description of files and file structures, the specification of file placement, and the representation of file accessing. File references are automatically translated into physical storage addresses. File (structure) access methods must be procedurally characterized. File accessing statistics are collected automatically.

Extensive facilities are also provided for describing data base structure and for characterizing data base access. Those facilities allow the description of arbitrary hierarchical and network data structures, data structure implementation techniques, and data structure access paths. IPSS automatically collects and reports statistics on data base accessing and access path utilization.

Software Resource Modeling. Software strategies are characterized procedurally, and are implicitly regarded as resources. Thus, they can be allocated and released. A process can be automatically delayed pending the availability of a software resource. Queueing and utilization statistics are automatically collected for all software resources.

Process Modeling. In IPSS, a process is called a "service," and there are two types. An "exogenous service" represents an external stimulus to the model (e.g., the arrival of a transaction), whereas an "endogenous service" represents some unit of internal processing (e.g., the execution of a software resource). There are built-in operations for process initiation, suspension, synchronization, communication, and termination. Process utilization and queueing statistics are collected automatically. Resource queueing and utilization statistics may be collected on a per process basis.

In addition to its special-purpose DBS-oriented modeling capabilities, IPSS provides a built-in multiple-seed random number generation capability, built-in probability distribution functions, and list processing capabilities. Basic programming capabilities are provided by IPSS's FORTRAN IV base language.

2. Modeling Support Facilities

Statistics Collection Control. IPSS provides for the automatic collection of many statistics. Control of statistics collection is limited to the resetting of statistics between consecutive simulations.

Statistics Reporting. IPSS produces statistics reports automatically at the end of a simulation. Aside from being

able to suppress the automatic generation of reports, the modeler has no control over statistics reporting.

Supplemental Statistics Collection And Reporting. Additional statistics collection and reporting can be programmed by the modeler in FORTRAN IV.

Model Behavior Tracing. Limited tracing facilities are provided by IPSS. A routine-execution trace of either modeler-written and/or IPSS routines is supported; in addition, the contents of all active process and I/O transactions can be displayed.

Post Simulation Processing. The modeler has the capability to program post simulation analysis, which can occur after a simulation and/or between consecutive simulations. Analysis routines are programmed in FORTRAN IV.

Model Synthesis. IPSS provides model source component library facilities which allow the modeler to store model segments for future reference. Coupled with these facilities is a simple macro facility for effecting textual substitution during retrieval of a stored model segment.

Model Verification And Validation. IPSS's error-checking, tracing, and statistics collection and reporting facilities as well as the diagnostic facilities provided by the FORTRAN IV run-time system, assist in model verification/validation.

Model Initialization And Modification. Model parameter values may be entered at the beginning of or between simulations. Such parameters can be referenced from both declarative and procedural model components. Additional parameter value entry and storage can be programmed using FORTRAN IV.

IPSS allows a wide range of model modifications which can be made at the beginning of a simulation or between consecutive simulations.

Model Processing. The processing of an IPSS model involves IPSS language translation, FORTRAN IV compilation, and linkage editing. Model processing is controlled using an operating system-independent control language, thereby minimizing the use of operating system job control language and allowing for optimization of model processing by batching translation, compilation, and linkage edit operations.
Model Execution. IPSS provides simulation-time diagnostic facilities. As with model processing, model execution is initiated and controlled using IPSS language directives. IPSS provides a variety of simulation termination control capabilities. Multiple simulations may be performed during a single IPSS run.

Model Optimization. IPSS provides no specific facilities for optimizing a model's storage space requirements and/or executional efficiency.

3. Program Product Qualities

IPSS is a public domain product. It currently exists only as a prototype developmental system. As a consequence, only a very limited evaluation of its program product qualities can be made. A substantial amount of development work and documentation remains to be done. IPSS's stability and reliability can only be ascertained by subjecting it to extensive use. Its portability is restricted to IBM System 360/370 due to the need for a PL/I compiler and internal assembler routines.

B. ECSS

The results of the evaluation of ECSS with respect to its modeling capabilities, modeling support facilities, and program product qualities are summarized below. Detailed evaluation results are presented in Appendix B.

1. Modeling Capabilities

ECSS modeling constructs are embodied in a modeling language comprised of a relatively few number of declarative and executable statement types. Since ECSS is a superset of SIMSCRIPT II.5, the use of ECSS necessitates a knowledge of SIMSCRIPT II.5. The ECSS language itself is relatively easy to learn due to its English-like form and the natural way in which its modeling constructs correspond to the components and operations of the DBS being modeled. In addition, the set of ECSS statement types is easily extended through the use of ECSS macro facilities.

DBMS Modeling. ECSS provides no special support for simulating DBMS components and processing activities. ECSS modeling facilities, although partially satisfying DBMSrelated modeling requirements, must be augmented with a substantial amount of lower-level coding and new data structures to achieve desired DBMS modeling capabilities.

Operating System Modeling. ECSS provides for the representation of a computer system's supervisory software as a distinct model component, definitionally independent of application software characterization. The concept of a "manager" mediating between requests for resources and the allocation of those resources is central to ECSS. Whenever a request occurs, or a resource is released, a manager routine is called to try to satisfy the request, or to reallocate the resource to a queued request, as necessary. ECSS supplies default managers for all definable resources. These managers embody typical resource allocation algorithms found in computer systems. Having such managers allows the characterization of supervisory software with minimal effort. The modeler is, however, not locked in to the default managers. To support the construction of new managers, the default managers are available for user modification and their operation is fully explained. Supervisor overhead can be represented explicitly and independently of other execution activity. ECSS automatically collects and reports statistics on supervisor overhead.

<u>Teleprocessing (TP) Modeling</u>. ECSS provides limited support for simulating TP resources and activities. Such support primarily pertains to the description of TP devices and device connectivity, and the representation of message transmission. A substantial amount of supplemental coding is required to achieve desired modeling capabilities related to line control, message management, and TP-related statistics collection.

Processor Resource Modeling. ECSS provides extensive facilities for simulating processors. Specific facilities are available for representing processors and multiprocessors, the memories in which they execute, the jobs that use them, and their management strategies. Processor management is an implicit aspect of simulated job execution. Processor utilization and queueing statistics are automatically collected and reported by ECSS.

Storage Resource Modeling. ECSS provides facilities for simulating arbitrary storage devices and storage management. A storage device may be represented as simply having a capacity which is incremented or decremented in response to allocations and deallocations. Alternatively, it may be represented as an address space which is allocated in distinct, contiguous pieces. In either case, default storage management algorithms are provided. Such storage device-related simulacra may be applied to the modeling of main memory, virtual memory, and secondary storage. ECSS automatically collects and reports storage utilization and queueing statistics.

<u>I/O Resource Modeling</u>. ECSS allows the definition of arbitrary I/O devices in terms of their simultaneous message capacity, nominal transfer rate, and maximum transfer rate for all concurrent messages. It also allows the arbitrary connection of any number of these devices to form an I/O data path. I/O management algorithms are provided, and can be easily modified or replaced. I/O management, including dynamic path selection, is implicitly performed for each simulated I/O operation. The representation of buffers, buffer usage, and buffer management, while not explicitly supported, may be readily accomplished using the concept of a storage device together with its associated storage management facilities and allocation/deallocation requests. ECSS automatically collects and reports statistics on I/O device utilization, queueing, and transmission rates, and I/O data path queueing and utilization.

Data Resource Modeling. ECSS does not support file (structure) description, file allocation to storage devices, or file accessing. It also does not support the representation of data structures, data structure implementation techniques, and data structure accessing. A substantial number of SIMSCRIPT statements and new data structures are required to achieve such capabilities. The ECSS macro facilities have been used to extend the ECSS language syntax with statements that realize many of the desired file-related modeling capabilities.

Software Resource Modeling. ECSS provides no explicit representation of software processes as resources.

Process Modeling. ECSS supports two types of processes: "external processes," which usually represent the dynamics of system loading or the behavior of equipment/users external to the system under study; and "jobs," which represent executable programs which implicitly require a simulated processor in order to execute. Extensive facilities are provided for process initiation, suspension, synchronization, termination, and interprocess communication. ECSS automatically collects and reports statistics on process execution; additionally, process types may be grouped into "families" for which ECSS automatically collects and reports statistics.

In addition to its special-purpose computer systemoriented modeling capabilities, ECSS also provides extensive general-purpose simulacra and basic programming capabilities via its SIMSCRIPT II.5 base language.

2. Modeling Support Facilities

Statistics Collection Control. ECSS allows the modeler to control the automatic collection and reporting of statistics. Control capabilities include the suppression/omission of selected statistics, reset of statistics, and collection of statistics for specified simulated-time intervals.

Statistics Reporting. In addition to producing statistics reports automatically at the end of a simulation, ECSS provides the modeler with run-time control of statistics reporting.

Supplemental Statistics Collection And Reporting. SIMSCRIPT II.5 provides special facilities for automatic statistics data collection and analysis based on modelerspecified directives. In addition, SIMSCRIPT II.5 provides special report generation features.

Model Behavior Tracing. ECSS provides extensive tracing facilities ranging from high-level statement execution tracing to detailed model change-of-state tracing. The modeler is provided with run-time control over trace options and trace start/stop times.

Post-Simulation Processing. ECSS provides the capability of selectively saving raw statistics data for post-simulation analysis. Behavior traces and standard statistics reports can be generated from the saved statistics data. Additional analysis can be programmed using SIMSCRIPT II.5.

Model Synthesis. A powerful macro facility is provided for modifying or extending the basic ECSS language syntax. Macros may be recursive, may have arguments, and may contain default values for arguments not specified at macro-call time. Model Verification And Validation. The combination of ECSS's error-checking, tracing, statistics collection and reporting, and model snapshot facilities and SIMSCRIPT II.5's error-detection and debugging-oriented features provides the modeler with powerful capabilities for model verification and validation.

Model Initialization And Modification. Model parameter value entry and storage can be programmed in SIMSCRIPT II.5. Data elements in ECSS-defined data structures are referenceable by name, permitting easy access/modification. Substitution of one subprogram for another can be accomplished easily through the use of subprogram variables.

Model Processing. Model processing is a multi-step process, involving ECSS translation, SIMSCRIPT II.5 compilation, and linkage-editing/loading. Diagnostic facilities are provided at each step in the process. Model processing is initiated and controlled via operating system job control language statements.

Model Execution. ECSS provides run-time diagnostic facilities. Generally, an error is considered fatal, causing the simulation to stop. ECSS provides the modeler with the capability to terminate a simulation at a specified simulatedtime. Simulation termination based on any other criteria must be modeler-programmed.

Model Optimization. ECSS/SIMSCRIPT II.5 provide the modeler with certain capabilities for optimizing a model's main storage space requirements and/or executional efficiency.

3. Program Product Qualities

ECSS is maintained by FEDSIM. Implementations of ECSS exist for the following computer systems: IBM System 360/370 series, Honeywell 600/6000 series, CDC 6000/7000 series, and UNIVAC 1100 series. Since the base language of ECSS is SIMSCRIPT II.5, a SIMSCRIPT II.5 compiler is required. ECSS is a stable program product whose reliability has been established by extensive use over a three-year period. ECSS courses and consultation are available from FEDSIM.

C. DIMUI

The results of the evaluation of DIMUI with respect to its modeling capabilities, modeling support facilities, and program product qualities are summarized below. Detailed evaluation results are presented in Appendix C.

1. Modeling Capabilities

As it currently exists, DIMUI is difficult to use due to the lack of a modeling language. DBS model synthesis involves the coding of FORTRAN IV subprograms and the input of model parameter values in fixed, pre-defined formats.

DBMS Modeling. DIMUI provides explicit facilities for simulating DBMS buffer usage and management, data structure traversal and accessing, data base access, data base access control and scheduling, and request scheduling. DIMUI provides a framework which the modeler tailors to a specific DBMS via the insertion of resource management strategies and characterizations of DML operations and other DBMS functions.

Operating System Modeling. DIMUI provides for the representation of certain computer system supervisory software functions as distinct model components, definitionally independent of application software characterization. Specifically, job scheduling, processor management, disk I/O scheduling, channel scheduling, buffer management, and disk space management strategies can be represented. DIMUI supplies default modules for each of the above supervisory functions. Resource management functions are performed implicitly in response to resource allocation/deallocation requests.

Teleprocessing (TP) Modeling. DIMUI provides no support for modeling TP resources and activities.

Processor Resource Modeling. Limited support is provided for simulating processors. Specific facilities are provided for representing processors, processor usage, interrupts, and processor management strategies. Processor management is an implicit aspect of simulated task execution. DIMUI provides a default uni-processor management strategy. Processor utilization statistics are automatically collected and reported.

Storage Resource Modeling. DIMUI allows the representation of disk and tape secondary storage devices. Facilities are provided for representing disk space usage and management, including a default disk space manager. Main memory is representable only as a collection of buffers organized into one or more buffer pools. Facilities are provided for the representation of buffers, buffer usage, and buffer management.

<u>I/O Resource Modeling.</u> DIMUI supports the representation of certain I/O devices, specifically, tape and disk units and channels. A simple channel-disk/tape unit architecture is supported. I/O device management is an implicit aspect of I/O device modeling. Disk I/O requests are managed by a disk scheduler; each channel is managed by a channel scheduler. DIMUI supplies default disk and channel scheduling strategies.

Specific facilities are provided for the representation of buffers, buffer usage, and buffer management. Buffering is an implicit aspect of simulated data base access. A variety of alternative buffer management strategies are built into DIMUI.

DIMUI automatically collects and reports statistics on tape/disk device utilization, channel utilization, and I/O requests.

Data Resource Modeling. DIMUI supports file (structure) description, file allocation to storage devices, and simulated file accessing. In addition, it supports the representation of data structures, data structure implementation techniques, and data structure traversal/accessing. The data structure modeling capability is sufficiently general to allow the representation of arbitrary hierarchical and network data structures.

Software Resource Modeling. DIMUI provides no explicit representation of software processes as resources.

Process Modeling. DIMUI supports the representation of processes as "tasks," which represent executable programs consisting of a series of processing and data structure access/traversal activities.

In addition to its special-purpose DBMS-oriented modeling capabilities, DIMUI provides a built-in multiple-seed random number generation capability, built-in probability distribution functions, and modeler-defined distribution tables. Basic programming capabilities are provided via DIMUI'S FORTRAN IV base language.

2. Modeling Support Facilities

Statistics Collection Control. DIMUI provides limited automatic statistics collection but does not provide the modeler with any control over the statistics collection process.

Statistics Reporting. Statistics reports are automatically produced at the end of a simulation.

Supplemental Statistics Collection And Reporting. The capabilities of FORTRAN IV are available for programming supplemental statistics collection and reporting.

Model Behavior Tracing. DIMUI's tracing facilities are limited to the automatic logging of all events and interrupts.

Post-Simulation Processing. Any post-simulation analysis would have to be programmed by the modeler in FORTRAN IV.

Model Synthesis. No special capabilities are provided for facilitating the model synthesis process.

<u>Model Verification And Validation</u>. DIMUI's error-checking, tracing, and statistics collection and reporting facilities provide limited assistance for model verification/validation.

Model Initialization And Modification. DIMUI provides extensive model parameterization, thereby facilitating model initialization/modification. Parameterization applies to selection of system-supported resource management strategies, selection of system-supported secondary storage device characteristics, selection of system-supported DBMS-related software strategies, workload description, data structure characteristics, and secondary storage hardware configuration. Additional model parameter value entry and storage can be programmed in FORTRAN IV.

Model Processing. Model processing is a multi-step process, involving FORTRAN IV compilation and linkage-editing. It is initiated and controlled via operating system job control language statements. No special capabilities related to model processing are provided.

Model Execution. DIMUI provides the modeler with the capability to terminate a simulation either when all events and interrupts have been processed or by an explicit command.

Model Optimization. There are no documented model optimization capabilities.

3. Program Product Qualities

DIMUI is a public domain product. It currently exists only as a developmental system. Consequently, only a very limited evaluation of its program product qualities can be made. Much additional documentation concerning DIMUI's modeling capabilities, internal operations, etc., is needed. DIMUI is portable, since it is implemented in standard FORTRAN IV.

V. CONCLUSIONS

The following conclusions have been reached regarding the basic DBS modeling capabilities of IPSS, ECSS, and DIMUI.

A. IPSS

Extensive support is provided for modeling data base structures, data base accessing, files, file accessing, and secondary storage device I/O and space management. No special support is provided for modeling TP subsystem components and activities. IPSS does not support the representation of computer system supervisory software as a distinct model component.

IPSS is most applicable to the modeling of a DBS from the perspective of its DBNS subsystem. With its focus on data base structure, data base accessing, DBMS workload, and secondary storage hardware and associated I/O activity, IPSS readily supports the examination of the influence on DBMS behavior of a variety of factors such as data structures, data structure implementations, data base access strategies, DBMS loading, secondary storage hardware configurations, and secondary storage resource management strategies.

The data base, file, and secondary storage related modeling capabilities of IPSS represent a significant contribution to computer system simulation modeling technology. FEDSIM recommends continuing interest in and support of the use and further development of those capabilities of IPSS.

B. ECSS

Extensive support is provided for modeling computer system supervisory software. The representation of a wide variety of computer system hardware is supported. Extensive support is provided for modeling processes and process interaction. Limited support for TP subsystem modeling is provided. No special support is provided for simulating DBMS components and activities.

ECSS is most applicable to the modeling of a DBS from a general computer system perspective, where the focus is on hardware, supervisory and application software, and processor and I/O activity. ECSS has been used successfully to model a wide variety of computer systems. While it does not currently provide special support for modeling certain DBMS and TP components and activities, its internal structure, powerful base language, and macro processor facilitate the extension of its basic computer system modeling facilities to modeling DBMS and TP subsystems.

In view of their different orientations, IPSS and ECSS have great potential for use as complementary tools for DBS modeling and performance evaluation. As an example, an IPSS model of a DBS's DBMS subsystem could be used to generate workload and performance data for use as inputs to an ECSS model of the DBS's computer system environment.

C. DIMUI

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DIMUI supports the representation of data base structure, data base implementation, and data management related tasks. Representation of computer system supervisory software is limited to data management related tasks. Support for the representation of computer system hardware is very limited, and TP subsystem modeling is not supported.

The usability and generality of DIMUI's approach to modeling data base structure and implementation, data base accessing, and data management related tasks is difficult to assess due to the current lack of a modeling language and adequate documentation.

APPENDIX A

IPSS EVALUATION RESULTS

ELING CAPABILITY	EXPLICITLY PROVIDED?	LEVEL OF MODELING EFFORT	REWARKS: HOW CAPABILITY IS ACHIEVED, LIMIT	TATIONS
A BASE MANAGEMENT SYSTEM (DEMS)				
BMS buffers				
Description	YES	12	BUFFER POOL statement	
Management algorithms Management	<u>8</u> 8	ROUTINE	No implicit buffer management capability	
Management/use operations	SEIX	STMT	GET/FREE BUFFER, FIND NEXT BUFFER STATEMENTS	ţs
Buffer-data base access interaction	YES	IMIS		
Utilization statistics collection	YES	NONE	Automatic statistics collection	
Queueing statistics collection	YES	STMT	START/STOP QUBJE STATISTICS statements	
ita base access control mechanisms	QN			
ita base access scheduling algorithms	Q	MODULE+	No implicit access management capability	
ita base access management	QN	_		

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DELING CAPABILITY	EXPLICITLY PROVIDED?	LEVEL OF MODELING EFFORT	REVARIS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS
TA BASE MANAGEMENT SYSTEM (Cont'd)			
Request scheduling algorithms	Q	_	
Request management	90	+aringow	No umplicit request management capability
Data base management utility functions	92	ROUTINE	
DEWS overhead	Q	STMT	PROCESS/SERVICE TIME, I/O statements
Request processing statistics collection	YES	NONE	Automatic statistics collection
Request gueveing statistics collection	9	+FINDOW	
Data base access statistics collection	YES	NONE	Automatic statistics collection
Data base access locality statistics collec	tion YES	NONE	Automatic statistics collection
Data base access queueing statistics collec	tion NO	+FINDOW	
DENS overhead statistics collection	Q	MODULE+	
DML operation statistics	YES	NONE	Automatic statistics collection

-	-	C.	0
MODELING CAPABILLIY	EXPLICITLY PROVIDED?	LEVEL OF MODELING EFFORT	REWARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS
OPERATING SYSTEM Resource management strategies	2	+ETIOOW	No implicit resource management capabilities
Resource management Separation from application program behavior	22	_	
Supervisory overhead	Q	IMIS	PROCESS/SERVICE TIME, 1/0 statements
Supervisory overhead statistics collection FilterPROCESSING RESOURCES	2	MODULE+	
Transmission control units	8		No explicit facilities are provided for modeling TP hardware. IPSS-defined I/O devices (DEVICE, ACCESS MECHANISM, CONTROL UNIT, CHANNEL, I/O PROCESSOR) could be adapted for describing TP hardware.
Communications lines	Q	DCL, MODULE	
Terminal 1/0 devices	Q		
Terminal control units	Q		

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	LEVE LCITLY MODE TDED? EFFO	L OF	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS
STORACE RESOURCES: PRUMARY MEMORY (Cont'd)			
Allocation/Deallocation requests	TWIS STIMI		GET/FREE MAIN STORMER, GET/FREE PARTITION statements
Capacity utilization statistics collection M	ES NOVE		Utilization statistics are collected automatically in response to allocation/deallocation requests
Capacity queueing statistics collection Y	TML SIML		Queueing statistics can be collected using START/STOP QUEUE STATISTICS statements
STORAGE RESOURCES: VIRTUAL MEMORY			
Definition	-		No explicit facilities for the representation of virtual
Mapping to secondary storage	Q		инногу, улгсиал инногу нападеленс, ог улгсиал пелогу изаде
Mapping to primary memory	•		
Page reference N	•		
Page transfer	nggw Q	tan	
Management strategies N	Q		
Management	Q		
Page fault statistics collection	Q		
Utilization statistics collection N	-		

		LEVEL OF	
ELING CAPABILLIY	EXPLICITLY PROVIDED?	MODELLING	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS
RACE RESOURCES: SECONDARY STORAGE, TAPE			
efinition	YES	120	DEVICE, VOLUME statements
apacity	9	Ŕ	Determined by values of DENSITY parameter of DEVICE statem and TAPE LENGTH parameter of VOLUNE statement
pace overhead	Q	Ŕ	Determined by values of DENSITY and IBG parameters of DEVICE statement
RESOURCES: TAPE DEVICES			
efinition	YES	12	DEVICE, ACCESS MECHANISM statements
ransfer rate	Q	12	Determined by values of DENSITY and SPEED parameters of DEVICE statement
ewind rate	YES	Ŕ	REWIND RATE parameter of DEVICE statement
atency	YES	122	START STOP TIME parameter of DEVICE statement
omputation of data transfer time	YES	NONE	Computed automatically for each READ/WRUTE PHYSICAL RECORD operation
omputation of rewind time	YES	NONE	Computed automatically for each REWIND TAFE operation
ead/write operations	YES	STIMT	READ/WRITE PHYSICAL RECORD statements

MORELINE CONNELLINE LIPEL CE ROULCITTUE LIPEL CE ROULCITTUE LIPEL CE ROULCITUE RANCES CONTECT RANCES CONTECT RANCES CONTECT READ/METER FASCIOL Lowering exerticities collection YES SIMCH STATEMENT SIMCH STATEMENT SIMCH STATEMENT SIMCH STATEMENT RANCH REALECTION YES SIMCH STATEMENT SIRCH STATEMENT SIRCH STATEMENT RANCH REALECTION YES SIMCH STATEMENT SIRCH STATEMENT SIRCH STATEMENT RANCH REALECTION YES SIRCH STATEMENT SIRCH STATEMENT SIRCH STATEMENT RANCH REALECTION YES SIRCH STATEMENT SIRCH STATEMENT SIRCH STATEMENT RANCH REALECTION <th></th> <th></th> <th></th> <th></th>				
LO RESOURCES: DIRECT-ACCESS STORME LO RESOURCES: DIRECT-ACCESS STORME Deputation of data transfer time YES NME Computed automatically for each RED/NEUTE PHYSICUL Red/NTLE operations YES SIMT RED/NEUTE PHYSICUL Red/NTLE operations YES SIMT RED/NEUTE PHYSICUL Red/NTLE operations YES SIMT RED/NEUTE PHYSICUL Seek operation YES SIMT RED/NEUTE PHYSICUL Seek operation YES SIMT RED/NEUTE PHYSICUL Seek operation YES SIMT RED/NEUTE RED/NEUTE PHYSICUL Seek operation YES SIMT SIMCH statement Seek operation YES SIMCH statement SIMCH statement Seek statistics collection YES NME SIMCH statistics and SIMCH operation Seek statistics collection YES NME SIMCH Statistics andify operation Utili	NODELING CAPABILITY EDG	RELICTITLY N	LEVEL OF MODELING EFFORT	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS
Computation of data transfer time YES KNR Computed automatically for each RED/ARTER PHYSICOL Read/write operations YES SMT REVORD operation Read/write operations YES SMT REVORD operation Sect operation YES SMT REVORD statements Sect operation YES SMT SEX LASS CALINERS statements Sect operation YES SMT SEX LASS CALINERS statements Sect operation YES SMT SEX LASS CALINERS statements Computation of search time YES NME Computed automatically for each SEMCH operation Seek statistics collection YES NME Computed automatically for each SEMCH operation Seek statistics collection YES NME Computed automatically for each SEMCH operation Utilization statistics collection YES NME Semth statistics collection VE ME NME Semth statistics collection ME Utilization statistics collection YES Semth statistics collection YES Oneusing statistics collection YES	I/O RESOURCES: DIRECT-ACCESS STORAGE DEVICES (Cont'd)			
Read/write operations YES SIMT READ/WRITE PHYSICIAL RECORD statements Seek operation YES SIMT SEEX DAGD CYLINDER statement Seek operation YES SIMT SEEX DAGD CYLINDER statement Seek operation YES SIMT SEEX DAGD CYLINDER statement Computation of search time YES NONE Computed automatically for each SEANCH operation Computation of search time YES NONE Computed automatically for each SEANCH operation Seek statistics collection YES NONE Automatic statistics collection VES NONE Automatic statistics collection VES Utilization statistics collection YES NONE/SIMT Automatic statistics collection Utilization statistics collection YES NONE/SIMT Automatics statements Oneueing statistics collection YES NONE/SIMT Automatics are collection Utilization statistics collection YES NONE/SIMT Automatics are collected automatically if the partistics are collected using the SIMT/SIMT STATEMENT	Computation of data transfer time	YES	NOVE	Computed automatically for each READ/WRUTE PHYSICAL RECORD operation
Seek operation YES Shirt SEEK DASD CALINDER statement Search operation YES Shirt SEARCH statement Computation of search time YES NORE Computed automatically for each SEMICH operation Seek statistics collection YES NORE Computed automatically for each SEMICH operation Read/write statistics collection YES NORE Automatic statistics collection Read/write statistics collection YES NORE Automatic statistics collection Utilization statistics collection YES NORE/SIMIC Automatically if the WIT FACILITY STATES statements Oneeing statistics collection YES NORE/SIMIC Automatically if the WIT FACILITY STATES statements	Read/write operations	YES	STMT	READ/WRITE PHYSICAL RECORD statements
Search operation YES SIMT SEARCH statement Computation of search time YES NONE Computed automatically for each SEARCH operation Seek statistics collection YES NONE Computed automatically for each SEARCH operation Read/write statistics collection YES NONE Automatic statistics collection Villitation statistics collection YES NONE Automatic statistics collection Utilitation statistics collection YES NONE/SIMT Sum / Statements Onewing statistics collection YES NONE/SIMT Queuing statistics are collected automatically if the ward statistics are collected automatically otherawise, theyyeacted automatically if the ward statistics	Seek operation	YES	STMT	SEEK DASD CVLINDER statement
Computation of search time YES NONE Computed automatically for each SEARCH operation Seek statistics collection YES NONE Image: Seek statistics collection Read/write statistics collection YES NONE Image: Automatic statistics collection Read/write statistics collection YES NONE Image: Automatic statistics collection Utilization statistics collection YES NONE/STMT Opereing statistics are collected automatically if the Multi Partitic Statement is used; otherwise, they may be collected using the STME/STME	Search operation	YES	STMT	SEARCH statement
Seek statistics collection YES NONE Hutomatic statistics collection Read/write statistics collection YES NONE Automatic statistics collection Search statistics collection YES NONE Automatic statistics collection Utilization statistics collection YES NONE/STMT States Statements Overeing statistics collection YES NONE/STMT Queueing statistics are collected automatically if the WLT PACILITY STATUS statement is used; otherwise, they may be collected using the STMT/STOP QUEUE STMT	Computation of search time	YES	NONE	Computed automatically for each SEARCH operation
Read/write statistics collection YES NONE Automatic statistics collection 5 Search statistics collection YES NONE Automatic statistics collection 6 Search statistics collection YES NONE Automatic statistics collection 7 Utilization statistics collection YES STMAT/STOP USAGE STATESTICS statements 0 Outweing statistics collection YES NONE/STMT Queueing statistics are collected automatically if the WLT PACILITY STATES statement is used; otherwise, they may be collected using the STMAT/STOP QUEUE STATESTICS	Seek statistics collection	YES	NONE	
5 Search statistics collection YES NONE Iteration statistics collection 0 Utilization statistics collection YES NONE/STMT Queueing statistics are collected automatically if the warr FACILITY STATUS statement is used; otherwise, they may be collected using the START/STOP QUEUE STATISTICS	Read/write statistics collection	A Say	NONE	Automatic statistics collection
Utilization statistics collection YES SIMT START/STOP USAGE STATISTICS statements Queueing statistics collection YES NONE/SIMT Queueing statistics are collected automatically if the Wall FACILITY STATUS statement is used; otherwise, they may be collected using the START/STOP QUEUE STATISTICS	Search statistics collection	YES N	NONE	
Queueing statistics collection YES NONE/STMT Queueing statistics are collected automatically if the WAIT FACILITY STATUS statement is used; otherwise, they may be collected using the STARTOF QUEUE STATISTICS	Utilization statistics collection	YES	SIMT	START/STOP USACE STATISTICS statements
statements.	Queueing statistics collection	YES	NONE/STMT	Queueing statistics are collected automatically if the WAIT FACILITY STATUS statement is used; otherwise, they may be collected using the START/STOP QUEUE STATISTICS statements.

		33				ine		ion		ĸ	
	EXPLICITLY PROVIDED?		YES	YES	9	YES	YES	YES	YES	YES	SI
0	LEVEL OF MODELING EFFORT		120	12	122	NONE	STMT	STMT	NONE/SIMT	NONE	熍
•	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS		DEVICE, ACCESS MECHANISM statements	TRANSFER RATE parameter of DEVICE statement	Determined by values of CYCLE TIME, DATA TRANSFER OFFSET, and MODE parameters of DEVICE statement	Computed automatically for each READ/WRITE PHYSICAL RECORD operation	READ/WRITE PHYSICAL RECORD statements	START/STOP USARE STATISTICS statements	Queueing statistics are collected automatically if the WAIT FACILITY STATUS statement is used; otherwise, they may be collected using the STAUT/STOP QUEUE STATISTICS statements	Automatic statistics collection	CONTROL UNIT statement

MODELING CAPABILITY	EXPLICITLY PROVIDED?	LEVEL OF MODELING EFFORT	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS
I/O RESOURCES: CONTROL UNITS (Cont'd)			
Transfer rate	YES	멾	MAX TRANSFER RATE parameter of CONTROL UNIT statement. No documented use for this value.
Message capacity	2	MODULE	Input, storage, and use of this value as a factor affecting control unit availability and utilization must be programmed by the modeler.
Utilization statistics collection	YES	STMT	START/STOP USAGE STRUISTICS statements
Queueing statistics collection	XEX	NONE/SIMT	Queueing statistics are collected automatically if the WAIT FACILITY STATUS statement is used; otherwise, they may be collected using the START/STOP QUEUE STATISTICS statements.
I/O RESOURCES: CHANNELS			
Definition	YES	12	DATA CHNNEL and/or IO PROCESSOR statements
Transfer rate	YES	ġ	MAX TRANSFER RATE parameter of DATA CHANNEL/IO PROCESSOR statements. No documented use for this value.
Message capacity	£	MODULE	Input, storage, and use of this value as a factor affecting channel availability and utilization must be programmed by the modeler.
Utilization statistics collection	SEL	SIMT	START/STOP USACE STATISTICS statements

		1 00	0	04	44	La	S	B	Ea	Ţ	9	8
-	ING CAPABILITY	ESCURCES: CHANNELS (Cont'd)	ueing statistics collection	ESCURCES: OTHER I/O DEVICES	inition	nsfer rate	sage capacity	putation of data transfer time	d/write operations	lization statistics collection	ueing statistics collection	d/write statistics collection
-	EXPLICITLY PROVIDED?		YES		YES	XEX	ON	YES	YES	YES	YES	YES
0	LEVEL OF MODELING EFFORT		NONE/SIMT		TCT	цЯ т	MODULE+	THOM	TMIS	TMT	STMT	ANCH
	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS		Queueing statistics are collected automatically if the WAIT FACHLITY STATUS statement is used; otherwise, they may be collected using the START/STOP QUEUE STATISTICS statements.		DEVICE, ACCESS MECHANISM statements	TRANSFER RAIE parameter of DEVICE statement		Computed automatically for each READ/WRIVE PHYSICAL RECORD operation	READ/WRITE PHYSICAL RECORD statements	START/STOP USAGE STATISTICS statements	Queueing statistics are collected automatically if the WALT FACILITY STATUS statement is used; otherwise, they may be collected using the START/STOP QUEUE STATISTICS statements.	Automatic statistics collection

BERLICTION EPOLICTION LEVEL OF PROJECTION DESCUENCE D RESOUNCES: 1/0 DEVICE CONNECTIVITY LEVEL OF PROVIDED? EPODER D RESOUNCES: 1/0 DEVICE CONNECTIVITY NORE PUILI-1 D RESOUNCES: 1/0 DEVICE CONNECTIVITY NORE PUILI-1 D RESOUNCES: 1/0 DEVICE CONNECTIVITY NORE PUILI-1 D RESOUNCES: 1/0 DEVICE NORE PUILI-1 D RESOUNCES: 1/0 DEVICE NORE PUILI-1 D RESOUNCES: 1/0 DEVICE NORE PUILI-1 Dynamic path selection NO NORE PUILI-1 Dynamic path selection NO ROTTRE PUILI-1 Total device statistics collection NO NO PUILI-1 Additer rate based NO NO PUILI-1 Dynamic path statistics collection NO NO PUILI-1	: HOM CAPABILITY IS ACHIEVED, LIMITATIONS		atemant	n path selection mechanism bases path selection on y status and facility select priority only; no ration of path request priority or transmission ies of path devices is taken.	nagement must be modeler-programmed, and is ated by SELECT/WAIT ACCESS PATH statements and lt-in path request queueing and selection sm.	WALT ACCESS PATH statements			h-related statistics collection must be -programmed.		(
ELING CAMBILITY ELING CAMBILITY RESOURCES: 1/0 DEVICE COMMETTIVITY Reth definition Path management strategies When the selection Path management strategies Ret allocation requests Ret allocation of effective path data Thit call the devices on a path Difficial devices are a path Difficial devices are a path Difficial devices are a path Difficial devices statistics collection Ret queueing statistics collection	LEVEL OF MODELING BEFORT REMARK		DCL PATH SI	NONE Built- facilit conside capacit	ROUTINE Path me facili the bu mechani	STMT SELECTI	ADDILE		MOULE+ All pat modeler		(
DELING CARABILITY DELING CARABILITY D RESOURCES: 1/0 DEVICE CONNECTIVITY Path definition phamic path selection phamic path selection ath management strategies ath management strategies ath allocation/deallocation requests for all 1/0 devices on a path tritical device statistics collection ath queueing statistics collection ath queueing statistics collection	EXPLICITLY N PROVIDED? E		YES I	SEX	ON N	YES S	2	QN	2		
	MODELING CAPABILITY	1/0 RESOURCES: 1/0 DEVICE CONNECTIVITY	Path definition	Dynamic path selection	Path management strategies	Path allocation/deallocation requests	Computation of effective path data transfer rate based on current states of all 1/0 devices on a path	Critical device statistics collection	Path queueing statistics collection		

REWARKS: HOW CAPABILITY IS ACHIEVED, LIMITATI		BUFFER POOL statement	No implicit buffer management capability.		GET/FREE BUFFER, GET NEXT BUFFER statements		Automatic statistics collection	START/STOP QUEUE STATISTICS statements
LEVEL OF MODELING EFFORT		Ŕ	ROUTINE	_	SIMT	STMT	NONE	SIMT
EXPLICITLY PROVIDED?		YES	Q	£	XES	YES	SEIX	YES
COELING CAPABILITY	/0 RESOURCES: BUFFERS	Definition	Buffer management strategies	Buffer management	Buffer allocation/deallocation requests	Buffer - 1/0 interaction	Utilization statistics collection	Queueing statistics collection

			•
MODELING CAPABILITY	SPLICITLY SPLICITLY	LEVEL OF MODELING EFFORT	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITWITIONS
DATA RESOURCES: FILLES/FILLE STRUCTURES			
Definition	YES	멾	RECORD-TYPE statement
Record characteristics	YES	ġ	FORWAT parameter of RECORD-TYPE statement
Space allocations	YES	Ŕ	EXTENT statement
Access methods	Q	ROUTINE	
Record-to-space allocation mappings	YES	12	LOCATION parameter of RECORD-TYPE statement
Space allocation-to-physical storage media mappings	YES	멾	AREA statement and AREA, AREA START parameters of EXTENT statement
Translation of file access into 1/0 activity	YES	TMTS	GET RECORD ADDRESS and I/O statements
File access requests	YES	STIMT	READ/WEITE PHYSICAL RECORD statements
Dynamic file creation/deletion	YES	STMT	CREATE/DESTROY DATA SET statements
Dynamic file space allocation	YES	STMT	CREATE/DESTROY DATA SET EXTENT, ALLOCATE/RELEASE DATA
Pila monocont destructor	ŝ	-	SET EXTENT STATEMENTS
rue mundement strategies	8	ROUTINE	
File menagement	Q		
	-	0	0

Mathematical Constant Land, or Recursor Mathematical Constant Land, or Recursor Math	0										7.II.
Moterine Consultant Environ Moterine Consection YES Moterine Consecon </td <td>-</td> <td>IEVED, LIMITATIONS</td> <td></td> <td></td> <td>RT STOP QUEUE STATISTICS</td> <td>tements</td> <td></td> <td>, and SET statements r characterizing ork types of data</td> <td></td> <td>statement</td> <td>/CREATE/DESTROY/FIND/MOD DENTIFY SET COCURRENCE, Lements</td>	-	IEVED, LIMITATIONS			RT STOP QUEUE STATISTICS	tements		, and SET statements r characterizing ork types of data		statement	/CREATE/DESTROY/FIND/MOD DENTIFY SET COCURRENCE, Lements
Motion Extra curve Motion Extra curve <td>•</td> <td>REMARKS: HOW CAPABILITY IS ACH</td> <td></td> <td>Automatic statistics collection</td> <td>WAIT/SET FACILITY STATUS OF STA statements</td> <td>START/STOP USAGE STATISTICS sta</td> <td></td> <td>The SCHEMA, RECORD TYPE, EXTENI provide a flexible mechanism fo arbitrary hierarchical and netw structures.</td> <td></td> <td>ORIGIN parameter of RECORD TYPE</td> <td>Acculre/Stoke/Mait Redord, Copy Route, Alter/Copy set, Create/1 Find Member, Identify Oner Sta</td>	•	REMARKS: HOW CAPABILITY IS ACH		Automatic statistics collection	WAIT/SET FACILITY STATUS OF STA statements	START/STOP USAGE STATISTICS sta		The SCHEMA, RECORD TYPE, EXTENI provide a flexible mechanism fo arbitrary hierarchical and netw structures.		ORIGIN parameter of RECORD TYPE	Acculre/Stoke/Mait Redord, Copy Route, Alter/Copy set, Create/1 Find Member, Identify Oner Sta
MORELINE CARABILLITY EXALICITING MULTIPLE CARABILITY EXALICITING <td>.0</td> <td>LEVEL OF MODELING REFORT</td> <td></td> <td>NONE</td> <td>STIMT</td> <td>STMT</td> <td></td> <td>搶</td> <td>121</td> <td>DCL, ROUTINE</td> <td>TMIS</td>	.0	LEVEL OF MODELING REFORT		NONE	STIMT	STMT		搶	121	DCL, ROUTINE	TMIS
MOELING CAPABILITY MOELING CAPABILITY MOELING CAPABILITY MOELING CAPABILITY MOELING CAPABILITY MORENOMCCS: FILES/FILE STRUCTURES (0 Access statistics collection Access statistics collection Utilization statistics collection Utilization Utilization statistics collection Utilization Utilization statistics collection Utilization	•	EX R. ICTTLY PROVIDED?	nt'd)	YES	YES	YES		SI	YES	YES	YES
59		MODELING CAPABILITY	DATA RESOURCES: FILES/FILE STRUCTURES (CON	Access statistics collection	Queueing statistics collection	Utilization statistics collection	DATA RESOURCES: DATA BASE	Data structure (DS) representation	Multiple DSs	DS-to-DS mappings	DG access/traversal operations
	-								59	,	

MORELINC CAMBILITY ECRLICITAL MAN RESOURCES: DWIN BASE (Cont'd) RESOURCES: DWIN BASE (Cont'd) Translation of access/traversal operations YES Translation of access/traversal operations YES into processing time and physical YES I/O activity YES Deto-ristle (structure) mapping YES Deto-file (structure) mapping YES Deto YES Deto YES Deto YES Deto YES Dynamic access path YES Deto YES Deto YES </th <th>ILEVEL OF MODELING EFFORT BCU, ROUTINE DCL, ROUTINE DCL, ROUTINE ROUTINE STMT STMT STMT NOVE NOVE</th> <th>REMARKS: HOM CAPABILITY IS ACHIEVED, LIMITATIONS ORIGIN parameter of RECORD TYPE statement, IML SERVICE routine NML SERVICE, MAIT DRL SERVICE COMPLETE REQUEST DML SERVICE, MAIT DRL SERVICE COMPLETE A DE access path is represented by a "route" Much is established by a CREATE HOUTE statement. CREATE/FIND HOUTE statement.</th>	ILEVEL OF MODELING EFFORT BCU, ROUTINE DCL, ROUTINE DCL, ROUTINE ROUTINE STMT STMT STMT NOVE NOVE	REMARKS: HOM CAPABILITY IS ACHIEVED, LIMITATIONS ORIGIN parameter of RECORD TYPE statement, IML SERVICE routine NML SERVICE, MAIT DRL SERVICE COMPLETE REQUEST DML SERVICE, MAIT DRL SERVICE COMPLETE A DE access path is represented by a "route" Much is established by a CREATE HOUTE statement. CREATE/FIND HOUTE statement.
DATA RESOURCES:DATA RESOURCES:DESCORES:DATA RESOURCES:DATA RESOURCES:DESCORES:DATA RESOURCES:DATA RESOURCES:DATA RESOURCES:DATA RESOURCES:DATA RESOURCES:DESCORES:DATA RESOURCES:DESCORES:DATA RESOURCES:DATA RESOURCES	ROUTINE DCL, ROUTINE DCL, ROUTINE DCL, ROUTINE ROUTINE STMT STMT NONE NONE	ORUGIN parameter of RECORD TYPE statement, DML SERVICE routine REQUEST DML SERVICE, WAIT DML SERVICE COMPLETE REQUEST DML SERVICE, WAIT DML SERVICE COMPLETE A D6 access path is represented by a "route" Muich is established by a CREATE KOUTE statement. CREATE/FIND ROUTE statements Automatic statistics collection Automatic statistics collection
Translation of access/traversal operationsYESinto processing time and physical i/O activityYESIF-to-secondary storage media meppingYESIF-to-secondary storage media meppingYESIF-to-virtual storage meppingYESIF-to-file (structure) meppingYESIF-to-file (structure) meppingYESIFL command characterizationYESIFL command invocationYESIFL command invocationYESIFL command invocationYESIFL command invocationYESIFL command statistics collectionYESIFL astructure accessing statisticsYESIFL astructureYESIFL astructureYES<	ROUTINE DCL, ROUTINE DCL, ROUTINE DCL, ROUTINE ROUTINE ROUTINE STMT STMT STMT NONE NONE	ORUGIN parameter of RECORD TYPE statement, DML SERVICE routine REQUEST DML SERVICE, WAIT DML SERVICE COMPLETE REQUEST DML SERVICE, WAIT DML SERVICE COMPLETE A D6 access path is represented by a "route" Muich is established by a CREATE KOUTE statement. CREATE/FIND ROUTE statements Automatic statistics collection Automatic statistics collection
De-to-secondary storage media mappingYESDe-to-virtual storage mappingYESDe-to-file (structure) mappingYESDef command characterizationYESDef command characterizationYESDef command invocationYESDef command invocationYESDef access pathsYESDynamic access path selectionYESDynamic access path statistics collectionYESData structure accessing statisticsYES	DCL, ROUTINE DCL, ROUTINE ROUTINE SIMT SIMT SIMT NONE NONE	ORUGIN parameter of RECORD TYPE statement, DML SERVICE routine REQUEST DML SERVICE, WAIT DML SERVICE COMPLETE A DS access path is represented by a "route" which is established by a CREATE HOUTE statement. CREATE/FIND ROUTE statements Automatic statistics collection Automatic statistics collection
De-to-virtual storage mappingYESDe-to-file (structure) mappingYESDr. command characterizationYESDr. command invocationYESDr. command invocationYESDr. access pathsYESDynamic access path selectionYESDress path statistics collectionYESData structure accessing statisticsYESData structure accessing statisticsYES	DCL, ROUTINE DCL, ROUTINE ROUTINE STMT STMT NOVE NOVE	ORUGIN parameter of RECORD TYPE statement, DML SERVICE routine REQUEST DML SERVICE, WAIT DML SERVICE COMPLETE A D6 access path is represented by a "route" Muich is established by a CREATE KOUTE statement. CREATE/FIND ROUTE statements Automatic statistics collection Automatic statistics collection
De-to-file (structure) mappingYESDr. cormand characterizationYESDr. cormand invocationYESDr. command invocationYESDr. access pathsYESDramic access path selectionYESCroess path statistics collectionYESData structure accessing statisticsYESData structure accessing statisticsYES	DCL, ROUTINE ROUTINE STMT STMT NONE NONE	DML SERVICE routine REQUEST DML SERVICE, WAIT DML SERVICE COMPLETE A DS access path is represented by a "route" which is established by a CREATE KOUTE statement. CREATE/FIND ROUTE statements Automatic statistics collection Automatic statistics collection
DML command characterization YES DML command invocation YES DFL command invocation YES DS access paths YES Dynamic access path selection YES Dynamic access ing statistics YES Data structure accessing statistics YES	ROUTINE STMT STMT STMT NOVE NOVE	DML SERVICE routine REQUEST DML SERVICE, WAIT DML SERVICE COMPLETE A D5 access path is represented by a "route" which is established by a CREATE HOUTE statement. CREATE/FIND ROUTE statements Automatic statistics collection Automatic statistics collection
DHL command invocation YES DS access paths YES Dynamic access path selection YES Dynamic access path selection YES Access path statistics collection YES Data structure accessing statistics YES Ollection YES	STMT SIMT NOVE NOVE	REQUEST DML SERVICE, WAIT DML SERVICE COMPLETE A D5 access path is represented by a "route" which is established by a CREATE KOVTE statement. CREATE/FIND ROUTE statements Automatic statistics collection Automatic statistics collection
DS access paths YES Dynamic access path selection YES Access path statistics collection YES Data structure accessing statistics YES collection YES	SIMT SIM NOVE NOVE	A DS access path is represented by a "route" which is established by a CREATE KOUTE statement. CREATE/FIND ROUTE statements Automatic statistics collection Automatic statistics collection
Dynamic access path selection YES Access path statistics collection YES Data structure accessing statistics YES collection	STMT NONE NONE	CREATE/FIND ROUTE statements Automatic statistics collection Automatic statistics collection
Access path statistics collection YES Data structure accessing statistics YES collection	NONE	Automatic statistics collection Automatic statistics collection
Data structure accessing statistics YES collection	NONE	Automatic statistics collection
• • • • • • • •	0	

		0	•
COPABILITY	EXPLICITLY PROVIDED?	LEVEL OF MODELING EFFORT	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATI
E RESOURCES			
ition	YES	RIN	BNDO SERVICE routine
ement strategies	QN	_	Software resource management must be modeler-p
ement	9	MOOULE	is facilitated by the implicit association of a each software resource, process synchronization etc.
ation/Deallocation requests	YES	IMIS	WALT/SET FACILITY STATUS statements
zation statistics collection	YES	NONE	
ing statistics collection	YES	NONE	Automatic statistics collection
83			
ition/characterization	YES	ROUTINE	ENDO/EXO SERVICE routines
cit processor requirement	QN	HODULE+	
ielays	YES	STMT	PROCESS/SERVICE TIME statements
ation	YES	STMT/DCL	REQUEST SERVICE statement for an endogenous se statement for an exogenous service
nation	SEL	TMIS	TERMINATE SERVICE statement

III
CAPABILITY
EXPLICITLY PROVIDED?
LEVEL OF MODELING EFFORT
REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS

MOELING CAPABILITY	EXPLICITLY PROVIDED?	LEVEL OF MODELING EFFORT	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITRATIONS
PROCESSES (Cont'd)			
Process list operations	XES	STMT	PLACE/FIND IN QUBJE, MERCE QUBJES Statements
Occurrence statistics collection	YES	NONE	Automatic statistics collection
Processor utilization statistics collection	YES	Ŋ	
Processor queueing statistics collection	YES	ť2	
Resource utilization statistics collection	YES	Ŕ	These statistics may be collected using TASK statistics collection mechanism.
Resource queueing statistics collection	YES	Ŋ	
I/0 statistics collection			
ONDINO			
Workload element representation	YES	DCL, ROUTINE	EVENT statement and EXO SERVICE routine
Workload element arrival pattern specification	YES	ROUTINE	Inter-arrival time generation routine
Workload element processing statistics collection	YES	NONE	Automatic statistics collection

MOREANS CAPABILITY	EXPLICITLY PROVIDED?	LEVEL OF MODELING EFFORT	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS
CENERAL-PURPOSE SIMILACRA			
Events			
Definition	R	ROUTINE	ENDO/ENO SERVICE routines which execute in zero simulated time can be used to represent events.
Internal events	Q	ROUTINE	BUDO SERVICE routine that executes in zero simulated time.
External events	Q	MODULE	
Recurt ing evenus	£	DCL, ROUTINE	The EVENT statement and its associated EXO SERVICE routine can be used to represent recurring events.
Event scheduling operations	Q	STMT	REQUEST SERVICE, FLACE IN QUEUE, EVENT STATEMENTS
List data structures			
Definition	YES	멾	QUBJE statement
Dynamic creation	Q	HODULE+	
List elements			An IPSS transaction (one or more 32-word blocks of a FORTRAN
Definition	Q	NONE	one-dumensional array) can be used as a list element.
Data aggregates	Q	STMT	IPSS built-in functions provide the capability of storing/ retrieving different data types into/from an IPSS transaction.

	SNOLTV			10		ribution funct								
	HIEVED, LIMIT			UES statement	merator	bability dist			ter trant	g facilities				
-	ABILITY IS AC		ANSACTION	UE, MERGE QUE	dom number ge	ariety of pro		ing routine	routines are	ge programin				
-	RKS: HOW CAP		TE/DESTROY TR	VPLACE IN QUE	-supplied ran	supplies a v		-supplied tim	FEXO SERVICE	RAN IV langua				
-	RDWA		CREA	FIND	IPSS	IPSS		SSdI	OUNE	FORT				
0	LEVEL OF MODELLING EFFORT		IMIS	STIME	NONE	STMF	ROUTINE	NONE	ROUTINE					
-	EXPLICITLY PROVIDED?		YES	YES	YES	YES	Q	YES	YES	YES				
-		(p.				tions				Ø				
-		ILACRA (Cont	leletion	erations	rator	bution func	Itions	nagement		l facilitie				
	CAPABILITY	URPOSE SIMU	: creation/d	ocessing op	number gene	lity distri	al distribu	rd clock ma	nt routines	onputationa				
0	SULLEUR	GENERAL-I	Dynamic	List pr	Random	Probabi	Empiric	Event a	Reentra	Basic c				

								of statistics										
REMARKS								IPSS provides automatic generation	reports in predefined formats.									
AVALLABLE ?		QN	QN	NO	SBY	YES	Q		YES	Q		YES	Q	Q				
SUPPORT FACILITY	TOWING CONTECTION CONTROL STITUTES	Suppression/resumption	Selective suppression	Selective amission	Reset	Cumulative collection	Interval collection	STATISTICS REPORTING	Automatic report generation	Selective report generation	Report generation scheduling	End-of-simulation	Periodically	Via external events				
-0	ALLABLE ? REWARKS	Additional statistics collection and reporting can be programmed in PORTRAN. System-defined data structures are accessible using IPSS built-in functions and FORTRAN statements. IPSS system-offined data structures can be modified. Many system-defined data structures cannot be easily augmented due to their static tabular nature.		YES Routine-execution trace only. Mditional tracing	NO facilities supported by the FORTRAN committee		QV.	ON ON	W	Post-simulation processing regrations can be	NO programmed in FORTRAN. No capability exists for saving raw statistics data; such a capability would have to be mediacrossicated at such a capability would	ON ON	2					
-----	-------------------	--	------------------------	---	--	-----------------	-----------------------------------	---	--	--	---	--------------------------------------	---	--	--	--	--	--
- 0	SUPPORT FACILITY	SUPPLANIAL STATISTICS COLLECTION AND REPORTING	MODEL REHAVIOR TRACING	Statement-execution	Change-of-state	Tracing control	Selective change-of-state tracing	Limited-range statement-execution tracing	2 Event-based scheduling of tracing activity	POST SIMULATION PROCESSING	Selective saving of raw statistics data	Graphical display of statistics data	Generation of standard statistics reports from raw statistics data					

Error conditions are detected by both IPSS and the FORTRAN run-time system. Macro capability provides for simple textual sub-stitution, and is applicable only to model source stored in an IPSS library. O FORTRAM run-time system may provide a diagnostic traceback. REMARKS 0 AVAILABLE ? XES YES XES 2 YES Sa 2 YES 2 2 On-line, interactive prompting/help facility for model source input Model source component library facilities MODEL VERIFICATION AND VALIDATION Run-time diagnostic facilities On-line model source editing Model debugging facilities Behavior statistics Routine traceback Formatted dumps Macro processing SUPPORT FACILLITY NODEL SYNTHESIS Snapshot Tracing 68

La contration

SPFORT PACILITY MALLABLE? SUPPORT PACILITY MALLABLE? MOEL VREPTCATTON AND VALIDATION (Cont'd) MALLABLE? Diagropoticies at model source statement level as well NO Diagropoticies at model source statement level as well NO Curline, interactive debugging facilities NO Septemental debugging facilities YES MOEL INTITALIZATION AND NOLFICATION YES MOEL INTITALIZATION YES MOEL INTITAL	-	REMARKS				Supplemental debugging can be programmed in FORTRAN.			Parameter values may be entered into a global parameter array at the beginning of or between simulations. The global parameter array can be referenced from both declarative and procedural model components.	Additional parameter value entry and storage can be programmed using FORTRAN.	IPSS allows a wide range of model modification; however, the modeler must in many cases anticipate at model definition time the types of changes to be made and the maximum number of certain model components. The latter restriction is due to the static tabular nature of many system-defined data structures.		
SUPPORE FACILITY MOREL VERUFICATION AND VALIDATION (Cont'd) MOREL VERUFICATION AND VALIDATION (Cont'd) biggrostics at model source statement level as well as at base language level Ch-line, interactive debugging facilities Supplemental debugging facilitie	0	AVALLABLE ?		8	QN	YES			YES	Say			
	-	SUPPORT FACILITY	MODEL VERUFICATION AND VALIDATION (Cont'd)	Diagnostics at model source statement level as well as at base language level	On-line, interactive debugging facilities	Supplemental debugging facilities	MODEL INITIALIZATION AND MODIFICATION	Pre-simulation input of model initialization data	System-defined capability for parameter value entry	Modeler-programmable parameter value entry and storage	Mo "lification with minimal or no model source re-processing		

	ration is limited to changing / storage I/O device configura- : disabling selected devices. be added.	
Synamical	Hardware re-configu a model's secondary tion by enabling or No new devices can	
AVAILABLE ?	83 83 83 83 93 83 84 83 92 83 83	
ON AND MODIFICATION (Cont'd)	values to model parameters onfiguration trax checking es for the storage/retrieval of lies lities lities unation of model processing to error(s) in a previous rindependent control language control model processing viously processed	

er PACILITY MALIABLE ? MALIABLE ? MALIABLE ? EXECUTION EXECUTION time diagnostic facilities ves diagnostic facilities ves function control multidat termination control multidate based ves function a stopic for initiate termination multidate termination on the stopic run ves	-0.	RMARKS	tror conditions are detected by both IPSS and the	CULINAN LUI-LINE SYSTEM.									
Rf FACILLITY EXECUTION EXECUTION -time diagnostic facilities spoint/restart listion termination control mulated-time based coess/brent-occurrence based ror-occurrence based ror-occurrence based ror-occurrence based ror-occurrence based ror-occurrence based trum system independent language to initiate control model execution a time system independent language to initiate control model execution a model during execution a model during execution iple simulations during a single run		AVALLARLE ? F	SAY	9		YES	YES	YES	YES	YES	01	Say	
	-	UPORT PACILLITY	DEL EXECUTION Run-time diagnostic facilities	Checkpoint/restart	Simulation termination control	Simulated-time based	Process/Event-occurrence based	Error-occurrence based	Run-time based	Operating system independent language to initiate and control model execution	Nun-time monitor providing on-line interaction with a model during execution	Multiple simulations during a single run	

NOEL OFTMIZATION Main storage space requirements Program overlay Deletion of unneeded data structures Release of initialization and other routines not required after start of simulation Omission of unneeded statistics collection Executional efficiency Optimizing compiler Suppression/omission of collection of unneeded statistics	9 9 9 9 ⁸³	Can be accomplished using linkage editor directives Optimization features of FORTRANN compiler
Main storage space requirements Program overlay Deletion of unneeded data structures Release of initialization and other routines not required after start of simulation Chinistion of unneeded statistics collection Executional efficiency Optimizing compiler Suppression/omission of collection of unneeded statistics	99999 9 ⁸³	Can be accomplished using linkage editor directives Optimization features of FORTRAN compiler
Program overlay Deletion of unneeded data structures Release of initialization and other routines not required after start of simulation Omission of unneeded statistics collection Executional efficiency Optimizing compiler Suppression/omission of collection of unneeded statistics	9 9 9 9 ^{SS}	Can be accompliated using linkage editor directives Optimization features of FORTRAN compiler
<pre>beletion of unreeded data structures Release of initialization and other routines not required after start of simulation Omission of unreeded statistics collection Executional efficiency Optimizing compiler Suppression/omission of collection of unreeded statistics</pre>	9 9 9 ⁸³	Optimization features of FOKORNN compiler
Release of initialization and other routines not required after start of simulation Cmission of unneeded statistics collection Executional efficiency Optimizing compiler Supression/omission of collection of unneeded statistics	QQ QQ 84	Optimization features of FOKTRAN compiler
Omission of unneeded statistics collection Esecutional efficiency Optimizing compiler Suppression/omission of collection of unneeded statistics	QN SEA	Optimization features of FORTRAN compiler
Executional efficiency Optimizing compiler Suppression/omission of collection of unneeded statistics	SA	Optimization features of FOKTRAN compiler
Optimizing compiler Supression/omission of collection of unneeded statistics	SEA	Optimization features of FORDRAN compiler
Supression/omission of collection of unneeded statistics		
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		REMARKS		8	Yes	Q.	Ŋ		Ŷ	Yes, except 1	No No	¥	Yes		Yes	Yes					0	
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		AM PRODUCT QUA	ENTATION	r's manual	guage reference	gram logic man	orials, usage	criptions of:	efault algorith	ystem-defined o	andon number ge	robability dist	inding routine	vent management	roceas manageme	rstem-defined o					-	
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PROGRAM PRODUCT QUALITY	REMARKS	
TRAINING		
Courses Consultation	No Yes	

APPENDIX B

ECSS EVALUATION RESULTS

		-	-	-	-0
	MODELLING CAPABILITY		EXPLICITLY PROVIDED?	LEVEL OF MODELING EFFORT	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS
	DATA BASE MANACEMENT	r system (dens)			BCSS provides no special support for simulating DBMS components and processing activities. BCSS modeling facilities, although partially satisfying DBMS-related modeling requirements, must be augmented with a substantial amount of lower-level coding and new data structures to achieve desired DBMS modeling capa- bilities.
	DBMS buffers				BCSS provides no explicit representation of buffer management. However, the concept of an BCSS storage device together with its associated storage management facilities and allocation/ deallocation requests is readily applicable to the representa- tion of buffers, buffer usage, and buffer management.
	Description			ġ	HAS CAPACITY clause of SPECIFY statement
	Management algor	cithms		NONE	The default storage management algorithm may require modification to reflect a particular buffer management strategy.
79	Management			NONE	Implicit storage management
	Usage operations		2	STMT	GET, GIVE, FREE statements
	Buffer-data base	e access interaction		ROUTINE	
	Utilization stat	tistics collection		NONE	
	Queueing statist	ics collection		NONE	Automatic statistics collection

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WABILITY WAVAENENT SYSTEM (Cont'd) ANVAENENT SYSTEM (Cont'd) use access control mechanisms use access scheduling algorithms use access management : scheduling algorithms : scheduling algorithms : management : management : management : process management in tillty functions rethead : processing statistics collection use access locality statistics ion rethead statistics collection rethead statistics collection rethead statistics collection rethead statistics collection rethead statistics collection rethead statistics collection rethead statistics collection

	ALT	z	agament strategies	nagement	from application pr	y overhead	y overhead statistic					
					ogram behavior		s collection					
	EXPLICITLY		YES	YES	XES	YES	YES					
	LEVEL OF MODELING EFFORT		NONE	NONE	NONE	DCL/SIMT	NONE					
•	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS		The built-in default resource managers may require modification/ replacement in order to model other resource management strategies.	Implicit resource management	All supervisory functions are provided by the resource maragers, and are therefore separate from the char sterizations of application programs.	Both the THEMANAGER INTERMUPTSstatement and the AS OVERHEAN clause of the EXECUTE statement allow the representation of supervisory overhead; overhead includes processor utilization only, no 1/0.	Automatic statistics collection	•			4	



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MODELING CAPABILITY	EQPLICITLY PROVIDED?	LEVEL OF MODELING FFPORT	REWARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS
TELEPROCESSING RESOURCES (Cont.'d)			
Computation of message transmission time	_	-	
Message management strategies			
Message management	- 2	DCL, STMT,	
TP statistics collection			
PROCESSOR RESOURCES			
Definition	YES	120	EXECUTES clause of SPECIFY statement
Execution rate	YES	Ŕ	EXECUTES clause of SPECHY statement
Execution rate degradation due to primary memory contention	YES	JMLS/TDD	DEGRADES clause of SPECIFY statement; DEGRADE, UPGRADE statements
Different execution rates for different instruction types	YES	122	EXECUTES clause of SPECIFY statement
Multiprocessor configurations	YES	Ŋ	ECEUTES and STORES clauses of SPECIFY statements

<u>s</u>	
NON	
Default execution management algorithms may require modification/replacement to reflect other management strategies.	

RELIGITATION RALLINA RELIGITA RECORDENT RALLINA RECORDENT RALLINA RECORDENT CENTRE GLANT RALLINA RECORDENT RECORDENT REPORTENT RECORDENT	CELTING CONVENTION EXPLICITING IRONICED/IN LONG OF EXPLICITING IRONICED/IN LONG OF EXPLICITING CONSECTING Control Utilization statistics collection YES NORE EXECUTE statement Consenting statistics collection YES NORE Executes collection Consenting statistics collection YES NORE Executes collection Consenting statistics collection YES NORE Mutomatic statistics collection Consenting statistics collection YES NORE Automatic statistics collection
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NDDELING BFFORT
REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS

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0	LEVEL, OF MODELING EFFORT		100	ICL		+371000W	ANNE	NONE	SIMI	NONE	NONE					
	EQPLICITLY PROVIDED?		YES	YES	Q	Q	YES	YES	YES	YES	YES					
	COELING CAPABILITY	TORACE RESOURCES: SECONDARY STORACE, DIRECT-ACCESS	Definition	Capacity	Physical organization	Space overhead	Space management strategies	Space management	Space allocation/deallocation requests	Space utilization statistics collection	Space queueing statistics collection					

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	E20PLICITLY PROVIDED?	LEVEL OF MODELING EFFORT	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS
I/O RESOURCES: TAPE DEVICES (Cont'd)			
Utilization statistics collection	YES	NONE	-
Queueing statistics collection	YES	NONE	Automatic statistics collection
Read/write statistics collection	YES	NONE	
Rewind statistics collection	Q	MODULE+	
I/O RESOURCES: DIRECT-ACCESS STORAGE DEVICES			
Definition	YES	DCL	TRANSMITS clause of SPECIFY statement
Transfer rate	SEL	12	TRANSMITS clause of SPECIFY statement
Latency	YES	12	ARSORRSPER MESSAGE clause of SPECIFY statement
Cylinder access time	YES	DCL	ABSORDSPER SEEK clause of SPECIFY statement
Computation of cylinder access time	YES	NONE	Implicit transmission management
Computation of data transfer time	YES	NONE	Implicit transmission management
Read/write operations	YES	STMT	RDCEIVE/SEND statements

(A) RECONCCSS DIRGT-MODES STRIMGE Devices (cont d) NE STM SEE statement Sent operation NE STM SEE statement Sent operation NE Me STM STM statement Sent operation NE Me STM statement Sent operation NE Me Me Me Sent statistics collection NE Me Me Me Red/Mile statistics collection NE Me Me Me O Resources: NT RECORD DEVICES NE Me Me Me O Resources: NT RECORD DEVICES NE Me Me Me Me Definition NS Di NN NNNNITS clause of SPCIFY statement Transfer rate NN NNNITS c	I/O RESOUNCES: DIRECT-ACCESS STDRAGE DEVICES (Cont'd) Seek operation Seek operation Search operation Computation of search time Search statistics collection Search statistics collection Seek statistics collection Read/write statistics collection Utilization statistics collection Utilization statistics collection Oueneing statistics collection I/O RESOUNCES: UNIT RECORD DEVICES Definition	<u>8</u> 8 8 8 8 8 8 8	- JIMIS	
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LEVEL OF EXPLICITLY MODELING PROVIDED? EFFORT REMARKS: HOW CAPABII		YES DCL Transmission device	YES DCL TRANSMITS clause of 5	YES DCL TRANSFERS clause of 5	YES DCI.	YES DCL Automatic statistics		YES DCL Transmission device	YES DCL TRANSMITS clause of S	YES DCL TRANSFERS clause of S	YES NOWE Implicit transmission	YES STMT RECEIVE/SEND statemen
E MODELING CAPABILITY P	I/O RESOURCES: CHANNELS	Definition	Transfer rate	Message capacity	Utilization statistics collection	Queueing statistics collection	1/0 RESOURCES: OTHER 1/0 DEVICES	Definition	Transfer rate	Message capacity	Computation of data transfer time	Read/write operations



ACHIEVED, LIMITATIONS		t transmission management		ion			rice together with its associated is and allocation/deallocation whe to the representation of wifter management.	ılgorithm						C
F G REMARKS: HOW CAPABILITY IS J		Performed as part of implici-		Automatic statistics collect			The concept of a storage dev storage management facilitie requests is readily applicab buffers, buffer usage, and b	Default storage management a	Implicit storage management	GET, FREE statements	NE			
LIEVEL OI MODELLIN EFFORT		NONE	NONE	NONE	NONE		Ŕ	NONE	ANON	IMIS	ROUTI			
EXPLICITLY PROVIDED?	(P.	YES	YES	YES	YES		8	Q	Q	QN	9			
ODELING CAPABILITY	O RESOURCES: 1/O DEVICE CONNECTIVITY (Cont'	Computation of effective path data transfer rate based on current states of all I/O devices on a path	Critical device statistics collection	Path utilization statistics collection	Path queueing statistics collection	O RESOURCES: BUFFERS	Definition	Buffer menagement strategies	Buffer management	Buffer allocation/deallocation requests	Buffer - 1/0 interaction			

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LING CAPABILITY EXPLICITING RESOURCES: BUFFERS (Cont'd) RESOURCES: BUFFERS (Cont'd) RESOURCES: BUFFERS (Cont'd) RESOURCES: BUFFERS (Cont'd) NO NO NO NO NO NO NO NO NO NO NO NO NO	LEVEL OF MODELING EFFORT REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS NONE Automatic statistics collection NONE Automatic statistics collection NONE Default transmission management algorithm NONE Implicit transmission management algorithm NONE MONE MULCATION and Gallocation are an implicit part of all
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ocation/deallocation requests YES N RESOURCES: FILES/FILE STRUCTURES inition	NONE Allocation and deallocation are an implicit part of all
RESOURCES: FILES/FILE STRUCTURES inition	data transfer and control operations.
inition	
ord characteristics	BCSS does not explicitly support the modeling of files o structures, or the simulation of file accessing.
ce allocations NO M	MODULE+
ess methods	

Description Experiment Accurate Experiment Experiment Dominic file experiment Experiment Dominic file experiment Experiment Experiment Experiment Dominic file experiment Experiment Dominic file experiment Experiment Dominic file experiment Experiment Experiment Experiment Dominic file	D, LIMITATIONS	
Particity Event MCM RECURCING EVEN MCM RECORDSS: FLEX/FILE Spece allocation 0 Montel Lo activity No Montel file access requests Dynamic file Montel File Montel Montel File Montel Montel MCM Statistics collection Montel Utilization statistics collection Montel	REWARKS: HOW CAPABILITY IS ACHIEVE	
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96	NODELING CAPABILITY	DATA RESOURCES: FILES/FILE STRUCTURES (C Space allocation-to-physical storage media meppings Translation of file access into 1/0 activity File access requests Dynamic file creation/deletion Dynamic file space allocation File menagement strategies File menagement strategies File menagement Access statistics collection Utilization statistics collection Utilization statistics collection
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At a contract is the two		MODELING CAPABILITY	EXPLICITLY PROVIDED?	LEVEL OF MODELING EFFORT	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS	
		DATA RESOURCES: DATA BASE				
Mitche Ra Rucha Bara Rucha Rucha Bara		Data structure (DS) representation			ECSS does not provide modeling constructs for the representation of data structures, data structure implementation techniques, and data structure accessing	
Cho-Ga ampting Cho-Ga ampting Conservations of constrictions Conservations		Multiple DSs				
Beass/transmit Beassie		DS-to-DS mappings				
Marketion of access/researced perators in access/researced perators in accessing the action is		DS access/traversal operations				
Provestoriants Proves		Translation of access/traversal operations in processing time and physical 1/0 activity	into NO	MODULE+		
Be-constructed storage mapping Be-constructed storage mapping Be-constructed storage mapping Be-constructed storage Be-constorage Be-co		DS-to-secondary storage media mapping				
R-co-tile (structure) metrical Re-comment dataseteritation Re-comment invocation	9	DS-to-virtual storage mapping				
H. comma transfer D. comma transfer	7	DS-to-file (structure) mapping				
		DML command characterization				
		DML command invocation				

0 BCSS provides no explicit representation of a software resource. REWARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS 0 LEVEL OF MODEL/ING EFFORT HODULE+ **WODULE+** EXPLICITLY PROVIDED? 8 No. Access path statistics collection DATA RESOURCES: DATA BASE (Cont'd) Utilization statistics collection Allocation/deallocation requests Queueing statistics collection Dynamic access path selection Data structure accessing statistics collection Management strategies MODELING CAPABILITY SOFTWARE RESOURCES DS access paths Definition Management 98

LEVEL OF ICITLY MODELING EFFORT REWARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS		ES ROUTINE JOB OF EXTERNAL PROCESS	ES NOVE JOB	ES STMT WAIT FOR statement	ES STMT START, SUBMIT, INITIATE, RUN Statements	ES STAT TERMINATE SLATEment		S STMT WALT FORSUBJOBS statement	S STMT WALT FOR SIGNAL, SIGNAL STATEMENT	S STMT WALT FOR1/0 statement	ES STMT PASS, WAIT FORMESSAGE, WAIT FORRESPONSES, WAIT FORINFUT statements	NOVE	IS DCL SIMSCRIPT II.5 set
MODELING CAPABILITY P	PROCESSES	Definition/characterization	Implicit processor requirement	Time delays	Initiation	Termination	Synchronization/Communication/Suspension	Mait for sub-process	Wait/post mechanism	Wait for 1/0	Inter-process message passing	Initialization, saving, and restoring of local process variables	Process lists

)	
CAPABILITY	E20LICTTLY PROVIDED?	LEVEL OF MODELING EFFORT	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS
PURPOSE SIMILACRA			
nition	YES	DCL, ROUTINE	
mal events	YES	DCL, ROUTINE	SINSCRIPT II.5 declarative statements and event routine
mal events	YES	DCL, ROUTINE	
tring events	YES	ROUTINE	AUTOMATIC EVENT routine
t scheduling operations	YES	STMT	SCHEDULE, CANCEL statements
ata structures			
nition	YES	멾	SINSCRIPT 11.5 set
Nic creation	YES	SIMI	CREATE statement
ements			
uttion	YES	멾	
aggregates	YES	12	SIMSCRUPT II.5 temporary entities
uic creation/deletion	SER	IMIS	CREATE, DESTROY statements
pesing merations	YES	STIMI	FILE, REMOVE statements

ODELING CAPABILITY	V MILLI MUN	TEVEL OF	
	PROVIDED?	MODELING	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS
BUERAL-PURPOSE SIMILACRA (Cont'd)			
Random number generator	YES	NONE	SINSCRIPT II.5 multiple seed, random number generator
Probability distribution functions	YES	STMT	SINSCRIPT II.5 built-in probability distribution functions
Empirical distributions	YES	DCL, STIMT	SINSCRIPT II.5 random step/linear variables; BCSS table functions
Event and clock management	YES	NONE	ECSS-supplied timing routine
Reentrant routines	YES	ROUTINE	JOB, EXTERNAL PROCESS routines are reentrant.
Basic computational facilities	XB		SINSCRIPT II.5 programming facilities
	-	Ö	0
ECSS provides the modeler with extensive capabilities for the control of automatic statistics collection. ()• . REMARKS AVAILABLE ? YES YES XES YES YES YES YES YES YES XES 2 Report generation scheduling STATISTICS COLLECTION CONTROL Automatic report generation Selective report generation Suppression/resumption Selective suppression Cumulative collection Via external events Interval collection End-of-simulation Selective omission STATISTICS REPORTING SUPPORT FACILLITY Periodically Reset 103

	AVAILABLE (REMARKS
SUPPLEMENTAL STATISTICS COLLECTION AND REPORTING	YES	SINSCRIPT II.5 provides special facilities for statistics collection (ACCUMUATE and TALLY statements) and for record
MODEL BEHAVIOR TRACING		and the report generation.
Statement-execution	SIX	
Change-of-state	Say	
Tracing control		
Selective change-of-state tracing	XEX	
Limited-range statement-execution tracing	Say	
Run-time control of tracing activity	YES	Both trace options and trace start/stop times can be
POST SIMILATION PROCESSING		specified.
Selective saving of raw statistics data	YES	
Graphical display of statistics data	Ş	
Generation of standard statistics reports from raw statistics data	XES	
•	0	0

	NE FACILITY	r simhesis	del source component libro	-line, interactive prumpt del source input	-line model source editin	cros processing	L VERIFICATION AND VALIDAY	m-time diagnostic facilit	del debugging facilities	Tracing	Formatted dumps	Behavior statistics	Routine traceback	Shapshot			
			ary facilities	ing/help facility for	6		TION	ies									
0	AVALLABLE?		9	8	Q	YES		YES		YES	Q	YES	YES	YES			
•	REMARKS					ECSS provides a powerful macro facility for modifying or extending the basic ECSS language syntax. Macros may be recursive, may have arguments, and may contain default values for arguments not set at macro-call time.							Standard SINSCRIPT II.5 routine traceback	SHOW SYSTEM, SHOW STATUS statements			

SUPPORT FACILITY	AVAILABLE?	REMARKS
MODEL VERIFICATION AND VALIDATION (Cont'd)		
Diagnostics at model source statement level as well as at base language level	YES	BCSS detected errors only
On-line, interactive debugging facilities	QN	
Supplemental debugging facilities	YES	SINSCRIPT II.5 provides extensive debugging-oriented facilities, including free-format output (LIST statement), complex operation monitoring (BEPORE and APTUR staremete) and monitoring theorem
MODEL INITIALIZATION AND MODIFICATION		
Pre-simulation input of model initialization data		
System-defined capability for parameter value entry	2	
Modeler-programmable parameter value entry and storage	YES	Using STREET 11.5
Modification with minimal or no model source re-processing		
Assigning new values to model parameters	QN	
Hardware re-configuration	YES	Re-processing of SYSTEM DESCRETENTION only
(Process) routine replacement	YES	Routine replacement can be accomplished easily
		through the use of subprogram variables.

A checkpoint/restart capability is supported by the CDC version of SIMSCRUPT II.5. This can be accomplished using a linkage editor or loader. REMARKS AVAILABLE ? YES YES 2 2 2 2 Q 2 Library facilities for the storage/retrieval of object/load modules Operating system-independent control language to initiate and control model processing Conditional termination of model processing at any step due to error(s) in a previous ĺ Inclusion of previously-processed model Run-time diagnostic facilities Model source syntax checking Diagnostics facilities Checkpoint/restart SUPPORT FACILITY MODEL PROCESSING MODEL EXECUTION components step のことにあるとないとないないので 107

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XEX XEX	Q
Allocation of data structures for unneeded stat can be suppressed. Specific SINSCRUPT set attr may be deleted if not needed for desired set op BCSS model initialization routines are released initialization is complete. Modeler-written ro can also be released if and when appropriate.	can also be released if and when appropriate. SINSCRIFT attribute packing and word placement

Language compiler (s), assemblers SIMSCRUPT II.5 compiler Other software products None	The charge (includes first-year maintenance) 5 compiler must be purchased/leased from CACI, Inc. ains all four implementations of BCSS (SIMMSCRIPT II.5 is available from CACI, Inc.). [after first year) [after first year) series, Honeywell 600/6000 series, CDC 6000 series, series innum (.5 compiler (.5 compiler (.5 compiler (.5 compiler	SINSCRUPT II.5 SINSCRUPT II.5 FEDSIM maintair maintenance is \$100/month (aft Excellent Excellent IBM 360/370 ser UNIVAC 1100 ser 220K bytes mini SINSCRUPT II.5 None	Availability Cost Probability of continuing, long-term support RESOURCE REQUIREMENTS Specific computer systems and/or operating systems Specific computer systems and/or operating systems Main memory space Language computer (s), assemblers Other software products POERDELLTY
	municia	220K bytes mini	Main memory space
O Main memory space 220K bytes minimum	series, Honeywell 600/6000 series, CDC 6000 series,	IBM 360/370 Ser UNIVAC 1100 Ser	Specific computer systems and/or operating systems
Specific computer systems and/or operating systems IBM 360/370 series, Honeywell 600/6000 series, CDC 6000 series, 01 Main memory space 220K bytes minimum			RESOURCE REQUIREMENTS
RESOURCE REQUIREMENTS Specific computer systems and/or operating systems Nain memory space Main memory space 220K bytes minimum		Excellent	Probability of continuing, long-term support
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Cost \$100/month (after first year) Probability of continuing, long-term support Excellent Probability of continuing, long-term support Excellent RESOURCE REQUIREMENTS Excellent Specific computer systems and/or operating systems IBM 360/370 series, Honeywell 600/6000 series, CC 6000 series, Main menory space 220K bytes minium	ains all four implementations of BCSS (SIMSCRUPT II.5 is available from CACI, Inc.).	FBDSIM maintair maintenance is'	Availability
Availability Fabrin mintains all four implementations of BCSS (SINGCRUTY II.5 maintenance is available from CACI, Inc.). Cost S100/month (after first year) Cost S100/month (after first year) Probability of continuing, long-term support Bcollent Resource Reguineers Bcollent Specific computer systems and/or operating systems IfM 360/370 series, thorewell 600/6000 series, CC 600 series, CC 600 series, CC 600 series, CO 600 series,			
MUNTRANCE Multiply Availability Indentity Cost Cost Cost Probability of continuing, long-term support Resource requirements Specific computer systems Main mercy space Main mercy space	5 compiler must be purchased/leased from CACI, Inc.	SINSCRIPT II.5	M-LVTSVAKCE
Other software products SINGCURPT II.5 complex must be purchased/heased from CAC1, Inc. MUNDAUX SINGCURPT II.5 complex must be purchased/heased from CAC1, Inc. MUNDAUX FEDS mintains all four implementations of ECS (SINGCURPT II.5 mintains all four implementatins all four implement	me charge (includes first-year maintenance)	aura-auo noncé	Other software products MAINTRANCE
Similator Similator Citer software products Similator Other software products Similator Murriswucz Similator			Simulator Other software products MAINTENANCE
ADDISTICTION COSTS Similator Similator Similator Cher sochware products Other sochware products MANTRAUCS			ACUTSTITION COSTS Simulator Other software products MALINTRAWICE

GAWN FROCUCT QUALITY REDWARKS BILLITY/RELLABILITY ECSS is a stable progrupy extensive use over BILLITY/RELLABILITY ECSS is a stable progrupy extensive use over UNEXTION PCSS is a stable progrupy extensive use over UNEXTURN Yes BECS is a stable progrupy extensive use over Yes UNEXTURN Yes BECS is a stable progrup extensive use over Yes UNEXTURN Yes BECS is a stable program of is Yes Extribution of: Yes Default algorithms Yes System-defined data structures Yes Rendom number generator algorithms No Probability distribution function algorithms Yes Timing routine Yes Event management Yes	rogram product whose reliability has be ver a two-year period.
BILITY/RELIABILITY BILITY/RELIABILITY BULATADILITY BUCSS is a stable progr by extensive use over Yes anguage reference manual rogram logic manual rest tutorials rest rest tutorials rest tutorials rest tutorials rest tutorials rest rest tutorials rest tutor	rogram product whose reliability has be ver a two-year period.
UNENTITIONYesser's menualYesanguage reference manualYesrogram logic manualNorogram logic manualYestotal structuresYesexcription of:Yesbefault algorithmsYesSystem-defined data structuresYesSystem-defined data structuresNoProbability distribution function algorithmsNoProbability distribution function algorithmsYesShent managementYes	
ser's menual Yes	
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Timing routine Yes Event management Yes	
Event management Yes	
Process management Yes	
System-defined subprogram communication	

- Same-	1 04 1	ROGRAM PRODUCT QUALITY		REMARKS
Cin Arts and an	H	RAINING Courses		Yes, FEDGIM offers the following BCSS courses:
				 Introductory course, covering SINSCRIPT II.5 and basic ECSS concepts, Advanced course, covering advanced ECSS concepts.
		CONSULTATION		Yes
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			-	0

APPENDIX C

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DIMUI EVALUATION RESULTS

	Pre Contraction of the contracti	(9					action	tion		SIIIS	rithms						
0	LEVEL OF LLEVEL OF WIDED? EFFORT		YES DCL	YES DCL	YES NOVE	YES STMT	YES NONE	NO ON	NO	YES SIMT	YES NONE	YES NONE	ON	NO N			
•	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS		"Buffer pool description" card	"Buffer pool description" card identifies any of several system-supported buffer management strategies.	Implicit buffer management	ALLOCATE, RELEASE commands	An implicit aspect of simulated data base accessing			LOCK, UNLOCK commands provide a mechanism for preventing/ permitting access to all or part of a data base.	Physical I/O operation scheduling only	Implicit data base access management at physical I/O level					

0 REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS Automatic statistics collection 0 LEVEL OF MODELING EFFORT ROUTINE HODDIE+ HODULE+ NONE SIMI EXPLICITLY PROVIDED? YES YES Q 9 2 2 9 2 2 Request processing statistics collection Data base management utility functions Request queueing statistics collection Data base access statistics collection Data base access locality statistics collection Data base access queueing statistics collection DBMS overhead statistics collection DATA BASE MANAGEMENT SYSTEM (Cont'd) DML operation statistics MODELING CAPABILITY DBMS overhead 116

		tegies		ition program be		atistics collec				tion due to on			
	EXPLICITILY PROVIDED?	SI	YES	havior YES	Q	tion NO		YES	XES	Q			
LEVEL OF	MORELING EFFORT	ANTE/ROUTINE	NONE		-	-		12	12	+3TINDOW			
•	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS	Default management strategies are provided for job scheduling, processor management, disk access schröuling, channel scheduling, core buffer management, and disk space manage- ment; these may require modification/replacement to reflect desired management strategies.	Implicit resource management				DIMUT provides no support for the modeling of TP resources, resource management, and processing activities.	"Processor description" card					

	YES STAT CEVITIA command	te NO MOUTEH	YES NOVE	YES NONE Implicit processor management	tes YES MODULE:++	NO MOULEH	tam YES NOVE An implicit aspect of processor man	YES NOVE Implicit processor management	YES NONE A default processor management rout	YES DCL "Processor description" cards	erent NO MODULE++		EXPLICITLY NODELING PROVIDED? EFFORT REMARKS: HOW CAPABILITY IS ACHIEVE
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•	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS		Automatic statistics collection			No explicit representation of primery memory: its or	representation is as a collection of "buffer pools" (see I/O RESOURCES: BUFFERS).											
0	LEVEL OF MODELING EFFORT		NONE	-	MODULE+		-			MODULE+			-					
	EXPLICITLY PROVIDED?		YES	9	8				-	9								
	DELING CAPABILITY	OCESSOR RESOURCES (Cont'd)	Utilization statistics collection	Queueing statistics collection	Utilization-by-process statistics collection	ORACE RESOURCES: PRIMARY MEMORY	Definition	Memory management strategies	Menory management	Allocation/deallocation requests	Capacity utilization statistics collection	Capacity queueing statistics collection						

CUMBILITY EXPLICITINA HOUTOBD? LEVEL CF EXPORT LEVEL CF SCURCES: SECOLUCITINA HOUTOBD? LEVEL CF LEVEL CF SCURCES: SECOLUCITINA DIRECT-ACCESS MOREINA HOUTOBD? LEVEL CF SCURCES: SECOLUCITINA DIRECT-ACCESS MOREINA HOUTOBD? LEVEL CF SCURCES: SECOLUCITY MOREINA HOUTOBD? MOREINA HOUTOBD? SCURCES: SECOLUCITY MOREINA HOUTOBD MOREINA HOUTOBD SCURCES: SECOLUCITY MOREINA HOUTOBD MOREINA HOUTOBD SCURCES: SECOLUCITINA HOUTOBD MOREINA HOUTOBD MOREINA HOUTOBD V YES MOREINA HOUTOBD MOREINA HOUTOBD V YES MOREINA HOUTOBD MOREINA HOUTOBD V YES MOREINA HOUTOBD MOREINA HOUTOBD V YES MOREINA HOUTOBILITY FEILOR MOREINA HOUTOBILITY LIDEATION/deallocation MOREINA HOUTOBH MOREINA HOUTOBILIZATION MOREINA HIBLOCK, FRELOCK commands LILIZATION MO MOUTOBH MOUTOBH MOUTOBILIZATION	Construction Large of BORLITITY Large of BORLITITY Large of BORLITITY Large of BORLITITY EXONCES: SECONOMER REMARKS: HAN CARBELLITY IS ACHIDODD, LI EXONCES: SECONOMER TODE "Unit description" and identifies any o apported DaD device types. I Lon YES NOE These characteristics are supplied for e apported DaD device types. I Lon YES NOE These characteristics are supplied for e device types. I V NOE NOE These characteristics are supplied for e device types. I V NOE NOE The characteristics are supplied for e device types. I V NOE NOE The characteristics are supplied for e device types. I V NOE NOE The characteristics are supplied for e device types. I Undation/deal Location NOE NOE The characteristics are supplied for e device types. I Location/deal Location NO Indication/deal Location/deal Location I I Location/deal Location NO Indication/deal Location I I Location/deal Location NO I I I Location/deal Location NO I I	om capability is achieved, limitarions
RESOUNCES: SECONARY STORAGE, DIRECT-ACOSS tion YES DCL "Inhit description" and identifies any of several system-support supported DNSD device types. ity YES NONE "These characteristics are supplied for each system-support device types must first be assembled into an internal to device types must first be assembled into an internal to before they can be referenced. overhead YES NONE "These characteristics of non-system-support device types must first be assembled into an internal to before they can be referenced. overhead YES NONE Trequire modification/replacement to characterize a part space management strategy. management YES NONE Inplicit secondary storage space management in response allocation/deallocation requests. allocation/deallocation requests YES NONE Inplicit secondary storage space management in response allocation/deallocation requests. wouldeship statistics collection NO NONE+ queueing statistics collection NO	RESOURCES: SECRAMENT, FIGN STOMMENT STOMMENT, FLON TIPE CD. "Unit description" and identifies any of the second DAD device types. The second for expression of the all argentization TES NOTE The extra stypical for expression in the referenced. FIGURE types must first be assembled in the second the second for the sec	
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allocation/deallocation requests YES STAT ALFLOCK, FRELOCK commands a utilization statistics collection NO MODULE+ e queueing statistics collection NO MODULE+	a illocation/deallocation requests YES STAT ALBLOCK, FRBLOCK commands utilization statistics collection NO 0 queueing statistics collection NO 0 HOULEH	condary storage space management in response to deallocation requests.
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e queueing statistics collection NO MOULE+	a queveing statistics collection No MOULE	

LEVEL EXPLICITLY MODELL PROVIDED? EFFORT NOARY STORAGE, TAPE	
NDARY STORAGE, TAPE	REPARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS
50	
ULU CII	"Unit description" card identifies any of several system- supported tape device types.
YES NOVE	
	These characteristics are supplied for each system-supported device type; the characteristics of non-system-supported device types must be assembled into an internal table before they can be referenced.
YES NONE	
VICES	
TDO SIA	"Unit description" card identifies any of several system- supported tape device types.
YES NOVE	
ancn say	These characteristics are supplied for each system-supported device type; the characteristics of non-system-supported
	device types must be assembled into an internal table before they can be referenced.
YES NOVE	

COMBILITY LEVEL OF MOBLING LEVEL OF MOBLING COMBILITY EXPLICITINY MOBLING MCDES: TWE DEVICES (Cont'd) MOBLING REMARKS: HOM CAMBILITY IS ACHIENDED, LINUTAMIT OPERation MCDES: TWE DEVICES (Cont'd) MOBLING REMARKS: HOM CAMBILITY IS ACHIENDED, LINUTAMIT OPERation MCDES: TWE DEVICES (Cont'd) MOBLING REMARKS: HOM CAMBILITY IS ACHIENDED, LINUTAMIT OPERation MCDES: TWE DEVICES (Cont'd) MOBLING MOBLING OPERation NO MODLEF Attion of rewind time NO MODLEF Statistics collection NES NUTE, METTE-VERITY commands Attion statistics collection NO MODLEF Statistics collection NO MODLEF Statistics collection NO MODLEF Attionatic statistics collection MODLEF MCDS: DIRECT-MODES STORMER DEVICES NONE MCD MODILEF MCD MODILEF MCD NONE			0	•
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Induction NO MOULE+ rite statistics collection YES NONE Automatic statistics collection URCES: DIRECT-ACCESS STORAGE DEVICES YES NONE Automatic statistics collection URCES: DIRECT-ACCESS STORAGE DEVICES YES NONE Automatic statistics collection URCES: DIRECT-ACCESS STORAGE DEVICES YES NONE Automatic statistics any of sever supported device types. Et rate YES NONE These characteristics are supplied for each system supported device types. V Feature of non-system supported device types. Feature state types.	ation statistics collection	YES	NONE	Automatic statistics collection
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These characteristics are supplied for each system-supported device type; those of non-system-supported device be assembled into an internal table before they referenced.	er rate	YES	NONE	
				These characteristics are supplied for each system-suppor device type; those of non-system-supported device types m be assembled into an internal table before they can be referenced.
er access time YES NONE	er access time	YES	NONE	

Icw-level I/O operations are simulated to higher-level data base access responsed Search operation not supported Automatic statistics collection Automatic statistics collection BH DIMUI provides no support for model, DIMUI provides no support for repre- units.
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0		0	•
OPELING CAPABILITY	EXPLICITLY	LEVEL OF MODELING EFFORT	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS
A RESOURCES: CHANNELS			
Definition	SEL	멅	"Channel description" card
Transfer rate	QN	_	
Message capacity	Q	MODULEH	•
Utilization statistics collection	SEIX	NONE	Automatic statistics collection
Queueing statistics collection	Q	+3100W	
10 resources: other 1/0 devices			Wo support is provided for the modeling of 1/0 devices other than tape units, disk units, and channels.
O RESOURCES: 1/O DEVICE CONNECTIVITY			Only a channel-disk/tape device architecture is supported; channel-device connectivity is specified on the "channel description" cards.
			A default channel scheduling algorithm is provided for controlling disk/tape device-channel connectivity
O RESOURCES: BUFFERS			· Contraction of the second se
Definition	YES	벐	"Buffer pool description" card
Buffer menagement strategies	YES	뷶	The "buffer pool description" card identifies any of several system-supplied buffer management strategies.

																1				
•	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS		"Extent description" card		·	"Extent description" card	Automatic translation of file access into I/O activity	FETCH, STORE, PREFEICH commands		ALELOCK statement										
Ō	LEVEL OF MODELING EFFORT		12	ROUTINE	ROUTINE	Ŕ	NONE	STMT	HODULE++	SIMT	_	+anno	_	HODULE+						
	EXPLICITLY PROVIDED?	(P)	YES	Q	YES	SEL	SEX	YES	Q	YES	Ŷ	QN	Q	Q	Q					
0	MODELING CAPABILITY	DATA RESOURCES: FILES/FILE STRUCTURES (Cont.	Space allocations	Access methods	Record-to-space allocation mappings	Space allocation-to-physical storage media mappings	Translation of file access into I/O activity	File access requests	Dynamic file creation/deletion	Dynamic file space allocation	File management strategies	File management	Access statistics collection	Queueing statistics collection	Utilization statistics collection					
0									12	7										

NODELING CAPABILITY
EXPLICITLY PROVIDED?
LEVEL OF MODELLING EFFORT
REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS

		,		ion stics										
	EXPLICITLY PROVIDED?	2	Q	2 9	2		 	2-	 -					
0	LEVEL OF MODELING EFFORT	STAT	+3TIOOOM	HODONE+				MODULE+			!			
•	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS	DS access paths are represented by stels (stack elements) which are explicit parameters of all DS accessed traversal operations.				No support for the representation of a software module as a resource.						~		

Metrics Metric Task description Minition/Americation V2 Korrine Task description Minitiation V2 Korrine Task description Minitation V2 Metric description V2 Minitation V2 Metric description V2 Minitation V2 Metric description V2 Metric description V2 V2 V2 Metric description V2	PROCESSES	EQPLICITILY PROVIDED?	LEVEL OF MODELING EFFORT	REVARKS: HOW CAPABILITY IS ACHIEVED, LIMITWIJONS
Metintical/characterizationImplicitRotticeTask descriptionHeylicit <pressent< td="">E2KMETask descriptionHeylicitE2SMTCWTM commentInitationE2SMTCWTM commentInitationE2SMTCWTM commentMittationE2SMTProtectionMittationE2MittationProtectionMittationE2SMTProtectionMittationE2SMT<!--</td--><td></td><td></td><td></td><td></td></pressent<>				
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Initialization, saving, and restoring of local process variables IS NOE	Inter-process message passing	Q	MODULE+	
	Initialization, saving, and restori of local process variables	PG YES	NONE	
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0	REMARKS: HOW CAPABILITY IS ACHIEVED, LIMITATIONS		No support for modeler-defined process lists (queues) and list processing operations.								Automatic statistics collection		Task description	"Workload description" card	Automatic statistics collection	
0	LEVEL OF MODELING EFFORT			HODOLE+		-		MODULE+			NONE		ROUTINE	범	NONE	
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0	ODELING CAPABILITY	ccesses (cont'd)	Process lists	Process list entry discipline	Process list operations	Occurrence statistics collection	Processor utilization statistics collection	Processor queueing statistics collection	Resource utilization satistics collection	Resource queueing statistics collection	I/O statistics collection	UNCLOW	Workload element representation	Workload element arrival pattern specification	Workload element processing statistics collection	

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HOW CAPABILITY IS ACHIEVED, LIMITATIONS	HOW CAPABILITY IS ACHIEVED, LIMITATIONS	multiple-seed random number generator	d set of probability distribution functions are d.	pplied timing routine	pplies necessary data structures and routines to e modeler to write reentrant FOKTRAN subroutines.	IV language facilities

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0	SUPPORT FACILITY	SISHHINS TROOM	Model source component	On-line, interactive put for model source input	On-line model source ed	Macro processing	MODEL VERIFICATION AND VI	Run-time diagnostic fac	Model debugging facilit	Tracing	Formatted dumps	Behavior statistics	Routine traceback	Shapehot			
			library facilities	compting/help facility	liting		NOLTATION	ilities	ies								
0	AVAILABLE?		Q	Q	Q	Q		YES		SELA	YES	YES	Q	£			
•	REMARKS	1						FORTRAN IV run-time diagnost		Selective logging of event a	Diagnostic dumps can be prod		May be provided by FORTRAN I				
Q					•			stic facilities		and interrupt occurrenc	oduced using the "Dump"		run-time system.				

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0 DIMUI supports extensive model parameterization The extensive model parameterization features facilitate model modification. May be programmed using FORTRAN IV Using FORTRAN IV . REMARKS -(J) AVALLABLE? YES YES XES XES XES YES Q 2 Pre-simulation input of model initialization data Diagnostics at model source statement level as well as at base language level Modification with minimal or no model source re-processing Assigning new values to model parameters On-line, interactive debugging facilities System-defined capability for parameter value entry MODEL VERIFICATION AND VALIDATION (Cont'd) Modeler-programmable parameter value entry and storage MODEL INITIALIZATION AND MODIFICATION Supplemental debugging facilities (Process) routine replacement Hardware re-configuration SUPPORT FACILITY C 136

.... 0 FORTRAN run-time diagnostic facilities • . REMARKS AVAILABLE? YES YES YES YES 2 2 2 8 2 Operating system-independent control language to initiate and control model processing Library facilities for the storage/retrieval of Conditional termination of model processing at any step due to error(s) in a previous Inclusion of previously-processed model components Run-time diagnostic facilities Model source syntax checking Simulation terminal control Diagnostics facilities Simulated-time based object/load modules Checkpoint/restart SUPPORT FACILITY MODEL PROCESSING MODEL EXECUTION step C 137

Simulation can be terminated at the completion of a specified process or after completion of all processes. (0) • -. REMARKS 0 AVAILABLE? XES Q 2 8 2 2 2 Q 2 Suppression/deletion of unneeded data structures Operating system independent language to initiate and control model execution Run-time monitor providing on-line interaction with a model during execution Multiple simulations during a single run Process/event-occurrence based Deletion of unneeded routines Main storage space requirements Error-occurrence based MODEL EXECUTION (Cont'd) Program over lay Run-time based NODEL OPTIMIZATION SUPPORT FACILLITY \bigcirc 1 138

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0 * Yes. DIMUI-IIMS User's Manual REMARKS Yes Yes Yes Yes Yes Yes 2 2 2 2 0 Probability distribution function algorithms Random number generator algorithms System-defined data structures Language reference manual PROGRAM PRODUCT QUALITY Process management Program logic manual Default algorithms Event management Timing routine Descriptions of: Text, tutorials User's manual DOCUMENTIATION 0 141

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