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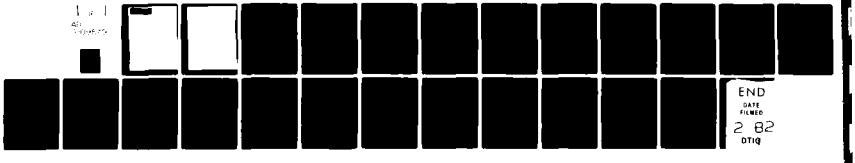

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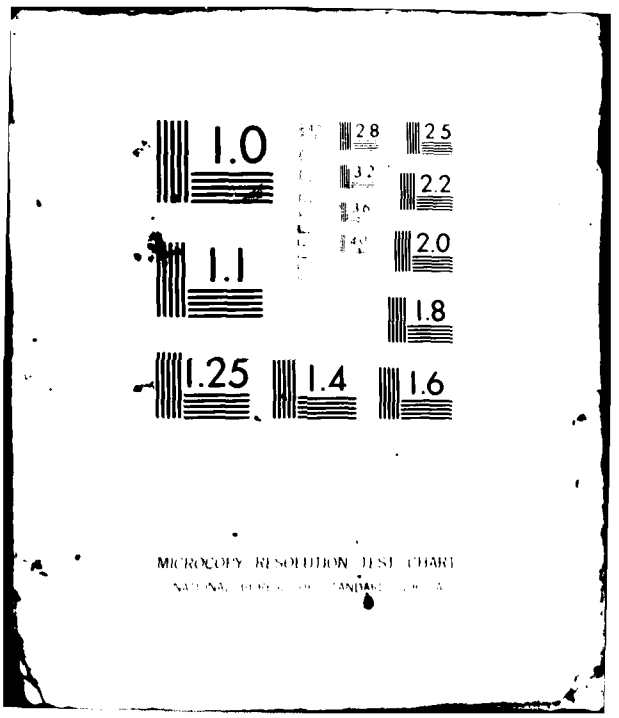
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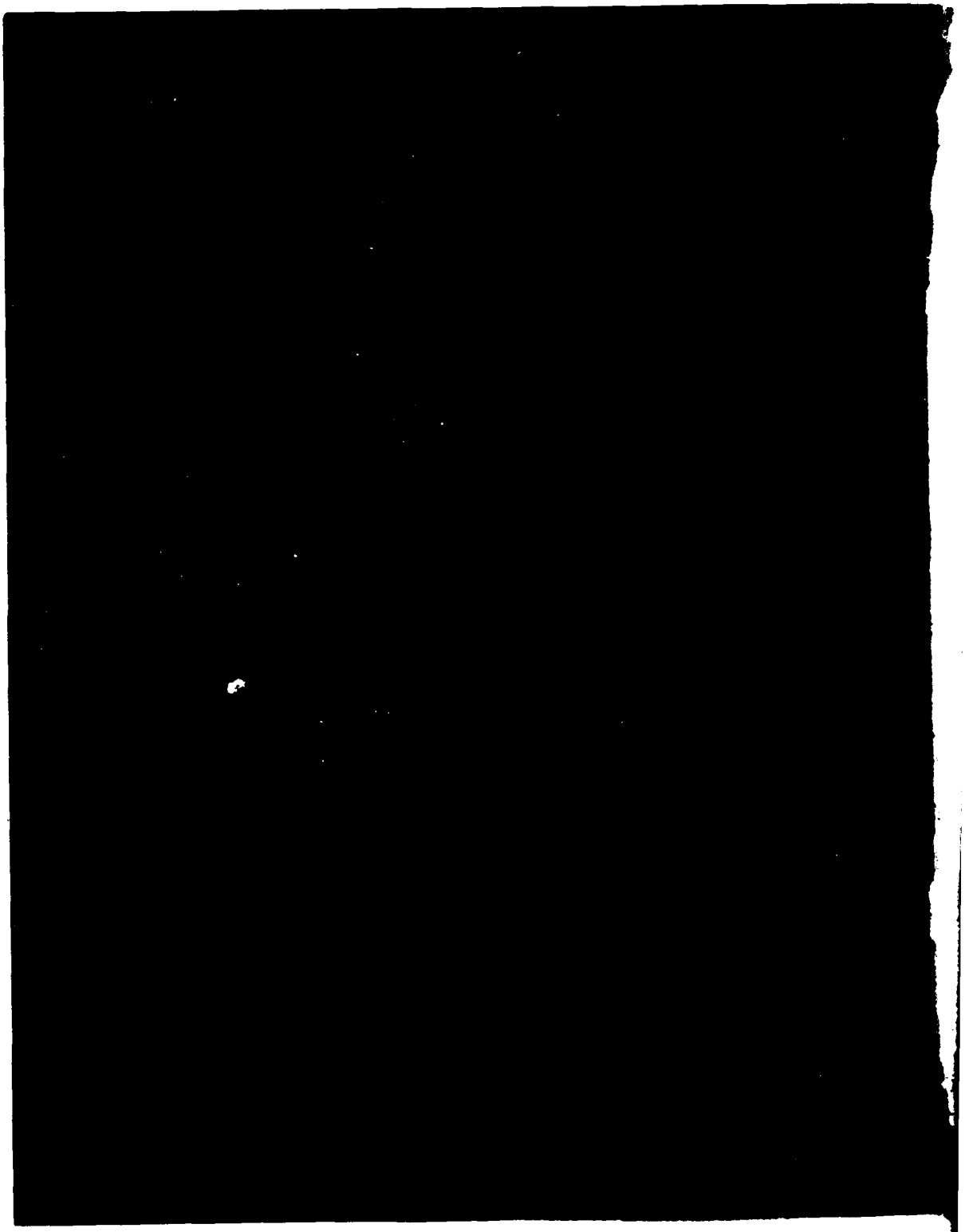

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A computer model (CONDUCT) has been developed that simulates corps and subordinate command, control, communications, and intelligence C³I functions with particular emphasis on the integration of the new generation of intelligence, surveillance, and target-acquisition systems within the developing 1982 and 1986 force structure. CONDUCT is an event-by-event simulation model written in GPSS-V (General Purpose Simulation System), representing the combat and combat support command/staff elements and communications nodes/nets for the operations and intelligence functions within a type corps. Maneuver and engineer units are represented to platoon level, artillery units to battery level, and target-acquisition and Combat Electronics Warfare →

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ABSTRACT (Cont'd)

Intelligence (CEWI) units to sensor team level. Major command posts and operations centers are subdivided into their primary functional areas, (e.g., CM&D, ASAC, DAME, FSE, G2, and G3 elements at DivMain). Also given are results from the initial 16-hr combat simulation.

A briefing structured around an analysis of data from the CONDUCT model is reported in HDL-SR-81-9, dated November 1981. In that analysis, Blue C^3 choke points and timelines for sensor and artillery missions, cueing missions, a nuclear refinement mission superimposed on conventional activities, and conventional first-strike duels against Red assets were determined in a dynamic C^3 environment.

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1. INTRODUCTION

CONDUCT (Control of Nuclear and Divisional Units, Communications and Tactics) is an event-by-event simulation model of the Army's tactical command, control, and communications (C^3) process. The present data base definition gives special emphasis to actions related to nuclear release intelligence, surveillance, and target acquisition. CONDUCT faithfully represents both the staff processing and the message flow causing or resulting from this staff processing under normal and degraded conditions. CONDUCT was constructed for use in the Theater Nuclear Force Survivability (TNF/S) study. The model was designed to provide data to and accept data from the other participants in this study. The C^3 data base presently used with the model is of the division and below with limited corps assets; however, the model is not limited to this level and could include all the functions within a type corps. CONDUCT is written in General Purpose Simulation System (GPSS-V) and is operational on the Harry Diamond Laboratories' (HDL) IBM 370/168 computer.

2. CONDUCT STRUCTURE

CONDUCT is organized around what are called "tasks." A task is a time-ordered set of related actions required to perform an activity under a situation of nondegraded C^3. The following are examples of tasks.

(1) Prepare and distribute the division operation order.
(2) Conduct a fire mission.
(3) Prepare a nuclear target list.

Each action which is required to define a particular task contains the following information:

- the office (staff) involved in the action,
- the times required to process the action by the staff and/or the officer in charge,
- the communication link used to transmit the action,
- the time required to transmit the action.

These individual related actions are then concatenated to form a task. An example of the time-ordered set of related actions required to conduct a direct support fire request from a forward observer is shown in table 1.

Each office is represented by a staff and by an officer in charge. The size of the staff is defined in part of the C^3 data base as user input. Incoming messages are queued and processed by priority and time of arrival. The staff is occupied for the amount of time defined in the task definition, and work on a task can be preempted by a task of a higher priority. The staff elements can be degraded and restored to original staff capacity according to a user-defined scenario.

Each communications medium (FM, AM, multichannel, telephone, courier) that would be used by each action in each task is represented. Messages are queued and processed by priority and time of arrival. The communication link is occupied for the amount of time defined in the task definition. Communication delays can occur as a result of degradation of the link or preemption by higher priority messages.

TABLE 1. EXAMPLE OF DIRECT SUPPORT FIRE REQUEST FROM FORWARD OBSERVER[a]

Step	Action	Communication link
1	FO calls in mission. FIST Chief acknowledges.	Company Fire Control Net
2	FIST Chief coordinates with Company commander.	Company Command Net
3	FIST Teams call FA FDO with mission. FA FDO acknowledges.	DS Bn Command Fire or Fire Direction Net
4	FA FDO gives order to batteries. Batteries acknowledge.	DS Bn Fire Direction Net
5	FA FDO alerts FIST Chief and FO that mission will be fired.	DS Bn Command Fire or Fire Direction Net
6	FA FDO gives order to fire.	DS Bn Fire Direction Net
7	FO or FIST Chief calls in results.	DS Bn Fire Direction Net
	Steps 4, 6, and 7 are repeated as necessary.	

[a] *FO — Forward Observer*
FIST — Fire Support Team
FA FDO — Field Artillery Fire Direction Officer
DS Bn — Direct Support Battalion

3. THE MODEL

3.1 General Characteristics

CONDUCT is a model of the tactical command, control, and communications networks of the Army written in GPSS-V. The functional configuration of the Army components is represented by a single slice—that is, only one brigade in the division, one battalion in the brigade, and so on.

The traffic in the network is represented by tasks that specify the routing of messages, the processing times, and the transmission times. Each task is repeated at given intervals partially varied by a random spread. Each message is assigned a priority, and different types of resources (i.e., staffs and communication links) can be preempted as needed. These various elements (staffs and communications links) can also be destroyed or degraded, and alternate destinations and routes are included where available.

The simulated time unit is 10 s.

3.2 Nodes

There are many different types of nodes represented in the network, as shown in table 2, and only one node of each type is assumed to be in agreement with the slice concept. No geographic location or coordinates are assigned to a node.

TABLE 2. REPRESENTATIVE NODES/OFFICES AT SEVERAL ECHELONS

Division Tactical Operations Center (TOC)
Assistant Commander
G2
G3
Collection, Management, and Dissemination
All Sources Production System
Fire Support Officer/Fire Support Element (FSO/FSE)
Electronic Warfare Section
Division Air Space Management Element
Division Artillery TOC
TOC Control (S3)
Targeting Element (Order of Battle)
Targeting Element (Target Production)
Fire Control Element
Maneuver Brigade
Commander
S2
S3
FSO/FSE
Signal Center
Brigade Intelligence Support Officer (BISO, CEWI Battalion)
CEWI Battalion (Combat Electronics Warfare Intelligence)
Commander
S3/Operations
Ground Surveillance Radar Team
Remote Sensors Team
Collection-Jamming Platoon
Communications-Jamming Team
Voice-Collection Team
Non-Communications Team
Communications-Security Team
Electronic Warfare Flight Platoon

3.2.1 *Staffing*

Each node is assigned either the proper number of staff members, according to the Table of Organization and Equipment (TOE) or the maximum number of concurrent tasks that a staff can process. Normally, one of them is given the role of officer in charge or commander, and the rest are assumed to be interchangeable and form the staff. When a node has only one person assigned to it, this person can be either a commander, a staff, or a commander with a staff of one. This option is controlled by the assigning of the appropriate time in the definition of the tasks.

A commander is represented by a FACILITY, and tasks queue up for processing according to priority. Once the commander starts on a task, this processing is not interrupted.

The staff is represented by a STORAGE of capacity equal to the number of staff members or maximum number of concurrent tasks. Tasks are accepted for processing according to their priority and order of arrival, and they are set aside when a task of higher priority is introduced. Staff is also required at times for the transmission of the messages.

3.2.2 *Numbering*

Nodes are assigned numbers less than 1000, and grouped according to their function. To save storage space for the program, these numbers are then reduced to consecutive integers, and this relationship is represented in the program by the functions REDUC and EXPAN; these functions are generated by the auxiliary FORTRAN program DIET. The FACILITY number and the STORAGE number for each node are then the reduced number. QUEUE's that reflect the times that messages have to wait for the staff are given the same number as the node, and those QUEUE's corresponding to the commander have the node number incremented by 300. Thus, if node 820 is assigned the reduced number 69, the FACILITY 69 represents the commander; the STORAGE 69, with a capacity of two, represents the staff; QUEUE 69 gives information on messages waiting for the staff; and QUEUE 369 gives information on messages waiting for the commander.

3.3 **Links**

Basically, two types of links are represented in the model: those that require a staff member at each end to be engaged in the task during the transmission, and those that do not. The first type is that of an FM net or telephone, and the second type is that of a multichannel link, which has its own staff to transmit the messages. Links of the first type are represented by FACILITY's, where only one message at a time can be transmitted. Links of the second type are represented by STORAGE's, where the capacity represents the number of channels available in that link. A sample of the types of links represented in the model is presented in table 3.

TABLE 3. REPRESENTATIVE COMMUNICATION NETS AT SEVERAL ECHELONS

Division Tactical Operations Center (DTOC)
Division Command/Operation Net (VHF/FM—very high frequency/frequency modulation)
Division Intelligence Net (VHF/FM)
Division Weather Net (VHF/FM)
Division Command/Operation Net (HF/SSB—high frequency/single sideband)
DTOC to Division Support Command (MC—multichannel)
DTOC to Division Tactical Command Post (MC)
DTOC to DIVARTY—Division/Artillery (MC)
Division Command/Operation Net (RATT—radio teletypewriter)
Division Intelligence Net (RATT)
DIVARTY
Command/Fire Net (VHF/FM)
TAB Command/Operation Net (VHF/FM)
TOC to Maneuver Brigade Fire Support Officer/Fire Support Element (FSO/FSE)
TOC to Maneuver Battalion FSO/FSE (Wire)
Fire Net No. 1 (RATT)
Fire Net No. 2 (RATT)
CEWI Battalion (Combat Electronics Warfare Intelligence)
Command Net (VHF/FM)
Tasking/Reporting Net (VHF/FM)
Operations Net (VHF/FM)
Air Mission Control Net (VHF/FM)
Intelligence Net (RATT)

A check can be performed to verify that a given link connects the two nodes specified in the task definition (see sect. 3.4). When LOGIC SWITCH 1 is set, this check is performed; when LOGIC SWITCH 1 is reset, the checking procedure is skipped. This checking procedure scans matrix MH1, which contains a list of all the nodes in each communication link or net. This matrix is generated by the auxiliary FORTRAN program DIET.

3.3.1 *FM Nets*

FM radios are commonly used for communications at the lower echelons. A number of nodes are included in each net. These nets are represented by FACILITY's, and preemption is allowed when LOGIC SWITCH 4 is set. A staff member is occupied at both the origination and destination nodes during transmission.

3.3.2 *Multichannel Links*

Multichannel radios are normally used at higher echelons, and each link can carry 12 or more messages simultaneously; these links are represented by STORAGE's. It is assumed in the model that personnel at the signal centers handle the transmission, thus freeing the staff at the nodes for other tasks during that time. Transmissions on multichannel links can also be preempted.

Some nodes are not connected directly by a multichannel link, but a connection has to be established over several links. Each of these links has to be available for the message to be transmitted. The matrix MH6 (another output from DIET) contains the information about which links form a given composite link. No checking can be done at present to verify that the correct link numbers are given for a composite link.

3.3.3 *Telephone Links*

These telephone links are assumed to connect directly the two nodes in question, and no switching is taken into account. Since the staff members at both ends are busy while the conversation lasts, telephone links are treated in the same manner as an FM net with only two nodes.

3.3.4 *RATT Nets*

The RATT (radio teletypewriter) usually does not need a staff member to attend it during the transmission of a message; consequently, such a link is represented in the same way as a multichannel link of capacity one.

3.3.5 *Courier*

Some messages are carried from one node to another by a courier. Since no statistics or other information are required in this case, all couriers are represented by a STORAGE of maximum capacity, similar to a multichannel link with an "infinite" number of channels. No staff is tied up by this type of "transmission."

3.3.6 *Numbering*

Four-digit numbers are selected for links, which are then reduced to the lowest possible integers after those assigned to nodes by the program DIET.

The second most significant digit indicates the type of link, with a 7 corresponding to a telephone link, an 8 to a multichannel link, and a 9 to a composite link. The last two digits for a composite link give the row number in MH6 where the link numbers are stored. The courier is assigned link number 9899.

Each link, including a composite link, is associated with a QUEUE of the same reduced number that gives statistics on calls waiting for that link.

3.4 **Tasks**

The traffic in the network is determined by tasks that are generated periodically. Each task reflects the communications on the battlefield associated with reports, fire missions, and other events. Each task defines the message routing, the communication links

used between nodes, the time on each link, the staff element used at each node, and the time each staff element spends processing the message. A sample list of tasks represented in CONDUCT is presented in table 4. New tasks can be defined or the present tasks modified with minimum effort

The characteristics of the task are stored in the parameters of the GPSS transaction. The time between messages from the same task reflects the expected frequency of such actions, and each message is assigned a basic priority. The flow diagram for the processing of a task is shown in figure 1.

TABLE 4 SAMPLE LIST OF TASKS REPRESENTED IN CONDUCT

Division Artillery Alerts Moving Target Locating Radar and Forward Observer of Suspected Activity
Sound/Flash Center to 8-in. Field Artillery (FA) Battalion
Moving Target Locating Radar to 8-in. FA Battalion
Direct Support (DS) Fire Request from Maneuver Company Command to FA Battery
DS Fire Request from Aerial Observer to FA Battery
DS Fire Request from Forward Observer to FA Battery
Heavy Mortar Fire Request from Forward Observer
Light Mortar Fire Request from Forward Observer
Tasking Message from Division Artillery to 8-in. and 155 mm FA Battalion
Target-Acquisition Battery Radar Section to 8-in. FA Battalion
Aerial Jamming Initiated by Collection Report
Tactical Report from Collection-Jamming Team to Division Command
Tactical Report from Collection-Jamming Team to Maneuver Brigade with Copy to ASP (All Sources Production Section)
Tactical Report from Collection-Jamming Team to ASP Section
Tasking Message from Division Command to Collection Jamming Team
Tasking Message from Corps Collection Management and Dissemination to Collection-Jamming Team
Artillery Mission Called by Ground Surveillance Radar Team
Jamming Initiated by Collection Report
Emitter Situation Report
Emitter Location and Identification Report
GUARDRAIL Tasking
GUARDRAIL Immediate Reporting
GUARDRAIL Delayed Reporting
Loss of Contact with Friendly Units
Bomb Report/Shell Report/Mortar Report
Division Weather Report
Combat Report
Initial Enemy Contact Report
Electronic Warfare Estimate
Battlefield Information Reporting System (BIRS)
NBC 1--Maneuver Company Initial Report of NBC (Nuclear, Biological, and Chemical) Attack
NBC 2--Evaluated Data Report
NBC 3--Expected NBC Contamination
NBC 4--Radiation Dose-Rate Measurements
NBC 5--Areas of NBC Contamination
Obstacle Report/Engineer Spot Report
Engineer Situation Report
Engineer Tasking Report
Intelligence Collection Requirements/EEI (Essential Elements of Information) Change
Intelligence Directive
Warning Order
Fragment Order
Air Defense Tactical Information Report

TABLE 4 SAMPLE LIST OF TASKS REPRESENTED IN CONDUCT (Cont'd)

Air Defense Intelligence Report
Air Defense Command and Control Orders
Air Defense Tracking Information
Air Defense Early Warning
Air Defense Friendly Flight Information
Air Defense Weapons Status Change
Situation Report from ADM (Atomic Demolition Munition) Unit
Intelligence Summary to ADM Unit
Tasking Message from Maneuver Battalion S2 to Combat Support Company
Tasking Message from Weapons Platoon Leader to Mortar Squadron
Tasking Message from Fire Support Team Chief to Forward Observer

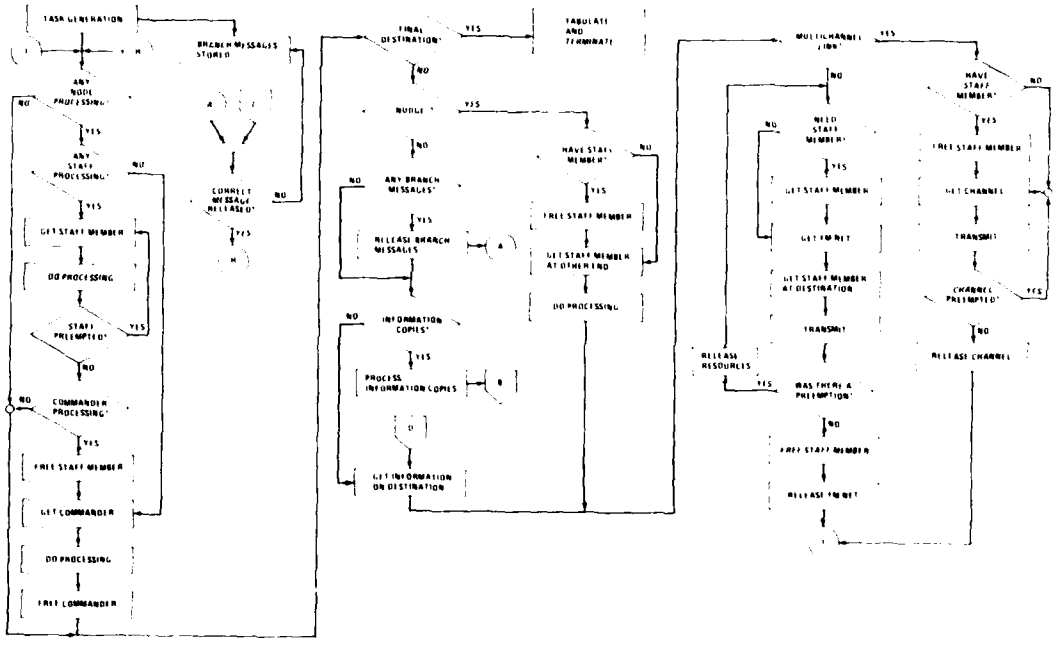

Figure 1. Flow diagram of overall processing.

3.4.1 *Node and Link Information*

The node number is specified in the last three digits of halfword parameters starting with the tenth and going up. The processing times at that node are given by the last two digits of the corresponding floating-point parameter for the commander and the preceding two digits for the staff. The link to get to that node is given by the last four digits of the corresponding fullword paramater, and the preceding digits give the transmission time. This scheme varies somewhat in the special cases discussed below.

3.4.2 *Acknowledgements of Messages*

If a message has to be acknowledged by the recipient, the time is included in the transmission time and no special processing is done for this function in the model.

3.4.3 *Branch Messages*

A message might be sent to several places from a certain node, and each of these messages may generate further communications. This multiplication of messages is represented by branch messages: the original message follows one of the paths, and one or more new messages are sent on the other branches. The branch messages are created at the same time the main message is created, and they are linked to a matching chain at a GATHER block. The original count is equal to the total number of branch messages in a task plus one (for the main message), and this number is stored in PB10 of the branch messages. The number of branch messages to be released at a node is stored in the corresponding byte parameter of the main message, an information copy (explained below), or a previously released branch message. The corresponding transactions are released and checked for the right originating node number after the transaction has completed the processing at the node. Transactions that correspond to branch messages elsewhere are put back on the matching chain, with a GATHER count reduced by the number of released messages.

3.4.4 *Information Copies*

At some nodes, information copies are sent out to one or more destinations before the message proceeds to the next destination. The number of these copies at a node is given by the fourth digit from the right in the corresponding halfword parameter; the following groups of parameters then contain the destination and processing times of the information copies. If the copy goes out on a multichannel link, a new message is queued for transmission and no further involvement is required by the main message. If one or more copies go out on an FM net, an attempt is made to transmit them simultaneously if staff members are available at the destinations. When all information copies on FM nets are transmitted, the processing of the main message continues with its transmission to the next node. This processing of information copies is illustrated in figure 2. The information copies then cause processing at their destination nodes and possibly release branch messages waiting there. If further processing is required at the node the main message has reached, with possibly more information copies going out afterward, the program allows for a destination node equal to the present node, which causes the transmission to be skipped.

3.4.5 *The "Nudge"*

At times an activity initiated by a message—for example, an artillery barrage—causes an incoming message to that node—for example, a report on the effects of the barrage by an observer. These circumstances are represented in the model by a nudge, flagged by a 1 as the fifth digit from the right in the halfword parameter. A nudge implies that the direction of transmission is reversed, and staff processing occurs at the sending node in the amount given by a two-digit number formed by the 6th and 5th digits from the right in the floating-point parameter. The main message waits for the arrival of the nudge before continuing to the next node, if any.

3.4.6 *Slice-Loading Messages*

The representation of only a slice of the divisional assets underestimates the utilization of links and the staff at certain nodes. For messages going from a higher to a lower echelon, this problem is not present. If a brigade wants to send copies of a message to its three battalions, the battalions can receive them simultaneously on an FM net. For

messages going from a lower to a higher echelon, this discrepancy is ameliorated by special slice-loading messages that duplicate the corresponding part of the main message and that occur at intermediate times. No processing takes place at the originating node, because it really would originate at one of the other realizations of this node. Then transmission and processing occur at one or more nodes at the higher echelon, after which the messages are terminated to denote consolidation of similar reports. These messages are not tabulated as completed messages. Such a message is marked by a 3 in PB4.

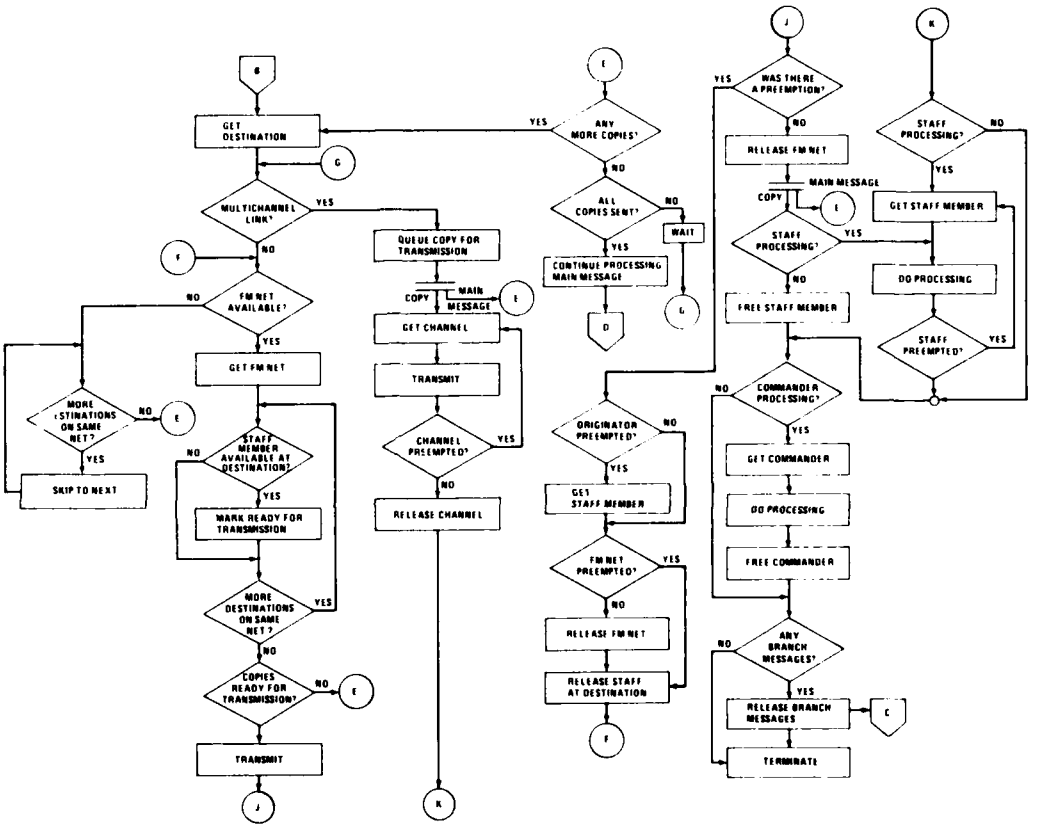

Figure 2. Flow diagram of processing of information copies.

3.5 **Priorities**

The standard five message classes are represented in this model: routine, priority, immediate, flash, and flash override. Within each class there can be differences in precedence of each message for the purpose of staff processing, whence the ranges of 10 to 29, 30 to 49, 50 to 69, 70 to 89, and 90 to 109 are assigned to each above class, respectively.

3.5.1 *Task Priority*

Each task has a basic priority that is assigned at generation and that can vary between 10 and 22 for routine messages, 30 and 42 for priority messages, 50 and 62 for immediate messages, 70 and 82 for flash messages, and 90 and 102 for flash override messages. These ranges within each priority class are used to simulate a staff member's decision to select one task over another task,

even though the selected task may have arrived later in time. For transmission, however, each task is processed on a first-in first-out basis within each priority class, with the higher priority classes being transmitted first.

3.5.2 *Other Additional Priority*

When a message is ready to be transmitted, it is assumed that it will get preference in the assignment to a staff member when compared to another message of the same basic priority that has yet to be processed. This preference is represented by a temporary increase of the priority of the message by 10 when it tries to get a staff member for transmission on an FM net.

3.6 **Preemption**

Priorities are assigned to different messages to ensure that more important messages are processed first. The priority of GPSS transactions assures that transactions of higher priority are pulled off the current events chain first, and consequently they get preference in the use of FACILITY's and STORAGE's. When a message or task of higher priority interrupts the processing of one already there, preemption occurs. In GPSS, preemption according to priority is possible for FACILITY's, but not for STORAGE's. Thus, preemption of multichannel links or staff members has to be handled differently from preemption of FM nets. It is assumed that a commander always finishes a task and is not preempted by newly arrived tasks of higher priority.

3.6.1 *Preemption of FM Nets*

FM nets are represented by FACILITY's, which can be preempted according to priority if LOGIC SWITCH 4 is in the set condition. The transaction using the FACILITY is pulled out of the future events chain, so that the staff can be released and transmission can be attempted again. A GPSS group is defined for users of each link, so that a message can check whether the link can be preempted. If not, the message releases the staff and waits a certain time. This procedure avoids having staff tied up by messages waiting to be transmitted, which can lead to a freeze of activities in the model.

3.6.2 *Preemption in a Multichannel Link*

A GPSS group of users of a link is used also to determine whether a channel can be preempted by a message attempting to use the link. If so, a message with the lowest priority in the link is replaced in the group by the arriving message after the preemption time is noted in PF1 in the preempted transaction. Thus, lack of membership in the group of users and PF1 signals that the transmission was interrupted when the transaction returns to the current events chain, and this step has to be repeated. Consequently, the time between the preemption and the end of the original transmission is lost for a transaction that has to retry.

3.6.3 *Staff Preemption*

A staff member can be preempted in a manner similar to a preemption in a multichannel link, as both are represented by STORAGE's. The main difference is that the task is not started from the beginning but only the remaining time, plus a fixed amount of spin-up time, is required to finish staff processing. Staff members are not preempted while communicating with another staff member.

3.7 **Time-Outs**

The viability of tasks varies with the function and contents of the message represented. In order to deal with obsolete tasks, a maximum time is assigned for each task through the FUNCTION TOUT. Before each transmission, the transmit time is checked, and if it exceeds the corresponding limit, the message is considered too old and is discarded. Branch messages that have not yet been released are also discarded, to avoid unnecessary transaction on the matching chain.

3.8 **Degradation**

Physical destruction, jamming, and other causes of attrition can eliminate or degrade the equipment and staff at the nodes that form the different nets represented in CONDUCT. The way degradation is implemented in the program is through a series of transactions generated by the auxiliary FORTRAN program JELLY and released in the model through a JOBTAPE. These transactions carry information on the node or link number degraded, the duration of the degraded state, the time degradation occurs, and the remaining or degraded assets, if the degradation is partial.

3.8.1 FM Net Degradation

An FM net can be degraded totally by making the corresponding FACILITY unavailable and removing any transaction using it as if it had been preempted. Partial degradation can be simulated by specifying which nodes in the net are out. This is done by giving the column numbers corresponding to these nodes in MH1, where the sign of the entry is changed to indicate that the node is out. When partial degradation occurs, LOGIC SWITCH 3 is set to indicate that this matrix has to be checked. A transaction using the FACILITY at the time the net is degraded finishes using the net without being interrupted.

3.8.2 *Multichannel Link Degradation*

Total or partial degradation of a multichannel link can be specified by the number of channels remaining in use. If the degradation is total, the corresponding STORAGE is made unavailable, and all transactions using the link are treated as if they had been preempted. The STORAGE is made available again after the duration of the degradation has elapsed.

If the degradation is partial, the capacity of the STORAGE is effectively reduced for the duration of the degradation and again increased to the original capacity by entering the required number of units. This artificial usage then has to be subtracted from the statistics of the run if a precise result is required. If more transactions are using the link than channels remain after degradation, a sufficient number of transactions of the lowest priorities present in the link are treated as if preempted.

3.8.3 *Staff Degradation*

The staff at a node is represented by a STORAGE, and it can be degraded totally or partially, in the same manner as a multichannel link. At this time there is no degradation that affects the commander at a node, but this possibility can be introduced in a straightforward way.

3.9 **Alternate Nodes and Links**

When the assets represented in the model are degraded, the actions that would be taken on the battlefield are simulated by allowing the substitution of nodes and links by alternate nodes and means of communications.

3.9.1 *Alternate Nodes*

When the STORAGE representing a node is made unavailable, representing the elimination of the staff, an alternate node is chosen as the destination of a message, if one exists. This node is given in matrix MH2, which also specifies the primary nets that serve this node. When a node is substituted, alternate means of communications have to be found. Halfword matrices 1 and 5, which give the nodes on a link and the links serving a node, are used to perform this search. If no link is found, a courier is used to carry the message. Branch messages are also shifted from a node to the alternate when required. If a node is eliminated after a message has reached it, the message and any branches down the line are dropped.

3.9.2 *Alternate Links*

When a link is unavailable, alternate links are sought using MH1 and MH5. When an alternate link cannot be found, the message is assigned to a courier.

A future development that has been considered is the assignment of composite multichannel links or the possibility of inserting intermediate nodes in the processing of a task.

3.10 **Program Outputs**

A GPSS program has a standard output, which usually contains much unneeded information. The output editor is used here to restrict this output. In addition, special FORTRAN subroutines are used to provide information on the link usage and task completion times.

3.10.1 *Edited Output*

Each printout contains the following information.

- The absolute simulated clock time and the relative (to the last RESET statement) clock time are given.

- The block count statistics are also printed, to provide an overview of the program activity to check for peculiarities and possible errors.

- The standard statistics for the FACILITY's are printed to provide information on the use of commanders and FM nets, depending on what the FACILITY represents.

- The standard statistics for the STORAGE's are printed to provide information on the utilization of the staff and the multichannel and similar links.

- The standard printout for QUEUE's is provided, to show how long a message has to wait for staff, for the commander, or for a communications link.

- A table is printed for each of the message types or tasks, showing a distribution of the transit times of all messages pertaining to that task. Variations in this transit time can be due to periods of waiting and to the different times taken by different branches of the same message. Slice-loading messages and messages that time out or are otherwise eliminated are not included in the tables.

3.10.2 *Special Output*

3.10.2.1 *Communications Scenario*

For a communications scenario, a record of the initial time, the duration, the link number, the originator, and the destination of each use of a link or net is given on a disk or tape file. The output is written by the FORTRAN subroutine, WRT, which is interfaced with the CONDUCT GPSS program through a HELPA block. The output during an initial loading period is suppressed, and only calls terminating during the period for collection of statistics are tabulated. These entries are then sorted by the FORTRAN program SRT by the time of call initiation. Calls that use composite links are included once for each link that is used in the composite one, but the originator and destination correspond to the composite link.

3.10.2.2 Task Completion Data

To provide an exact account of the transit times of tasks and the time of completion of each task, a record of each task's transit time and the time of completion are given on a disk or tape file. The output is written by the FORTRAN subroutine TPLT which is interfaced with the CONDUCT GPSS program through a HELPA block. The output during an initial loading period is suppressed, and only tasks terminating during the period for collection of statistics are tabulated. These entries are then plotted according to task ID by the

auxiliary FORTRAN program TPLOT. The independent axis is the task termination time, and the dependent axis is the elapsed time from initiation of each task.

4. SUGGESTED APPLICATION OF CONDUCT

Results from CONDUCT can be and have been used to

(a) highlight C^3I "choke points,"
(b) compare architecture alternatives,
(c) develop system performance criteria,
(d) evaluate impact of C^3 degradation,
(e) train at various levels of combined arms organization,
(f) assist in evaluation of communication security improvements, and
(g) evaluate the nuclear release process within corps.

5. SUPPORTING COMPUTER PROGRAMS

5.1 **DIET**

DIET is an auxiliary FORTRAN program which prepares the information from the C^3 data base for use in CONDUCT. The inputs to DIET include the following:

(1) node/staff, net, and link definitions with assigned numeric identifiers,
(2) staff capacities,
(3) link capacities (in the case of multichannel),
(4) connectivity of the communication nets and links,
(5) staffs and alternates with the alternate's primary communication net,
(6) colocated nodes/staffs,
(7) switchable radios and the assigned nets, and
(8) composite links.

DIET reduces the assigned numeric identifiers to consecutive integers for use in CONDUCT in order to minimize STORAGE requirements. The other inputs to DIET are then converted to this new numbering system. The output from DIET is a file of GPSS program statements. The output from DIET includes the following:

(1) GPSS discrete functions REDUC and EXPAN which define the relationship between the assigned numeric identifiers and new consecutive integers,

(2) GPSS storage initial cards for inputs 2 and 3,

(3) GPSS halfword matrix definition cards and initial cards for inputs 4, 5, 6, 7, and 8,

(4) listing of node/staff, net, and link definitions with the assigned numeric identifiers and the new assigned consecutive integers, and

(5) FORTRAN data statement which defines the relationship between the assigned numeric identifiers and new consecutive integers for use in the GPSS HELP block FORTRAN program WRT, which outputs the communication call scenario.

Outputs 1, 2, and 3 are incorporated in CONDUCT. Output 5 is incorporated as part of WRT.

5.2 **JELLY**

JELLY is an auxiliary FORTRAN program which generates a GPSS JOBTAPE of transactions for use in CONDUCT that jam communication nets and links, degrade links, and/or degrade staff elements. The inputs to JELLY include the following:

(1) clock time when degradation occurs,

(2) duration of degradation,

(3) link number (multichannel), net number (radio), or node number (staff) affected by the degradation, and

(4) degree of degradation (total or partial degradation, remaining capacity of multichannel links or staff elements, or node(s) jammed or radio nets).

These inputs are required for each asset affected by the degradation and for each time interval of degradation. The output from JELLY is a time-ordered file of the degradation scenario which is associated with the GPSS JOBTAPE JOBTA1 in CONDUCT.

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