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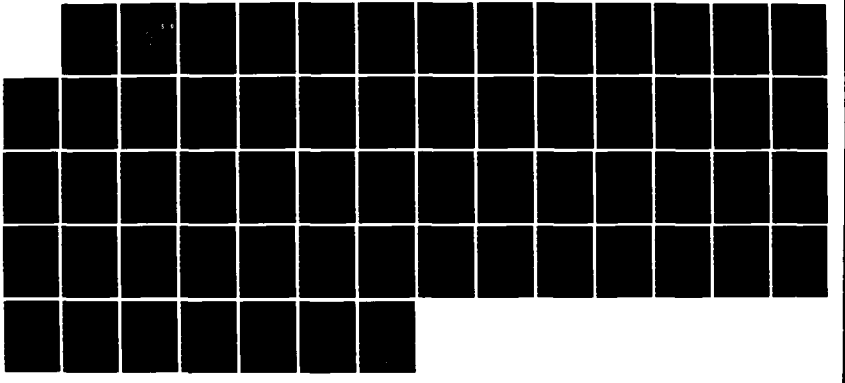

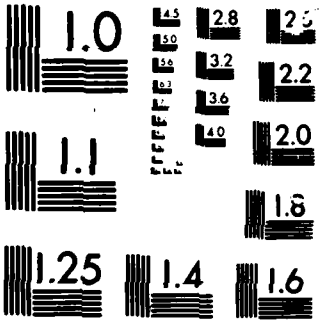

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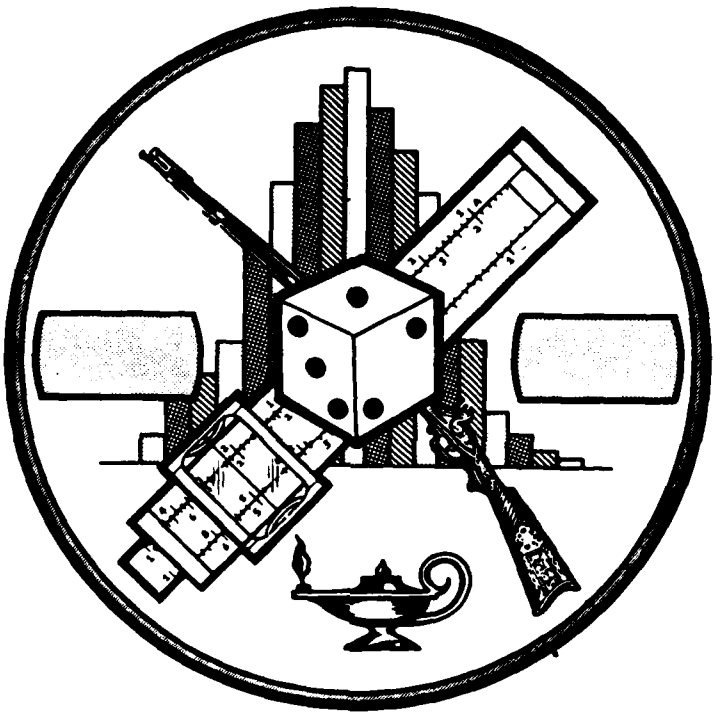

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This report documents an analysis of the G3 section of U.S. Army corps and division main command posts (G3 Main). The G3 analysis, performed by the Combined Arms Operations Research Activity, identified and prioritized analytic aiding opportunities to support the G3 through the use of computer applications. The analysis and assessment process was based on the near-term (five-year) automated environment of main CPs and current U.S. Army doctrine. A structured functional analysis was performed to identify specific G3 Main tasks and products and then (continued)

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December 1985

Combined Arms Operations Research Activity (CAORA)
Studies and Analysis Directorate
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G3 ANALYSIS

VOLUME I: MAIN REPORT

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ABSTRACT

This report documents an analysis of the G3 section of U.S. Army corps and division main command posts (G3 Main). The G3 analysis, performed by the Combined Arms Operations Research Activity, identified and prioritized analytic aiding opportunities to support the G3 through the use of computer applications. The analysis and assessment process was based on the near-term (five-year) automated environment of main CPs and current U.S. Army doctrine. A structured functional analysis was performed to identify specific G3 Main tasks and products and then to assess opportunities to aid G3 performance. A prioritization methodology was refined and exercised to develop a recommended priority to conduct research and to develop analytic aids.

1. INTRODUCTION.

a. Purpose. The purpose of this report is to document an analysis of the G3 section of U.S. Army corps and division main command posts (G3 Main). The purpose of the G3 analysis was to identify opportunities for aiding the performance of the G3 during tactical operations through the use of computer applications. The G3 analysis was performed by the Combined Arms Operations Research Activity (CAORA) during the period January - July 1985. The G3 analysis was a substudy of the Combined Arms Center (CAC) Command and Staff Decision Aids Project. The G3 analysis was performed to assist the Combined Arms Combat Developments Activity (CACDA) to refine requirements for software applications on tactical automated systems.

b. Problem statement. The analysis documented in this report was performed to assist CACDA by answering the following questions:

(1) What are the opportunities for aiding the performance of the G3 during tactical operations through the use of computer applications?

(2) What aiding opportunities require analytic techniques which transform tactical data into meaningful decision information (analytic aids)?

(3) What criteria should be applied to prioritize analytic aid development?

(4) What is the recommended development priority for G3 analytic aiding opportunities?

c. Background. The CAC Command and Staff Decision Aids Project was established in response to a February 1984 directive from Commander, Training and Doctrine Command (TRADOC), which tasked the Combined Arms Center "...to initiate an effort leading to the use of advanced technology systems to help the field commander and his staff in deciding on a course of action in critical battlefield situations..." and to "...describe additional work to be done to develop means by which commanders can use computers to improve decision making." Project guidance called for a constrained effort initially to identify ongoing efforts and to "...determine gains which might be realized by increasing the effort." The Command, Control, Communications, and Intelligence Directorate (C3I), CACDA, was designated as the CAC lead for the Command and Staff Decision Aids Project. C3I, CACDA, requested CAORA support in a constrained project to develop a prototype application and to analyze opportunities for expanded application development in support of evolving automated battlefield control systems. The G3 analysis documents identified opportunities for application development in support of the G3 Main. Concurrently, CAORA developed an Integrated Unit Movement Planning Aid (MOVEPLAN) as a "proof of principle" prototype to refine the application development process. The MOVEPLAN prototype will provide a near-term capability to field users and a validated software requirement to the materiel developer.

d. Approach. The general approach employed to identify and prioritize opportunities for aiding the performance of the G3 during tactical operations was a structured functional analysis of the G3 Main. The structured functional analysis, depicted in figure 1-E, focused on the doctrinal G3 Main tasks and products to develop qualitative assessments of aiding opportunities. The analysts recognized that the specific manner of task performance and the forms of products may vary from command to command, but that underlying opportunities for aiding performance have potential for transfer across commands.

e. Report organization. This report is organized in two volumes. Volume I provides an executive summary and a main report which reflect analysis objectives, analysis methodology, assumptions, analysis highlights, conclusions, and recommendations. Volume I is designed as a ready reference for stand-alone use. Volume II provides additional technical information and functional descriptions which supported the analysis. Appropriate lists, figures, and tables are included in the main report to clarify the analysis methodology, analysis, and conclusions.

2. OBJECTIVES. The following objectives were established to accomplish the G3 analysis:

a. Identify the G3 Main critical tasks.

b. Identify the G3 Main products which are supported by the critical tasks.

c. Identify a taxonomy of aiding technologies.

d. Assess the potential of identified technologies to aid G3 Main performance.

e. For those products which require analytic aiding technologies, assess the appropriateness of alternative analytic techniques.

f. Develop a methodology for prioritizing analytic aiding opportunities.

g. Prioritize analytic aiding opportunities based on appropriate criteria.

h. Document the analysis with appropriate findings and recommendations.

3. METHODOLOGY. A sequential methodology was developed to accomplish the analysis objectives. A flow diagram of the major steps in the methodology is shown in figure 1-E.

4. ASSUMPTIONS. The following assumptions apply to the analysis in this document.

a. Near-term (five-year) requirements for automation at G3 Main will include various commercial microcomputer systems and the Maneuver Control System (MCS).

b. Doctrinal literature and tactical standing operating procedures (TSOP) accurately describe G3 products and tasks. Additionally, the current doctrinal literature and TSOP will remain in effect for the near term.

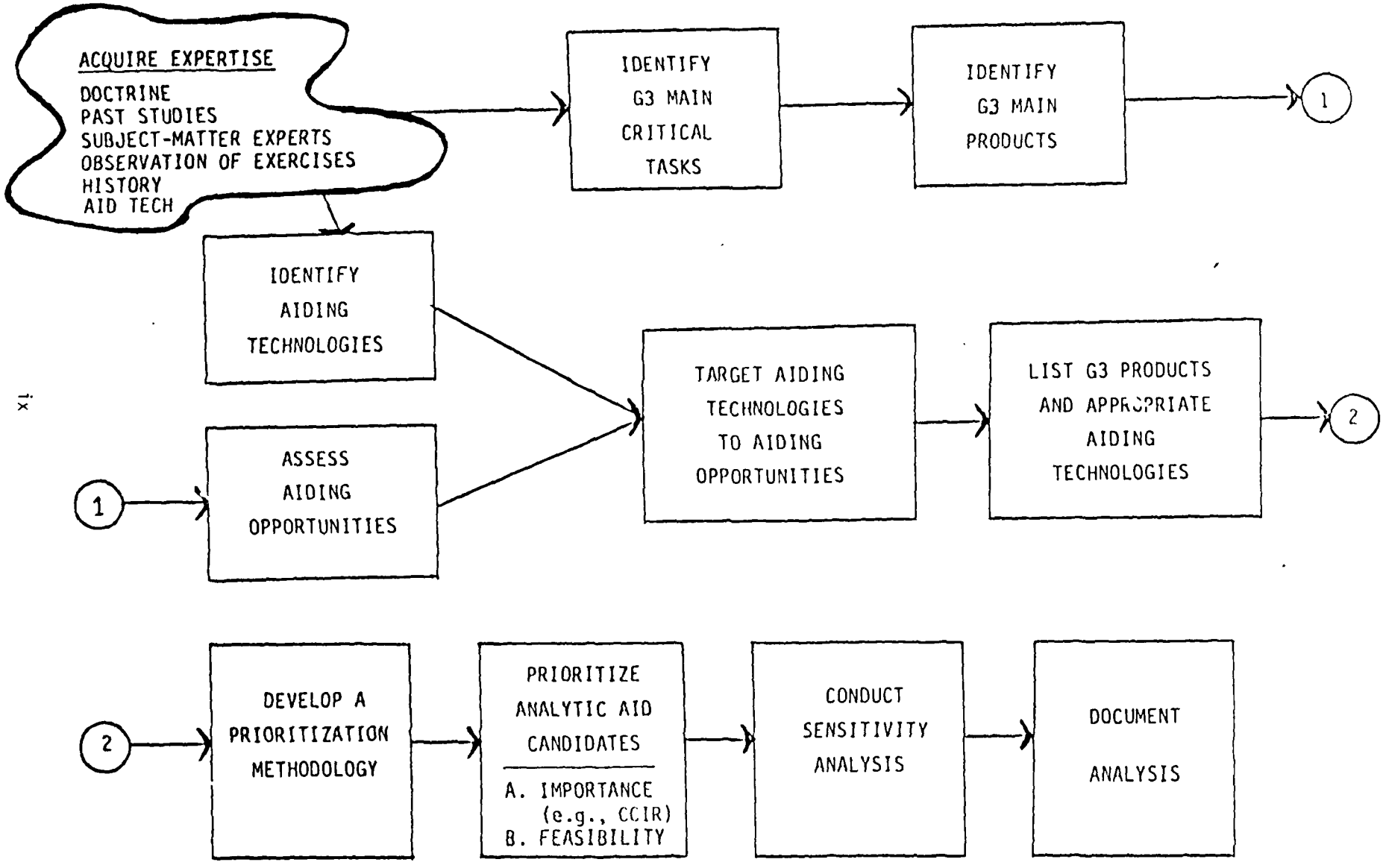


Figure 1.1 G3 analysis methodology

c. The Division Commander's Critical Information Requirements (CCIR), published by CACDA, are baseline information requirements and are subject to modification or validation by a working group of corps commanders.

d. A purpose of tactical automation is to improve the performance of the tactical commander and staff.

e. G3 products and tasks are similar at corps and division and are similar for different type corps and divisions.

f. Bias of military and civilian analysts in making qualitative judgments about importance and feasibility of analytic aids can be reduced.

5. RESULTS AND DISCUSSION. Key results of the analysis are provided in this section.

a. Analysis summary.

(1) Seven major functions of the G3 and 43 G3 Main critical tasks were identified. Decomposition of critical tasks facilitated identification of aiding opportunities. A single comprehensive, doctrinally approved and operationally validated list of G3 critical tasks does not currently exist. Focused, structured observation and experimentation may help to further define G3 critical tasks.

(2) Fifty-nine G3 Main products were identified. G3 tasks were mapped to the products which they support to clarify opportunities for aiding. Tables 1-E and 2-E list the G3 Main formal and implied products.

(3) A classification scheme (taxonomy) for aiding technologies was identified and elaborated. The taxonomy facilitated targeting of appropriate technologies to aiding opportunities identified during the detailed task and product analysis. The taxonomy is adequate as a first-order technique for assessment of potential technology solutions to command and control deficiencies.

(4) Fifty-three different G3 Main analytic aiding opportunities were identified which have potential to support the development of specific G3 products.

(5) A methodology for prioritizing analytic aiding opportunities was developed. The methodology employed a hierarchical model to assess the relative importance and feasibility of each aiding opportunity. The methodology was consistently applied to the G3 analytic aiding opportunities to generate a recommended priority list for aid development. Table 3-E lists the aiding opportunities in order of adjusted rank.

b. Sensitivity analysis. A limited sensitivity analysis was performed to examine the relationships between adjusted scores, raw scores, scores based solely on feasibility, and scores based solely on importance. Graphical analysis was the primary technique employed to investigate sensitivity. The four sets of scores were displayed in stem and leaf plots and scatter plots.

Table 1-E. G3 Main formal products

OPORD *
- Task Organization
- Situation
- Mission
- Execution
- Service Support
- Command and Signal
- Fire Support Annex
- Air Defense Annex
- Engineer Annex
  - Obstacle Appendix
  - Denial Appendix
  - ADM Appendix
- Deception Annex
- Army Aviation Annex
- Rear Area Protection Annex
- Operations Security Annex
- Airspace Management Annex
- Psychological Operations Annex
- Civil Affairs Annex
- CE Annex
- NBC Defense Annex
- Chemical Support Annex
- Service Support Annex
- Task Organization Annex
- Intelligence Annex
- Electronic Warfare Annex
- Road Movement Annex
- Air Movement Annex
- Operations Overlay Annex

Warning Order
Frag Order
Movement Order
Admin/Logistics Order
Aircraft Mission Request (Army Aviation)
Artillery Situation Report
Air Request/Task Message (Pre-planned)
ADM Target Folder
Post Strike Analysis (Nuclear Strike)
Chemical Strike Warning
Nuclear Strike Warning
ECM Daily Summary
Electronic Warfare Support Measures (ESM) Report
Engineer Barrier Report
Engineer Mission Coordination Sheet
Engineer Trace Report
Engineer Situation Report

* OPLAN is not included separately; difference between OPORD and OPLAN is that OPLAN contains assumptions and specifies the time or conditions under which it will be placed into effect.

Table 1-E. G3 Main formal products (concluded)

Engineer Report-Damage
Air Defense Status Report
Aircraft Hostile Fire Report
Air Defense Engagement Report
Commander's Situation Report (SitRep)
Unit Location Update
Command, Control and Communication CM Spt Request
Minefield Report
Engineer Spot Report
Air Request/Task Message (Immediate)
PSYREP
Spot PSYREP
Airspace Management Procedures Request
ECM Mission Request
Intelligence Summary
NBC 1 (Observer's Initial Report)
NBC 2 (Evaluated Data Report)
NBC 3 (Immediate Warn of Expected Contam)
NBC 5 (Rpt of Areas of Actual Contam)
NBC 6 (Detailed Information on Chem/Bio Attack)
NBC Downwind Message
MIJI Report
OPSEC Spot Report
Required Ammunition Supply Rate (RSR) Report
PSYOP Support Request
Movement Code
Training Plans
Maintain/Update TSOP
Nuclear Release Request
Chemical Release Request

Table 2-E. G3 Main implied products

Mission Analysis
Operations Estimate
Directed Staff Estimates
Briefings
Maintain the Current Situation
Project Unit Status
Project Critical Shortages
Maintain the Staff Journal
Allocate/Prioritze Replacement Personnel, Materiel and Units
Maintain the Troop List
Exchange of Information

Table 3-5. Analytic aiding opportunities (adjusted rank order)
(continued on following pages)

AID DESCRIPTOR	AID ID#	ADJUSTED RANK	RAW RANK	ABSOLUTE RANK DIFF	ADJUSTED IMPORTANCE RANK	ADJUSTED FEASIBILITY RANK
Unit Movement Planner	3-51	1	1	0	1	12
Force Movement Analyzer	3-24	2	3	1	2	11
Air Movement Analyzer	3-04	3	4	1	4	19
Fuel Consumption Rates	3-26	4	5	1	7	10
Air Movement Planner	3-05	5	2	3	13	3
Assign Critical Replacement Units, Personnel, and Materiel	3-08	6	6	0	11	13
Terrain Management	3-46	7	12	5	10	29
Denial Preparation	3-19	8	22	14	12	30
Time Analyzer	3-47	9	7	2	28	4
Pre-Position Decontamination Supplies	3-18	10	17	7	15	27
Compare Alternate Courses of Action	3-13	11	42	31	3	49
Obstacle Preparation	3-31	12	14	2	17	28
Predict Contamination (ID Affected Units)	3-39	13	9	4	36	2
Forecast Unit Status	3-52	14	30	16	6	40
Chemical Effects Prediction	3-20	15	18	3	23	18
Expenditure Rates (FS)	3-22	16	11	5	33	6
Basic Load Allocations	3-10	17	8	9	42	1
Nuclear Effects Prediction	3-21	18	16	2	30	15
Aircraft Asset Analyzer	3-02	19	10	9	26	21
Priorities of Fire (FS)	3-40	20	24	4	18	32
Priorities/Allocation (ADA)	3-38	21	33	12	9	43
Rear Area Protection Capabilities	3-41	22	39	17	8	45

Table 3-E. Analytic aiding opportunities (adjusted rank order)
(continued)

AID DESCRIPTOR	AID ID#	ADJUSTED RANK	RAW RANK	ABSOLUTE RANK DIFF	ADJUSTED IMPORTANCE RANK	ADJUSTED FEASIBILITY RANK
Troop Exposure (NBC)	3-50	23	19	4	35	17
Evaluate Damage Repair Alternatives	3-17	24	27	3	21	31
Forecast Tube Replacement (FS)	3-25	25	13	12	39	9
Forecast Usage Rates (RSR)	3-53	26	23	3	32	23
Allocate CAS and RECCE	3-11	27	28	1	31	25
Controlled Supply Rate (CSR)	3-15	28	13	15	43	7
Route Evaluation (AVN)	3-44	29	35	6	5	52
ADM Employment	3-33	30	29	1	38	20
Task Organization	3-45	31	31	0	22	34
Target Allocation (Chemical)	3-48	32	25	7	40	16
Aircraft Requirements	3-03	33	32	1	25	35
Prescribed Nuclear Load (PNL)	3-37	34*	26	8	37	22
Prescribed Chemical Load (PCL)	3-36	34*	26	8	37	22
Optimal Friendly Employment (EW)	3-34	35	36	1	14	44
Organize for Combat (FS)	3-35	36	37	1	24	36
Allocate Engineer Resources	3-07	37	15	22	41	26

* Ties were allowed for ranks. PCL and PNL had a tie for all scoring schemes. Therefore, the adjusted ranks ranged from 1-52 for a total of 53 aiding opportunities.

Table 3-5. Analytic aiding opportunities (adjusted rank order) (concluded)

AID DESCRIPTOR	AID ID#	ADJUSTED RANK	RAW RANK	ABSOLUTE RANK DIFF	ADJUSTED IMPORTANCE RANK	ADJUSTED FEASIBILITY RANK
Target Susceptibility (NBC)	3-49	38	34	4	27	37
Fallout Prediction (Nuclear)	3-23	39	21	18	48	8
Hazard Areas (NoC)	3-27	40	20	20	45	14
Allocate Replacements	3-06	41	43	2	16	48
Obstacle Emplacement Plan	3-30	42	41	1	29	39
Integrate CAS (FS)	3-28	43	44	1	20	42
Relative Combat Power	3-42	44	45	1	34	38
Control Procedure (A2C2)	3-14	45	46	1	19	51
NBC Effects Evaluation	3-29	46	38	8	47	24
Post-Strike Analysis (Nuclear)	3-16	47	31	16	50	5
Determine Replacement Priorities	3-43	48	47	1	44	41
Allocate Critical Assets (ECM)	3-01	49	40	9	51	33
Assign PSYOP Assets	3-09	50	49	1	46	47
Obstacle Effectiveness	3-12	51	48	3	49	46
PSYOP Effectiveness	3-32	52*	50	2	52	50

* Ties were allowed for ranks. PCL and PNL had a tie for all scoring schemes. Therefore, the adjusted ranks ranged from 1-52 for a total of 53 aiding opportunities.

(1) Comparison of leaf plots. Five analytic aids consistently scored in the top two cells across all scoring schemes. The specific aiding opportunities are: Air Movement Analyzer, Fuel Consumption Rates, Assign Critical Replacements, Unit Movement Planner, and Force Movement Analyzer. These aids were robust across all scoring schemes. Figure 2-E shows a leaf plot of aids based on adjusted scores.

(2) Comparison of scatter plots. Graphical techniques were also employed to examine the relationships between adjusted, raw, importance, and feasibility ranks. Figure 3-E shows a scatter plot comparison of adjusted ranks and raw ranks. This figure shows that the top four aids were dominant (low rank) for both raw and adjusted ranking procedures. Further, the bottom five aids were consistently inferior. However, in the rank interval 5-47 there was a great amount of variability between raw and adjusted ranks. Additional scatter plots are in appendix I.

(3) Conclusions from sensitivity analysis. Of the top 20 aids, based on adjusted score, six consistently ranked in the top 20 over all scoring/ranking schemes. Aids in the midrange (approximately 10-40) are highly sensitive to the effects of alternative subcriteria weights.

c. Limitations.

(1) The analysis was based on the best available doctrinal literature and references documenting aiding technologies. However, a corps headquarters ARTEP has not been developed and the division headquarters ARTEP is under revision. The Combined Arms Training Activity (CATA) is working to standardize the critical tasks at division and corps, but a doctrinally approved and operationally validated consolidated list does not currently exist. In many cases, substantial additional research, experimentation, and field observation will be required prior to development of specific automated aids which will actually improve performance.

(2) Though analytic techniques were decomposed in the targeting process, it is possible that a combination of analytic techniques may be embedded in a single aid.

(3) The possibility exists that analytic aids will evolve as the automated environment and the literacy of automation users mature. In this event, an application which initially employs math model techniques might later be revised to use artificial intelligence techniques.

6. CONCLUSIONS. The following conclusions resulted from the G3 analysis.

a. The objectives of the G3 analysis were accomplished.

b. Specific opportunities for aiding the performance of the G3 during tactical operations were identified and appropriate aiding technologies were targeted.

c. Fifty-three distinct G3 analytic aiding opportunities were identified.

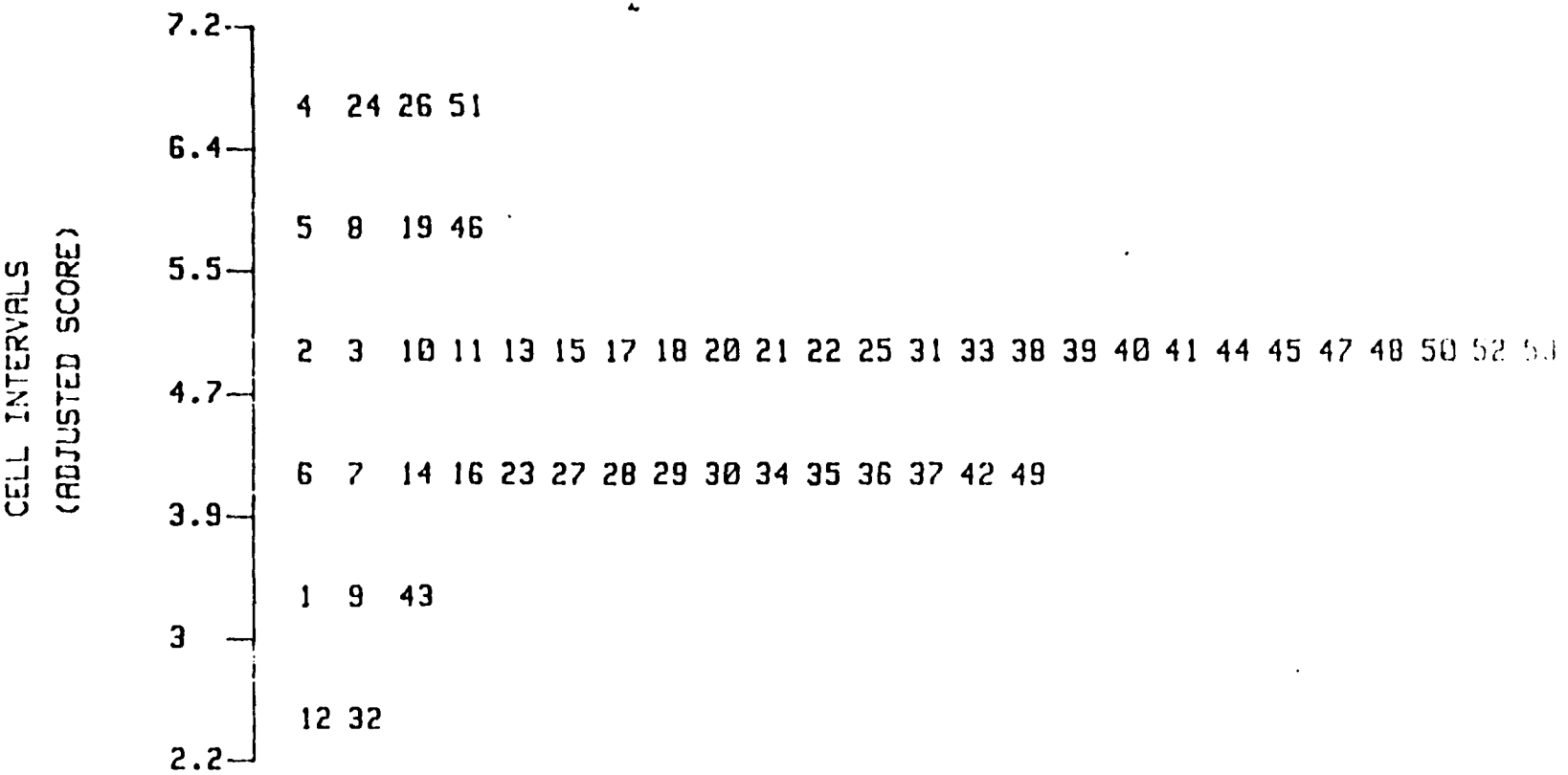


Figure 2-E. LEAF PLOT OF ADJUSTED SCORES (EQUAL CELLS).

(Numbers shown are aid identification numbers)

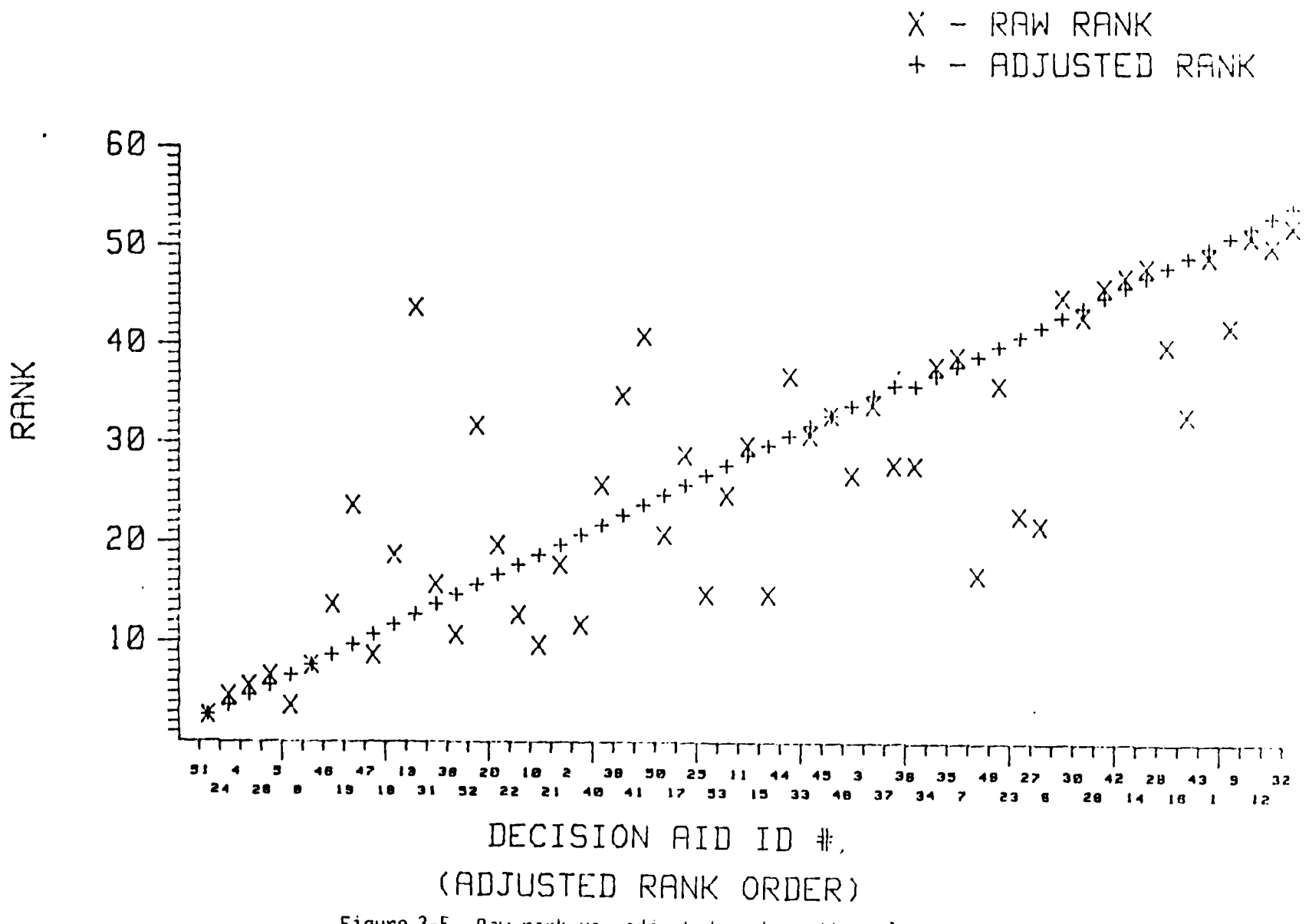


Figure 3-E. Raw rank vs. adjusted rank scatter plot

d. Criteria of importance and feasibility provide a rational basis for prioritizing analytic aid development. The two primary criteria can be further decomposed to facilitate assessment of relevant factors such as development cost, training, frequency of product development, and potential time savings.

e. A recommended priority for development of G3 analytic aids was compiled based on the above criteria using a hierarchical prioritization structure. The five aids which consistently ranked at the top of the priority list are Air Movement Analyzer, Assign Critical Replacements, Force Movement Analyzer, Fuel Consumption Rates, and Unit Movement Planner.

f. Additional research, field observation, and experimentation are required to define and standardize G3 tasks and products.

g. The methodology employed to analyze the G3 Main may be applied to other functional areas to identify and prioritize development of automated aids.

h. The prioritized list of G3 analytic aiding opportunities provides a rational basis for focused development of decision aid prototypes.

7. RECOMMENDATIONS.

a. That the G3 analysis be approved as an accurate, comprehensive study which identifies and prioritizes G3 aiding opportunities based on current doctrine.

b. That the G3 analysis be presented to the Combat Developer (C3I, CACDA) to assist in focused development of decision aids for the Maneuver Control System (MCS).

c. That G3 Main products and tasks be standardized to enable efficient training of high-performing staffs and to facilitate rapid, successful transition from a manual to an automated U.S. Army Tactical Command and Control System.

d. That the analytic methodology described in this report be approved as an appropriate methodology for identifying aiding opportunities in battlefield functional areas.

e. That increased emphasis be placed on analysis of the command and control process through observation and experimentation to define the process and to improve procedures within the process.

MAIN REPORT

1. INTRODUCTION.

a. Purpose. The purpose of this report is to document an analysis of the G3 section of U.S. Army corps and division main command posts (G3 Main). The purpose of the G3 analysis was to identify opportunities for aiding the performance of the G3 during tactical operations through the use of computer applications. The G3 analysis was performed by the Command Control Analysis Division (CCAD), Studies and Analysis Directorate (SAD), Combined Arms Operations Research Activity (CAORA) during the period January - July 1985. The G3 analysis was a substudy of the Combined Arms Center (CAC) Command and Staff Decision Aids Project. The G3 analysis was performed to assist the Combined Arms Combat Developments Activity (CACDA) to refine requirements for software applications on tactical automated systems.

b. Problem statement. The analysis documented in this report was performed to assist CACDA by answering the following questions:

(1) What are the opportunities for aiding the performance of the G3 during tactical operations through the use of computer applications?

(2) What aiding opportunities require analytic techniques which transform tactical data into meaningful decision information (analytic aids)?

(3) What criteria should be applied to prioritize analytic aid development?

(4) What is the recommended development priority for G3 analytic aiding opportunities?

c. Background. The CAC Command and Staff Decision Aids Project was established in response to a February 1984 directive from Commander, Training and Doctrine Command (TRADOC), which tasked the Combined Arms Center "...to initiate an effort leading to the use of advanced technology systems to help the field commander and his staff in deciding on a course of action in critical battlefield situations..." and to "...describe additional work to be done to develop means by which commanders can use computers to improve decision making." Project guidance called for a constrained effort initially to identify ongoing efforts and to "...determine gains which might be realized by increasing the effort." The Command, Control, Communications, and Intelligence Directorate (C3I), CACDA, was designated as the CAC lead for the Command and Staff Decision Aids Project. C3I, CACDA, requested CAORA support in a constrained project to develop a prototype application and to analyze opportunities for expanded application development in support of evolving automated battlefield control systems. The G3 analysis documents identified opportunities for application development in support of the G3 Main. Concurrently, CAORA developed an Integrated Unit Movement Planning Aid (MOVEPLAN) as a "proof of principle" prototype to refine the application development process. The MOVEPLAN prototype will provide a near-term capability to field users and a validated software requirement to the materiel developer.

d. Approach. The general approach employed to identify and prioritize opportunities for aiding the performance of the G3 during tactical operations was a structured functional analysis of the G3 Main. The structured functional analysis, depicted in figure 1, focused on the doctrinal G3 Main tasks and products to develop qualitative assessments of aiding opportunities. The analysts recognized that the specific manner of task performance and the forms of products may vary from command to command, but that underlying opportunities for aiding performance have potential for transfer across commands. The detailed analysis methodology is described in paragraph 3.

e. Report organization. This report is organized in two volumes. Volume I provides an executive summary and a main report which reflect analysis objectives, analysis methodology, assumptions, analysis highlights, conclusions, and recommendations. Volume I is designed as a ready reference for stand-alone use. Volume II provides additional technical information and functional descriptions which supported the analysis. Appropriate lists, figures, and tables are included in the main report to clarify the analysis methodology, analysis, and conclusions.

2. OBJECTIVES. The following objectives were established to accomplish the G3 analysis:

a. Identify the G3 Main critical tasks.

b. Identify the G3 Main products which are supported by the critical tasks.

c. Identify a taxonomy of aiding technologies.

d. Assess the potential of identified technologies to aid G3 Main performance.

e. For those products which require analytic aiding technologies, assess the appropriateness of alternative analytic techniques.

f. Develop a methodology for prioritizing analytic aiding opportunities.

g. Prioritize analytic aiding opportunities based on appropriate criteria.

h. Document the analysis with appropriate findings and recommendations.

3. METHODOLOGY. A sequential methodology was developed to accomplish the analysis objectives. A flow diagram of the major steps in the methodology is shown in figure 1. The following subparagraphs provide a description of each element of the analysis methodology.

a. Acquire expertise. CAORA analysts performed an extensive review of doctrinal literature and related studies, consulted with subject-matter experts, observed G3 activities during REFORGER, and studied historical reports. The principal product of this step was an initial foundation of knowledge about G3 Main activities. A secondary product was development of a library of reference materials to support the analysis. Controlled experiments, surveys, interviews, and structured observations of command posts were considered but were not feasible in the initial constrained analysis effort.

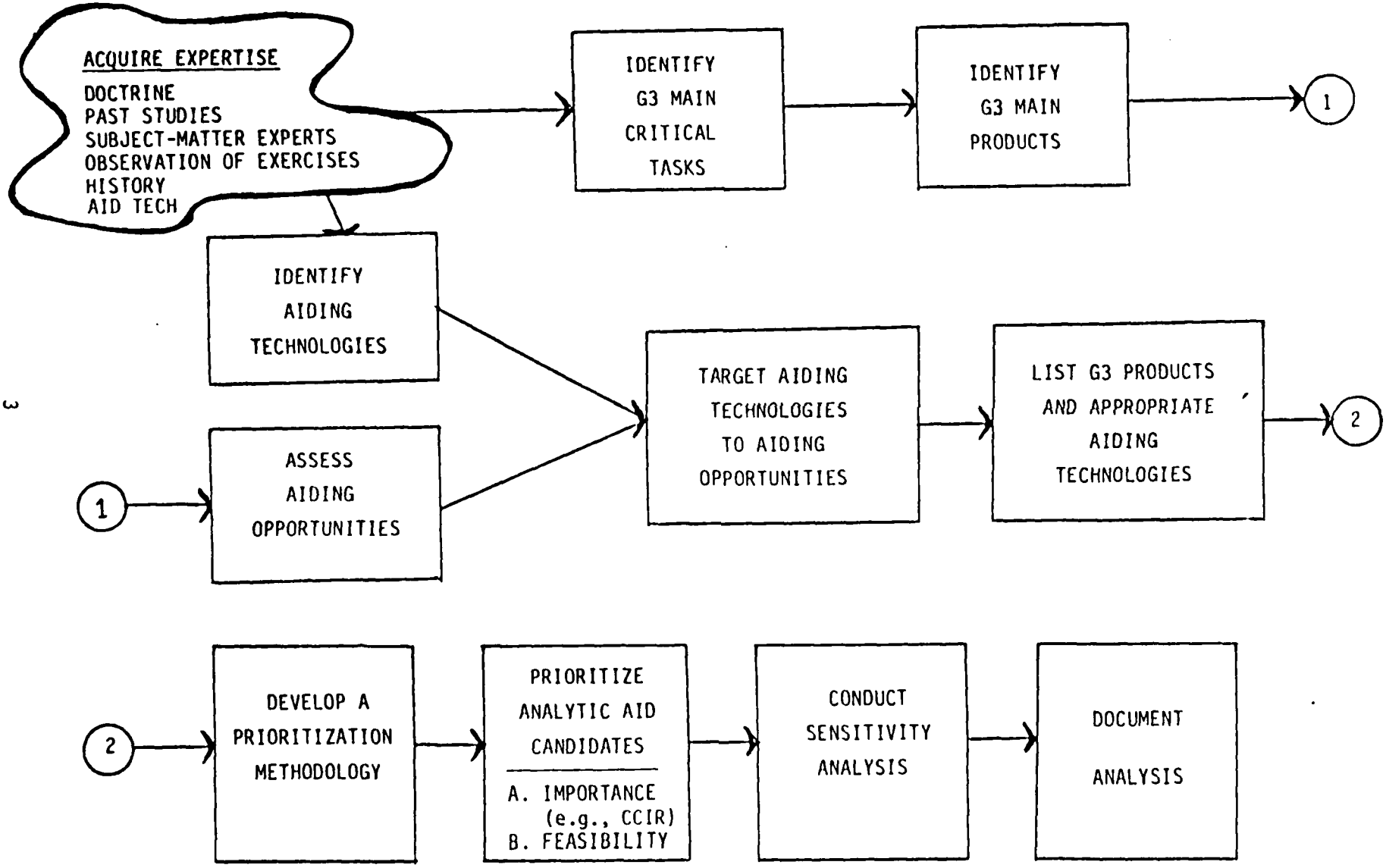


Figure 1. G3 analysis methodology

b. Identify G3 Main critical tasks. First, soldiers who work at G3 Main were identified using doctrinal publications. Next, the expertise acquired from literature, consultation, and limited field observation was focused to compile a list of G3 Main critical tasks. The task list was refined by cross-checking doctrinal literature (FM 101-5, A-TEP 100-2, FC 101-55), technical reports (CACRA TR 1-85, CCS2 functional analyses), and obtaining required clarification from subject-matter experts. The principal G3 activities were decomposed to define specific tasks. A task reference sheet was then developed to provide a brief description of the elements of each task.

c. Identify G3 Main products. Techniques similar to the task analysis were applied to identify the principal G3 Main products. The sources for task analysis were used as well as CACRA's Command Information Database (CID) which facilitates cross-mapping of tasks to the products which they support. The CID was developed from detailed analysis of five corps and nine division tactical standing operating procedures (TSOP) and doctrinal literature. The CID assisted analysts in refining the list of G3 Main products reflected in doctrinal literature.

d. Identify aiding technologies. A review of computer science, information system, and decision support literature clarified a classification scheme of aiding technologies. The consistent taxonomy decomposed aiding technologies into information processing techniques, user interface techniques, and analytic techniques. Analytic techniques were further subdivided into categories of artificial intelligence (AI), mathematical models, optimization techniques, computer simulations, and decision analysis. The taxonomy enabled the targeting of appropriate technologies to aiding opportunities identified during the detailed task and product analysis. Brief descriptions follow.

(1) Information processing. Information processing technologies encompass architectural capabilities inherent to automated information processing. Some example technologies in the class include information storage, access, security, distribution, and communications. Specific realizations of these technologies are UNIX, DbASE II, and Electronic Mail.

(2) User interface. User interface technologies include hardware and software developments which enhance the capability of a human operator to interact with an automated information system. Typical examples in this class are help menus, interactive tools such as the mouse and bit tablet, graphic displays, standard format prompts, touch-sensitive screens, and voice input or output.

(3) Analytic techniques. Analytic techniques are embedded or adaptable relational models which transform data which resides in the database. The transformation process goal is to yield meaningful information from existing or readily-available data. In many cases, the analytic techniques have existed and been refined in a manual operating environment but speed, quality, and number of processing steps have been expanded in an automated environment. However, as in the case of AI, emerging analytic techniques have also been identified for potential aiding of human performance. The analytic technologies were further decomposed to focus analytic aiding opportunities. A brief description of each category is provided below.

(a) Artificial intelligence (AI). AI techniques refer to applications which employ inference rules based on expert knowledge. The analysts could not assess the preferences of AI to other analytic aiding alternatives due to the relative immaturity of AI. However, the DARPA Strategic Computing Program and other initiatives may clarify the role of AI as a sound analytic technique.

(b) Mathematical models (MM). Math models encompass straightforward computational techniques which utilize basic relationships to obtain information. Examples are:

$$\text{distance} = \text{rate} \times \text{time}$$

$$\text{sector force ratio} = \frac{\text{value of enemy forces in sector}}{\text{value of friendly forces in sector}}$$

Information processing and user interface technologies (DBASE II, LOTUS 1, 2, 3) facilitate the use of math models in an automated environment.

(c) Optimization techniques (OT). Optimization techniques employ operations analysis methods to search for a "best" solution. OT generally requires definition of an objective function (optimization criteria) and a statement of constraints. Example OT applications are linear programming, goal programming, and networks. In some cases, OT methods may interact with heuristic, perhaps AI techniques, to yield a "best feasible" solution under operator control.

(d) Simulation (SIM). Simulations are event- or time-sequenced models which may have math models or optimization techniques embedded. Simulations facilitate the investigation of variable relationships over time or some other designated independent variable(s). Example simulations include deterministic or stochastic (probabilistic) war games or queuing models.

(e) Decision analysis (DA). DA techniques employ game theory, utility/value models, or decision trees to examine alternative strategies. Use of a decision payoff matrix, which seeks a dominant outcome for a given alternative, is a DA method.

e. Assess aiding opportunities. An initial qualitative assessment was made to determine opportunities for aiding the development of G3 Main products. The qualitative assessment was based on a general knowledge of aiding technologies, both current and projected, and a detailed understanding of the products and the tasks which support product development. This initial screening considered frequency of product development, time and coordination required, task/product complexity, and training and experience required to develop the product.

f. Target aiding technologies to aiding opportunities. For each product with assessed potential for technological aiding, a further judgment was made concerning the specific aiding technologies which could be applied. A more detailed understanding of aiding technologies was required to make this assessment. The assessment further ranked the potential of "competing" analytic technologies to satisfy the identified opportunity.

g. List G3 products and appropriate aiding technologies. Each G3 main product and its supporting tasks were examined to determine whether the three aiding technologies - analytic, information processing, or user interface - might be useful. A matrix was developed to list the products and to identify the appropriate technologies for each. In addition, for those products which were assessed to have potential for analytic aiding, a description of the specific analytic aid was developed. An assessment was then made concerning the appropriateness of alternative analytic aiding technologies. A brief aid descriptor (name) was then assigned.

n. Develop a prioritization methodology.

(1) A methodology was required to prioritize the aiding opportunities since infinite resources are not available for development. Alternative techniques for structuring preferences were investigated. Specific techniques considered were decision tables using dominance or minimax decision criteria and a hierarchical model developed by Thomas L. Saaty (reference 10). An approach which provided discrimination between competing aiding opportunities was desired. Decision tables would identify groups of aids with similar dominance or minimax characteristics but would not provide information about differences within groups of aids. Saaty's analytic hierarchy process (AHP) provided an objective method to obtain a priority value for each individual aid. The basic methodology applied, using Saaty's technique, was to formulate a hierarchy of separable criteria to evaluate each aiding opportunity. A method of pairwise comparisons was employed to determine the relative utility (weight) of each criteria. A commercial software application, "Expert Choice," facilitated the computation of criteria values. Figure 2 depicts the hierarchy which was developed to evaluate each aid individually and then to obtain a weighted score for each aid relative to all other aids. A worksheet was developed for individual aid evaluation. An example of the worksheet is provided at figure 3.

(2) Criteria for expressing preferences were developed. The primary criteria of importance and feasibility were selected based on a review of information system literature and current application development experience. Importance encompasses the factors which contribute to improved G3 effectiveness. Feasibility encompasses considerations of major costs associated with developing, training users, fielding, and maintaining applications. The two primary criteria were further decomposed into three subcriteria for each. The primary criterion of importance was decomposed to subcriteria of frequency of use, estimated time and quality savings, and the extent to which the aid supports the Division Commander's Critical Information Requirements (CCIR). The primary criterion of feasibility was decomposed to subcriteria of cost, operational environment, and technical capability. A discussion of each subcriterion is provided in the following subparagraphs.

(a) Importance.

1 Frequency. This subcriterion of importance was used to assess the frequency of potential use of a specific aid in a 24-hour period during mid- to high-intensity combat operations. The premise was that aids which are used repeatedly have higher utility than those which are used infrequently.

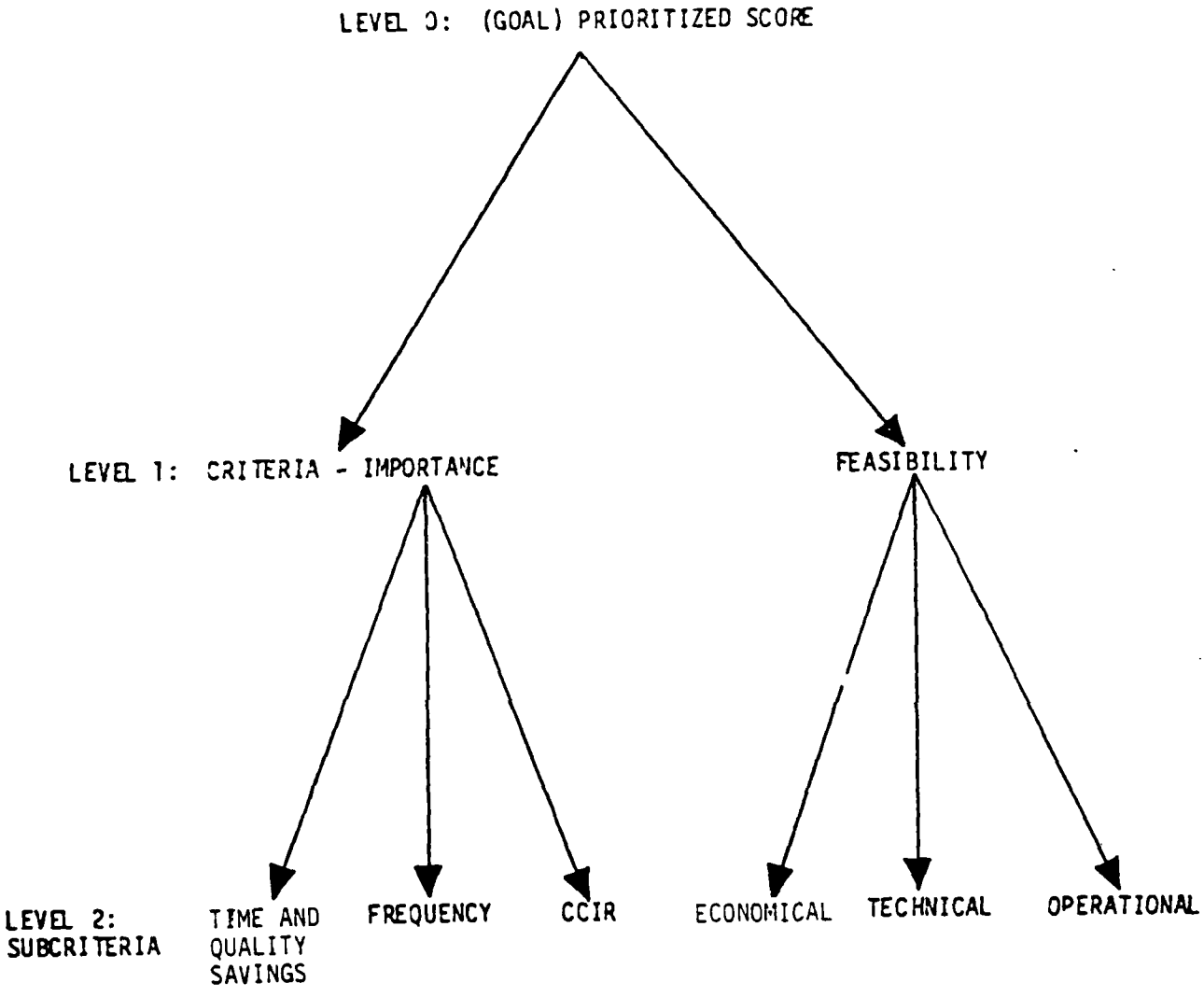


Figure 2. Hierarchy of aid criteria

AID PRIORITIZATION WORKSHEET

1. AID DESCRIPTOR: Task Organization
2. AID NUMBER: 3-45
3. PRODUCT SUPPORTED: OFCRD (Task Organization)
4. PRIMARY ANALYTIC TECHNIQUE: Decision Analysis
5. SUPPORTING ANALYTIC TECHNIQUE(S): Artificial Intelligence, Math Model
6. TASK(S) SUPPORTED (BY NUMBER): 1a, 1b, 3a
7. CCIR SUPPORTED (TOTAL NUMBER): 11
8. BRIEF AID DESCRIPTION: This aid is designed to organize combat and combat support units for combat based on mission, terrain, unit status, etc.
9. RANKING BY SCALES (IMPORTANCE):

	RAW SCORE	WT	ADJ SCORE
a. Frequency (Low, High)	4.3	.109	.469
b. Time and Quality Savings (Small, Large)	6.1	.198	1.208
c. CCIR (Few, Many)	3.3	.360	1.188

10. RANKING BY SCALES (FEASIBILITY):

a. Operational (Low, High)	5.6	.190	1.064
b. Economical (High Cost, Low Cost)	4.7	.048	.226
c. Technical (High Risk, Low Risk)	6.5	.095	.618
TOTAL SCORES:	30.5	1.000	4.77

Figure 3. Example aid prioritization worksheet

2 Time and quality savings. This subcriterion of importance was used to assess the potential for more rapid product development and improved product quality for a single iteration. Factors considered in the assessment were task/product complexity, number of variables considered, product content/volume, and training or competence required for effective task performance. The underlying premise was that aids which reduce time and improve quality during a single product iteration have higher utility than those aids which save little time or quality.

3 CCIR. Each aid was rated on a ratio scale based on the number of major subcategories of CCIR which it supported. The underlying premise was that aid utility increases with increasing production/support of CCIR.

(b) Feasibility.

1 Operational. Each aid was considered in terms of costs associated with the operational environment. Factors considered were aid transparency and user literacy. The underlying premise was that transparent aids which minimize requirements for training (user literacy) have the highest utility.

2 Economical. Each aid was considered in terms of costs required for research to refine requirements, prototype development, maintenance and training, hardware availability, and fielding/conversion of systems. The underlying premise was that a near complete, straightforward, easily supported prototype has the highest utility.

3 Technical. Each aid was considered in terms of the existence of near-term or current technologies for aid development and fielding. This was basically a risk assessment. Factors considered included communications, automation, software development technologies, data availability, and maturity of analytic techniques. The underlying premise was that applications which are dependent on existing, well-established technologies are minimal risk candidates.

i. Prioritize analytic aid candidates. For each aid requiring analytic techniques, a prioritization worksheet was prepared and an assessment was recorded by CAORA analysts for each subcriterion of importance and feasibility. An interval scale was used to express the extent to which each potential analytic aid satisfied each subcriterion. The transition to a focus on analytic aids was based on the recognition that the combat developer and materiel developer are making progress in the application of information processing and interface technologies but are experiencing difficulty defining requirements for analytic techniques to support tactical commanders and their staffs. For each aid, the analysts reviewed the relevant materials to better understand the purpose of the aid, the potential analytic techniques, and the extent of support to the CCIR. A mapping was made to determine which CCIR subcategories were required or would be produced by the aid. After discussion, a consensus was obtained concerning the ranking of the aid for each subcriterion. The result was a raw score for each subcriterion. The raw scores were added to obtain a total raw score for each aid. The total raw score reflects the value of each aid if all criteria (importance, feasibility) and the six subcriteria are equally weighted. Weights for the criteria of importance and feasibility were obtained by the method of pairwise comparison. Within each criterion, relative weights were obtained for the subcriteria using the same method. The relative weight of each subcriterion was

multiplied by the weight of its corresponding criterion to obtain six subcriteria weights that are comparable across criteria and sum to one. These relative weights were multiplied by raw subcriteria scores to obtain adjusted subcriteria scores. Adjusted subcriteria scores were then added to obtain an adjusted total score for each aid. The adjusted total score was the primary basis for recommended priority for development of potential aid candidates.

j. Conduct sensitivity analysis. Weighting of criteria and the structure of the hierarchy were varied to examine the sensitivity of the prioritized list to the methodology. A limited sensitivity analysis was performed to examine the relationships between adjusted scores, raw scores, scores based solely on feasibility, and scores based solely on importance. Graphical analysis, utilizing leaf plots and scatter plots, was the primary technique employed to investigate sensitivity. It is important to emphasize that the methodology embedded a sensitivity data collection scheme, since the raw scores reflect an equal weighting of utilities across subcriteria, while the adjusted scores reflect the net effect of the pairwise comparison of subcriteria and criteria.

k. Document analysis. The results of the analysis were compiled and recorded in a two-volume technical report. A briefing was prepared to present results and recommendations to decision makers.

4. ASSUMPTIONS. The following assumptions apply to the analysis in this document.

a. Near-term (five-year) requirements for automation at G3 Main will include various commercial microcomputer systems and the Maneuver Control System (MCS).

b. Doctrinal literature and TSOP accurately describe G3 products and tasks. Additionally, the current doctrinal literature and TSOP will remain in effect for the near term.

c. The CCIR, published by CACDA, are baseline information requirements and are subject to modification or validation by a working group of corps commanders.

d. A purpose of tactical automation is to improve the performance of the tactical commander and staff.

e. G3 products and tasks are similar at corps and division and are similar for different type corps and divisions.

f. Bias of military and civilian analysts in making judgments about importance and feasibility of analytic aids can be reduced.

5. RESULTS. Key results of the analysis are provided in this section.

a. G3 Main critical tasks.

(1) Before G3 Main critical tasks were determined, the study team identified the soldiers who work at G3 Main. FC 101-55, "Corps and Division Command and Control," provided a model for the command post organization of a heavy division. From that model, a list of soldiers in the G3 section at the main command post and a list showing their location in the current operations

or plans cell were derived. The lists, shown in appendix C, were reinforced by the Table of Organization and Equipment (TOE) for HHC Heavy Division (Army of Excellence), TOE 87004J410, 1 April 1984.

(2) Four primary documents were analyzed to identify and define G3 Main critical tasks. A comparison matrix was organized to reflect the documents which validated each task. The matrix facilitated identification of gaps or differences between documents. The comparison matrix is shown at table 1. Seven major G3 functions composed of a total of 43 critical tasks were identified and compiled. Differences across documents were not significant; however, the potential utility of a single comprehensive, doctrinally approved G3 critical task list was highlighted by the analysis. A list currently exists in FC 101-55 which may deserve review and revision as shown by the comparison matrix disparities.

(3) A separate reference sheet was prepared to delineate the key elements of each major function and critical task. The reference sheets were key documents which supported the assessment of aiding opportunities. An example task reference sheet is shown at figure 4; the complete set of 50 reference sheets is in appendix D. As an example, note that a subtask for successful organization for combat is estimation of numbers and types of units to be organized and prioritized. This subtask implies an opportunity for analytic aiding.

b. G3 Main products. A detailed analysis of G3 tasks, doctrinal literature, TSOP, and the CID resulted in the compilation of G3 information products. The products were divided into two categories: formal and implied. Formal products were defined as standard documents produced and disseminated by the G3. Implied products were materials generally developed by the G3 for internal use or for informal coordination. Forty-eight formal products and 11 implied products were identified for the G3 Main. Listings of the formal and implied products are provided in tables 2 and 3. One formal product of the G3 is Task Organization, which may be disseminated as a main element or the Operations Order, as an annex to the Operations Order, or as an element of a Warning Order or Fragmentary Order. The task, Organize units for combat, supports the development of the product Task Organization. The relationship of task, subtask, and product was key to the analysis process which led to the identification of opportunities to aid during the development of G3 products.

c. Assessment of aiding opportunities.

(1) A classification scheme of aiding technologies was developed using computer science, information system, and decision support literature. The taxonomy decomposed aiding technologies into information processing techniques, user interface techniques, and analytic techniques. Analytic techniques were further subdivided into categories of artificial intelligence (AI), mathematical models, optimization techniques, computer simulations, and decision analysis (DA).

(2) A list of G3 Main products and the G3 Main tasks which support their development was compiled using the CID. This list enabled analysts to examine task, subtask, and product and to assess aiding opportunities. Figure 5 shows the tasks which support the product Task Organization. A complete list of products and supporting tasks is contained in appendix G. For the Task Organization example, the assessment at this point in the analysis was that an aiding opportunity did exist.

Table 1. Comparison matrix showing G3 critical tasks and supporting documents (continued on following pages)

TASK	FM 101-5	ARTEP 100-?	FC 101-55	CAORA TR 1-85
1. Develop plans based on missions.				
a. Prepare and communicate plans and orders.	X	X	X	X
b. Organize and equip units for combat.	X	X	X	X
c. Analyze and implement training programs.	X	X	X	
d. Plan for employment of fire support.	X	X	X	X
e. Plan for employment of nuclear and chemical weapons.	X	X	X	X
f. Integrate CSS into scheme of maneuver.	X	X	X	X
g. Plan for employment of EW.	X	X	X	X
h. Develop communications plan.	X	X	X	X
i. Reinforce terrain; plan obstacles and M-CM-S operations.[1]	X	X	X	X
j. Establish air defense priorities	X	X	X	X

[1] Wording is adapted from CAORA item except that "M-CM-S" (mobility-countermobility-survivability) from FC 101-55 was used instead of "mobility." This task includes "Develop division river crossing plan" from ARTEP 100-2.

Table 1. (continued)

TASK	FM 101-5	ARTEP 100-?	FC 101-55	CAORA TR 1-85
k. Integrate USAF assets into operations plans.	X	X	X	X
l. Integrate Army Aviation assets into operations plans.	X	X	X	X
2. Initiate intelligence preparation of the battlefield.[2]				
a. Prepare analysis of area of operations.				X
b. Formulate the intelligence collection plan.	X	X		X
c. Prepare the reconnaissance, surveillance, and target acquisition plans.	X	X		X
d. Allocate intelligence resources.				X
3. Control and coordinate combat operations.				
a. Implement and update plans and orders.	X	X	X	X

[2] Although the overall function is not a G3 responsibility, some of its tasks are performed by the G3, so the function is retained in the list for clarity.

Table 1. (continued)

TASK	FM 101-5	ARTEP 100-2	FC 101-55	CAORA TR 1-85
b. Direct combat operations and coordinate all command post functions.	X	X	X[3]	X
c. Supervise execution of operations to ensure compliance with commander's concept and decisions.	X	X	X	X
d. Evaluate TSOP.	X		X	X
e. Maintain current situation status.[4]	X	X	X	X
f. Concentrate/shift combat power.	X	X	X	X
g. Conduct PSYOP and civil-military operations.	X[5]	X	X[6]	
h. Coordinate airspace management.	X	X	X	X
i. Direct/coordinate conduct of EW.	X	X	X	X
j. Conduct deception operations.	X		X	X
k. Coordinate NBC offensive operations.	X		X	
4. See the battlefield and the enemy.				
a. Collect intelligence information.	X	X	X	X

[3] FC 101-55 indicates that the G3 directs combat operations at the main CP, but the Chief of Staff coordinates the command post functions.
[4] Wording is from FC 101-55 and includes status of resources, operations estimate, and intelligence estimate from ARTEP 100-2.
[5] FM 101-5 assigns supervision of PSYOP to the G3, but CMO to the G5.
[6] FC 101-55 indicates the G3 conducts PSYOP, but the G5 coordinates CMO.

Table 1. (continued)

TASK	FM 101-5	ARTEP 100-2	FC 101-55	CAORA TR 1-85
b. Analyze/evaluate enemy capabilities.	X	X	X	X
c. Determine enemy courses of action, combat effectiveness, and vulnerabilities.	X	X	X	X
d. Disseminate intelligence, intelligence estimates, and combat information.			X	X
5. React to enemy NBC operations.				
a. React to nuclear attack.	X	X	X	X
b. React to chemical or biological attack.	X	X	X	X
c. Conduct NBC defensive operations.	X		X	X
6. Secure and protect the corps/ division.				
a. Develop and implement OPSEC programs.	X	X		X
b. Conduct offensive counter-intelligence operations.	X			X
c. React to enemy EW.	X	X	X	X
d. Conduct RACO.	X	X		X
e. React to enemy air attack.	X	X		X

Table 1. (concluded)

TASK	FM 101-5	ARTEP 100-2	FC 101-55	CAORA TR 1-85
7. Provide for CSS.				
a. Arm the system.	X	X	X	X
b. Fuel the system.	X	X	X	7
c. Fix the system.	X	X	X	X
d. Man the system and support the troops.	X	X	X	X

7 *The CID shows no G3 action for "Fuel the system."*

SAMPLE TASK REFERENCE SHEET

G3 TASK REFERENCE SHEET 1b

1. TASK: Organize and equip units for combat.

2. SUPPORTING DOCUMENTS: ARTEP 100-2, FM 101-5.

3. TASK DECOMPOSITION:

a. Compile and maintain the troop list to include continual review and revision to ensure that the number and type of units assigned are those which can best accomplish and support the command mission.

b. Recommend the organization and equipping of units: estimate numbers and types of units to be organized and priority for phase-in or replacement of personnel and equipment in those units.

c. Recommend assignment or attachment of combat, combat service support units or teams, and unit replacements; assign such units within the command in accordance with requirements of the situation.

d. Receive and process assigned units or teams to include such orientation, training, and reorganization as may be required. Prepare plan to activate and deactivate units. Prepare plans for mobilization and demobilization.

e. This task is successfully accomplished if the unit prioritizes assignment of replacements to subordinate units and task organizes in a manner which will mass superior combat power at the critical time and place.

Offense: As a general guide, the force ratio (relative combat power) of the friendly force to the enemy force should be 5:1 or better at the point of the main effort.

Defense: As a general guide, the force ratio (relative combat power) of the friendly force to the enemy force should be no worse than 1:3 at the point of the enemy main attack.[1]

[1] These force ratio guidelines for offense and defense are taken from ARTEP 100-2.

Figure 4. Example G3 task reference sheet

Table 2. 63 Main formal products

OPORD *
- Task Organization
- Situation
- Mission
- Execution
- Service Support
- Command and Signal
- Fire Support Annex
- Air Defense Annex
- Engineer Annex
  - Obstacle Appendix
  - Denial Appendix
  - ADM Appendix
- Deception Annex
- Army Aviation Annex
- Rear Area Protection Annex
- Operations Security Annex
- Airspace Management Annex
- Psychological Operations Annex
- Civil Affairs Annex
- CE Annex
- NBC Defense Annex
- Chemical Support Annex
- Service Support Annex
- Task Organization Annex
- Intelligence Annex
- Electronic Warfare Annex
- Road Movement Annex
- Air Movement Annex
- Operations Overlay Annex

Warning Order
Frag Order
Movement Order
Admin/Logistics Order
Aircraft Mission Request (Army Aviation)
Artillery Situation Report
Air Request/Task Message (Pre-planned)
ADM Target Folder
Post Strike Analysis (Nuclear Strike)
Chemical Strike Warning
Nuclear Strike Warning
ECM Daily Summary
Electronic Warfare Support Measures (ESM) Report
Engineer Barrier Report
Engineer Mission Coordination Sheet
Engineer Trace Report
Engineer Situation Report

* OPLAN is not included separately; difference between OPORD and OPLAN is that OPLAN contains assumptions and specifies the time or conditions under which it will be placed into effect.

Table 2. G3 Main formal products (concluded)

Engineer Report-Damage
Air Defense Status Report
Aircraft Hostile Fire Report
Air Defense Engagement Report
Commander's Situation Report (SitRep)
Unit Location Update
Command, Control and Communication CM Spt Request
Minefield Report
Engineer Spot Report
Air Request/Task Message (Immediate)
PSYREP
Spot PSYREP
Airspace Management Procedures Request
ECM Mission Request
Intelligence Summary
NBC 1 (Observer's Initial Report)
NBC 2 (Evaluated Data Report)
NBC 3 (Immediate Warn of Expected Contam)
NBC 5 (Rpt of Areas of Actual Contam)
NBC 6 (Detailed Information on Chem/Bio Attack)
NBC Downwind Message
MIJI Report
OPSEC Spot Report
Required Ammunition Supply Rate (RSR) Report
PSYOP Support Request
Movement Code
Training Plans
Maintain/Update TSOP
Nuclear Release Request
Chemical Release Request

Table 3. G3 Main implied products

Mission Analysis
Operations Estimate
Directed Staff Estimates
Briefings
Maintain the Current Situation
Project Unit Status
Project Critical Shortages
Maintain the Staff Journal
Allocate/Prioritze Replacement Personnel, Materiel and Units
Maintain the Troop List
Exchange of Information

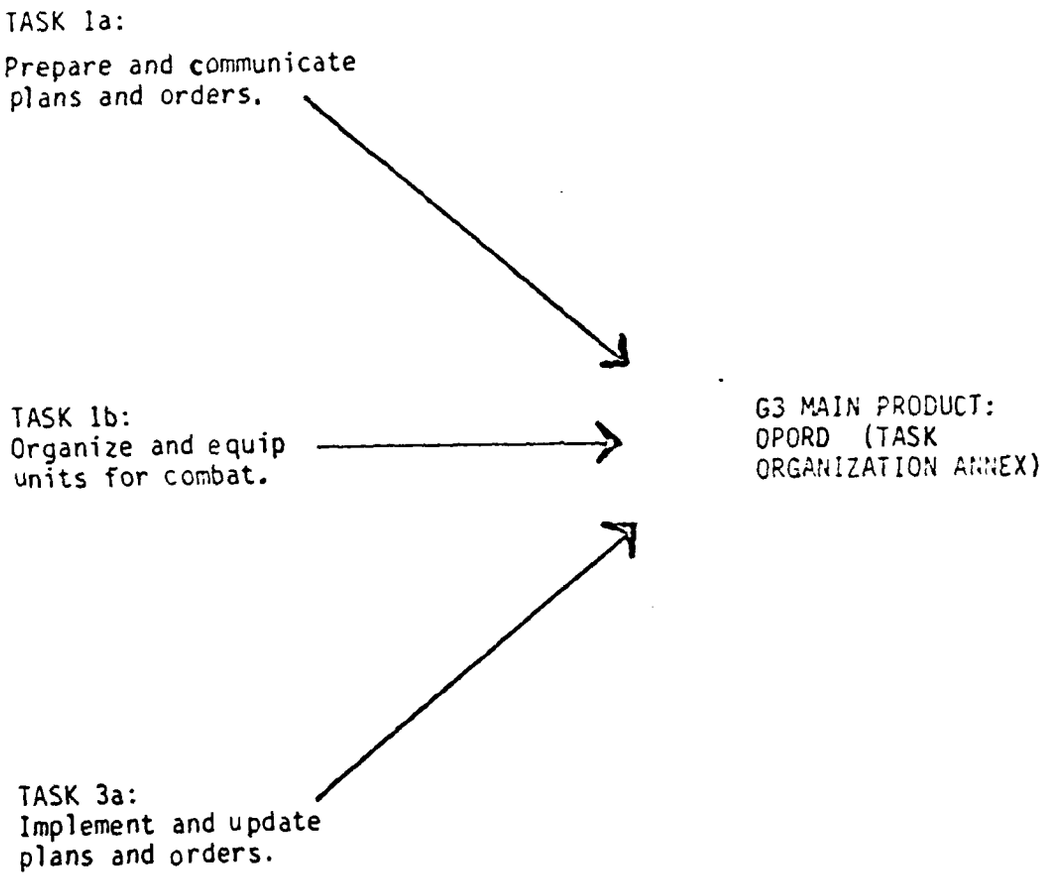


Figure 5. Task mapping for G3 Main product Task Organization

(3) Analysts made an assessment of the specific aiding technologies which could be applied to G3 Main products. In some cases, particularly in AI technologies, a positive assessment could not be made due to the relative immaturity of the technology. However, for most products and technologies, a positive assessment was possible. The Task Organization product was assessed as definitely requiring information processing and user interface technologies and medium probability of analytic support using DA techniques, low probability of mathematical model support, and uncertainty concerning AI applications.

(4) Analysts assigned a descriptor (name) to each analytic aiding opportunity. A Task Organization aid could be developed, employing analytic techniques to improve quality and timeliness, with consideration of variables such as weather, terrain, unit status, leadership, etc.

d. G3 Main products and appropriate aiding technologies. Table 4 shows the matrix which was developed to list the 59 G3 Main products and to map appropriate aiding technologies to support product development. The matrix reflects the qualitative assessment of aiding opportunities for each product. In some cases, a single product might be supported by more than one analytic aid. In table 4, for example, two potential analytic aids to support development of the Execution paragraph of the Operations Order were identified and were listed in the right-hand column with appropriate aid descriptors. Figure 6 is a brief description of the potential analytic aids which might be developed for the products shown on the first page of the matrix in table 4. A total of 53 different analytic aiding opportunities were identified at this point in the analysis. Each analytic aiding opportunity was identified by a distinct aid descriptor.

e. Prioritization of analytic aid candidates.

(1) A prioritization methodology was developed based on an investigation of alternative techniques for structuring preferences. Thomas L. Saaty's analytic hierarchy process (AHP) (reference 10) provided an objective method to obtain a priority value for each individual aid. A hierarchy of separable criteria was formulated, and a method of pairwise comparisons was used to determine the relative utility (weight) of each criteria. A commercial software application, "Expert Choice," facilitated the computation of criteria values. Local and global weights of the criteria and subcriteria are reflected in figure 7.

(2) The 53 analytic aiding opportunities were prioritized based on adjusted ranks. The ranks were based on the total adjusted score for each aiding opportunity. Table 5 shows the prioritized list. A graphical display of aid scores was developed to examine the distribution of aids over the scoring spectrum. Figure 8 presents a leaf plot of adjusted scores which shows the distribution of scores and the aid identification numbers [1] which fall in each cell. Insights derived from this display were that adjusted scores had a single mode, were slightly skewed toward higher scores, and that the distribution of scores was approximately normal. Use of a leaf plot as opposed to a bar chart further conveyed information concerning the specific aiding opportunities contained in each cell. Eight of the top 20 are in the two highest cells of the leaf plot. Additional technical information is available in appendix I, annex V.

[1] Aid identification numbers, such as 3-1, 3-2, etc., were assigned to an approximately alphabetical listing of aid descriptors. The "3" stands for "G3."

Table 4. A matrix of products, aiding opportunities and aid descriptors (continued on following pages)

LEGEND:

INFO - Information
AI - Artificial intelligence
MM - Mathematical model
OT - Optimization technique
SIM - Simulation
DA - Decision analysis

Y - Yes
N - No
? - Requires more information
✓ - Definitely requires aiding technology

H - High probability of problem solution
M - Medium probability of problem solution
L - Low probability of problem solution

G3 PRODUCTS	ANALYTIC AID ASSESSMENT	AIDING TAXONOMY: INFO PROCESSING	AIDING TAXONOMY: USER INTERFACE	ANALYTIC AID TECHNIQUES: AI	MM	OT	SIM	DA	AID DESCRIPTOR
OPORD Task Organization	Y	✓	✓	?	L			M	Task Organization
Situation	Y			SEE	OPERATIONS		ESTIMATE		
Mission	N								
Execution	Y	✓	✓		M	L	L		Terrain Management
					H		M		Force Movement Analyzer
Service Support	Y	✓		?	H		L		Basic Load
					H				CSR
				?			M	M	Replacement Priorities
					H				Fuel Consumption Rates
Command & Signal	N	✓	✓						

Table 4. (continued)

G3 PRODUCTS	ANALYTIC AID ASSESSMENT	AIDING TAXONOMY: INFO PROCESSING	AIDING TAXONOMY: USER INTERFACE	ANALYTIC AID TECHNIQUES: AI	MM	OT	SIM	DA	AID DESCRIPTOR
Fire Support Annex	Y	✓	✓	?		L	M	M	Priorities of Fire
				?	L			M	ORG for Combat
				?	M			M	PCL
				?	M			M	PNL
					H	M	L	M	Expenditure Rates
Air Defense Annex	Y	✓	✓	?	L	M	M	M	Priorities/Allocation
Engineer Annex:									
Obstacle App	Y	✓	✓	?	M	M	L	L	Obstacle Preparation
Denial App	Y	✓	✓	?	M	M	L	L	Denial Preparation
ADM App	Y	✓	✓	?	M	M	L	L	Optimal ADM Employment
Deception Annex	N								
Army Avn Annex	Y	✓		?	M		L		Aircraft Requirements
Rear Area Protection Annex	Y	✓	✓		L		L	L	RAP Capabilities
Operations Security Annex	N								
Airspace Management Annex	Y	✓	✓	?			M	M	Control Procedures/Status
Psychological Operations Annex	Y	✓			L			M	Operational Effectiveness
				?	L	L	L	M	Assign PSYOP Assets
Civil Affairs Annex	N	✓	✓						
CE Annex	N	✓	✓						
NBC Defense Annex	Y	✓	✓		H				Troop Exposure
				?			M	M	Target Susceptibility
				?			M	M	Pre-Position Decon Supplies

Table 4. (continued)

G3 PRODUCTS	ANALYTIC AID ASSESSMENT	AIDING TAXONOMY: INFO PROCESSING	AIDING TAXONOMY: USER INTERFACE	ANALYTIC AID TECHNIQUES: AT	MM	OT	SIM	DA	AID DESCRIPTOR
Chemical Spt Annex	Y	✓	✓	?		L	M	L	Target Allocation
Service Spt Annex	Y	✓	✓	SEE NBC DEFENSE ANNEX					
Task Organization Annex	Y	SEE TASK ORGANIZATION UNDER OPORD		?	M	M	M	M	Allocate Replacement Equipment, Supplies, Troops
Intelligence Annex	N	✓	✓						
Electronic Warfare Annex	Y	✓	✓	?		L	M	L	Optimal Friendly Employ
Road Movement Annex	Y	SEE MOVEMENT ORDER							
Air Movement Annex	Y	SEE MOVEMENT ORDER							
Operations Overlay Annex	N	✓	✓						
Warning Order	Y				M			M	Time Analyzer
Frag Order	Y	SAME AS REQUIREMENTS AS IN OPORD AND ANNEXES							
Movement Order	Y	✓	✓	?	H	L	M		Unit Movement Planner
				?	M		M		Air Movement Analyzer
					H	M			Air Movement Table (Army Aviation & AF)
Admin/Logistics Order	Y	SEE OPORD - SERVICE SUPPORT							
Aircraft Mission Request (Army) Aviation	Y	✓	✓	?		L	M		Route Evaluation
					H		M		Acft Asset Analysis

Table 4. (continued)

G3 PRODUCTS	ANALYTIC AID ASSESSMENT	AIDING TAXONOMY							AID DESCRIPTOR
		INFO PROCESSING	USER INTERFACE	ANALYTIC AID TECHNIQUES					
				AI	MM	OT	SIM	DA	
Artillery Situation	Y	✓			H				Forecast Tube Replacement
Air Request/Task Message(Pre-Planned)	Y	✓	✓	?			L	M	Integrate w/F.S. Plan
ADM Target Folder	N	✓	✓						
Post Strike Analysis (Nuclear	Y	✓			H				Fallout Prediction
					H		M		Damage Analysis (Effects on Enemy)
Chemical Strike Warn	Y	✓			H				Chem Effects Prediction
Nuclear Strike Warn	Y	✓			H				Nuc Effects Prediction
ECM Daily Summary	N	✓	✓						
Electronic Warfare Support Measures (ECM) Report	N	✓							
Engineer Barrier Rpt	Y	✓	✓	?	M	L	M	L	Obstacle Emplacement
Engineer Mission Coordination Sheet	Y	✓	✓	?	M		M	M	Allocate Resources
Engineer Trace Rpt	N	✓	✓						
Engineer Situation Report	N	✓	✓						
Engineer Rpt (Damage)	Y	✓	✓				L	M	Evaluate Damage Repair Alternative

Table 4. (continued)

G3 PRODUCTS	ANALYTIC AID ASSESSMENT	AIDING TAXONOMY							AID DESCRIPTOR
		INFO PROCESSING	USER INTERFACE	ANALYTIC AID TECHNIQUES					
				AI	MM	OT	SIM	DA	
Air Def Status Rpt	N	✓	✓						
Acft Hostile Fire Rpt	N	✓							
Air Defense Engagement Report	N	✓							
Commander's Situation Rpt (SITREP)	Y	SEE PROJECT UNIT STATUS							
Unit Location Update	N	✓	✓						
Command, Control and Communication CM Spt Request	N	✓	✓						
Minefield Report	N	✓	✓						
Engineer Spot Report	Y	✓			H	M			Combat Effectiveness
Air Request/Task Message (Immediate)	Y	✓	✓	?			M	M	Allocate CAS & RECCE
PSYREP	N	✓							
Spot PSYREP	N	✓							
Airspace Management Procedures Request	N								
ECM Mission Request	Y	✓	✓	?	M		M		Allocate Critical Assets
Intelligence Summary	N								
NBC 1 (Observer's Initial Report)	N								

Table 4. (continued)

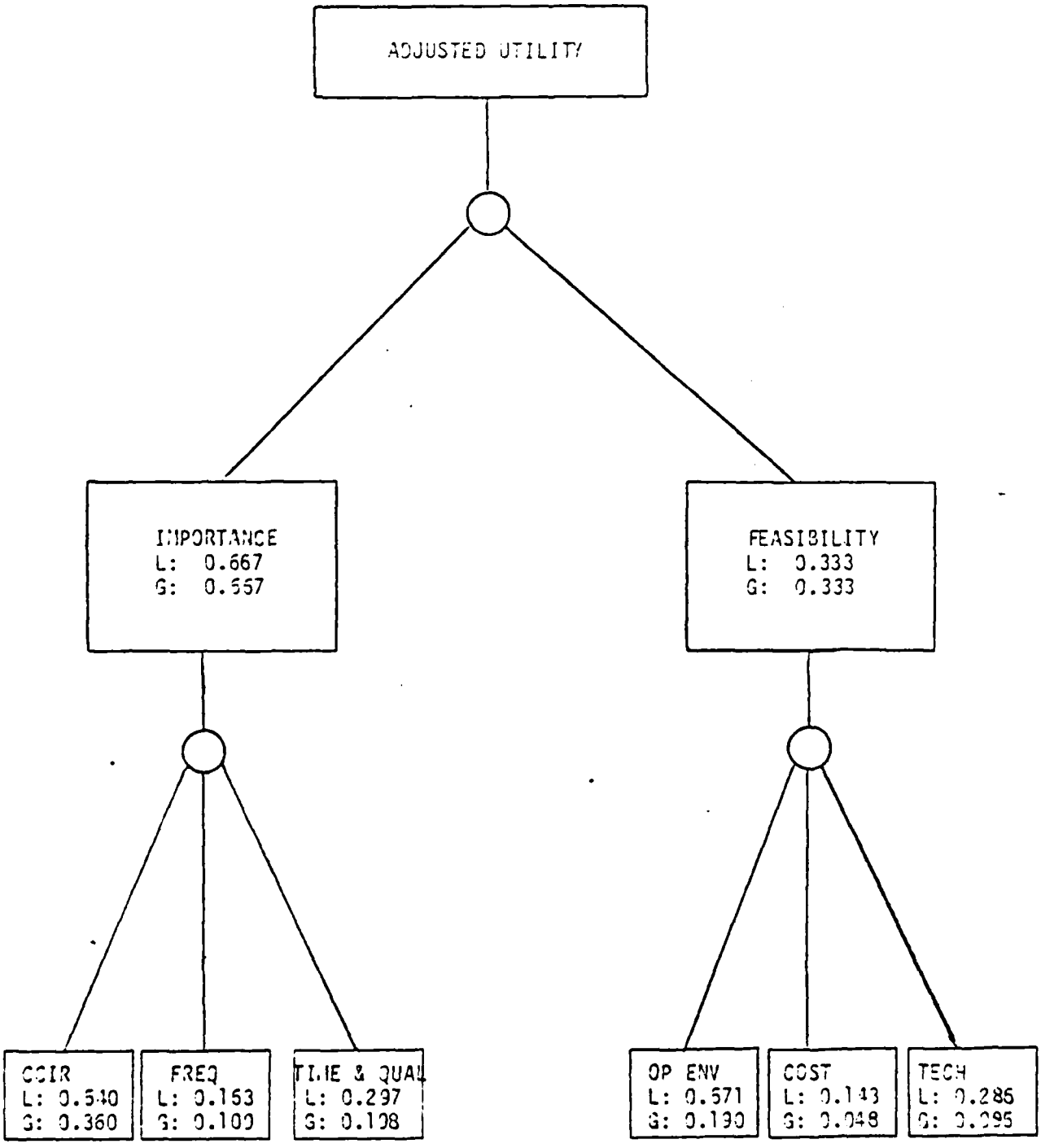
G3 PRODUCTS	ANALYTIC AID ASSESSMENT	AIDING TAXONOMY							AID DESCRIPTOR
		INFO PROCESSING	USER INTERFACE	ANALYTIC AID TECHNIQUES					
				AI	MM	OT	SIM	DA	
NBC 2 (Evaluated Data Report	Y	✓	✓		M		L		NBC Effects Evaluation
NBC 3 (Immediate Warning of Expected Contamination)	Y	✓	✓		H		M		Predict Contamination (IDs Affected Unit)
NBC 5 (Report of Areas of Actual Contamination)	Y	✓	✓	?	H				Hazard Areas
NBC 6 (Detailed Information on Chem/ Bio Attack)	N	✓							
NBC Downwind Message	N	✓							
MIJI Report	N	✓							
OPSEC Spot Report	N	✓							
Required Ammunition Supply Rate Report	Y	✓			H		L		Forecast Usage Rates
PSYOP Support Request	N	✓	✓						
Movement Code	Y	SEE MOVEMENT ORDER							
Training Plans	?								
Maintain/Update TSOP	N	✓							
Nuclear Release Req	N								
Chemical Release Req	N								

Table 4. (concluded)

G3 PRODUCTS	ANALYTIC AID ASSESSMENT	AIDING TAXONOMY							AID DESCRIPTOR
		INFO PROCESSING	USER INTERFACE	ANALYTIC AID TECHNIQUES AI	MM	OT	SIM	DA	
Mission Analysis	N	✓	✓						
Operations Estimate	Y	✓	✓		H				Relative Combat Power
				?	L		M	M	Compare Courses of Action
				OPORD AND ANNEXES AIDS SUPPORT THIS PRODUCT					
Directed Staff Estimates	?								
Briefings	?								
Maintain the Current Situation	?								
Project Unit Status	Y	✓	✓		H				Forecast Unit Status
Project Critical Shortages	Y	SEE PROJECT UNIT STATUS							
Maintain Staff Journal	N	✓							
Allocate/Prioritize Personnel, Materiel and Units	Y	✓	✓	?	M	L	M	M	Assign Critical Replacement Units, Personnel and Materiel
Maintain the Troop List	N	✓							
Exchange Information	N	✓	✓						

AID DESCRIPTOR	PRODUCT SUPPORTED	BRIEF DESCRIPTION
Task Organization	OPORD (Task Organization)	This aid is designed to organize combat and combat support units for combat based on mission, terrain, unit status, etc.
Terrain Management	OPORD (Execution)	This aid is designed to assign units to terrain.
Force Movement Analyzer	OPORD (Execution)	This aid is designed to investigate force movement alternatives and time required for force movement.
Basic Load	OPORD (Service Support)	This aid is designed to determine basic load based on ammunition availability, intensity of conflict, and resupply.
Controlled Supply Rate (CSR)	OPORD (Service Support)	This aid is designed to analyze ammunition expenditure rates and, where required, recommend control rate restrictions.
Replacement Priorities	OPORD (Service Support)	This aid is designed to assign replacement priorities based on mission, strength, and location.
Fuel Consumption Rates	OPORD (Service Support)	This aid is designed to determine fuel requirements based on type vehicles, mission, terrain, weather, etc.

Figure 6. Sample brief description of potential analytic aids



LEGEND:

L: Local utility weighting for criteria/subcriteria.

G: Global utility weighting for criteria/subcriteria.

Figure 7. Hierarchy, local and global weights

Table 5. Analytic aiding opportunities (adjusted rank order)
(continued on following pages)

AID DESCRIPTOR	AID ID#	ADJUSTED RANK	RAW RANK	ABSOLUTE RANK DIFF	ADJUSTED IMPORTANCE RANK	ADJUSTED FEASIBILITY RANK
Unit Movement Planner	3-51	1	1	0	1	12
Force Movement Analyzer	3-24	2	3	1	2	11
Air Movement Analyzer	3-04	3	4	1	4	19
Fuel Consumption Rates	3-26	4	5	1	7	10
Air Movement Planner	3-05	5	2	3	13	3
Assign Critical Replacement Units, Personnel, and Materiel	3-08	6	6	0	11	13
Terrain Management 3-46	7	12	5	10	29	
Denial Preparation 3-19	8	22	14	12	30	
Time Analyzer 3-47	9	7	2	28	4	
Pre-Position Decontamination Supplies	3-18	10	17	7	15	27
Compare Alternate Courses of Action	3-13	11	42	31	3	49
Obstacle Preparation	3-31	12	14	2	17	28
Predict Contamination (ID Affected Units)	3-39	13	9	4	36	2
Forecast Unit Status	3-52	14	30	16	6	40
Chemical Effects Prediction	3-20	15	18	3	23	18
Expenditure Rates (FS)	3-22	16	11	5	33	6
Basic Load Allocations	3-10	17	8	9	42	1
Nuclear Effects Prediction	3-21	18	16	2	30	15
Aircraft Asset Analyzer	3-02	19	10	9	26	21
Priorities of Fire (FS)	3-40	20	24	4	18	32
Priorities/Allocation (ADA)	3-38	21	33	12	9	43
Rear Area Protection Capabilities	3-41	22	39	17	8	45

Table 5. Analytic aiding opportunities (adjusted rank order)
(continued)

AID DESCRIPTOR	AID ID#	ADJUSTED RANK	RAW RANK	ABSOLUTE RANK DIFF	ADJUSTED IMPORTANCE RANK	ADJUSTED FEASIBILITY RANK
Troop Exposure (NBC)	3-50	23	19	4	35	17
Evaluate Damage Repair Alternatives	3-17	24	27	3	21	31
Forecast Tube Replacement (FS)	3-25	25	13	12	39	9
Forecast Usage Rates (RSR)	3-53	26	23	3	32	23
Allocate CAS and NECCE	3-11	27	28	1	31	25
Controlled Supply Rate (CSR)	3-15	28	13	15	43	7
Route Evaluation (AVN)	3-44	29	35	6	5	52
ADM Employment	3-33	30	29	1	38	20
Task Organization	3-45	31	31	0	22	34
Target Allocation (Chemical)	3-48	32	25	7	40	16
Aircraft Requirements	3-03	33	32	1	25	35
Prescribed Nuclear Load (PNL)	3-37	34*	26	8	37	22
Prescribed Chemical Load (PCL)	3-36	34*	26	8	37	22
Optimal Friendly Employment (EW)	3-34	35	36	1	14	44
Organize for Combat (FS)	3-35	36	37	1	24	36
Allocate Engineer Resources	3-07	37	15	22	41	26

* Ties were allowed for ranks. PCL and PNL had a tie for all scoring schemes. Therefore, the adjusted ranks ranged from 1-52 for a total of 53 aiding opportunities.

Table 5. Analytic aiding opportunities (adjusted rank order)
(concluded)

AID DESCRIPTOR	AID ID#	ADJUSTED RANK	RAW RANK	ABSOLUTE RANK DIFF	ADJUSTED IMPORTANCE RANK	ADJUSTED FEASIBILITY RANK
Target Susceptibility (NBC)	3-49	38	34	4	27	37
Fallout Prediction (Nuclear)	3-23	39	21	18	48	8
Hazard Areas (NBC)	3-27	40	20	20	45	14
Allocate Replacements	3-06	41	43	2	16	48
Obstacle Emplacement Plan	3-30	42	41	1	29	39
Integrate CAS (FS)	3-28	43	44	1	20	42
Relative Combat Power	3-42	44	45	1	34	38
Control Procedure (A2C2)	3-14	45	46	1	19	51
NBC Effects Evaluation	3-29	46	38	8	47	24
Post-Strike Analysis (Nuclear)	3-16	47	31	16	50	5
Determine Replacement Priorities	3-43	48	47	1	44	41
Allocate Critical Assets (ECM)	3-01	49	40	9	51	33
Assign PSYOP Assets	3-09	50	49	1	46	47
Obstacle Effectiveness	3-12	51	48	3	49	46
PSYOP Effectiveness	3-32	52*	50	2	52	50

* Ties were allowed for ranks. PCL and PNL had a tie for all scoring schemes. Therefore, the adjusted ranks ranged from 1-52 for a total of 53 aiding opportunities.

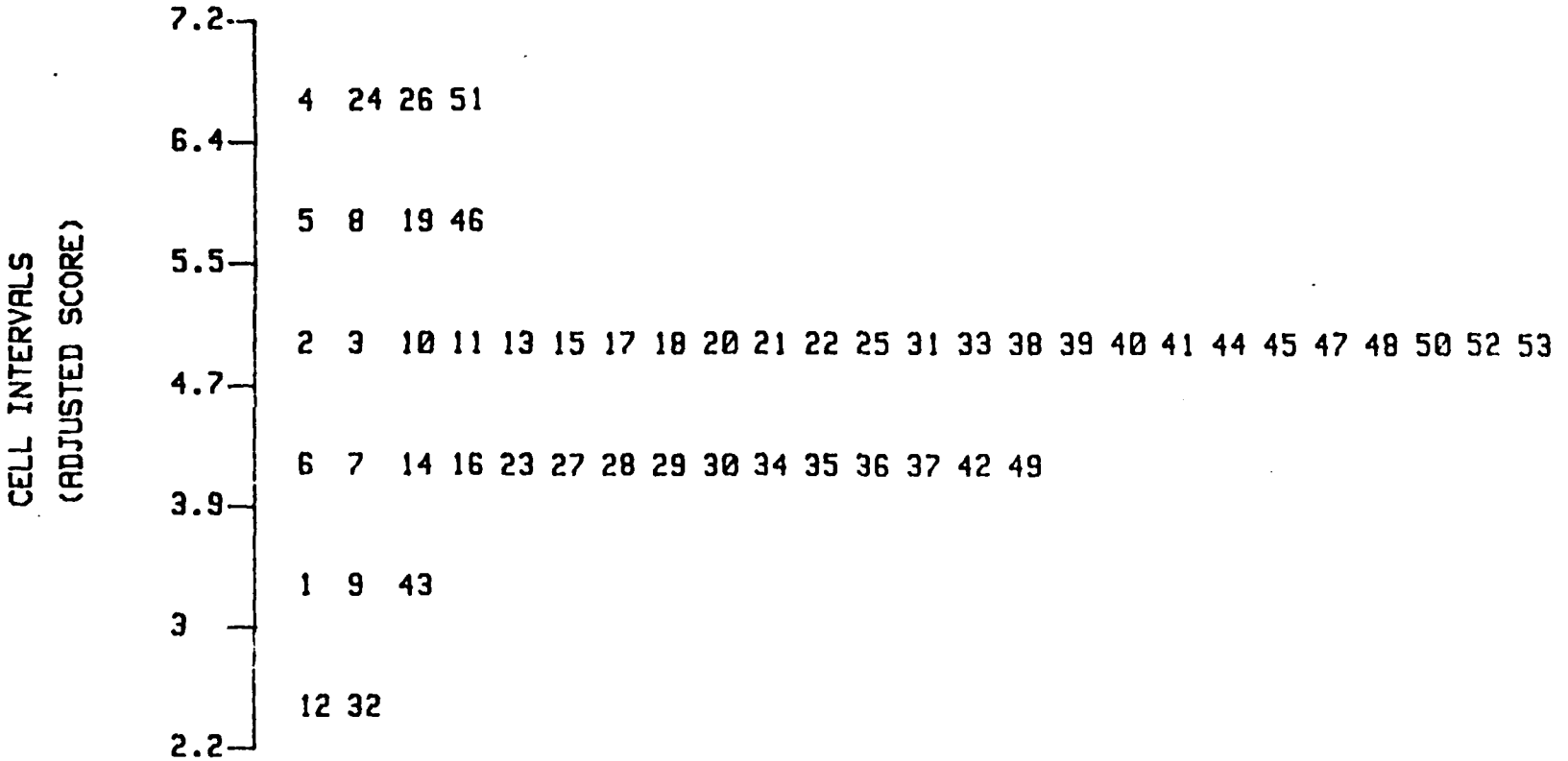


Figure 8. LEAF PLOT OF ADJUSTED SCORES (EQUAL CELLS).

(Numbers shown are aid identification numbers)

f. Sensitivity analysis. A limited sensitivity analysis was performed to examine the relationships between adjusted scores, raw scores, scores based solely on feasibility, and scores based solely on importance. Graphical analysis was the primary technique employed to investigate sensitivity. The graphs are explained in detail in appendix I. A summary is provided in the following subparagraphs.

(1) Comparison of leaf plots. Five analytic aids consistently scored in the top two cells across all scoring schemes. The specific aiding opportunities are: Air Movement Analyzer, Fuel Consumption Rates, Assign Critical Replacements, Unit Movement Planner, and Force Movement Analyzer. These aids were robust across all scoring schemes. The methodology embedded a sensitivity data collection scheme. The raw scores reflect an equal weighting of utilities across subcriteria, while the adjusted scores reflect the net effect of the pairwise comparison of subcriteria and criteria. Further decomposition of scores in terms of feasibility and importance clarified their net effects on adjusted scores. Additional variation of scores was not feasible nor necessary based on the results of the initial investigation.

(2) Comparison of scatter plots. Graphical techniques were also employed to examine the relationships between adjusted, raw, importance, and feasibility ranks. Figure 9 shows a scatter plot comparison of adjusted ranks and raw ranks. This figure shows that the top four aids were dominant (low rank) for both raw and adjusted ranking procedures. Further, the bottom five aids were consistently inferior. However, in the rank interval 5-47 there was a great amount of variability between raw and adjusted ranks. Additional scatter plots are in appendix I.

(3) Conclusions from sensitivity analysis. Of the top 20 aids, based on adjusted score, six consistently ranked in the top 20 over all scoring/ranking schemes. Aids in the midrange (approximately 10-40) are highly sensitive to the effects of alternative subcriteria weights.

6. DISCUSSION. The following subparagraphs summarize the analysis and highlight the key constraints which limit the extension of the analysis to other related command and control development activities.

a. Limitations.

(1) The analysis was based on the best available doctrinal literature and references documenting aiding technologies. However, a corps headquarters ARTEP has not been developed and the division headquarters ARTEP is under revision. The Combined Arms Training Activity (CATA) is working to standardize the critical tasks at division and corps, but a doctrinally approved and operationally validated consolidated list does not currently exist. In many cases, substantial additional research, experimentation, and field observation will be required prior to development of specific automated aids which will actually improve performance.

(2) Though analytic techniques were decomposed in the targeting process, it is possible that a combination of analytic techniques may be embedded in a single aid.

(3) The possibility exists that analytic aids will evolve as the automated environment and the literacy of automation users mature. In this event, an application which initially employs math model techniques might later be revised to use artificial intelligence techniques.

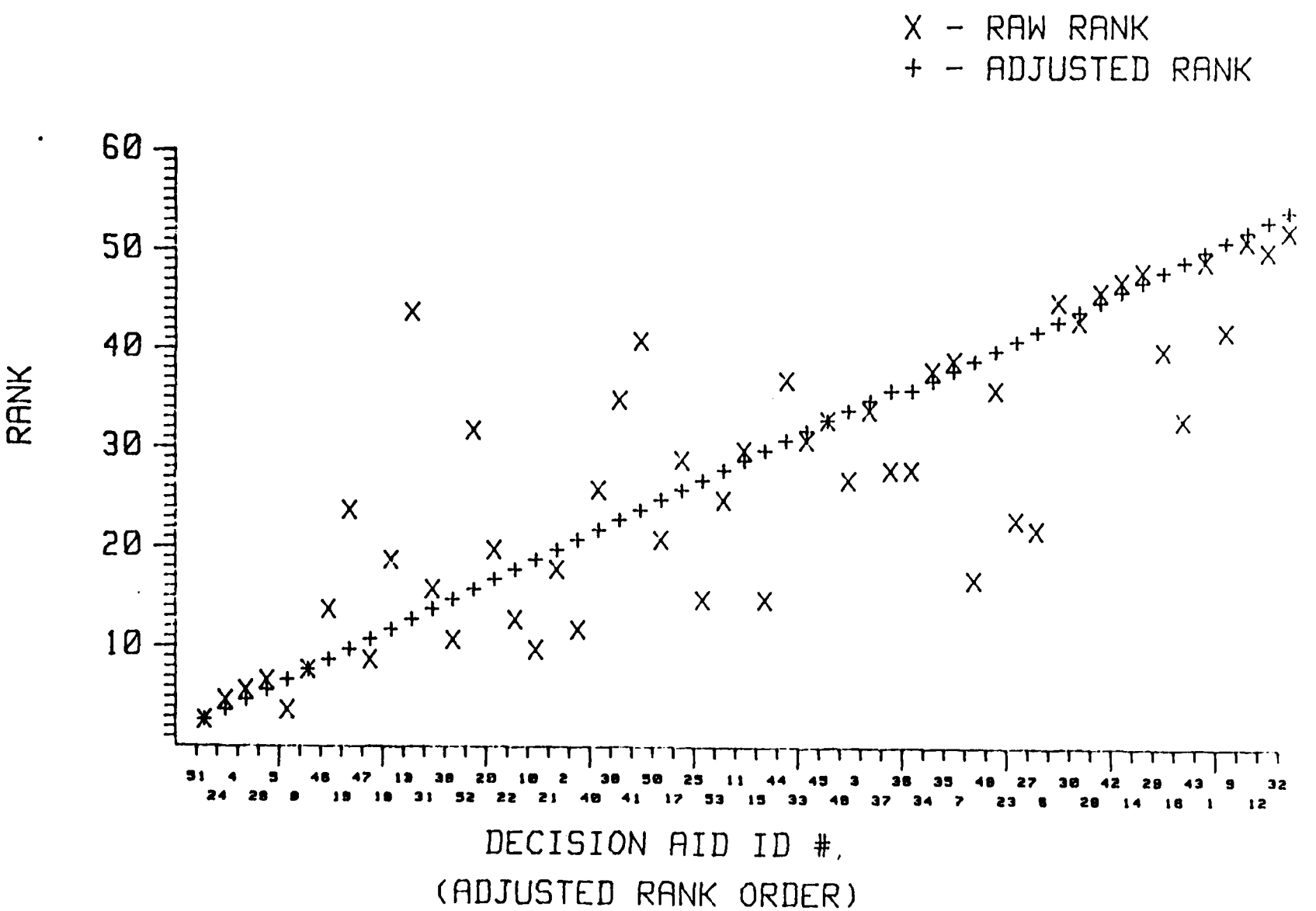


Figure 9. Raw rank vs. adjusted rank scatter plot

(4) There may be a precedent relationship between candidate aids. IBM's Information Systems Planning Guide recommends that the initial application development project span the most tasks to facilitate follow-on application development. The IBM concept suggests a different prioritization methodology. In the event a formal program is established to develop applications, the IBM approach deserves consideration but was not feasible in the initial constrained analysis of G3 Main tasks.

b. Analysis summary.

(1) Seven major functions of the G3 and 43 G3 Main critical tasks were identified. Decomposition of critical tasks facilitated identification of aiding opportunities. A single comprehensive, doctrinally approved and operationally validated list of G3 critical tasks does not currently exist. Focused, structured observation and experimentation may help to further define G3 critical tasks.

(2) Fifty-nine G3 Main products were identified. G3 tasks were mapped to the products which they support to clarify opportunities for aiding. As with G3 tasks, a single comprehensive, doctrinally approved and operationally validated list of G3 products does not currently exist.

(3) A classification scheme (taxonomy) for aiding technologies was developed and elaborated. The taxonomy facilitated targeting of appropriate technologies to aiding opportunities identified during the detailed task and product analysis. The taxonomy is adequate as a first-order technique for assessment of potential technology solutions to command and control deficiencies.

(4) Fifty-three different G3 Main analytic aiding opportunities were identified which have potential to support the development of specific G3 products.

(5) A methodology for prioritizing analytic aiding opportunities was developed. The methodology employed a hierarchical model to assess the relative importance and feasibility of each aiding opportunity. The methodology was consistently applied to the G3 analytic aiding opportunities to generate a recommended priority list for aid development.

(6) Several aiding opportunities were dominant for all scoring schemes and several were clearly inferior across all scoring schemes. Dominant aiding opportunities were Air Movement Analyzer, Assign Critical Replacements, Force Movement Analyzer, Fuel Consumption Rates, and Unit Movement Planner.

7. CONCLUSIONS. The following conclusions resulted from the G3 analysis.

a. The objectives of the G3 analysis were accomplished.

b. Specific opportunities for aiding the performance of the G3 during tactical operations were identified and appropriate aiding technologies were targeted.

c. Fifty-three distinct G3 analytic aiding opportunities were identified.

d. Criteria of importance and feasibility provide a rational basis for prioritizing analytic aid development. The two primary criteria can be further decomposed to facilitate qualitative assessment of relevant factors such as development cost, training, frequency of product development, and potential time savings.

e. A recommended priority for development of G3 analytic aids was compiled based on the above criteria using a hierarchical prioritization structure. The five aids which consistently ranked at the top of the priority list are Air Movement Analyzer, Assign Critical Replacements, Force Movement Analyzer, Fuel Consumption Rates, and Unit Movement Planner.

f. Additional research, field observation, and experimentation are required to define and standardize G3 tasks and products.

g. The methodology employed to analyze the G3 Main may be applied to other functional areas to identify and prioritize development of automated aids.

h. The prioritized list of G3 analytic aiding opportunities provides a rational basis for focused development of decision aid prototypes.

8. RECOMMENDATIONS.

a. That the G3 analysis be approved as an accurate, comprehensive study which identifies and prioritizes G3 aiding opportunities based on current doctrine.

b. That the G3 analysis be presented to the Combat Developer (C3I, CACDA) to assist in focused development of decision aids for the Maneuver Control System (MCS).

c. That G3 Main products and tasks be standardized to enable efficient training of high-performing staffs and to facilitate rapid, successful transition from a manual to an automated U.S. Army Tactical Command and Control System.

d. That the analytic methodology described in this report be approved as an appropriate methodology for identifying aiding opportunities in battlefield functional areas.

e. That increased emphasis be placed on analysis of the command and control process through observation and experimentation to define the process and to improve procedures within the process.

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