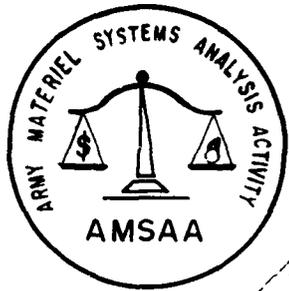


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FINAL REPORT

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**ANNUAL REPORT  
FISCAL YEAR 1982**

**INVENTORY  
RESEARCH  
OFFICE**

**January 1983**

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US Army Inventory Research Office  
US Army Materiel Systems Analysis Activity  
800 Custom House, 2d & Chestnut Sts.  
Philadelphia, PA 19106

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes work done by the US Army Inventory Research Office during the period October 1981 - September 1982. Reports published during the period are listed, along with papers presented at professional meetings and notes on other professional activities.		

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US ARMY INVENTORY RESEARCH OFFICE  
OVERVIEW

This report describes IRO activities in FY1982. Annual Reports for previous years go back to FY1966.

Three projects were completed in FY1982. Five new projects were started and ten were carried over from the previous year. This seems to denote a trend in the tenor of IRO activities towards projects covering work areas rather than specific delimited problems. This typifies our work, for example, on development and application of multi-echelon models in provisioning, on level of repair analysis, and on war planning. There is no end to the problems in these areas and, as models are developed and put into use, more and more situations come to light that require attention; with this comes the need for model enhancements and extensions. What has happened in the past year can be summarized as follows:

Multi-Echelon Modeling--more and more use is being made of the SESAME model. Significant enhancements have been incorporated, including, among others, capability to handle asymmetric support structures and to determine optimum stockage automatically within either budget or availability constraints. Other enhancements called for by the Provisioning Technical Working Group are being added.

Level of Repair Analysis--an optimizing model that simultaneously considers spares and maintenance resources (test equipment manpower) was developed. Called OATMEAL, the model was successfully tested on three CECOM systems. Documentation is in process, after which application to systems at other commands is expected.

War Planning--Combat PLL/ASL models are in a satisfactory state. Most of the Combat PLLs called for (there were 60 in the first increment) have been developed. Some have been published and distributed as DA pamphlets; others are in various stages of user review. The few in the first increment not yet completed are awaiting correction of invalid input data.

Because of problems in developing input data at the DARCOM Major Subordinate Commands (MSCs) for Combat ASL computation, a revised approach using data from the field is being considered. Test of this new methodology will begin in FY1983.

In the War Reserves area, IRO worked with ALMSA during the year on systems design, mostly on problems arising in computational methodology. Considerable time was spent on policy issues with DARCOM, DA, and overseas commands particularly on relationships between War Reserves and Combat PLL/ASL computation.

A significant amount of work was carried on in the forecasting area in testing appropriateness of use of the Poisson failure assumption, in evaluating the influence of sortie length on aircraft component failure rates, and updating initial engineering estimates of failure rates as

field experience becomes available. The Poisson assumption work was completed and the rest was nearing completion by the end of the year.

The IRO provided assistance in the implementation of Retail Inventory Management Stockage Policies (RIMSTOP) in the SAILS-ABX, in DS4 (CONUS), and DARCOM installation Supply Account Activities. A Shortage Cost (Lambda) Generator model was developed and programmed for automatically computing these values to meet supply performance or budget targets and was implemented on a variety of computers. Assistance continues to be provided to posts, depots and other installations on problems that inevitably arise when a major new system is implemented. This effort is expected to continue into FY1983 as implementation continues.

In May, Professor Larry LeBlanc, Vanderbilt University, concluded his assignment to the IRO as a Mobilization Designee with a 2-week tour. He finished up his work on a multi-echelon formulation with multiple constraints, using a Lagrangian approach.

Ed Hughes, a graduate Operations Research (OR) student at University of North Carolina, spent his summer here and did a splendid job in developing and programming a multi-echelon supply/repair simulation. This is to be used in evaluating various heuristics for combining dependent and independent failure streams.

Some final personnel notes: Alan Kaplan was recipient of both the DARCOM and DA Systems Analysis Awards for his work on SESAME. Martin Cohen and Robert Deemer received Sustained Superior Performance Awards for their work on the Combat PLL/ASL and RIMSTOP programs, respectively.

US ARMY INVENTORY RESEARCH OFFICE  
COMPLETED STUDY SUMMARY

TITLE: War Reserve Requirements for New Weapon Systems

IDENTIFICATION NUMBER:  
IRO Project No. 258

REPORT: Appendix C - War Reserve Budgets Using SESAME, of new SESAME User's Guide (to be published).

SPONSOR: DARCOM Directorate for Supply, Maintenance and Transportation, DRCSM-PPW

PROJECT OFFICER:  
Donald A. Orr/Bernard B. Rosenman

INITIATION/PROGRAMMED COMPLETION DATES:  
September 1977/November 1981

ABSTRACT: Heretofore War Reserve requirements have not been developed for new weapon systems until they have actually been deployed. It is desired, however, to estimate what these requirements will be for budgetary purposes far in advance of that time.

A procedure for estimating War Reserve budgetary requirements for new weapon systems that are scheduled for deployment in the POM/FYDP period was developed. The procedure is capable of use during early phases of weapon system development when data on expected failure rates, maintenance support planning, etc., are only partially available.

MAJOR CONCLUSIONS/RECOMMENDATIONS:  
The Bare Bones Standard Initial Provisioning (BBSIP) Model, previously developed by IRO, was adapted for use for War Reserve computations. This new model, the Bare Bones War Reserve Model (BBWARRSV), was tried out on six new weapon systems by estimating their funding requirements for 1980-84 POM. Briefings on the procedure and results of the computations were given at DARCOM, DA, and DoD, resulting in approval of its use as a standard procedure, and it has been used for POM submissions since FY1979.

The BBWARRSV has now been superseded by WAR version of SESAME. (SESAME is the refined all-purpose provisioning computational model.) This "SESAME-4-WAR" will run many components and several scenarios at a time and hence alleviate much of the manual workload which is associated with BBWARRSV program runs in completing the required format of the budget tableau.

IMPLEMENTATION STATUS:  
The design and distribution of SESAME-4-WAR were put under the aegis of the DARCOM Provisioning Technical Working Group. The IRO has provided the specs and final program. Distribution of

IRO Project No. 258 (cont)

the final version of the program was made in November 1981.  
Documentation of the program and procedures is in Appendix C  
of the new SESAME User's Guide.

RELATED STUDIES:

None.

US ARMY INVENTORY RESEARCH OFFICE  
COMPLETED STUDY SUMMARY

TITLE: Financial Management of the Army Industrial Fund

IDENTIFICATION NUMBER:  
IRO Project No. 279

REPORT: "A Model for Projecting Army Industrial Fund Cash Requirements,"  
Alan Kaplan, IRO Final Report, April 1982 (AD A115961).

SPONSOR: DARCOM Office of the Comptroller, Finance and Accounting  
Division, Property and Cost Policy Branch, DR CCP-FW)

PROJECT OFFICER:  
Alan J. Kaplan

INITIATION/PROGRAMMED COMPLETION DATES:  
October 1979/March 1982

ABSTRACT: The cash flow model is a methodology for projecting future cash requirements for Army Industrial Fund activities. It is based on an analysis of what variables impact cash. The model uses both simulation and statistical forecasting techniques. Both the methodology and validation by tests with real world data are discussed in the final report.

MAJOR CONCLUSIONS/RECOMMENDATIONS:  
The model offers improved accuracy in forecasting future cash requirements, but because of the inherent variability of the processes affecting cash needs, significant errors are still possible. Use of the model would reduce, but not eliminate, the need for cash reserves.

IMPLEMENTATION STATUS:  
Sponsor decided to implement model as part of a larger system being developed by Boeing Computer Services, but then funding problems arose. Implementation is now uncertain.

RELATED STUDIES:  
None.

US ARMY INVENTORY RESEARCH OFFICE  
COMPLETED STUDY SUMMARY

TITLE: Test of Poisson Failure Assumption

IDENTIFICATION NUMBER:  
IRO Project No. 292

REPORT: "Test of Poisson Failure Assumption," Sally Frazza, IRO  
Technical Report, September 1982.

SPONSOR: DARCOM Directorate for Supply, Maintenance and Transportation,  
DRCSM-W

PROJECT OFFICER:  
Sally Frazza

INITIATION/COMPLETION DATES:  
December 1981/June 1982

ABSTRACT: In several stockage models currently in use for Army systems (for example, SESAME and Combat PLL/ASL), the assumption is made that replacement of repair parts follows the Poisson probability distribution. To investigate the accuracy of the Poisson Failure assumption, an empirical test was performed using maintenance data from several Sample Data Collection Plans. Primary results are based on a variance to mean ratio (VMR) test, or Poisson variance test.

MAJOR CONCLUSIONS/RECOMMENDATIONS:

The data tested were not Poisson in time, although removals at each unit were less variable than those for an entire weapon system across units. Results as a function of usage were more promising. While not all of the data pass the VMR test for Poisson, few of the VMR were larger than 2. The importance of incorporating usage data in the prediction of failures cannot be overemphasized.

IMPLEMENTATION STATUS:

No specific recommendations for action were formulated.

RELATED STUDIES:

1. "Operational Readiness Oriented Logistics Support Models," IRO Project No. 260 (ongoing).
2. "Combat PLL/ASL Methodology," IRO Project No. 283 (ongoing).

US ARMY INVENTORY RESEARCH OFFICE  
ONGOING STUDY SUMMARY

**TITLE:** Forecasting Methods for Parts Support of Depot Overhaul

**IDENTIFICATION NUMBER:**  
IRO Project No. 259

**SPONSOR:** DARCOM Directorate for Supply, Maintenance and Transportation,  
DRCSM-WRS

**PROJECT OFFICER:**  
W. Karl Kruse/Edwin Gotwals

**INITIATION/PROGRAMMED COMPLETION DATES:**  
January 1981/March 1983

**PROBLEM:** The Parts Explosion (PE) process at the MSCs produces forecasts of the parts needed to support overhaul programs. Despite several attempts to correct the deficiencies of this process, the MSCs remain dissatisfied with the parts forecasts. One MSC has stopped using PE altogether, while several others have devised computer bridges and manual procedures designed to improve the products of PE.

**OBJECTIVES:**  
To identify the problems associated with PE and recommend corrective actions.

**CURRENT STATUS:**  
Although the complaints have been about the PE process, the problems which appear in the output of PE are caused by problems in the Maintenance Overhaul Factor Reporting System (MOFARS) and the Overhaul Consumption Data (OCD) processes. The MOFARS is a system by which the depots and MSCs coordinate their planning data. The OCD file is the MSC's repository for overhaul factors and is updated primarily by MOFARS.

For the most part, the MSCs' complaints relate to the incompleteness of the OCD file. At the overhaul depot it is a simple matter to update the Mortality Data File (MORT) which is the depot repository for overhaul factors. However, the system at the MSC requires that the OCD always be compatible with the NSNMDR. Various checks make it unnecessarily difficult for the MSCs to update the OCD based on consumption experience.

This study recommends expanding the capability of the overhaul depot forecasting system so that long term forecasts can be produced there which are suitable for use by the MSCs for timely procurement of parts. However, DESCOM, which would have been responsible for producing these forecasts, believes that responsibility belongs with the MSCs. Other alternatives developed suggest more efficient ways to process the overhaul facility information at the MSCs.

IRO Project No. 259 (cont)

A final report is in progress and should be published by  
30 March 1983.

RELATED STUDIES:

"Overhaul Factor Forecasting," Peter Fatianow, IRO Final  
Report, May 1975.

US ARMY INVENTORY RESEARCH OFFICE  
ONGOING STUDY SUMMARY

TITLE: Operational Readiness Oriented Logistics Support Models

IDENTIFICATION NUMBER:  
IRO Project No. 260

SPONSOR: DARCOM Directorate for Supply, Maintenance and Transportation,  
DRCSM-WRS/PMP

PROJECT OFFICER:  
Alan J. Kaplan/Martin Cohen/Meyer Kotkin/Karl Kruse

INITIATION/PROGRAMMED COMPLETION DATES:  
October 1977/Continuing Project

PROBLEM: Multi-echelon inventory models allow the achievement of system operational availability goals at least cost. A number of models exist in the literature, but none was fully satisfactory for Army use.

OBJECTIVES: To promote use and implementation of improved multi-echelon models.

CURRENT STATUS:

The IRO continued to supply technical support to the DARCOM Provisioning Technical Working Group. The SESAME computer program is now widely used by DARCOM MSCs and Project Manager Offices (PMOs) in weapon system development and production. Two major changes were made to SESAME during the last fiscal year. First was the inclusion of a heuristic for computing stock levels for asymmetric supply systems (i.e., systems in which all locations in an echelon do not necessarily have the same operating parameters). A full scale test of the heuristic on AAH data supplied by TSARCOM showed that near-optimal results can be obtained with considerably less computational burden than an exact technique. The heuristic is also being used in Project 291 where a multi-echelon reparables model is being implemented in Europe. The second major change was the inclusion of a goal-seeker option that allows the user to input a budget or operational availability target.

An initial study on the coordinated use of single echelon models in a multi-echelon system was completed during this fiscal year. The study concluded that it was possible, in a two-echelon system, to use single echelon models to approximate the optimal stock levels. Results of this study are being used in an investigation of multi-echelon systems using EOQ type policies rather than one-for-one resupply.

Research is underway to evaluate the application of a negative binomial approximation for the pipeline distribution in place of the currently used "TWO POINT." If found to work better, it will be incorporated into SESAME in FY1983 during a planned

IRO Project No. 260 (cont)

redesign of the program, which will be done to facilitate program maintenance and operating efficiency. An improved heuristic for treatment of delays due to piece-part unavailability during repair will also be incorporated during redesign.

Work continues on the development of a SESAME type mode for use in a nonstationary environment. An exact dynamic two-echelon model for a system with fixed asset levels has been developed. This appears to be the first exact nonstationary multi-echelon model. Computational aspects of this model are being investigated as are real-time control questions.

RELATED STUDIES:

1. "Supply Performance Objectives for Upper Echelons in a Multi-Echelon Supply System," Sally Frazza and Alan Kaplan, IRO Technical Report, December 1981.
2. SESAME User's Guide, DARCOM Pamphlet 700-18.
3. "Mathematics of the SESAME Model," Alan Kaplan, IRO Technical Report, February 1980.
4. "Estimating System Availability with Redundancy Spares and Installation Times," Alan Kaplan, IRO Technical Report, March 1981.
5. "An Exact N-Echelon Inventory Model: The Simple Simon Method," W. Karl Kruse, IRO Technical Report, March 1979.
6. "A Heuristic in Multi-Echelon Multi-Indented Inventory Problems," Meyer Kotkin, IRO Technical Report, December 1978.
7. "On the Optimal Stock Levels in Multi-Echelon Maintenance Systems," Meyer Kotkin, IRO Technical Report, June 1978.

US ARMY INVENTORY RESEARCH OFFICE  
ONGOING STUDY SUMMARY

TITLE: RIMSTOP Implementation

IDENTIFICATION NUMBER:  
IRO Project No. 261

SPONSOR: Deputy Chief of Staff for Logistics, Army  
Assistant Director for Supply Management, DALO-SMP-U

PROJECT OFFICER:  
Robert L. Deemer/Arthur Hutchison

INITIATION/PROGRAMMED COMPLETION DATES:  
May 1978/March 1983

PROBLEM: As a result of work done by a study group under its auspices, DoD issued DoD Directive 4140.44 and DoD Instructions 4150.45 and .46 containing policies for the management of consumable and reparable secondary items at the consumer and intermediate levels of field supply. It is required that all DoD components implement these policies, which include the requirement for use of inventory models that are far more advanced than those now in use. There are a number of technical and human-computer interface problems that must be overcome in order for implementation to be done successfully.

OBJECTIVES:

To evaluate the Army's procedures for implementing the consumable RIMSTOP model at the retail level. To determine the need to modify this model to consider operational constraints such as mobility, workload and ADP run times.

To develop a standard ADP program to compute requisition shortage costs ( $\lambda$ ) for use by the Installation Supply Accounts, SAILS, and DS4.

To assist in evaluating initial implementation processes and making necessary adjustments where appropriate.

CURRENT STATUS:

Simulation runs were made comparing the fixed safety level model and RIMSTOP. Results indicate that the RIMSTOP model out-performs the Army's current stockage model when comparing stock availability per inventory investment dollar. The breadth of stock is increased using RIMSTOP but the overall stockage depth is significantly reduced for a baseline availability target.

It was also shown that inventory weight and cube will not increase with the implementation of RIMSTOP. Therefore, no immediate plans exist to modify the RIMSTOP model to include weight and cube constraints.

IRO Project No. 261 (cont)

The final report on the simulator has been written and published.

The computer program to generate the requisition short cut ( $\lambda$ ) necessary for computing various shortage levels was written and debugged. Commencing in November 1981, SAILS sites started using RIMSTOP as they were converted to SAILS-ABX. Preliminary results show an increase in inventory dollars. However, inadequacies in the reporting system do not allow evaluation of associated supply performance. The Army Logistics Center is working on correcting this deficiency.

In March 1982, Letterkenny Army Depot started using RIMSTOP on their Installation Supply Account (ISA) activities. As of April 1982, and July 1982, Tobyhanna Army Depot and Redstone Arsenal, respectively, began using RIMSTOP. Again an inadequate system for measuring performance did not allow accurate evaluation of achieved supply performance.

The DSU level implementation of RIMSTOP has been delayed until a reliable performance measure is operational. A COBOL program was developed to read the data for the LAMBDA-Generator which will then pass the necessary data to the FORTRAN subroutines for calculation of the LAMBDA values.

A draft report of the LAMBDA-Generator process has been typed and is being reviewed prior to distribution.

RELATED STUDIES:

1. "Calculation of Percent Error Tables for Use in the RIMSTOP Implementation," Arthur Hutchison, IRO Technical Report, September 1980 (AD A090141).
2. "Evaluation of Several Forecasting Techniques for Retail Level Stockage," Arthur Hutchison, IRO Technical Report, September 1980 (AD A090104).

US ARMY INVENTORY RESEARCH OFFICE  
ONGOING STUDY SUMMARY

TITLE: Evaluation of Provisioning Procedures

IDENTIFICATION NUMBER:  
IRO Project No. 265

SPONSOR: DARCOM Directorate for Supply, Maintenance and Transportation,  
DRCSM-PM

PROJECT OFFICER:  
Donald A. Orr

INITIATION/PROGRAMMED COMPLETION DATES:  
May 1979/September 1983

PROBLEM: Many Army proponents feel initial support requirements (Spare & Repair Parts), when determined in accordance with DoDI 4140.42 policies, are inadequate to support newly fielded systems at their required operational availability. To bolster or belie this intuition, evaluations of provisioned quantities based on field performance are needed. Although Army policy requires such evaluations (Post Provisioning Review) 360 days after initial deployment of the end item, such analyses have been barely extant at best. A main (but not the only) reason for the dearth of reviews has been a lack of a paradigm and consequent systematic procedures for collecting and analyzing data in a reasonable, feasible manner.

With the advent of SIP and the sophisticated SESAME program, it is feasible to compute part quantities in accordance with .42 or with some cost effective optimal technique. These programs, suitably adjusted, can also evaluate the impact of these support quantities and other possible realized quantities in terms of system availability. Another potentially solvable problem via the program is to assess the impact on quantities and operational readiness when the actual provisioning parameter set (experienced field values of repair times, task distributions, washout and failure rates) differs from the original parameter set used to ascertain initial issue.

OBJECTIVES:

Phase 1 - To design an evaluative system for detail comparisons of theoretical, hypothetical, and actual provisioning quantities and subsequent operational readiness values. To consider computed SIP, ERPSL models' quantities and real life adjustment thereof. To use the above evaluator on data obtained from pilot tests on selected end items and identify any shortcomings in DoDI 4140.42 procedures.

IRO Project No. 265 (cont)

CURRENT STATUS:

This project has become one phase of an expanded provisioning study taken over by AMSAA. This expanded project is planning to study the budgeting process, general problems in provisioning and fielded systems that are similar to those currently being provisioned. The IRO has been working with MSCs and PMOs on sample data collection plans and evaluative schemes for the M1 tank. Data on the M1 tank are being collected by PECO Enterprises, Inc., and stored and retrieved thru the INFONET system of Computer Science Corporation.

During FY1982 problems arose on designing forms and instituting procedures for collecting maintenance action data for off-vehicle maintenance and for GS and depot activities. The problems were slowly resolved thru meetings (between TACOM, AMSAA-IRO, CSC, M1 PMO, PECO).

The PATRIOT was also chosen to be evaluated. Sample data collection forms are being revised to provide for collection of the additional data needed for this purpose.

RELATED STUDIES:

"Provisioning Methodology Validation Assessment Study, " AMSAA Project No. 81-5A.

US ARMY INVENTORY RESEARCH OFFICE  
ONGOING STUDY SUMMARY

TITLE: Updating Failure Factors

IDENTIFICATION NUMBER:  
IRO Project No. 275

SPONSOR: DARCOM Directorate for Supply, Maintenance and Transportation,  
DRCSM-PM

PROJECT OFFICER:  
Donald A. Orr

INITIATION/PROGRAMMED COMPLETION DATES:  
April 1979/December 1982

PROBLEM: Engineering estimates of failure factors (replacement rates of components) often do not reflect actual experience once the end item is fielded. Updating of these estimates is needed particularly for the later provisioning requirements of long-term procurement and deployment programs (including FMS).

OBJECTIVES: To develop an automated method of combining initial failure factors with experienced replacement rates for parts in fielded systems.

CURRENT STATUS: A strawman package of working papers has been developed to define factors, describe scenarios, code and store scenario information and factors, and to update the various factors using inference techniques on experienced wholesale or retail demand data.

Meetings have been held to uncover implementation problems and make recommendations on redesign of pertinent files. Which items can be candidates and which of a number of alternative updating schemes would be most practicable, for updating automatically in an initial implementation, are questions that are considered.

MICOM has agreed to incorporate the IRO algorithm (a special case of which is their local update procedure) in bridging programs which access CCSS files. It is intended to give this FORTRAN-COBOL program to the other Commands to use for automated updating.

The update algorithm has been debugged and the bridging program is expected to be available to other commands in November 1982.

A description of the update procedures has been written and incorporated into the revision of DARCOM PAM 750-5, "Objective Determination of Failure Factors" (to be published).

IRO Project No. 275 (cont)

RELATED STUDIES:

"New Concepts for Provisioning Parameter Estimates, Part I,"  
Donald A. Orr, IRO Technical Report, December 1976 (AD A034589).

US ARMY INVENTORY RESEARCH OFFICE  
ONGOING STUDY SUMMARY

TITLE: Supply Performance Indicators

IDENTIFICATION NUMBER:  
IRO Project No. 278

SPONSOR: DARCOM Directorate for Supply, Maintenance and Transportation,  
DRCSM-WRS

PROJECT OFFICER:  
Edwin Gotwals

INITIATION/PROGRAMMED COMPLETION DATES:  
October 1979/September 1983

PROBLEM: Presently there are no statistics collected on a routine basis that can give early warning of changes in conditions which might degrade stock availability. Based on findings from the IRO Project 267, "Stock Availability Improvement," it is felt that by monitoring the errors made when estimating key input parameters to the supply control studies, trouble areas can be spotted in time to do something about them.

OBJECTIVES: To identify the model parameters in CCSS whose forecast error most affect supply performance and to develop a method to monitor these errors.

CURRENT STATUS: After several delays, work on this project was finally resumed. The ALMSA and the Supply Management Functional Coordinating Group were briefed on the concepts of the project and both agreed to support and monitor its progress. The TACOM is writing the data extract programs for collecting the appropriate CCSS data (target date December 1982). The IRO is developing monitoring methods and data management details in preparation for the data experiments and demonstrations.

RELATED STUDIES: IRO Stock Availability Improvement Briefing, April 1978, (IRO Project 267).

US ARMY INVENTORY RESEARCH OFFICE  
ONGOING STUDY SUMMARY

TITLE: War Reserve ADP System Project

IDENTIFICATION NUMBER:  
IRO Project No. 281

SPONSOR: DARCOM Directorate for Supply, Maintenance and Transportaion,  
DRCSM-PPW

PROJECT OFFICER:  
Steven Gajdalo

INITIATION/PROGRAMMED COMPLETION DATES:  
April 1980/December 1984

PROBLEM: Computations of war reserves, Total Logistics Readiness/  
Sustainability (TLR/S), and LOGPLANS at the Materiel Readiness  
Commands are only partially automated and are not standardized.  
Under this arrangement it is difficult to justify/audit com-  
puted requirements and to respond to "what if" questions from  
DA and DoD. A new regulation (DoDI 4140.47) has directed  
that all Services and Defense Logistics Agencies have a common  
baseline for war reserve computations, necessitating major  
changes in current DARCOM approaches to computations.

OBJECTIVES: To develop a standard automated capability to compute require-  
ments and produce output products for the full range of war  
reserve and mobilization planning actions (i.e., General  
Mob/AR 11-11, TLR/S, LOGPLANS). These applications are to be  
in consonance with the DoD 4140.47 and with other DoD and DA  
guidance.

CURRENT STATUS: The functional description for Computing War Reserves has been  
completed, approved, and scheduled for implementation in  
May 1984.

Work on development of functional specifications for TLR/S  
and LOGPLANS is in progress. Completion is expected in  
FY1983. Thereafter, the IRO effort will be primarily con-  
sulting in nature.

RELATED STUDIES:

1. "Updating Failure Factors," IRO Project No. 275 (ongoing).
2. "Provisioning Master Record Redesign," current effort of  
the PMR Work Group.
3. "War Reserve Requirements for New Weapons Systems," IRO  
Project No. 258.
4. "Operational Readiness Oriented Logistic Support Models,"  
IRO Project No. 260 (ongoing).

IRO Project No. 281 (cont)

5. "RIMSTOP Implementation," IRO Project No. 261 (ongoing).
6. "Combat PLL/ASL Methodology," IRO Project No. 283 (ongoing).

US ARMY INVENTORY RESEARCH OFFICE  
ONGOING STUDY SUMMARY

TITLE: Combat PLL/ASL Methodology

IDENTIFICATION NUMBER:  
IRO Project No. 283

SPONSOR: DARCOM Directorate for Supply, Maintenance and Transportation,  
DRCSM-PM

PROJECT OFFICER:  
Bernard B. Rosenman/Martin Cohen

INITIATION/PROGRAMMED COMPLETION DATES:  
March 1980/September 1983

PROBLEM: This is the IRO portion of DA-sponsored work to develop stock-  
age lists for Organizational and Direct Support Units. The  
lists are to contain the parts needed for combat operations.

OBJECTIVES: To develop an automated method of producing least-cost stockage  
lists that will meet operational availability targets for  
essential end items without hampering mobility. The IRO's  
responsibility is the development and test of appropriate  
models and computational procedures and preparation and evalu-  
ation of initial lists. It is expected that MRSA will take  
over production of Combat PLLs/ASLs once the models and  
procedures are deemed to be operating satisfactorily.

CURRENT STATUS: Mandatory Parts Lists (Recommended Organizational Stockage)  
methodology has been developed and lists have been prepared  
for the entire Armor Division except for a few companies for  
which data is not yet available.

Models have been developed for computing supporting ASLs.  
Because of difficulties encountered in obtaining data from  
DARCOM MSCs, an alternative system using data from the field  
has been developed and is being evaluated.

This work is being carried on in conjunction with AMSAA,  
MRSA, the DARCOM MSCs, Army Logistics Center and TRADOC  
activities.

RELATED STUDIES:  
"War Reserves ADP System Project," IRO Project No. 281 (ongoing).

US ARMY INVENTORY RESEARCH OFFICE  
ONGOING STUDY SUMMARY

TITLE: Treatment of Item Essentiality in CCSS

IDENTIFICATION NUMBER:  
IRO Project No. 286

SPONSOR: DARCOM Directorate for Supply, Maintenance and Transportation,  
DRCSM-WRS

PROJECT OFFICER:  
W. Karl Kruse

INITIATION/PROGRAMMED COMPLETION DATES:  
June 1981/June 1983

PROBLEM: Since implementation of DoDI 4140.39 within the Army, the MSCs have been uncomfortable with the low safety levels (SL) produced by the CCSS for higher cost, low demand items.

Although an item essentiality weighting factor can be applied in the computations, the model has been implemented without this feature. Consequently, the model tends to produce SLs which are quite sensitive to the annual dollar value of demand.

OBJECTIVES:

The original objective of this project was to develop an item essentiality weight for each item to be used in the SL calculation. However, recent research at IRO in multi-echelon inventory models has caused us to rethink the study objective. There is now reason to question the basic formulation of the DoDI 4140.39 model itself. The model of the DoDI views the wholesale system in isolation from the rest of the supply system. When the wholesale level is viewed as the top level in a simple two-echelon system, it is found that the optimal wholesale stockage is not nearly as sensitive to dollar value as the DoDI 4140.39 policies stipulate they should be. Since this is a fundamental problem which cannot be corrected with essentiality weights, we have redefined the objective of the study so as to consider the wholesale stockage policies in a multi-echelon context.

CURRENT STATUS:

After discussion of our finding with OSD and the other services, we have developed a more general multi-echelon supply model to evaluate wholesale policies. In addition, OSD has formed the Supply Management Policy Group whose goal is to implement "sparing to availability" concept within the DoD components. We plan to introduce the results from this study to that group. This should also foster the implementation of more appropriate supply models in the Army supply system.

RELATED STUDIES:

None.

US ARMY INVENTORY RESEARCH OFFICE  
ONGOING STUDY SUMMARY

TITLE: Supply/Maintenance Trade-Off Analysis

IDENTIFICATION NUMBER:  
IRO Project No. 287

SPONSOR: US Army Communications-Electronics Command, DRSEL-PL-SA

PROJECT OFFICER:  
Donald Orr/Alan Kaplan

INITIATION/PROGRAMMED COMPLETION DATES:  
November 1980/September 1983

PROBLEM: In developing a logistical support concept for a weapon system to be deployed, supply and maintenance decisions are made that impact the life cycle cost of the end item in question. In order to make the most of the Army's investment in dollars and manpower, optimization of the process that leads to initial commitments of stockage, repairmen, test equipment, and transport over several echelons of support is highly desirable.

Currently existing maintenance support or life cycle cost models used by the Army that make repair level and stockage decisions for the user, do not truly optimize by considering the tradeoffs and interactions amongst the repair, supply and transport processes. There is a need to marry an initial supply support program which makes multi-echelon stockage decisions in a cost-effective manner with an efficient algorithm for allocating repair and test equipment and skilled personnel to the various repair echelons.

OBJECTIVES:

1. To develop a hands-on computer program for making stockage and repair decisions in a multi-echelon environment.
2. Program will operate with input sets similar to SESAME and GEMM models in order to give the user guidance on where to repair, what to repair, where to place test equipment,
3. Program will accept user specified constraints on what are desirable solutions.
4. Program will be "portable" (i.e., it will be easy to adapt for use on a variety of computers.
5. Current state of the art techniques will be applied to quickly develop a product which is significantly better than current computer packages. Subjects for future research and refinement will be identified and treated in a follow-on effort.

IRO Project No. 287 (cont)

CURRENT STATUS:

The IRO has developed a mixed integer program that, in conjunction with SESAME (which produces stockage costs) and a preprocessor (which produces Test Equip/MOS and transportation costs), determines optimal task distribution and placement of TE/MOS. The preprocessor was developed by CECOM systems analysis group.

The OATMEAL program (the integer LP) has been tested on three CECOM systems with satisfactory results. A back end evaluator has also been added to rapidly analyze perturbations of the optimal maintenance policy vector and other parameter changes.

A report on the model is in draft form.

This project number has also been used to investigate the proper use of ORLA models (including OATMEAL) for test program sets (TPS) decision making. Reports on our findings and recommendations are being made to the TPS management task force. More widespread use of OATMEAL should be forthcoming.

RELATED STUDIES:

AMSAA study - M109 General Test Equipment Requirements Analysis (in progress).

US ARMY INVENTORY RESEARCH OFFICE  
ONGOING STUDY SUMMARY

TITLE: Predicting Failure Rates of Aircraft Components Using Sortie Data

IDENTIFICATION NUMBER:  
IRO Project No. 290

SPONSOR: US Army Troop Support and Aviation Materiel Readiness Command,  
DRSTS-BAS

INITIATION/PROGRAMMED COMPLETION DATES:  
October 1981/June 1983

PROBLEM: Recent studies have presented evidence indicating a relationship between jet aircraft component failures and elapsed sortie time. These studies showed that a high percentage of the total failures within a sortie occurred early in the sortie. (If this is true, then a unit flying short sorties over a fixed flying hour program will generate more failures than a similar unit flying the same number of hours but with longer sortie length.)

Currently, the Army uses only flying hours to predict failure rates. It is felt that if these study findings are applicable to Army aircraft (primarily helicopters), a sortie dependent model can be developed and failure rate estimates improved.

OBJECTIVES:

To determine empirically the relationship between component failure rate and sortie length. To develop a demand forecast model using this relationship and to test this model against alternatives which use only flying hour history.

CURRENT STATUS:

Data analysis is nearing completion. Analysis of flying hour data indicates that sorties are highly correlated with flying hours. This finding implies that use of sorties will not improve the current flying hour dependent demand forecasts. The project will be closed out; a final report will be written detailing the analysis and indicating possible areas of future research but no additional work will be undertaken by IRO at this time.

RELATED STUDIES:

1. "Projection of Peacetime Maintenance Data from Naval Aircraft to Obtain Wartime Requirements for Spare Parts and Manpower," Pierpont Buck, Paper given at 47th Symposium of Military Operations Research Society on 8 July 81, Institute for Defense Analyses.
2. "Demand Forecasting with Program Factors," Martin Cohen, AMC Inventory Research Office, September 1975, (AD A017858).
3. "Saber Sustainer," COL Christopher C. Shaw, Briefing, Air Force Studies and Analysis, March 1981.

IRO Project No. 290 (cont)

4. "Time Dependent Failure Rates for Jet Aircraft,"  
Maurice Shurman, Briefing, Boeing Company, Seattle, WA,  
1980.

US ARMY INVENTORY RESEARCH OFFICE  
ONGOING STUDY SUMMARY

TITLE: Implementation of RIMSTOP for Repairable Items

IDENTIFICATION NUMBER:  
IRO Project No. 291

SPONSOR: Deputy Chief of Staff for Logistics, Army Assistant Director  
for Supply Management, DALO-SMP-U

PROJECT OFFICER:  
Arthur Hutchison

INITIATION/COMPLETION DATES:  
June 1982/December 1983

PROBLEM: USAREUR has experienced problems with the current AR 710-2  
stockage policies when used for levels computations for manage-  
ment of major assemblies. The policy is not applicable to a  
multi-echelon environment, and is particularly inappropriate  
when level of operating tempo is variable.

OBJECTIVES: To develop a stockage model for management of major assemblies  
in USAREUR.

CURRENT STATUS:

A trip was made to USAREUR in July 1982 to do some basic  
operational analysis and to discuss with potential users what  
they would like a management model to do. As a result of these  
discussions, a decision was made to design an interactive sys-  
tem to determine requirements and management assets within a  
Corps. The system is to be capable for later extension to  
cover echelons above Corps in USAREUR. A capability is also  
to be developed to generate projections of depot overhaul  
workload for the Mainz facility.

A multi-echelon METRIC-type model has been programmed on an  
IBM Personal Computer. The USAREUR has agreed to a test within  
V Corps. The program will be taken to Europe early in FY1983  
to demonstrate it and to get user reaction.

RELATED STUDIES:

1. "Mathematics of the SESAME Model," Alan Kaplan, IRO Technical  
Report, February 1980.
2. "On the Optimal Stock Levels in Multi-Echelon Maintenance  
System," Meyer Kotkin, IRO Technical Report, June 1978.

US ARMY INVENTORY RESEARCH OFFICE  
ONGOING STUDY SUMMARY

TITLE: Over-Ocean Cargo Forecasting

IDENTIFICATION NUMBER:  
IRO Project No. 293

SPONSOR: DARCOM Directorate for Supply Management and Transportation,  
Supply and Distribution Division, DRCSM-PST

PROJECT OFFICER:  
Robert L. Deemer/Edwin P. Gotwals

INITIATION/PROGRAMMED COMPLETION DATES:  
July 1982/March 1983

PROBLEM: In November 1976, the IRO completed a study on the DARCOM over-ocean cargo forecast methodology. Recommendations for methods to improve the forecasts were made in both procedures and data to be used to make the forecast. However, implementation of procedures has not resulted in expected increase in accuracy of forecasts. Since the Army is the largest shipper (in tons) via Military Sealift Command (MSC) and DARCOM is responsible for a large phase of the total Army outbound forecast, some refinements and/or changes are needed to get an acceptable level of accuracy.

OBJECTIVES: To determine how the computational procedures for the forecasts can be improved. To develop more reliable methods of determining accuracy of forecasts and develop consistent forecasts for the various types of forecasts.

CURRENT STATUS: A field trip was made to Logistics Control Activity (LCA), the major forecasting element in the DARCOM portion of the Army forecast, to review how the various forecasts are produced. Also, field trips to MSC and DA were made to review what the actual problems are and how DA handles the forecasts they receive. The MSC's main concern is the long range forecast which is used to project budgets and ship charter requirements. Military Airlift Command's (MAC's) biggest concern is the short range forecast because they do not use commercial aircraft for much of their lift and are more concerned with scheduling the crews for the various flights.

Following these original trips, other visits were made to ARRCOM, CECOM, AND TARCOM to see how they develop their portions of the forecast. A revised study approach will be developed as soon as the results from these fact-finding visits are analyzed.

IRO Project No. 293 (cont)

RELATED STUDIES:

"Over-Ocean Cargo Forecasting," R. L. Deemer and D. A. Orr,  
IRO Final Report, November 1976, ADA034113.

US ARMY INVENTORY RESEARCH OFFICE  
ONGOING STUDY SUMMARY

TITLE: Dollars vs. Readiness

IDENTIFICATION NUMBER:  
IRO Project No. 294

SPONSOR: DARCOM Directorate for Supply, Maintenance and Transportation,  
Deputy Director for Weapon System Management, DRCSM-W

PROJECT OFFICER:  
Bernard B. Rosenman

INITIATION/PROGRAMMED COMPLETION DATES:  
February 1982/September 1984

PROBLEM: Supply management activities within DARCOM are commodity, rather than weapon system oriented. Budget preparation and execution are similarly managed. As a result, it is now not possible to determine the effects of resource investments on the readiness and sustainability of weapon systems.

In recent years, the DoD and Congress have begun to press for use of management techniques that will allow estimates to be made of how changes in amount and allocation of resources would affect weapon system readiness. Data sources are not organized for ready access nor are management models adequate for this purpose.

OBJECTIVES:

To develop methodology for determining how materiel readiness/sustainability could be expected to change as dollars invested in various resources (float end items, repair parts, test equipment, maintenance personnel, etc.) are changed.

CURRENT STATUS:

Work was suspended after a preliminary analysis was done, as a result of a DARCOM decision to manage this effort within the framework of a Weapon System Functional Coordinating Group (FCG). The FCG is expected to be established early in FY1983, at which time our work will be resumed. In the meantime, we have stayed in close contact with similar programs now under way in the Air Force and Navy.

RELATED STUDIES:

1. "Operational Readiness Oriented Logistics Support Models," IRO Project No. 260, (ongoing).
2. "Treatment of Item Essentiality in CCSS," IRO Project No. 286 (ongoing).
3. "Supply/Maintenance Trade-Off Analysis," IRO Project No. 287 (ongoing).

US ARMY INVENTORY RESEARCH OFFICE  
LOGISTICS MANAGEMENT ASSISTANCE

In addition to its formal work program, the IRO provides assistance upon request to DARCOM Headquarters and its Commands, and to other DA and DoD activities. This assistance involves work of a short term nature, generally requiring no more than a few man-months of effort. Some of the tasks worked on in FY1982 are described below.

CCSS Functional Coordinating Groups - The IRO continues to provide representation on the FCG's for Supply Management, Maintenance Management, Provisioning, War Reserves and Mobilization. This involves attendance at meetings where System Change Requests are evaluated and doing short term studies on problems of immediate interest to the Groups. Attendance at the DARCOM Logistics Systems Review Committee meetings is also involved, where review of IRO projects is sometimes on the agenda.

Assistance to Supply Management Activities at DARCOM and its MSCs - Supply Performance Analyzer runs were made for the MSCs (at DARCOM's request) to compute new shortage cost ( ) values for use after implementation of revised policies on minimum procurement quantity. Assistance was also given to MICOM and TSARCOM on running the SPA.

Assistance was given to CECOM in developing new Cost to Procure/ Cost to Hold values.

The IRO served on a special study team that provided assistance to TACOM in connection with supply performance problems. A "quick-fix" to the Protectable Levels formula resulted from this visit.

As a result of a DARCOM decision to expedite implementation of the IRO model for computing Minimum Buys for nonstocked items, the IRO was called on to resolve a number of implementation issues.

Two other IRO models were proposed for earlier than originally planned implementation during the year. One, the Inter-Depot Re-Distribution Model, required assistance to ALMSA in tracking down some subtle bugs in their program that were causing it to malfunction when exported to the MSCs. The other, the Quantity Discount Model, required that assistance be given, particularly in the procurement area, on implementation procedures. This was done in conjunction with the Procurement Research Office.

The IRO provided representation to the DARCOM Study Group on the transfer of PAA items to the Army Stock Fund. Mr. Hutchison accompanied a DARCOM team to Europe on 28 August-11 September to discuss potential impacts of item transfer on USAREUR supply management and financial activities.

The IRO took part in DA/DARCOM/USAREUR War Reserves Meetings and the World-Wide War Reserves Conference during which implementation of DoDI 4140.47 and interfaces with Combat PLL/ASL were important discussion areas. Continuing representation was also provided on the OSD Working Group on War Reserves, which met several times during the year to discuss policy and procedural issues raised by the services and DLA in the implementation of DoDI 4140.47.

Provisioning and Integrated Logistics Support - The IRO worked on the task group headed by MICOM that rewrote DARCOM PAM 750-5, "Objective Determination of Failure Factors." Assistance was also provided to MRSA in their revision of DARCOM PAM 700-10 (Logistics Provisioning Procedures and Techniques) and on their ILS study.

Dr. Orr was named to chair the Models Working Group of the Army TPS Manager Action Committee (ATMAC).

The IRO also provided consulting advice and supporting analyses on two Manpower and Logistics Analysis (MALA) programs: the M1 tank and the AH-64 attack helicopter. This work was done as a result of questions raised by DoD on MALA results. On the attack helicopter, IRO pinpointed differences between SESAME and MALA-TARMS derived budget estimates; these arose from discrepancies in input data sources and provisioning policies.

Assistance to Office of Secretary of Defense - The IRO was called on a number of times during the year to provide consulting advice. Examples of matters worked on are:

- o The IRO provided information and assistance to Boeing Computer Services Company, which was awarded a contract by OSD to do an evaluation of forecasting techniques. The IRO research data base, consisting of demand and flying hour data on 24,000 aviation parts over the years 1967-1981, was given to Boeing for use in their study.
- o The IRO is providing continuing representation to the OSD Supply Management Study Group. The main focus of the Group is now on implementation of "sparing to weapon system availability" concepts in a multi-echelon support environment.
- o At the request of OSD, a technical review was done of the Navy methodology used by them to evaluate expected impact of changes in procurement policy on supply performance and funding requirements.

Other Consulting Assistance - A number of organizations and individuals visited the IRO to discuss our research results and possible applicability to their own work. Among them were:

- o Concepts Analysis Agency - in connection with their tasking by DCSLOG to review the Army's War Reserves policies and computational methods.
- o Navy Fleet Materiel Systems Office - to discuss recent IRO inventory modeling efforts, particularly for reparable items.
- o Canadian Department of Defense - Dr. Paul Vincent and CPT Robert Benn, of their Operations Research group, to discuss the IRO inventory models.

- o Australian Department of Defense - Dr. Richard Watson, of their Central Studies Establishment, visited to exchange information on inventory models.
- o Navy Postgraduate School - Professor Alan McMasters, in connection with study assigned to NPG by CNO to evaluate Navy provisioning models.

US ARMY INVENTORY RESEARCH OFFICE  
PROFESSIONAL ACTIVITIES

Alan Kaplan was awarded both the DA and DARCOM Systems Analysis Awards for his work on development and dissemination for use of the SESAME Initial Provisioning Model. Awards were presented by Mr. Walter Hollis, Deputy Secretary of the Army (Operations Research) at the Pentagon on 13 January 1982.

Mr. Kaplan was also designated by Mr. Hollis to serve on an Army panel that performed a peer review of a TRASANA study, "Middle East Armor Attrition." This is part of a DA program to monitor the quality of Army operations research studies.

Ms. Sally Frazza was awarded her M.S. in Systems Engineering (Operations Research) by the Moore School of Electrical Engineering of the University of Pennsylvania in January 1982.

Papers published in technical journals, participation in meetings of professional activities are as follows:

Technical Papers

"Empirical Inventory Simulation: A Case Study," Alan Kaplan and Sally Frazza, accepted for publication by Decision Sciences (to appear in January 1983 issue).

Professional Meetings

Alan Kaplan, "Application of SESAME to Integrated Logistic Support," given at DoD Materiel Readiness and Sustainability Symposium, held at Center for Naval Analysis, Alexandria, VA, 20-22 September 1982.

Meyer Kotkin, "Queues with Isolated Serves," presented at National ORSA/TIMS meeting in Houston, TX, 21 October 1981.

"Some Results on Asymmetric Inventory Systems," presented at Multi-Echelon Inventory Conference, Miami, FL, 9 December 1981.

Chaired session on Multi-Echelon Inventory Systems, held at National ORSA/TIMS meeting, Detroit, MI, 19 April 1982.

Donald Orr, "Updating Failure Rates for Future Planning," presented at Military Operations Research Symposium, Monterey, CA, 1-3 December 1981.

Bernard B. Rosenman, "Dollars vs. Readiness," prepared for Military Operations Research Symposium, Monterey, CA, 1-3 December 1982. (Mr. Rosenman was unable to attend and paper was given by Dr. Orr.)

"The Defense Authorization Act of FY1978 and You," prepared for session of the Military Applications Section at the National

ORSA/TIMS meeting, San Diego, CA, on 25-27 October 1982.  
(Mr. Rosenman was unable to attend; written version of the paper was distributed at the session.)

"Combat PLL/ASL Methodology," part of a three-part paper, with LTC Robert Stisis (DADCSLOG) and Wilson Heaps (AMSAA), given at the DoD Materiel Readiness and Sustainability Symposium held at the Center for Naval Analyses, Alexandria, VA, 20-22 September 1982.

#### Other

Consulting assistance was given by Mr. Kotkin to TACOM systems analysts on simulation and analytical model approaches for a problem in maintenance systems in which customers require one or two servers. He also provided materiel to Professor S. Zanakis, Florida International University, in discussions on models for real-time production/inventory systems.

Mr. Rosenman presented a lecture a to graduate Inventory Theory class at Cornell University in December 1981.

Members of the staff continued to serve as referees for various professional journals. Papers were refereed last year for the following:

- o Management Science
- o Journal of the Operations Research Society of America
- o OPSEARCH
- o IEEE Transactions on Engineering Management

US ARMY INVENTORY RESEARCH OFFICE  
TRAINING

Training courses were taken by members of the staff as follows:

Martin Cohen, "Programming with ADA," given by Princeton Chapter of ACM/IEEE, 14 November 1981.

Robert Deemer, "Integer Programming," given by ALMC, Fort Lee, 16-20 November 1981.

Sally Frazza, "Programming with ADA," given by Princeton Chapter of ACM/IEEE, 14 November 1981.

"Recent Developments in Forecasting," given by ORSA/TIMS, Philadelphia, 24 February-10 March 1982.

"Mini-Computer Seminar," 9-11 June 1982.

Ed Gotwals, "Large Scale Distribution Problems," given by ORSA/TIMS, Philadelphia, 17-31 March 1982.

"Applied Regression Analysis," given by ALMC, Fort Lee, 11-13 May 1982.

"Simulation Modeling and Analysis," given by ALMC, Fort Lee, 12-16 July 1982.

Alan Kaplan, "The MICOM Systems Data Communication Seminar for Mini-Computer Users," given by The Datastore, Inc., Cherry Hill, NJ, 10 November 1981.

"Integer Programming," given by University of PA, 11 January-7 May 1982.

Donald Orr, "Multiobjective Mathematical Programming and Military Applications," given by ALMC, Fort Lee, 8-12 March 1982.

"Large Scale Distribution Problems," given by ORSA/TIMS, Philadelphia, 17-31 March 1982.

US ARMY INVENTORY RESEARCH OFFICE  
REPORTS

"Supply Performance Objectives for Upper Echelons in a Multi-Echelon Supply System," Sally Frazza and Alan Kaplan, Technical Report No. 82/1, December 1981 (AD A115906).

"Annual Report - Fiscal Year 1981," Final Report, January 1982 (AD A115907).

"A Model for Projecting Army Industrial Fund Cash Requirements," Alan Kaplan, Final Report No. 279, April 1982 (AD A115961).

"Comparison of RIMSTOP (Retail Inventory Management Stockage Policy) to Current Retail Inventory Policies, Art Hutchison, Final Report No. 261, November 1981 (AD A119428).

"The Output of  $M(t)/G(t)/\infty$  Queues, Meyer Kotkin, Technical Report No. 82/2, July 1982 (AD A120545).

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