AD-
FINAL REPORT
IRO REPORT No. 271

THE DRIVER CONCEPT FOR PROJECTING RESOURCE REQUIREMENTS: TWO PILOT TESTS

US ARMY
DARCOM

U.S. ARMY
INVENTORY
RESEARCH
OFFICE

MARCH 1980

ROOM 800
U.S. CUSTOM HOUSE
2nd and Chestnut Streets
Philadelphia Pa. 19106

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: IRO ~~Report No.~~ 271

2. GOVT ACCESSION NO.: AD-A086625

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): THE DRIVER CONCEPT FOR PROJECTING RESOURCE REQUIREMENTS: TWO PILOT TESTS

5. TYPE OF REPORT & PERIOD COVERED: Final Report

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): DONALD A. ORR

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
US Army Inventory Research Office, ALMC
Room 800, US Custom House
2nd & Chestnut Streets, Philadelphia, PA 19106

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:

11. CONTROLLING OFFICE NAME AND ADDRESS:
US Army Materiel Development & Readiness Command
5001 Eisenhower Avenue
Alexandria, VA 22333

12. REPORT DATE: March 1980

13. NUMBER OF PAGES: 81

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Information and data contained in this document are based on input available at the time of preparation. Because the results may be subject to change, this document should not be construed to represent the official position of the US Army Materiel Development & Readiness Command unless so stated.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Manpower
Resources
Workload
Forecasting
Allocation

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

Entities, whose values depend on Army policy and which drive the workload and resource requirements of Army organizations, are analyzed for the Materiel Management (MM) and Maintenance (MS) Directorates of CERCOM and TARCOM. These drivers, which are typically classes of entities such as major items, secondary items, requisitions, product improvement programs, and fielded weapon systems, vary from year to year. Man years and dollars necessary to perform functions related to the "management" of these drivers, if such resources had been and are rationally allocated, should vary in a similar fashion. Forecasting

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Abstract (cont)

changes in driver values over future years should allow corresponding forecasts in resource requirements to be made.

The results of testing these driver concepts on the historical data bases of the four above mentioned directorates produced mixed results. The CERCOM MS analysis produced good statistical results in the area investigated (pre-issue development). The TARCOM MS results were poor in a historical statistical sense. In the two MM directorates, the analysis indicated some functional areas where the historical trends fulfilled the postulated relations and other areas where the historical resources expended did not track the related driver values. Data availability was generally easier in the MM area.

SUMMARY

Entities, whose values depend on Army policy and which drive the workload and resource requirements of Army organizations, are analyzed for the Materiel Management (MM) and Maintenance (MS) Directorates of CERCOM and TARCOM. These drivers, which are typically classes of entities such as major items, secondary items, requisitions, product improvement programs, and fielded weapon systems, vary from year to year. Man years and dollars necessary to perform functions related to the "management" of these drivers, if such resources had been and are rationally allocated, should vary in a similar fashion. Forecasting changes in driver values over future years should allow corresponding forecasts in resource requirements to be made.

The results of testing these driver concepts on the historical data bases of the four above-mentioned directorates produced mixed results. The CERCOM MS analysis produced good statistical results in the area investigated (pre-issue development). The TARCOM MS results were poor in a historical statistical sense. In the two MM directorates, the analysis indicated some functional areas where the historical trends fulfilled the postulated relations and other areas where the historical resources expended did not track the related driver values. Data availability was generally easier in the MM area.

Historically, resource expenditure is neither always rational nor unconstrained. Mere statistical relationships without causes are misleading and conversely, the absence of a historical validation of a causal connection is merely disappointing, not disastrous. If the driver is valid, then its increase should be accompanied by an increase in resources, regardless of what happened in the past.

In this light, the pursuance of the driver concept, as reflected in Chapter I and II of this report, lies in tracking the changes in drivers from some point in time. This point implies a baseline for which the resource allocation was satisfactory or to which adjustments could be made as the future evolvement made apparent what manhour-to-driver ratios were satisfactory. These ratios might evolve naturally as the impact was assessed of the actual allocation of resources via the rationale of corresponding

changes in driver values.

For such a dynamic system of resource management, driver values falling in certain classes should be weighted by a class factor which experience has shown to be, in some sense, valid. This is what the historical data and technical formulas for workload yielded in this study - fairly good estimates of weighting factors. Also apparent was some degree of utility for using weight factors across commands.

The recommendations of this study are:

a. Conduct seminars at MM Directorates on how to develop drivers and use their forecasted values to project MM requirements.

b. Pursue limited analysis of other organizations within Commands if they can list and project drivers for their areas with reasonable time and effort.

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION: BACKGROUND AND ORGANIZATION

This report summarizes the data analyses and lessons learned on two pilot tests of the driver approach to projecting resource requirements. In early FY 1978, the sponsor - the Directorate for Resource Management, DARCOM - asked IRO to conduct a test of the driver concept, which we had developed in 1973 but had not tested with real manhour and dollar data, to determine the feasibility of obtaining resource and workload driver data and to determine the efficacy of projecting future requirements from predicted driver values.

A test was conducted at CERCOM, analyzing the Materiel Management and Maintenance Engineering Directorates; results were briefed to DRCRM in December 1978 and May 1979. Another test was requested, analyzing TARCOM Directorates' data; this was completed in January 1980.

The results and the briefings are contained herein. The report is organized similarly to the final report on the earlier project on drivers, IRO #207 [1]; briefing charts are inclosed and commentary is added to expand important points. Before presenting the briefings and narrative, we outline the driver concept and its purpose (Chapter I), summarize our experiences and recommendations from the test, make some optimistic and pessimistic points re the general area of resource forecasting (Chapter II) and describe the data extraction experience (Chapter III).

IRO Report #207 [1] will give a more extensive description of the driver concept and the data requirements in an ideal situation, not limited by real world data bases.

The Driver Concept

A purposeful organization performs certain functions to reach certain goals. To perform these functions a workload is generated which requires resources in terms of manpower and dollars. In order to best allocate available resources, say people and money, a higher level agency, say the Army, needs projections of the future resource requirements of its constituent organizations. But the constituents should be constrained (or driven) in what they work upon in order to reach goals based on Army plans and should not base work on internally generated decisions. In other words, what external driver, controllable or predictable from higher level planning documents, generates the necessary workload, which in turn requires certain needed resources?

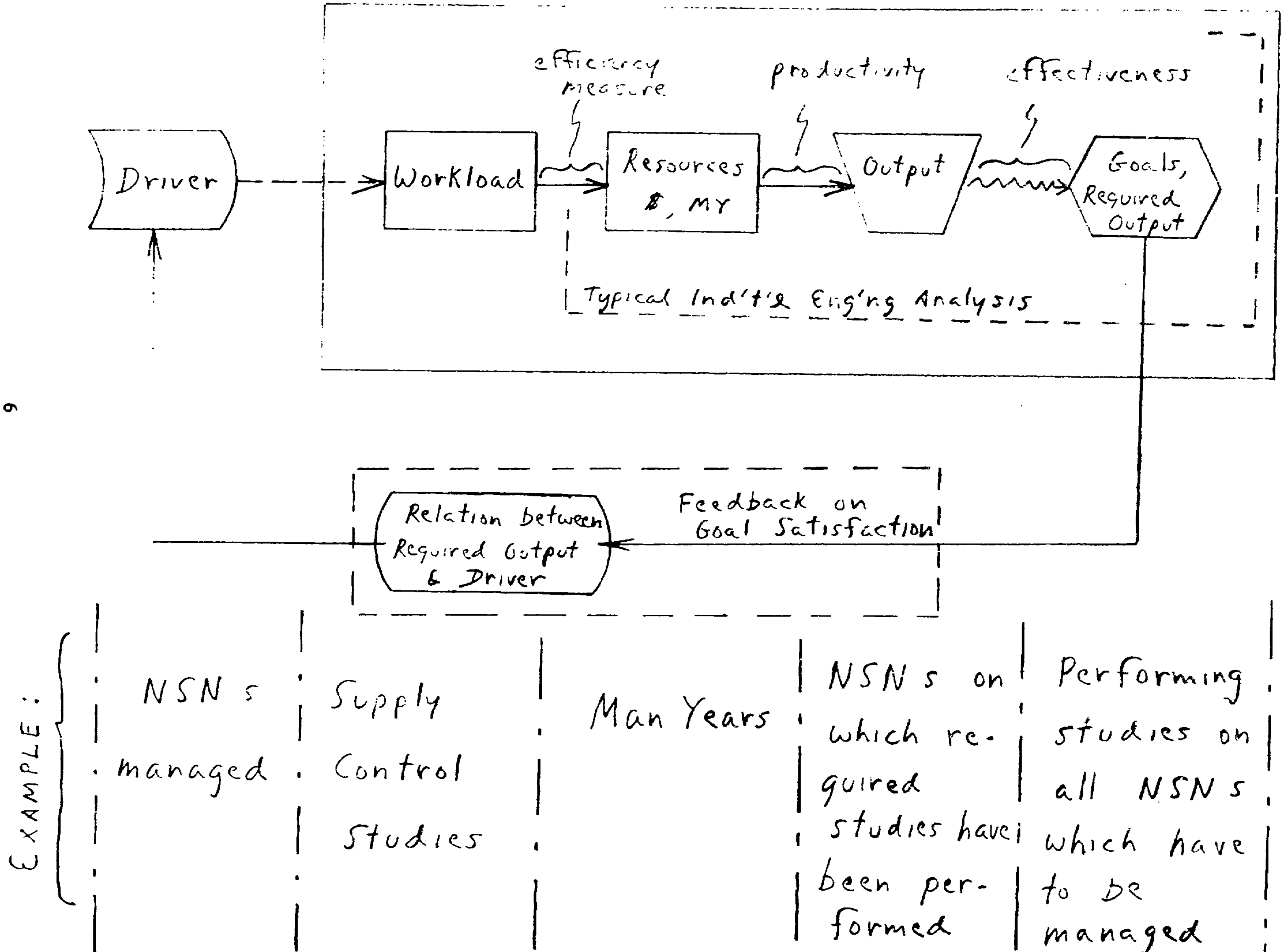
Determining sets of drivers is our concern. They are to be quantifiable and predictable, causally related to the functions of a particular organization. They should not be merely statistically related historically to work performed, not be subjected to internal manipulation and not be construed as a work measure. We also wish the set of drivers which account for the major portion of workload and resources of an organization to be small. Examples of drivers considered in the tests discussed in this report are:

a. Number of items managed weighted by dollar value.

b. Number of systems under development weighted by complexity.

We are concerned with relating drivers to resources needed, by-passing the workload measured value as a complicating step (see Figure 1). In this report we do not address such concepts as efficiency, productivity, and effectiveness; the effective utilization of resources to reach goals and the use of the mentioned measures is important but beyond our scope. Yet it is important to see the proper relations of these measures to avoid their misuse. Figure 1 and the example show how the driver concept relates as a predictive tool for resources. A prescriptive tool for allocating resources internally and prioritizing functions to better reach ultimate goals is another matter.

FIGURE 1


Driver
Workload
efficiency measure
Resources $, MY
productivity
Output
effectiveness
Goals, Required Output
Typical Ind't'l Eng'ng Analysis
Feedback on Goal Satisfaction
Relation between Required Output & Driver
EXAMPLE:
NSNs managed
Supply Control Studies
Man Years
NSNs on which required studies have been performed
Performing studies on all NSNs which have to be managed

CHAPTER II

LESSONS LEARNED AND RECOMMENDATIONS

Although the data extraction difficulties were more than expected we were not disappointed with the test. Referring to the conceptual limitations in Chapter I, the driver approach is not a cure-all that some may have thought it to be. We did not expect many strong historical statistical relationships between past driver values and resources expended, and this statement is not based upon hindsight. Although we did such statistical analysis and it took lengthy calendar time for the Commands to provide necessary data (see Chapter III), we still feel it is often pointless and dangerous to rely on these previous relations, which are based on nonrational expenditure as opposed to rationalized need.

However, it is necessary to build up a data base of a particular structure to estimate and to update the weighting factors for our drivers. In general, this type of data was not available to the extent we desired. It was necessary to use several ad hoc mathematical techniques, in conjunction with some plausible assumptions, to obtain weighted driver values. This is one reason why analysis of maintenance directorates at other Commands cannot be carried out routinely; also automation is needed to make the processing less tedious.

On the other hand, the analysis at other Commands of the Materiel Management Directorates could be done by them with the aid of guidance package, albeit some compendium of "tricks" may be incorporated and could be discussed in a seminar.

Pessimistic Points and Caveats re Resource Forecasting in General

1. HISTORICAL EXPENDITURES OF RESOURCES ARE NOT NECESSARILY RATIONAL. For example say driver X is 10 in 1975 and 20 in 1976; however, man years expended in the related functions for those years were 15 and 12. Hence it's plausible the need doubled, but some decision maker did not react to that need or some constraint limited expenditure or....who knows?

2. HISTORICAL ALLOCATIONS OF RESOURCES ARE NOT NECESSARILY RATIONAL. Driver X doubles from 1975 to 1976 and Driver Y remains the same. Function X

receives $10 in 1975 and receives $12 of an available $30 in 1976; function Y had $15 in 1975 and received the remaining $18 of 1976 money. It is apparent that the pseudo-rationale gave each function a 20% increase but isn't it more reasonable to have reversed the allocation based on the drivers' changes?

3. PEOPLE DON'T FLUCTUATE. Although driver values and workload may be shifting amongst several functions and subaccounts, at a certain level of aggregation the number of people, i.e., man years, may not change much from year to year regardless of overall local need to borrow people from some other department for a period of time.

4. ACCOUNTING STRUCTURE CONSTRAINS REPORTING. The AMS account codes do not group or make apparent all of the functions and their manhours as related to a single driver. In some cases the account codes comprise different functions depending on the Command. In our original concept we intended to group driver related functions across accounts or sub-organization, but this turned out not to be realizable the way the data reporting was structured. Part of the problems is that in the past the AMS accounts reported more sub-elements.

5. CHANGES IN ACCOUNTING STRUCTURE CONFOUND ANALYSIS. Transfer of resources to different accounts or redefinitions of accounts after a particular year muddles the analyses. This happened twice in our tests.

6. DRIVER VS RESOURCES RELATIONS ARE NOT STATISTICALLY STABLE. From remarks 1 to 5 , many occurrences of historically stable relations cannot be expected. Obtaining "absolute" requirements will be harder than projecting a relative requirement of a resource based on the percentage increase in driver values from a baseline year. Also it will be difficult, in absolute terms, to compare the real needs across Commands.

7. 10% ACCURACY - RULES OF THUMB. Don't expect better than 10% accuracy in resource need for a given driver value. Don't expect better than 10% accuracy in a future projection of a driver value. (The SWAG percentages originate with the author to illustrate the point)

8. UNKNOWN PAYOFF. From remark 7, one could often expect 20% uncertainty in the projected value of man years or dollars. However, even

if the mean value is more accurate than that value obtained using another method, there is no procedure or model for translating that increased accuracy into performance measure. In other words, even if the projected necessary resources are obtained, how does system readiness or supply availability or the procurement contract process improve? And if the resources are not obtained, what is the impact on performance even if resource forecasting is more accurate?

9. WORK IS ELASTIC. A further complication to the problem in remark 8 is that "Work" will expand or contract to fit resources allowed. An average or shortage of resources will not improve or degrade performance in a simple relation that can be easily discerned.

Optimistic Points re Resource Forecasting

1. EXPENDITURES CAN REFLECT NEED. If a stable driver - expenditure relation exists while driver values are changing, one can usually assume that the expended resources were needed. For example if the driver changes from 10 to 12 and expanded resources increases from 50 to 60, that 20% increase was needed. One problem is that there might be an initial backlog or resource "need gap" that has to be identified, e.g. originally 100 resource units were required to do the work properly.

2. AN APPROACH FOR INTRA-COMMAND PROJECTING AND PLANNING CAN BE FORMULATED.

a. List all drivers for a Command (or an Agency within which resources can be shifted).

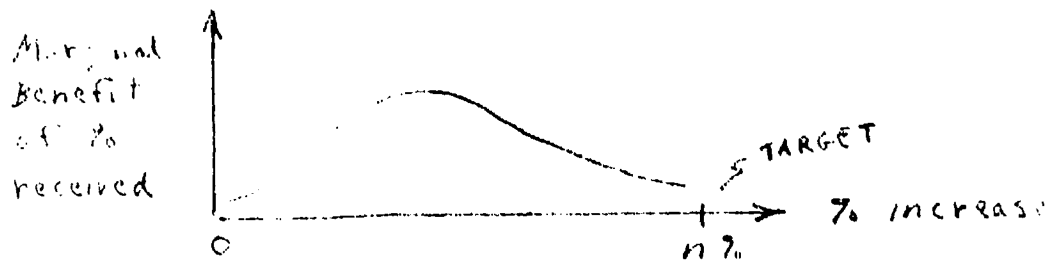
b. Pick a baseline year and indicate % changes in all listed drivers for other years, from that baseline year.

c. Weight each % change by the % of total workload driven by that driver. Composite weighted changes by years will indicate those years significantly different (say greater than 15% change) from baseline.

d. Even if changes in resources are not made available, the peak and valley years for specific functions driven by specific drivers can be addressed by an internal shifting of resources.

3. AN APPROACH FOR INTER-COMMAND RESOURCE FORECASTING AND PLANNING MAY BE POSSIBLE.

Each Command would submit to higher level their composite % change for a standard set of drivers over five years in the future. Unless specific information is available, higher level should not address the efficiency, effectiveness or productivity in utilizing resources at individual commands, but treat the % changes from baseline as valid requests. (Assume resources in the base year are reasonable) The allocation of available resources amongst commands is a problem in itself and only one guideline is mentioned here: an Agency will not be helped much with an allocation far from his targetted request nor will an Agency be hindered much with an allocation just short of his request; hence, the following curve is indicated:



A computer routine could allocate, one dollar at a time, the available resources to the Command which would derive most benefit, at that point, of that dollar.

4. THE ULTIMATE DRIVER - WEAPON SYSTEM LIFE CYCLE. The development, procurement, and support of a weapon system generates certain necessary functions in R&D, maintenance, materiel management, and procurement. If workload profiles could be built up over the projected years and over phases of life cycle by individual systems, and properly weighted with regard to functions performed, an ultimate driver vector and the necessary resources could be established. Ideally the CERCOM Maintenance Directorate is striving towards this concept in their new cost performance reporting system.

Recommendations

Based on the two pilot tests at CERCOM and TARCOM of the driver concept and availability of data, and based on the discussion in this chapter, the following recommendations (see chart T-26) are made.

a. Develop guidance package for remaining MRC's MM directorates and conduct seminars. Use driver values and their trends to study MM requirements.

b. Suspend driver analysis of maintenance until the CERCOM experience with an adequate, automated data base is monitored.

c. Pursue limited analysis of other functional organizations of Commands if:

(1) Other studies (at higher level aggregation) are not successful.

(2) These organizations can list and project drivers for their areas with reasonable time and effort.

CHAPTER III

DATA EXTRACTION

In order to perform the driver analysis of an agency (in these tests, the MM and MS Directorates), three types of data are required.

1. MH and $ by AMS codes and by year.
   a. Historical (e.g. 1976, 1977, 1978, 1979).
   b. Projected by current local methods (e.g. 1979 , 1980, 1981).
2. Nominal values (unweighted) of proposed drivers.
   a. Historical (1976 - 1979).
   b. Projected from trends or known planning documents (1979 - 1981).
3. Special data on MH spent or MH needed (historical or formulated) on functions performed related to driver categories to determine weighting factors for drivers.

In summary, 1.a. was not difficult to obtain (although accounting changes in reporting expenditures can cause havoc), 1.b. was nice to have but not necessary for basic analysis, 2.a. and 2.b. were available but not without problems, particularly in MS, with formatting, compiling or manually interpreting the data. Type 3 data were usually not available to the extent or breakout desirable to perform an ideal analysis of the weights; at times assumptions or extrapolations augmented the basic data.

What follows is a list of experiences on solicitating and manipulating the data.

1. All three types of data were obtained in a timely fashion and of an adequate nature from the CERCOM MM Directorate. Weights for the secondary item drivers were obtained by the average MH per item spent on the OROSS 2000 items by dollar value category. On some AMS codes the MH spent on major item functions vs MH spent on secondary item functions were not broken out and had to be estimated on a percentage basis from experience.

2. In the TARCOM MM Directorate the dollar value categories did not distinguish amongst the MDV, HDV, and VHDV categories. Work performed on major vs secondary items and on new vs established items was not distinguished. The original submissions on the nominal values of the drivers were felt to be in error and the directorate resubmitted new values.

3. In both Maintenance Engineering Support (MS) Directorates, the number

of different systems in the field and their age were not readily available. In the pre-issue area, work accounting was not always directly by weapon system, and in the case of CERCOM, with its many systems, a utility program had to be written to restructure the data. The status and history of the systems at both Commands were not on a standard computer file but were eventually provided in a manual form. Manhour data were extensive but tedious to restructure manually for determining the weighting factors as outlined in this report. CERCOM MS is planning to automate their status files on all end items being developed or supported as part of their cost reporting performance system; this will make it much easier to evolve and maintain driver values over the years.

4. In each directorate, some problems surfaced regarding changes in accounting and definitions of categories at various organizationa levels. The problems were resolved or the data adjusted or discounted in our analysis.

5. The calendar time in obtaining the data for this study was lengthy in some instances. Some manhours normally expended for performing daily business had to be rationed towards these tests, so we truly appreciated the time and support we did receive.

Some useful mathematical techniques that arose for manipulating data to obtain weights are summarized below:

1. Obtain weighting factors from manhours spent on a set of items that are always worked upon. On a priority basis, CERCOM's OROSS 2000 items were allocated MH and presumably reflected the need to manage these types of items by dollar category.

2. If detailed breakout of MH for several types of items is not available, solve for unknown weights by fitting several years of MH to an equation for a weighted sum of the types of items. This was done in the cataloging area using the equation

$$W_o \cdot (E_1+E_2) + W_1N_1 + W_2N_2$$

where E_1, E_2 = number of established major and secondary items.

N_1, N_2 = number of new major and secondary items.

3. Sampling can aid in determining a workable classification of items. Complexity classes were determined for systems by taking a sample of end items.

4. Technical estimates or formulas for workloading may be better indicators of relative need of MH than historical data. This approach was successful in the CERCOM maintenance analysis.

5. The virtual system concept (see charts) is a reasonable way of extrapolating backward and forward in time to estimate systems managed that do not have current historical data on workload.

CHAPTER IV

COMMENTARIES TO BRIEFINGS

The three briefings, as they were originally structured for presentation are in the Appendix. These commentaries highlight the points to be made as our analysis evolved. Some charts are self explanatory and some may be skipped because of previous familiarity with the material.

1. CERCOM Pilot Test, Materiel Management

C-3. See Chapter III.

C-4. See Chapter II.

C-5. The drivers of workload in the materiel management AMS codes 21112. xxx are listed here. In the symbolic notation, E = established, N = new, 1 = major, 2 = secondary; W refers to weights applied to a grouping of the items; E1 - E2 - $\bar{E}$ symbolizes a count of stocked NSNs.

C-6. Historical data was provided on the MH spent per item by item managers by dollar value categories. It is of interest to note the MH/item ratios for the 2000 items deemed most important and which are given work priority (OROSS 2000); these ratios presumably can reflect unconstrained, necessary MH and could have been applied to all items in 1976 and 1977 if resources had allowed. A relative weighting, which is sufficient for analyzing changes in weighted drivers, is found by dividing all class weights by the LDV weight. The "suggested" weighting scheme, which was used in the subsequent analysis, incorporated some rounded values for simplication.

C-7, C-8. One approach in the driver analysis is to determine ratios of manhour per unit driver (weighted or not). As discussed in Chapter II, one may not find many stable ratios historically, but when one does, presume the ratio represents MH spent as needed per driver unit.

These charts indicate, for AMS coded work .12, .111, .112, which MH "tracked" driver values reasonably well and which did not (and for the latter we presume that the historical expenditure did not reflect all the need).

C-9. On this chart is tabulated the needed manhours in secondary item management and requirements computations as reflected in the changing values of the driver $E2^W$. The "percentage" changes in the driver from year to year are indicated (1.152, 1.017, 1.051). The actual MH from 1976 to 1978 in areas .12 and .111 are not changing in the same manner; note particularly the relatively large value in 1976 of $E2^W$ x 1.1, yet in other years the needed and actual MH are in the same ball park. This chart illustrates that the driver values can pinpoint peak (or valley) years, either past or future, which conventional history or forecasts do not readily indicate. The chart also exemplifies the baseline method of adjusting a given year's MH by future changes in the related driver $E2^W$.

<u>C-10</u>. Based on historical data from 1976-1978, the MH spent in .20 (essentially cataloging) per established item was approximately 1.5, regardless if the item was major or secondary. This is intuitively sensible, since after the major cataloging functions are completed (when the item is new), remaining data maintenance is item independent. By fitting the weighted driver function 1.5 (E1 + E2) + W1 x N1 + W2 x N2 to the known cataloging hours for 1976 and 1977, the weights W1 = 37.65 and W2 = 11.65 were found. As a check, using these weights, the projected hours for 1978 differed from the actual hours by 7.5%; also the predicted portion of 1978 MH spent on new items was 20%, whereas the actual portion was 22%.

<u>C-11</u>. In the areas .41 and 42, the ratios found as indicated were fairly stable for years 1977 and 1978. The ratios for 1976 were discounted. Quarterly observations of MH vs stocked NSN's in 1977 indicated ratios fairly consistent around 3.09.

<u>C-12</u>. This chart compares the actual and forecasted MH (by CERCOM) for each AMS code with those obtained by multiplying the related driver values for each year by the obtained ratios or weights on the previous charts. Note that CERCOM forecasts for 1979 and 1980 were identical and represented some percentage increase over 1978. The IRO driver method tracks the individual peaks and valleys of the drivers over the years 1976-1980. Coincidentally the aggregate forecasts by CERCOM and IRO in 1979 were quite close, although closer examination shows individual entries differing by AMS breakout. The IRO forecast of needed MH for 1980 is higher but a natural consequence of the underlying rationale and of the projected numbers of major and secondary items to be managed then.

2. CERCOM Pilot Test; Maintenance

C-17, C18. See Chapter I and reference [1].

C-19. See Chapter III.

C-20. See Chapter II.

C-21. This chart lists the drivers for work performed under AMS codes 738017.xxx. The check marks designate those accounts which had significant MH or dollars. Since we could only collect reliable data on drivers PI and PI* (systems undergoing PIP's), AMS accounts wholly or partially driven by F (fielded systems) were not analyzed. The procedure for weighting the PI count by a workload profile will be discussed in forthcoming charts.

C-22. First we outline the methodology for obtaining the weights or profiles for adjusting the pre-issue systems count.

C-23. A sample of 50 systems was categorized by complexity, i.e. a count of different parts comprising the system. Instead of using historical MH expenditures per system, which were hard to obtain and may not reflect need, workload formulas developed and tested at CERCOM were used to relate many types of functions performed and their MH to parts counts and tech manual pages. Knowing the parts counts and pages of the sampled systems, the needed MH per system are averaged by category and by functions performed in ADV (advance development phase), EDV (engineering development), LRIP (low rate initial production), and PDN (production). The resulting table presents "weights" by complexity class and pre-issue phase.

C-24. On this chart are listed some of the pertinent facts gleaned from data provided on almost 700 end items in pre-issue phases circa 1978-79. For 385 end items, "complete" data was available, including dates entering pre-issue, dates for field deployment, part counts, and current phase of development. The average span of years spent in pre-issue did not increase much with complexity; in many cases of electronic equipment, less complex end items are sub-assemblies of large systems and the timing of their development and deployment is keyed to that of the more complex end item. Breaking the total span into 12 units of time, regardless of actual years, we found on average that 3/12 of the span was spent in ADV, etc. Note that for the years observed, about the same number of systems were taken under development as were just completing pre-issue work; thie fact led to a "no-growth" assumption useful in developing the concept of "virtual" systems.

C-25. From the data provided, we could observe thru a "window" of width 1978-1979 only those systems then on file as pre-issue systems. We could not observe systems that left pre-issue before 1978, nor those systems expected to enter pre-issue after 1979. We developed a set of these unobserved or virtual systems, which would contribute to the workload in the years 1975-1984, by assuming a continued "reincarnation" of the systems observed with the same workload profile. Later the final driver results could then be adjusted for any known net increase of systems planned to be developed in the future.

It was also necessary to use the observed facts to allocate the tabulated MH weights across a profile related to development phase which could be adapted to any span of years. Compiling the observed system data, tempered with some experienced guesstimates, the 3 time units of ADV, 4 units of EDV and 5 units of LRIP-PDN were percentage factored in terms of work completed in the manner indicated. For example, 20% of EDV is accomplished in the first time unit of that phase. Then using this breakout of the 12 units, the pre-issue years spanned by any particular system can be work-factored. For example, if the system spans 3 years, the first year covers 4 of the 12 time units and thereby encompasses 100% of ADV and 20% of EDV; knowing that system's complexity class, the weight for ADV plus 20% of the EDV weight (see C-23) would be recorded in the first year of the profile. Similarly 70% of EDV plus 30% of LRIP-PDN would be assigned to the second year; the remaining 70% of the latter phase would be accomplished in the third year.

C-26. An example (based on actual observed system counts and generated profiles) is tabulated on this chart. The actual systems' profiles are cross hatched; there were 36 systems that had the unique profile indicated, spanning 1976-1979, and 9 systems that spanned 1975-1981 with the tabulated profile on the lower half of the chart. Virtual systems' profiles are also shown on the chart, leaving and entering pre-issue before and after (with some overlap) the observed systems. The numbers entered in the profiles by year represented the MH-weights as determined by the procedure in C-25. The total MH-weighted driver value for a particular year is found by multiplying the numbers in a column by the number of systems on the right of the chart and summing.

C-27. An extensive tabulation, of which the C-26 example was only a part, leads to the PI driver values for years 1976-1981 given on line a. Line b is the accumulated driver values when the three very large systems observed are excluded. Historical ratios can be computed, 1976-1978, of the MH and dollars per driver value PI, PI'. These ratios are indicated c/a, c/b, d/a, and d/b. The values of the ratios for at least two out of the three years are fairly stable, indicating good tracking of driver vs resource. It is also interesting to note that if one interprets the PI values in line a as representing an absolute MH requirement as needed (in general we only look at relative changes in drivers but here, from how PI was derived, there is some basis for the absolute interpretation), then a-c represents a "gap" between needed and expended MH, and this gap is fairly constant around 300,000 MH per year. Again as mentioned in Chapter II, it is difficult to translate this gap into an impact on work quality or system performance.

3. TARCOM Pilot Test - Commentary to Charts

Charts Addressing Materiel Management Analysis

T-4. This chart tabulates the man years (MY) and organizational dollars (ORG $) by AMS codes 721112.xx. No contractural dollars were reported. These figures were provided at the directorate level and are in agreement (and presumeably auditable) with data furnished to GAO. Man years and dollars (thousands) summarize that reported under the various AMS accounts across all the directorate's organizations and as such will be more than the sum of the three commodity divisions' reports; the directorate and divisional levels of reporting may be inconsistent for other reasons also.

T-5. The drivers for the AMS codes analyzed are listed here. They are the same as those postulated and analyzed at CERCOM. Some commands (as did TARCOM) may wish the capability to add or replace drivers of their choice to reflect "any special exigencies of their operations," but for uniformity of analysis and potential implementation, we have maintained a standard set of drivers. In any eventual reporting system, directorates may provide their own drivers and yearly values of such as memo entries.

T-6. Compare this chart with C-6. The weights were based upon relative MH per item spent by item managers by item categories. We could not pin-point MH need by isolating time spent on OROSS-2000 items as was done in the CERCOM analysis. In any case the TARCOM weight for VHDV-HDV-MDV combined was much lower than the average CERCOM weight for these categories. However, the overall secondary item average weight for TARCOM catalog ($\sim$2.0) was about half of the CERCOM overall weight ($\sim$4.0). The large number of LDV items at CERCOM pulled down its overall weight. The weight for the provisioning category was chosen to be the remaining catalog's average, this value being a reflection of the range of items that need provisioning work.

T-7, T-8. These charts tabulate the yearly patterns in the values of the set of drivers for the three commodity divisions:

FH - Combat Vehicles, FR-Special Purpose Vehicles, FT - Tactical Vehicles. The driver ED^W was obtained by multiplying the number of secondary items in each year that were in each category ("HDV", LDV, NS, PROV) by the category weight and summing. The value $\bar{W}$ is the average secondary item weight by year.

T-9, T-10, T-11. These three charts tabulate the historical data (1977-79) on the ratios of MH spent per driver value in the areas of commodity management (.11) and requirements computation (.12). For lines "1" the driver value was the corresponding E1 for the division and year; for lines "2", $E2^W$ was the driver related to hours spent on secondary items.

Note that the ratios are much higher for major item hours and note also that in many cases the trend in the ratios is decreasing by year, i.e., the number of items are reported as increasing but the MH are decreasing. It is difficult to relate this trend to the impact on quality of work performed or on the eventual support or readiness of systems or on supply performance. Nor can one, without extensive operational analysis, evaluate efficiency, productivity, surplus MH or backlog of item management.

T-12. Not knowing actual "need" of MH as reflected in the ratios discussed on the previous charts, one can only establish a base line year and use the driver values to project backward and forward. The year 1978 was chosen and the driver values E1, $E2^W$ for years 1977-1981 were multiplied by the 1978 MH/driver values for each commodity division and summed to yield the aggregate MY values on lines 2 and 4 of chart T-12 (MY = MH/1800). The increasing trend lines are apparent. The total directorate MY from Chart 4 are entered on lines 1 and 3 for comparison. Even discounting other man hours in these codes that were not analyzed, the directorate MY are not responsive to these trends; in the area of requirements computation there may be a surplus of MY.

T-13. This chart's entries are similar to T-12. However, the basic ratios (i.e. weights) used were those obtained for these categories in the CERCOM analysis. In the area .20 the weighted driver (E1 + E2) W0 + N1 x W1 + N2 x W2 used TARCOM values for E1, E2, N1, N2, but CERCOM weights W0, W1, W2. Similarly the TARCOM drivers M and E1 + E2 - $\bar{E}$ for .41 and .42 were multiplied by CERCOM ratios. It was necessary to do this because the TARCOM data was not broken out in a manner sufficient to derive weights in these codes. Using CERCOM weights as a norm was the next best thing and also allowed a check of these weights for reasonableness since the projected MY for TARCOM were not unreasonable. Note especially that the available TARCOM MY for .20 and .42 (~110,~ 69), while not reacting to the pattern in the lines below them, will eventually be "needed" in the 80-81 time frame.

Charts Addressing Maintenance Engineering Support

T-15. See Charts C-5, C-21, T-5.

T-16. This chart lists the TARCOM systems in Pre-Issue development broken out by the same complexity categories utilized in the CERCOM analysis. The individual systems are listed identified via their part counts. Two submissions came from TARCOM Maintenance Directorate: those systems that have been supported in Pre-Issue up to the 78-79 time frame and are nearly ready for field issue, and those "later" systems that still remain in pre-issue or are projected to be under development in future years.

T-17. The entries on lines A and B represent the average MH for system spent over the three vehicle divisions (MC, combat; MT, tactical; MV, special purpose) and Initial Support branch (MI). Line C for the most part is an average of A & B; however, some MH data in MV (asterisked) might be suspect so the MH weights for categories $\prec$400 and $\prec$1600 were reasonable guesses.

T-18, T-19. A basic pillar of our approach is to allocate the MH weights amongst phases of development and span of years in Pre-Issue for systems to generate workload profiles. As with the CERCOM analysis the ADV, EDV, LRIP and PDN phases are represented by 12 units of time. These 12 units are grouped into years as shown on the chart, which can be used for systems spanning 2, 3, 4, 5, 6, 7 years in Pre-Issue. The percent of workload in each phase which is estimated to be done in a particular time unit can be used to break out MH by years in a systems span. For example, a system with 5000 parts which spent 3 years in pre-issue has 14000 MH-weight (see T-17) assigned to the years as follows:

10% in ADV
45% in EDV — Based on CERCOM experience.
45% in LRIP, PDN

The chart also indicates that for each system leaving pre-issue, one enters; this leads to the virtual system concept as used on CERCOM analysis.

T-20. This example chart is identical to the example used in the CERCOM briefing. The observed shaded workload profiles for 36 systems spanning 1976-79 and the nine systems spanning 1975-81 are augmented by identical profiles for virtual systems that left pre-issue in the part or are entering pre-issue in the future. Summing the MH-weights entered in each profile for each year, multiplied by the number of systems, yields a profile weighted number of system worked upon in each year. These figures are tabulated in the last row of the chart and actually represent the weighted driver for this example.

T-21. An actual tabulation of systems, identified via part counts, is entered in the left column. All unique profiles spanning particular years are represented by numbers in the year columns. The entrance and span of virtual systems with the same profile of numbers as the listed systems are indicated by | and . The totals give the weighted driver values by year for all these systems.

T-22. In the P3 area the driver values PI based on observations of systems circa 78-79 and based on all systems (including planned TARCOM systems for future development) are tabulated. Notice the large dips in 1980 and large "recovery" in 1981 on the PI values. In contrast more MY and $ are projected to be reported in the 80-81 P3 area due to an accounting change.

For Q8 area (product improvements) the PI* driver value represents a tabulation of only those systems undergoing modification (PIPS").

Only an incomplete analysis could be made of the publications areas R1, R2 since we did not obtain counts or weighting factors for already fielded systems, which also drive the workload, e.g. producing and updating field tech manuals. The weights W' used here on PI systems were based on MH spent in R1 on the observed systems by complexity categories. Again there is an accounting change in years 80-81 on reportable MY for this area.

The "$\wedge$" entries indicate some of the fractional changes across compared years in driver values versus dollars or man years.

T-24, T-25. Some of the overall comparisons across the two pilot tests and general recommendations are listed here. An extensive discussion of what can be done in the future and consequent recommendations based on lessons learned in these tests can be found in the initial section of the report.

The reversal of the ratio of CERCOM to TARCOM weights in secondary item management to that of the normalized weights in major item support is interesting.

APPENDIX

BRIEFING SLIDES

PILOT TEST OF DRIVER CONCEPT FOR RESOURCE

REQUIREMENTS PROJECTIONS

(TARCOM)

IRO PROJECT 271

IPR

JANUARY 1980

BRIEFING OBJECTIVE

SUMMARIZE ANALYSIS OF TARCOM MAINTENANCE AND MATERIAL DIRECTORATES RE DRIVER CONCEPT.

SUMMARIZE AND DRAW CONCLUSIONS FROM TARCOM AND CERCOM PILOT TEST EXPERIENCES.

PRESENT RECOMMENDATIONS RE STUDY AND DRIVER CONCEPT IN GENERAL.

T- 2

PAST EVENTS AND STATUS

DEC 78	CERCOM MM ANALYSIS BRIEFED TO MRC AND DRCDRM.
MAY 79	CERCOM MAINTENANCE ANALYSIS BRIEFED TO MRC & DRCDRM.
JUN 79	TARCOM SELECTED AS SECOND PILOT TEST.
NOV 79	TARCOM MM AND MAINTENANCE ANALYSIS BRIEFED TO MRC. MM WISHED TO RESUBMIT DATA FOUND TO BE ERRONEOUS.
JAN 79	PREVIOUS BRIEFING MODIFIED TO REFLECT GOOD DATA. GENERAL RESULTS REMAIN THE SAME.

F - 3

AMS CODES		77 MY	77 ORG $ CONT	78 MY	78 ORG $ CONT	79* MY	79* ORG $ CONT
721112.00	SUPPLY MANAGEMENT OPR	817	$14,924.3	820	15,440.1	807	14,936.2
.10	INVENTORY CONTROL	50	987.6	50	567.3	49	518.3
.11	COMMODITY MANAGEMENT	119	2,350.5	119	2,100.2	118	2,027.2
.12	REQUIREMENTS COMPUTATIONS	353	6,799.6	354	7,403.3	349	6,306.0
.13	OTHER INV CONTROL & LOG SUPPORT FUNCTIONS	1	18.6	1	13.3	1	1.1
.20	LOGISTICS DATA MGT	110	1,886.1	110	1,809.0	109	1,621.0
.41	REQUISITION PROCESSING	26	230.2	26	582.9	26	551.4
.42	INVENTORY ACCOUNTING	69	1,118.4	69	917.7	68	704.0
.50	TRAINING	2	35.7	2	15.0	2	16.3
.90	SUP MGT OPERATIONS SUPPORT	87	1,497.6	89	2,031.4	85	3,191.9

*EXPENDITURES ARE THROUGH AUGUST 1979.

T-7

MATERIAL MANAGEMENT DRIVERS

AMS CODE	DESCRIPTION	DRIVERS	SYMBOL
721112.11	COMMODITY MANAGEMENT	EST. MAJOR ITEMS	E1
		EST. SECONDARY ITEMS WGTED	$E2^W$
.12	REQUIREMENTS COMPUTATION		E1
			$E2^W$
.20	LOGISTICS DATA MGT. (CATALOGING)	WEIGHTED SUM OF ESTABLISHED & NEW ITEMS	$(E1 + E2)\ W_0 + W_1N1 + W_2N2$
.41	REQUISITION PROCESSING	MANUAL REQUISITIONS	M
.42	INVENTORY ACCOUNTING & STOCK CONTROL	STOCKED NSN'S	$E1 + E2 - E$
.50	TRAINING	(RESOURCES NIL)	
.90	SUP MGT OPERATIONS SUPPORT	(NOT ANALYZED)	

T-5

OBTAINING WEIGHTS FOR $E2^W$

AVERAGED (FOR EACH ITEM CLASS BELOW) THE MH PER ITEM SPENT BY ITEM MANAGERS OVER THE YEARS 77-79 AND OVER THE 3 COMMODITY DIVISIONS

CLASS	WEIGHT	COMMENTS
VHDV, HDV, MDV	2.60	AVERAGE A LOT LOWER THAN CERCOM'S FOR THIS GROUP.
LDV	1.88	LOW VARIABILITY. AVERAGE VALUE COMPARABLE TO CERCOM'S.
NON-STOCKED, INSURANCE	1.0	(see LDV comment, bracketed together)
PROVISIONED	2.0	AVERAGED WEIGHT FOR ABOVE CLASSES USED.

TO OBTAIN OVERALL WEIGHT R FOR A CATALOG IN A GIVEN YEAR, MULTIPLY ABOVE WEIGHTS BY % OF ITEMS IN EACH GROUP AND ADD.

T-6

DRIVER VALUES BY YEAR & COMMODITY DIVISION

DIVISION	DRIVER	77	78	79	80	81
	Q	2.04	2.05	2.04	1.99	1.99
	$E2^W$	14359	14193	20895	23091	23563
	E1	1719	1721	1722	1722	1724
FH	E2	11447	11361	16713	19060	19532
	N1	2	1	0	2	328
	N2			1583	2347	472
	E1 + E2 - E	5588	5503	6801	6853	6853
	M	15469	18426	13634	14507	15435
	Q	2.00	2.00	2.00	1.99	1.99
	$E2^W$	26117	32070	36316	35978	35978
	E1	451	461	495	504	514
FT	E2	19295	22273	24397	24226	24226
	N1	10	34	9	10	0
	N2	2937	706	1465	1223	1223
	E1 + E2 - E	9370	12358	14516	14354	14364
	M	37297	31636	25362	26747	28497

T - 7

DRIVER VALUES BY YEAR & COMMODITY DIVISION (CONT)

DIVISION	DRIVER	77	78	79	80	81
	Q	1.98	1.98	2.00	2.00	2.00
	$E2^W$	50562	52299	50155	55298	61188
	E1	44	46	51	56	63
FR	E2	36158	37137	35964	38567	42063
	N1	2	5	5	7	1
	N2	774	1229	2045	2399	0
	E1 + E2 - E	16902	17678	16510	19009	21712
	M	31328	30699	14508	16684	19186

AMS Codes		77 MH	77 MH/DRIVER	78		79		80	81
721112.									
.11 Comm. Mgt.	1	40745	90.3	37[illegible]2	80.7	34829	70.4		
	2	33337	1.28	30454	.950	28497	.785		
.12 Req'm'ts Comp't'n	1	44456	98.6	48154	104.5	48432	97.8		
	2	66684	2.55	72231	2.25	72648	2.00		
.20 Logistics Data Mgt.									
.41 Req. Proc's'ng									
.42 Inv'ty Acc't'ng									

Comments

(FT) DOWNWARD TREND IN RATIOS

Key: 1 = Major, 2 = Secondary Items

AMS Codes		77 MH	77 MH/DRIVER	78		79		80	81
721112.									
.11 Comm. Mgt.	1	24830	14.4	29724	17.3	36995	21.5		
	2	20316	1.41	24320	1.71	30269	1.45		
.12 Reqm'ts Comp'tn	1	43946	25.6	37689	21.9	3[illegible]33	21.6		
	2	65919	4.59	56534	3.98	55699	2.67		
.20 Logistics Data Mgt.									
.41 Req. Proc's'ng									
.42 Inv'ty Acc't'ng									

35

Comments (FH)

T - 10

AMS Codes		77 MH	77 MH/DRIVER	78		79		80	81
721112.									
.11 Comm. Mgt.	1	21440	487	20902	454	17880	351		
	2	17542	.347	17101	.327	14630	.292		
.12 Req'm'ts Comp't'n	1	51760	1176	49581	1078	43906	861		
	2	77640	1.54	74371	1.42	65860	1.31		
.20 Logistics Data Mgt.									
.41 Req. Proc's'ng									
.42 Inv'ty Acc't'ng									

Comments (FR) DOWNWARD TREND IN RATIOS

7 - 11

AMS Codes	77 MY	78	79	80	81
721112.					
.11 Comm. Mgt.	119 84.5	119 88.7	118 99.7	104.2	108.0
.12 Req'm'ts Comp't'n	353 178	354 188	349 211	223	234
.20 Logistics Data Mgt.					
.41 Req. Proc's'ng					
.42 Inv't'y Acc't'ng					

Comments

78 BASELINE: DRIVERS (E1, E2[W]) x $\left(\frac{MH}{DRIVER}, 1978\right)$

MY on lines 1 & 4 are from chart

T-12

AMS Codes	77 MY	78	79	80	81
721112.					
.11 Comm. Mgt.					
.12 Req'm'ts Comp'tn					
.20 Logistics Data Mgt.	110 81.8	110 74.1	109 103.0	109.0	91.4
.41 Req. Proc's'ng	26 55.4	26 53.2	26 35.2	38.1	41.6
.42 Inv'ty Acc't'ng	69 54.7	69 61.0	68 64.9	69.0	73.7

Comments

(CERCOM MH WGTS X DRIVER) / 1800

Values in top lines are from chart + r-13

MM DIRECTORATE ANALYSIS

SUMMARY

ACCOUNTABLE DATA CURRENTLY NOT SEGRECATED TO THE EXTENT PREFERABLE FOR DRIVER ANALYSIS.

TO A LARGE DEGREE, HISTORICAL MH DO NOT FOLLOW YEARLY DRIVERS.

REQUIREMENTS BASED ON AVERAGE WEIGHTS, OR BASELINE RATIO FACTORS, TIMES DRIVERS SEEM REASONABLE WHEN COMPARED TO HISTORICAL MY. FUTURE DRIVER-RELATED REQUIREMENTS IN TERMS OF PERCENTAGE INCREASES OVER A BASELINE CAN INDICATE TRENDS IN MY REQUIREMENTS.

T-17

MAINTENANCE SUPPORT DRIVERS

MH	$	AMS CODE	DESCRIPTION	DRIVERS	SYMBOL
✓	✓	738017.000 P1(P2)	PROGRAM DEVELOPMENT	STAFF	
✓	✓	P3(P4)	MAINT ENGINEERING (PRE-ISSUE)	NUMBER OF PRE-ISSUE END ITEMS [redacted] IN YEAR WEIGHTED BY WORKLOAD PROFILE IN THAT YEAR (DEPENDS ON COMPLEXITY & PHASE)	PI
✓	✓	Q1(Q2)	MAINT ENGINEERING (FIELD)	NUMBER OF FIELDED END ITEMS IN YEAR WEIGHTED BY COMPLEXITY AND AGE	F
✓	✓	Q3(Q4)	OTHER ENGINEERING & ANALYSIS		F, (PI)
✓	✓	Q5(Q6)	TECH ASSISTANCE		F
	✓	Q7(Q8)	ENGINEERING FOR PIP's	SIMILAR TO PI, COUNTING ONLY END ITEMS UNDERGOING PRODUCT IMPROVEMENTS	PI*
✓	✓	R1(R2)	PUBLICATIONS		F, PI, PI*
		S1 } S4	NET		

F-15

TARCOM SYSTEMS WITH PART COUNTS

<100 THRU 78-79	<100 LATER	<400 THRU 78-79	<400 LATER	<1600 THRU 78-79	<1600 LATER	<6400 THRU 78-79	<6400 LATER	<20000 THRU 78-79	<20000 LATER
[illegible]	2	254	113	1294	903	3166	5636	10227	6730
[illegible]	27	378	231	691	613	5247	6041	11547	7099
12	33	202	230	616	428	4440	6073	12424	9861
29	54	324	202	448	767	6426	6226		9931
10	23	322	175	658	463	6426	3645		7851
6[illegible]	12	230	306	443	945	2766	4855		11674
12	10	300	323	427	1348	2285	2483		7466
69		110	228		715	1762	5856		13581
54		149				2379	2966		6554
12						4067	3381		
6							1848		
13							1762		
23							1771		
							4063		
13	7	9	8	7	8	10	14	3	9

#↑ SYSTEMS↑

7-16

WEIGHTING FACTORS FOR PRE-ISSUE

	< 100	< 400	< 1600	< 6400	< 20000
A.	2186	3962	4285	15022	22698
B.	1509	18117*	13236*	12560	29222
C.	1850	5000	7000	14000	25000

A. (MC, MT, MV, MI) MAN HOURS/SYSTEM FOR TABULATED END ITEMS 78-79

B. (MC, MT, MV, MI) MAN HOURS/SYSTEM FOR LATER TABULATED ITEMS (THRU 85)

C. WEIGHT CHOSEN FOR ANALYSIS

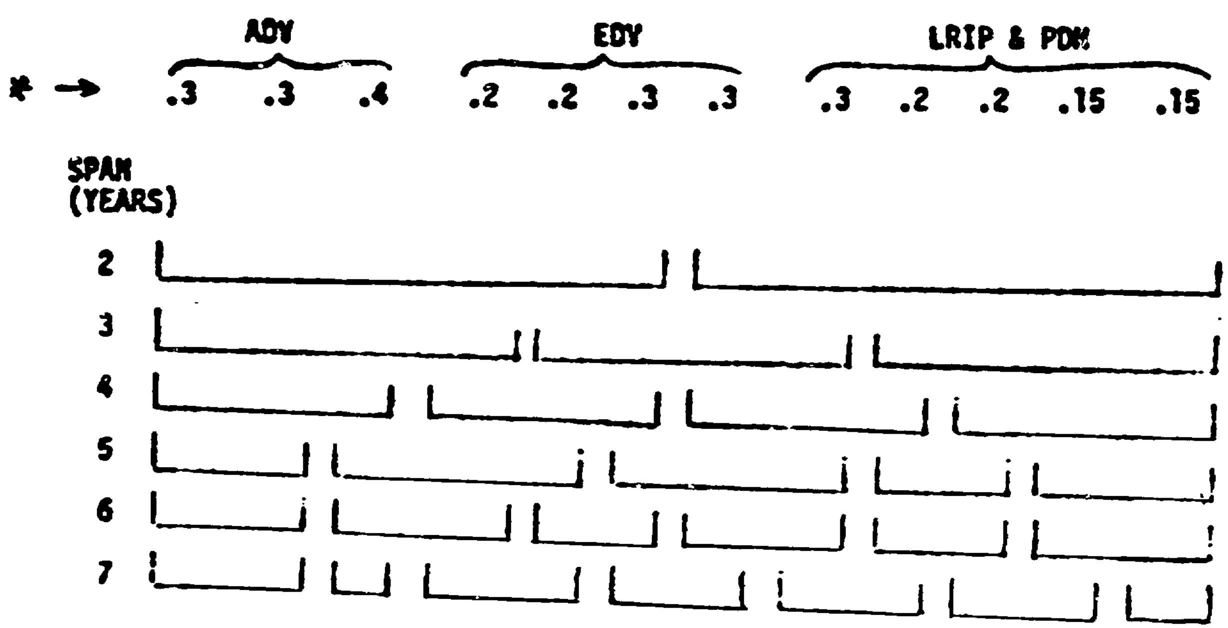
*DOMINATED BY LARGE MH IN MV

T-17

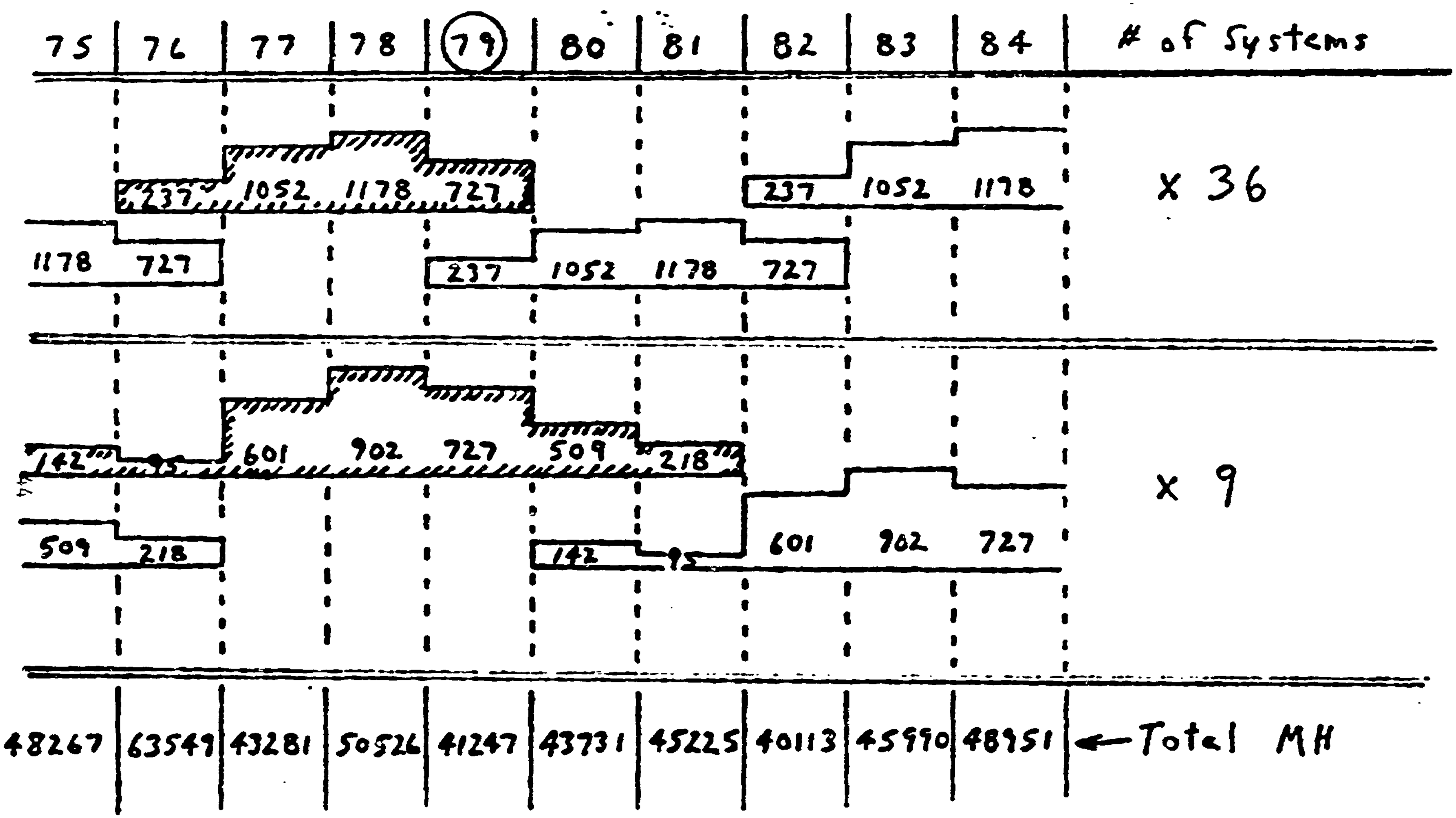
USE OF FACTS (CERCOM)

FROM C., FOR EACH SYSTEM LEAVING, THERE IS ONE ENTERING WITH THE SAME WORKLOAD PROFILE (WITH SOME OVERLAP). THIS "NONE GROWTH" ASSUMPTION CAN BE RELAXED LATER TO ADJUST FINAL RESULTS. FOR SOME FUTURE, LOW PERCENTAGE GROWTH (* OR KNOWN LARGE SYSTEMS)

ALLOCATION OF PHASE LENGTHS FOR VARIOUS SPANS OF YEARS:



Example of Tabulation of Workload Profiles



Profile of Workload Weight Factors (MC, MT, MV, MI) for Systems circa 77-78

Systems	74	75	76	77	78	79	80	81	82
10000			2270	7263	8171	4994	▷—	—	—
53, 16, 12, 29				2186		▷		▷	
1294*		814	2142	1328		▷—	—	—	▷
254			1664	2298		▷—	—		
10227*	1362	4994	9079	4086	3178	▷—	—	—	—
378		753	1981	1228		▷—	—	—	▷
3166			6309	8713		▷—	—	▷—	—
5247, 4440				2854	7511	4657	▷—	—	—
11547*		1362	4994	9079	4086	3178	▷—	—	—
202, 322				753	1981	1228	▷—	—	—
691			814	2142	1328	▷—	—	—	▷
10, 69				918	1268	▷—	—	▷—	—
2766, 2285, 1762, 6426*, 6426, 4067			1502	4807	5408	3305	▷—	—	—
324				1664	2298	▷—	—	▷—	—
61, 6					918	1268	▷—	—	▷
12					2186	▷	▷	▷	▷
616, 658, 427			429	1371	1543	943	▷—	—	—
448				814	2142	1328	▷—	—	—
230, 300			396	1268	1426	872	▷—	—	—
54, 12, 13, 23				415	1093	678	▷—	—	—
2379				1502	4807	5408	3305	▷—	—
443						4285	▷	▷	▷
149					1664	2298	▷—	—	▷
12424*			1362	4994	9079	4086	3178	▷—	—
110				219	700	787	481	▷—	—
Total				100275	107296	93808	77494	120814	

AREA			77	→	78	→	79	→	80	→	81	82
PRE-ISSUE	P3	MY	32	1.09	35	.86	30		(87)*		(79)	
		$	.700		.933		.854		(2.148)*		(1.966)	
	PI SYSTEMS, W (DATA THRU 78-79)		100275	1.07	107296	.87	93808	.83	77494	1.56	120814	123091
	PI SYSTEMS, W (COMPLETE SUBMISSION)		180451		171012		173453	.90	156390	1.15	180214	193620
PIP	Q8	$	.452	.62			.283					
	PI*		24294	.52			12745					
PUBLICATIONS (PRE-ISSUE)	R1	MY	45		54		64		(129)		(128)	
	R1 + R2	$	3.6	1.18	4.24	.6[illegible]	2.65					
	PI SYSTEMS, W' (DATA THRU 78-79)		19832	1.07	21242	.86	18203		16111		23805	
	PI SYSTEMS, W' (COMPLETE)		34488		32987		33702		30920		35410	

Yearly Changes

MAINTENANCE DIRECTORATE

ANALYSIS SUMMARY

1. MH DATA (ACTUAL & PROJECTIONS) WAS EXTENSIVE. A FEW INSTANCES OF CARELESS OR INCONSISTENT ENTRIES.

2. DATA ON PRE-ISSUE TIME FRAME BY SYSTEM WOULD HAVE BEEN HELPFUL.

3. BY NECESSITY, CERTAIN ASSUMPTIONS AND CERCOM FINDINGS HAD TO BE UTILIZED.

4. COLLECTING, CONSOLIDATING, TABULATING AND ANALYZING SYSTEM BY SYSTEM IS TEDIOUS AND IMPRACTICAL ON A ROUTINE BASIS.

5. IN A FEW INSTANCES MH OR $ FOLLOW THE RELATED DRIVER PATTERN.

6. PERCENTAGE CHANGES IN DRIVER VALUES IN FUTURE YEARS ARE FELT TO BE USEFUL INDICATORS OF SHIFTS IN REQUIREMENTS.

T - 23

CONCLUSIONS

MM

1. IN MM, STATISTICAL HISTORICAL DRIVER-RESOURCE RELATIONSHIPS WILL NOT NECESSARILY BE FOUND.

2. PERCENTAGE INCREASES IN DRIVER VALUES FROM A BASELINE IS VALUABLE AS A COARSE INDICATOR OF REQUIREMENT TRENDS.

3. GUIDANCE PACKAGE FOR REPEATING IRO ANALYSIS OF CERCOM, TARCOM AT OTHER COMMANDS SEEMS FEASIBLE.

Maint

4. HISTORICALLY, DRIVER-RESOURCES RELATION WAS NOT STRONG AS CERCOM WAS.

5. PERCENT CHANGE IN PRE-ISSUE DRIVER IS USEFUL BUT LIMITED UNLESS FIELD MAINTENANCE, TECH ASSISTANCE, PUBS FOR FIELDED SYSTEM CAN BE ANALYZED.

6. IMPLEMENTATION AND MAINTENANCE OF THE PROCEDURE IS NOT PRACTICAL AT COMMANDS WITHOUT AUTOMATED PROCEDURES FOR ACCOUNTING END ITEMS MH AND STATUS OF DEVELOPMENT (PRE-ISSUE & FIELD).

T- 24

MISCELLANEOUS COMPARISONS

		TARCOM	CERCOM
AVERAGE WEIGHTS	SEC ITEMS BY $ VALUE	2.0	4.0
	MAJ ITEMS BY COMPLEXITY	3.0	1.5

o ———————— o

- CERCOM MAINTENANCE IS INCORPORATING DRIVER CONCEPT INTO THEIR PERFORMANCE COST REPORTING SYSTEM.
- TARCOM MM DESIRES FLEXIBILITY OF ADDING DRIVERS OF THEIR CHOOSING.
- TARCOM-AMSAA STUDY OF PROCUREMENT DIR SEEMS VALID AND IN THE SPIRIT OF DRIVER CONCEPT.

NOTHING COMPARABLE DONE AT CERCOM AS YET.

RECOMMENDATIONS

- DEVELOP GUIDANCE PACKAGE FOR REMAINING MRC'S MM AND CONDUCT SEMINARS. USE DRIVER VALUES AND THEIR TRENDS TO PROJECT MM REQUIREMENTS.
- AFTER ABOVE, TERMINATE 271 STUDY.
- SUSPEND DRIVER ANALYSIS OF MAINTENANCE UNTIL THE CERCOM EXPERIENCE WITH AN ADEQUATE, AUTOMATED DATA BASE IS MONITORED.
- PURSUE ANALYSIS OF OTHER FUNCTIONAL ORGANIZATIONS OF COMMANDS IF:

  OTHER STUDIES (AT HIGHER LEVEL OF AGGREGATION) ARE NOT SUCCESSFUL.

  THESE ORGANIZATIONS CAN LIST AND PROJECT DRIVERS FOR THEIR AREAS WITH REASONABLE TIME AND EFFORT.

PILOT TEST OF DRIVER CONCEPT FOR RESOURCE REQUIREMENTS PROJECTIONS

IRO PROJECT 271

IPR TO DRM

DECEMBER 1978

C-1

OBJECTIVES

(WITH CERCOM AS TEST COMMAND)

- ASSESS THE AVAILABILITY OF TYPICAL DATA NECESSARY TO COMPUTE DRIVERS AND DETERMINE THE DIFFICULTY IN EXTRACTING DATA.
- COMPUTE DRIVERS FOR RECENT YEARS AND RELATE TO ACTUAL RESOURCES EXPENDED AND RESOURCES THAT WERE NEEDED.

  MATERIAL MGT DIRECTORATE (AMS CODE 721112)

  MAINTENANCE SUPPORT DIRECTORATE (AMS CODE 738017)

-2-

STATUS

MATERIAL MANAGEMENT ANALYSIS

SUFFICIENT DATA WAS AVAILABLE AND EASILY OBTAINABLE.

WEIGHTED DRIVER VALUES HAVE BEEN COMPUTED FOR 1976-80.

MANHOURS HAVE BEEN RELATED TO THESE DRIVERS.

MAINTENANCE SUPPORT ANALYSIS

REQUIRED DATA IS HARD TO EXTRACT FOR MAINTENANCE SUPPORT DRIVERS.

CERCOM TO WRITE UTILITY PROGRAM FOR EXTRACTION. EFFORT HAS LAGGED.

MANHOURS EXPENDED THRU 76-78 OBTAINED.

C-3

CAVEATS

- HISTORICAL EXPENDITURE OF RESOURCES DOES NOT NECESSARILY REFLECT NEED.
- HISTORICAL ALLOCATION OF RESOURCES WAS NOT NECESSARILY RATIONAL.

HISTORICAL REGRESSION, ESPECIALLY AGAINST NON-CAUSAL, NON-EXTERNAL DRIVERS IS PARTICULARLY SUSPECT.

IN OUR CONCEPT, HISTORICAL DRIVER VALUES RELATE TO <u>NEEDED</u> MANHOURS.

MATERIAL MANAGEMENT DRIVERS

AMS CODE	DESCRIPTION	DRIVERS	SYMBOL
721112.111	COMMODITY MANAGEMENT	EST. MAJOR ITEMS	E1
		EST. SECONDARY ITEMS WGTED	$E2^W$
.112	SUPPLY TECH ASSISTANCE		E1
.12	REQUIREMENTS COMPUTATION		E1
			$E2^W$
.20	LOGISTICS DATA MGT. (CATALOGING)	WEIGHTED SUM OF ESTABLISHED & NEW ITEMS	$(E1 + E2) W_0 + W_1 N1 + W_2 N2$
.41	REQUISITION PROCESSING	DEMANDS RECEIVED	D
.42	INVENTORY ACCOUNTING & STOCK CONTROL	STOCKED NSNS	$E1 + E2 - \bar{\bar{E}}$
.13	INTERSERVICE (IL)	PENDING	$E1, E2^W$?

WEIGHTS FOR $E2^W$

- TIME SPENT WHEN RESOURCES CONSTRAINED

	MH/ITEM (76)	MH/ITEM (77)
VHDV	365	372
HDV	120	120
MDV	8.25	10.6
LDV	.96	.7

- TIME SPENT AS NEEDED (BASED ON OROSS 2000)

	MH/ITEM	SUGGESTED WGTS		"NEEDED" MH/ITEM
VHDV	415	375	> 1.25	412.5
HDV	356	300	> 12	330
MDV	26.7	25		27.5
LDV	1.13	1		1.1

C-6

.12 ANALYSIS SUMMARY

(REQUIREMENT COMPUTATION)

MAJOR

MANHOURS SPENT ON MAJOR ITEMS/E1 = 25.43

"TRACKS" WELL, I.E. ABOVE RATIO IS CONSISTENT

HENCE ASSUME REPRESENTS NEED

SECONDARY

ACTUAL MANHOURS DID NOT REPRESENT NEED, SO DOES NOT TRACK $E2^W$

SEE UPCOMING CHART ON $E2^W$ AND PROJECTED MANHOURS BY YEAR

C-7

.11 ANALYSIS SUMMARY

(COMMODITY MANAGEMENT)

.111 MAJOR

MANHOURS ON MAJOR ITEMS/E1 = 18.66 "TRACKS" WELL

.111 SECONDARY

AGAIN PAST MANHOURS DID NOT NECESSARILY REPRESENT NEED SO DOES NOT TRACK $E2^W$

SEE FOLLOWING CHART

.112 COMMODITY MGT - SUPPLY TECH ASSISTANCE

MANHOUR VS E1 "TRACKS" WELL (RATIO VARIES BETWEEN 9.2 and 8.9)

$E2^W$ AND MANHOURS AND PROJECTIONS BY YEAR

	76	77	78	79	80
$E2^W$	720823	370461	426770		
			1.152	1.017	1.051
ACTUAL MH (.12)	395724	425986	406282	439680*	439680*
NEEDED MH ($E2^W$ X 1.1)	792905	407507	469447	477427	501776
				1.017	1.051
ACTUAL MH (.111)	174646	154557	144538	156015*	156015*

HAVE NO IDEA OF NEED SO PICK ONE YEAR AS BASELINE AND PROJECT USING % INCREASES IN $E2^W$ I.E.

154557 X 1.152 X 1.017 X 1.051

*ECOM FORECASTS

.20 ANALYSIS SUMMARY

(CATALOGING)

MANHOUR CATALOGING ESTABLISHED MAJOR ITEMS/E1 = 1.56

MANHOUR CATALOGING ESTABLISHED SECONDARY ITEMS/E2 = 1.50

USING ABOVE RESULTS AND KNOWN CATALOGING HOURS FOR 76-77:

MANHOUR CATALOGING NEW MAJOR ITEMS/N1 = 37.65

MANHOUR CATALOGING NEW SECONDARY ITEMS/N2 = 11.65

1978:

% MH ON NEW ITEMS SAMPLED	% MH ON NEW ITEMS PROJECTED FROM WGTS
22%	20%

PROJECTED HOURS VS ACTUAL HOURS DIFFERED BY 7.5%

C-12

.41 ANALYSIS SUMMARY

(REQUISITION PROCESSING)

MH/MANUAL REQUISITIONS = 1.185
MH/DEMANDS RECEIVED = .3955
} TRACK WELL EXCEPT 1976

.42 ANALYSIS SUMMARY

(INVENTORY ACCTNG & STOCK CONTROL)

	1976	1977	1978
ACTUAL MH/STOCKED NSNs	3.77	3.12	3.03

BASED ON ANALYSIS OF QUARTERLY REPORTS IN 1977, NEED SEEMS TO BE RATIO 3.09

BOTTOM LINE (EXCLUDING .13)

	MH	1976	1977	1978	1979	1980
.111	ECOM (SECONDARY)	174646	154557	144538	156015	156015
	IRO		154557	178049	181076	190311
	ECOM (MAJOR)	136667	134875	133526	145885	145885
	IRO: E1 X 18.66	138793	132318	134053	143682	144615
.112	ECOM	68195		63637	68890	68890
	IRO: E1 X 9	66942	63819	64656	69300	69750
.12	ECOM (SECONDARY)	395724	425986	406282	439680	439680
	IRO	792905	407507	469447	477427	501776
	ECOM (MAJOR)	186223	183436	181785	196539	196539
	IRO: E1 X 25.43	189167	180342	182707	195830	197102
.20	ECOM	192453	206194	197275	212748	212748
	IRO: (E1 + E2) X 1.5 + N1 X 37.65 + N2 X 11.65	192453	206194	182141	191947	223300
.4	ECOM	490576	382750	368244	397130	397130
	IRO: DX.3955 + (E1+E2) X 3.09	386230	386727	366795	379403	385329
	ECOM				1,616,887	1,616,887
	IRO				1,638,665	1,712,183

CONCLUSIONS

- IRO DRIVER ANALYSIS CAN PROJECT CERCOM MATERIAL MANAGEMENT MANHOUR NEED USING FORECASTED DRIVER VALUES - FROM RATIOS AND WEIGHTS OR FROM A BASELINE YEAR.
- EXTENDABLE TO DOLLAR RESOURCE REQUIREMENTS.
- EXTENDABLE TO OTHER COMMANDS WITH PROPER GUIDANCE.
- CURRENT INADEQUACIES OF MAINTENANCE SUPPORT DATA BASE, TIGHT PERSONNEL RESOURCES AND LARGE NUMBER OF END ITEMS ARE CAUSING PROBLEMS.
- TEST OF DRIVER CONCEPT IN MAINTENANCE SUPPORT AT ANOTHER COMMAND MAY BE ADVISABLE.

PILOT TEST OF DRIVER CONCEPT FOR RESOURCE REQUIREMENTS PROJECTIONS

IRO PROJECT 271

IPR TO DRCDRM

MAY 1979

C - ; 4

PURPOSE OF BRIEFING

- SUMMARIZE IRO DRIVER CONCEPT
- EXPLAIN PROCEDURE FOR OBTAINING DRIVERS FOR CERCOM MAINTENANCE DIRECTORATE (PRE-ISSUE)
- PRESENT RELATIONS AMONG DRIVER VALUES, NEEDED RESOURCES AND EXPENDED RESOURCES
- DISCUSS USEFULNESS OF DRIVERS AS A TOOL IN FORECASTING AND MANAGING RESOURCES IN CERCOM MAINTENANCE DIRECTORATE

C-15

OBJECTIVES

(WITH CERCOM AS TEST COMMAND)

- ASSESS THE AVAILABILITY OF TYPICAL DATA NECESSARY TO COMPUTE DRIVERS AND DETERMINE THE DIFFICULTY IN EXTRACTING DATA.
- COMPUTE DRIVERS FOR RECENT YEARS AND RELATE TO ACTUAL RESOURCES EXPENDED AND RESOURCES THAT WERE NEEDED.

    MATERIAL MGT DIRECTORATE (AMS CODE 721112)

    MAINTENANCE SUPPORT DIRECTORATE (AMS CODE 738017)

C-17

WHAT A DRIVER IS

A DRIVER IS A STIMULUS FOR WORKLOAD WHICH HAS THESE ATTRIBUTES:

(1) IT IS QUANTIFIABLE

(2) ITS QUANTITATIVE VALUE FOR FUTURE YEARS CAN BE PROJECTED

(3) ITS VALUE DEPENDS ON DA/DoD DECISIONS AND NOT MSC FUNCTIONAL DIRECTORATE DECISIONS

(4) IT ACCOUNTS FOR A SIGNIFICANT AMOUNT OF RESOURCES

(A) BY DIRECT CAUSE AND EFFECT

(B) STOCHASTICALLY

C-18

WHAT A DRIVER ISN'T

- IT IS NOT A WORK MEASUREMENT (AN INPUT NOT AN OUTPUT)

  SUCH AS NUMBER OF PAGES OF MANUALS PUBLISHED

  INEFFICIENCY OF COMMAND MAY PRODUCE UNNECESSARY WORK WHICH DISTORTS VALUE OF THESE MEASURES

- IT IS NOT A VARIABLE IDENTIFIED PURELY BY STATISTICAL METHODS TO BE RELATED TO REQUIREMENTS

  E.G.: NUMBER OF DEMANDS RECEIVED MAY CORRELATE WITH MH IN MAINTENANCE SUPPORT BUT IS NOT A DIRECT LOGICAL STIMULUS TO WORK LIKE NUMBER OF DIFFERENT EQUIPMENTS BEING MAINTAINED

STATUS

MATERIAL MANAGEMENT ANALYSIS

SUFFICIENT DATA WAS AVAILABLE AND EASILY OBTAINABLE.

WEIGHTED DRIVER VALUES HAVE BEEN COMPUTED FOR 1976-80.

MANHOURS HAVE BEEN RELATED TO THESE DRIVERS.

MAINTENANCE SUPPORT ANALYSIS

PRE ISSUE:

- REQUIRED DATA FOR DRIVERS WAS HARD TO EXTRACT INITIALLY
- WILL BE EASIER IN FUTURE WITH CERCOM'S PROGRAMS WRITTEN FOR THIS PROJECT AND WITH IRO'S CURRENT TABULATION.
- MANHOURS HAVE BEEN RELATED TO DRIVERS FOR P3 ACCOUNT AND CAN BE FOR Q7 ACCOUNT.

FIELD:

- COUNT OF FIELDED SYSTEMS BY COMPLEXITY AND AGE NOT CURRENTLY FEASIBLE

CAVEATS

HISTORICAL EXPENDITURE OF RESOURCES DOES NOT NECESSARILY REFLECT NEED.

HISTORICAL ALLOCATION OF RESOURCES WAS NOT NECESSARILY RATIONAL.

HISTORICAL REGRESSION, ESPECIALLY AGAINST NON-CAUSAL, NON-EXTERNAL DRIVERS, IS PARTICULARLY SUSPECT.

IN OUR CONCEPT, HISTORICAL DRIVER VALUES RELATE TO NEEDED MANHOURS.

C-2?

MAINTENANCE SUPPORT DRIVERS

MH	$	AMS CODE	DESCRIPTION	DRIVERS	SYMBOL
		738017.000 P1(P2)	PROGRAM DEVELOPMENT	STAFF	
✓	✓	P3(P4)	MAINT ENGINEERING (PRE-ISSUE)	NUMBER OF PRE-ISSUE END ITEMS [redacted] IN YEAR WEIGHTED BY WORKLOAD PROFILE IN THAT YEAR (DEPENDS ON COMPLEXITY & PHASE)	PI
✓	✓	Q1(Q2)	MAINT ENGINEERING (FIELD)	NUMBER OF FIELDED END ITEMS IN YEAR WEIGHTED BY COMPLEXITY AND AGE	F
		Q3(Q4)	OTHER ENGINEERING & ANALYSIS		F, (PI)
✓	✓	Q5(Q6)	TECH ASSISTANCE		F
	✓	Q7(Q8)	ENGINEERING FOR PIP's	SIMILAR TO PI, COUNTING ONLY END ITEMS UNDERGOING PRODUCT IMPROVEMENTS	PI*
✓	✓	R1(R2)	PUBLICATIONS		F, PI, PI*
		S1 } S4 }	NET		

METHODOLOGY TO OBTAIN PI

- PRE-ISSUE SYSTEMS SAMPLED TO ESTABLISH COMPLEXITY CLASSES (BY LINE ITEM COUNT)
- FORMULAS FOR NEEDED WORK (INVOLVING LINE ITEM COUNTS AND PUB. PAGES) APPLIED TO SAMPLED SYSTEMS TO ESTABLISH NORMATIVE WORKLOAD VALUES (WEIGHTS) BY COMPLEXITY CLASSES AND PHASES OF DEVELOPMENT.
- "SNAPSHOT" TAKEN OF ALL PRE-ISSUE SYSTEMS (CIRCA 78-79) AND CATALOGUED BY COMPLEXITY, CURRENT DEVELOPMENT PHASE, AND SPAN OF YEARS IN PRE-ISSUE.
- VIRTUAL (UNSEEN SYSTEMS) SYSTEMS ESTABLISHED FOR PAST YEARS AND FUTURE YEARS.
- WORKLOAD PROFILES OVER A SYSTEM'S SPAN OF YEARS ESTABLISHED BASED ON ITS COMPLEXITY CLASS.
- FOR EACH YEAR 75-84, YEARLY SEGMENTS OF EACH UNIQUE PROFILE ARE WEIGHTED BY NUMBER OF SYSTEMS HAVING THAT PROFILE.

DETAILS

NEEDED MH BY COMPLEXITY CLASS AND DEVELOPMENT PHASE *

LINE ITEM BOUND	ADV MH	EDV MH	LRIP & PDN MH
100	231	1388	1345
400	237	1503	1454
1600	269	1734	1725
6400	380	2614	2703
20000	797	5998	6523
60000	1819	13295	14121
> 60000	4101	31052	36987

* ON THIS & SUBSEQUENT CHARTS, ASTERISKS INDICATE ASPECTS OF THIS TECHNIQUE WHICH COULD BE REFINED BY EXPERTS AT CERCOM

<u>FACTS FROM SNAPSHOT OF CATALOG OF END ITEMS</u>

A. 385 END ITEMS WITH "COMPLETE" DATA

CLASS	1600	6400	20000	60000	> 60000
NUMBER	280	74	26	2	3
AVG SPAN	4.3	3.81	4.19	4.5	4.5

B. 289 END ITEMS WITH INCOMPLETE DATA. FOR MOST PART THESE ARE SYSTEMS IN ADV PHASE RECENTLY ENTERED AND WITH LI COUNTS UNESTABLISHED.

C. 215 END ITEMS "ENTERED" IN 77-78

219 END ITEMS "LEFT" (FIELDED) IN 78-79.

* D. RELATIVE PERCENTAGE LENGTHS OF TIME IN EACH PHASE:

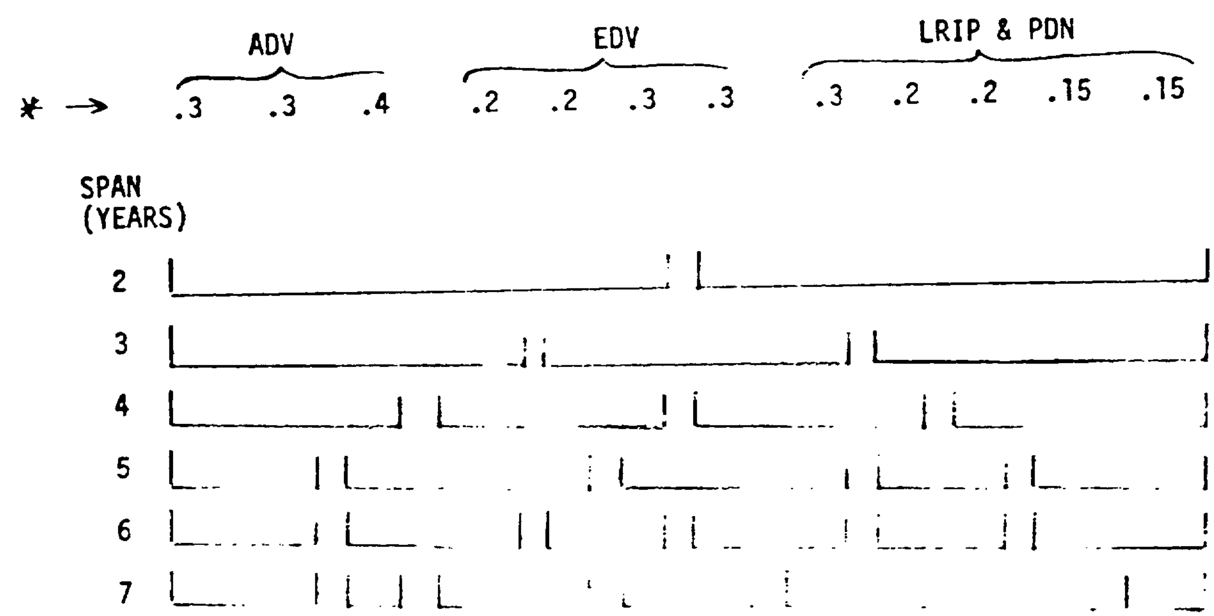
ADV	EDV	LRIP	PDN
3/12	4/12	1/12	4/12
25%	33.3%	8.4%	33.3%

C-24

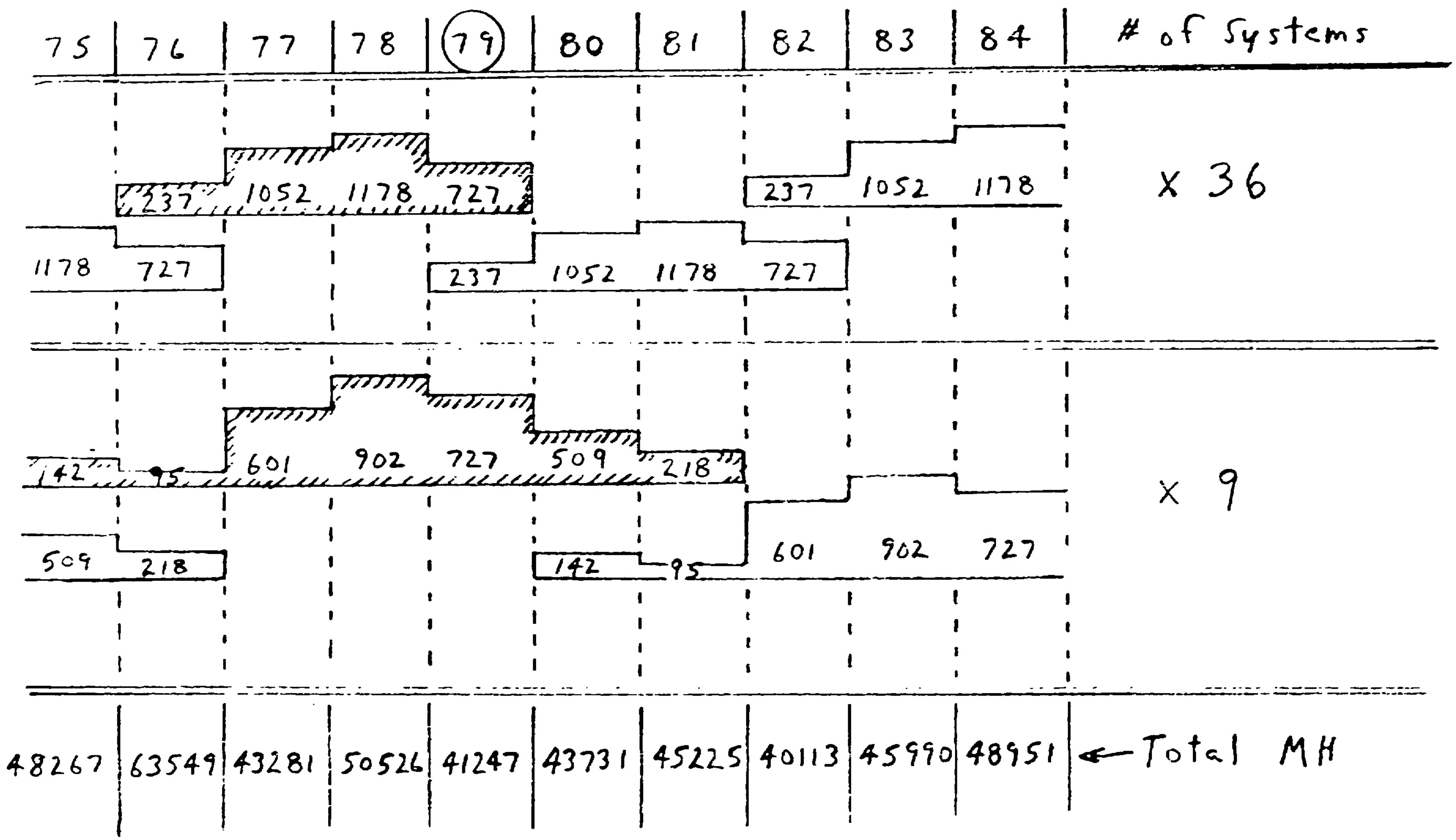
USE OF FACTS

FROM C., FOR EACH SYSTEM LEAVING, THERE IS ONE ENTERING WITH THE SAME WORKLOAD PROFILE (WITH SOME OVERLAP). THIS "NONE GROWTH" ASSUMPTION CAN BE RELAXED LATER TO ADJUST FINAL RESULTS. FOR SOME FUTURE, LOW PERCENTAGE GROWTH (* OR KNOWN LARGE SYSTEMS)

ALLOCATION OF PHASE LENGTHS FOR VARIOUS SPANS OF YEARS:



Example of Tabulation of Workload Profiles



BOTTOM LINE PI VS. P3 ACCOUNT

	76	77	78	79	80	81
a. PI	525419	517568	588269	546568	496542	560925
b. PI' (excluding > 20000 LI)	439859	440183	534315	486821	410982	483540
c. MH: P3	226045	221786	272649			
d. $: P3	2.74M	2.95M	3.41M			
c/a	.430	.429	.465			
c/b	.514	.504	.510			
a-c	299374	295782	315620			
d/a	5.21	5.70	5.80			
d/b	6.23	6.70	6.38			

CONCLUSIONS

IRO DRIVER ANALYSIS CAN PROJECT CERCOM MAINTENANCE SUPPORT MANHOUR NEED FOR PRE-ISSUE WORK USING FORECASTED PRE-ISSUE SYSTEMS WEIGHTED BY PROFILE OVER TIME.

PAST DRIVER VALUES OF PI FORM CONSISTENT RATIOS TO HISTORICAL MH AND DOLLARS. BOTH FUTURE NEEDS & LIKELY EXPENDITURES CAN BE FORECASTED FOR P3 ACCOUNT.

APPARENT GAP ($\sim$ 300000 MH) EXISTS BETWEEN NEEDED (BASED ON W.L. FORMULAE) AND USED MH. BACKLOG OR QUALITY EFFECT?

ANALYSIS CAN BE EXTENDED TO Q7 (PIP) ACCOUNT WITH SPECIFIC ENUMERATION OF PIP's WEIGHTED BY FOREGOING METHOD.

EVEN IF ONLY A ROUGH COUNT OF FIELDED SYSTEMS AND AGE DISTRIBUTIONS CAN BE OBTAINED, AN ANALOGOUS METHOD MAY OBTAIN IMPROVED FORECASTS FOR OTHER 738017 CODES.

C-28

BIBLIOGRAPHY

1 Kaplan & Orr, "Methodology for Projection of Resource Requirements," IRO Final Report #207, November 1973, AD771049.

DISTRIBUTION

COPIES	
1	Deputy Under Sec'y of the Army, ATTN: Office of Op Resch
	Headquarters, US Army Materiel Development & Readiness Command
1	DRCPA-S
1	DRCDRM
1	DRCPS
1	DRCPS-P, ATTN: Ms. Lamb
1	DRCMM-R
1	DRCMM-M
1	DRCRE
1	DRCCP
1	DRCPP
1	DRCDE
1	DRCQA
	Commander, USA Armament Materiel Readiness Cmd, Rock Island, IL 61201
1	ATTN: DRSAR-MM
1	ATTN: DRSAR-SA
	Commander, USA Communications & Electronics Materiel Readiness Cmd, Ft. Monmouth, NJ 07703
1	ATTN: DRSEL-MM
1	ATTN: DRSEL-SA
	Commander, USA Missile Command, Redstone Arsenal, AL 35809
1	ATTN: DRSMI-S
1	ATTN: DRSMI-D
	Commander, USA Troop Support & Aviation Materiel Readiness Command, St. Louis, MO
1	ATTN: DRSTS-SP
1	ATTN: DRSTS-SPSS ______ DRSTS-BA(1)
	Commander, US Army Tank-Automotive Materiel Readiness Command, Warren, MI 48090
1	ATTN: DRSTA-F
1	ATTN: DRSTA-S
1	Commander, US Army Tank-Automotive Research & Development Command, ATTN: DRDTA-V, Warren, MI 48090
1	Commander, US Army Armament Research & Development Command, ATTN: DRDAR-SE, Dover, NJ 07801
1	Commander, US Army Aviation Research & Development Command, St. Louis, MO 63166
1	Commander, US Army Communications Research & Development Command, ATTN: DRSEL-SA, Ft. Monmouth, NJ 07703
1	Commander, US Army Electronics Research & Development Command, ATTN: DRDEL-AP, Adelphi, MD 20783
1	Commander, US Army Mobility Equipment Research & Development Cmd, ATTN: DRDME-O, Ft. Belvoir, VA 22060
1	Commander, US Army Natick Research & Development Command, ATTN: DRXNM-O, Natick, MA 01760
1	Commander, US Army Logistics Center, Ft. Lee, VA 23801
	Army Depot, New Cumberland, PA 17070

COPIES	
1	Commander, US Army Depot Systems Command, Chambersburg, PA 17201
1	Commander, US Air Force Logistics Cmd, WPAFB, ATTN: AFLC/XRS, Dayton, Ohio 45433
1	US Navy Fleet Materiel Support Office, Naval Support Depot, Mechanicsburg, PA 17055
1	Mr. James Prichard, Navy SEA Systems Cmd, ATTN: PMS 3061, Dept of US Navy, Wash., DC 20362
1	Air Force Institute of Technology, ATTN: SLGQ, Head Quantitative Studies Dept., Dayton, OH 43433
1	US Army Military Academy, West Point, NY 10996
1	Librarian, Logistics Mgt Inst., 4701 Sangamore Rd., Wash.,DC 20016
1	RAND Corp., ATTN: S. M. Drezner, 1700 Main St., Santa Monica, CA 90406
1	US Army Materiel Systems Analysis Activity, ATTN: DRXSY-CL, Aberdeen Proving Ground, MD 21005
1	Commander, USDRC Automated Logistics Mgt Systems Activity, P.O. Box 1578, St. Louis, MO 63188
1	Director, Army Management Engineering Training Agency, Rock Island Arsenal, Rock Island, IL 61202
1	Defense Logistics Agency, Cameron Sta, Alexandria, VA 22314
2	Defense Logistics Studies Info Exchange, DRXMC-D
10	Defense Documentation Center, Cameron Sta., Alexandria, VA 22314
1	Logistics Studies Office, DRXMC-LSO, ALMC, Ft. Lee, VA 23801
1	Procurement Research Office, DRXMC-PRO, ALMC, Ft. Lee, VA 23801
1	DARCOM Intern Training Center, Red River Army Depot, Texarkana, Tx 75501
1	US Army Training & Doctrine Command, Ft. Monroe, VA 23651
1	US Army Research Office, ATTN: Robert Launer, Math. Div., P.O. Box 12211, Research Triangle Park, NC 27709
1	US Army Materiel Systems Analysis Activity, ATTN: DRXSY-MP, Aberdeen Proving Ground, MD 21005
1	Air Force Logistics Management Center, ATT: AFLMC/LGY, Gunter Air Force Station, AL 36114
1	Engineer Studies Center, 6500 Brooks Lane, Wash., DC 20315
1	Commandant, ALMC, ATTN: Jon T. Miller, DAS, DRXMC-A, Ft. Lee, VA 23801