CANNIBALIZATION OF 5-TON TRUCKS

AUGUST 1977

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SYSTEMS ANALYSIS DIVISION, PLANS & ANALYSIS DIRECTORATE
U.S. ARMY TANK AUTOMOTIVE MATERIALS READINESS COMMAND

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Cannibalization of 5-Ton Trucks

Determine the shortage of 5-Ton Truck gas (R6602) and multifuel (LDS 465/1A) engines from June 1977 through September 1981. Estimate the cost of cannibalizing excess 5-Ton Trucks to obtain engines to fill these deficits.
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CANNIBALIZATION OF 5 TON TRUCKS

By

Reginald Joules
Systems Analysis Div
Plans & Analysis Directorate
FOREWORD

The author wishes to acknowledge the prompt assistance of Mr. Clarence Wheeler of Cost Analysis Division, Comptroller in costing the cannibalization schedules.
I. PURPOSE:

The purpose of this study is to determine the total deficits of 5 Ton Truck gas (R6602) and multifuel (LDS 465/1A) engines expected between June 1977 and September 1981, and estimating the cost of cannibalizing excess vehicles around the world to obtain engines to fill these deficits.

II. SCOPE:

The analysis considers only cannibalization of excess 5 Ton Trucks as a source of supply of engines. Other alternatives such as buying replacement engines, possible modification of some other engines for replacements, or early replacement of the fleet are not addressed.

III. BACKGROUND:

A. The shortage is created by the fact that new replacement engines available do not meet EPA clean air standards.

B. Other alternatives are being studied by other organizations.

C. In this study only one source of supply to meet the deficits is considered, namely, cannibalization.

D. The study establishes the total demand during the period from June 1977 through September 1981, based upon the following factors:

1. Given projections of monthly demands.

2. An overall pipeline demand that is equal to four times the average monthly demand.

3. Existing backorders.

E. The operational readiness is not considered as a factor in this study; it is assumed that all demands must be met, that no slack is allowed.

F. The basic data such as monthly demands, current stock of serviceable and unserviceable engines, vehicle washout rates, engine loss and washout rates, distribution of vehicles according to location, etc. were provided by the Tactical Vehicle Division.

G. The cannibalization schedules were costed by Cost Analysis Division, Comptroller Directorate.
IV. APPROACH:

A. Since the problems of gas and multifuel engines are similar but separate, compute the values separately, but use identical steps.

B. On a year-by-year basis, compute the deficits. Take into account existing backorders, pipeline requirements, monthly demands from the field, monthly returns from the field, loss of returnable engines in the field, loss due to washout, and available supply of serviceable and unserviceable engines. (Overview Flow Diagram (OFD), Function Block 1.0).

C. On a year-by-year basis, compute the number of excess vehicles that will be available for cannibalization by using the projected vehicle washout rates. Using the engine loss rates (loss in the field + loss at depot level), estimate the number of rebuildable engines that will be available from the excess vehicles. (OFD, Function Block 2.0).

D. Compare the yearly deficits to the number of rebuildables that will be available from the yearly excess lots. If the deficit during a given year is larger than the supply of rebuildables, the difference will have to be made up by the extras available from previous years. (OFD, Function Block 3.0).

E. Once the total cannibalization requirement for each year is determined, develop a breakdown of cannibalization based upon geographical location. Since the overall expenses for labor and transportation to depot (which is located in the U. S.) will be the cheapest in the U. S. and the most expensive in the Pacific, cannibalization should be maximized in the U. S. and minimized in the Pacific, with Europe handling the overflow from the U. S. Therefore, if there are not enough cannibalizable trucks in the U. S. during a given year, the supply in the U. S. during the previous years should be searched first before scheduling cannibalization in Europe, and in the Pacific. (OFD, Function Block 4.0).

F. Translate the requirements for rebuildable engines to the number trucks to be cannibalized. This is to allow for the losses described above while discussing availability. (OFD, Function Block 5.0).

G. Obtain cannibalization and shipping costs and calculate the total cost of this program.
STUDY APPROACH

OVERVIEW FLOW DIAGRAM

1.0

COMPUTE YEARLY DEFICITS

2.0

COMPUTE NUMBER OF REBUILDABLE ENGINES THAT MAY BE OBTAINED THROUGH CANNIBALIZATION

3.0

COMPUTE YEARLY REQUIREMENTS FOR REBUILDABLES (MAY OR MAY NOT CORRESPOND TO YEARLY DEFICITS)

4.0

COMPUTE AVAILABILITY OF REBUILDABLES WITH RESPECT TO TIME AND LOCATION

5.0

CONVERT REQUIREMENTS FOR REBUILDABLES TO CANNIBALIZATION REQUIREMENTS TO OBTAIN CANNIBALIZATION SCHEDULE

6.0

CONSULT COST ANALYSIS FOR COST
STUDY APPROACH
FUNCTION DIAGRAM 1.0

1.0

COMPUTE DEMANDS

CONSIDER
BACK ORDERS
PIPELINE REQUIREMENTS
MONTHLY DEMANDS 1.1

COMPUTE SUPPLY

CONSIDER
CURRENT STOCKS
RETURNS FROM FIELD 1.2

COMPUTE DEFICITS 1.3
STUDY APPROACH
FUNCTION DIAGRAM 2.0

COMPUTE YEARLY EXCESS VEHICLES 2.1

COMPUTE REBUILDABLES THAT WILL BE AVAILABLE FROM THESE EXCESS VEHICLES 2.2
STUDY APPROACH
FUNCTION DIAGRAM 3.0

Start at
(FY 1977)

Yes

Requirements Greater than Rebuildables Available?

No

Set Rebuildables needed = Rebuildables Available

Is This Starting Year (FY 77)?

Yes

Set Rebuildables needed = Rebuildables Available

No

Print Error Message

Compute Shortage

Add this shortage to previous year’s requirements:

Do previous year’s Calculation again

Is the year under consideration Final Year (FY81)?

Yes

Study
Next Year

No

Exit
STUDY APPROACH

FUNCTION DIAGRAM 4.0

1. Compute available rebuildables with respect to year for U.S., Europe and Pacific

2. Compute rebuildables needed from U.S. every year (use 4.2.1)

3. Compute rebuildables needed from Europe every year (use 4.2.1)

4. Compute rebuildables needed from Pacific every year (use 4.2.1)
STUDY APPROACH
FUNCTION DIAGRAM 4.2.1

Start at FY 1977

Requirements Greater than Rebuildables Available?

Yes
Set Rebuilds Needed = Rebuilds Available
Compute Shortage

No
Set Rebuilds Needed = Requirements

Is This FY 77?
Yes
Set Requirement for This Year at Next Location = Shortage

No
Add Shortage to Previous Year's requirements at this location; Calculate again for previous year

Is The Year Under Consideration FY 81?
Yes
No
Study Next Year

Exit
V. ASSUMPTIONS

A. Starting deficit (deficit at end of FY76) is assumed to be zero for both categories.

B. Pipeline demand, numerically equal to four times the monthly demand, is to be met in FY77. Therefore, there will be no pipeline demands in the following years, as long as there is constant flow.

C. Since no gas vehicle washout rate is available for FY81, the rate is assumed to be zero.

D. The vehicle washout rate and engine loss rate will be uniform in U.S., Europe and the Pacific areas.

E. Engine loss rate is constant during the period under consideration (June 1977 - September 1981).

F. Distribution of vehicles over the three areas remains constant during the period under consideration (gas trucks: 85% in U.S., 13% in Europe, 2% in the Pacific; multifuel trucks: 67% in U.S., 24% in Europe, 9% in the Pacific).

VI. DISCUSSION

Deficits:

Tables 1 and 2 show the yearly supply, yearly and cumulative demand and cumulative deficits by considering the factors discussed in Approach. These tables clearly illustrate the problem.

A negative deficit during a given year in effect decreases the total demand for the following year.

DEMAND is the sum of total demand from the field over the year, pipeline demands (if any), back orders (if any), and previous deficits.

SUPPLY is the sum of net returns of unserviceables (through rotation, after losses), serviceable stock (if any), and unserviceable stock (if any).

DEFICIT = DEMAND - SUPPLY
### TABLE 1. CUMULATIVE DEFICITS OF GASOLINE ENGINES

<table>
<thead>
<tr>
<th>FY</th>
<th>YEARLY DEMAND</th>
<th>CUMULATIVE DEMAND</th>
<th>YEARLY SUPPLY</th>
<th>CUMULATIVE DEFICIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>77 (May - Sep)</td>
<td>762</td>
<td>762</td>
<td>845</td>
<td>-83</td>
</tr>
<tr>
<td>78</td>
<td>468</td>
<td>385</td>
<td>316</td>
<td>69</td>
</tr>
<tr>
<td>79</td>
<td>468</td>
<td>537</td>
<td>316</td>
<td>221</td>
</tr>
<tr>
<td>80</td>
<td>468</td>
<td>689</td>
<td>316</td>
<td>373</td>
</tr>
<tr>
<td>81</td>
<td>468</td>
<td>841</td>
<td>316</td>
<td>525*</td>
</tr>
</tbody>
</table>

*Total deficit is 525

Basic Input Data used for developing this Table:

Net monthly unserviceables through rotation after losses (10% field loss and 25% washout) is

\[ 39 \times (1 - 0.1) \times (1 - 0.25) \approx 26 \]

Serviceable stock on hand as of May 31, 77 is 222.

Unserviceables on hand after washout is 691 \times (1 - 0.25) \approx 518

Backorders as of May 31 = 450

Pipeline demands = 4 \times 39 = 156
### TABLE 2. CUMULATIVE DEFICITS OF MULTIFUEL ENGINES

<table>
<thead>
<tr>
<th>FY</th>
<th>YEARLY DEMAND</th>
<th>CUMULATIVE DEMAND</th>
<th>YEARLY SUPPLY</th>
<th>CUMULATIVE DEFICIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>77 (May - Sep)</td>
<td>1266</td>
<td>1266</td>
<td>1304</td>
<td>-38</td>
</tr>
<tr>
<td>78</td>
<td>1404</td>
<td>1366</td>
<td>884</td>
<td>482</td>
</tr>
<tr>
<td>79</td>
<td>1404</td>
<td>1885</td>
<td>884</td>
<td>1001</td>
</tr>
<tr>
<td>80</td>
<td>1404</td>
<td>2405</td>
<td>884</td>
<td>1521</td>
</tr>
<tr>
<td>81</td>
<td>1403</td>
<td>2924</td>
<td>884</td>
<td>2040*</td>
</tr>
</tbody>
</table>

*Total deficit is 2040

Basic Input Data used for developing this Table:

Net monthly unserviceables through rotation after losses (10% field loss and 30% washout) is

\[
117 \times (1 - 0.1) \times (1 - 0.3) = 74
\]

Serviceable stock on hand as of May 31, 77 is 153.

Unserviceables on hand after washout is

\[
1233 \times (1 - 0.3) = 856
\]

Back orders as of May 31 = 330

Pipeline demands = 4 \times 117 = 468

### B. Availability of Rebuildables through Cannibalization:

Tables 3 and 4 show the number of trucks that will be available for cannibalization based upon vehicle washout rates, and the rebuildable engines that can be obtained from these excess vehicles after allowing for normal losses.

\[
\text{Total strength} = \text{Total Strength for previous year} \times \left(1 - \frac{\text{Vehicles washout rate for previous year}}{\text{Vehicle washout rate for that year}}\right)
\]

\[
\text{Trucks available for cannibalization during a given year} = \text{Total strength for the year} \times \left(1 - \frac{\text{field loss rate}}{\text{washout rate at depot}}\right)
\]
TABLE 3. AVAILABILITY OF REBUILDABLE GASOLINE ENGINES

<table>
<thead>
<tr>
<th>FY</th>
<th>Total Strength</th>
<th>Vehicle Washout Rate</th>
<th>Trucks Available for Cannib.</th>
<th>Engine Loss Rate</th>
<th>Rebuildable Engines Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>6752</td>
<td>0.13</td>
<td>879</td>
<td>0.325</td>
<td>592</td>
</tr>
<tr>
<td>78</td>
<td>5874</td>
<td>0.02</td>
<td>117</td>
<td>0.325</td>
<td>79</td>
</tr>
<tr>
<td>79</td>
<td>5757</td>
<td>0.02</td>
<td>115</td>
<td>0.325</td>
<td>78</td>
</tr>
<tr>
<td>80</td>
<td>5642</td>
<td>0.15</td>
<td>846</td>
<td>0.325</td>
<td>571</td>
</tr>
<tr>
<td>81</td>
<td>4796</td>
<td>0.02</td>
<td>0</td>
<td>0.325</td>
<td>0</td>
</tr>
</tbody>
</table>

TABLE 4. AVAILABILITY OF REBUILDABLE MULTIFUEL ENGINES

<table>
<thead>
<tr>
<th>FY</th>
<th>Total Strength</th>
<th>Vehicle Washout Rate</th>
<th>Trucks Available for Cannib.</th>
<th>Engine Loss Rate</th>
<th>Rebuildable Engines Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>9792</td>
<td>0.02</td>
<td>166</td>
<td>0.37</td>
<td>105</td>
</tr>
<tr>
<td>78</td>
<td>8157</td>
<td>0.02</td>
<td>163</td>
<td>0.37</td>
<td>103</td>
</tr>
<tr>
<td>79</td>
<td>7994</td>
<td>0.02</td>
<td>160</td>
<td>0.37</td>
<td>101</td>
</tr>
<tr>
<td>80</td>
<td>7834</td>
<td>0.02</td>
<td>157</td>
<td>0.37</td>
<td>99</td>
</tr>
<tr>
<td>81</td>
<td>7677</td>
<td>0.02</td>
<td>154</td>
<td>0.37</td>
<td>97</td>
</tr>
</tbody>
</table>

C. Deficits vs Availables:

The yearly deficits shown in Tables 1 and 2 are cumulative since they are intended to show the deficits if no action is taken to curb the shortage. Tables 5 and 6 compare the yearly shortages and the rebuildable engines that could be obtained through cannibalization. The last columns show the yearly deficits after cannibalization.

As mentioned earlier if the shortages during a given year is greater than the number of rebuildables available from cannibalization, excess rebuildables available from previous years should be used to cover the difference. The fourth columns in Tables 5 and 6 show the number of rebuildables that should be made available each year.
### TABLE 5. DEFICITS VERSUS AVAILABLES OF GASOLINE ENGINES

<table>
<thead>
<tr>
<th>FY</th>
<th>Shortages</th>
<th>Rebuildables From Cannibalization</th>
<th>Rebuildables Needed</th>
<th>Deficits After Cannibalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>0</td>
<td>592</td>
<td>64</td>
<td>0</td>
</tr>
<tr>
<td>78</td>
<td>69</td>
<td>78</td>
<td>78</td>
<td>0</td>
</tr>
<tr>
<td>79</td>
<td>152</td>
<td>79</td>
<td>79</td>
<td>0</td>
</tr>
<tr>
<td>80</td>
<td>152</td>
<td>571</td>
<td>304</td>
<td>0</td>
</tr>
<tr>
<td>81</td>
<td>152</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>525</td>
<td>525</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Note that there will be a shortage of 152 engines in FY81, but no trucks will be available for cannibalization. Therefore, 304 rebuildables should be made available in FY80 (even though the shortage in FY80 will be only 152) to cover the shortage in FY81.

Similarly, though there will be no shortage in FY77, 64 rebuildables should be made available in FY77 to cover the shortage in FY79.

### TABLE 6. DEFICITS VERSUS AVAILABLES OF MULTIFUEL ENGINES

<table>
<thead>
<tr>
<th>FY</th>
<th>Shortages</th>
<th>Rebuildables From Cannibalization</th>
<th>Rebuildables Needed (From Availables)</th>
<th>Deficits After Cannibalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>0</td>
<td>105</td>
<td>105</td>
<td>0</td>
</tr>
<tr>
<td>78</td>
<td>482</td>
<td>103</td>
<td>103</td>
<td>274</td>
</tr>
<tr>
<td>79</td>
<td>519</td>
<td>101</td>
<td>101</td>
<td>418</td>
</tr>
<tr>
<td>80</td>
<td>520</td>
<td>99</td>
<td>99</td>
<td>421</td>
</tr>
<tr>
<td>81</td>
<td>519</td>
<td>97</td>
<td>97</td>
<td>422</td>
</tr>
<tr>
<td>Totals</td>
<td>2040</td>
<td>505</td>
<td>1535*</td>
<td></td>
</tr>
</tbody>
</table>

*Note that even if all available excess multifuel trucks are cannibalized, the shortage cannot be met.*
D. Source Breakdown in Terms of Year and Location:

Tables 7 and 8 show from where required rebuildables will be obtained.

TABLE 7. SOURCE BREAKDOWN IN TERMS OF YEAR AND LOCATION FOR GASOLINE ENGINES

<table>
<thead>
<tr>
<th>FY</th>
<th>Total</th>
<th>U.S.</th>
<th>EUR</th>
<th>PAC</th>
<th>Number of Rebuildables Needed (From Available)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>100%</td>
<td>85%</td>
<td>13%</td>
<td>2%</td>
</tr>
<tr>
<td>77</td>
<td>592</td>
<td>503</td>
<td>77</td>
<td>12</td>
<td>88</td>
</tr>
<tr>
<td>78</td>
<td>78</td>
<td>66</td>
<td>10</td>
<td>2</td>
<td>66</td>
</tr>
<tr>
<td>79</td>
<td>79</td>
<td>67</td>
<td>10</td>
<td>2</td>
<td>67</td>
</tr>
<tr>
<td>80</td>
<td>571</td>
<td>485</td>
<td>74</td>
<td>11</td>
<td>304</td>
</tr>
<tr>
<td>81</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Since 79 rebuildables will not be available in the U.S. during FY 78, the balance necessary should be obtained from supplies in the U.S. during previous years. Since there is a potential of 503 rebuildables in the U.S. during FY77, the balance should be drawn from this supply. The total requirement for U.S. is changed from the original 64 to 76. The total is also changed from 64 to 76 (but these changes are not shown on Table 7).

Similarly, in FY78 only 67 rebuildables will be available in the U.S. through cannibalization. Since a total of 79 is needed, attempt should be made to obtain the remaining 12 from the supplies in the U.S. during previous years before going to the supplies in Europe and Pacific during FY 79. A search for the supplies in U.S. during previous years shows that U.S. will have sufficient supply in FY77, to cover this difference. The requirement from U.S. for FY77 is again changed from 76 to 88, with a similar change in total requirement for FY77 (these final figures are shown on Table 7).
TABLE 8. SOURCE BREAK DOWN IN TERMS OF YEAR AND LOCATION FOR MULTIFUEL ENGINES

<table>
<thead>
<tr>
<th>FY</th>
<th>Potential Rebuildables</th>
<th>Number of Rebuildables Needed (From Availables)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total 100%</td>
<td>U.S. 67%</td>
</tr>
<tr>
<td></td>
<td>77</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>78</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>79</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>81</td>
<td>97</td>
</tr>
</tbody>
</table>

E. Conversion:

Tables 7 and 8 show a breakdown of rebuildable engines needed in terms of year and location. However, in order to determine how many vehicles are to be cannibalized, it is necessary to take into account the losses in field and at depot level.

The loss rates for gas and multifuel engines are 0.325 and 0.37 respectively. Thus, for example, if 100 gas rebuildables are needed, it will be necessary to cannibalize, as a rule,

$$100 \div (1 - 0.325) = 148 \text{ vehicles.}$$

Tables 9 and 10 show actual cannibalization requirements in terms of time and location.
### TABLE 9. CANNIBALIZATION SCHEDULE FOR EXCESS GAS TRUCKS

Distribution of Cannibalization Requirements

<table>
<thead>
<tr>
<th>FY</th>
<th>U.S.</th>
<th>Europe</th>
<th>Pacific</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>130</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>78</td>
<td>99</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>79</td>
<td>98</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>80</td>
<td>450</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>81</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### TABLE 10. CANNIBALIZATION SCHEDULE FOR EXCESS MULTIFUEL TRUCKS

Distribution of Cannibalization Requirements

<table>
<thead>
<tr>
<th>FY</th>
<th>U.S.</th>
<th>Europe</th>
<th>Pacific</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>112</td>
<td>40</td>
<td>15</td>
</tr>
<tr>
<td>78</td>
<td>110</td>
<td>39</td>
<td>15</td>
</tr>
<tr>
<td>79</td>
<td>107</td>
<td>38</td>
<td>15</td>
</tr>
<tr>
<td>80</td>
<td>105</td>
<td>38</td>
<td>15</td>
</tr>
<tr>
<td>81</td>
<td>103</td>
<td>37</td>
<td>15</td>
</tr>
</tbody>
</table>

### F. Cannibalization Costs:

The costs for cannibalization involve three factors.

1. Removal of engines from washed out vehicles
2. Preparation of engines for shipment.
3. Transportation of engines to depot in the U.S.
Cost breakdowns for gas and multifuel trucks are shown in Tables 11 and 12. (Courtesy of Cost Analysis Div, Comptroller).

**TABLE 11 COST BREAKDOWN FOR CANNIBALIZATION OF GAS ENGINES**

<table>
<thead>
<tr>
<th>REMOVAL OF ENGINES FROM WASHED OUT VEHICLES: YEAR (FY)</th>
<th>U.S.</th>
<th>EUROPE</th>
<th>PACIFIC</th>
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Total cost for cannibalization of 777 gasoline engines = $201,833. Average unit cost = $259.76.
### Table 12: Cost Breakdown for Cannibalization of Multifuel Engines

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</table>

Total cost for cannibalization of 800 multifuel trucks = $276,452. Average unit cost = $345.57.
CONCLUSIONS

1. The shortage of 5 Ton Truck gasoline engines (R6602) can be successfully combated through cannibalization. However, cannibalization can solve only one fourth of the shortage as far as 5 Ton Truck multifuel engines (LDS 465/1A) are concerned, as shown on Table 5 of the report.

2. The costs associated with the computed cannibalization schedules are shown on Tables 11 and 12. The average unit costs for cannibalization of gas and multifuel engines are $259.76 and $345.57 respectively. The average unit cost is a function of the cannibalization schedule. Any change in the cannibalization schedules shown in Tables 9 and 10 will alter the unit costs due to escalation factors and location differentials.
1. In order to determine the cost-effectiveness of cannibalization, it is recommended that costs determined herein be compared to other possible alternatives.

2. The computer program inclosed with this study (Appendix) can be used to compute new cannibalization schedules and associated costs (as in Tables 9, 10, 11 and 12), if desired. Currently, the program output (sample inclosed) contains only the cannibalization requirements and matrices for the three cost factors shown on Tables 11 and 12. However, it is possible to modify the output routines to list more information.
Documentation for the inclosed computer program for calculating the cannibalization requirements for 5 Ton Trucks can be obtained on request from DRSTA-SA, USATARCOM, Warren, MI 48090

The source and object files as well as the absolute overlay for the loaded programs are stored on permanent files on the CDC 6600 Computer System at Picatinny Arsenal, Dover, N.J.
PROGRAM CONTROLS(GAS, MULTI, INPUT, OUTPUT, TAPE1=INPUT,
TAPE2=MULTI, TAPE3=INPUT, TAPE4=OUTPUT)

REAL NO
INTEGER RELDNS
DIMENSION MO(5), BO(5), SERU(5), UNSRU(5),
PIPE(5), OTH(5), VEHNOR(5), DISTR(3), YPLY(5),
DEF(5), CDEF(5), DEM(5), SUP(5), REQ(5), REBLDA(5),
REBLIN(5,3), YEXESS(5), RBLDA(5,3), RBLIN(5,3),
RBLDNS(5,3), BASECOST(3), TRANS(3)

COMMON /DEFICT/ROT, MO, SERU, UNSRU, BO, PIPE, OTH,
/REBLDA/CDEF, DEM, SUP, ROTG, YPLY
/REBLIN/PIPE, OTH, VEHNOR,
/YEXESS/REBLDA, ENGG
/REQMTS/
/REBLIN
/AVAILTL/DISTR,
/REBLDA
/AVAILTL/DISTR
/REBLIN
/CSCHED
/RBLDNS
/COST/BASECOST, TRANS

DATA REPT1, REPT2, 1H1, 2HNO/

111 CONTINUE
CALL ZEROS
CALL READER
CALL DEFICT
CALL REBLDA
CALL REQMTS(REBLDA, REBLIN, CDEF)
CALL AVAILTL(REBLDA, REBLIN)
CALL CSCHED(RBLIN, ENGG, RBLDNS)
CALL COST(RBLDNS)

C COST CALLS MATRICES
WRITE(6,1)
1 FORMAT(" ANOTHER RUN? (IN) OR 'NO' FOR NO ")
READ(5,2)REPT
2 FORMAT(A10)
IF(REPT.NE.REPT1.AND.REPT.NE.REPT2) GOTO 111
STOP
END
C***************************EOP
**EOF**

SUBROUTINE ZEROS
DIMENSION REBLIN(5,3)
COMMON /PELMNTS/REBLIN

111 I=1,15
REBLIN(I)=0.

111 CONTINUE
RETURN
END
C************

SUBROUTINE READER

INTEGER TAPE
REAL NO
LOGICAL RANDOM,TAPES
COMMON /DEFICT/ROT,NO(5),SERU(5),UNSRU(5),BO(5),
      PIPF(5),OTH(5),DEF(5),BDEF(5),DEN(5),SUP(5),
      POTG,YRLY(5),/REBILDS/CURSTR,ENGL,VEHWS(5),
      VESSES(5),REBDA(5),ENGG /REGNATS/REBLEN(5,3)
      /AVHITL/DISTR(3),REBDA(5,3) /REBINTL/
      /F&H(5,3),/CSCHFD/REBINS(5,3)
      /COST/BASECST(3),TRANSP(3)
      NAMELIST/NAMEALL/BO,PIPE,MO,OTH,SERU,UNSRU,ROT,
      UENG, ENGL, CURSTR, ENGL, BASECST, TRANSP

DATA REPT1,REPT2/1HN,2HN/
111 WRITE(6,1)
   1 FORMAT(" RANDOM READ?('N' OR 'NO' FOR NO)=")
   2 READ(5,2)REPT
   2 FORMAT(A10)
      RANDOM=.FALSE.
      IF (REPT.NE.REPT.AND.REPT.NE.REPT) RANDOM=.TRUE.
   3 WRITE(6,3)
   3 FORMAT(" TAPE(INTEGER)=? ")
   5 READ(5*)TAPE
   5 TAPE5=TAPE.EQ.5
   7 IF ((RANDOM.AND.TAPE5).OR.(.NOT.RANDOM.AND..NOT.TAPE5))
     L GOTO 122
   9 WRITE(6,4)RANDOM,TAPE
  11 FORMAT(" RANDOM=".'12'," NOT PERMITTED"/>
     13 GOTO 111
  122 IF (RANDOM) GOTO 133
     REWIND TAPE
     READ(TAPE,NAMEALL)
     GOTO 144
  133 WRITE(6,5)
  135 FORMAT(" ENTER VALUES INTO NAMELIST $NAMEALL")/
     REPT(TAPE,NAMEALL)
  144 RETURN
END
C************
C

SUBROUTINE DEFICT
REAL NO, MOPERYR
LOGICAL CDEFNEG
DIMENSION MO(5), SERU(5), UNSRU(5), SO(5), PIPE(5), OTH(5),
D, DEF(5), CDEF(5), DEM(5), SUP(5), YRLY(5), MOPERYR(5)
COMMON/DEFICT/ROTPI, MO, SERV, UNSRV, SO, PIPE, OTH,
C
DATA MOPERYR/4.0, 4*12.0/

C
DEFI=0.0
ROTG=1.0-ROTPI
DO 111 I=1, 5
YRLY(I)=MO(I)*MOPERYR(I)
RECOVER=YRLY(I)*ROTG
SUP(I)=SERU(I)+UNSRU(I)+RECOVER
DEM(I)=SO(I)+PIPE(I)+YRLY(I)+OTH(I)
DEF(I)=DEM(I)-SUP(I)
CDEF(I)=DEF(I)+DEFI
CDEFNEG=CDEF(I), LT. 0.0
DEFI=0.0
IF(CDEFNEG)DEFI=CDEF(I)
'F(CDEFNEG)CDEF(I)=0.0
111 CONTINUE
RETURN
END
C********************
SUBROUTINE PEBILDS
DIMENSION UEHWR(5), REBLDA(5), YEXESS(5)
COMMON/PEBILDS/CURSTR, ENGL, UEHWR,
                  YEXESS, REBLDA, ENGG
C
ENGG = 1.0 - ENGL
DO 111 I = 1, 5
    YEXESS(I) = CURSTR*UEHWR(I)
    REBLDA(I) = YEXESS(I)*ENGG
    CURSTR = CURSTR - YEXESS(I)
111 CONTINUE
RETURN
END
C********************
C*****************************
SUBROUTINE REQMSTS(REBIDA,REBLDN,CDEF)
DIMENSION REO(5),CDEF(5),REBIDA(5),REBLDN(5,3)
C
1=1
100 REO(I)=CDEF(I)
II=1
111 IF(REO(I),GT,REBIDA(I))GOTO 133
REBLDN(I,1)=REO(I)
122 IF(1.EQ.5)GOTO 155
I=I+1
GOTO 160
133 REBLDN(I,1)=REBIDA(I)
SHORT=REO(I)-REBIDA(I)
REO(I)=REBIDA(I)
IF(I.EQ.1)GOTO 144
II=II-1
REO(I)=REO(I)+SHORT
GOTO 111
144 WRITE(6,1)I,SHORT
1 FORMAT("WARNING: NEEDS FOR",I2,"TH YEAR CANNOT BE MET/"
1 ,F6.0," REBUILDABLES SHOULD BE MADE AVAILABLE.")
GOTO 122
155 RETURN
END
C*****************************
C**************************

SUBROUTINE AVAILTL (REBLDA, REBLDN)
DIMENSION DISTR(3), REBLDA(5), REBLDN(5,3), REBLDA(5,3)
COMMON/AVAILTL/DISTR,

C
DO 122 J=1,3
DISTR= DISTR(J)
DO 111 I=1,5
REBLDA(I, J)= REBLDA(I)* DISTR
111 CONTINUE
CALL PBLNTRL (REBLDA, REBLDN, J)
122 CONTINUE
RETURN
END
C**************************
C***************
SUBROUTINE PBLDNLRI (RELD, REBLN, J)
DIMENSION RELDA(5,3), REBLD(5,3)
COMMON/REBLDNLRI/REBLD

C
1 = 1
100 II = 1
111 IF (REBLDII, J) .GT. RELDA(II, J) GOTO 133
REBLDII, J) = RELDA(II, J)
122 IF (I.EQ.5) GOTO 155
II = II + 1
GOTO 100
133 REBLDII, J) = RELDA(II, J)
SHORT = REBLDII, J) - RELDA(II, J)
REBLDII, J) = RELDA(II, J)
144 IF (II.EQ.1) GOTO 144
II = II - 1
REBLDII, J) = REBLDII, J) + SHORT
GOTO 111
144 REBLDII, J+1) = SHORT
GOTO 122
155 RETURN
END
C***************
C****************************************************************
SUBROUTINE CSCHED(FBLDN,ENGG,FBLDNS)
INTEGER FBLDNS
DIMENSION FBLDN(5,3),FBLDNS(5,3)
IYP=1976
WRITE(6,1)
1 FORMAT(/**/FY",10X,"DISTRIBUTION OF CANNIB REQMNTS"/
     0.13X,"U.S. EUROPE PACIFIC")
DO 122 I=1,5
   IYP=IYP+1
   DO 111 J=1,3
      FBLDNS(I,J)=HINT*5.0001E-1+FBLDN(I,J)/ENGG
   CONTINUE
111   WRITE(6,2)IYP,(FBLDNS(I,J),J=1,3)
2 FORMAT(15,X,3(15,2X))
122 CONTINUE
RETURN
END
C****************************************************************
C***************
SUBROUTINE COST(RBLINS)
INTEGER RBLINS
REAL LOC,LOCDIFF
DIMENSION BASECOST(3),TRANSP(3),ESCFACT(5),LOCDIFF(3,3),
      RBLINS(5,3),COSTS(5,3,3)
COMMON/COST/BASECOST,TRANSP
DATA LOCDIFF/2*(1.0,1.136,1.250),3*0.0,/
     1 0.0750,1.1385,1.1943,1.2433,1.2906/

C DO 100 J=1,3
100 CONTINUE
TOTAL=0.0
DO 133 K=1,3
UNITCOS=BASECOST(K)
   DO 122 J=1,3
      LOC=LOCDIFF(J,K)
      DO 111 I=1,5
         COSTS(I,J,K)=ESCFACT(I)*RBLINS(I,J)*LOC*UNITCOS
         TOTAL=TOTAL+COSTS(I,J,K)
111 CONTINUE
122 CONTINUE
133 CONTINUE
CALL MATRICES(COSTS,TOTAL)
RETURN
END
C***************
SUBROUTINE MATRIXCOST(COSTS, TOTAL)
REAL LOC, LOGDIFF
DIMENSION COSTS(5,3), WORDS(5,3), COSTLOC(3), IYR(5)
1 WORDS/10ENGINE REM, 10HOURAL COST, 7HMATRIX/. 2*1H, 
2 10HPREPARATION, 10HFOR-TRAN, 10HSPORTATION, 
3 10H COST MATR, 3HIX/. 
4 10ENGINE TRA, 10HSPORTATION, 10H COST MAT. 
10 CONTINUE 
DO 11 K=1,3
WRITE(6,1) (WORDS(J,K), J=1,5) 
1 FORMAT(/'*1X, 5A10//')
WRITE(6,2)
2 FORMAT(' FY' ',20X' 'LOCATION' ', 'U.S. EUROPE PACIFIC')
WRITE(6,3) (IYR(I), COSTS(I, J, K), J=1,3, I=1,5)
3 FORMAT(5(5,15,6X, 3(2X,F8.0) )//)
111 CONTINUE 
C
WRITE(6,4)
4 FORMAT('/* M ATRIX OF COSTS WITH RESPECT TO TIME &', 
'LOCATION:/'//1)
WRITE(6,5)
5 FORMAT(1X,7X, 'LOGDIFF')
6 DO 133 J=1,3
7 DO 122 K=1,3
8 COSTLOC(J)=COSTLOC(J) + COSTS(I, J, K)
122 CONTINUE 
133 CONTINUE 
WRITE(6,5) IYR(I), COSTLOC
5 FORMAT(5(5,15,6X, 3(2X,F8.0) )//)
134 CONTINUE 
WRITE(6,6) TOTAL
6 FORMAT('/* TOTAL COST FOR THE ENTIRE OPERATION IS $', 
'/* F8.0///1 Returns
END
### GAS ENGINES

```
C**************************
$NAME=ALL B0=450,,4*0,,PIPE=156,,4*0,,MO=5*39,,
0TH=5*0,,SERV=222,,4*0,,UNS=518,,4*0,,RTL=0,,325,
VEM=0,,3*0,,2*0,,0,15,,0,0;DISTR=0,05,,0,13,,0,02,
CUPST=6752,,ENGL=0,325,,BASE=51,68,,21,05,,144,53,
TRANS=1,0,,1,474,,1,6735
C**************************
```

Data for calculation of Gas Engines (File "GAS")

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**ENGINE REMOVAL COST MATRIX:**

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**PREPARATION-FOR-TRANSPORTATION COST MATRIX:**

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GAS ENGINES (Contd)

ENGINE TRANSPORTATION COST MATRIX:

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MATRIX OF COSTS WITH RESPECT TO TIME & LOCATION:

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<tr>
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<td>25428.</td>
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</tr>
<tr>
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TOTAL COST FOR THE ENTIRE OPERATION IS $ 202349.
MULTIFUEL ENGINES

DATA FOR
CALCULATION OF
MULTIFUEL
ENGINES
(FILE "MULTI")

WARNING: NEEDS FOR 2TH YEAR CANNOT BE MET
274. REBUILDABLES SHOULD BE MADE AVAILABLE.
WARNING: NEEDS FOR 3TH YEAR CANNOT BE MET
419. REBUILDABLES SHOULD BE MADE AVAILABLE.
WARNING: NEEDS FOR 4TH YEAR CANNOT BE MET
421. REBUILDABLES SHOULD BE MADE AVAILABLE.
WARNING: NEEDS FOR 5TH YEAR CANNOT BE MET
423. REBUILDABLES SHOULD BE MADE AVAILABLE.

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<tr>
<th>FY</th>
<th>DISTRIBUTION OF CANNIBAL REMNANTS</th>
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<td>105</td>
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ENGINE REMOVAL COST MATRIX:

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PREPARATION-FOR-TRANSPORTATION COST MATRIX:

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<th>PACIFIC</th>
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<td>2690.</td>
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### ENGINE TRANSPORTATION COST MATRIX:

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### MATRIX OF COSTS WITH RESPECT TO TIME & LOCATION:

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<th>FY</th>
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<tr>
<td>1977</td>
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**TOTAL COST FOR THE ENTIRE OPERATION IS $274727.**