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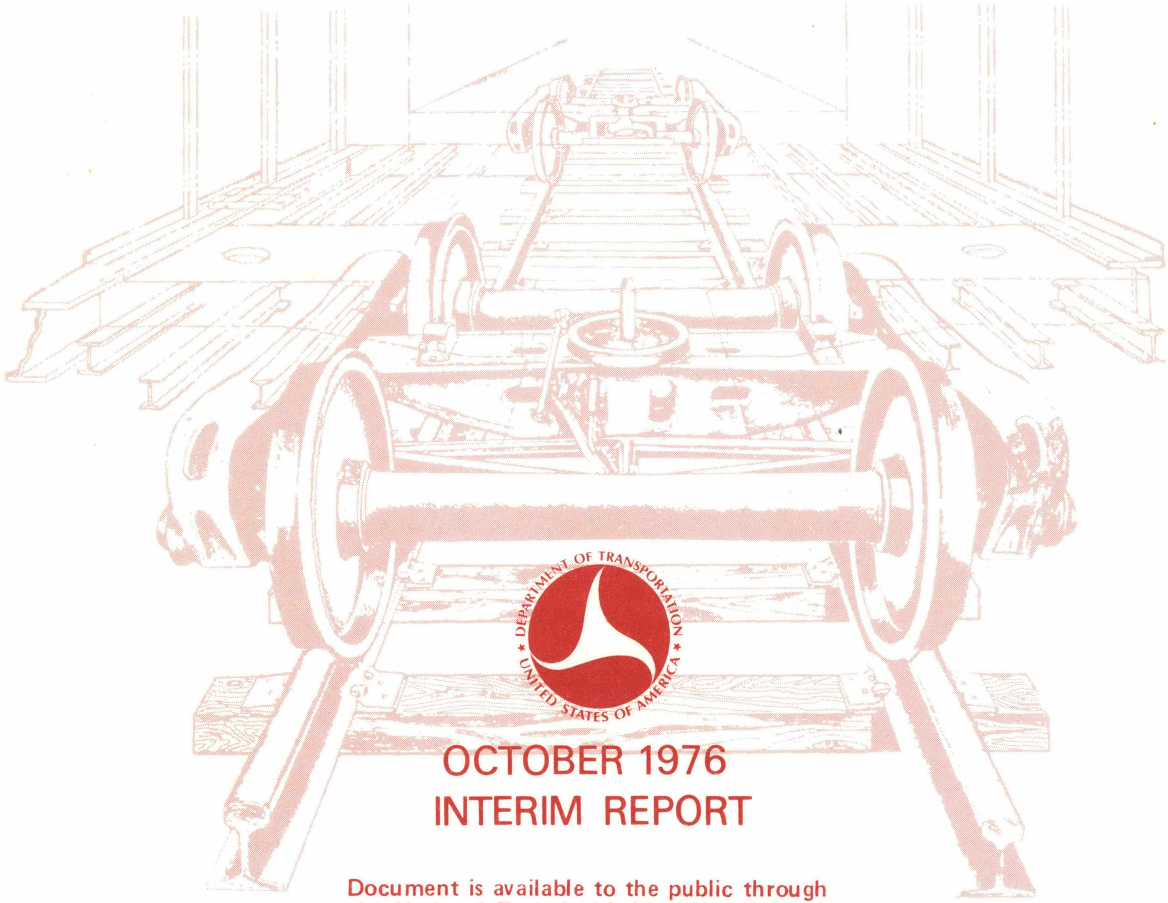
FREIGHT CAR TRUCK DESIGN OPTIMIZATION

ECONOMIC ANALYSIS REPORT - PHASE I

Southern Pacific Transportation Company
Technical Research and Development Group



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INTERIM REPORT

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NOTICE

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16. Abstract

This report summarizes the truck economic research accomplished during Phase I of the Federal Railroad Administration's three-phase Truck Design Optimization Project (TDOP). In this phase:

- A truck economic methodology was developed with the cooperation of representatives from the railroad industry and their suppliers. The methodology is for industry use to help establish the cost performance of the individual railroads' existing trucks and evaluate investments in proposed truck improvements.
- The economic data elements were identified and procedures were developed at various levels of specification to collect the information. An overall truck cost information system was designed. The system will provide a user with the processing capability to establish the integrated truck economic data base and present the data for evaluation.
- Economic data analysis guidelines were developed to establish and evaluate the cash flows of investments in proposed improvements to existing trucks. The approach to evaluating the operating cost performance of existing trucks through the exploitation of the economic data base was developed.

The report recommends that the railroad industry adapt the TDOP methodology developed thus far to their individual company environments and begin to establish working procedures for the economic selection of existing trucks and proposed improved truck designs. Suggested further economic research is also identified.

17. Key Words Freight Car Truck operating costs, Freight Car Truck operating conditions, Freight Car Truck cost performance evaluation, Improved Freight Car Truck investment evaluation, Freight Car truck cash flow

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Final Phase I Economic Analysis Report

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FREIGHT CAR TRUCK DESIGN OPTIMIZATION

Economic Analysis Report - Phase I

SUMMARY

I CONCLUSIONS FOR PHASE I

- A truck economic methodology was developed with the cooperation of representatives from the railroad industry and their suppliers. The methodology is for industry use to help establish the cost performance of the individual railroads' existing trucks and evaluate investments in proposed truck improvements.

- The economic data elements were identified and procedures were developed at various levels of specification to collect the information. An overall truck cost information system was designed. The system will provide a user with the processing capability to establish the integrated truck economic data base and present the data for evaluation.

- Economic data analysis guidelines were developed to establish and evaluate the cash flows of investments in proposed improvements to existing trucks. The approach to evaluating the operating cost performance of existing trucks through the exploitation of the economic data base was developed.

II RECOMMENDATIONS FOR PHASE I

Representatives of the railroad industry and its suppliers should progressively implement the truck economic methodology developed thus far in Phase I by:

- Developing their truck economic data base beginning with off-line maintenance costs and expanding to on-line maintenance, freight damage, derailment, delay, and other truck-related costs.

- Exploiting available car movement information to associate the costs in the data base with mileage, age, load, and track conditions.

- Establishing truck utilization cost performance measures (costs/gross ton miles) for comparative economic analysis of competing designs.

- Introducing the cost of equity as well as debt into the calculations for predicting investment yields where it is currently being omitted.

- Adapting the TDOP methods to individual company conditions and establishing working procedures for the economic selection of existing and proposed improved truck designs.

- Continuing the truck economic research to establish a working model for determining economic life cycles over a broad range of truck designs and to expand and test procedures for Type II trucks. (See Section III, D, Future Requirements.)

III OVERVIEW FOR PHASE I

A. Need for Procedures

The need for procedures to help make economic selections among truck designs was made apparent by the results of the initial Phase I economic research. Data were not readily available to determine and help control the economic operating performance of existing or proposed trucks[1]. (The economic impact of the freight car truck's operating performance in the industry is significant. National average annual investments in trucks are estimated at $500 million for the years 1976-1980[2]. Trucks will also have an economic effect, currently unknown, on national estimated average annual railroad capital expenditures of $1.5 billion; operating expenses of $13 billion and operating revenues of $15 billion for the same period.)[3]

B. Development of the Procedures

1. The Economic Data Requirements

During Phase I the data requirements for establishing the on- and off-line truck economic data base were identified as:

- Operating costs
  - Maintenance
  - Commodity Loss & Damage
  - Derailment
  - Train Delay and Lost Car Day
  - Other Train and Roadway Component

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[1] Methodology for a Comprehensive Study of Truck Economics, Report No. FRA-OR&D 75-58, April 1975, Interim Report - NTIS availability.

[2] Derived from Railway Age, Jan. 26, 1976, p 25 (new car average annual demand forecast) and a first quarter 1976 average delivered installed price estimated by a Class I railroad.

[3] Ibid, pp 58 and 61

- Operating conditions
  - Mileage (empty and loaded)
  - Load
  - Age
  - Track
  - Speed

2. Economic Data Collection

Detailed procedures were developed for collecting maintenance costs, commodity loss and damage costs, and the truck-related car mileage, load, age, and track conditions. Guidelines were developed for derailment and other train and roadway component costs.

3. Truck Cost Information System

The truck cost information system was designed in the form of an information flowchart with a description of the movement and processing of the data from source to data base to output generation.

4. Economic Data Analysis Guidelines

The Truck Economic Model was established to be used for evaluating incremental investments in proposed truck improvements. The model includes the identification of the investment cash flow data elements; the method of combining the data for analysis; the analytical method (net present value) of measuring the profitability of the proposed investment; and the procedure for determining the cost of capital used in net present value calculations and for analyzing risk.

The approach to evaluating the cost performance of existing trucks through the exploitation of the truck economic data base was developed. The approach includes guidelines for selecting trucks for analysis; methods of providing indicators to help isolate the operating costs caused by the trucks selected; the introduction of truck utilization cost performance measures to be used in the overall economic analysis for estimating and comparing the operating costs of existing and improved trucks.

C. Recent Developments

The portion of the results of the economic research (noted above in Section B, items 1 through 4) that was completed since the last interim report[4/] includes the development of data collection procedures for truck maintenance performed by outside contractors; truck-related car commodity loss and damage costs, empty and loaded mileage, age, load, and roadway conditions. In addition, data analysis guidelines were developed and include: the approach to operating cost evaluation; methods for determining the cost of capital (including its relationship with net present value) and analyzing risk.

D. Future Requirements

Economic research not scheduled in Phase I, required in the future, includes: developing procedures for establishing truck-related train delay costs, lost car day costs and train speed; developing analytical procedures for establishing the truck economic life cycle model for a wide range of truck designs and operating conditions.

[4/] Truck Economic Data Collection and Analysis, Report No. FRA-OR&D 75-58A, March 1976 Interim Report, NTIS availability.

In addition, while the TDOP data collection and analysis procedures developed thus far in Phase I can provide truck component performance evaluation data (e.g., wear and failure frequency distributions to gross ton miles, related to a range of track conditions) the data are derived from the reported information in the truck economic data base and are not, by themselves, sufficient for prediction purposes. In order to predict, for example, the wear and failure rates of truck components the rates must be developed from actual physical measurements of a representative sample of the components in conjunction with the rates derived from the data base for the same components. (Once the wear and failure rates are established the wear and failure life can be predicted in terms of gross ton miles and extrapolated to years of remaining service.) A program should be implemented in which cars of a selected class operating in similar conditions are equipped with new existing trucks and Type I trucks and placed into service. The car class truck performance should be continuously monitored throughout the program to establish the comparative component wear rates. The time period and number of observations should be established in sufficient magnitude to permit the accumulation of an adequate amount of data necessary for accurate prediction purposes. The monitoring procedure should include the recording of actual physical measurements of the truck components at predetermined time intervals and/or predetermined gross ton mile intervals. These data would in turn be monitored by the truck cost information system which would keep track of the trucks at all times during their operation.

Appendix A

TRUCK ECONOMIC DATA COLLECTION PROCEDURES

CONTENTS

Appendix A

TRUCK ECONOMIC DATA COLLECTION PROCEDURES

I INTRODUCTION

This Appendix A brings together all of the economic data collection and integration procedures developed during Phase I to be used to establish the freight car truck economic data base. New procedures developed since the last interim report are included. References are provided for the user to locate those previously established. The appendix also contains a Truck Economic Data Source and Application Table. The table includes a list of the data categories required to evaluate the cost performance of existing trucks and to evaluate investments in proposed improvements to them. In addition, the sources of the data are shown and brief instructions provided to integrate and apply the data to develop the truck economic data base.

The procedures were developed by the TDOP staff with the cooperation of the following organizations within the railroad industry and its suppliers (listed alphabetically):

- Association of American Railroads
- ACF Industries
- American Steel Foundries
- Burlington Northern
- Canadian National Railroad
- Canadian Pacific Railroad
- Dresser Industries
- Federal Railroad Administration
- General American Transportation Company
- National Castings Division
- North American Car Company

- Pacific Fruit Express Company
- Pullman-Standard, Inc.
- Santa Fe Railroad Company (ATSF)
- Seaboard Coast Line
- Southern Pacific Transportation Company
- Southern Railways
- Track Train Dynamics Program
- Trailer Train Company
- Transportation Systems Center

Potential users of the TDOP procedures are encouraged to evaluate their practicality by beginning with a review of the data provided in Table A-6 (e.g., users who adjust the table entries to conform to their specific existing data sources and files will complete an important step toward developing working input procedures tailored to their company's environment.)

II. INFORMATION SYSTEM STRUCTURE

The economic research effort revealed the need for an information system to bring together the required economic data.[1] A generalized truck cost information system structure was designed in the form of flowchart with accompanying narrative describing its use.[2] The flowchart illustrates the movement of the data from field and file origins to integration in the truck economic data base and final presentation to the user in report format.[3] The narrative provides computer processing guidelines for the data. A less detailed illustration is shown in this appendix in Figure A-1, page A-5 for the user's convenience as a reference.

1/ Op. Cit., Report No. FRA-OR&D 75-58 p. 21

2/ Truck Economic Data Collection and Analysis, March 1976, Interim Report No. FRA-OR&D 75-58A pp B-10 thru B-13

3/ Ibid, see pp B-51 thru B-70 for report formats and sort and aggregation techniques

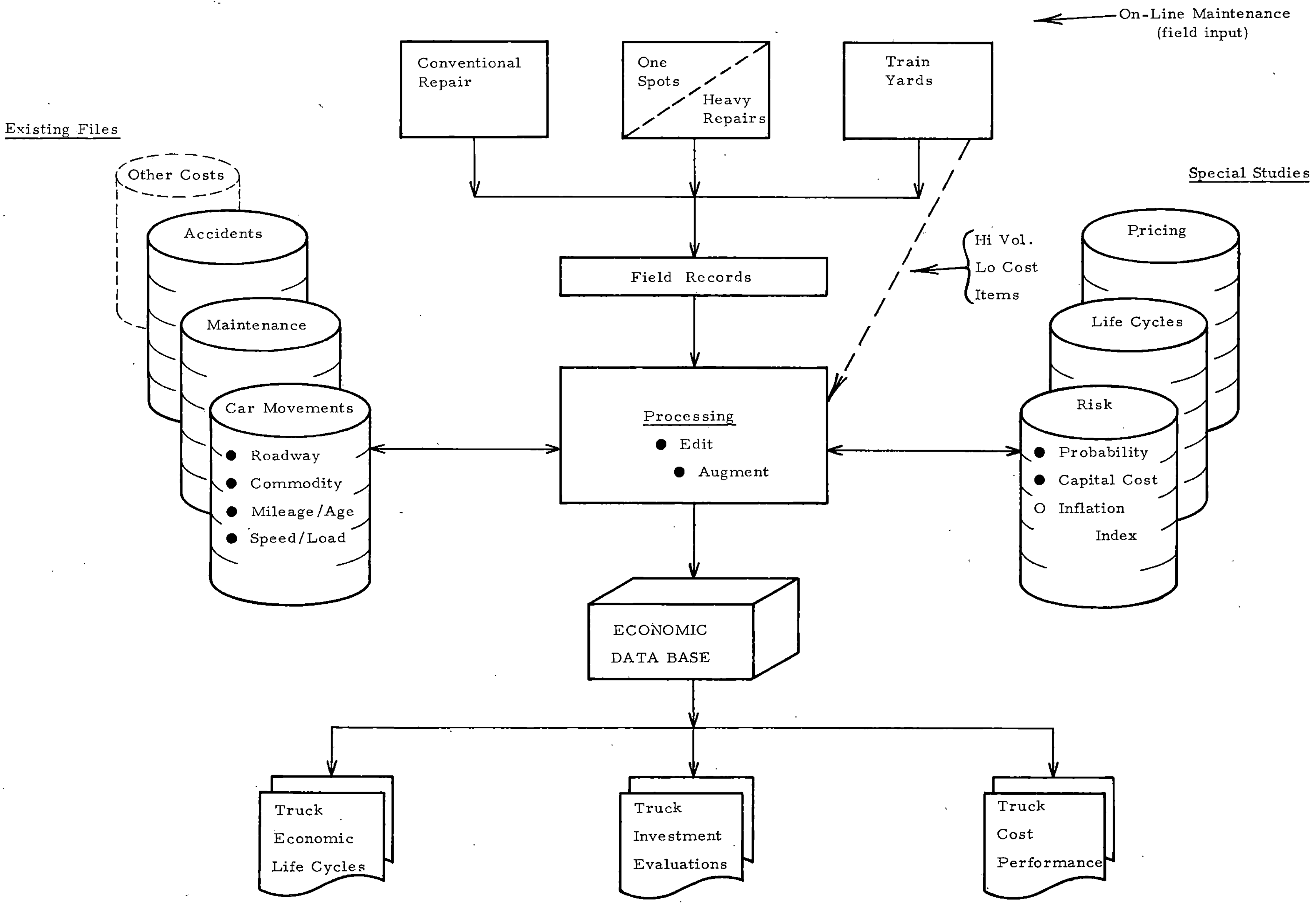

FIGURE A-1. GENERALIZED TRUCK COST INFORMATION SYSTEM

III. DATA COLLECTION PROCEDURES

The guide for the user of this section is the Truck Economic Data Source and Application Table A-6, pages A-33 and A-34. First, the column headings in the table are explained and then the procedures are described (or referenced to their location in prior TDOP economic reports).

A. Guidelines

1. Data Category

The column contains the list of the data elements required for truck economic analysis.

2. Data Source

The column contains the list of short descriptions to help users locate their data in their organizations. Sometimes the source is shown as a document when it is readily identifiable, sometimes as a publication, sometimes an organization group.

3. Data Application

The table contains eight columns which provide instructions for collecting and integrating the data.

- File - the data in this column are self-explanatory. (Additional detail is found in the following Section B, Description of the Procedures).
- Format and Convert

  -Format: The format instruction is meant to advise the user to develop a data record that conforms to the user's needs. In that way the format specification can provide the user with the capability of selecting from the source data other data elements contained in the source not necessarily applicable to truck cost performance evaluation but useful for other purposes such as other car component performance evaluation, e.g., the off-line truck component repair data source (i.e., car repair billings) contains other car component repair data not necessarily related to truck operating behavior such as a worn out coupler body. The by-product has a potential for economic benefits.

- Convert: The convert instruction refers to establishing a common code classification to facilitate the orderly processing of the data (see Section II, footnote 2, page A-4).

- Key to Tape - the key to tape instruction only applies to cost data for which a detailed truck component data file does not exist (see the table).

- Tape to Tape - the tape to tape instruction advises the user to move truck-related data from existing tapes to a truck tape, where necessary, e.g., car movements, especially because of the large volume of data covering all cars. This step selects only the cars under study.

- Price - AAR Car Repair Billing prices are recommended for this application.

- Edit - edit routines, for cost data not currently being collected, are required. The minimum edits can be easily patterned after the AAR Car Repair Billing routines. More sophisticated routines are advisable such as validating production count (e.g., number of cars repaired). Each railroad will have to provide the validation technique in accordance with the data each has available. One railroad observed maintains a car movement system that contains a record of the dates and times of cars, by car number, spent on repair tracks. The record provides a readily available cross-check of the production count (e.g., number of cars repaired) that are reported in the on-line maintenance cost collection TDOP procedure.[4]

- Set Up File - the instruction means to set up the computer file. The computer file is the prerequisite for establishing the truck economic data base. Some data are to be collected periodically and may not require a computer file (e.g., special study of train delay). Rather the data are to be manually introduced at the analysis stage.

4/ Ibid, pp B-22 thru B-34 contains the maintenance procedure and Section B, page A-8 of this Appendix contains the car movement procedure.

- Manual Options - some users may find it economically advantageous to collect data manually as opposed to automatically, (e.g., car class descriptions).

B. Description of the Procedures

The following description of the procedures follows the order of the list shown in the Data Category column of Table A-6.

1. Off-line Truck Maintenance (Item I. A.1.)

The procedure is included in a prior report. [5]

2. On-line Truck Maintenance (Item I.A.2.)

The procedure is also included in a prior report.[6]

3. Outside Truck Maintenance (Item I.A.3.)

Individual railroads that make heavy use of outside contractors for truck maintenance may find it economical to automate the collection of the data. (One private car line company observed does collect this category of data automatically).

The procedure recommended by TDOP for heavy use of outside contractors is straightforward and easily incorporated into the overall system. Outside contractors must provide an input document (record of repairs) similar to the off-line and on-line maintenance data collection document used by the railroad. The document must conform as a minimum requirement to the railroads' coding and keypunching methods. The processing of the data then follows the TDOP maintenance procedures already described.

Some railroads will find it more economical to handle the data manually where they make only light use of outside contractors. In that event the railroad can elect to code the maintenance invoice received from the contractor for data base entry. Alternatively, the railroad may experience such minimal cost of outside maintenance as to handle the data manually at the data analysis stage (which takes place following the extraction of the other cost data from the base).

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[5] Ibid, pp B-14 thru B-21

[6] Ibid, pp B-22 thru B-34

4. Related Maintenance (Items I.B.1 thru 5)

The procedure for collecting related maintenance costs can be determined from the data sources and applications shown in Table A-6, (some of these associated data are most likely to be handled manually in the initial stage of establishing the overall cost collection system until the magnitude of the costs becomes more clearly established.

5. Commodity Loss and Damage Related Cost (Item I.C.1.)

A prior report identified the data elements and sources for this category of cost.[7] This section provides the instructions for collecting the data. The procedure is as follows:

- Access the existing freight damage payments file and select:
  - car numbers and initials for the car class whose truck performance is being studied
  - commodity code[8]
  - amount paid in settlement of the claim
  - railroad's proportion of money paid out on the claim (to establish the magnitude of the loss for which the railroad is responsible)
  - waybill month and year (billing dates for the time period being studied)
  - cause-reason for claims[9]
    - Improper handling-all damage not otherwise provided for (Symbol 3)
    - defective or unfit equipment (Symbol 4)

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[7] Ibid, pp. B-35 and B-36

[8] Sort by commodity code as well to determine the proportion of each of the commodity payments associated with the car class to the total of the commodity payments where the car class is not dedicated to carrying one commodity to determine the order of magnitude.

[9] These causes are suggested as a beginning point in the collection procedure. The user has the option of selecting all causes. See op. cit., FRA-OR&D 75-58A p. B-35 for references to the available data.

- Review the accession listing. Select out the nominal losses and damages and enter the remaining data into the truck economic data base using the application instructions shown in Table A-6.
- Access the source documents (that support the claims) using the waybill numbers for retrieving them and set aside in a manual file.[10]

6. Derailments (Item I.C.2.)

The input documents to be used to collect derailment costs are described in a prior report.[11] See also Section 11, Car Movements, which provides the procedure for collecting the history of the movements of individual cars prior to a derailment.

7. Train Delay and Lost Car Days (Item I.C.3 and 4)

The procedure for collecting and integrating these costs were to be established based upon a special study. The approach suggested can be found in the first interim report.[12] The study was not scheduled for completion in Phase I.

8. Other Claims (Item I.C.5.)

A review of the commodity loss and damage data collection procedure together with the brief instructions in Table A-6 provides the user with sufficient information to set-up the Other Claims file, (i.e., the car initial and number, dates of incident, claim causes and payments are well documented in these claim files).

9. Roadway (Item I.C.6.)

These costs should be developed with the help of the guidelines provided in the FRA Report No. RPD-11-CM-R, 3 volumes, January 1976 "Procedure For Analyzing The Economic Costs of Railroad Roadway For Pricing Purposes."

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[10] The source documents provide the exact or approximate dates and locations of the losses and damages.

[11] Op. cit., FRA-OR&D 75-58A, pp B-36, B-37.

[12] Op. cit., FRA-OR&D 75-58, pp 6 and 16.

10. Car Class and Truck Description (Item II A and B)

Table A-6 provides adequate instructions for collecting these data.

11. Car Movement Data Acquisition System (Item II, C thru G)

a. Introduction

The development of this procedure originates from:

- Analysis of one of the car movement systems currently in operation by various Class I railroads.
- Modification of the system and the establishment of a working procedure to select, from the system's existing tape records, empty and loaded car mileage, gross weight on rail and the car's geographic movements.

b. On Line Car Movement History Data Sources

Review of car movement systems currently in operation by various railroads indicates that car movement histories are available. Records kept in either automated or manual form contain detailed on line information by car number on the following items:

- Shipper
- Consignee
- Commodity
- Waybill No.
- Point of origin
- Point of destination
- Time of departure
- Line haul movement
- Train ID
- Time of arrival
- Delivery in interchange and location
- Receipt from interchange and location
- Loaded miles
- Empty miles

- Bad order status
- Storage status
- Dates and times spent on repair trucks
- Dates and times turned in or released from shops or repair truck
- Car condition status
- Dates and locations of car spotted in train yards
- Geographical area of each event

c. Off-Line Car Movement History Data Sources

Off-line car movement data are available (in less detail) from the Universal Machine Language Equipment Register (UMLER). Various performance records are kept by the railroads, usually in automated form for verifying car hire costs and revenues. Exchanges of such data (e.g. loaded and empty mileage, locations and time periods spent by a foreign car over a railroad's lines) among railroads can provide each railroad its detailed on and off line car movements.

The UMLER records, which can be accessed by all member railroads, contain information ranging from complete car specifications to interchange receipts and deliveries; loaded and empty miles by car number; per diem; incentive per diem; and mileage rates as well as the dollar amounts involved according to Car Hire Rules.

The AAR Telerail Automated Information Network system (TRAIN II) represents the major source of off line car movement information. The TRAIN II records are an expansion of TRAIN I. Its vastly increased capability to function as a freight car information and control system is indicated by some of the new inputs described by the AAR:[13/]

[13/] TRAIN II's goal: A 10% increase in car utilization by Kenneth Ellsworth Railway Age, September 8, 1975

- Placement: indicating that a car has been turned over to a shipper for loading
- Loading Report: indicating that a shipper has released a car to a railroad
- Origin and Destination Reports: providing information that a car has been loaded, where it is headed, and what it is carrying.
- Interchange: providing information of interchange receipts and deliveries for car tracing purposes.
- Regional Boundary Crossing: reporting the crossings of regional boundaries, thus narrowing down the areas in which a car can be found, whereas TRAIN I simply reported interchanges.
- Arrival at Destination: making it possible to compute the line haul segment of transit time.
- Unloading: meaning that an empty car is now or will soon be available for allocation.
- Bad Order/Storage/Hold: reporting on cars going either to or from any of these positions.
- Empty Car Destination Report: showing that an empty car has been dispatched and where it is headed. Reports automatically include information on last commodity loaded.

d. Data Reduction

Information selected from the car movement history tapes, currently available, can be reduced in a readily useable form to facilitate the analysis of the data. Since the history tapes contain the geographic locations of car movements the track conditions can be derived by manually accessing the railroad's track charts to determine track geometries, grades, curves, and roadbed subgrades. This procedure however, is suggested only for sampling purposes because the track files have not yet been computerized for automatic retrieval in the cases observed.

Lacking computerized track data at this point in time, a preliminary car movement data reduction can be obtained with a minor programming effort.[14/] Presenting the data in a format similar to that shown in Tables A-1 and A-2 is suggested. The specifications for the Output Format field descriptions in the tables are provided as a reference for the potential user (they are not for the casual reader).

[14/] TDOP economic staff estimate: 2 man weeks

TABLE A-1

ON LINE CAR MOVEMENT HISTORY, AND OPERATING CONDITIONS — CAR MOVEMENT SUMMARY

Mo/Da/Yr RAILROAD COMPANY NAME Page

Report No. ON LINE CAR MOVEMENT HISTORY AND OPERATING CONDITIONS From Mo/Da/Yr to Mo/Da/Yr

(1) Activity	(2) Location	(3) Station Number	(4) Mo/Da/Yr	(5) Miscellaneous ID	(6) Comdty	(7) L/E	(8) Gr Wgt (Tons)	(9) Miles	(10) Car Ton Miles	(11) Wheel Loads (Lbs)
Car: ______ Class: ______ Car Kind: ______ Mechanical Designation: ______ Truck Specifications: ______										
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-

CAR MOVEMENT SUMMARY

(1) Commodity	(2) Loaded Car Miles/Comdty	(3) Loaded Car Ton Miles/Comdty	(4) Percent of Loaded Car Ton Miles	(5) Percent of Total Car Ton Miles	(6) Avg Tons/ Loaded Car Mile/Comdty
Autoparts	x——x	x——x	xx.xx	xx.xx	xxx.xx
Asphalt	x——x	x——x	xx.xx	xx.xx	xxx.xx
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
etc	etc	etc	etc	etc	etc
Total Loaded Car Miles	x——x	Total Loaded Car Ton Miles x——x	100.00	xx.xx	Avg Tons/Loaded Car Mile xxx.xx
Total Empty Car Miles	x——x	Total Empty Car Ton Miles x——x		xx.xx	Avg Tons/Empty Car Mile xx.xx
Total L/E Car Miles	x——x	Total L/E Car Ton Miles x——x		100.00	Average Tons/ Car Mile xxx.xx

(Repeat for all car numbers specified)

TABLE A-2

ON LINE CAR POPULATION SUMMARY

ON LINE CAR POPULATION SUMMARY From Mo/Da/Yr to Mo/Da/Yr Page

(1)	(2)	(3)		(4)	(5)	(6)	
Commodity	Loaded Pop. Miles/Comdty		Loaded Pop. Ton Miles /Comdty	Percent of Loaded Pop. Ton Miles	Percent of Total Pop. Ton Miles		Average Tons /Loaded Mile /Comdty
Autoparts	x——x		x——x	xx.xx	xx.xx		xxx.xx
Asphalt	x——x		x——x	xx.xx	xx.xx		xxx.xx
-	-		-	-	-		-
-	-		-	-	-		-
-	-		-	-	-		-
etc	etc		etc	etc	etc		etc
Total Loaded Pop. Miles	x——x	Total Loaded Pop. Ton Miles	x——x	100.00	xx.xx	Average Tons /Loaded Mile	xxx.xx
Total Empty Pop. Miles	x——x	Total Empty Pop. Ton Miles	x——x		xx.xx	Average Tons /Empty Mile	xx.xx
Total L/E Pop. Miles	x——x	Total L/E Pop. Ton Miles	x——x		100.00	Average Tons /Mile	xxx.xx

(1) Specifications for Output Format Field Descriptions (Table A-1, top half)

1. Page Heading Line 1

Date	The date this report was created.
Company Title	Railroad's name.
Page Number	Sequential page number for this report.

2. Report Heading Line 3

Report Identification	Report identification by no.
Report Title	Specified by the user.
Period	Time period covered by report.

3. Report Heading Lines 5 & 6

Activity (Column 1)	Lists reported events for the time period covered, as specified in Item 2.
Location (Column 2)	Alphanumeric description of the city and state for each reported activity.
Station Number (Column 3)	Railroad station number of the reported event.
Mo/Day/Yr (Column 4)	Date for each reported event.
Miscellaneous ID (Column 5)	Miscellaneous ID includes one of the following: ● Identifies the connecting road when car is delivered to or received in interchange. ● Identifies the train in which a car is entrained during arrival and departure events. ● Identifies in a coded form the zone within a train yard, the track no. and the location on the track where car was spotted.
Commodity (Column 6)	Alpha commodity description.
L/E (Column 7)	Indicates status of car, loaded L or empty E.

Gross Weight, Tons (Column 8)	Gross weight of car in tons. For an empty car this figure is the tare weight.
Miles (Column 9)	On reported arrival events the mileage figure represents the distance from the previously reported departure station.
Car Ton Miles (Column 10)	This figure is derived by multiplying the reported gross weight by the miles covered between departure and arrival events.
Wheel Loads, Lbs (Column 11)	Gross weight (tons) x 250

4. Car Heading Line 8

Car Identification	Prints the Road initial and the car number.
Class	Prints the car class.
Car Kind	Prints the AAR car kind.
Mechanical Designation	Prints the AAR Mechanical designation.
Truck Specifications	Alphanumeric description of truck specifications can be obtained by the Mechanical Dept. specifications and given as an input along with the car number that information is requested for.

5. Car Movement Summary (Table A-1, bottom half) Line 1

Summary	Prints "Car Movement Summary" indicating the end of the reported detailed activities and the beginning of the car activity summary data.

6. Car Movement Summary Headings (Lines 3, 4 & 5)

Commodity	Prints commodities in alphanumeric code.
Loaded Car Miles/Comdty (Column 2)	Prints the sum of loaded car miles per commodity carried during the time period specified.

Loaded Car Ton Miles/Comdty (Column 3)	Prints the sum of loaded car ton miles by commodity carried during the time period specified.
Percent of Loaded Car Ton Miles (Column 4)	Prints the percentage of loaded car ton miles/comdty to the total loaded car ton miles.
Percent of Total Car Ton Miles (Column 5)	Prints the percentage of loaded car ton miles/comdty, total loaded car ton miles and total empty car ton miles to the total L/E car ton miles.
Average Tons/Loaded Car Mile/Comdty (Column 6)	Prints the average gross weight in tons per loaded car mile for the type of commodity carried within the specified time period. It is obtained by dividing the loaded car ton miles/commodity by the loaded car miles/commodity.

7. Additional Summarized Data

Total Loaded Car Miles (Column 2)	Prints the total number of loaded miles irrespective of commodity.
Total Empty Car Miles (Column 2)	Prints the total number of empty miles during the time period specified.
Total L/E Car Miles (Column 2)	Prints the total number of miles travelled during the specified time period. This is the sum of total loaded car miles and total empty car miles.
Total Loaded Car Ton Miles (Column 3)	Prints the sum of the loaded car ton miles/comdty for the time period specified.
Total Empty Car Ton Miles (Column 3)	Prints the sum of the empty car ton miles for the time period specified.
Total L/E Car Ton Miles (Column 3)	Prints the sum of the total loaded car ton miles and total empty car ton miles.

Average Tons/Loaded Car Mile (Column 6)	Prints the weighted average gross weight in tons per loaded car mile. It is obtained by dividing the total loaded car ton miles by the total loaded car miles for the time period specified.
Average Tons/Empty Car Mile (Column 6)	Prints the average gross weight in tons per empty car mile. It is obtained by dividing the total empty car ton miles by the total empty car miles for the time period specified. As a cross check the resulting figure should be the car tare weight in gross tons.
Average Tons/Car Mile Column 6)	Prints the weighted average gross weight in tons per car mile. It is obtained by dividing the total L/E car ton miles by the total L/E car miles for the time period specified.
8. On Line Population Summary (Table A-2)	
Car Population Summary Heading Line 1	Prints "On Line Car Population Summary" following the end of the car activity summary of the last car of each car series or groups of cars specified. Also prints the time period specified. The term population refers to the total no. of cars within each car series or car group examined. Provisions for more than one population should be made for this report. A population in the input format should be given by one or more car series or by a number of individual cars.
9. Summarized Data	
Commodity (Column 1)	Prints commodities in alphanumeric code.

Loaded Population Miles/Comdty (Column 2)	Prints the sum of loaded car miles/comdty for all the cars included in the population.
Total Loaded Population Miles (Column 2, following above)	Prints the sum of total loaded car miles for all the cars included in the population.
Total Empty Population Miles (Column 2, following above)	Prints the sum of total empty car miles for all the cars included in the population.
Total L/E Population Miles (Column 2, following above)	Prints the sum of total loaded population miles and total empty population miles.
Loaded Population Ton Miles/ Comdty (Column 3)	Prints the sum of loaded car ton miles/comdty for all the cars included in the population examined.
Total Loaded Population Ton Miles	Prints the sum of the loaded car ton miles/comdty for all the cars included in the population examined.
Total Empty Population Ton Miles (Column 3, following above)	Prints the sum of the empty car ton miles for all the cars included in the population.
Total L/E Population Ton Miles (Column 3, following above)	Prints the sum of total loaded population ton miles and total empty population ton miles.
Percent of Loaded Population Ton Miles Column 4)	Prints the percentage of loaded population ton miles/comdty to the total loaded population ton miles.
Percent of Total Population Ton Miles (Column 5)	Prints the percentage of loaded population ton miles/comdty, total loaded population ton miles and total empty population ton miles to the total L/E population ton miles.
Average Tons/Loaded Mile/Comdty (Column 6)	Prints the weighted average gross weight in tons per loaded car mile for all cars included in the population, for the type of commodity carried by the population examined. It is obtained by dividing the loaded population ton miles/comdty by the loaded population miles/comdty.

Average Tons/Loaded Mile (Column 6, following above)	Prints the weighted average gross weight in tons per loaded car mile for all cars included in the population examined. It is obtained by dividing the total loaded population ton miles by the total loaded population miles.
Average Tons/Empty Mile (Column 6, following above)	Prints the average gross weight in tons per empty car mile for all cars included in the population examined. It is obtained by dividing the total empty population ton miles by the total empty population miles for the time period specified. As a cross check the resulting figure should be the average car tare weight for all cars included in the population.
Average Tons/Mile (Column 6, following above)	Prints the weighted average gross weight in tons per car mile for all cars included in the population examined. It is obtained by dividing the total L/E population ton miles by the total L/E population miles.

(2) Clarification

The above suggested procedures can be clarified by an example examining a population of two cars and five different commodities as shown below:

Population: 2 cars; XCG673311 & XCG673312

Commodity: 5 types; A, B, C, D & E

Status L/E: As reported

Miles: As reported

Gross Weight: (tons) As reported

Time Period: As specified

Selected fields of output format are given in Tables A-3, A-4, and A-5 with reference to the attached footnote explication used in the computations, pages A-23 through A-28.

TABLE A-3

ON LINE CAR MOVEMENT FILE - CAR XCG673311*

(Arbitrary Numerical Values, For Illustration Only)**

L/E	Comdty	Gross Weight (tons)	Miles	Car Ton Miles[A.1/]
L	A	100	25	2500
L	B	85	80	6800
L	C	60	65	3900
E		20	70	1400
E		20	105	2100
L	A	55	35	1925
L	C	65	40	2600
E		20	75	1500
			495	22725

CAR MOVEMENT SUMMARY— CAR XCG673311*

Loaded Car[B.1/] Miles/Comdty	Loaded Car Ton[B.5/] Miles/Comdty	%Loaded[B.9/] Car Ton Miles	%. Total[B.10/] Car Ton Miles
A --- 60	A --- 4425	24.97	19.47
B --- 80	B --- 6800	38.36	29.93
C --- 105	C --- 6500	36.67	28.60
Total Loaded[B.2/] Car Miles --- 245	Total Loaded Car[B.6/] Ton Miles --- 17725	100.00	78.00
Total Empty[B.3/] Car Miles --- 250	Total Empty Car[B.7/] Ton Miles --- 5000		22.00
Total L/E[B.4/] Car Miles --- 495	Total L/E Car[B.8/] Ton Miles --- 22725		100.00

Average Tons/Loaded Mile/Comdty[B.11/]

A ---- 73.75 (4425/60)

B ---- 85.00 (6800/80)

C ---- 61.90 (6500/105)

Average Tons/Loaded Mile[B.12/] ---- 72.35 (17725/245)

Average Tons/Empty Mile[B.13/] ---- 20.00 (5000/250)

Average Tons/Mile[B.14/] ---- 45.91 (22725/495)

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*See pages A-29 thru A-31 for footnote explication

**See page A-24 for metric equivalents

TABLE A-3 (Cont'd.)

ON LINE CAR MOVEMENT FILE - CAR XCG673311**

(Arbitrary Numerical Values, For Illustration Only)

L/E	Comdty	Gross Weight (tons)***	Kilometers (kms)	Car Ton kms[A.1/]
L	A	90.71	40.2	3649.9
L	B	77.11	128.7	9927.8
L	C	54.43	104.6	5693.9
E		18.14	112.7	2044.0
E		18.14	169.0	3065.9
L	A	49.90	56.3	2810.4
L	C	58.97	64.4	3795.9
E		18.14	120.7	2190.0
			796.6	33177.8

CAR MOVEMENT SUMMARY—CAR XCG673311*

Loaded Car[B.1/] kms/Comdty		Loaded Car Ton[B.5/] kms/Comdty		% Loaded[B.9/] Car Ton kms	% Total[B.10/] Car Ton kms
A	--- 96.6	A	--- 6460.4	24.97	19.47
B	--- 128.7	B	--- 9927.8	38.36	29.93
C	--- 169.0	C	--- 9489.8	36.67	28.60
Total Loaded[B.2/] Car kms	--- 394.3	Total Loaded Car[B.6/] Ton kms	--- 25878.0	100.00	78.00
Total Empty[B.3/] Car kms	--- 402.3	Total Empty Car[B.7/] Ton kms	--- 7299.9		22.00
Total L/E[B.4/] Car kms	--- 796.6	Total L/E Car[B.8/] Ton kms	--- 33177.8		100.00

Average Tons/Loaded km/Comdty [B.11/]

A ---- 66.90 (6460.4/96.6)
B ---- 77.11 (7927.8/128.7)
C ---- 56.15 (9489.8/169.0)

Average Tons/Loaded km/[B.12/] ---- 65.63 (25878.0/394.3)

Average Tons/Empty km/[B.13/] ---- 18.14 (7295.9/402.3)

Average Tons/km[B.14/] ---- 41.65 (33177.8/796.6)

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*Metric equivalents for previous page

**See pages A-29 thru A-31 for footnote explication

***Metric tons used in above example

TABLE A-4

ON LINE CAR MOVEMENT FILE - CAR XCG673312*

(Arbitrary Numerical Values, For Illustration Only)**

L/E	Comdty	Gross Weight (tons)	Miles	Car Ton Miles[A.1/]
L	A	110	35	3850
L	B	75	60	4500
E		20	40	800
E		20	125	2500
L	D	90	70	6300
L	E	80	45	3600
E		20	90	1800
L	D	40	40	1600
			505	24950

CAR MOVEMENT SUMMARY— CAR XCG673312*

Loaded Car[B.1/] Miles/Comdty	Loaded Car Ton[B.5/] Miles/Comdty	% Loaded[B.9/] Car Ton Miles	% Total[B.10/] Car Ton Miles
A --- 35	A --- 3850	19.39	15.43
B --- 60	B --- 4500	22.67	18.04
D --- 110	D --- 7900	39.80	31.66
E --- 45	E --- 3600	18.41	14.43
Total Loaded[B.2/] Car Miles --- 250	Total Loaded[B.6/] Car Ton Miles --- 19850	100.00	79.56
Total Empty[B.3/] Car Miles --- 255	Total Empty[B.7/] Car Ton Miles --- 5100		20.44
Total L/E[B.4/] Car Miles --- 505	Total L/E Car[B.8/] Ton Miles --- 24950		100.00

Average Tons/Loaded Mile/Comdty[B.11/]

A	----	110.00	(3850/35)
B	----	75.00	(4500/60)
D	----	71.82	(7900/110)
E	----	80.00	(3600/45)
Average Tons/Loaded Mile[B.12/]	----	79.40	(19850/250)
Average Tons/Empty Mile[B.13/]	----	20.00	(5100/255)
Average Tons/Mile[B.14/]	----	49.41	(24950/505)

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* See pages A-29 thru A-31 for footnote explication

** See page A-26 for metric equivalents

TABLE A-4 (Cont'd.)

ON LINE CAR MOVEMENT FILE - CAR XCG673312**

(Arbitrary Numerical Values, For Illustration Only)

L/E	Comdty	Gross Weight (tons)***	Kilometers (kms)	Car Ton kms[A.1/]
L	A	99.79	56.3	5620.9
L	B	68.04	96.6	6569.9
E		18.14	64.4	1168.
E		18.14	201.2	3649.9
L	D	81.65	112.7	9197.8
L	E	72.57	72.4	5255.9
E		18.14	144.8	2628.
L	D	36.29	64.4	2336.
			812.7	36426.4

CAR MOVEMENT SUMMARY— CAR XCG673312*

Loaded Car[B.1/] kms/Comdty		Loaded Car Ton[B.5/] kms/Comdty		% Loaded[B.9/] Car Ton kms	% Total[B.10/] Car Ton kms
A	--- 56.3	A	--- 5620.9	19.39	15.43
B	--- 96.6	B	--- 6569.9	22.67	18.04
D	--- 177.0	D	--- 11533.8	39.80	31.66
E	--- 72.4	E	--- 5255.9	18.41	14.43
Total Loaded[B.2/] Car kms	--- 402.3	Total Loaded[B.6/] Car Ton kms	--- 28980.5	100.00	79.56
Total Empty[B.3/] Car kms	--- 410.4	Total Empty[B.7/] Car Ton kms	--- 7445.9		20.44
Total L/E[B.4/] Car kms	--- 812.7	Total L/E Car[B.8/] Ton kms	--- 36426.4		100.00

Average Tons/Loaded km/Comdty[B.11/]				
	A	----	99.79	(5620.9/56.3)
	B	----	68.04	(6569.9/96.6)
	D	----	65.15	(11533.8/177.0)
	E	----	72.57	(5255.9/72.4)
Average Tons/Loaded km[B.12/]		----	72.03	(28980.5/402.3)
Average Tons/Empty km[B.13/]		----	18.14	(7445.9/410.4)
Average Tons/km[B.14/]		----	44.82	(36426.4/812.7)

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* Metric equivalent for previous page

** See pages A-29 thru A-31 for footnote explication

*** Metric tons used in above example

TABLE A-5

ON LINE CAR POPULATION SUMMARY* (EXAMPLE)

(Arbitrary Numerical Values, For Illustration Only)**

Loaded[C.1/] Population Miles/Comdty		Loaded[C.5/] Population Ton Miles/Comdty		% Loaded[C.9/] Population Ton Miles	% Total[C.10/] Population Ton Miles
A	95	A	8275	22.02	17.36
B	140	B	11300	30.07	23.70
C	105	C	6500	17.30	13.63
D	110	D	7900	21.03	16.57
E	45	E	3600	9.58	7.55
Total Loaded[C.2/] Population Miles	495	Total Loaded[C.6/] Population Ton Miles	37575	100.00	78.81
Total Empty[C.3/] Population Miles	505	Total Empty[C.7/] Population Miles	10100		21.19
Total L/E[C.4/] Population Miles	1000	Total L/E[C.8/] Population Miles	47675		100.00

Average Tons/Loaded Mile/Comdty[C.11/]		
A	87.11	(8275/95)
B	80.71	(11300/140)
C	61.90	(6500/105)
D	71.82	(7900/110)
E	80.00	(3600/45)
Average Tons/Loaded Mile[C.12/]	75.91	(37575/495)
Average Tons/Empty Mile[C.13/]	20.00	(10100/505)
Average Tons/Mile[C.14/]	47.68	(47675/1000)

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* See pages A-29 thru A-31 for footnote explication

** See page A-28 for metric equivalents

TABLE A-5 (Cont'd.)

ON LINE CAR POPULATION SUMMARY* (Example)

(Arbitrary Numerical Values, For Illustration Only)

Loaded[C.1/] Population kms/Comdty		Loaded[C.5/] Population Ton kms/Comdty		% Loaded[C.9/] Population Ton kms	% Total[C.10/] Population Ton kms
A	152.9	A	12081.3	22.02	17.36
B	225.3	B	16497.7	30.97	23.70
C	169.0	C	9489.8	17.30	13.63
D	177.0	D	11533.8	21.03	16.57
E	72.4	E	5255.9	9.58	7.55
Total Loaded[C.2/] Population Kilometers	796.6	Total Loaded[C.6/] Population Ton kms	54858.5	100.00	78.81
Total Empty[C.3/] Population Kilometers	812.7	Total Empty[C.7/] Population Kilometers	14745.7		21.19
Total L/E[C.4/] Population Kilometers	1609.3	Total L/E[C.8/] Population Kilometers	69604.2		100.00

Avg. Tons/*** Loaded km/Comdty[C.11/]

A	79.02	(12081.3/152.9)
B	73.22	(16497.7/225.3)
C	56.15	(9489.8/169.0)
D	65.15	(11533.8/177.0)
E	72.58	(5255.9/72.4)
Average Tons/Loaded km[C.12/]	68.86	(54858.5/796.6)
Average Tons/Empty km[C.13/]	18.14	(14745.7/812.7)
Average Tons/km[C.14/]	43.25	(69604.2/1609.3)

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*Metric equivalent for previous page

**See pages A-29 thru A-31 for footnote explication

***Metric tons used in above example

Footnote Explication

(Reference: Tables A-3, A-4, A-5)

A. On line car movement file data (see pages A-23 thru A-26)

1. Car ton miles = Gross weight (tons) x Miles

B. Car movement summary (see pages A-23 thru A-26)

1. Loaded car miles/comdty = Sum of Loaded car miles for each commodity
2. Total Loaded car miles = Sum of all miles under Loaded (L) status
   or
   = Sum of Loaded car miles/comdty for all commodities involved
3. Total Empty car miles = Sum of all miles under Empty (E) status
4. Total L/E car miles = Sum of all miles traveled by car
   or
   = Total Loaded car miles + Total Empty car miles
5. Loaded car ton miles/comdty = Sum of Loaded car ton miles for each commodity
6. Total Loaded car ton miles = Sum of all car ton miles under Loaded (L) status
   or
   = Sum of Loaded car ton miles/comdty for all commodities involved
7. Total Empty car ton miles = Sum of all car ton miles under Empty (E) status
8. Total L/E car ton miles = Sum of all car ton miles
   or
   = Total Loaded car ton miles + Total Empty car ton miles
9. Percent of Loaded car ton miles = $\frac{\text{Loaded car ton miles/comdty}}{\text{Total Loaded car ton miles}} \times 100$

   Computed for each commodity

10. Percent of total car ton miles: The following items are given as a percentage of total car ton miles

a) Loaded car ton miles/comdty computed for each commodity

b) Total Loaded car ton miles

c) Total Empty car ton miles

11. Average tons/Loaded car mile/comdty = $\frac{\text{Loaded car ton miles/comdty}}{\text{Loaded car miles/comdty}}$

12. Average tons/Loaded car mile = $\frac{\text{Total Loaded car ton miles}}{\text{Total Loaded car miles}}$

13. Average tons/Empty car mile = $\frac{\text{Total Empty car ton miles}}{\text{Total Empty car miles}}$

14. Average tons/car mile = $\frac{\text{Total L/E car ton miles}}{\text{Total L/E car miles}}$

C. <u>On line population summary</u> (see pages A-27 & A-28.)

1. Loaded population miles /comdty = Sum of Loaded car miles/comdty for all cars in the population examined

2. Total Loaded population miles = Sum of all miles under Loaded (L) status for all cars in the population examined

or

= Sum of Loaded population miles/comdty for all commodites involved

3. Total Empty population miles = Sum of all miles under Loaded (L) status for all cars in the population examined

4. Total L/E population miles = Total Loaded population miles + Total Empty population miles

5. Loaded population ton miles /comdty = Sum of Loaded car ton miles/comdty for all cars in the population examined

6. Total Loaded population ton miles = Sum of Loaded population ton miles/ comdty for all commodities

7. Total Empty population ton miles = Sum of all car ton miles under Empty (E) status for all cars in the population examined

8. Total L/E population ton miles = Total Loaded population ton miles + Total Empty population ton miles

9. Percent of Loaded population ton miles = $\frac{\text{Loaded population ton miles/comdty}}{\text{Total Loaded population ton miles}} \times 100$

Computed for each commodity

10. Percent of Total population ton miles: The following items are given as a percentage of the Total L/E population miles

a) Loaded population ton miles/comdty computed for each commodity

b) Total Loaded population ton miles

c) Total Empty population ton miles

11. Average tons/Loaded mile /comdty = $\frac{\text{Loaded population ton miles/comdty}}{\text{Loaded population miles/comdty}}$

Computed for each commodity

12. Average tons/Loaded mile = $\frac{\text{Total Loaded population ton miles}}{\text{Total Loaded population miles}}$

13. Average tons/Empty mile = $\frac{\text{Total Empty population ton miles}}{\text{Total Empty population miles}}$

14. Average tons/mile = $\frac{\text{Total L/E population miles}}{\text{Total L/E population miles}}$

Conversion Factors

1. 1 mile = 1.609344 kilometers
2. 1 short ton = 0.907185 metric tons
3. 1 ton mile = 1.45997 ton kilometers

e. Age (Item II. H.)

Table A-6 provides adequate instructions for collecting these data.

f. Speed and Physical Measures (Item II. I. and III.)

Procedures for collecting these data were not scheduled for Phase I.

g. Truck Financial Costs

Procedures developed in a prior report together with Table A-6 provide adequate instructions for collecting these data.[15]

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[15] Op. Cit., Report No. FRA-75-58A, pp B-46 thru B-50

TABLE A-6
TRUCK ECONOMIC DATA SOURCE AND APPLICATION

Data Category	Data Source	Data Application							
		File	Format and Convert[3]	Key To Tape	Tape To Tape	Price	Edit	Set Up File	Manual Options
I. Operating Cost									
A. Truck maintenance									
1. Off-line	Repair bills[1]	Car repair billing	x		x		x	x	
2. On-line	Repair facilities	Set up input[6]	x	x		x	x	x	
3. Outside	Sub-contractors	Invoices	x	x			x	x	x
B. Related maintenance									
1. Off-line car	Repair bills[1]	Car repair billing	x		x		x	x	
2. On-line car	Repair facilities	Set up input[6]	x	x		x	x	x	
3. Off-line loco	Joint agreements	Invoices	x	x			x	x	x
4. On-line loco	Repair facilities	Cost accounting	x		x		x	x	x
5. On-line facilities	Shops, rip tracks	Cost accounting	x		x		x	x	x
C. Related operating[2]									
1. Commodity L & D	Freight claims bureau	Damage payments	x		x		x	x	
2. Derailment	Accident bureau	R.R. Accid./FRA/Retire.	x		x		x	x	
3. Train delay	Operating Dept.	Field study							x
4. Lost car days	Operating Dept.	Field study							x
5. Other claims[4]	Claims bureaus	Claims payment	x		x		x	x	x
6. Roadway	FRA	FRA cost study[7]							x
II. Operating Conditions									
A. Car Class	Rail. Equip. Regis.	Register							x
B. Truck description	Design engrg.	Configuration specs.							x
C. Mileage (E/L)	Car use dept.	Car movement	x		x			x	
D. Wheel load (E/L)	Car use dept.	Car movement	x		x			x	
E. Commodity	Car use dept.	Car movement	x		x			x	
F. Geography	Car use dept.	Car movement	x		x			x	
G. Track	Engrg. Dept.	Track charts							x
H. Age	UMLER[5]	Register	x		x			x	
I. Speed	Recorders/Simulation	FRA cost study[7]							x

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[1] Optional: "No-bill" repair records

[2] On and off-line

[3] Convert file data to common code classification

[4] Property damage, personal injury, areal

[5] Universal Machine Language Equipment Register

[6] TDOP Report No. FRA-OR&D 75-58A, pp B-8 to B-34

[7] FRA (Railroad Roadway) Report No. RPD-11-CM-R (3 vols.) Jan., 1976

TABLE A-6 (Cont'd.)
TRUCK ECONOMIC DATA SOURCE AND APPLICATION

Data Category	Data Source	Data Application
III. Physical Measures		
A. Existing truck[8]	Truck shop	Disassemble trucks and measure[9]
B. Improved truck[8]	Performance spec.	Life cycle comparison[10]
IV. Truck Financial Costs		
A. Cash flow out		Cash flow calculation data[11]
1. Incremental improvement		Cash out
a. Manufacturer's price	Builder estimate	Direct material
b. Use taxes	Accounting Department	State and local taxes
c. Modifications	Truck Engineering Bureau	In-house additive
d. Installation	Shop facilities	In-house labor assembly
2. Current assets	Cost & Price Analysis Bureau	Working capital requirements
3. Income taxes	Corporate Tax Bureau	Cash loss
4. Opportunity cost	Equipment Controller Department	Loss of alternate equipment use
B. Cash flow in		Cash in
1. Operating cost difference	Existing vs estimated improved truck records	Operating benefit
2. Investment credits	Corporate tax bureau	Reduce initial investment
3. Scrap value	Dealer estimate	Last period cost recovery
4. Current assets	Cost & Price Analysis Bureau	Period phased cost recovery
5. Capital gains/losses	Corporate tax bureau	Tax shield

8/ Selected components within the major groupings: wheel & axle assembly, side frame, bolster, suspension system, brake rigging

9/ Truck selection (builder, age, service, and component)

10/ Economic operating life cycle analysis

11/ See the detail in: Op.Cit., Report No. FRA-OR&D 75-58A, pp. B-46 thru B-49

Appendix B

TRUCK ECONOMIC DATA ANALYSIS GUIDELINES

CONTENTS

Appendix B

TRUCK ECONOMIC DATA ANALYSIS GUIDELINES

I. INTRODUCTION

Research effort for establishing the truck component economic operating life cycle model began in Phase I. Results of the initial effort revealed that neither the required data were available nor were the truck component cost data collection procedures developed, within the railroad industry, to acquire the data.[1/] The need for a practical means to collect and integrate the economic life cycle data was apparent. To meet the need the design of the truck cost information system, originally scheduled for Phase II,[2/] was rescheduled to Phase I and completed [3/] in place of the life cycle model developmental effort. [4/] Research on the analytical procedures to develop the model was resumed during the closing period of Phase I. An approach to evaluating the operating cost performance of existing trucks was developed and is included in Section II.

More specific guidelines were established for developing capital investment analytical procedures. The guidelines include the methods of determining the cost of money acquired for investments in proposed improvements to trucks and the net present value, as well as methods of analyzing risk which are included in Section III.

1/ Op.cit., Report No. FRA-OR&D 75-58, pp 5-7

2/ Ibid, p 17

3/ Op.cit., Report No. FRA-OR&D 75-58A, Appendix B

4/ For a comprehensive study showing the complexity of developing the model and the unavailability of the data see "Final Report on IDENTIFICATION OF AREAS WHERE TECHNOLOGY ADVANCEMENTS CAN BE UTILIZED TO IMPROVE SAFETY AND SERVICE DEPENDABILITY IN THE RAILROAD INDUSTRY," by R. H. Byers, et al of Battelle-Columbus Labs., Columbus, Ohio, for the AAR, Nov. 27, 1974, 2 vols.

II. COST PERFORMANCE EVALUATION

This section contains the developmental approach to cost performance evaluation through the exploitation of the truck economic data base.

First, truck selection guidelines are provided. Second, methods of providing indicators to help isolate the operating costs caused by the trucks selected are described. Third, a truck utilization cost performance measure is introduced. The measure is to be used in the overall economic analysis to estimate and compare the cash flows out, generated by investments in proposed improvements to existing trucks as well as the operating costs of competing existing trucks. The three basic steps in this approach are dependent, for their effectiveness, upon the use of the data provided by the Car Movement Data Acquisition System (see Appendix A, Section III, B.11). That is, the Truck Economic Model previously established [5/] is a specific model that applies to a particular truck design that incurs costs in specific operating conditions (cars, track, load, mileage, age, commodity, speed). The car movement file contains these operating condition data (except speed) for application to the specific model.

A. Truck Selection Guidelines

Car classes built and put into service within the last three years should be selected for economic data base entry. Limiting the selection to classes having a relatively few number of cars in the series will facilitate familiarizing the user with the procedures, due to the relatively low volume of detail to be processed. Approximately fifty to one hundred cars are suggested to also provide the advantage of a one hundred per cent sample. The initial selection can be made arbitrarily for instructional purposes or can be engineering-oriented based on judgments of car classes with trucks suspected of poor performance. Three years are chosen (beginning with the year 1973 in the cases observed) because most of the required data are available in existing

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[5/] Op.cit., Report No. FRA-OR&D 75-58A, B-9 files for that time period. An exception may be on-line home car truck component maintenance costs.[6] The time period selected also offers the user the opportunity of analyzing and comparing the costs incurred by competing trucks operating in the most recent service conditions. (However, these data must be eventually supplemented by actual periodic physical measurements of the same trucks operating in the same conditions before economic life cycles can be reliably estimated. That is, the three year time period may not be necessarily representative of the total economic life experience.)

B. Indicators for Isolating Truck-Caused Cost

The reported costs in the economic data base are not likely to reveal, by themselves, the costs caused by the truck in operation. However, the data base will provide the user with cause-oriented indicators. These indicators are the frequencies and reasons for the incurring of all of the individual costs under all of the specific car movements over a broad range of truck designs. Thus, a user who may elect to analyze commodity loss and damages to determine the costs attributable to truck operations, will find the costs associated in the data base with all the other relevant information needed for the determination as opposed to having to judge the associations or integrate them piecemeal.

For example, the commodity loss and damage cost evaluation should begin with a selection process to determine loss and damage costs per $100 of revenue (revenue is derived automatically from freight traffic systems which are easily interfaced with loss and damage systems) for specific causes, car classes and commodities, for the cars with truck designs under analysis. These data will reveal the order of magnitude of payments and indicate the source documents supporting the claim that should be collected for further detail. (The reported cause categories are not

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6/ Op.cit., FRA-OR&D 75-58A, see pp B-4 to B-34 for cost collection and integration procedures.

specific enough to allow for a determination of truck caused cost.) However, the data base is comprehensive and integrated so that the selection process also provides the user with the frequency of the payments (costs) related to the specific time periods (which are derived from the claim source documents) by each cause category. The process excludes causes that do not appear to be truck-related such as theft or employee errors (but the data are available, if desired). In addition, the other costs, associated by car number and time of incident are provided such as car and truck component maintenance, switching, inspection, lost car day, train delay and derailment.[7/]

These cost data are further supplemented by data from the car movement file which provides the car associated operational data: empty and loaded mileage; wheel loads; rail, tie, ballast, subgrade, curve and grade conditions; age. The loss and damage experience can be thusly reviewed in the total truck system context which provides the user with the total cost effects (history) of the car class. These data should help the user narrow the areas for further investigative action, such as engineering analysis to isolate the specific truck-caused commodity losses and damages. (By developing a well integrated data base the user will have the capability to conduct the analysis starting with any one of the cost categories, such as derailments, as well as the loss and damage costs described in the above example.)

C. Truck Utilization Cost Performance Measures

The user should focus his efforts on establishing a measure that relates the costs incurred by specific truck designs to the truck's specific operating conditions. The measure can be expressed as the total operating costs (the numerator) to the total gross ton miles (the denominator) at various speeds and roadway conditions. The denominator is derived from the mileage and tonnage data

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[7/] Train delay and lost car day costs are to be developed from special studies which include the cost of switching and inspection, see Op.Cit., Report No. FRA-OR&D 75-58 pp 16 and 18.

available in the Car Movement File which also leads to the roadway conditions. The measure has application for the overall economic analysis because it can be used to evaluate and compare the historical operating costs of existing trucks operating under the same conditions, as well as their mechanical performance. Under the provision that mechanical performance of proposed improved existing trucks is being monitored and sufficient data have accumulated in the data base, then estimates can be made of the operating costs per gross ton mile (cash flow out) generated by proposed investments in improvements and compared with the historical operating costs per gross ton mile of existing trucks. (See SUMMARY, Section III, D. Future Requirements.) Use of traffic forecasts in terms of gross ton miles per class per period will permit a more accurate estimation of the truck operating costs. This truck utilization cost performance measure is recommended for development by users of the TDOP procedures as an initial step in establishing economic life cycle analytical procedures.

III. INVESTMENT EVALUATION

A Truck Economic Model was developed and presented in the TDOP's first economic analysis interim report. The net present value method of evaluating incremental investments in proposed improvements to Type I general purpose railroad freight car trucks was established in that Model.[8/]

The TDOP's second economic analysis interim report contains the listing of the investment cash flow elements to be used with the Truck Economic Model. The report also contains the method of combining the cash flow elements for calculating their net present value.[9/]

This Appendix B contains a further refinement to the Truck Economic Model. The method of determining the cost of the money acquired for a capital investment is provided. The net present value method of evaluating investments

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8/ Op. cit., Report No. FRA-OR&D 75-58, pp 1, 8-10

9/ Op. cit., Report No. FRA-OR&D 75-58A, pp B-46 to B-50 in proposed improvements to existing general purpose trucks is included to demonstrate its close relationship with the cost of capital application. In addition, methods of analyzing the risk associated with the investment's cash flows are provided.

A. The Cost of Capital

1. Introduction

The subject of the cost of capital will be covered in two parts. The first part is contained in this Appendix B. This part provides a description of the "standard" method of determining the cost of capital for nonregulated profit making organizations whose existing and proposed capital structure is made up of a mix of debt and equity.[10] The current market price of the equity must be known at any given time. (The equity can consist of preferred and common stock and retained earnings.)

The second part of the cost of capital description will apply to the methods of modifying the "standard" approach for adaptation to the railroad industry. This part will be covered in a later phase (however, a brief discussion is to be found in Section III, 3).

2. The "Standard" Cost of Capital Model

a. Definition

There seems a consensus among investment evaluation theorists and practitioners that the cost of capital is the minimum rate a new investment must earn after taxes to avoid a loss resulting from its cash flow. Sometimes it is stated as the rate that must be earned that leaves the value of the firm (i.e., the common stockholder's equity) at least unchanged. More simply, it is "....the cost of the new funds which will soon be invested in new projects."[11]

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[10] Some financial theorists hold the cost of capital concept as a universally accepted standard and at the same time recognize the standard is not universally applied. See Basic Business Finance, P. Hunt, et al, Richard D. Irwin, Inc., Homewood, Ill., 60430, 1974, pp 204, 208.

[11] Financial Decision Making-Theory and Practice, A. B. Cohen, Prentice Hall, Inc., Englewood Cliffs, N. J., 1972, p 387.

b. The "Standard" Method

The cost of capital is expressed as a percent and is used to discount the truck investment's net cash flows in order to calculate their net present value. The elements of cost that must be considered are:

- earning per share and market price
- underwriting (e.g., cost of selling the issues)
- administrative (e.g., legal, printing, secretarial)
- sinking fund (e.g., cost of bond retirements)
- interest (bond coupon rate) and dividends (preferred and common stock)
- proceeds from the issue
- federal taxes

To simplify the presentation the underwriting, administrative and sinking fund elements will be grouped as one, under "flotation" costs, without distinguishing their form or cash flow timing.

The following methods can be used to calculate the cost of capital for both present and proposed capital structures. Where multiple estimates are made probabilities must be assigned (see Section III, C).

- Cost of Debt per bond[12]

$$C = (1-t) \frac{I + \frac{V-(P-F)}{n}}{\frac{V+P-F}{2}}$$

Where:

C = cost of debt after tax

t = federal tax rate

I = annual dollar interest to be paid on the bond

V = face value of the bond

P = proceeds (market price of the issue)

F = flotation costs

n = number of years

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[12] Various methods of calculating the cost of capital are well covered in most college business tests, Op.Cit., Basic Business Finance, Chaps. 8-10.

- Cost of Preferred Stock (per share)

$$X = \frac{D}{P-F}$$

Where:

X = cost of preferred stock

D = dividend

P = proceeds (market price of the issue)

F = flotation cost

- Cost of Common Stock (per share)

$$S = \frac{Da}{P-F} + G$$

Where:

S = cost of common stock-new issue to new stock holders

Da = anticipated dividend

F = flotation cost

G = growth rate [13]

P = anticipated new issue market price

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[13] Anticipated dividends, earnings and market price

- Cost of Retained Earnings (per equivalent share of common stock)

$$R = \frac{D\,(1-t_m)}{M} + G$$

Where:

R = cost of retained earnings

D = anticipated dividends/share

t_m = marginal tax rate[14]

M = current issue market price of common stock

G = growth rate

c. Weighted Average Cost of Capital[15]

Since the costs of capital discussed in this section consist of a mixture of debt and equity the various costs must be weighted to accurately determine the average cost of the estimates.

$$W_c = (C)\,(P_1) + (X)\,(P_2) + (S)\,(P_3) + (R)\,(P_4)$$

Where:

W_c = weighted average cost of capital

C = cost of debt after tax

X = cost of preferred stock

S = cost of common stock (new issue to new stockholders)

R = cost of retained earnings

P_n = percent of the amount of money provided by each of the capital instruments to the total of the money provided by all of the capital instruments

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[14] The marginal tax rate is the weighted average personal income tax rate of the investors. See "The Weighted Average Marginal Tax Rate on Dividends Received by Individuals in the U.S.", V. Jolivet, American Economic Review, June, 1966, pp 473-477.

[15] This concept is not universally accepted. See, for example, The Cost of Capital, W. G. Lewellen, Wadsworth Publishing Co., Inc., Belmont, Calif. 1969.

3. Cost of Capital Considerations for the Railroad Industry

Methods of determining the cost of capital for incremental investments in proposed improvements to freight car trucks require special analysis. The current suggested method of applying the cost of capital to investments as it appears in an Interstate Commerce Commission study are not adequate.[16/] This is true because the method does not allow for the recovery of the cost of equity capital. The possible effect of the ICC method can be examined in the light of the unique regulatory-competitive nature of the railroad industry. For example, their earnings are regulated and at the same time railroad companies compete with one another for profits, in addition to competing with other industries, regulated and nonregulated, for profits. While public utility regulation is intended to provide fair earnings' opportunities there are valid questions raised whether traditional earnings' standards are currently appropriate.[17/] The estimate of the profitability of a truck investment is dependent, in large part, on the prices a railroad charges for its services. The prices, in turn, are dependent upon external regulations. To the extent the regulation does not allow for the full absorption of capital costs the railroad must reflect that lack of absorption in its truck investment profitability predictions.

[16/] See "Rail Carload Cost Scales By Territories For The Year 1970", Interstate Commerce Commission, Statement No. ICI-70, Washington, D.C., May 1973, item 3, page 6.

[17/] See "Net Investment - Railroad Rate Base and Rate of Return", Verified Statement No. 2 (Ex Parte No. 271), Affiant: J. Rhoads Foster, before the Interstate Commerce Commission, pp 19-21, and 77-79

B. Net Present Value Method

The use of the net present value method for an accurate profitability prediction is dependent upon the accuracy of the cost of capital estimate (i.e., "i" in the following formula).

- The Net Present Value Calculation[18]

$$P_v = \sum_{t=1}^{n} \frac{A}{(1 + i)^t} - C$$

Where:

P_v = net present value of the estimated net cash benefits, of positive or negative or zero dollar value

A = estimated net cash benefits received each period

C = cost (i.e., present value of the estimated incremental net cash out discounted at the cost of capital)

t = time periods (e.g., first year, second, third)

i = cost of capital (i.e., the discount rate)

n = number of time periods (e.g., one year, two)

The net present value calculation provides a comparison of the absolute dollar value of the net cash flows in and out. That comparison can, in turn, be made with alternatives to arrive at the most profitable of proposals. However, the calculation does not provide for a ranking of the proposals. (See the following section)

18/ Present value formulas, are readily available. See The Dow-Jones-Irwin Guide to Interest, L. R. Rosen, Dow-Jones-Irwin, Inc., Homeward, Ill., 1974, pp 1, 2, and 79-148

- The Profitability Index

Ranking can be provided by using the profitability index which is:

$$PI = \frac{P_v + C}{C} = \frac{\text{Present value of proceeds}}{\text{Present value of outlays}}$$

Since the present value method does not reflect the relative size of alternative investments (i.e., a net present value of $10 may result from an investment of $100 or $100000) the use of this index provides an indication of the relative desirability of any given investment opportunity.

As a general rule, when choosing among mutually exclusive investments the proposal having the largest net present value should be selected, without regard to the profitability index.

C. Risk Analysis

- Probabilities

There will usually be a range of estimates made as opposed to only one estimated net cash benefit. The assignment of probabilities [19] to the range of estimated net present values will be required to determine the most likely or expected value in the range. The historical base of the estimates (truck market size, growth and share; variable operating costs;[20] resource availability of skills and material; the investment's cash flows) will serve to help assign the probabilities. For example, there will doubtless be more than one estimate of inflationary price trend to choose from. The TDOP economic staff would suggest an index more closely allied to railroad prices broken down by labor, material and supplements from which

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[19] The calculations are well enough known as to preclude their repeating here. See, Modern Business Statistics, J. E. Freund, F. S. Williams, Prentice-Hall, Inc. 1958, Chapter 6.

[20] The fixed costs (properly identified) do not enter into the evaluation of a proposed incremental investment. See, Op.Cit., Report No. FRA-OR&D 75-58, pp 2,3.

a user can select probabilities[21] as opposed to broader indices such as the Gross National Product price deflator. But that choice will be a matter for individual users to decide in relationship to the best "fit" to their railroad's investment conditions.

Where historical experience for truck investment estimates are lacking, probabilities can be assigned from, perhaps, the past experience of other investment predictions (within the same company; among similar companies). The probabilities may have to be assigned based on the experienced judgment of railroad officials, at least by agreeing on the adverse limits of the profitability prediction (worst vs best to be expected).

- Sensitivity Analysis

In addition to the assignment of probabilities to investment cash flow estimates, other calculations should be made and presented to the decision-maker that disclose how sensitive the estimates are to related conditions beyond the railroad's control. For example, investment tax credits are a matter for congressional legislation as opposed to the unilateral actions of a railroad. Cash outflow predictions based on the effect of different possible investment tax credit legislation (including <u>no</u> credit allowance) should be made to determine the degree to which the proposed profitability of a truck investment is dependent on the credit.

Almost certainly, sensitivity analysis should be applied to the cost of capital estimate. Particularly is that true for computing cost of capital, based on the Rail Form A suggested method, using debt cost only, as well as computing full capital cost absorbtion.[22]

- Standard Deviation

Alternative investments can be ranked by comparing the expected net present value of their cash flows. Where there is a range of possible net present

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[21] Op.Cit., <u>Railway Age</u>, p 62.

[22] See Section 3, Cost of Capital Considerations for Railroad Industry, page B-11.

values, then the assignment of probabilities over the range will result in a probability distribution function. (The wider the dispersion of possible outcomes the greater the risk involved in an investment.) Standard deviation, although not a direct measure of risk, is a measure of dispersion that provides a good indicator of the risk involved. (The risk factor in itself is set by the market.)

The expected net present value of two investment alternatives being the same would result in the selection of the investment with the smallest measure of dispersion or standard deviation. When two alternative investments have the same variability with different expected net present values the risk can be measured relatively by calculating the coefficients of variation. Ranking two alternative investments by the coefficient of variation, the investment with the lower coefficient of variation would be the one bearing less risk.

.0 ECONOMIC RELATIONSHIPS

.1 INTRODUCTION

Engineering studies conducted in freight car truck dynamics extend throughout the history of railroad operations. The need to develop trucks sustaining heavier loads and higher speeds to meet the continuing change in traffic demands is as evident today as it was 100 years ago. (Report of Master Car-Builder's Association, 1882) (Reference 1).

However, only recently, with the innovative FRA sponsored research (Phase I TDOP), have truck engineering studies received equally intensive support from the rigorous test of economic evaluation. The strong emphasis in Phase II's SOW on well-planned procedures for the integration of the engineering and economic tasks greatly enhances the probabilities of converting truck research into lower railroad operating costs and improved profits.

The asset structure of railroads is largely composed of heavy investments in fixed plant and rolling stock. Improvements resulting from the TDOP Phase II research must have practical economic application in such an intensively fixed asset industry. "If the perfect freight car were invented now, and all new equipment were of the new design, it would take on the order of twenty years before half of the fleet represented the new design."(Reference 2)

Near term indirect cost benefits will be made available through the development and exploitation of the economic data base which will contain the cost behavior data for existing general and special purpose trucks. For example, users who develop a TDOP data base for their own operating conditions will have the capability of identifying poor truck performers for which performance indices are being established before chronic defects can reach epidemic proportions (early component defect warnings).

2.2 DEFINITION OF PERFORMANCE INDICES AND ECONOMIC RELATIONSHIPS

2.2.1 Integration of the Engineering/Economic Tasks

In the past, freight car trucks, test sites and the types of tests selected for design performance analysis have been largely conducted in the absence of actual, on-line and off-line detailed operating conditions, deterioration effects and other costs associated with the truck components life-cycle history. In Phase II of TDOP the performance definition effort will be supported by actual wear and failure data for off-line maintenance (and similar related data that may be available from the FAST program) within one to four months of the project start-

Data Management

up date. Wear and failure data will include the costs and incidents of thin and high flanges; worn roller bearings and adapters; flawed axles; worn center plates, bolsters, side frames and friction snubbers; broken and worn springs; thin wheel rims; bent brake beams and other evidence of deterioration. These data will be related to the car numbers, repair locations and dates of repair for the same car classes selected for engineering testing.

Subsequently, the data base will be expanded and integrated over the 30-month contract period. The expanded data base will include the cost of the relevant commodity loss and damage, derailment, on-line home car truck maintenance and other operating costs and car movements (e.g., load, mileage, track conditions) Further, the project's technical staff will be able to query the data base for evidences of truck deterioration. This procedure will arm the technical staff with a powerful tool to help define the performance characteristics and indices throughout the life of the project for different cars and trucks in service over a wide variety of operating conditions. For example, ride quality tests may be conducted for the purpose of establishing performance characteristics under vertical vibration excitation. In that case the data will include the cost of the car related freight damage claims; the actual change-out frequency and cost of worn friction snubbers, springs; other costs and car movement data associated by car number for the same class as the cars being tested. Figure 2-1 illustrates an overview of the engineering/economic integration.

2.2.2 Method of Relating Truck Performance Indices to Operating Costs and Profits

Unit cost measures will be developed based on performance indices to define the operating cost behavior of existing trucks. These same measures will be used to predict the cost behavior of improvements to existing trucks. This procedure will provide the capability of predicting the comparative operating costs of the existing and the improved trucks. For the purpose of predicting operating profits, the unit cost measures must be incorporated into the economic life cycle models. The life cycle models will be more extensive than the unit cost measures and will include all the economic factors associated with the life of a truck. For example, the profitability prediction of a truck improvement must include non-operating factors: investment credits applicable to certain kinds of capital equipment; schedules of allowable expense associated with depreciable assets (commonly known as depreciation), tax shields and capital cost rates. Comparisons of existing truck economic life cycle costs with estimates of similar costs for truck improvements will provide profitability predictions (which must eventually be validated by truck improvement life cycle testing). A discussion of our methodology follows:

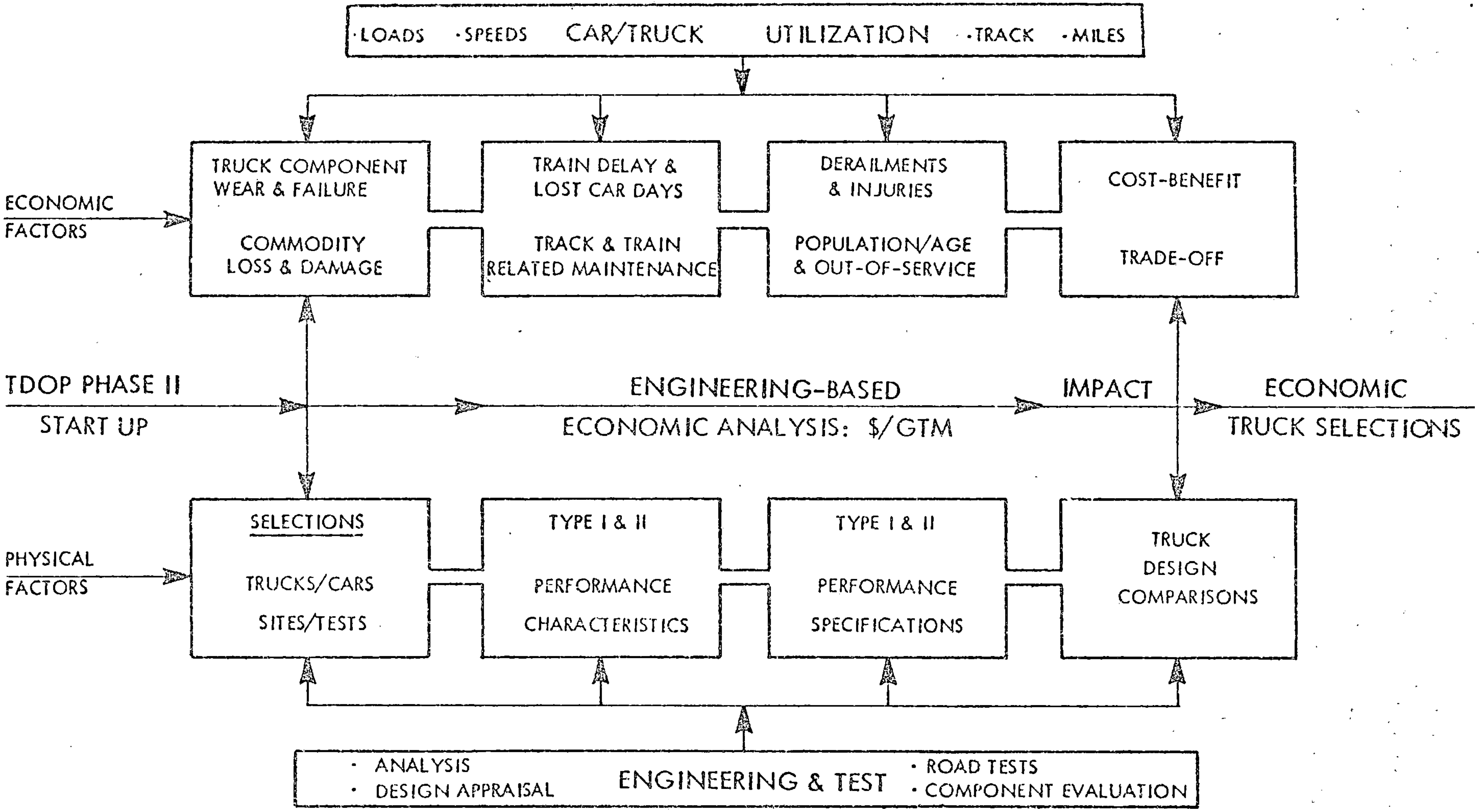


Figure 2-1 Overview Of Engineering/Economic Integration

2.2.1 Performance Indices and Operating Cost Relationships

This section provides an example of how we will relate Performance Indices to erating costs in TDOP Phase II. We have selected one from among the three indices included the technical discussion which states that "....flange pressure in pounds and angle of attack degrees are the performance indices for curve negotiation." (Section 1.3.2.1 Thin Flange elated to Curving Performance). This example meets the practical requirement set forth in e SOW: "The contractor shall define performance indices which can be correlated to the onomics of railroad operations." Our purpose is to provide a working procedure for the lection, derivation and use of engineering-based unit cost measures. While our example rovides ease of presentation it does not imply that the measure will be used alone. No single dex can be expected to characterize truck performance (just as no single index or financial tio taken from the financial statements can characterize the overall fiscal posture of a rofit-making organization). It is the sum of all the relevant performance indices (ride quality, urve negotiability, hunting, loadpaths, safe speed, track inputs) that will determine the conomic impact of these interacting forces.

.2.2.1.1 Selection of Unit Cost Measures.

A critical requirement for establishing actual cost/indices relationships is in the election of cars and trucks for testing (as well as the tests themselves). Limited research unds and the need for the railroad industry to achieve near term cost benefits require that elevant economic data be available from existing files. These data must represent current nd anticipated operating costs and conditions and will also provide the opportunity for the ndustry to realize the highest payoff over the shortest period of time.

Generally, with respect to car movements, the required data cannot be expected to e found available prior to 1973. The results of the TDOP Phase I economic analysis revealed that railroad (Class I) car movement systems do not appear to have achieved operational status rior to that period. The availability of data from such systems are necessary for establishing the historical experience of the truck in service (loads, distances, track conditions, down time). The UP railroad we have chosen to perform testing and supply data has an adequate car movement system.

With respect to the tests themselves, wear data must be available that reflect the effect of truck force and motion e.g., the frequency and cost of changing out worn and broken springs and friction snubbers are essential to help establish the cost behavior of existing trucks related to ride quality performance indices. In addition, the cost of lading damage and worn heel treads will be needed for relating cost effects to the lateral dynamics of the vehicle, i.e. unting. As with the car movement data, the UP railroad can make the required cost data vailable.

We have selected thin flange related to curve negotiability as one of the ngineering based unit cost measures for three reasons:

1) Relatively high cost impact
2) Data availability
3) Generally accepted reason for wheel condemnation or reprofiling

Thin flanges represented the highest frequency of wheel change out reported in a 974 study of off-line billings.(Reference 3)

COMPONENT	($000) COST	$ TO TOTAL	RANKING
Thin Flange	$ 5,202	39.0	Highest Cost
High Flange	1,990	14.9	Second Highest Cost
Thin Rim	1,334	10.0	Third Highest Cost
All Other	4,822	35.4	All Other
TOTAL	$13,348	99.3%	

2.2.2.1.2 Definition of Unit Cost Measures: Cost of Thin Flange Wear per Pound-Mile

1) Derivation of Denominator: Pound Mile
   a) Wear = work
   b) Work = force x distance
   c) Force = flange force
   d) Flange force = average flange force in pounds per degree of curve x number of degrees per curve. (Flange force does not increase linearly with curvature. Correction factors will be applied to sharpen this definition in actual application).

e) Distance = number of miles per curve

f) Number of miles per curve = percent of curved track x total number of miles

2) Derivation of Numerator: Cost of Thin Flange Wear

a) Thin flange wear = average symmetrical 16th inch thin flange metal loss per wheel set

b) Cost = maintenance cost and associated cost related to operating conditions

c) Maintenance cost = labor, material and overhead charged to truck symmetrical thin flange wheel change-out or repairs: (inspection; switching, turning, equipment operation; facility use; new, secondhand and reconditioned material; supervision; administration; fringe benefits; fixed charges; supporting supplies; inventory) (Reference 4)

d) Associated cost = the directly related costs of train delay and lost car days (i.e. standard cost per car); other truck, car, roadway component repairs (including component shop reconditioning); derailments; injury; property damage; commodity losses and damages; and other "hidden" costs such as any freight revenue lost or high liability and freight protection insurance costs traceable to thin flange wear.

e) Operating conditions = car and truck configuration (e.g., type wheels, springs, stabilizers, truck spacing), mileage (empty and loaded); wheel loads; type commodity; speed; age; roadway conditions (rail, tie, ballast, curves, grades, climate) service (e.g., unit, mixed).

2.2.2.1.3 Isolating Truck Caused Costs.

The example we have chosen to define the relationships of performance indices to operating costs must next be demonstrated to have practical application.

1) Operating Costs. The measure of the cost of thin flange wear per pound mile, contains two assumptions that must be validated. The first assumption is that data will be available to isolate symmetrical thin flange wear in curves believed to be caused by lozenging as opposed to unsymmetrical wear believed to be caused by eccentricities in the brake rigging. The measure also assumes data will be available to distinguish between equilibrium speed in curves and over or under speed which causes additional flange wear. Our procedure for isolating symmetrical thin flange wear will be to select the wheel set finger gauge readings for each wheel changed out or repaired (e.g. turned while on the car) reported by field

forces. The repair cost of the symmetrically worn wheel sets will be entered into the maintenance cost portion of the unit cost measure numerator. Cases in which the reported information specifies that the mate wheel was sold for scrap can probably be attributed to brake rigging eccentricities. This narrowing process will continue and data applied to unit cost measures for unsymmetrical wear patterns where, for example, the costs attributable to brake rigging eccentricities can be measured by the crabbing angle performance index.

With respect to the associated costs, the train delay and lost car day costs will be derived from special studies.(Reference 5) The other associated costs will come from establishing correlations between the reported reasons for truck component changeouts and other repairs and costs that will be associated in the data base by car number and the dates the costs were incurred. For example, one would not expect a high degree of correlation between thin flange and lading damage. (For a brief description of the general methodology for isolating truck-caused commodity losses and damages and other costs see the last economic analysis report of TDOP Phase I (Reference 6))

2) Operating Conditions. Car movement data is the key factor in establishing the unit cost measures related to a truck's operating environment. Existing on-line, real-time railroad car movement systems provide an historical record of individual car movements by day. The readily available data includes empty and loaded mileage, loads, commodities, arrival and departure by time of day, train identification, and geographic locations. The geographic locations, in turn, provide the opportunity to access track charts for more detailed information such as whether rail is jointed or continuously welded, type of rail, curves, grades, weight, ties, ballast, subgrade. These data will allow us to study correlations between symmetrical thin flange wear and degrees of curves traversed versus tangent track. This is an important step for establishing the truck-caused wear and other costs that may be directly attributable to curved track.

The relationships between unit cost and operating conditions will also be tested by fitting the historical data to a model based on multiple regression equations. The dependent or explained variable of the equation will be costs such as operating and maintenance costs, and the explanatory variables will be operating conditions, such as empty and loaded mileage, loads, commodities and track conditions. When estimated by linear form, the coefficient of an explanatory variable will indicate the percent change in cost associated with one percent change in mileage (empty or loaded), loads, commodities and track conditions. The importance of the model will be its ability to predict costs for future changes in the explanatory variables. These predictions will be based on the coefficients of the explanatory variables, in cases where these coefficients are economically and statistically significant.

2.2.2.2 Performance Indices and Operating Profit Relationships

The link between the performance indices and operating profits is the economic life cycle. Economic life cycle data include the performance indices-based unit cost measures which will be converted to total operating cost by summing the total number of units for a given set of operating conditions. In addition, other operating and non-operating costs must be introduced into the life cycle calculations. This is best done by developing simple life cycle models first and gradually developing more complete ones along with the gradual expansion of the data base.

2.2.2.2.1 Truck Economic Life Cycle Models.

Some reference material describing the development of economic life cycle models is available. Evidence of their practical application is not. In our life cycle research efforts, we will consult such references as the Logistic Support Cost Model used at Wright-Patterson Guide (Reference 8). However, since these publications are weapons-systems oriented they have limited application with respect to railroad operations except for their maintenance system checklist guidelines. All these complex models are handicapped by the time it would take to make the models operational. A simpler approach is required.

1) Truck Component Replacement Cycles. First, we will develop simplified models for predicting a component's optimum replacement cycle interval, based on limited but readily available maintenance cost data. Off-line home car truck maintenance cost records serve this purpose for cars with a history of predominantly continuous off-line service. The cost and time intervals of replacing components worn out as a result of routine use, combined with the same data for failure, are the basic inputs for the simplified prediction of the probabilities of such occurrences.

This procedure has many advantages. Significant wear and failure trends may emerge and highlight for the engineers the need to intensify the testing effort toward one or more performance characterizations. Grossly poor component performances (of the car class being tested) can provide an early warning to the test engineer and the railroad who adopts these procedures.(Reference 9) The early warning may produce a measurable and favorable impact on operating costs which would be translated rapidly into near term cost avoidances. This also lays the groundwork for developing expanded models.

2) Expanded Models. Subsequently, we will expand the component replacement cycle analysis into more fully developed truck economic life cycle models. The data requirements and the analytical procedures will become more complete as we introduce population statistics to convert unit cost measures to total costs. Mean time between replacements will be established for predicting the service performance of the existing trucks. Increased refinement will be introduced for tracking the truck's operating conditions; inspection capability; maintenance practices; gauge availability; material availability; rail, tie and ballast conditions. Because of the exacting detail required, our approach is to make certain that the data collected at any one time have been fully exploited before moving into more sophisticated models. We are committed to avoidance of massive data acquisitions unless there is a clearly stated rationale for their use in realizing cost-benefit tradeoffs.

The non-operating investment costs must be established for improvements to existing trucks. (See the incremental investment evaluation procedure established in Phase I - References 5, 6 and 9). The investment evaluation procedure brings together the truck cash flow items: "first" or fixed costs, opportunity costs and cost-benefit tradeoffs such as lower maintenance, losses and damages (i.e. the difference between existing and improved truck operating costs). In addition, the investment credits and tax shields arising from depreciation schedules and capital gains and losses must be included in the calculations. Moreover, we plan to conduct a general railroad cost of capital study.

3) Impact of Type II Truck Costs, Output and Profits. By using economic theory of regulated industry, it can be demonstrated that the adoption of an improved truck will help a railroad increase its profits. The proof of such an apparently unrealistic possibility is based on the behavior pattern of certain costs and demand parameters. First, it is probable that the improved Type II truck will require a higher fixed cost relative to that of the existing truck. The effect of such a possibility, which is not unrealistic, will be to bring about an upward shift in the average cost curve, as shown by AC2 in Figure 2-2. Second, the variable costs such as maintenance cost of the improved truck should be lower relative to that of

the existing truck. Such a possibility will bring about a downward shift of the marginal cost curve, as shown by MC2. Third, let us assume that the price or the rate structure (or average revenue = marginal revenue) for the railroad's services will remain unchanged despite the adoption of the improved truck. Needless to say, this assumption is also realistic both because of the regulation of the industry by the Interstate Commerce Commission as well as the fact that demand conditions generally depend upon long term phenomena such as population, income, tastes and preferences of the consumers and availability of substitutes for the services of the railroads. Consequently, we have not introduced any shift in the price or the demand function (AR = MR).

Given the conditions of setting the price equal to marginal cost so as to allow a regulated rate of return above the average costs, Figure 2-2 shows that in the absence of the Type II truck, the firm will be in equilibrium at P1 where it produces and sells output/services OMI (ton/miles) at price P1M1 and earns profit given by P1A1R1S1. The adoption of Type II truck increases the fixed costs and hence shifts the AC curve to AC2, decreases the maintenance costs and shifts the MC1 downward to MC2. The MC2 intersects MR = AR curve at P2, giving the price of PM2 and increased equilibrium output of OM2 and increased profits, shown by the rectangle P2Q2R2S1.

In order to empirically verify the theoretical possibility, we will estimate the costs. The possibility of increased profits after the acceptance of the Type II truck will simply depend upon the relationship between the changes in the fixed and the marginal costs. In order to compare the increased fixed costs with the decrease in the variable marginal costs, we will convert these costs into "annualized costs" by dividing the estimated costs by the expected life of the Type II (or Type I, if the life of the Type II truck cannot be estimated). If the decrease in marginal costs swamp the increase in annualized fixed costs, there will be an increase in the profits for the railroad, despite the fact that there will be no increase in the rate of return set by the regulated agency. The increased profits will obviously be derived from the substantial reduction in marginal costs associated with the improved performance indices of the Type II truck.

4) Cost Benefit Studies. We will conduct cost/benefit trade-off studies to determine to whom the anticipated profits will accrue. A railroad that takes the initiative to invest in an improved truck will only do so in anticipation of realizing additional net profit. Improved truck destined for interchange service must pass

through AAR approval procedures. This implies that the benefit would accrue to all railroads. In that instance, the improvement would have to attract additional net profit-bearing revenue from other modes of transportation for railroads to make an affirmative investment decision relating to truck improvements. An improvement could arise to an existing truck entering interchange service, that was of such a nature as to be compatibly intermixed with unimproved existing trucks (such as a mechanical off-the-shelf modification). In that case, other railroads, not investing in improved trucks, may find it to their benefit to make maximum use of the railroads' trucks that have been improved (a condition that sometimes arises when critical car shortages develop). This will happen where the improvement favors the lowering of such costs as lading damage, track damage, train delay, lost car days, and derailments. In those instances the lion's share of the benefits may well accrue to other railroads using the improved truck rather than the one who invested in the improvement. Such a condition militates against the investment being made. However, the investment would probably be made when the improvement lowers the maintenance cost to the point where off-line repair billings (i.e. accounts payable) were reduced enough to offset the investment costs. In the former case there may be room to maneuver a solution through the per diem rate structure (better trucks, higher rates) however cumbersome that may seem today. In any event, we will address the savings potential to individual railroads who might adopt the proposed improvements following the development of the economic data base when we will subject the data to sensitivity analysis.

Lastly, in view of the size of the existing national fleet (at least three million trucks), we will also develop a gradual progressive implementation strategy for improved trucks. Such a strategy implies that long term profit realization will also be gradual and progressive but steady (assuming an improved truck emerges) and consistent with this heavy fixed-asset industry.

2.2.2.2 Adequacy of Type I Freight Car Truck Test Data for Quantifying Economic-Based Performance Indices

Actual "live" economic data collected during Phase I consisted of off-line repair bills for two classes of cars: a total of 163 individual cars (see page B-14 of Reference 9). The purpose was to test the maintenance cost acquisition subsystem of the economic methodology that had been developed in Phase I. The opportunity to conduct this test was provided by the prime contractor without charge to the Government sponsor. (The prime contractor had been experimenting with collecting off-line car repair costs prior to the beginning of TDOP Phase I). At the suggestion of TDOP staff member (who had originally helped design and conduct experiments prior to Phase I) the prime contractor decided to collect off-line repair costs relating to the car classes being tested under TDOP for their own purposes. In a cooperative gesture the prime contractor also allowed the data to be used in the TDOP Project. Performance indices were not related to these costs at the time of their collection. They are not adequate for use in Phase II because they are not complete. Cost data were not collected for any of the other categories of cost, including car movements because of the effort required to establish their very existence (considered within the industry at the time to be not available).

Since the off-line data can be collected with minimal resources (see page B-17 of Reference 9) and since the economic data base, to be reliable, must be consistent (i.e. all truck costs must be related to the same car class for the car trucks being tested), we recommend that all the required data be collected on the subcontractor's railroad for the same general purpose and special purpose trucks that are selected in Phase II. Figure 2-3 provides an illustration of the relationship of performance indices to operating costs and profits within the truck economic system.

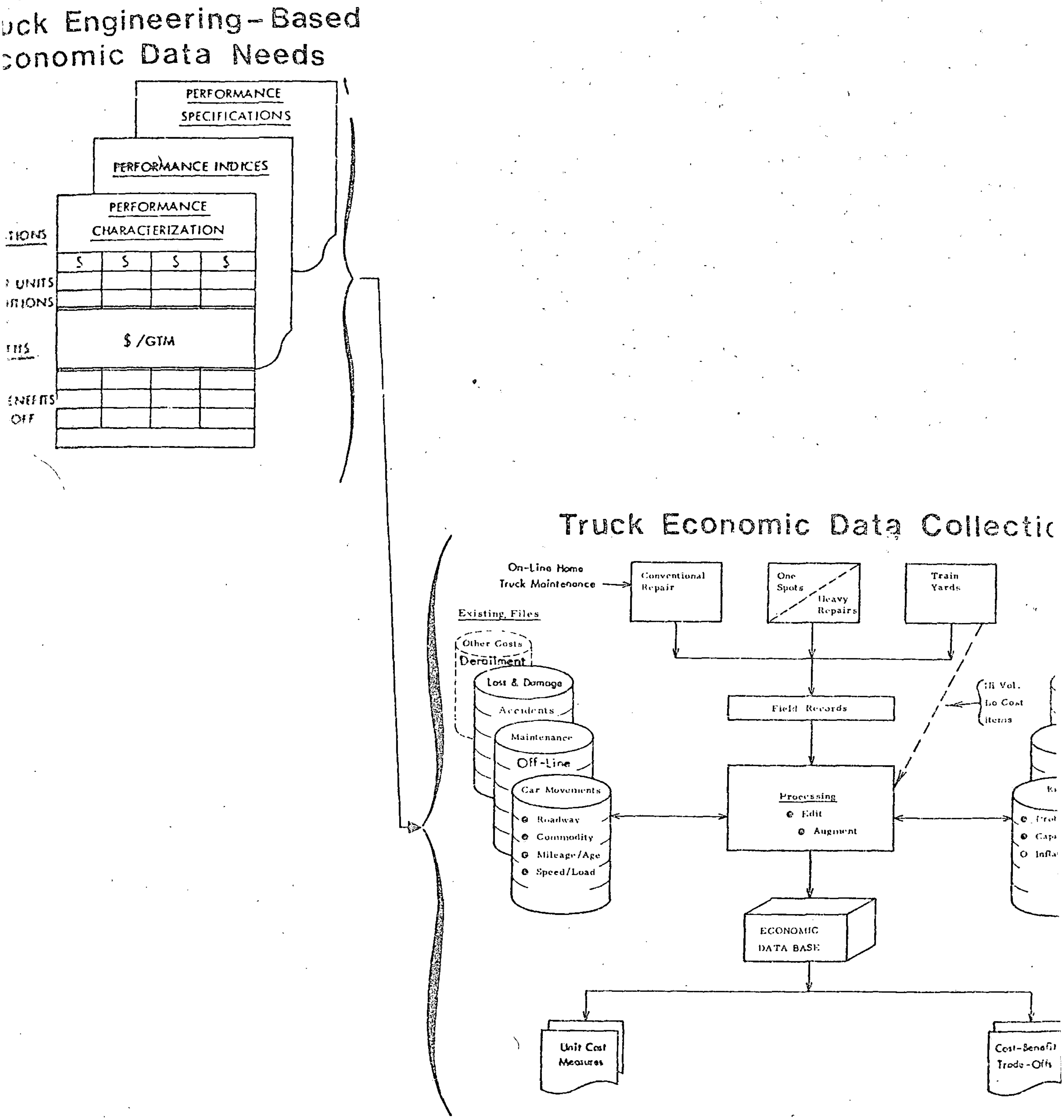
2.3 ESTABLISH REQUIREMENTS FOR ADDITIONAL ECONOMIC DATA

The additional economic data required for Phase II are specified in Table 2-1. These schedules provide our time-phased plan for acquiring the data. They include an identification of each data element, their organizational sources data collection methods for the activities. The data collection system provides the capability to relate operating costs and conditions to the performance indices. The system also has provision for accommodating data representing a national experience. In addition, we have provided for the validation of the data base through the use of physical measurements to be taken of existing trucks of the same class as those selected.

Need for Physical Measurements.

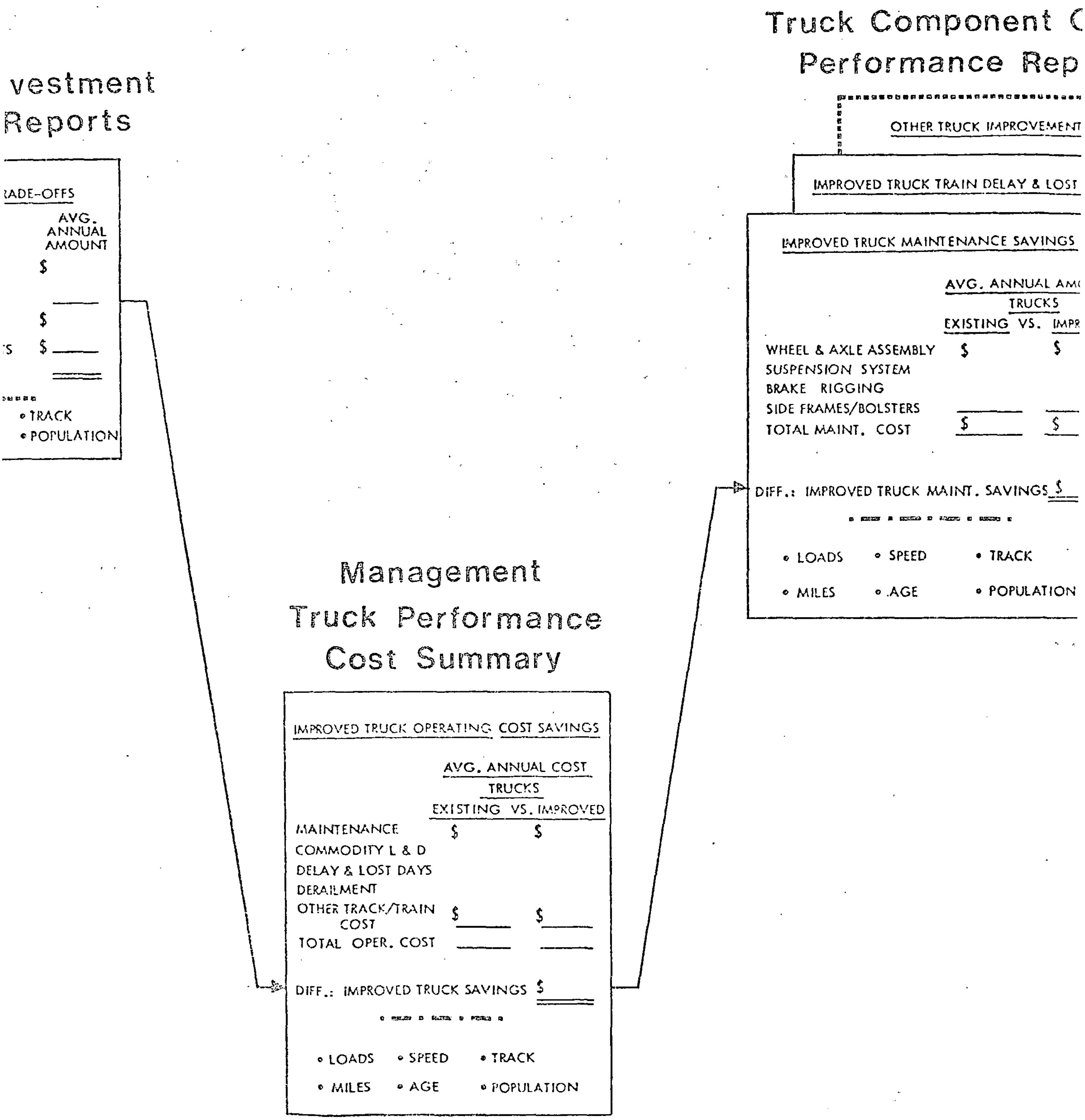
For a user of the truck economic methodology to accurately predict the wear and failure rates of truck components, the rates that will be developed from the economic data base must be validated by rates developed from actual physical measurements of a representative sample of the same truck components.

The wear and failure data that will be in the economic data base will reflect data reported by the field forces who actually perform the maintenance tasks. Because of the variety of conditions under which the data are collected these data may not be necessarily


ıck Engineering-Based
conomic Data Needs

Truck Economic Data Collecti

Figure 2-



vestment
Reports

ADE-OFFS

	AVG. ANNUAL AMOUNT
	$
	$
S	$

• TRACK

• POPULATION

Management
Truck Performance
Cost Summary

IMPROVED TRUCK OPERATING COST SAVINGS

	AVG. ANNUAL COST TRUCKS	
	EXISTING	VS. IMPROVED
MAINTENANCE	$	$
COMMODITY L & D		
DELAY & LOST DAYS		
DERAILMENT		
OTHER TRACK/TRAIN COST	$	$
TOTAL OPER. COST		

DIFF.: IMPROVED TRUCK SAVINGS $

• LOADS • SPEED • TRACK

• MILES • AGE • POPULATION

Truck Component C
Performance Rep

OTHER TRUCK IMPROVEMENT

IMPROVED TRUCK TRAIN DELAY & LOST

IMPROVED TRUCK MAINTENANCE SAVINGS

	AVG. ANNUAL AM TRUCKS	
	EXISTING	VS. IMPR
WHEEL & AXLE ASSEMBLY	$	$
SUSPENSION SYSTEM		
BRAKE RIGGING		
SIDE FRAMES/BOLSTERS		
TOTAL MAINT. COST	$	$

DIFF.: IMPROVED TRUCK MAINT. SAVINGS $

• LOADS • SPEED • TRACK

• MILES • AGE • POPULATION

Performance Indices Related To Truck Op

DATA NEEDS	GROUP SOURCE		DATA COLLECTION		
	PRIME	ALT.	CONTACT	SYSTEM	FI
I BASIC REFERENCES					
A, PUBLICATIONS					
1, OFFICAL RAILWAY EQUIPMENT REGISTER	R.R. SUB	PUBLISHER	MECH. DEPT		
2, POCKET LIST OF RAILROAD OFFICALS	R.R. SUB	PUBLISHER	MECH. DEPT		
3, YEARBOOK OF RAILROAD FACTS	R.R. SUB	AAR	ECO. BUREAU		
4, ANNUAL STATISTICS OF US CLASS I RR'S (10 YRS)	R.R. SUB	AAR	ECO. BUREAU		
5, ICC RAIL FORM AND USER INSTRUCTIONS	R.R. SUB	ICC/AAR	ECO. BUREAU		
6, FREIGHT CLAIM RULES OF ORDER	R.R. SUB	AAR	CLAIMS BUREAU		
7, R.R.'S TELEPHONE DIRECTORY	R.R. SUB		COMM. BUREAU		
8, ANNUAL FINANCIAL REPORTS (ICC, CORP. 10 YRS)	R.R. SUB	AAR	ACCTG. DEPT.		
9, WHEEL AND AXLE MANUAL	R.R. SUB	AAR	MECH. DEPT.		
10, R.B. MANUAL	R.R. SUB	AAR	MECH. DEPT.		
11, ANNUAL ACCIDENT BULLETINS (FRA- 10 YRS)	R.R. SUB	FRA	ACCID. BUREAU		
12, RAIL FORM A AND USER INSTRUCTIONS	R.R. SUB	AAR	ECO. BUREAU		
13, FIELD MANUAL	R.R SUB	AAR	MECH. DEPT.		
14, COMPLETE CAR REPAIR BILLING OFFICE MANUAL	R.R SUB	AAR	MECH. DEPT.		
15, FREIGHT STATION ACCOUNTING CODE DIRECTORY	R.R SUB	AAR	ACCTG. DEPT.		
16, MANUAL OF POSTED SPEEDS	R.R SUB	AAR	TRANS. DEPT.		
17, MANUAL OF COMMODITIES, CODES AND USER INSTR.	R.R SUB	AAR	TRANS. DEPT.		
18, GENERAL RULES COVERING LOADING OF SHIPMENTS	R.R SUB	AAR	TRANS. DEPT.		
19, INSTRUCTIONS GOVERNING INSPECTION, SELECTION	R.R SUB		TRANS. DEPT.		
20, FRA RAILROAD FRT. CAR SAFETY STANDARDS	R.R. SUB	FRA	MECH. DEPT.		
21, RAIL EQUIPMENT ACCIDENT INCIDENT REPORT	R.R. SUB	FRA	ACCID. BUREAU		
22, PER DIEM TASK FORCE REPORT 12/16/68	R.R. SUB	FRA	ECO. BUREAU		
B. REPORTS					
1, ORGANIZATION CHARTS	R.R. SUB		EXEC. DEPT.		
2, M OF E LABOR FORCE	R.R. SUB		MECH. DEPT.	SKILLS INVENT.	PERSON
3, CHART OF ACCOUNTS	R.R. SUB		ACCTG. DEPT.		
4, ACCNT 314 TEN YR HISTORY	R.R. SUB	AAR/PRIME	ACCTG. DEPT.	ICC	BUDGET
5, DESTROYED CAR PAYMENTS	R.R. SUB		ACCTG. DEPT.	CAP. ACCTS.	RETIRE
6, AAR CAR REPAIR BILLING	R.R. SUB		ACCTG. DEPT.	CRB	
7, RUN THROUGH AGREEMENTS	R.R. SUB	AAR	ACCTG. DEPT.		
8, CAR AND ROADWAY BUDGET VS. ACTUAL	R.R. SUB		MECH. DEPT.		COST A
9, AAR 'WHY MADE' CODE MATRIX	R.R. SUB	AAR/PRIME	MECH. DEPT.	CRB	FIELD
10, DETAILED TRUCK COMPONENT PRICE LIST	R.R. SUB	SUPPLIERS	PURCH. DEPT.	ORDERING	TRUCK
11, SPECIMENS OF ROUTINE FREIGHT CAR REPORTS	R.R. SUB	AAR, FRA	EXEC. DEPT.	VARIOUS	VARIOU
12, AAR STANDING CAR COMMITTES	R.R. SUB	AAR	MECH. DEPT.		
13, CAR CLASSIFICATION	R.R. SUB	AAR	MECH. DEPT.	CAR CLASS	CAR SP
14, CAR FLEET	R.R. SUB		MECH. DEPT.	CAR BUDGET	REPAIR
15, DETAILED TRACK CHARTS	R.R. SUB		M OF W	TRACK ENGRG.	DRAWIN
16, DETAILED CAR SPECS AND COST	R.R. SUB	SUPPLIER	PUR. DEPT.	ORDERING	CAR SP
17, DETAILED TRUCK SPECS	R.R. SUB	SUPPLIER	MECH. DEPT.		TRUCK
19, ACCIDENT REPORTS	R.R. SUB	FRA	ACCID. BUREAU	ACCIDENT	ACCIDE
19, DERAILMENT STATISTICS	R.R. SUB	FRA	MECH. DEPT.	ACCID/INCIDENT	DERAIL
20, RETIREMENT RECORD	R.R. SUB		MECH. DEPT.	RETIREMENT	ACCTG.
21, LOSS, DAMAGE DETAILED REPORTS	R.R. SUB	AAR	LOSS + DAMAGE	FREIGHT CLAIMS	CLAIMS
22, REVENUE E'COST	R.R. SUB		TRANS. DEPT.	CAR BUDGET	FRT.
C, SYSTEMS AND PROCEDURES					
1, COST ACCOUNTING	R.R. SUB		ACCTG. DEPT.	COST CONTROL	COST A
2, INVENTORY CONTROL	R.R. SUB		PURCH. DEPT.	MAT'L MNGT.	MIN/MA
3, CAR REPAIR BILLING	R.R. SUB	AAR	MECH. DEPT.	CRB	ACCTS.
4, CAR REPAIR REPORTING BY COMPONENT	R.R. SUB		MECH. DEPT.		
5, CAR MILEAGE REPORTING	R.R. SUB	AAR	MECH. DEPT.	CAR MOVE	MILEAG
6, CAR INVESTMENT EVALUATION	R.R. SUB		ECO. BUREAU	CAP. BUDGET	INVEST
7, CAR INVESTMENT EVALUATION	FRA	AAR	DIFF OF ECO.		
8, INFLATIONARY PRICING	R.R. SUB		ECO. BUREAU	PRICE + COST	L + M
9, INFLATIONARY PRICING	AAR		OFF. OF ECO.		
10, INFLATIONARY PRICING	SUPPLIER		ECO. + STATE		
12, INFLATIONARY PRICING	OTHER R.R.		ECO. BUREAU		
13, CAR SPECIFICATIONS	R.R. SUB	AAR	SYSTEMS	UMLER	ULMER
14, CAR FLEET PHYSICAL CONDITION	R.R. SUB		MECH. DEPT.	FLEET CONDIT	MAINTE
15, CAR REPAIR BILLING OFFICE MANUAL	R.R. SUB	AAR	SYSTEMS	CRB	CRB
16, MAINTENANCE FORECAST	R.R. SUB	AAR	M OF W	BUDJET	COST
17, MAINTENANCE FORECAST	R.R. SUB	AAR	MECH. DEPT.	BUDJET	COST
19, MAINTENANCE POLICY AND PRACTICE	R.R. SUB	AAR	MECH. DEPT.	CAR REPAIR	MANUAL
20, MAINTENANCE POLICY AND PRACTICE	R.R. SUB	AAR	M OF W	TRACK REPAIR	MANUAL
21, MAINTENANCE POLICY AND PRACTICE	R.R. SUB	AAR	MECH. DEPT.	LOCO REPAIR	MANUAL
22, CAR MOVEMENT	R.R. SUB		TRANS. DEPT.	CAR UTIL.	CAR ME
23, CAR MOVEMENT	FRA		SYSTEMS	TRAIN I + II	CAR M
24, CAR MOVEMENT	OTHER R.R.		SYSTEMS	CAR UTIL.	CAR M
25, OPERATING AND CAPITAL BUDGETING	R.R. SUB		SYSTEMS	BUDGET	COST
26, CAR MAINTENANCE PROJECT COST ESTIMATING	R.R. SUB	OTHER R.R.	MECH. DEPT.	PROJECT	PROJEC
27, LIMIT COST OF REPAIRS	R.R. SUB	AAR	MECH. DEPT.		
28, LIMIT COST OF REPAIRS	OTHER R.R.'S	AAR	MECH. DEPT.		
29, REPAIR DEFINITION AND CLASSIFICATION	R.R. SUB	OTHER R.R.	MECH. DEPT.	MAINTENANCE	MANUAL
30, LOSS AND DAMAGE CLAIM REPORTING	R.R. SUB	AAR	FREIGHT CLAIMS	L + D	L + D
31, PROPERTY DAMAGE AND PERS. INJURY	R.R. SUB	AAR/FRA	CLAIMS BUREAU	CLAIMS	CLAIMS
32, ACCIDENT AND DERAILMENT REPORTING	R.R. SUB	AAR/FRA	ACCID. BUREAU		
33, CAR COMPONENT ECO. LIFE CYCLE DETERMINATION	R.R. SUB	AAR/FRA/TTD	VARIOUS	VARIOUS	VARIOU
34, TRAIN DELAY AND LOST CAR COST REPORTING	R.R. SUB	AAR/FRA/TTD	VARIOUS	VARIOUS	VARIOU
35, CAR REVENUE FORECASTING	R.R. SUB	AAR/FRA/TTD	EXEC.	FORECASTING	FORECA
II INITIAL INTERVIEWS					
1, SELECTED DEPARTMENTS IN R.R. ORGAN.	R.R. SUB				
2, SELECTED DEPARTMENTS IN R.R. ORGAN.	PRIME				

c Data Requirements PROPOSAL No. 550/7703/RB

DATA NEEDS	GROUP SOURCE		DATA COLLECTION		
	PRIME	ALT.	CONTACT	SYSTEM	FILE
TEST ECONOMIC METHODOLOGY					
OPERATING COSTS AND PRODUCTION					
1. OFF-LINE HOME CAR	PRIME	FAST	MECH. DEPT.	OFF-LINE BILLING	CRB
2. OFF-LINE HOME CAR	R.R. SUB	AAR	SYSTEMS	OFF-LINE BILLING	CRB
3. ON-LINE HOME CAR	PRIME	FAST	MECH. DEPT.	TRUCK INFO.	FIELD
4. ON-LINE HOME CAR	R.R. SUB		SYSTEMS	TRUCK INFO.	FIELD
5. OUTSIDE MAINTENANCE	PRIME		MECH. DEPT.	SUBCONTRACTS	INVOICE
6. OUTSIDE MAINTENANCE	R.R. SUB		SYSTEMS	SUBCONTRACTS	INVOICE
7. RELATED TRACK, TRAIN, FACILITY MAINT.	PRIME	FAST	VARIOUS	INTERNAL MIS	COST ACCTG.
8. RELATED TRACK, TRAIN, FACILITY MAINT.	R.R. SUB		SYSTEMS	INTERNAL MIS	COST ACCTG.
9. COMMODITY LOSSES AND DAMAGES	PRIME		L + D BUREAU	FREIGHT CLAIMS	CLAIMS
0. COMMODITY LOSSES AND DAMAGES	R.R. SUB	AAR	SYSTEMS	FREIGHT CLAIMS	CLAIMS
1. DERAILMENTS AND OTHER ACCIDENTS	PRIME	AAR	VARIOUS	VARIOUS	VARIOUS
2. DERAILMENTS AND OTHER ACCIDENTS	R.R. SUB	FRA	SYSTEMS	VARIOUS	VARIOUS
3. TRAIN DELAY	PRIME	AAR	MECH. DEPT.	SPECIAL STUDY	
4. TRAIN DELAY	R.R. SUB	FRA	MECH. DEPT.	SPECIAL STUDY	
5. LOST CAR DAYS	PRIME	AAR	MECH. DEPT.	SPECIAL STUDY	
6. LOST CAR DAYS	R.R. SUB	FRA	MECH. DEPT.	SPECIAL STUDY	
7. PROPERTY DAMAGE, PERSONAL INJURY	PRIME	AAR	CLAIMS BUREAU	PROP. + PERS.	PROP. + PERS.
8. PROPERTY DAMAGE, PERSONAL INJURY	R.R. SUB	FRA	SYSTEMS	PROP. + PERS.	PROP. + PERS.
9. OTHER COSTS	PRIME	R.R. SUB	ECO. BUREAU		
OPERATING CONDITIONS					
1. CAR CLASS AND TRUCK DESIGN	PRIME		SYSTEMS DEPT.	UMLER	CAR SPEC.
2. CAR CLASS AND TRUCK DESIGN	P.R. SUB	AAR	PUR. DEPT.	INVENT. CONTROL	PUR. ORDERS
3. TRAIN IDENTIFICATION	PRIME	AAR	SYSTEMS DEPT.	CAR MOVEMENT	CAR UTILIZATION
4. COMMODITY CARRIED	PRIME	AAR			
5. MILEAGE EMPTY, LOADED	PRIME	AAR			
6. WHEEL LOAD EMPTY, LOADED	R.R. SUB	FRA			
7. ROADWAY CONDITIONS	R.R. SUB	FRA			
8. SERVICE	R.R. SUB	FRA			
9. SPEED	R.R. SUB	FRA			
0. AGE	PRIME		SYSTEMS DEPT.	ULMER	CAR SPEC.
1. AGE	R.R. SUB	AAR	PUR. DEPT.	INVENT. CONTROL	PUR. ORDERS
ECONOMIC DATA BASE					
1. FILE MERGE	PRIME	R.R. SUB	PRIME	TOOP	SET-UP
2. PHYSICAL MEASUREMENTS FOR EXISTING TRUCKS	PRIME		PRIME	TOOP	TEST
3. PHYSICAL MEASUREMENTS FOR EXISTING TRUCKS	R.R. SUB		PRIME	TOOP	TEST
4. PHYSICAL MEASUREMENTS FOR IMPROVED TRUCKS	PRIME		PRIME	TOOP	TEST
5. PHYSICAL MEASUREMENTS FOR IMPROVED TRUCKS	R.R. BUS		PRIME	TOOP	TEST
6. CAR/TRUCK POPULATION	SUPPLIER	AAR	SUPPLIER	MARKETING	SALES
7. CAR/TRUCK POPULATION	PRIME		PRIME		
8. CAR/TRUCK INVENTORY	R.R. SUB		PUR. DEPT.	INVENTORY	PUR. ORDERS
9. CAR/TRUCK INVENTORY	PRIME		PRIME		
0. DATA BASE INTERROGATION	PRIME		PRIME	D.B.I.	SET-UP
1. ECO DATA COLLECTION, INTRROGATION STUDY	PRIME		PRIME	SPECIAL STUDY	FIELD
2. ECO DATA COLLECTION, INTRROGATION STUDY	R.R. SUB		R.R. SUB	SPECIAL STUDY	FIELD
3. ON-HAND DATA USE	PRIME	R.R. SUB	PRIME	CRB	OFF-LINE
INCREMENTAL INVESTMENT IN TRUCK IMPROVEMENT EVALUATION DATA					
1. AAR CAR REPAIR BILLING STANDARD PRICE	PRIME	R.R. SUB	PRIME	OFFICE MANUAL	PRICE STRUCTURE
2. MANUFACTURERS DELIVERED PRICE OF IMPROVEMENT	PRIME	SUPPLIER	PRIME	SUPPLIER	ENGRG.
3. MODIFICATION AND INSTALLATION COST	PRIME	R.R. SUB	PRIME	MECH. DEPT.	CAR ENGRG.
4. CURRENT ASSETS REQUIRED [WORKING CAPITAL]	PRIME	R.R. SUB	PRIME	ECO. BUREAU	PRICE + FLCOST
5. OPERATING COST DIFFERENTIAL	PRIME	R.R. SUB	PRIME	ECO. DATA BASE	D.B.I.
6. INVESTMENT CREDITS	PRIME	R.R. SUB	PRIME	ECO. BUREAU	PRICE + F'CAST
7. SCRAP VALUE	PRIME	R.R. SUB	PRIME	SCRAP DEALER	
8. CAPITAL GAINS/LOSSES	PRIME	R.R. SUB	PRIME	ECO. BUREAU	PRICE + F'CAST
9. PRESENT VALUE TABLES	PRIME		PRIME		
0. RAILROAD COST OF CAPITAL	PRIME	R.R. SUB	PRIME	SPECIAL STUDY	VARIOUS
1. INFLATIONARY INDICES FOR R.R. LABOR, MATERIAL	R.R. SUB	PRIME	ECO. DEPT.	INVEST EVAL.	RATES (FRT, Y
2. FREIGHT CAR BUDGET, REVENUE AND TONNAGE	R.R. SUB	PRIME	ECO. BUREAU	INVEST EVAL.	PRICE + F'CAST
3. OPPORTUNITY COST	PRIME	R.R. SUB	ECO. BUREAU	INVEST EVAL.	PRICE + F'CAST
4. TAXES	PRIME	R.R. SUB	ACCTG. DEPT.	TAX	
5. DETAILED PERFORMANCE INDICES DESCRIP. MEASUR	PRIME			TOOP	ENGRG.
6. CASH FLOW TIMING	PRIME	R.R. SUB		TOOP	ECO.
7. DEPRECIATION SCHEDULE	PRIME	R.R. SUB	PRIME	TOOP	ECO.
8. RISK ELEMENTS	PRIME	R.R. SUB		TOOP	ECO.
9. CURRENT ASSETS RECOVERED	PRIME	R.R. SUB	PRIME	TOOP	ECO.
THE APRIL ASSOCIATES SUPPORTING EFFORTS					
PRINCIPAL ECONOMIC PRODUCTS FOR PHASE II					
ECONOMIC PRODUCTS FOR EXISTING TRUCKS					
TRUCK ECO DATA COLLECTION, ANALYSIS PROCED.					
2. INTERIM, OPERATIONAL ECO LIFE CYCLE MODELS					
3. ECO DATA BASE INTERROGATION PROCEDURE					
4. STANDARD COST RATES FOR TRUCK DELAY					
5. ANALYTICAL PROCEDURE FOR ISOLATING TRUCK COSTS					
6. UNIT COST MEASURES COST COMPARISONS					
7. TRUCK CONTRIBUTION TO PROFITS					
ECONOMIC PRODUCTS FOR IMPROVED TRUCKS					
INCREMENTAL INVESTMENT EVALUATION					
2. TRUCK COMPONENT IMPROVEMENT					
3. PLAN FOR IMPLEMENTING IMPROVEMENTS					
4. ECO FEASABILITY OF COLLECTING DATA					
5. R.R. COST OF CAPITAL MODEL					

quate for accurate cost performance prediction purposes (i.e. decision-making). Examples the variety of conditions are: differing field maintenance practices, differing repair lities, equipment, skills, accurate gauge availability, inspection procedures and material ilability. The economic data base must earn credibility as an appropriate tool to support engineering effort. It must also be demonstrated as an appropriate tool for its many other ntial uses. In the short run, it will provide the railroad with early warning signals of ntial epidemics such as cracks developing in the fillets of the side frames of trucks ersed over widely separated geographic regions. In the long run, it will provide economic cycle data essential to predicting the profitability of investments in trucks. In addition, railroad community is well aware of the difference between the relatively simple running ntenance wear measurements taken by field forces to guide their component change-out isions, and the more complex exacting measurements taken by the engineer to understand k performance parameters. Lastly, the economic data base must be demonstrated to be d before it can be accepted as a useful tool for truck performance prediction purposes.

A program will be implemented in which the trucks of a selected class operating in lar conditions will be measured, wear rates developed and compared with similar data in data base. A procedure to accomplish this task, and an estimate of the cost to implement llows.

1) Procedure.

   a) Select a representative sample of cars with original wheels approaching condemning limits. These cars should be of the same class and operating under similar operating conditions as the car(s) being tested.

   b) Jack car and remove trucks identifying them with car numbers and end position (deliver exchange truck and install).

   c) Remove car from jack, disassemble truck, gauge and record measurements.

   d) Truck bolster measurements

      - longitudinal centerplate diameter
      - lateral centerplate diameter
      - centerplate depth
      - distance between outside bolster gibs
      - distance over inside gibs
      - friction shoe pocket wear
      - friction shoe pocket lateral wear

Critique of Wyle TDOP Proposal: Economic Relationships

This document presents a critique of Chapter 2, Economic Relationships, of Wyle Laboratories' proposal 550/7703/RB. The critique focuses upon the discussion presented in pp. 2-8 to 2-12 which demonstrates a misunderstanding of elementary economic concepts. While there are several other errors and inconsistencies throughout Chapter 2, the errors continued in pp. 2-8 to 2-12 are so basic to demonstrating an understanding of elementary economics that we choose to focus our comments on those pages.

There are four major errors in section 2.2.2.2.1 of the proposal.

- Figure 2-2 presents a model of demand and revenues for a *perfectly competitive industry*. Yet the railroad industry is a *regulated oligopoly*.
- The discussion evidences a misunderstanding of the terms "marginal" and "variable" costs.
- The shape and position of curves on the graph are inconsistent with the discussion in the text.
- The figure shows a reduction rather than an increase in profits, despite the fact it is supposed to show an increase.

We discuss each of these errors in the following sections.

1 Perfect Competition vs Regulated Oligopoly

The demand for railroad services is represented in Figure 2-2 by the line P = AR = MR. This is identified in the last sentence of the first paragraph on p. 2-11, "...the demand function (AR = MR)." AR stands for average revenue and an average revenue curve is indeed identical to a demand curve.

The average revenue curve is horizontal in the figure. This implies demand is perfectly elastic (i.e. that the railroad can increase its sales revenues without lowering its price to get extra traffic). A horizontal demand curve is the textbook case of the demand curve for the output of a firm in a perfectly competitive industry.* Yet we know that railroads are not perfectly competitive and in fact are a regulated oligopoly.

Oligopoly is an industry structure characterized by a small number of firms selling a relatively standardized commodity and experiencing economies of scale in production. Another characteristic of an oligopoly industry is a negatively sloped demand curve. These are indeed characteristics of the railroad industry.

The "perfectly competitive" model has been used to represent railroads despite the fact that, "At best, ..., the market structure of the railroad industry is one of oligopoly, ...".** This demonstrates either a misunderstanding of the industry or a misapplication of the most basic model of market structure.

2 Marginal vs. Variable Costs

The discussion in the text evidences a misunderstanding of the terms marginal and variable cost. Marginal cost is used interchangeably with variable cost despite important differences between them. To demonstrate this we first define cost terms and then show how the terms have been misused.

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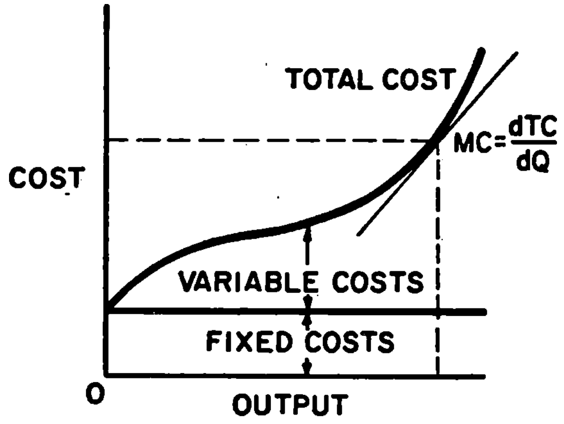
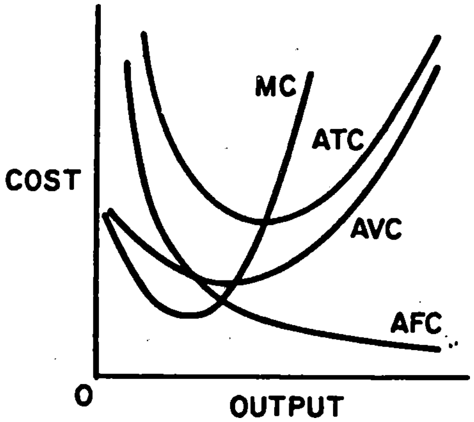
*Samuelson, Paul F., *Economics*, Ninth Edition, p. 482.

**Phillips, C.F., *The Economics of Regulation*, First Edition, p. 514.

Fixed costs are those costs which are invariant with the level of output. *Variable costs* are those costs which vary with the level of output. *Total costs* for any given level of output is defined as the sum of all fixed and variable costs, i.e. TC = FC + VC. *Marginal cost* is the derivative of total cost with respect to output, i.e. MC = dTC/dQ. Note however that since the fixed cost term vanishes upon differentiation the derivatives of total cost and variable cost are the same and MC = dTC/dQ = dVC/dQ. *Average costs,* either average fixed cost, average variable costs, or average total cost, are simply the appropriate cost divided by the quantity of output. The representative shapes of these costs are shown in the figures below.



TOTAL COSTS



AVERAGE COSTS

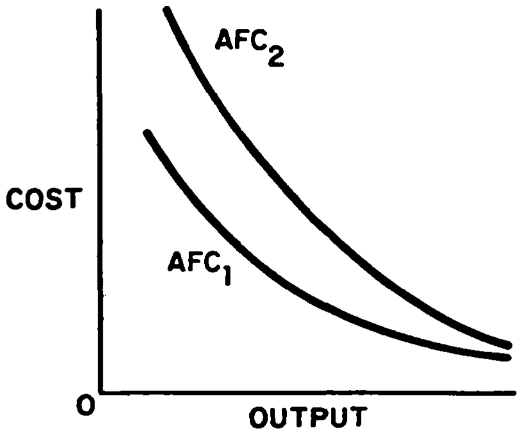
Introduction of the improved truck could be expected to lower variable costs but increase fixed costs. Maintenance and other operating expenditures would be reduced but the initial cost of the truck would be greater. The possibility of increased profits will depend upon the relationship between changes in fixed and variable costs. To state that reductions in maintenance costs "will bring about a downward shift of the marginal cost curve" suggests the author is using marginal and variable costs interchangeably, and that the author does not realize the important distinction between them. This is likely the case since the author states:

> "The possibility of increased profits after the acceptance of a Type II truck will simply depend upon the relationship between changes in the fixed and the marginal costs."

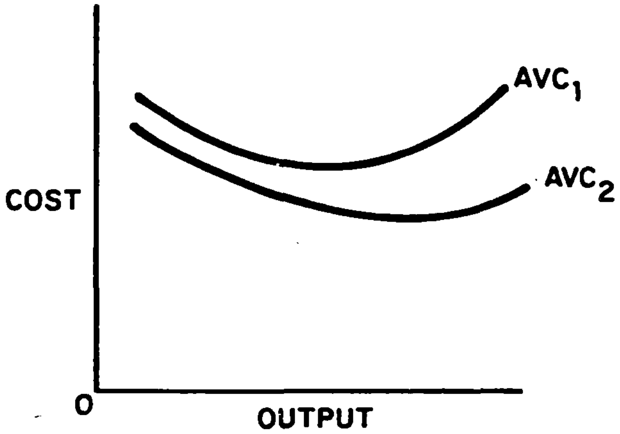
It is conceivable that for a given level of output total costs and variable costs would be lower for an improved truck but marginal costs would be greater. The correct comparison is between changes in fixed and variable costs, not between fixed and marginal costs.

3 The Shape of the Curves

The difference between AC1 and AC2 in figure 2.2 is supposedly the introduction of an improved truck that has a higher fixed cost, but lower variable costs. The likely impact of this change on average fixed and variable costs is correctly presented below.



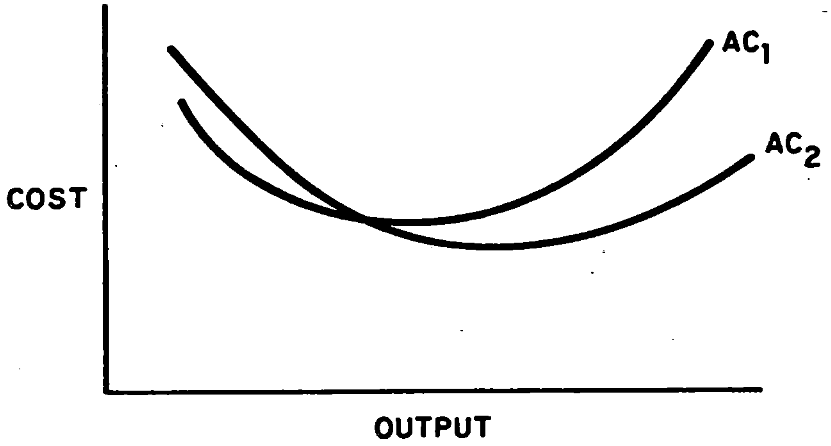
AVERAGE FIXED COSTS



AVERAGE VARIABLE COSTS

New average fixed cost (AFC_2) should be higher at low levels of output but the differential between the two curves would decrease as output increases. New average variable costs (AVC_2) could be expected to be lower even at low levels of service with the differential between AVC_2 and AVC_1 increasing as output increases.

The combined effect of these changes in fixed and variable costs would be to reduce new average total cost (AC2) as output increases. Figure 2-2 has AC2 always greater than AC1 and rising more rapidly at higher levels of output, despite lower variable costs at higher levels of output. The correct position of the curves is presented below. Note the curves are "flatter" than in figure 2-2 because of the economies of scale present in the industry.



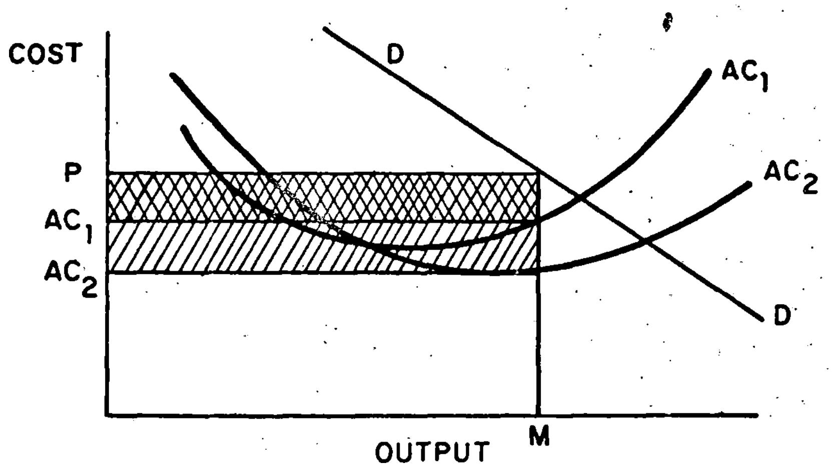
AVERAGE TOTAL COST

The position of the marginal cost curves (MC1 and MC2) is also incorrect in Figure 2-2. Given the shape of AC1 and AC2, average cost for the improved truck increases more rapidly beyond point M2. Therefore, the marginal cost of the new truck, scenario, MC2, should be greater than MC1. The figure shows just the opposite with MC1 consistently greater than MC2.

4 Graphical Results of the Analysis

With misplaced marginal and average cost curves it is little wonder that the graph does not show what is purported in the text. Profits in the absence of a new truck are P1A1R1S1. Profits with a new truck are P2Q2R2S1. A comparison of the area of these two rectangles shows that total profits are smaller with the new truck. Average profit (Q2P2) is also smaller with the new truck in comparison to Q1P1. Thus the graph simply does not show the, "increased profits, shown by the rectangle P2Q2R2S1".

This cannot be dismissed as merely a drafting error. The fact is that given the shape and position of the curves there is no way one could show an increase in profit. Moreover, there would not be a change in output from M1 to M2 since the price, S1, is unchanged and set by regulation. What the graph should properly show is increased profits at the previous level of price and output. The correspondence of that output with marginal cost equal to marginal revenue will only occur if the regulatory agency sets the "perfect price". However, regulatory agencies set prices on rate of return rather than MC = MR. The correct graphical analysis of improved freight car trucks is shown below.



IMPACT OF TYPE 2 TRUCK ON COSTS, OUTPUT AND PROFITS

Note the important differences between this figure and figure 2.2. Demand, DD, is negatively sloped, average costs are lower with the new truck and profits are increased. Old profits are represented by the double crosshatched area. The net increase in profits is represented by the single crosshatched area. The average cost curves are flatter given the economies of scale in the railroad undustry and other regulated oligopolies.

SUMMARY

The proposal presents the wrong model, applied using the wrong cost variables, to produce the wrong results.

Freight Car Truck Design Optimization,
Economic Analysis Report -Phase I, 1976
US DOT, FRA, Southern Pacific Transportation
Company