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*Final Report* *October 1975*

# BLOCKING AND TRAIN OPERATIONS PLANNING

*By:* WAHEED SIDDIQEE, DONATO A. D'ESOPO, PAUL L. TUAN

*Prepared for:*

UNITED STATES RAILWAY ASSOCIATION
PROCUREMENT DIVISION USR-441
2100 - 2nd STREET S.W.
WASHINGTON, D.C. 20595

SRI Project 3759

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*Approved by:*

DAVID R. BROWN, *Director*
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ABSTRACT

This report summarizes the functional details of various computer-aided methodologies developed by Stanford Research Institute to conduct detailed analyses of blocking and train operations schemes and yard operations. Technical details and User's Manuals for various computer programs developed during the course of the project have been documented separately as User's Manual for Network Analysis Computer Programs and User's Manual for Yard Operations Analysis Computer Programs. This work was done under Contract USRA-C-50042 for the United States Railway Association to assist it in developing system-wide operating and management plans for rail operations in the Northeastern and Midwestern states. However, the methodologies and the programs described in this report can be used for analyzing rail operations in any railroad network.

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## LIST OF ILLUSTRATIONS



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ACKNOWLEDGEMENTS

We wish to acknowledge the guidance and suggestions received from Messrs. Charles Hoppe, Hugh Randall, and Neal Owen of USRA. Their active participation in the research led to many of the ideas presented in this report. Thanks are also due to Messrs. James Page and Thomas Strawser of Penn Central Transportation Company, and Messrs. Donald Nelson, Louis Hill, Noel Ball, Ray Neal, Mike Kenney, Larry Kaufer, and Bruce Barber, of USRA, who participated actively during various phases of the project.

## THE PROJECT TEAM

The study was conducted in the Transportation Engineering and Control Group (TECG) headed by Dr. Robert S. Ratner, who was Project Supervisor. The project team consisted of the following staff members:

| | |
|---|---|
| Dr. Waheed Siddiqee<br>Staff Scientist<br>TECG | Project Leader |
| Mr. Donato A. D'Esopo<br>Senior Operations Analyst<br>Management Systems Division | Task Leader, Blocking and Train Operations Analysis and Programs |
| Dr. Paul L. Tuan<br>Senior Operations Analyst<br>TECG | Task Leader, Detailed Yard Analysis and Programs |
| Mr. Albert E. Moon<br>Senior Transportation Systems Analyst<br>TECG | Blocking Strategy Analysis<br>Research Design |
| Mr. Stephen J. Petracek<br>Research Engineer<br>TECG | O/D Table Generation Programs |
| Ms. Rilla Reynolds<br>Research Associate<br>TECG | Programming Assistance in Blocking and Train Operations |
| Dr. James M. Ketchel<br>Senior Research Psychologist<br>TECG | Assistance in Blocking Strategy Analysis |
| Mrs. Barbara Wheeler<br>Mathematician<br>Digital Development Group | Computer Program Development, Detailed Yard Simulation |
| Mr. H. Steven Procter<br>Systems Analyst<br>TECG | Yard Operations Analysis, Programming Development and Assistance |
| Mr. Joseph P. Fredrick<br>Research Engineer<br>Digital Development Group | Programming Development and Assistance, and Yard Simulation |
| Mr. Ashok Nigam<br>Operations Analyst<br>Operations Evaluation Department | Programming Assistance and Data Reduction |

# I INTRODUCTION

## A. Background

Under the Regional Rail Reorganization Act of 1973 (Public Law 93-235, Title II), the United States Railway Association (USRA) was to develop a system-wide operating and management plan for rail operations in the Northeastern and Midwestern states consolidating the railroad networks and operations of several bankrupt railroads. A key element of this plan was to construct operating schemes for blocking railroad cars and forming trains, for routing and scheduling these trains within the network--both on rail lines and through railroad yards. The railroad considered has about 20,000 miles of track, part double track and part single track. Approximately 40,000 cars are to be handled per day, including both loaded and empty cars. The total number of distinct origins and destinations considered is in the range of 500 to 600.

On September 27, 1974, SRI was awarded a contract by USRA to assist in developing a preliminary plan for an operating system, using relatively gross computer-aided analysis techniques. The first generation of computer-aided methodologies and USRA's preliminary system plan were completed in February 1975. The preliminary system plan was based on representing the Northeastern and Midwestern railroad network, with 147 origin/destination nodes connected through 246 links. Results based on these studies are included in USRA's report entitled, "Preliminary System Plan," dated February 26, 1975. While the development of preliminary system plans was in its last stages, the USRA's contract with SRI was extended to develop further analysis techniques, so that a more detailed final system plan could be developed. Two parallel efforts were initiated during the latter part of February. The first effort was to develop more sophisticated computer programs to analyze the blocking and train operation schemes in more detail by representing the network with 494 origin-destination nodes and 650 links. The second effort was to develop a computer program to simulate the yard operations as realistically as possible so that yard capacity, and ability to build enough blocks to support the road operations plans, could be more realistically evaluated and improved yard operations techniques could be developed. Both of these efforts were completed in July 1975. This report summarizes the functional details of various computer-aided methodologies developed to date.

## B. Problem Statement

It is necessary to define the following frequently used terms before describing the problem:

- Node--a geographical location where a railroad car is loaded, released for load, or received on the system; or is unloaded, reloaded, or delivered from the system. The level of resolution of a node can vary from individual shippers and consignees to a large geographical area, e.g., a state. The level used in the SRI model is a gathering point representing major interchange points and the locations where local and industrial crews distribute and collect cars from shippers with minor interchanges being included as local cars to their normal serving yard.

- O/D Traffic Table--a listing of all origin-destination node pairs along with the number of loaded and empty cars traveling between them on a daily, weekly, or monthly basis. The traffic used in the SRI model is average daily traffic.

- Network--a specification of how the various nodes of a railroad system are interconnected. This is typically a list of links of connected nodes along with link lengths in miles and average link transit times.

- Block--a group of cars that travel as a single entity between two nodes. A block can be a pure block or a mixed block. A pure block contains only cars going to the same ultimate destination. A mixed block contains cars going to a common intermediate destination, where they will be switched and may become part of another block.

- Blocking Strategy--rules for forming pure and mixed blocks at each node of the network, based on network geometry, originating and transit traffic, and designer's judgment.

- Train--a combination of one or more blocks having a common intermediate or final destination.

- Train Routing and Scheduling Strategy--rules for forming trains and assigning routes and departure times to each train.

- Classification of Nodes--the nodes in the network have been grouped into the following classification to aid the designer in preparing realistic blocking strategies and to simplify the calculation of train movement times by assigning average yard delay times to each type of node.

    - Class 1--is a junction point that does not originate or terminate traffic, or switch cars. Blocks may be passed at a Class 1 node and trains may change routes.

- Class 2--a node that originates or terminates flows but does not switch cars. This type of node has also been referred to as a nontransit node (yard) occasionally in this report.

- Class 3--an ordinary transit yard that switches medium volumes of cars as an intermediate yard in addition to originating and terminating traffic flows.

- Class 4-- a major system transit yard that switches large volumes of cars and may have some originating and terminating traffic.

With the above definitions, the problem of developing system-wide operating and management plans for rail operations can be stated in terms of the following subproblems:

. Establishment of demand data, i.e., an O/D traffic table giving the daily movement of freight cars between all O/D pairs.

. Establishment of a representation of the existing network of railroad tracks and yards.

. Development of strategies to form blocks of cars at different nodes (i.e., originating points, intermediate yards, and major system yards).

. Development of strategies to form trains consisting of several blocks of cars and routing them via suitable links.

. Development of efficient yard operating strategies.

The overall objective is to develop optimum block and train formation and routing strategies which are optimum in a suitable sense. Some important factors in comparing various alternatives are:

. Operational requirements at various yards, e.g., the number of cars to be switched and blocks to be made at various yards.

. The number of car switchings required.

. Road statistics, e.g., link loadings, car miles, and ton miles.

Calculations of the necessary data from which to compare various alternatives of blocking, train formation, and routing for the large network considered, and detailed yard analyses are nontrivial tasks. A combination of human judgment (to generate suitable practical alternatives) and computer aids (to do repetitive calculations) is required. A summary of the methodologies developed by the SRI-USRA team to conduct extensive analyses of various alternatives is presented in Section II.

## II SUMMARY OF THE COMPUTER-AIDED METHODOLOGIES

The approach used by SRI-USRA team in developing the system-wide operating and management plans for rail operations was to use rail operations experience to make the more complex or judgmental decisions, while using computer programs to do the extensive, repetitive calculations needed to compare various alternatives.

The overall methodology can be divided into three processes: The first process is to analyze and develop blocking strategy for each node (yard) of the network. The second process is to analyze and develop train and network statistics. The third process is to perform detailed anlyses of selected yards. In the following list of eight steps, the first four steps are associated with the process of blocking strategy analysis and development; Steps (5) and (6) are associated with the process of analyzing and developing trains and network statistics; and Steps (7) and (8) are related to detailed yard analysis. Figures 1, 2, and 3 respectively depict the flow diagrams of these three processes in which the role played by the designer (man) and the role played by the computer (machine) are clearly defined.

(1) A suitable representation of the railroad network is prepared, e.g., to develop the preliminary system plans, the bankrupt railroad's network in the Northeastern and Midwestern states was represented by 147 nodes, 23 junction points, and 246 links. Later, a more detailed representation with 494 nodes and 650 links was developed to conduct more detailed analyses and to develop the final system plan.

(2) An O/D table tape prepared by USRA, giving monthly traffic demand between various O/D pairs is read and is converted to an average daily traffic O/D table by a computer program developed by SRI. The program generates a permanent O/D file and prints out an O/D table giving average daily traffic flows for the designer as an aid in developing blocking strategies at various nodes.

(3) The designer manually prepares a preliminary blocking strategy at each node, based on experience and study of the network and O/D table. In a later version of the program, a preliminary blocking strategy, based on some heuristic rules, is generated automatically. Further discussion on automatic generation of blocking strategy is included in Section IV of this report as well as in the "User's Manual for Network Analysis Computer Programs". The specification of blocking strategy at each node essentially consists of:

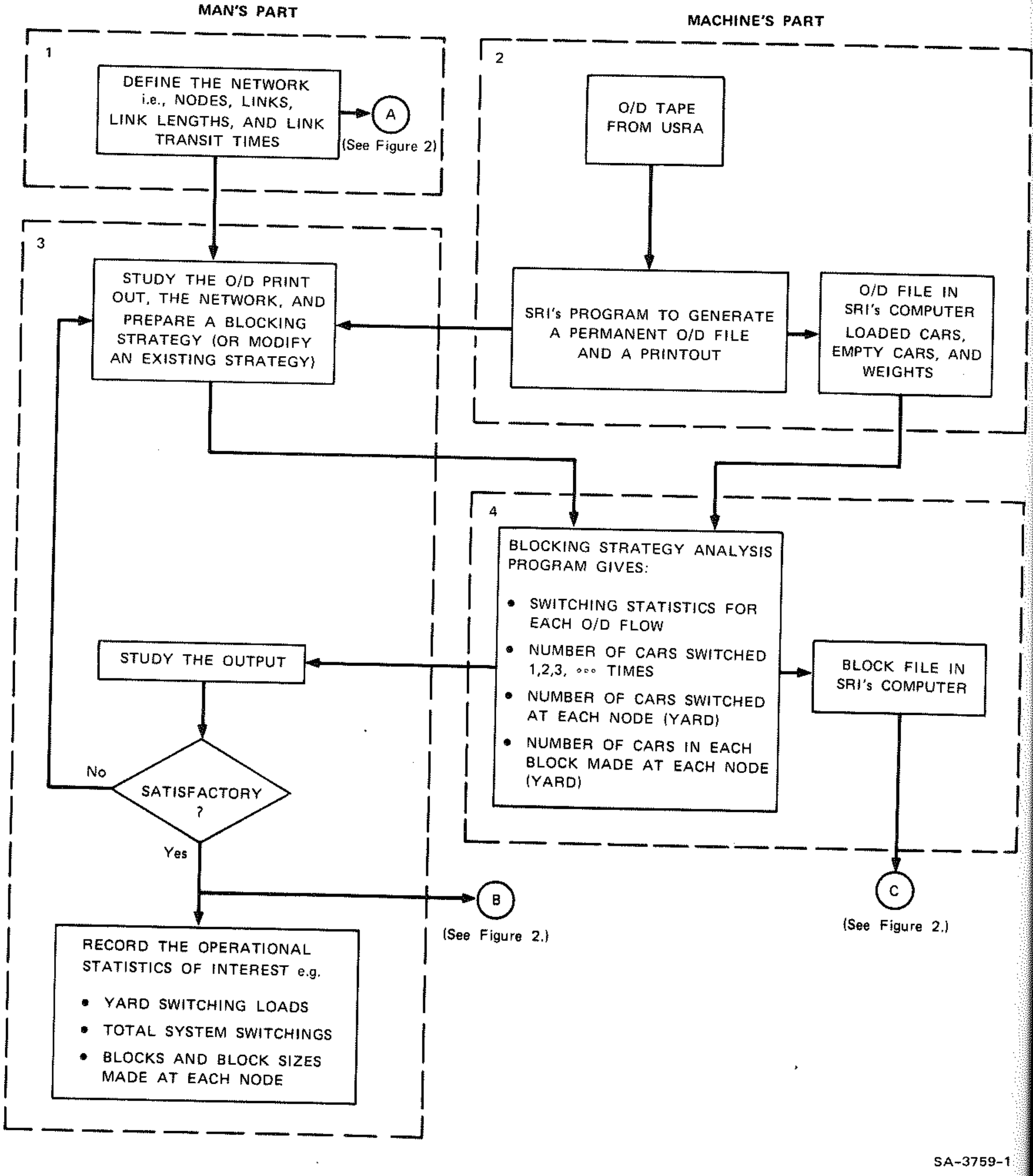


FIGURE 1 BLOCKING STRATEGY ANALYSIS AND DEVELOPMENT PROCESS

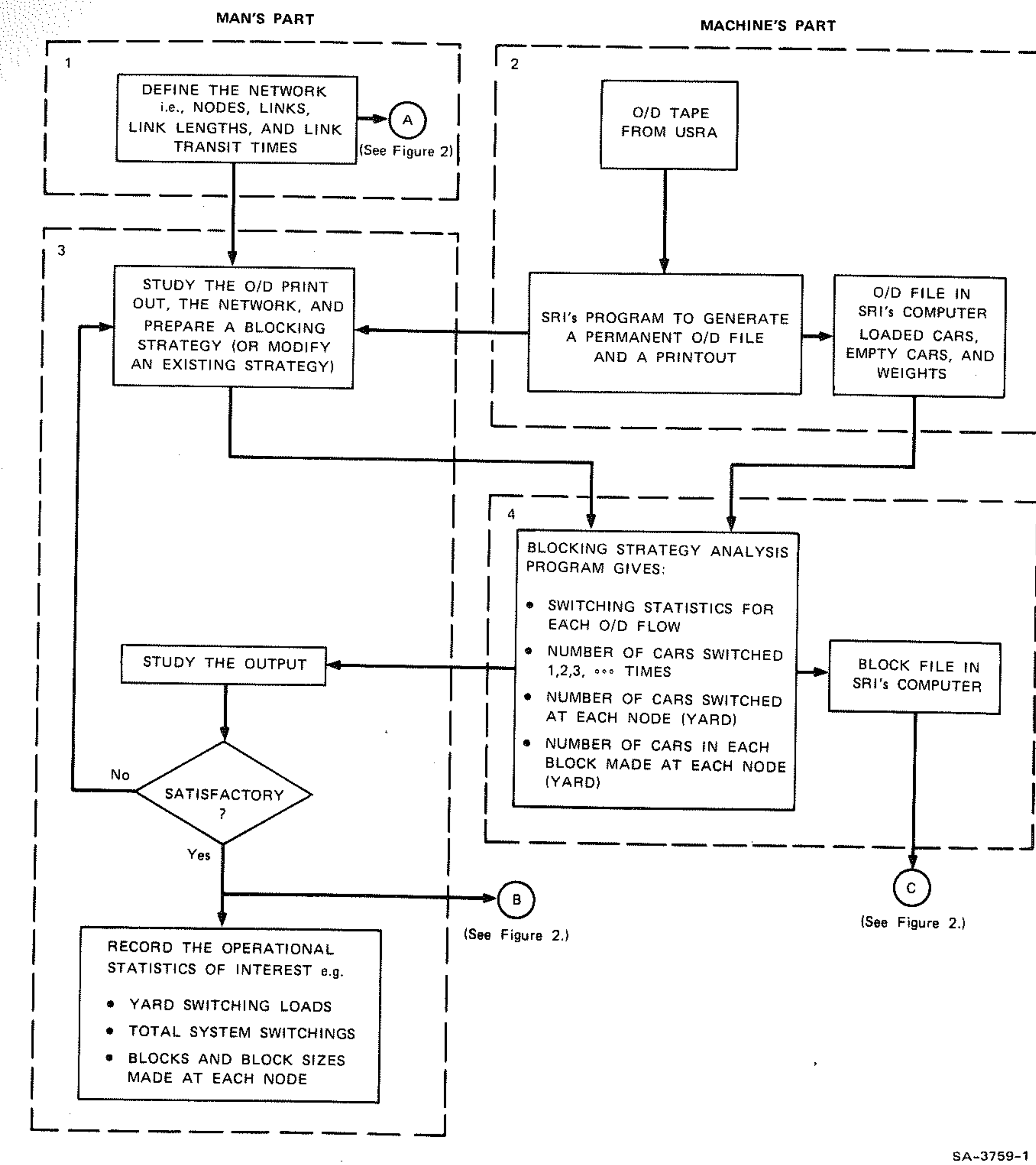


FIGURE 1 BLOCKING STRATEGY ANALYSIS AND DEVELOPMENT PROCESS



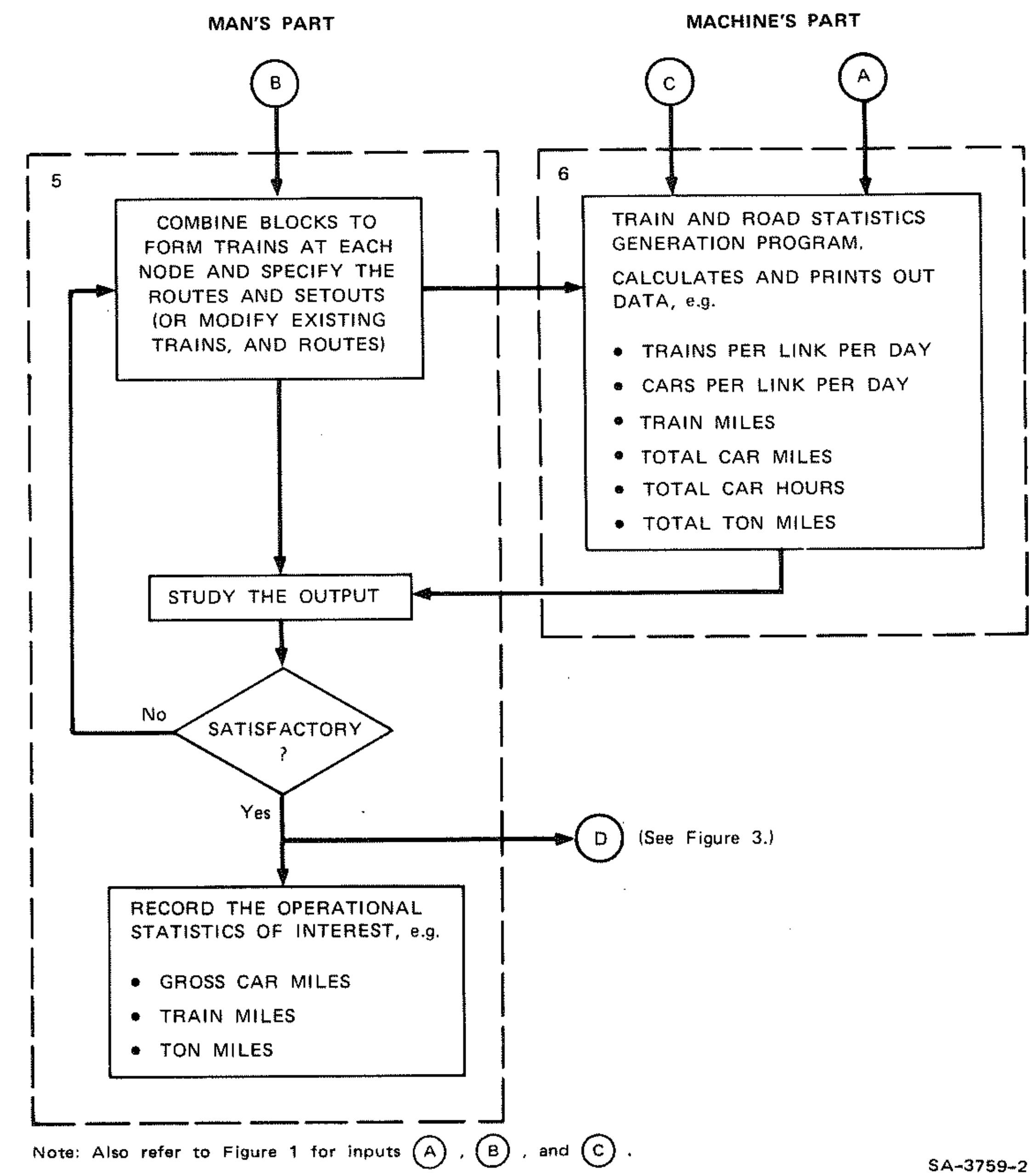


FIGURE 2 TRAINS AND ROAD STATISTICS ANALYSIS AND DEVELOPMENT PROCESS

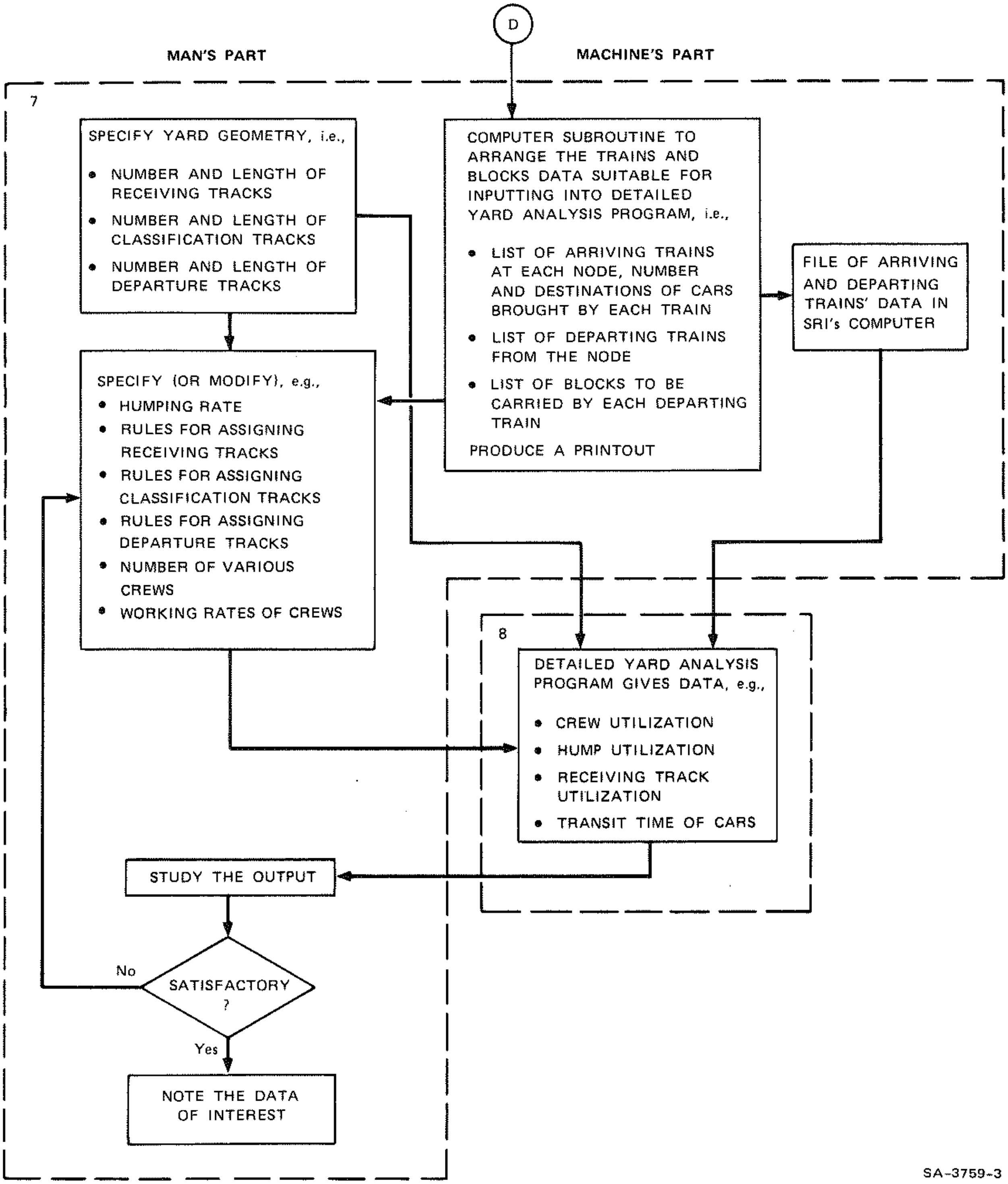


FIGURE 3 DETAILED YARD ANALYSIS PROCESS

(a) Specifying block destinations of various blocks to be made at the node

(b) Specifying the destinations of other groups of cars to be included in each block.

As an example, the designer may specify that at Node 1, he wishes to make a block destined for Node 53 containing cars for Nodes 53, 54, 74, and 89; another block destined for Node 87 containing cars for destination Nodes 87, 90, 91, ..., etc. It is to be ensured that all destinations are accounted for. Note that the designer need only specify the destination of nodes included in each block. The actual number of cars in each block is automatically calculated by program based on the O/D table as discussed below. The details of the exact format to specify the blocking strategy is included in the User's Manual for Network Analysis Computer Programs.

(4) The specified blocking strategies for all the nodes are inputted to the Blocking Strategy Analysis Program, which uses the specified strategies along with the O/D file stored in the computer. The program is designed to calculate the number of cars in each block by adding not only all cars originating at the node for the destinations included in the block but also the cars that were sent to the node by other nodes through the specified strategy. The specifications of blocking strategies at each node in combination with O/D table uniquely determines several operating characteristics through simple mathematical relationships, e.g., number of car switchings at each node, number of cars switched 1, 2, 3, ..., times, blocks and block sizes made at each node, and total system switchings. These data are used to analyze the proposed blocking strategy. Sample outputs of this program are included in Section III. The program also generates and stores a block file in the computer to be used with train formation and road statistics analysis program. The designer can modify the blocking strategy, using an editing program, and rerun the program many times to accomplish a satisfactory strategy.

(5) After a few iterations, when the blocking strategy has been refined to the satisfaction of the designer, e.g., the yard loadings are satisfactory, the number of car switchings are acceptable, the block sizes are satisfactory, the designer manually combines various blocks, generated by the proposed blocking strategy, into trains and specifies a route for each train. The designer may also specify the departure time of

each train. The formats for specifying these data are included in Section III of this report and also in the User's Manual for Network Analysis Computer Programs.

(6) These manually generated train routing and departure times data are then applied to the "Train Formation and Road Statistics Generation" program. The specification of train composition (blocks in each train) and their routing in combination with network details (link length in miles or travel times) uniquely determines several operational characteristics through simple mathematical relationships, e.g., train miles, car miles, ton miles, and trains per link. These operational characteristics are used to analyze the proposed train formation and routing strategies. The designer can modify the composition, routing and scheduling of trains and rerun the program many times to accomplish a satisfactory set of trains.

(7) The arriving train data at the yard to be analyzed in detail (e.g., cars brought by various trains for different blocks to be made at the yard) are established by suitably rearranging the results of blocking and train formation strategies through a computer subroutine developed by SRI. These data are inputted to the yard analysis simulation program along with the specification of yard geometry, humping rate, crew numbers and their processing rates, and so on.

(8) The yard analysis programs generate many operational data, such as crew utilization, hump utilization, class track utilization, and average car transit times. The designer may modify data such as the humping rate, sequence of humpings, class track assignment, and crew numbers, and study the effects on yard operations until a satisfactory operation is accomplished.

The detailed yard analysis program is essentially an independent program. The only interfaces between the detailed yard analysis and the train statistics and blocking strategy program are the specifications of arriving and departing trains, and the block specifications. If the detail of arriving and departing trains and their block contents can be specified by other sources (e.g., from actual field data), the programs can provide the yard operations analysis in the same manner.

## III EXAMPLES OF INPUTS AND OUTPUTS OF VARIOUS PROGRAMS

In this section we present several examples of inputs and outputs associated with various processes and programs to elaborate the general explanations given in Section II. Examples will be presented in the same sequence as used for explaining the various processes. It will be useful to refer to Figures 1, 2, and 3 as needed.

### A. Blocking Strategy Analysis and Development Process

#### 1. Program Inputs

##### a. Network Definition and Network Data Input

There are two types of network definitions: first, a graphical representation of the entire network; and second, a specification of nodes, links in terms of connected node pairs, link lengths in miles, and link transit times in minutes. A graphical representation of the network used for developing the preliminary system plan is shown in Figure 4. This network consists of 147 nodes, 246 links, and 23 junction points. Nodes are identified by unique numbers from 1 through 147; junction points are identified by unique numbers from 160 through 182. The real names of the nodes are also indicated on the map. A graphical representation of the network used for developing the final system plan is shown in Figure 5.* This network consists of 494 nodes and 650 links. For inputting the network details into the computer, the nodes, links, link lengths, and link transit times are specified in terms of node name, node classification, link origin, link destination, link length, and link transit times. A sample of node specification input data is shown in Table 1. A sample of specified link table is shown in Table 2. This link table is a part of the actual link table used for the network shown in Figure 4.

##### b. O/D Data Input

The traffic flow between various origin destination pairs is contained in a tape prepared by USRA, which provides the number of loaded and empty cars and the associated net weight in tons (i.e., car weight excluded) traveling between each origin-destination pair on a monthly basis. A program prepared by SRI reads the tape, generates a permanent file in the SRI computer, and produces a printout giving the average rounded off daily traffic flows between various origin destination

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*Attached separately at the end of the report.

Table 1

SAMPLE NODE SPECIFICATION INPUT (147-Node Network)

| Node Number | Node Name | Abbreviation | Class |
|---|---|---|---|
| 1 | Roselake | RLK | 3 |
| 2 | Madison | MAD | 2 |
| 3 | Exermont | EXM | 2 |
| 4 | Paris | PAR | 3 |
| 5 | Terrehaute | THT | 3 |
| . | . | . | . |
| . | . | . | . |

Table 2

SAMPLE OF LINK TABLE INPUT

| Origin Node | Destination Node | Miles | Time (minutes) |
|---|---|---|---|
| 14 | 15 | 22 | 60 |
| 15 | 16 | 65 | 120 |
| 16 | 169 | 42 | 70 |
| 26 | 169 | 51 | 95 |
| 26 | 40 | 42 | 80 |
| 40 | 50 | 70 | 120 |
| 50 | 51 | 34 | 60 |
| 51 | 60 | 29 | 75 |
| 60 | 61 | 26 | 45 |
| 61 | 62 | 42 | 70 |
| 62 | 81 | 80 | 130 |
| 81 | 82 | 8 | 30 |

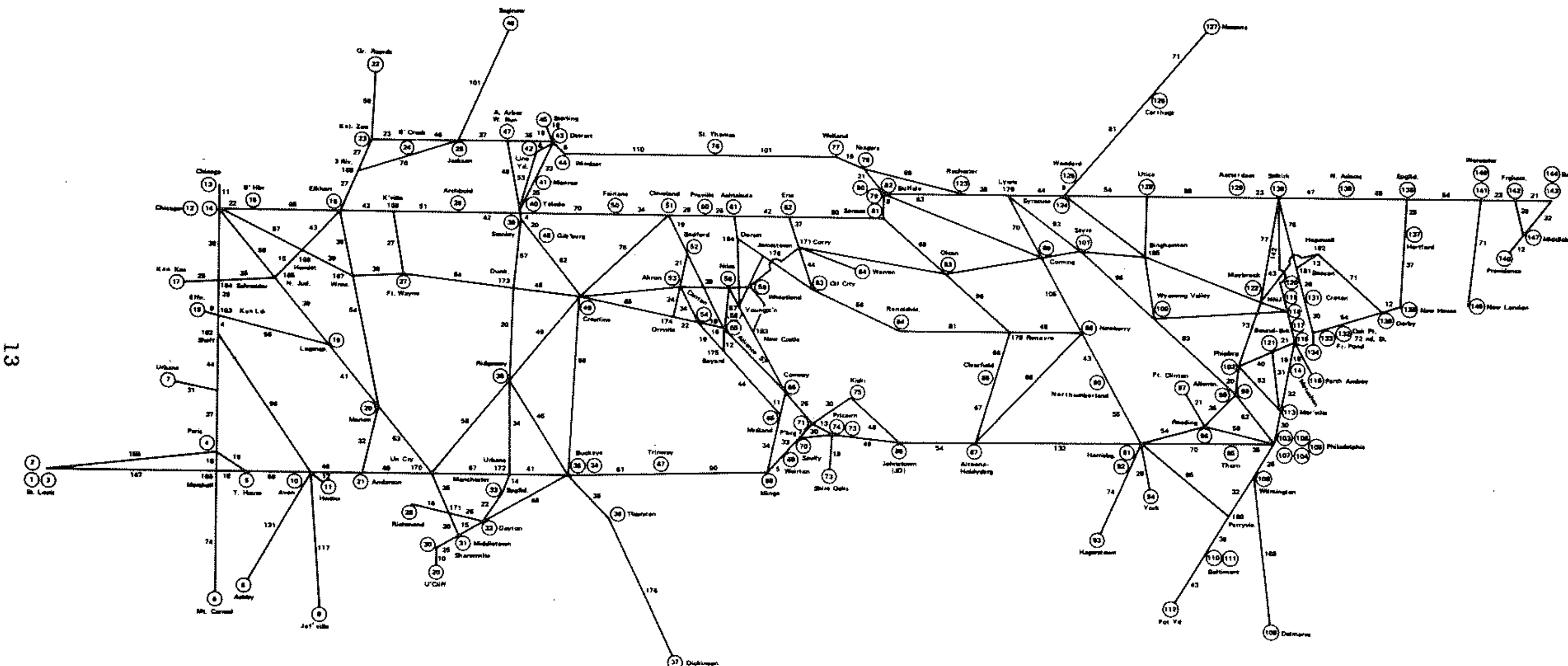

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FIGURE 4 GRAPHICAL REPRESENTATION OF 147-NODE NETWORK pairs. Less than 1/2 car per day is rounded off to zero and between 1/2 and 1 is treated as 1 car per day. Average daily tonnage is calculated separately and is rounded off in a manner similar to the car count. Because of the independent calculation of daily car count and associated net tonnage, it occasionally happens that the daily loaded car count is printed as zero but the associated net tonnage has a small finite value, e.g., refer to fifth row in the sample O/D data printout in Table 3. This is actually helpful since the designer thereby becomes aware that some monthly traffic exists between the respective nodes.

Table 3

SAMPLE OF O/D DATA PRINTOUT

| Origin | Destination | Tonnage (net) | Loaded Cars | Empty Cars | Total Cars |
|---|---|---|---|---|---|
| 6 | 1 | 55 | 1 | 0 | 1 |
| 6 | 4 | 491 | 6 | 2 | 8 |
| 6 | 6 | 1033 | 16 | 19 | 35 |
| 6 | 7 | 1012 | 14 | 0 | 14 |
| 6 | 10 | 8 | 0 | 2 | 2 |
| 6 | 11 | 67 | 1 | 0 | 1 |
| 6 | 15 | 203 | 3 | 0 | 3 |
| 6 | 16 | 180 | 3 | 0 | 3 |
| 6 | 23 | 108 | 1 | 0 | 1 |
| 6 | 39 | 0 | 0 | 1 | 1 |
| Totals | | 3157 | 45 | 24 | 69 |

c. <u>Blocking Strategy Input</u>

Blocking strategy input consists of specifying at each node the block destinations of all blocks the designer wishes to make at the node and of specifying all destinations included in each block. Table 4 shows a portion of blocking strategy specifications for Node 1 of the network of Figure 4. Referring to Table 4, number 1 in the first column refers to the origin node. The numbers 66, 39, 34, ..., in the second column are the block destination nodes of the several blocks the designer has specified to be made at Node 1. Considering the block for destination 66 (Conway), the block will contain cars for Nodes 66, 71, 85 through 88 (a dash between two numbers means all numbers in between are included), 103 through 114, and 90 through 97. Considering

Table 4

SAMPLE OF BLOCKING STRATEGY SPECIFICATION

| Block Origin Node | Block Destination Node | Other Destination Nodes Included in Block | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 66 | 71 | 75 | 85 | -88 | 103 | -114 | 90 | -97 |
| 1 | 39 | -48 | 50 | | | | | | |
| 1 | 34 | -37 | 65 | 67 | -70 | 72 | -74 | | |
| 1 | 3 | | | | | | | | |
| 1 | 4 | 17 | 18 | | | | | | |
| 1 | 5 | 6 | 7 | | | | | | |
| 1 | 2 | | | | | | | | |
| 1 | 12 | -15 | | | | | | | |
| 1 | 16 | 22 | -26 | | | | | | |
| 1 | 11 | 28 | -33 | | | | | | |
| 1 | 98 | -100 | 102 | 115 | -122 | | | | |
| 1 | 124 | -129 | | | | | | | |
| 1 | 51 | 52 | 60 | -64 | 77 | -84 | | | |
| 1 | 130 | -147 | | | | | | | |
| 1 | 10 | -1 | | | | | | | |

the block for 10 (the last block in the second column), the -1 sign in front of this block destination is designed to indicate that all the remaining destinations, so far not accounted for, are to be included in this block. This possibility of assigning all the remaining cars to a certain block destination by simply indicating a -1 sign is very convenient, since otherwise the designer will have to write all the remaining destinations. It also ensures that all destinations have been assigned to some block. The blocking strategy analysis program is designed to calculate the number of cars in each block at a node by adding both the number of cars originating at the node and the number of cars sent to that node by other nodes for the respective destination.

## 2. Outputs of Blocking Strategy Analysis Programs

The blocking strategy program, which consists of several subroutines, provides several useful outputs that the designer can study. The designer can then revise the blocking strategy to test the implications of various changes. Five types of data are provided:

- Individual flow handlings
- System-wide car handlings
- Yard loadings
- Transit traffic in yards
- Blocks and block sizes.

a. Individual Flow Handling Output

This output gives the number of times cars are handled (switched) before reaching a destination from various origins. The program is designed to print any selected data specified by the designer. A typical specification for printing selected data is shown in Table 5. Table 6 shows a portion of the flow handling output associated with destination Nodes 32, 33, 34, 35, 36, and 37. It is assumed that cars are handled once at the originating node, once at the destination node, and once at each intermediate node (yard). Thus, considering the flows associated with destination Node 35 (Grandview), all cars from Node 3 destined for Node 35 are handled once at Node 3, once at intermediate Node 34, and once at destination Note 35--i.e., three times. The numbers in the column give the product of the number of cars and the number of handlings. The 21 cars from Nodes 3 to 35 were handled three times; therefore, the number of car handlings from this flow is 63 as indicated. Similar remarks apply to other flows. From this output, the designer can spot those flows that are perhaps handled too many times. For example, referring again to Table 6, the flows from Node 58 to Node 35 are switched at three intermediate nodes before reaching Node 35, i.e., at Nodes 57, 49, and 34. The designer may wish to improve his strategy by checking blocking strategies at Nodes 34, 49, or 57.

If the designer does not want a switching count at certain yards (i.e., in case the block is being delivered to an interchange yard to be switched by other railroads) he may specify the node numbers of all such yards as an input to the program. The program will not count switchings at all these specified yards. Exact details of this feature are explained in the User's Manual for Network Analysis Computer Programs.

b. System-wide Car Handling Output

This is a system-wide car handling output and gives the total number of cars switched 1, 2, 3, ..., times. It also gives the total number of system switchings and total number of switchings in all intermediate yards. These system-wide figures are very helpful in comparing blocking strategies quickly on a system-wide basis. A sample output is shown in Table 7.

Table 5

SAMPLE OF SPECIFICATIONS FOR PRINTING SELECTED FLOW HANDLING DATA

| | | |
|---|---|---|
| OUTPUT CONTROLS | | |
| FLOW HANDLING IS PRINTED IF NUMBER OF HANDLINGS IS | 1 | AND CARS IN FLOW IS AT LEAST 1 |
| | 2 | 20 |
| | 3 | 15 |
| | 4 | 10 |
| | 5 | 5 |
| | 6 | 1 |
| | 7 | 1 |
| | 8 | 1 |
| | 9 | 1 |
| | 10 | 1 |

Table 6

SAMPLE OF FLOW HANDLING OUTPUT

FLOW HANDLINGS FOR STRATEGY CONRAIL 2A-85   12 FEB 75   75/05/68. 10.10.12.

| DESTINATION | | ORIGIN | | LOADS | EMPTIES | CARS | CARS*HANDLINGS | ---INTERMEDIATE | YARDS--- | |
|---|---|---|---|---|---|---|---|---|---|---|
| 32 | DAYTON | 32 | DAYTON | 1 | 15 | 16 | 16 | | | |
| 33 | SPRINGFIEL | 30 | SHARONVILL | 29 | 54 | 83 | 166 | | | |
| | | 33 | SPRINGFIEL | 0 | 3 | 3 | 3 | | | |
| 34 | BUCKEYE | 34 | BUCKEYE | 0 | 5 | 5 | 5 | | | |
| 35 | GRANDVIEW | 3 | EXERMONT | 10 | 11 | 21 | 63 | 34 | | |
| | | 12 | CHICAGO | 38 | 8 | 46 | 138 | 34 | | |
| | | 14 | COLHOUR | 5 | 17 | 22 | 44 | | | |
| | | 30 | SHARONVILL | 22 | 18 | 40 | 80 | | | |
| | | 35 | GRANDVIEW | 53 | 28 | 81 | 81 | | | |
| | | 39 | STANLEY | 4 | 34 | 38 | 76 | | | |
| | | 50 | FAIRLANE | 1 | 25 | 26 | 52 | | | |
| | | 58 | GATEWAY | 5 | 0 | 5 | 25 | 57 | 49 | 34 |
| | | 61 | ASHTABULA | 1 | 14 | 15 | 45 | 51 | | |
| | | 62 | ERIE | 1 | 11 | 12 | 48 | 60 | 51 | |
| 36 | THURSTON | 36 | THURSTON | 1 | 32 | 33 | 33 | | | |
| | | 39 | STANLEY | 1 | 30 | 31 | 93 | 34 | | |
| 37 | DICKINSON | 3 | EXERMONT | 11 | 4 | 15 | 45 | 34 | | |
| | | 30 | SHARONVILL | 4 | 11 | 15 | 45 | 34 | | |
| | | 37 | DICKINSON | 178 | 162 | 340 | 340 | | | |
| | | 39 | STANLEY | 2 | 19 | 21 | 63 | 34 | | |

Table 7

SYSTEM-WIDE CAR HANDLING OUTPUT

| | | | | | | |
|---|---|---|---|---|---|---|
| CAR HANDLINGS FOR STRATEGY CONRAIL 2A-85 12 FEB 75 | | | | | | |
| TOTAL CARS HANDLED 1,2,3 TIMES | 6774 | 13176 | 13752 | 3730 | 250 | 4 |
| TOTAL HANDLINGS = | 90576 | | | | | |
| TOTAL EXCESS HANDLINGS = | 21978 | | | | | |

According to this table, 6,774 cars were handled once (these were local cars and cars that had nodes, with no switch counts, as the origin or destination nodes), 13,176 cars were handled twice (i.e., these cars went directly from origin to destination), 13,752 cars were handled three times (i.e., these cars went from origin to destination through one intermediate yard), and so on. The total handlings 90,576 is the sum: 6,774 + 2 (13,176) + 3 (13,752) + 4 (3,730) + 5 (250) + 6 (4). Total excess handlings 21,978 is the sum: 13,752 + 2 (3,730) + 3 (250) + 4 (4) and gives the total number of intermediate yard car handlings.

c. Yard Loadings Output

This output gives the number of cars handled at each yard as a result of prepared blocking strategy. Displayed are the number of inbound cars, outbound cars, local cars, cars in transit, and total number of cars switched at every yard. A breakdown of loaded and empty cars is also indicated as well as the weight in tons. A sample output showing loadings of some selected yards is given in Table 8.

d. Transit Traffic in Yards Output

This output gives the number of cars in transit at various nodes with their final destinations and the next intermediate yard (if applicable) through which cars will go before reaching their destination. A sample output of the transit traffic in various yards is shown in Table 9. To illustrate the use of this table, consider the column associated with Node 12 (Chicago). The first number 3 in this column means that Node 12 will have three cars for Node 1 (ROSELAKE) and these three cars will go to Node 1 via PAR (Paris). As another example, consider the fourth entry in the same column, which is 7. This means that Node 12 will have seven cars for Node 4 (PARIS) and these will go directly to Paris without being handled at any intermediate yard, since no name is indicated beside the number 7. The seven cars for Paris include the three previously

Table 8

SAMPLE OUTPUT OF YARD LOADINGS

YARD LOADING FOR STRATEGY CONRAIL 2A-85 12 FEB 75 75/05/08. 10.10.12.

| | | INBOUND | | | | OUTBOUND | | | | LOCAL | | | | TRANSIT | | | | TOTAL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LOAD | EMTY | CARS | TONS | LOAD | EMTY | CARS | TONS | LOAD | EMTY | CARS | TONS | LOAD | EMTY | CARS | TONS | LOAD | EMTY | CARS | TONS |
| 1 | ROSFLAKE | 285 | 112 | 397 | 24475 | 134 | 93 | 227 | 15009 | 3 | 9 | 12 | 581 | 165 | 124 | 289 | 18969 | 587 | 338 | 925 | 59034 |
| 4 | PARIS | 21 | 64 | 85 | 4115 | 35 | 19 | 54 | 4011 | 2 | 17 | 19 | 688 | 65 | 115 | 180 | 9889 | 123 | 215 | 338 | 18703 |
| 5 | TERREHAUTE | 35 | 58 | 93 | 5220 | 56 | 51 | 107 | 6023 | 1 | 20 | 21 | 722 | 7 | 1 | 8 | 629 | 99 | 130 | 229 | 12594 |
| 10 | AVON | 53 | 150 | 203 | 9036 | 89 | 74 | 163 | 8730 | 1 | 5 | 6 | 232 | 1362 | 1135 | 2497 | 139052 | 1505 | 1364 | 2869 | 157050 |
| 11 | HAWTHORNE | 172 | 230 | 402 | 23385 | 177 | 255 | 432 | 20673 | 27 | 207 | 234 | 9962 | 89 | 67 | 156 | 9399 | 465 | 759 | 1224 | 63419 |
| 12 | CHICAGO | 167 | 196 | 363 | 22722 | 1529 | 662 | 2191 | 142330 | 3 | 85 | 88 | 2832 | 90 | 62 | 152 | 13244 | 1789 | 1005 | 2794 | 181128 |
| 13 | CHICAGO59 | 189 | 268 | 457 | 24028 | 99 | 130 | 229 | 10979 | 0 | 56 | 56 | 1680 | 1 | 3 | 4 | 214 | 269 | 457 | 746 | 36901 |
| 14 | COLHOUR | 159 | 117 | 276 | 16616 | 151 | 153 | 304 | 19293 | 0 | 82 | 82 | 2464 | 0 | 0 | 0 | 6 | 310 | 352 | 662 | 38381 |
| 16 | ELKHART | 108 | 95 | 203 | 12924 | 86 | 181 | 267 | 11661 | 1 | 22 | 23 | 756 | 1160 | 1297 | 2457 | 126822 | 1355 | 1595 | 2950 | 152163 |
| 19 | LOGANSPORT | 63 | 62 | 125 | 7815 | 46 | 74 | 120 | 7029 | 3 | 32 | 35 | 1166 | 28 | 6 | 34 | 2695 | 140 | 174 | 314 | 18617 |
| 20 | MARION | 53 | 97 | 150 | 8881 | 128 | 44 | 172 | 8659 | 2 | 12 | 14 | 560 | 48 | 41 | 89 | 5284 | 231 | 194 | 425 | 23384 |
| 21 | ANDERSON | 73 | 57 | 130 | 8488 | 69 | 59 | 128 | 6274 | 4 | 5 | 9 | 604 | 5 | 4 | 9 | 659 | 151 | 125 | 276 | 16025 |
| 23 | KALAMAZOO | 72 | 53 | 125 | 8605 | 75 | 65 | 140 | 6691 | 1 | 20 | 21 | 684 | 37 | 26 | 63 | 3617 | 185 | 164 | 349 | 19597 |
| 25 | JACKSON | 119 | 64 | 183 | 10358 | 66 | 96 | 162 | 7442 | 2 | 50 | 52 | 1633 | 81 | 127 | 208 | 10208 | 268 | 337 | 605 | 29641 |
| 27 | FT.WAYNE | 80 | 81 | 161 | 9090 | 87 | 77 | 164 | 10338 | 8 | 56 | 64 | 2368 | 0 | 1 | 1 | 30 | 175 | 215 | 390 | 21826 |
| 30 | SHARONVILL | 614 | 860 | 1474 | 67711 | 662 | 538 | 1200 | 77589 | 34 | 202 | 236 | 8949 | 1 | 18 | 19 | 663 | 1311 | 1618 | 2929 | 154912 |
| 31 | MIDDLETOWN | 91 | 50 | 141 | 11542 | 37 | 153 | 190 | 7670 | 0 | 56 | 56 | 1688 | 4 | 3 | 7 | 445 | 132 | 262 | 394 | 21345 |
| 32 | DAYTON | 80 | 61 | 141 | 9525 | 78 | 102 | 180 | 7812 | 1 | 15 | 16 | 571 | 13 | 12 | 25 | 1224 | 172 | 190 | 362 | 19132 |
| 34 | BUCKEYE | 15 | 80 | 95 | 3751 | 20 | 159 | 179 | 6590 | 0 | 5 | 5 | 159 | 968 | 848 | 1816 | 117449 | 1003 | 1092 | 2095 | 127949 |
| 38 | RIDGEWAY,O | 31 | 52 | 83 | 4394 | 65 | 37 | 102 | 6157 | 1 | 1 | 2 | 107 | -1 | 1 | 0 | 1 | 96 | 91 | 187 | 10659 |
| 39 | STANLEY | 209 | 366 | 575 | 30159 | 316 | 413 | 729 | 36664 | 13 | 109 | 122 | 4329 | 405 | 486 | 891 | 57070 | 943 | 1374 | 2317 | 128222 |
| 40 | AIRLINE | 148 | 137 | 285 | 24912 | 105 | 87 | 192 | 13658 | 1 | 16 | 17 | 583 | 33 | 54 | 87 | 4282 | 287 | 294 | 581 | 43435 |
| 43 | DETROIT | 398 | 352 | 750 | 41727 | 454 | 335 | 789 | 43391 | 1 | 159 | 160 | 4837 | 430 | 311 | 741 | 43447 | 1283 | 1157 | 2440 | 133402 |
| 44 | WINDSOR | 47 | 66 | 113 | 5357 | 49 | 37 | 86 | 5464 | 0 | 8 | 8 | 245 | 0 | 0 | 0 | 0 | 96 | 111 | 207 | 11066 |
| 49 | CRESTLINE | 47 | 99 | 146 | 7175 | 91 | 44 | 135 | 10023 | 1 | 33 | 34 | 1093 | 183 | 105 | 288 | 19827 | 322 | 281 | 603 | 38118 |
| 51 | CLEVELAND | 32 | 123 | 155 | 6530 | 104 | 298 | 402 | 21060 | 2 | 118 | 120 | 3831 | 195 | 181 | 376 | 24353 | 333 | 720 | 1053 | 55774 |
| 52 | BEDFORD | 298 | 244 | 542 | 34618 | 271 | 111 | 382 | 23314 | 15 | 65 | 80 | 3669 | 1 | 7 | 8 | 311 | 585 | 427 | 1012 | 61912 |
| 53 | AKRON | 31 | 30 | 61 | 3588 | 26 | 29 | 55 | 2626 | 1 | 9 | 10 | 352 | 3 | 1 | 4 | 332 | 61 | 69 | 130 | 7098 |
| 54 | CANTON | 68 | 101 | 169 | 9721 | 72 | 62 | 134 | 9833 | 27 | 55 | 82 | 4904 | 11 | 10 | 21 | 1051 | 178 | 228 | 406 | 25509 |
| 55 | ALLIANCE | 54 | 26 | 80 | 7423 | 33 | 36 | 69 | 3517 | 0 | 18 | 18 | 549 | 49 | 32 | 81 | 5374 | 136 | 112 | 248 | 16863 |
| 56 | NILES,OH | 71 | 80 | 151 | 8073 | 60 | 114 | 174 | 7329 | 2 | 33 | 35 | 1172 | 30 | 80 | 110 | 5223 | 163 | 307 | 470 | 21797 |
| 57 | YOUNGSTOWN | 99 | 83 | 182 | 12637 | 110 | 240 | 350 | 16918 | 1 | 43 | 44 | 1367 | 70 | 40 | 110 | 8111 | 280 | 406 | 686 | 39028 |
| 58 | GATEWAY | 121 | 161 | 282 | 19694 | 162 | 161 | 323 | 25607 | 0 | 1 | 1 | 30 | 9 | 14 | 23 | 1352 | 292 | 337 | 629 | 46683 |
| 59 | WHEATLAND | 91 | 191 | 282 | 14540 | 150 | 84 | 234 | 16188 | 13 | 75 | 88 | 3716 | 0 | 0 | 0 | 0 | 254 | 350 | 604 | 34444 |
| 60 | PAINESVILL | 108 | 58 | 166 | 17025 | 55 | 95 | 150 | 8597 | 1 | 28 | 29 | 954 | 36 | 43 | 79 | 4085 | 200 | 224 | 424 | 30661 |
| 61 | ASHTABULA | 70 | 168 | 238 | 14849 | 16 | 180 | 196 | 7958 | 1 | 22 | 23 | 779 | 162 | 199 | 361 | 22137 | 249 | 569 | 818 | 45723 |
| 62 | ERIE | 104 | 32 | 136 | 12104 | 60 | 85 | 145 | 7224 | 10 | 37 | 47 | 2252 | 42 | 24 | 66 | 4097 | 216 | 178 | 394 | 25677 |
| 63 | OILCITY | 14 | 90 | 104 | 4055 | 53 | 19 | 72 | 7120 | 1 | 38 | 39 | 1230 | 0 | -1 | -1 | -30 | 68 | 146 | 214 | 12375 |
| 66 | CONWAY | 107 | 168 | 275 | 16357 | 66 | 117 | 183 | 9737 | 7 | 54 | 61 | 2399 | 2039 | 1817 | 3856 | 240409 | 2219 | 2156 | 4375 | 268902 |
| 68 | MINGO | 46 | 224 | 270 | 11600 | 113 | 93 | 206 | 20758 | 15 | 192 | 207 | 7500 | 1 | 0 | 1 | 30 | 175 | 509 | 684 | 39888 |
| 70 | SCULLY | 101 | 208 | 309 | 15101 | 68 | 85 | 153 | 10305 | 2 | 35 | 37 | 1265 | 22 | 52 | 74 | 3422 | 193 | 380 | 573 | 30093 |
| 74 | PITCARIN | 78 | 39 | 117 | 8050 | 62 | 90 | 152 | 8187 | 1 | 49 | 50 | 1531 | 37 | 58 | 95 | 6599 | 178 | 236 | 414 | 24367 |
| 75 | KISKI | 67 | 105 | 172 | 9562 | 70 | 64 | 134 | 8512 | 12 | 51 | 63 | 2541 | 0 | 0 | 0 | 0 | 149 | 220 | 369 | 20615 |
| 78 | NIAGARA | 116 | 236 | 352 | 16545 | 320 | 76 | 396 | 25256 | 16 | 47 | 63 | 2183 | 132 | 140 | 272 | 14828 | 584 | 499 | 1083 | 58812 |
| 81 | SENECA | 56 | 107 | 163 | 11179 | 72 | 126 | 198 | 10474 | 0 | 9 | 9 | 270 | 80 | 114 | 194 | 11195 | 206 | 356 | 564 | 33118 |
| 82 | FRONTIER | 285 | 404 | 689 | 35117 | 522 | 246 | 768 | 50481 | 7 | 69 | 76 | 2621 | 466 | 303 | 769 | 50342 | 1280 | 1022 | 2302 | 138561 |
| 84 | REYNOLDSVI | 9 | 40 | 49 | 1878 | 94 | 13 | 107 | 11368 | 1 | 11 | 12 | 459 | 1 | 0 | 1 | 106 | 105 | 64 | 169 | 13811 |
| 87 | HALLIDAYSB | 71 | 253 | 324 | 13747 | 139 | 86 | 225 | 21363 | 1 | 80 | 81 | 2535 | 15 | 21 | 36 | 2154 | 226 | 440 | 666 | 39799 |
| 88 | NEWBERRY | 58 | 192 | 250 | 13456 | 99 | 177 | 276 | 16385 | 4 | 61 | 65 | 2193 | 48 | 29 | 77 | 6324 | 209 | 459 | 668 | 38358 |
| 89 | CORNING | 86 | 67 | 153 | 10813 | 68 | 66 | 134 | 8957 | 4 | 5 | 9 | 642 | 5 | 0 | 5 | 528 | 163 | 138 | 301 | 20940 |
| 90 | N.UMBERLAN | 69 | 21 | 90 | 7733 | 33 | 61 | 94 | 4327 | 0 | 20 | 20 | 616 | 0 | 1 | 1 | 30 | 102 | 103 | 205 | 12706 |
| 91 | ENOLA | 205 | 215 | 420 | 26381 | 132 | 289 | 421 | 20098 | 5 | 61 | 66 | 2270 | 886 | 866 | 1752 | 110135 | 1228 | 1431 | 2659 | 158884 |
| 96 | READING | 22 | 28 | 50 | 3025 | 29 | 18 | 47 | 2294 | 0 | 21 | 21 | 642 | 17 | 22 | 39 | 2516 | 68 | 89 | 157 | 8477 |
| 98 | ALLENTOWN | 186 | 6 | 192 | 16149 | 340 | 6 | 346 | 31360 | 128 | 1 | 129 | 13473 | 593 | 362 | 955 | 57607 | 1247 | 375 | 1622 | 118589 |
| 100 | COXTON | 287 | 56 | 343 | 26339 | 231 | 55 | 286 | 19241 | 32 | 1 | 33 | 2789 | 0 | -1 | -1 | -29 | 550 | 111 | 661 | 48340 |

Table 9

SAMPLE OUTPUT OF TRAFFIC IN TRANSIT YARDS

TRAFFIC IN TRANSIT YARDS FOR STRATEGY CONRAIL 2A-65   12 FEB 75   75/05/06. 10.10.12.

| | 1 RLK | 4 PAR | 5 THT | 10 AVO | 11 HTN | 12 CHI | 13 C59 | 14 CHR | 16 ELK | 19 LOG | 20 MAR | 21 AND | 23 KZO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 ROSELAKE | 409 | 29 | 5 | 318 | 24 AVO | 3 PAR | 2 PAR | 6 PAR | 4 AVO | 1 AVO | 4 AVO | 5 AVO | 1 ELK |
| 2 MADISON | 4 | 16 | 7 | 244 | 18 AVO | 2 PAR | 1 PAR | 1 PAR | 7 AVO | 1 AVO | 1 AVO | 2 AVO | 3 ELK |
| 3 EXERMONT | 5 | 16 | 3 AVO | 522 | 17 AVO | 4 PAR | 2 PAR | 2 PAR | 8 AVO | 1 AVO | 23 AVO | 13 AVO | 2 ELK |
| 4 PARIS | 7 | 104 | 2 | 54 | 5 AVO | 7 | 1 | 0 | 2 AVO | 2 AVO | 0 AVO | 1 AVO | 0 ELK |
| 5 TERREHAUTE | 32 | 13 | 115 | 49 | 6 AVO | 8 PAR | 0 PAR | 0 PAR | 0 AVO | 0 AVO | 0 AVO | 1 AVO | 0 ELK |
| 6 MT.CARMEL | 2 THT | 61 | 14 | 23 | 11 AVO | 26 PAR | 1 PAR | 11 PAR | 0 AVO | 2 AVO | 0 AVO | 0 AVO | 0 ELK |
| 7 URBANA | 5 THT | 3 | 6 | 57 | 3 AVO | 19 | 3 CHI | 4 CHI | 8 AVO | 0 AVO | 0 AVO | 1 AVO | 2 ELK |
| 8 ASHBY | 5 AVO | 5 AVO | 3 AVO | 135 | 53 AVO | 15 AVO | 2 HTN | 4 AVO | 0 AVO | 13 AVO | 0 AVO | 4 AVO | 0 ELK |
| 9 JEFFERSONV | 10 AVO | 3 AVO | 5 AVO | 189 | 29 AVO | 60 | 3 HTN | 5 AVO | 1 AVO | 9 AVO | 1 AVO | 10 AVO | 0 ELK |
| 10 AVON | 5 | 5 | 2 | 208 | 13 | 23 | 2 HTN | 1 | 3 | 1 | 0 | 1 | 0 ELK |
| 11 HAWTHORNE | 45 | 11 | 6 | 202 | 636 | 41 | 3 | 2 AVO | 15 AVO | 6 AVO | 1 AVO | 4 AVO | 0 ELK |
| 12 CHICAGO | 7 | 16 | 7 | 120 | 39 AVO | 451 | 40 | 43 | 1269 | 13 | 39 ELK | 15 ELK | 23 ELK |
| 13 CHICAGO59 | 6 CHI | 2 CHI | 1 CHI | 39 | 16 AVO | 54 | 513 | 6 | 234 | 9 CHI | 3 ELK | 1 ELK | 1 ELK |
| 14 COLHOUR | 4 CHI | 1 CHI | 0 CHI | 8 CHI | 3 AVO | 55 | 7 | 358 | 87 | 0 CHI | 1 ELK | 0 ELK | 1 ELK |
| 15 BURNSHARBO | 34 CHI | 2 CHI | 0 CHI | 3 C59 | 1 AVO | 69 | 13 | 12 | 42 | 0 CHI | 2 ELK | 0 ELK | 1 ELK |
| 16 ELKHART | 12 | 4 AVO | 0 AVO | 29 | 8 AVO | 47 | 4 | 1 | 227 | 2 BUK | 1 | 0 | 3 |
| 17 KANKAKEE | 5 PAR | 8 | 0 PAR | 17 | 5 AVO | 17 | 1 CHI | 1 CHI | 221 | 5 | 2 LOG | 1 ELK | 2 ELK |
| 18 EFFNER | 0 PAR | 1 | 0 PAR | 9 LOG | 4 AVO | 2 LOG | 0 CHI | 2 CHI | 2 MAR | 22 | 19 | 5 MAR | 0 ELK |
| 19 LOGANSPORT | 1 AVO | 0 AVO | 1 AVO | 32 | 12 AVO | 36 | 20 CHI | 5 CHI | 5 MAR | 159 | 29 | 9 MAR | 0 ELK |
| 20 MARION | 2 AVO | 0 AVO | 0 AVO | 18 | 0 AVO | 24 ELK | 2 ELK | 4 ELK | 45 | 15 | 165 | 3 | 1 ELK |
| 21 ANDERSON | 3 AVO | 1 AVO | 1 AVO | 65 | 5 AVO | 18 ELK | 3 ELK | 1 ELK | 24 | 2 MAR | 4 | 138 | 0 ELK |
| 22 GRANDRAPID | 12 ELK | 0 AVO | 0 AVO | 2 ELK | 0 AVO | 38 | 2 ELK | 1 ELK | 44 | 1 MAR | 7 ELK | 0 ELK | 33 |
| 23 KALAMAZOO | 4 ELK | 2 AVO | 0 AVO | 3 ELK | 0 AVO | 28 | 2 ELK | 4 ELK | 27 | 0 MAR | 2 ELK | 0 ELK | 146 |
| 24 BATTLECREE | 4 ELK | 2 AVO | 0 AVO | 41 | 3 AVO | 10 ELK | 1 ELK | 0 ELK | 28 | 0 MAR | 9 ELK | 1 ELK | 13 |
| 25 JACKSON | 5 ELK | 0 AVO | 0 AVO | 3 ELK | 0 AVO | 21 | 5 ELK | 2 ELK | 33 | 0 MAR | 8 ELK | 2 ELK | 14 |
| 26 ARCHBOLD | 1 ELK | 0 AVO | 0 AVO | 1 ELK | 0 AVO | 9 ELK | 1 ELK | 8 ELK | 24 | 0 MAR | 0 ELK | 0 ELK | 0 ELK |
| 27 FT.WAYNE | 1 AVO | 0 AVO | 1 AVO | 13 | 2 AVO | 31 | 5 CHI | 3 CHI | 16 | 3 MAR | 32 | 1 MAR | 2 ELK |
| 28 RICHMOND | 3 HTN | 0 HTN | 0 HTN | 21 | 15 | 5 HTN | 1 HTN | 0 AVO | 1 AVO | 2 BUK | 0 AVO | 4 AVO | 0 ELK |
| 29 UNDERCLIFF | 0 HTN | 0 HTN | 0 HTN | 0 HTN | 0 | 0 SHV | 0 HTN | 0 AVO | 0 MDT | 0 MDT | 0 BUK | 0 BUK | 0 ELK |
| 30 SHARONVILL | 15 HTN | 5 HTN | 7 HTN | 27 | 91 | 164 | 12 HTN | 5 AVO | 24 | 12 | 25 | 14 | 29 |
| 31 MIDDLETOWN | 2 HTN | 0 HTN | 1 HTN | 5 HTN | 29 | 9 HTN | 1 HTN | 2 AVO | 1 | 1 | 1 BUK | 1 BUK | 0 ELK |
| 32 DAYTON | 16 HTN | 0 HTN | 1 HTN | 2 HTN | 45 | 11 HTN | 1 HTN | 0 AVO | 1 MDT | 3 MDT | 1 BUK | 0 BUK | 0 ELK |
| 33 SPRINGFIEL | 1 HTN | 0 HTN | 0 HTN | 3 HTN | 12 | 3 HTN | 0 HTN | 0 AVO | 0 MDT | 1 MDT | 1 BUK | 0 BUK | 0 ELK |
| 34 BUCKEYE | 0 | 1 AVO | 0 AVO | 4 | 5 | 3 | 0 ELK | 0 ELK | 2 | 1 | 1 | 0 | 0 ELK |
| 35 GRANDVIEW | 5 BUK | 0 AVO | 1 AVO | 10 BUK | 4 BUK | 46 BUK | 4 ELK | 21 | 12 BUK | 2 BUK | 4 BUK | 2 BUK | 1 ELK |
| 36 THURSTON | 1 BUK | 0 AVO | 0 AVO | 2 BUK | 1 BUK | 3 BUK | 0 ELK | 0 ELK | 5 BUK | 0 BUK | 0 BUK | 0 BUK | 0 ELK |
| 37 DICKINSON | 3 BUK | 0 AVO | 0 AVO | 4 BUK | 2 BUK | 12 BUK | 1 ELK | 2 ELK | 12 BUK | 0 BUK | 0 BUK | 0 BUK | 0 ELK |
| 38 RIDGEWAY,O | 1 AVO | 0 AVO | 2 AVO | 14 | 1 AVO | 13 ELK | 1 ELK | 0 ELK | 19 STY | 0 BUK | 0 BUK | 1 BUK | 0 DET |
| 39 STANLEY | 0 | 1 AVO | 0 AVO | 9 | 5 AVO | 11 AIR | 2 ELK | 2 ELK | 14 | 1 MAR | 1 ELK | 6 | 4 DET |
| 40 AIRLINE | 1 STY | 0 AVO | 0 AVO | 2 STY | 1 AVO | 20 | 1 ELK | 4 ELK | 16 | 0 MAR | 0 ELK | 0 STY | 2 DET |
| 41 MONROE | 1 STY | 0 AVO | 0 AVO | 4 STY | 1 AVO | 11 AIR | 2 ELK | 1 ELK | 9 AIR | 0 MAR | 1 ELK | 0 STY | 0 DET |
| 42 LINCOLNYAR | 1 STY | 0 AVO | 0 AVO | 1 STY | 0 AVO | 17 DET | 0 ELK | 0 ELK | 4 DET | 0 MAR | 0 ELK | 0 STY | 0 DET |
| 43 DETROIT | 8 STY | 1 AVO | 1 AVO | 12 | 6 AVO | 100 | 4 ELK | 21 | 60 | 3 MAR | 3 ELK | 1 STY | 2 |
| 44 WINDSOR | 2 STY | 0 AVO | 1 AVO | 7 DET | 2 AVO | 8 DET | 1 ELK | 1 ELK | 7 DET | 0 MAR | 1 BUK | 2 STY | 4 DET |
| 45 STERLING | 1 STY | 0 AVO | 0 AVO | 1 STY | 0 AVO | 14 DET | 0 ELK | 0 ELK | 3 DET | 0 MAR | 0 ELK | 0 STY | 1 DET |
| 46 SAGINAW | 0 STY | 0 AVO | 0 AVO | 1 STY | 0 AVO | 10 JKN | 0 ELK | 1 ELK | 3 JKN | 0 MAR | 0 ELK | 0 ELK | 18 JKN |
| 47 WILLOWRUN | 0 STY | 0 AVO | 0 AVO | 7 STY | 2 AVO | 11 JKN | 1 ELK | 0 ELK | 6 JKN | 0 MAR | 1 ELK | 1 ELK | 13 |
| 48 GIBSONBURG | 0 STY | 0 AVO | 0 AVO | 2 STY | 0 AVO | 4 AIR | 0 ELK | 4 ELK | 18 STY | 0 MAR | 0 ELK | 1 ELK | 0 DET |
| 49 CRESTLINE | 2 AVO | 0 AVO | 1 AVO | 14 | 1 AVO | 10 | 4 ELK | 1 ELK | 14 | 0 BUK | 0 BUK | 1 BUK | 0 DET |
| 50 FAIRLANE | 1 STY | 0 AVO | 0 AVO | 4 CLF | 1 AVO | 20 ELK | 1 ELK | 0 ELK | 30 | 0 BUK | 0 BUK | 0 BUK | 0 DET |
| 51 CLEVELAND | 1 | 0 AVO | 0 AVO | 4 | 1 AVO | 11 | 0 ELK | 4 ELK | 16 | 0 BUK | 0 BUK | 0 BUK | 0 DET |
| 52 BEDFORD | 3 CLE | 0 AVO | 0 AVO | 42 | 7 AVO | 42 | 1 ELK | 5 ELK | 9 CLE | 0 BUK | 1 BUK | 1 BUK | 0 DET |
| 53 AKRON | 0 AVO | 0 AVO | 0 AVO | 5 CRL | 0 AVO | 4 CRL | 0 ELK | 0 ELK | 1 CRL | 0 BUK | 0 BUK | 0 BUK | 0 DET |
| 54 CANTON | 0 AVO | 0 AVO | 0 AVO | 5 CRL | 1 AVO | 15 CRL | 0 ELK | 6 ELK | 13 CRL | 0 BUK | 1 BUK | 0 BUK | 1 DET |
| 55 ALLIANCE | 0 AVO | 0 AVO | 0 AVO | 5 CRL | 0 AVO | 6 CRL | 0 ELK | 1 ELK | 1 CRL | 0 BUK | 0 BUK | 0 BUK | 0 DET |

mentioned Roselake cars. Other numbers can be interpreted similarly. The information associated with transit traffic at each node helps the designer to understand the traffic patterns generated by his proposed blocking strategy and thereby facilitates his analysis and improvements.

#### e. Blocks and Block Sizes Output

This output is one of the mose useful ones. It gives a list of all the blocks made at each node along with the number of loaded and empty cars and the total weights. A sample output showing blocks made at Nodes 1 through 5 is given in Table 10. This output gives the designer a complete picture of block sizes, contents, and weights made at each node as a result of his proposed strategy. Some blocks may be found to contain too many or too few cars. If so, the designer can then revise his strategy based on this information and rerun the program until satisfactory block sizes are formed.

## B. Trains and Road Statistics Analysis and Development Process

### 1. Program Inputs

#### a. Network Definition and Network Data Input

The link table input shown in Table 2 is used also in the Trains and Road Statistics Analysis Program. Additionally, a set of standard routes are defined to simplify route specifications of trains as explained below. Standard routes are expressed as a sequence of nodes as shown in Table 11. Typically, standard routes are selected between nodes that are some distance apart, and where portions of the standard route are expected to be frequently used by trains. Specification of any two nodes on a standard route automatically defines the entire path between the two nodes thereby simplifying the specification of train routing. Referring to Table 11 and also to Figure 4, the number in the first column is the serial number of the standard route. Considering the first standard route that occupies the first two rows, the route starts at Node 12 and traverses through Nodes 14, 15, 16, ..., 81, 82, 123, 179, ..., and ends at Node 144. Similarly standard route number 2 starts at Node 2 and goes through Nodes 1, 160, 5, ..., 68, 69, 70, 74, ..., and ends at Node 115. Other standard routes can similarly be defined. Selection of the number and composition of standard routes is, to a great extent, arbitrary. Many good sets of standard routes are possible. They are simply a mechanized route coding aid.

The usefulness of the concept of standard route will be clearer when the specification of trains and their routing is explained in the following section.

Table 10

SAMPLE OUTPUT OF BLOCKS AND BLOCK SIZES

BLOCKS AT EACH ORIGIN FOR STRATEGY CONRAIL 2A-85   12 FEB 75   75/05/08. 10.10.12.

| ORIGIN | DESTINATION | | CARS | TONS | LOADS | EMPTIES |
|---|---|---|---|---|---|---|
| 1 ROSELAKE | 1 | ROSELAKE | 409 | 25061 | 288 | 121 |
| | 2 | MADISON | 4 | 138 | 0 | 4 |
| | 3 | EXERMONT | 5 | 206 | 1 | 4 |
| | 4 | PARIS | 13 | 615 | 4 | 9 |
| | 5 | TERREHAUTE | 38 | 2481 | 17 | 21 |
| | 10 | AVON | 50 | 2826 | 24 | 26 |
| | 11 | HAWTHORNE | 82 | 3511 | 21 | 61 |
| | 12 | CHICAGO | 51 | 5783 | 41 | 10 |
| | 16 | ELKHART | 40 | 2403 | 20 | 20 |
| | 34 | BUCKEYE | 19 | 1054 | 7 | 12 |
| | 39 | STANLEY | 16 | 691 | 9 | 7 |
| | 51 | CLEVELAND | 10 | 428 | 4 | 6 |
| | 66 | CONWAY | 80 | 5142 | 54 | 26 |
| | 98 | ALLENTOWN | 44 | 3325 | 41 | 3 |
| | 124 | DEWITT | 36 | 3589 | 30 | 6 |
| | 130 | SELKIRK | 27 | 1781 | 25 | 2 |
| 2 MADISON | 1 | ROSELAKE | 155 | 8195 | 66 | 89 |
| | 2 | MADISON | 319 | 12184 | 74 | 245 |
| | 10 | AVON | 65 | 2662 | 14 | 51 |
| | 34 | BUCKEYE | 35 | 1668 | 10 | 25 |
| | 39 | STANLEY | 45 | 1587 | 5 | 40 |
| | 66 | CONWAY | 31 | 1709 | 18 | 13 |
| 3 EXERMONT | 1 | ROSELAKE | 153 | 11367 | 100 | 53 |
| | 2 | MADISON | 6 | 191 | 0 | 6 |
| | 3 | EXERMONT | 24 | 1529 | 12 | 12 |
| | 10 | AVON | 117 | 7043 | 60 | 57 |
| | 11 | HAWTHORNE | 78 | 4313 | 37 | 41 |
| | 34 | BUCKEYE | 79 | 4918 | 35 | 44 |
| | 39 | STANLEY | 34 | 1742 | 15 | 19 |
| | 66 | CONWAY | 96 | 8208 | 78 | 18 |
| | 130 | SELKIRK | 61 | 5397 | 59 | 2 |
| 4 PARIS | 1 | ROSELAKE | 29 | 2113 | 17 | 12 |
| | 2 | MADISON | 16 | 697 | 3 | 13 |
| | 3 | EXERMONT | 15 | 1209 | 11 | 4 |
| | 4 | PARIS | 104 | 4795 | 23 | 81 |
| | 5 | TERREHAUTE | 12 | 1117 | 9 | 3 |
| | 6 | MT.CARMEL | 61 | 2119 | 6 | 55 |
| | 7 | URBANA | 3 | 239 | 2 | 1 |
| | 10 | AVON | 51 | 3777 | 34 | 17 |
| | 11 | HAWTHORNE | 17 | 1134 | 9 | 8 |
| | 12 | CHICAGO | 20 | 966 | 5 | 15 |
| | 17 | KANKAKEE | 8 | 431 | 3 | 5 |
| | 18 | EFFNER | 1 | 100 | 1 | 0 |
| 5 TERREHAUTE | 1 | ROSELAKE | 5 | 252 | 3 | 2 |
| | 2 | MADISON | 7 | 233 | 1 | 6 |
| | 4 | PARIS | 2 | 119 | 1 | 1 |
| | 5 | TERREHAUTE | 115 | 5969 | 37 | 78 |
| | 6 | MT.CARMEL | 14 | 593 | 3 | 11 |
| | 7 | URBANA | 6 | 503 | 5 | 1 |
| | 10 | AVON | 37 | 2489 | 23 | 14 |
| | 11 | HAWTHORNE | 15 | 886 | 9 | 6 |
| | 12 | CHICAGO | 8 | 313 | 1 | 7 |

Table 11

SAMPLE OF STANDARD ROUTES SPECIFICATIONS

| Serial Number | Origin Node | Intermediate Nodes |
|---|---|---|
| 1 | 12 | 14 15 16 169 26 40 50 51 60 61 62 81 82 123 |
| | | 179 124 128 129 130 135 136 140 142 143 144 (last node of route 1) |
| 2 | 2 | 1 160 5 10 21 170 172 34 67 68 69 70 |
| | | 74 86 87 91 95 103 113 114 115 |
| 3 | 12 | 14 166 167 27 173 49 174 54 55 66 |
| 4 | 170 | 38 49 51 |
| 5 | 29 | 30 31 32 34 |
| 6 | 12 | 14 164 163 162 161 4 160 6 |
| 7 | 46 | 25 168 16 167 20 21 |
| . | . | . |
| . | . | . |

A yard delay allowance by the class type of each node is also specified as shown in Table 12.

Table 12

YARD DELAY ALLOWANCES

| | | | | |
|---|---|---|---|---|
| YARD DELAY ALLOWANCES BY TYPE ARE (MINUTES) | 45 | 45 | 90 | 1[illegible] |

The meaning of the numbers in the above table are as follows: The first number 45 is associated with Class 1 yards and indicates an average delay in minutes experienced by any train that stops at a node of the Class 1 type; the second number is associated with Class 2 yards, and so on. The average delays are specified by the designer, based on his knowledge of yard types, and constitute a simplified model of yard delays to calculate train movement times in the network.

### b. Train Composition and Routing Input

The designer has to combine manually various blocks made at each node into trains based on his experience and judgment and also has to specify a route and departure time for the train. Any blocks that have to be set out or picked up have also to be specified, along with the node where these will be set out or picked up. Since the computer already has a block file in which the number of cars in each block and the total weight are all indicated, the specification of trains essentially means the specification of block origin and destination to be included in any proposed train, the route, the departure time, and indication of pick up or set outs. Note that a block is uniquely identified by specifying its origin and destination. An example of the train specification process is shown in Table 13.

Table 13

SAMPLE OF TRAIN SPECIFICATION INPUT

Train Origin Node — Train Destination Node — Intermediate Nodes to Define Route Uniquely

Train Number 35

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BA5 | T | 10 | 24 | 21 | 168 | 23 | |
| BA5 | N | 2 | | | | | Number of Trains |
| BA5 | D | 1130 | | | | | Departure Time |
| BA5 | D | 2145 | | | | | |
| BA5 | | 10 | 24 | -0 | -0 | | |
| BA5 | | 10 | 27 | -0 | 167 | | |
| BA5 | | 20 | 27 | -0 | 167 | | Set Out Node |
| BA5 | | 16 | 24 | -0 | -0 | | |
| BA5 | | 23 | 24 | -0 | -0 | | |
| BA5 | | 27 | 16 | 167 | -0 | | |
| BA5 | | 16 | 23 | -0 | -0 | | |

Block Origin — Block Destination — Pickup Node

The meaning of the different entries in this table are as follows: Each row is punched on a separate computer input card. The first row, which represents the first card, is called a "train card." BA5 on this card indicates the train symbol; T indicates that this is a train card. The first number 10 is the origin node of the train and the second number 24 is the destination node of the train. The third, fourth, and fifth numbers, i.e., 21, 168, and 23 are the intermediate nodes needed to specify the route uniquely between Nodes 10 and 24. Note that Nodes 21 and 168 can be connected by many paths. However, since the two nodes are on the standard route number 7 (refer to Table 11 and Figure 4), it is not necessary to specify the intermediate Nodes 20, 167, and 16 to uniquely define the desired route. The computer program automatically picks up the route portion lying along the standard route without the need to specify the intermediate nodes. Thus, if any portion of a route between any origin and destination lies along a standard route, it is not necessary to specify the intermediate nodes for the section of the route that lies along the standard route. The only nodes that need be specified are those at the beginning and end of the route.

The second row, which represents the second card, indicates the need for multiple trains where applicable. If the designer feels that the total number of cars in the blocks to be carried is more than a single train can carry, he may specify the number of identical trains in which the blocks to be carried will be equally divided. The second card can be omitted if only one train is desired.

The third and fourth rows represent train departure time specification cards. In the example shown, the two trains have been specified to depart at 1130 and 2145 hours, respectively. The number of departure time cards should be equal to the number of trains specified. If the departure card is omitted, the program assumes a midnight departure of the train.

The remaining rows in Table 13 each represent a block. The fifth row is for block (10-24) originated at 10 and destined for 24. The sixth row is for block (10-27) to be set out at 167. The tenth row is for block (27-16) to be picked up at 167 and so on. Table 13 represents a complete specification of train BA5. The symbol BA5 is also chosen by the designer. All the blocks in the system have to be similarly combined to form trains. This train input is applied to the train and road statistics analysis program, which generates several useful outputs as explained below.

### 2. Outputs of Trains and Road Statistics Analysis Program

The outputs of train and road statistics analysis program can be categorized in three groups. These are:

. Block movement review outputs

. Train and link statistics outputs

. Incoming and outgoing train data for specified yards.

Each of these three types of outputs are discussed below.

a. Block Routing Review Outputs

These outputs are intended basically to help the designer find whether or not he has specified the complete movement of each block correctly (e.g., some blocks were overlooked or some were set out but not picked up). Because of the large number of blocks involved (e.g., around 2000 blocks in the network under consideration) and hundreds of trains to be specified, it almost always happens, particularly in the first go round, that some blocks are either overlooked, set out but not picked up, or assigned to more than one train simultaneously. The program checks each block in the blocking table and follows its movement in accordance with the specified trains and their routes and flags whenever there is an incomplete journey of a block or if a block has been assigned to more than one train simultaneously.

Table 14 shows a part of the block routing review output. The complete output consists of a display of the content and movement of all blocks in the system in which any omissions on the part of the designer is flagged. Referring to Table 14, and considering the first row, the meanings of various entries are as follows. The numbers in the first and second column refer to block origin and block destination. Thus, the first row refers to block (1-2). The third and fourth number indicate the number of loaded and empty cars in the blocks. The block (1-2) has no loaded cars and four empty cars. The fifth number is the weight of the block, i.e., 138 tons. The symbol BT2 indicates the train in which block (1-2) traveled. The number 2 in the bracket beside BT2 gives the serial number of the train assigned by the computer, in accordance with the sequence of the input train cards. This serial number is helpful in finding the train data cards if some modifications are to be made in the train. Referring to the third row, the meanings are that the block (1-16) has 20 loaded and 20 empty cars, it weighs 2403 tons, it moved in train BC1(9) which brought it to Node 21 and then it was picked up by the train BA3(32), which brought it to the final destination. Considering now the block (4-7) shown below block (1-16), a sequence of dashes is indicated instead of a train symbol. This is an indication that this particular block was overlooked by the designer, i.e., it did not move at all and is sitting at its origin. Similar remarks apply to block (6-58) shown at the bottom of the figure. This block was carried by train AC7 and was brought to Node 51, but was not

Table 14

SAMPLE OF BLOCK ROUTING REVIEW OUTPUT

| Block Origin | Block Destination | Loaded Cars | Empty Cars | Tons | Trains in Which Block was Carried | Transfer Node | |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 0 | 4 | 138 | BT2(2) | | |
| 1 | 3 | 1 | 4 | 206 | BT1(1) | | |
| 1 | 16 | 20 | 20 | 2403 | BC1(9) | 21 | BA3(32) |
| . | . | . | . | . | | | |
| . | . | . | . | . | | | |
| 4 | 7 | 2 | 1 | 239 | ------ | | |
| 4 | 10 | 34 | 17 | 3777 | BB7(16) | | |
| . | . | . | | | | | |
| . | . | . | | | | | |
| 6 | 58 | 10 | 20 | 1622 | AC7(92)51------ | | |
| . | . | | | | | | |
| . | . | | | | | | |

Dashes in this column indicate no block movement at all

Dashes in this and other columns on the right side indicate partial movement

picked up at Node 51. These built-in checks in the program are essential features in helping the designer to rectify his omissions. Knowing which blocks he forgot to move, the designer can revise or modify the train specifications until every block has been completely routed to its destination.

### b. Train and Link Statistics Outputs

The specification of blocks for various trains and their routing in combination with link tables, their lengths, and their transit times uniquely defines many statistics associated with trains and links, e.g., train miles, car miles, ton miles, train hours, car hours, trains per link per day, cars per link, and car miles per link. The program has been designed to calculate several of these numbers that are printed in two sets of tables. The first set is arranged with reference to trains and the second with reference to links. Table 15a shows the beginning portion of the output with reference to trains and Table 15b shows the end portion of the same output, which also includes totals in each column. The symbols L, E, and T under the headings of cars or car miles refer to loaded, empty, and total cars. Table 16a shows the beginning portion of the output referring to each link. Table 16b shows the end portion of the same output along with totals. It is to be noted that some grand totals (e.g., total car miles) are calculated independently in both train outputs and in link outputs and come out to be identical as they should be.

#### c. Incoming and Outgoing Train Data for Specified Yards

A computer subroutine has been developed by SRI the purpose of which is to generate the list of arriving and departing trains (with respective arrival and departure times) and of blocks carried by them for any specified transit yard. This list consists of the trains generated by the designer in the train formation process and is intended for inputting into the detailed yard analysis program to analyze the yard operations in detail, if the specified trains were to be handled in the yard under consideration. The latest version of the subroutine actually produces a set of train computer cards in proper format for direct use in the detailed yard analysis program. A sample of the output of this program is included in the description of yard analysis program input/output examples in the next section.

## C. Detailed Yard Analysis Process

The detailed yard analysis process consists of two stages. In the first stage, the designer can use a preliminary program to analyze, on a quick checkup basis, the building up of various blocks (to be made in the yard) as a function of arriving trains and as a function of the sequence of humping the arriving trains. The output of this first stage program can be helpful in making preliminary decisions related to class track assignments and possible time sharing of tracks. The second stage consists of using detailed subroutines to analyze the yard operations in finer details as will be explained in the following sections.

### 1. Program Inputs

#### a. Yard Geometry Input

Yard geometry input consists of specifying a unique number to each of the receiving tracks, classification tracks, and departure

Table 15a

BEGINNING PORTION OF TRAIN STATISTICS OUTPUT

| TRAIN | COUNT | TRAIN MILES | CAR MILES L | CAR MILES E | CAR MILES T | TON MILES | TRAIN HOURS | CAR HOURS L | CAR HOURS E | CAR HOURS T |
|---|---|---|---|---|---|---|---|---|---|---|
| BT1 | 1 | 0 | 0 | 0 | 0 | 0 | 1.25 | 66.25 | 90.00 | 156.25 |
| BT2 | 1 | 0 | 0 | 0 | 0 | 0 | 1.25 | 25.00 | 24.75 | 49.75 |
| BB2 | 1 | 224 | 13440 | 12768 | 26208 | 1577632 | 6.67 | 400.00 | 380.00 | 780.00 |
| BB3 | 1 | 224 | 12674 | 21539 | 34213 | 1784184 | 7.42 | 377.92 | 667.00 | 1044.92 |
| BF1 | 1 | 982 | 99164 | 5444 | 104608 | 8273724 | 31.75 | 3153.83 | 171.67 | 3325.50 |
| BA1 | 1 | 310 | 18975 | 9766 | 28741 | 2894988 | 16.58 | 1108.92 | 610.33 | 1719.25 |
| BB1 | 1 | 236 | 4956 | 14396 | 19352 | 828596 | 7.42 | 155.75 | 452.42 | 608.17 |
| BB4 | 1 | 236 | 10010 | 10670 | 20680 | 1161288 | 8.92 | 380.92 | 405.25 | 786.17 |
| BC1 | 1 | 454 | 20029 | 36057 | 56086 | 2576300 | 15.83 | 663.75 | 1207.58 | 1871.33 |
| BC2 | 1 | 417 | 21684 | 33777 | 55461 | 3185880 | 15.25 | 777.50 | 1204.75 | 1982.25 |
| BD1 | 1 | 589 | 45942 | 10602 | 56544 | 4834512 | 17.92 | 1397.50 | 322.50 | 1720.00 |
| BD2 | 1 | 589 | 48768 | 24243 | 73011 | 4563967 | 18.67 | 1486.25 | 741.25 | 2227.50 |
| BE1 | 1 | 953 | 46363 | 3588 | 49951 | 3691418 | 30.42 | 1487.08 | 115.25 | 1602.33 |
| BB5 | 1 | 90 | 910 | 7318 | 8228 | 291276 | 11.00 | 111.00 | 893.00 | 1004.00 |
| BB6 | 1 | 90 | 4770 | 1080 | 5850 | 710370 | 11.00 | 583.00 | 132.00 | 715.00 |
| BB7 | 1 | 146 | 9932 | 3867 | 13799 | 1055759 | 7.75 | 488.25 | 222.83 | 711.08 |
| BB8 | 1 | 146 | 9393 | 5917 | 15310 | 1062871 | 7.75 | 530.92 | 241.25 | 772.17 |
| AB1 | 1 | 310 | 8506 | 11840 | 20346 | 1205280 | 16.08 | 414.25 | 614.17 | 1028.42 |
| AB50 | 1 | 152 | 5676 | 5552 | 11228 | 739418 | 11.42 | 415.17 | 404.50 | 819.67 |
| BB9 | 1 | 224 | 1753 | 5141 | 6894 | 281900 | 7.42 | 53.83 | 164.83 | 218.67 |
| BB10 | 1 | 131 | 16113 | 1572 | 17685 | 1791556 | 10.08 | 1240.25 | 121.00 | 1361.25 |
| BB11 | 1 | 131 | 1048 | 16637 | 17685 | 589107 | 10.08 | 80.67 | 1280.58 | 1361.25 |
| BB12 | 2 | 234 | 17433 | 12870 | 30303 | 1663506 | 13.33 | 993.33 | 733.33 | 1726.67 |
| BB13 | 2 | 234 | 14274 | 14859 | 29133 | 1626300 | 13.33 | 813.33 | 846.67 | 1660.00 |
| BB14 | 3 | 672 | 55328 | 16128 | 71456 | 4482240 | 19.25 | 1584.92 | 462.00 | 2046.92 |
| BB15 | 2 | 448 | 13888 | 40768 | 54656 | 2126656 | 14.83 | 459.83 | 1349.83 | 1809.67 |
| BB16 | 5 | 1120 | 76384 | 40544 | 116928 | 6059872 | 33.33 | 2273.33 | 1206.67 | 3480.00 |
| BT3 | 2 | 24 | 1236 | 1548 | 2784 | 172440 | 2.00 | 103.00 | 129.00 | 232.00 |
| BT4 | 2 | 24 | 1536 | 2520 | 4056 | 184416 | 2.00 | 128.00 | 210.00 | 338.00 |
| BA2 | 1 | 167 | 19918 | 10832 | 30750 | 1960272 | 14.50 | 1680.50 | 910.17 | 2590.67 |
| AB2 | 1 | 179 | 14355 | 5286 | 19641 | 1431623 | 15.50 | 1185.50 | 434.50 | 1620.00 |
| BA3 | 1 | 167 | 9432 | 7285 | 16717 | 1110293 | 8.92 | 499.50 | 391.25 | 890.75 |
| BA4 | 1 | 119 | 5503 | 2659 | 8162 | 574378 | 6.17 | 284.67 | 150.33 | 435.00 |
| AB3 | 1 | 119 | 4410 | 3417 | 7827 | 447348 | 6.17 | 241.17 | 170.33 | 411.50 |
| BA5 | 1 | 244 | 15293 | 4234 | 19527 | 1124253 | 11.92 | 730.50 | 190.17 | 920.67 |
| AB4 | 1 | 221 | 7538 | 6089 | 13627 | 591406 | 11.25 | 373.33 | 295.42 | 668.75 |
| BC3 | 1 | 119 | 3699 | 2756 | 6455 | 323229 | 5.50 | 166.17 | 128.17 | 294.33 |
| CB1 | 1 | 119 | 2500 | 5670 | 8170 | 388153 | 5.50 | 125.00 | 262.50 | 387.50 |
| BC4 | 2 | 350 | 9386 | 25891 | 35277 | 1534067 | 16.17 | 434.67 | 1196.42 | 1631.08 |
| BB50 | 1 | 77 | 953 | 1704 | 2657 | 151041 | 3.00 | 35.00 | 60.00 | 95.00 |
| BC5 | 1 | 187 | 13263 | 8290 | 21553 | 1319019 | 9.08 | 645.33 | 402.92 | 1048.25 |
| BE2 | 1 | 727 | 47882 | 15057 | 62939 | 3968523 | 25.42 | 1657.67 | 531.67 | 2189.33 |
| BC40 | 1 | 158 | 6122 | 6132 | 12254 | 698972 | 6.75 | 278.25 | 274.50 | 552.75 |
| BF3 | 1 | 296 | 15045 | 18629 | 33674 | 1766942 | 9.67 | 487.67 | 603.33 | 1091.00 |
| BC6 | 1 | 292 | 9589 | 8549 | 18138 | 950316 | 11.42 | 341.25 | 315.75 | 657.00 |
| CB2 | 1 | 142 | 5271 | 1526 | 6797 | 405429 | 5.67 | 226.92 | 79.17 | 306.08 |
| BD3 | 1 | 365 | 13505 | 8030 | 21535 | 1320935 | 11.25 | 416.25 | 247.50 | 663.75 |
| AT1 | 1 | 0 | 0 | 0 | 0 | 0 | 2.50 | 19.00 | 143.00 | 162.00 |
| AT2 | 1 | 0 | 0 | 0 | 0 | 0 | 2.50 | 58.50 | 104.50 | 163.00 |
| AA1 | 1 | 22 | 1034 | 1034 | 2068 | 163328 | 3.50 | 140.00 | 124.50 | 264.50 |
| AA2 | 1 | 22 | 1188 | 902 | 2090 | 143726 | 3.00 | 136.00 | 61.00 | 197.00 |
| AB5 | 2 | 334 | 9352 | 34569 | 43921 | 1865724 | 28.00 | 784.00 | 2898.00 | 3682.00 |
| AA3 | 2 | 174 | 14790 | 7221 | 22011 | 1454292 | 11.00 | 888.00 | 433.50 | 1321.50 |
| AA4 | 1 | 87 | 3915 | 4263 | 8178 | 513300 | 3.00 | 135.00 | 147.00 | 282.00 |

Table 15b

END PORTION OF TRAIN STATISTICS OUTPUT

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| FF39 | 1 | 71 | 71 | 142 | 213 | 9514 | 5.00 | 5.00 | 10.00 | 15.00 |
| FA7 | 1 | 939 | 36810 | 95097 | 131907 | 4523586 | 39.50 | 1481.50 | 3560.00 | 5041.50 |
| FF40 | 2 | 264 | 4224 | 25770 | 29994 | 1000548 | 24.50 | 324.00 | 1783.25 | 2107.25 |
| FT50 | 1 | 0 | 0 | 0 | 0 | 0 | 4.00 | 0.00 | 4.00 | 4.00 |
| FF41 | 1 | 66 | 0 | 1032 | 1032 | 34272 | 2.08 | 0.00 | 32.67 | 32.67 |
| FF43 | 1 | 66 | 1926 | 450 | 2376 | 245526 | 2.08 | 60.25 | 13.75 | 74.00 |
| FF44 | 1 | 12 | 180 | 816 | 996 | 37656 | .33 | 5.00 | 22.67 | 27.67 |
| FA8 | 1 | 914 | 26011 | 63690 | 89701 | 3366528 | 32.42 | 864.83 | 2147.58 | 3012.42 |
| FF45 | 1 | 213 | 3808 | 13074 | 16882 | 673716 | 8.47 | 145.97 | 509.97 | 655.93 |
| FF70 | 1 | 173 | 2076 | 9169 | 11245 | 407761 | 7.42 | 89.00 | 393.08 | 482.08 |
| FA9 | 1 | 816 | 16725 | 39216 | 55941 | 2275494 | 26.75 | 534.08 | 1274.42 | 1808.50 |
| FE7 | 1 | 219 | 9375 | 27837 | 37212 | 1432059 | 9.25 | 404.08 | 1208.58 | 1612.67 |
| FF46 | 1 | 74 | 3364 | 5951 | 9315 | 483695 | 2.17 | 99.00 | 175.25 | 274.25 |
| FF47 | 1 | 74 | 2301 | 1807 | 4108 | 248409 | 2.17 | 67.75 | 53.25 | 121.00 |
| FF48 | 1 | 63 | 414 | 1632 | 2046 | 80881 | 1.80 | 11.23 | 42.95 | 54.18 |
| FE5 | 1 | 598 | 16248 | 33075 | 49323 | 2053435 | 26.00 | 660.67 | 1360.08 | 2020.75 |
| FF50 | 1 | 98 | 1159 | 2166 | 3325 | 158617 | 5.67 | 49.08 | 110.00 | 159.08 |
| FT13 | 1 | 0 | 0 | 0 | 0 | 0 | 1.00 | 21.00 | 12.00 | 33.00 |
| FT14 | 1 | 0 | 0 | 0 | 0 | 0 | 1.00 | 7.00 | 9.00 | 16.00 |
| FF51 | 1 | 150 | 5400 | 11700 | 17100 | 748650 | 7.67 | 264.00 | 535.00 | 799.00 |
| FF52 | 1 | 194 | 2113 | 25673 | 27786 | 899356 | 10.17 | 95.08 | 1225.58 | 1320.67 |
| FT15 | 1 | 0 | 0 | 0 | 0 | 0 | 2.00 | 64.00 | 2.00 | 66.00 |
| FT16 | 1 | 0 | 0 | 0 | 0 | 0 | 2.00 | 6.00 | 18.00 | 24.00 |
| FF53 | 1 | 71 | 0 | 497 | 497 | 15407 | 5.00 | 0.00 | 35.00 | 35.00 |
| FF55 | 1 | 121 | 751 | 6112 | 6863 | 235464 | 5.25 | 32.25 | 259.50 | 291.75 |
| FF56 | 1 | 96 | 5188 | 4939 | 10127 | 605252 | 4.50 | 243.00 | 231.75 | 474.75 |
| BF2 | 1 | 831 | 34004 | 10920 | 44924 | 3796533 | 26.17 | 1088.58 | 349.75 | 1438.33 |
| CF7 | 1 | 206 | 9978 | 9712 | 19690 | 1149081 | 9.33 | 356.33 | 339.08 | 695.42 |
| CC35 | 1 | 58 | 1334 | 2958 | 4292 | 279502 | 3.42 | 77.58 | 155.25 | 232.83 |
| CF50 | 1 | 333 | 8172 | 22491 | 30663 | 1776213 | 12.50 | 304.75 | 831.00 | 1135.75 |
| EC22 | 1 | 209 | 4921 | 8252 | 13173 | 695008 | 8.75 | 160.17 | 259.58 | 419.75 |
| ED22 | 1 | 445 | 12460 | 31150 | 43610 | 1804920 | 15.75 | 441.00 | 1102.50 | 1543.50 |
| ED23 | 1 | 375 | 13500 | 33750 | 47250 | 2082000 | 13.58 | 489.00 | 1222.50 | 1711.50 |
| ED24 | 1 | 449 | 18078 | 34186 | 52264 | 2027639 | 16.50 | 672.50 | 1249.50 | 1922.00 |
| ED50 | 1 | 417 | 7094 | 16797 | 23891 | 1026114 | 14.50 | 248.00 | 583.50 | 831.50 |
| ED25 | 1 | 371 | 10727 | 28803 | 39530 | 1750840 | 14.33 | 414.17 | 1102.50 | 1516.67 |
| ED26 | 1 | 379 | 20664 | 42226 | 62890 | 2871831 | 16.00 | 809.50 | 1638.50 | 2448.00 |
| ED27 | 1 | 387 | 11610 | 18963 | 30573 | 1371915 | 14.50 | 432.00 | 679.00 | 1111.00 |
| ED6 | 1 | 164 | 4728 | 9856 | 14584 | 582536 | 6.50 | 190.75 | 397.00 | 587.75 |
| DE30 | 1 | 164 | 7626 | 1928 | 9554 | 770504 | 6.50 | 291.50 | 72.00 | 363.50 |
| FC8 | 1 | 185 | 3238 | 11596 | 14834 | 678771 | 5.83 | 100.67 | 355.33 | 456.00 |
| FT17 | 1 | 8 | 200 | 112 | 312 | 28544 | 3.00 | 75.00 | 42.00 | 117.00 |
| FT18 | 1 | 8 | 256 | 520 | 776 | 35216 | 3.00 | 96.00 | 195.00 | 291.00 |
| FT19 | 1 | 8 | 40 | 128 | 168 | 6536 | 2.50 | 12.50 | 40.00 | 52.50 |
| FT20 | 1 | 8 | 192 | 88 | 280 | 15688 | 2.50 | 60.00 | 27.50 | 87.50 |
| EE6 | 1 | 21 | 42 | 0 | 42 | 2835 | .75 | 1.50 | 0.00 | 1.50 |
| BF4 | 1 | 483 | 24129 | 14826 | 38955 | 2525985 | 18.00 | 834.00 | 533.50 | 1367.50 |
| CB8 | 1 | 344 | 21934 | 7747 | 29681 | 1889810 | 11.92 | 729.17 | 246.42 | 975.58 |
| CB9 | 1 | 153 | 2970 | 2848 | 5818 | 265380 | 5.17 | 108.33 | 106.00 | 214.33 |
| DA7 | 1 | 440 | 25751 | 33715 | 59466 | 3170035 | 13.58 | 782.42 | 1030.92 | 1813.33 |
| DA8 | 1 | 295 | 2197 | 13244 | 15441 | 590749 | 7.58 | 56.08 | 339.67 | 395.75 |
| DD55 | 1 | 88 | 2552 | 1408 | 3960 | 349008 | 11.50 | 333.50 | 184.00 | 517.50 |
| DD56 | 1 | 88 | 792 | 2904 | 3696 | 163152 | 11.50 | 103.50 | 379.50 | 483.00 |
| AD33 | 1 | 429 | 22316 | 7229 | 29545 | 2258233 | 14.58 | 732.67 | 224.92 | 957.58 |
| AD5 | 1 | 295 | 12856 | 1312 | 14168 | 1406680 | 7.58 | 327.33 | 33.33 | 360.67 |
| TOTAL | 564 | 112656 | 5716129 | 4627984 | 10346113 | 607095717 | 4908.37 | 237130.25 | 200126.33 | 437256.58 |

Table 16a

BEGINNING PORTION OF LINK STATISTICS OUTPUT

| LINKS LINK | MILES | TRAINS | CARS L | CARS E | CARS T | TONS ALL | TRAIN MILES | CAR MILES L | CAR MILES E | CAR MILES T | TRAIN HOURS | CAR HOURS L | CAR HOURS E | CAR HOURS T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 - 15 | 22 | 21 | 1413 | 409 | 1822 | 126773 | 462 | 31086 | 8998 | 40084 | 21.00 | 1413.00 | 409.00 | 1822.00 |
| 15 - 14 | 22 | 18 | 770 | 1078 | 1848 | 86493 | 396 | 16940 | 23716 | 40656 | 18.00 | 770.00 | 1078.00 | 1848.00 |
| 15 - 16 | 65 | 21 | 1427 | 458 | 1885 | 128547 | 1365 | 92755 | 29770 | 122525 | 42.00 | 2854.00 | 916.00 | 3770.00 |
| 16 - 15 | 65 | 18 | 808 | 1084 | 1892 | 93201 | 1170 | 52520 | 70460 | 122980 | 36.00 | 1616.00 | 2168.00 | 3784.00 |
| 16 - 169 | 42 | 17 | 1217 | 392 | 1609 | 107469 | 714 | 51114 | 16464 | 67578 | 19.83 | 1419.83 | 457.33 | 1877.17 |
| 169 - 16 | 42 | 15 | 715 | 843 | 1558 | 79442 | 630 | 30030 | 35406 | 65436 | 17.50 | 834.17 | 983.50 | 1817.67 |
| 26 - 169 | 51 | 16 | 722 | 852 | 1574 | 80301 | 816 | 36822 | 43452 | 80274 | 25.33 | 1143.17 | 1349.00 | 2492.17 |
| 169 - 26 | 51 | 18 | 1229 | 399 | 1628 | 108787 | 918 | 62679 | 20349 | 83028 | 26.50 | 1945.92 | 631.75 | 2577.67 |
| 26 - 40 | 42 | 18 | 1239 | 408 | 1647 | 109194 | 756 | 52038 | 17136 | 69174 | 24.00 | 1652.00 | 544.00 | 2196.00 |
| 40 - 26 | 42 | 16 | 720 | 856 | 1576 | 80657 | 672 | 30240 | 35952 | 66192 | 21.33 | 960.00 | 1141.33 | 2101.33 |
| 40 - 50 | 70 | 21 | 1576 | 434 | 2010 | 132410 | 1470 | 110320 | 30380 | 140700 | 42.00 | 3152.00 | 868.00 | 4020.00 |
| 50 - 40 | 70 | 20 | 819 | 1116 | 1935 | 95848 | 1400 | 57330 | 78120 | 135450 | 40.00 | 1638.00 | 2232.00 | 3870.00 |
| 50 - 51 | 34 | 22 | 1596 | 531 | 2127 | 135647 | 748 | 54264 | 18054 | 72318 | 22.00 | 1596.00 | 531.00 | 2127.00 |
| 51 - 50 | 34 | 21 | 867 | 1124 | 1991 | 101967 | 714 | 29478 | 38216 | 67694 | 21.00 | 867.00 | 1124.00 | 1991.00 |
| 51 - 60 | 29 | 18 | 1187 | 299 | 1486 | 104663 | 522 | 34423 | 8671 | 43094 | 22.50 | 1483.75 | 373.75 | 1857.50 |
| 60 - 51 | 29 | 17 | 517 | 991 | 1508 | 66630 | 493 | 14993 | 28739 | 43732 | 21.25 | 646.25 | 1238.75 | 1885.00 |
| 60 - 61 | 26 | 18 | 1153 | 324 | 1477 | 100671 | 468 | 29978 | 8424 | 38402 | 13.50 | 864.75 | 243.00 | 1107.75 |
| 61 - 60 | 26 | 17 | 537 | 978 | 1515 | 71058 | 442 | 13962 | 25428 | 39390 | 12.75 | 402.75 | 733.50 | 1136.25 |
| 61 - 62 | 42 | 19 | 1306 | 364 | 1670 | 121168 | 798 | 54852 | 15288 | 70140 | 22.17 | 1523.67 | 424.67 | 1948.33 |
| 62 - 61 | 42 | 19 | 623 | 1101 | 1724 | 61328 | 798 | 26166 | 46242 | 72408 | 22.17 | 726.83 | 1284.50 | 2011.33 |
| 62 - 81 | 80 | 19 | 1271 | 348 | 1619 | 116052 | 1520 | 101680 | 27840 | 129520 | 41.17 | 2753.83 | 754.00 | 3507.83 |
| 81 - 62 | 80 | 19 | 609 | 1041 | 1650 | 79417 | 1520 | 48720 | 83280 | 132000 | 41.17 | 1319.50 | 2255.50 | 3575.00 |
| 81 - 82 | 8 | 24 | 1346 | 492 | 1838 | 125747 | 192 | 10768 | 3936 | 14704 | 12.00 | 673.00 | 246.00 | 919.00 |
| 82 - 81 | 8 | 24 | 665 | 1139 | 1804 | 86902 | 192 | 5320 | 9112 | 14432 | 12.00 | 332.50 | 569.50 | 902.00 |
| 1 - 160 | 147 | 11 | 583 | 500 | 1083 | 66472 | 1617 | 85701 | 73500 | 159201 | 43.08 | 2283.42 | 1958.33 | 4241.75 |
| 160 - 1 | 147 | 12 | 707 | 503 | 1210 | 62518 | 1764 | 103929 | 73941 | 177870 | 47.00 | 2769.08 | 1970.08 | 4739.17 |
| 5 - 160 | 18 | 12 | 712 | 535 | 1247 | 63877 | 216 | 12816 | 9630 | 22446 | 8.00 | 474.67 | 356.67 | 831.33 |
| 160 - 5 | 18 | 11 | 583 | 500 | 1083 | 66472 | 198 | 10494 | 9000 | 19494 | 7.33 | 388.67 | 333.33 | 722.00 |
| 5 - 10 | 59 | 12 | 697 | 529 | 1226 | 77274 | 708 | 41123 | 31211 | 72334 | 22.00 | 1277.83 | 969.83 | 2247.67 |
| 10 - 5 | 59 | 13 | 773 | 609 | 1382 | 71531 | 767 | 45607 | 35931 | 81538 | 23.83 | 1417.17 | 1116.50 | 2533.67 |
| 10 - 21 | 46 | 19 | 986 | 732 | 1718 | 105538 | 874 | 45356 | 33672 | 79028 | 38.00 | 1972.00 | 1464.00 | 3436.00 |
| 21 - 10 | 46 | 18 | 872 | 847 | 1719 | 88020 | 828 | 40112 | 38962 | 79074 | 36.00 | 1744.00 | 1694.00 | 3438.00 |
| 21 - 170 | 49 | 16 | 851 | 659 | 1510 | 91017 | 784 | 41699 | 32291 | 73990 | 21.33 | 1134.67 | 878.67 | 2013.33 |
| 170 - 21 | 49 | 15 | 763 | 775 | 1538 | 79260 | 735 | 37387 | 37975 | 75362 | 20.00 | 1017.33 | 1033.33 | 2050.67 |
| 170 - 172 | 57 | 6 | 341 | 216 | 557 | 35105 | 342 | 19437 | 12312 | 31749 | 14.00 | 795.67 | 504.00 | 1299.67 |
| 172 - 170 | 57 | 6 | 259 | 295 | 554 | 30702 | 342 | 14763 | 16815 | 31578 | 14.00 | 604.33 | 688.33 | 1292.67 |
| 34 - 172 | 41 | 7 | 291 | 355 | 646 | 35277 | 287 | 11931 | 14555 | 26486 | 11.67 | 485.00 | 591.67 | 1076.67 |
| 172 - 34 | 41 | 7 | 372 | 242 | 614 | 38248 | 287 | 15252 | 9922 | 25174 | 11.67 | 620.00 | 403.33 | 1023.33 |
| 34 - 67 | 61 | 8 | 443 | 241 | 684 | 45032 | 488 | 27023 | 14701 | 41724 | 14.00 | 775.25 | 421.75 | 1197.00 |
| 67 - 34 | 61 | 7 | 367 | 442 | 809 | 49096 | 427 | 22387 | 26962 | 49349 | 12.25 | 642.25 | 773.50 | 1415.75 |
| 67 - 68 | 90 | 8 | 435 | 241 | 676 | 44235 | 720 | 39150 | 21690 | 60840 | 20.00 | 1087.50 | 602.50 | 1690.00 |
| 68 - 67 | 90 | 7 | 363 | 430 | 793 | 48451 | 630 | 32670 | 38700 | 71370 | 17.50 | 907.50 | 1075.00 | 1982.50 |
| 65 - 68 | 34 | 7 | 235 | 474 | 709 | 36045 | 238 | 7990 | 16116 | 24106 | 6.17 | 274.17 | 553.00 | 827.17 |
| 68 - 65 | 34 | 6 | 339 | 227 | 566 | 39885 | 204 | 11526 | 7718 | 19244 | 7.00 | 395.50 | 264.83 | 660.33 |
| 65 - 66 | 11 | 6 | 367 | 237 | 604 | 43008 | 66 | 4037 | 2607 | 6644 | 3.50 | 214.08 | 138.25 | 352.33 |
| 66 - 65 | 11 | 6 | 256 | 346 | 602 | 34597 | 66 | 2816 | 3806 | 6622 | 3.50 | 149.33 | 201.83 | 351.17 |
| 38 - 170 | 58 | 10 | 415 | 521 | 936 | 44083 | 580 | 24070 | 30218 | 54288 | 18.33 | 760.83 | 955.17 | 1716.00 |
| 170 - 38 | 58 | 10 | 576 | 311 | 887 | 57432 | 580 | 33408 | 18038 | 51446 | 18.33 | 1056.00 | 570.17 | 1626.17 |
| 38 - 49 | 49 | 9 | 580 | 252 | 832 | 57605 | 441 | 28420 | 12348 | 40768 | 13.50 | 870.00 | 378.00 | 1248.00 |
| 49 - 38 | 49 | 11 | 381 | 634 | 1015 | 44876 | 539 | 18669 | 31066 | 49735 | 16.50 | 571.50 | 951.00 | 1522.50 |
| 49 - 51 | 75 | 8 | 447 | 180 | 627 | 45266 | 600 | 33525 | 13500 | 47025 | 16.00 | 894.00 | 360.00 | 1254.00 |
| 51 - 49 | 75 | 8 | 245 | 536 | 781 | 32160 | 600 | 18375 | 40200 | 58575 | 16.00 | 490.00 | 1072.00 | 1562.00 |
| 34 - 49 | 66 | 3 | 213 | 64 | 277 | 21597 | 198 | 14058 | 4224 | 18282 | 5.75 | 408.25 | 122.67 | 530.92 |

Table 16b

END PORTION OF LINK STATISTICS OUTPUT

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 145 - 146 | 62 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 146 - 145 | 62 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 146 - 147 | 12 | 2 | 38 | 121 | 159 | 6488 | 24 | 456 | 1452 | 1908 | .67 | 12.67 | 40.33 | 53.00 |
| 147 - 146 | 12 | 2 | 109 | 80 | 189 | 11092 | 24 | 1308 | 960 | 2268 | .67 | 36.33 | 26.67 | 63.00 |
| 143 - 147 | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 147 - 143 | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 142 - 147 | 28 | 2 | 166 | 20 | 186 | 14005 | 56 | 4648 | 560 | 5208 | 1.43 | 118.97 | 14.33 | 133.30 |
| 147 - 142 | 28 | 2 | 34 | 115 | 149 | 5933 | 56 | 952 | 3220 | 4172 | 1.43 | 24.37 | 82.42 | 106.78 |
| 13 - 14 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14 - 13 | 11 | 1 | 40 | 62 | 102 | 5045 | 11 | 440 | 682 | 1122 | 1.00 | 40.00 | 62.00 | 102.00 |
| 13 - 12 | 0 | 6 | 101 | 132 | 233 | 11189 | 0 | 0 | 0 | 0 | 3.00 | 50.50 | 66.00 | 116.50 |
| 12 - 13 | 0 | 4 | 149 | 208 | 357 | 19168 | 0 | 0 | 0 | 0 | 2.00 | 74.50 | 104.00 | 178.50 |
| 14 - 12 | 0 | 22 | 951 | 1326 | 2277 | 115547 | 0 | 0 | 0 | 0 | 44.00 | 1902.00 | 2652.00 | 4554.00 |
| 12 - 14 | 0 | 29 | 1690 | 761 | 2451 | 160147 | 0 | 0 | 0 | 0 | 58.00 | 3380.00 | 1522.00 | 4902.00 |
| 1 - 3 | 0 | 6 | 342 | 185 | 527 | 27259 | 0 | 0 | 0 | 0 | 1.50 | 85.50 | 46.25 | 131.75 |
| 3 - 1 | 0 | 3 | 238 | 134 | 372 | 26829 | 0 | 0 | 0 | 0 | .75 | 59.50 | 33.50 | 93.00 |
| 1 - 2 | 0 | 6 | 113 | 267 | 380 | 15950 | 0 | 0 | 0 | 0 | 6.00 | 113.00 | 267.00 | 380.00 |
| 2 - 1 | 0 | 7 | 259 | 324 | 583 | 32191 | 0 | 0 | 0 | 0 | 7.00 | 259.00 | 324.00 | 583.00 |
| 2 - 3 | 0 | 2 | 39 | 35 | 74 | 4126 | 0 | 0 | 0 | 0 | 1.00 | 19.50 | 17.50 | 37.00 |
| 3 - 2 | 0 | 4 | 146 | 106 | 252 | 16370 | 0 | 0 | 0 | 0 | 2.00 | 73.00 | 53.00 | 126.00 |
| 34 - 35 | 0 | 7 | 193 | 316 | 509 | 24439 | 0 | 0 | 0 | 0 | 10.50 | 289.50 | 474.00 | 763.50 |
| 35 - 34 | 0 | 3 | 277 | 77 | 354 | 31717 | 0 | 0 | 0 | 0 | 4.50 | 415.50 | 115.50 | 531.00 |
| 57 - 58 | 0 | 4 | 130 | 176 | 306 | 21059 | 0 | 0 | 0 | 0 | 4.00 | 130.00 | 176.00 | 306.00 |
| 58 - 57 | 0 | 4 | 172 | 175 | 347 | 26980 | 0 | 0 | 0 | 0 | 4.00 | 172.00 | 175.00 | 347.00 |
| 72 - 74 | 0 | 4 | 185 | 108 | 293 | 20350 | 0 | 0 | 0 | 0 | 6.00 | 277.50 | 162.00 | 439.50 |
| 74 - 72 | 0 | 3 | 80 | 135 | 215 | 12157 | 0 | 0 | 0 | 0 | 4.50 | 120.00 | 202.50 | 322.50 |
| 79 - 82 | 0 | 2 | 105 | 47 | 152 | 10472 | 0 | 0 | 0 | 0 | 4.00 | 210.00 | 94.00 | 304.00 |
| 82 - 79 | 0 | 3 | 43 | 91 | 134 | 5375 | 0 | 0 | 0 | 0 | 6.00 | 86.00 | 182.00 | 268.00 |
| 80 - 82 | 0 | 3 | 84 | 153 | 237 | 11138 | 0 | 0 | 0 | 0 | 7.50 | 210.00 | 382.50 | 592.50 |
| 82 - 80 | 0 | 3 | 89 | 61 | 150 | 11239 | 0 | 0 | 0 | 0 | 7.50 | 222.50 | 152.50 | 375.00 |
| 91 - 92 | 0 | 3 | 112 | 74 | 186 | 11392 | 0 | 0 | 0 | 0 | 3.00 | 112.00 | 74.00 | 186.00 |
| 92 - 91 | 0 | 3 | 110 | 113 | 223 | 10504 | 0 | 0 | 0 | 0 | 3.00 | 110.00 | 113.00 | 223.00 |
| 98 - 99 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 99 - 98 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 103 - 104 | 0 | 6 | 150 | 113 | 263 | 17781 | 0 | 0 | 0 | 0 | 9.00 | 225.00 | 169.50 | 394.50 |
| 104 - 103 | 0 | 6 | 135 | 118 | 253 | 15957 | 0 | 0 | 0 | 0 | 9.00 | 202.50 | 177.00 | 379.50 |
| 103 - 105 | 0 | 4 | 105 | 17 | 122 | 8967 | 0 | 0 | 0 | 0 | 6.00 | 157.50 | 25.50 | 183.00 |
| 105 - 103 | 0 | 3 | 71 | 78 | 149 | 7223 | 0 | 0 | 0 | 0 | 4.50 | 106.50 | 117.00 | 223.50 |
| 103 - 106 | 0 | 2 | 53 | 60 | 113 | 5124 | 0 | 0 | 0 | 0 | 3.00 | 79.50 | 90.00 | 169.50 |
| 106 - 103 | 0 | 1 | 63 | 45 | 108 | 4869 | 0 | 0 | 0 | 0 | 1.50 | 94.50 | 67.50 | 162.00 |
| 103 - 107 | 0 | 3 | 78 | 26 | 104 | 7185 | 0 | 0 | 0 | 0 | 4.50 | 117.00 | 39.00 | 156.00 |
| 107 - 103 | 0 | 4 | 23 | 104 | 127 | 5498 | 0 | 0 | 0 | 0 | 6.00 | 34.50 | 156.00 | 190.50 |
| 110 - 111 | 0 | 4 | 115 | 51 | 166 | 15380 | 0 | 0 | 0 | 0 | 6.00 | 172.50 | 76.50 | 249.00 |
| 111 - 110 | 0 | 4 | 59 | 121 | 180 | 7731 | 0 | 0 | 0 | 0 | 6.00 | 88.50 | 181.50 | 270.00 |
| 115 - 119 | 0 | 3 | 165 | 0 | 165 | 14168 | 0 | 0 | 0 | 0 | 3.00 | 165.00 | 0.00 | 165.00 |
| 119 - 115 | 0 | 1 | 50 | 0 | 50 | 4031 | 0 | 0 | 0 | 0 | 1.00 | 50.00 | 0.00 | 50.00 |
| 115 - 120 | 0 | 3 | 188 | 28 | 216 | 17288 | 0 | 0 | 0 | 0 | 6.00 | 376.00 | 56.00 | 432.00 |
| 120 - 115 | 0 | 1 | 65 | 35 | 100 | 6515 | 0 | 0 | 0 | 0 | 2.00 | 130.00 | 70.00 | 200.00 |
| 133 - 132 | 0 | 2 | 59 | 45 | 104 | 6200 | 0 | 0 | 0 | 0 | 8.00 | 236.00 | 180.00 | 416.00 |
| 132 - 133 | 0 | 4 | 55 | 57 | 112 | 4169 | 0 | 0 | 0 | 0 | 16.00 | 220.00 | 228.00 | 448.00 |
| 140 - 141 | 0 | 2 | 36 | 33 | 69 | 4002 | 0 | 0 | 0 | 0 | 2.00 | 36.00 | 33.00 | 69.00 |
| 141 - 140 | 0 | 2 | 45 | 27 | 72 | 4339 | 0 | 0 | 0 | 0 | 2.00 | 45.00 | 27.00 | 72.00 |
| 143 - 144 | 0 | 3 | 97 | 2 | 99 | 7300 | 0 | 0 | 0 | 0 | 6.00 | 194.00 | 4.00 | 198.00 |
| 144 - 143 | 0 | 5 | 9 | 122 | 131 | 4272 | 0 | 0 | 0 | 0 | 10.00 | 18.00 | 244.00 | 262.00 |
| TOTALS | 23570 | 2787 | 135680 | 111832 | 247512 | 145092111112656 | | 5718129 | 4627984 | 10346113 | 4908. | 237130. | 200126. | 437257. |

tracks and of specifying their capacities in terms of the number of cars each track can hold. An example of specifying receiving tracks is shown in Table 17.

Table 17

EXAMPLE OF SPECIFYING RECEIVING TRACKS

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Length | 51 | 56 | 58 | 130 | 40 | 136 | 156 | 155 | 153 | 155 | 150 |

(Note: Length is expressed in the number of cars the track can hold.) Classification and departure tracks are similarly specified.

b. Inputs Related to Various Yard Operations

Several inputs related to yard operations have to be specified. Many of these inputs represent actual operations but some are specified in terms of equivalent effects. A list of inputs related to yard operations is given in Table 18. Typical values of each input are also indicated.

c. Inputs Related to Yard Crews

A sample of input specifications associated with Inbound Inspection Crews (Receiving Track Crews), Departure Engine Crews (Pullout Crews), and Outbound Inspection Crews (Departure Track Crews) is shown in Table 19. Referring to the entries for IB (Inbound) Inspection Crew data, the meaning of various entries are:

- DOWNTIME is the time the crew takes to get ready for actual inspection process after its trick (shift) starts and the administration time just before the end time. A typical value is 5 minutes.

- CREW BREAK is the time lapsed between the end of inspection of a track and beginning of inspection of another track. A typical value is 5 minutes.

- PRINT CREW DATA is a data printout option.

- TAU is a look-ahead time window to see if a crew currently busy will become available within Tau minutes, so a new crew will not be required. A typical value is 10 minutes. (Also refer to Table 18 last line.)

Table 18

INPUTS RELATED TO YARD OPERATIONS

| Abbreviation Used in Program | Meaning | Typical Value |
|---|---|---|
| Hump speed | Rate of humping when actually humping a train. | .3 minute/car |
| Hump break constant | Time lapsed between finish of humping a train and beginning of humping the next. | 10 minutes |
| Make up | Time needed to couple all cars on a track before pulling the track. | 10 minutes |
| Air test | Time needed to perform air test on each track. | 10 minutes |
| Engine travel time | Time for a pullout engine to travel to the classification track. | 5 minutes |
| T-pull | Time for a departure engine to pull the cut out of classification track and travel to the departure track. | 5 minutes |
| Interference time | Average delay in pulling out a track because of interference of tracks. | 10 minutes |
| Multiple pull interference | Additional delay in pulling a train consisting of blocks made at different tracks or a block made in parts on more than one track. | 15 minutes for each additional engine movement |
| Start pull | Time lead for initiating classification track pullout operation in relation to its departure time. | 3 hours |
| Tau | A user specified look-ahead time to check if a better receiving track and/or a better departure track and/or a crew presently busy could become available within the time period Tau. | 10 minutes |

Table 19

SAMPLE OF INPUTS RELATED TO YARD CREWS

| IB DOWN | INSP TIME | CREW DATA CREW BREAK | PRINT CREW DATA | TAU |
|---|---|---|---|---|
| 5 | | 5 | 1 | 10 |

| CREW | RATE | INSP CONS | START | LUNCH | | FINISH | OVERTIME |
|---|---|---|---|---|---|---|---|
| 1 | .250 | 10 | 630 | 1100 | 1130 | 1430 | 0 |
| 2 | .250 | 10 | 1430 | 1900 | 1930 | 2230 | 0 |
| 3 | .250 | 10 | 2230 | 400 | 430 | 630 | 0 |

| OB DOWN | INSP TIME | CREW DATA CREW BREAK | PRINT CREW DATA | TAU |
|---|---|---|---|---|
| 10 | | 5 | 1 | 10 |

| CREW | RATE | INSP CONS | START | LUNCH | | FINISH | OVERTIME |
|---|---|---|---|---|---|---|---|
| 1 | .500 | 10 | 630 | 1100 | 1130 | 1430 | 0 |
| 2 | .500 | 10 | 730 | 1200 | 1230 | 1530 | 0 |
| 3 | .500 | 10 | 1430 | 1900 | 1930 | 2230 | 0 |
| 4 | .500 | 10 | 1500 | 1930 | 2000 | 2300 | 0 |
| 5 | .500 | 10 | 2230 | 300 | 330 | 630 | 0 |
| 6 | .500 | 10 | 2300 | 330 | 400 | 700 | 0 |

| DEP ENGINE DOWN TIME | CREW DATA CREW BREAK | PRINT CREW DATA | TAU |
|---|---|---|---|
| 5 | 5 | 1 | 10 |

| CREW | RATE | INSP CONS | START | LUNCH | | FINISH | OVERTIME |
|---|---|---|---|---|---|---|---|
| 1 | .200 | 10 | 630 | 1100 | 1130 | 1430 | 0 |
| 2 | .200 | 10 | 700 | 1130 | 1200 | 1500 | 0 |
| 3 | .200 | 10 | 730 | 1200 | 1230 | 1530 | 0 |
| 4 | .200 | 10 | 1430 | 1900 | 1930 | 2230 | 0 |
| 5 | .200 | 10 | 1500 | 1930 | 2000 | 2300 | 0 |
| 6 | .200 | 10 | 1530 | 2000 | 2030 | 2330 | 0 |
| 7 | .200 | 10 | 2230 | 300 | 330 | 630 | 0 |
| 8 | .200 | 10 | 2300 | 330 | 400 | 700 | 0 |
| 9 | .200 | 10 | 2330 | 400 | 430 | 730 | 0 |

- The numbers in the column heading CREW are the crew serial numbers.

- The .25 numbers under RATE column are the inspection rate expressed as minutes per car. A typical value is 0.25 minute per car.

- The numbers under INSP CONS are the constant amounts of time added to inspection time calculated on a per car basis to calculate the total inspection time per track, i.e., if the number of cars to be inspected on a track is x, then total inspection time is calculated as: (Inspection Rate) (x) + (Inspection Constant). A typical value for the Inspection Constant is 10 minutes.

- START indicates the starting time of shifts corresponding to the crew.

- LUNCH indicates lunch period for each crew.

- FINISH indicates the finishing time of the shifts

- OVERTIME indicates the allowable overtime for corresponding crews.

The explanations given above apply also to the Departure Engine Crew Data and Outbound Inspection Crew Data.

d. Input Data Related to Arriving Trains

The input data associated with arriving trains consists of the train identifications (IDs), the arrival times of the trains at the yard, and the number of cars being brought by each train for various blocks to be made at the yard. These input data can also be manually prepared (e.g., based on real observed data) or can be produced by the blocking strategy and train development programs discussed earlier if the yard analysis is to be conducted for the proposed blocks and trains. A sample of input data for arriving trains is shown in Table 20.

The meaning of different entries in this table are:

- NO indicates the serial number of train, e.g., 1, 2, ... .

- TRAIN indicates ID, e.g., Local, and BT204.

- TIME is the arrival time at the yard, e.g., 0 means midnight, 40 means 40 minutes after midnight, and 455 means 4:55 am.

Table 20

SAMPLE OF A PORTION OF INPUT DATA RELATED TO ARRIVING TRAINS

INPUT TRAFFIC MATRIX

| NO | TRAIN | TIME | BATCHES | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | LOCAL | 0 | 1 - 5 | 2 - 8 | 3 - 1 | 5 - 8 | 6 - 2 | 8 - 0 | | |
| | | | 9 - 8 | 16 - 0 | 18 - 1 | 19 - 4 | 22 - 8 | 23 - 0 | 24 - 2 | |
| | | | 26 - 2 | 28 - 2 | 29 - 1 | 30 - 2 | 31 - 0 | 32 - 10 | 33 - 0 | |
| | | | 34 - 0 | 35 - 3 | 39 - 1 | 42 - 11 | 72 - 30 | 110 - 4 | 120 - 1 | |
| | | | 131 - 3 | 137 - 1 | 140 - 5 | 151 - 0 | 160 - 3 | 189 - 1 | 198 - 0 | |
| | | | 207 - 0 | 230 - 2 | 260 - 1 | 300 - 4 | 440 - 1 | 460 - 1 | | TOTAL CARS = 136 |
| 2 | BT204 | 40 | 1 - 7 | 2 - 3 | 3 - 1 | 5 - 4 | 6 - 2 | 9 - 2 | 30 - 2 | |
| | | | 16 - 5 | 18 - 1 | 19 - 2 | 22 - 1 | 26 - 2 | 29 - 1 | 131 - 1 | |
| | | | 31 - 1 | 35 - 5 | 39 - 2 | 72 - 4 | 110 - 7 | 120 - 1 | | |
| | | | 137 - 1 | 151 - 2 | 189 - 1 | 198 - 1 | 207 - 1 | 230 - 1 | | TOTAL CARS = 61 |
| 3 | BB703 | 45 | 18 - 1 | 19 - 1 | 22 - 1 | 23 - 1 | 24 - 3 | 30 - 2 | 131 - 2 | |
| | | | 32 - 8 | 35 - 1 | 39 - 1 | 42 - 4 | 72 - 2 | 110 - 1 | 300 - 3 | |
| | | | 137 - 1 | 140 - 1 | 160 - 2 | 189 - 5 | 198 - 3 | 230 - 3 | 39 - 1 | |
| | | | 1 - 2 | 5 - 1 | 6 - 1 | 9 - 1 | 32 - 5 | 35 - 1 | 230 - 1 | |
| | | | 42 - 4 | 72 - 1 | 110 - 2 | 140 - 2 | 160 - 1 | 189 - 1 | | |
| | | | 300 - 2 | | | | | | | TOTAL CARS = 72 |
| 4 | BB401 | 455 | 24 - 1 | 26 - 1 | 28 - 1 | 30 - 2 | 32 - 8 | 35 - 3 | 189 - 1 | |
| | | | 120 - 2 | 131 - 1 | 137 - 1 | 140 - 5 | 151 - 1 | 160 - 6 | 460 - 9 | |
| | | | 198 - 1 | 207 - 2 | 230 - 4 | 260 - 4 | 300 - 32 | 440 - 4 | | TOTAL CARS = 89 |
| 5 | FB001 | 513 | 1 - 11 | 2 - 15 | 3 - 3 | 5 - 48 | 6 - 12 | 8 - 2 | 30 - 3 | |
| | | | 9 - 9 | 18 - 3 | 19 - 2 | 22 - 7 | 26 - 1 | 28 - 3 | | TOTAL CARS = 119 |

- BATCHES are indicated as sets of two numbers: the first number is the block destination number to be made at the yard and the second number is the number of cars brought by the train for the respective block. For example, the first set of numbers associated with train BT204 is "1-7," meaning the train has brought seven cars to be included in Block destination 1 to be made at the yard. Similarly, the second set of numbers "2-3" means three cars for Block destination 2. The set of numbers are continued in second, third, ... rows, if necessary.

- TOTAL CARS indicates the total number of cars brought by trains. This number is necessary for proper receiving track assignment.

e. Inputs Related to Class Track Assignments and Time Sharing

If the number of blocks to be made at the yard is less than or equal to the number of classification tracks, then each block can be made independently on a separate track. Otherwise, the blocks have to be mixed initially and then the respective tracks have to be rehumped or the tracks have to be time shared if conditions permit. The program has the capability to simulate preplanned time sharing of the tracks. It is necessary to assign various class tracks to one or more blocks initially and to indicate the time periods during which the various blocks are desired to be made on the respective tracks. A sample of class track assignment is shown in Table 21. The numbers under the heading NO. are the track serial numbers. The numbers under the heading LENGTH are the track lengths in terms of the number of cars the track can accommodate. The numbers under the heading BLOCKS are the block destination numbers (not the number of cars). The time period during which the blocks will be made on each track is indicated against each track. For example, the first row of the sample table indicates that class track number 1, having a capacity of 63 cars will be used to collect cars for block destination 5 during the hours 0 to 2359 (i.e., throughout 24 hours). The fourth row indicates that track number 4, having a capacity of 61 cars will be used to collect cars for block 1 during the hours 0 to 229 and 1330 to 2359. Other entries are to be similarly interpreted. 999 indicates a local block.

f. Input Data Related to Departing Trains

The input data associated with departing trains are similar to the data for arriving trains except that in departing trains the number of cars to be included in each block is not specified. These numbers are calculated by the program logic based on the specified departure times. A sample of data associated with departing trains is shown in Table 22. Meanings of different entries are:

Table 21

SAMPLE INPUT OF CLASS TRACK ASSIGNMENT

| NO. | LENGTH | BLOCKS | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 63 | 5 | 0 | -2359 | | | |
| 2 | 62 | 2 | 0 | -1859 | | | |
| 3 | 59 | 42 | 0 | -1614 | | | |
| 4 | 61 | 1 | 0 | -229 | 1 | 1330 | -2359 |
| 5 | 58 | 19 | 0 | -2359 | | | |
| 6 | 57 | 6 | 0 | -2359 | | | |
| 7 | 55 | 2 | 1900 | -2359 | 32 | 930 | -1529 |
| 8 | 56 | 1 | 230 | -1329 | | | |
| 9 | 56 | 72 | 0 | -2359 | | | |
| 10 | 52 | 32 | 0 | -930 | 32 | 1530 | -2359 |
| 11 | 51 | 160 | 0 | -2359 | | | |
| 12 | 49 | 8 | 0 | -2359 | | | |
| 13 | 48 | 140 | 0 | -2359 | | | |
| 14 | 46 | 28 | 0 | -2359 | | | |
| 15 | 46 | 110 | 0 | -159 | 110 | 1300 | -2359 |
| 16 | 44 | 35 | 0 | -529 | 35 | 1500 | -2359 |
| 17 | 44 | 3 | 0 | -2359 | | | |
| 18 | 44 | 131 | 0 | -2359 | | | |
| 19 | 43 | 22 | 0 | -159 | 22 | 715 | -2359 |
| 20 | 41 | 18 | 0 | -2359 | | | |
| 21 | 38 | 460 | 0 | -2359 | | | |
| 22 | 39 | 151 | 0 | -2359 | | | |
| 23 | 41 | 42 | 1615 | -2359 | | | |
| 24 | 37 | 26 | 0 | -2359 | | | |
| 25 | 37 | 440 | 0 | -2359 | | | |
| 26 | 36 | 300 | 0 | -2359 | | | |
| 27 | 36 | 9 | 0 | -630 | 9 | 1700 | -2359 |
| 28 | 33 | 9 | 631 | -1659 | | | |
| 29 | 33 | 230 | 0 | -2359 | | | |
| 30 | 30 | 120 | 0 | -2359 | | | |
| 31 | 30 | 24 | 0 | -529 | 24 | 1100 | -2359 |
| 32 | 29 | 260 | 0 | -2359 | | | |
| 33 | 29 | 198 | 0 | -2359 | | | |
| 34 | 27 | 24 | 900 | -1059 | | | |
| 35 | 27 | 110 | 200 | -1259 | | | |
| 36 | 25 | 16 | 0 | -2359 | | | |
| 37 | 25 | 31 | 0 | -2359 | | | |
| 38 | 22 | 207 | 0 | -2359 | | | |
| 39 | 22 | 189 | 0 | -2359 | | | |
| 40 | 20 | 999 | | | | | |
| 41 | 20 | 22 | 200 | -714 | | | |
| 42 | 21 | 29 | 0 | -2359 | | | |
| 43 | 26 | 24 | 530 | -859 | | | |
| 44 | 29 | 999 | | | | | |
| 45 | 27 | 34 | 0 | -2359 | | | |
| 46 | 29 | 137 | 0 | -2359 | | | |
| 47 | 25 | 999 | | | | | |
| 48 | 25 | 999 | | | | | |
| 49 | 23 | 999 | | | | | |
| 50 | 23 | 23 | 0 | -2359 | | | |
| 51 | 22 | 39 | 0 | -2359 | | | |
| 52 | 22 | 35 | 530 | -1459 | | | |
| 53 | 19 | 33 | 0 | -2359 | | | |
| 54 | 19 | 999 | | | | | |
| 55 | 22 | 30 | 0 | -2359 | | | |

Table 22

SAMPLE INPUT DATA RELATED TO DEPARTING TRAINS

Early Pullout Time for Blocks of Train BA001

-1 Indicates Early Pullout
0 Indicates Routine Pullout

Estimated Number of Cars

Actual Train Departure Time of Train BA001

DEPARTURES

| TRAIN | TIME | PRI | EST NO. | BLOCKS | | | | |
|---|---|---|---|---|---|---|---|---|
| BA001 | 215 | -1 | 138 | 72 | 120 | | | |
| BT201 | 300 | -1 | 66 | 32 | | | | |
| BD003 | 301 | -1 | 93 | 300 | | | | |
| BB104 | 330 | 0 | 79 | 5 | | | | |
| BB701 | 400 | 0 | 62 | 26 | 29 | | | |
| BB103 | 405 | -1 | 93 | 2 | | | | |
| BB702 | 430 | -1 | 117 | 28 | | | | |
| BT201 | 500 | 0 | 66 | 32 | | | | |
| BD004 | 630 | 0 | 27 | 230 | | | | |
| BA006 | 630 | -1 | 132 | 42 | | | | |
| BD003 | 700 | -1 | 93 | 300 | | | | |
| BB501 | 730 | 0 | 56 | 35 | | | | |
| BF002 | 735 | 0 | 85 | 260 | 440 | 460 | | |
| BB402 | 915 | -1 | 89 | 22 | | | | |
| BB104 | 930 | -1 | 79 | 5 | | | | |
| BC007 | 1000 | 0 | 28 | 151 | | | | |
| BB101 | 1000 | 0 | 78 | 9 | | | | |
| BB102 | 1020 | 0 | 114 | 1 | | | | |
| BC002 | 1045 | -1 | 71 | 140 | | | | |
| BB103 | 1100 | 0 | 138 | 2 | | | | |
| BC004 | 1115 | -1 | 84 | 110 | | | | |
| BB109 | 1130 | 0 | 94 | 3 | 8 | | | |
| BA006 | 1130 | -1 | 132 | 39 | | | | |
| BA001 | 1200 | 0 | 138 | 72 | 120 | | | |
| BD003 | 1200 | -1 | 93 | 300 | | | | |
| BB104 | 1300 | 0 | 79 | 5 | | | | |
| BB602 | 1300 | 0 | 80 | 24 | | | | |
| BB105 | 1400 | 0 | 64 | 6 | | | | |
| BB702 | 1400 | 0 | 117 | 28 | | | | |
| BC004 | 1420 | 0 | 84 | 110 | | | | |
| BA006 | 1435 | -1 | 132 | 42 | | | | |
| BB110 | 1530 | 0 | 112 | 16 | | | | |
| BB402 | 1600 | 0 | 89 | 22 | 23 | | | |
| BB501 | 1600 | 0 | 56 | 33 | 35 | | | |
| BT201 | 1700 | 0 | 66 | 32 | | | | |
| BA006 | 1700 | 0 | 132 | 34 | 39 | 42 | | |
| BB110 | 1730 | 0 | 112 | 16 | 18 | 19 | | |
| BD003 | 1800 | 0 | 93 | 300 | | | | |
| BB102 | 1845 | -1 | 114 | 1 | | | | |
| BC002 | 1900 | 0 | 71 | 140 | | | | |
| BB101 | 1900 | -1 | 78 | 9 | | | | |
| BC003 | 2000 | 0 | 49 | 160 | | | | |
| BB702 | 2020 | -1 | 117 | 28 | | | | |
| BB105 | 2100 | -1 | 64 | 6 | | | | |
| BB102 | 2120 | 0 | 114 | 1 | | | | |
| BT201 | 2200 | -1 | 66 | 32 | | | | |
| ~~BC005~~ | ~~2220~~ | ~~0~~ | ~~129~~ | ~~178~~ | ~~207~~ | | | |
| BT202 | 2230 | 0 | 11 | 31 | | | | |
| BB101 | 2300 | 0 | 78 | 9 | | | | |
| BT201 | 2300 | 0 | 66 | 32 | | | | |
| BC005 | 2330 | 0 | 129 | 131 | 137 | 189 | 198 | 207 |
| BA001 | 2359 | -1 | 138 | 72 | 120 | | | |
| BB105 | 10001 | 0 | 64 | 6 | | | | |
| BB104 | 10030 | -1 | 114 | 5 | | | | |

- TRAIN indicates the train IDs of departing trains.

- PRI. A zero under this column indicates that the blocks of the associated trains will be pulled out at a prespecified time (e.g., 3 hours) before desired departure time and the respective train will depart as soon as inspection is completed. A -1 sign indicates that the designer wishes to pull out the blocks earlier at the specified time from the class tracks and bring them to departure tracks. The inspection and departure of these blocks is to be completed consistent with the actual desired departure time of the train indicated against the same train symbol later in the list with a 0 in PRI column. As an example consider the first row associated with train BA001. The -1 sign and the time 215 indicate that the designer wants to pull out blocks 72 and 120 at 215 and bring them to departure tracks. The actual departure time of train BA001 is 12 as indicated in the table. The early pullout technique is frequently helpful in increasing yard capacity.

- EST NO. indicates the block identities to be carried by respective train. For example, in the first row, Train BA001 is specified to carry Blocks 72 and 120.

As in the case of arriving trains, the data for departing trains can either be manually specified based on real observations, or computer specified outputs of blocking strategy and train formation programs, if yard analysis is to be conducted for some proposed strategy.

2. Program Outputs

The program is designed to start either with some prespecified initial conditions or with totally empty yard tracks at 0 hours (midnight) on the first day and go through the simulation process for day 1, day 2, ..., until a steady state stabilized process is established, i.e., when the yard operations for the next day become almost identical with the previous day. This happens typically within two or three days depending upon the traffic patterns. Much of the significant information about yard operations is available after the second day's simulation. The logic of how each output is calculated is explained briefly in Section IV of this report and also in User's Manual for Yard Operations Analysis Computer Programs.

We have included a few selected samples of program outputs to indicate the type of information provided by the programs.

The following sample outputs have been included:

- Prehump and humping scenarios
- Block build-up scenario
- Hump utilization analysis
- Crew utilization analysis
- Receiving track utilization analysis
- Hump and block formation scenario
- Class track loading scenario
- Departing trains scenario
- Yard transit times statistics

A complete set of all the program outputs is included in the User's Manual for Yard Operations Analysis Computer Programs.

a. <u>Prehump and Humping Scenarios</u>

Table 23 shows a sample of prehump and humping scenarios. The entries under ARR TIME, REC TIME, and other headings of five digit number columns are to be interpreted as follows: The left most number indicates the simulation day, e.g., day 2 in the sample shown. The next two numbers are the hour of the day and the last two numbers are minutes of the hour. The entries under INST TIME, QUE TIME TO HUMP, etc., are indicated also in hours and minutes respectively. For example, the QUE TIME TO HUMP for the second train BT204 is 108 meaning one hour and eight minutes. The meaning of other entries are self-explanatory.

b. <u>Block Build-Up Scenario</u>

Table 24 and Figure 6 show samples of block build-up output generated by the preliminary program of the yard analysis process. Table 24 gives the output in a tabular form. The meaning of different entries are as follows: There are three columns associated with each block. For example, counting from the left, the first three columns are associated with Block 9. The first entry (20100) in the first row indicates the day of simulation (second day in the example) and the time at which some cars associated with the block were humped (0100 hours in the example). The second entry (i.e., 2) indicates the number of cars humped at the indicated time associated with Block 9. The third entry (i.e., 113)

Table 23

OUTPUT SHOWING PREHUMP AND HUMPING SCENARIO

CLASS SWING RUN 16 AVON NODE 30 DATA FROM CASE 19C 10/6/75

| NO. | TRAIN | NO. CARS | ARR TIME | REC DELAY | REC TRACK | REC TIME | INSP CREW | INSP DELAY | INSP TIME | INSP TIME | READY TO HUMP | QUE TIME TO HUMP | START HUMP | HUMP TIME | END HUMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | LOCAL | 136 | 20000 | 0 | 9 | 20000 | 3 | 20 | 20020 | 44 | 20109 | 35 | 20144 | 53 | 20237 |
| 2 | BT204 | 61 | 20040 | 0 | 4 | 20040 | 3 | 29 | 20109 | 25 | 20139 | 108 | 20247 | 24 | 20311 |
| 3 | BB703 | 72 | 20045 | 0 | 5 | 20045 | 3 | 54 | 20139 | 28 | 20212 | 109 | 20321 | 28 | 20349 |
| 4 | BB401 | 89 | 20455 | 0 | 4 | 20455 | 3 | 0 | 20455 | 32 | 20532 | 0 | 20532 | 35 | 20607 |
| 5 | FB001 | 119 | 20513 | 0 | 5 | 20513 | 3 | 19 | 20532 | 40 | 20617 | 0 | 20617 | 46 | 20703 |
| 6 | AB007 | 94 | 20605 | 7 | 4 | 20612 | 1 | 23 | 20635 | 34 | 20714 | 0 | 20714 | 37 | 20751 |
| 7 | FB002 | 84 | 20659 | 9 | 5 | 20708 | 1 | 6 | 20714 | 31 | 20750 | 11 | 20801 | 33 | 20834 |
| 8 | BB205 | 58 | 20755 | 0 | 3 | 20755 | 1 | 0 | 20755 | 25 | 20825 | 19 | 20844 | 23 | 20907 |
| 9 | BT203 | 76 | 20800 | 0 | 4 | 20800 | 1 | 25 | 20825 | 29 | 20859 | 18 | 20917 | 30 | 20947 |
| 10 | BB704 | 128 | 20845 | 0 | 5 | 20845 | 1 | 14 | 20859 | 42 | 20946 | 11 | 20957 | 50 | 21047 |
| 11 | DB002 | 83 | 20854 | 0 | 6 | 20854 | 1 | 52 | 20946 | 31 | 21022 | 35 | 21057 | 32 | 21129 |
| 12 | BB201 | 43 | 20905 | 0 | 1 | 20905 | 1 | 117 | 21022 | 21 | 21048 | 51 | 21139 | 17 | 21156 |
| 13 | BB202 | 59 | 20925 | 0 | 11 | 20925 | 1 | 123 | 21048 | 55 | 21148 | 18 | 21206 | 23 | 21229 |
| 14 | DB006 | 78 | 21117 | 0 | 4 | 21117 | 1 | 31 | 21148 | 30 | 21223 | 16 | 21239 | 30 | 21309 |
| 15 | BT204 | 61 | 21240 | 0 | 5 | 21240 | 1 | 0 | 21240 | 25 | 21310 | 9 | 21319 | 24 | 21343 |
| 16 | DB002 | 83 | 21254 | 0 | 6 | 21254 | 1 | 16 | 21310 | 31 | 21346 | 7 | 21353 | 32 | 21425 |
| 17 | CB008 | 93 | 21300 | 0 | 11 | 21300 | 1 | 46 | 21346 | 33 | 21424 | 11 | 21435 | 36 | 21511 |
| 18 | CB006 | 94 | 21305 | 9 | 4 | 21314 | 2 | 121 | 21435 | 34 | 21514 | 7 | 21521 | 37 | 21558 |
| 19 | AB001 | 113 | 21425 | 0 | 5 | 21425 | 2 | 49 | 21514 | 38 | 21557 | 11 | 21608 | 44 | 21652 |
| 20 | CB001 | 85 | 21553 | 0 | 6 | 21553 | 2 | 4 | 21557 | 31 | 21633 | 29 | 21702 | 33 | 21735 |
| 21 | BB603 | 115 | 21635 | 0 | 4 | 21635 | 2 | 0 | 21635 | 39 | 21719 | 26 | 21745 | 45 | 21830 |
| 22 | CB002 | 73 | 21645 | 0 | 11 | 21645 | 2 | 34 | 21719 | 28 | 21752 | 48 | 21840 | 28 | 21908 |
| 23 | FB003 | 102 | 21705 | 0 | 5 | 21705 | 2 | 47 | 21752 | 36 | 21833 | 45 | 21918 | 40 | 21958 |
| 24 | BB203 | 66 | 21725 | 0 | 9 | 21725 | 2 | 108 | 21833 | 57 | 21935 | 33 | 22008 | 26 | 22034 |
| 25 | CB007 | 24 | 21741 | 0 | 1 | 21741 | 2 | 154 | 21935 | 16 | 21956 | 48 | 22044 | 9 | 22053 |
| 26 | AB006 | 68 | 21746 | 0 | 6 | 21746 | 2 | 210 | 21956 | 27 | 22028 | 35 | 22103 | 27 | 22130 |
| 27 | BB205 | 58 | 21955 | 0 | 3 | 21955 | 2 | 33 | 22028 | 25 | 22058 | 42 | 22140 | 23 | 22203 |
| 28 | CB009 | 53 | 21959 | 0 | 2 | 21959 | 2 | 59 | 22058 | 23 | 22126 | 47 | 22213 | 21 | 22234 |
| 29 | AB008 | 124 | 22010 | 0 | 4 | 22010 | 2 | 116 | 22126 | 41 | 22212 | 32 | 22244 | 48 | 22332 |
| 30 | BB204 | 70 | 22125 | 0 | 5 | 22125 | 3 | 110 | 22235 | 28 | 22308 | 34 | 22342 | 27 | 30009 |
| 31 | BT204 | 61 | 22140 | 0 | 6 | 22140 | 3 | 128 | 22308 | 25 | 22338 | 41 | 30019 | 24 | 30043 |
| 32 | BB208 | 106 | 22200 | 0 | 11 | 22200 | 3 | 138 | 22338 | 37 | 30020 | 33 | 30053 | 41 | 30134 |
| | | ===== | | ==== | | | | ==== | | ===== | | ===== | | ===== | |
| | | 2629 | | 25 | | | | 10006 | | 1721 | | 1449 | | 1706 | |

Table 24

SAMPLE OF BLOCK BUILD-UP OUTPUT IN TABLE FORM

Simulation Day

Time

Number of Cars Humped or Pulled at This Time

Residual Number of Cars from Previous Day

Cumulative Number of Cars

| BLOCK | 9 | 111 | BLOCK | 16 | 5 | BLOCK | 18 | 7 | BLOCK | 19 | 19 | BLOCK | 22 | 41 | BLOCK | 23 | 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20100 | 2 | 113 | 20100 | 5 | 10 | 20100 | 1 | 8 | 20100 | 2 | 21 | 20100 | 1 | 42 | 20406 | 1 | 3 |
| 20254 | 8 | 121 | 20328 | 5 | 15 | 20254 | 1 | 9 | 20254 | 4 | 25 | 20254 | 8 | 50 | 20808 | 2 | 5 |
| 20328 | 2 | 123 | 20808 | 2 | 17 | 20328 | 1 | 10 | 20328 | 2 | 27 | 20328 | 1 | 51 | 20851 | 1 | 6 |
| 20400 | -123 | 0 | 21004 | 1 | 18 | 20406 | 1 | 11 | 20406 | 1 | 28 | 20406 | 1 | 52 | 21146 | 1 | 7 |
| 20406 | 1 | 1 | 21400 | 5 | 23 | 20721 | 3 | 14 | 20721 | 2 | 30 | 20721 | 7 | 59 | 21400 | -7 | 0 |
| 20721 | 9 | 10 | 21530 | -23 | 0 | 20808 | 3 | 17 | 20851 | 3 | 33 | 20808 | 6 | 65 | 21442 | 1 | 1 |
| 20851 | 8 | 18 | 21615 | 1 | 1 | 20851 | 3 | 20 | 21004 | 2 | 35 | 20851 | 4 | 69 | 21925 | 1 | 2 |
| 21104 | 2 | 20 | 21709 | 4 | 5 | 21004 | 2 | 22 | 21104 | 4 | 39 | 21104 | 1 | 70 | 0 | 0 | 0 |
| 21326 | 7 | 27 | 0 | 0 | 0 | 21104 | 2 | 24 | 21146 | 4 | 43 | 21146 | 8 | 78 | 0 | 0 | 0 |
| 21400 | 2 | 29 | 0 | 0 | 0 | 21146 | 2 | 26 | 21326 | 3 | 46 | 21326 | 3 | 81 | 0 | 0 | 0 |
| 21500 | -29 | 0 | 0 | 0 | 0 | 21400 | 1 | 27 | 21400 | 2 | 48 | 21400 | 1 | 82 | 0 | 0 | 0 |
| 21628 | 17 | 17 | 0 | 0 | 0 | 21442 | 2 | 29 | 21442 | 4 | 52 | 21400 | -82 | 0 | 0 | 0 | 0 |
| 21615 | 7 | 24 | 0 | 0 | 0 | 21530 | -29 | 0 | 21530 | -52 | 0 | 21442 | 8 | 8 | 0 | 0 | 0 |
| 21709 | 12 | 36 | 0 | 0 | 0 | 21615 | 1 | 1 | 21615 | 2 | 2 | 21528 | 2 | 10 | 0 | 0 | 0 |
| 21752 | 25 | 61 | 0 | 0 | 0 | 21709 | 1 | 2 | 21709 | 2 | 4 | 21615 | 4 | 14 | 0 | 0 | 0 |
| 21847 | 1 | 62 | 0 | 0 | 0 | 21847 | 1 | 3 | 21752 | 3 | 7 | 21709 | 1 | 15 | 0 | 0 | 0 |
| 21925 | 9 | 71 | 0 | 0 | 0 | 21925 | 1 | 4 | 21847 | 1 | 8 | 21752 | 3 | 18 | 0 | 0 | 0 |
| 22015 | 21 | 92 | 0 | 0 | 0 | 22251 | 1 | 5 | 21925 | 7 | 15 | 21847 | 1 | 19 | 0 | 0 | 0 |
| 22251 | 3 | 95 | 0 | 0 | 0 | 22349 | 2 | 7 | 22015 | 1 | 16 | 21925 | 5 | 24 | 0 | 0 | 0 |
| 22349 | 16 | 111 | 0 | 0 | 0 | 0 | 0 | 0 | 22251 | 1 | 17 | 22015 | 3 | 27 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22349 | 2 | 19 | 22251 | 3 | 30 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22349 | 11 | 41 | 0 | 0 | 0 |

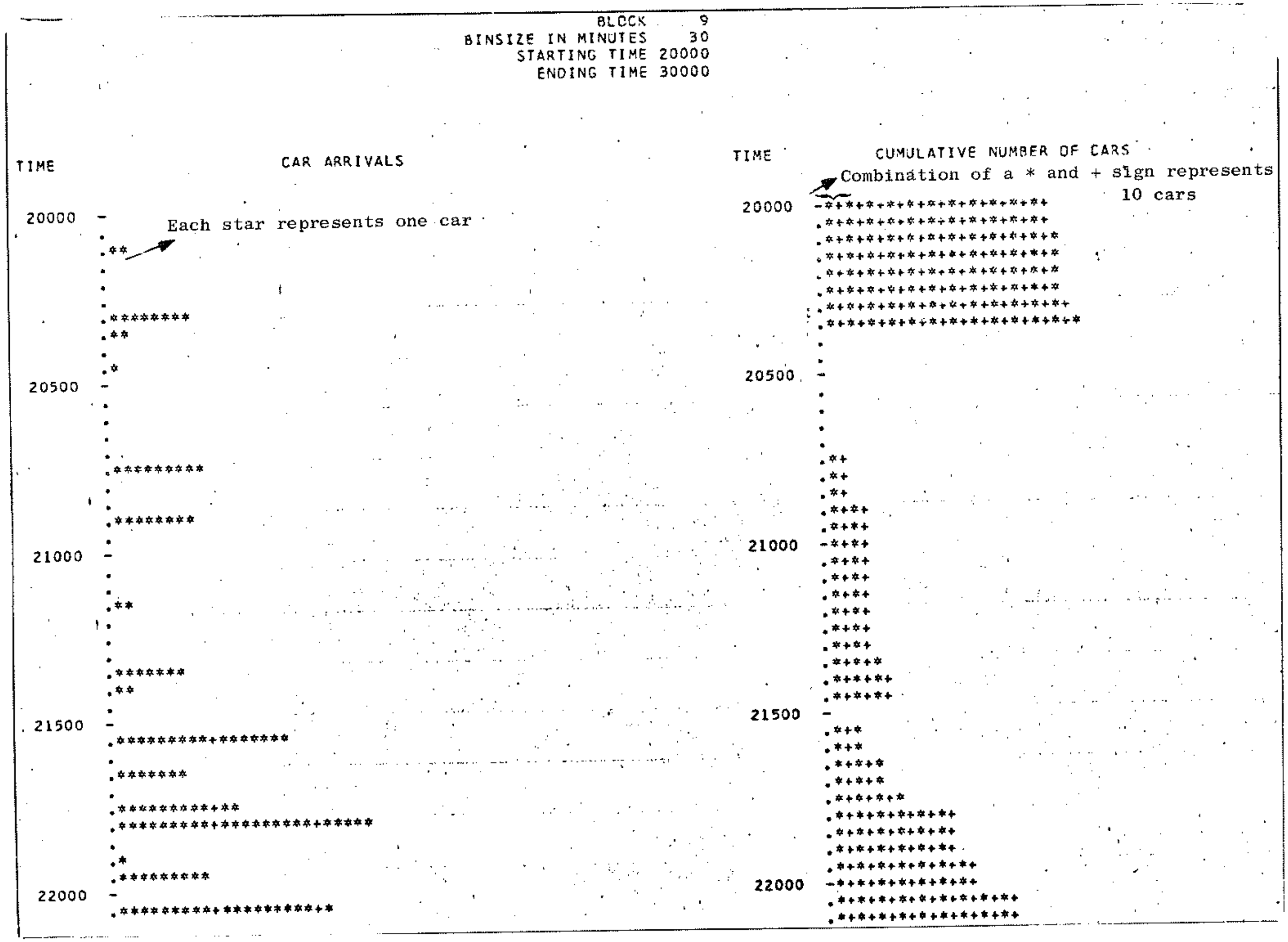



FIGURE 6. SAMPLE OF BLOCK BUILD-UP OUTPUT IN A GRAPHICAL FORM

indicates the cumulative total of cars humped at the time of entry. Considering the fourth row, the -123 indicates that 123 cars were removed from the block based on the departure times of the associated train. The process of block build-up continues from here onward again starting from 0 residual, as shown. The cycle is on a 24-hour basis. The residual number of cars at 2349 hours is indicated on top to the right of the block number, e.g., for Block 9, the residual number of cars from the previous day is 111. Information related to other blocks is similarly interpreted.

Figure 6 shows in a graphical form a portion of the block build-up of Block 9. The information contained in this graphical display is the same as the information in tabular form, but graphical presentation gives a perspective that is visually more readily understandable--particularly in spotting time gaps when no cars are arriving for certain blocks. The possibilities of track time-sharing could be explored by studying such gaps.

c. Hump Utilization Analysis

This output gives an analysis of hump utilization in terms of service time, idle time, and nonproductive time. The overall hump utilization is also calculated as the fraction of 2400 hours when the hump is actually being used for humping. In the sample shown in Table 25 the overall hump utilization is 71.2 percent. Other entries are self-explanatory. IDLE TIME indicates the time when the hump is available but the train to be humped is not yet ready. Nonproductive times are the inherent time delays between the end of humping of a train and the start of the humping of the other. These inherent delays are specified by the analyst as the hump break constant as defined in Table 18.

d. Crew Utilization Analysis

An analysis of how each crew was used is provided both in a tabular form and in a graphical form. Table 26 shows part of the tabular form display of the activities of inbound Crews 1 and 2. A similar display is provided for Departure Engine Crews and Outbound Inspection Crews. Meanings of various entries are self-explanatory. For convenience, the information displayed in tabular form is also provided in a graphical form as shown in Figure 7. In this figure, the numbers 1, 2, 3, ... in the left column refer to the crew numbers. The rows on the top indicate the time. Each dot represents 15 minutes and the numbers 1, 2, 3, ... refer to hours 1, 2, 3, ... 24. Because of space limitations, the hours are broken into 8-hour groups and are displayed in three sets of 1 to 8, 8 to 16, and 16 to 24 hours. The XX marking against each crew indicate the busy period. Each character, i.e., X, L, U or space represents

Table 25

OUTPUT SHOWING HUMP UTILIZATION

HUMP UTILIZATION UTILIZATION = 71.2 PERCENT

| | TRAIN NO. | START TIME | SERVICE TIME | END TIME | IDLE TIME | NONPROD TIME |
|---|---|---|---|---|---|---|
| 30 | BB204 | 12342 | 27 | 20009 | 0 | 10 |
| 31 | BT204 | 20019 | 24 | 20043 | 0 | 10 |
| 32 | BB208 | 20053 | 41 | 20134 | 0 | 10 |
| 1 | LOCAL | 20144 | 53 | 20237 | 0 | 10 |
| 2 | BT204 | 20247 | 24 | 20311 | 0 | 10 |
| 3 | BB703 | 20321 | 28 | 20349 | 133 | 10 |
| 4 | BB401 | 20532 | 35 | 20607 | 0 | 10 |
| 5 | FB001 | 20617 | 46 | 20703 | 1 | 10 |
| 6 | AB007 | 20714 | 37 | 20751 | 0 | 10 |
| 7 | FB002 | 20801 | 33 | 20834 | 0 | 10 |
| 8 | BB205 | 20844 | 23 | 20907 | 0 | 10 |
| 9 | BT203 | 20917 | 30 | 20947 | 0 | 10 |
| 10 | BB704 | 20957 | 50 | 21047 | 0 | 10 |
| 11 | DB002 | 21057 | 32 | 21129 | 0 | 10 |
| 12 | BB201 | 21139 | 17 | 21156 | 0 | 10 |
| 13 | BB202 | 21206 | 23 | 21229 | 0 | 10 |
| 14 | DB006 | 21239 | 30 | 21309 | 0 | 10 |
| 15 | BT204 | 21319 | 24 | 21343 | 0 | 10 |
| 16 | DB002 | 21353 | 32 | 21425 | 0 | 10 |
| 17 | CB008 | 21435 | 36 | 21511 | 0 | 10 |
| 18 | CB006 | 21521 | 37 | 21558 | 0 | 10 |
| 19 | AB001 | 21608 | 44 | 21652 | 0 | 10 |
| 20 | CB001 | 21702 | 33 | 21735 | 0 | 10 |
| 21 | BB603 | 21745 | 45 | 21830 | 0 | 10 |
| 22 | CB002 | 21840 | 28 | 21908 | 0 | 10 |
| 23 | FB003 | 21918 | 40 | 21958 | 0 | 10 |
| 24 | BB203 | 22008 | 26 | 22034 | 0 | 10 |
| 25 | CB007 | 22044 | 9 | 22053 | 0 | 10 |
| 26 | AB006 | 22103 | 27 | 22130 | 0 | 10 |
| 27 | BB205 | 22140 | 23 | 22203 | 0 | 10 |
| 28 | CB009 | 22213 | 21 | 22234 | 0 | 10 |
| 29 | AB008 | 22244 | 48 | 22332 | 0 | 10 |
| 30 | BB204 | 22342 | 27 | 30009 | 0 | 10 |
| 31 | BT204 | 30019 | 24 | 30043 | 0 | 10 |
| 32 | BB208 | 30053 | 41 | 30134 | 0 | 10 |
| | | | ==== | | ==== | ==== |
| | | | 1838 | | 134 | 550 |

Table 26

OUTPUT SHOWING INBOUND INSPECTION CREW UTILIZATION

IB INSP CREW 1 UTILIZATION = 74.4 PERCENT

| | TRAIN NO. | START TIME | SERVICE TIME | END TIME | IDLE TIME | NONPROD TIME |
|---|---|---|---|---|---|---|
| -3 | | 20630 | 0 | 20635 | 0 | 5 |
| 6 | AB007 | 20635 | 34 | 20709 | 0 | 5 |
| 7 | FB002 | 20714 | 31 | 20745 | 5 | 5 |
| 8 | BB205 | 20755 | 25 | 20820 | 0 | 5 |
| 9 | BT203 | 20825 | 29 | 20854 | 0 | 5 |
| 10 | BB704 | 20859 | 42 | 20941 | 0 | 5 |
| 11 | DB002 | 20946 | 31 | 21017 | 0 | 5 |
| 12 | BB201 | 21022 | 21 | 21043 | 0 | 5 |
| 13 | BB202 | 21048 | 12 | 21100 | 0 | 0 |
| -2 | | 21100 | 0 | 21130 | 0 | 30 |
| 13 | BB202 | 21130 | 13 | 21143 | 0 | 5 |
| 14 | DB006 | 21148 | 30 | 21218 | 17 | 5 |
| 15 | BT204 | 21240 | 25 | 21305 | 0 | 5 |
| 16 | DB002 | 21310 | 31 | 21341 | 0 | 5 |
| 17 | CB008 | 21346 | 33 | 21419 | 1 | 5 |
| -3 | | 21425 | 0 | 21430 | 0 | 5 |
| | | | ==== | | ==== | ==== |
| | | | 557 | | 23 | 140 |

IB INSP CREW 2 UTILIZATION = 76.0 PERCENT

| | TRAIN NO. | START TIME | SERVICE TIME | END TIME | IDLE TIME | NONPROD TIME |
|---|---|---|---|---|---|---|
| -3 | | 21430 | 0 | 21435 | 0 | 5 |
| 18 | CB006 | 21435 | 34 | 21509 | 0 | 5 |
| 19 | AB001 | 21514 | 38 | 21552 | 0 | 5 |
| 20 | CB001 | 21557 | 31 | 21628 | 2 | 5 |
| 21 | BB603 | 21635 | 39 | 21714 | 0 | 5 |
| 22 | CB002 | 21719 | 28 | 21747 | 0 | 5 |
| 23 | FB003 | 21752 | 36 | 21828 | 0 | 5 |
| 24 | BB203 | 21833 | 27 | 21900 | 0 | 0 |
| -2 | | 21900 | 0 | 21930 | 0 | 30 |
| 24 | BB203 | 21930 | 0 | 21930 | 0 | 5 |
| 25 | CB007 | 21935 | 16 | 21951 | 0 | 5 |
| 26 | AB006 | 21956 | 27 | 22023 | 0 | 5 |
| 27 | BB205 | 22028 | 25 | 22053 | 0 | 5 |
| 28 | CB009 | 22058 | 23 | 22121 | 0 | 5 |
| 29 | AB008 | 22126 | 41 | 22207 | 13 | 5 |
| -3 | | 22225 | 0 | 22230 | 0 | 5 |
| | | | ==== | | ==== | ==== |
| | | | 605 | | 15 | 140 |

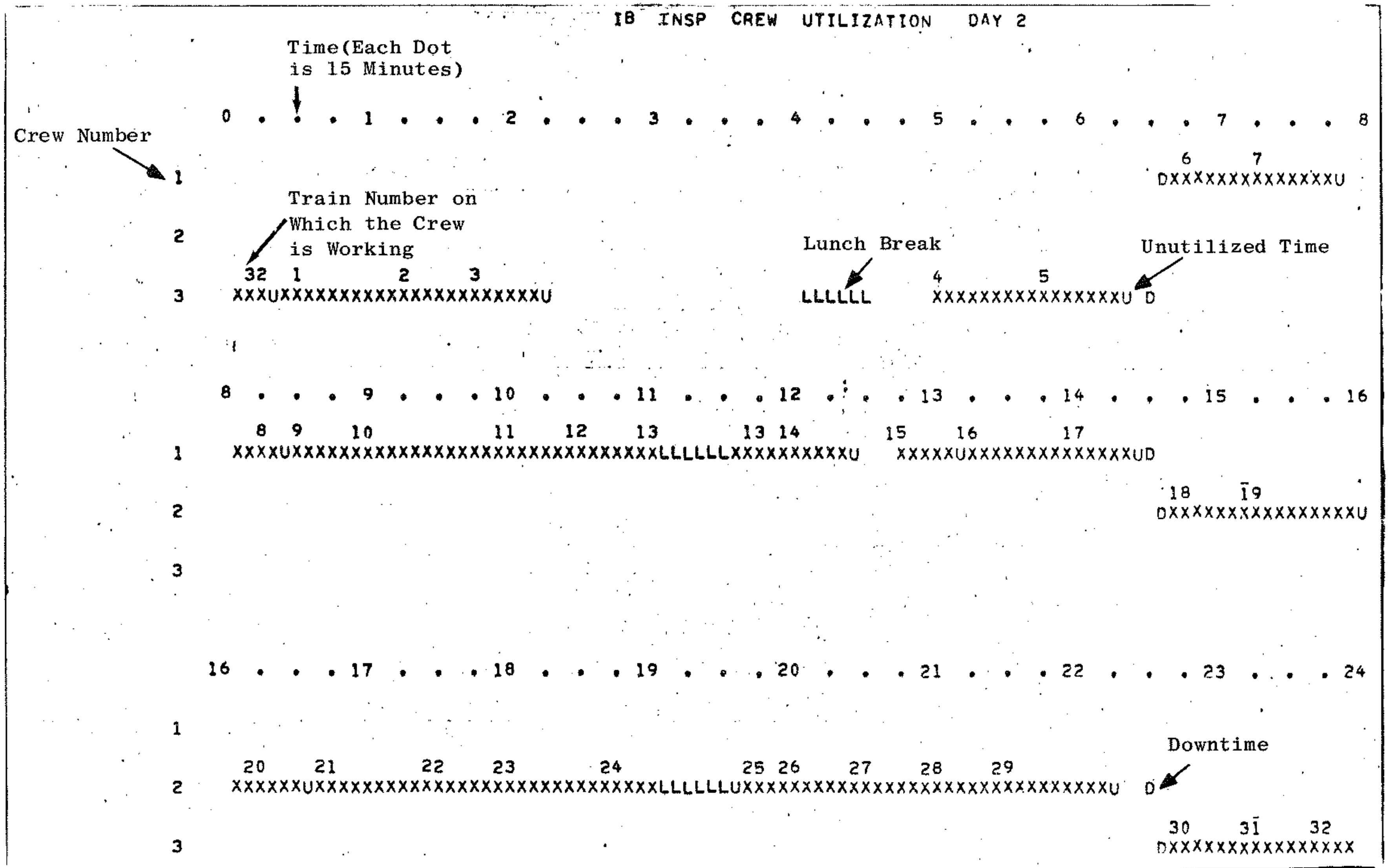



FIGURE 7. SAMPLE OF GRAPHICAL DISPLAY OF CREW UTILIZATION

FIGURE 7. SAMPLE OF GRAPHICAL DISPLAY OF CREW UTILIZATION

5 minutes. For example, in Figure 7 Crew 1 starts working at 0630 hour and is busy inspecting train Numbers 6 and 7 (the numbers are shown above the set of XX) until 0745 hours. The U marks following the X marks are the durations of unavailable time indicating the inherent delay between the end of the inspection of one train and the beginning of the inspection of another. The L markings indicate lunch periods. The D symbol indicates crew downtime at the start and end of the trick (shift). Empty spaces indicate idle time.

e. Receiving Track Utilization Analysis

This output provides the analysis of the usage of each of the receiving tracks in both tabular form and graphical form. Similar outputs are provided for class tracks and departure tracks. Table 27 and Figure 8 show samples of tabular and graphical displays, respectively. Meanings of various entries and symbols are similar to those given for crew utilization outputs.

f. Hump and Block Formation Scenario

This is one of the most useful outputs and shows a time scenario of the way cars belonging to various blocks of the outgoing trains are being formed as the arriving trains are humped. Table 28 shows part of the output for the hours from midnight (0 hours) until 0800 hours. The top most row, which starts with 0 and has dots between the numbers 1, 2, ..., represents time starting from 0 hours. Each dot represents 15 minutes. The numbers in the second row, e.g., 30, 31, 32, 1, 2, and 3, are numbers of incoming trains being humped. Consider Train 30. Numbers in this column represent the numbers of cars brought by Train 30 for various blocks shown under the BLOCK column. When Train 30 is humped (indicated by XX under number 30), three cars for Block 72 are sent to their respective tracks, one car for Block 120 is collected on its respective track, one car for Block 32 is collected on its respective track, and so on. Similar remarks apply for other incoming trains. The outgoing train associated with each block is also shown in the column under the heading NO. For example, Blocks 72 and 120 both are associated with Train BA001. The numbers under the very first column on the left are the desired departure times of outgoing trains. The star sign, *, attached with some of the entries in the block column means that time history of that particular block is already being displayed above with reference to some other train. For example in Table 28, the first star sign from the top of the column appears with Block 32, which is associated with the second part of Train BT201 that is scheduled to depart at 0500 hours. The time history of this block is already being displayed along with the first part of Train BT201 that is scheduled to depart at 0300 hours.

The usefulness of this output lies in the fact that it provides an overall interface between arriving trains and departing trains.

Table 27

OUTPUT SHOWING RECEIVING TRACK UTILIZATION

IB INSP TRACK 1 UTILIZATION = 25.2 PERCENT

| | TRAIN NO. | START TIME | SERVICE TIME | END TIME | IDLE TIME | NONPROD TIME |
|---|---|---|---|---|---|---|
| 12 | BB201 | 20905 | 251 | 21156 | 540 | 5 |
| 25 | CB007 | 21741 | 312 | 22053 | 0 | 5 |
| | | | ==== | | ==== | ==== |
| | | | 603 | | 540 | 10 |

IB INSP TRACK 2 UTILIZATION = 10.8 PERCENT

| | TRAIN NO. | START TIME | SERVICE TIME | END TIME | IDLE TIME | NONPROD TIME |
|---|---|---|---|---|---|---|
| 28 | CB009 | 21959 | 235 | 22234 | 0 | 5 |
| | | | ==== | | ==== | ==== |
| | | | 235 | | 0 | 5 |

IB INSP TRACK 3 UTILIZATION = 13.9 PERCENT

| | TRAIN NO. | START TIME | SERVICE TIME | END TIME | IDLE TIME | NONPROD TIME |
|---|---|---|---|---|---|---|
| 8 | BB205 | 20755 | 112 | 20907 | 1043 | 5 |
| 27 | BB205 | 21955 | 208 | 22203 | 0 | 5 |
| | | | ==== | | ==== | ==== |
| | | | 320 | | 1043 | 10 |

IB INSP TRACK 4 UTILIZATION = 71.0 PERCENT

| | TRAIN NO. | START TIME | SERVICE TIME | END TIME | IDLE TIME | NONPROD TIME |
|---|---|---|---|---|---|---|
| 2 | BT204 | 20040 | 231 | 20311 | 139 | 5 |
| 4 | BB401 | 20455 | 112 | 20607 | 0 | 5 |
| 6 | AB007 | 20612 | 139 | 20751 | 4 | 5 |
| 9 | BT203 | 20800 | 147 | 20947 | 125 | 5 |
| 14 | DB006 | 21117 | 152 | 21309 | 0 | 5 |
| 18 | CB006 | 21314 | 244 | 21558 | 32 | 5 |
| 21 | BB603 | 21635 | 155 | 21830 | 135 | 5 |
| 29 | AB008 | 22010 | 322 | 22332 | 0 | 5 |
| | | | ==== | | ==== | ==== |
| | | | 1702 | | 515 | 40 |

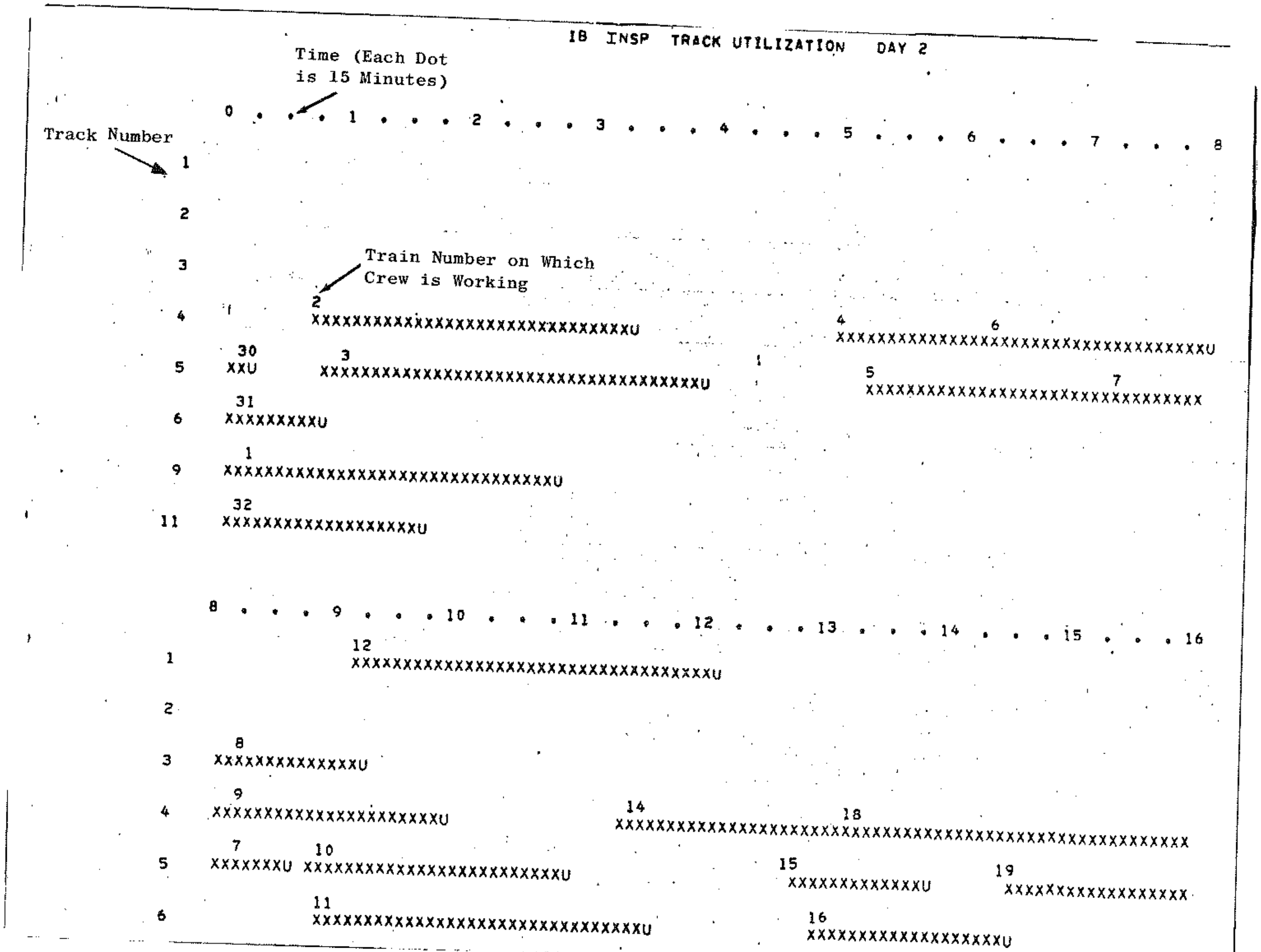



FIGURE 8. SAMPLE OF GRAPHICAL DISPLAY OF RECEIVING TRACK UTILIZATION

Table 28

SAMPLE OF HUMP AND CLASSIFICATION TRACK DISPLAY

HUMP AND CLASSIFICATION TRACKS DISPLAY DAY 2

Outbound Train Number

Inbound Train Number

```
0 . . . 1 . . . 2 . . . 3 . . . 4 . . . 5 . . . 6 . . . 7 . . . 8
 30 31   32      1          2     3                   4      5       6
1 XXUXXXXXXUXXXXXXXXXUXXXXXXXXXXXXUXXXXXXUXXXXXXUU     XXXXXXXXUXXXXXXXXXUXXXXXXXXXU
```

| TIME | NO. | BLOCK | 30 | 31 | 32 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 215 | BA001 | 72 | 3 | 4 | 5 | 30 | 4 | 3 | 0 | 0 | 0 |
| 215 | BA001 | 120 | 1 | 1 | 2 | 1 | 1 | 0 | 2 | 0 | 0 |
| 300 | BT201 | 32 | 1 | 0 | 13 | 10 | 0 | 13 | 8 | 0 | 24 |
| 301 | BD003 | 300 | 20 | 0 | 4 | 4 | 0 | 5 | 32 | 0 | 1 |
| 330 | BB104 | 5 | 0 | 4 | 0 | 8 | 4 | 1 | 0 | 48 | 1 |
| 400 | BB701 | 26 | 0 | 2 | 2 | 2 | 2 | 0 | 1 | 1 | 7 |
| 400 | BB701 | 29 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 4 |
| 405 | BB103 | 2 | 0 | 3 | 0 | 8 | 3 | 0 | 0 | 15 | 0 |
| 430 | BB702 | 28 | 0 | 0 | 6 | 2 | 0 | 0 | 1 | 3 | 13 |
| 500 | BT201 | 32* | | | | | | | | | |
| 630 | BD004 | 230 | 4 | 1 | 2 | 2 | 1 | 4 | 4 | 0 | 0 |
| 630 | BA006 | 42 | 1 | 0 | 0 | 11 | 0 | 8 | 0 | 0 | 0 |
| 700 | BD003 | 300* | | | | | | | | | |
| 730 | BB501 | 35 | 0 | 5 | 13 | 3 | 5 | 2 | 3 | 0 | 0 |
| 735 | BF002 | 260 | 3 | 0 | 3 | 1 | 0 | 0 | 4 | 0 | 0 |
| 735 | BF002 | 440 | 8 | 0 | 4 | 1 | 0 | 0 | 4 | 0 | 0 |
| 735 | BF002 | 460 | 9 | 0 | 8 | 1 | 0 | 0 | 9 | 0 | 0 |
| 915 | BB402 | 22 | 0 | 1 | 0 | 8 | 1 | 1 | 0 | 7 | 6 |
| 930 | BB104 | 5* | | | | | | | | | |
| 1000 | BC007 | 151 | 2 | 2 | 1 | 0 | 2 | 0 | 1 | 0 | 0 |
| 1000 | BB101 | 9 | 0 | 2 | 0 | 8 | 2 | 1 | 0 | 9 | 0 |
| 1020 | BB102 | 1 | 0 | 7 | 0 | 5 | 7 | 2 | 0 | 11 | 1 |
| 1045 | BC002 | 140 | 2 | 0 | 11 | 5 | 0 | 3 | 5 | 0 | 0 |
| 1100 | BB103 | 2* | | | | | | | | | |
| 1115 | BC004 | 110 | 4 | 7 | 8 | 4 | 7 | 3 | 0 | 0 | 0 |
| 1130 | BB109 | 3 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 3 | 0 |
| 1130 | BB109 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 1130 | BA006 | 39 | 0 | 2 | 0 | 1 | 2 | 2 | 0 | 0 | 0 |
| 1200 | BA001 | 72* | | | | | | | | | |
| 1200 | BA001 | 120* | | | | | | | | | |
| 1200 | BD003 | 300* | | | | | | | | | |
| 1300 | BB104 | 5* | | | | | | | | | |
| 1300 | BB602 | 24 | 1 | 0 | 4 | 2 | 0 | 3 | 1 | 0 | 24 |
| 1400 | BB105 | 6 | 0 | 2 | 0 | 2 | 2 | 1 | 0 | 12 | 0 |
| 1400 | BB702 | 28* | | | | | | | | | |
| 1420 | BC004 | 110* | | | | | | | | | |
| 1435 | BA006 | 42* | | | | | | | | | |
| 1530 | BB110 | 16 | 0 | 5 | 0 | 0 | 5 | 0 | 0 | 0 | 2 |
| 1600 | BB402 | 22* | | | | | | | | | |
| 1600 | BB402 | 23 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| 1600 | BB501 | 33 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

The designer gets a feel for the status of various blocks after the humping of each train. He may use this information to change the sequence of humping to form certain blocks earlier than others, if necessary.

g. Class Track Loading Scenario

This is another very useful output. It shows the loading of each class track as a function of time while cars are being sent to and pulled out from them. The complete output consists of a 24-hour scenario for all the class tracks. However, because of space limitations, the output is printed in parts, as shown in Figure 9.

Referring to the figure again, the time is shown on the top most row. Each dot represents 15 minutes. Track numbers are shown in the left most column. The number of cars in each track at 15-minute intervals is shown against each track. Overloading of a track is indicated by a star, *, starting from the times of overloading. For example, in the figure shown, Track 10 starts becoming overloaded at 0945 hours. As shown in Table 21, the capacity of Track 10 is 52 cars. Thus, when the number of cars assigned to this track exceeds 52, it is overloaded, as indicated in Figure 9. The designer can use this display to study the consequences of his track assignment and track time sharing strategy. One or more overloaded tracks would indicate the need to modify the strategy.

If the overloading of tracks cannot be rectified by reassigning the tracks and their time sharing periods, it would indicate that the solution of the problem lies somewhere else, e.g., early pullouts, and addition of tracks. The program has the capability to test various alternatives by modifying the number of tracks, pullout times, etc.

h. Departing Trains Scenarios

Table 29 shows the details associated with departing trains. The meaning of various entries are self-explanatory. The times indicated under START, START PULL, and so on are to be interpreted as explained already in paragraph a. The figure shows the desired scheduled time of departure under SCHEDULE. The amount of time the train is late or early is shown under LATE. For example, Train BB104 is 26 minutes early, indicated by the minus sign associated with 26.

This output gives the designer important information about departing trains. If some trains are too late or too early, he may wish to change the humping sequence, pulling sequence, and so on.

Time (Dot Indicates 15 Minutes)

Track Numbers

Represents Overloading

CLASS TRACK LOADING MATRIX, DAY 1

| TR. | 8 | • | • | • | 9 | • | • | • | 10 | • | • | • | 11 | • | • | • | 12 | • | • | • | 13 | • | • | • | 14 | • | • | • | 15 | • | • | • |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 47 | 47 | 47 | 47 | 47 | 47 | 47 | 47 | 47 | 47 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 5 | 5 | 5 | 5 | 5 | 5 | 19 | 19 |
| 3 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 25 | 25 | 25 | 34 | 34 | 34 | 35 | 35 | 35 | 35 | 35 | 35 | 40 | 40 |
| 4 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 10 | 10 |
| 5 | 26 | 26 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 16 | 17 | 17 | 17 | 17 | 17 | 17 | 18 | 18 |
| 6 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 52 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 10 | 10 | 10 | 10 | 10 | 10 | 12 | 12 |
| 8 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 11 |
| 9 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 32 | 32 | 32 | 36 | 36 | 36 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 |
| 10 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 56* | 56* | 56* | 56* | 56* | 56* | 56* | 56* | 56* | 56* | 56* | 58* | 58* | 58* | 59* | 67* | 67* | 69* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 8 | 8 |
| 12 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 18 | 18 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 18 |
| 14 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 16 | 16 | 16 | 16 | 17 | 17 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 16 | 16 | 16 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 16 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 11 | 11 | 11 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 14 | 0 | 0 | 5 | 5 | 5 | 0 | 0 | 0 | 1 | 4 |
| 18 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 26 | 26 | 26 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 40 | 0 | 0 | 0 | 0 | 0 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 7 |
| 20 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 17 | 17 | 17 | 18 | 18 | 18 | 19 | 19 | 19 | 19 | 19 | 19 | 20 | 20 |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 |

Table 29

SAMPLE OF DEPARTING TRAINS SCENARIO

SAMPLE OF DEPARTING TRAINS SCENARIO

| | TRAIN | BLOCK | CLASS TRACK | START | DEP TRACK | ENGINE | START PULL | END PULL | NO CARS | TOTAL CARS | INSP CREW | START INSP | END INSP | SCHEDULE | LATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BA001 | 72 | 9 | 20015 | 11 | 7 | 20015 | 20040 | 3 | | | | | | |
| 1 | BA001 | 120 | 30 | 20015 | 11 | 8 | 20015 | 20050 | 1 | 72 | | | | 20215 | |
| 2 | BT201 | 32 | 10 | 20100 | 1 | 7 | 20100 | 20125 | 41 | 41 | | | | 20300 | |
| 3 | BD003 | 300 | 26 | 20101 | 2 | 8 | 20101 | 20126 | 33 | 33 | | | | 20301 | |
| 4 | BB104 | 5 | 1 | 20130 | 5 | 7 | 20130 | 20155 | 14 | 77 | 5 | 20155 | 20304 | 20330 | -26 |
| 5 | BB701 | 26 | 24 | 20200 | 3 | 7 | 20200 | 20225 | 36 | | | | | | |
| 5 | BB701 | 29 | 42 | 20200 | 3 | 8 | 20200 | 20235 | 19 | 55 | 6 | 20235 | 20333 | 20400 | -27 |
| 6 | BB103 | 2 | 2 | 20205 | 12 | 9 | 20205 | 20230 | 61 | | | | | | |
| 6 | BB103 | 2 | 7 | 20205 | 12 | 7 | 20230 | 20335 | 40 | 101 | | | | 20405 | |
| 7 | BB702 | 28 | 14 | 20230 | 4 | 9 | 20235 | 20300 | 31 | 74 | | | | 20430 | |
| 8 | BT201 | 32 | 10 | 20300 | 1 | 8 | 20300 | 20325 | 23 | 64 | 6 | 20325 | 20427 | 20500 | -33 |
| 9 | BD004 | 230 | 29 | 20432 | 1 | 7 | 20432 | 20457 | 29 | 29 | 5 | 20457 | 20542 | 20630 | -48 |
| 10 | BA006 | 42 | 3 | 20430 | 3 | 8 | 20430 | 20455 | 20 | | | | | | |
| 10 | BA006 | 42 | 23 | 20430 | 3 | 9 | 20430 | 20505 | 38 | 58 | | | | 20630 | |
| 11 | BD003 | 300 | 26 | 20500 | 2 | 8 | 20500 | 20525 | 13 | 46 | | | | 20700 | |
| 12 | BB501 | 35 | 16 | 20530 | 5 | 7 | 20530 | 20555 | 41 | 41 | 6 | 20555 | 20646 | 20730 | -44 |
| 13 | BF002 | 260 | 32 | 20535 | 10 | 8 | 20535 | 20600 | 22 | | | | | | |
| 13 | BF002 | 440 | 25 | 20535 | 10 | 9 | 20535 | 20610 | 28 | | | | | | |
| 13 | BF002 | 460 | 21 | 20535 | 10 | 8 | 20605 | 20640 | 35 | 85 | 1 | 20640 | 20753 | 20735 | 18 |
| 14 | BB402 | 22 | 19 | 20715 | 1 | 1 | 20715 | 20740 | 42 | | | | | | |
| 14 | BB402 | 22 | 41 | 20715 | 1 | 2 | 20715 | 20750 | 17 | 59 | | | | 20915 | |
| 15 | BB104 | 5 | 1 | 20730 | 5 | 3 | 20735 | 20800 | 61 | 61 | | | | 20930 | |
| 16 | BC007 | 151 | 22 | 20800 | 10 | 1 | 20800 | 20825 | 28 | 28 | 1 | 20825 | 20909 | 21000 | -51 |
| 17 | BB101 | 9 | 27 | 20800 | 9 | 2 | 20800 | 20825 | 32 | | | | | | |
| 17 | BB101 | 9 | 28 | 20800 | 9 | 3 | 20805 | 20840 | 9 | 41 | 2 | 20840 | 20931 | 21000 | -29 |
| 18 | BB102 | 1 | 4 | 20820 | 6 | 1 | 20830 | 20855 | 51 | | | | | | |
| 18 | BB102 | 1 | 8 | 20820 | 6 | 2 | 20830 | 20905 | 26 | 77 | 1 | 20905 | 21014 | 21020 | -6 |
| 19 | BC002 | 140 | 13 | 20845 | 8 | 3 | 20845 | 20910 | 42 | | | | | | |

i. Yard Transit Time Statistics

This output gives the overall performance of the yard in terms of transit times of cars and total number of cars handled per day. A histogram of transit time is also shown. Figure 10 is a sample output associated with transit times. As indicated in this figure, the mean transit time in the simulated yard is 11 hours and 21 minutes and the standard deviation is 6 hours and 42 minutes. The histogram shown in the bottom of the figure gives the number of cars having transit times of 1 through 29 hours. Referring to the histogram shown graphically on the left side, each star, *, represents five cars. The numbers 1000 and 2000 indicate 10 and 20 hours respectively, indicating the scale of time. The same information is displayed in a tabular form on the right side. For example, the number of cars delayed between 0 and 1 hour is 20, and between 1 and 2 hours is 10. The percentage of cars delayed by 1, 2, ... hours is also indicated. This output is very useful in evaluating and comparing yard performance on an overall level.

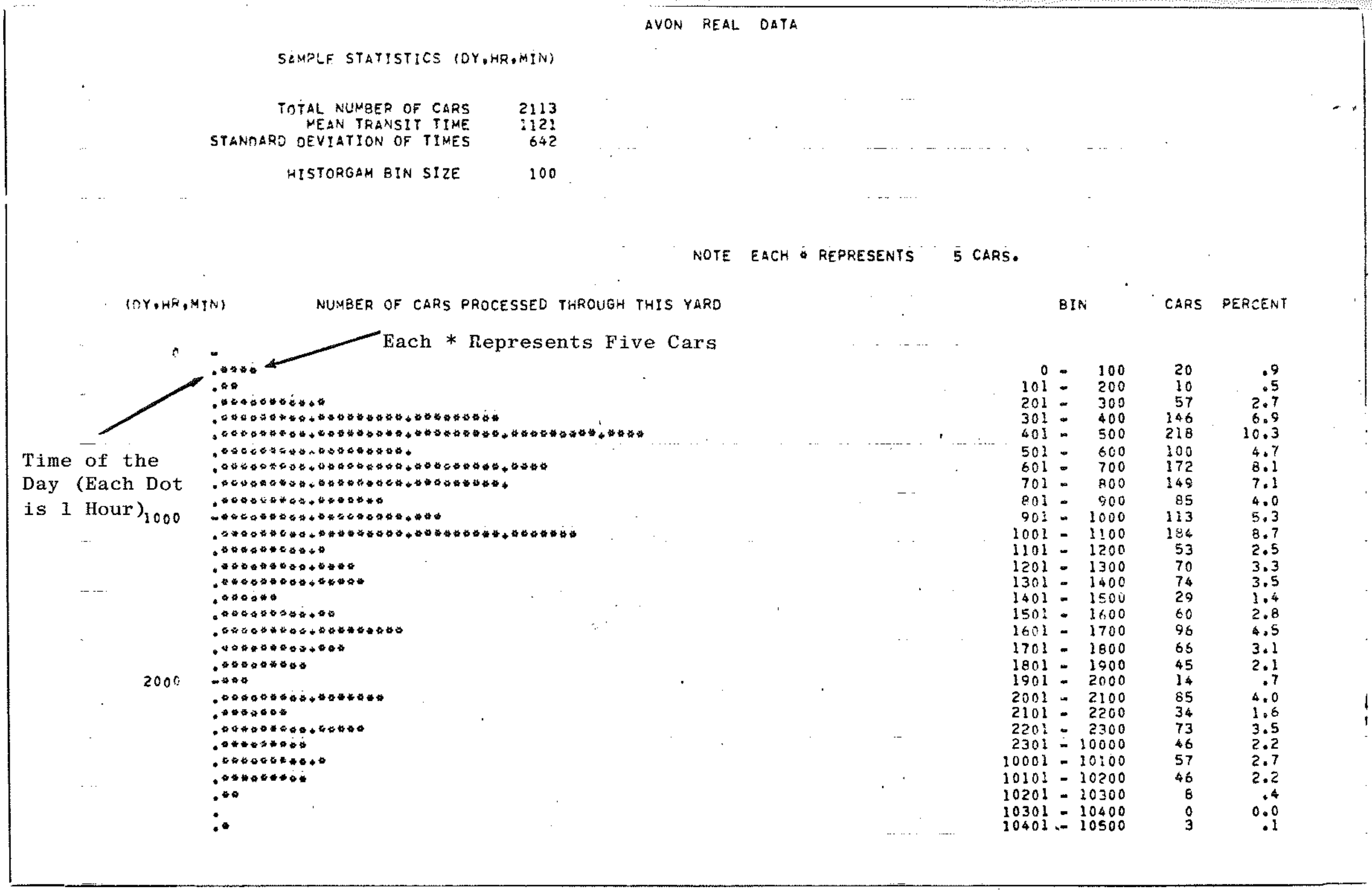



FIGURE 10. SAMPLE OF YARD TRANSIT TIME STATISTICS

# IV MODELS AND ASSUMPTIONS ASSOCIATED WITH VARIOUS PROCESSES

In this section we present the various models (e.g., mathematical relationships) and assumptions associated with each of the three processes discussed in Section II. The methodologies and computer programs associated with blocking strategy and network analysis processes were designed essentially for planning purposes and to compare several alternatives of restructuring the Northeastern and Midwestern railroad network, on a gross level, using a daily cycle of traffic. The yard simulation program is relatively more dynamic and simulates yard operations in considerable detail. These methodologies and computer programs can be very useful in developing preliminary operating plans for ConRail as well as for any other railroad. Recommendations for enhancing the usefulness of the methodologies and the computer programs are included in Section V.

## A. Blocking Strategy Analysis and Development Process

### 1. Basic Relationships and Assumptions

The mathematical relationships used in calculating the flow handlings, system switchings, yard loadings, block sizes, etc., are essentially bookkeeping processes based on appropriate summations and products of number of cars, number of times each car is switched, etc. These processes are conceptually quite straightforward. The bookkeeping process is performed on a daily basis assuming that the traffic, as given by the O/D traffic data, is repetitive in a daily cycle. Thus, a flow which travels from an origin O to a destination D through some intermediate nodes is assumed to start at O, appear in all intermediate nodes and reach D every day at some point in time, during the 24-hour period. The calculation of flow handlings, system switchings, block sizes, and so on, therefore represent average values on a per day basis. Since the purpose of the study was to compare various alternatives for planning, the assumption of repetitive daily traffic, which greatly simplifies the calculations, is justifiable.

### 2. Automatic Development of Blocking Strategies

Manual preparation of a blocking strategy for a large network is a laborious, time-consuming process. For example, preparation of initial blocking strategies for the 147-node network typically took 2 to 3 man-days. In the case of the 494-node network, it required typically 5 to 6 man-days. For any given O/D traffic data and a given network, it is the preparation of the initial blocking strategy that takes the most time. Once an initial strategy is prepared and the associated measures of effectiveness (e.g., flow handlings, system switchings, and yard loadings) are available, modification and improvements in the blocking strategy are not as time consuming. To provide the designer with a preliminary blocking strategy as a point of departure, SRI has developed a program to automatically generate an initial blocking strategy, based on the geometry of the network and some heuristic principles.

The automatic development of blocking strategies in the subsystem is based on rules and principles believed to result in good but not optimal strategies. (In fact, no criteria of optimality has been proposed for this study.) Such rules and principles are generally referred to as "heuristics" and accordingly the strategy developed is called the "heuristic blocking strategy." The two primary principles utilized are known as block early and block late.

The block early principle, roughly speaking, requires the formation of a block to a final destination at the first transit yard at which it is possible to do so. This concept can be described more precisely using the term "block-size collection point," defined as follows: if the traffic in a yard, both originating and in transit to another yard, is sufficient by itself (i.e., not considering possible inclusion of traffic at more remote points) to justify sending a block to the other yard, the yard originating the block is termed a block-size collection point, or collection point for short, for the destination. A set of collection points for each final destination is called a collection point strategy. In these terms, the block early principle requires designating any transit yard as a collection point for a final destination, if the total traffic originating at that yard and points farther away on the shortest routes passing through the transit yard up to but not including more remote collection points constitutes a blockable quantity.

The block late principle, on the other hand, requires sending cars from each yard as far as possible in the direction they are going, subject to three conditions: (1) that the quantity sent be block size, (2) that the block destination be a transit yard unless the block is pure (a pure block contains cars for only one destination), and (3) that the block contains no cars for which there is a collection point between origin and block destination.

The heuristic strategy developed by the subsystems is a compromise between these two principles. The compromise involves applying the block early principle to develop a complete collection point strategy for each destination, then building blocks out of each origin, according to the block late principle modified, so that cars are not permitted to go past their collection points. The number of cars that defines minimum block size is an input. Both the collection point strategy and blocking strategy are constructed entirely automatically.

The heuristic strategy makes a distinction between ordinary transit yards (Class 3) and major system yards (Class 4). The effect of the distinction is to restrict the use of ordinary transit yards to handling cars originating at or destined to nearby nontransit yards (Class 2). (A nontransit yard N is said to be "nearby" a transit yard, T, if no transit yard lies on the shortest route from N to T.)

This distinction affects the collection point strategy as follows: An ordinary transit yard (Class 3) will be a collection point for a destination if (1) the destination is not nearby and (2) its own originating traffic for the destination plus the traffic for the destination originating in nearby upstream nontransit yards constitutes a block-size quantity. This distinction similarly affects the automatically generated blocking strategies. Blocks destined for ordinary transit yards from yards that are not nearby are permitted to include only traffic destined to that yard and to other nearby nontransit yards. In view of these restrictions, a block is made at an origin to a destination if any of the following rules apply:

1. The destination is a major system yard (Class 4) and the traffic from the origin to that yard and beyond (excluding (a) traffic that is collected at collection points short of the yard, and (b) traffic already blocked to points beyond the yards) constitutes a block-size quantity.

2. The destination is an ordinary transit yard (Class 3) and the traffic from the origin to the yard and to nearby nontransit yards (excluding traffic covered by rule 1) constitutes a blockable quantity.

3. The destination is a nontransit (Class 2) and traffic from origin to destination constitutes a blockable quantity. A block created according to this rule is a pure block.

4. The origin is a collection point for the destination. A block created by this rule is also a pure block.

5. The origin is a nontransit yard (Class 2) and no Class 3 or Class 4 yard lies between the origin and the destination.

6. The origin is of Class 3 and (a) the destination is of Class 2 and no Class 3 or Class 4 yard lies in between or (b) the destination is of Class 3 or 4 and no Class 4 yard lies in between.

7. If the origin is of Class 4, blocks are made to destinations as for Class 3 and in addition blocks are made to all other Class 4 yards.

Rules 1 through 4 generate blocks based on flow volume, network geometry and yard classifications. These rules are applied first starting from the most distant points working toward the origin. All nodes that are defined by them either to be block destinations or to be included in such blocks are omitted from further consideration. Next, rules 5 through 7 are applied to the remaining nodes to select some among them as block destinations. Finally, all nodes not designated as block destinations are assigned to the nearest block available on the shortest path working backwards and towards origin.

The simple heuristic has been tested by applying it to both the Node 147 and Node 494 networks. To facilitate the modifications in the automatically developed blocking strategies or other existing strategies, an editor program has been developed that permits manual modification of the strategies. Further details of the automatic generation of a blocking strategy and associated computer subroutines are included in the User's Manual.

## B. Train and Road Statistics Analysis and Development Process

### 1. Basic Relationships and Assumptions

The mathematical relationships used in calculating train miles, car miles, ton miles, trains per link per day, and so on, are essentially bookkeeping processes based on appropriate summation and products of individual trains, individual car flows, car weights, link length and transit times, and so on. These relationships are conceptually quite straightforward. As in case of blocking strategy analysis, the bookkeeping process associated with train and road statistics analysis is performed on a daily basis, assuming that each of the generated trains will start from the origin, travel along the designated links, and reach its destination at some point in time during a 24-hour period. The calculation of car miles, ton miles, and so on, therefore represent average values per day. Again, as in the case of the blocking strategy analysis process, the purpose of study was to compare various alternatives for planning purposes; therefore, the simplifying assumption of daily repetitive traffic is justifiable.

### 2. Calculation of Train Arrival Times at Various Yards

The designer specifies a departure time at the origin of each train as explained in Section III. Starting from the specified departure time, the program adds the link transit times of all links (see Table 2) and the yard delay times (see Table 12) along which the train has been routed and calculates the arrival time at the destination yard. The main purpose of developing this subroutine is to generate, on an average basis, the expected arrival times of trains at certain yards that the designer may wish to analyze in detail to see if his proposed blocking strategy and train scheduling can be handled by the yard under consideration. As mentioned earlier, the output of this subroutine is a set of computer cards that can be used directly as input to the yard analysis program.

## C. Detailed Yard Analysis Process

### 1. Assumptions and Limitations

The following is a list of assumptions and limitations in the current version of the yard simulation model:

- Only one hump with a single lead can be simulated. In the event a yard is bi-directional (i.e., Eastbound and Westbound) with a hump for each direction, the entire complex will have to be treated as two separate simulations.
- The entering and exiting of cars into and out of a yard can only be expressed as inbound and outbound trains with predetermined schedules and block destinations. For example, locally generated cars or incoming cars from the opposite yard are defined as inbound trains with designated train code and block composition.
- It is assumed that all cars are the same length and size.
- Weight and rolling stock types are not considered.
- The priority of train processing is based upon a predetermined processing sequence defined by the analyst before the simulation run. During the simulation, the processing order is then based on a first-in first-serve discipline in a sequential manner according to the prescribed sequence.
- The physical geometry of the yard (e.g., distance from one track to another, and location of switches and retarders) is not a part of the model structure. Therefore, the travel time between points in the yard is either expressed as an average time constant or is not considered (i.e., set to zero).
- The traffic schedule and volume are defined on a 24-hour basis from 0000 to 2400 hours. The same train schedule and traffic matrix are repeated daily. However, by using the program iteratively, it is also possible to study yard operations for varying daily conditions.

- The program is designed to start either with some pre-specified initial conditions of the yard or with a totally empty yard at zero hours (midnight) on the first day.

2. Basic Relationships and Models

In this section we describe briefly the logic used in the program to assign various yard resources and the mathematical relationships used to calculate various operating characteristics.

a. Assignment of Various Yard Resources

The basic logic used in assigning various yard resources when a need arises is to search for the most appropriate resource currently available and use it on a first-come first-serve basis. The following examples elaborate this logic.

- When a train arrives in a yard, the program searches for the shortest receiving track that could accommodate the arriving train. If this track is empty, it is assigned to the arriving train. If there are two available tracks of the same length, the lower number track is selected. If the track is already occupied by some train, the program checks to detect whether the track could become empty in the next few minutes. The amount of time allowed for waiting is a designer's choice and has been shown as the input "Tau" in Table 18. If the desired track could become available within the next "Tau" minutes, it is assigned to the newly arrived train and the time of arrival of the respective train on the chosen track is advanced corresponding to the wait time. If the desired track is not going to be available in the next "Tau" minutes, the program looks for the next shortest track and goes through the same logic until a receiving track is found and then assigns that track to the newly arrived train. This logic is repeated whenever a new train arrives.

- When a train has arrived at the receiving track, the program searches for those crews who are supposed to be on duty (i.e., by looking at the data related to inbound inspection crew, Table 19). If at this time, some crews are already working on some train, it checks if any of them could be free within the next "Tau" minutes. (The meaning of Tau is the same as explained above.) If so, this crew is assigned to the train which has just arrived; otherwise, it looks for a free crew whose working hours (including allowed overtime) are within the time limits needed to complete inspection. If no crew is free presently, the crew which is projected to become available first is assigned to the newly arrived train and a corresponding inspection delay is displayed in the "Inspection Delay" column, Table 23.

- Assignment of class tracks to various blocks and the times during which the tracks are to be used for various blocks is a preplanned input by the designer and can be varied before each run of the program.

- Assignment of departure track, departure engine, and departure engine crew is done by the program logic in a manner similar to that of inbound track assignment and inbound inspection crew, i.e., the program searches for the most appropriate resource <u>currently</u> available and assigns it to the demand on a first-come first-serve basis.

  Exact program logic to accomplish the above noted assignment of resources is included in User's Manual for Yard Operations Analysis Computer Programs.

b. <u>Mathematical Relationships Associated with Various Operating Characteristics of the Yard</u>

Yard operating characteristics, such as hump utilization, inbound inspection crew utilization, and class track utilization, are calculated as simple ratios with the following general form:

$$\text{Resource utilization} = \frac{\text{Total time the resource spent in performing the service}}{\text{Total time period during which the resource was available}}$$

In case of inbound inspection tracks, hump, and outbound inspection tracks, the utilization is calculated on a 24-hour availability basis, i.e., the utilization is expressed as a fraction of 24 hours during which the tracks or hump performed useful service.

In the case of the inbound inspection crew, departure engine, and outbound inspection crew, the utilization is expressed as a fraction of trick period (shift duration which is typically 8 hours), i.e., crew utilization is expressed as a fraction of 8 hours during which the crew performed useful work. A shift which is not finished at midnight of the day being displayed is not considered in the calculation for that day. Such service time is shown again in the display of the following day and the utilization is calculated for that day based upon the entire eight-hour shift.

Mean transit time $\overline{T}$ of cars in the yard is calculated using the following relationship:

$$\overline{T} = \frac{\sum_i \sum_j \beta_{ij} \; T_{ij}}{N} \qquad (1)$$

where $\beta_{ij}$ = Batch of cars with identical destination block numbers from inbound train i to outbound train j

$N = \sum_i \sum_j \beta_{ij}$, or total nubmer of cars entered and exited during the simulation period (e.g., 24 hours)

$T_{ij}$ = Transit time for $\beta_{ij}$, which is the elapse time between arrival and actual departure of the batch.

The standard deviation S in the transit time is calculated using the following relationship.

$$S = \sqrt{\frac{\sum_i \sum_j \beta_{ij} \; T_{ij}^{2} - N\overline{T}^{2}}{N - 1}} \qquad (2)$$

## V CONCLUDING REMARKS AND SOME RECOMMENDATIONS

### A. Concluding Remarks

The methodologies and computer programs discussed in this report were developed under quite pressing circumstances. The overriding consideration throughout the project was the need to develop techniques suitable for fast analysis of several alternative blocking and train operation plans for the Northeastern and Midwestern railroad network to establish a preliminary system plan and then a final system plan within the deadlines set up under the Regional Rail Reorganization Act of 1973. Because many operational decisions in railroad operations involve human judgment and because no well-defined single criterion of optimality exists to test competing plans, it was decided in the early stages of the project to develop techniques wherein the vital decision and evaluations related to railroad operations are made by man, and extensive calculations and bookkeeping operations are performed by machines as explained in Figures 1, 2, and 3. Some simplifying assumptions were made to facilitate quick development of analytical techniques and related computer programs. However, such assumptions were made in consultation with USRA team members to ensure that vital results will not be distorted to an unacceptable degree.

The computer programs and methodologies developed by SRI should be treated essentially as planning tools. Used as planning tools, the gross effects of changes in blocking, in train operations and in yard capacities can easily be simulated. For example, it is possible to test the overall system effects of closing yards, the downgrading or upgrading of mainlines and opening of yards. It is also possible to test the system-wide effects of major changes in operating philosophy on yard and mainlines, such as short trains and long trains.

Used as a planning tool, the SRI programs would be quite valuable to ConRail, requiring neither extensive manpower nor computer time particularly when using an accurate and up-to-date data base. The blocking strategy analysis programs could be used to generate preliminary blocking books for various yards. The train and road statistics analysis program could be used to develop preliminary operating plans of trains. The yard analysis program could be used to develop improved and efficient yard operational procedures at many yards to increase their capacity.

### B. Some Recommendations and Possible Improvements

The SRI programs in their present forms are quite valuable to analyze and develop preliminary operating plans. However, several possibilities exist for modifications and improvements to the basic programs. Below we present a list of some of the improvements which can be looked into in the future:

. <u>Possible Improvements Related to Blocking Strategy Analysis and Train Statistics Programs</u>:

- Develop methods for altering blocking strategies and train formation strategies considering the associated costs including car miles costs, switching costs, yard congestion costs, etc.

- Use visual aids to analyze blocking strategy. SRI has already developed a preliminary plotter program which shows graphically how various flows converge to a destination.

- Make the blocking strategy analysis programs suitable to analyze the effects of daily and hourly variations in the arrival of trains.

- Improve the automatic blocking strategy program to consider more detailed classification of yard and more sophisticated logic to form blocks.

- Develop a technique to automatically combine blocks and form trains using possibly standard routes.

- Develop a program to automatically generate a train file using standard routes, Train IDs, departure times, and so on.

- Convert the whole system to time-sharing with interaction blocking strategy and train editing capability.

. <u>Possible Improvements in Yard Analysis Program</u>

- Improve the model to include flat yard operations.

- Create more realistic modeling of pullout track interference. (In the present model, the interference effect is represented as an average delay applied uniformly to the pullout times whenever there is a predicted interference possibility.)

- Randomize the yard input parameters to make the model more realistic, i.e., use statistical distribution functions rather than fixed values, for train arrival time, hump delay, inspection rate, pullout time, and so on.

- Include costs of various yard operations.

- Include rehumping and multistage blocking schemes.

- Include bad-ordered car handling.

- Include capability to prespecify some or all receiving and departure tracks.

This is only a partial list of improvements and modifications that seem desirable. Several other features have been suggested from time to time during the course of the project.

# FOLDOUT MAP – Figure 5

- The report includes a pocket in the back with a large foldout map of ConRail, approximately 3’ x 5’ dimension.
- The first page is a photograph of the entire map, on a single page.
- After this are 5 more zoomed in views of the same map, taken from left to right (west to east) for a higher resolution view of smaller portions of the map.

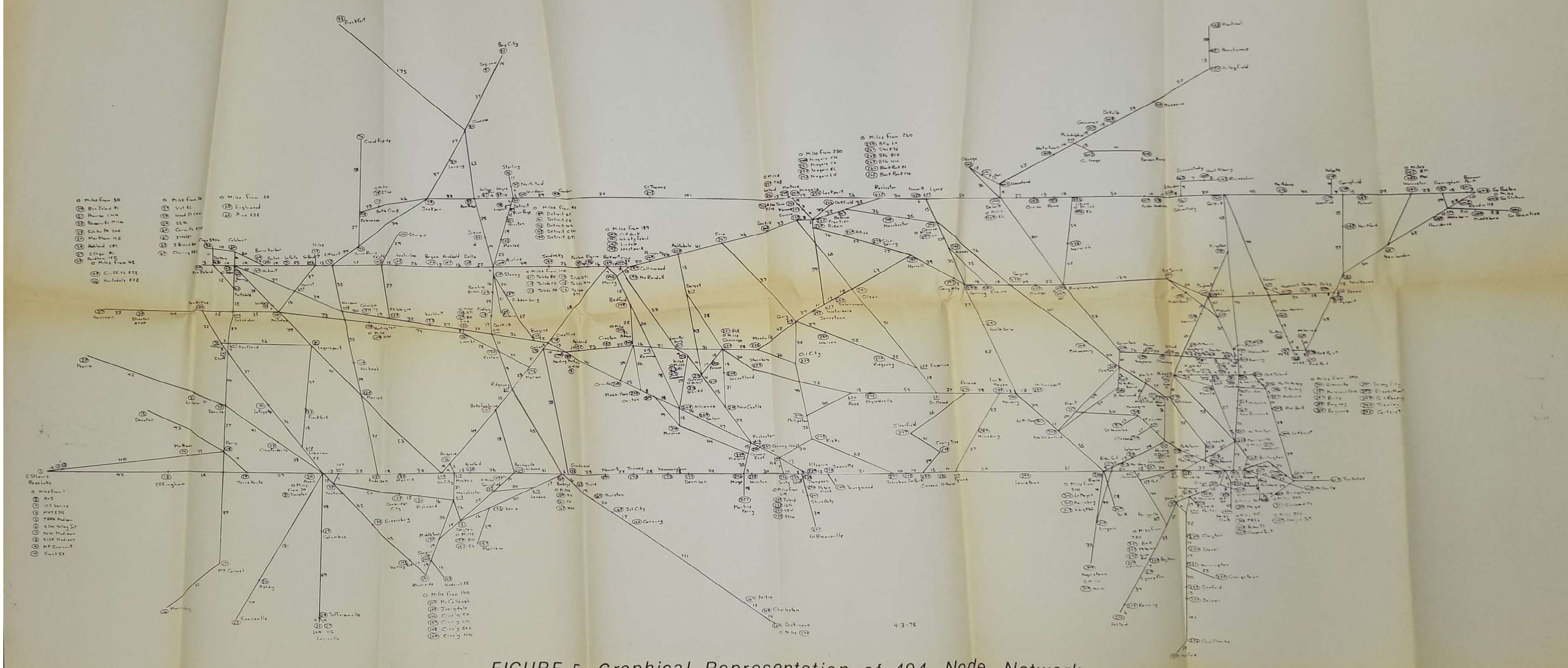
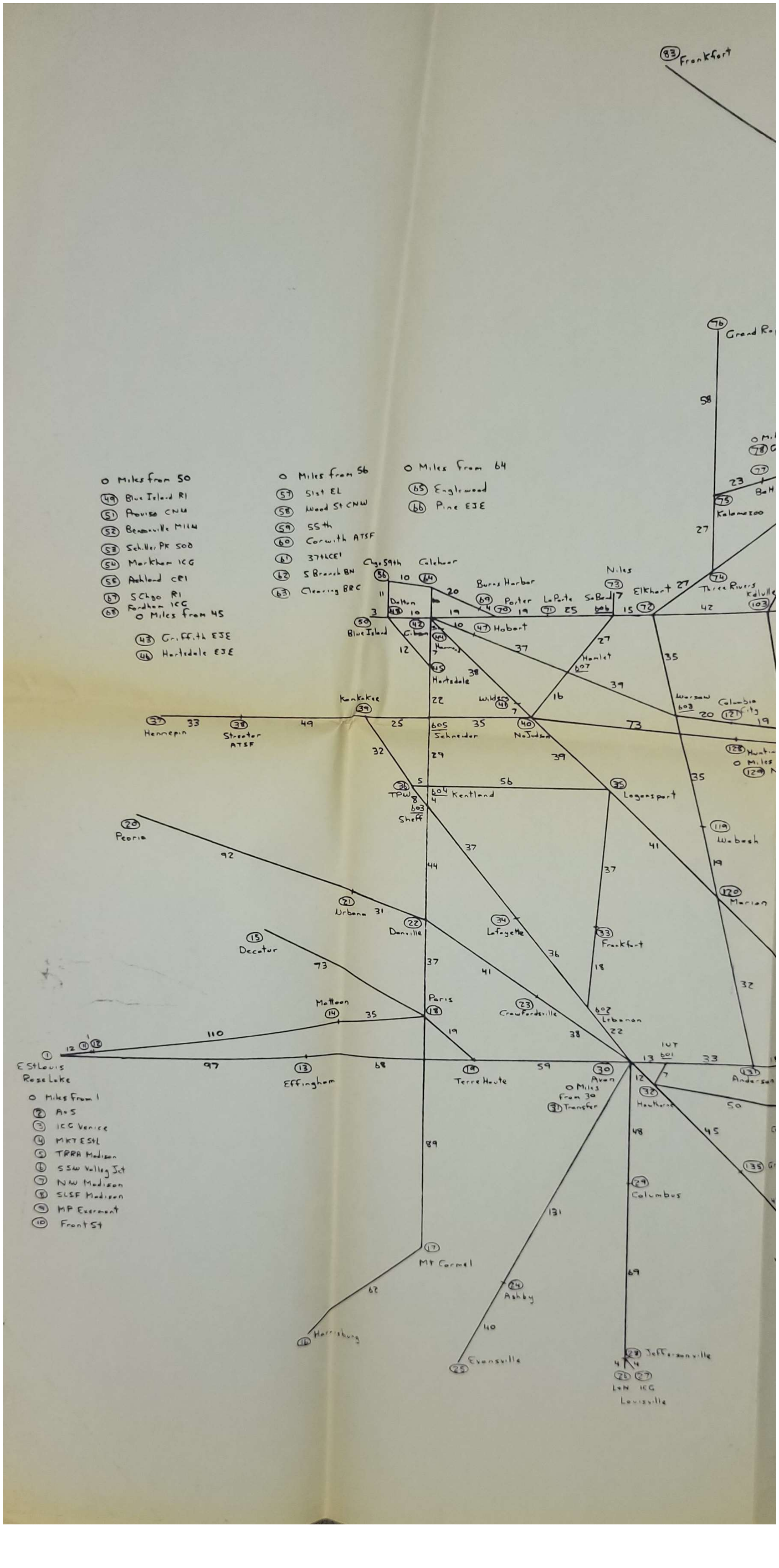


FIGURE 5. Graphical Representation of 494 Node Network



Frankfort
Grand Ra
58
Kalamazoo
Three Rivers
Elkhart
Niles
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LaPorte
Porter
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Hobart
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49 Blue Island RI
51 Proviso CNW
52 Bensenville MILW
53 Schiller PK SOO
54 Markham ICG
55 Ashland CRI
57 S Chgo RI
68 Fordham ICC
0 Miles from 45
43 Griffith EJE
44 Hartsdale EJE
0 Miles from 56
57 51st EL
58 Wood St CNW
59 55th
60 Corwith ATSF
61 37th CEI
62 S Branch BN
63 Clearing BRC
0 Miles from 64
65 Englewood
66 Pine EJE
Chgo 59th
Calumet
Dolton
Gibson
Blue Island
Hartsdale
Hamlet
Wildcat
Warsaw
Columbia City
Kankakee
Hennepin
Streator ATSF
Schneider
No Judson
Huntington
Kentland
Logansport
TPW
Sheff
Peoria
Wabash
Marion
Urbana
Danville
Lafayette
Frankfort
Decatur
Mattoon
Paris
Crawfordsville
Lebanon
E St Louis
Rose Lake
0 Miles from 1
2 A+S
3 ICC Venice
4 MKT E St L
5 TRRA Madison
6 SSW Valley Jct
7 NW Madison
8 SLSF Madison
9 MP Evermont
10 Front St
Effingham
Terre Haute
Avon
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31 Transfer
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Anderson
Columbus
Mt Carmel
Ashby
Harrisburg
Evansville
Jeffersonville
L+N
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Louisville

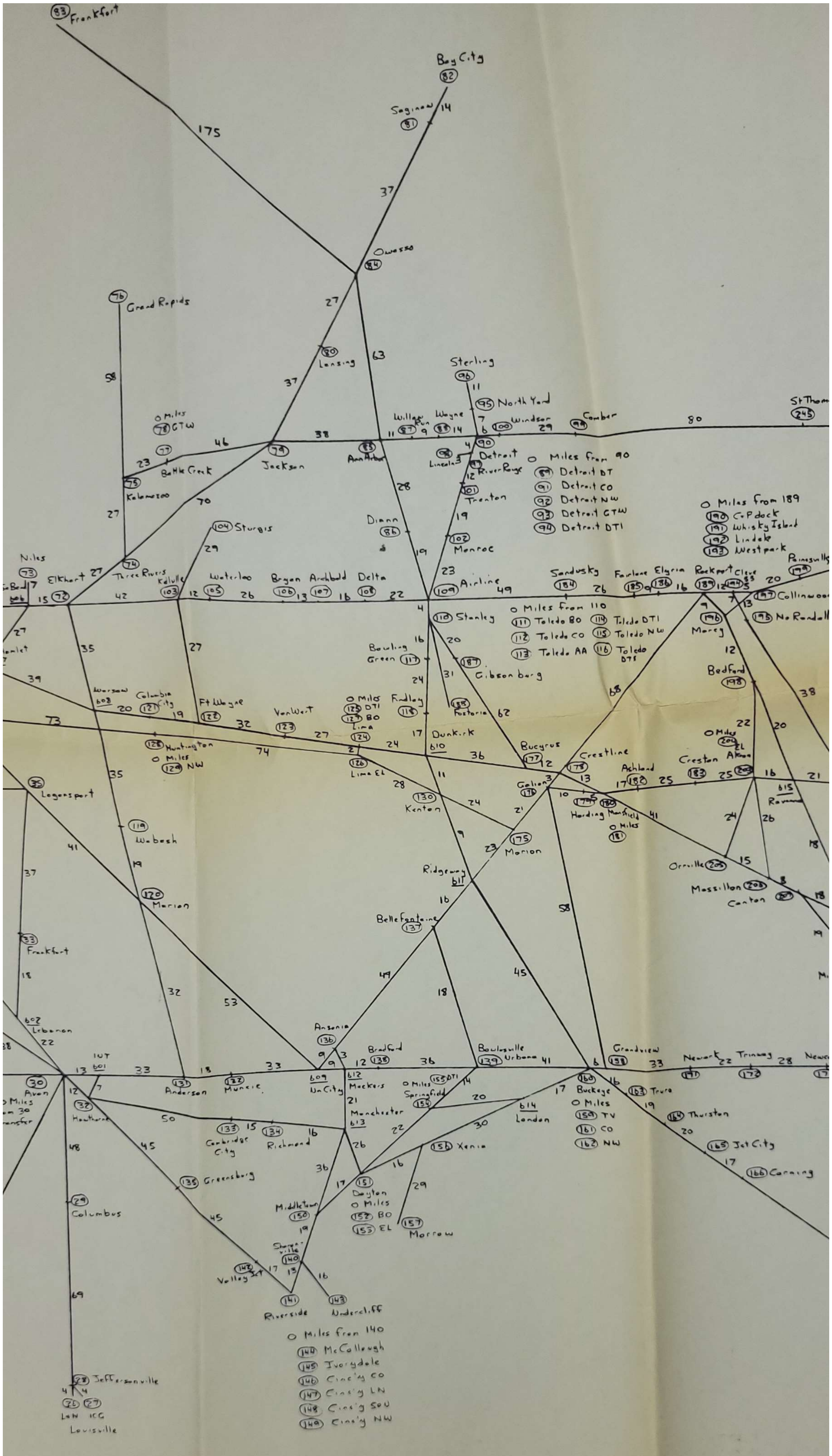
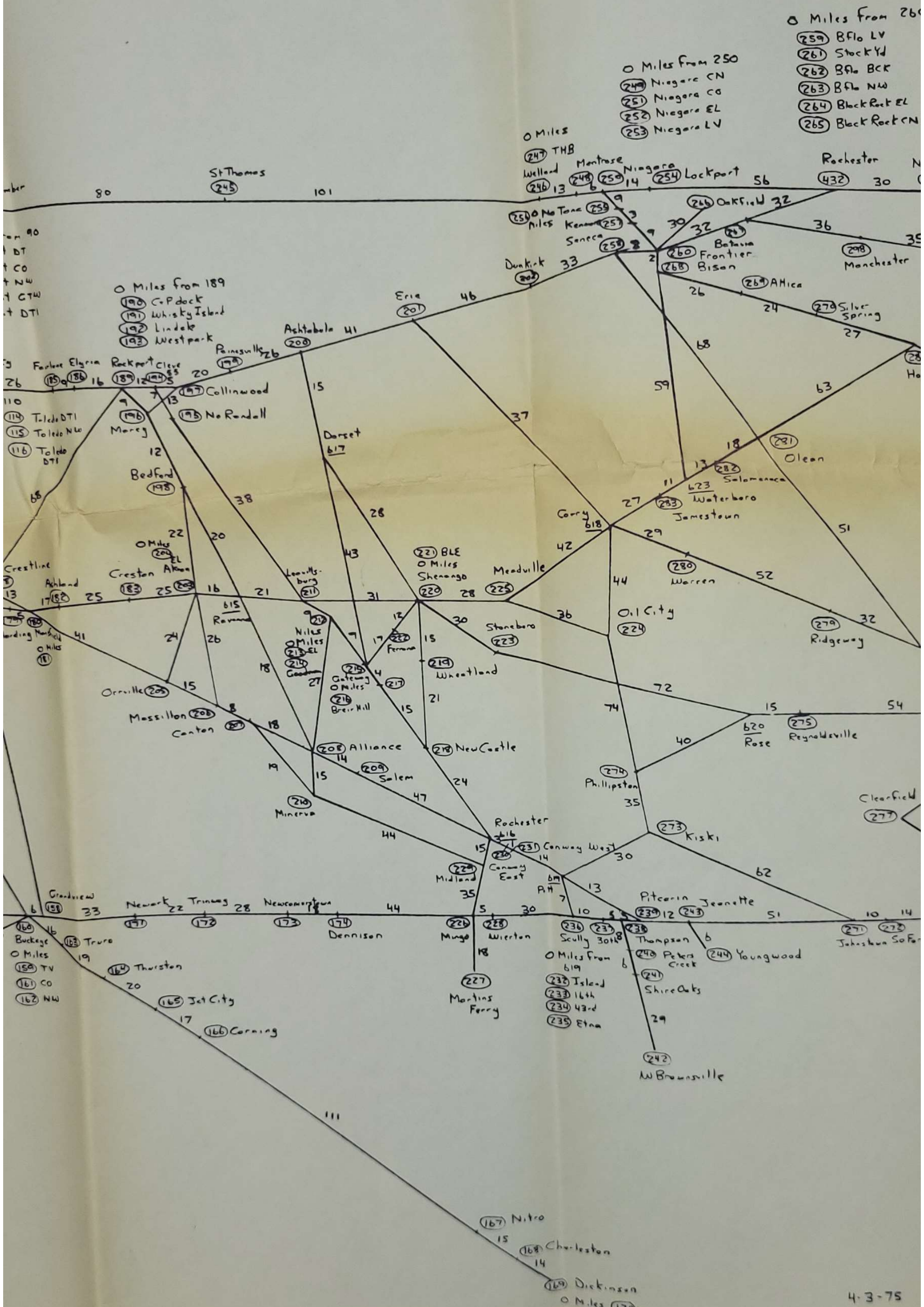



FIGURE 5. Graphic

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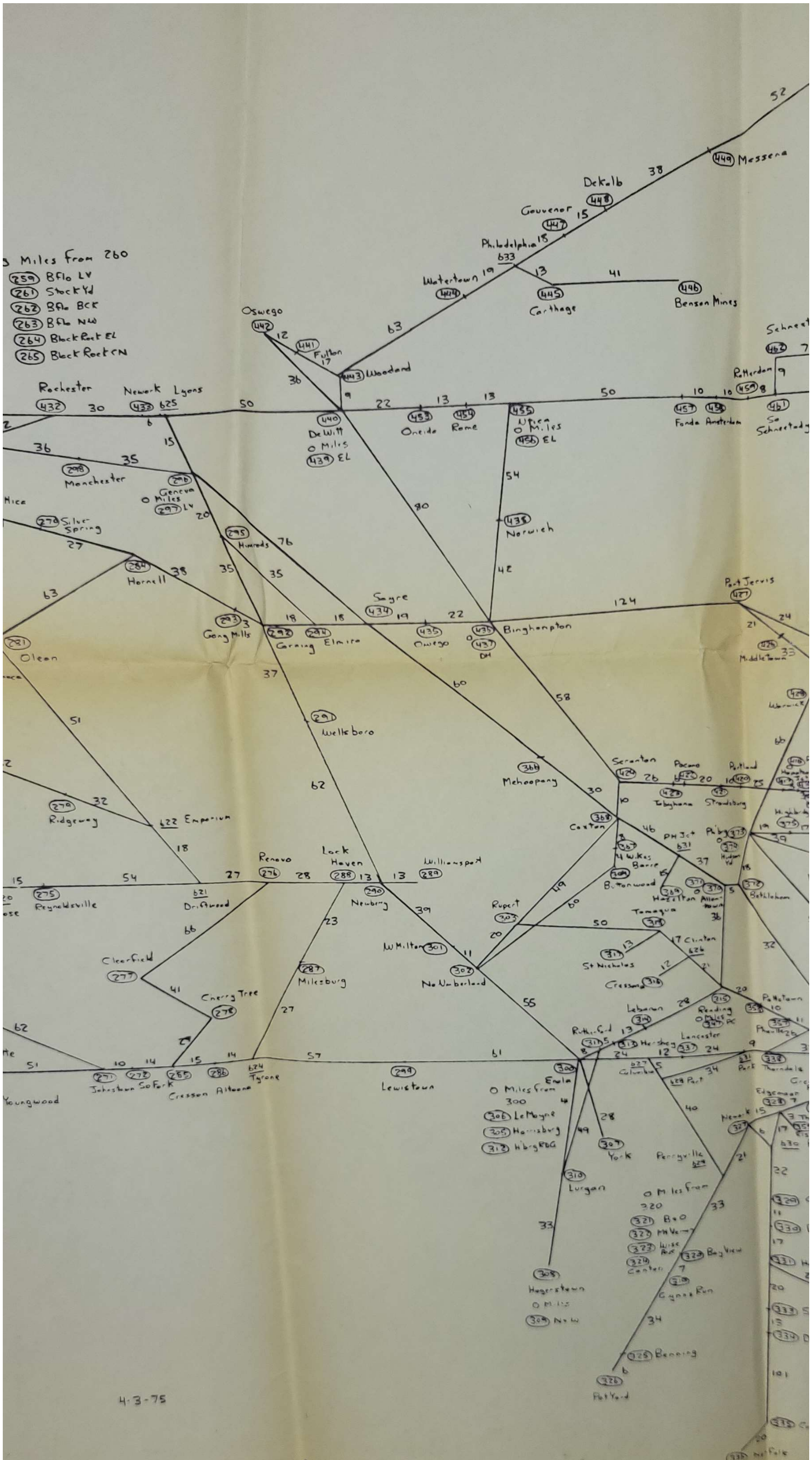


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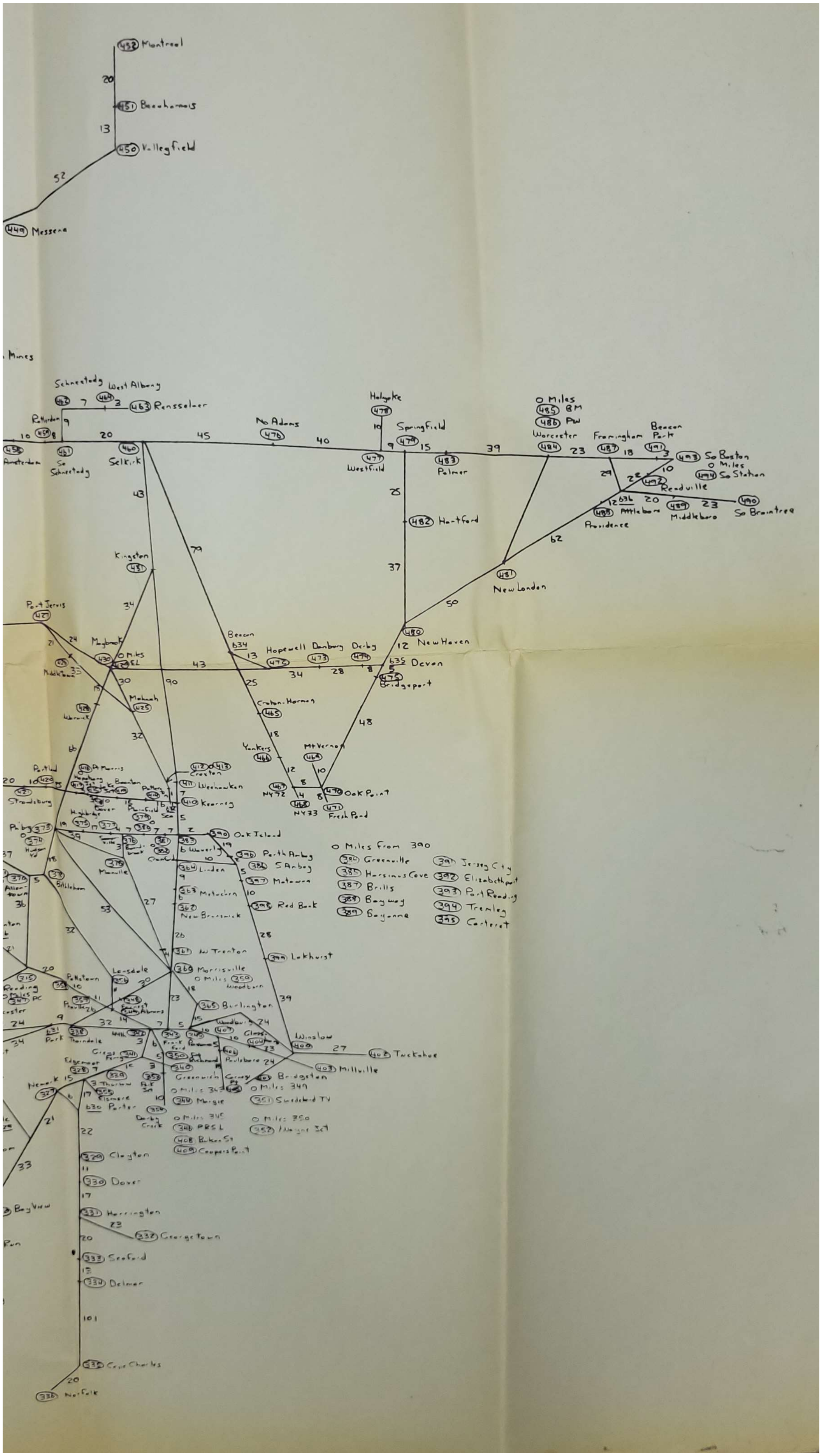

Montreal
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Springfield
Westfield
Palmer
Worcester
Framingham
Beacon Park
So Boston
So Station
Readville
Attleboro
Middleboro
So Braintree
Providence
Hartford
New London
Kingston
Port Jervis
Maybrook
Beacon
Hopewell
Danbury
Derby
New Haven
Devon
Bridgeport
Mahwah
Croton-Harmon
Yonkers
Mt Vernon
Oak Point
Fresh Pond
Weehawken
Kearney
Stroudsburg
Bethlehem
Allentown
Manville
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Red Bank
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Lakehurst
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Winslow
Tuckahoe
Millville
Bridgeton
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Bayway
Bayonne
Jersey City
Elizabethport
Port Reading
Tremley
Carteret
Clayton
Dover
Harrington
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Bay View