REPORT ON RAIL SERVICES PLANNING STUDY LIGHT DENSITY RAILROAD COSTING METHODOLOGY

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I. INTRODUCTION

The purpose of this report is to document a methodology for light-density railroad cost analysis which will be used in Phases I and II of the North Dakota Rail Services Planning Study. The methodology prescribes a set of procedures for the calculation of line-segment unit costs, and for the application of those unit costs to a particular light-density network.

The report is organized as follows. Section II formulates a theoretical model or framework for the analysis of line-segment costs. Section III sets forth a method for calculating a series of unit costs from a carrier's R-1 annual report and applying the unit costs to a line or set of lines. Section IV describes a procedure for calculating the expenses associated with moving traffic to and from the junction points or interchange points of the line-segments.

II. THEORETICAL FRAMEWORK

In estimating line-segment or network costs, an understanding of the types and classifications of rail costs is essential. This section of the report begins with a discussion of the concept of rail networks or subsystems and a delineation of costs into several useful categories. Using these categories and concepts, a theoretical model of cost-output relationships is developed.

2.1 Basic Propositions

Many transportation analysts have a familiarity with the use of Interstate Commerce Commission (ICC) costing formulas in the calculation of "shipment costs." But the estimation of line-segment costs differ significantly from the estimation of shipment costs using URCS or Rail Form A. In the case of the latter, costs are estimated for a typical movement, normally between a single origin and a single destination. In the case of the former, costs must be estimated for all classes of traffic originating and/or terminating on a line-segment, normally entailing an array of origins and destinations.

From a systems perspective, a line-segment may be envisioned as a subsystem of a carrier's overall network. As a subsystem, a line-segment possesses on a smaller scale many of the same attributes or characteristics of the larger system of which it is a part. But as a subsystem, a line or network of lines also possesses certain characteristics which are different than those of other subsystems, such as traffic mix, density, track quality and condition, and function.

The concept of a line or network of lines as a functioning subsystem of a broader system allows the statement of a set of basic propositions which permit the development of a theoretical model.

1. A line-segment, as a subsystem of a carrier's network, has certain directly assignable physical assets associated with its operation and existence

(such as land, track, other roadway materials, roadway buildings and structures, etc.)

2. A line-segment has a production function which is somewhat similar to that of the railway as a whole, in that the same factor inputs (i.e., track, equipment, labor, materials and supplies) are required in order to generate output.

3. Because the production functions of the various subsystems utilize the same factors of production, the variable inputs such as locomotives, freight cars, containers, engineers, firemen, brakemen, and conductors can almost always be utilized on another subsystem of the carrier's network.

4. A line-segment, as a subsystem of a carrier's network, is subject to short run economies of utilization or density in much the same manner as the rail network as a whole.

5. A line-segment is not a self-contained subsystem of a carrier's network but rather interacts with other subsystems, interchanging freight cars, locomotives, and crews.

These five propositions regarding the nature and functions of line-segments underlie many of the assumptions, suppositions, and definitions in the theoretical model.

2.2 Cost Classifications and Definitions

Costs are frequently defined or classified in more than one manner or according to more than one criterion. In developing a theory of light-density analysis, four different categorizations of costs are especially illuminating and useful. In the following discussion, railroad costs are categorized according to: (1) subsystem or function, (2) traceability, (3) behavior with output, and (4) accountability.

2.2.1 On-Line Versus Off-Line Costs

From the preceding propositions, two broad categories of cost may be defined according to subsystem functions:

1. On-line or on-network costs;
2. Off-line or off-network costs.

On-line costs comprise the operating, capital, and opportunity costs associated with serving and maintaining a set of light-density lines. Off-line costs represent the variable expense associated with moving traffic to and from the junction points, over other subsystems of a carriers' network.

2.2.2 Line-Specific Versus Allocated Costs

As proposition #1 states, a line or network of lines has certain directly assignable physical assets associated with its existence. Items such as land, track, structures, roadway materials, and buildings are "line-related" or "line-specific" costs. The annual expenses for these items can be assigned directly to a line or network of lines.

Other factors of production such as equipment or train and engine crew labor may be used on several different networks or lines. The annual expenses for these items cannot be directly and solely attributed to any given line-segment. Instead, they must be allocated among the various lines or networks in the carriers' system based on the level of activity on each. Such expenses are referred to as "allocated" costs.

2.2.3 Fixed Capacity Versus Variable Costs

On-line costs may also be classified according to behavior with output. Certain line-related costs are fixed in nature and do not vary with output. A large proportion of maintenance of way (MOW) expenditures on light-density lines are constant per mile of track. Items such as superintendence, vegetation control, and time-related deterioration of track and roadway assets are independent of the level of traffic on a line. Likewise, the opportunity cost of capital invested in roadway facilities is incurred regardless of whether one or one thousand carloads are handled.

Other on-line costs such as locomotive ownership, fuel, and train crew labor vary directly with the level of activity on a line. If no traffic is generated or handled, then no locomotive or freight car costs are incurred. The equipment is utilized on other subsystems.

2.2.4 Accounting Classifications

On-line expenses are normally classified according to four broad functional categories found in railroad accounting systems. These classifications consist of:

1. Maintenance of Way
2. Maintenance of Equipment
   a) Locomotives
   b) Freight Cars
3. Transportation
   a) Train Operations
   b) Yard Operations
   c) Common Operations
   d) Specialized Service Operations
   e) Administrative Support Operations
4. General and Administrative

Within each classification or subclassification lie a range of individual cost items. For example, costs for locomotive fuel, train and engine crews, train inspection and lubrication, and train dispatching constitute individual line items under the general classification of train operations.

2.3 Cost Finding Process

The process of estimating costs for a network of lines constitutes a three step process. First, a series of unit costs are calculated which represent the variable expense per unit of output (e.g., fuel costs per locomotive hour of operation) or the fixed capacity cost per mile of track (e.g., opportunity cost on net liquidation value of roadway assets). In a second and independent step, the number of annual output units or "service units" consumed in the provision of service, and the number of track-miles in the network are calculated. The level of annual expenses attributable to the network of lines is calculated by multiplying the service units by the related unit costs.

2.3.1 Sources of the Unit Costs

On-line unit costs are derived from two basic sources. The majority of the unit costs are calculated from accounting expenses and operating data contained in the carrier's R-1 reporting schedules. R-1 unit costs are "allocated" unit costs. They represent the cost per unit of output for items such as locomotive depreciation and return on investment which cannot be directly and solely assigned to a particular line-segment.

The remaining on-line unit costs are derived from engineering or economic-engineering analysis of the line or set of lines. MOW expenses and net liquidation value (NLV) are line-specific costs which can be directly assigned to a set of lines. A "normalized" MOW cost per mile of track for a network is derived from engineering estimates and cost-density relationships. A NLV per mile of track is similarly calculated using resale and/or scrap value of land and track materials, and engineering estimates of recovery cost.

Off-line unit costs are allocated unit costs. They are derived from R-1 expense and operating data, using ICC cost finding formulas RFA or URCS. Burlington Northern's RFA has been used to generate off-line unit costs for Phase I of the Rail Services Planning Study.

A more detailed explanation of the calculation and sources of the off-line and on-line unit costs is provided in Section III of the report.

2.3.2 An Operating Model

The second step in the cost-finding process, the estimation of annual service units for a set of lines, is accomplished through the use of an operating model. The model predicts the service units attributable to the consolidation and gathering activities which occur on a network of lines. The model also predicts the number of service units generated by the movement of traffic to and from the junction points of the network.

In understanding and modeling light-density operations, three concepts are of primary importance: (1) train class or service, (2) shipment level of service, and (3) scheduled frequency of service. Train service may be categorized as either: way train or local service, through train service, or unit train service. Way train service constitutes the class of operations involving consolidation and delivery activities on a network of light-density lines. Way trains operate between classification yards and stations, spotting empty cars and pulling loaded ones. Through trains operate primarily between classification yards, and do not normally switch cars at individual stations. In terms of light-density networks, through trains normally consist of bridge or overhead traffic which neither originates nor terminates on the network of lines. Unit train service involves direct service between stations and does not require yard classification.

Shipment service level is a composite variable which captures the types and extent of activities that occur at individual stations on the network as well as at classification yards off the network. There are four basic service levels: (1) single car, (2) multiple car, (3) trainload, and (4) unit train. A true unit train constitutes a direct, cyclical, continuous movement between an origin and destination normally involving a dedicated locomotive and freight car set. A trainload shipment also involves direct origin-destination service. But a trainload shipment is not a cyclical, continuous movement. Trainload shipments may be sporadic and spread out over a year. There are other operational differences between unit train and trainload service which are documented in (Tolliver 1984).

There are few, if any, unit train shipments originating or terminating on light-density networks. However, there may be trainload shippers in addition to multiple-car and single-car shippers.

From a modeling perspective, trainload shipments are treated as a separate, solid train. Multiple-car shipments are treated in one of two manners. An explanation of multiple-car modeling procedures involves an understanding of scheduled way train operations.

Way trains typically operate between a classification yard and outlying stations along a designated route, according to a general timetable and schedule. Single-car, three-car, and other small multiple-car shipments are generally handled in scheduled way train service. The frequency of service is determined by the demand for cars along the route and by the operating condition of the lines. Light-density lines, because of low demand and poor operating conditions typically receive once a week service.

If large multiple-car shippers are located on a line the scheduled frequency of way train service may be inadequate for handling such shipments. If the frequency of service is less than four times per week, the detention/waiting time at stations will exceed tariff free time significantly. In modeling large multiple-car shipments, the concept of a direct or shuttle way train is introduced. Shuttle way trains operate between classification yards and large multiple-car shippers, providing expedited service in those cases where the frequency of scheduled way train service is low. If the service frequency is three times a week or less, large multiple-car shipments are assumed to be handled in shuttle way train service.

2.4 Cost-Output Relationships

In calculating the R-1 unit costs, accounts or groups of accounts are correlated with the output measures to which they are most closely related. Cost-output relationships may be determined through statistical analysis, engineering cost analysis, or developed from operational knowledge. The ICC has developed a series of cost-output relationships for use in abandonment costing and in the evaluation of light-density surcharges using a combination of the three approaches. For the most part these cost-output relationships have been adopted ~~for the most part~~ in the development of a methodology for the Rail Services Planning Study.

2.4.1 Locomotive Operations and Ownership

Road locomotive repairs and maintenance are a function of the weight of the units and the distance traveled. This relationship is captured by the output variable "road locomotive gross ton-miles". Unlike repairs, the servicing of road locomotive units is not related to the weight of the unit but is a pure function of distance. Servicing expenses are therefore correlated with road locomotive unit miles.

Locomotive depreciation, rentals and leases, and opportunity costs are obviously more closely related to time rather than distance or use. The logical output measure for these expenses is road locomotive hours of operation. Locomotive fuel, the major locomotive operating expense, is clearly use-related. On light-density networks, locomotives spend a sizable portion of operating time at low speeds, idling, or switching cars at stations. These are fuel-intensive activities. For this reason, the hours of operation provide a better measure of fuel consumption than miles or gross ton-miles.

Yard locomotive activities involve the switching of cars over short distances. The principal measure of this activity is the number of yard locomotive hours consumed. Unlike road locomotives which engage in running and switching activities under a variety of conditions, all yard locomotive expenses can be related to the hours spent switching.

2.4.2 Transportation Expenses

Train operating expenses other than fuel are related to one of two output measures: train-hours or train-miles. During light-density operations, train and engine crews spend a large proportion of their time running at low speeds or switching at industry sidings. For this reason, the ICC has recommended that crew wages be developed on a train-hour rather than a train-mile basis.

All other train operating expenses are related to train-miles of output. These include train inspection and lubrication, operating signals and interlockers, operating highway grade crossings, and train dispatching. All yard operating expenses are correlated with yard switching hours.

2.4.3 Other Equipment Costs

Freight car repairs and depreciation are a function of time and usage. The ICC has developed factors for the apportionment of each expense between car-days and car-miles. Freight car opportunity costs, as in the case of locomotive units, are time-related and are expressed on a car-day basis.

Trailer and container ownership costs are principally time-related. While on the rail leg of an intermodal shipment, the repairs and maintenance which accrue are due to weather, environment, or time as opposed to use. All TOFC/COFC ownership costs are thus expressed on a trailer- or container-day basis.

2.4.4 General and Administrative Expenses

General and administrative expenses involve items such as marketing, sales, legal and secretarial services, accounting and finance, and research and development. These expenses are clearly related, at least in part, to the level of activity for the system as a whole, as well as to the level of activity on individual subsystem. Because certain accounting, financial, and other functions are required whenever carloads are originated or terminated, regardless of size of load, these expenses are felt to be most closely related to car-miles rather than gross ton-miles of output.

This section of the report has attempted to develop a theory of light-density cost analysis. By defining a network of light-density lines as a subsystem of a carrier's overall system, five basic propositions were set forth. On the basis of these propositions, definitions were given for allocated and line-specific costs, fixed capacity and variable costs, and off-line versus on-line costs. A three-step process of cost-finding was introduced, and unit cost calculations and operational modeling techniques were overviewed. In addition some basic cost-output relationships were formulated. Having developed this theoretical background, the report now turns to a detailed description of the costing methodology and procedures.

III. ON-LINE METHODOLOGY

As indicated in Section II, line-segment costs may be grouped into two classifications based on systems terminology--on-line costs and off-line costs. The method by which on-line unit costs are calculated is discussed in this section of the report.

The calculation of on-line costs involves three sets of procedures or submodels. The purpose of the first set of procedures is to calculate a series of unit costs from the Class I carrier's R-1 report and/or from engineering estimates of line-related expenses. The second set of procedures constitute an operating model which predicts the number of train hours, car-miles, and other service units generated on an annual basis by the network of lines. Annual network expenses are calculated in a third submodel or procedure by multiplying the annual service units by the related unit costs.

3.1 Locomotive Operating, Maintenance and Ownership Unit Costs

Road locomotive units costs are "allocated" rather than "line-specific" unit costs. Road locomotive costs are calculated so as to reflect all direct and indirect expenses associated with the activity of units outside of classification yards.

Road locomotive operating and maintenance costs include: (1) repairs, (2) fuel or power, (3) servicing, (4) machinery, and (5) overhead. Road locomotive ownership costs include: depreciation, rentals, and leases (DRL) and return on investment (ROI).

3.1.1 Road Locomotive Repairs and Ownership

Road locomotive repairs, DRL, and ROI are calculated directly from expenses contained in Line 2 of Schedule 415. Table 3.1 shows the location of each expense item within Schedule 415, as well as the related output measure.

As Table 3.1 depicts, all but one of the unit costs have been developed on a locomotive-hour basis. This is consistent with the theoretical model constructed in Chapter II wherein the depreciation, repairs, and fuel consumption of locomotive units operating over light-density line-segments were shown to be more closely related to locomotive hours than to unit miles.

TABLE 3.1 ROAD LOCOMOTIVE OPERATING, MAINTENANCE AND INVESTMENT UNIT COSTS.

Unit Costs	Schedule 415 Columns	Production or Output Measure
Repairs	(b)	Locomotive Gross Ton-Miles
Depreciation, Rentals and Leases	(c)+(d)+(e)+(f)	Locomotive Hours
Net Investment Base	[(g)+(h)]-[(i)+(j)]	Locomotive Hours

Locomotive repairs for each class of unit are obtained directly from column (b) of Schedule 415. Locomotive depreciation, rentals, and leases (DRL) are calculated by adding the expenses for depreciation [Schedule 415, col. (c) + col. (d)], retirements [Schedule 415, col. (e)], and leases and rentals [Schedule 415, col. (f)]. Locomotive investment (the net investment base) is calculated for each type of unit by subtracting accumulated depreciation [Schedule 415, col. (i) + col. (j)] from the investment base [Schedule 415, col. (g) + col. (h)]. The unit cost for locomotive ROI is calculated by multiplying the net investment base by the appropriate cost of capital.

3.1.2 Locomotive Machinery

Locomotive machinery costs represent the maintenance and ownership costs associated with the machinery used exclusively in the maintenance of locomotive units. Determining the road locomotive expenses for this item requires a two step process. First, the expenses for locomotive machinery must be extracted from Schedule 415. Second, the expenses must be allocated between road and yard units.

Locomotive machinery repairs, DRL, and the net investment base are calculated from line 38 of Schedule 415 using the same columns for each unit cost as those depicted in Table 3.1 for locomotive units. Once calculated in this manner, locomotive machinery expenses are then allocated to each class of locomotive based on the ratio of the repair expenses for that class to the total repairs for all locomotive types. The allocation ratio for diesel yard locomotives, for example, is determined by dividing the repair expenses for yard diesel locomotives [Schedule 415, col. (b)] by the total repair expenses for all locomotives. The logic behind this allocation procedure is that the costs associated with locomotive machinery (equipment used exclusively and directly in the repair and maintenance of locomotives) are positively and proportionately related to the amount of expenditures made for repairs on each type of locomotive unit.

The production or output unit for road locomotive machinery is road locomotive gross ton-miles. For yard locomotive machinery expenses, the output measures is yard locomotive switching hours.

3.1.3 Locomotive Fuel and Power Unit Costs

A major aspect of line-segment locomotive cost is locomotive fuel and/or power. As in the case of locomotive maintenance and depreciation expenses, locomotive fuel and power expenses are developed on a locomotive-hour basis. The expenses for locomotive fuel are taken from Schedule 410 of the carriers' R-1 report. Table 3.2 documents the source of the expenses, in terms of Schedule 410 line numbers.

TABLE 3.2 LOCOMOTIVE FUEL AND POWER UNIT COSTS.

Unit Costs	Schedule 410 Line Number	Production or Output Measure
Road Locomotive Fuel	409	Diesel Road Locomotive Hrs
Yard Locomotive Fuel	425	Diesel Yard Locomotive Hrs
Road Locomotive Power	410	Other Road Locomotive Hrs
Yard Locomotive Power	426	Other Yard Locomotive Hrs

Road locomotive hours are developed from Schedule 755 as follows. First, the average road train speed (running) is calculated as: [(Line 115) - (Line 116)]/Line 5. Second, using the average train speed, the number of road locomotive hours (running) is calculated as the quotient of the number of road locomotive unit miles and the average speed. Third, the number of road locomotive hours train switching is derived by dividing the number of locomotive unit miles train switching (Line 12) by the average locomotive speed switching (6 MPH).[1] The sum of hours running and train switching yields the total number of annual road locomotive hours.

3.1.4 Locomotive Servicing and Overhead Unit Costs

The expenses associated with servicing road and yard locomotive units are derived from Schedule 410, while the production units are developed from Schedule 755. The unit cost of servicing road locomotives is calculated by dividing the account expenses (Schedule 410, Line 411) by the number of road locomotive miles (Schedule 755, Line 11). This output unit is used instead of road locomotive hours because the servicing of road locomotive units is more closely related to the miles of operation than to time.[2]

Locomotive overhead costs comprise the administrative and other expenses which are incurred as a result of maintaining, serving, and managing the locomotive fleet. These expenses vary with the level of activity on a given subsystem, and are allocated to various subsystems on a locomotive-hour basis.

The various elements of locomotive overhead and their Schedule 410 line numbers are enumerated in Table 3.3.

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[1]This constant was developed and is used by the Interstate Commerce Commission.

[2]The road locomotive unit service unit was stipulated by the ICC in Ex Parte 402.

TABLE 3.3 LOCOMOTIVE OVERHEAD EXPENSE ITEMS.

Item	Schedule 410 Line Number
Administration	201
Equipment Damage	204
Fringe Benefits	205
Other Casualities and Insurance	206
Dismantling Road Property	217
Other	218

3.2 Transportation Unit Costs

Train and engine crew wages are developed on an hourly basis from the ICC's Quarterly Wage Statistics, Form B. Locomotive fuel, power, and servicing costs have already been discussed. The remaining transportation expenses are organized into four classifications: (1) train operations, (2) yard operations, (3) common train and yard expenses, and (4) specialized service operations.

Train operating and overhead costs reflect the cost of administration, dispatching, and other activities related to road train operations. The various components of train operations and overhead, and the Schedule 410 line numbers are listed in Table 3.4. With the exception of fringe benefits, all items are expressed on a train-mile basis. Fringe benefits are applied separately as a markup ratio on train and crew labor expenses.

TABLE 3.4 TRAIN OPERATING EXPENSE ITEMS.

Item	Schedule 410 Line Number
Administration	401
Dispatching Trains	404
Operating Signals & Interlockers	405
Operating Drawbridges	406
Highway Crossing Protection	407
Train Inspection & Lubrication	408
Clearing Wrecks	413
Fringe Benefits	414
Other Casualities & Insurance	415
Joint Facilities	416 & 417
Other	418

The components of yard operating and overhead cost are depicted in Table 3.5. All yard operating and overhead items are related to yard switching hours.

TABLE 3.5. YARD OPERATING EXPENSE COMPONENTS.

Item	Schedule 410 Line Number
Administration	420
Controlling Operations	422
Yard Terminal Clerical	423
Operating Switches, Signals, Retarders and Humps	424
Clearing Wrecks	429
Fringe Benefits	430
Other Casualities and Insurance	431
Joint Facilities	432-433
Other	434

Unless specialized services or ancillary activities such as installing grain doors on boxcars are encountered, common and specialized services unit costs are not required.

3.3 General and Administrative Expenses

General and administrative expenses, with the exception of property taxes, are developed from Schedule 410, Lines 601-618. Property taxes are treated as line-related expenses, and are developed from state tax records on a track-mile basis.

The various elements of general and administrative expenses are enumerated in Table 3.6. As Section II discussed, these expenses are developed on a car-mile basis.

TABLE 3.6. GENERAL AND ADMINISTRATIVE COST ELEMENTS.

Item	Schedule 410 Line Number
Officers-General & Administrative	601
Accounting, Auditing & Finance	602
Management Services & Date Processing	603
Marketing	604
Sales	605
Industrial Development	606
Personnel & Labor Relations	607
Legal & Secretarial	608
Public Relations & Advertising	609
Research & Development	610
Fringe Benefits	611
Casualities & Insurance	612
Writedown of Uncollectibles	613
Other Taxes	615
Joint Facility	616 & 617
Other	618

3.4 Freight Car Expenses

Car repairs, depreciation, and ROI unit costs may be developed from Schedule 415 in a manner analogous to the locomotive procedure. An alternative method of developing car costs is an economic-engineering approach set forth by the ICC in

Ex Parte 334. This method uses the replacement value of a particular type of freight car in conjunction with its anticipated usage to derive a cost per car-mile and car-day.

The Rail Services Planning Study utilizes Burlington Northern car-day and car-mile costs developed in this manner. These unit costs were compiled and presented by the BN in verified testimony before the North Dakota Public Service Commission.

3.5 Service Unit Calculations

Annual service units are calculated for a given network of lines in accordance with the theoretical model set forth in Section II. The operations component of the model predicts the number of scheduled way trains required per year along each route, as well as the number of shuttle way trains and trainloads needed.

Many of the train operating service units are calculated initially at the route level, and then summed across all routes to obtain a network total. The description of this process begins with a discussion of the identification of way train routes and mileages.

3.5.1 Definition of Routes and Mileages

The delineation of way train routes is based on either published timetables and schedules, or on data provided by trainmasters in the area. In addition to the division point (classification yard) and weekly service frequency, the round trip way train miles must be estimated for each route. Round trip mileages are derived from carrier timetables or distance tariffs and follow the actual route of the train.

In addition to round-trip mileages for each route, the distance from each station to the division point and from each division point to each major market must be calculated. Station way train mileages are calculated from the carrier's distance tariff.

3.5.2 Calculation of Annual Trains by Route

The initial step in the estimation of annual service units is the calculation of the number of scheduled way trains, shuttle way trains, and trainloads for each route. The number of scheduled way trains per week is calculated as follows:

$$SCWT_i = 365/SERV_i$$

where:

$SCWT_i$ = Scheduled way trains on route "i"

$SERV_i$ = Weekly service frequency, route "i".

If the scheduled service frequency is < = 3, each large multiple-car shipment is assumed to constitute a shuttle way train. Otherwise, all multiple-car shipments are assumed to be handled in scheduled way train service.

3.5.3 Calculation of Train-Miles and Train-Hours

Using the estimated number of scheduled way trains, shuttle way trains, and trainloads the annual number of train miles on each route is calculated next. Scheduled way trains are assumed to run the length of route and back each trip. Shuttle way trains and trainloads are assumed to run directly between a given station and the classification yard. The train-miles for these two classes of service consist of the distance between the station and the division point, times the number of trains per year. Annual route train-miles are the sum of the train-miles for the three classes of service.

The service unit "train-hours" is comprised of two individual components: (1) train-hours running and (2) train-hours switching. The annual train-hours running on a given route are calculated directly from the train-miles as follows:

$$THR_i = TM_i/MPH_i$$

where:

THR_i = Train-Hours Running, Route "i"

TM_i = Annual Train Miles, Route "i"

MPH_i = Average Train Speed, Route "i"

The average train speed reflects the operating conditions and any speed limitations which might exist on a given route.

Train-hours switching constitute the total switching time at each station during the year. The minutes required at each station are a function of the number of cars switched and the shipment level of service. A separate calculation must first be performed for each level of service, as indicated below.

$$LSM_{ij} = CS_{ij} \cdot ASM \cdot SMR_j \cdot SPR$$

where:

LSM_{ij} = Locomotive switching minutes at station "i", for service class "j"

ASM = Average RFA switching minutes per car

SMR_j = Switching minute efficiency ratio for service level "j"

SPR = Spotted-to-pulled ratio

CS_{ij} = Cars switched at station "i", service level "j".

Each service level corresponds to a shipment class size (e.g., 23-26 cars). There are twelve possible classes or values for "j". The switching efficiency ratio expresses the relative switching time for a given service class in comparison to the single-car average. The spotted-to-pull ratio indicates the frequency with which an empty car must be spotted for every load which is pulled. The SPR is 2 for most car types.

Total train-hours switching at a given station are given by:

$$LSM_i = \sum_j LSM_{ij}$$

3.5.4 Calculation of Road Locomotive Service Units

Once the annual train-miles and train-hours are compiled by class of train service, the road locomotive hours and unit miles can be estimated. Road locomotive miles (RLM) are calculated separately for each of three classes of train service on each route as indicated below.

$$RLM_{ij} = TM_{ij}\ ALU_j$$

where:

ALU_j = Average locomotives required for service class. The number of units required for each train class will vary with the average train weight and network conditions. For light-density networks, shuttle way trains usually require a single unit while trainloads typically require two. Scheduled way trains normally need at least one unit, with two locomotives being necessary under extreme conditions.

Road locomotive hours are calculated from annual train hours in an analogous manner. The locomotive unit hours consumed at each station are a function of the switching time and the number of units required. For a specific class of shipment service, the locomotive unit hours required at a particular station are given by:

$$LHS_{ij} = LSM_{ij}\ ALU_j.$$

The individual totals by service class are then summed to obtain the station total.

Road locomotive hours running (LHR) are calculated for each route from annual RLM as follows:

$$LHR_i = RLM_i/MPH_i.$$

Network locomotive hours are obtained by summing the LHS for all stations, and the LHR across all routes.

3.5.5 Calculation of Car-Miles and Car-Days

Car-miles on-line are calculated for each station as follows:

$$CM_i = SW_i CS_i SPR$$

where:

SW_i = Station way train miles

CS_i = Cars switched at station "i".

Network car-miles are given by:

$$CM = \sum_i CM_i$$

Car-days are modeled under the assumption of efficient way train operations. For shuttle way trains and trainloads, a two-day cycle is assumed. The car is spotted on the first day, and loaded and returned to the yard on the second day. A three-day cycle is assumed for single-car and small multiple-car shipments.

Once the service units have been calculated for all categories, annual expenses are obtained by multiplying the network service units by the unit costs.

IV. OFF-LINE PROCEDURE

Off-line costing is a variant of shipment costing. The objective of off-line casting is to estimate the average variable cost associated with the transportation of all network traffic from the point of origin to the junction point, or from the junction point to the destination (in the case of outbound traffic). This section of the report documents in detail the derivation of off-line unit costs, the estimation of off-line service units, and the calculation of annual off-line expenses.

The most simple and perhaps intuitive explanation of how the variable unit costs obtained from RFA or URCS are converted into estimates of variable off-line cost is as follows. Based on the attributes of the commodity, the operational tendencies and characteristics of the freight car, the distance and other movement-related factors the number of service units consumed in the provision of off-line service are determined. The service or production units are then multiplied by the cost per unit to estimate off-line expenses. A generic equation which summarizes this calculation is given below.

$$C_{ij} = SU_{ij} \times UC_i$$

where:

C_{ij} = Cost of service activity "i" for shipment "j"

SU_{ij} = Numbers of service units "i" consumed on shipment "j"

UC_i = Unit cost per service activity "i"

Substituting locomotive unit mile(s) for service activity "i" will result in the cost-finding equation for road locomotive expenses.

The term "shipment" in the above equation actually refers to a stream or class of traffic. Each shipment stream represents an annual number of tons or carloads of a given commodity, shipped between a specific origin and destination, in a particular car-type.

Off-line costing begins (or ends) at the junction point of the line or network. For each shipment stream the shortest distance between the junction and the shipment origin or destination is computed from railroad distance tariffs. This figure, expanded to account for circuitous routing, serves as the basic means for the calculation of distance-related off-line costs. Total annual off-line costs represent the summation of off-line expenses for all shipment streams.

4.1 Off-Line Unit Costs

Off-line unit costs may be compiled using either Rail Form A or the Uniform Railroad Costing System. Both formulas use regression analysis to determine the variability of costs by account classifications. The output files of the formulas provide a series of variable unit costs which reflect specific cost elements.

The unit costs used in Phase I of the Rail Services Planning Study have been taken from Burlington Northern's Rail Form A. The variable RFA unit costs consist of a cost per:

1. Gross ton mile,
2. Locomotive-unit mile,
3. Train mile (crew wages),
4. Train mile (non-wage expense),
5. Car mile (non-ownership expense),
6. Carload, originated and terminated (station clerical, claims clerical, and terminal supplies),
7. Ton of freight (loss and damage),

8. Switch engine minute.

In addition to these RFA variable unit costs, a cost per car day and car-mile (ownership) have been developed from Burlington Northern verified testimony. These unit costs are used in lieu of the RFA average for all car types.

Rail Form A unit costs actually consist of three separate unit costs. The first represents the operating expenses, rents, and taxes per unit of output. The second unit cost reflects the variable cost of capital for road. The third constitutes the variable cost of capital for equipment.

The various Rail Form A unit costs used in the Rail Services Planning Study are detailed in Table 4.1.

TABLE 4.1 RAIL FORM A VARIABLE UNIT COSTS, BURLINGTON NORTHERN, 1983.

(a) Service Unit	(b) Operating Expenses, Rents & Taxes		(c) Cost of Capital, Road		(d) Cost of Capital Equipment	
	RFA Core	Value	RFA Core	Value	RFA Core	Value
Gross Ton Mile	B(3171)	0.00258440	B(3214)	0.00023877	B(3240)	0.00002581
Locomotive Unit Mile	B(3172)	1.82664740	B(3215)	0.00610282	B(3241)	0.11184151
Train Mile -Wages	B(3173)	8.38593972	-		-	
Train Mile -Other	B(3174)	1.39049542	B(3216)	0.00513087	B(3242)	0.00316081
Station Clerical	B(3176)	14.87890410	B(3217)	0.64897340	-	
TOFC Clerical	B(3177)	4.44084096	B(3218)	0.18346169	-	
Station Employee Special Service	B(3184)	0.29133075	B(3225)	0.01162382	-	
TOFC Tie Down & Special Service	B(3185)	56.67466688	B(3226)	0.95518331	-	
Train Supplies -Running	B(3186)	0.42748259	-	-	-	
Train Supplies -Terminal	B(3187)	4.09968114	-	-	-	
Carload Claims Clerical	B(3190)	2.29429346	B(3228)	0.10895013	-	
TOFC Claims Clerical	B(3191)	4.13807279	B(3229)	0.19650649	-	
Engine Minute	B(3198)	3.5353033447	B(3232)	.1673772025	B(3245)	.0287470129

4.2 Calculation of Off-Line Service Units

Off-line service units may be categorized according to three principal service activities, resulting in: (1) line-haul, distance-related service units; (2) line-haul, switching service units; and (3) terminal service units.

Three fundamental operating/performance factors must be calculated prior to the determination of line-haul service units. These are: (1) the average freight train speed, running; (2) the actual (route) mileage for the shipment; and (3) the number of intermediate yard switching events. The average freight train speed for the Burlington Northern has been calculated from data contained in Schedule 755 (Form OS-A) of BN's Annual R-1 Report. The actual route miles, involving circuitous and empty mileage, are calculated from the short line miles. The number of classification yard switches, referred to as intertrain/intratrain switches, are determined from the route train mileage and a distance interval between switches.

In addition to the three operating factors listed above, certain train performance factors must be calculated before road locomotive service units can be estimated and common train mile costs allocated to the various shipments within a train. These performance factors include the average number of locomotive units per train and the average trailing weight of the train (cars, contents, and caboose), and are derived from Schedule 755, by class of train.

Car-miles (running) are determined by multiplying the train miles by the number of cars in the shipment. Car-days (running) are calculated by dividing the car-miles (running) by the average train speed, and dividing by 24 to convert hours to days.

The road locomotive unit miles, by class of train, are determined by multiplying the average number of units per train by the applicable number of train miles. The shipment gross ton-miles, the remaining line-haul distance-related service unit, are comprised of two elements: (1) the gross ton-miles generated by the freight car, and (2) the gross ton-miles generated by the shipment. The gross ton-miles generated by the freight car, the tare ton miles (TARTM), are calculated as follows:

$$TARTM = TARE_{CT} \times TM$$

where:

$TARE_{CT}$ = Tare weight of the freight car used in tons

TM = Round trip train miles

The net ton miles associated with the lading are calculated by multiplying the net tons of the consignment by the loaded train miles.

The number of car-miles, car-days, and locomotive minutes consumed at intermediate yards are calculated by multiplying RFA engineering estimates by the number of intertrain switches. In addition to the mileage-related intertrain switches described previously, a switch at the junction point is also allowed. This switch is a substitute for the Rail Form A terminal switch which is normally allowed at origin.

The basic terminal (nondistance-related) service units consist of the number of carloads originated and terminated and the number of tons of freight consigned. Both are determined directly from the attributes of the shipment. As noted above, only one origin/termination switch is allowed. This is because the remaining switch has been accounted for in the on-line calculation.

In addition to the number of carloads and tons consigned, the car-days, car-miles, and locomotive switching minutes at origin and destination are calculated within the program. The locomotive minute service units are determined by multiplying the average switching minutes per car times the number of cars in the shipment, and then multiplying this value by the spotted-to-pulled ratio to account for both the switching of the empty car in and the loaded car out.

Car-days at origin/destination consist of two elements: (1) time spent switching (delivery and pickup by way-train), and (2) loading or unloading time. For car types which have a spotted-to-pulled ratio of 2.0, 4 car-days accrue at origin for a single car shipment, and 4 days at destination. The analogous figure for a boxcar is 3.8 days. These performance factors are based on ICC special studies, and are used in Rail Form A.

Car-miles switching at origin and destination are calculated by multiplying the RFA average per switch times the number of cars consigned. This value is then multiplied by the spotted-to-pulled ratio.

Once the disaggregate service units have been calculated for each of the three classes of service activities, these totals are aggregated for the shipment. Total car-days are the sum of: (1) car-days running, (2) car-days line-haul switching, and (3) car-days at origin/destination. Car-miles switching are aggregated in an analogous manner. Aggregate locomotive switching minutes are calculated similarly as the sum of the intermediate yard and origin/destination minutes.

A series of adjustments are built into the off-line procedure to account for the efficiencies associated with multiple-car and trainload handling. The methodology calls for a reduction of origin/destination switching minutes per car, based on a sliding scale of adjustment factors. This scale results in a 60 percent reduction from the single-car base for a 26-car shipment.

The number of car-days at origin and destination are reduced by 25 percent for multiple-car shipments. In addition, station clerical (billing) costs, in addition, are adjusted downward for multiple-car shipments by assuming that 25 percent of the costs are associated with the shipment (and are thus fixed per shipment), while 75 percent of the costs are associated with the number of carloads consigned.

In summary, off-line costs are estimated using a modified shipment costing algorithm. A more detailed explanation of this procedure will be provided in forthcoming reports in the Rail Services Planning Study.