PROCEEDINGS —

Twenty-second Annual Meeting

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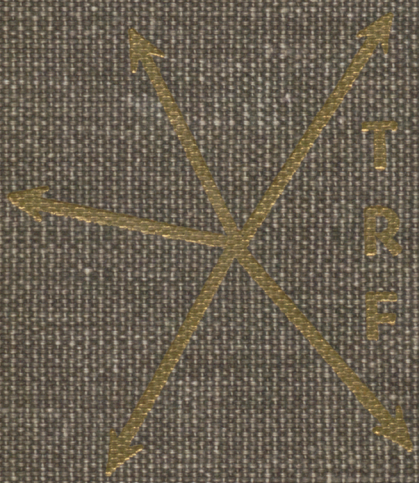

TRANSPORTATION RESEARCH FORUM

PROCEEDINGS —

Twenty-second Annual Meeting

Theme:

"Opportunities and Challenges in the New Environment of Transportation"

November 4-5-6, 1981
Golden Gateway Holiday Inn
San Francisco, California

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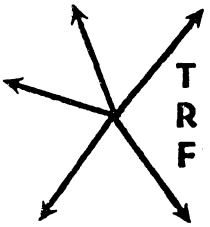

TRANSPORTATION RESEARCH FORUM

Applications of A Freight Network Model To the Analysis of Competitive Situations

by Robert C. Bushnell, Ph.D. and Edward S. Pearsall, Ph.D.***

INTRODUCTION

THE INTEGRATED Transportation Network Model (the model) is a computer implemented model useful for generating and evaluating the cost and time properties of overland shipping routes. It has been previously described (see references).

In general, the model will, for any of a number of commodity categories, generate a selection of routes over which it is reasonable to ship the commodity in question. These routes depend on link characteristics such as track condition, speed limits and grades, and on interchange characteristics such as intercompany compatibility and the availability of facilities like coal docks or grain elevators. The algorithm recognizes that routes for bulk commodities are higher time-cost, lower dollar-cost routes whereas the routes for finished manufactured products and especially containers, are more rapid but higher cost routings. The system can also generate TOFC and unit train routings which take into account the special needs of these movements.

As output the computer model produces the routings, the expected time of delivery and the over-the-rail cost. The model also includes an algorithm which generates the approximate applicable tariff. The model can utilize any defined network but currently it operates over a highly detailed network of the State of Michigan and a less detailed network for the U.S. and Canada with waterborne connections to the rest of the world.

The nature of the model structure permits network and parameter alteration to allow its use for both actual and projected situations.

The following elements may be changed in the course of use of the model:

1. Links, added, deleted, or disabled and their properties (distance, grade, speed limit) altered.
2. Nodes may be inserted, deleted or disabled and their properties changed (transfer times, inter-company relation, facility availability, port size and access).
3. Transportation company equipment and costs may be changed.
   a. Equipment may be changed or augmented in their characteristics: costs, life, capacity.
   b. Wage rates, fuel costs, interest rates, maintenance rates, etc. may be altered.
4. Different parts of the network can remain distinct or be assigned common ownership.

As a result, the model allows the examination of a wide variety of problems. In this paper we explain the use the model has had in exploring 10 applications which have been brought to our attention

Sample Output (Table 1)

Sample output from the interactive program appears in Table 1. The program prompts for what is to be input in (6I5) Format. In the example in Table 1, the user has replied by asking for information from place 70 (Syracuse) to place 330 (Savannah, Ga.) by two modes: 4 (Highway) and 5 (Rail), for commodity 3 (general cargo), product 20 (Miscellaneous Products). He has requested a maximum of 2 routes to be generated for each mode.

Three types of Output are produced: the Route listings, the Routes Analyses and the Detailed Costs Listing. The Routes listing shows the mode number and place name, the cumulative time, in days, for total transit time, for time in line haul and for delay time in year or load/unload. For each link, the speed in miles per hour, the cumulative distance in miles per hour and the road used are also shown.

The Route Analysis shows for each route all modes used, the expected and maximum days transit, the distance in miles, the computed cost and rate in cents per hundredweight and the fuel used in gallons per hundredweight.

The Costs listing displays the component costs for each mode. For highway segments separate costs are shown for each of up to three different methods of operation—owner operator, relay driver and (for long hauls) two-man sleeper

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TABLE 1

SAMPLE PROGRAM OUTPUT

```
INPUT:FROM TO MODE COMMODITY PRODUCT ROUTES
  70  330   45    3   20    2
  70  330   45    3   20    2

Origin Node: Syracuse, N.Y
Destination: Savannah, Ga.
Mode: Highway/Waterway Systems
Commodity Class: General Cargo
Number of Routes Found:  1

Route  1
```

Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
70	0.500	0.0	0.500	0.	0.0	Syracuse, N.Y.	At Origin
70	0.500	0.0	0.500	0.	1.00	Syracuse, N.Y.	On Highway
120	0.565	0.065	0.500	78.	50.00	Binghamton, N.Y.	On Interstate 81
131	0.614	0.114	0.500	137.	50.00	Scranton, Pa.	On Interstate 81
130	0.629	0.129	0.500	155.	50.00	Wilkes Barre, Pa.	On Penn. Turnpike
132	0.643	0.143	0.500	172.	50.00	Hazleton, Pa.	On Interstate 81
160	0.704	0.204	0.500	245.	50.00	Harrisburg, Pa.	On Interstate 81
170	0.767	0.267	0.500	320.	50.00	Baltimore, Md.	On Interstate 83
180	0.801	0.301	0.500	361.	50.00	Washington, D.C.	On Interstate 95
210	1.222	0.389	0.833	467.	50.00	Richmond, Va.	On Interstate 95
211	1.242	0.409	0.833	491.	50.00	Petersburg, Va.	On Interstate 95
235	1.312	0.479	0.833	575.	50.00	Rocky Mt., N.C.	On Interstate 95
233	1.354	0.521	0.833	625.	50.00	Smithfield, N.C.	On Interstate 95
234	1.417	0.583	0.833	700.	50.00	Lumberton, N.C.	On Interstate 95
300	1.464	0.631	0.833	757.	50.00	Florence, S.C.	On Interstate 95
311	1.522	0.688	0.833	826.	50.00	Rosinville, N.C.	On Interstate 95
330	1.944	0.777	1.167	933.	50.00	Savannah, Ga.	On Interstate 95
330	2.444	0.777	1.667	933.	1.00	Savannah, Ga.	At Destination

```
Origin Node: Syracuse, N.Y.
Destination: Savannah, Ga.
Mode: Railway/Waterway Systems
Commodity Class: General Cargo
Number of Routes Found:  2

Route  2
```

Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
70	0.500	0.0	0.500	0.	0.0	Syracuse, N.Y.	At Origin
70	0.833	0.0	0.833	0.	1.00	Syracuse, N.Y.	On Conrail System (PC)
61	1.374	0.207	1.167	149.	30.00	Selkirk, N.Y.	On Conrail System (PC)
142	1.558	0.392	1.167	282.	30.00	Hackensack, N.J.	On Conrail System (PC)
148	1.942	0.442	1.500	294.	10.00	Hoboken, N.J.	On Conrail System (PC)
141	2.292	0.458	1.833	302.	20.00	Newark, N.J.	On Conrail System (PC)
152	2.342	0.508	1.833	350.	40.00	Trenton, N.J.	On Conrail System (PC)
150	2.709	0.543	2.167	383.	40.00	Philadelphia, Pa.	On Conrail System (PC)
151	2.736	0.570	2.167	409.	40.00	Wilmington, Del	On Conrail System (PC)
170	3.142	0.642	2.500	478.	40.00	Baltimore, Md.	On Conrail System (PC)
180	3.184	0.684	2.500	519.	40.00	Washington, D.C.	On Conrail System (PC)
181	3.531	0.698	2.833	527.	25.00	Alexandria, Va.	On Conrail System (PC)
181	3.864	0.69*	3.167	527.	1.00	Alexandria, Va.	On Richmond, F'berg & Potomac (RF&P)
210	4.309	0.809	3.500	634.	40.00	Richmond, Va.	On Richmond, F'berg & Potomac (RF&P)
210	4.309	0.809	3.500	634.	1.00	Richmond, Va.	On Seaboard Coast Line (SCL)
211	4.666	0.833	3.833	657.	40.00	Petersburg, Va.	On Seaboard Coast Line (SCL)
231	5.081	0.914	4.167	735.	40.00	Norlina, N.C.	On Seaboard Coast Line (SCL)
230	5.473	0.973	4.500	791.	40.00	Raleigh Durham, N.C.	On Seaboard Coast Line (SCL)
232	5.941	1.107	4.833	888.	30.00	Hamlet, N.C.	On Seaboard Coast Line (SCL)
290	6.162	1.328	4.833	994.	20.00	Columbia, S.C.	On Seaboard Coast Line (SCL)
330	6.453	1.620	4.833	1134.	20.00	Savannah, Ga.	On Seaboard Coast Line (SCL)
330	7.953	1.620	6.333	1134.	1.00	Savannah, Ga.	At Destination

Route 3

Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
70	0.500	0.0	0.500	0.	0.0	Syracuse, N.Y.	At Origin
70	0.833	0.0	0.833	0.	1.00	Syracuse, N.Y.	On Conrail System (PC)
80	1.282	0.115	1.167	83.	30.00	Rochester, N.Y.	On Conrail System (PC)
90	1.687	0.187	1.500	143.	35.00	Buffalo, N.Y	On Conrail System (PC)
100	1.774	0.274	1.500	227.	40.00	Erie, Pa.	On Conrail System (PC)
688	1.816	0.316	1.500	267.	40.00	Ashtabula, Ohio	On Conrail System (PC)
680	2.205	0.372	1.833	321.	40.00	Cleveland, Ohio	On Conrail System (PC)
687	2.676	0.510	2.167	420.	30.00	Marion, Ohio	On Conrail System (PC)
630	3.136	0.636	2.500	511.	30.00	Dayton, Ohio	On Conrail System (PC)
620	3.541	0.707	2.833	571.	35.00	Cincinnati, Ohio	On Conrail System (PC)
620	3.874	0.707	3.167	571.	1.00	Cincinnati, Ohio	On Southern Railway (SOU)
830	3.988	0.821	3.167	653.	30.00	Lexington, Ky.	On Southern Railway (SOU)
480	4.888	1.388	3.500	925.	20.00	Chattanooga, Tenn.	On Southern Railway (SOU)
440	5.473	1.640	3.833	1076.	25.00	Atlanta, Ga.	On Southern Railway (SOU)
420	5.646	1.813	3.833	1159.	20.00	Macon, Ga.	On Southern Railway (SOU)
330	6.073	2.240	3.833	1364.	20.00	Savannah, Ga.	On Southern Railway (SOU)
330	7.573	2.240	5.333	1364.	1.00	Savannah, Ga.	At Destination

(Continued)

TABLE 1 (Cont'd)

SAMPLE PROGRAM OUTPUT

ALTERNATIVE ROUTES ANALYSIS

Origin Node: Syracuse, N.Y.
Destination: Savannah, Ga.
Commodity Class: General Cargo
Product Type: Miscellaneous Products

	Delivery Time (Days) Expected	Maximum	Distance Miles	Cost Ct/Cwt	Rate Ct/Cwt	Fuel Ga/Cwt	Equipment Rig/Car/Ship
Route 1							
Highway 1	2.44	3.44	933.	516.	799.	1.178	Standard 45-Foot Box
Highway 2	1.82	2.82	933.	421.	799.	1.178	Standard 45-Foot Box
Highway 3	0.78	1.78	933.	435.	799.	1.178	Standard 45-Foot Box
Total	1.82	2.82	933.	421.	799.	1.178	Split Percent: 38.5
Route 2							
Railroad	7.95	10.52	1134.	76.	331.	0.114	Standard Box Car
Total	7.95	10.52	1134.	76.	331.	0.114	Split Percent: 30.5
Route 3							
Railroad	7.57	9.94	1364.	76.	331.	0.117	Standard Box Car
Total	7.57	9.94	1364.	76.	331.	0.117	Split Percent: 30.9

Costs on Highway Segments (Owner-Operators)

	Fuel	Driver	Maint	Rig	Tires	Taxes	$Total	$Rate	$Marg	Per Truckload/Mile Tons	$Cost	$Rate	Fuel
Route 1	131.94	187.66	53.01	82.46	17.76	43.47	5.16	7.99	2.83	11.0	1.217	1.884	0.278

Costs on Highway Segments (Driver Relays)

	Fuel	Driver	Maint	Rig	Tires	Taxes	$Total	$Rate	$Marg	Per Truckload/Mile Tons	$Cost	$Rate	Fuel
Route 1	131.94	129.61	53.01	45.59	17.76	43.47	4.21	7.99	3.77	11.0	0.994	1.884	0.278

Costs on Highway Segments (Two-Man Teams)

	Fuel	Driver	Maint	Rig	Tires	Taxes	$Total	$Rate	$Marg	Per Truckload/Mile Tons	$Cost	$Rate	Fuel
Route 1	131.94	139.95	53.01	48.63	17.76	43.47	4.35	7.99	3.64	11.0	1.025	1.884	0.278

Costs on Railroad Segments

	Fuel	Crew	Track	Loco	Cars	Switch	$Total	$Rate	$Marg	Per Railcarload/Mile Tons	$Cost	$Rate	Fuel
Route 2	8.84	5.33	3.17	4.51	42.51	11.88	0.76	3.31	2.55	70.0	0.941	4.086	0.141
Route 3	9.24	6.42	2.75	5.88	41.26	10.48	0.76	3.31	2.55	70.0	0.780	3.397	0.120

cab operation. Costs in terms of cents and fraction of cents per hundred pounds for such costs as fuel, driver, maintenance, equipment, tires and taxes are shown on the left. The sum of these costs is shown as a total in dollars per hundredweight together with an algorithm generated revenue rate and the difference between rate and costs labeled "margin."

On the right, unit cost is shown in terms of vehicle (truck load, railcar load) together with per mile dollars of revenue generated and gallons per mile of fuel used. The individual cost items depend on the individual mode model. For rail, costs are fuel, crew cost, track maintenance, locomotive capital cost, car capital cost and switching cost. For waterborne movements, costs are fuel, crew, insurance, maintenance, general overhead and ship capital cost.

This particular example may be of special interest since it illustrates that competitive rail routes may be spatially quite diverse.

Application to the Competitive Position of Detroit as A North European Container Port (Table 2)

The first application concerns the position of Detroit, Michigan as a container port. Presently, there is no regular container ship service to Great Lakes Ports. A number of studies have tried to justify the establishment of a regular service. Recently, the Port Authority of Detroit utilized the model to undertake an investigation into the costs of shipping from Detroit to Europe via a number of modes. The model results for a number of shipping alternatives as presented by the Detroit/Wayne County Port Authority is shown in Table 2. All figures in the table are cost per hundredweight. It may be seen that the "land bridge" through Canada was the most advantageous. Interestingly, runs of the model revealed that the cheapest total cost resulted when the transfer to ocean-going container ships is carried out at Montreal rather than at Halifax. Even though the container ship must steam further, the railway savings justify the earlier transfer.

The costs of direct service from Detroit to North Europe were computed initially using ships of a size that could negotiate the Seaway were not large or fast enough to negotiate the ocean segments economically. However, imitating a procedure used for overseas shipment of grain, the computer model evaluated a Seaway shuttle service from Detroit to Montreal where transshipment to larger more efficient ocean-going container ships would be made. The con-

TABLE 2

CARRIER COSTS TO SHIP CONTAINERIZED MISCELLANEOUS PRODUCTS FROM DETROIT TO NORTHERN EUROPE

		Cost Per Hundredweight[1]			
	Transit Days	Existing Conditions	Doubled Fuel Prices	Lengthened Seaway Season	Doubled Fuel Prices and Lengthened Season
Rail/Ship (Montreal)	16	$2.20	$2.73	$2.20	$2.73
Rail/Ship (Newark)	16	2.28	2.85	2.28	2.85
Rail/Ship (Baltimore)	17	2.37	2.98	2.37	2.98
Feeder Ship (Montreal)	15.5[2]	2.44	2.93	2.19	2.68
Truck/Rail/Ship (Toronto/Montreal)	16	2.78	3.42	2.78	3.42
Direct Ship[3]	16	3.50	3.63	2.70	2.83

Source: Transportation Cost Network Model, WSU School of Business Administration.

1 Calculations represent variable costs and exclude fixed administrative overhead costs. Transshipment costs are also excluded.
2 Assumes ship calls only at Detroit and Montreal with 80% full containers on the lake segment.
3 Assumes 80% full containers, the load factor experienced by the Windsor Detroit Barge Line.

clusion was that if the volume at Detroit was sufficient, a container shuttle service to Montreal would be economical. As a result of this investigation, two groups are now active. One group supports the shuttle service, as suggested by the model. A second group is investigating the design of a ship specific and optimal for direct service.

Application to the Florida Meat Packing Industry (Table 3)

Until recently, beef calves bred and raised in Florida were sent to the Midwest for feeding, slaughter and processing. That part of the meat destined for Florida consumption was shipped from the processing location to Florida. The cost of fuel having increased, researchers at the University of Florida (with the use of the model) have investigated the possibility of establishing a cattle feeding and meat packing industry in Florida. The use of the model was to evaluate the transportation effect of the proposed change in the meat packing industry. The rail costs of exporting the live calves to the Midwest from Florida and shipping the reefered meat from the midwest to Florida was balanced against the cost of shipping grain by barge to Florida. Sample barge calculations are shown in Table 3.

The computer printout reveals that the waterway module does not include a provision for computing a maximum (stochastic) delivery time different from the (deterministic) expected time nor a revenue (rate) algorithm different from costs. Since the waterborn mode costs include a return on invested capital, $ rate is shown as $ cost.

Evaluating the Effects of a Rail Merger (Table 4)

The Grand Trunk Western Railroad is a U.S. subsidiary of the Canadian National Railroad. The question arose as to whether the Canadian "land bridge" route would become more competitive for container traffic from the U.S. Midwest and South after acquisition of the DT & I by the Grand Trunk Western.

Table 4 shows that a Grand Trunk Western routing can be competitive when considerations such as more frequent Montreal sailings and parameters such as time delay at Detroit, under the control of the railroad are taken into consideration.

Institution of Cross Lake (Truck) Ferry (Table 5)

The State of Michigan Department of

TABLE 3

ST. LOUIS TO TAMPA GRAIN BY BARGE

```
INPUT:FROM TO MODE COMMODITY PRODUCT ROUTES
1140  370    5    5    1    1
1140  370    5    5    1    1

Origin Node: St. Louis, Mo.
Destination: Tampa, Fla.
Mode: Railway/Waterway Systems
Commodity Class: Grain
Number of Routes Found:  1
```

Route 1 Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
1140	0.500	0.0	0.500	0.	0.0	St. Louis, Mo.	At Origin
1140	0.500	0.0	0.500	0.	1.00	St. Louis, Mo.	On Mississippi River and Tributaries
1380	8.745	7.745	1.000	1039.	1.00	New Orleans, La.	On Intracoastal Waterway (Gulf Coast)
1375	9.214	8.214	1.000	1120.	7.20	Gulfport, Miss.	On Intracoastal Waterway (Gulf Coast)
370	12.764	11.264	1.500	1647.	1.00	Tampa, Fla.	At Destination

ALTERNATIVE ROUTES ANALYSIS

```
Origin Node: St. Louis, Mo.
Destination: Tampa, Fla.
Commodity Class: Grain
Product Type: Farm Products, Field Crops
```

Route 1	Delivery Time (Days) Expected	Maximum	Distance Miles	Cost Ct/Cwt	Rate Ct/Cwt	Fuel Ga/Cwt	Equipment Rig/Car/Ship
Waterway	12.76	12.76	1647.	52.	52.	0.044	Super Barge Train and Tow
Total	12.76	12.76	1647.	52.	52.	0.044	Split Percent: 100.0

Route 1	Costs on Waterway Segments Fuel	Crew	Insur	Maint	Over	Ship	$Total	$Rate	$Marg	Per Bargeload/100 Miles KTons	$Cost	$Rate	Fuel
	7.01	11.94	3.39	2.06	0.0	26.74	0.52	0.52	0.0	8.0	0.504	0.504	0.043

TABLE 4

MEMPHIS TO NORTH EUROPE CONTAINER ROUTES

```
Origin Node: Memphis, Tenn
Destination: North Europe
Mode: Railway/Waterway Systems
Commodity Class: Containers
Number of Routes Found:  5
```

Route 1 Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
460	0.500	0.0	0.500	0.	0.0	Memphis, Tenn	At Origin
460	0.833	0.0	0.833	0.	1.00	Memphis, Tenn	On Southern Railway (SOU)
440	2.179	0.679	1.500	459.	25.00	Atlanta, Ga	On Southern Railway (SOU)
310	5.788	1.475	4.313	841.	1.00	Charleston, S.C	On Ocean
1840	14.243	8.618	5.625	5579.	27.64	North Europe	At Destination

Route 2 Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
460	0.500	0.0	0.500	0.	0.0	Memphis, Tenn.	At Origin
460	0.833	0.0	0.833	0.	1.00	Memphis, Tenn.	On Louisville and Nashville (L&N)
440	2.908	1.075	1.833	516.	20.00	Atlanta, Ga.	On Louisville and Nashville (L&N)
440	2.908	1.075	1.833	516.	1.00	Atlanta, Ga.	On Seaboard Coast Line (SCL)
231	4.556	1.722	2.833	996.	40.00	Norlina, N.C.	On Seaboard Coast Line (SCL)
220	7.626	1.981	5.646	1120.	1.00	Norfolk, Va.	On Ocean
1840	15.630	8.671	6.958	5558	27.64	North Europe	At Destination

(Continued)

TABLE 4 (Cont'd)

MEMPHIS TO NORTH EUROPE CONTAINER ROUTES

Route 3							
Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
460	0.500	0.0	0.500	0.	0.0	Memphis, Tenn.	At Origin
460	0.833	0.0	0.833	0.	1.00	Memphis, Tenn.	On Louisville and Nashville (L&N)
620	2.946	1.112	1.833	534.	20.00	Cincinnati, Ohio	On Louisville and Nashville (L&N)
620	3.168	1.112	2.056	534.	1.00	Cincinnati, Ohio	On Detroit, Toledo & Ironton (DT&I)
710	4.504	1.449	3.056	795.	1.00	Detroit, Mich.	On Grand Trunk Western (GT)
713	4.915	1.527	3.389	851.	30.00	Port Huron, Mich.	On Grand Trunk Western (GT)
713	4.915	1.527	3.389	851.	1.00	Port Huron, Mich.	On Canadian National (CN)
1720	6.742	2.020	4.722	1362.	45.00	Montreal, Canada	On Canadian National (CN)
1720	9.555	2.020	7.535	1362.	1.00	Montreal, Canada	On Ocean
1840	16.856	8.009	8.847	5334.	27.64	North Europe	At Destination

Route 4							
Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
460	0.500	0.0	0.500	0.	0.0	Memphis, Tenn.	At Origin
460	0.833	0.0	0.833	0.	1.00	Memphis, Tenn.	On Illinois Central Gulf (ICG)
770	1.954	0.787	1.167	473.	26.00	Chicago, Ill.	On Illinois Central Gulf (ICG)
770	2.954	0.787	2.167	473.	1.00	Chicago, Ill.	On Conrail System (PC)
40	6.874	2.041	4.833	1488.	35.00	Boston, Mass.	On Conrail System (PC)
40	9.353	2.041	7.313	1488.	1.00	Boston, Mass.	On Ocean
1840	16.799	8.174	8.625	5556.	27.64	North Europe	At Destination

Route 5							
Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
460	0.500	0.0	0.500	0.	0.0	Memphis, Tenn.	At Origin
460	0.833	0.0	0.833	0.	1.00	Memphis, Tenn.	On Missouri Pacific (MOPAC)
1144	1.618	0.451	1.167	379.	35.00	East St. Louis, Mo.	On Missouri Pacific (MOPAC)
1144	2.618	0.451	2.167	379.	1.00	East St. Louis, Mo.	On Conrail System (PC)
40	7.329	2.163	5.167	1593.	35.00	Boston, Mass.	On Conrail System (PC)
40	9.809	2.163	7.646	1593.	1.00	Boston, Mass.	On Ocean
1840	17.254	8.296	8.958	5661	27.64	North Europe	At Destination

ALTERNATIVE ROUTES ANALYSIS

Origin Node: Memphis, Tenn.
Destination: North Europe
Commodity Class: Containers
Product Type: Miscellaneous Products

	Delivery Time (Days) Expected	Maximum	Distance Miles	Cost Ct/Cwt	Rate Ct/Cwt	Fuel Ga/Cwt	Equipment Rig/Car/Ship
Route 1							
Railroad	5.79	7.86	841	73.	279	0.069	Flat Car Inc. COFC and TOFC
Ocean	8.45	8.45	4738.	168.	168	0.354	Super Ocean-Going Container Ship
Total	14.24	16.31	5579	241	447	0.423	Split Percent: 24.1
Route 2							
Railroad	7.63	10.00	1120.	97.	328.	0.096	Flat Car Inc. COFC and TOFC
Ocean	8.00	8.00	4438.	160.	160.	0.331	Super Ocean-Going Container Ship
Total	15.63	18.00	5558	257	489	0.428	Split Percent: 22.6
Route 3							
Railroad	9.55	12.29	1362.	125.	371	0.137	Flat Car Inc. COFC and TOFC
Ocean	7.31	7.31	3972.	148.	148	0.296	Super Ocean-Going Container Ship
Total	16.86	19.60	5334	273.	519	0.434	Split Percent: 22.4
Route 4							
Railroad	9.35	12.04	1488.	119.	393.	0.141	Flat Car Inc. COFC and TOFC
Ocean	7.45	7.45	4068.	147.	147.	0.304	Super Ocean-Going Container Ship
Total	16.80	19.49	5556	266	541	0.444	Split Percent: 15.3
Route 5							
Railroad	9.81	12.55	1593.	128.	393	0.156	Flat Car Inc. COFC and TOFC
Ocean	7.44	7.44	4068.	147.	147	0.304	Super Ocean-Going Container Ship
Total	17.25	19.99	5661	275	541	0.460	Split Percent: 15.6

Costs on Railroad Segments										Per Railcarload/Mile			
	Fuel	Crew	Track	Loco	Cars	Switch	$Total	$Rate	$Marg	Tons	$Cost	$Rate	Fuel
Route 1	5.37	3.96	2.90	3.01	50.97	6.86	0.73	2.79	2.06	60.0	1.042	3.978	0.098
Route 2	7.49	5.27	2.99	4.03	67.20	9.75	0.97	3.28	2.32	60.0	1.036	3.518	0.103
Route 3	10.51	6.41	3.83	4.95	84.04	15.12	1.25	3.71	2.46	60.0	1.100	3.269	0.121
Route 4	11.13	7.00	2.94	2.48	82.79	12.64	1.19	3.93	2.74	60.0	0.959	3.173	0.113
Route 5	12.50	7.49	3.29	4.58	86.92	13.05	1.28	3.93	2.66	60.0	0.963	2.964	0.118

Costs on Ocean Segments										Per Shipload/100 Miles			
	Fuel	Crew	Insur	Maint	Over	Ship	$Total	$Rate	$Marg	KTons	$Cost	$Rate	Fuel
Route 1	56.59	10.34	6.74	3.68	2.84	86.45	1.68	1.68	0.0	32.4	2.302	2.302	0.484
Route 2	53.01	9.85	6.48	3.54	2.73	83.16	1.60	1.60	0.0	32.4	2.343	2.343	0.484
Route 3	47.44	9.34	6.08	3.32	2.56	78.05	1.48	1.48	0.0	32.4	2.419	2.419	0.484
Route 4	48.59	9.13	5.95	3.25	2.50	76.32	1.47	1.47	0.0	32.4	2.345	2.345	0.484
Route 5	48.59	9.13	5.95	3.25	2.50	76.32	1.47	1.47	0.0	32.4	2.345	2.345	0.484

Transportation Division of Port Planning has recently had approved a plan for implementing regular cross Lake Michigan truck ferry service between Michigan and Wisconsin. As part of the planning this model was utilized to investigate the movements for which the new ferry service would be competitive. Table 5 shows an example of the output utilized. Since this is a rather simple

TABLE 5

CROSS-LAKE TRUCK FERRY

```
LOG ON AT 18:01:18 ON 06-28-81
#SOURCE -SOR(4)
# $RUN GDG7:RSLOAD O=GDG7:PARAMETERS.NM 1=-NODELIST.NM 2=-ROADNET.NM 3=-RAILNET.NM 4=-WATERNET.NM 5=*MSOURCE
#EXECUTION BEGINS
 LIST OF CONTROL OPTIONS
NO.   CONTROL OPTION
99    TERMINATE PROGRAM, RETURN CONTROL TO MTS
00    REPEAT LIST OF CONTROL OPTIONS
01    RUN ROUTE FINDING ALGORITHM
02    GENERATE NETWORK FROM DATA FILES
03    READ GENERATED NETWORK
04    SAVE GENERATED NETWORK
05    PRINT ORIGIN/DESTINATION LIST
06    PRINT MODE/ROUTE FILTER CODES
07    PRINT COMMODITIES LIST
08    PRINT PRODUCT CLASSIFICATIONS
09    PRINT CARRIERS LIST
10    DISPLAY PARAMETERS FILE
11    DISPLAY PLACES FILE
12    DISPLAY HIGHWAYS FILE
13    DISPLAY RAILWAYS FILE
14    DISPLAY WATERWAYS FILE
15    INQUIRE PLACE
16    INQUIRE CARRIER
17    ABRIDGE/UNABRIDGE ROUTES DISPLAY
18    TERMINAL/STORED FILE OUTPUT SWITCH

 INPUT CONTROL OPTION NUMBER
03
 INPUT CONTROL OPTION NUMBER
01
 INPUT:FROM TO MODE COMMODITY PRODUCT ROUTES
6617  850    1    3   20    1
6617  850    1    3   20    1

Origin Node: MIDLAND          MIDL
Destination: Oshkosh, Wis.
Mode: Highway System
Commodity Class: General Cargo
Number of Routes Found:  1

Route   1
Node     Time   Travel   Delay    Dist.   Speed   Place Name                Carrier or System
6617    0.500    0.0     0.500      0.     0.0    MIDLAND          MIDL     At Origin
6617    0.500    0.0     0.500      0.     1.00   MIDLAND          MIDL     On Highway
4730    0.506    0.006   0.500      6.    45.00   DICE CORNER      MIDL     On MICHIGAN ROADS
6628    0.526    0.026   0.500     27.    43.00   MT PLEASANT      ISAB     On MICHIGAN ROADS
6349    0.547    0.047   0.500     46.    38.00   REMUS            MECO     On MICHIGAN ROADS
3638    0.559    0.059   0.500     58.    42.00   JCT M21/M13      SHIA     On MICHIGAN ROADS
3637    0.564    0.064   0.500     64.    45.00   *LAKEVIEW        MT.C     On MICHIGAN ROADS
3604    0.577    0.077   0.500     78.    45.00                             On MICHIGAN ROADS
3589    0.587    0.087   0.500     91.    58.00   CEDAR SPRINGS    KENT     On MICHIGAN ROADS
3558    0.598    0.098   0.500    103.    44.00   &CASNOVIA        MUSK     On MICHIGAN ROADS
4629    0.610    0.110   0.500    116.    45.00                             On MICHIGAN ROADS
6294    0.620    0.120   0.500    126.    40.00   MUSKEGON         MUSK     On MICHIGAN ROADS
 840    0.620    0.120   0.500    126.    15.00   Milwaukee, Wis.           On CROSSLAKE FERRY
 850    0.692    0.192   0.500    212.    50.00   Oshkosh, Wis.             On U.S. Route 41
 850    1.192    0.192   1.000    212.     1.00   Oshkosh, Wis.             At Destination

                    ALTERNATIVE ROUTES ANALYSIS

Origin Node: MIDLAND          MIDL
Destination: Oshkosh, Wis.
Commodity Class: General Cargo
Product Type: Miscellaneous Products

                 Delivery Time (Days)   Distance    Cost      Rate      Fuel      Equipment
Route   1         Expected   Maximum      Miles     Ct/Cwt    Ct/Cwt    Ga/Cwt    Rig/Car/Ship
  Highway 1         1.19       2.19       212.      138.      358.     0.267   Standard 45-Foot Box
  Highway 2         1.15       2.15       212.      123.      358.     0.267   Standard 45-Foot Box
     Total          1.15       2.15       212.      123.      358.     0.267   Split Percent: 100.0

        Costs on Highway Segments (Owner-Operators)                                Per Truckload/Mile
          Fuel Driver  Maint     Rig  Tires  Taxes  $Total $Rate  $Marg            Tons  $Cost  $Rate   Fuel
Route 1   29.94 48.86  12.03   33.67   4.03   9.86   1.38   3.58   2.19            11.0  1.438  3.718  0.278

        Costs on Highway Segments (Driver Relays)                                  Per Truckload/Mile
          Fuel Driver  Maint     Rig  Tires  Taxes  $Total $Rate  $Marg            Tons  $Cost  $Rate   Fuel
Route 1   29.94 48.86  12.03   18.62   4.03   9.86   1.23   3.58   2.34            11.0  1.282  3.718  0.278
```

(Continued)

TABLE 5 (Cont'd)

CROSS-LAKE TRUCK FERRY

```
 INPUT CONTROL OPTION NUMBER
 Attention interrupt at 2A9C0A
#   $2.82,   $4.58T
#ED -ROADNET.NM
:A 1548    'C'
:   1548      C 6294. 840  1     .1 15.  CROSSLAKE FERRY
:$RES

 INPUT CONTROL OPTION NUMBER
02
  2634  NUMBER OF NETWORK NODES
  3926  NUMBER OF HIGHWAY LINKS
  5286  NUMBER OF RAILWAY LINKS
  1530  NUMBER OF WATERWAY LINKS
  2458  NUMBER OF INTERMODAL LINKS

 INPUT CONTROL OPTION NUMBER
01

 INPUT:FROM TO MODE COMMODITY PRODUCT ROUTES
 6617  850     1    3   20     1
 6617  850     1    3   20     1

 Origin Node: MIDLAND          MIDL
 Destination: Oshkosh, Wis.
 Mode: Highway System
 Commodity Class: General Cargo
 Number of Routes Found:  1

 Route  1
 Node   Time   Travel  Delay    Dist.   Speed   Place Name              Carrier or System
 6617  0.500   0.0     0.500      0.     0.0    MIDLAND          MIDL  At Origin
 6617  0.500   0.0     0.500      0.     1.00   MIDLAND          MIDL  On Highway
 3441  0.508   0.008   0.500      9.    49.00                           On MICHIGAN ROADS
 3706  0.518   0.018   0.500     19.    40.00   JCT M52/M46      SAGI  On MICHIGAN ROADS
 3946  0.527   0.027   0.500     28.    41.00   ST. CHARLES      SAGI  On MICHIGAN ROADS
 3718  0.534   0.034   0.500     35.    45.00   &CHESANING       SAGI  On MICHIGAN ROADS
 4786  0.541   0.041   0.500     42.    45.00   NEW HAVEN        SHIA  On MICHIGAN ROADS
 6435  0.547   0.047   0.500     49.    40.00   OWOSSO           SHIA  On MICHIGAN ROADS
 3693  0.559   0.059   0.500     61.    43.00   JCT M52/I69      SHIA  On MICHIGAN ROADS
 3547  0.564   0.064   0.500     69.    57.00                           On MICHIGAN ROADS
 6420  0.575   0.075   0.500     79.    43.00   LANSING          INGH  On MICHIGAN ROADS
 3831  0.582   0.082   0.500     87.    42.00   JCT I69/M27      EATO  On MICHIGAN ROADS
 3832  0.587   0.087   0.500     93.    49.00   &POTTERVILLE     EATO  On MICHIGAN ROADS
 6360  0.592   0.092   0.500     98.    46.00   CHARLOTTE        EATO  On MICHIGAN ROADS
 3841  0.605   0.105   0.500    112.    44.00   BELLVUE          EATO  On MICHIGAN ROADS
 4117  0.611   0.111   0.500    118.    44.00   JCT M78/M66      CALH  On MICHIGAN ROADS
 6086  0.619   0.119   0.500    126.    43.00   BATTLE CREEK     CALH  On MICHIGAN ROADS
 4464  0.635   0.135   0.500    144.    46.00   *SHERWOOD        BRAN  On MICHIGAN ROADS
 4294  0.641   0.141   0.500    151.    49.00   LEONIDAS         ST.J  On MICHIGAN ROADS
 6073  0.645   0.145   0.500    156.    47.00   MENDON           ST.J  On MICHIGAN ROADS
 6061  0.656   0.156   0.500    168.    49.00   THREE RIVERS     ST.J  On MICHIGAN ROADS
 6065  0.668   0.168   0.500    181.    42.00   WHITE PIGEON     ST.J  On MICHIGAN ROADS
  760  0.681   0.181   0.500    194.    44.00   South Bend, Ind.       On MICHIGAN ROADS
  773  0.723   0.223   0.500    245.    50.00   Gary, Ind.             On Interstate 90
  770  0.752   0.252   0.500    279.    50.00   Chicago, Ill.          On Interstate 90
  840  0.824   0.324   0.500    366.    50.00   Milwaukee, Wis.        On Interstate 94
  850  1.229   0.396   0.833    452.    50.00   Oshkosh, Wis.          On U.S. Route 41
  850  1.729   0.396   1.333    452.     1.00   Oshkosh, Wis.          At Destination

                          ALTERNATIVE ROUTES ANALYSIS

 Origin Node: MIDLAND          MIDL
 Destination: Oshkosh, Wis.
 Commodity Class: General Cargo
 Product Type: Miscellaneous Products

                 Delivery Time (Days)  Distance   Cost     Rate     Fuel     Equipment
                  Expected  Maximum      Miles    Ct/Cwt   Ct/Cwt   Ga/Cwt   Rig/Car/Ship
 Route  1
    Highway 1       1.73      2.73       452.     261.     503.     0.571   Standard 45-Foot Box
    Highway 2       1.40      2.40       452.     210.     503.     0.571   Standard 45-Foot Box
       Total        1.40      2.40       452.     210.     503.     0.571   Split Percent: 100.0

            Costs on Highway Segments (Owner-Operators)                      Per Truckload/Mile
              Fuel  Driver  Maint    Rig  Tires  Taxes  $Total  $Rate  $Marg    Tons  $Cost  $Rate   Fuel
 Route  1    63.93  90.83  25.69  50.68   8.61  21.06   2.61   5.03   2.42     11.0  1.270  2.448  0.278

            Costs on Highway Segments (Driver Relays)                        Per Truckload/Mile
              Fuel  Driver  Maint    Rig  Tires  Taxes  $Total  $Rate  $Marg    Tons  $Cost  $Rate   Fuel
 Route  1    63.93  62.81  25.69  28.02   8.61  21.06   2.10   5.03   2.93     11.0  1.022  2.448  0.278
```

application, the complete computer output, before, with alteration and after, is shown in Table 5. A link has been added to the "Roadnet" file which is the Crosslake ferry. The model is run with the new link in place. The link is then disabled by the convention of placing a character in the first position of a line in the file to be ignored. The program is then restarted, a new (internal) network generated (without the link) and the same origin-destination pair run. As may be seen (and could have been expected) the time and cost differ significantly. It is to be noted that the "cost" with the crosslake link does not include the toll or charge which must be added by hand.

Abandonment of Cross Lake (Rail) Ferry (Table 6)

The Chessie System recently petitioned for abandonment of the Manitowoc-Luddington rail ferry service. In preparing its opposition to the petition, the State of Michigan used the model to examine the alternatives for shippers presently using the service. Some of the results derived are shown in Table 6. As can be seen, some of the traffic would be able to utilize an alternative cross-lake ferry to Frankfort whereas other traffic was diverted completely outside of Michigan.

Only Routes 4 and 5 are reproduced together with the Complete Alternative Routes Analysis and Costs. Route 1 was via CNW Conrail (through Chicago Elkhart) Route 2 via CNW & Chessie (through Chicago, Fostoria), Route 3 via CNW and N & W (through Chicago and Fort Wayne). The Route 4 detail may be of interest since it shows yard detail as the shipment moves through the Detroit Metropolitan yard complex.

Rail Abandonment — North West Region of Michigan (Table 7)

In any case of rail line abandonment, the question arises as to the remaining shipping alternatives after abandonment. In any such consideration, regard must be taken of the circuity or availability of service following abandonment. For this particular study, a large number of individual examples have been considered. A single typical example is shown in Table 7. This is an interesting example since according to the model, the alternative, although more costly, is a shorter route. Although individual routes of this sort can be derived by hand, the advantage of computer use is that a wider variety of alternatives may be generated quickly.

In the example given in Table 7, we consider deleting from the network all Chessie links in the Northwestern portion of Michigan's lower peninsula north of Manistee. This includes 58 miles of track from Manistee north to Traverse City, 30 miles north along the west shore of Traverse Bay to Northport and 78 miles north from Traverse City to Petosky (and also a 9 mile span from Williamsburg to Elk Rapids). Of the communities formerly served, only Manistee (Chessie), Thompsonville (Ann Arbor Rail Road) Petosky (Michigan Northern) and Traverse City (Michigan Northern) would retain any rail service. In the table, the model has been run from Traverse City to Midland, Michigan both with and without the Chessie track.

Specific Route Analysis (Table 9)

The competitive situation on any corridor may be assessed by means of the model. For example, the model the output shown in Table 9 concerns TOFC shipments from Detroit to Atlanta. A similar analysis can be provided for any or all modes between selected city pairs for a variety of products. While not definitive, such reports do provide first cut information on the alternatives present in the market.

Shipper Negotiation of Tariff and Car Rentals with Carriers

Prior to deregulation, there was no incentive for shippers to be concerned about the routings actually taken by carriers. Now, however, with deregulation an announced goal of the ICC, it behooves large shippers to know the carrier's business as well as their own. A major oil company is considering using the model as a bargaining tool with its carriers. They reason that carriers with less expensive routes can afford to give them a better rate than carriers with more expensive routes. Another company, a major chemical company, has a fleet of tank cars which both are used for transporting their products and also are rented out to the railroads so that the cars need not sustain unproductive backhauls. The rental the company receives is related to the miles traveled. Hithertofore the railroads have quoted and paid only the short-line rail mileages even when the actual miles traveled were much more circuitous. Hence, the chemical company receives less rental revenue than it would were its cars routed more directly and expeditiously toward their destination. Hithertofore, since the possible locations to which cars may be routed are so various and the using railroads

TABLE 6

CROSS-LAKE RAIL MOVEMENTS AFTER MANITOWOC — LUDDINGTON ABANDONMENT

Route 4

Node	Time	Travel	Delay	Dist.	Speed	Place Name		Carrier or System
860	0.500	0.0	0.500	0.	0.0	Wausau, Wis.		At Origin
860	1.500	0.0	1.500	0.	1.00	Wausau, Wis.		On Chicago & Northwestern (C&NW)
853	2.021	0.188	1.833	90.	20.00	Green Bay, Wis.		On Chicago & Northwestern (C&NW)
851	2.091	0.257	1.833	132.	25.00	Appleton, Wis.		On Chicago & Northwestern (C&NW)
850	2.448	0.281	2.167	149.	30.00	Oshkosh, Wis.		On Chicago & Northwestern (C&NW)
840	2.906	0.406	2.500	239.	30.00	Milwaukee, Wis.		On Chicago & Northwestern (C&NW)
770	3.345	0.512	2.833	315.	30.00	Chicago, Ill.		On Chicago & Northwestern (C&NW)
770	4.678	0.845	3.833	323.	1.00	Chicago, Ill.		On Grand Trunk Western (GT)
760	5.105	0.939	4.167	413.	40.00	South Bend, Ind.		On Grand Trunk Western (GT)
6039	5.160	0.994	4.167	459.	35.00	SCHOOLCRAFT	KALA	On Grand Trunk Western (GT)
6074	5.166	0.999	4.167	464.	35.00	VICKSBURG	KALA	On Grand Trunk Western (GT)
6080	5.172	1.005	4.167	469.	35.00	PAVILION	KALA	On Grand Trunk Western (GT)
6086	5.195	1.028	4.167	488.	35.00	BATTLE CREEK	CALH	On Grand Trunk Western (GT)
6360	5.226	1.059	4.167	514.	35.00	CHARLOTTE	EATO	On Grand Trunk Western (GT)
6420	5.247	1.080	4.167	532.	35.00	LANSING	INGH	On Grand Trunk Western (GT)
6422	5.251	1.084	4.167	535.	35.00	TROWBRIDGE	INGH	On Grand Trunk Western (GT)
6438	5.286	1.120	4.167	565.	35.00	DURAND	SHIA	On Grand Trunk Western (GT)
6477	5.310	1.144	4.167	585.	35.00	HOLLY	OAKL	On Grand Trunk Western (GT)
6492	5.419	1.252	4.167	598.	5.00	WATERFORD	OAKL	On Grand Trunk Western (GT)
6502	5.427	1.260	4.167	605.	35.00	PONTIAC	OAKL	On Grand Trunk Western (GT)
6499	5.438	1.271	4.167	614.	35.00	BIRMINGHAM	OAKL	On Grand Trunk Western (GT)
6498	5.444	1.277	4.167	619.	35.00	ROYAL OAK	OAKL	On Grand Trunk Western (GT)
6238	5.455	1.289	4.167	629.	35.00	HIGHLAND PARK	WAYN	On Grand Trunk Western (GT)
6235	5.505	1.339	4.167	635.	5.00	MILWAUKEE JCT	WAYN	On Grand Trunk Western (GT)
7321	5.547	1.380	4.167	640.	5.00	BAY CITY JCT	WAYN	On Grand Trunk Western (GT)
6234	5.555	1.389	4.167	641.	5.00	WEST DETROIT	WAYN	On Grand Trunk Western (GT)
6233	5.580	1.414	4.167	644.	5.00	DELRAY (JCT)	WAYN	On Grand Trunk Western (GT)
6226	5.597	1.430	4.167	646.	5.00	ECORSE JCT	WAYN	On Grand Trunk Western (GT)
6209	5.697	1.530	4.167	658.	5.00	TRENTON	WAYN	On Grand Trunk Western (GT)
6207	5.710	1.543	4.167	664.	20.00	ROCKWOOD (DTSR)	WAYN	On Grand Trunk Western (GT)
6205	5.720	1.553	4.167	669.	20.00	NEWPORT	MONR	On Grand Trunk Western (GT)
6202	5.728	1.562	4.167	673.	20.00	WARNER	MONR	On Grand Trunk Western (GT)
6201	5.735	1.568	4.167	676.	20.00	MONROE	MONR	On Grand Trunk Western (GT)
6198	5.755	1.589	4.167	686.	20.00	VIENNA	MONR	On Grand Trunk Western (GT)
6197	5.760	1.593	4.167	688.	20.00	WHITING	MONR	On Grand Trunk Western (GT)
700	6.114	1.614	4.500	698.	20.00	Toledo, Ohio		On Grand Trunk Western (GT)
700	6.614	1.614	5.000	698.	1.00	Toledo, Ohio		At Destination

Route 5

Node	Time	Travel	Delay	Dist.	Speed	Place Name		Carrier or System
860	0.500	0.0	0.500	0.	0.0	Wausau, Wis.		At Origin
860	1.500	0.0	1.500	0.	1.00	Wausau, Wis.		On Chicago & Northwestern (C&NW)
853	2.021	0.188	1.833	90.	20.00	Green Bay, Wis.		On Chicago & Northwestern (C&NW)
852	2.081	0.247	1.833	126.	25.00	Manitowoc, Wis.		On Chicago & Northwestern (C&NW)
852	3.081	0.247	2.833	126.	1.00	Manitowoc, Wis.		On Ann Arbor (AA)
6674	3.303	0.470	2.833	206.	15.00	FRANKFORT	BENZ	On Ann Arbor (AA)
6669	3.364	0.531	2.833	228.	15.00	THOMPSONVILLE	BENZ	On Ann Arbor (AA)
6181	4.059	1.225	2.833	478.	15.00	FEDERMAN	MONR	On Ann Arbor (AA)
700	4.445	1.278	3.167	497.	15.00	Toledo, Ohio		On Ann Arbor (AA)
700	4.945	1.278	3.667	497.	1.00	Toledo, Ohio		At Destination

ALTERNATIVE ROUTES ANALYSIS

Origin Node: Wausau, Wis.
Destination: Toledo, Ohio
Commodity Class: General Cargo
Product Type: Miscellaneous Products

	Delivery Time (Days) Expected	Maximum	Distance Miles	Cost Ct/Cwt	Rate Ct/Cwt	Fuel Ga/Cwt	Equipment Rig/Car/Ship
Route 1							
Railroad	5.80	8.09	549.	48.	205.	0.051	Standard Box Car
Total	5.80	8.09	549	48.	205.	0.051	Split Percent: 18.4
Route 2							
Railroad	6.16	8.45	605.	51.	205.	0.058	Standard Box Car
Total	6.16	8.45	605.	51.	205.	0.058	Split Percent: 19.2
Route 3							
Railroad	6.15	8.44	571.	51.	205.	0.052	Standard Box Car
Total	6.15	8.44	571.	51.	205.	0.052	Split Percent: 19.2
Route 4							
Railroad	6.61	8.91	698.	56.	205.	0.063	Standard Box Car
Total	6.61	8.91	698.	56.	205.	0.063	Split Percent: 20.0
Route 5							
Railroad	4.94	6.93	497.	38.	205.	0.025	Standard Box Car
Total	4.94	6.93	497.	38.	205.	0.025	Split Percent: 23.2

	Costs on Railroad Segments Fuel	Crew	Track	Loco	Cars	Switch	$Total	$Rate	$Marg	Per Railcarload/Mile Tons	$Cost	$Rate	Fue
Route 1	3.54	2.58	2.14	1.18	30.20	8.35	0.48	2.05	1.57	70.0	1.224	5.235	0.12
Route 2	4.17	2.85	2.25	1.49	32.16	8.35	0.51	2.05	1.54	70.0	1.186	4.750	0.13
Route 3	3.66	2.69	2.89	1.47	31.99	8.35	0.51	2.05	1.54	70.0	1.252	5.033	0.12
Route 4	4.61	3.28	2.79	1.93	34.66	8.35	0.56	2.05	1.50	70.0	1.116	4.118	0.12
Route 5	1.72	2.34	1.93	1.40	25.85	4.45	0.38	2.05	1.68	70.0	1.062	5.783	0.07

TABLE 7

NORTHWEST MICHIGAN RAIL ABANDONMENT

```
INPUT:FROM TO MODE COMMODITY PRODUCT ROUTES
6695 6617    8    3   20    1
6695 6617    8    3   20    1

Origin Node: TRAVERSE CITY   GRAN          (EXAMPLE:  COMPLETE NETWORK IN PLACE)
Destination: MIDLAND         MIDL
Mode: Railway/Waterway Systems
Commodity Class: General Cargo
Number of Routes Found:  1
```

Route 1

Node	Time	Travel	Delay	Dist.	Speed	Place Name		Carrier or System
6695	0.500	0.0	0.500	0.	0.0	TRAVERSE CITY	GRAN	At Origin
6695	1.500	0.0	1.500	0.	1.00	TRAVERSE CITY	GRAN	On CHESAPEAKE AND OHIO
6669	1.641	0.141	1.500	27.	8.00	THOMPSONVILLE	BENZ	On CHESAPEAKE AND OHIO
6651	1.750	0.250	1.500	48	8.00	ONEKAMA JCT	MANI	On CHESAPEAKE AND OHIO
6650	1.792	0.292	1.500	56.	8.00	PARKDALE	MANI	On CHESAPEAKE AND OHIO
6649	1.802	0.302	1.500	58.	8.00	MANISTEE	MANI	On CHESAPEAKE AND OHIO
6645	1.828	0.328	1.500	63.	8.00	STRONACH	MANI	On CHESAPEAKE AND OHIO
6635	1.938	0.438	1.500	84.	8.00	WALHALLA	MASO	On CHESAPEAKE AND OHIO
6637	1.965	0.465	1.500	97.	20.00	BALDWIN	LAKE	On CHESAPEAKE AND OHIO
6656	2.002	0.502	1.500	115.	20.00	REED CITY	OSCE	On CHESAPEAKE AND OHIO
6679	2.029	0.529	1.500	128.	20.00	EVART	OSCE	On CHESAPEAKE AND OHIO
6631	2.073	0.573	1.500	149.	20.00	FARWELL	CLAR	On CHESAPEAKE AND OHIO
6630	2.083	0.583	1.500	154.	20.00	CLARE	CLAR	On CHESAPEAKE AND OHIO
6621	2.119	0.619	1.500	171	20.00	COLEMAN	MIDL	On CHESAPEAKE AND OHIO
6617	2.160	0.660	1.500	191.	20.00	MIDLAND	MIDL	On CHESAPEAKE AND OHIO
6617	3.660	0.660	3.000	191.	1.00	MIDLAND	MIDL	At Destination

ALTERNATIVE ROUTES ANALYSIS

	Delivery Time (Days) Expected	Maximum	Distance Miles	Cost Ct/Cwt	Rate Ct/Cwt	Fuel Ga/Cwt	Equipment Rig/Car/Ship
Route 1							
Railroad	3.66	5.48	191.	24.	130.	0.011	Standard Box Car
Total	3.66	5.48	191.	24.	130.	0.011	Split Percent: 100.0

	Costs on Railroad Segments									Per Railcarload/Mile			
	Fuel	Crew	Track	Loco	Cars	Switch	$Total	$Rate	$Marg	Tons	$Cost	$Rate	Fuel
Route 1	0.70	0.90	0.52	0.82	18.64	2.67	0.24	1.30	1.06	70.0	1.777	9.558	0.083

```
INPUT:FROM TO MODE COMMODITY PRODUCT ROUTES
6695 6617    8    3   20    1
6695 6617    8    3   20    1

Origin Node: TRAVERSE CITY   GRAN          (EXAMPLE:  NORTHWEST CHESSIE LINKS DELETED)
Destination: MIDLAND         MIDL
Mode: Railway/Waterway Systems
Commodity Class: General Cargo
Number of Routes Found:  1
```

Route 1

Node	Time	Travel	Delay	Dist.	Speed	Place Name		Carrier or System
6695	0.500	0.0	0.500	0.	0.0	TRAVERSE CITY	GRAN	At Origin
6695	1.500	0.0	1.500	0.	1.00	TRAVERSE CITY	GRAN	On MICHIGAN NORTHERN
6691	1.717	0.217	1.500	26.	5.00	WALTON JCT	GRAN	On MICHIGAN NORTHERN
6689	1.858	0.358	1.500	43.	5.00	MISSAUKEE JCT	WEXF	On MICHIGAN NORTHERN
6661	1.892	0.392	1.500	47.	5.00	CADILLAC	WEXF	On MICHIGAN NORTHERN
6656	2.150	0.650	1.500	78.	5.00	REED CITY	OSCE	On MICHIGAN NORTHERN
6656	3.150	0.650	2.500	78.	1.00	REED CITY	OSCE	On CHESAPEAKE AND OHIO
6679	3.177	0.677	2.500	91.	20.00	EVART	OSCE	On CHESAPEAKE AND OHIO
6631	3.221	0.721	2.500	112.	20.00	FARWELL	CLAR	On CHESAPEAKE AND OHIO
6630	3.231	0.731	2.500	117.	20.00	CLARE	CLAR	On CHESAPEAKE AND OHIO
6621	3.267	0.767	2.500	134.	20.00	COLEMAN	MIDL	On CHESAPEAKE AND OHIO
6617	3.308	0.808	2.500	154.	20.00	MIDLAND	MIDL	On CHESAPEAKE AND OHIO
6617	4.808	0.808	4.000	154.	1.00	MIDLAND	MIDL	At Destination

ALTERNATIVE ROUTES ANALYSIS

	Delivery Time (Days) Expected	Maximum	Distance Miles	Cost Ct/Cwt	Rate Ct/Cwt	Fuel Ga/Cwt	Equipment Rig/Car/Ship
Route 1							
Railroad	4.81	6.88	154.	29.	120.	0.009	Standard Box Car
Total	4.81	6.88	154.	29.	120.	0.009	Split Percent: 100.0

	Costs on Railroad Segments									Per Railcarload/Mile			
	Fuel	Crew	Track	Loco	Cars	Switch	$Total	$Rate	$Marg	Tons	$Cost	$Rate	Fuel
Route 1	0.47	0.72	0.42	0.62	24.22	2.67	0.29	1.20	0.91	70.0	2.048	10.883	0.081

TABLE 8

UNIT TRAIN ROUTINGS

Origin Node: Billings, Mont.
Destination: Detroit, Mich.
Mode: Railway (Unit Trains)/Waterway Systems
Commodity Class: Coal
Number of Routes Found: 5

Route 1

Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
950	0.500	0.0	0.500	0.	0.0	Billings, Mont	At Origin
950	1.167	0.0	1.167	0.	1.00	Billings, Mont	On Burlington Northern (BN)
770	4.964	2.130	2.833	1495.	30.00	Chicago, Ill.	On Burlington Northern (BN)
770	5.964	2.130	3.833	1495.	1.00	Chicago, Ill.	On Chessie System (C&O)
710	7.703	2.537	5.167	1832.	35.00	Detroit, Mich.	On Chessie System (C&O)
710	8.203	2.537	5.667	1832.	1.00	Detroit, Mich.	At Destination

Route 2

Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
950	0.500	0.0	0.500	0.	0.0	Billings, Mont.	At Origin
950	1.167	0.0	1.167	0.	1.00	Billings, Mont.	On Burlington Northern (BN)
1110	4.548	1.715	2.833	1196.	30.00	Kansas City, Mo.	On Burlington Northern (BN)
1110	4.882	1.715	3.167	1196.	1.00	Kansas City, Mo.	On Norfolk & Western (N&W)
710	6.758	2.591	4.167	1932.	35.00	Detroit, Mich.	On Norfolk & Western (N&W)
710	7.258	2.591	4.667	1932.	1.00	Detroit, Mich.	At Destination

Route 3

Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
950	0.500	0.0	0.500	0.	0.0	Billings, Mont.	At Origin
950	1.167	0.0	1.167	0.	1.00	Billings, Mont	On Burlington Northern (BN)
770	4.964	2.130	2.833	1495.	30.00	Chicago, Ill.	On Burlington Northern (BN)
770	6.297	2.464	3.833	1503.	1.00	Chicago, Ill.	On Grand Trunk Western (GT)
710	7.947	2.780	5.167	1807.	40.00	Detroit, Mich.	On Grand Trunk Western (GT)
710	8.447	2.780	5.667	1807	1.00	Detroit Mich	At Destination

Route 4

Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
950	0.500	0.0	0.500	0.	0.0	Billings, Mont.	At Origin
950	1.167	0.0	1.167	0.	1.00	Billings, Mont	On Burlington Northern (BN)
870	3.552	1.386	2.167	906.	30.00	Duluth, Minn	On Burlington Northern (BN)
870	5.219	1.386	3.833	906.	1.00	Duluth, Minn.	On Great Lakes/St. Lawrence (Laker)
723	6.488	2.655	3.833	1345.	10.88	De Tour, Mich.	On Great Lakes/St Lawrence (Laker)
710	8.852	3.518	4.333	1631	14.97	Detroit Mich	At Destination

Route 5

Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
950	0.500	0.0	0.500	0.	0.0	Billings, Mont	At Origin
950	1.167	0.0	1.167	0.	1.00	Billings, Mont	On Burlington Northern (BN)
770	4.964	2.130	2.833	1495.	30.00	Chicago, Ill	On Burlington Northern (BN)
770	6.630	2.797	3.833	1511.	1.00	Chicago, Ill.	On Conrail System (PC)
710	7.660	3.160	4.500	1812.	35.00	Detroit, Mich.	On Conrail System (PC)
710	8.160	3.160	5.000	1812.	1.00	Detroit, Mich	At Destination

ALTERNATIVE ROUTES ANALYSIS

Origin Node: Billings, Mont.
Destination: Detroit, Mich.
Commodity Class: Coal
Product Type: Coal

	Delivery Time (Days) Expected	Maximum	Distance Miles	Cost Ct/Cwt	Rate Ct/Cwt	Fuel Ga/Cwt	Equipment Rig/Car/Ship	
Route 1								
Railroad	8.20	10.64	1832.	75.	119.	0.149	Hopper	
Total	8.20	10.64	1832.	75.	119.	0.149	Split Percent:	17.3
Route 2								
Railroad	7.26	9.48	1932.	75.	119.	0.161	Hopper	
Total	7.26	9.48	1932.	75.	119.	0.161	Split Percent:	20.2
Route 3								
Railroad	8.45	10.88	1807.	75.	119.	0.150	Hopper	
Total	8.45	10.88	1807.	75.	119.	0.150	Split Percent:	17.4
Route 4								
Railroad	5.22	7.21	906.	41.	77.	0.065	Hopper	
Gt. Lakes	3.63	3.63	725.	32.	32.	0.017	Super Great Lakes Bulk Carrier	
Total	8.85	10.84	1631.	73.	109.	0.082	Split Percent:	27.7
Route 5								
Railroad	8.16	10.45	1812.	73.	119.	0.144	Hopper	
Total	8.16	10.45	1812.	73.	119.	0.144	Split Percent:	17.5

Costs on Railroad Segments

	Fuel	Crew	Track	Loco	Cars	Switch	$Total	$Rate	$Marg
Route 1	12.45	8.62	5.29	6.96	34.01	7.58	0.75	1.19	0.44
Route 2	13.64	9.09	5.61	9.08	30.70	7.34	0.75	1.19	0.43
Route 3	12.58	8.50	5.44	6.38	34.87	7.58	0.75	1.19	0.43
Route 4	5.31	4.26	2.24	3.52	21.13	4.36	0.41	0.77	0.36
Route 5	12.14	8.52	5.33	5.75	33.82	7.09	0.73	1.19	0.46

Per Railcarload/Mile

	Tons	$Cost	$Rate	Fuel
Route 1	100.0	0.818	1.295	0.162
Route 2	100.0	0.781	1.228	0.167
Route 3	100.0	0.833	1.312	0.166
Route 4	100.0	0.901	1.689	0.143
Route 5	100.0	0.802	1.309	0.159

Costs on Great Lakes/Seaway Segments

	Fuel	Crew	Insur	Maint	Dver	Ship	$Total	$Rate	$Marg
Route 4	2.77	2.05	0.0	1.85	0.88	24.47	0.32	0.32	0.0

Per Shipload/100 Miles

	KTons	$Cost	$Rate	Fuel
	55.0	4.906	4.906	0.262

TABLE 9

DETROIT - ATLANTA TOFC

```
INPUT:FROM TO MODE COMMODITY PRODUCT ROUTES
  710  440    9    7    20      5
  710  440    9    7    20      5

Origin Node: Detroit, Mich.
Destination: Atlanta, Ga.
Mode: Highway/Railway Systems
Commodity Class: TOFC
Number of Routes Found:  5
```

Route 1

Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
710	0.500	0.0	0.500	0.	0.0	Detroit, Mich.	At Origin
710	0.500	0.0	0.500	0.	1.00	Detroit, Mich.	On Highway
710	1.000	0.0	1.000	0.	1.00	Detroit, Mich.	At TOFC Facility
690	1.512	0.179	1.333	129.	30.00	Lima, Ohio	On Detroit, Toledo & Ironton (DT&I)
620	2.336	0.336	2.000	261.	35.00	Cincinnati, Ohio	On Detroit, Toledo & Ironton (DT&I)
620	2.559	0.336	2.222	261.	1.00	Cincinnati, Ohio	On Southern Railway (SOU)
440	4.157	1.269	2.889	766.	25.00	Atlanta, Ga.	On Southern Railway (SOU)
440	4.657	1.269	3.389	766.	1.00	Atlanta, Ga.	At TOFC Facility
440	4.657	1.269	3.389	766.	1.00	Atlanta, Ga.	On Highway
440	5.157	1.269	3.889	766.	1.00	Atlanta, Ga.	At Destination

Route 2

Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
710	0.500	0.0	0.500	0.	0.0	Detroit, Mich.	At Origin
710	0.500	0.0	0.500	0.	1.00	Detroit, Mich.	On Highway
710	1.000	0.0	1.000	0.	1.00	Detroit, Mich.	At TOFC Facility
711	1.363	0.030	1.333	25.	35.00	Plymouth, Mich.	On Chessie System (C&O)
522	3.870	0.870	3.000	599.	1.00	Elkhorn City, Ky.	On Clinchfield (CRR)
281	4.660	1.327	3.333	873.	1.00	Spartanburg, S.C.	On Seaboard Coast Line (SCL)
440	5.299	1.633	3.667	1093.	30.00	Atlanta, Ga.	On Seaboard Coast Line (SCL)
440	5.799	1.633	4.167	1093.	1.00	Atlanta, Ga.	At TOFC Facility
440	5.799	1.633	4.167	1093.	1.00	Atlanta, Ga.	On Highway
440	6.299	1.633	4.667	1093.	1.00	Atlanta, Ga.	At Destination

Route 3

Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
710	0.500	0.0	0.500	0.	0.0	Detroit, Mich.	At Origin
710	0.500	0.0	0.500	0.	1.00	Detroit, Mich.	On Highway
710	1.000	0.0	1.000	0.	1.00	Detroit, Mich.	At TOFC Facility
690	1.512	0.179	1.333	129.	30.00	Lima, Ohio	On Detroit, Toledo & Ironton (DT&I)
620	2.336	0.336	2.000	261.	35.00	Cincinnati, Ohio	On Detroit, Toledo & Ironton (DT&I)
620	2.559	0.336	2.222	261.	1.00	Cincinnati, Ohio	On Louisville and Nashville (L&N)
440	4.244	1.355	2.889	750.	20.00	Atlanta, Ga.	On Louisville and Nashville (L&N)
440	4.744	1.355	3.389	750.	1.00	Atlanta, Ga.	At TOFC Facility
440	4.744	1.355	3.389	750.	1.00	Atlanta, Ga.	On Highway
440	5.244	1.355	3.889	750.	1.00	Atlanta, Ga.	At Destination

Route 4

Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
710	0.500	0.0	0.500	0.	0.0	Detroit, Mich.	At Origin
710	0.500	0.0	0.500	0.	1.00	Detroit, Mich.	On Highway
710	1.000	0.0	1.000	0.	1.00	Detroit, Mich.	At TOFC Facility
711	1.363	0.030	1.333	25.	35.00	Plymouth, Mich.	On Chessie System (C&O)
620	3.051	0.385	2.667	308.	35.00	Cincinnati, Ohio	On Chessie System (C&O)
620	3.274	0.385	2.889	308.	1.00	Cincinnati, Ohio	On Louisville and Nashville (L&N)
440	4.959	1.403	3.556	797.	20.00	Atlanta, Ga.	On Louisville and Nashville (L&N)
440	5.459	1.403	4.056	797.	1.00	Atlanta, Ga.	At TOFC Facility
440	5.459	1.403	4.056	797.	1.00	Atlanta, Ga.	On Highway
440	5.959	1.403	4.556	797.	1.00	Atlanta, Ga.	At Destination

Route 5

Node	Time	Travel	Delay	Dist.	Speed	Place Name	Carrier or System
710	0.500	0.0	0.500	0.	0.0	Detroit, Mich.	At Origin
710	0.500	0.0	0.500	0.	1.00	Detroit, Mich.	On Highway
710	1.000	0.0	1.000	0.	1.00	Detroit, Mich	At TOFC Facility
700	1.414	0.081	1.333	58.	30.00	Toledo, Ohio	On Norfolk & Western (N&W)
620	3.497	0.497	3.000	409.	35.00	Cincinnati, Ohio	On Norfolk & Western (N&W)
620	3.719	0.497	3.222	409.	1.00	Cincinnati, Ohio	On Southern Railway (SOU)
440	5.318	1.429	3.889	914.	25.00	Atlanta, Ga.	On Southern Railway (SOU)
440	5.818	1.429	4.389	914.	1.00	Atlanta, Ga.	At TOFC Facility
440	5.818	1.429	4.389	914.	1.00	Atlanta, Ga.	On Highway
440	6.318	1.429	4.889	914.	1.00	Atlanta, Ga.	At Destination

(Continued)

TABLE 9 (Cont'd)

DETROIT - ATLANTA TOFC

ALTERNATIVE ROUTES ANALYSIS

Origin Node: Detroit, Mich.
Destination: Atlanta, Ga.
Commodity Class: TOFC
Product Type: Miscellaneous Products

	Delivery Time (Days) Expected	Maximum	Distance Miles	Cost Ct/Cwt	Rate Ct/Cwt	Fuel Ga/Cwt	Equipment Rig/Car/Ship
Route 1							
Railroad	5.16	6.88	766.	60.	260.	0.070	Flat Car Inc. COFC and TOFC
Total	5.16	6.88	766.	60.	260.	0.070	Split Percent: 17.1
Route 2							
Railroad	6.30	8.29	1093.	76.	260.	0.094	Flat Car Inc. COFC and TOFC
Total	6.30	8.29	1093.	76.	260.	0.094	Split Percent: 23.9
Route 3							
Railroad	5.24	6.96	750.	61.	260.	0.068	Flat Car Inc. COFC and TOFC
Total	5.24	6.96	750.	61.	260.	0.068	Split Percent: 17.1
Route 4							
Railroad	5.96	7.86	797.	69.	260.	0.074	Flat Car Inc. COFC and TOFC
Total	5.96	7.86	797.	69.	260.	0.074	Split Percent: 16.6
Route 5							
Railroad	6.32	8.31	914.	76.	260.	0.088	Flat Car Inc. COFC and TOFC
Total	6.32	8.31	914.	76.	260.	0.088	Split Percent: 25.2

	Costs on Railroad Segments									Per Railcarload/Mile			
	Fuel	Crew	Track	Loco	Cars	Switch	$Total	$Rate	$Marg	Tons	$Cost	$Rate	Fuel
Route 1	5.02	3.60	1.65	2.42	37.14	10.60	0.60	2.60	2.00	60.0	0.947	4.081	0.110
Route 2	7.34	5.14	2.70	3.96	47.72	8.89	0.76	2.60	1.85	60.0	0.832	2.860	0.103
Route 3	4.80	3.53	1.72	2.83	37.81	10.60	0.61	2.60	1.99	60.0	0.981	4.168	0.108
Route 4	5.26	3.75	1.49	3.29	43.92	11.42	0.69	2.60	1.91	60.0	1.041	3.922	0.111
Route 5	6.45	4.30	1.84	4.15	47.29	11.82	0.76	2.60	1.85	60.0	0.997	3.420	0.115

so numerous, they have not felt it advantageous to attempt to second guess the railroads. Now, however, it is hoped that by use of the model the revenue due from actual mileage traveled by the rental cars may be recovered.

Use of the Model with Car Location Message Systems

In recent years, Car Location Message (CLM) systems provide a means whereby shippers can keep track of their cars by receiving CLM notifications from railroad company computer systems regarding the receipt of their cars at railroad yards. The railroads encourage the systems since potentially it relieves them of car tracing. Many large rail customers now have systems which track their cars. A useful implementation must do more than simply track a car's progress, however; it must include information about where the car should next appear and when it may be expected. Large users with standard routings can provide such information to their computers in a rather straight forward way. However, for computer companies hoping to process such information for many small companies, linking this model to their car locator software allows them to evaluate the next appearance of a car against a computer generated expected time.

In short, this model of car routings, costs and times has proved to be a valuable working tool for generating and evaluating alternative routes and their properties.

REFERENCES

1. Bushnell, Robert C., James T. Low, Edward S. Pearsall, James B. Wiley and others, *Final Report: Future Transportation Systems of the Great Lakes Region: Energy and Economics.*
   Vol 1: Executive Summary
   Vol 2: Transportation Systems of the Great Lakes Region
   Vol 3: The Integrated Network Model: Methodology and Description
   Vol 4: The Integrated Network Model: Programs and Procedures
   Vol 5: Supplemental Reports
   Wayne State University School of Business Administration, Detroit, various dates, 1979-1980.
2. Bushnell, Robert C., James T. Low, Edward S. Pearsall and Richard Smith, *An Integrated Computer Model for Analyzing Modal Shifts Due to Changes in Costs and Conditions,* School of Business Administration, Wayne State University,

Detroit, Michigan, paper presented at TIMS/ORSA Joint National Meeting, May 1, 1979.

3. Bushnell, Robert C., James T. Low and Edward S. Pearsall, "Simulating the Impact of Changes in a Statewide Freight System," in *Proceedings of* 1980 *Winter Simulation Conference,* Institute of Electrical and Electronics Engineers, New York, 1980, pp. 51-59.
4. Cornelius, John L., Eric O. Fornell, Leon P. Hammond and Douglas F. Thompson, *An Assessment of Transportation Advantages in the Port of Detroit.* A report to the Detroit/Wayne County Port Authority, December 19, 1980, 21 pages.