

was 3751 min (Table 1); the average departure delay time per train was 208 min. The 18 trains moved 1332 cars. The average delay time per car caused by delayed departure was 221 min. The total conflict delay time amounted to 684 min, or a 38-min delay per train, which is 90 percent higher than the low of 20 min/train in alternative 1. It is also slightly higher than the 36 min/train in the existing yard design. The bottleneck in alternative 2 is the point at which the classification track leads merge at the crossover at the departure tracks. This bottleneck causes considerable difficulty for the trim engines.

The west side of the departure yard was not modeled in the simulated design. However, additional conflict delay is certain to arise if both sides of the departure yard are used, because the crossover tracks will be blocked for certain lengths of time by trains being readied for departure (i.e., coupled and air-tested) and during departure.

Split train makeups were observed in the activity logs of the computer-simulated design that showed overflows at several one-side-only departure tracks and the need for additional track space.

In alternative 2, the trim engines moved 1567 cars from the classification tracks to the departure tracks. As in alternative 1, more cars could have been moved if additional assignments had been made to the trim engine left idle from 2115 to the end of the simulation at 2400.

EVALUATION OF ALTERNATIVES

Clearly, the existing yard design shows the poorest performance among the three alternatives in that it handles the least number of trains in a day (17 trains) and creates the longest delay (264 min/train; see Table 1). Alternative 1 shows the best performance among the three: It handles 19 trains with the least delay (199 min/train); the two trim engines move the largest number of cars (1597 cars versus 1567 cars in alternative 2); and departing trains leave with a total of 1456 cars. This total exceeds the number of cars on departing trains

by 124 in alternative 2 and by 245 cars in the existing yard design.

In general, the difference between the extended classification-track design (alternative 1) and the crossover design (alternative 2) is not significant under the given traffic demand. It is conceivable that under higher traffic demand levels, alternative 1 will perform significantly better than will alternative 2 because the crossover tracks may frequently be blocked, causing delay for trimming operations.

CONCLUSIONS

The simulation model CONFLICT was developed and applied to a real-world problem and proved to be an extremely powerful tool for evaluating trim-end designs. The use of CONFLICT is not limited to design evaluation, however. The model is also considered a useful tool for evaluating operational methods at the trim end and outbound schedules.

ACKNOWLEDGMENT

This research was performed under a contract with the Transportation Systems Center (TSC) of the U.S. Department of Transportation. John Hopkins of TSC was the technical monitor. The sponsor was the Office of Freight Systems, Federal Railroad Administration (FRA); William F. Cracker was the FRA program manager.

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Publication of this paper sponsored by Committee on Railroad Operations Management.

CAPACITY: Model for Estimating Rail Yard Capacity and Resource Requirements

W. A. STOCK, M. SAKASITA, M. A. HACKWORTH, P. J. WONG, D. B. KORETZ, AND V. V. MUDHOLKAR

The estimation of a rail yard's capacity and resource requirements is a key task in the overall yard design process. A model for estimating yard capacity and resource requirements, CAPACITY, is presented. It is capable of working from planning-level or actual observed traffic data. This model is a microscopic table-driven simulation. It requires a minimum of computer resources and is intended to be used by the yard designer in an iterative and interactive manner. The model provides the designer with an extensive series of output reports that detail the yard's performance, capacity, and resource requirements. The application of the model in a real-world yard rehabilitation study of the Boston and Maine Railroad's East Deerfield Yard is discussed. By using the CAPACITY model, this study concluded that the proposed design for the East Deerfield Yard could handle the contemplated traffic load.

The estimation of a rail yard's capacity and re-

source requirements is a key task in overall yard design; it relates to almost all other tasks in the design process. In particular, it affects and is affected by (a) the analysis of alternative sites, (b) the economic analysis, (c) the hump profile design, and (d) the yard throat (trim-end) design. The results of these four major tasks not only affect the analysis of the capacity and resource requirements but also usually make it necessary to iterate the entire study process.

This paper briefly describes a computer-assisted method for estimating yard capacity and resource requirements and the application of the method to a real-world problem. The conceptual approach of the

method simulates traffic movements in the yard by recording the event occurrence times and the number of cars accumulated on each track. This method is codified in a computer model called CAPACITY. The purpose of the CAPACITY model is to provide the yard designer with an interactive computer tool that can ease the work performed in the evaluation process of yard capacity and resource requirements. The CAPACITY model was developed as part of a yard design methodology study sponsored by the Federal Railroad Administration (FRA). Details regarding the model can be found in the final report of that study (1). As part of this effort, CAPACITY was applied in a rehabilitation study of the Boston and Maine Railroad's East Deerfield Yard. The portion of the East Deerfield study on yard capacity and resource requirements will be discussed here from the viewpoint of the CAPACITY model. Again, more-detailed information can be found elsewhere (2,3). The model has also been applied to studies on other railroads, including Chicago and North Western; Consolidated Rail Corporation (Conrail); Richmond, Fredericksburg, and Potomac; and Union Pacific.

MODEL DESCRIPTION

CAPACITY is a deterministic computer simulation model that traces the building, movement, and departure of trains, blocks, and cars in the various portions of the rail yard. Since the emphasis in CAPACITY is on the yard design more than on the yard operations, some of the yard operating rules are simplified. The result of this approach is that CAPACITY is a very economical model that can be run repeatedly at low cost.

The model is designed to run from planning-level data. To this end, detailed consists from every arriving train need not be given; rather, trains may be classified into consist mix groups, in which consists are given on a percentage basis. Process control parameters, such as rate of humping, are required; but to make the model simple to use, all such parameters have internal defaults. Only the identities of the blocks taken by departing trains need be specified; the model actually builds the blocks for the departing trains.

CAPACITY simulates queuing within the yard that might result from the scarcity of certain resources, such as the hump, hump engine or engines, trim engine or engines, and inspection crews. However, because the model is intended primarily for the designer, it creates receiving, classification, and departure tracks as the traffic demand requires; the number and lengths of these created tracks are reported as part of the output.

CAPACITY represents the block movements in the yard following a given set of rules. The basic flowchart of the model is given in Figure 1. Note in particular the sequential structure of the program. The lack of loops, particularly between the front-end and back-end simulations, greatly aids efficiency.

CAPACITY is generally run for three days, starting from an empty yard. Experience with numerous runs of the model indicates that a steady-state condition is normally reached by the end of the second day (assuming that the yard is not oversaturated). At the user's option, results for the warm-up days need not be printed.

CAPACITY optionally allows the user to specify dual receiving yards, dual lead humps, dual class yards, and dual departure yards. These are nominally designated in the model as east (E) and west (W); however, these designations are entirely arbitrary. When the user has only a single rather than a dual facility, references to that facility are con-

sistently entered as E or W.

Figure 2 shows the maximum overall yard system as simulated in CAPACITY. (In examining Figure 2, it should be kept in mind that any or all of the dual E and W facilities may be collapsed into a single facility.) The flow of traffic, as simulated in CAPACITY, moves from left to right across this figure. The exact operational procedures in each of the boxes in Figure 2 may differ from yard to yard. CAPACITY deals with this problem by accepting variable time lengths for each simulated operation within the boxes and across the entire yard. The operational functions are then chronologically linked as shown in Figure 2. Essentially, the computer model represents car movements in the yard by following the sequence of operations. CAPACITY optionally allows the user to specify crew break periods for the yard. However, pieces of work are not interrupted for the scheduled crew breaks. For example, the crew working the hump will finish humping a train and then take the required crew break in its entirety. It is also assumed that all engine movements--i.e., movements to the engine house, yardings of trains, buggy movements, engine turnaround, and so on--are uninterrupted by external activities.

The simulation of the yard is divided into front-end and back-end simulations. The front-end simulation includes that portion of Figure 2 from "Arriving Trains" through "Hump". A simplified flowchart of the front-end processing is given in Figure 3. Trains arrive and may skip inspection or the entire receiving yard (e.g., rehumps). The trains being inspected must wait for this service; next they must be queued to be humped. If the yard has dual hump leads and the train is being humped to both the E and W classification yards (spray train), an additional delay may occur since only one of the humps can be active in such a circumstance. At user discretion, a further hump delay may also be assessed against each train to simulate moves not otherwise accounted for in the model.

CAPACITY allows the user to designate certain blocks as preclassified bypass blocks. These blocks go directly from the receiving yard to the departure yard, bypassing the hump and storage on the classification tracks. Instead, these blocks are effectively stored on the departure tracks. Unless a departing train soon takes these bypass blocks, such a scheme can constitute an inefficient use of the departure tracks, which considerably increases the track requirements there.

The back-end simulation extends from "Classification Yard" through "Departing Trains" (or "Class Yard Clears") in Figure 2. A simplified flowchart of this process is given in Figure 4. Not shown in the flowchart are several user options that may be invoked. If the classification yard is becoming filled, the user may designate early-trim moves, which remove blocks of cars from the class yard to the departure yard to await a departing train whose makeup occurs much later. Like bypass-block moves, these early-trim moves can increase departure yard track requirements. As an aid to simulating re-switching and the departure of trains directly from the classification yard (e.g., local turns), the user may designate departing trains as classification yard clears, which depart directly from the classification yard, bypassing the departure yard and departure inspection.

The net accumulation of cars on the classification tracks is computed during the back-end simulation by subtracting the cars trimmed from the cumulative car arrivals computed during the front-end simulation (see Figure 5). The net accumulation of cars on any classification track is given by the height of the shaded area in Figure 5; the area be-

tween the curves is the car hours. CAPACITY optionally allows the user to specify a track length for each block on the classification tracks. When this length is exceeded, the model interprets this event as implying that an extra track of the same length will be available to store the block. The model assumes that as many tracks as are required to

store the block will be made available. During the trimming and departure yard simulation, additional pulls will be made for each track on which the block is stored until all the cars in the block have been placed on the departing train or until an optional user-specified car limit for that block on the departing train has been attained (whichever occurs first). This train length is also used by the model to compute an approximate number of departure tracks required for the block.

Finally, it is important to note the unidirectional flow indicated in Figure 2; reswitching, such as rehumping, is not simulated directly by the model. This approach is in keeping with the planning-level emphasis of the model; it also permits the model to run at a negligible computer cost (e.g., \$2-\$3/run), so that it can be used in an iterative and interactive manner. However, reswitching moves can be easily handled by using a manual process whereby a rehumping move is entered into the model as a classification yard clear followed by an arriving train that bypasses the receiving yard. In real-life applications of the model, reswitchings have been readily simulated in this manner. CAPACITY contains optional features that the user can invoke to facilitate this process.

INPUT OF CAPACITY MODEL

Six types of input data are required to run the model:

1. Yard geometry,
2. Yard operations,
3. Crew staffing,
4. Arriving trains,
5. Classification-yard assignment, and
6. Departing trains.

These input types are described briefly below.

Yard Geometry

The inputs regarding yard geometry consist of the number of receiving yards, the number of classification yards, and the number of departure yards. Detailed yard geometric characteristics, such as number of tracks, are not included.

Yard Operations

Various parameters related to yard operations are used in the computations. The model user can either input the most appropriate values of these param-

Figure 1. Flowchart of CAPACITY.

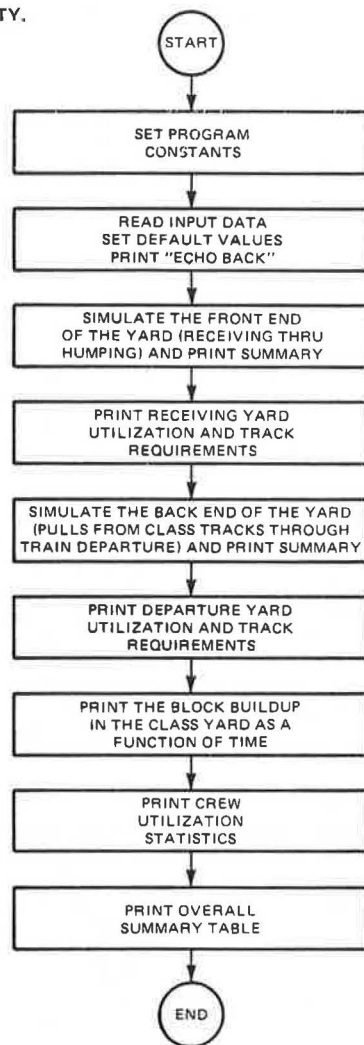


Figure 2. Classification yard system as simulated by CAPACITY model.

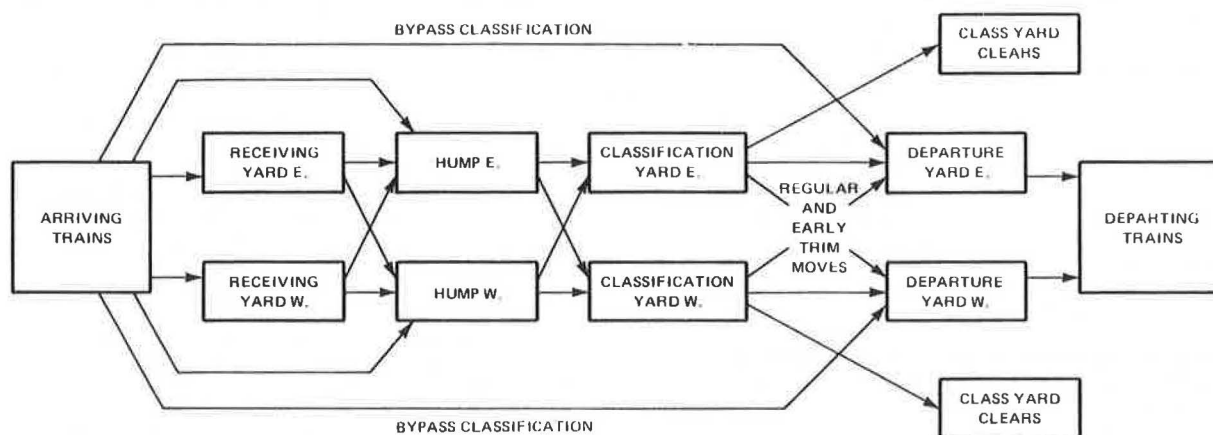
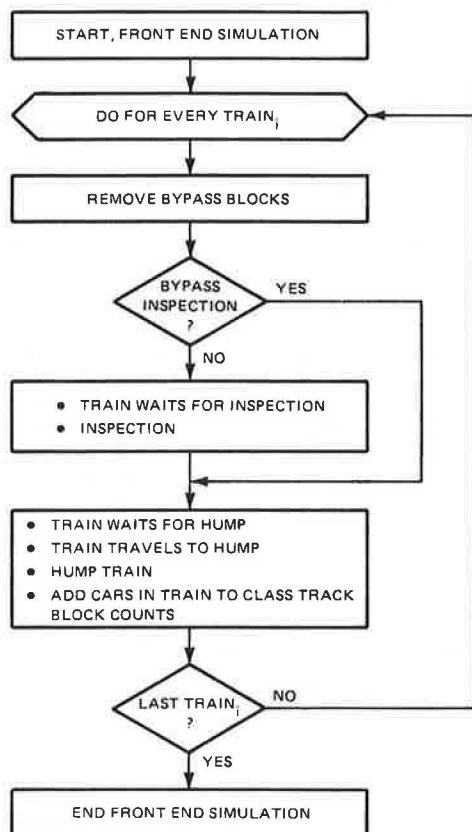


Figure 3. Simplified processing of arrival trains.



eters or use default values that are preset in the computer program. These parameters include

1. Times required to perform inspections (min/car),
2. Rate of humping (cars/min),
3. Loss time between humping two trains (min),
4. Time needed to couple cars at classification track (min/car), and
5. Travel times between various subyards (min).

Crew Staffing

CAPACITY traces individual yard crews. Trains will sometimes have to queue to wait for a crew. Some of the key parameters associated with crewing are the crew type (e.g., inspection, hump engine, etc.); the yard direction the crew works (E or W), if restricted; and the crew's break periods.

Arriving Trains

No default values are included for arriving trains. The key arrival train parameters include the train identification (I.D.) and arrival time. In addition, the input data define the number of cars in each arriving train and the block consist pattern independently. This permits several arriving trains to have the same block mix in a percentage sense, which reduces input requirements. From these two types of data, the program computes the number of cars for each block type in each train.

Classification-Yard Assignment

The data required to specify the classification yard assignments include, for each classification yard

Figure 4. Simplified processing of departure trains.

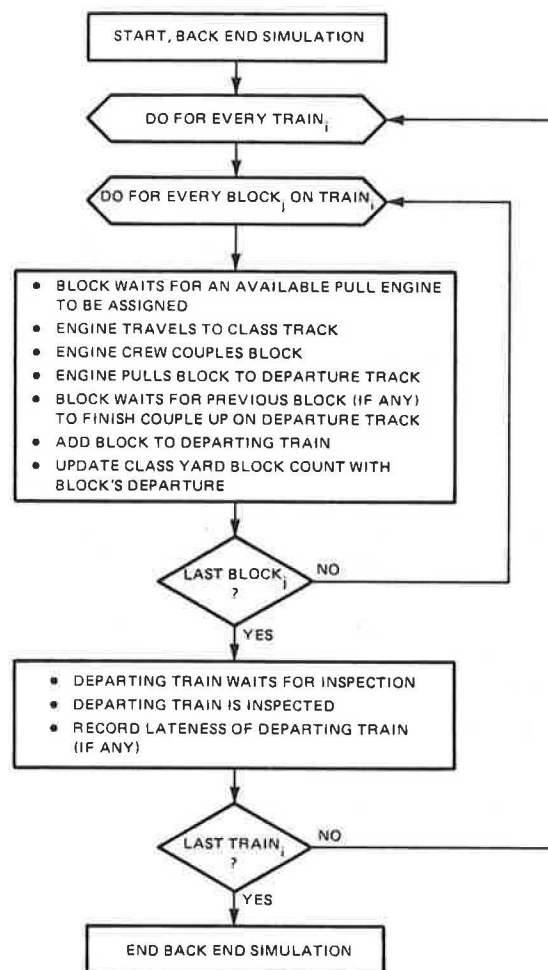
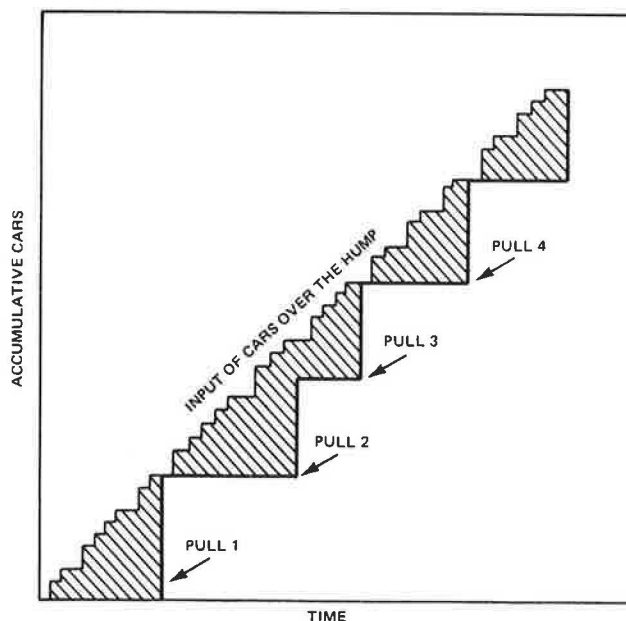


Figure 5. Example of accumulation on one classification track.



direction, the block I.D.'s stored there and optional classification track lengths.

Departing Trains

The information to specify the departing train patterns includes, for each train I.D., the cut-off time period, the scheduled departure time, the block carried (in order of pull), and the departure yard (E or W) in which the train is made up.

OUTPUT OF MODEL

The output from CAPACITY consists of six parts. The first part is an echo-back of the input data divided into the six input categories discussed above. The second part is the arrival train history, which shows the receiving yard occupancy and the hump use. This output presents a summary of the history of the use of each subyard. Both numerical (Figure 6) and graphical outputs are given. From these outputs it is possible to estimate the required number of receiving tracks and their lengths.

The third part of the output is a numerical output of the trim-end simulation, analogous to that shown for the front end in Figure 6. Here all the activities of the trim engines and events associated with building departing trains are reported. Also included as part of this output is a diagram of departure yard track occupancy and requirements.

The fourth part of the output is the block build-up scenario in the classification yard (Figure 7). This output, which presents the accumulation of cars of each block over time, is useful in estimating the required number of classification tracks and their

lengths. Here the lengths of the classification tracks are defined as a user input. The required number of tracks is computed from the maximum number of cars accumulated for each block and the track length.

The fifth part of the output is a report of the crew and engine use. This information is presented in both numerical and graphical forms.

The sixth part of the output is a summary of the average overall detention times of cars in the yard. This shows clearly the overall yard performance and is thus one of the most important single measures of effectiveness.

APPLICATION OF MODEL TO EAST DEERFIELD YARD

The CAPACITY model was used in the evaluation of yard capacity and resource requirements for the East Deerfield Yard rehabilitation study for the Boston and Maine Railroad (2). The purpose of the analysis was to estimate the volume of traffic that can be handled at the East Deerfield Yard under proposed design and operating conditions. The CAPACITY model was used to test the yard's ability to handle four potential traffic levels (scenarios):

1. Average day: 628 cars/day, 12 arriving and 12 departing trains;
2. Heavy day: 779 cars/day, 16 arriving and 12 departing trains;
3. Maximum day: 828 cars/day, 16 arriving and 12 departing trains; and

Figure 6. Receiving yard and hump use history (partial).

CAPACITY DEMONSTRATION RUN

ARRIVING TRAIN HISTORIES -

NO.	TRAIN	E/W	NO. BYP. CARS	NO. HUMP CARS	NO. TOT. CARS	ARR. TIME	QUEUE TIME INSP.	INSP. CREW	START INSP.	INSP. PER.	END INSP.	QUEUE TIME HUMP	HUMP CREW	EXTRA DELAY HUMP	START HUMP	HUMP PER.	END HUMP	END REC. YD. OCC.
71	2RW6	W	0	81	81	2:21:00	0:15	RINS4	2:21:15	2:42	2:23:57	0:00	HUMP1	0:00	3:00:02	0:27	3:00:29	3:00:24
72	80685	W	0	62	62	2:21:30	0:15	RINS6	2:21:45	2:04	2:23:49	0:51	HUMP2	0:12	3:00:57	0:20	3:01:17	3:01:12
73	5156D	W	0	76	76	2:21:45	0:17	RINS5	2:22:02	2:32	3:00:34	0:43	HUMP3	0:00	3:01:22	0:25	3:01:47	3:01:42
74	DOVGN	W	0	49	49	2:22:00	2:04	RINS6	3:00:04	1:38	3:01:42	0:05	HUMP1	0:00	3:01:52	0:16	3:02:08	3:02:03
75	XT	E	0	40	40	3:00:30	0:15	RINS1	3:00:45	1:20	3:02:05	0:00	HUMP2	0:00	3:02:40	0:13	3:02:53	3:02:18
76	RAMP	W	0	44	44	3:02:00		BYPASS REC. YD.				0:58	HUMP1	0:00	3:02:58	0:15	3:03:13	
77	S118	W	0	69	69	3:00:45	0:15	RINS4	3:01:00	2:18	3:03:18	0:00	HUMP3	0:00	3:03:23	0:23	3:03:46	3:03:41
78	CRBW1	E	0	67	67	3:01:20	0:15	RINS2	3:01:35	2:14	3:03:49	0:00	HUMP1	0:00	3:04:24	0:22	3:04:46	3:04:11
79	SHOPA	W	0	20	20	3:03:30	0:15	RINS4	3:02:45	0:40	3:04:25	0:21	HUMP2	0:00	3:04:51	0:07	3:04:58	3:04:53
80	R110A	W	0	103	108	3:01:00	0:15	RINS5	3:01:15	3:36	3:04:51	0:07	HUMP3	0:00	3:05:03	0:36	3:05:39	3:05:34

22

22

51	2634	2695	1:02:43	3:12:24	1:16:51	0:24	14:31
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Figure 7. Classification track block buildup (partial).

CAPACITY DEMONSTRATION RUN

WEST CLASS YARD BLOCK BUILD-UP MATRIX FOR DAY 3

BLK. NO.	GRP. NO.	-MAXIMUM NUMBER OF CARS FOR HOUR BEGINNING AT-																							MAX. NO. TRKS. DAY REQD.	CARS IN	CARS OUT	CAR HRS.		
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22					23	
39	45	11	23	23	27	27	27	27	28	28	36	36	36	46	46	50	51	51	51*	7	10	11	11	11	11	51	1	7	7	639
6	46	7	7	7	7	7	7	7*	0	0	0	0	0	2	2	4	6	6	6	6	6	7	7	7	7	7	1	7	7	104
44	47	2	3	3	4	4	4	4	5	5	9	9	9	9	10	10	12	12	12	12*	1	2	2	2	2	12	12	12	133	
138	47	3	3	3	3	9	9	9	9	9	9	9	9	10	10	11	15	15	16	16*	0	2	3	3	3	16	16	16	170	
SUM	47	5	6	6	7	13	13	13	14	14	18	18	18	20	20	23	27	27	28	28	1	4	5	5	5	28	1	28	28	304

22

22

* DENOTES PULL OCCURRED DURING NAMED HOUR -- NOTE NUMBER OF CARS PULLED NOT NECESSARILY SAME AS MAXIMUM NUMBER OF CARS FOR HOUR

WEST CLASS YARD SUMMARY STATISTICS STRICTLY OVER THE 24 HOURS OF THE ABOVE TABLE --

CARS IN	1509
CARS OUT	1509
TOTAL CAR HOURS	12134.88
AVERAGE DETENTION TIME, HOURS	8.04

Table 1. Summary of East Deerfield scenarios and results of CAPACITY tests.

Item	Scenario 1 ^a	Scenario 2 ^b	Scenario 3 ^c	Scenario 4 ^d
Physical assumption				
No. classification tracks	18	18	18	18
Humping rate (cars/min)	2.7	2.7	2.7	2.7
No. hump engines	1	1	1	2
No. trim-end engines	1	1	1	2
Results				
Avg detention time in yard (h)	17.03	17.25	17.29	13.31
Cars into yard (per day)	628	779	828	1111
Cars over hump (per day)	1095	1369	1414	1791
Hump use (%)	27.9	34.2	36.6	45.9
Hump-engine use (%)	62.6	72.7	76.8	46.6
Hump-crew use (%)	74.2	86.2	91.0	55.2
Trim-engine use (%)	69.9	77.4	81.0	64.9
Trim-crew use (%)	82.9	91.8	96.0	77.0
Projected incidental overtime (crew h/day)	0.5	1.6	1.8	0.5

^aEight receiving and departure tracks were sufficient; no critical buildup in the receiving and departure yard.

^bEight receiving and departure tracks were sufficient; possible buildup in receiving and departure yard during second shift.

^cEight receiving and departure tracks were sufficient; possible buildup in receiving and departure yard during second shift.

^dEight receiving and departure tracks were insufficient; critical buildup occurred several times during the day; at least 10 tracks are needed in the receiving and departure yard, probably more.

4. Mechanicville Yard traffic added: 1111 cars/day, 19 arriving and 12 departing trains.

The planned yard has one receiving and departure yard that consists of eight tracks that have a total capacity of almost 600 cars (two tracks hold 94 cars, and the others average 65 cars). There are 18 classification tracks (averaging 68 cars in length) served by a single hump. In addition, there are car-cleaning tracks, a car-repair area, and a locomotive fueling and repair area.

Simulated operating strategies and parameters were consistent for the four scenarios. The hump engine, if available, was generally assumed to perform all humping and reswitching functions including pulling cars from the classification yard back over the hump and rehumping. One hump engine and one trim engine were assumed for the first three scenarios and two hump engines and two trim engines for the fourth scenario. The trim engine can double over classification tracks when feasible in pulling cars from the classification tracks to the receiving and departure yard. Appropriate input parameters and traffic loadings were used for all scenarios.

Capacity of the East Deerfield Yard under the four scenarios was estimated by examining (a) receiving and departure-track requirements, (b) hump and trim-engine use and number of cars handled by the trim engine, (c) classification-track requirements, (d) departure train delays, and (e) average car detention time in the yard.

A summary of each scenario and the numerical results obtained are given in Table 1. It was concluded that the yard would be able to handle scenario 1 traffic easily, with fluid day-to-day operation. Scenario 2 traffic also presented few problems; this traffic level is essentially the yard's design capacity. Scenario 3 represents the maximum traffic level (with assumed traffic patterns) that the design can handle. However, the scenario 4 analysis indicated that, with significant further capital investment and intensified operations, Mechanicville's work could be handled with ease.

The current average detention time per car at East Deerfield Yard is approximately 31 h. The average detention figures from the East Deerfield CAPACITY runs (slightly more than 17 h) indicate that the new plan would significantly improve the yard operations. The results show a nearly constant level of efficiency, even as the yard approaches capacity. However, the addition of any more traffic without additional facilities and equipment would

cause the average detention time to rise sharply.

CONCLUSIONS

This paper has described the rail yard simulation model CAPACITY. The model's application to the Boston and Maine Railroad's real-life design problem at East Deerfield Yard demonstrated the practicality and utility of the model.

This application demonstrated the proposed East Deerfield Yard's capability to handle normal day-to-day traffic with ample fluidity. As the traffic load increases, the analysis indicates that, with careful yard mastering, constant work, and no unforeseen problems, the load will not choke the yard.

Further development could be made with the CAPACITY model; however, it is not clear that it would be desirable to push CAPACITY in the direction of a fully detailed yard operations simulation model. Two other enhancements to CAPACITY that would expand the model's applicability have been suggested. One would be to allow input of arriving and departing train schedules that extend across several days rather than replication of a single day's traffic load over each simulated day, as the model currently does. This change would permit the buildup and clearing of transient overloads to be studied. A second change would be to randomize the traffic loadings and operational parameters to reflect real-life variability. The efficiency of the CAPACITY model makes it ideal for the long-period simulation required to achieve a reasonable level of confidence in the random output measures of effectiveness generated by such a Monte Carlo modeling approach.

ACKNOWLEDGMENT

This research was performed under a contract with the Transportation Systems Center (TSC) of the U.S. Department of Transportation. John Hopkins of TSC was the technical monitor. The sponsor was the Office of Freight Systems, Federal Railroad Administration; William F. Cracker was the FRA program manager.

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Publication of this paper sponsored by Committee on Railroad Operations Management.

Possibilities for Local Public and Cooperative Ownership of Short-Line Railroads

PETER S. FISHER AND MICHAEL F. SHEEHAN

The short-line railroad has become an important option in the development of alternatives to the abandonment of branch lines by major railroads in the United States. The purpose of this paper is to explore the relative merits of two seldom-used institutional arrangements for the ownership and operation of short lines: local public ownership (by municipalities, counties, or special districts) and incorporation of the short line as a cooperative of shippers. The experience with publicly owned short-line railroads is described. Some have been publicly owned since their inception, whereas several others have been established recently to maintain service on abandoned branch lines. The very limited experience with cooperative railroads is also described, and certain legal and financial aspects of cooperative operation are analyzed. The paper concludes with an analysis of the relative advantages and disadvantages of locally owned short lines in general and public and cooperative short lines in particular. Short lines can generally operate much more cheaply than can major railroads. A shippers' cooperative or other locally owned short line is likely to provide better service and engender greater shipper support, thereby generating more revenue. Local public ownership possesses additional advantages, especially where it can internalize substantial community-wide benefits from rail preservation. A public railroad can also direct railroad policy toward public objectives such as community development.

The short-line railroad has become an important option in the development of alternatives to the abandonment of branch lines by major railroads in the United States. This paper explores the relative merits of two seldom-used institutional arrangements for the ownership and operation of short lines: local public ownership (by municipalities, counties, or special districts) and incorporation of the short line as a cooperative of shippers. Both arrangements show considerable promise and have certain advantages over the more common alternatives--shipper-owner for-profit corporations, private independent ownership, and ownership as a subsidiary of a major railroad.

A short line is defined by the Interstate Commerce Commission (ICC) as a line-haul railroad (not a switching or terminal line) that has gross revenues under \$10 million, i.e., a class III railroad. There are currently more than 285 short lines in the United States, many of which have been established in the wake of abandonments (1). Nineteen short lines were formed between 1976 and 1978 alone to operate lines abandoned when Consolidated Rail Corporation (Conrail) took over the bankrupt eastern railroad network in April 1976.

The number of short lines will probably grow significantly over the next decade. The movement toward deregulation of the railroads can be expected to reduce the cross-subsidization of branch lines that the major railroads are unable to operate profitably. Short lines can be expected to develop to maintain service on these lines in many in-

stances. There is also the prospect of additional bankruptcies of entire railroad companies. With bankruptcy, the abandonment process is greatly facilitated. Service will generally be continued only on those portions of the bankrupt system that another railroad purchases. In the case of light-density branch lines, continuation is unlikely unless an existing short-line railroad company steps in or a new local line is created.

There is also the prospect of growing involvement of the states and the federal government in facilitating and subsidizing the formation of short-line railroads. Federal financial assistance is available under several branch-line subsidy programs. The Rock Island Transition and Employee Assistance Act of 1980 in particular has promoted the development of short lines through its loan program for "noncarrier entities." Several states have also become involved in the acquisition of railroad rights-of-way with the intention of facilitating continued operation of branch lines as short-line railroads.

There is a variety of institutional arrangements for ownership and operation of short lines. The majority of the approximately 285 short lines that existed in 1978 were profit-making corporations. About a third of these were independent, another third were shipper-owned or industry-owned, and a third were owned or controlled by a major railroad (2,1).

There have been several cases of short lines owned and operated by local governments; at least five such railroads existed as of 1980. More common are arrangements in which a municipality or special district owns the right-of-way and/or trackage and then leases the line to a private short-line operator (or, in some cases, to a major railroad). Finally, a short-line railroad could be organized as a cooperative that had local farmers, cooperative elevators, farm-supply companies, and other local businesses as members. We know of only one example of a railway officially organized as a cooperative. This paper is concerned with the merits of these two less-common institutional arrangements for the ownership and operation of short lines: local public ownership and ownership by a shippers' cooperative.

EXPERIENCE WITH PUBLICLY OWNED SHORT LINES

Local governments have become involved with short lines in various capacities over the last 120 years. The most common form of involvement is one