CONFLICT: Railroad Classification Yard Trim-End Simulation Model

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Trim-end design evaluation plays an important part in the entire design process for railroad classification yards because the trim end is usually one of the major bottlenecks in a classification yard. A computerized tool called CONFLICT is described that can be used in the trim-end design evaluation process. CONFLICT simulates trim-end activities in both parallel and in-line classification yards. Sample applications of the model to real-world problems have proved that CONFLICT is extremely useful in evaluating trim-end designs.

One of the most important functions of a classification yard is to make up departing trains by coupling cars in the classification yard and having them pulled to the departure yard. These activities necessitate many trips by the trim engines back and forth between the classification and the departure yards. The engines travel with a string of cars from the classification yard to the departure yard and travel light on return. These engine movements conflict at the trim end, which creates a bottleneck in the yard operations. The conflicts of engine movement may be caused by several interrelated factors, such as geometric conditions, yard traffic characteristics, and trim-engine operations. Often it is not clear which factor contributes most to the engine conflicts. The problem can be alleviated by a careful analysis of engine conflicts realized under given conditions.

CONFLICT, a computer simulation program for engine movement between classification yard and departure yard, was developed to analyze yard conflict problems and evaluate yard design at the trim end. The model was applied to the Elkhart Yard of Consolidated Rail Corporation (Conrail) (1).

The simulation model was designed to be as simple as possible but at the same time flexible and precise enough to be useful to yard analysts. The model is capable of simulating most yard geometries and train operations. It can simulate 300 links (100 classification tracks, 30 departure tracks, 20 activity links, and 150 en-route links); 100 routes; and 8 engines.

Many assumptions were adopted to make the simulation model feasible; these included a travel-time calculation rule, a route-decision rule, operational strategy (input), delay of outgoing and incoming trains, and classification-cut rules (input).

Several measures of effectiveness can be used in evaluating yard trim-end geometry, including the throughput of cars carried in the trim engine, the delay of the trim engines, and the delay of the outbound trains.

OVERVIEW OF MODEL

CONFLICT is an event-step simulation model in which the advancement of clock time is determined by the occurrence of events to be simulated, which include the following:

1. Time when the head of the engine or cut enters a link,
2. Time when the tail of the engine or cut exits a link,
3. Time when a train is scheduled to depart from the departure yard, and
4. Time when an engine selects a route.

Figure 1 shows the overall structure of the simulation model. The simulation process starts with reading in the input variables--such as the train departure schedule and the cutoff time of a car block--and setting certain initial values for the rest of the variables (initialization).

The simulation program keeps track of each engine movement in terms of event occurrence times. Whenever the clock time is updated, a new series of decisions and computations begins, as indicated in Figure 1 at point A.

If the engine is in the classification yard, the program must first find the departure track to which the engine will be sent and then determine the route to the departure track. (The departure track number is an input variable specified by the model user.) The route (or a series of links) to be taken to the departure track is determined on the basis of conditions of conflict with other engine movements at the time that the decision is made.

If the engine is in the departure yard, the program must first find the classification-yard track to which the engine will be sent and then choose the route to be taken on the basis of current conflict information; that is, the route chosen is the one that avoids conflict. The immediate destination of the engine (or the classification track to which the engine is sent) is determined from a table that indicates the sequence of the work assigned to the engine by the model user. The route-selection process occurs at box 2 in Figure 1. The route selection for the line-haul engine is also performed in this subroutine.

If the event does not involve any decision making, the engine can be advanced to the next event point (box 3 in Figure 1).

If it is time to take statistics on yard operations, this activity must be performed next (box 4). If it is not the end of the simulation, the next event occurrence must be updated before the simulation proceeds (box 5).

MODEL INPUT

The input to CONFLICT can be divided into six categories:

1. General simulation information,
2. Yard-geometry information,
3. Engine and engine-schedule information,
4. Classification-track inflow information,
5. Outbound-train schedule, and
6. Initialization of engines and track.

Each of these categories is described briefly below.

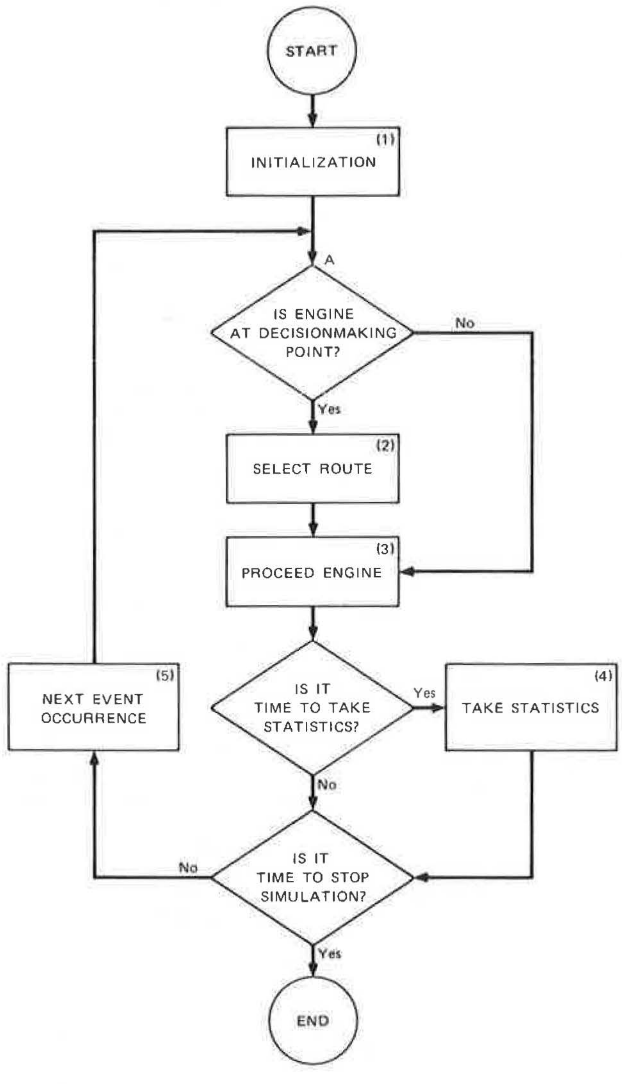
General Simulation Information

General simulation information includes simulation program options, the simulation time period, and operational parameters.

Yard-Geometry Information

Information related to yard geometry includes individual-link data, individual-route data, and ori-

Figure 1. Overall structure of CONFLICT model.



gin-destination (OD) route-matrix data.

A link is a section of track between switches. It is assumed that only one engine can occupy a link at one time. Two types of links are considered: activity links and en-route links. An activity link is one on which an engine may stop or that is located at the simulation boundary. Links that are not activity links are considered en-route links.

The OD route matrix indicates a set of routes that connect the origin and the next activity link. The entries in each cell are the route numbers (to the next activity link) in the order of preference.

Engine and Engine-Schedule Information

Two kinds of information are included in this category: (a) information related to the engine itself and (b) information related to the engine schedule. Engine information data are engine type and speeds and are rather simple and self-explanatory. However, the data related to engine schedule require further explanation.

The schedule of each engine is specified by the user in the time sequence of activities to be performed. The following engine activities can be simulated in the model: (a) line-haul engine assignment, (b) train departure, (c) departure track starting, (d) doubling operations, and (e) coupling operations.

The model is capable of simulating different engine-assignment methods. For example, if eight activities are to be conducted at the yard and two engines are available, and if the user wants to have each activity performed by the first available engine, the user can specify each activity as a separate assignment in the data setting. Under the same conditions, if the user wants to let one engine perform a series of activities in a given sequence, he or she can specify those activities collectively as one assignment.

Classification-Track Inflow Information

Classification-track inflow information defines the block types, the number of cars, and the time of each batch arrival to each classification track. Cars are considered to flow into classification tracks in batches.

Outbound-Train Schedule

The outbound-train schedule contains relevant information on outbound trains that depart from the departure yard.

Initialization of Engines and Track

Data related to engines and classification-track loadings can be initialized. The initialization of each engine is critical to running the program: without it, the model cannot start. In contrast, classification-track initialization is not critical; if tracks are not initialized, the program assumes zero cars on each classification track at the simulated starting time.

MODEL OUTPUT

Model output is divided into three categories:

1. Echo-back input data, which enable the user to identify the yard design and operations simulated by the model;
2. Conflict-related data, which include delay time of engines caused by conflict for each link, route, and OD combination and delays per engine; and
3. Traffic-related data, which include traffic flows at each link and route in terms of number of cars and engines and number of trips made and cars carried by each engine.

Figures 2, 3, and 4 are samples of key output. Figure 2 shows an engine activity report, which records all moves made by each engine and contains the following information: engine number, block number, outbound-train number, start of pull time, origin-track number, end of pull time, destination-track number, amount of delay, and the route number on which the delay occurred. The user can pinpoint the route numbers and the OD track combinations that experience delays caused by engine conflicts.

Figure 3 shows a departure-yard occupancy diagram. A series of asterisks indicates the track and the time duration occupied by each outbound train. The number at the beginning of each series of asterisks indicates the departure-train number.

Figure 4, a train departure report, shows scheduled and actual train departure times and train delays in both train minutes and car minutes. If a train delay becomes progressively longer as time passes, the capacity of the trim end modeled is ob-

Figure 2. Engine activity report.

NO.	ENG NO.	BLK NO.	TRAIN NO.	START TIME PULL	TRK NO.	END TIME PULL	TRK NO.	RTE NO.	DELAY DUE TO CNFLCT (MIN)	RTE NO.	DELAY DUE TO CNFLCT (MIN)	RTE NO.	DELAY DUE TO CNFLCT (MIN)	RTE NO.	DELAY DUE TO CNFLCT (MIN)	RTE NO.	DELAY DUE TO CNFLCT (MIN)	RTE NO.	DELAY DUE TO CNFLCT (MIN)
1	1	85	1	18	68	40	88	0	0	0	0	0	0	0	0	0	0	0	0
2	1	0	0	40	88	50	67	0	0	0	0	0	0	0	0	0	0	0	0
3	2	22	2	31	56	110	91	125	20	0	0	0	0	0	0	0	0	0	0
4	2	0	0	110	91	130	59	0	0	0	0	0	0	0	0	0	0	0	0
5	1	4	1	107	67	137	88	137	12	0	0	0	0	0	0	0	0	0	0
6	1	0	0	137	88	150	45	0	0	0	0	0	0	0	0	0	0	0	0
7	2	39	3	213	59	234	87	0	0	0	0	0	0	0	0	0	0	0	0
8	2	0	0	234	87	248	57	0	0	0	0	0	0	0	0	0	0	0	0
9	1	1	4	214	45	304	89	121	32	0	0	0	0	0	0	0	0	0	0
10	1	0	0	304	89	329	45	140	4	75	8	0	0	0	0	0	0	0	0
11	2	62	3	302	57	347	87	125	28	0	0	0	0	0	0	0	0	0	0
12	2	0	0	347	87	403	69	0	0	0	0	0	0	0	0	0	0	0	0
13	1	1	4	344	45	421	89	0	0	0	0	121	20	0	0	0	0	0	0
14	1	0	0	421	89	435	45	0	0	0	0	0	0	0	0	0	0	0	0
15	2	5	5	424	69	450	90	0	0	0	0	0	0	0	0	0	0	0	0
16	2	0	0	450	90	506	69	0	0	0	0	0	0	0	0	0	0	0	0
17	1	1	4	449	45	531	89	121	24	0	0	0	0	0	0	0	0	0	0
18	1	0	0	531	89	550	52	0	0	0	0	0	0	0	0	0	0	0	0
19	2	5	5	528	69	601	90	137	12	0	0	0	0	0	0	0	0	0	0
20	1	78	6	602	52	625	87	0	0	0	0	0	0	0	0	0	0	0	0
21	2	0	0	601	90	628	53	142	12	0	0	0	0	0	0	0	0	0	0
22	1	0	0	625	87	636	68	0	0	0	0	0	0	0	0	0	0	0	0
23	2	10	7	630	53	656	88	0	0	122	16	0	0	0	0	0	0	0	0
24	2	0	0	656	88	718	49	140	4	74	4	0	0	0	0	0	0	0	0
25	2	24	7	721	49	735	88	0	0	0	0	0	0	0	0	0	0	0	0
26	2	0	0	735	88	750	54	0	0	0	0	0	0	0	0	0	0	0	0
27	1	85	14	717	68	758	90	137	20	0	0	0	0	0	0	0	0	0	0
28	1	0	0	758	90	809	67	0	0	0	0	0	0	0	0	0	0	0	0
29	2	13	7	801	54	826	88	122	8	0	0	0	0	0	0	0	0	0	0
30	2	0	0	826	88	840	60	0	0	0	0	0	0	0	0	0	0	0	0
31	1	4	14	831	67	858	90	0	0	0	0	0	0	0	0	0	0	0	0
32	1	0	0	858	90	912	55	0	0	0	0	0	0	0	0	0	0	0	0
33	2	19	7	849	60	926	88	125	12	60	12	0	0	0	0	0	0	0	0
34	2	0	0	926	88	940	61	0	0	0	0	0	0	0	0	0	0	0	0
35	1	8	9	916	55	951	91	55	16	125	8	0	0	0	0	0	0	0	0
36	1	0	0	951	91	1001	65	0	0	0	0	0	0	0	0	0	0	0	0
37	2	52	7	955	61	1021	88	125	8	0	0	0	0	0	0	0	0	0	0
38	2	0	0	1021	88	1031	64	0	0	0	0	0	0	0	0	0	0	0	0
39	1	28	9	1025	65	1055	91	65	8	0	0	0	0	0	0	0	0	0	0
40	2	34	10	1054	64	1125	89	127	4	0	0	0	0	0	0	0	0	0	0
41	1	0	0	1055	91	1128	43	77	16	140	4	0	0	0	0	0	0	0	0
42	2	0	0	1125	89	1136	70	0	0	0	0	0	0	0	0	0	0	0	0
43	1	29	9	1143	43	1205	91	0	0	0	0	0	0	0	0	0	0	0	0
44	2	54	10	1157	70	1230	89	137	8	127	4	0	0	0	0	0	0	0	0
45	1	0	0	1205	91	1231	45	77	12	0	0	0	0	0	0	0	0	0	0
46	2	0	0	1230	89	1244	51	0	0	0	0	0	0	0	0	0	0	0	0
47	2	9	12	1247	51	1302	87	0	0	0	0	0	0	0	0	0	0	0	0
48	2	0	0	1302	87	1332	50	140	4	73	12	0	0	0	0	0	0	0	0
49	1	1	11	1346	45	1408	89	0	0	0	0	0	0	0	0	0	0	0	0
50	1	0	0	1408	89	1422	45	0	0	0	0	0	0	0	0	0	0	0	0
51	2	7	12	1344	50	1436	87	0	0	0	0	122	36	0	0	0	0	0	0
52	2	0	0	1436	87	1455	46	0	0	0	0	0	0	0	0	0	0	0	0
53	1	1	11	1436	45	1510	89	121	16	0	0	0	0	0	0	0	0	0	0
54	1	0	0	1510	89	1528	45	0	0	0	0	0	0	0	0	0	0	0	0
55	2	49	12	1508	46	1541	87	122	16	0	0	0	0	0	0	0	0	0	0

Figure 3. Departure-yard occupancy diagram.

CONFLICT - DEMONSTRATION RUN

WEST DEPARTURE YARD OCCUPANCY DIAGRAM

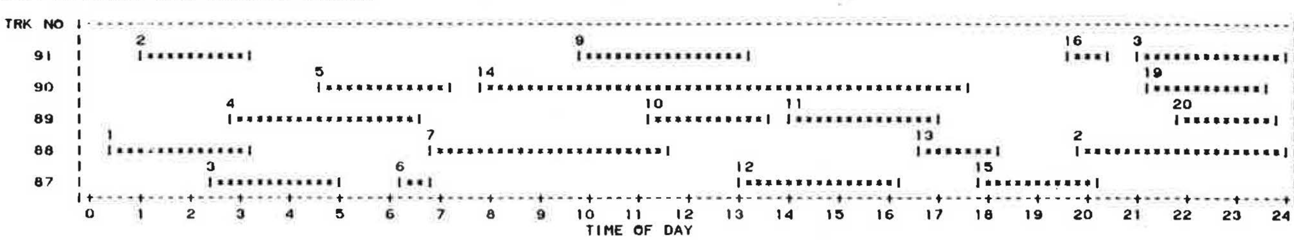


Figure 4. Train departure report.

ELKHART - BASE CASE

T R A I N D E P A R T U R E R E P O R T

TRAIN NO.	SCHEDULED DEPARTURE TIME	ACTUAL DEPARTURE TIME	TRAIN DELAY TIME (MIN)	NUMBER OF CARS ON TRAIN	TOTAL DELAY TIME OF CARS ON DEPT. TRAINS (MIN)
1	300	305	5	75	375
2	315	316	1	35	35
3	533	601	1	55	55
4	500	633	90	90	8100
6	500	657	117	26	3042
5	503	703	120	96	11520
7	600	1112	312	74	23088
9	800	1305	305	88	26840
10	830	1331	301	99	29799
12	933	1616	436	53	23108
11	900	1703	483	90	43230
14	1100	1712	372	116	43152
13	1000	1758	478	28	13384
15	1300	2005	425	76	32300
16	1330	2021	411	52	21372
19	1803	2333	333	98	32340
20	1830	2341	311	60	18660
TOTAL 17			4495	1211	330370

AVERAGE DELAY TIME PER TRAIN IS 264 MINUTES
AVERAGE DELAY TIME PER CAR IS 272 MINUTES

viously less than the existing demand.

APPLICATION OF MODEL

CONFLICT was applied to Conrail's Elkhart Yard, a first-generation computerized hump yard that has an in-line receiving yard, a hump with electronic retarder controls, a classification yard with a fishtail configuration, and two parallel departure yards (Figure 5).

Approximately 1100-1200 cars are pulled daily from the classification yard to the departure yard at the westbound trim end of Elkhart Yard. The existing geometry of the yard's westbound trim end can move more than 1200 cars/day through the westbound departure yard. This capacity is insufficient, however. Such factors as the long travel distance for the trim engines between the classification yard and the departure yard, short classification tracks that range in length from 24 to 50 cars, and the insufficient length of the single pullout lead for the longest classification track contribute to this insufficient capacity.

To increase the capacity of the trim end, three alternative designs have been proposed:

1. Extended classification tracks with dual pullout leads,
2. Extended classification tracks with crossovers in the departure yard, and
3. Extended classification tracks with dual pullout leads and relocation of the departure yard.

Computer simulations that use the CONFLICT model were performed for the trim-end designs of the existing yard and for alternatives 1 and 2. Alternative 3 was not evaluated because the design itself exceeds the budget constraints put on capital improvement. The objective of the simulation was to determine which of the two alternatives (1 or 2) would perform better under higher traffic demand and the degree of difference between the alternative designs and the existing design.

The trim-end designs of the existing yard and the two alternatives are described briefly below.

Existing Yard

The existing westbound yard has 33 classification tracks that range in length from 24 to 50 cars. Five departure tracks range in length from 107 to 112 cars. There is only one pullout lead from trim-end maneuvers (Figure 6). The existing geometry of the westbound trim end limits yard capacity for increased traffic demand.

Alternative 1

In alternative 1 (Figure 7), the classification tracks in the middle of the yard are extended to 1000-1500 ft. The westbound classification yard holds 41-50 cars on each track. A pullout lead is added to the existing lead, and the track layout around the trim end is modified. The yard engines still travel an extra distance from the convergence point of the classification track (point A, Figure 7) to the pullout leads. However, the extra distance involved is much less than that under the existing configuration.

This alternative provides improvements in the departure yard also. The departure yard has five tracks that range from 108 to 112 cars long. Two additional tracks 112 cars long adjoin the existing yard. Dead excess ladders with parallel leads provide capacity for making trains simultaneously.

Alternative 2

In alternative 2 (Figure 8), the westbound classification tracks in the middle of the yard are extended to 1500 ft, and the classification track leads merge in the middle of the departure track. The westbound classification track lengths vary from 41 to 50 cars. From the merge point of the classification and departure tracks, a series of crossovers is installed to the outermost departure track. The tracks on the west side of the crossover can be used as pullout leads as well as departure tracks. This configuration shortens the travel distances of the trim engines as long as each outbound train is sufficiently short to avoid blocking the crossover.

The seven departure tracks proposed in alternative 2 have a capacity of 107-142 cars when the sections of the track on the east and west sides are combined. When a train exceeds the length of the east section of track, the train sections must be stored on both sides of the crossover. Just prior to departure, the cuts will be coupled. During this time, a completed train is blocking a crossover. The trim engine building a train on the far track will need to use the pullout lead to reach the far track or wait for the departure of the train blocking its route.

OPERATIONAL PARAMETERS AND ASSUMPTIONS USED FOR SIMULATION

To achieve uniformity in the yard-design computer simulations, most operational procedures were held constant for the three simulated design plans. In general, the yard-design simulations were based on

Figure 5. Configuration of Elkhart Yard (capacity at 2600 cars/day).

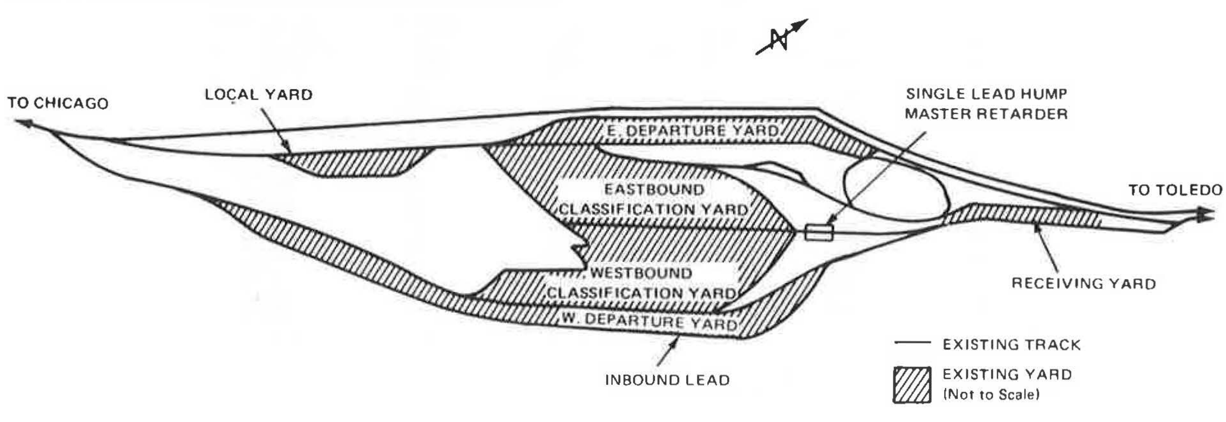


Figure 6. Existing trim-end design.

Figure 7. Trim-end alternative 1: extended classification tracks with dual pullout leads.

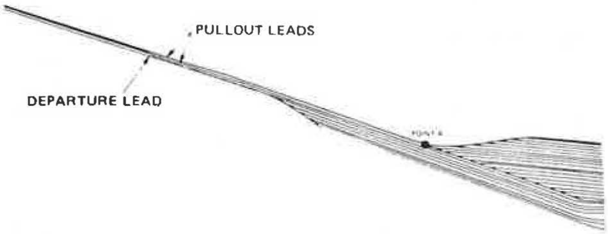
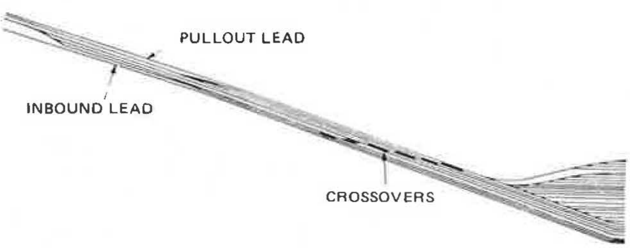


Figure 8. Trim-end alternative 2: extended classification tracks with crossovers in departure yard.



the following operational parameters and assumptions:

1. The input traffic level is set at an inflow rate of 1800 cars/day to the westbound yard,
2. A 24-h period of trim-end operations that starts at midnight is simulated,
3. Two trim engines are assigned to do the work in the westbound yard,
4. The pull speed of the trim engines is a constant 6 mph and the shove speed is 4 mph,
5. The engine work schedule remains the same for each simulated plan,
6. The schedule allows making trains simultaneously but a train is built by one engine only,
7. Track overflows on classification tracks are prevented by limiting the flow of cars onto a classification track to the track's capacity,
8. Departure-track assignment is performed manually by assigning the shortest departure track that is adequate to perform a train makeup,
9. There are no constraints on line-haul engine availability, and
10. In alternative 2, the duration of crossover blocking due to extra trimming work and train-departure preparation is assumed to be 20 min if the train is built on both sides of a split departure track; crossover blocking occurs prior to the train departure.

SIMULATION RESULTS

The results of the simulation of the existing design and alternatives 1 and 2 are summarized in Table 1. The findings for the existing yard and each alternative are discussed briefly below.

Existing Yard

The simulation for the existing yard covered a period from 0000 to 2400. During this period, 17 of 19 trains scheduled were built; they carried a total of 1211 cars (Table 1). The trim engines moved 1370 cars during this period. The number of trains processed in a 24-h period was much less than the total number of trains planned for departure and much less than the total input flow to the yard. This implied that the yard was oversaturated and therefore that the amount of delay for both trains and cars would increase indefinitely as the simulation time grew. The total train departure delay time was 4487 min, or 264 min/train. The average delay time per car on departed trains was 272 min. During the simulated period, conflict (adverse events) caused a total delay of 620 min, or an average of 36 min/train. Most of the conflicts were caused by the heavy occupancy of the pullout lead.

At traffic levels of 1800 cars/day and higher, trim-end operations in the existing yard are severely hampered because of the lack of an extra pullout lead. In addition, the long travel time of the trim engines from the classification yard to the departure yard causes train delays, which compound as the daily operations proceed.

Alternative 1

When two trim engines were working, the work schedule of the simulation was completed earlier than 2400. Within 24 h, 19 trains were built. The total train departure delay time amounted to 3780 min, or 199 min/train (Table 1). There were 1456 cars on the 19 trains. The average delay time per car caused by delay departure was 205 min. In comparison with the existing yard, conflict delay time was substantially reduced. The total conflict delay time amounted to 380 min at an average of 20 min/train.

Train delay time decreased substantially toward the end of the 24-h period. The last two trains built in the simulated time period were delayed by 122 min and 117 min. This is well below this alternative design's maximum delay of 369 min for one train. The number of cars moved by the two trim engines was 1597 cars within 24 h; however, had one trim engine not been left idle from 2130 to the end of the simulation at 2400, more cars could have been moved.

Alternative 2

The simulation of the second alternative ended at 2400. During the simulated time period, 18 scheduled trains were built. Total departure delay time

Table 1. Summary for conflict evaluation.

Item	Existing Design	Extended Classification-Track Design	Crossover Design
No. trains built	17	19	18
Total train departure delay (min)	4487[a]	3780	3751[a]
Avg train departure delay (min)	264[a]	199	208[a]
Avg delay per car (min)	272[a]	205	221[a]
Total no. cars on departed trains	1211	1456	1332
Total conflict delay (min)	620	380	684
Avg conflict delay per train (min)	36	20	38
No. trim-engine trips	85	90	90
No. cars moved by trim engines	1370	1597	1567
Simulation end time	2400	2400	2400

[a]These numbers do not reflect the delays associated with the trains that were not built during the 24-h period.

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

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CAPACITY: Model for Estimating Rail Yard Capacity and Resource Requirements

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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 resource 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