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The Problems and Operational Techniques of Super Volume Classification Yards

*by Herbert T. Landow**

ABSTRACT

THERE ARE A LIMITED NUMBER of locations in the railway network of the U.S. where the potential volume of traffic is sufficient to overwhelm normal classification yard design parameters. These are the super volume points. Although few in number, they represent a significant opportunity to the railways for both widespread service improvement and cost savings.

The two primary locations for such yards are St. Louis and Chicago. A study in 1974 of the "St. Louis problem" considered the super volume class yard in both its economic and technological aspects. This paper concentrates on the technological aspects by which operational problems were to be solved in a 10,000 cars per day facility. The prospective yield was a return of $75 million per year on a $150 million investment.

Included are discussions of problems of receiving yard capacity, hump capacity, class yard bowl design, output blocking technique and train assembly method. Each stage of production is explained in respect to the volumes to be handled and the method by which the solution was to be achieved. A simulation of this yard was performed and the results of the simulation in terms of capacity utilization of various key resources is shown.

The objective of the paper is to communicate knowledge of both the design problems and possible solutions.

* * *

If Pauline (whose perils were a weekly event) were to take a nap on the typical railroad track, she wouldn't be in danger except once every 6 hours.[1] It is doubtful if Pauline would have survived, however, at the super volume points in the U.S. such as Chicago and St. Louis. At these network nodes the concentrations are so intense as to be manageable only by having a multiplicity of intra-city routings which disperse the traffic.

For most of the railroads serving these cities, that city is a system end point rather than a central node. This is why St. Louis and Chicago developed as a network of train yards for each line haul road, with transfer pullers hauling interline connections as needed. Prior studies of St. Louis and Chicago have been oriented to interchange yards, thereby focusing such pullers into one location.

It was in this context that a comprehensive planning study[2] was undertaken in St. Louis to examine the multiple issues of railroad efficiency and community development. Prior reports and papers have discussed several aspects of these studies.[3, 4, 5, 6] This paper, however, will focus solely on previously unpublished aspects of operations methodology and yard geometry that were considered in the design of Alternative #2. This was a single yard for the St. Louis region that would act as the single train yard for all lines and which would originate and terminate all road trains. Interchange (70% of all traffic) would be effected by the simple arrival and departure of road trains at a common yard.

Given the need to handle local traffic to and from industrial base yards, the effective inbound train frequency at the yard was 125 per day. This is equivalent to an inbound train move each 11:52 minutes. The yard had to be capable of accepting traffic growth and have adequate reserves for periodic derailments, power outages, switch failures, etc.

The reward for tackling such an extraordinary traffic density is an annual return of $75 million on a $150 million investment (1974 dollars). This was by far the highest return on investment of the three alternatives studied.

To make the concept work it was clear that we could not literally handle all trains over a single key track or facility. The guiding principles of the design were:

1. Traffic dispersion in compactly placed multi-track routes and parallel facilities.
2. Grade separation for potentially conflicting routes including main line-yard separation.
3. Train classification and reassembly by sequential flow line processing in which each step moves away from prior steps so as to avoid interferences.
4. Management through an organiza-

*162 Merlin Avenue, North Tarrytown, N.Y.

tion and staff specially designed to handle the high density operations.

Due to space limits we will not be able to examine issues such as the management techniques, servicing areas, soil conditions, weather factors, and community impacts, all of which were studied. We will, however, examine the basic processing steps that required 10 humps ordered in 3 rows (3,3,4). Figures 1-6 show the track layout of this 8 mile long yard. Copying and reassembly of the figure may clarify the yard design for the reader.

RECEIVING SYSTEM (Figures 1 & 2)

Two receiving yards were planned. Their combined traffic intake would be 10,000 cars per day. Although the two receiving yards (North and South) delivered cars to the same hump region (Figure 3B), their outer ends are 2.2 miles apart, pointing to the key bridges across the Mississippi (MacArthur and Merchants) and the key junctions for all east side traffic. The effect of this was to bring almost all trains (114 of 125) into the receiving yards at their outer ends rather than near the humps.

North Receiving (Figure 1) is entered at CP junction with a ladder track arrangement for four simultaneous moves (1A). Both the northwest and northeast quadrant traffic enters the system here in 58 trains per day with 4007 cars.[7] The outbound counterflow is to the northwest with 20 trains of 1570 cars.

Tracks 1-4 are 8000′ long. Shorter trains are handled on tracks 5-10. This latter group had midlength crossovers (1B) to facilitate combining two short trains for a single move to the hump.

Inspection is done from vehicles by two inspections teams. Each team consists of several men working on the same train at one time. The AAR network model showed a utilization rate of 42% for the inspection crews.

South Receiving (Figure 2) is entered (2A) with a six ladder track arrangement allowing four entry moves simultaneously with two outbound moves on the adjacent main lines. The volume entering is 56 trains per day with 3807 cars. The inbound traffic peaks in the period from 6 p.m. to midnight.

The Q junction throat of six tracks is subdivided to the west into a middle group of two tracks to the MacArthur Bridge for use by the southwest group of lines. The two adjacent pairs of tracks provide several grade separated routes to Valley Junction where the south and southeast groups enter the system.

Two inspection teams are provided in South Receiving. The simulation showed a 47.4% utilization rate. For only 4 hours of 24 did the utilization rate exceed 75%. Car space occupancy showed a 15.8% utilization of the 1200 car capacity available.

PREMIXER

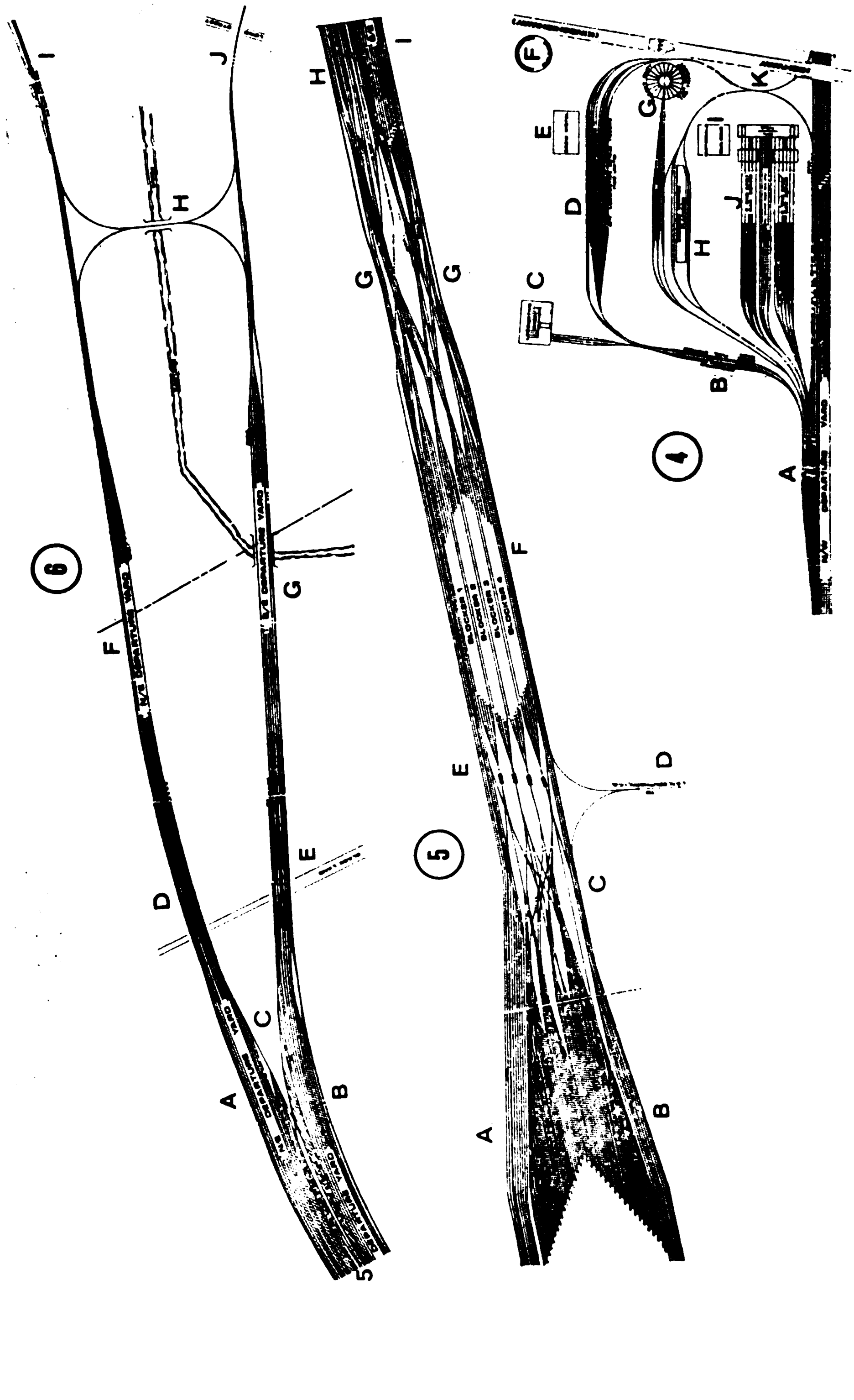
The next stage in the production process is the classification of the cars. This is not a simple move to a hump, however. Three humps are involved. The current traffic load is roughly 10,000 cars per day. Growth projections made with econometric models found that a 2.8% growth rate through 1990 could be expected. More serious in growth terms, would be the consequences of successfully solving the "St. Louis problem." Traffic now diverted by way of Memphis, Chicago or secondary routes could reappear at St. Louis. The design of the yard, therefore, has to be capable of handling 15,000 cars per day, not merely 10,000.

It is doubtful if we can expect the St. Louis railroads to agree that the capacity of a single hump crest is over 5,000 cars per day. The truth of an upper limit is open to some debate insofar as not all participants share the same knowledge of or confidence in the technology and technique available.

How then was the volume to be classified? Given an average car length of 58 feet, how many hump crests would be needed to share the work load? A strategic choice had to be made. One crest was too few. Two crests would provide volumes of 5000 per day now with possibe growth to 7500. West Colton is rated at a level similar to this, but not all involved railroads are ready to recognize this as a feasible design parameter. Three crests would allow volumes of 3333 each with further growth capability. This was in the realm of known and proven performance and accepted for the design.

An unusual feature of the yard should now become apparent. If the class tracks are in several groups—each controlled by a single hump crest—we must presort the cars in order to deliver them to the proper crest. Remember that this is not a problem to be resolved by dual crests and a scissor crossover. Such a technique would absorb too much capacity and cripple the operation.

In a three way split we require three humps (1,2,3) in the presorting stage and three in the final sort stage (A,B,C). The relative locations are shown on Figure 3 (3F,3K).



4
A B C D E F G H J K
DEPARTURE YARD
5
A B C D E F G H I
BLOCKER 1
BLOCKER 2
BLOCKER 3
BLOCKER 4
6
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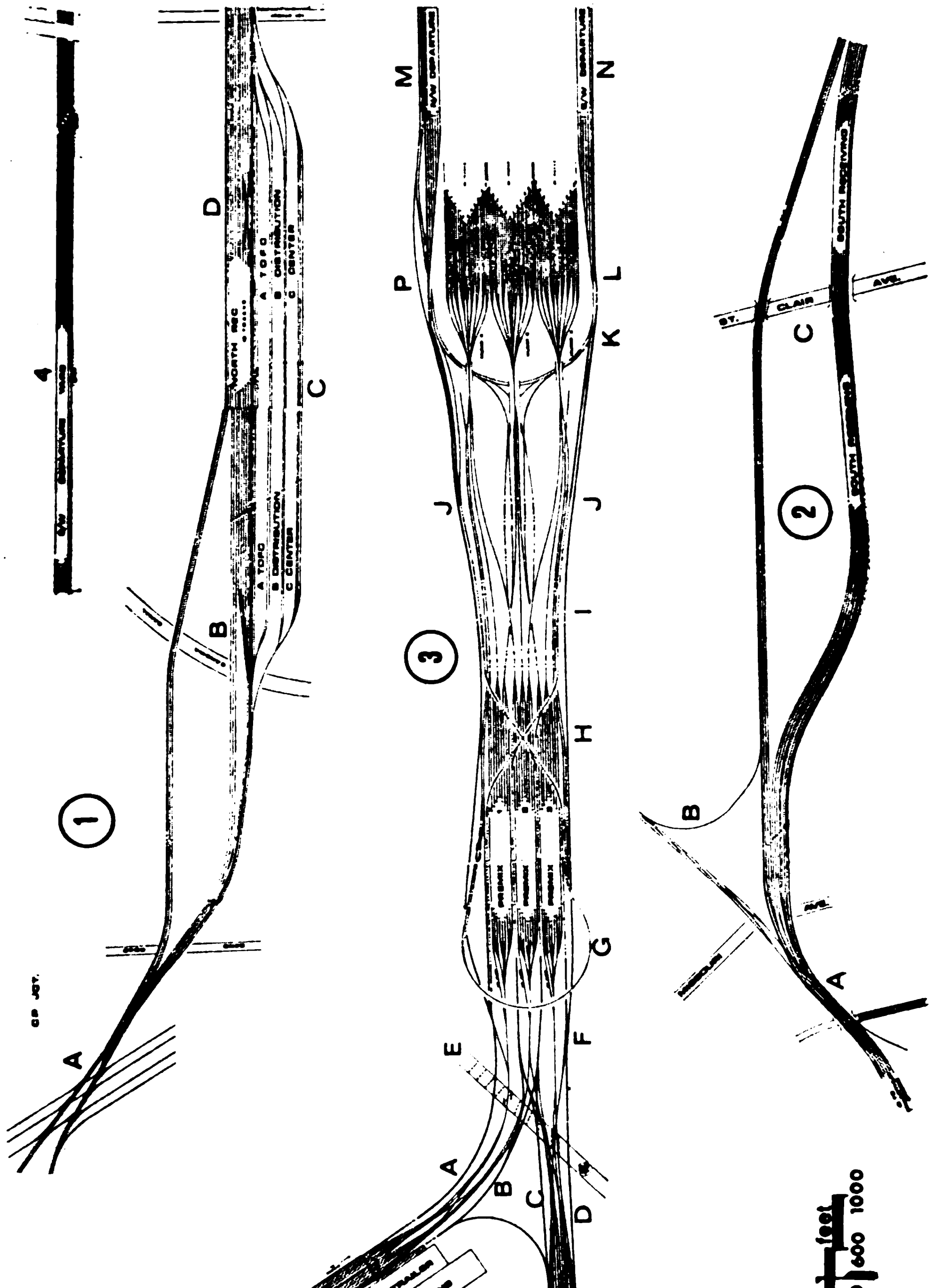
DEPARTURE YARD
E/B DEPARTURE YARD
W/B DEPARTURE YARD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ROUTES—PREMIX TO BOWL

There are nine routes connecting these two sets of crests. The first three (1A, 2-B, 3-C) are straight shoves. The next four are crossover shoves whose route conflicts are resolved by bridges. (3I) Route 2-A over 1-B is one crossover pair. Route 2-C over 3-B is another such pair. Grades are limited to 2.5% and the cut length is 30 cars using two unit engines.

The last two routes (1-C, 3-A) use a 1% grade to cross over the full layout by means of a 12° loop track at location G. Using a 2 inch superelevation the balancing speed for the operation is 15.5 m.p.h. Cars are pulled from the premixer so as to clear the loop approach (near 3H).

The tasks at the first row of humps are not only to sort cars for humps A, B, C but also to remove bad order cars, cabooses, and set aside no-hump cars. As an extra stage of production, the premixer would seem uneconomic. Taken in the larger sense, however, the cost undertaken here makes the restructuring of the entire St. Louis yard network possible, resulting in vast savings otherwise unavailable.

The connections from the receiving yards are made on four double track ladders, two from each receiving yard. Ladders are connected in such a way that North Receiving can reach humps 1 and 2 while South Receiving can reach humps 2 and 3.

SHOVES TO PREMIXER, HUMPS 1, 2, 3

The hump shove moves from receiving to premix were simulated using six crews. The hump crews are busy but not overloaded with an average utilization rate of 30.96%. This is based upon hump time plus a ten minute return interval to prepare for the next shove. In 5 hours of 24 the rate went over 40% with one peak of 60% at midnight.

PREMIXER UTILIZATION

The three humps for the premixer (1,2,3) at location 3F were utilized 39% of the available time. This hump is of low profile design with a maximum bowl length of 30 cars (1800 feet). Each bowl has 9 tracks.

Utilization factors were:

Hump	% 24 Hours	# Hours in 24 over 60%	Maximum 1 Hour Rate
1	41.4%	5	86.7%
2	34.7%	5	86.7%
3	42.4%	7	76.7%

The three bowls in the premix have a limited capacity. Their overall utilization of car holding capacity was 17.3% of 1200 cars with a maximum of 33.2% in any one hour. This is premised upon frequent removal of cars to the next stage of production (Humps A, B, C). The per track utilization was not simulated but it seems probable that the premixer should have more tracks in the bowl. Further tests are recommended to test this thesis.

The simulated volume on the 8th day of the 15 day run showed 8375 cars to be humped. This gives a true picture of total hump volume after excluding six run through trains and 24 unit trains, but including all local traffic from the industrial base yards.

MAIN LINES

Of special interest are the main line operations while all three premixer humps are in operation. The main lines surround the receiving yards. (See Figure 3-A,B,C,D) The outer tracks (3A, 3D) are connected at grade directly to the southwest and northwest quadrant departure yards (3M and 3N). Inbound Conrail and B&O trains may also use these routes inbound to the receiving yards.

The solution to this critical potential conflict (main line versus premixer hump operations) lies in a grade separated crossover system whose center is location 3H. The crossover tracks are shown with dotted lines. The east side approach begins at location 3J on both the north and south sides of the yard. A double track main line connects this point with the southwest and northwest departure yards (3M and 3N). A grade of 1% raises the crossover tracks from 3J to 3H on both the north and south sides.

The west side of the crossover system returns to grade level at location 3G and connects to the four main line tracks (3A, 3B, 3C and 3D). From the northeast side (3M) one can go over the premixer to alignments 3B, 3C, 3D. From the southeast side (3N) one can go over the premixer to locations 3A, 3B, 3C. All premixer humps can be working while these crossovers are made, including either north or south receiving working to hump #2. Thus, this critical point in the geometry of the yard remains fluid at all times and a failure of one or more tracks leaves alternate routes available.

Although interlocking conflicts were simulated (no passage if no clear route), the main line utilization rate in terms of hours of usage, remained very low. This indicates a fluid condition with respect to unexpected delays and line blockages.

SHOVES TO HUMPS A, B, C

Seven crews were simulated for the shoves to humps A, B and C. Their average utilization was 47.9%. During 11 of 24 hours their utilization exceeded 50% with the maximum for a single hour of 76.9%. The most intense 3 hour peak averaged 68.6%. The use of very short 30 car cuts accounts for the busy status of these engines. At no time, however, did anything approaching saturation arise, and the system is fluid.

The hump crests themselves (a simulated resource whose unavailability delays the engines mentioned above) had the following utilization:

Hump	% Utilization	Maximum %-1 Hour
A	52.1%	90.9%
B	43.3%	75.0%
C	60.0%	90.0%

Plainly these humps are busy but not saturated. The average utilization of 51.8% includes time approaching the hump and the departure of light engines. The utilization is only 33% during actual hump time at a hump speed of 4.4 miles per hour into a 23 track class yard. The use of 3 humps to absorb the volume results in a small short switching area below the hump. This materially assists hump capacity by minimizing car closure effects due to variations in rolling resistance. Like any single hump yard, a breakdown can be serious, but is recoverable if service is restored within 4 hours. For longer outages traffic must be rerouted or held-out as is normal practice throughout U.S. railroading. Emergency reserve yards were retained by the plan in the St. Louis region for just such long term emergencies. At 33% utilization, however, there is sufficient time for mistakes, peak hour rushes, growth, and maintenance outages.

SHOP CONNECTIONS

Additional routes are necessary to connect the Premixer to the shop areas. (Figure 4) All locomotive, caboose and car servicing is in this area. In addition, no-hump cars are handled through this region. The routes needed must be absolutely clear of the humping operations to humps A, B and C.

The means for doing this include connecting the southwest departure yard (3N) by an under-hump loop double track to location 3P. Here it passes under the main lines and northwest departure loads and rises to a shop entry yard. (4A)

From the loop track at the lower level are a series of connections to the premixer and north side mains. These tracks allow for all moves to the shop area including light engine delivery to southwest departure (3N) and inbound locomotives from north and south receiving.

BOWL DESIGN FACTORS

The parameters involved included an analysis of the number of outbound trains for each railroad and the blocking needs for each train. The total of 125 trains per day only required 56 tracks due to a recycling of the same trains more than once per day. The addition of 8 swing tracks raised track needs to 64. This was further increased to 70 to allow for growth and/or future train categories that may be desired.

This analysis was merely in terms of train needs. The objective of the yard, however, is not merely to build outbound trains, but to block those trains for economical handling by the receiving railroad. Thus a tradeoff is taking place between marginal costs in the St. Louis yard versus costs in other yards throughout the U.S.

Clearly the economic tradeoff varies by type of train. Outbound trains going directly to other major hump yards do not need to be blocked in St. Louis. At the other extreme we have intercity locals and moves to industrial districts which require extensive blocking.

At a gross average of 4 blocks per train for 112 blocked trains, we have a need for 448 blocks. We cannot provide one track per block. Instead, we will first create the trains to be accumulated in a 70 track bowl (described above) and then, at outbound call time for any specific train, put those cars through a blocking process as required by that particular train. Thus a dynamic blocking policy can be employed, blocking cars in a train in accordance with the actual consist on a particular day.

In the bowl, therefore, we have three adjacent class yards (23,24,23 tracks) totaling 70 tracks. A major feature of the bowl is its length. It is designed to hold full trains on one track, with length ranging from 6800′ to 8700′. The length is somewhat uniform to give maximum flexibility in train assignment to tracks without regard to length.

BOWL UTILIZATION

Each portion of the yard was simulated and resource utilization checked.

The utilization of car standing capacity in the bowl was:

Tracks	Hump	Utilization %
1-23	A	21.3%
24-47	B	20.7%
48-70	C	26.2%

TRIMMING

The bowl should not be trimmed from the high end. The resulting time loss at the hump is not acceptable given alternative means for handling periodic slow rolling cars that stop short. Alternatives include either the redesigned Dowty booster retarder or one of the several cable pullback methods now operating in Europe and the U.S. These systems will insure that the cars will be closed up in the interval from clearance to 2500′.

PULLBACK MOVES

The maximum free roll distance contemplated was 2500′ with the last retarder placed 1250′ (22 car lengths) from the clearance point. Given the length of the average track at 7890′, it is obvious that we will have to periodically pullback those tracks which are filling the interval 0 to 2500′. By periodically pulling these tracks back we create more space as needed while keeping the free rolling distance to workable levels. The cost of this pullback is an unusual one—but a price to be paid for the larger economics of the system.

The periodic set-back to 5000′ and 7500′ will be done as required. Two crews are on duty at all times for this purpose. Each crew would pullback 20 trains per eight hour shift.

To couple such strings of cars prior to the pullback requires coordination between crew and hump so as not to be coupling cars on a track which is about to receive an impact from the latest cut on the high end. The hump computer will be tracking these new cars and be able to signal the crew of the current status of the track. This is an unusual procedure but one that can be worked out with complete safety using field sensing devices. The ground crewman will use a powered cart to find cars needing coupling prior to the pullback move.

BLOCKING GRIDS (Figure 5)

The next production stage is the blocking of the outbound trains. If a train is not to be blocked it can merely be set over to one of the 4 departure yards. Trains to be blocked are shoved toward the blocker humps (5E). These are low humps feeding a six track grid of 156 car capacity.

The outbound train call is determined by the receiving railroad. It also specifies the blocking pattern to be executed. The yard administration performs this job to order and delivers the train with caboose to the departure track.

Four blockers were designed into the system to feed a like number of departure yards. These systems perform simultaneously. Four trains can be blocked while four prior trains are finishing their setover to the departure tracks.

BOWL TO BLOCKER CONNECTIONS

Sixteen ladder tracks (5C) connect the 70 track bowl with the 4 blocking humps, main lines and departure leads. As a test of the adequacy of the ladder design, a Monte Carlo simulation was performed. Interference was found for 14 of 400 trains during peak hours. As peak output occurs only periodically, we can expect only 1 or 2 train delays per day due to ladder track conflicts. The delay will be approximately 15 minutes. This is well within allowable performance criteria.

Engine utilization for shoves to the blockers was 50.9% of the 5 crews available. In 3 of 24 hours the utilization reached the 80% level. These peaks were scattered in the day.

BLOCKER UTILIZATION

The peak production rate designed into the system is 8 blocked trains per hour (30 minutes each). The average output is 5.1 per hour, a 63.7% load factor. The peak output is scheduled in the 6 p.m.—midnight period with 38 trains averaging 6.3 trains per hour, 79% utilization. The blocker is occupied during both its input (humping) phase and while it is being cleared from the east end (5G). The result is to leave the 4 blockers under full utilization for 4 of 24 hours.

The local trains may need more than the basic six blocks. In order to create these blocks, several of the blocker tracks are pulled back and rehumped. (This procedure is used at Barstow on the ATSF.) A rehump of two tracks creates a total of 16 blocks.[8]

DELIVERY TO DEPARTURE YARDS

A key factor in keeping the blockers clear and ready for the next train, is the procedure used at location 5G. The move to the departure yard does not proceed through the blocker—but away from it (via 5H, 5I), thereby leaving the blocker clear for the next train to be humped as soon as the six tracks have been pulled.

Double track ladders extend from each six track blocker. Three of the six tracks extend to each side of this double track ladder. Removal of trains from the blocker is done by teams of two crews and engines which are working in parallel on the adjacent ladder tracks. Each crew doubles over 3 tracks to build half of the outbound train. The two halves are delivered to the departure yard and assembled there.

The crew utilization for the departure assembly job is 40.1% of the 4 teams provided (8 crews). During 8 of 24 hours the utilization exceeded 50% with a maximum of 70%. Only 3 of 25 hours exceeded 60%.

The eastbound departure yards are entered by a pullback move to the east. The west departure yards are reached by outside ladders (5H, 5I) and an eastward move as the three track sets are cleared. This is followed by a shove to the west departure yards on a double track ladder extending to both the northwest (5A, 3M) and southwest (5B, 3N).

Two trains may be simultaneously blocked and assembled for the same departure yard. The leads are designed for this. The traffic study showed only one case in 24 hours where more than four trains were going to the same quadrant. This was at 7-8 a.m. with 8 trains total, of which 5 were to go to the southwest quadrant. The maximum delivery of trains per hour to any one quadrant is 4 (2 simultaneously per half hour). The fifth train would be routed through another departure yard. Using the main line flyover (3H) and the double wye at 6H it is possible to use any departure yard which is convenient in response to peak loads, maintenance periods, derailments, etc.

DEPARTURE YARDS

The 24 departure tracks have standing capacity of 19.2% of a days output. The available time per train, is 4 hours, 36 minutes. The normal time required for coupling air hoses, air tests and random delays is 1.5 hours. Track utilization, therefore, is approximately 32%, a comfortable level for peak loads and abnormal circumstances.

CONCLUSION

The economic-technological issue is whether it is feasible to build consolidated train yard facilities at the super-volume points in the U.S. The findings from the St. Louis study are affirmative. The economic reward is significant. The study of the technological aspect of the problem—explored in this paper in some detail—shows that we can handle the volume by changing the method of classification and reassembly to suit the volume involved. Technological innovation was limited in scope.

The resource utilization analysis of this plan shows that a fifth blocker and larger premixer bowls should be reviewed as possible needs. All other resources including main lines, humps, engine crews and inspection crews were not excessively busy. The yard remained fluid despite its unusual workload.

The remaining issue, that of successful day-to-day yard management, has not been explored here due to lack of space. The subject has been carefully considered, however, and the findings suggest that the yard is operable without unusual personnel or abnormally high morale. The essential factor is an operations planning team equipped to plan ahead of the actual operations.

The opportunities for improved service performance and cost reduction make it imperative that the concept of super volume class yards be developed further.

FOOTNOTES

1 Train miles and track miles, 1973, all U.S. railroads.

2 Sponsored by the U.S. DOT, UMTA, HUD, State of Illinois.

3 Comprehensive Areawide Railroad Consolidation and Relocation Study, St. Louis Region, Executive Summary. East-West Gateway Coordinating Council, St. Louis, Mo., June 1974.

4 Areawide Rail Consolidation, St. Louis Region, Alternative Plans and Recommendations. Federal Railroad Administration, August, 1974, Unpublished Report. (Level 2 Report).

5 Hoover, Thomas and Minger, Wayne K. "Computer Simulation of a High-Volume Rail Gateway." Transportation Research Forum, Proceedings, vol. xvi, no. 1, 1975, pp. 139-147.

6 Landow, Herbert, "The Cost and Service Effects of Alternative Terminal Reorganization Plans." Transportation Research Forum, Proceedings, vol. xvi, no. 1, 1975, pp. 133-138.

7 All traffic and resource utilization statistics are taken from the 8th day of a 15 day computer simulation of traffic during October, 1972.

8 Landow, Herbert "Yard Switching with Multiple-Pass Logic." Railway Management Review, vol. 72, no. 1, 1972, pp. 11-23.