Principles of Unit-Train Productivity

A. T. LEWIS

ABSTRACT

The premise that the railroad industry must increase both quality and productivity of the railroad transportation product forms the basis of this paper. This increase is brought about by the emerging "just-in-time" manufacturing environment and increasing emphasis on productivity in the U.S. industrial climate. It is argued that knowledge of unit-train principles is important as a method to increase both quality and productivity. Statistics are presented from crew cost and car movement records to show the contrast between controlled service and random or mixed service. Although somewhat theoretical in nature, the discussion calls for setting operating goals to approach unit-train ideals in an effort to control operating costs (crew and fuel), reduce assets employed (locomotives, cars, trackage), and produce marketable, high-quality transportation. The statistical results presented are important in all operations whether they consist of true unit trains or only partly of unit trains.

The future opportunity of railroad operations is likely to lie in the area of precision or "just-in-time" freight service. Although unit-train-type operations have been a major cost control mechanism in the past, it is important to also see them as a precision revenue-gathering mechanism in the future. To this end, familiarity with unit-train characteristics and their control must be gained so that marketable, cost-effective precision freight services can be produced.

In this paper unit-train principles are emphasized, that is, what the underlying operational and delivery system characteristics of unit-train operations are. Once these are clearly seen, the opportunity exists to organize and manage many operations, unit train or not, to produce these valuable characteristics, valuable because they allow increased cost control and the ability to market precision transportation products.

The strong point of railway operations has always been train operations--the ability to move large amounts of goods and materials across the face of the globe with a bare minimum of direct labor and direct energy costs. All other railway operations detract from this singular strong point. Unit trains capitalize on this strength by minimizing support operations while offering to simplify and strengthen the key operation in a railway's economic makeup--trains. To the extent possible, unit-train principles must be understood and applied to other railway operations. The long-distance-freight (LDF) train is a good example. Both the classic unit train and other operations that mimic its characteristics must now become precision freight operations in the new industrial economy forming in the United States.

PRODUCTIVITY DEFINED

Productivity may be defined as the joint productivity of the set of resources employed. Note that the word "productivity" implies that something is to be produced. Now in railway operations, it is often concluded that the product is gross ton-miles. Therefore, productivity might be gross ton-miles (GTM) produced per unit of resource expended. But the equation is complicated because a composite or joint resource employed must be sought instead of a single oversimplified resource such as GTM per gallon of fuel. The concept of a joint resource is not easily understood.

A joint resource is an abstract idea, but an important abstract idea whose formulation is subject to debate. As much as one would like to simplify the problem by restricting its inputs to the individual areas of responsibility, formulation of the joint resource can be simplified only at the risk of misunderstanding the true economics of the corporate product.

But what are these GTMs? GTMs have been a useful statistical reference point in the industry for a long time but could a GTM be sold to a customer? GTMs are only a useful measure, not the real goal of productivity. How about net ton-miles? Maybe railroads' productivity goal is net ton-miles per unit of joint resource used. One can feel a little better about that. How much will you pay for a net ton-mile? How much will a net ton-mile cost?

Both questions are stated with a common denominator--dollars. Therefore, the productivity that must be controlled and improved with unit-train-like operations is a ratio:

$$\frac{\$\text{Revenue produced}}{\$\text{Joint resources expended}} = \text{Productivity} \qquad (1)$$

If this ratio is not greater than 1.0, the job is not worth doing.

Now for a look at unit-train productivity. To do this, a set of joint resources must be identified. These are as follows:

1. Above-rail resources
   a. Crews
   b. Fuel
   c. Locomotives
   d. Cars
2. Supporting resources
   a. Main tracks
   b. Sidings or second main track
   c. Auxiliary tracks
   d. Service or shop facilities

But resources do not stop at corporate boundary lines and control transportation productivity as experienced by the customer. The customer also has resources directly tied to the transportation operation, which cannot be ignored. They are

1. Inventory in transit,
2. Inventory to prevent stock-out (buffer),
3. Warehouse or stockpile space (buffer), and
4. Excess work force to overcome variability (buffer).

An understanding of productivity at this level of joint resource expenditure is needed in today's transportation environment. The relationships among the joint resources must be understood and workable management control to optimize the resource set must be gained. Unit-train knowledge can help do this.

UNIT-TRAIN OPERATIONS

To dwell a moment on details of unit-train operations, the nice thing about unit trains is that they are predictable--they have a uniformity about their character and performance that allows different management. Some of the buffers from the system can be removed.

What buffers might there be? To start with the above-rail costs, the buffers or hidden inefficiencies in the system may be as follows:

- Short crew districts
- Excess crew members
- Excess fuel
- Excess locomotives
- Excess cars

A plot of crew cost per train mile operated versus length of crew district is shown in Figure 1. This plot simply takes payroll by crew pool, divides by train miles produced, and categorizes by crew district length. This plot is taken from actual records and describes total dollar payout. Logical arguments, such as whether "long pools" really pay, aside, the relationship is quite clear: long pools produce lower-cost train operations and furthermore unit-train type operations are conducive to long pools.

Along with giving the unit-train crew a singular "unit" responsibility to move the train over the road, the need for excess crew population goes away. Three-man crews are common practice these days and two-man crews are clearly practical. Although the one-man crew is not advocated here, tonnage ore trains in some parts of Europe are operated with only a mechanic or engineer. Unit trains having no work en route lend themselves to these minimum crew populations.

Figure 2 describes the "hurry and wait" characteristics of railroading. The area under the curve is train miles produced (mph x hours = miles). One plot shows a train hurrying at 50 mph and then waiting for a meet or an unplanned event. The long wait is where a set of cars is disassembled or switched before movement can continue to destination. The net effect of this movement system is an average movement represented by a straight horizontal line. This is the ideal that is sought and unit trains with their uniformity and simplicity of organization can help do that. Uniformity is important for the following three reasons:

1. The uniform operation can be produced with less fuel. Energy is not lost up the stack in high-speed windage losses or wasted with only the braking system to reaccelerate. For example, the difference between 40-mph and 50-mph operations on a railroad system in flat or rolling country is in the magnitude of a 9 percent reduction in road fuel cost.
2. If one does not need bursts of speed because of the environment for uniform operation, one does not need a high horsepower-ton ratio to move trains. The unit-train philosophy can reduce the number of locomotives needed to produce a given amount of GTMs. These locomotives currently cost in the vicinity of $1.3 million apiece and generate approximately $25,000/year average in fixed or nonvariable maintenance costs. The railroad should determine how many locomotives can be reduced from its operations.
3. Unit-train philosophy need not be limited to a slow-speed coal operation. Trailvan (TV) or container trains are unit trains, and here unit-train uniformity is important to capture markets. Uniformity is needed to guarantee a reduced transit time. Figure 3 shows this possibility by dependably compressing the time axis to produce the same ton-miles as the variable mixed-freight operations.

Before freight car savings are added to this presentation, one needs to spend a moment on the understanding of how variability destroys a transportation product. Figure 4 is a plot of frequency versus transit time that shows how cars move in

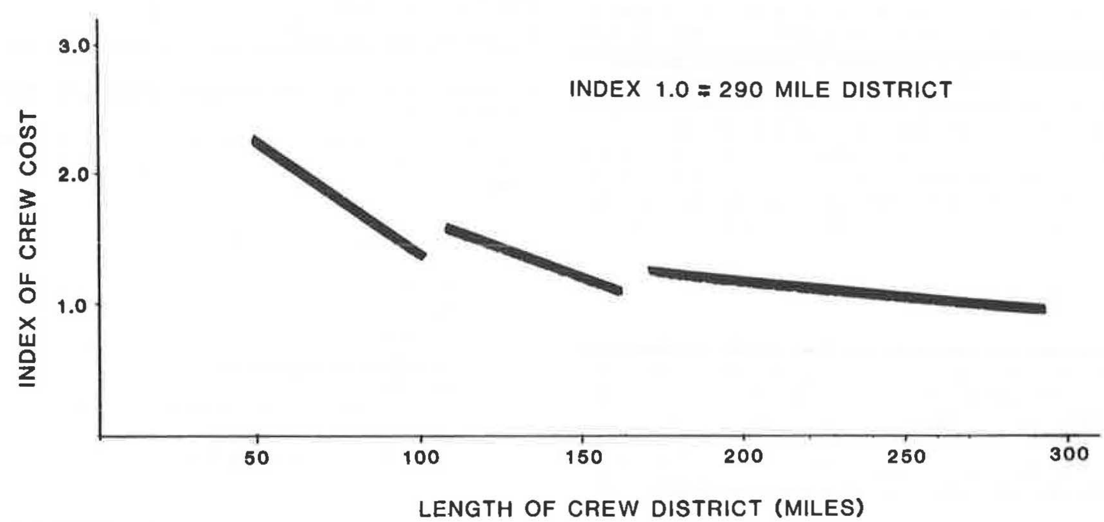

FIGURE 1 Variation in crew cost per mile.

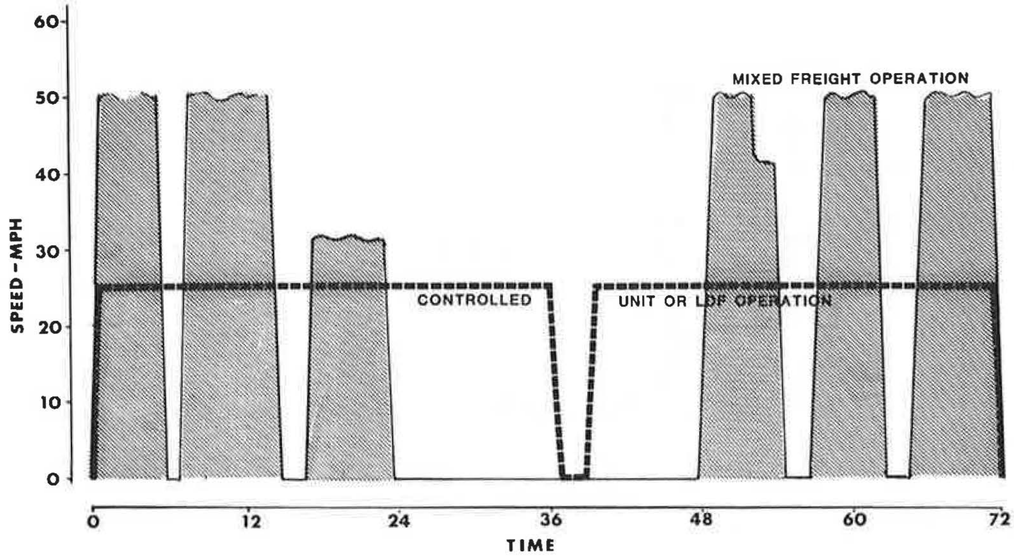

FIGURE 2 Controlled operation to reduce cost.

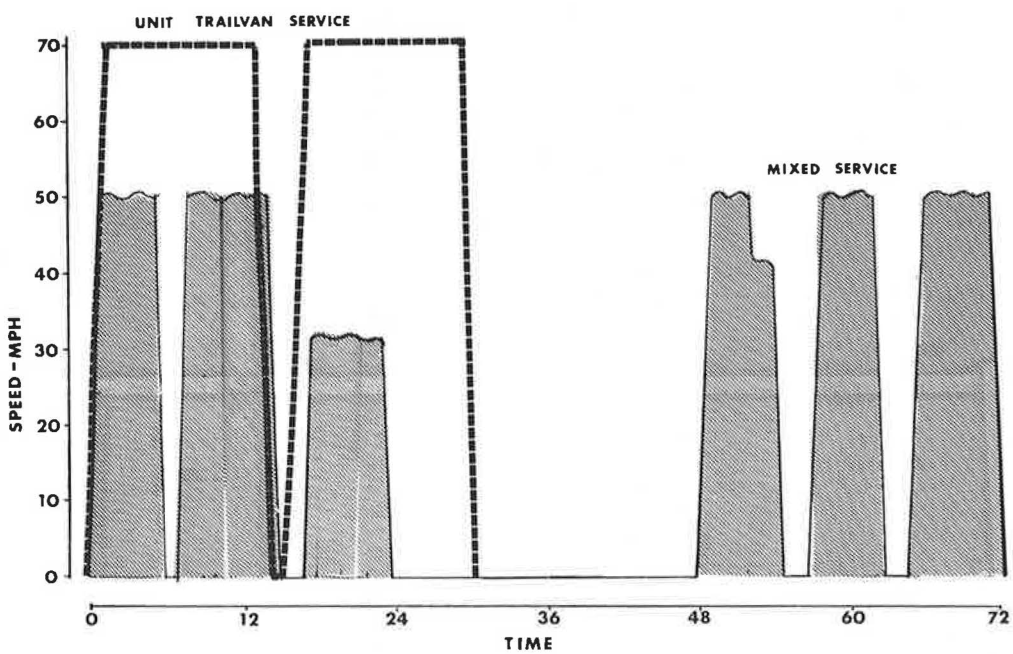

FIGURE 3 Controlled operation to gain market.

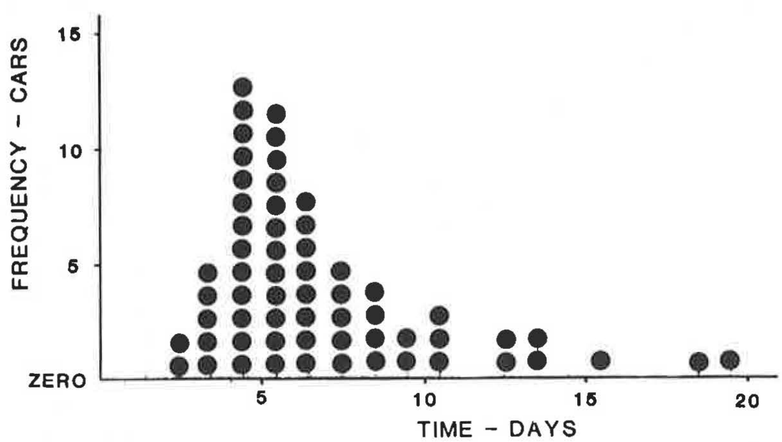

FIGURE 4 Sample dock-to-dock time in mixed-freight service.

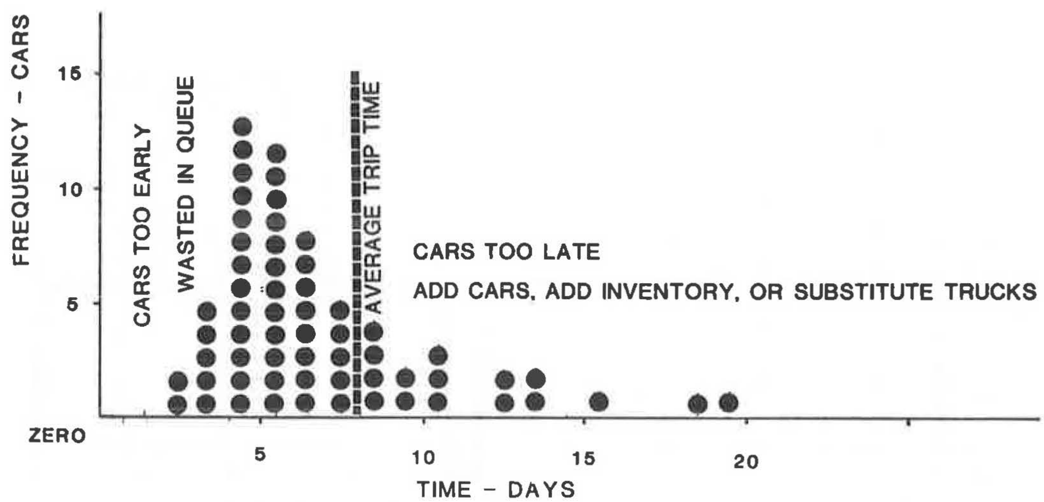

FIGURE 5 Wasted assets in variable service.

mixed-freight service. It is difficult to see how the railroad industry, to say nothing of the customer, tolerates it.

To look at this illustration in another manner (Figure 5), the question is how many freight cars are needed to commit to this service in order to command 100 percent of this customer's business. The average transit time in the sample is 8.4 days. Adding a similar 8.4 days for return, 3 days to load, and 3 days to unload, there is a 23-day car cycle or a yield of 16 loads per year.

But some of these cars have arrived 1 or 2 days too early and their crews are due for a paid vacation in terms of per diem or excess investment before they will do useful work again. The cars to the right of the dashed line are excess cars that one must have available to catch the next load because the slow movers cannot be depended on to get back to the loading zone. But this is ridiculous, so car management reduces the car days committed to this service. This, in fact, is done by playing statistical roulette with a badly variable transportation product. The result is that all railroads have owned too many cars (excess assets) and the companion transportation performance produced has pushed customers one by one toward use of trucks. Unit-train operations have the potential to simplify and attack this area of railroad inefficiency and market loss.

A contrast is provided by two plots of car performance in unit-train service. The first (Figure 6) shows a closely controlled unit coal operation. The second (Figure 7) shows a TV train service. Again use of resources is controlled and assets required can be reduced. An illustration of this efficiency can be found in piggyback car miles per day, which is a considerably higher multiple than the various increments of the general service fleet.

The lesson is that unit-train operations control the car cycle and, by controlling the car cycle, control excess resources. The benefits of precision freight service begin to appear when the car cycle is dealt with.

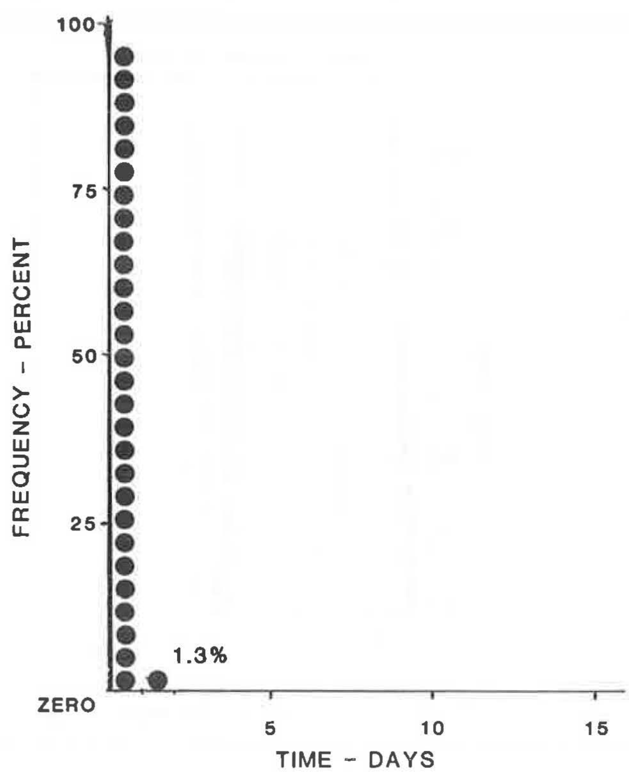

FIGURE 6 Sample elapsed time in unit coal service.

PHYSICAL PLANT PRODUCTIVITY

The productivity of the physical plant may be thought of as ton-miles or loaded car miles produced per mile of track. The point here is to use as little track as possible to produce marketable services. What this means is that double track should be used or retained only when really needed; sidings should be minimized, leaving them only where trains commonly meet; auxiliary tracks should be reduced as close to zero as they can be brought. Figure 8 shows variations in track productivity in different railroad systems. There is a need to be concerned about the productivity of physical plant assets.

It is hard to get the ball rolling in track reduction, but the uniformity of unit-train or LDF operations can provide an opening to attack unproductive physical plant. The railroad should look at its double track and determine where opposing fleets of trains meet day after day and where on this network the traffic is really one way day after day. The occasional train or uncontrolled conflict point

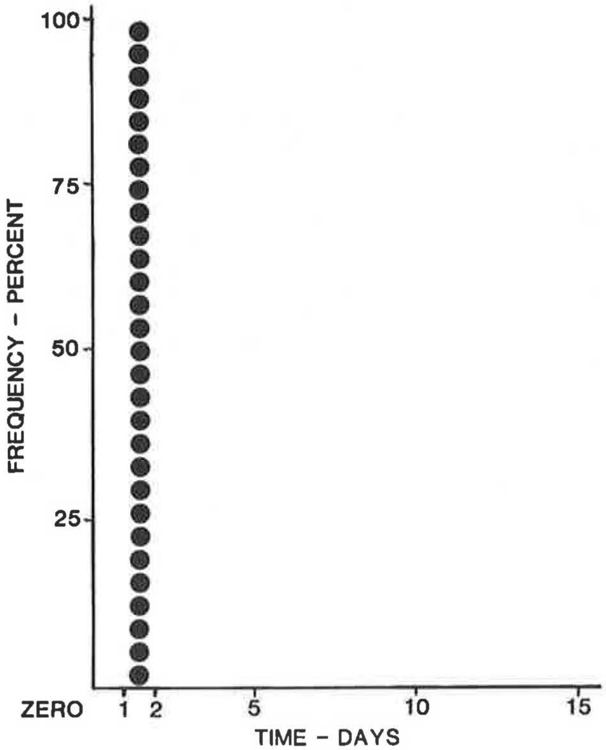

FIGURE 7 Sample elapsed time in TV service.

cannot justify underutilized tracks at today's replacement costs of $0.33 million per mile.

The uniformity of planned unit-train operations becomes doubly important in single-track territories. If one can maintain a planned and controlled operation, sidings need to be maintained only at the locations required for common meetings of trains. Sidings to support random operation are no longer needed.

Another facet of unit-train cost-reduction opportunities lies in reducing auxiliary tracks to zero. If auxiliary tracks are going to be reduced, first the ideal--a regular, 7-day operation that loads and unloads on the main track at each destination--should be visualized. The only additional tracks required are a handful of shop tracks. No switching or sorting, no car storage requirements. Coal, ore, grain, potash, containers, trailers, and tank trains can all operate in this fashion. From a practical standpoint in territories with high-density main tracks, an unloading siding and storage tracks for traffic surges will have to be provided, but classification yards, industrial yards, and low-productivity spur tracks drop out of such a system. Productivity per main track mile and productivity per auxiliary track mile must be part of the railroad equation and unit-train operations can help bring this about.

CUSTOMER-OWNED RESOURCES

Although so far only railroad-owned resources have been discussed, the picture is not yet complete. The customer-owned resources are a part of the economic productivity equation that one ignores only at his peril. The customer resources employed in the transportation operation were mentioned earlier.

Unit trains can address these costs by controlling transit time and variability. Consider the case of the automobile manufacturing plant today. It is not like it used to be. The automobile industry's money is no longer tied up in inventory in transit, buffer stocks, and warehouse space. The traffic manager knows how many hours' worth of inventory he has on the floor--commonly 4 hr. The traffic manager knows the precise transit time and variability that

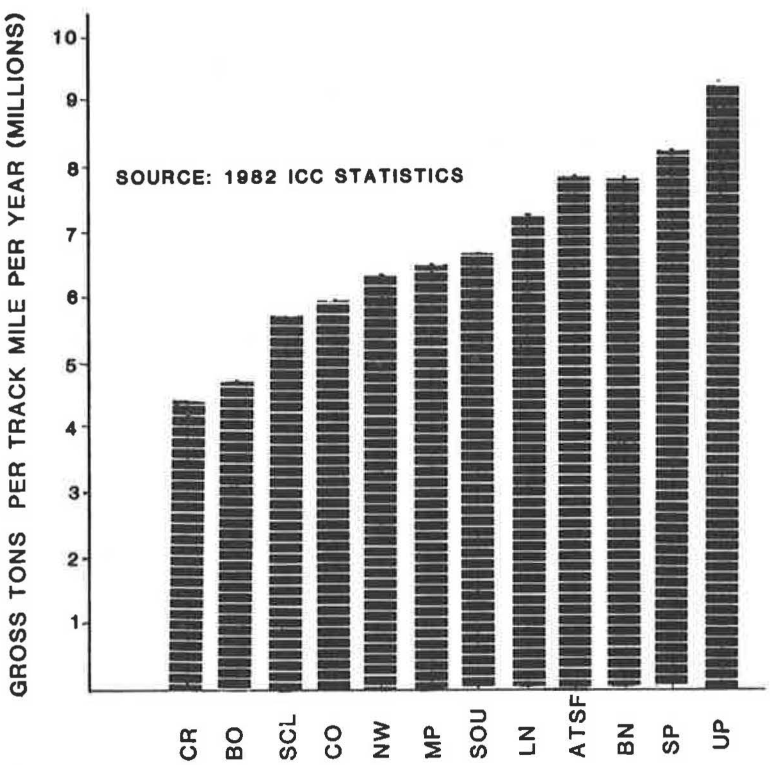

FIGURE 8 Productivity of trackage for various roads.

describe each supply line coming into his plant, for example, 22.5 hr ± ___ hr.

This is the way in which modern industrial America is thinking. And to participate in this renaissance, the railroads must consider the customer resource cost in the productivity equation. It may appear that this has little to do with unit trains but that is not so--the unit-train principles have to be understood. These provide a uniformity of operation that allows the cost elements and service criteria to be controlled. The uniformity allows precision production with reduced crew cost, reduced fuel, reduced horsepower, reduced car fleets (controlled car cycles), reduced support forces, and minimum trackage. These all stem from controlling variability so that resources are not wasted on buffers to isolate uncoordinated operations of labor, plant, equipment, and customer inventories.

Excellent examples of this step forward in the industry can be found. The interplant automobile trains of the Consolidated Rail Corporation, which have three-man run-through crews, operate on utterly reliable schedules between parts plants and assembly plants. Other emerging potentials can be found in the operations of steel distribution centers and lumber drop points. Some of these ideas are still emerging, but the unit-train potential is there.

The problem is not just productivity; it is productivity in a precision freight system. Unit-train operations and operations that mimic unit-train principles stand a strong chance of providing the industry the productivity and precision that it needs. Last, it must not be forgotten that the productivity sought is a ratio (Equation 1) and that productivity times volume leads to profits. Although one likes to think in physical units, the worth of what is done will be measured in dollars by the productivity equation.

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Optimal Use of Classification Yards

JAMES A. WETZEL

ABSTRACT

Railroad classification yards are an integral part of a railroad network. At these yards cars are classified, assembled or reassembled, and dispatched in trains from origin to destination. The objective of the classification yard is to eliminate reclassification of cars at intermediate yards between origin and destination. The efficiency of the classification yard is determined by its location, design, and operation. The design and productivity of flat and hump yards are discussed as well as a proposed method for upgrading hump-yard analog control systems.

The optimum railroad operating system provides transportation service between traffic origin and destination in the shortest time and at the least cost.

In general, freight traffic is consolidated at a yard located at or near its origin for movement in trains to its destination. The nature and volume of traffic moving between origin and destination pairs govern the frequency of operation and the physical facilities required for providing optimum service. The geometry of the yard design is a function of these volume requirements and the nature of the business. An analysis of traffic flow between origin-destination (OD) pairs will help to determine the optimum location, size, and design of a yard.

Although it is desirable to transport traffic in unit trains directly from origin to destination, it is unlikely--except for the movement of coal, ore, grain, and containers--to find a sufficient traffic volume from a single source to a single destination to operate unit-train service. On the Consolidated Rail Corporation (Conrail) 20 percent of the traffic moves in unit grain, coal, or ore trains, 19 percent in Trailvan (TV) trains, and the remainder (61 percent) in symbol trains that must be classified through yards. Therefore, it is necessary to emulate unit trains by creating through trains between the major gateways of the system. These gateways are identified as freight traffic centers at major industrial locations, intersecting railroad routes, and junctions with other railroads.

The evolution of the large automatic hump yard, which is the key to the optimum rail network, began in 1924 when the first retarder was installed at Gibson Yard on the Indiana Harbor Belt Railroad.

The improved efficiency of the hump yard attracted more traffic, and as motive power increased in size and trains grew longer and heavier, classi-