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Informal Note #2

# QUANTIFYING THE ECONOMICS IN COMPARING SPEED CONTROL SYSTEMS

## 1.0 Background

Although economics is not the only criteria for choosing among alternative speed control systems, it is one of the most important. Herein, we present some preliminary thoughts on how to quantify into economic terms the performance of various systems. We shall not be concerned in this discussion with calculating the costs (i.e., capital, operations, and maintenance) of various systems; we defer this topic to a later time.

## 2.0 Quantifying Performance

The functions of a speed control system can be stated simply as: "controlling car speeds and headways so that switching can be performed reliably and so that proper coupling takes place on the class tracks." Given that several speed control systems can perform the above functions within specified requirements, then we would say that the system which could accomodate the higher hump-speed is to be preferred.

Thus, we see that the performance of a speed control system has the three following elements: reliable switching, proper coupling, and high hump-speed. Unfortunately, these three elements tend to work against each other, i.e., high hump-speed is not conducive to reliable switching and proper coupling. The performance of any speed control system is a trade-off between the three elements.

Consequently, the foundation of any performance evaluation method is to quantify these elements. I would like to suggest the metrics shown in Table 1.

TABLE I

SPEED CONTROL PERFORMANCE METRICS

- Reliable Switching -- measured in percentage of misswitched cars

- Proper Coupling -- measured in
  - Percentage of uncoupled cars (i.e., coupling speeds less than 1 mph)
  - Percentage of over speed impacts (i.e., coupling speeds in excess of 6 mph)

- High Hump Speed -- measured in feet of car per second over the hump

Other Factors

- Noise — Nearly 40 percent of all existing hump yards are located in ~~noise areas~~ commercial or residential areas (i.e, areas that may be considered to be noise sensitive).
- Safety

## 3.0 Translating Performance Metrics into Dollars

In order to translate the performance metrics into dollars, one must first determine their effect on the operations of the yard, and then attach dollars to these operational effects. This translation is not straightforward; one must make certain assumptions concerning the way the yard is operated. Below, we shall discuss each of the metrics listed in Table 1.

## 3.1 Percent of Miss-switched Cars

Assuming a given yard hump throughput (say 3,000 cars per day), the percent of miss-switched cars can be translated into the number of occurrences per day.

The occurence of a miss-switched car, in a classification track, requires that prior to the cars being pulled to the departure track to form an outbound train, the "miss-switched" car be "dug-out" and set-aside, say on a slough track. This can be done at either end of the classification yard. If done by the hump-engine from the front end of the classification yard, the hump must be shutdown to avoid the possibility of cars colliding with the hump-engine. If done by the trim-engine from the back-end of the classification yard, then the "digging-out" operation takes place while the trim-engine is pulling the tracks to the departure yard. This later operation entails pulling all cars up-to-and-including the miss-switched car, setting-over the miss-switched car, and doubling back to pick up the remainder of cars in the classification track. Although the latter operation is the most typical way of handling miss-switched cars, the former operation does occur.

The most stratightforward way to cost the effect of a miss-switched car is to assume the trim-engine does the work and estimate the time it takes. Typical estimates run about 20 minutes* on the average to "dig-out" a car. The dollar costs of the 20 minutes of trim-engine work can be estimated. This number can then be multiplied by the number of miss-switched occurrences per day to give the daily cost of miss-switches.

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*This number must be verified.

3.2 Percent of Uncoupled Cars

Assuming a given yard hump throughput (say 3,000 cars per day), the percent of uncoupled cars can be translated into the number of occurences per day.

The occurence of an uncoupled car in a classification track requires more work for the trim-engine in pulling the track to the departure track. If all the cars in the track were coupled, the trim-engine would couple to the first car in the track and pull the entire track. However, because all cars are not coupled, the trim-engine will couple to the first car in the track and shove into the track to attempt to couple all cars and then pull the first group of cars up to the first uncoupled car; then the trim-engine will shove against the first uncoupled car (after the knuckles have been opened if need be by a brakeman) to couple the first uncoupled car. This operation of pulling and shoving to uncover and to couple uncoupled cars keeps taking place until the entire track is coupled.

Estimates to "couple" a track run from 15 to 20 minutes* on the average. These numbers (once obtained) can be translated into "X minutes to couple an uncoupled car." This number X can be translated into dollars by obtaining the cost for X minutes of trim-engine time. By multipling this dollar value by the number of uncoupled car occurrences per day, we can obtain the cost per day of uncoupled cars.

3.3 Percent of Over-Speed Impacts

Assuming a given yard hump throughput (say 3,000 cars per day), the percent of over-speed impacts can be translated into the number of occurences per day.

An over-speed impact can damage both the car and the freight. If we assume that each over-speed impact results in damage, then we must estimate the average dollar value of damage per over-speed impact. I suspect the FRA must be doing studies in this area; if so, we need to get these statistics. If not, we must gain the cooperation of a few railroads and have them give to us some information on the average amount of shipper's claims against the railroad for freight damage in yards. Estimating

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*This number must be verified.

these numbers can be quite tricky.

However, in concept, if we could get the average dollar value of damage per over-speed impact and multiply by the number of over-speed occurrences per day, we would obtain the cost per day of over-speed impacts.

## 3.4 High Hump Speed

The determination of the economic consequences of a higher hump speed is subtle and requires some judgement. Three possibilities exist depending on the yard operations and configuration:

- Case 1: Higher hump speed leads to greater blocking (classification) capability.
- Case 2: Higher hump speed leads to higher overall yard throughput.
- Case 3: Combination of Case 1 and Case 2.

### 3.4.1 Case 1: Greater Blocking Capability

In many existing yards, the overall yard throughput would be constrained by the throughput of the pull-out end of the yard. In these situations, unless the throat were re-designed, increasing the hump speed would not increase the overall throughput of the yard. However, one can use the increased hump speed to make more blocks (i.e., finer classification of cars) through two-stage switching and using the technique of geometric switching (see Figure 1).* Santa Fe at Barstow Yard uses this technique via a second mini-hump yard to provide finer classification for certain industrial blocks. However, Southern Pacific at West Colton can use the same technique by humping cars a second time over the main hump; this is possible since the West Colton hump speed is 50% faster than most other hump yards (i.e., 7 cars per minute versus 5 cars per minute).

Consequently, increased hump speed can be translated into making more blocks with the same physical plant (i.e., same number of classification tracks). The economic benefit of this increased blocking capability can be obtained by estimating the cost of building more classification

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*For a discussion of two-stage switching see: "Yard System Design for 2-stage Switching," American Railway Engineering Association Committee 14, (Draft 1-23-78).

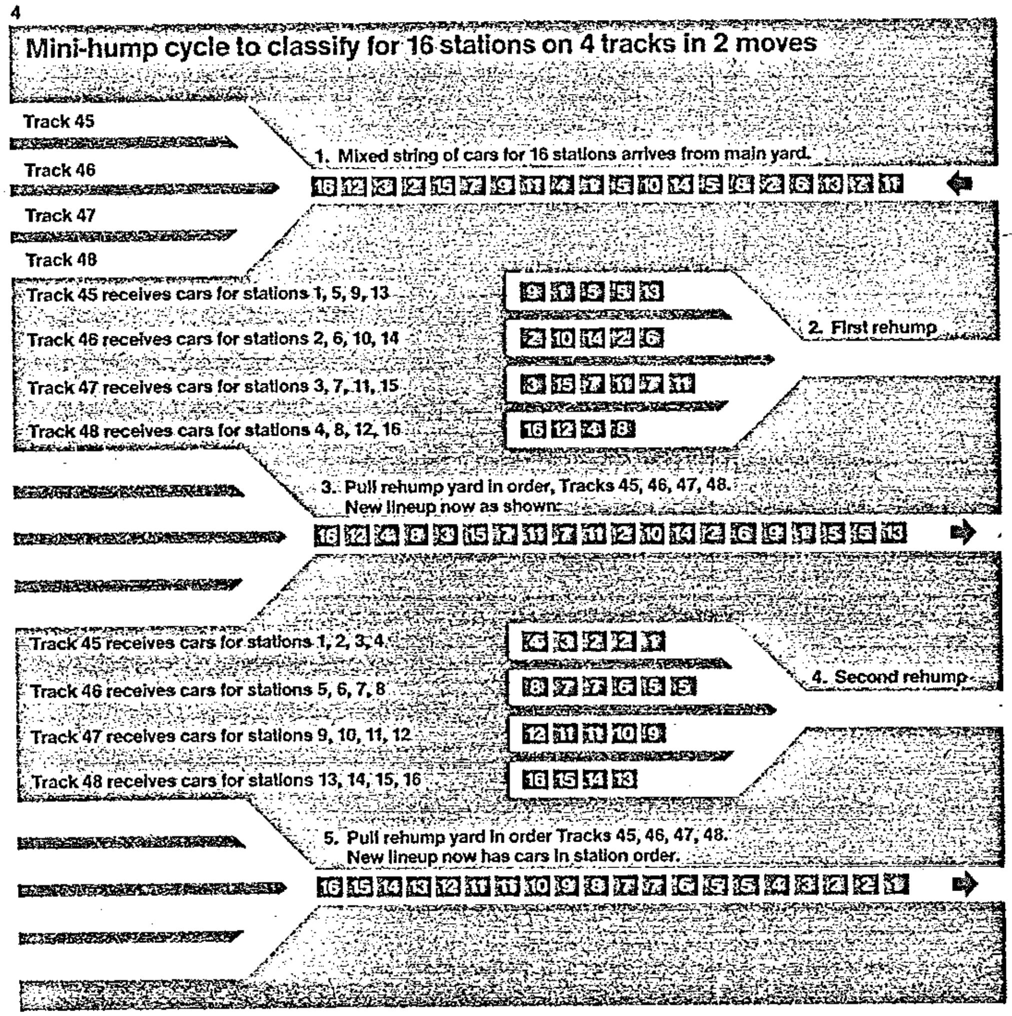


FIGURE 1: EXAMPLE ILLUSTRATING MORE CLASSIFICATIONS USING TWO-STAGE SWITCHING (GEOMETRIC SWITCHING)

tracks to obtain this same block capability. For example, consider Santa Fe's Barstow Yard. Assume that at Barstow the hump speed could be increased so that two-stage switching and geometric blocking could be accomplished over the main hump so that the same number of classifications can be made as in the present main hump and mini-hump configuration. Then the economic benefits of the increased hump speed is equivalent to the price of building the mini-hump yard, since the increased hump speed allows the same job to be done without a mini-hump yard.

### 3.4.3 Case 2: Greater Overall Throughput

If the pull-out end of the yard is not the bottleneck, then increased hump speed can be translated into increased overall yard throughput. This, in turn, can be translated into two economic consequences.

1. Increased throughput implies shorter terminal detention time for cars in the yard. The economic value of this reduced detention time can be evaluated (in concept) by assuming average per diem and average car costs.
2. Increased throughput for a given physical plant size can be evaluated by costing the equivalent plant needed to obtain the same throughput using a normal hump speed. For example, if we can double the throughput of a yard by increasing the hump speed, then to first-order, the value of the increased hump speed is the value of building another equivalent yard (i.e., one yard does the work of two).

### 3.4.3 Case 3: Combination of Case 1 and Case 2

If we could determine the economic benefits of Case 1 and 2, and if we could estimate the amount of greater blocking capability and increased overall yard throughput provided by increased hump speed, then the economic benefits of both are obtained by using methods developed for Case 1 and 2.

### 3.4.4 Which Case is Applicable for Our Study

The overall throughput of most current hump yards is constrained by the pull-out end of the yard; this is acknowledged by most operational people. This can be seen by the fact that hump speeds of 5 cars per minute are routinely achieved by most humps. If we assume the hump is utilized 75% of the time (i.e., two hump engines working simultaneously), then the hump can deliver 5,400 cars per day. Since even the most productive yard has throughputs less than 4,000 cars per day (i.e., more likely 3,500 cars per day), then hump speed is not the constraining bottleneck limiting overall yard throughput; in fact, as previously indicated, it's the trim-end which is the bottleneck.

Because of these facts and the fact that most new speed control systems are likely to go into rehabilitating existing yards,* it would seem that Case 1 is the most applicable for our economic analysis.

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*The cost to rework the trackage in the throat end of an existing yard is very high.