

Performance Indicator

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1. DESCRIPTION

In congested/conflicting situations, when TMS operates to prevent conflicts and smooth the traffic, the main goal of TMS is to limit the delays suffered by the running trains. So the natural Performance Indicator of TMS action is the (planned) average delay of the running trains. This synthetic information represents the global estimation of the achievable optimised exit delays for all trains, calculated by TMS at each plan generation. The achievable delay reduction derives from a comparison between this information and the disturbances occurring to the traffic (initial and intermediate delays of trains).

The proposed Performance Indicator varies throughout the time, in consequence of the changes in the traffic conditions (entry of new trains, exit of some trains, traffic perturbations), which trigger the re-planning by TMS. Then the Performance Indicator will be shown in a delay/time graph, together with the information about entry/exit delays. The graph will show the following lines:

1. average actual entry delay (received by the TMS when each train enters the model)
2. average planned exit delay (estimated by TMS at the exit point for each train). This number represents the average of the exit delays reachable by the trains in TMS plan if the TMS plan is executed as expected
3. average actual exit delay (received by the TMS when trains leave the model)

The three above numbers, considered altogether along time and joined with the actual progress of the traffic conditions, should provide the Dispatcher with the dynamic progress of TMS solutions.

In particular, values on the first and the third lines are updated on the basis of actual events (real entry and exit of trains), whereas values on the second line are the result of the optimisation plan by CRS1 and it is produced in advance with respect to the events.

This is well shown in the resulting graph, as it will be explained in the next.

Moreover, should be noted that the behaviour of trains, looking at the exit delay values, is “similar” to the behaviour expected by CRS1 plans. That follows from the correct execution of the TMS plans.

In the following, two possible graphical presentations of the Performance Indicator are illustrated. The graphs show the trend of the average delay values during a simulation with 8 trains. The involved trains and their initial delays are:

Train Name	Entry delay (seconds)
670-T-1	-60
455-H-1	1170
210-T-1	0
670-H-1	0
550-H-1	0
170-T-1	660
408-H-1	0
434-H-1	-960

Both the approaches aim at showing comparable values. A final conclusion summarises the main differences between them.

2. EXAMPLE 1

Figure 1 represents the final graph for the first example. On the x-axis it is represented the simulation time in minutes, while on the y-axis the absolute values of the delays in seconds are reported.

The lines represent:

1. the average actual entry delay (blue line)
2. the average planned exit delay (yellow line)
3. the average actual exit delay (red line)

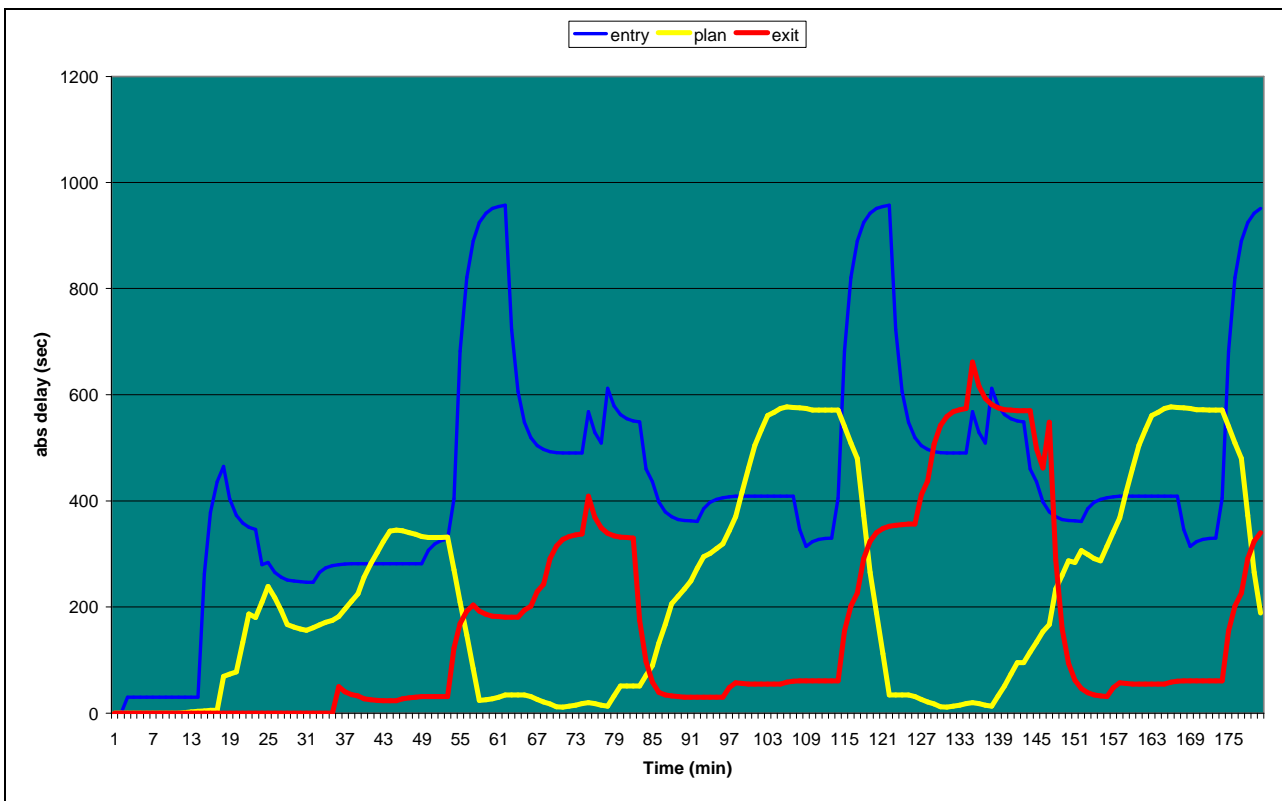


Figure 1 - Performance Indicator

- The sample time is 60 sec for each computation and the duration of the simulation is 3 hours.
- Delay values are treated as absolute values.
- The average entry delay is computed on a Time Window of 30 minutes. So the average entry delay value is the mean of the entry delay values of those trains whose actual entry time is in the time window starting from now till 30 min before now. At each time, (every 60 sec) the final value is the mean between the resulting value and the preceding one (in order to made the line smoother).
- The average exit delay is computed on a Time Window of 30 minutes. So the average exit delay value is the mean of the exit delay values of those trains whose actual exit time is in the time window starting from now till 30 min before now. At each time, (every 60 sec) the final value is the mean between the resulting value and the preceding one in (order to made the line smoother).
- The average planned exit delay is also computed on a Time Window of 30 minutes. This is made in order to make these values comparable as possible.
In this case the average planned exit delay value is the mean of the planned exit delay values of that trains whose planned exit time is in the time window starting from now till 30 min after now. At each time, (every 60 sec) the final value is the mean between resulting value and those ones computed in the last 5 minutes (in order to made the line smoother).

2.1. COMMENTS

It can be observed that the trend of the actual exit delay values is well correlated to the trend of the planned values. In fact, the curves (the red and the yellow lines) could almost be placed one on the other, simply by shifting one of them of a range of about 30 min, that is to say the width of the time window chosen. This demonstrates how the plan computed by CRS1 is able to manage the dynamic development of the model with efficacy, anticipating the progress of the events in the environment. Differently, we cannot observe a so precise relationship between events for the actual entry delay values (blue line). The reason is that entry delays are treated as absolute values, so only their global and quantitative influence can be appreciated on the graphical representation.

In order to give a more complete description of CRS1 plan computing, we report also the following graphic.

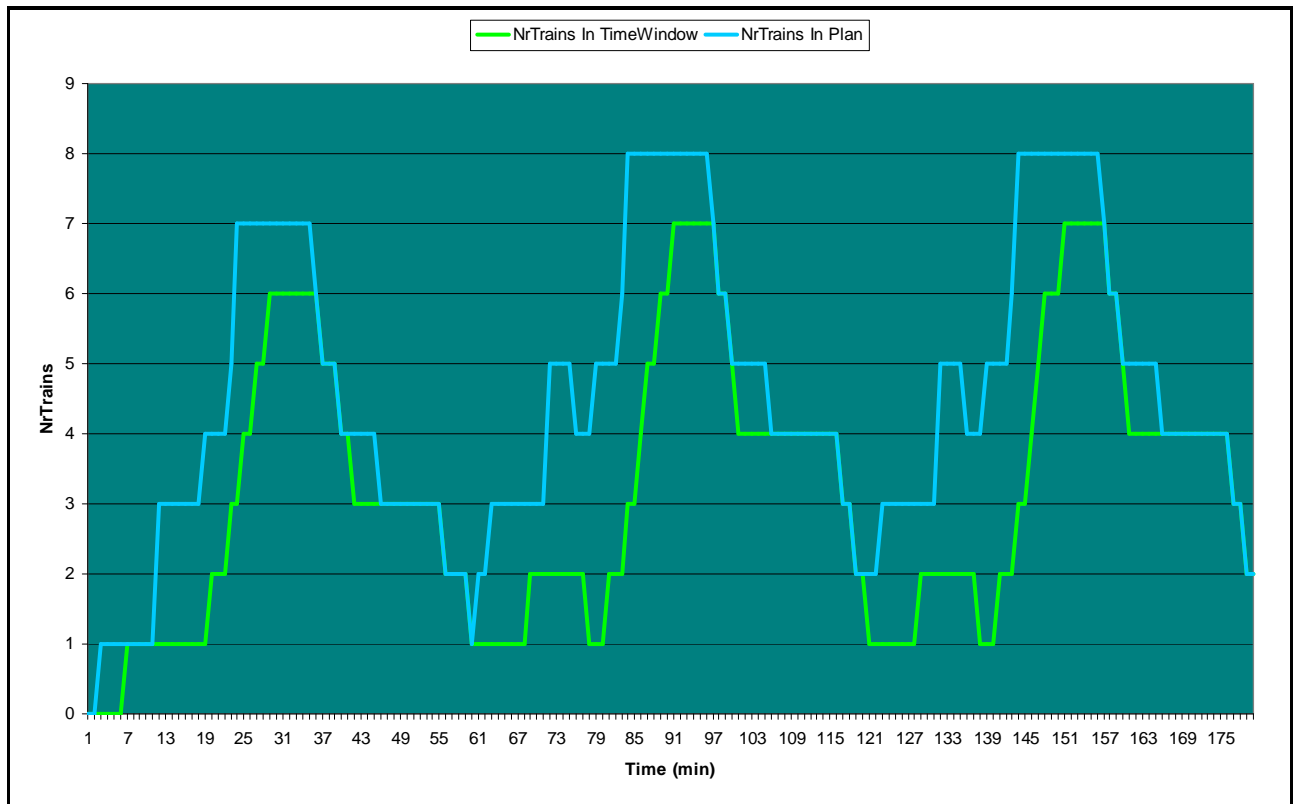


Figure 2 - Trains in plan

Figure 2 reports the trend of the average number of trains involved in the plans produced by CRS1. In particular, the blue line represents the average total number of trains that CRS1 takes into account in the actual plan, while the green line reports only the average number of trains used while computing the average planned exit delay (i.e. trains whose planned exit time is in the time window which starts from now till 30 min after now).

Even if the number of the running trains in this example is quite little, it is evident how the CRS1 plan considers a larger number of trains in order to compute a global and steady optimized solution.

The attached [Example1.avi](#) provides the animation of the example.

3. EXAMPLE 2

The second representation plots the same lines as the graph in the previous example, but in an asynchronous way. The reason is that, in order to make the three lines as much as possible compliant (that is to say, to consider the same trains for the three lines), different update times must be defined for the different values. In fact, the TMS plan includes all the trains already present in the area at that moment, plus all the trains expected to enter the area within the "Time Window ". During the simulation, the TMS plans are updated in order to take into account new trains (or to comply with the modified traffic conditions) and the trains in plan change (when new trains enter the plan, when some trains already in the plan enter the area, when trains leave the area)

In order to explain the approach, the attached "[Example2.ppt](#)" provides the explicit description, step-by-step, of the graphs generation. In the approach, at time t all the trains in plan are considered and the average planned exit delay is reported (purple line). As CRS1 generates the plan in advance, it can happen that some trains in plan are not entered yet. Only when all the trains in plan are actually entered, the average actual entry delay is reported (yellow line). The same occurs for the exit of trains: only when all the trains in plan actually left, the average actual exit delay is reported (blue line).

According to this approach, the three lines are updated at different time values (the average actual exit delay line is updated always after the other two lines. The average planned exit delay line and the average actual entry delay line can be updated at the same time, or it can happen that the average planned exit delay line anticipates the average actual entry delay line).

As well as in Example 1, in this representation the actual exit delay line is well correlated to the planned exit delay line (the purple and blue lines are quite overlapped).

The attached [Example2.avi](#) provides the animation of the example.

4. CONCLUSION

The main differences between the two proposals can be summarised as follows:

	Update time of the three lines	Time correlation between the three lines
Example 1	Synchronous	Time window shift
Example 2	Asynchronous	No shift

The two proposals should be discussed with ProRail, in order to choose the approach which better fits Dispatchers attitude.