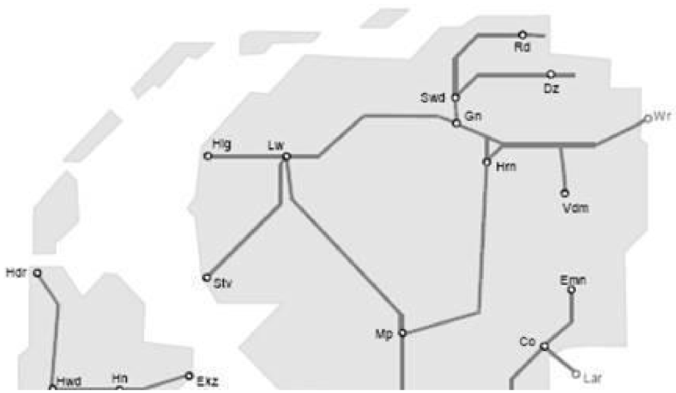
Speed control study for ETMET 2013 project (“Each Ten Minutes a Train”)

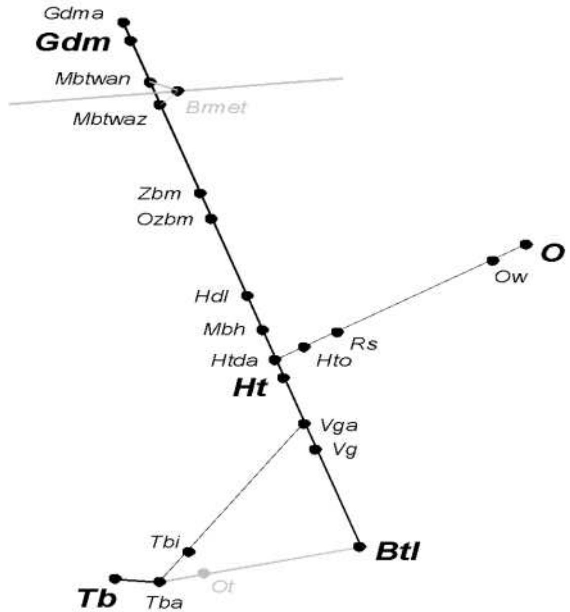
's-Hertogenbosch environment

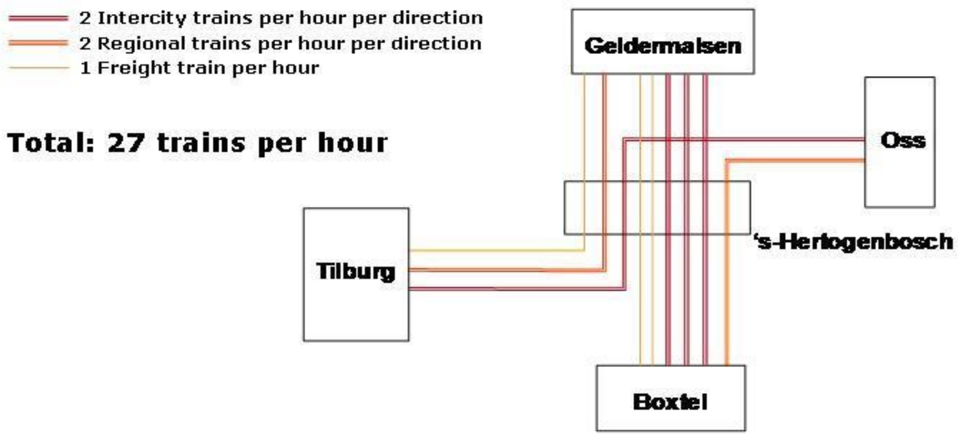
TMS results 2011



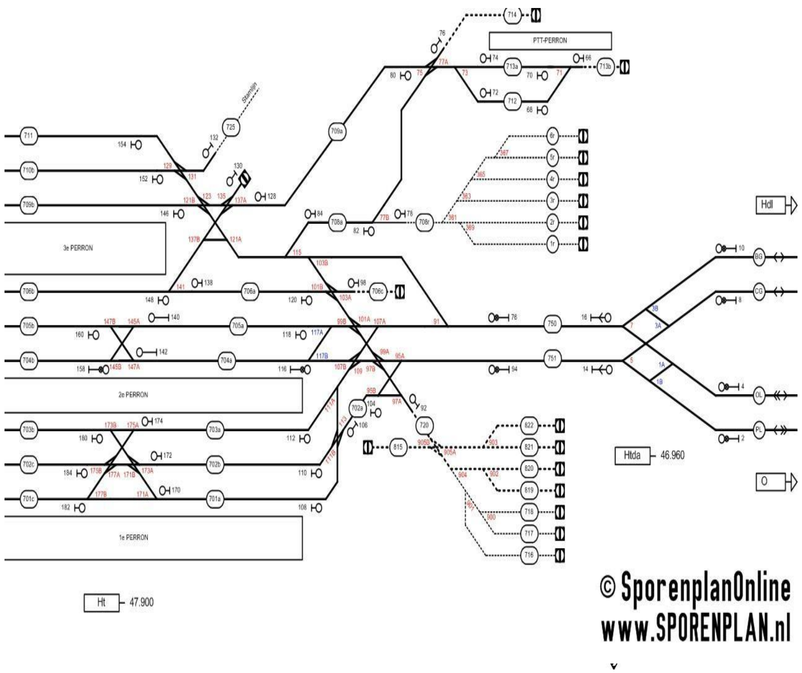
1. THE PROJECT

The ETMET project aim is to study the possibility to grant a frequency of one passenger train every 10 minutes, on a mainly two-track route where will run six intercity trains, six regional trains and two freight trains (total 14 trains) per hour in the morning and evening peak hours.



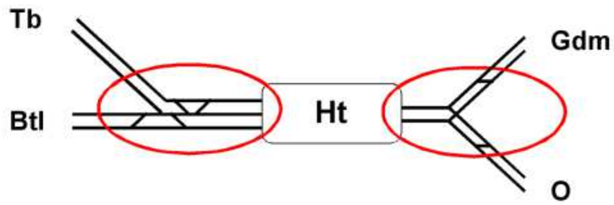


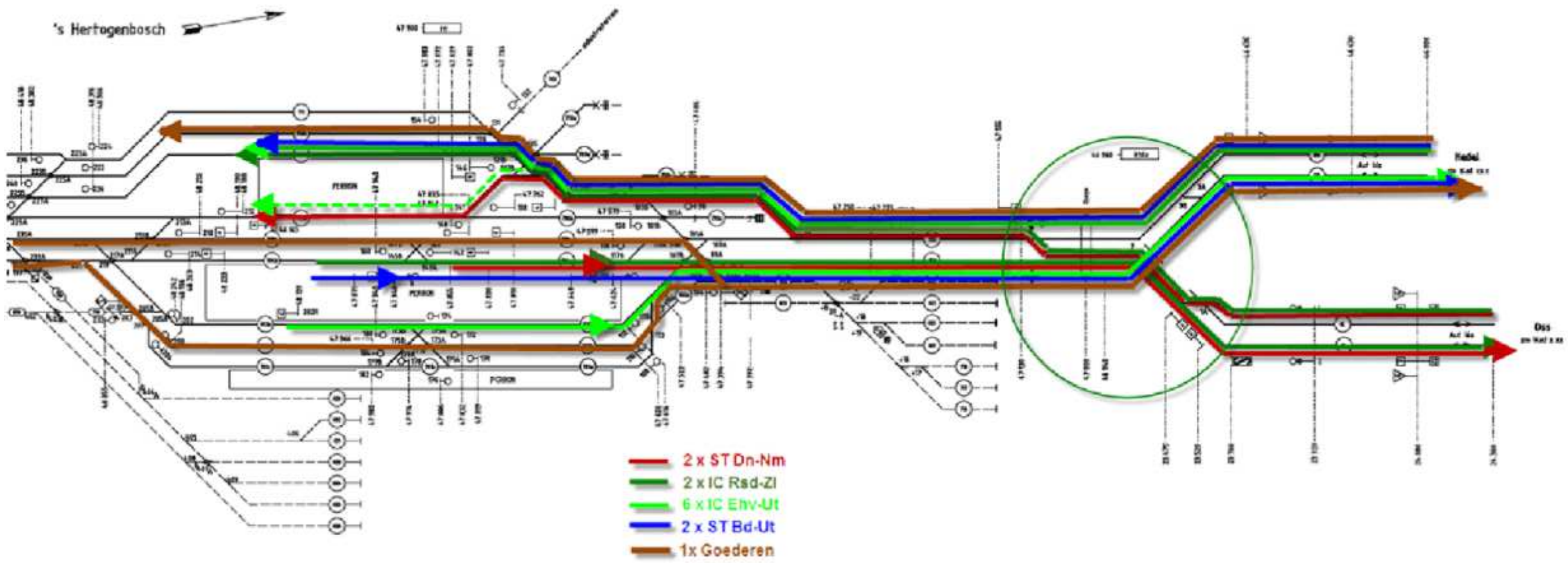
2. THE NETWORK



The study area used for the tests is a subarea around Den Bosch, (Tilburg, Oss, Boxtel and Geldermalsen), which is between Amsterdam and Eindoven.

The network presents two main bottlenecks in 's-Hertogenbosch (see Ht)





3. SIMULATION TESTS

FRISO (Flexible Rail Infrastructure Simulation Environment) is used to perform the simulation study.

It contains a detailed description of the infrastructure and safety system, which makes a detailed study of the punctuality at station level possible.

FRISO can simulate the rail traffic driving trains, updating signal aspects, etc…It can do by itself implementing some rules taken from real world and from railway common usage, in particular for what deals with speed profiles, precedence, routing and safety system, or following advisory speeds and route booking coming from the TMS (Traffic Management System).

The TMS is linked to FRISO and computes a feasible plan for all trains, decides precedence and calculates advisory speeds for trains based on the current position and speed.

The TMS optimizes jointly on all trains and their entire journey through the study area, and tries to minimize delays, detecting and avoiding conflicts, when possible.

The software architecture contains synchronisation mechanisms that allow consistent time management and interaction between the simulator FRISO and the TMS.

For each scenario, 25 runs of 6 hours (4 hours plus 2 hours to warm up the model to fill with trains) in order to reasonably statistically reliable statements were performed.

Each run used a different distribution of the entry delays of trains.

4. TEST RESULTS

In order to evaluate the effects of TMS some *performance indicators* are analysed:

- *Punctuality*
- *Delay percentiles*
- *Mean and standard deviation of delays*
- *Number of unplanned stops*

and then compared with the same parameters of two no-TMS environments, applying 2 different decision strategies for routing and precedence:

- FCFS, *"first come first served"*
- VaVo, *Vaste Volgorde that means "fixed order"*

Note that, in both cases, FRISO drives trains by applying always the maximum allowed speed, considering infra and train speed limits.

Note that "tardiness" (defined as MAX (0, delay)), is a better global delay estimator than algebraic average, as an early arrival of a train should not compensate a late arrival of another train. Indeed, TMS doesn't consider optimal the early arrival condition.

Tables and graphics below show results, statistics and TMS performance improvements.

All trains	**Entry**	**FCFS Exit**	**VaVo exit**	**TMS exit**
delays [sec]				
average per train	**114**	**68**	**74**	**69**
std	**129**	**177**	**169**	**140**
tardiness [sec]				
average per train	**120**	**94**	**101**	**88**
std	**121**	**157**	**146**	**122**
punctuality				
1 min	**39.1%**	**57.4%**	**51.9%**	**51.4%**
3 min	**75.4%**	**85.5%**	**79.6%**	**86.1%**
5 min	**90.7%**	**89.0%**	**89.6%**	**94.6%**
7 min	**97.0%**	**92.4%**	**94.3%**	**96.7%**

delay percentiles [sec]				
5%	**-48**	**-118**	**-121**	**-110**
10%	**-18**	**-83**	**-89**	**-81**
50%	**86**	**33**	**48**	**55**
90%	**287**	**352**	**307**	**219**
95%	**365**	**488**	**436**	**313**
unplanned stops				
number/hour	**-**	**6.42**	**6.73**	**1.19**
# trains	**2660**	**2660**	**2660**	**2660**

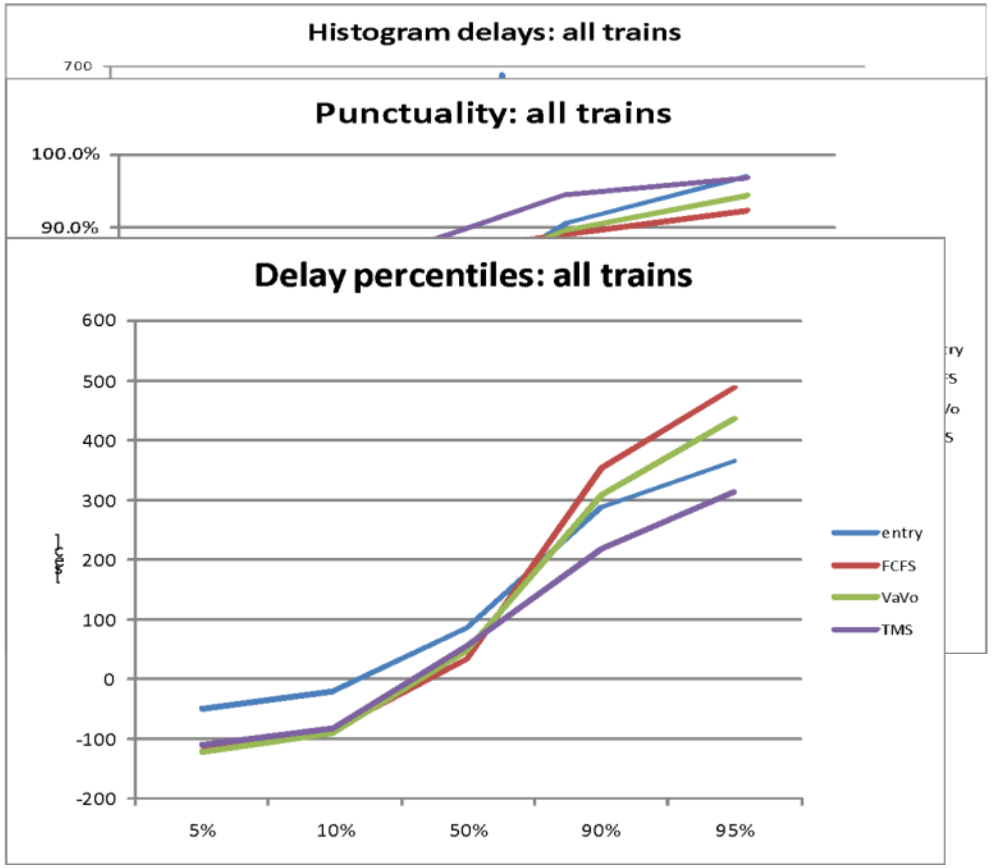
All trains	**Improvements at exit with respect to entry**			**Improvements TMS w.r.t. FCFS and VaVo at exit**	
	FCFS	**VaVo**	**TMS**	**FCFS**	**VaVo**

average tardiness	22%	16%	27%	7%	13%
std delay	-38%	-32%	-9%	21%	17%
5 min punctuality	-2%	-1%	4%	6%	6%
90% delay percentile	-23%	-7%	24%	38%	29%
10%-90% bandwidth	-43%	-30%	2%	31%	24%
number of unplanned stops	-	-	-	81%	82%

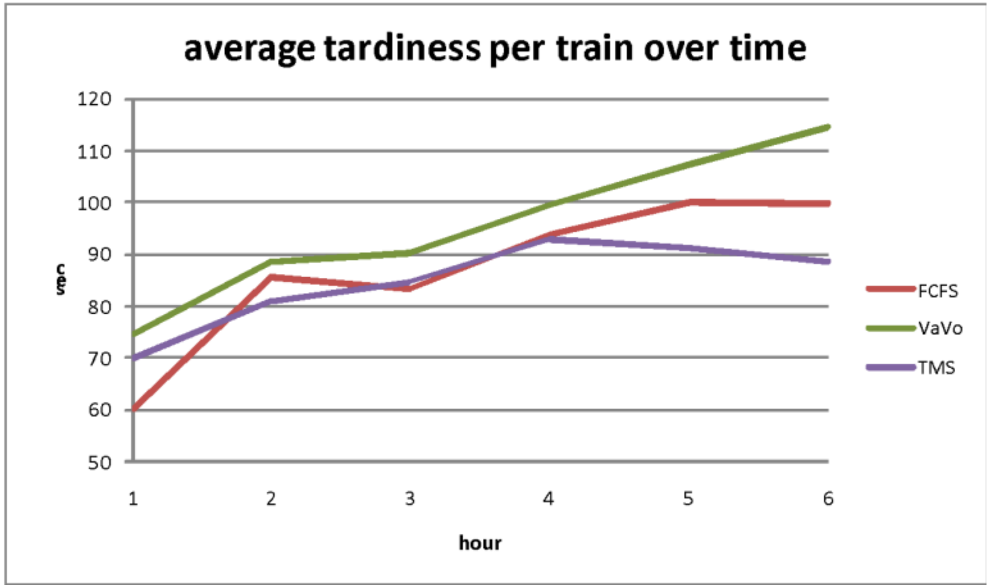
Table 1: Summary Results

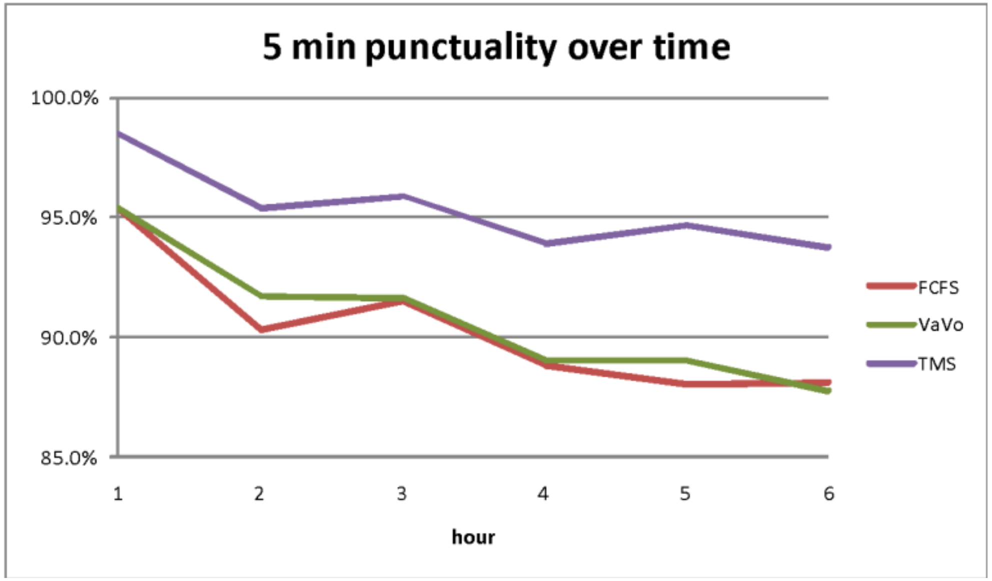
Tabel 2: Comparison and improvements of TMS

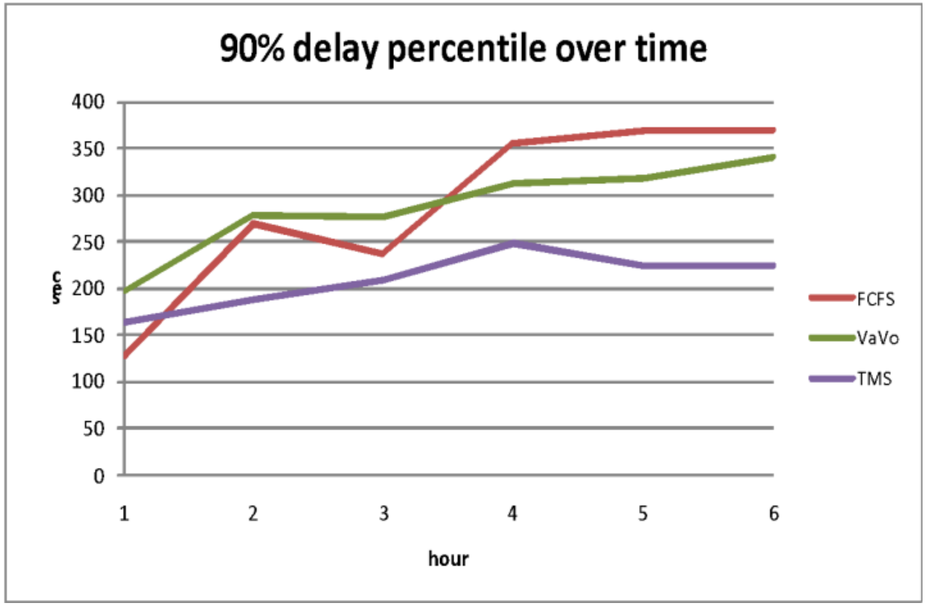
Graphics



Graphics: trend over time

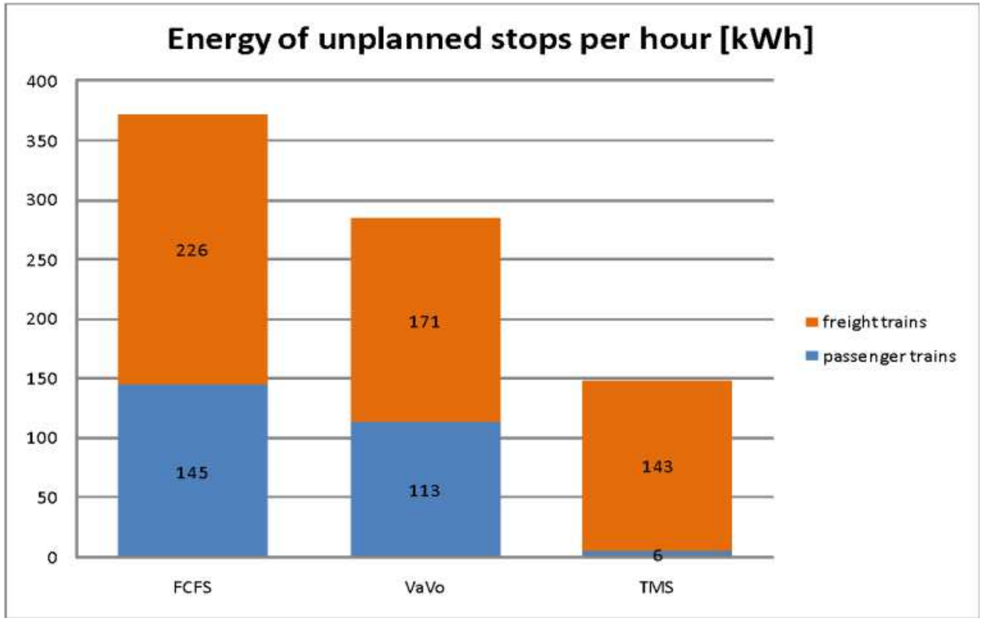


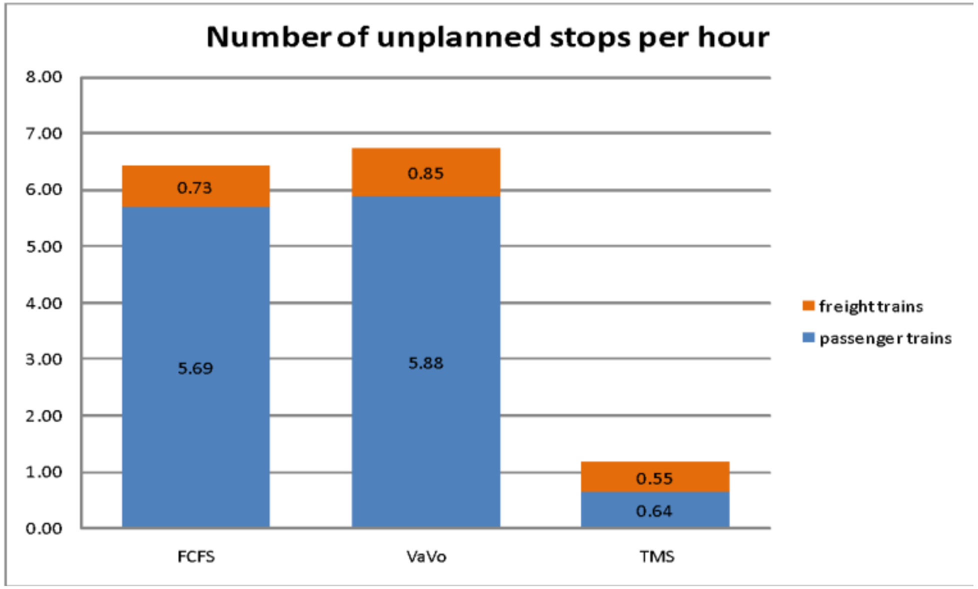


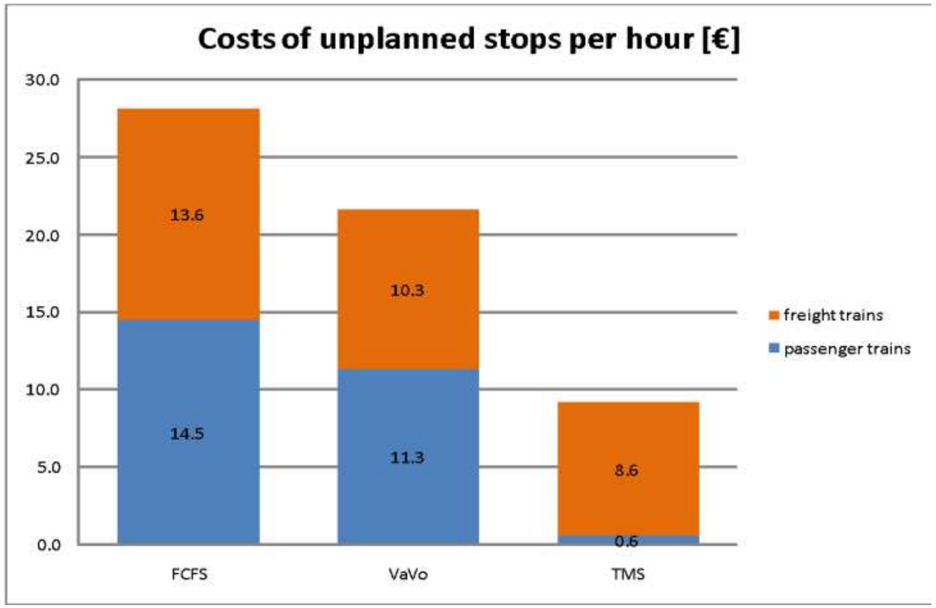


Graphics: Unplanned stops

Improvements TMS with respect to FCFS and VaVo	all trains		passenger trains		freight trains	
	FCFS	VaVo	FCFS	VaVo	FCFS	VaVo
costs unplanned stops	67%	58%	96%	95%	37%	16%
number unplanned stops	81%	82%	89%	89%	25%	35%






Costs of unplanned stops per hour [€]
30.0
25.0
20.0
15.0
10.0
5.0
0.0
13.6
14.5
10.3
11.3
8.6
0.6
FCFS
VaVo
TMS
freight trains
passenger trains