New display-designs for visualisation of Maglev-transit-operations

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Abstract

Novel computer based display designs for visualisation of high speed trains operation based on a fictive maglev-network are proposed. In order to find optimal solutions, only human factors such as mental capacity, visual system and information processing capability are considered. The proposed designs allow a dispatcher to quickly assess a real situation and to find a good disposition.

1 Introduction

In the early days of train traffic, the speed of trains was low and dispatching time not a critical aspect. Time-travel diagrams plotted by hand on a sheet of paper were a very convenient tool for dispatcher’s decision making. Later on, computers were used to support the decision making by calculating time-travel diagrams and drawing them on a display [6, 7]. While trains became faster and faster, the dispatch tools have not been developed adequately. The important aspect of a user centred display design [14] has never been considered. The use of maglev-trains in high speed train systems [12] introduces some new important aspects like high velocity (500 km/h), high train density, fixed block dispatching, a high degree of automation and network homogeneity. The availability of the system becomes more important than ever before. Hence, the dispatcher has to evaluate a lot of information and to find an optimal solution on dispatching problems in a very short time. Inappropriate decisions may be very expensive for the holding company.
As nowadays time-travel diagrams only allow for slow and inconvenient decision making, new diagrams are proposed, taking into account mental models on human decision making [9] and human capacity [1, 4]. In this article the following fictive maglev-train network is assumed:

![Figure 1. Map of a fictive maglev-network](image)

### 2 Analysis of existing time-travel diagrams

To find a new optimal display design, the existing time-travel diagram has to be analysed, considering the information the dispatcher can gain from it [2]. Figure 2 shows a time-travel diagram corresponding to the network shown in Fig. 1.

The diagram contains information about the process variables:
- position,
- time,
- velocity,
- driving direction,
- train identification.
The presentation form of this information [13] is important for its perception by the dispatcher. The time-travel diagram uses the two dimensions of a plane [2] for the process variables "position" and "time". While the vertical represents the time axis, with time in minutes, the horizontal represents the position axis, on which the railway, related to relevant railway stations, is shown. Thus, the two continua "position" and "time" form the continuum "plane". The upper section of the diagram shows the past, the lower section the future. The actual train position can be found in between, the events being linked by a line. The plotted lines are calculated for future events by extrapolation, based on the actual values of the process variables.

The representation of the past is not relevant for train-disposition. It only disturbs the perception of important information. Therefore the representation of the past can be neglected and should only be used for statistical representations, i.e. in a second diagram. However, the representation of the present is very important for decision making. Only the present shows information...
which can be compared with the projected status. It also gives an overview of the actual situation. The importance of the present is neglected in currently existing time-travel diagrams. Representation of the future is very important to yield a trend, to show conflict situations in advance, and to evaluate consequences of decisions made in the present. The gradient of a line shows the train velocity. Although quantitative information is not given, qualitative is. The latter can be obtained by comparing two lines directly. To do so, the distance of two lines has to be small and the difference of rake huge [10]. In addition, only lines of a certain length can be compared. The information on velocity derived from the diagram is only the fact, whether a train runs faster than another or not. The gradient of lines also represents information on direction. Crossing lines may represent a crash or a simple passing-by. This is one reason for the high workload of a dispatcher. The beginning points of lines represent trains entering the railway and the ending points trains represent trains leaving the railway. The vertical line distance shows the time interval between trains, the horizontal one the distance of trains. An underlying grid simplifies the evaluation of train positions. The whole display is obtained by overlaying multiple graphical displays: for each train running on a chosen railway a single graphical display is generated. This display represents the position in time and space of the train. The overlay of all displays forms a complete time-travel diagram. Lines are color coded and marked by a train identification number to allow trains to be identified.

3 Proposition of new diagrams

To support the dispatcher in an optimal way, we develop an intelligent assistant system [3] called DISPOS to recognise conflicts, to simulate the future and to propose optimal dispositions. The visualisation consists of two diagrams: a topographical map (Fig.1) and a novel time-travel diagram (Fig.2).

3.1 Topographical map

The map (Fig.1) is formed by station, network and train components. Stations are topographically arranged to correspond to the dispatcher’s internal mental model [15]. The whole display is sorted by train numbers. A station is represented by a rectangle. Its size corresponds to the size of the city, which is double coded using different sizes of text. Running trains are coded by triangles, standing trains by circles. Conflicts are calculated by the system and marked red (see Z7, Braunschweig / Z3, near Magdeburg in Fig. 2). The two directions of the railway can be distinguished by the color of railroad (lighted or dark) or by the color of the trains. The future can be previewed using the "simulation" button and is visualised using animation.
The user interface is designed according to recent guidelines [8, 11] and allows the dispatcher to zoom into the map, to get detailed information on trains by clicking on them, and to call up the diagram shown in Fig. 3.

### 3.2 Novel time-travel diagram

The novel time-travel diagram consists of four parts: train identification number, railway, delay time, and premature time. The menu corresponds to the one in Fig. 1 (meets the requirements of consistency [11]).

**Train identification number**

Every train is marked by a train identification number valid for a whole horizontal bar. This number corresponds to the one in Fig. 1 (consistency [11]).

**Guideway**

The railway is split up for each train to visualise the entering- and leaving area of trains. Stations correspond to the ones shown in Fig. 1. The two directions of the guideway are coded light and dark like in Fig. 1. A station entered next by a train is coloured on the guideway. Important is the diagonal structure of the display. Passing trains or trains in wrong directions can easily be identified using human pattern recognition capabilities [10]. As the order of trains corresponds to that in reality, there is no cognitive workload to the dispatcher. The future is visualised by animation clicking on the "simulation" button or towing a triangle.

**Delay and premature time**

Time behaviour is visualised by a button right to a railway bar. An empty button means "in time", blank text "too late", grey text "to early". Arrival times are shown by clicking on the button. In case of a conflict, the button disappears and the corresponding train symbol is flashing.

**Velocities**

Velocities are visualised by bars on the right side of the diagram. The bar length shows the maximum velocity possible due to train or railway (up to 400 km/h). A small green bar shows the velocity the dispatcher has to choose to get the train in time. A fat blue bar shows the current train velocity. The dispatcher can easily interact by moving this bar inside the given area to change the train velocity.
Figure 3. Novel time-travel diagram
This diagram allows to add as many functions as can be invented, e. g. a time pointer, an engine diagram, the position of passing zones or the visualisation of the projected status.

4. Conclusion

Time-travel diagrams previously used in train disposition [6, 7] do not meet the requirements of high speed train disposition as they do not contain high velocity, high train density and high availability (to give just a few examples). Hence, new diagrams need to be developed using a user centred design approach [14], utilising human decision making [4] and human capacity [1, 4]. This work has introduced new display designs using modern computer simulation applied to high speed train disposition. Thus the dispatcher is provided with an efficient tool for the assessment of a real traffic situation which allows to quickly find a good disposition.

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6. References


