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Train simulation on British Rail

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Abstract

A successful railway operation depends on providing a reliable service at a competitive price. The accurate matching of the track infrastructure provision and the timetable is central to achieving these requirements. If over provision is made in track infrastructure then the cost of installation and maintenance will be higher that necessary but there will be greater flexibility in operation leading to greater reliability of service; conversely, under provision of infrastructure whilst reducing costs will result in poor service reliability. Computer simulation of railway operation is a technique which has been used by British Rail for some time to achieve this balance. This paper describes the VISION simulator plus its associated AC traction supply simulator OSLO. The paper also emphasises the flexibility of VISION by describing the way it has been adapted to meet the specific needs of RENFE.

1 Introduction

British Rail has used computer simulation for more that 20 years as an aid to planning changes to infrastructure, changes to timetables and in the design of train regulation strategies. It was this latter requirement that lead to British Rail Research designing its first train operation simulator in 1970. This powerful simulator, which was called GATTS (General Area Timebased Train Simulator), ran on a mainframe computer and because of this was less than user-friendly and required complex skills and computer knowledge to set up and run a simulation. Nevertheless, it was used extensively to help with the design of British Rails' Automatic Route Setting algorithms which were first applied in 1983 and which later became a standard part of the BR's Integrated Electronic Control Centres (IECC) which are in use extensively on

BR. However, by 1987 it was decided that a new, easier to use simulator, was needed which would take full advantage of modern computing technology and this lead British Rail Research to develop VISION and OSLO simulators.

2 VISION

2.1 Aims The name VISION stands for 'Visualisation and Interactive Simulation of Infrastructure and Operations on rail Networks'. VISION was designed as an easy-to-use simulator with the capability of modelling the full range of railway operations currently in use or planned on BR and which could be used by train timetable and infrastructure planners who were not computer experts. One of the important requirements was the ability to monitor the progress of simulations in a way that would be familiar to the train planners. This suggested the use of a mimic diagram which would have an appearance similar to those used by signalmen in modern railway signalling control centres such as BR's IECC.

Another requirement was the ability to model quite large areas having over 1000 signals, 300 route miles and 500 junctions with a simulation speed faster than realtime.

2.2 Hardware In order to achieve these aims it was decided to use RISC technology and this has resulted in a simulator which runs on an IBM RS/6000 computer with high resolution display. The screen graphics uses the GKS interface running under X Windows. The software design takes advantage of the many years of BR's earlier experience in writing simulators and it uses some of the original GATTS modelling concepts with drastic modernisation to make it more user friendly. One of the major changes is in the method of specification of the infrastructure data.

3. Infrastructure layout

In the earlier GATTS simulator the definition of the layout was a complex process requiring great care and skill to ensure an accurate model. For VISION, the decision was taken to employ the high resolution display which is used for the mimic diagram, as an easy-to-use infrastructure input facility that would enable the user to draw a schematic diagram on the screen which would represent the track layout in such a way that it would be easily interpreted and checked. For example, a part of the layout that appeared on the screen to be a set of facing points would be interpreted automatically as such by the system - a sort of WYSIWYG (What You See Is What You Get). As the screen diagram is schematic it is necessary to input information relating a feature on the screen to its position on the track. This is easily achieved as the simulator allows the user to input the milepost mileage of the feature. This technique is used for defining the position of items such as signals, gradient changes, speed restrictions etc. In the past, one source of difficulty in defining the longitudinal positions of track items was caused by the fact that there are often many different track datums arising from historical reasons. It was decided at an early stage that it should be possible to define the positions of items on the track in a natural way, that is with respect to the track mileage datum at the point of the item. VISION provides just such a facility and this has proved an invaluable aid to the rapid creation of accurate models of track infrastructure.

The infrastructure input available includes the following:-

- Gradients - 1 in x or per cent or per mil
- Speed restrictions
- Track curvature
- Track circuit boundaries
- Signals - type, position, sighting distance, overlap
- Changes of milepost mileage datum
- ATP beacons
- Stopping point of trains
- Position of platforms

There are facilities for panning and zooming and also a cut and paste facility which allows portions of a layout to be re-positioned within that layout or even imported into another layout. The system can cope with large complex layouts and one simulation has modelled a complex layout involving two London termini with 32 platforms, over 300 track miles, 500 sets of points and over 1200 signals.

4. Signalling systems

VISION was designed to model all types of fixed block signals found on BR and it can model 2 to 5 aspect colour light signals, shunting signals and semaphore signals. New features such as ATP can also be modelled as can pure moving block type signalling systems. Coded track circuits have been simulated for overseas railways and level crossings for simulation of LRT systems. The method of simulating the signalling system has been designed such that it is a relatively straightforward task to model additional types of signalling.

5. Train performance

The simulator accurately calculates the train performance of each train on its tractive effort, mass, load, braking rate, train resistance, loading factor and maximum speed. There is access to a library of tractive effort and resistance curves for standard BR stock but the user can also input his own curves if

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required.

6. Timetables

For each train a timetable can be input which defines the train's stopping and passing points together with the departure and arrival times. Minimum dwell times at stations may also be specified together with stock working that must be achieved. It is also possible to specify passenger connections that are required. The timetable data can also provide routing information which can be used for automatic routing.

7. Train regulation and Routing

The simulator will run the trains according to the timetable if this is possible. However, if there is a conflict between two trains then one of a number of automatic regulation strategies can be applied. The following strategies are available to decide on priorities:-

- 'first come, first served'
- timetable order
- minimum lost time
- minimum cost regulation

The later regulation strategy requires the user to assign a cost for delays for each category of train.

If the automatic regulation decision strategy being used produces a priority decision that the user does not desire then he can over-ride the decision by specifying any number of individual regulation decisions which are applied between named trains.

Normally, the routing of the trains is pre-defined by the user but there is also a facility to allow the simulator to automatically re-route selected trains if the preferred route is unavailable. The user identifies the selected trains and the signals at which automatic re-routing is allowed but there is no need for the user to specify the alternative route as the simulator automatically chooses the best alternative route at simulation time. This facility can be very useful in allowing the automatic re-platforming of trains.

8. Simulation technique

The simulation is carried out using a fixed-increment discrete-time simulation technique. The basic time increment can be set down to a value as small as 1 second which will give a very precise simulation at the expense of simulation time. A more useful increment to use would be 5 seconds. As

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well as the basic time increment there is also control over the route setting time intervals which can be any integer number of time increments and might typically be 30 seconds. The maximum speed of the simulation is a function of these parameters and also the complexity of the area and the number of trains running.

9. Running a simulation

During the running of the simulation the mimic diagram shows the sections of track occupied by the trains plus the route set ahead. Also shown on the diagram are the signal aspects plus information on each train giving rather its lateness with respect to the timetable or its speed. As the simulation progresses a second screen shows the reason for any train facing a red signal plus summaries of the arrival, departure or passing times together with the degree of lateness or earliness.

A first step in running a simulation is often to carry out what is referred to as a timing run. For this the simulator calculates all the train movements accurately but it ignores any interactions between trains. This is a useful way of checking the train, timetable and track data as errors will often result in trains appearing to run very early or late. By this means the user can immediately identify any timings that are impossible to achieve. This run can also be used to establish a set of basic timings which can then be used for the construction of a timetable. This gives VISION the further capability of being used also as an aid to timetable planning.

The simulation speed may be set by the user and, for moderately sized simulations, speeds of up to 10 times real-time may be achieved. The simulator can be being stopped and started at any time allowing the user to interact with the simulation to introduce perturbations.

10. Perturbed running

Proving that a given timetable can be run under ideal conditions is only a first step to showing it is an acceptable timetable. The second step is to investigate the robustness of the timetable. VISION enables variations in train characteristics or timetable to be easily introduced such as reduction on tractive effort or maximum train speed. Automatic multiple simulation runs with introduction times of trains based on a user-defined probability distribution of train starting times are also possible.

11. Post simulation processing

During the simulation run a detailed log is produced which is used to provide a variety of reports. The most basic of these is a history of each train's

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movements as shown in Figure 1. Summaries of time lost by different train categories can be produced together with weighted cost functions based on the regulation strategy cost factors. Other reports include train graphs and platform occupation diagrams each of which allows the user to specify the time period, the area to be plotted, the trains to be plotted plus the colours to be used. This latter output is particularly useful when considering splitting and joining movements in platforms. Another output is the energy consumption figure for each train or group of trains.

Various summaries of signalling information can also be output to show the number of trains stopping at each signal and the number of trains facing a given signal aspect. Headways between trains can be deduced from track circuit occupation information.

12. OSLO

The VISION simulator assumes that the maximum tractive effort available for each train is a function only of speed and is independent of the movements of other trains. This is not strictly true for electric traction as the tractive effort will be a function of the voltage at the train which will depend in turn on the position of the train in question together with the movement of other trains in the vicinity. If the train movements are to be accurately simulated in these circumstances we need to model the electrical network and electric traction of the train. This modelling of AC electrified lines can be carried out using an add-on module to VISION called OSLO (Overhead Systems LOading).

13. Electrical modelling

The electrical modelling is very comprehensive and it can cope with the following features:-

- Fixed voltage supply points
- Synchronous motor alternator supplies
- Step-up and step-down transformers
- Auto-transformer feeding
- Booster transformers
- Fixed capacitor power factor correction
- Auxiliary loads

Extensive post-simulation output processing is available. It includes graphing of electrical parameters for trains either against distance or time and graphing of the electrical parameters for any supply point or other node in the network as a function of time. Summaries of rms loadings are also available as are energy consumptions for each train or group of trains.

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These features combined with the comprehensive train movements features of VISION result in a powerful electrified simulator which is invaluable in the design of new electrified systems. Extensive use was made of OSLO in the design of the BR's East Coast electrification scheme.

14. Use of VISION

Whatever combination of changes to a railway operation is being planned, the use of VISION can be expected to prove beneficial. New or modified track, signalling, electrification, timetables, rolling stock or regulation strategies - or any combination of these - can be evaluated to compare the cost-effectiveness of the various possible alternatives. VISION is designed to be used easily and effectively by railway planners who are not computer experts. It can be used to demonstrate proposals to decision makers. It allows the likely consequences of decisions to be seen clearly. Above all, it makes possible substantial cost savings by ensuring that enough resources - but not more than enough - are provided to run the regional services.

BR Research carry out many simulations for customers in BR, Railtrack and around the world and have great expertise in helping to design effective railway layouts and timetables. Many customers come to Derby to see the simulations run or to carry out the runs themselves. The software is also available for customers to run under licence on their own computers. A number of railways with very different conditions of operation now use VISION in this way. In each case, the software has been configured to ensure a good match to the customer's special circumstances. This in turn provides one mechanism of enhancing the capabilities of all versions from which all customers benefit. The work carried out in connection with the recent supply of VISION to RENFE provides a good example of this process.

15. VISION for RENFE

Users of computers in many countries are becoming accustomed to working with software which communicates with them only in English - or, more usually, American English. However, many nationalities very reasonably expect to be able to work in their own language. For this reason, a version of VISION has been created which works entirely in Spanish and the user manual has been similarly translated. In doing this work, the structure of the software has been modified to make translation into most languages relatively straightforward.

Different railway operators have developed different customs for the symbols and colours used in their planning procedures and control system displays. Just as the standard VISION mimics the graphics used in BR's IECC signalling control system, so RENFE wanted the display in their version to correspond with their conventions. The software has been modified so that most of the colours and symbols can be adjusted to the customer's requirements by the way it is configured during installation.

The standard VISION uses BR multi-aspect signalling conventions. These can be used to give a representative simulation of a variety of signalling systems. However, some signalling systems impose additional constraints or allow additional freedom compared with the standard VISION simulation. To ensure that RENFE's signalling is accurately simulated and realistically represented, a number of modifications have been made to their version. In particular, certain signal aspects and indications impose maximum speeds. There are also some limited conditions under which trains may pass stop signals. All trains in RENFE's version of VISION will obey these rules.

16. Development of VISION

No simulator, however powerful, can represent all the rich variety of conditions and situations which arise on railways around the world. VISION is as powerful as any in this regard but additional features are continually being added to meet customer's requirements. Recent examples are a more accurate simulation of route release when trains clear junctions, the ability to count the numbers if trains crossing junctions and the ability to count numbers of movements of points. All customers, both licensed users and those who have simulation run for them, have the opportunity to influence future developments and thus are able to increase the many benefits they gain from using VISION.

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