Railway Operation Simulator
(RailOS)

User manual

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1 Introduction

Welcome to the Railway Operation Simulator (RailOS), a program that allows you design, build and operate your own railway.

The main features include the ability to:

- build a railway of any size;
- add text of any available colour, font and size;
- set preferred and bi-directional running directions;
- choose light or dark backgrounds;
- add user-defined graphics;
- develop timetables with shuttle services, changes in direction, splits, joins, and repeating services;
- operate trains under timetable or signaller control;
- save an operating session to continue later;
- allow random failures and delays; and
- zoom-out for a wider display.

The minimum recommended screen resolution is 1024 x 768. RailOS will adapt to other resolutions and to resized windows but the higher the resolution the better it will be to use.

A wide selection of track types is available for building the railway, together with station elements consisting of platforms, concourses, footbridges and underpasses. Also available are non-station named locations for sidings, works, depots, junction approaches and anything else that needs a name. Location names and other text are displayed in user-selectable font, style, size and colour. Location names and other text may be moved in order to improve the appearance of the railway and areas of track may be selected and cut, copied, pasted, deleted, mirrored, flipped and rotated. Railway files may be saved and loaded in both development form during construction and in operational form on completion. Track element lengths and line speed limits may be set individually, along tracks, or in areas by selection, as can preferred running directions.

Trains may operate to a timetable developed using the internal timetable editor, or under signaller control. Three types of route are available:-

Automatic signal routes: set either signal to signal or signal to any following signal in preferred directions, the route is retained after trains pass and signals automatically return to green (in stages for other than two-aspect signals) as blocks ahead are cleared;

Preferred direction routes: set either signal to signal or signal to any following signal in preferred directions, the route is cleared as trains pass; and

Unrestricted routes: set from most types of track element to other track elements in any direction, again the route is cleared as trains pass.

In addition trains will run on track that has no route set, but they are then much more vulnerable to derailments and crashes.

Signalling can be two, three or four-aspect, and ground signals are also available.

Please note that the terms 'point' (singular) and 'points' (plural) are UK railway terms for what in other countries are termed 'switch' or 'switches'. This manual uses UK terminology. The singular 'point' is often referred to as a 'set of points' in UK railway documents but 'point' will be used herein for brevity.

1.1 Notes for Windows 10 and 11 users

When running under Windows 10 there is a display anomaly in that if the taskbar is hidden when the screen is maximised the display flashes, especially when routes are being set. Therefore to avoid this please either have the taskbar showing or don't maximise the screen.

Windows 11 has an even more prominent display flashing problem but it can be avoided in the same way - either have the taskbar showing or don't maximise the screen.

Windows 11 reduces the size of the 'Actions Due' panel so that the text is cropped. It also crops the bottom of the performance panel (the functions of these panels are explained later). Because of this from v2.20.3 these panels are now resizeable and can be enlarged by grabbing a corner with the mouse and expanding them. Please note that the 'Actions Due' panel should be tall enough to allow 20 entries so as to prevent a vertical scrollbar appearing which obscures some of the text.

Windows 11 enlarges the text on pre-Windows 11 railway layouts. Therefore when operating these railways some of the text might need to be reduced in size or repositioned in order to avoid obscuring other railway features.

The reasons why these anomalies occur isn't known but internet searches show that others often complain about them. Microsoft normally advises users to update their display drivers but the problems still occur with up to date drivers.

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2 General features

2.1 Backgrounds & trackside signal locations

White, black or dark blue backgrounds may be selected when there is no railway present and no mode selected (see section 2.6). Track displays black on a white background or white on a dark background. All other colours display the same on either type of background, so try not to select too dark a text colour for dark backgrounds or too light a text colour for a white background. When black or white is selected as a text font colour the stored colour is always black, and it always displays white on a dark background and black on a white background. This means that it is not possible to display black text on a dark background, or white text on a white background, which wouldn't be very useful in any case! Any saved railway or session may be displayed on any background provided the background is selected before the railway or session is loaded. When RailOS is opened it will use the same background that was in use when it was last closed. This allows a preference to be selected and retained without having to keep changing it via the menu.

Signals can be located on the left hand or right hand side of the track so as to reflect correct practice for the railway in question. When no railway is present and no mode selected (see section 2.6) a message states which side of the track signals will be on. This can be changed by selecting 'Convert to right [or left] hand signals' in the 'Mode' menu. This option is only available with no railway present and no mode selected. Note that the side that signals will be on is configured within RailOS rather than being a feature of a particular railway, so a railway built with signals on the left can be loaded as a railway or as a session with signals on the right if that option is selected, and vice versa. Signal location only affects the appearance of a railway, operation is exactly the same whichever side the signals are on. Just like background colour the signal location in use when RailOS closes will be the same when it is next opened, thereby avoiding the need to change it each time.

2.2 Train characteristics and floating window display

Train status information is displayable by a floating window enabled by menu selection and made visible by hovering the mouse over a train or a continuation where a train is to enter. The floating window can also provide details of the train's timetable from the current point onwards, and track element information if required (see section 2.4).

2.3 Folders and Files

When RailOS is opened for the first time a number of folders ('folder' is a modern term for 'directory') are created in the working folder (also known as the current directory), which is normally where the program itself - 'RailOS32/64.exe' - resides. To make sure that RailOS32/64.exe is in the working folder set up a desktop shortcut to it and check in the shortcut properties that the 'Start in:' entry matches 'Target:', but without '\RailOS32/64.exe'.

The folders created by RailOS are:

Formatted timetables - for user-readable timetables, see sections 5.10 and 5.12;
Images - for storing railway images, see section 3;
Graphics - for storing user-defined graphics, see sections 3.1 and 3.2;
Performance logs - for storing logs of operating sessions, see section 6.7;

Program timetables - for program-readable timetables, see section 5;
Railways - for storing railways that are operational or being developed, see sections 3 and 4; and
Sessions - for storing operating sessions, see section 6.3.

The folders for storing railways, timetables and sessions can be changed by the user if required, and these changes will be saved when RailOS closes and reloaded next time it opens.

There are two types of railway file. Development files, used during building and modifying a railway, have the extension '.dev'. Railways that are ready for operation have the extension '.rly'. Timetable files (extension '.ttb') may be saved during development and when finished, and during operation the current state of the railway (a 'session' - extension '.ssn') may be saved at any time and reloaded at a later time.

During operation a performance log of all activities is compiled. This may be viewed on-screen or hidden, and is saved after operation along with a performance summary in a permanent text file (extension '.txt').

Railway image files (extension '.bmp' - bitmap files) may be saved at any time, consisting of track and text, with or without an element grid (useful for planning purposes during construction); with preferred directions; and during operation. Image files always display with black track on a white background, regardless of the track colour and background in use.

Users may add their own graphic files with extension .bmp, .jpg, .gif or .png, and these are saved in the 'Graphics' folder. Information on their use is provided in section 3.1.

It is suggested that unwanted performance logs, sessions and images be deleted periodically as they can take up a considerable amount of space. This particularly applies to image files. If particular images are to be saved then it is best to convert them to '.jpg' files rather '.bmp' files, using a suitable image processing program, since '.jpg' files use much less memory. If particular sessions, performance logs or images are to be saved, then it is probably best to rename them to something more meaningful so that they are easy to distinguish from other similar files - but be sure to retain the same extension (i.e. '.ssn', '.bmp', '.jpg' etc.).

All files apart from images - i.e. railways, timetables, performance logs and sessions, as well as an error log if a fatal error is encountered during program use, are text files, and are readable using a word processor or text editor, though it is strongly recommended that any file that is used by RailOS shouldn't be altered outside the program or it may not work correctly afterwards. A number of other files are used, temporary files with extension .tmp that store timetables when multiple railways are in use at the same time (these can be deleted after all railways are closed), a configuration file 'Config.txt' that stores the current background colour, the trackside signal location - left hand or right hand, the folder locations for railways, timetables and sessions that are in use when RailOS closes, colour preference for heatmaps, and default values for track element length and speed limit.

Help.chm is RailOS's on-screen help file, opened by selecting 'Help' then 'Railway help' or by pressing key F1.

A number of other .bpl and .dll files are stored in the same folder as RailOS32/64.exe. These must not be moved as they are needed for the program to operate.

2.4 Information

An information panel is normally displayed during use, indicated by a blue 'I' symbol. This shows in brief what options are available at a particular stage. Additionally, hovering the mouse over any button gives information about its function.

The name of the railway that is currently loaded is displayed in the title bar at the top of the screen, together with the name of the timetable if loaded. If no railway is loaded or a railway is under development but has not yet been saved the title bar displays 'New railway under development'.

The 'Information' tab offers four options: track information, train status information, train timetable information, and display of long service references. All these act as toggles, allowing the relevant information to be shown or hidden. By default track information and long service reference display are off, but train status and timetable information are on. When the first three are on, the information is displayed in a floating window when the mouse hovers over a track element or a train. Service references are described later but in brief they represent train identifiers. Train headcodes in the UK consist of four characters, and during operation a train appears on screen with these four characters. However additional characters are often required in order to allow for longer headcodes in other countries, and to identify uniquely in the timetable trains with the same headcode. Up to eight characters are permitted in all, with the last four in all cases shown on the train itself. The last option 'display of long service references' shows the full (up to eight characters) train identifier on screen above the train. These only show when there are more than four characters because the train itself is indicated by these four characters.

2.5 Navigation and Zoom

Navigation of a large railway is achieved by holding down the right mouse button on a blank area of screen and dragging with the mouse, or by using buttons or keys to change the viewpoint as described in more detail in section 3.1. A 'zoom' button allows the display to change between detailed and wide view, the wide view displaying at 1/4 scale so that the equivalent of 16 detailed screens may be displayed on a single wide view. The viewpoint may be changed for each type of view so there is no limit (apart from system memory) to the size of railway that may be created. Note that the wide view only displays track and locations, no location names or text is displayed.

2.6 Program modes

A number of different modes are available from the 'Mode' menu. These include 'Build/modify railway', 'Set preferred directions', 'Create a timetable' etc. When any of these modes has been selected it will be seen that the 'File' and 'Mode' menus are greyed out and therefore unavailable. In order to change modes or to carry out any operations from the 'File' menu the current mode must first be exited by clicking the red cross. This will make the other menu items available again.

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3 Building a new railway or modifying an existing railway

Select menu item 'Mode' then 'Build/modify railway', and the build/modify toolbar will appear. Only those tools that are available at any particular stage are enabled, the others are greyed-out. The tools are as follows:-

 Add or remove track elements
 Connect gaps
 Link all track together
 Add or change text
 Move text or user graphics
 Set or change location names
 Change text or location name font
 Change text or graphic grid alignment
 Check and set track element lengths and speed limits
 Toggle screen grid
 Signal aspect selector
 Save railway
 Select user graphic
 Exit build mode

At the start with no railway loaded the available tools are  add track elements,  add or change text,  change font,  change text grid alignment,  screen grid, and  exit build mode.

To assist in designing and building railways an option is provided to save railway image files. Select the 'Images' menu item, then 'Save basic railway image' or 'Save railway image + grid'. These generate bitmap images in the 'Images' folder, which resides in the working folder, which is normally where 'RailOS32/64.exe' resides. These images may be manipulated and printed out using any image processing program, or inserted into a word processor. They can help considerably in finding the optimum track layout during design.

3.1 Adding and deleting track and user-defined graphics

Click  to add elements, and the railway element panel will appear, containing a wide range of elements, each on its own button, for building a railway.

Selection is by clicking the chosen element, then left clicking the railway area below to place it. It is often helpful to display the screen grid during building to indicate element locations. As many of the same element as required may be placed by repeatedly left clicking the mouse in the railway

area, and other elements may be selected and placed similarly. To remove an element just right click it.

To navigate off the visible screen the easiest method is to hold down the right mouse button on a blank area of screen and drag the railway with the mouse to a new position. Other methods are to click the relevant 'move viewpoint' buttons → ← ↑ and ↓, or press the arrow keys on the keyboard. Holding down the Control (Ctrl) key when navigating moves the viewpoint by a small amount, and holding down the Shift key moves it by a large amount. Think of the railway area as infinitely large, with a window 60 elements wide by 36 elements high visible at any time (60 x 36 elements is for a screen resolution of 1024 x 768, other resolutions contain different numbers of elements). The 'Home' button (or 'Home' key on the keyboard) brings the display back to the original screen, or 'New home' sets a new 'home' position. The zoom-out button ↖ ↗ ↙ ↘ (or 'End' key on the keyboard) displays the railway at a quarter scale, and in this mode there are 'Home' and 'New home' buttons as before but these operate independently of zoomed-in mode. When zoomed-out, the zoom button changes to zoom-in ↘ ↙ ↗ ↖, which brings the view back as it was, as does pressing the 'End' key again. To display a particular area of a large railway quickly, zoom-out, then click the area of screen required. This displays the clicked and surrounding area in zoomed-in mode. In zoomed-out mode the railway can be dragged as described above or moved using the relevant buttons or keys. All available keyboard shortcut keys are set out in section 7.

During build the 'unlinked track' icon is displayed on the left. All track must be properly linked before preferred directions or track lengths and speeds can be set and the railway saved for operation. Linking allows every element to store the positions and types of adjacent elements, and that information is interrogated and applied by trains and routes during operation. Prior to linking, any element can be placed anywhere, but linking will only be successful for a viable railway. Track is linked using the 'link track' button, but note that if there are unconnected gaps these must be connected first. Any faults in the layout are indicated by appropriate messages when the 'link track' button is left clicked. When correctly linked the icon appears.

All track elements, when placed, are allocated an identification code, referred to as the element ID, for example '15-27', based on the position of the element on the screen. In this example the element would be at horizontal position 15 working left to right (first horizontal position being 0) and vertical position 27 working from top to bottom (first vertical position being 0). After the first element has been placed all subsequent elements are placed relative to it. Elements that take negative values (i.e. above the top position of the screen on which the first element was placed or to the left of the leftmost position of the screen on which the first element was placed) are preceded by 'N', so an ID of 'N12-N06' would represent an element 12 places to the left of the first screen and 6 places above the top of the first screen. Element IDs are used in timetables, performance logs and warnings etc.

User-defined graphics can be added to improve the appearance of the railway, incorporating any image file of type .bmp, .gif, .jpg or .png. These files must be saved in the 'Graphics' folder in order to be used. You may wish to apply a graphic with a transparent background, and for this you will probably need to manipulate the file using an image editor, of which there are many available, some free. To add graphics click the 'select user graphic' button, and select from the files

listed. Left click the railway at the desired location for the graphic and it will be placed there, right click it and it will be removed. Note that any user graphic can be removed by right clicking when a graphic has been selected, it doesn't have to be the one selected. Once placed, a graphic can be moved, as described below in section 3.2. Try to avoid placing a graphic directly over text, track or locations, as it will be obscured by these elements when the screen is updated. Also be mindful of the graphic colour in relation to light or dark backgrounds - dark graphics won't show up well or at all with a dark background, and similarly for light coloured graphics against a white background.

3.1.1 Track element types

Straights, curves, buffers, bridges, points and crossovers

Hopefully these are all fairly self-evident. However points and crossovers can't be placed next to buffers as there must be room for a train (2 elements long) without fouling any of these elements. Note also that some straight elements have directional arrows. These are purely for visual clarity, they don't need to relate to preferred directions (though clearly they should to avoid confusion). Preferred directions are set separately and described in section 4.

Signals

Signals can be two, three or four-aspect, or ground position lights. The signal type button  represents four-aspect, and clicking the button changes it to three-aspect  , then two-aspect  , then ground position light  , then back to four-aspect. Signals of the appropriate type are placed on the railway whenever the corresponding signal button is selected. Note that two, three and four-aspect signals all appear the same when placed, but the type is indicated in the floating window when track information is selected.

Signals can be positioned on the left or the right of the track relative to the direction of travel (see section 2.1). Trains recognise and act on signals in the direction of travel only. Signals are not normally permitted immediately before or after a bridge because it wouldn't be possible to truncate the route to that signal (see 'route setting and cancelling'). This is because a bridge is potentially ambiguous as it may have two routes set on it. However this restriction can be overridden if required - an on-screen message provides information.

Note that signals can't be placed next to buffers as there must be room for a train (2 elements long) in the siding without straddling a signal. Also two same-direction signals can't be placed next to each other as there must be room for at least one element of a train between them.

Level crossings

All crossings are closed to trains initially (i.e. barriers raised), and are opened in one of two ways:

The first and usual way is by creating a preferred direction or unrestricted route through it, automatic signal routes aren't permitted. The barriers begin to lower as soon as the route is in place, the lowering indicated by the 'barriers down' graphic flashing. While it is flashing other routes can be created elsewhere in the railway but no other route can be created across the crossing

until the barriers are fully down. They stay down while there is a route in place, and start to rise as soon as all routes have been cleared - in this case the 'barriers up' graphic flashes. The barriers take 30 seconds to lower and 10 seconds to rise. The first signal behind and facing the barriers stays red until the barriers are fully down.

The second way is to left click it (provided that there is no route through it and no train on it). This opens the crossing manually. In this case the barriers begin to lower as before, but now the colour is green rather than red to indicate manual operation. Signals behave as before. Trains can cross with or without routes, and the crossing will remain open until closed manually, again by left clicking when there is no route across it. A manually opened crossing will not close automatically after a train has passed because there may be other trains that need to use it. Opening and closing times are as before. A level crossing that is opened by a route cannot be closed manually. The green colour is a reminder that the crossing is to be closed manually when no longer required, to avoid the heavy time penalty that would be incurred if forgotten. To help in this respect if any manual crossing is open to trains without a route across it a warning icon  is shown on the left hand side of the screen, flashing if flashing is selected. Also all such level crossings are shown flashing in zoom out mode.

Level crossings display differently for barriers up and down, with barriers shown across the road for down and across the railway for up. Although modern barrier crossings don't really lie across the railway I think it makes it clearer that the way is blocked for trains if barriers are shown in this way. Crossings can be placed across any number of directly parallel tracks, but can only be placed on plain horizontal or vertical track elements. Note that level crossings cannot be placed adjacent to each other on the same track.

Up to three minutes is allowed for the barriers to remain down before penalty times start clocking up, so it doesn't pay to set routes or open a crossing manually too far in advance of trains. If a barrier is lowered and then raised (by cancelling the route or manually) before any trains have passed, then the three minutes allowance isn't given, penalty times begin clocking up right away. Penalties are shown in the performance log summary (see section 6.7) as 'excess minutes of level crossing barrier down time'. If several logs are created successively it might be noticed that this figure is lower in later logs than earlier ones. This is because a log created when crossing barriers are down but before a train has passed doesn't deduct the three minutes allowance, whereas a later log created after the train has passed will include it.

Level crossings are treated as being closed to trains in all states other than with barriers fully down, so if a train runs into one when the barriers are not fully down then there is a crash (it's assumed to have hit a road vehicle) and the train has to be removed by the signaller.

Parapets

These are visual elements only, to improve the appearance of the railway by indicating bridge and tunnel parapets, they don't play any part in operation. They can also be used to bracket track gaps (see below) together when a continuous railway is split on screen for a more compact display and the bracketed tracks labelled to indicate where they continue on screen.

Continuations

Elements that represent the limit of the railway, where track extends outside RailOS's control area are referred to as 'Continuations' The dotted section represents the outside edge. Trains enter and leave the railway at these elements. Continuations used for train entry should be protected by entry signals, ideally placed so that a stopped train has its rear element on the continuation so the whole train is visible. This is because following trains will not enter when the entry is blocked by a train, but if the earlier train is held further along then the later train will crash into it.

Gaps

Gaps  represent elements that connect to other elements that are not immediately adjacent. There must always be an even number of gaps which are arranged in paired connections. When part of a train moves off one gap it appears immediately on the connected gap. Gaps allow continuous sections of railway to be separated visually, for example to display a long section of track on a single screen. They are also useful for long bridges or tunnels, to avoid having several single-element bridges adjacent to each other. Right clicking the mouse on a gap that has been set shows the two connected gaps - flashing red for the clicked gap, and flashing green for the connected gap. This is useful during operation as a reminder of which gap connects to which. If the connected gaps are widely separated the screen viewpoint can be moved to find the connected gap - this is particularly useful in zoom-out mode. Left clicking the mouse on the screen in zoom-in mode stops the gaps flashing.

When first placed, the oval area of the gap is hollow, to indicate that it isn't yet connected to another gap. When unconnected gaps are present in a railway under construction the  icon is displayed at the left side of the screen, and the  'connect gaps' button is enabled, which is used to connect gaps to each other in turn. During connection RailOS highlights a gap with flashing red and white circles, at which point the corresponding gap should be left-clicked, this is then highlighted briefly with a green circle before the next gap to be connected is highlighted. The screen may be zoomed-out and navigated freely during gap setting, because connected gaps may not always lie on the same screen (though it's clearer if they are). When all gaps have been connected the  icon is displayed and the  'link track' button becomes available. To disconnect gaps delete one of the gaps and replace it.

3.2 Adding and deleting text, and moving text and graphics

Text may be added to the railway by left clicking the  'add or change text' button. When this is selected left click the position on screen where the text is to be added, and a text box will appear. Replace the information text that is already present with that required and press 'Enter'. The text will remain where placed in the font that has been selected. To change the font left click the  'change font' button and enter the font, style, colour and size that is required.

To delete text, right click the first character with 'add or change text' selected and it will be erased. To change existing text, left click the first character with 'add or change text' selected and a text box will appear with the existing text in it ready for modification, when changed press 'Enter'.

IMPORTANT: Do not change the names of named locations (see later) by this method, otherwise the displayed name will be changed but the location name within the timetable will not change and the result will cause confusion.

If the font of existing text is to be changed without changing anything else then select 'add or change text' if not already selected, left click the first character to bring up the edit box with the original text, then change the font using the  button with the edit box still present. Then press 'enter' without changing anything else, and the text will be changed to the new font. Note that this is slightly different to changing the fonts of named locations. For them the font may be changed first, then the location selected with the  button, 'enter' pressed, and the font will change. The difference is because it is sometimes required to change several location name fonts at the same time, and it would be tedious to keep having to change it for each separately. This is not usually the case however for separate pieces of text.

A quick way to select a new text font is to left click the first character of a piece of text in the desired font, and press 'enter' when the edit box with the original text appears. This will leave the original text in place but the selected font will have changed and can be used for new text or location names.

When placed, text and graphics may be moved by left clicking the  'move text or graphics' button. When that has been selected, left click and hold the mouse over the first character of the text or anywhere within the graphic and drag it to its new location. The  'change text or graphic grid alignment' button may be used to set the required precision. When the smallest bar shows green then the text or graphic will move at the finest precision - one pixel at a time. Each time the button is clicked the bar showing green will move to the right, successively for 2, 4, 8 and 16 pixel precision, then back to 1 pixel precision. Lower precision values (higher numbers) are useful for aligning separate pieces of text or graphics with each other.

Text (but not graphics) can be placed on stations and non-station named locations (see section 3.3), but try to avoid placing text or graphics too close to track, as they may be partly erased by moving trains and not appear again until the screen is updated, which might be some time. Arial 7pt is clear and small enough to allow text to fit between two tracks, only the bottom of the descenders are erased by trains but this doesn't degrade the appearance too much.

If railways are to be shared with other users or used on other computers, ensure that the fonts used for text and named locations are standard Microsoft Windows types, or the Windows operating system will default to the nearest font which might spoil the appearance. Also ensure that any graphic files used by the railway are shared also, because although railway files contain graphic names and positions, they do not incorporate the graphics themselves.

3.3 Named locations

Two types of named location are provided: stations, and non-station named locations. Station elements consist of platforms, concourses, footbridges and underpasses. These are indicated by reddish-brown coloured elements, the narrow ones representing platforms that may be placed alongside horizontal or vertical track elements, or along the straight track of points; the full square representing a concourse, positioned where there is no track and used to link platforms together; and footbridges/underpasses that lie at 90 degrees to the track and link platforms and concourses

across vertical or horizontal track. Footbridges/underpasses allow station elements to be linked together that would otherwise be too far apart. All station elements that are linked together take the same name. Trains stop at platforms if the timetable includes the station as a stop, and the stop position is central for through platforms (with one extra free element behind than in front for platforms with an odd number of elements), and is at the buffers for terminal platforms. The arrangement at through platforms allows other trains to stop both in front of and behind earlier trains when there is room at the platform to do so, and at terminal platforms allows other trains to stop behind existing trains at the buffers.

Non-station named locations are shown as blue squares, and are used to name sidings, depots, works, buffers, tunnels, bridges, continuations, junction approaches and anything else that needs a name. They are positioned either on blank elements or on top of track elements other than bridges gaps and level crossings. Note that track cannot be placed on top of a non-station named location, the track must be placed first. All non-station named elements that are linked take the same name, but they do not link to stations so they may be positioned adjacent to station elements but have their own name. Trains will stop at all non-station named locations (providing the name is in the timetable) except continuations - continuation names are for identification and logging purposes only - and it is recommended that these be named for these purposes. The stop position is fixed relative to the length of the named location and direction of train travel, but in all cases the train stops with its front adjacent to the end of the location, to allow as much room as possible behind for other trains.

Named elements link together vertically and horizontally, but not diagonally. This is straightforward for non-station named locations because they consist of full-sized (16 x 16 pixel) elements only. It can be more confusing for stations, because platforms only occupy part of an element. The point to remember is that an element with a platform on it is a station element, so it will link to any other station element in the vertical or horizontal directions. Hence the following two arrangements are horizontally linked  and  , but the next arrangement is not linked because the station elements are diagonal to each other 

Note that named locations may be located where there are signals. This is useful when space is tight but is not generally recommended because problems may occur when trains are required to split - see 'splits and joins'. Locations with very long platforms that are designed to hold two or more trains can use embedded signals, but signaller control may be required to move trains up a platform to their departure position.

Names are allocated using the  'name location' button. Any named element may be selected for this purpose except footbridges and underpasses. Names are case-sensitive and must be unique (King's Cross and KING'S CROSS are different locations as far as RailOS is concerned). A warning is given if a second location is given the same name as an earlier one. If it is so named, the earlier name is erased. When a name has been given it appears as text on the display in the font that is currently set. Generally the position of the name will need to be adjusted using the  'move text or graphics' button as described earlier. Fonts may be changed using the  'change text font' button, and this font will apply for all future names. If it is wished to change the font of existing names then first change the default font, select one of the named elements using the 

button, then just press 'enter' and the name will change to the new font. This may be done repeatedly to change several location name fonts in turn if required. Note that this is a different procedure to changing the font of existing text that doesn't represent a location name. This is explained in section 3.2 above.

When a location is named and the text positioned on screen, the positioning system works as follows: if there is space, the top of the text is placed slightly higher than the highest named element. If there isn't space above the highest named element then it is placed slightly lower than the lowest. If the named location covers the entire height of the screen or more, so that there is no higher or lower space for the name, then it is placed in the centre of the screen, at the horizontal position of leftmost named element. This has been explained to avoid confusion when it is found that location names occupy different positions on screen in different circumstances, and to provide an indication of where to expect the name to be positioned in each case.

To erase or change the name of a named location select one of the named elements as above, then erase or change the contents of the box and press 'enter'.

IMPORTANT: Do not change the names of named locations by using the 'change text' method described in section 3.2 (unless it is intended that the displayed name be different to the timetabled name), otherwise the displayed name will change but the location name within the program (the name used by the timetable) will not change and the result may cause confusion. Trains always comply with the timetable regarding the location name, regardless of what text is on screen. If the screen text is lost or altered inadvertently for a location name, the internal location name may be checked by selecting 'Information', 'Track information' and 'Show', and may be recovered on screen by left clicking the  **button and selecting the location. Its name will then appear in the box and may be re-entered by pressing 'enter', at which time it will reappear on the screen - as well as the earlier changed name, which may be removed or moved elsewhere if required.**

RailOS will allow text to be added to the railway that is the same as named locations, but this should be avoided if possible. If this is done and a location name is erased or changed, then the wrong text may be affected, because RailOS doesn't know which of the two (or more) identical pieces of text should be allocated to the named location.

When a location name element is first placed, it is shown striped, to indicate that it isn't yet named. When named it changes to full colour. In zoom-out mode unnamed locations appear pink for stations, and green for non-station named locations. These help identify locations that still await naming. A railway that contains unnamed locations has the  icon on the left. When all are named this changes to  .

When building a railway try to avoid naming a location until all associated named elements have been placed. Although additional named elements may be added to an existing named location, and they will take the same name, the process can be time-consuming, especially with a large location and a slow computer.

If a named location has any of its elements deleted it will revert to being unnamed and its name will disappear from the screen.

3.4 Saving and loading railway files

There are two types of railway file. Development files, used during building and modifying a railway, have the extension '.dev'. Railways that are ready for operation (operational railways) have the extension '.rly'. By default all railway files are stored in the 'Railways' folder that resides in the working folder, which is normally the folder that contains 'RailOS32/64.exe'. Users can change this folder by navigating to a different location and either saving or loading a railway file. The selected location will be retained in Config.txt when RailOS closes and will be reloaded when it restarts.

During development, files may be saved (as .dev files) by clicking the  button, new files requiring a new name, but thereafter being saved under the same name unless 'Save railway as' is selected.

When all gaps (if there are any) have been connected, all track linked, and all locations named, the file may be saved as a '.rly' file. This situation is indicated by the corresponding three left screen icons all being green -  . When saved as an operational railway these icons are not displayed.

Operational railways may be modified, but if anything significant is changed then the railway will revert to development status. If it is still operational, it may be resaved under its old name, but this will have to be selected manually, it isn't automatic. Beware though that existing timetables may need corresponding alteration if they are not compatible with the changed railway. If changes are made to preferred directions only (described later), then these are not regarded as significant changes and the railway may be resaved automatically under its old name by left clicking the  button. Such changes won't affect timetable compatibility but may well affect the ability to set automatic signal and preferred direction routes (explained later).

When a railway is saved the 'Home' position of the detailed (i.e. zoomed-in) display will be saved, but not the 'Home' position of the zoomed out display nor the actual position of the display at the time of saving. To change the 'Home' position select the display required then left click 'New home'. On reloading the railway the first display will be at the 'Home' position.

3.5 Selecting, cutting, copying and pasting etc.

During build, in 'Build/modify' mode, complete areas of the display may be manipulated using the 'Edit' and 'Select' menus, and selected areas can be filled with particular track elements or deleted. After clicking 'Select', the area is formed by clicking on the screen then dragging the left mouse button. A dotted rectangle is shown which grows as the mouse is dragged, and is fully defined when the button is released. If a different area is required then the process can be restarted by left clicking the mouse button as before. When defined, the 'Edit' menu presents a range of options for cutting, copying, deleting, rotating etc. When cutting or copying are selected, left click the mouse anywhere inside the area, then drag it to the new position. It will stay where it is when the button is released, but it may be picked up and moved again if desired. If it is to be moved to another screen then drag it to or beyond the edge, move the viewpoint in the required direction, then pick it up and move it again. When its position is as required go back to the 'Edit' menu and paste the area. Pasting overwrites any track or text that lies in the pasted area. After a cut, pasting retains

all track lengths, speed limits, location names and preferred directions. These same values are also retained when a selection is flipped, mirrored or rotated. After a copy, pasting retains everything except location names. The reason is that two locations can't have the same name. Note that any additional elements needed to link repositioned areas to the existing railway will require speeds and lengths setting where the defaults are unsuitable, and any gaps within the selected area will be unset and require resetting.

For any action except copy preferred directions need to be reset for elements that link to repositioned elements, and if there are train entry and exit points in the repositioned area the element identifiers will need to be changed in the timetable (see later).

To fill a selected area with a particular track element click the required track element button - any except a level crossing. What happens is exactly the same as if the element is selected and the screen left clicked at every position within the area, so blank spaces are filled with the element but existing elements within the area are not overwritten. Similarly if a platform element is selected it will be placed next to existing valid track elements but if there is no track then nothing happens. Although any element can be selected apart from level crossings the most useful ones are horizontal and vertical track elements, where areas can be filled quickly without having to click each position individually.

After a selection has been made there is an option to 'Reselect'. This reselects the repositioned area and is useful for example for repeated copying of the same selection.

When text is enclosed within a selection then it will be moved, copied or rotated etc. along with the track. Be aware though that to move or copy text the top left hand corner of the first character of the text must be enclosed within the selection (and this point will be slightly above the first visible character). Hence even though the text may appear to move with the selection it may be found that on pasting it has been left behind. If this happens then it may easily be repositioned using the  'move text or graphics' button. Track and graphics must be wholly enclosed within the selection to be moved or copied etc.

When an area is selected prior to rotating by 90 degrees right or left the area is first checked to see whether or not it is square, and if not then it is changed to a square. The option is then given to keep this square or to select again. Only square selections are permitted because otherwise on rotation existing areas of the railway may be erased inadvertently as the horizontal and vertical dimensions are interchanged. This danger doesn't arise with square selections as both dimensions are the same. The square that RailOS selects is obtained by retaining the left hand vertical side of the user-selected area and making the horizontal dimension the same by extending or reducing it to the right of the left hand edge. If that process makes the square extend beyond the right hand edge of the screen then the right hand edge is retained instead and the square extended or reduced to the left of the right hand edge. Also for 90 degree rotations any text, including named locations, that is enclosed is not rotated because text always stays horizontal and attempting to rotate it by 90 degrees would give a very poor result with much of the text obscured by track elements. Instead it is retained as a vertical list along the left hand edge of the selected area. It can then be positioned appropriately by using the  'move text or graphics' button. Graphics are repositioned when rotating, mirroring or flipping, but are not themselves re-orientated. If it is required to have re-orientated graphics then the manipulation should be done in an image editor and the changed file saved in the 'Graphics' folder with a new name.

Note that if the selected area contains a lot of elements then there will be a delay before the next action can be selected, especially when cutting. Please avoid clicking the mouse buttons or dragging the area during this time because although nothing appears to happen the actions take place after the delay and may not be what is expected. The information panel gives advice as appropriate.

An option is also provided to set track element lengths and/or line speeds. This is in addition to the ability to set these parameters along the track, which is described later. The option to set an area as a whole is useful for example at stations, where blanket speed limits often apply and track element lengths may be made much shorter so that more track detail may be included without extending distances. Note that when using this option each track element length is set individually to the values chosen. When setting lengths along the track (described below), the complete length is chosen and is divided up between the number of elements that are included. Before this option can be used the track must have been successfully linked together - see section 'Adding and deleting track and other railway elements'. Information about track lengths and line speeds is available from the 'Information' menu by selecting 'Track information'. Then, when the mouse hovers over a track element these values may be seen, along with the track identifier (ID), which is used in timetabling.

3.5.1 Pasting in an application after cutting or copying from another RailOS32/64.exe application

When a selected area has been cut or copied, it is loaded into the Windows clipboard and can be pasted into a different RailOS32/64.exe application by opening it, clicking on 'Mode', then 'Build/Modify Railway', then Edit', then 'Paste'. A second RailOS32/64.exe application can be opened in one of several ways: double clicking on the RailOS32/64.exe icon in Windows Explorer; double clicking on the RailOS32/64.exe icon if present on the desktop; or single clicking on the RailOS32/64.exe icon if present on the taskbar with the shift key held down. For this latter method to work there must be an existing program icon either on the desktop or the taskbar.

There are some things to be aware of when pasting via the clipboard a segment of railway that was cut or copied from another application:-

1. Pasting in a new application from the Windows clipboard is similar to pasting in the same application in that a cut will include location names whereas a copy won't. However user graphics won't be pasted in either case because the corresponding graphic files must be present in the Graphics folder, and that can't be guaranteed for a different application which may be in a different location to the original application.

2. The selected area will be pasted in the top left hand corner of the screen, and any existing elements already there will be deleted. Move the viewpoint to relocate the railway if necessary to avoid any deletions then in the other application click 'Cancel', select the area again and cut or copy again, and return to the receiving application to paste it.

3. If a cut segment includes a location name that is already present in an existing railway then the earlier name will be erased.

4. Ensure that the application that is to receive the external segment doesn't have any selections of its own still valid or a paste from another application will fail or produce unwanted effects. If a

selection has already been made in the receiving application, perhaps to move an earlier pasted segment, click 'Edit' then 'Cancel' to clear the selection before selecting the area to be cut or copied in the other application.

5. When an area has been cut or copied from an application for pasting in another application, wait until the clipboard has been fully loaded before changing to the receiving application or the paste may not succeed. When the information panel message says "Left click in selection and drag" then the clipboard has been fully loaded.

6. It is recommended to click 'Edit' then 'Cancel' in the original application after pasting in the new application in order to retain the original railway. However if a segment was cut then gaps may need to be reset and the track re-linked because in this case cancelling pastes the segment back in its original position so track linking is lost and gaps are pasted as unset.

7. When pasting from one application into another make sure that both applications have the same version number or changes that are made between versions may interfere with the process and give unexpected results.

3.6 Setting track element lengths and speed limits

These may be set by selecting an area as described earlier in 'Selecting, cutting, copying and pasting etc.', or alternatively by selecting along a length of track by left clicking the  'check and set track element lengths and speed limits' button. Before either method can be used the track must have been successfully linked together - see section 3.1 'Adding and deleting track and other railway elements'. After the above button has been clicked, left click the track element that represents the start of the length to be set, then left click another element in the direction required towards the final element of the length to be set and on the desired route, and continue in this way until the final element is reached.

Sometimes, if there are two or more routes in different directions from the start position to the next selected position, RailOS may choose the wrong direction. In this case erase the selection as described below, then select the start position again, and select the element that is next to the start position in the desired direction. This will set the direction correctly and further points can be selected until the desired end point is reached. If there is only one route between the start and end points then the second element may be the end point.

To truncate part of a selected length just right click at the truncate point. To erase a selection completely truncate to the start point, and to cancel a start selection without making a second selection just click it again.

Note that the selection can't end on leading points, because RailOS doesn't know which of the two legs to include. At each position the box will indicate the cumulative length of the current selection, and the speed limit. If the speed limits differ along the length then 'Mixed' will show in the speed limit box. When the end point has been reached the required overall length and speed limit may be entered in the boxes provided. If the length is to be changed but not the speed limit then don't alter the speed limit value, and vice versa. Other options include restoring the selection default values - i.e. just reset to the default values (normally 100m and 200km/h - *but can be changed in Config.txt file - see below*) between and including the start and end points selected;

restoring ALL default values - i.e. reset all track elements to their default values (a warning message is given if this is selected); and cancel without making any changes.

Default values, normally 100m and 200km/h, are loaded into RailOS from the configuration file Config.txt. These values can be changed if required by direct editing of this file using Notepad or any other text editor. Instructions for editing are contained in the file itself. If changes are made make sure that the file is saved as text only and retains the name Config.txt. It can be reloaded without having to exit RailOS using the 'Mode' menu. Note that only the changed default element length and speed limit will reload when there is a railway present, the other values remain the same until the program is restarted. It is strongly recommended that settings other than default lengths and speed limits only be changed within the program and not by editing Config.txt directly.

If just a single element is to have its length or speed limit set, then use the selection method described in 'Selecting, cutting, copying and pasting etc.

In this mode a colour code is used to indicate whether or not each element is set to its default values: original colour = both defaults; red = default length but non-default speed limit; green = default speed limit but non-default length; and blue = both have non-default values.

Selecting menu items 'Information', 'Track information', 'Show' will display individual element lengths and speed limits in the floating window when the mouse is hovered over an element.

To check the distance between two points proceed as for setting lengths, note the overall length in the 'Length' box, then click 'cancel'.

RailOS only works in metric units but conversion facilities are included to change imperial lengths to metric, and speeds in miles per hour to kilometres per hour.

3.6.1 Heatmaps

Heatmaps provide a quick way to illustrate how data are distributed within an area. The data can be anything, they don't have to represent heat. They are called heatmaps simply because they were first used to illustrate heat distributions. RailOS provides two maps, one for track element lengths and one for track element speed limits. When the  'check and set track element lengths and speed limits' button is clicked two new buttons appear, one for each type of heatmap. Clicking one of these buttons brings up the appropriate map, as well as a diagram that calibrates the colours against lengths or speed limits. The colours use a rainbow spectrum where (on first load) red represents the shortest lengths and lowest speed limits, with increasing values in both cases progressing through orange, yellow, green, cyan, blue and finally violet. These colours can be reversed if preferred, as described below.

The maps are useful for checking quickly whether lengths and speed limits are set appropriately - station areas and sidings generally have short lengths and low speed limits, whereas sections of track between stations have longer lengths and higher speed limits. Similarly the diverging track of points generally has a lower speed limit than the straight track, and crossovers generally have lower speed limits than surrounding track. The heatmap quickly shows up any elements that have inconsistent values.

Some people prefer the shortest lengths and lowest speed limits to be represented by violet, with increasing values progressing through all the colours to red. To reverse the colours open the 'Mode' menu before any railway is loaded, and click 'Heatmaps: Red = high values'. This preference is stored in the configuration file Config.txt when the program closes and is automatically selected on each subsequent opening of the program. The menu item acts as a toggle so that when the reversed colours are selected the option changes to 'Heatmaps: Red = low values'.

Heatmaps show up best against a black background.

****

4 Setting preferred directions (PDs)

PDs are the directions that trains travel in during normal operation. Most signals are set along PDs, and special arrangements are generally needed to allow trains to travel in non-PDs. Track elements in RailOS railways may have PDs set either way, both ways, or not set.

The method used to set PDs is the same as that used to set lengths and speed limits, but before they can be set the track must have been successfully linked together - see section 3.1 'Adding and deleting track and other railway elements'.

Select menu items 'Mode' then 'Set preferred directions'. Note that if another mode has been selected first then that must be exited by clicking the red cross before the 'Mode' menu becomes available again. When in 'Set preferred directions' mode left click the track element that represents the start of the section to have a PD set, then left click another element in the direction required towards the final element to be set and on the desired route, and continue in this way until the final element is reached. Sometimes, if there are two or more routes in different directions from the start position to the next selected position, RailOS may choose the wrong direction. In this case erase the selection as described below, then select the start position again and select the element that is next to the start position in the desired direction. This will set the direction correctly and further points can be selected until the desired end point is reached. If there is only one route between the start and end points then the second element may be the end point.

To truncate part of a selected length just right click at the truncate point. To erase a selection completely truncate to the start point, and to cancel a start selection without making a second selection just click it again. Note that the selection can't end on leading points, because RailOS doesn't know which of the two legs to include. In this case select an element further along in order to add it.

Note that if the railway is complex a message may say that a path can't be found to the selected element. This is usually because there are too may search paths from the last selected element and the search is becoming too long. In these circumstances select an element nearer to the last selected element.

At each position relevant buttons will be available consisting of 

'add section' to add the selected length to the complete set of PDs, 

'erase one' to erase the selection (i.e. remove any PDs from the selected length), and 

'erase all' to remove all PDs from the railway. A warning message is given if this is selected. Keyboard shortcut keys available for these buttons are set out in section 7. Additionally whenever the 

'add section' button is enabled it also has focus, meaning that instead of clicking the button the 'enter' key may be pressed. This is often quicker when adding several sections in succession.

In this mode a colour code is used to indicate PDs: original colour = no PD; red = one PD - the arrows indicate the direction; and green = both directions set (bidirectional running). Bidirectional running is often used in stations to allow flexibility in routing trains.

The PD is indicated by an arrow on the relevant track on each element, which is clear for all elements except points where just one arrow is shown on the leading part of the points for one or both directions. This may be ambiguous in some circumstances for the point in isolation, but

preferred directions cannot end on points, so reference to the directions of adjacent elements should make the situation clear.

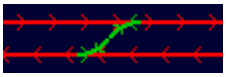
In this mode bidirectional tracks may be set for complete areas, via the 'Edit' and 'Select' menu items. Select the area required as described under 'Selecting, cutting, copying and pasting etc.', then select 'Edit' and 'Set bidirectional tracks'. This option is useful for quickly setting bidirectional running in station areas to allow flexibility in routing trains.

Note that if track is changed after PDs have been set, elements that have been changed and adjacent elements have their PDs erased. In these circumstances it is recommended to go back to the 'set preferred directions' mode to check and reset the necessary directions.

Another option available from the 'Edit' menu is 'Check Preferred Directions for Conflicts'. This examines all track elements and PDs, and highlights track elements without PDs; PDs that are not linked to other PDs; or PDs that are set in opposite directions to adjacent PDs. This is very useful for finding missing or conflicting links that are easily overlooked in a visual inspection. It is important to recognise that not all highlighted conflicts require changes, many can be dismissed when inspection shows them not to matter.

Example situations:


Conflicts are reported but no action need be taken because only unrestricted routes are possible between parallel tracks with opposite PDs regardless of whether PDs are set on them or not.


Although there is no matching PD for the top diverging leg in the leftwards direction and no matching PD for the bottom diverging leg in the rightwards direction the checker doesn't report any conflicts. In this situation these mismatches don't matter because a preferred direction route can never be set across the diverging legs with single direction PDs in opposite directions on the parallel tracks, regardless of whether or not any PDs are set on them.


No conflict is reported in either of these situations. Although there are mismatches where the bidirectional PDs meet the single direction PDs preferred direction routes can be set from the left to the signals to allow trains to change direction. This is a frequent requirement.


No conflict is reported here for the same reason as above - a preferred direction route can be set from the left to the signal to allow a train to change direction.


A conflict is reported here because the signal element has a PD in the opposite direction to the direction of travel of the signal, so it isn't possible to set a preferred route from the left to the signal.


A conflict is reported but since the segment in advance of the signal is named it allows trains from the left to reach the named location prior to changing direction and returning. Therefore no action is needed.

****

5 Timetables

Note: Before and during timetable development please keep in mind the 'Important points' set out in section 5.11. These summarise some important aspects that will help to avoid errors.

Program-readable timetables normally reside in the 'Program timetables' folder in the working folder and have a '.ttb' extension. Users can change this folder by navigating to a different location and either saving or loading a timetable file. The selected location will be retained in Config.txt when RailOS closes and will be reloaded when it restarts.

Timetables are readable using the timetable editor within RailOS, selected via the menu using 'Mode' then 'Create timetable' to construct a new one, or 'Edit timetable' to read or change an existing one. For full editing capability, including the ability to validate the timetable, the completed railway ('.rly' file) that the timetable relates to should be loaded before the timetable is opened for editing. For complex services, especially shuttles with feeder and finishing services (explained later), and to a lesser extent for splits, joins and linked services, it will take some time to understand fully the timetable coding system. For simple services that don't have any of these features understanding should be easier, though it will still take time and practice when unfamiliar with its use. It is suggested that simple timetables be set up first until familiarity is gained, before moving on to more complex timetables. Sample timetables are provided that give examples of both simple and complex services.

Timetables consist of 'entries', usually with one entry per train service. Entries appear in detail in the large window on the right of the timetable editor, and are listed in the smaller window on the left with one line per entry. The program-readable timetable begins with an entry consisting of a timetable start time in the format HH:MM (hours and minutes). No text may precede this start time, but text may follow it though following text is ignored by the editor.

Subsequent entries represent trains and services, but an entry beginning with '*' may be used as a comment, and is ignored by the editor. When either a blank line is found, or no more lines, the program-readable timetable ends. Entries preceding the timetable start time (marked '-' in the window on the left of the editor) or following the end of the program-readable part (marked '+'), may be used for comments and are ignored by the editor.

Trains and service entries consist of information and service codes in a strict format for the editor to interpret. Service code buttons in the editor insert relevant codes at the cursor position, for convenience, and location names may be selected from the drop-down box similarly if a railway with names is loaded. This information may be entered longhand if preferred.

During railway operation the timetable clock displays hours, minutes and seconds in 24 hour format, but timetable events just use hours and minutes, again in 24 hour format. In fact the hours may exceed 24, where 24:00:00 to 48:00:00 represents the second full day of operation, and so on. The timetable clock displays up to 95:59:59 (i.e. 4 full days) then after the next second it resets to 00:00:00. The time values of timetable events may also exceed 24 hours, up to a maximum of 95 hours and 59 minutes (95:59). Any timetable time event that exceeds this value, including the maximum time value for any repeat service, will be rejected with an error message during validation.

Timetable events may seem a bit cryptic at first but the coding that is used allows a great many trains and services with complex operations to be created from relatively few commands.

A typical service is as follows:-

```
2V31;Nottingham to Cardiff;150;150;250;25;2500  )      Headcode;description;train data (start speed 150km/h)
07:00;Snt;N19-29 N20-29                         )      Start new train + starting elements (train moving)
07:03;pas;Kings Norton Approach (NE)            )  =   Pass location
07:05;Fer;N89-39 N89-40                         )      Finish by exiting railway + valid exit elements
R;30;2;12                                       )      Repeat service
```

The first line in the above service is for a new train (new trains have codes Snt or Snt-sh on the second line) and consists of:

service headcode - 2V31; (Headcode format is described in section 5.3)
description - Nottingham to Cardiff;
starting speed - 150km/h; }
maximum train running speed - 150km/h; } These should be
mass - 250te; } whole numbers
maximum braking force - 25te (see section 6.5 'Train performance'); and }
power - 2500kW. }

Each piece of information is separated by a semicolon. One additional optional item is permitted on this line - maximum signaller-control speed. This is the maximum speed at which the train may run when it is under signaller control. The default value if nothing is specified for this speed is 30km/h, but it may be set to a different value if required, for example:-

2V31;Nottingham to Cardiff;150;150;250;25;2500;75 would give the above train a signaller-controlled speed of 75km/h.

For entries that represent new services (i.e. not new trains and do not have codes Snt or Snt-sh on the second line), just the headcode and optional description is required on the first line. For example 1S16;London to Glasgow. New services continue on from earlier services so the train data is normally the same as for the preceding service. If a new description is not provided then the earlier description is used.

For the example above (2V31) the second line is 07:00;Snt;N19-29 N20-29.
This tells RailOS that at 07:00 a new train is required (Start new train), located with the rear of the train on track element N19-29 and the front on N20-29 (trains always occupy two track elements). The train is moving when it is created because its starting speed is 150km/h.

The next line is 07:03;pas;Kings Norton Approach (NE), which tells RailOS that at 07:03 the train is expected to pass (pas) Kings Norton Approach (NE). This name ' Kings Norton Approach (NE)' must be a named location that must have this exact name.

The next line is 07:05;Fer;N89-39 N89-40, which tells RailOS that at 07:05 the train is expected to finish by exiting the railway (Finish exit railway) at either track element N89-39 or N89-40. The last line R;30;2;12 tells RailOS to repeat (**R**;30;2;12) the service every 30 minutes (R;**30**;2;12), with the last two characters of the headcode increasing by 2 for each repeat (R;30;**2**;12), i.e. first repeat 2V33, next 2V35, next 2V37 etc, and in all there are to be 12 repeats (R;30;2;**12**).

Another service might be:-

```
2K14;Shirley to Birmingham Snow Hill;0;120;250;25;2500   )       Headcode;description;train data (stationary start)
07:00;Snt;140-32 139-32                                  )       Start new train + starting elements
07:01;Tyseley                                            )       Depart location
07:03;07:04;Small Heath                                  )  =    Arr. and Dep. location
07:07;07:07;Moor Street                                  )       Arr. and Dep. location
07:10;Snow Hill                                          )       Arr. location
07:10;dsc;Birmingham Snow Hill to Shirley                }       Change service description
07:11;cdt                                                )       Change direction of train
07:12;Fns;2K15                                           )       Finish and form new service + its headcode
```

This is a new train as before, but the starting speed is zero, and the track elements 140-32 and 139-32 correspond to a platform at Tyseley, so the train begins at 07:00 stopped at Tyseley. The next line 07:01;Tyseley tells RailOS that the train departs at 07:01 from Tyseley, then 07:03;07:04;Small Heath tells RailOS that the train arrives at 07:03 at Small Heath then departs at 07:04. This line could be split into two separate lines 07:03;Small Heath and 07:04;Small Heath if preferred, it means exactly the same to RailOS. If a line consists of a time and a location, RailOS determines whether the time represents arrival or departure from the context. Line 07:07;07:07;Moor Street tells RailOS that the train both arrives at and departs from Moor Street at 07:07. The train won't depart as soon as it has arrived however, because a minimum period of 30 seconds must elapse between any two consecutive events. Therefore, if the train arrives early, say at 07:05, then it will wait until 07:07 to depart. If it arrives at 07:07 exactly, it will depart at 07:07 and 30 seconds (i.e. 07:07:30), and if it arrives at any later time it will depart 30 seconds later. In other words a train will never depart before a scheduled time, but may depart at any time after that time depending on its arrival time, with a minimum wait period of 30 seconds. Line 07:10;Snow Hill tells RailOS that the train will arrive at Snow Hill at 07:10; line 07:10;dsc;Birmingham Snow Hill to Shirley changes the service description (description) to 'Birmingham Snow Hill to Shirley', and line 07:11;cdt tells RailOS that the train changes direction (change direction of train) at 07:11. The final line 07:12;Fns;2K15 tells RailOS that the train finishes at 07:12 and forms a new service with headcode 2K15 (Finish new service). Another service entry will be needed to take up the story for 2K15. Note that if this new service has a description in its first line then that description will override the earlier one, but if it has no description, just a headcode, then the earlier description will apply.
Service codes - Snt, Fns, cdt etc - use capital 'S' for 'Start' events, capital 'F' for 'Finish' events, and small letters for intermediate events.

5.1 Service references for complex services

In all the earlier examples services have been identified by headcodes, and for simple services like those described headcodes are all that are required for identification purposes. However, for more complex types of service, where there are links to other services but headcodes are required to remain the same (as required for example on many suburban services), more complex 'service references' are used. *In the following examples shuttles and joins are used to illustrate the application of service references. The details of how shuttles and joins operate and are coded will be provided later.*

The point to note is that all linked references must be unique*, (services that don't link to other services can just be identified by headcodes, and those headcodes don't have to be unique) so if the same headcode is to be used for more than one linked service a prefix (own choice up to 4 extra characters) should be added, **though in all cases the final four characters must represent a headcode (see section 5.3).**

*[*Shuttle services may have two links, one each for the 'out' and 'back' service legs - where one link is from 'out' to 'back' and the other from 'back' to 'out' again. This will be explained later.]*

The following entries represent firstly a non-shuttle linked pair of services where the link represents a join:-

First entry:

```
1A21;Glasgow to London;200;200;200;20;2500  )      Headcode;description;train data
07:00;Snt;N89-13 N88-13                     )      Start new train + starting elements (moving train)
07:00;pas;Galton Br. Approach (W)           )      Pass location
07:03;pas;New Street Approach (NW)          ) =    Pass location
07:08;Birmingham New Street                 )      Arr. location
07:11;Fjo;1A23                              )      Finish and join another service + its headcode
R;30;4;12                                   )      Repeat service
```

Second entry:

```
1A23;Edinburgh to London;200;200;200;20;2500  )      Headcode;description;train data
07:02;Snt;N89-13 N88-13                      )      Start new train + starting elements (moving train)
07:02;pas;Galton Br. Approach (W)            )      Pass location
07:05;pas;New Street Approach (NW)           )      Pass location
07:10;Birmingham New Street                  ) =    Arr. location
07:11;jbo;1A21                               )      Joined by other service + its headcode
07:15;Birmingham New Street                  )      Dep. location
07:23;Fer;149-22                             )      Finish by exiting railway + valid exit elements
R;30;4;12                                    )      Repeat service
```

Here, the first service entry - 1A21 reaches Birmingham New Street at 07:08, and at 07:11 the service finishes, by joining train 1A23 (code Fjo signifies 'Finish, join other', in this case 1A23). The second service entry is for the corresponding train 1A23, which reaches Birmingham New Street at 07:10, and is joined by 1A21 at 07:11 (code jbo signifies 'joined by other', in this case 1A21). The two references 1A21 and 1A23 are the two linked service references and must appear in each other's entries for a proper linkage. In this case there is no need for any prefixes because these headcodes are not used elsewhere. Service codes - Snt, pas, Fjo, jbo, Fer and many others are described in detail later.

Note that the repeat information must be identical for all linked services.

The next pair of entries represent shuttle services 2-2P48 and 3-2P49 (shuttles will be explained in detail later):-

First entry:

```
2-2P48;Four Oaks to Kings Norton  )      Reference;description;train data
07:06;Sns-sh;3-2P49;2-2P49        ) =    Start new service from feeder, then form shuttle + linked shuttle ref. +
                                         feeder ref.
07:07;Four Oaks                   )      Dep. location
.
.[lines removed to simplify]
.
07:56;Kings Norton                )      Arr. location
07:56;Fns;3-2P49                  ) =    Finish and form new service + its reference
R;90;0;08                         )      Repeat service
```

Second entry:

```
3-2P49;Kings Norton to Four Oaks  )      Reference;description;train data
07:56;Sns;2-2P48                  ) =    Start new service from another service + its reference
07:58;Kings Norton                )      Dep. location
```

```
.
. [lines removed to simplify]
.
08:35;Four Oaks                    )       Arr. location
08:35;cdt                          ) =     Change direction of train
08:36;Fns-sh;2-2P48;3-2P48         )       Finish and link back to shuttle, finally form new finishing service +
                                           linked shuttle ref. + finishing service ref.
R;90;0;8                           )       Repeat service
```

This pair of services is just one pair of a number of similar pairs, all of which provide the same train service with the same headcodes, but at different time intervals. The other pairs are not shown. Here it will be seen that the first entry for 2-2P48 contains the linked service 3-2P49 in two places - line 07:06;Sns-sh;3-2P49;2-2P49 and line 07:56;Fns;3-2P49. This is because, being a shuttle, it links at both ends to the reverse shuttle service. Similarly the entry for 3-2P49 has its linked service 2-2P48 in two places, at the start and at the end for the same reasons. The other service references: 2-2P49 and 3-2P48 represent the initial shuttle feeder service and the final shuttle finishing services, which are not shown. Prefixes are required because the same headcode is used in several sets of linked services, and as the other sets must not use the same reference, the headcode must be prefixed so as to make the overall reference unique.

It is recommended to use different prefixes for separate same-headcode services even when the timetable doesn't strictly require it (i.e. where linked trains with the same headcode aren't used), because it is then easier to identify which service is at fault when errors are reported by the timetable syntax or validity checkers.

Note that because headcode letters and numbers are very small, it is easy to confuse letter 'g' (shown as 9) with number '9' (shown as 9).

5.2 Timetable service codes

5.2.1 Simple (unlinked) service codes

Codes: Snt; cdt; pas; dsc; cms; Frh; Fer; Time;Location (Arrival or departure); Time;Time;Location (Arrival and departure);

These codes are all independent of each other and independent of other codes. Note that new trains (code Snt) may be stationary or moving, and may be started under signaller control if required. This is done by adding ';S' after the Snt line - e.g. Snt;146-12 147-12;S. No further lines except repeats are permitted for these entries.

Start new train	HH:MM;Snt;rear element ID - space - front element ID [+ optional ';S']
Change direction	HH:MM;cdt
Pass	HH:MM;pas;Location
Change description	HH:MM;dsc;New description
Change maximum speed	HH:MM;cms;New maximum speed (whole number)
Finish remain here	Frh
Finish exit railway	HH:MM;Fer;list of valid exit element IDs (at least 1) separated by spaces
Arrival or departure	HH:MM;Location [+ optional ;Minimum Dwell Time in seconds for arrivals only] (program will determine whether arrival or departure from the context)
Arrival and departure	HH:MM;HH:MM;Location [+ optional ;Minimum Dwell Time in seconds]

5.2.2 Service changes

Codes: Sns; Fns.

These always link together such that a Sns service always follows from an earlier Fns service.

Start new service from another service	HH:MM;Sns;other service ref.
Finish and form a new service	HH:MM;Fns;new service ref.

5.2.3 Splits

Split codes: Sfs; fsp; rsp.

These always link together such that an Sfs service always follows from an earlier fsp (split from front) or rsp (split from rear) service.

Start new service from a split	HH:MM;Sfs;service ref. of the train that splits
Front split	HH:MM;fsp;new (split-off) service ref.
Rear split	HH:MM;rsp;new (split-off) service ref.

A train may split from the front, where the new split-off service appears in front of the original service, or from the rear. The line that contains these codes also contains the service reference for the split-off service. The split-off service has code Sfs (start from split) and also the service reference for the service that it splits from.

One thing to beware of during operation is that the platform (or non-station location) at which the split occurs must be long enough to allow it. The condition is that both trains must be at a platform after the split, although only one element of the train (half its length) need be at a platform. Additionally two of the final four elements that the two trains stand on must overlap the two elements of the original train. Within those conditions RailOS will try to ensure that the front of the front train doesn't exceed the end of the platform so as to remain protected by a signal that lies one element beyond the platform. These conditions mean that the original train may be (and usually is) repositioned during the split. Therefore the minimum platform length is two elements, providing there is a track element linked at each end. If one end is a buffer then the platform must be at least three elements long. When the timetable is first validated (either during editing or on loading for operation) a check is made that each location at which a split occurs has at least one platform that is long enough, but it is up to the signaller to ensure that the actual platform that the train arrives at is long enough for the split. If it isn't then a warning message is given and the train will need to be moved under signaller control to find an appropriate platform. To be safe it is best to ensure that platforms where splits are to occur are several elements long. A second thing to beware of is to try to ensure that after a split both trains lie behind a protecting signal. If one of the trains straddles a signal, then that signal does not provide any protection, and when the train's departure time is reached it will depart possibly without a route having been set. Note that because the number of train elements that will be standing at platforms is maximised, it may be necessary to move an obstructing train further away than would appear to be strictly necessary, but when it has been moved sufficiently the split will occur.

When trains split the proportion of mass and power that are transferred to the split-off train can vary between 1% and 99% for the mass, and between 0% and 100% for the power. 0% for power

is useful when dropping off wagons or coaching stock. To apply this feature a fourth element is added to the end of the split command e.g. 09:48;fsp;0D00;25-35. In this example the split-off train has 25% of the original mass leaving the train that splits with 75%, and has 35% of the power leaving the train that splits with 65%. In all cases the brake force remains in the same proportion as the mass so braking performance stays the same as for the original train. The maximum speed also remains the same as for the original train. If no fourth element is provided the mass and power split evenly between the two.

If a train that splits at a location has a minimum dwell time (MDT) specified for its arrival (see arrival information in section 5.2.1) then the front train remains at the location for at least the MDT whereas the rear train remains at the location for at least the MDT + 30 seconds. This allows the front train to depart first.

5.2.4 Joins

Join codes: Fjo; jbo.

These always link together such that an Fjo service always links to a jbo service.

Joined by another train	HH:MM;jbo;joining train service ref.
Finish and join another train	HH:MM;Fjo;service ref. of train to join

Join codes are Fjo ('finish, join other') for the service that finishes by joining another service, and jbo ('joined by other') for the service that has the other service joined onto it.
The lines that contain these codes also contain the service references of the corresponding linked services. The thing to beware of during operation is that both trains must be received at the same platform - fairly obvious of course but easy to overlook at a large station when the trains arrive at different times. Failure to observe this will result in signaller control being needed to position the trains correctly. Also necessary is that the receiving platform must be long enough to accommodate the two trains. Try to receive joining trains at platforms where there will be at least one platform element free for the second train, which may be behind or in front of the first train depending on the arrival direction of the second train.

When trains join, their masses, powers and brake forces are added, and the maximum running speed becomes the smaller of the values for the two trains. Warning messages are given when one or other train is waiting for the other.

Note that when repeat service trains join, each service must have the same repeat number. Services with different repeat numbers will not join, even though the headcodes correspond correctly. Service repeat numbers are provided in the train status floating window.

If one or both trains that are to join have a minimum dwell time (MDT) set on arrival (see arrival information in section 5.2.1) then both trains remain at the location for at least their own MDT.

5.2.5 Shuttle services

Codes: Snt-sh; Sns-sh; Frh-sh; Fns-sh; Sns-fsh; F-nshs

The linkage for these codes is quite complex and is explained below.

Start new shuttle train at a timetabled stop
HH:MM;Snt-sh;rear element ID - space - front element ID;linked shuttle service ref.
Start new shuttle service from a feeder
HH:MM;Sns-sh;linked shuttle service ref.;feeder service ref.
Finish and repeat shuttle, finally remain here
HH:MM;Frh-sh;linked shuttle service ref.
Finish and repeat shuttle, finally form a finishing service
HH:MM;Fns-sh;linked shuttle service ref.;finishing service ref.
Start new non-repeating shuttle finishing service
HH:MM;Sns-fsh;linked shuttle service ref.
Finish non-repeating shuttle feeder service
HH:MM;F-nshs;linked shuttle service ref.

A shuttle service is a service that runs from A to B (outbound shuttle), then forms a new service that runs back from B to A (inbound shuttle) and forms a new service that links to the first repeat of the original service. **Shuttles are the only way for a service to link back to a service whose first train starts at an earlier time, all other links are forward links to later services.** The pattern must repeat at least once, and may repeat as many times as required.

In practice shuttle services may be a lot more flexible than this, for (a very complex) example: the outbound shuttle may run from A to B; then it forms a new service that runs from B to C; then part of the train splits off to form a new service that runs to D (the service that splits off repeats as many times as there are shuttles but is not part of the shuttle in that it can't link back into the shuttle sequence); the remaining train at C changes direction then continues on to E, where it is joined by another service from F (the joining service from F repeats as many times as there are shuttles but is not part of the shuttle). The service from F, together with the train joined from E then returns to A as the inbound shuttle, where it links back to the first shuttle service. The essential feature of a shuttle service is that it represents a loop, with the same start and end locations, and a final service that links back to the starting service. Intermediate events (splits, joins, direction changes etc) are possible, and any number of Fns service finishing events that link to corresponding Sns service starts, but the final finish must link back to the starting shuttle using Frh-sh or Fns-sh, thereby completing the loop. No other finish types are allowed. In the above example the shuttle runs from A to B to C to E then back to A. The split off part to D and the service that starts from F and joins at E are not part of the shuttle loop.

There are two more points to remember, the first is that a shuttle loop cannot consist of a single service. In other words a service that runs from 'A' to 'B', then continues on by returning to 'A', cannot be a shuttle. There must be at least one change of service, i.e. the shuttle finishing service reference must be different from the shuttle starting service reference. This is not to say that the same headcode can't be used for these two services because it can, so to all appearances the same service does in fact keep looping for as many times as there are repeats (though the performance log will still record the fact that a change of service has occurred, albeit with the same headcode). However the service reference (prefix + headcode) must change at some point within the loop. This represents a program restriction in that a service is not permitted to link back to itself. The second point is that a shuttle must have at least one repeat. This should be fairly self-evident since a shuttle that doesn't repeat is just two linked services.

It is recognised that the coding of shuttle services may be difficult to learn, but it is considered to be well worth the effort as sophisticated and interactive services become available. Nevertheless it is possible to run very respectable railways without any shuttles at all, if preferred. A series of

interleaving shuttle services is provided in a sample timetable (Birmingham). Study of these will lead to a good understanding of how they work.

The simplest form of shuttle is one that starts as a new train at the shuttle loop start (and end) location (hereafter referred to as the 'loop location'), and at the end of all the repeats remains at that location. The code that starts this type of shuttle is Snt-sh, meaning 'start a new train that is a shuttle'. The corresponding finishing code is Frh-sh, meaning 'finish and remain here or form a repeating shuttle'. The lines that contain these codes also contain the service references for the linked shuttle service.
When setting the times for shuttle links the time for the Frh-sh event must correspond to the time for the corresponding Snt-sh event + 1 repeat time, and the repeat time must be at least as much as the minimum time to complete the loop. For example, if the minimum time to complete a shuttle loop is 25 minutes, then the repeat time might be 30 minutes, with an additional dwell time at the station where the service changes to the new shuttle of 5 minutes. This then makes the overall loop time correspond to the repeat time, which is what is required.

As well as the looping shuttle services themselves, two other associated services are available, known as 'shuttle feeder' and 'shuttle finishing' services. A feeder service is a non-repeating service that ends at the loop location. It is normally used as a train of empty stock from a depot to the station at which the shuttle begins. This service starts as a normal service but ends with code F-nshs, which means 'finish non-repeating shuttle feeder service'. The shuttle service that it forms begins with code Sns-sh, meaning 'start a new shuttle service from a feeder service'. A finishing service is a similar non-repeating service but starts when all the repeating shuttles have finished, and is typically an empty stock movement back to the depot. The code for a shuttle that links to a finishing service (as well as back to other shuttles while they are still repeating) is Fns-sh, meaning 'finish and form a new finishing service or a repeating shuttle'. The corresponding starting code for the finishing service is Sns-fsh, meaning 'start a new finishing service from a shuttle'. The lines that contain the shuttle codes (Sns-sh and Fns-sh) also contain two linked service references, the first is the linked shuttle reference (outbound references inbound and vice versa), and the second is the non-repeating feeder or finishing service reference. The lines that contain the non-repeating service codes (F-nshs and Sns-fsh) have just one linked service reference, corresponding to the relevant shuttle. Feeder and finishing services don't have to appear together, a particular shuttle may have a feeder service but no finishing service, a finishing service but no feeder service, both, or neither. Also a single service can be both a finishing service from one shuttle and a feeder service for another shuttle, which is useful when a shuttle service changes frequency or stopping locations.

When setting the times for shuttle links the time for the Fns-sh event must correspond to the time for the corresponding Sns-sh event (or Snt-sh event if there is no feeder) + 1 repeat time. This is exactly the same as the situation for Frh-sh described above.

When setting the time for a finishing service the Sns-fsh event time must correspond to the time for the corresponding Fns-sh event + 'n' times the repeat time, where 'n' is the number of repeats. For example, if the shuttle repeats at 30 minute intervals and there are 20 repeats, then if the Fns-sh time is 07:45, the corresponding Sns-fsh time should be 07:45 + (30 x 20) minutes, i.e. 17:45.

To summarise: a shuttle MUST contain at least an outbound service and a separate but linked inbound service. The outbound service starts at the loop location with either Snt-sh (if it is created there) or Sns-sh (if it follows on from a feeder service). The inbound service is the one that

finishes at the shuttle loop location with Frh-sh (if it remains there after all the repeats) or Fns-sh (if it continues on as a finishing service after all the repeats). The “linked shuttle service ref." (listed at the start of this section) for the outbound service is the service reference of the inbound service, and vice versa. In practice, and what often makes it complicated, is that there can be many more intermediate services between outbound and inbound, with service changes, splits and joins and so on, but for any particular shuttle there is only ever one outbound service (beginning Snt-sh or Sns-sh) and one inbound service (finishing with (Frh-sh or Fns-sh), both of which repeat as many times as are required.

5.2.5.1 A simple shuttle example:

This was created by contributor BWJM who has kindly given permission for its inclusion.

It consists of a depot, where the train starts and ends its day, and two stations, West Station and East Station, where the train shuttles back and forth between. All track is bidirectional.

The timetable starts off simply:

```
06:00
```

Next we define a "shuttle feeder service", XX00, which brings the train from the depot into service at West station.

```
XX00;Shuttle Depot to Station;0;100;500;500;500;100
06:00;Snt;15-13 16-13
06:01;West Depot
06:02;West Station
06:05;F-nshs;S001
```

Then we have the "outbound" service, S001, from West Station to East Station.

```
S001;Eastbound Shuttle
06:05;Sns-sh;S002;XX00
06:06;West Station
06:07;East Station
06:08;cdt
06:10;Fns;S002
R;10;2;10
```

Then it returns back to West Station as S002.

```
S002;Westbound Shuttle
06:10;Sns;S001
06:11;East Station
06:12;West Station
06:13;cdt
06:15;Fns-sh;S001;XX99
R;10;2;10
```

The above shuttle operation repeats 10 times and each loop takes 10 minutes to complete. It incrementally uses headcodes **S003** through **S022** in the process, with odd for eastbound and even for westbound.

Once rush hour is over, the train goes out of service and returns to West Depot as **XX99**. Note that this service is timed to start after S022 is done: 07:55. You need to count up all the repeats of the shuttle to figure out the correct start time!

```
XX99;Shuttle Station to Depot
07:55;Sns-fsh;S002
07:56;cdt
07:57;West Station
07:58;West Depot
Frh
```

5.3 Headcodes

Headcodes (i.e. the last four characters in a service reference) must consist of four consecutive alphanumeric characters, i.e. capital or small letters, or digits. The only restriction is that repeating services with increasing digits between repeats must contain digits as the last two characters. The standard British headcode consists of 'digit letter digit digit', but other systems use different formats.

5.4 Timetable validation & restrictions on timetabling

The 'Validate timetable' button in the timetable editor is available only when a railway is loaded and a timetable is open in the editor and saved to a file. A timetable that is in course of development can't be validated until it has been saved (or saved under a different name using the 'Save timetable as...' button), because the validator works on the file.

Two sets of checks are carried out, the first for syntax, and the second for overall structure. The first will reveal incorrect coding, the second will reveal incorrect timings such as a departure before an arrival, incorrect sequences such as arrival at Station A followed by departure from Station B, and incorrect service reference linkages etc. Checking is quite comprehensive, so a timetable that is validated should load and operate correctly.

Timetable integrity is validated with respect to internal consistency, not with respect to railway layout. It is the user's responsibility to make sure that a timetable is consistent with the railway. For example if a train is to stop in sequence at A, B, C, D, but station layout is A, D, C, B, then when the train reaches D RailOS 'thinks' that stations B and C have been missed, so 'missed location' logs will be sent to the performance file. As far as the timetable is then concerned B and C are no longer listed. However the check for missed locations is only carried out as far as the next change-of-direction (cdt) if there is one. This allows for services that stop at some locations on the way out and at the same or others on the way back. For example, stations may be set out in sequence W, X, Y and Z, and a train stops at W and Z on the way out, then changes direction and stops at Y, X and W on the way back. When it arrives at Z ready to return, it hasn't missed X and Y, so 'missed location' logs are not sent for these because they come after the change-of-direction. This situation would normally be set up by changing service at Z (new headcode), but RailOS allows that same service to change direction and continue if required.

Note that trains that are timetabled to stop at the same location twice without a change of direction in between will give a warning as they may be correct (running in a ring for example) or may indicate a missing change of direction.

Timetabling restrictions

Because of programming constraints there are some restrictions in RailOS timetable structure that are not found in real life. These have been kept to a minimum but if they occur an error message will indicate the nature of the restriction. In almost all such cases, with a bit of thought, workarounds can be found that reflect real-life practice. These restrictions are due to the validator needing to associate a location name with every event that takes place when a train is at a location. All Fns events are named first, from a preceding arrival (where the location is named explicitly in the timetable) or from an Snt event that is at a location, then Sns events are named from the preceding Fns location. Therefore an Fns that follows an Sns event can't be named because the Sns event hasn't yet been named. After Fns and Sns events are named fsp and rsp events are named from a preceding arrival or from an Snt event that is at a location, and Sfs events named from the preceding fsp or rsp events. Therefore an Fns event can't follow an Sfs event without a departure and arrival between them, and fsp and rsp events can't follow an Sfs event again without a departure and arrival between them. These are the restrictions that are likely to be encountered in practice, but in almost all cases there will be workarounds available.

An example workaround is when a locomotive brings a train into a terminal station, drops off the carriages (by splitting the train into locomotive and unpowered stock), then runs round the stock to attach (join) at the other end to take the train back out of the station. The validator requires that either the loco or the stock changes its service reference before the join, because a service can't split and then rejoin the same service reference. Another restriction is that a train that splits off from another (begins with Sfs - starts from split) can't immediately change to a new service (i.e. can't end with Fns - finish and start a new service). The way round this is to have the split-off train finish with Fjo - finish and join another train, and the original train change to a new service then have the split-off train rejoin it using jbo - joined by other train. Therefore in the case of a run-around there are two possibilities: (a) the loco splits off from the stock, runs around and rejoins the stock using Fjo, and the stock changes to a new service then rejoins the loco using jbo; and (b) the stock splits off from the loco and rejoins the loco using Fjo, and the loco changes to a new service, runs round the stock, then rejoins it using jbo.

5.5 Timetabled and automatic warnings

Any service event (except Fjo - see later) may be preceded by 'W', e.g. W14:23;Moor Street. This represents a 'warning', and when the service reaches this point a warning message is given at the top of the display area accompanied by three short beeps if sound is turned on. Warnings scroll up in two columns, ten in all, and may be erased by right clicking. The latest is in red and bold text, and earlier ones in blue and regular text. Warnings are useful for example to indicate when a route will need to be set in the near future, say when a train is approaching a junction at the end of a route controlled by automatic signals. Warnings that are set for repeating services are given for each repeat.

Warnings are also provided automatically in circumstances where the signaller may need to take some action, these include trains prevented from entering or being created because existing trains are obstructing them; equipment and train failures and restoration; random delays imposed; routes locked; trains unable to split because the platform is too short or another train is in the way; and trains waiting for another train to join or to be joined by.

Remember to set separate warnings where there are different entries for similar services, e.g. a shuttle feeder service is listed separately from the shuttle service that it feeds, so both the feeder

and the shuttle should have warnings at similar locations if appropriate, but the repeat feature will take care of all warnings for the shuttle services themselves.

If a warning is set for an arrival and departure event - HH:MM;HH:MM;Location - the warning is given on arrival only, not departure.

Warnings are not permitted for Fjo codes. If a warning is required when trains join (as opposed to when they are waiting to join - at which time an automatic warning is given) the 'W' should precede the jbo event, not the Fjo event

5.6 Showing and hiding the timetable editor

Finding track element identification numbers (IDs) for Snt and other events that require them is made easier by having the appropriate railway loaded, then temporarily 'hiding' the timetable by left clicking the 'Hide' button, and examining the track by enabling track information and hovering the mouse over the required element. Note that the editor can't be hidden while an entry is being created, it must first be saved by clicking 'Save entry', but it can be saved in any state of completion.

5.7 Repeating services

Most services may be followed by repeats, as in one of the examples described earlier, consisting of R;mins;digits;num, where 'R' is the 'repeat' marker, 'mins' is the number of minutes increase between repeats, 'digits' is the last two headcode digit increase between repeats (this may be zero if all headcodes are to be the same, and if not zero then the numbers roll over at 00), and 'num' is the number of repeats. A repeat service that has a value other than zero for 'digits' must have digits as the last two characters of the headcode. Note that shuttle feeder and finishing services (F-nshs and Sns-fsh) can't have any repeats, and shuttle services (Snt-sh, Sns-sh, Frh-sh and Fns-sh) must have at least 1 repeat.

When a repeating service has been created, it can be expanded into separate equivalent services using the 'Expand repeats' button - enabled when a timetable has been saved and validated and a repeating service is selected. For example a service that repeats every 30 minutes with 2 digits increase per repeat and 8 repeats in all can be expanded into 9 separate services at 30 minute intervals, consisting of the original service and 8 repeats. In addition every service that links to the repeat - splits, joins and new services - will also expand similarly. This can be very useful when developing timetables that have similar services but with different stopping patterns, uneven headcodes or timings. This is usually the case with real timetables. A repeat service is created first, then expanded, and each separate service edited to correspond with the real timetable. This is normally a much faster process than repeated copying and pasting, especially if there are several linked services.

5.8 Using the timetable editor

The editor is available from the 'Mode' menu, when a new timetable can be created or an existing timetable edited. The service list on the left of the editor shows all entries, the program-readable part beginning with START and followed by service references or 'Comment' if the entry begins with '*'. If this part ends with a blank line it is marked END. Other entries are marked '-' or '+' for before or after the program-readable part, and contain the first few letters of the text. Services are shown and can be edited in the service entry panel on the right of the editor.

The buttons provided are hopefully self-explanatory, and each has an associated hint, seen by hovering the mouse over it when it's active.

Cutting, copying and pasting of whole entries is quickly done using the buttons (or keyboard shortcut keys as set out in section 7), but note that pasting a copied entry does it directly below the highlighted entry, it is not to be used in conjunction with the 'Insert new entry' button. More versatile copying, cutting, pasting and deleting is done using 'CTRL C', 'CTRL X', 'CTRL V' and 'Delete' respectively. With these keyboard shortcut keys sections of an entry or whole entries can be cut, copied, pasted and deleted by highlighting the relevant section, then pressing 'CTRL X' to cut, 'CTRL C' to copy, 'CTRL V' to paste, or 'Delete' to delete. 'CTRL Z' can be used to undo any changes. Pasting with CTRL shortcut keys can be done into new or different entries than those cut or copied from and they can be used in conjunction with the 'Insert new entry' button. Note that buttons (or SHIFT shortcut keys - see section 7) and CTRL shortcut keys are NOT interchangeable. For example a copy made with the 'Copy' button or SHIFT C can't be pasted using CTRL V.

Commas must not be used within services because commas are used internally by the timetable editor to separate the events in a service, and if extra ones are added then the events that they appear in will be split and will not be understandable to the editor. The commas that separate the events are not visible. Similarly semicolons are used to separate the components of each event, and they must not be used for any other purpose wthin services. Semicolons are of course visible so their presence is clearer. Commas and semicolons may be used freely outside services, i.e. in text preceding the start time, in text following all services, and in comments between services.

When adding services it is often helpful to copy an earlier service, then modify it, for example by changing service references, and adding or subtracting minutes using the 'Add mins' and 'Sub mins' buttons with the number of minutes in the white box (these change affect all time values in the entry by the same amount). It is best not to use the HH:MM time format in any position other than as a legitimate service time, because if add or subtract minutes is used it changes every HH:MM time that it finds in the entry.

Note that when entering a service almost all buttons are greyed out until either 'Save entry' or 'Cancel' are clicked.

If a timetable is changed then it must be saved before it can be validated. If a timetable is being developed from an earlier one and the original is to be retained, then the 'Save timetable as' option may be used to save it under a new name.

Some timetables extend to many services, when it can be difficult to find a particular service, for example if an error message relating to it is given. To help in this respect a button is provided to list all services in alphabetical order. A service that is selected in the service list and shown in the service entry panel when in alphabetical order will still be selected and shown when the original order is restored. It is recommended to use alphabetical order to find services, and the original order to modify or correct them, particularly if comments had been inserted at specific points in the original order, because comments will all be located together in alphabetical order. Care is needed in using this facility because changes made whilst in alphabetical order won't be saved if the original order is restored. Of course if alphabetical order is preferred then by all means make

changes using it, and save the timetable in that order. Warning messages are given during use to help prevent losing changes that you may wish to keep.

Services can also be listed in time (chronological) order of train starting time using the 'Time Order' button. This works similarly to alphabetical order in terms of saving entries and warnings during use. Trains are updated in the order in which they appear in the timetable, which isn't noticeable in normal circumstances, but if there are severe delays and several trains are waiting to enter the railway but can't because other trains are obstructing their entry, they will only enter in proper time order if the timetable is listed in time order.
It is not necessary to load a railway in order to edit its timetable, but it is necessary to have the railway loaded in order to validate the timetable from within the editor. All timetables are validated prior to loading for operational use but for new or changed timetables it is better to check validity with the editor open so that changes may be made if necessary. In order to use the list of railway locations from the timetable editor drop-down box it is necessary to have a railway loaded, but this may be in the form of either a '.rly' file or a '.dev' file, though only a .rly file will permit validation. Note that loading a timetable for operational use and for editing are different activities, a timetable still has to be loaded in order to operate the railway after it has been edited and validated. Note also that continuation names are for location identification when trains enter and exit the railway, they are not stopping locations. For this reason continuation names must not be used in the timetable, the validation check will raise an error if they are. Also for this reason the location name drop-down box in the timetable editor excludes continuation names.

5.9 Non-timetabled services

Non-timetabled services may be set up to use manual (i.e.signaller) control only. Here all control is manual but a timetable is still needed to allow new trains (or trams - signaller control is often more appropriate for trams) to be created and to set data such as powers and maximum running speeds. These entries have start events of the form - Snt;146-12 147-12;S - where the final 'S' indicates that it is started under signaller control. For these services it is useful to use the description to indicate the route, so that this shows in the floating window during operation and so helps in applying correct control.

Trains or trams operated under signaller control need skill to stop at required positions because there is no automatic location stopping as there is under timetable control. A train (tram) being stopped by a signaller command brakes at up to three quarters of its maximum braking effort (this may be considerably less if there is a long element in front), and it takes effect when it reaches the end of the next full element. It will always stop at a full element, so there is a need to be aware of element lengths, speed (the higher the speed the more difficult the judgement), and position when the 'stop' command is given. For regular stopping under signaller control - as may be required for tram operation - it is suggested to experiment then mark the brake application positions using text markers.

5.10 Formatted timetables

When a timetable has been saved and validated (the appropriate railway .rly file has to be loaded in order to validate it), it may be exported. Exported timetables help in operating the trains and are located in the 'Formatted timetables' folder. They may be exported from within the timetable editor by left clicking the appropriate button, or, when loaded for operation, from menu items 'File' and 'Export timetable'. Timetables are created in two forms (a) traditional timetable format in

spreadsheet form ('.csv' - comma-separated variable files), readable and reformattable by Microsoft Excel or any spreadsheet program, and (b) chronological order in plain text ('.txt' files), readable by any word processor or text editor. The chronological timetable in particular should be useful in planning operations in a proper sequence, and should match the performance log quite closely if the railway is operated efficiently and without delays. Note that these timetables are likely to be quite big if there are many repeating services, so be aware that a lot of paper will be required if they are printed as a whole files.

5.11 Important points to note in timetabling

1. All train and service entries must contain a single start event which must come immediately after the first line, i.e after the line that contains the service reference.

2. Except for signaller-controlled trains (see 5.9) all entries must contain a single finish event, which must either come last, or, if the service is to repeat (see 5.7), must be the one before last - the last being the repeat.

3. Signaller-controlled trains (see 5.9) must contain either a start event on its own, or a start and a repeat.

4. All location names used in the timetable must be where trains can stop, even if they are only used as passing points. The drop-down box in the timetable editor gives a list of valid locations if a railway with names is loaded. Note that although continuations can be named trains cannot stop there.

5. Avoid illegal sequence events by ensuring that arrivals are followed by departures from the same location, and moving train events (e.g. pass times, departures & Snt events for moving trains) are not followed by events that can only occur when stationary and vice versa. Note that an Snt event is treated as moving (even if the starting speed is zero) unless (a) the start location is the next timetabled departure point for that train and the starting speed is zero; or (b) the train is a signaller controlled train, its starting point is a location, and its starting speed is zero.

6. Note that although a time-location (HH:MM;Location name) event can represent an arrival or a departure (RailOS will determine which from the context), it cannot be both. If both an arrival and a departure from the same location is required without any events in between then a time-time-location event (HH:MM;HH:MM;Location) can be used, where the first time is the arrival and the second the departure. The times can be the same, in which case departure will be 30 seconds after arrival, or different.

7. The only way for a service to link back to a service whose first train is earlier than the linking service is by using a shuttle.

8. RailOS only works in metric units but conversion facilities are included to change speeds in miles per hour to kilometres per hour, and horsepower to kilowatts, and vice versa, and the floating information window gives speeds in both forms.

5.12 Timetable conflict analysis

With long or complex timetables it is usually difficult to ensure that train timings don't conflict. For example two or more services might be scheduled to arrive at or pass a location at the same time with only one platform available, or two or more services might be scheduled to pass or depart from a location within a minute of each other when it takes two minutes to clear the next signal, or three services might be scheduled to occupy platforms at a location with only two platforms, each with room for only one train. Additionally, it is easy during timetable compilation to omit a necessary change of direction, when, instead of a train retracing its earlier route it is left stranded at buffers or moves away in the wrong direction. Operating the services to check for these sorts of conflicts is far from ideal as it can take a very long time, especially as most timetables run for several hours.

To help highlight these situations the timetable editor includes an analysis facility, accessed by clicking the 'Conflict Analysis' button at the top of the editor next to the 'Timetable start time' box. This is available when a railway has been loaded and its timetable opened in the editor and validated.

Analyses are provided only for timetabled trains. No analysis is possible for trains that start under signaller control.

Clicking the button opens a new panel with options to analyse arrivals, departures, trains at locations and directions. Arrivals and departures each include a box to specify the number of minutes within which scheduled arrivals or departures will be listed. The arrival analysis lists events when two or more services are scheduled to arrive at or pass a location within the number of minutes specified (0 minutes represents simultaneous arrival). In each case relevant locations are listed in alphabetical order with the number of platforms at the location and the number of trains arriving or passing, followed by the services involved with a repeat number if appropriate, the time that the service is due to arrive or pass, and an approach code - explained later. Departure analysis is similar. The service repeat number together with the first service reference (headcode + prefix if present) is given for ease of comparison with the entry in the timetable editor. For two or more trains at a location the relevant services are listed together with the time at which they are there at the same time. Direction analysis examines train facing directions on creation and missing or questionable changes of direction during operation.

The analyses are written to a file that is saved in the 'Formatted timetables' folder. It is in comma separated variable (.csv) format so that it can be opened using a spreadsheet program such as Microsoft's Excel. If used with Excel an oddity to be aware of is that any service of the form nEnn where 'n' represents a digit, e.g. 4E23, will be listed as 4.00E+23 because Excel interprets it as a number in scientific notation. The same happens if it is entered in quotes or the cell is formatted as text. Excel seems to insist that regardless of any cell format anything that looks like a number is a number! The only way to make it display correctly seems to be to add a single inverted comma (') before the entry, after which it displays as it should with a small green triangle that warns of the presence of this inverted comma. However once aware of this effect it is relatively easy to interpret the display as the appropriate service without making any change.

Approach codes normally relate to the direction from which a train approaches a location, and, for departures, exit codes normally relate to the direction taken after departure. To determine these codes the timetable is examined and if two services have the same location listed at any time

before the arrival location (but after a change of direction if there is one) then they are allocated the same approach code. Similarly for departures - if two services have the same location listed after the departure location (but before a change of direction if there is one) then they are allocated the same exit code. However this system isn't perfect. If there are two routes from a location to another location, where one service takes one route and another the other, then they will have the same approach code but will approach from different directions. The same applies for departures and exit codes. More likely is where two services approach from the same direction but one stops at locations on the way whereas the other doesn't. In such cases there might well not be a common location listed in each service's timetable prior to the arrival location, and they will be allocated different approach codes even though their approach direction is the same. The same applies for departures and exit codes. These codes are particularly valuable in cases where there are stations with only two platforms that serve 'up' and 'down' directions. In these cases where services have different approach or exit codes then the risk of conflict can normally be dismissed, and often there are many such stations. Potential problems are more likely at large stations served by several different routes. Different codes will be given for services arriving from different routes, though trains from these routes might arrive at the same side of the station. To offset the risk of conflict these stations normally have plenty of platforms to accommodate trains arriving at the same time at the same side of the station.

Although the analyses look complex, especially for complex railways and/or intense services, they will become easier to use with a bit of practice. Users will be familiar with their own railways and will soon recognise locations and times when real conflicts are possible, and quickly narrow down areas for more detailed examination accordingly. To help identify quickly likely points of conflict for arrivals and departures asterisks are placed before location names where the number of same approach or exit codes is equal to or greater than the number of platforms. Also for trains at locations asterisks are similarly placed where the number of trains exceeds the number of platforms. Asterisk entries may not in fact represent conflicts when there is room for more than one train at a platform.

An important point to note is that approach and exit codes apply only for services listed at a particular location within a particular time range - i.e. those that are listed on the same line. They do not have a universal meaning. Code A on one line might relate to one approach direction and code A on another line to a completely different approach direction - similarly for exit codes. In fact it will be seen that the first service at any location is always allocated code A, both for arrivals and departures.

The direction analysis is more detailed than that carried out during timetable validation, when attention is drawn to one or more locations listed in a service without a change of direction between them. The direction analysis extends this by examining all services from initial creation to finish, including all changes of service (including shuttles), splits and joins. In this way a missing change of direction will be highlighted when the same location appears twice without a change of direction between them even when the locations appear in different services. Similarly questionable changes of direction are highlighted where there are no locations on either side with the same name. As for the other analyses it isn't perfect. Linked services that are routed round a loop will have missing changes of direction highlighted even though the route is correct. Also trains that enter a terminal station using one route, perhaps from a siding or depot, change direction and then leave on a different route, will have the direction change flagged as potentially unnecessary because there are no locations either side with the same name, though the movements are legitimate. The aim is to highlight potential errors so they can be examined and either

dismissed if they aren't errors, or corrected if they are. The facing direction analysis examines the starting direction of a train on creation. Trains facing buffers with no location before or at the buffers will be listed as potential errors.

It will be seen that some potential errors are listed twice or more where they occur before one or more service splits. This is because the service that splits to another service and continues is listed, and the services that represent each split service are listed separately. In these cases there won't be as many potential errors as appear at first sight.

After any corrections have been made as a result of examining the direction analysis it is best to run the analysis again to reveal any other potential errors that were masked earlier.

Sometimes with a shuttle finishing service an additional change of direction will be needed for a train to reverse an earlier change of direction in the return shuttle, in cases where it continues forwards to a siding or depot.

Timetables don't require that service references be unique, except for services that reference other services, so it is often the case that several services are listed with the same reference, which will normally take the form of a simple headcode without a prefix. Listing these for analysis purposes would be very unhelpful as the actual service referred to would be ambiguous. To get round this problem, when the same reference is encountered a second time in a timetable it will be given the suffix '/1', a third similar reference will be suffixed '/2', then '/3' and so on. The order of these suffixes relates to the order in which the services are listed in the timetable. These suffixes are only used in the analyses, they don't appear anywhere else.

If entry or exit locations don't have names the element ID is given instead. For exits only the first listed ID is given, so if there are more then conflicts are less likely.

When the first draft of a timetable has been completed and validated, an analysis file should be generated and the listings examined for potential conflicts. Any that appear too tight for proper timekeeping can be used to adjust the timetable accordingly and a new analysis carried out. Often changing the timing of a service will cure one conflict only to create a new one with another service. In these cases more drastic surgery might be needed such as changing repeat timings to interleave better with conflicting services. In most cases several iterations will be necessary before a satisfactory or perhaps more likely a 'least worst' arrangement is found.

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6 Operating a railway

When a railway has been saved as a '.rly' file and has one or more valid timetables it is ready for operation.

Select menu items 'File', and 'Load railway', then double click on the required file to bring up the railway. Then select menu items 'File' and 'Load timetable', and double click the required timetable. Finally select menu items 'Mode' and 'Operate railway'.

The railway is now in 'Pre-start' mode, which means that the clock is stopped and trains won't run until the 'Run' button  is left clicked, but routes may be set (see later) and train information is available. It is worth setting up automatic signal routes in this mode, which can be done manually or automatically (from v1.2.0) using the 'Preset automatic signal routes' button  . This sets automatic signal routes on all track sections without points, crossovers, level crossings and non-facing signals that have single preferred directions set and that lie between non-ground signals or between continuations and non-ground signals. This feature helps to speed up automatic signal route setting, but other automatic signal routes may also be needed, for example across junctions that aren't used, and can be set individually as described later. Automatic signal routes may be set on tracks that are due to have trains created on them when the timetable begins, and signals that lie behind these trains will be set appropriately as soon as the trains are created. Beware though that any trains that are already in motion may be affected by such signals, so try not to have more than one train created on a given route at any one time. If trains are created on other types of route then the route behind the train will be removed.

After the 'run'  button is clicked and the railway is operating, this button changes into a 'pause' button . When this is left clicked the clock stops and operation is suspended. Information is available in this mode but no action may be taken that affects the railway such as route setting or taking signaller control of trains. Note that if operation is halted for any reason - by a screensaver, displaying on-screen help, or by temporarily changing to another application - it will be in 'pause' mode when it is restored. Also when the 'run' button is clicked the 'Preset automatic signal routes' button changes into a 'Call-on' button  so it can no longer be used for its original purpose.

During operation, although trains are normally running to a timetable, they will run wherever the track leads. They stop at signals and buffers (if there is time and braking capacity), and timetabled stop locations, but will only stop for trains in front if they are being called-on, under signaller control (see later), or at a timetabled stop location. Hence it is the signaller's responsibility to keep trains safe and on the right tracks. Errors other than crashes and derailments may usually be corrected by taking signaller control and making appropriate corrections, at the cost of time and possible delays to other trains. A train that runs on a wrongly set trailing point will become derailed. Crashed and derailed trains must be removed from the railway by the signaller.

6.1 Route setting and cancelling

Three types of route are available by left clicking the appropriate button: automatic signal routes  (two half-size blue buttons), preferred direction routes  (two half-size green buttons), and unrestricted routes  (red button). Automatic signal and preferred direction routes may only be set on tracks with preferred directions allocated (via the 'Mode' and 'Set preferred directions' menu items, see section 4), but unrestricted routes (red route button) may be set from any point to any other point (other than points, bridges or crossovers and providing there's a track between them), regardless of preferred directions. Unrestricted routes are intended for unusual movements only. When a route is set the direction is indicated by small coloured arrows on the first and last elements of the route. A route that does not involve any point changes will be set in about half a second, but if point changes are needed then about 2.5 seconds are required. In 'Pre-start' mode routes are set instantly.

Preferred direction (green) and automatic signal (blue) routes can be set in two different ways. For authentic operation they should be set from a signal or continuation (or buffer for preferred direction) to the next signal/continuation/buffer - top half-size buttons, but to allow for quicker route setting they can be set from a signal/continuation/buffer to any following signal/continuation/buffer (intermediate signals being skipped) - bottom half-size buttons.

Preferred direction routes and unrestricted routes are cancelled automatically as a train runs along them, and all signals passed change to red. Automatic signal routes are not cancelled by trains, they remain in place until cancelled by the signaller (or by a train running on them in the wrong direction). When a train passes a signal on an automatic signal route it changes to red, but (in the absence of any following trains) at the same time the next earlier signal changes to yellow, the next earlier signal to that one changes to double yellow, and the next earlier one to green. That is for four-aspect signals, three-aspect signals omit the double yellow and two-aspect signals omit both yellow aspects. Facing ground signals clear but don't affect the aspect changes for non-ground signals.

In this way trains may proceed from section to section without intervention by the signaller. If an automatic signal route ends at a continuation then when trains pass the last signal it changes to red as normal, and after a time interval it will change (for four-aspect signals) to yellow, then double yellow, then green. Other aspect signals behave appropriately. The time interval is based on the speed of the departing train - the faster the train the sooner the signal changes.

When a route start and end point are selected the program tries to find an appropriate track linking them. The strategy used is to search from start to end, following points initially in their 'set' direction, and beginning the search in the direction that moves closer to the end point. If there is more than one valid route between the selected start and end points then RailOS may select either depending on how the points are set. To force a particular selection set the points for the favoured route. Similarly if it is found that RailOS cannot find a suitable route even though you know there is one, probably because there are facing points with so many ways out that the search takes too long, then set one or more facing points for the desired route beginning with those closest to the start point. Note though that sometimes a preferred direction or automatic signal route can't be set because the preferred directions won't allow it, and that isn't necessarily obvious during operation, so it's advisable to make sure that preferred directions are set on all tracks that are to be used in normal operation.

When selected, routes may be truncated or cancelled, by left clicking the 'route cancel' button  and then right clicking an appropriate track element as follows:

Start of a route - cancels the entire route (but see the next paragraph);
For automatic signal and preferred direction routes there are three options
1. element immediately before a facing signal - truncates the route from the start to the signal;
2. a mid-route signal - truncates the route to the next facing signal;
3. element immediately after a signal - truncates the route from the signal to the end.

For unrestricted routes behaviour is similar for 1 and 2 above, but clicking any other element truncates the route from that point to the end of the route.

Routes that consist of a mixture of preferred direction and unrestricted route sections are regarded by RailOS as a single route, which may be cancelled as a whole. However a route that consists of a mixture of automatic and other types of route sections is regarded by RailOS as a series of separate routes, with automatic signal sections being individual routes, and mixtures of others similarly being regarded as individual but separate routes. In these circumstances when a route is cancelled, just the relevant section is cancelled.

If a signal is placed immediately before or after a bridge, a warning message is given on trying to link the track, because bridges can't be used as truncate points so the route can't be truncated to that signal. Bridges can't be used as truncate points because they are potentially ambiguous as they can have two routes on them. An option to ignore the warning is offered and accepted by using a specific key combination.

Note that a train that runs in the wrong direction on any part of a route will cancel the whole of that route and all signals will change to red immediately. Also if a train is introduced by the timetable at a point in the middle of an existing unrestricted or preferred direction route then the route behind the train will be erased and all signals reset to danger. If this happens on an automatic signal route then the route will remain in place but the signals behind the train will be reset because of the presence of the new train. Any of these events may cause following trains to run past red signals (SPADs) and/or to crash into the new train.

Try to avoid creating automatic signal routes where they may need to be cancelled. The above situation gives one reason, but another is when the route runs into a cul-de-sac. RailOS will provide some protection here in that it won't allow an automatic signal route into buffers.

To cancel a preferred direction or unrestricted route directly in front of a train select an element ahead of the train, because any element that the train stands on is automatically cleared from the route.

Trains will run whether or not protected by routes and signals, but without protection derailments and crashes are much more likely. When not in a route points may be changed manually by left clicking them. This is useful for manoeuvring a train under signaller control without having to set a route. Points that are linked directly to other points and together provide a means of moving from one track to a parallel track are changed together when one of them is left clicked. If one of a pair of such linked points is in a route or has a train on it then the other can't be changed manually.

If two or more trains are on the same platform, are not protected, and there is at least one track element separating them, then they may crash when one of them reaches its departure time unless they are facing in opposite directions. However if the two are directly adjacent then this won't happen as a train won't start if there is a train directly in front of it.

6.2 Approach locking

If a route is attempted to be cancelled in front of a moving train (i.e. within three non-red running signals - i.e. not ground signals - of a train that is protected by the route), or is occupied by a moving train, then a warning is given that the route will be locked if cancellation proceeds. In this case all signals on the locked section change immediately to red, but the route remains in place in order to protect the trains (no other conflicting routes may be set while it remains in place). It will remain locked for a period of two minutes to allow all relevant trains to come to a stop. Locked routes are marked with crosses over the locked section. A route that is locked by the signaller incurs a performance penalty in that it makes SPADs (signals passed at danger) more likely. A train approaching or on a route protected only by ground signals will be locked if it is cancelled no matter how many ground signals there are between the train and the cancellation point. This is because ground signals are often located very close together.

If a train is running on an unprotected section of track before reaching a route, then that route may be cancelled immediately because the route is not protecting the train.

Routes that are locked cannot be truncated.

6.3 Session saving and loading

At any stage during operation a 'session' may be saved by left clicking the  'save session' button. Here the current state of the entire railway is saved to file, to be loaded again at a later time. These files have the extension '.ssn' and by default are stored in the 'Sessions' folder, which resides in the working folder which is normally where 'RailOS32/64.exe' - resides. Users can change this folder by navigating to a different location and loading a session file. The selected location will be retained in Config.txt when RailOS closes and will be reloaded when it restarts. A unique name is given to each session file on creation, and indicated in a window. This may be changed later if required using the file name change function of 'Windows Explorer'.

Sessions will load in pre-start mode if saved during pre-start mode (i.e. routes may be set, points changed, and train failure rate set - see section 6.11), or as paused if saved when either operating or paused.

6.4 Running trains

When running, the front reporting number (headcode) character is red, to show that it is the front - obvious when moving of course but not so when stopped. In signaller-control mode (see later) the front is indicated by a blue character, both to show that it is the front and that it is in signaller-control mode.

Train status and timetable information is turned on by default, but this can be hidden by selecting menu items 'Information', Train information' and 'Hide status' and/or 'Hide timetable'. With one or

both of these turned on the information is given in a floating window when the mouse hovers over a train.

Trains have different background colours to indicate the different train states as follows:-

grey = moving (black or white in zoom-out mode depending on the background colour);
pale green = stopped at a timetabled location;
pink = train ready to start from a timetabled location (changes 10 secs before departure);
bright green = stopped by a signal;
red = crashed or derailed;
light cyan = stopped at buffers, no attention needed;
cyan = stopped at buffers unexpectedly;
lavender blue = stopped by a train in front;
magenta = call-on available;
yellow = signal-passed-at-danger (SPAD);
caramel = stopped under signaller control;
orange = train failed.

In zoom-out mode (accessed by left clicking the  button or pressing the 'end' key) any train that requires attention (stopped by a signal, stopped unexpectedly at buffers, SPAD, crashed/derailed, call-on or failed), is shown flashing, with the colour appropriate to the condition.

Icons are also provided on the left hand side of the screen if signaller attention is needed somewhere on the railway, flashing if flashing is selected. These are especially useful for large railways when trains may need attention that are off-screen and can't be seen. Selecting zoom-out will enable the train or trains (which will be flashing) to be located quickly. The icons are as follows:-  shows that a train is held at signals;  shows that a train has arrived unexpectedly at buffers (i.e. it is under timetable control and still has timetable events to complete);  shows that a train may be offered a call-on;  shows that a signal has been passed at danger;  and  show that a derailment or crash have occurred respectively; and  shows that a failure has occurred.

Sometimes events occur that require signaller attention but are not covered by any of the above symbols. Such events include trains prevented from entering or being created by existing trains, locked routes, or on points set to diverge; trains unable to split because the platform is too short or another train is in the way; and trains waiting for another train to join or to be joined by. In these cases warnings are given in red above the railway display area. These warnings scroll up in two columns (ten visible warnings in all) as later warnings are given, but they may be cancelled by right clicking on the warning. Cancellation is appropriate when a warning has been acted upon or does not require action. It will be seen that when the mouse hovers over any of the warnings the clock stops. This is to prevent new warnings scrolling up just as the right click cancel button is pressed, as then the wrong warning might be cancelled.

These warnings are in addition to any that have been set in the timetable (see section 5.5 - 'Timetabled and automatic warnings'). Timetabled warnings are useful for example to indicate when a route will need to be set in the near future, say when a train is approaching a junction at the end of a route controlled by automatic signals.

Except when there are split platforms (see below) trains should approach stop locations by passing along all the relevant named elements rather than by entering obliquely via points and missing out some of the named elements. This is to avoid the train missing the relevant stop point for that platform and thereby failing to stop. Stop points are set assuming straight entry into platforms. However this situation can be handled by using split platforms e.g.  , where a section of track with no adjacent platform lies between two track sections that have platforms belonging to the same location. Trains treat these as two separate platforms. This is useful in the situation mentioned above and shown in the diagram where an adjoining track meets the main track partway along a platform, as it allows trains to stop at each separate platform segment. Approaching trains scheduled to stop at the station will stop at the first platform that they meet.

Empty stock can be created (trains with zero power). In the timetable the Snt starting entry should be immediately followed by 'Fjo' for finish and join other train. e.g.

```
0X00;Empty stock;0;200;60;6;0          )   Zero start speed and zero power
07:00;Snt;40-13 41-13                  )   Start new unpowered vehicle at a named siding
08:30;Fjo;2A50                         )   Finish and join 2A50
```

Empty stock can be picked up by powered trains using the 'jbo - joined by other' command in the timetable. Empty stock that is to be present but not picked up can have 'Frh - finish and remain here' after the starting entry, or be created as a non-timetabled service under signaller control (see section 5.9).

Having zero power also allows trains to enter the railway with an entry speed but no power, but this isn't recommended as the train will coast to a stop or be stopped by a signal and thereafter be unable to move. A train that has zero entry speed and zero power scheduled to enter at a continuation will block the entry for any other train after its entry time. In this case all that can be done and even though it can't be seen on the railway is to take it under signaller control by right clicking its entry point and remove it from the railway.

6.5 Train performance

Trains accelerate and brake according to the characteristics that are set in the timetable and conditions on the track. The power that is quoted represents gross power, but only 80% of that power is available at the wheels because of internal losses. Acceleration always assumes the application of maximum power.

Braking force is the maximum available force available to reduce the speed of the train. It's expressed in the same units as the train mass - metric tonnes - and it establishes the maximum rate of deceleration that is possible. The maximum deceleration rate can be found from the ratio of braking force in tonnes to train mass in tonnes, where a value of 1 (i.e. 100%) equals -1g, where g is the rate of acceleration due to gravity. The maximum brake force allowed by RailOS is the train mass, corresponding to a deceleration rate of -1g where a train travelling at 200km/h would come to rest in 5.7 seconds and travel only 157 metres. It's unlikely that any train would have such a high value, and a value around 10% or 15% is more realistic. A value of 10% gives a stopping time from 200km/h of 57 seconds and distance travelled of 1.57km. The rate would normally be higher for rapid acceleration/deceleration suburban or underground trains and lower for heavy freights.

Braking force expressed in tonnes sometimes causes confusion because tonne is a unit of mass rather than force, but it's a convenient value to use and one tonne force represents the force that earth's gravity exerts on a mass of one tonne. The formula that links the two is given by Braking force = (Mass x Deceleration)/9.81, where Braking force and mass are both expressed in tonnes, deceleration is expressed in metres per second per second, and 9.81 is the gravitational constant also expressed in metres per second per second. This is valid for all terrestrial railways but not for railways elsewhere in the universe!

Normal braking uses up to half the maximum braking effort provided that there is time to respond, and calculations are made when the train reaches the end of each track element. This explains why a train that has reached the element immediately preceding a red signal comes to a complete stop before accelerating again, even if the signal changes from red before the train has stopped. The braking calculation is done by first calculating the maximum speed that the train can have at the end of the next element in front, then looking forward for the distance from that point that is needed to come to a stop using half the maximum braking effort. If no reason to brake is found in that distance then the train accelerates if it can, or stays at the same speed if it can't. If there is a reason to brake then the braking rate is calculated to achieve the necessary stop or speed restriction in the distance needed. Under normal circumstances there should never be a need to brake at more than half the maximum rate, but if signals are reset in front of a train or points are changed that direct the train into a siding then much heavier braking will be needed. The floating window indicates the braking rate that is applied - light braking up to 50% of maximum, heavy braking from 50% to 90% of maximum, and emergency braking above 90%. When emergency braking is used there is a very good chance that the train will fail to stop in the required distance.

When a train enters the railway from outside or is created on the railway, then the starting speed will be as set in the timetable unless there is a reason to reduce it, for example because of adverse signals. This means that a new train should never pass a signal at danger or crash into buffers because of excess starting speed, but it may crash into an existing train if the new train isn't protected and the existing train is in its way.

6.6 Calling-on

A train that is held outside a station or non-station location by a signal, which is red because another train is preventing its entry on the track that the held train is directed towards, may be called-on by the signaller into the location. Under these circumstances the train speed is severely restricted (30km/h max), and the train will stop adjacent to the existing train providing it is not moving towards the called-on train. Call-on availability is indicated by the  'call-on' button, and also by the same symbol on the left hand side of the screen, flashing if flashing is selected. If the signaller wishes to call-on the train then the 'call-on' button is left clicked, then the signal that is holding the approaching train is left clicked. The position lights then illuminate on the signal and unless a route or part-route has already been set an unrestricted route is created into the location and the train enters it.

The following conditions have to be met before a call-on is available:-

a) the approaching train has stopped at a signal but not at a stopping location;

b) if the blocking train is facing the approaching train it is stopped awaiting a join or change of direction, has terminated, or is under signaller control - otherwise it might depart and crash into the called-on train (take the train under signaller control temporarily to meet this condition);
c) at least one location element is free to accept the approaching train;
d) points (if any) are set for a direct route into the location;
e) the approaching train is to stop at the location;
f) there are no more facing signals between the train and the location;
g) the train in front is preventing the stop signal being released for the approaching train;
h) the train in front is not exiting at a continuation;
i) the signal is within 4km of the location;
j) the route into the location does not conflict with any other route; and
k) the train to be called on has power available.

If one or more of these conditions cannot be met and the train has to enter the station then it will have to be taken under signaller control and allowed to pass the red signal. Trains under signaller control will always stop for trains in front, providing they are not moving towards the called-on train. From v1.2.0 an unrestricted route may be set from the stop signal to the platform and this will set all the points appropriately to allow a call-on.

After a train has been called-on and is stopped at the location, it can't depart until the track is clear to the next signal in front.

6.7 Performance logs

During operation a performance log is available by left clicking the  'show performance log' button. This may be hidden again by left clicking the  'hide performance log' button. The log panel may be dragged to any part of or outside the main screen by left clicking the text at the top of the panel and holding down the button while the log is moved. The log shows all significant events such as arrivals, departures, changes of direction etc. For timed events, providing the time is within a minute of the scheduled time, before or after, it is classed as 'on time'. Note that at least 30 seconds must elapse between any two consecutive train events. Therefore if the scheduled departure time is the same as the arrival time, departure will occur either on time (providing the train arrived at least 30 seconds early), or 30 seconds after the arrival time. When the train is within 10 seconds of departure the background will change to pink to indicate that the train is ready to depart, and on departure it will start to accelerate away with a grey background.
The log is saved to a text file along with a performance summary, score and rating when operation stops. This is available for viewing in folder 'Performance logs'.

6.8 Signaller control

Normally trains run to a timetable, but whenever a train is stopped at a signal, by buffers, at a station, or by having failed, the signaller may take control by right clicking on the train and selecting 'take signaller control' from the popup menu. The train then no longer runs to the timetable, which is suspended for the duration of signaller control. It remains under the direction of the signaller until timetable control is restored.

Signaller-control mode is normally used to manoeuvre a train that has become misplaced, perhaps by arriving at an inappropriate platform, by taking a wrong route, after a SPAD, or to remove it after a derailment or crash. Failed trains can also be taken under signaller control to allow them to

be repaired or to join a rescue train (see section 6.11). Trains may also be created under signaller control (see section 5.9), in which case they remain under signaller control at all times. This mode is useful for rescue trains and sometimes appropriate for tram or light rail services.

All signaller commands are issued via a popup menu by right clicking on the train, and the options that are available vary according to circumstances. 'Change direction' is not available when any part of a train is on a continuation, or the element in front of a train is a continuation, because the train has then reached the point where its only course is to remain stationary or leave. 'Stop' is similarly not available if a train is on or close to a continuation, and if a train is stopping on a signaller command and it reaches a continuation then it will continue to exit - the command will effectively have been given too late. The reason for these restrictions is that RailOS needs to distinguish between trains entering and trains leaving at continuations, and a stopped train that is leaving can be confused with a train that should enter. 'Restore timetable control' availability depends on the circumstances when signaller control was taken. If the train was at a timetabled stop, then the train must be returned to and stopped at that location (though not necessarily at the same platform) before the timetable can be restored. If the train wasn't at a timetabled stop then the timetable may be restored whenever the train is stopped.

Note that when a stop command has been given the train only acts on it at the end of the next full element, which is when train speeds and times are calculated for the next element. If movement by a single track element is required then select 'Step forward one element'. Note that if this is selected and there is a red signal in front then the signal element will be entered and the signal will no longer hold the train. If the train is stopping under signaller control the popup menu is not available until it has stopped.

When under signaller control the maximum running speed is 30km/h by default (for safety reasons since the train is often not protected by a route in these circumstances). This speed may be changed if required by an appropriate timetable entry (see section 5), but it can't be changed during operation.

A train under signaller control will obey signals, stop at buffers, and also stop for trains in front that are either stationary or moving away from it (trains under timetable control only stop - without crashing - for trains in front when entering a timetabled location). Signaller-controlled trains will crash into closed or changing level crossings, so these should be opened either manually or by setting a route across them at least 30 seconds before the train reaches them. Also they won't stop at timetabled locations because the timetable has been suspended.

When a train under signaller control (or after a call-on) has stopped because of a train in front, it won't move (unless instructed to by the signaller and the train is not immediately in front) until the train in front has passed the next forward signal, or points direct it away from the train in front .

6.9 Adjusting the timetable clock

During operation, but only when paused and not zoomed-out, clicking the  'adjust timetable clock' button brings up the adjustment screen. This disables all other functions and allows the clock speed to be slowed down or speeded up, from a slowest speed of one sixteenth normal (useful for very big railways), to a fastest of sixteen times normal (useful when there are periods with little happening). Train speeds always change in accordance with timetable clock speeds, but route setting, level crossing barrier delays and point setting only change for faster speeds, for

slower speeds they remain the same as for normal speed. This is to avoid very long waiting times for routes and points to set and barriers to change. The clock can also be incremented by any amount by clicking the appropriate buttons as many times as is required. When the clock is incremented only the clock is affected, train positions stay the same. However if train movements were required during the time that has been skipped then they will run late.

6.10 Actions due

During operation a list of trains with required operator action times is available by clicking the 'show actions due' button. It can be removed by clicking the 'hide' button.

The list is updated approximately every two seconds and contains a maximum of twenty trains. Headcodes are shown in ascending order of time to act in order to avoid delays, based normally on the time to reach a red signal. The time given should be regarded as a guide only, as it is estimated from available information which is likely to change. Accuracy improves as the time shortens, so trains with short times to act are those that require early attention. This feature is particularly helpful for railways that spread over several screens when many trains are out of sight. Left clicking any listed headcode hovers the mouse over the train in question, with train information displayed provided that train information has not been deselected via the Information menu. If the train is already visible on screen then the viewpoint isn't changed, but if it isn't then the viewpoint is changed so that the train is centred on the screen. Make sure that the panel itself isn't located over the screen centre, or trains will be hidden by it. The panel can be moved to any position on or outside the main screen by left clicking on the 'Actions Due' text at the top of the panel, holding down the mouse key and dragging it to where it is needed, and information about a train in the list is obtained by right clicking the listed headcode, again provided that train information is selected.

The time displayed represents timetable time, not real time, so a time to act of say thirty minutes with a railway operating at 16x speed represents a real time of less than two minutes.

The list includes running trains, failed trains and trains due to enter at continuations. Trains scheduled to start other than at a continuation are only taken into account when they appear. No advance warning times are given for impending crashes, derailments or unexpected buffer stops, as in real operation, though when these things happen the time to act will be shown as 'NOW'. A '+' symbol next to a headcode means that the train is subject to a random delay (see section 6.13).

Times are normally estimated based on the time taken for a train to reach the next red signal, unless the train is on an automatic signal route, when the time taken to reach the final red signal in the route is estimated. A train stopped at an automatic signal doesn't require operator action, though the train in front that is stopping it might well do, and if so that one will be listed. Scheduled stops before the next red signal are incorporated in the estimated time, with dwell times at each stop added taking account of early or late running. Trains running under signaller control don't have scheduled stops while under such control, so the estimated time excludes any timetabled stops before the red signal.

Trains are excluded from the list if their action time is 60 minutes or more, if there are trains in front before the next red signal, or if their next scheduled event is anything other than an arrival, departure or pass. These latter conditions can result in trains appearing in the list with short action times, for example:-

If a train is standing at a red signal after entering at a continuation and preventing another's entry, the waiting train will appear as soon as the offending train has its signal cleared, which will leave the new train with a very short time to reach the signal.

If a train is due to finish and start a new service at a location, the new service may be facing a red starter signal and due to depart soon after it is created, giving a short action time.

Similarly for a train that changes direction at a location, the action time will only appear after the change of direction.

Note that it is sometimes good practice to hold a train at a red signal, especially if it is running early, if setting a route for it would cause another train to be delayed. In such cases the 'NOW' indication in the list should be ignored until the other train has cleared its route ahead of the held train.

6.11 Train failures

RailOS includes the ability to allow random train failures. The failure rate is set during pre-start mode, i.e. after 'Operate' is selected from the 'Mode' menu but before the 'Run' button is clicked. The setting is in the box at the top right hand side of the screen and defines the mean (average) time between train failures (MTBF) in hours where 0 is the minimum and 9,999 the maximum. If the box is left blank or the value is 0 there will be no train failures. The MTBF value must be a whole number, fractions aren't allowed. The value applies for all trains individually, so a setting of 1 hour between failures for a railway with 10 operating trains means that on average there will be a train failure every 6 minutes. It is important to recognise that the MTBF value represents an average length of time, it does not indicate when a failure will occur - failures occur randomly. The lower the MTBF value (provided that it isn't zero) the more frequently trains will fail. Another important point is that the MTBF value is in terms of timetable clock time. Therefore an MTBF of 1 hour on a railway running at 16x speed means that on average each train will fail just less than once every 4 minutes in real time, because 60/16 = 3minutes 45 seconds.

A session that is saved with an MTBF setting will load with the same setting, and can't be changed unless operation is stopped and 'Operate' selected to re-enter pre-start mode.

Trains that can't fail:

those without power - i.e. empty stock;
those that are on a continuation (entering or leaving the railway);
those that have terminated;
those that have crashed or derailed;
those that are stopped and under signaller control; and
those that have already failed.

If you are mathematically minded and want to calculate a suitable MTBF value, first decide how many failures (on average) you want to occur during a typical operating session, call that number A. Then decide how long (in timetable hours) a typical session should last, call that number B. Then make an estimate of the average number of trains present on the railway at any time that can fail, and call that number C. The required failure rate is B x C/A. For example, a session lasting 4

timetable hours with an average of 6 trains present that can fail will produce one failure (on average) during the session with a MTBF value of 4 x 6 = 24 hours. Therefore if you want to see 3 failures on average in each such session the value should be divided by 3, giving a final value of 8 for the MTBF. If you aren't mathematically minded or it sounds too complicated then just experiment with different MTBF values and see what happens.

All failures are of onboard power, so a train that fails when moving will coast to a stop, to allow it to move clear of junctions if required. Alternatively it can be taken under signaller control and ordered to stop, when the brakes will be applied. While coasting a train will still obey all signals, speed restrictions and location stops provided that its braking capacity allows it to do so. After a failed train has stopped it can no longer comply with the timetable.

There are two ways to deal with a failed train. When stopped and taken under signaller control it can be repaired, and power will be restored to its original value. It can then be returned to timetable control to continue running to its timetable. The other way is to bring out a standby train to join it under signaller control. When the standby train is adjacent to the failed train they can join, provided that both trains are under signaller control. Either train can be selected as the train to be joined by the other, but if it is intended that the failed train should continue running to its timetable then that train must be joined by the standby train. When joining the masses of the two trains are added and the joint power is the power of the standby train. Standby trains kept in reserve to recover failed trains should therefore have a high power to mass ratio or the joint train will be underpowered. After joining in this way the train can be returned to timetable control to continue running to its normal timetable, although it will probably run late. If the failed train is to be towed away to a depot or to exit the railway then the standby train can be selected as the train to be joined by the failed train.

Unless you intend to repair all failed trains it is recommended to keep a number of standby trains at various points on the railway ready to rescue failures. These trains should be created as non-timetabled services so they are always under signaller control (see section 5.9). Standby trains stopped under signaller control won't fail, but they may do so when running.

A failed train is shown with an orange background, and flashes in zoom-out mode for easy identification. Also the icon  is shown at the left hand side of the screen, flashing if flashing is selected, to show that one or more trains have failed.

6.12 Skipping timetabled events & becoming a follow-on service early

When trains suffer delays it is often useful to be able to skip stops and other timetabled events in order to make up time and re-establish a normal schedule, especially when other services depend on connections. This is normal practice on real railways.

This can be done in the simulation in one of two ways: (a) skipping events within a service; and (b) terminating a service and becoming the follow-on service at a location prior to that in the timetable.

(a) Skipping events within a service. When operating (not paused) and a train is stopped at a signal or a location and is under timetable control, right click it to show the popup menu and select 'Skip timetabled event(s)'. This gives a list of events from that point onwards, similar to timetable

information in the floating window. Left-clicking an event selects that event as the next, i.e. the selected event itself isn't skipped. There have to be restrictions on events that can be selected related to where the train is at the time and where the selected event takes place.

1. Trains stopped at a signal:
   Only arrivals, passes or exit railway events can be selected since all others take place at locations and the train hasn't yet arrived at a location.

2. Trains stopped at a location:
   i) any event up to and including the departure from that location can be selected, when all events before the selection are skipped;
   ii) any event after the departure that is an arrival, pass or exit railway can be selected, when all events after the departure but before the selection are skipped.

With this option it isn't possible to skip the finish event, so if a train is required to terminate early and become the follow-on service option (b) must be selected.

(b) Terminating a service early and becoming the follow-on service at a location prior to that in the timetable. Several conditions need to be met for this option to be available:

The train must be operating under timetable (not signaller) control;
It must be stopped at a location and have power available;
The final event in the timetable must be to form a new service;
The new service must either stop at or pass the current location; and
No events have been skipped after the normal departure time.

In most cases these conditions are easily met.

To select this option right click the stopped train and click 'Terminate here and become follow-on service xxxx' where 'xxxx' is the service reference for the next service. A warning message is given pointing out that timetabled events will be skipped and offering the option to proceed or not. Clicking 'Yes' immediately changes the service to the follow-on service, and the train will be facing the opposite direction. This is normally what is required but if the direction change isn't wanted then it can be changed under signaller control in the normal way.

If a train has a minimum dwell time (MDT - see arrival information in section 5.2.1) set for arrival at the location where later timetabled events are to be skipped, then it will remain at that location for at least that MDT. If it is to become a follow-on service early and the follow-on service has an MDT set for arrival at the location, then that MDT will be ignored because the follow-on service arrival has been skipped.

6.13 Random delays, point and signal failures, and temporary speed restrictions

Delays occur regularly on real railways and can also occur in RailOS if selected. The most frequent are delays at stations and other locations from a wide variety of causes. Points and signals can also fail, and temporary speed restrictions (TSRs) are often imposed for engineering work, trespassers, animals on the track and so on.

Four options are offered each for delays and failures: none (the default setting), minor, moderate and major, selectable at any time during operation by a menu tab. Delays at locations are at frequencies that vary inversely with duration, such that short delays are common and longer delays less common. Point failures can occur any time they change state, either by route setting or manually, and signal failures can occur any time they change aspect. Temporary speed restrictions occur randomly at any time. In all cases the delay, failure and TSR frequencies increase with increasing selection from minor to major (see 'Delay and failure data' below). For most railways a reasonable balance of delays and failures will be found with the same setting for each - i.e minor delays with minor failures and the same for moderate and major. However flexibility is provided with different settings where it is thought to be more appropriate for particular railways.

Failures and TSRs are indicated by a black (white background) or white (dark background) rounded square around the failed element.

If a point failure occurs during route setting the route won't be set. If an already failed point is encountered when route setting and the route is in the 'set' direction then the route passes through the point. If it's in the 'non-set' direction then the search routine will try to find an alternative route, otherwise the route will fail. Trains can run on failed points in the direction that's set but with a speed restriction of 10km/h. Failed points can't be changed manually. When a point has failed an estimate of the repair time is shown in the track information window.

Signals can fail when they change aspect when route setting or when a train passes them under timetable control. If a signal failure occurs during route setting the route won't be set. Existing failed signals don't affect route setting, but trains must stop as for a red signal. Failed signals can only be passed under signaller control, when it is recommended to select 'Step forward one element', after which timetable control can be restored. Signal repair time estimates are shown as for points.

TSRs occur at random times. They don't affect route setting but impose a speed limit of 10km/h. TSR removal time estimates are shown as for failure repair times.

When a failure or TSR occurs a message is given and the performance file, on-screen log and warning panel record the event. Similarly when a failure is repaired or a TSR lifted a message is given and the performance file, on-screen log and warning panel are updated accordingly.

The delay and failure selections in place when a session is saved are recorded in the file and reinstated when the session is reloaded.

Delay and failure data:

	Minor	Moderate	Major	
Points	1000	400	200	direction change events per failure
Signals	2000	1000	500	aspect changes per failure
TSRs	200	100	50	days between restrictions per plain track element
Delays	1 - 11	1 - 24	1 - 49	minutes (the longer the delay the less frequently it occurs)

6.14 **Setting reminders**

Reminders can be set for future timetabled events to alert the user to something that needs to be done when that event is reached. Examples are when a train is running late and it is intended to skip some stops when the train reaches a certain location or to become a new service early; to hold a train at a location longer than normal because another train is running late but takes priority and will need to cross its path; when a train is being routed into a wrong platform and will require signaller control to reposition it when it arrives; and so on.

A reminder is similar in its effects to a warning (see section 5.5). Warnings are set during timetable editing whereas reminders are set during operation. Right click a train that is running under timetable control then left click 'Set reminder'. A list of future events for that train is listed and when one is left clicked a confirmatory message is given in case the wrong one has been selected, and when accepted the reminder is set. Once set a reminder can't be removed, if it isn't wanted then just ignore it. When it triggers it appears in the warning log at the top of the display area and is accompanied by three short beeps if sound is turned on. It is also listed in the performance log. Reminders don't repeat for repeating services, they relate only to the train for which they are set. This differs from warnings, where each repeat repeats the warning(s). Reminders can't be set where there is already a warning in place for a selected event because there is no need to do so, the notification will be given for the warning just as it would for a reminder. If this is attempted a message will be given to inform the user.

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7 Keyboard shortcut keys		
Menus	Accelerator keys can also be used - hold down 'Alt' and press the required underlined key	
File menu		
Ctrl+ A	Save railway as	
Ctrl+ I	Load TT	
Ctrl+ L	Load railway	
Ctrl+ N	Load session	
Ctrl+ S	Save railway	
Shift+ Del	Clear all	
Alt+ F4	Exit	
Mode menu		
Ctrl+ B	Build mode	
Ctrl+ O	Operate mode	
Ctrl+ P	Set preferred directions	
Ctrl+ T	Edit timetable	
Ctrl+ Alt+ T	Create timetable	
Edit menu		
Ctrl+ E	Select	
Ctrl+ R	Reselect	
Ctrl+ Del	Delete selection	
Shift+ Esc	Cancel selection	
Ctrl+ C	Copy	
Ctrl+ X	Cut	
Ctrl+ V	Paste	
Information menu		
Shift+ Ctrl+ I	Track information toggle	
Shift+ Ctrl+ S	Train status toggle	
Shift+ Ctrl+ T	Train timetable toggle	
Shift+ Ctrl+ L	Long service reference toggle	
Help menu		
F1	On-screen help	
Position buttons		
Home key	Home position	
Shift+ H	New home	
End key	Toggle zoom	
Up arrow	Move viewpoint up	} Holding down the Ctrl key when pressing these
Down arrow	Move viewpoint down	} keys moves the viewpoint by a much smaller amount,

Right arrow	Move viewpoint right	} and holding the Shift key moves it by a much larger
Left arrow	Move viewpoint left	} amount.
Track build panel		
Shift+ A	Add/remove track	
Shift+ D	Set lengths/speeds	
Shift+ F	Change font	
Shift+ G	Toggle grid	
Shift+ I	Insert image	
Shift+ J	Join gaps	
Shift+ L	Link track	
Shift+ M	Move text or graphics	
Shift+ N	Name locations	
Shift+ S	Cycle signal types	
Shift+ T	Add text	
Esc	Exit track build mode	
Ctrl+ S	Save railway	
Operating panel		
r	Run	
p	Pause	
a	Set automatic signals	
l	Toggle performance log	
d	Toggle actions due	
1	Automatic signal (blue) route, signal or continuation to next signal or continuation	
2	Preferred direction (green) route, signal, buffer or continuation to next signal, buffer or continuation	
3	Unrestricted route	
4	Automatic signal (blue) route, signal or continuation to any following signal or continuation	
5	Preferred direction (green) route, signal, buffer or continuation to any following signal, buffer or continuation	
t	Timetable clock adjust	
c	Cancel route	
o	Call on	
Esc	Exit operation mode	
Ctrl+ S	Save session	
Clock adjust panel		
Shift+ A	Apply changes	
Shift+ R	Reset values	
Preferred direction panel		
Shift+ A	Add preferred direction	
Shift+ D	Delete one preferred direction	
Shift+ C	Delete all preferred directions	
Esc	Exit preferred direction mode	

Ctrl+ S	Save railway	
Timetable panel		
Shift+ S	Show timetable edit panel	
Shift+ H	Hide timetable edit panel	
Shift+ L	Previous	
Shift+ N	Next	
Shift+ C	Copy entry	} note that these keys and buttons can't be used in conjunction
Shift+ X	Cut entry	} with Ctrl+ C etc for entries listed below - for example a copy
Shift+ P	Paste entry	} using Shift+ C won't paste with Ctrl+ V
Shift+ E	Delete entry	
Shift+ J	Invert entry	
Shift+ U	Move up	
Shift+ D	Move down	
Shift+ I	Insert new entry	
Shift+ Z	Toggle AZ order	
Shift+ F	Conflict Analysis	
Shift+ Q	Syntax check	
Shift+ V	Validate	
Shift+ T	Save timetable	
Shift+ A	Save timetable as	
Shift+ R	Reload timetable	
Shift+ O	Export timetable	
Esc	Exit timetable mode	
Ctrl+ C	Copy (when editing an entry)	copy selected text
Ctrl+ X	Cut (")	cut selected text
Ctrl+ V	Paste (")	paste selected text
Ctrl+ Z	Undo (")	undo last action
	Save entry, Cancel, AddMins	} can't use shortcut keys here as the relevant panel has focus and
	& SubMins	} a shortcut key will be treated as trying to enter text

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