

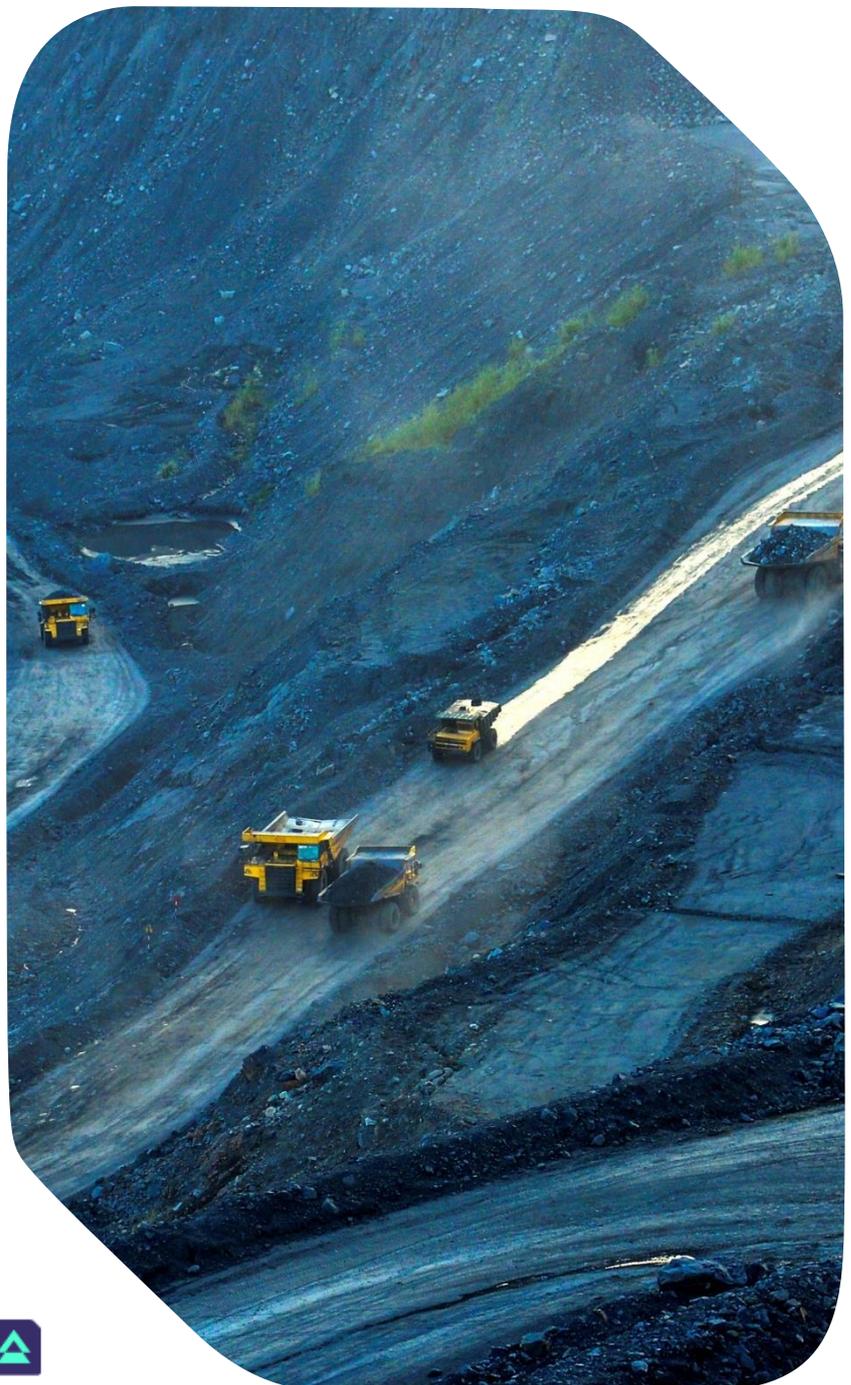


**micromine**  
alastri

# Introduction to **Micromine** **Alastri Haul Infinity**

Training Booklet

Version 01 November 2021



# Introduction

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Haul Infinity software is used to calculate mine site haulage for operational improvement, scheduling, feasibility studies and cost estimation. Its reporting functions include travel times, cycle times, elevation profiles, velocity profiles, engine load and fuel load.

Haul Infinity can be interfaced with scheduling systems to understand haulage requirements over the life of project or used at the daily level to optimise truck assignments. Haul Infinity spans all levels of the planning chain, providing a platform for discussion and informed decision making regardless of background.

## Terminology

Design Window	The main 3D design area in the Network tab
Viewport	Any 3D visualisation area
Tab	Tabbed working area
Panel	Interactive frame within a tab
Dialog	A new window that opens to enter information
Dropdown	A dropdown box that lets you choose from a list
Icon / Button	A button that can be pressed
Checkbox	A box that can be ticked on or off

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# Prerequisites

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To complete the workshops in this series you will require:

1. A valid 20-digit license key.
2. A personal login to <https://www.alastri.com/>.
3. Haul Infinity installed on your computer.

## Download sample data set

1. Go to [alastri.com.au](http://alastri.com.au) and login using your credentials.
2. Download the sample data set for Haul Infinity.
3. Extract the archive to a working folder.
4. The following exercises refer to this as the "sample data folder".

## Download from truck list

1. Go to <https://licensing.alastri.com.au/trucks> and login using your credentials.
2. Type "CAT 777E" in the search bar, without the quotes.
3. Click the download icon to save the specification file to your computer.
4. Navigate to your downloads folder.
5. Move the file "CAT777E Dual Slope.opentruck" to your working directory.

# System Requirements

The following information outlines the recommended system requirements to run the Alastri suite of products. As the hardware required depends on the complexity of the mine and the amount of data, meaningful minimum requirements cannot always be listed. Ultimately the only way to know whether specific hardware will work for a specific mine site is to validate the software's performance during the free trial period.

- For large multi-pit mines with raw LIDAR surfaces and block models with 80M blocks the requirements will be at the extreme end.
- The minimum requirements will only support small mines with a small block model and surfaces with low triangle counts. Running Alastri Haul Infinity on minimum system requirements may slow the application response, depending on the size of the model. Use recommended requirements for optimal use.
- Please note that as our software develops over time, these requirements may change, and hardware upgrades may become necessary.

Component	Minimum	Standard	Extreme
Processor	Intel i5	Intel i7	Intel i9
Memory (RAM)	8 GB	64 GB	128 GB
Operating System	Windows 10 x64	Windows 10 x64	Windows 10 x64
Video Memory (GRAM)	2 GB	8 GB	12 GB
Monitor	1920 x 1080	Dual 1920 x 1080	Triple 1920 x 1080
Video Connection	HDMI, DisplayPort, DVI, VGA - <i>USB not supported</i>		
Video Driver	Driver no more than 6 months old (OpenGL 4.6+)		
Hard Drive	Solid State Drive with at least 50 GB Free		

Power Connection	AC Power - <i>Battery power not supported (plug in the laptop)</i>
Network Connection	Consistent, reliable, high speed (>1 MB/s) connection to the Internet .NET 4.7.2
Software Prerequisites	Microsoft Visual Studio 2019 C++ Redistributables ( <a href="https://aka.ms/vs/16/release/vc_redist.x64.exe">https://aka.ms/vs/16/release/vc_redist.x64.exe</a> )  Microsoft Excel
Input Devices	Keyboard and Mouse with a left mouse button, right mouse button, and middle mouse button/scroll wheel

Many IT departments block downloads of Microsoft prerequisites, so you may need to download them manually. The installation error "Element Not Found" indicates that you must download and install these manually.

- Microsoft .NET Framework 4.5.1.
- Microsoft VSTO Runtime for Office 2010.

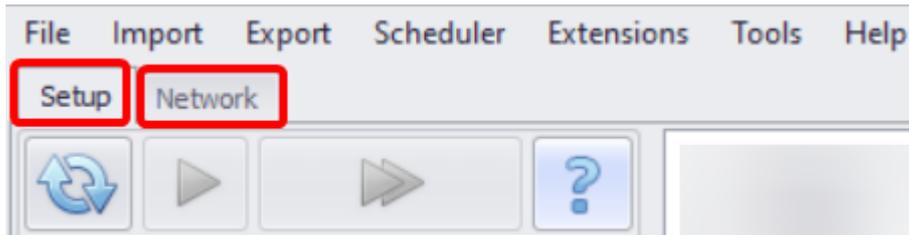
# First Principles

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Alastri Haul Infinity (HI) is a point-to-point 3D Haulage analysis tool designed to produce reliable and robust cycle time calculations for load and haul mining operations. It creates a digital haulage twin for your mine, which mimics the mine site travel times and fuel burn of trucks on site.

It can calculate reliable cycle times, allowing the calculation of truck and fuel requirements so haulage operating, and capital costs can be accurately determined.

This information is collected in two tabs – the **Setup** tab and the **Network** tab.



<b>Setup tab</b>	Contains a series of steps that must be completed to create a valid project. To proceed to the next steps and run your model you'll be prompted to complete every step of this tab.
<b>Network</b>	Import and edit the haul network that the trucks will be running on.

This document provides only a brief description of all the steps and tools for working with your haulage network. For a full and detailed description, see Haul Infinity Documentation section of the main documentation portal.

The exercises in this chapter are for familiarisation purposes and are deliberately light on detail. More in-depth discussion follows in the next section.

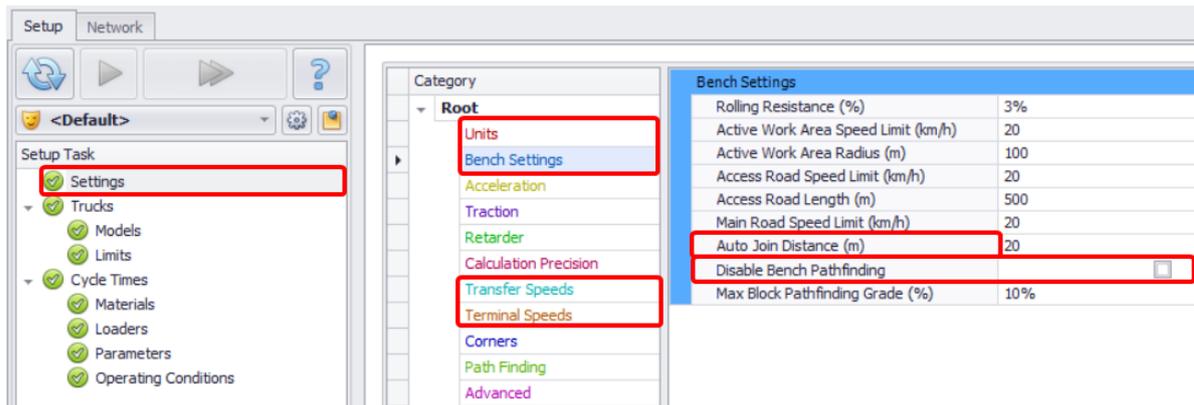
Unless otherwise noted, each exercise follows from the preceding exercise.

# Setup tab

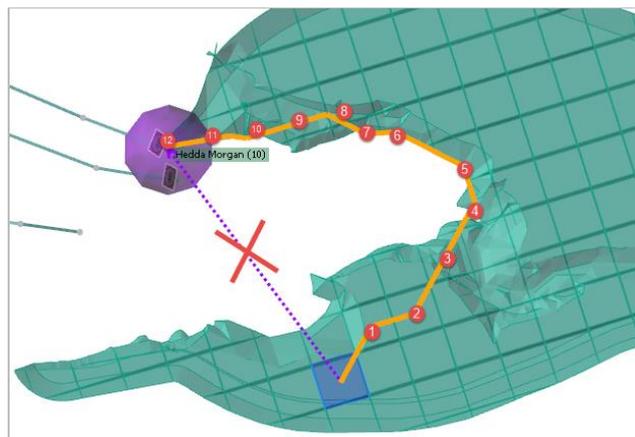
The Setup tab contains a series of steps that must be completed to create a valid project. To proceed to the next step and run your model you'll be prompted to complete every step of this tab.

## Settings step

The first step in creating a project is to review the project settings and set units of measurements, options, and thresholds for subsequent reference.



1. **Units** – select the units of measurement which match your site coordinate system and local standards. Use the **Quick Set** dropdown to select Metric or Imperial units of measurement.
2. **Bench Setting** - set speed limits on the bench. When not travelling on designed haul routes.
  - a. **Auto Join Distance** is the Radius from the block to a route onto the network. Keep this reasonable 100-200m. If this is made too big (~1,000m) trucks may be seen to fly through the air/walls to access the network.
  - b. Do not disable **Bench Pathfinding**. This is how a truck works out how to drive on the bench to arrive at a designed haul route. If Bench Pathfinding is Disabled, trucks will fly across a void.



3. **Transfer Speed** - the defaults speed when a new project is created is 0, causing trucks to stop when exiting/entering ramps. Always set this to the Ramp speed (in this demo project = 25 km/h).
4. **Terminal Speeds** - should always be set to 0. Trucks are stopped when being loaded or unloading.

## Trucks Models

Haul Infinity evaluates and compares as many truck types as you choose to import. If you are querying from a scheduling package, the truck names must match the names in the scheduler. Your customised trucks can be imported and exported in the “. opentruck” file format.

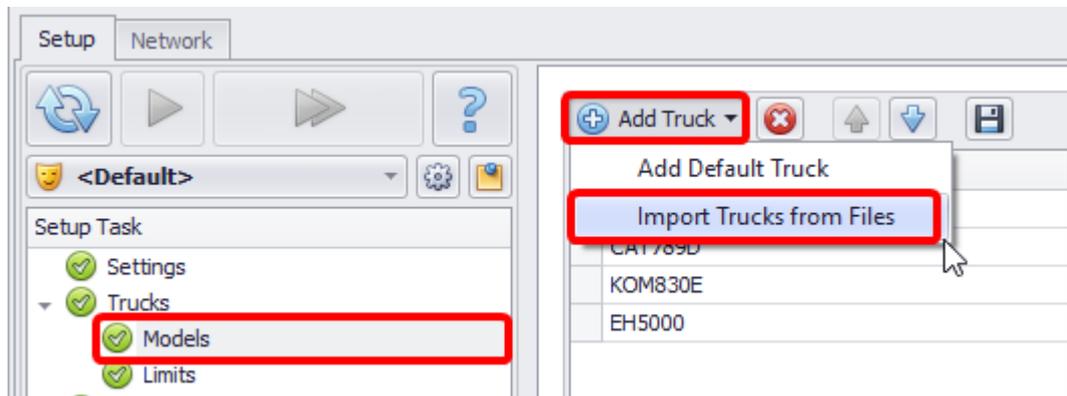
To download a truck:

- Navigate to the Alastri truck library and download:

- Caterpillar 789D
- Caterpillar 777E
- Komatsu 830E
- Hitachi EH3500

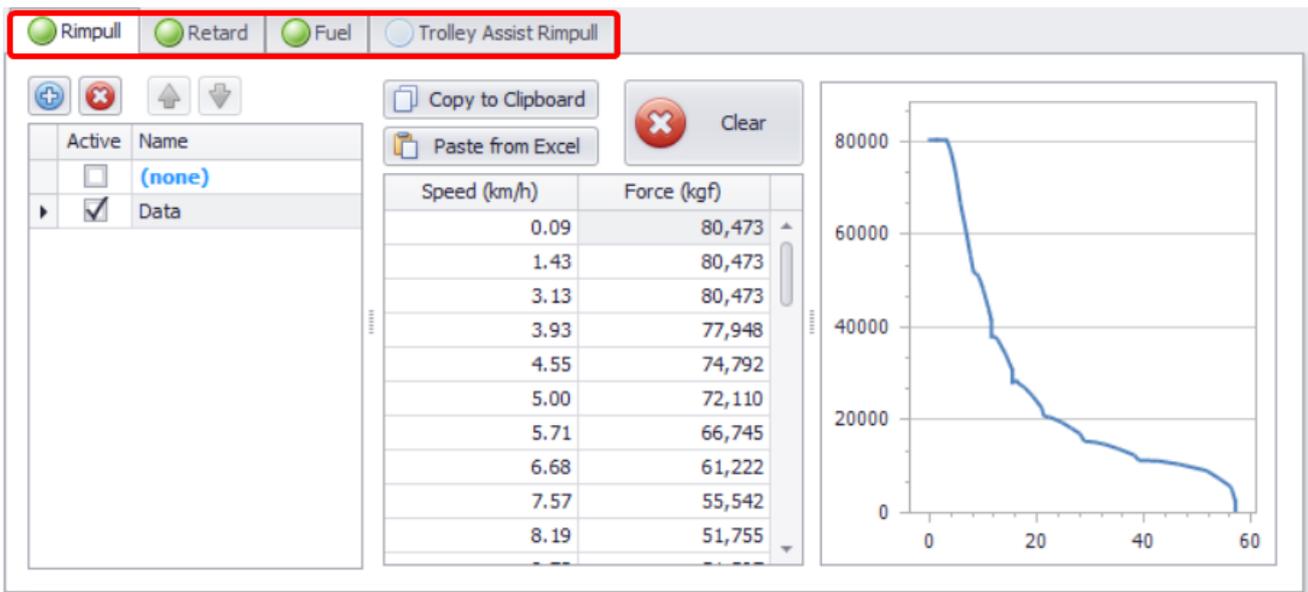
To import a truck:

From the **Add Truck** button dropdown select “Import Trucks from Files” option and import the trucks from your downloads folder.



- Alastri creates these files from Manufacturer Specification data.
  - Komatsu do not supply us with Fuel data.
  - These are the truck specification weights. If site have changed or replaced the tray, these weights can be edited.
  - These values are the truck specification data. If the site haulage engineers have data collected from site, these values can be copied to Excel, edited, and pasted back here.
- ✓ The truck name and details will populate the panels.

Each truck is defined by its axle weights, rimpull, retard, fuel and trolley assist curves (if applicable).



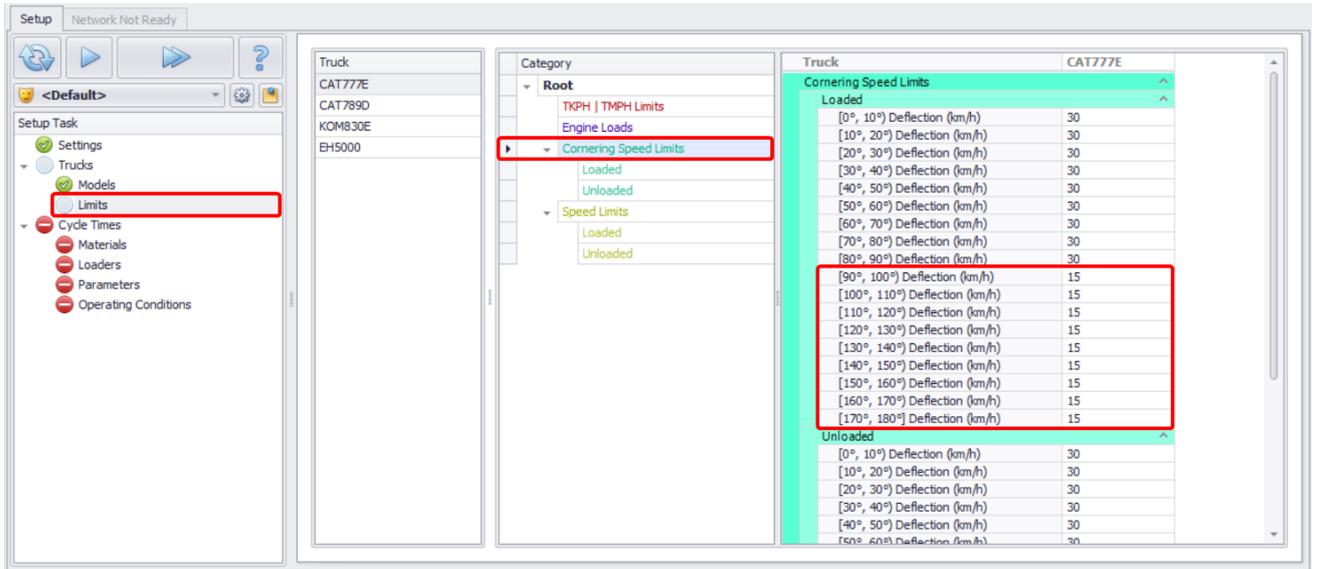
These parameters will be used to calculate the truck acceleration, stopping distance, fuel rates, TKPH delays, and speed limits on ramps and corners.

1. Axle data is used to calculate road friction forces and TKPH on tires during travel. It shows the full and empty weight over each axle, the number of tyres on that axle, and whether it is driven.
2. The available curves are Rimpull, Retard, Fuel and Trolley Assist Rimpull.
  - a. **Rimpull** is the amount of tractive force that the engine delivers to the ground through torque on the drive wheels. Rimpull curves show the propulsion force in kilograms (kgF) against truck velocity (km/h). For mechanical trucks, the rimpull curve shows a characteristic series of humps as the transmission steps down through different gear ratios. Electric trucks typically show a smoother rimpull profile.
  - b. Haul Infinity uses **Retard** curves to calculate the maximum safe braking force without overheating the brakes. They show the braking force that the truck should be using at a particular velocity. Braking curves are not used to calculate stopping distances. The deceleration properties are set in *Setup > Settings > Acceleration*.
  - c. **Fuel** curves show the fuel consumption in liters per hour at different engine loads. Haul Infinity uses this to calculate total fuel burned on each haul cycle.
  - d. **Trolley Assist** provides an (optional) secondary rimpull curve, which is used when trucks cross traverse a Trolley Assisted segment. Segments have a trolley property. When toggled on, the truck switches to the trolley rimpull curve while traversing the segment.

Calibrate this graph with data from the Fleet Management System.

# Trucks Limits

Truck limits define how a truck interacts with the road network under different conditions.



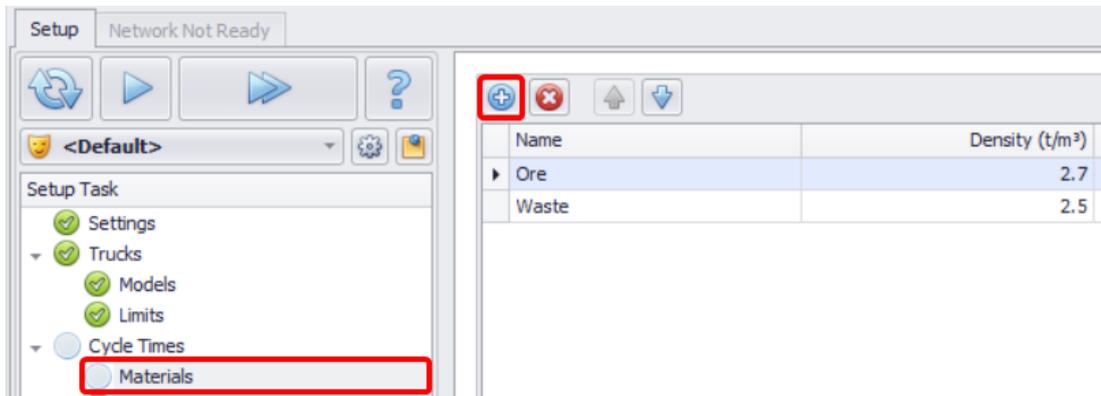
1. **TKPH Limits** - Haul Infinity automatically adds TKPH delays to cycle times, to keep tires below the TKPH limit. TKPH limits can be found in the tire manufacturer's handbook. For this tutorial, leave the TKPH limits at default values.
2. **Engine Loads** - Optionally update engine loads for more accurate fuel burn predictions. For this tutorial, leave engine loads at default values.
3. **Cornering Limits** - For angles of deflection greater than 90 degrees (a right angle turn), reduce the cornering speed to 15 km/hr.
4. **Speed limits** - Haul Infinity automatically assigns speed limits to loaded/unloaded trucks based on the inputs in this table. For Loaded and Unloaded trucks, where the gradient is greater than 7%, set a speed limit = 20.

Haul Infinity will always choose the lowest speed between the default and road signage

## Cycle Times > Materials

The Cycle Times steps hold constants which are specific to a given haul, such as excavator loading time, operating condition, materials, and payload.

1. Press blue plus button and add "Ore" with a density of 2.7 t/m<sup>3</sup>,
2. Press blue plus button and add "Waste" with a density of 2.5 t/m<sup>3</sup>.



Enter the absolute minimum number of materials required to accurately model haulage.

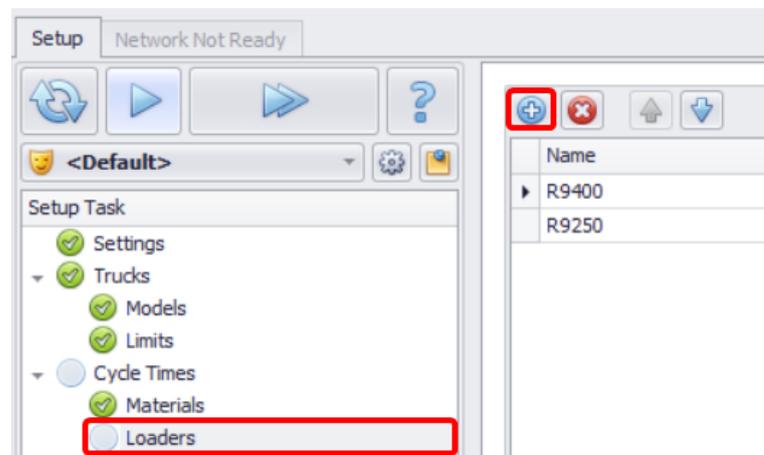
- If two materials have different truck payloads, split them.
- If two materials have different load times, split them.

Haul Infinity makes all calculations in wet tonnes (dry tonnes + moisture) by default. It uses the **Moisture** and **Swell** fields to convert between wet tonnes, dry tonnes, and volume for productivity reporting.

## Cycle Times > Loaders

Loader types define the dig rates for cycle time and trucking calculations.

1. Press blue plus button and add New Loader, rename it to "R9400",
2. Press blue plus button and add New Loader, rename it to "R9250".



## Cycle Times > Parameters

The parameters table holds cycle time inputs for every combination of loader, truck, and material.

- Fields with normal **black** text are editable - you can change values in these rows.
- Fields with grey text are calculated – values in these rows vary depending on populated inputs.

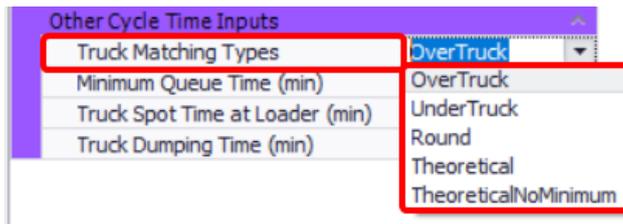
1. **Calculations** - The sections **Loader Payload Calculation**, **Truck Payload Calculation**, **Loading Calculation** are used to calculate cycle times from first principles.

Loader Payload Calculation	
Bucket Payload (t)	20
Bucket Heaped Capacity (m³)	8
Limitation	Volume
Maximum Bucket Payload (t)	19.4
Truck Payload Calculation	
Tray Payload (t)	100
Tray Heaped Capacity (m³)	40
Limitation	Volume
Maximum Tray Payload (t)	92.9
Loading Calculation	
Nominal Number of Passes	4.8
Truck Filling Type	FullTrucks
Number of Passes	5
Utilized Truck Payload (t)	92.9
Loader Cycle Time (s)	30
Loader First Pass Delay (s)	20
Loader Load Time (min)	2.83
Truck Load Time (min)	2.00

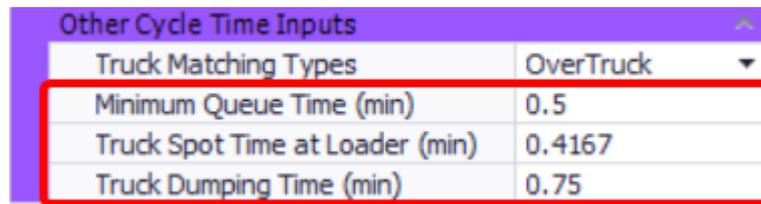
2. The section **Overrides** is used to calculate productivities from historical inputs.
  - a. Haul Infinity distinguishes between “Truck Load Time” and “Loader Load Time”. Loader Load Time = Truck Load Time + Truck Spot Time. This distinction is important to ensuring that loader productivity calculations accurately catch the delays between each load, as well as the loading time itself.

Overrides	
Loader Load Time (min)	0
Truck Load Time (min)	0
Truck Utilized Payload (t)	0

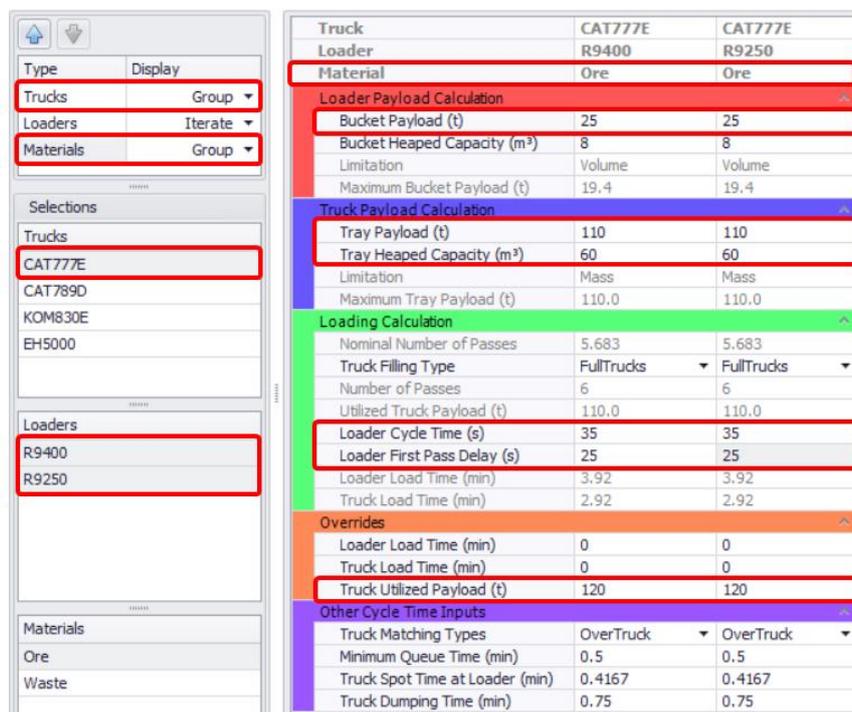
3. **Truck Matching Types:**
  - a. “OverTruck” - no digger wait time, some truck queue time.
  - b. “UnderTruck” - no truck wait time, some loader hang time.
  - c. “Round” - some truck queue time, some loader hang time (round the truck numbers to the nearest whole number).
  - d. “Theoretical” - zero queue or hang time (uses the theoretical number of trucks without rounding, allowing the fleet to have “half a truck” (a decimal number of trucks).
  - e. “TheoreticalNoMinimum” - same as theoretical matching type, but not including minimum waiting time.



4. **Minimum Queue Time:**
  - a. Minimum Queue Time = 0. This removes queue time from the Haul Infinity cycle times.
5. **Truck Spot Time at Loader** – enter the truck spotting time for each loader type.
6. **Truck Dumping Time** – if the historical truck dumping time includes the dump spot time, be sure to zero the “SpotAtDumpSeconds” property in Crucher/Stockpiles nodes on the network.



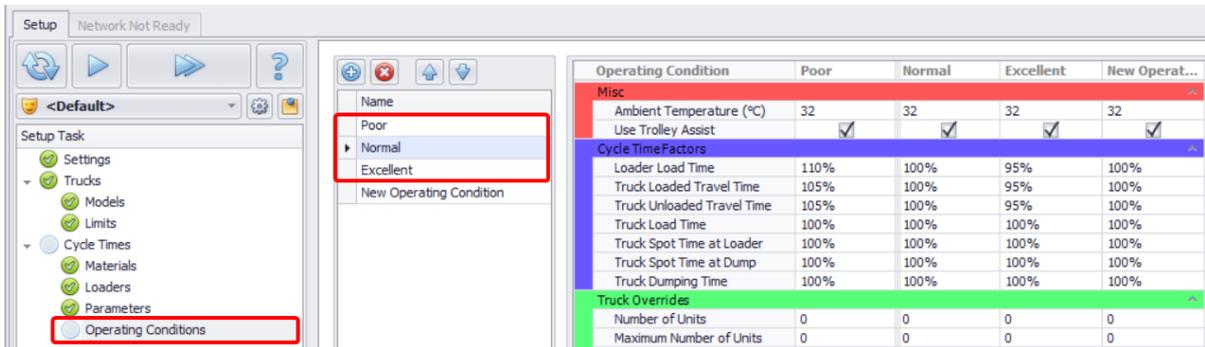
- Group the Trucks and Materials.
- Select all Loaders (using <CTRL> or <Shift> buttons).
- Setup the Parameters for the CAT777E:
  - Tray Payload = 60m<sup>3</sup> / 110t,
  - Set up the bucket capacities for each Loader & Material for the CAT777E,
    - set the bucket payload to 25 t for ore,
    - set the bucket payload to 20 t for waste,
  - Loader Cycle Time = 35 s,
  - Loader First Pass Delay = 25 s,
  - Overrides: Truck Utilized Payload = 120 t.



## Cycle Times > Operating Conditions

When querying a specific haul, the operating conditions can be used to quickly toggle one or more input parameters to different values.

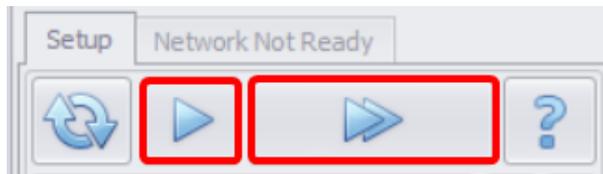
This is for in depth analysis of networks under different operating conditions.



Operating Conditions factors are a multiplication factor that you can base on historical data or analysis. These can be queried during scheduling to apply wet seasons conditions, for example.

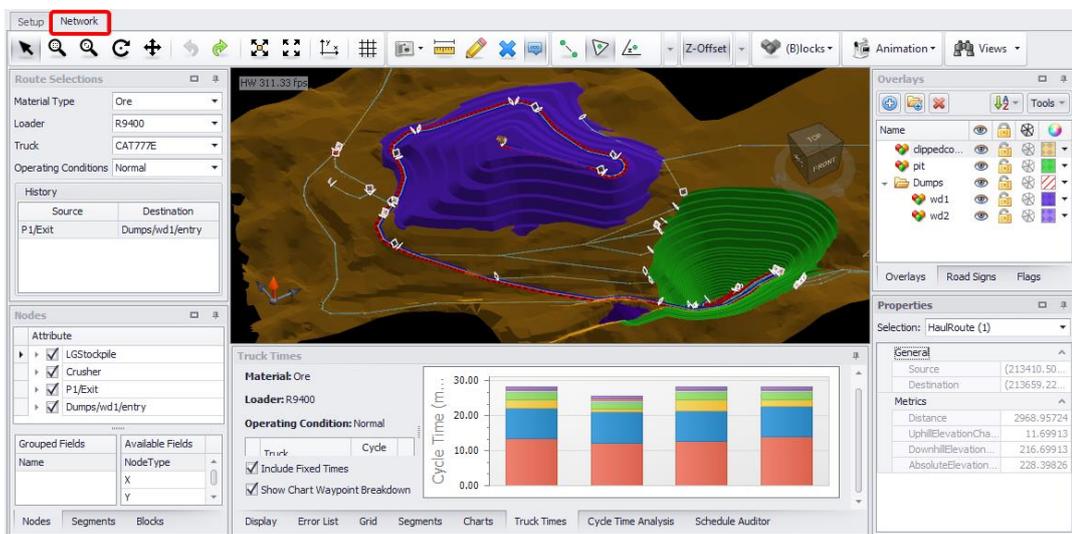
## Run Setup Steps

When you have completed all the Setup steps of the Setup Task list, click the blue play button to run the last step or all steps to confirm and move to the **Network** tab.



## Network tab

The **Network** tab is the main workspace in Haul Infinity, where you can draw a 3D road network over of existing pits and topos and interact with it to create nodes and routes for haulage.

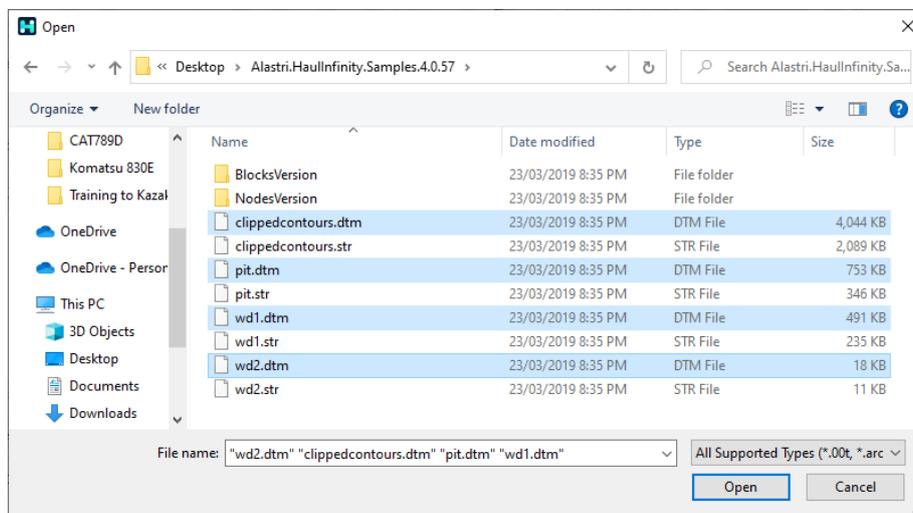


# Import Surfaces

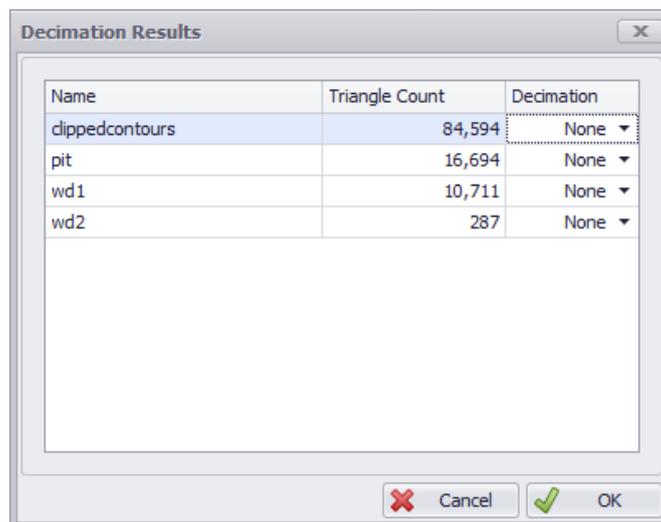
Road networks can be drawn directly onto survey surfaces and mine designs. Surfaces are imported through the **Overlays** panel.

To import a surface:

1. Go to the **Network** tab.
2. Find the **Overlays** panel in the right of the screen.
3. Press the blue plus icon  to import surfaces.
4. Navigate to the sample data folder and import.
  - a. "clippedcontours.dtm"
  - b. "pit.dtm"
  - c. "wd1.dtm"
  - d. "wd2.dtm"

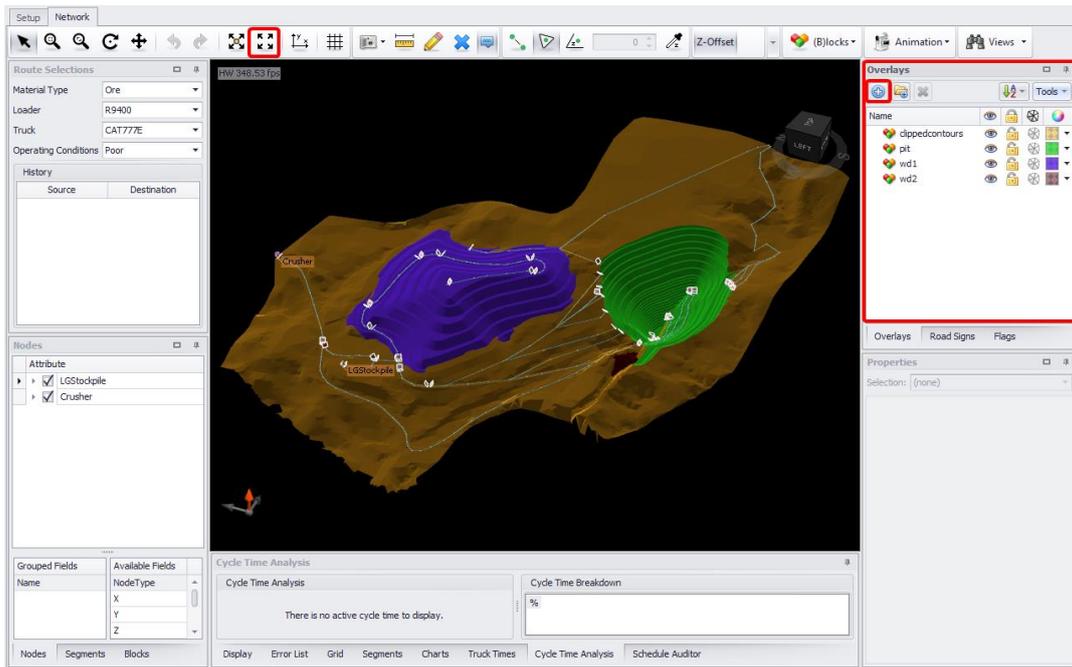


The **Decimation Results** dialog will appear, where you can see the triangle count and specify the decimation required (in this demo project, decimation is not required). Make the necessary changes and click OK. When importing large files, you may need to reduce the image size by excluding every tenth one (decimation).



Press Zoom All  to centre the data.

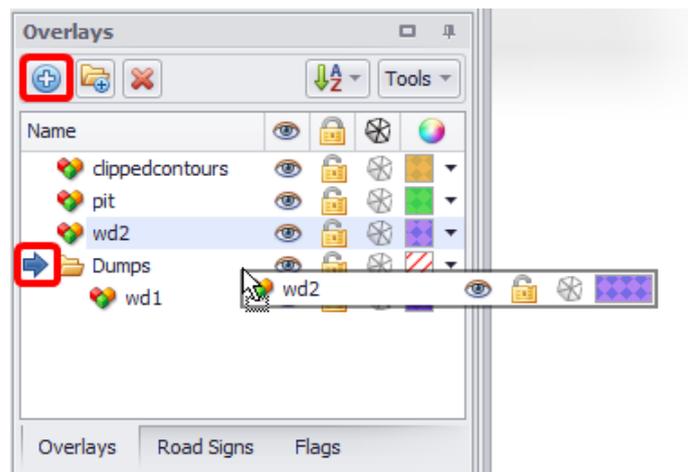
- ✓ The topography, pit design and dump design should now be centred in the viewport. These are the surfaces on top of which the network will lie.



When working with multiple pits, dumps, and surveys, group them into folders to make it easier to browse and find the surface required.

➤ Group surfaces into folders:

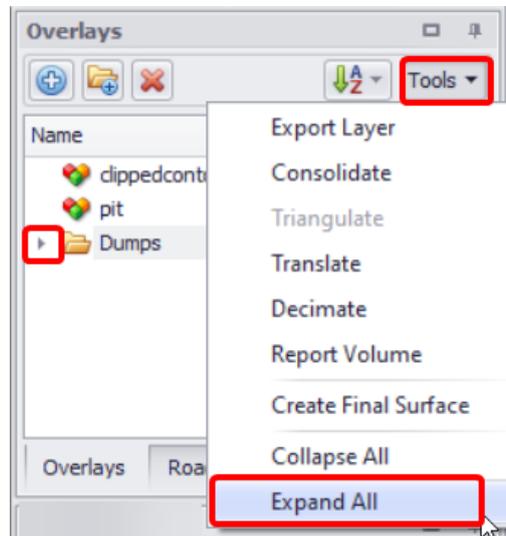
1. Press the blue plus button to add a new folder.
2. Rename it to "Dumps".
3. Select "wd1" dump and drag and drop it to the folder created.
4. Repeat for "wd2".



You can change the order in which folders and their items are displayed by dragging and dropping them. The place of insertion is pointed by blue arrows.

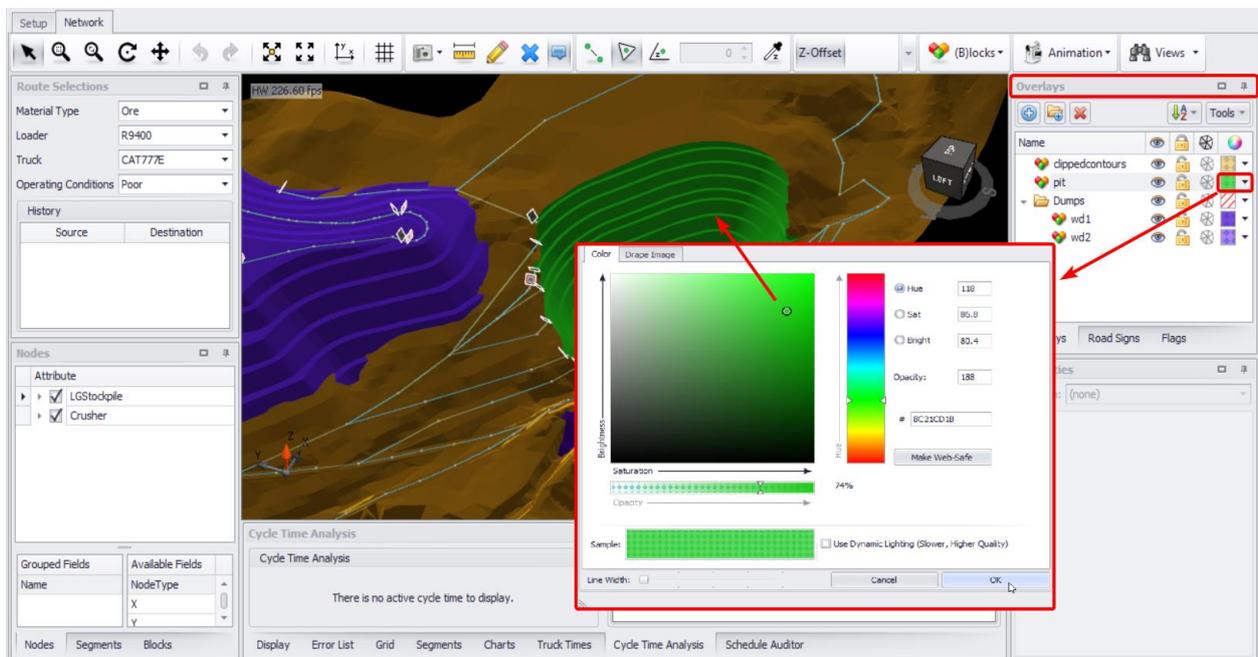
## Changing surfaces colours

1. Expand out the folders in the **Overlays** panel (manually or using Tools button > "Expand" option).



2. Open the dropdown in the far right column.
3. Select a new colour.
4. Press OK.

➤ Change your pit colour to green and your dump colour to blue for easier viewing.

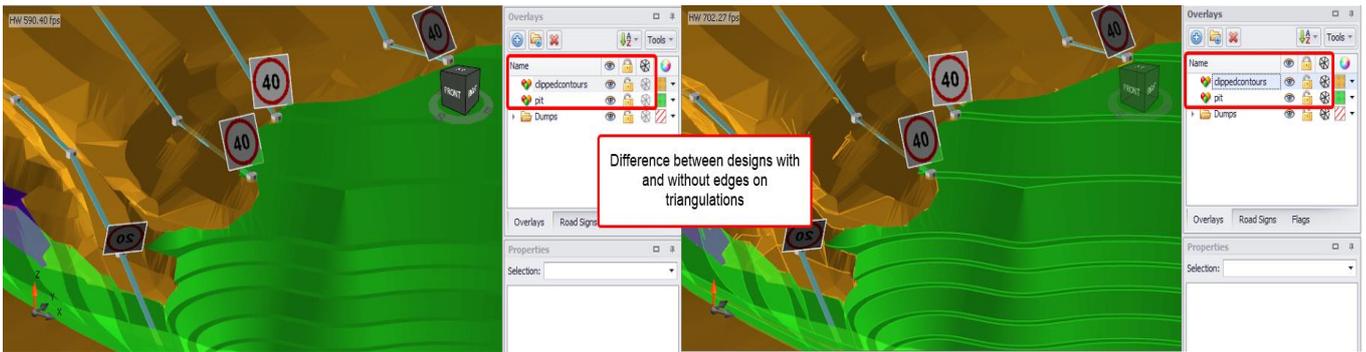


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When the lock icon is closed, the draw tool will not snap to that surface.  
Use this setting to draw through surfaces to the data underneath.

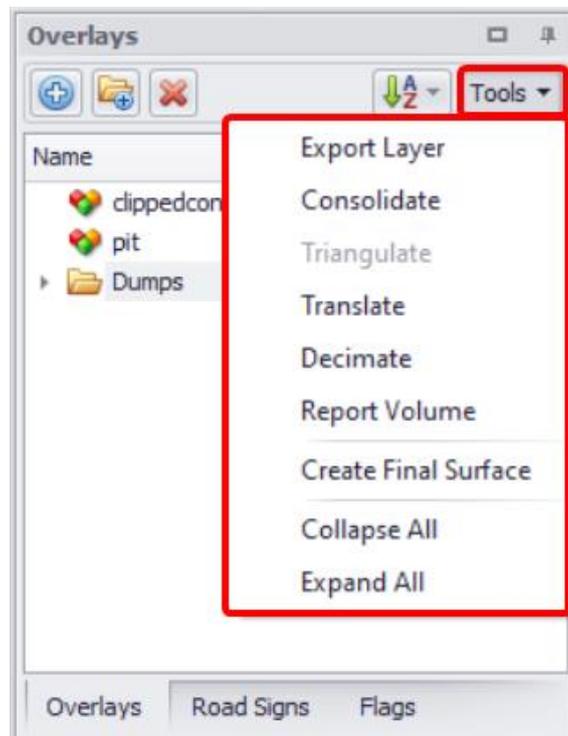
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Tick the edges icon  to toggle visibility of the underlying surfaces.



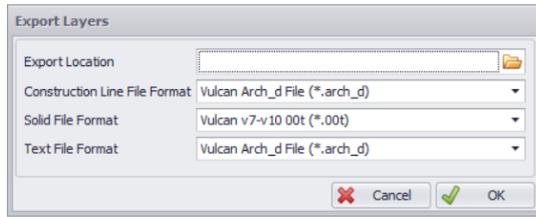
## Overlays panel Tools

Use the **Tools** button located in the top right corner of the **Overlays** panel to perform various actions with the imported layers.



The options, available from its dropdown are described in the table below.

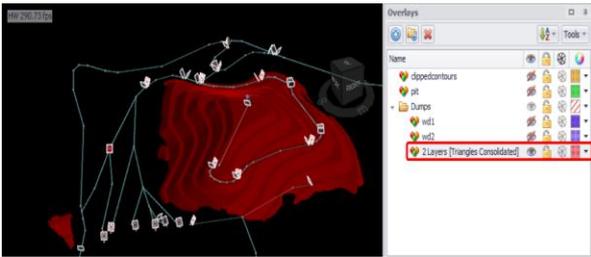
## Export Layer



- Export Single Layer. Select one layer you wish to export and in **Save As** window specify its name and saving path.

- Export Multiple layers. Use <CTRL> and <SHIFT> keys to select multiple layers you wish to export. When exporting multiple, the program allows you to place them into zip file (folder icon in the **Export Location** field). Specify applicable format for Construction Line, Solid and any Text what you may have loaded as well. Available formats include “.arch\_d”, “.str”, “.dxt”, “.obj”, “.shp”, “.00t”.

## Consolidate

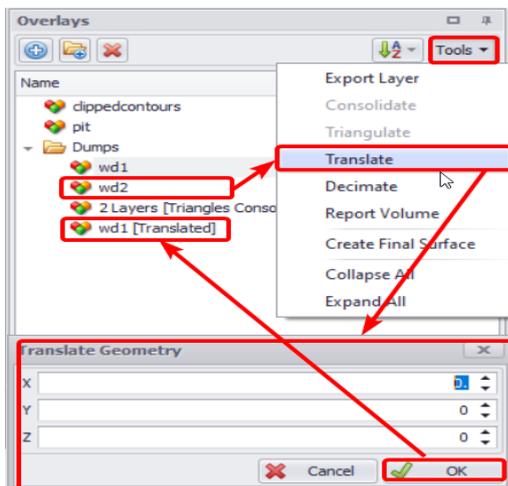


Allows to consolidate multiple layers into one. Choose layers required and select “Consolidate” option from the **Tools** button dropdown. Selected files will be merged into one new generated layer, which contains these consolidated items.

## Triangulate

Triangulation function is used to triangulate lines, available only when polylines file is imported, otherwise greyed out.

## Translate



Translation function is used to shift information in X, Y and Z-directions if you need a slight change or if you wish to change grids. Translated files will be automatically added to the same folder where original layer is stored.

Translated file is automatically named after original one and followed by “[Translated]”.

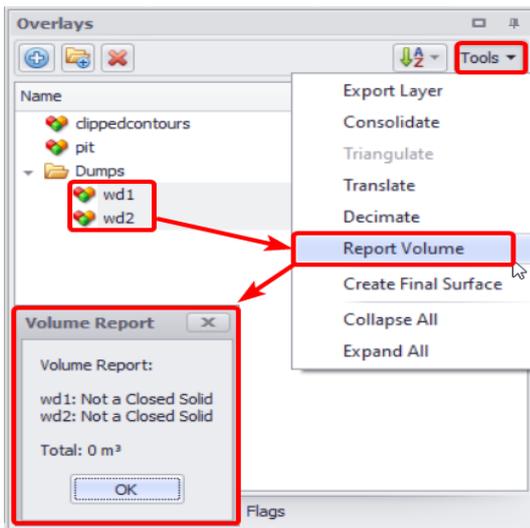
## Decimate

The Decimation function automatically runs when a triangulated file is imported into the software.

If you didn't decimate a larger surface when importing it, you still can decimate it using "Decimate" dropdown option. Select a file, choose the level of decimation required (including <None>) and this function will retriangulate the given layer at a lower resolution. On completion the results will be displayed and the user has the option whether to use the original data or the decimated.

---

## Report Volume



Report Volume is an option to display total volumes of **closed** solids from layers in the **Overlays** panel.

---

## Create Final Surface

"Create Final Surface" function is more orientated towards Spatial Conformetrics app.

---

## Collapse All and Expand All

The last two dropdown options are used to collapse and to extend all folders. It is particularly useful when working with larger projects with multiple layers, organised in many folders and subfolders.

## Draw a Network

Using our overlays as reference, we are going to draw in a road network upon which the truck fleet will run.

### Movement and Rotation

**Pan:**



or middle click and drag

**Zoom:**



or mouse scroll

**Rotate:**



or right click and drag

### Snap Mode

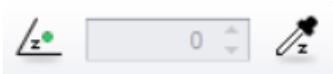
The snap mode dictates what we can connect segments to while drawing. The shortcut keys <Q>, <W>, <E> can be used to switch between the three modes:



Snap to points on the network



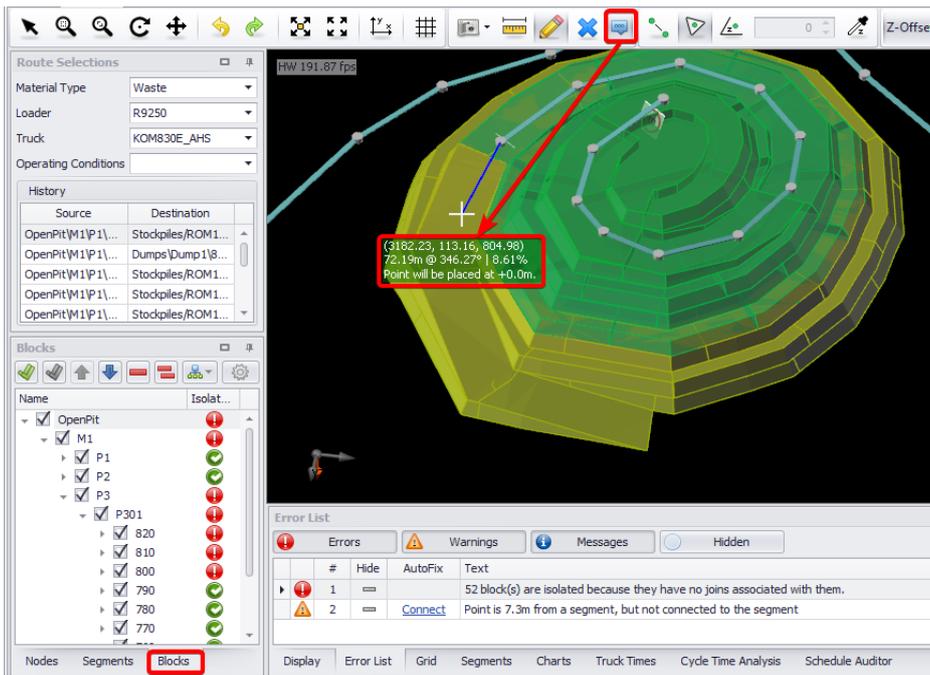
Snap to surface model



Snap to constant elevation

### Draw Tool

Press the pencil icon  and left click on the surfaces to draw roads that connect the pit and dump. The shortcut key <D> can be used to start and stop drawing.



Tip 1:

To draw a ramp, display your pit blocks from below. This way, you will immediately see how the isolated blocks become connected (painted green in viewport and marked with green tick in the **Blocks** panel on the left.

Tip 2:

Show Mouse Text (press

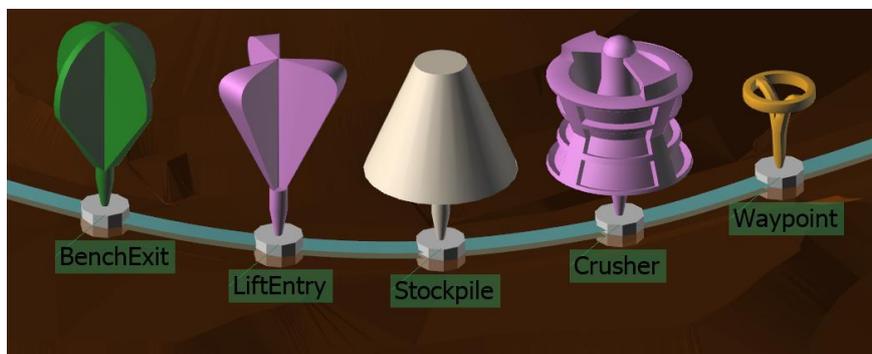


) and when drawing networks on ramps check a tooltip and make sure the slope is not too big.

## Define Sources and Destinations

Nodes are fixed load points (or dump points) that we manually connect to the network. Typically, these represent pit centroids, dump centroids, stockpiles and crusher bins.

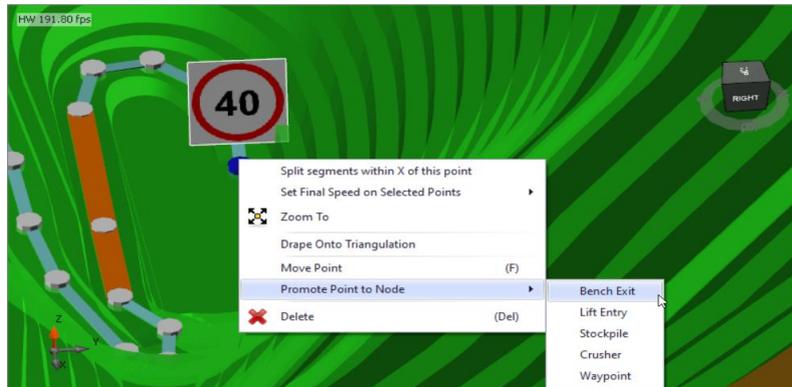
## Types of Nodes



Node	Source	Destination
Bench Exit	✓	
Lift Entry		•
Stockpile	•	•
Crusher		•
Waypoint	A waypoint is neither a source nor a destination	

## Promoting a node

Creating a node is as simple as right clicking a point on the network and selecting “Promote Point to Node”.



### ➤ Create nodes:

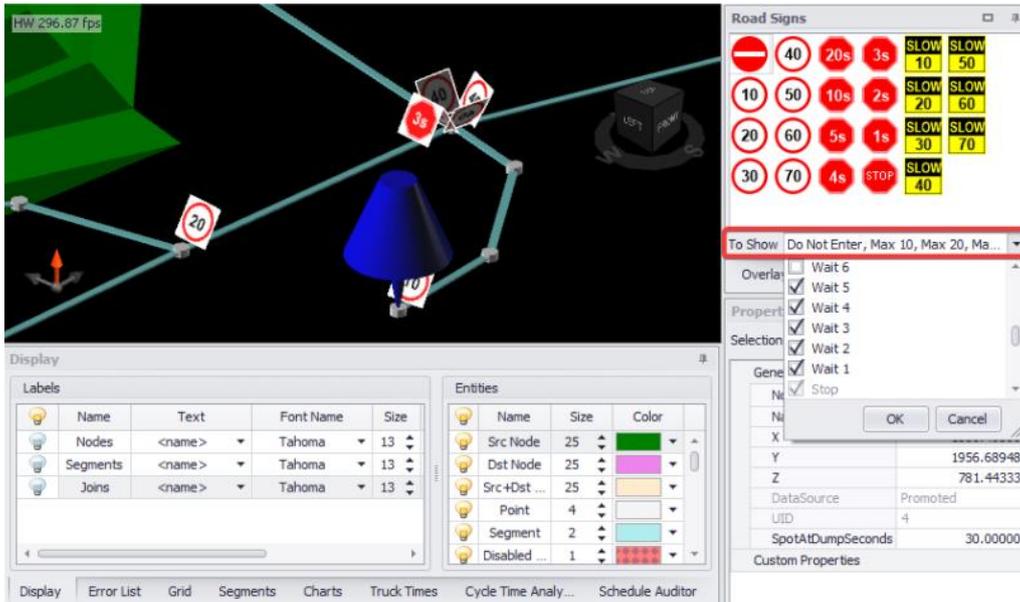
- Find the toe of the pit ramp and promote to a Bench Exit.
- Find the crest of the dump ramp and promote to a Lift Entry.

## Set Road Rules

Road signs can be dragged and dropped onto the network to reproduce the site road rules.

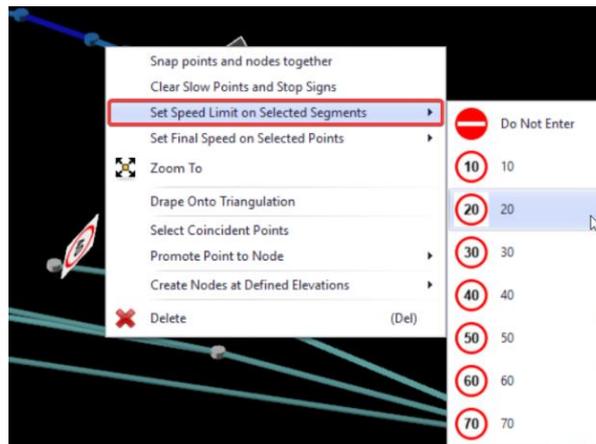
<b>Maximum speed:</b>		Trucks are restricted to this maximum speed.
<b>Slow point:</b>		Trucks slow down approaching this sign, then speed up.
<b>Stop and wait:</b>		Trucks stop and wait at this sign for the number of seconds.
<b>Do not enter:</b>		Trucks cannot enter from this direction (but may exit).

The Road Signs menu can be found in the top right panel with the Overlays and Flags menus. Additional signs are available in the “To Show” dropdown.

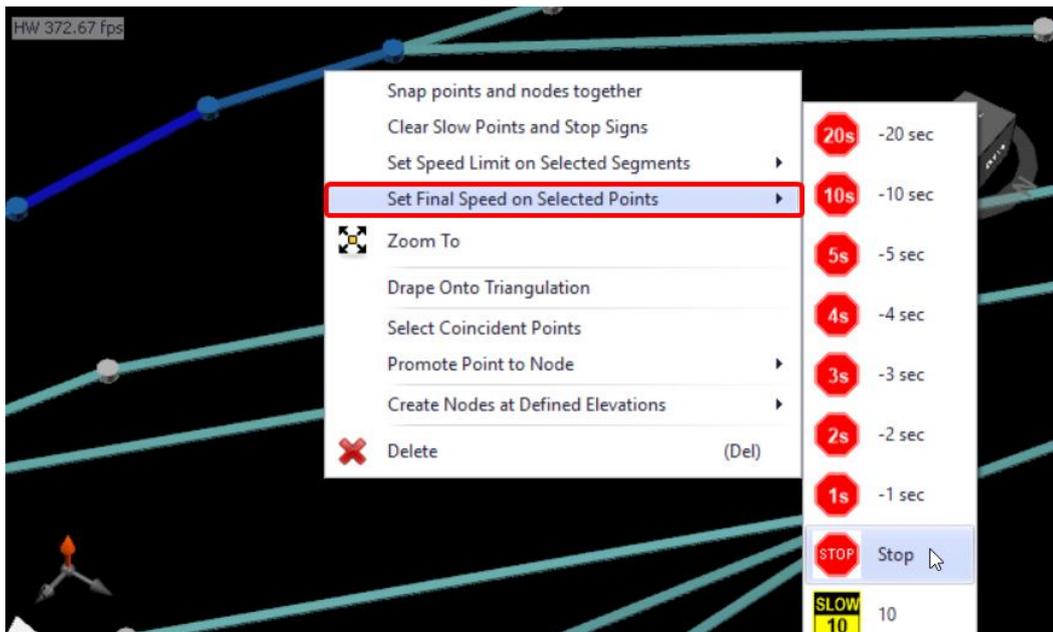


To set road rules:

- Drag and drop some signs onto the network to create safe intersections and appropriate speeds.
- Select some segments > Right click > “Set Speed Limits on Selected Segments”.

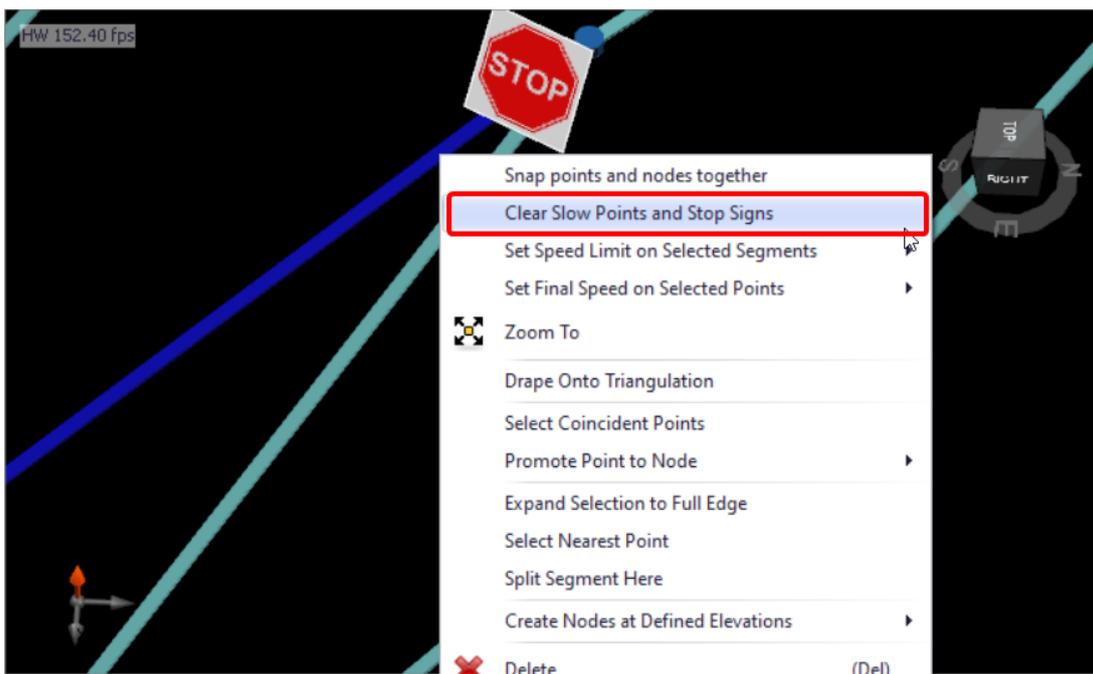


- Select some points > Right click > “Set Final Speed on Selected Points”.



## Removing road rules

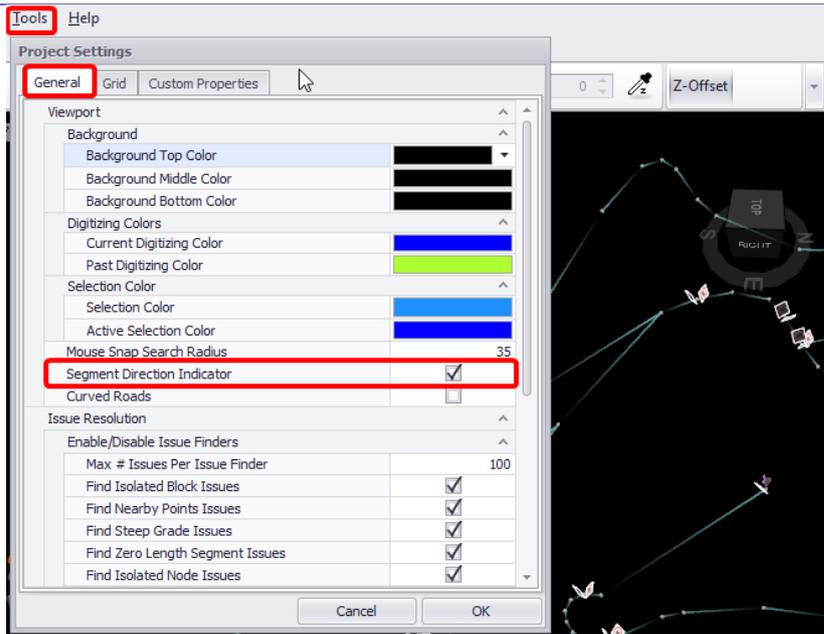
Stop signs and slow points can be removed from segments via the right click menu.



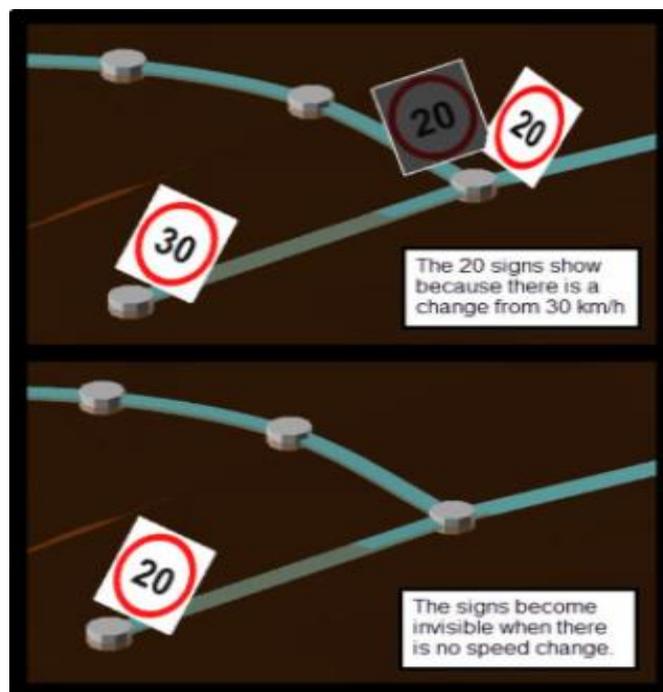
Speed signs are never "removed" because all segments have a speed. Speed signs will be visible whenever there is a change in speed: at a terminal point, at an intersection, or anywhere on the road you have dropped a sign. To make a sign invisible, change the speed limit to be equal to the neighbouring segments.



Segments have forward and backward speed properties. Enable them in *Tools > Project Settings > General > Segment Direction Indicator*.



- Find a road with a 40 km/h speed limit.
- Drag a 20 km/h sign onto the road. The sign is visible because there is a speed change from 40 to 20 km/h.
- Drag a 40 km/h sign over the top of the 20 km/h sign. The sign will disappear because there is no speed change along the segment.



# Query a Haul

Every haul route is defined by several parameters – such as truck type, material, loader, source, and destination.

## Pre-start checks

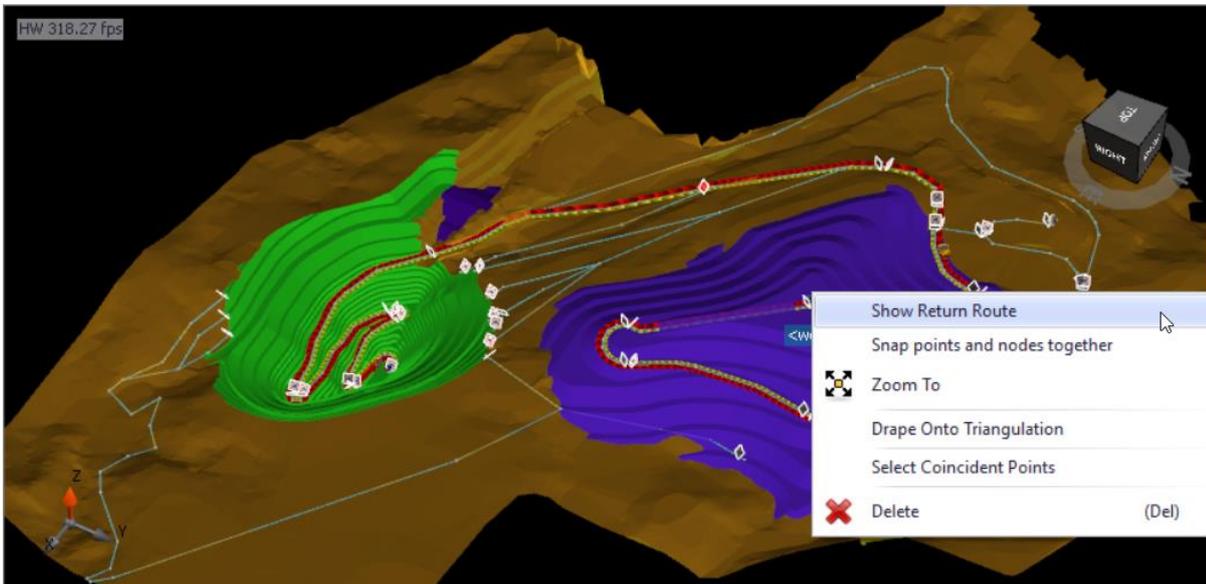
- |              |                          |  |
|--------------|--------------------------|--|
| Travel Times | <input type="checkbox"/> | Is there a source node connected to a destination node on the network? |
|              | <input type="checkbox"/> | Is a truck defined in the Trucks > Models step?                        |
| Cycle Times  | <input type="checkbox"/> | Is a material defined in the Cycle Times > Materials step?             |
|              | <input type="checkbox"/> | Is a loader defined in the in the Cycle Times > Loaders step?          |
|              | <input type="checkbox"/> | Are the Loader Bucket Payloads set?                                    |
|              | <input type="checkbox"/> | Are the Truck Payloads set?  |

If you answered “yes” to all the above, continue to the next step.

## Route Selection

Follow these steps to activate a haul:

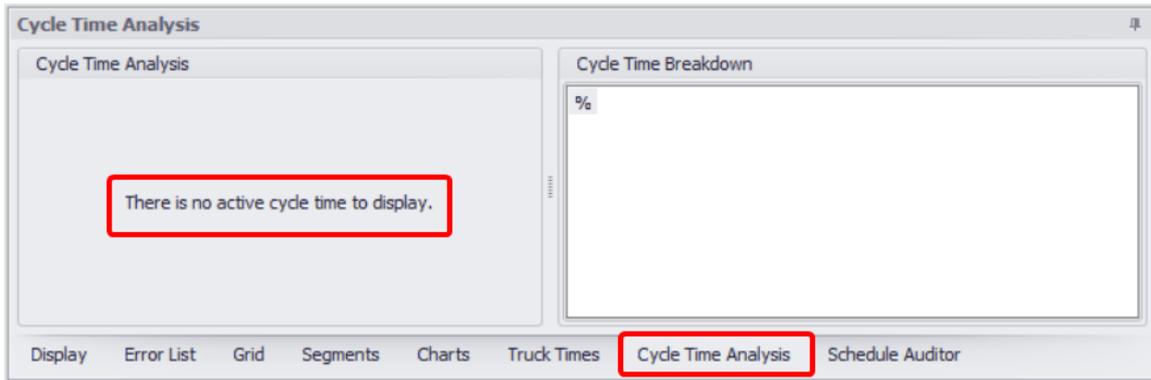
1. Left click on the Bench Exit node that you drew in the pit.
2. While holding the <CTRL> key, left click on the Lift Entry node that you drew on the dump.
3. Right click and select “Show Return Route”.



Haul Infinity calculates the fastest route between the source and destination and then displays that route on screen. The red arrows represent the loaded route, and the yellow arrows represent the return route. Depending upon the network, sometimes the return route will take a different path than the loaded route.

Try Return on Same Route” is an option in *Setup > Settings*. Use this setting to force trucks to return on the same route.

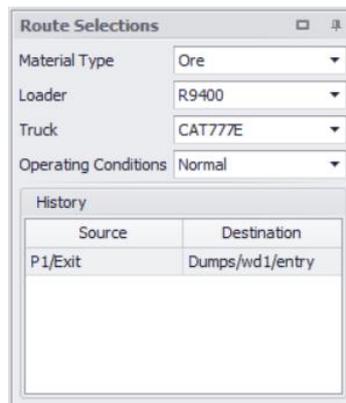
With the route still active, open the **Cycle Time Analysis** tab below the viewport. You should see the error message “There is no active cycle time to display.”



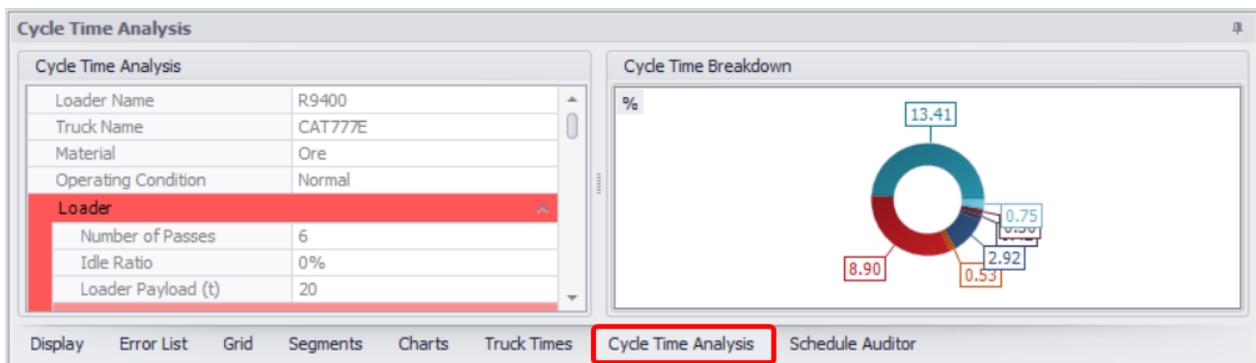
To make cycle time calculations, Haul Infinity needs to know the material type, loader, and truck type.

➤ **Enter route parameters:**

1. Find the **Route Selections** panel to the left of the viewport.
2. Set material to "Ore".
3. Set loader to R9400.
4. Set truck to CAT77E.
5. Set operating condition to "Normal".



You will notice that the **Cycle Time Analysis** panel now shows numerical and graphical results.



# Network Analysis

There are four tiers of network analysis in order of increasing complexity.

- Daily operational checks
- Process a schedule
- Export to lookup table
- Live scheduling queries

Each method gives us increasing control over the data from Haul Infinity.

## Daily Operational Checks

When a haul is queried in Haul Infinity, information about that haul is displayed in the **Charts** tab, the **Truck Times** tab, and the **Cycle Time Analysis** tab.



### Charts

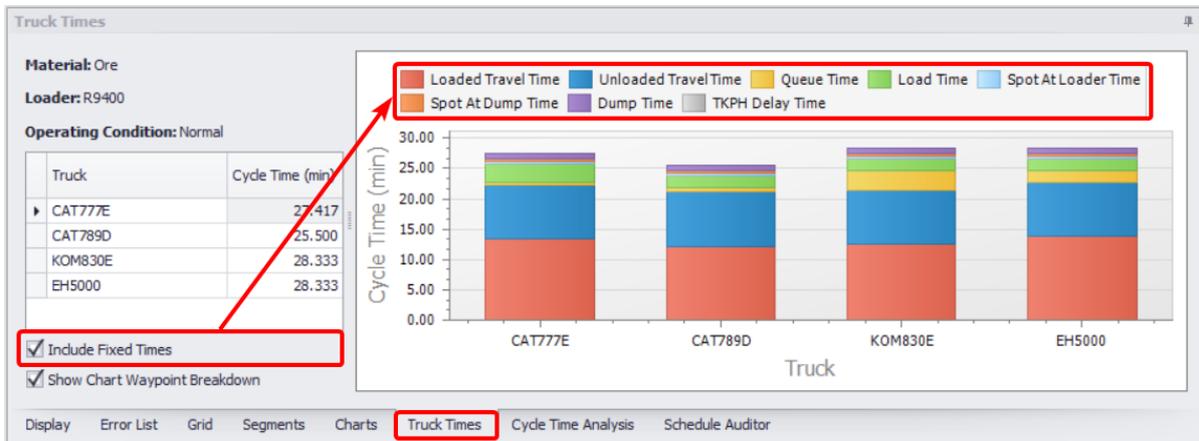
The **Charts** tab can be configured to display elevation, velocity, fuel burn and engine load over time or distance. Use this tab to find out where the trucks are slowing down, and why.



- In the **Trucks** list flag trucks that charts you wish to display.
- Specify Primary and Secondary axis scales (Auto by default).
- Overlapping road signs on the chart can be dragged across the charts area or hidden (**Show Signs** checkbox).
- Toggle **Show Waypoints** checkbox to show/hide network waypoints.
- Hover the mouse cursor over the curve to display the position of the truck on the road in the viewport.
- You can export and save the chart(s) displayed using **Export to Excel** button.

## Truck Times

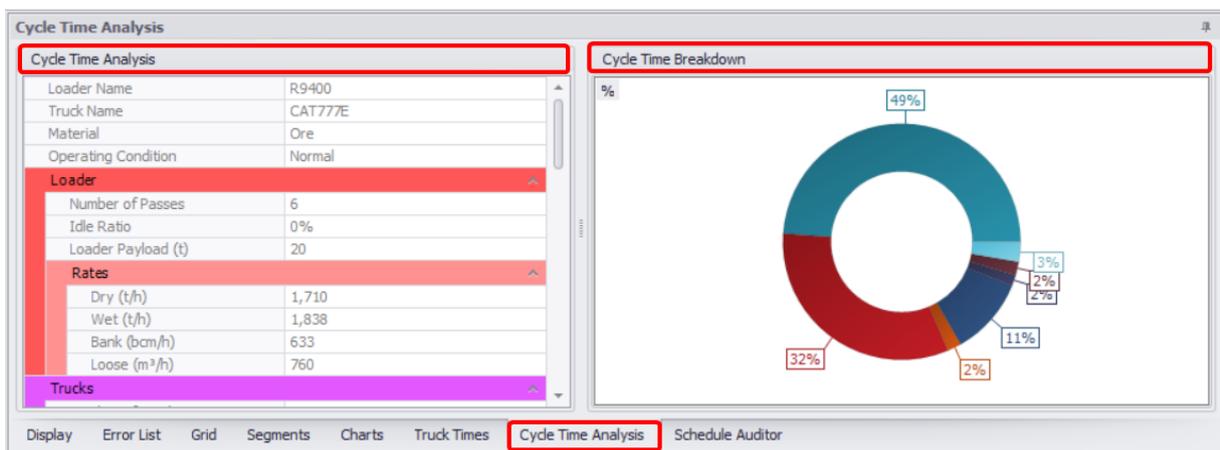
The **Truck Times** tab presents a stacked bar graph of the cycle time. Use this tab to compare the performance of two or more truck types.



- Select the route for which you wish to display cycles from the network viewport or from the **History** panel on the left.
- Flag the **Include Fixed Time** checkbox if you want to display non-productive truck times on the graph, i.e: Queue time, Load Time, Spot at Loader Time, Spot at Dump Time, Dump Time, and TKPH Delay Time.
- Flag the **Show Chart Waypoint Breakdown** checkbox to display a breakdown by waypoints.
- Hover the mouse cursor over the required truck graph to display the applicable cycle time values.

## Cycle Time Analysis

The **Cycle Times Analysis** tab displays the key performance indicators for the active haul. Use this tab to compare fleet sizes, cycle times, fuel burn, TKPH values, productivity rates and delays.



In the **Cycle Time Analysis** panel on the left see a detailed analysis of time cycles, applicable to the Loader, Truck, Material and Operation Conditions, selected in the **Route Selection** panel.

The **Cycle Time Breakdown** panel on the right displays the ring chart of cycle time breakdown into the intervals listed in the legend. Toggle the percent icon in the top left corner to switch units from minutes to percent.

## Process a Schedule

The **Schedule Auditor** is a tool provided expressly for mine schedulers, to generate bulk haulage calculations across an entire schedule. To use this feature, you must supply an existing schedule that specifies sources, destinations, loaders, trucks, and materials moved. Haul Infinity will then generate the full cycle time breakdown and 3D haul strings for each schedule record. This can be used to estimate truck fleet mobilisation and utilisation over time.

### *Pre-Start Check*

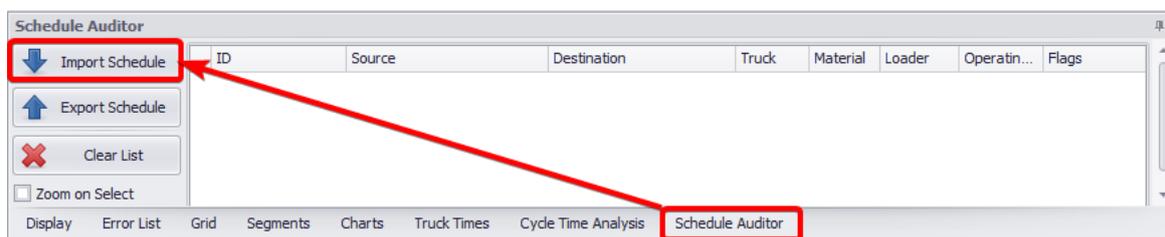
Inspect the schedule for errors:

1. Navigate to the sample data \NodesVersion folder.
2. Open ScheduleWithNodes.csv.
3. Make sure that each row in the schedule contains a source, destination, truck type, material, and loader.
4. Remove any blank rows.
5. Save the schedule in a CSV format.

### *Schedule Import*

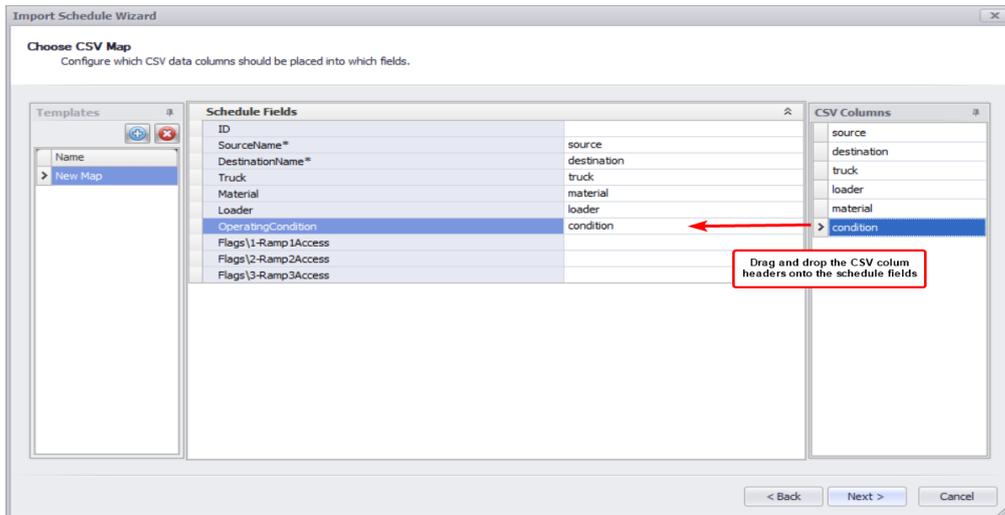
Import to Haul Infinity from CSV:

1. Navigate to the sample data \NodesVersion folder.
2. Open SampleModelWithNodes.hinf.
3. Find the **Schedule Auditor** below the viewport and open it.
4. Click **Import Schedule**.

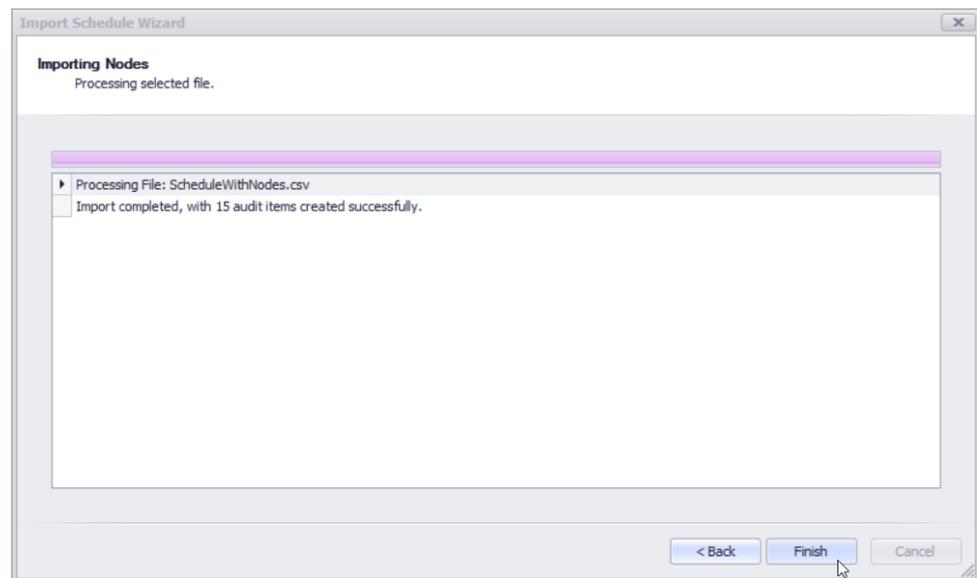


5. Navigate to the sample data \NodesVersion folder.
6. Open ScheduleWithNodes.csv.
7. Click the blue plus icon to create a new CSV mapping template.

8. Drag and drop the CSV column headers to the corresponding schedule field. The ID and Flag fields can be left blank.



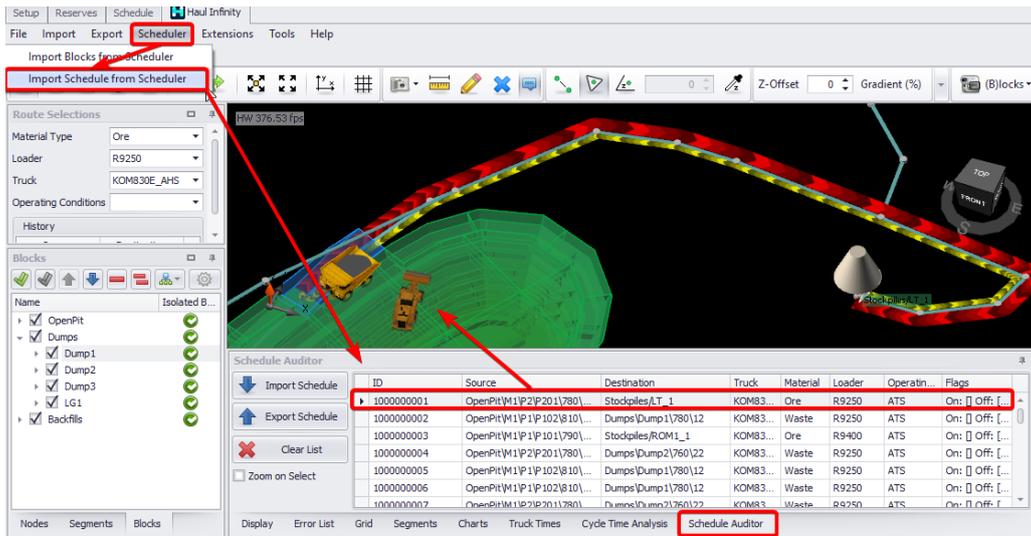
9. Click Next to continue.
10. Click Finish when the import is complete.



## Import Schedule from Scheduler

If you are using Haul Infinity within the Scheduler (ATS or APS), you can import a schedule directly from the scheduling app.

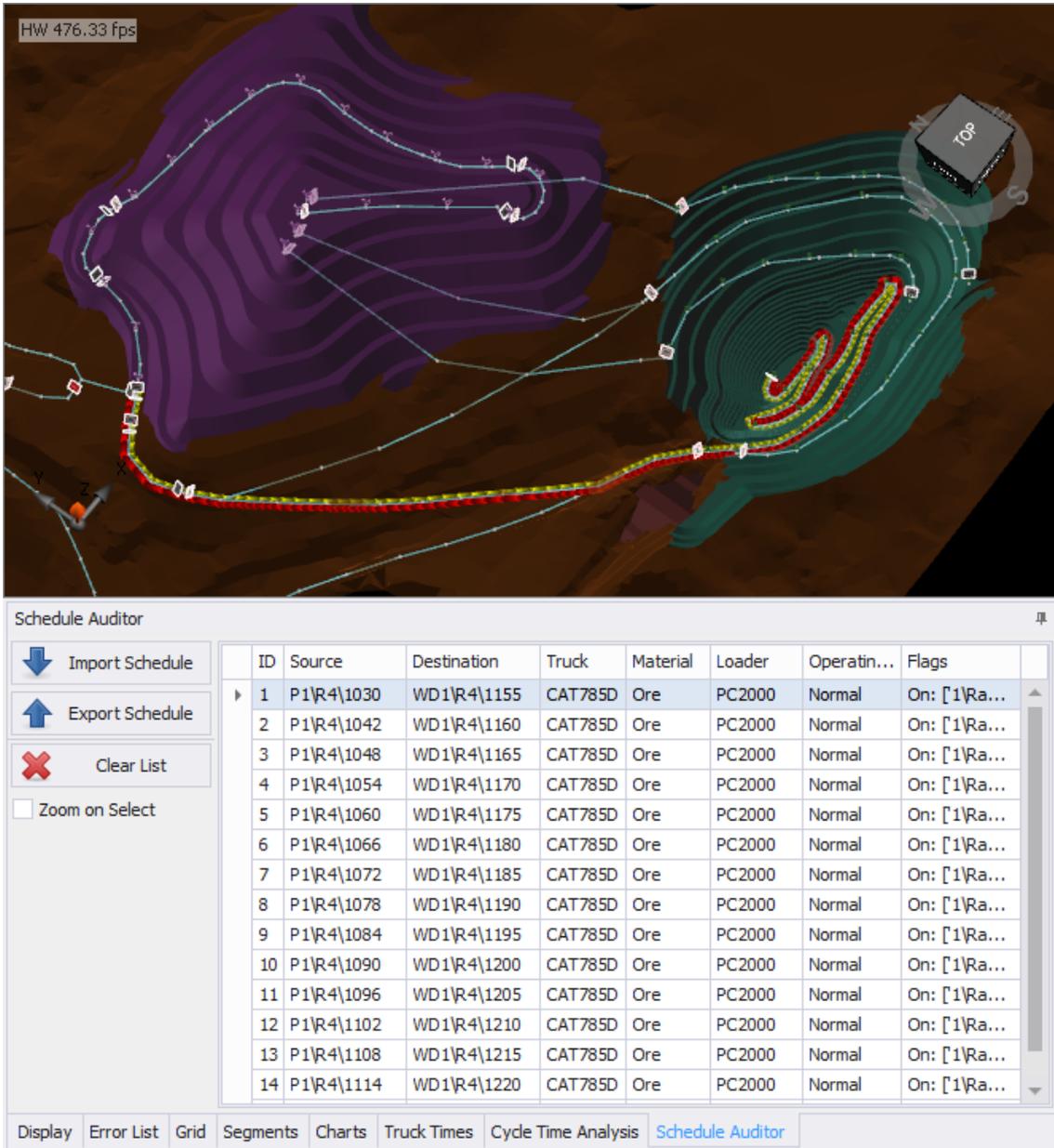
1. In Alastri Tactical Scheduler:
  - a. Run all the Setup Tasks.
  - b. In the **Schedule** tab, run Scenario or Full Schedule.
2. In Haul Infinity:
  - a. In the top tab bar locate the **Scheduler** tab.
  - b. Select "Import from Scheduler". Imported strings will be displayed as a list in the **Scheduler Auditor** tab.
  - c. Double click any line in the list to animate the haul in the viewport.



Note that the Sources and the Destinations must **exactly match** between the Schedule and the Haul Infinity project. This means that for every source or destination in the schedule, there must be a node or a block that has that name. Moreover, if the schedule specifies a haul from source A to destination B, then there must be a physical path on the network for a truck to travel between A and B.

## Schedule Audit

Double click the first line in the schedule auditor to activate the haul in the viewport. We can use the arrow keys to move forward and backward through the schedule; this lets us inspect the haulage solutions provided by Haul Infinity and make any functional changes to the network as required.



The screenshot displays the 'Schedule Auditor' window. At the top left, it shows 'HW 476.33 fps'. The main area is a 3D terrain map with purple and green contour lines. A network of haul routes is overlaid on the map, with a specific route highlighted in red and yellow. A 'Top' button is visible in the upper right corner of the map. Below the map is a table with the following columns: ID, Source, Destination, Truck, Material, Loader, Operatin..., and Flags. The table contains 14 rows of data. To the left of the table are buttons for 'Import Schedule', 'Export Schedule', 'Clear List', and a 'Zoom on Select' checkbox. At the bottom of the window are several tabs: 'Display', 'Error List', 'Grid', 'Segments', 'Charts', 'Truck Times', 'Cycle Time Analysis', and 'Schedule Auditor' (which is currently selected).

ID	Source	Destination	Truck	Material	Loader	Operatin...	Flags
1	P1\R4\1030	WD1\R4\1155	CAT785D	Ore	PC2000	Normal	On: [1\Ra...
2	P1\R4\1042	WD1\R4\1160	CAT785D	Ore	PC2000	Normal	On: [1\Ra...
3	P1\R4\1048	WD1\R4\1165	CAT785D	Ore	PC2000	Normal	On: [1\Ra...
4	P1\R4\1054	WD1\R4\1170	CAT785D	Ore	PC2000	Normal	On: [1\Ra...
5	P1\R4\1060	WD1\R4\1175	CAT785D	Ore	PC2000	Normal	On: [1\Ra...
6	P1\R4\1066	WD1\R4\1180	CAT785D	Ore	PC2000	Normal	On: [1\Ra...
7	P1\R4\1072	WD1\R4\1185	CAT785D	Ore	PC2000	Normal	On: [1\Ra...
8	P1\R4\1078	WD1\R4\1190	CAT785D	Ore	PC2000	Normal	On: [1\Ra...
9	P1\R4\1084	WD1\R4\1195	CAT785D	Ore	PC2000	Normal	On: [1\Ra...
10	P1\R4\1090	WD1\R4\1200	CAT785D	Ore	PC2000	Normal	On: [1\Ra...
11	P1\R4\1096	WD1\R4\1205	CAT785D	Ore	PC2000	Normal	On: [1\Ra...
12	P1\R4\1102	WD1\R4\1210	CAT785D	Ore	PC2000	Normal	On: [1\Ra...
13	P1\R4\1108	WD1\R4\1215	CAT785D	Ore	PC2000	Normal	On: [1\Ra...
14	P1\R4\1114	WD1\R4\1220	CAT785D	Ore	PC2000	Normal	On: [1\Ra...

We may at any time switch to the **Charts**, **Truck Times**, and **Cycle Time Analysis** tabs for more detail on the active haul.

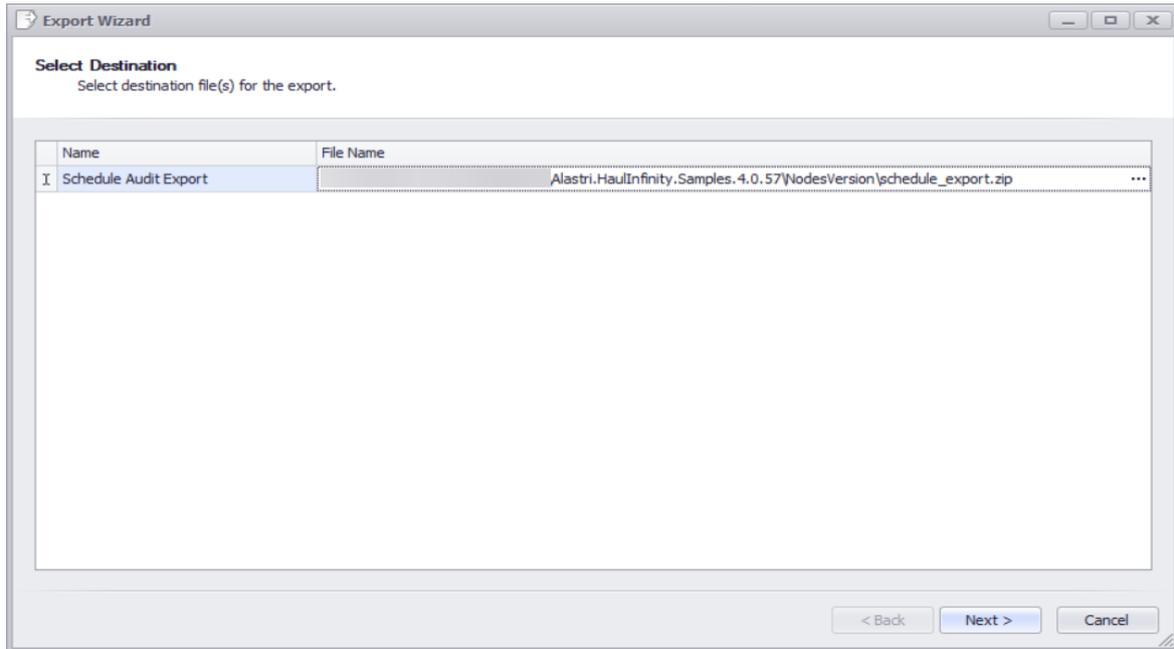
Roads can be flagged open or closed in the schedule. Use flags to model a changing road network over time.

## Schedule Export

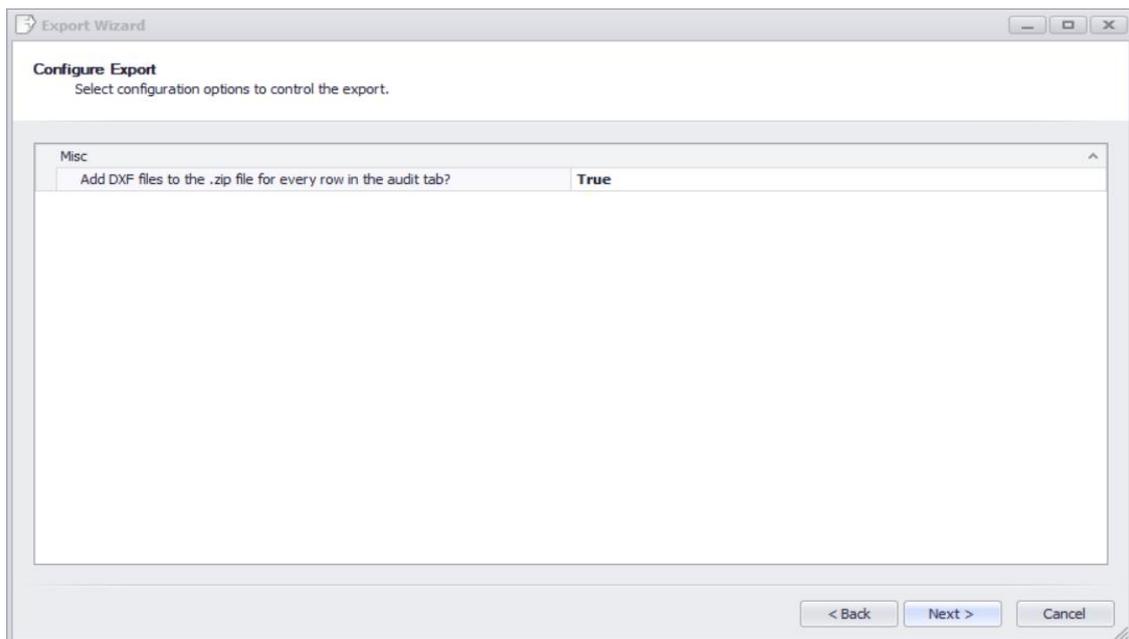
Once you have audited the schedule to your satisfaction, the calculated results can be exported for use in cost modelling and fleet selection.

To export the schedule:

1. Open the **Schedule Auditor** tab.
2. Click “Export Schedule”
3. Navigate the samples folder.
4. Enter a file name “schedule\_export” and continue.



5. Set “Add DXFs” to true. This will generate a 3D haul string for every row in the schedule.



6. Press Next to continue.

7. Press Finish to exit.

The export will be saved as a zip file that contains a CSV summary and named DXFs of every haul.

#### Inspect the export:

1. Open Windows File Explorer.
2. Navigate to where you saved the schedule export.
3. Right click on "schedule\_export.zip" and extract the contents.
4. Open "00-Summary.csv"
5. Every row in the schedule has been fully appended with cycle times, distance travelled, productivity rates, fuel burn and TKPH calculations.

This gives us a solid foundation on which to base decisions for cost estimation, budget forecasts and equipment mobilization.

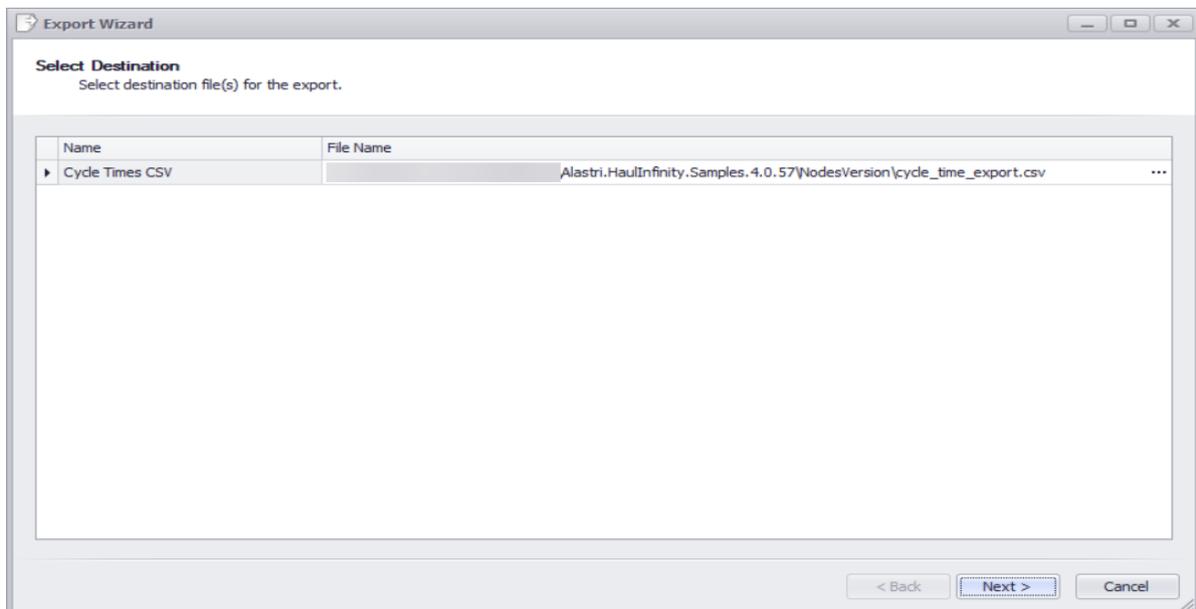
### Export Lookup Table

A complete table of network connections can be exported through *Export > Cycle Times to CSV*. This will create a lookup table of every possible permutation of source, destination, truck, loader, and material. The complete lookup table can number in the tens of thousands of rows.

You might choose to do this when evaluating multiple scenarios, so you don't have to process each schedule one by one in Haul Infinity, or when generating dispatch tables for your fleet management database.

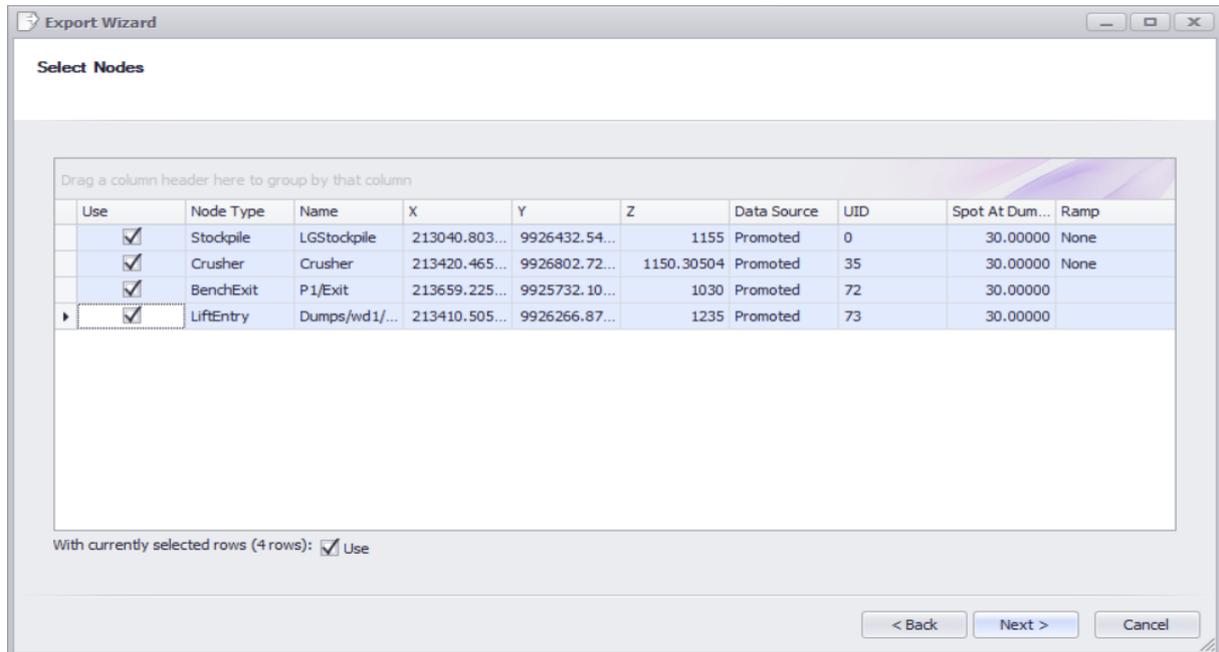
#### To export the complete network:

1. Go to *Export > Cycle Times to CSV*.
2. Select a destination folder.
3. Enter the file name as "cycle\_time\_export".
4. Click Next.



5. Select all material types for export.
6. Select all blocks for export.
7. Select all operating conditions for export.
8. Select all loaders for export.
9. Select all truck types for export.

- Select all roads flags for export. Select all sources and destinations for export. You can also drag and drop headers to organize columns order, or remove those, you don't want to see in export file.



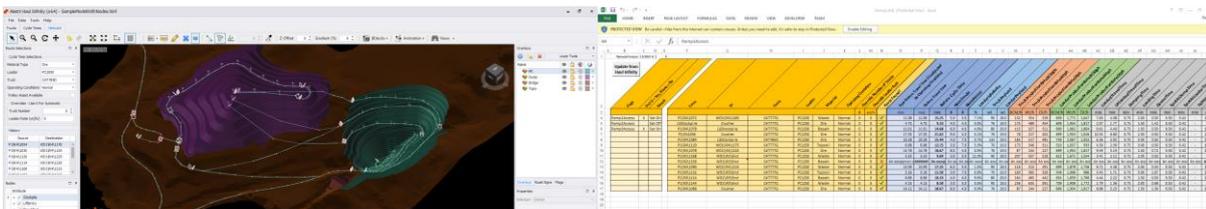
- Run export. This will generate a haul for every single combination of material, operating condition, loader, truck and flag between every source and every destination.

## Live Scheduling Queries

Haul Infinity can create a live connection with any mine planning package that enables scripting, including Microsoft Excel. Advanced users can connect Haul Infinity to their projects directly, without having to do any imports or exports. This feature is referred to as the interop, which is short for interoperability.

To interop with Haul Infinity:

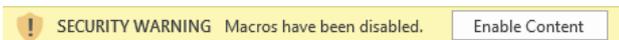
1. Navigate to the sample data \NodesVersion folder.
2. Open SampleModelWithNodes.hinf.
3. Open Interop.xlsb.
4. If you have dual screens, arrange Haul Infinity and Microsoft Excel side by side.



5. In the Interop, click “Enable Editing”



6. In the Interop, click “Enable Content”



7. Locate the “Update from Haul Infinity” button in the top left of the Steps tab, and press it.
8. The table should now be updated with cycle time values.

We can query any number of hauls by changing the haul parameters in columns F through column M. The dropdown boxes have automatically been populated with every source, destination, truck, loader and material in the open project.

- If you change any haul parameters in the Interop, the calculations update instantly.
- If you change the network in Haul Infinity, the calculations update instantly.

The Interop formulas can be copied and pasted into any format or layout, from daily dispatch calculations to three-month plans. For advanced users, the macros can be edited in Visual Basic for Applications.

A Haul Infinity project must be open for the Interop to connect to.

# Node Exercises

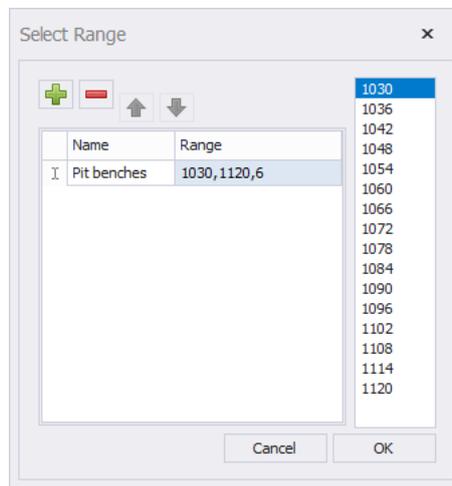
These exercises illustrate the best practices for using nodes in a project.

## Create Nodes at Elevation

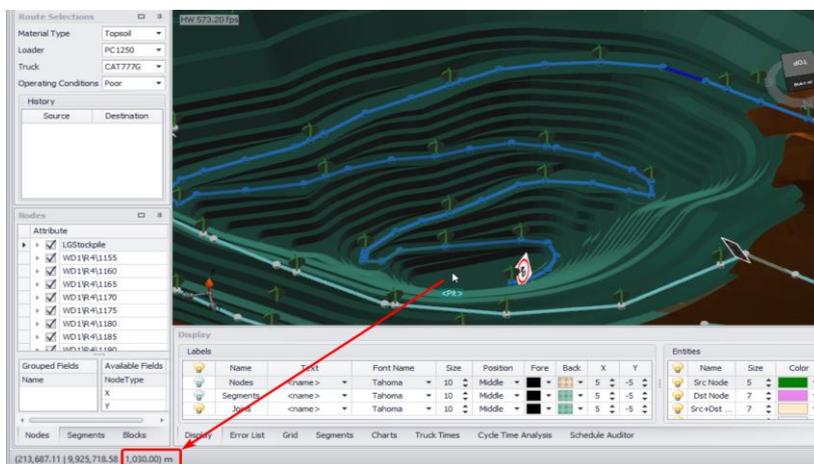
Use this tool to create entry points for each bench in the pit or dump.

To create nodes by elevation:

1. Navigate to the sample data \NodesVersion folder.
2. Open SampleModelWithNodes.hinf.
3. Centre the pit in the Network tab.
4. Hover the mouse over the pit floor and read the RL from the status bar in the bottom left of the screen. This should be 1030.
5. Hover the mouse over the ramp crest and read the RL from the status bar. This should be 1120.
6. Double-click the pit ramp to select the entire length.
7. Right click > Create Nodes at Defined Elevations > As Bench Exits.



8. Enter the range as <floor>,<crest>,<bench height>.
  9. Press OK to continue.
- This will create nodes on the pit ramp at six metre intervals between the 1030 and 1120 elevations, as shown in the picture below.



## Node Naming

Nodes must have the same unique name in all projects and documentation.

- If you are processing a schedule, the nodes must have the same name as the schedule sources and destinations
- If you are interfacing with dispatch, the nodes must have the same name as they are called in the fleet management system

This means that nodes must be renamed from their default names.

To rename nodes in the Grid panel:

1. Navigate to the sample data \NodesVersion folder.
2. Open SampleModelWithNodes.hinf.
3. Centre the pit in the **Network** tab.
4. Drag a box over the dump to select all dump nodes.
5. Open the **Grid** tab below the viewport.
6. Change the selection to “Nodes”.
7. Edit node names in the **Name** column.

Grid

Selection: Node (21) Change the selection to Nodes

NodeType	Name	X	Y	Z	DataSource	UID	SpotAtDumpSeconds	Ramp
LiftEntry	WD1R4\1155	213143.55594	9926304.19228	1155	Drawn	2	30.00000	Ramp4
LiftEntry	WD1R4\1160	213193.91619	9926346.84051	1160	Drawn	3	30.00000	Ramp4
LiftEntry	WD1R4\1165	213216.26666	9926409.92125	1165	Drawn	4	30.00000	Ramp4
LiftEntry	WD1R4\1170	213257.83347	9926464.21324	1169.95808	Drawn	5	30.00000	Ramp4
LiftEntry	WD1R4\1175	213323.27724	9926452.14129	1175	Drawn	6	30.00000	Ramp4
LiftEntry	WD1R4\1180	213386.5107	9926440.96442	1180.02604	Drawn	7	30.00000	Ramp4
LiftEntry	WD1R4\1185	9926432.64254	1185	Drawn	8	30.00000	Ramp4	

Display Error List **Grid** Segments Charts Truck Times Cycle Time Analysis Schedule Auditor

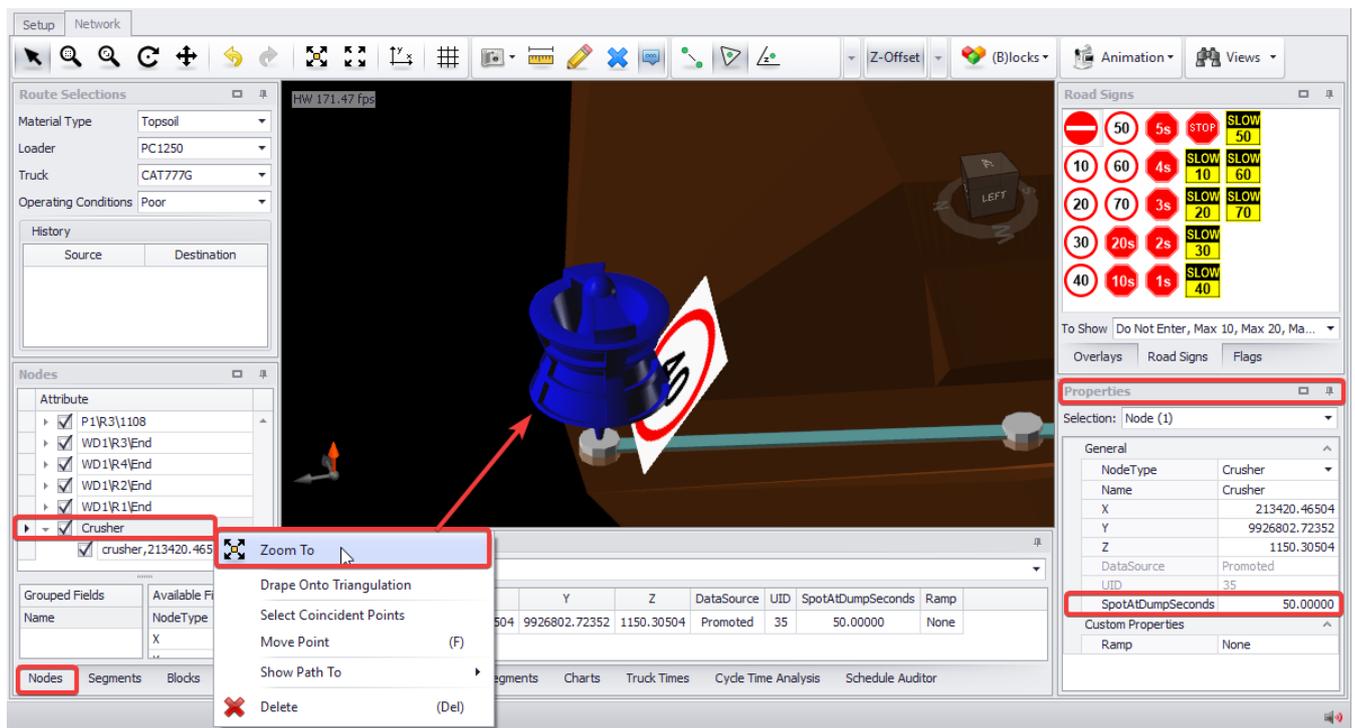
Nodes can be renamed with formulas in Microsoft Excel.  
Use the Export button > “Nodes & Segments to CSV”.

## Dump Time at Nodes

Every node has a SpotAtDumpSeconds property which controls the dump spot time at that location. For example, spot time at the crusher may be different from spot time on the main dump.

Set spot time at the crusher:

1. Navigate to the sample data \NodesVersion folder.
2. Open SampleModelWithNodes.hinf.
3. Open the **Nodes** panel in the bottom left of the screen.
4. Find "Crusher" in the list.
5. Right click and select "Zoom to". This should centre the crusher in the viewport.
6. Go to the **Properties** panel in the bottom right of the screen.
7. Change the SpotAtDumpSeconds from 30 to 50 seconds.



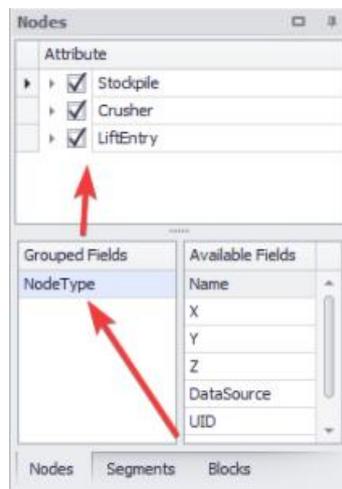
✓ This will increase the total cycle time of the truck by twenty seconds.

## Use the Nodes Panel

The **Nodes** panel is where nodes can be organised into groups for finding, hiding, and editing.

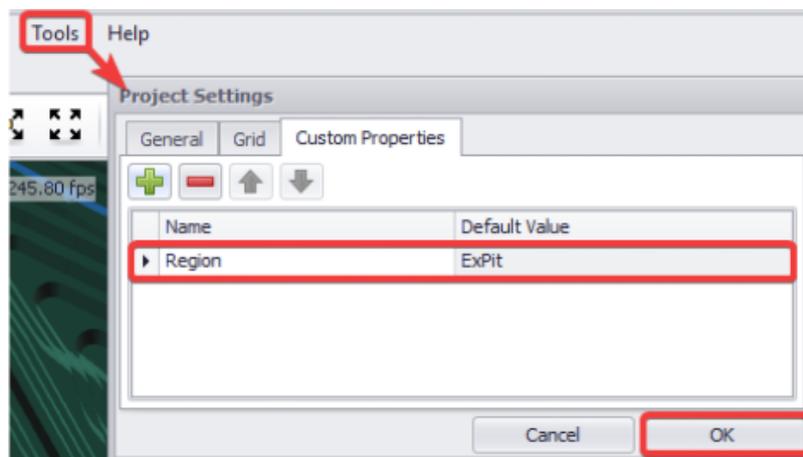
Organise nodes by property:

1. Navigate to the sample data \NodesVersion folder.
2. Open SampleModelWithNodes.hinf.
3. Open the **Nodes** panel in the bottom left of the screen.
4. Clear the **Grouped Fields** by dragging each row into the **Available Fields** list.
5. To organise nodes by their type, drag "NodeType" from the **Available Fields** list into the **Grouped Fields** list.
6. To organise nodes by their ramp, drag "Ramp" from the **Available Fields** list into the **Grouped Fields** list.



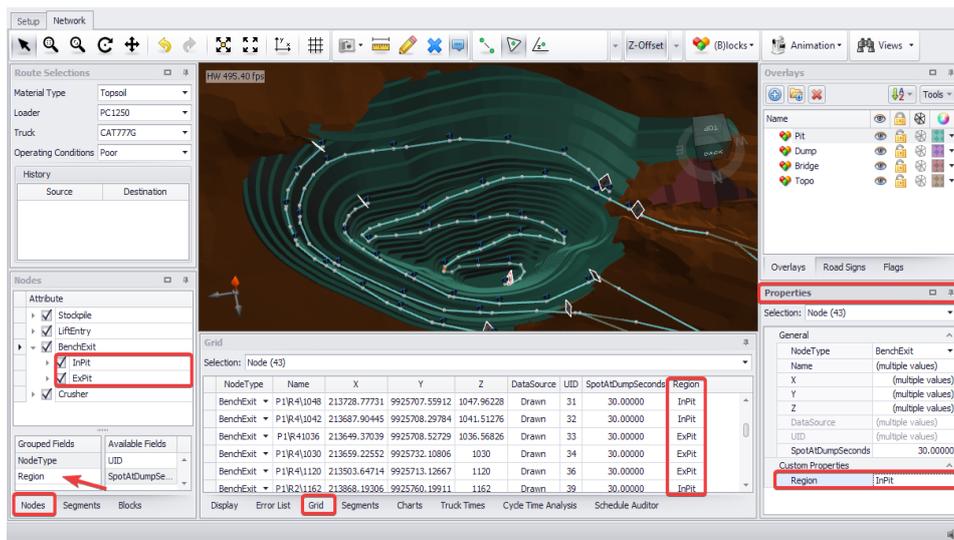
Create custom node properties:

1. Go to *Tools > Project Settings > Custom Properties*.
2. Press the green plus icon  to add a new property.
3. Rename the new property to "Region" and set the default to "Ex-Pit".
4. Press OK to accept.



5. Drag a box over the pit to select all in-pit nodes.
6. In the **Properties** panel change the selection the "Nodes".
7. In the **Properties** panel change the "Region" to "In-Pit".

- Go to the **Nodes** panel and drag "Region" to the top of the **Group Fields**.



- ✓ The nodes will now be grouped into in-pit and ex-pit nodes.

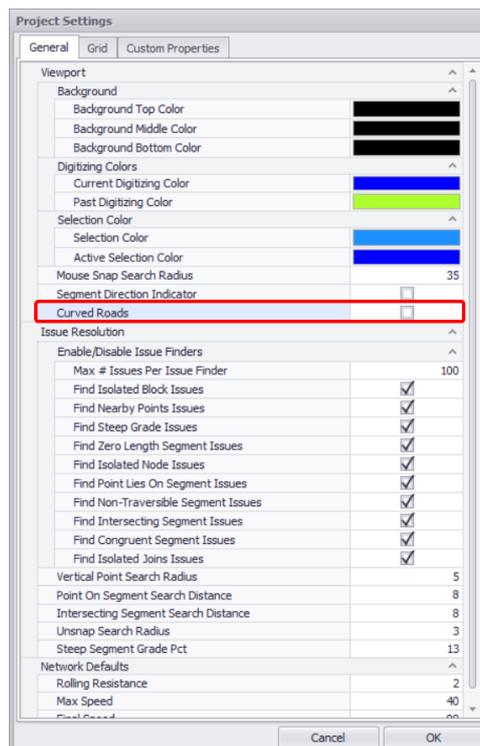
## Segment Exercises

These exercises illustrate the best practices for managing segments in a network.

### Curved Roads

Turn on curved roads by going to *Tools > Project Settings > General > Curved Roads*.

Haul Infinity will interpolate curved corners on roads so that less points are required to draw the network. This affects corner radius and overall cycle time.

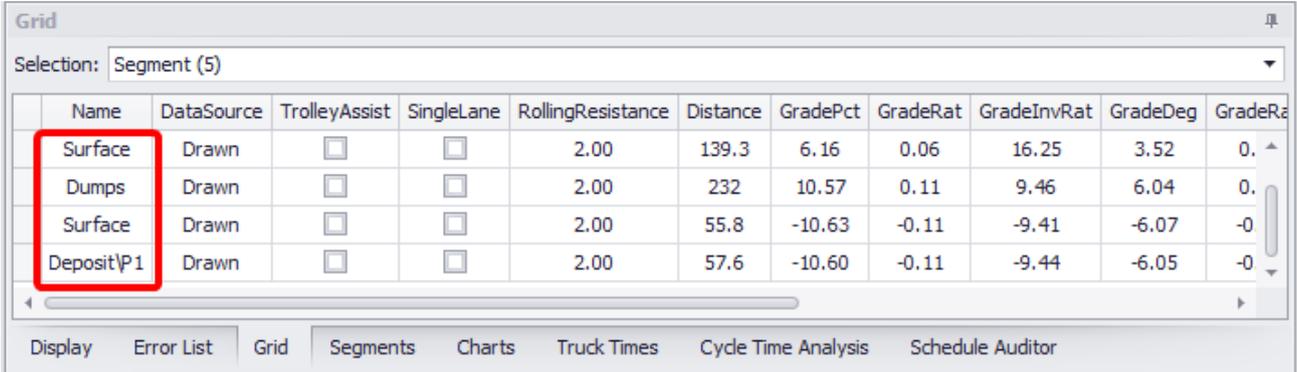


## Segment Naming

The **Segments** panel is where segments can be organised by name for finding, hiding, and editing.

To name segments in the Network tab:

1. Navigate to the sample data \NodesVersion folder.
2. Open SampleModelWithNodes.hinf.
3. Centre all data in the viewport.
4. Box select all roads in the network.
5. In the **Properties** panel, rename them to "Surface".
6. Box-select all roads in the pit.
7. In the **Properties** panel, rename them to "Deposit\P1".
8. Double-click the dump ramp and rename the segments to "Dumps".



Grid

Selection: Segment (5)

Name	DataSource	TrolleyAssist	SingleLane	RollingResistance	Distance	GradePct	GradeRat	GradeInvRat	GradeDeg	GradeRa
Surface	Drawn	<input type="checkbox"/>	<input type="checkbox"/>	2.00	139.3	6.16	0.06	16.25	3.52	0.
Dumps	Drawn	<input type="checkbox"/>	<input type="checkbox"/>	2.00	232	10.57	0.11	9.46	6.04	0.
Surface	Drawn	<input type="checkbox"/>	<input type="checkbox"/>	2.00	55.8	-10.63	-0.11	-9.41	-6.07	-0
Deposit\P1	Drawn	<input type="checkbox"/>	<input type="checkbox"/>	2.00	57.6	-10.60	-0.11	-9.44	-6.05	-0

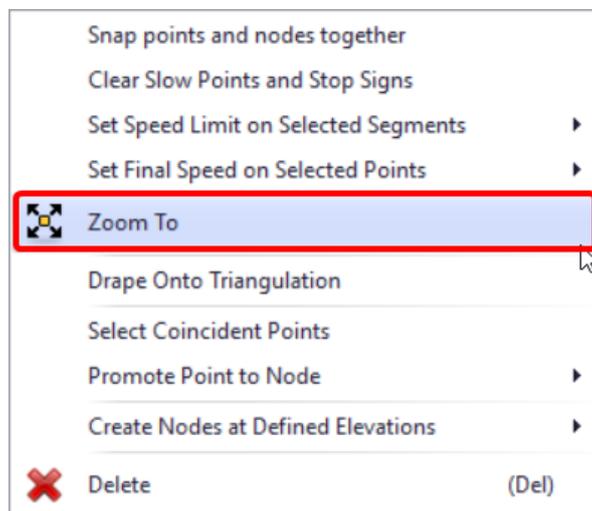
Display Error List Grid Segments Charts Truck Times Cycle Time Analysis Schedule Auditor

## Segment Groups

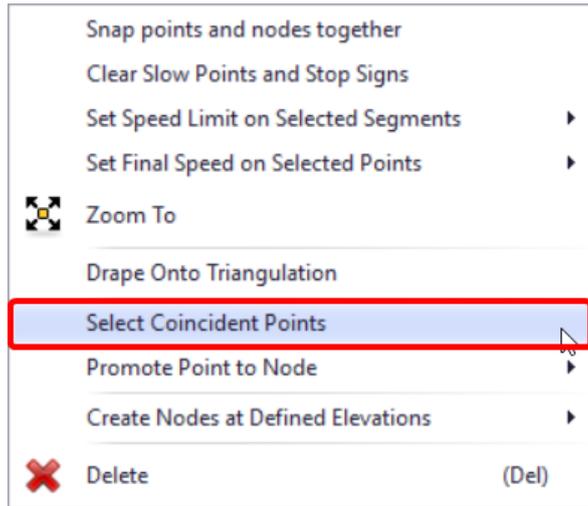
Grouping segments by name or data source can make it much easier to edit and interact with the network later on, especially if you have many interim pit ramps criss-crossing at different elevations.

Editing segments in groups:

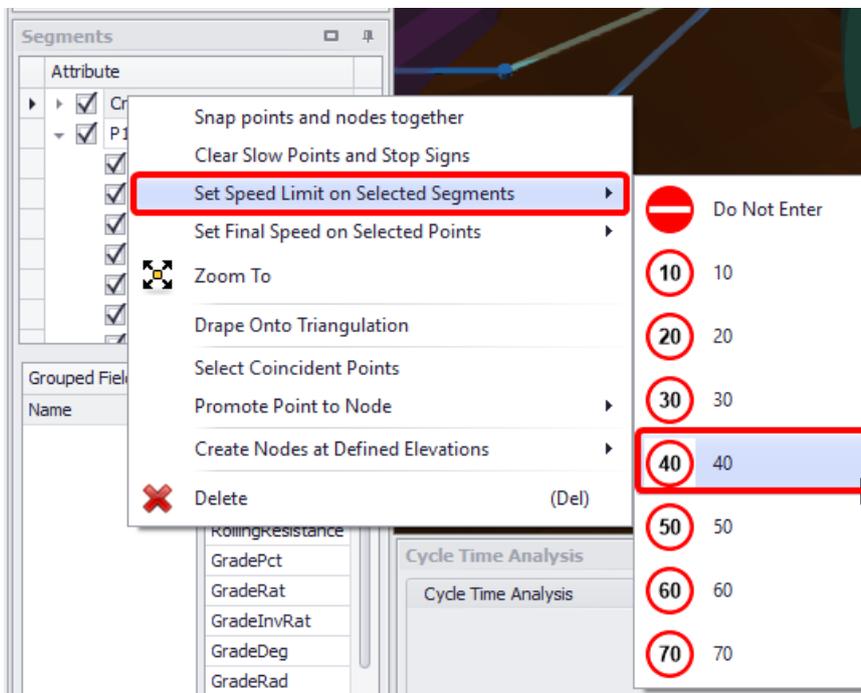
1. Go to the **Segments** panel and set the **Grouped Fields** to "Name"
2. Use the tick boxes to toggle visibility on and off.
3. Right Click > "Zoom To" to centre the group in the viewport.



4. Right Click > "Select Coincident Points" to select all nodes in the pit / in the dump.

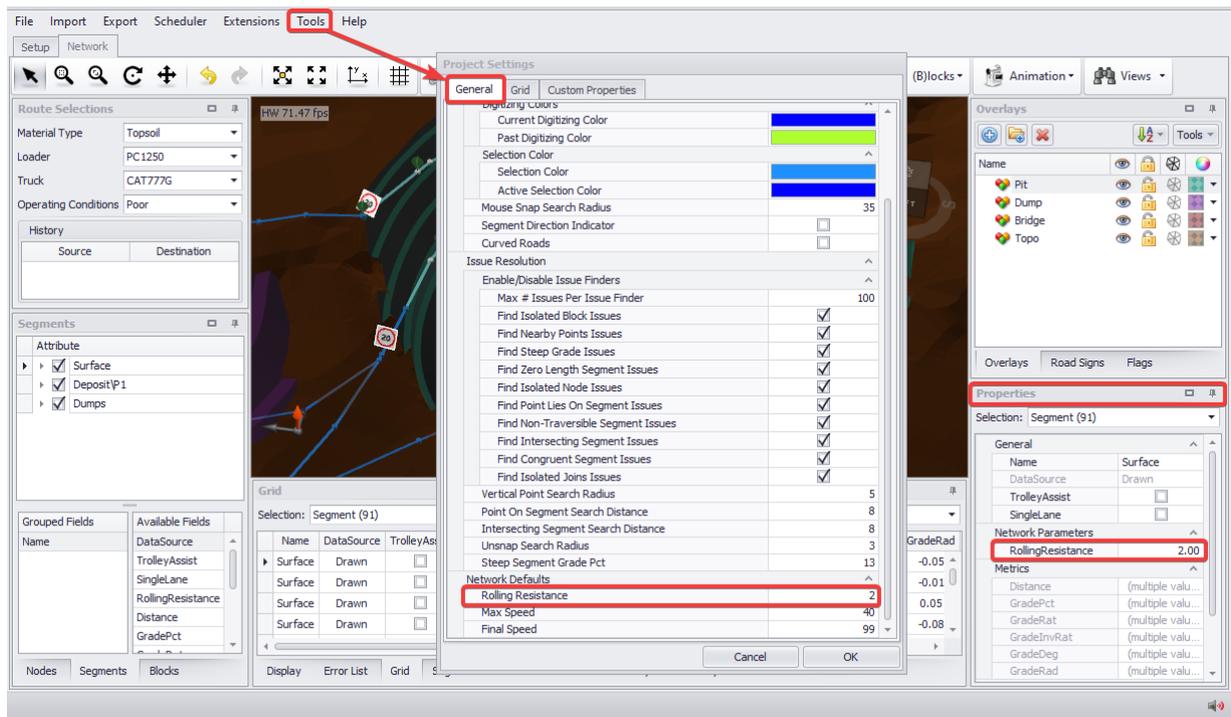


5. Right Click > “Set Speed Limit on Selected Segment” to set speeds in the pit / on the dump.



6. Select the “Surface” group and change the in-pit rolling resistance in the **Properties** panel.

The default rolling resistance is set in *Tools > Project Settings > General*.

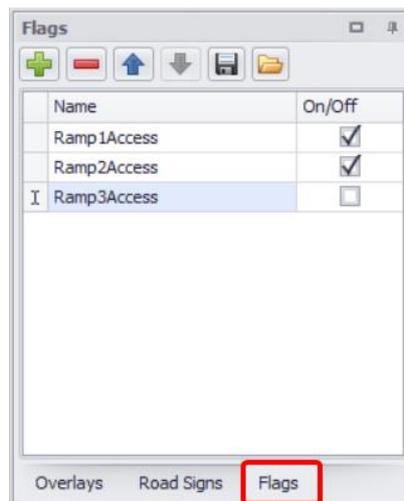


## Segment Flags

Flags are used to toggle road segments on or off. Flags can be referenced from your scheduling package to turn roads on and off according to a set of user-defined criteria. This may include staged ramp availability, seasonal calendar delays or restricted access periods. Using flags allows Haul Infinity to intelligently route trucks given a haul network which may be dynamic over time.

To turn off flagged segments:

1. Open the **Flags** panel.
2. Untick the flag.

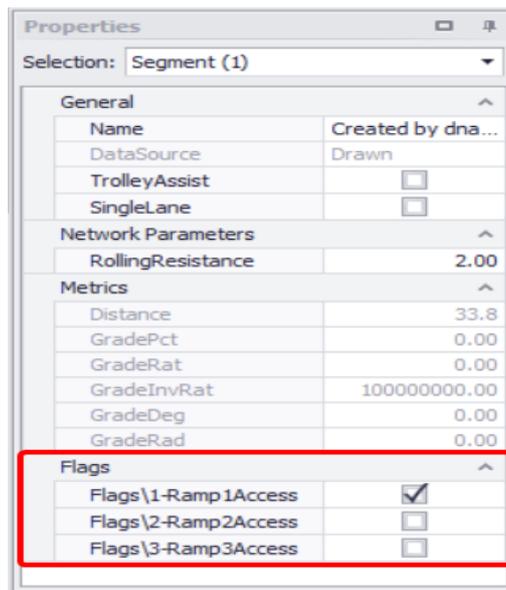


- ✓ This turns off any roads which have this flag in their properties.

To apply a flag to a segment:

1. Click on the segment.

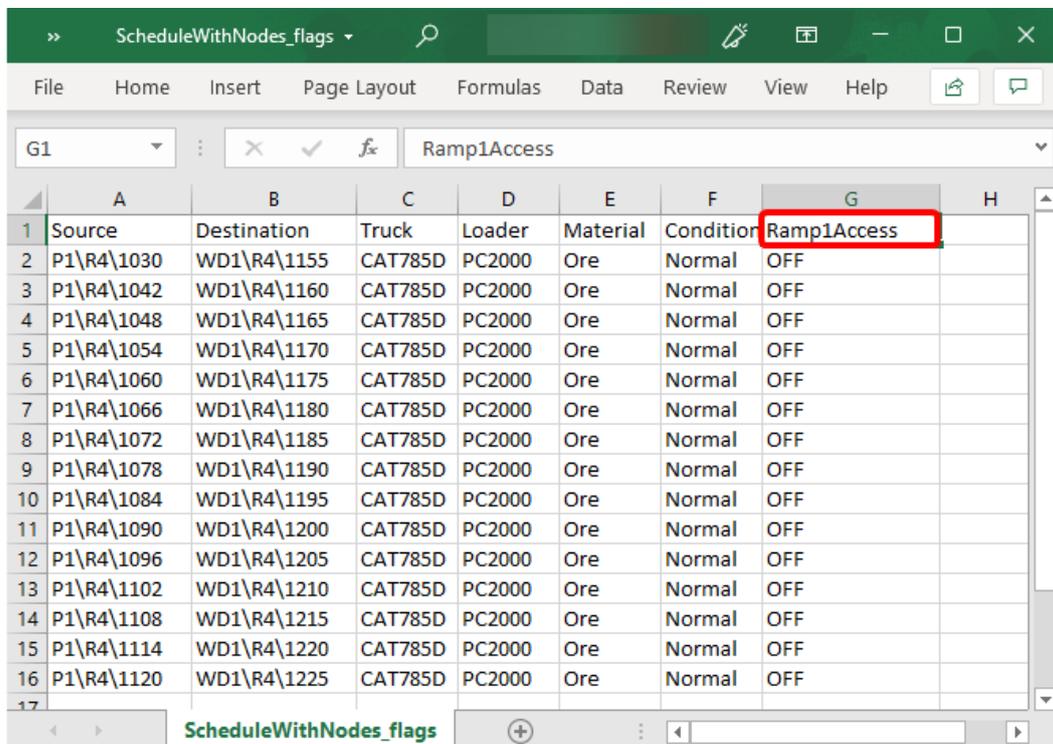
2. Tick the flag in the **Properties** panel.



- ✓ When the flag is turned off, this segment will not be traversable.

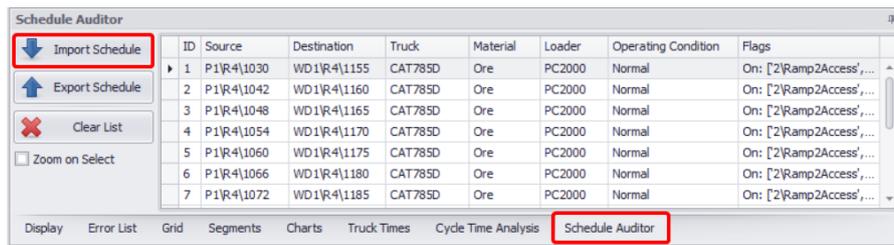
To add a flag to a schedule:

1. Navigate to the sample data \NodesVersion folder.
2. Open ScheduleWithNodes.csv.
3. At the first empty column, add a column header "Ramp1Access".
4. Set values in the column to "OFF".

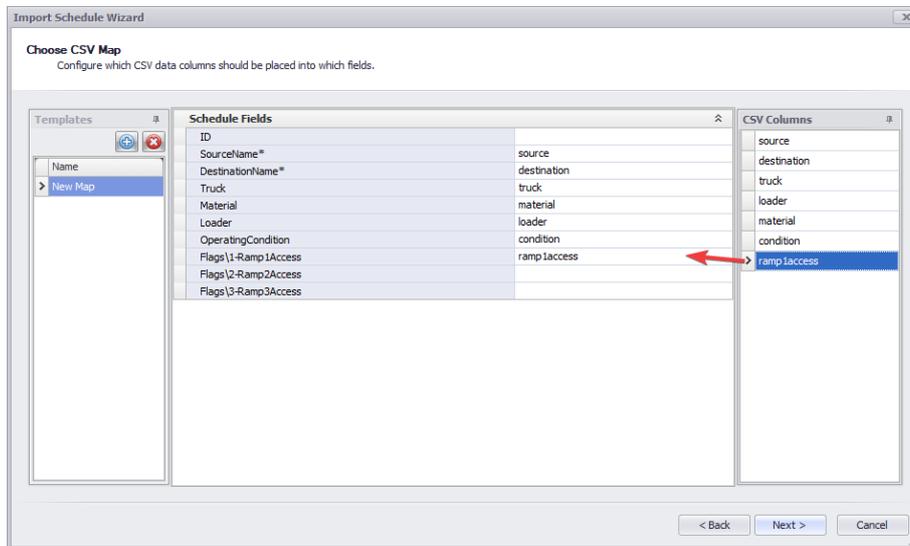


1. Save and close the schedule.
2. Navigate to the sample data \NodesVersion folder.
3. Open SampleModelWithNodes.hinf.

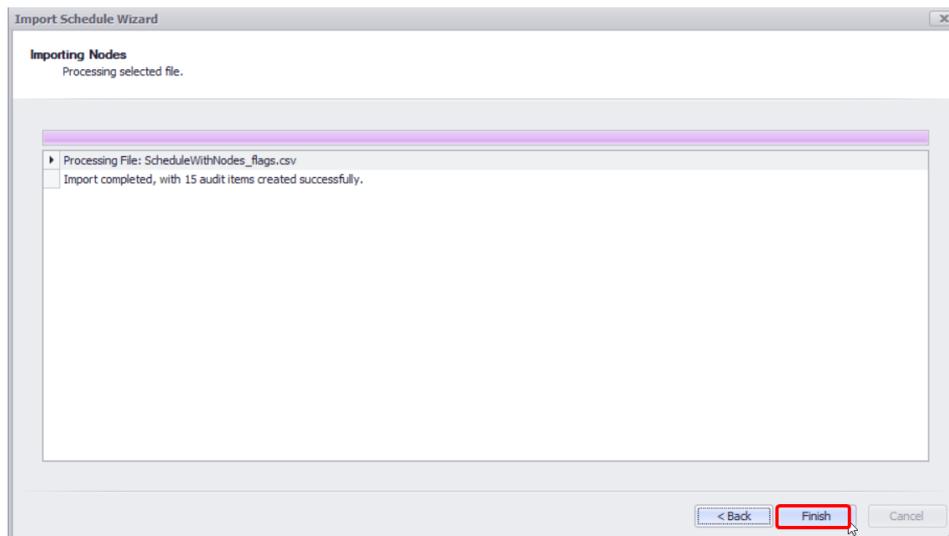
- Go to the **Schedule Auditor** tab and click **Import Schedule** button.



- Specify path to the saved .CSV file, which contains schedule to be imported and click NEXT.
- Map the fields to the column headers, including the "Ramp1Access" flag state and press NEXT.



- Review import results and click Finish to continue.



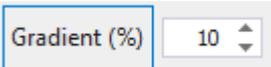
- Double click on the haul route in the list to display its animation in the viewport.
- ✓ When activating hauls through the schedule auditor, those hauls will correspond to the flag states in the schedule.

## Gradient Tools

Haul Infinity has tools for drawing segments at a specified grade, and for applying grades to existing segments.

### Gradient Draw Tool

To draw a ramp at 10 % grade:

1. Select the draw tool 
2. Set the snap mode to triangles 
3. Set the Gradient tool to 10% 
4. While in plan view, draw a road over the surface terrain.
5. Press <ESC> to exit the draw tool.
6. Turn off the Gradient tool by clicking on the "Gradient" text.
7. Rotate the viewport to see the 10% ramp.

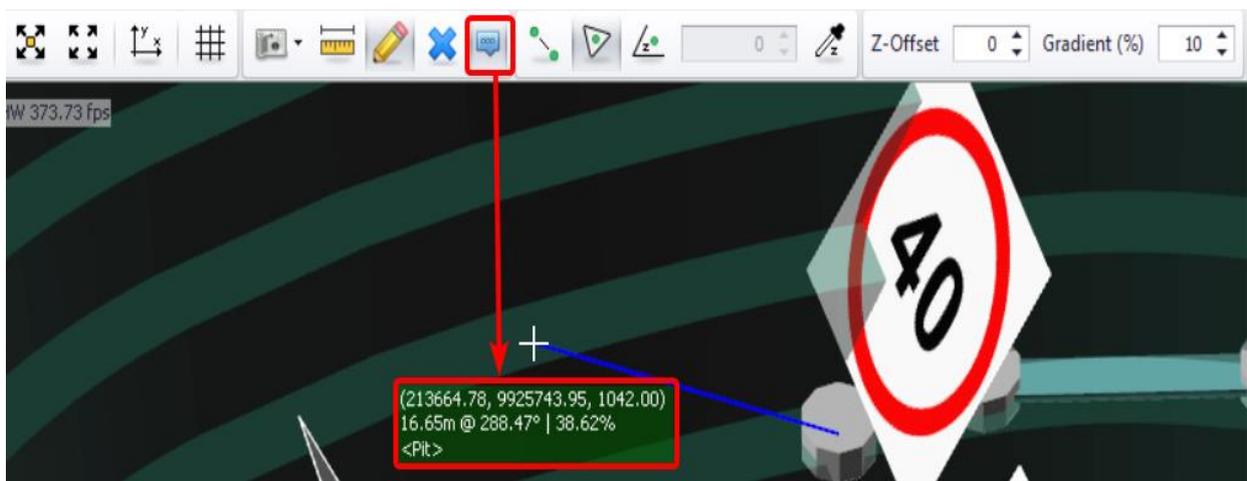
Use this tool to draw ramps when you don't have an existing design to snap to.

### Tooltips and offsets

When drawing an interim ramp up the side of a pit or dump, use the tooltips and offset dialog to get the best results.

Reading from tooltips:

1. Activate mouse over tooltips 
2. Select the draw tool and set the snap mode to triangles.
3. Find a spot at the toe of the dump and start drawing a ramp.
4. Hover the mouse over the next bench level to see the distance, bearing and gradient. Find a 10% gradient and continue the ramp.



Offset by coordinates:

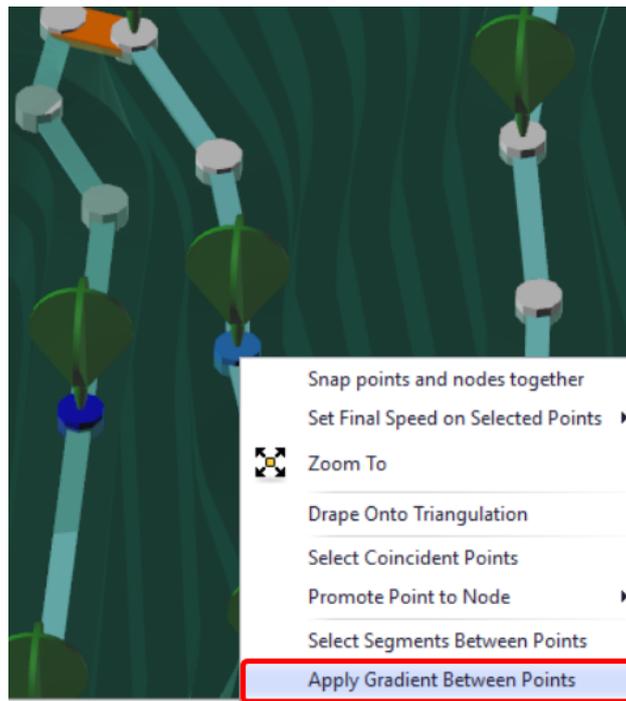
1. Find the next point on the ramp that is approximately 10% grade.
2. Hold control and left click to open the coordinate menu.

3. Change the gradient to exactly 10%.
4. Round the distance to the nearest whole number.
5. Press OK to continue.

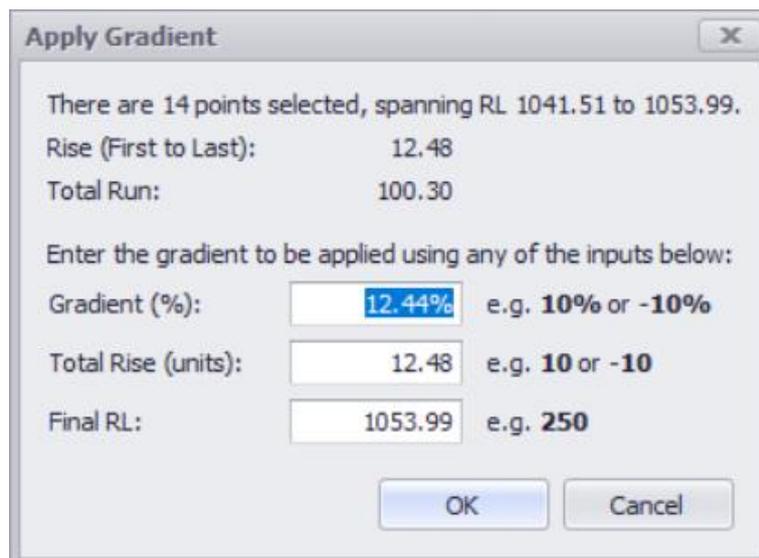
### Apply Gradient Between Points

To apply a gradient between points:

1. Hold <CTRL> key to select two points on the same road.
2. Right click > "Apply Gradient Between Points".



3. Set the gradient for all segments between the two points.



### Vertical offset tool

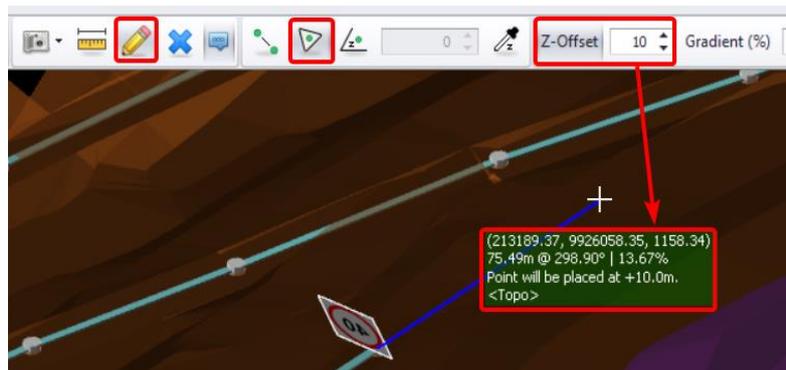
The Z-offset tool can be used to draw elevated roads such as a skyway or overpass.

## Draw segments with vertical offset:

4. Set snap mode to triangles.
5. Select the draw tool.



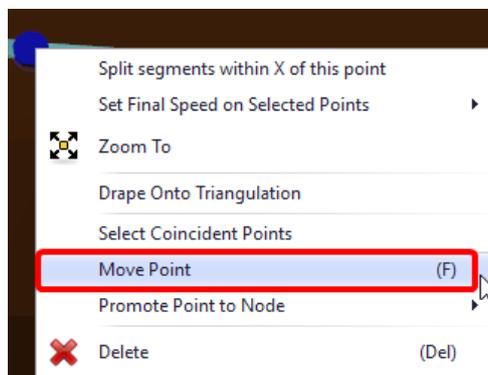
6. Change the Z-offset to 10 metres
7. Draw road over the topo surface.
8. Press <ESC> to exit the draw tool.
9. Turn off the z-offset tool by clicking on the "Z-Offset" text.



## Move a Point

To move a point:

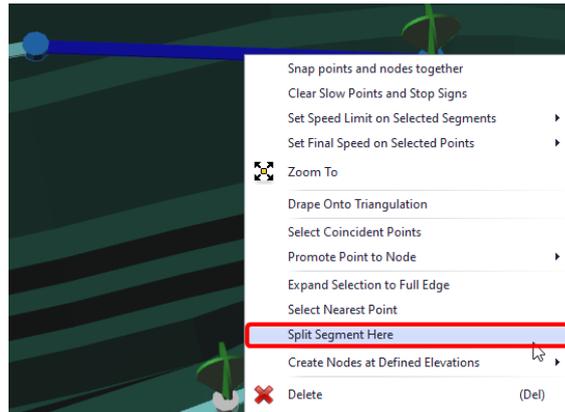
1. Double click a point on the network.
2. Right click > "Move Point".
3. Click where you want to move the point.



## Insert a Point

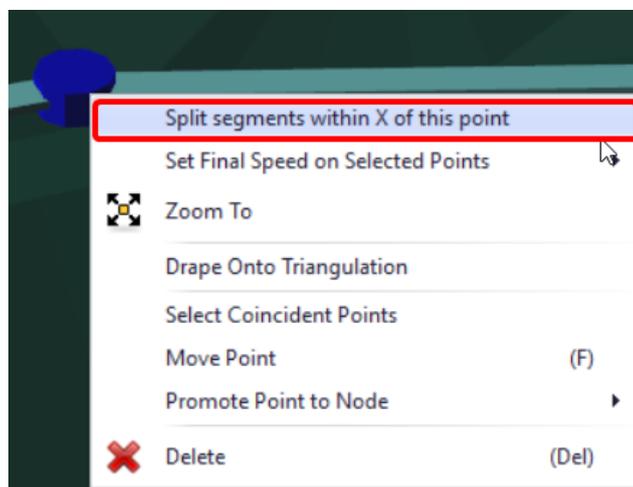
To insert a point:

1. Left click a segment on the network.
2. Right click > "Split Segment Here".

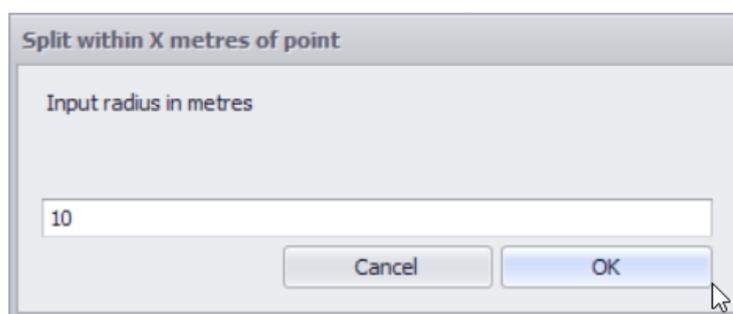


To insert points at a distance from another point:

1. Select a point on the network.
2. Right click > "Split segments within X metres of this point".



3. In the **Split within X metres of point window** enter a distance in metres, such as 10.



4. Press OK to apply.

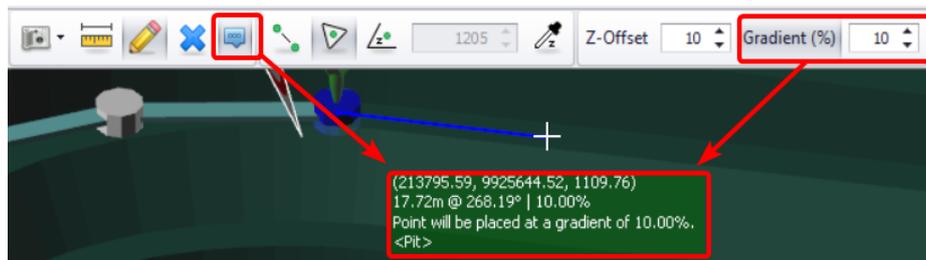


- ✓ You will see new point(s) within specified radius.

## Tooltips

When drawing a road, the tooltips will show the coordinates, distance, bearing and gradient of the point being drawn. This can be used to draw ramps at the correct grade over topo or designs.

To enable tooltips, press  or the <Space> bar on the keyboard.

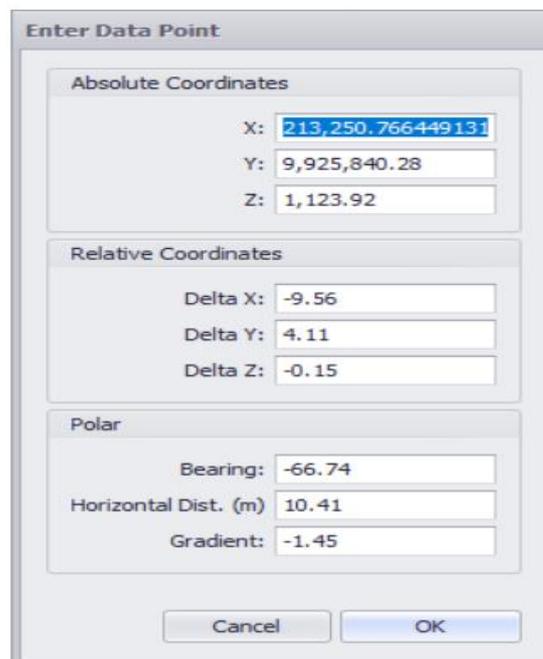


## Coordinate Menu

When drawing roads, the coordinates menu accepts absolute coordinates, relative offsets, and polar offsets.

To open the coordinate menu:

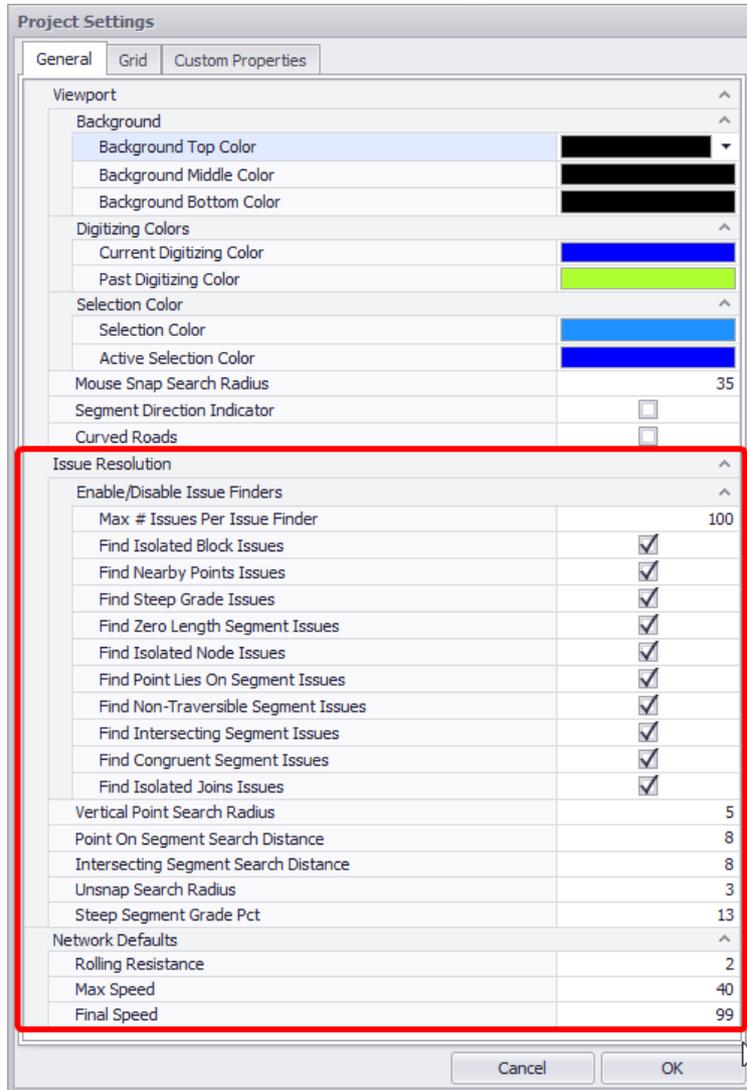
1. Press keyboard shortcut <D> to begin drawing.
2. Draw a point on the network.
3. Hold <CTRL> and click to draw a new point.
4. The coordinate menu will open with the coordinates of the clicked point.



# Error List Resolution

Haul Infinity detects problems in the network and lists them in the **Error List** tab below the viewport. Always keep the error list open while making changes to the network.

Error thresholds can be set in *Tools > Project Settings > General > Issue Resolution*.

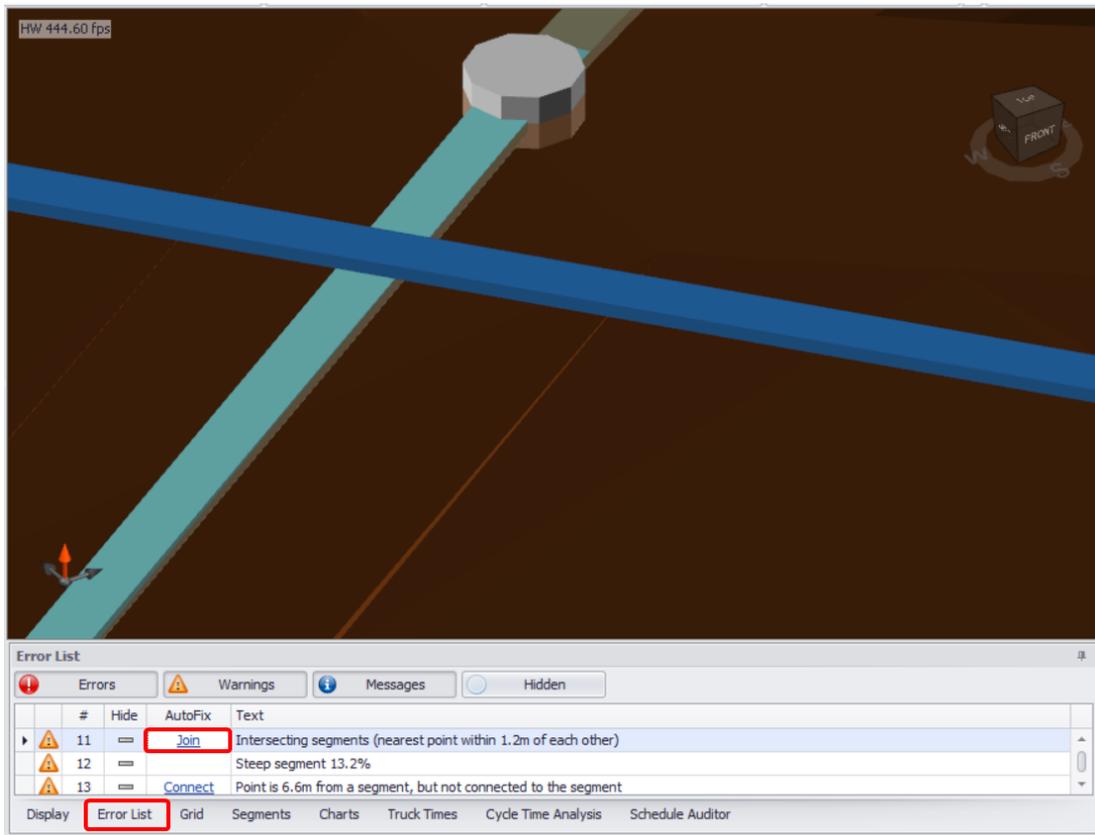


## Intersecting Segments

Intersecting segments occur when two segments cross over each other within a certain distance. This may look like a valid vehicular intersection, but the trucks will not be able to travel from one segment to the other.

Create overlapping segments:

1. Change snap mode to triangles.
2. Draw a single segment over the surface.
3. Draw a second segment crossing over the first.
4. Open the Error List and find the “Intersecting Segments” error.
5. AutoFix the error.



## Unsnapped Points

Unsnapped points occur when two points are within a threshold distance of each other. This may look like a valid network connection, but the trucks will not be able to travel from one segment to the other.

➤ **Create unsnapped points:**

1. Change snap mode to triangles.
2. Draw a single segment over the surface.
3. Draw a second segment parallel to the first, almost on top of it.
4. Open the **Error List** and find the “Unsnapped points” error.
5. AutoFix the error.

## Point Over Segment

Points over segments occur when a point is within a threshold distance of a segment, but not connected to that segment. This may look like a valid network connection, but the trucks will not be able to travel from one segment to the other.

### ➤ Create a point over a segment:

1. Change snap mode to triangles.
2. Draw a single segment over the surface.
3. Draw a second segment by clicking in the centre of the first segment, and then over the top (create a T-junction).
4. Open the **Error List** and find the "Point is 0.0 metres from a segment" error.
5. AutoFix the error.



## Zero Length Segments

Zero length segments usually occur when importing survey data or road networks that have duplicate points in them.

### ➤ Create a zero-length segment:

1. Draw a segment.
2. Change snap mode to points.
3. Select the end-point > Right click > "Move Point".
4. Move the end-point to the start-point. This creates a zero-length segment.
5. Open the **Error List** and find the "Zero Length Segment" error.
6. AutoFix the error.

## Duplicate Segments

Duplicate segments may occur when importing survey data or road networks that have duplicate strings in them.

### ➤ Create a duplicate segment:

1. Change snap mode to triangles.

2. Draw a single segment over the surface.
3. Change snap mode to points.
4. Draw a duplicate segment over the top of the first.
5. Open the **Error List** and find the “Two segments with identical start and end points locations” error.
6. AutoFix the error.

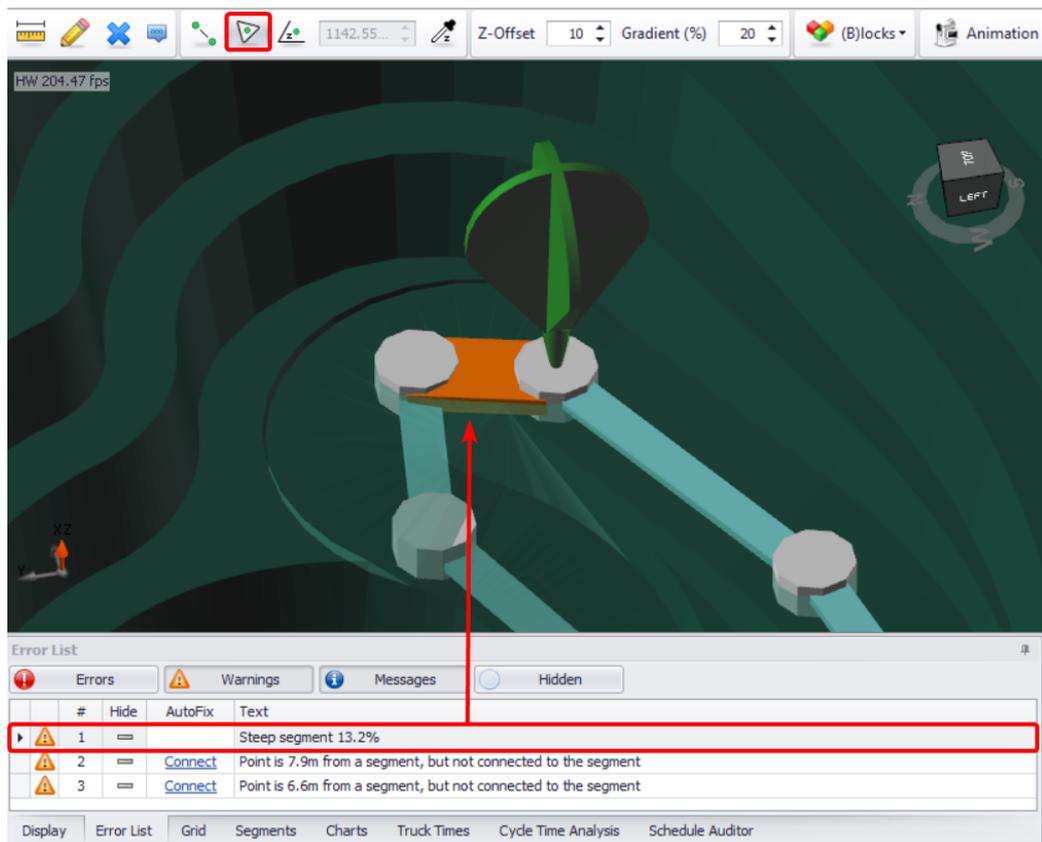
## Step Segments

Step segments are defined as roads too steep for the truck’s rimpull and braking curves, or greater than the global maximum gradient in Project Settings.

### ➤ Create a steep segment:

1. Set snapping mode to triangles.
2. Set the Gradient tool to 20%
3. Draw a ramp over the surface.
4. Press okay to accept.
5. Open the **Error List** and find the “Step Segment” error.

Step segments must be fixed manually by re-drawing the ramp or smoothing the segments.



## Truck TKPH Exercises

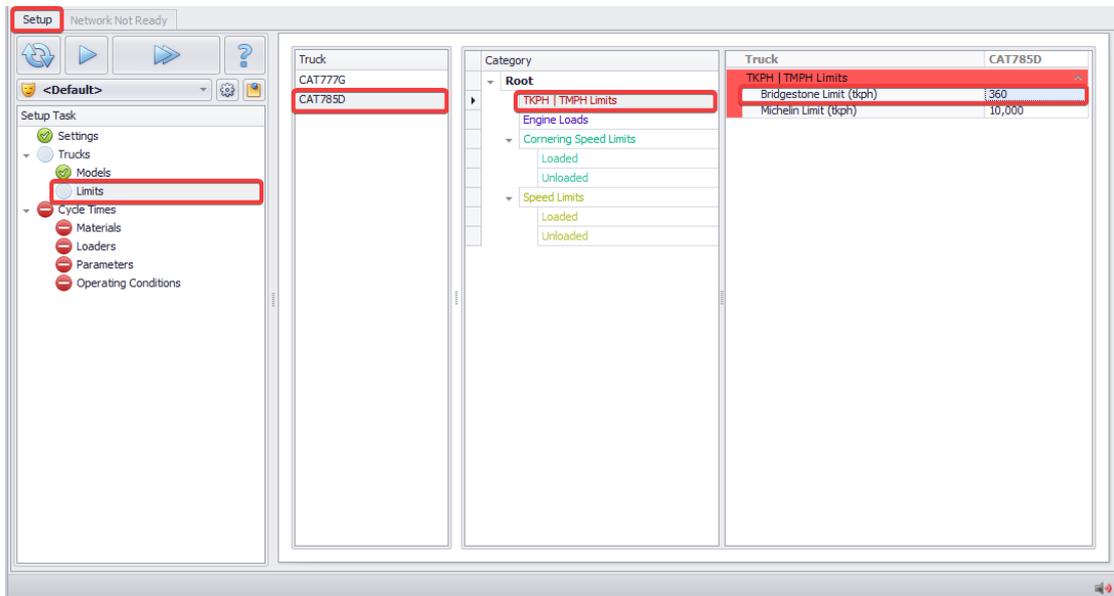
TKPH calculations are used to keep the tyre temperature within safe limits. This is calculated as a function of payload and distance travelled.

## Enter TKPH Constraint

Each truck type will have a different TKPH limit depending upon the tyres on the machine.

To create TKPH constraints:

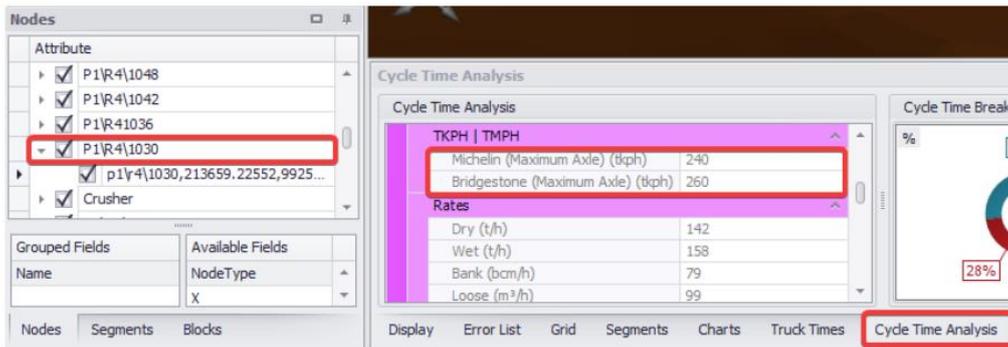
1. Look up the tyre TKPH limits from the tyre manufacturer. In this example we will be running CAT 785D trucks with Bridgestone 33.00R51 VRLS E1A tyres, with a TKPH rating of 603.
2. Navigate to the sample data \NodesVersion folder.
3. Open SampleModelWithNodes.hinf.
4. Go to the **Setup** tab and open **Limits** step.
5. Select CAT785D from the trucks list.
6. Select the **TKPH Limits** from the categories.
7. Leave the Michelin constraint at 10,000
8. Change the Bridgestone constraint to 360.



Whenever the tyre TKPH rises above 360, Haul Infinity will implement a TKPH delay in the cycle time for the tyres to cool down.

To see the TKPH value on a given haul:

1. Go to the **Network** tab.
2. Find the source node P1\R4\1030 on the floor of the pit.
3. Right click on the node > "Show Path To" > "Loaded" > "LiftEntry" > "WD1\R4\End".
4. Open the **Cycle Time Analysis** tab.
5. Scroll down to the TKPH values.
6. Read the TKPH values for Axle 1 and Axle 2.



Whenever these values rise above a TKPH constraint, then a TKPH delay will be implemented.

Michelin TKPH values require an ambient temperature to be specified.

The default is 32°C in *Setup > Operating Conditions > Normal*.

## Truck Speed Exercises

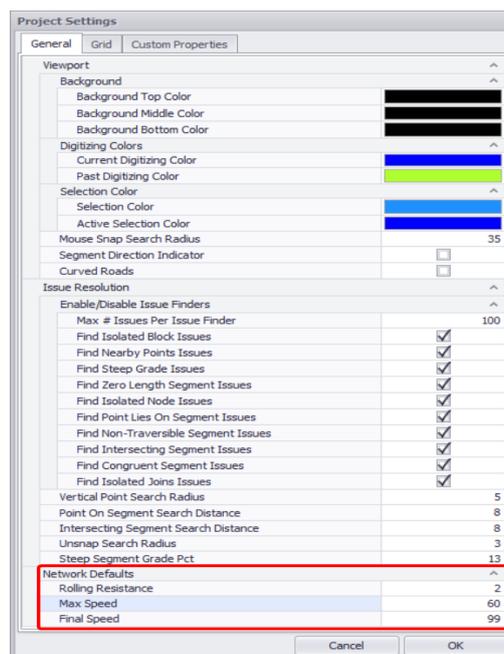
Road networks in Haul Infinity have default speeds, signposted speeds, global maximum speeds, cornering speeds and ramp speeds. Wherever two speed settings conflict, the lowest speed will be chosen.

### Change the Default Speed

Whenever a new segment is drawn, it is automatically signposted at the default speed.

To change the network default speed:

1. Go to *Tools > Project Settings > General > Network Defaults*.
2. Change the Max Speed to 60.



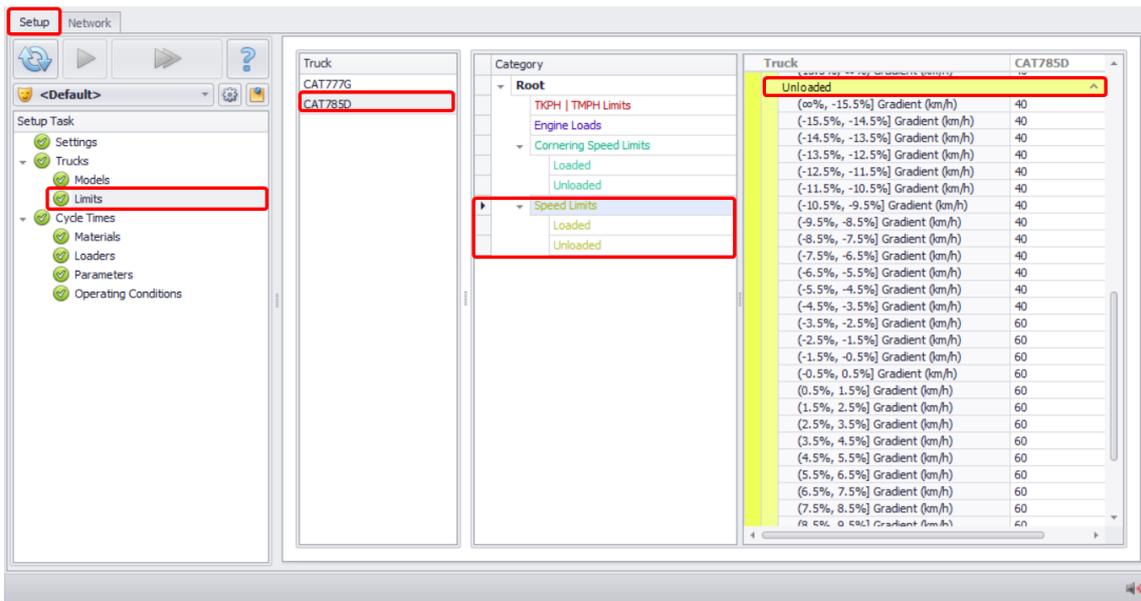
- ✓ Newly drawn segments will now have a speed limit of sixty kilometres per hour.

## Global Speed Limits

A truck is never allowed to travel faster than its global speed limit. The global speed limits are set individually for each truck in the **Trucks** steps.

To set global speed limits:

1. Open SampleModelWithNodes.hinf from the samples folder.
2. Go to the **Trucks > Limits** step.
3. Select the CAT785D from the trucks list.
4. Go to the **Speed Limits** fields.
5. Set the unloaded speed limit to 40.



This means that even if you place a 60 km/h sign on the network, the CAT 785D trucks will never travel faster than 40 km/h. For example, you might use this to lock the CAT 785s in fifth gear but leave the CAT 777s unlocked.

## Downhill Speed Limits

A truck is never allowed to exceed its loaded or unloaded downhill speed limit. The downhill speed limits are set individually for each trucks in the **Trucks > Limits** step.

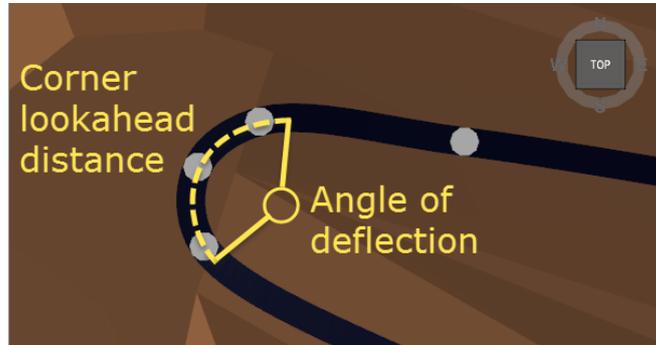
To set downhill speed limits:

1. Open SampleModelWithNodes.hinf from the samples folder.
2. Go to the **Trucks > Limits** step.
3. Select the CAT785D from the truck list
4. Go to the **Speed Limits** fields.
5. Change the loaded downhill speed limit to 17 km/h for gradients greater than 4%.

This can be useful for locking trucks in second gear downhill loaded, or fourth gear downhill unloaded, according to your site safety rules and operating practices.

## Cornering Speeds

Cornering speeds are used to slow down trucks at intersections and switchbacks. Corners are measured by the angle of deflection and the lookahead distance.



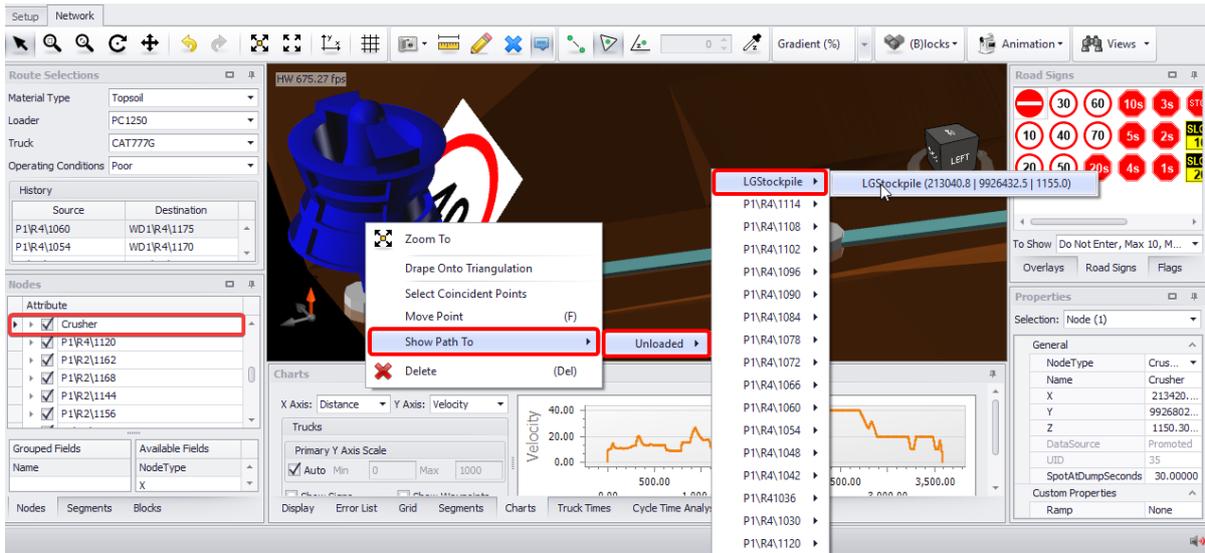
The angle of deflection is calculated from the total distance travelled during cornering (the “corner lookahead distance”).

To set cornering speed limits:

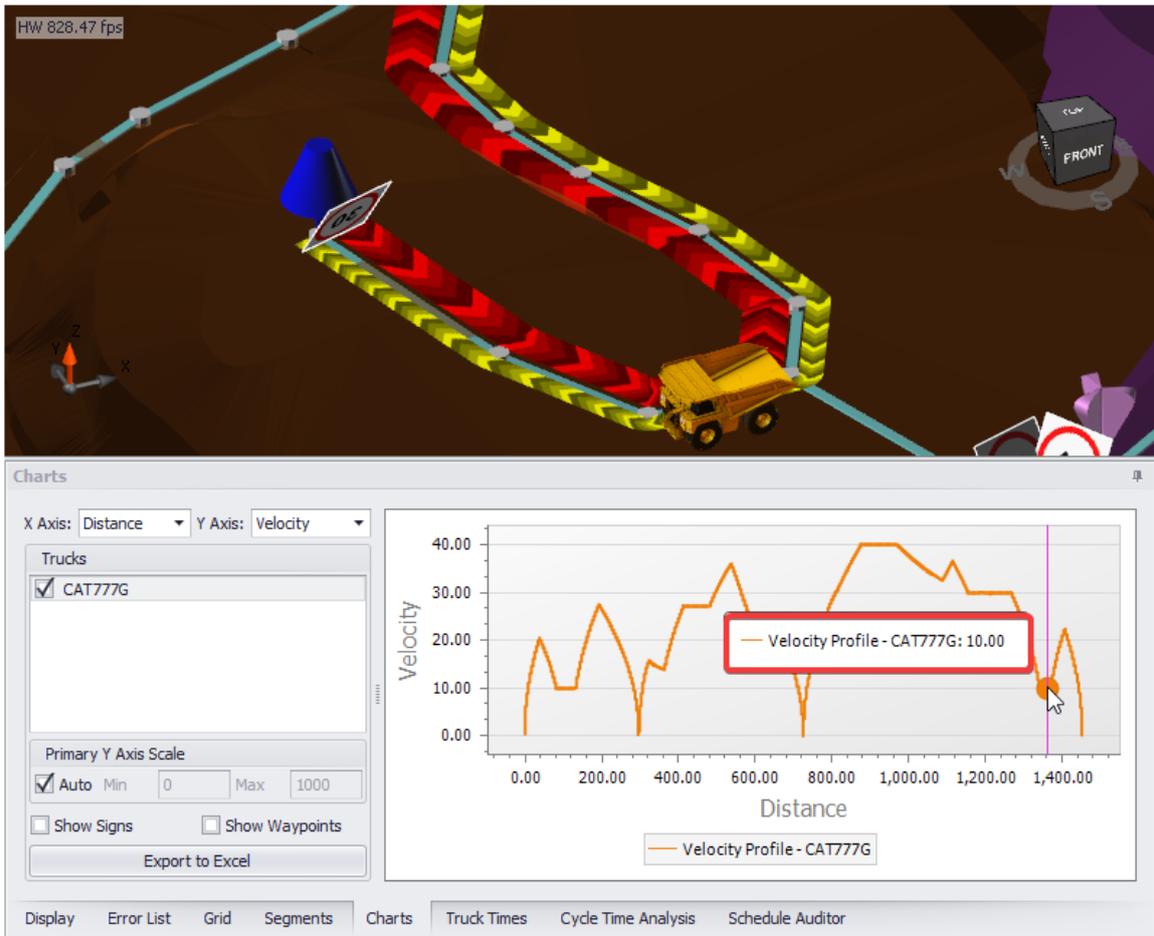
1. Open SampleModelWithNodes.hinf from the samples folder.
2. Go to the **Trucks > Limits** step.
3. Go to the **Cornering Speed Limits** fields.
4. Set the speed limit to 10 km/h for deflections greater than 80 degrees.

Cornering Speed Limits	
Loaded	
[0°, 10°) Deflection (km/h)	100
[10°, 20°) Deflection (km/h)	100
[20°, 30°) Deflection (km/h)	100
[30°, 40°) Deflection (km/h)	100
[40°, 50°) Deflection (km/h)	100
[50°, 60°) Deflection (km/h)	100
[60°, 70°) Deflection (km/h)	100
[70°, 80°) Deflection (km/h)	10
[80°, 90°) Deflection (km/h)	10
[90°, 100°) Deflection (km/h)	10
[100°, 110°) Deflection (km/h)	10
[110°, 120°) Deflection (km/h)	10
[120°, 130°) Deflection (km/h)	10
[130°, 140°) Deflection (km/h)	10
[140°, 150°) Deflection (km/h)	10
[150°, 160°) Deflection (km/h)	10
[160°, 170°) Deflection (km/h)	10
[170°, 180°) Deflection (km/h)	10

5. Go to the **Network** tab.
6. Select the Crusher > Right click > “Show Path To” > “Stockpile”.



7. Go to the **Charts** tab.
8. Confirm that the truck is slowing on corners.



- ✓ Velocity profile curve shows that on selected section truck slowed down to 10 km/h.

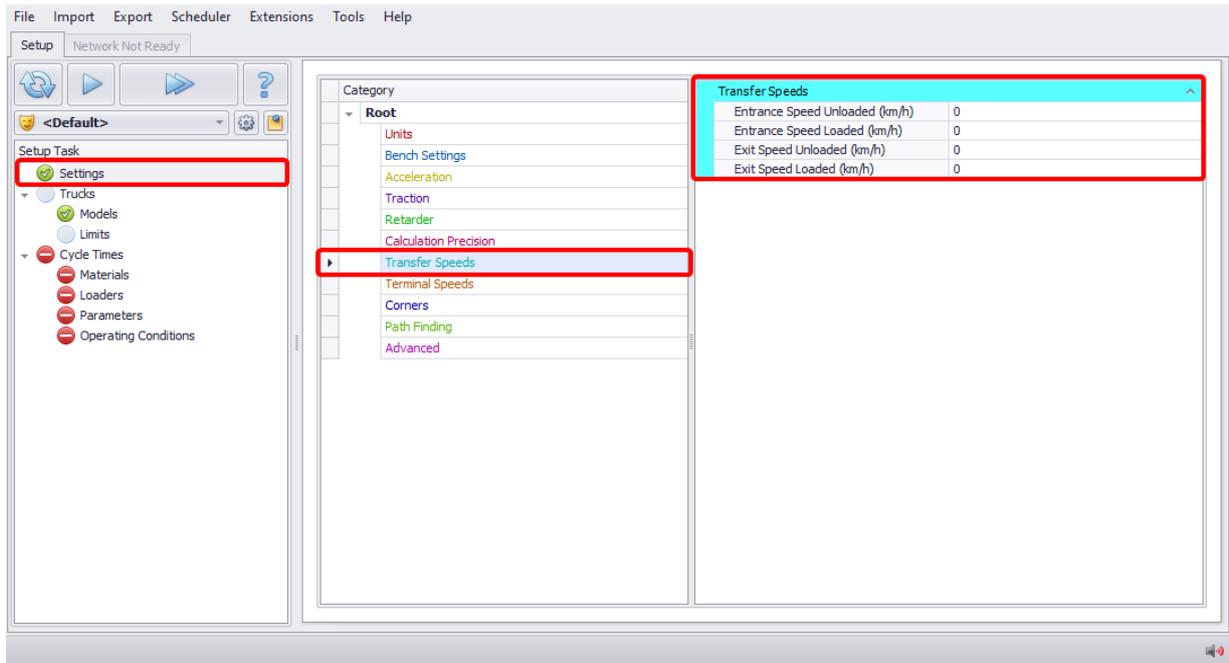
## Transfer Speeds

Transfer speeds are the speeds at which a truck arrives at and exits from a node. In almost all projects this should be set to zero since trucks slow to a stop at the digger and at the dump.

If you are modelling a partial haul, for instance terminating at the on-ramp to a highway, then the “Exit Speed Loaded” and the “Entry Speed Unloaded” could be set to the speed limit of the highway.

Note that this will apply to all nodes in the project.

If you are modelling a conventional truck and shovel operation, leave these values at zero.



## Road Signage

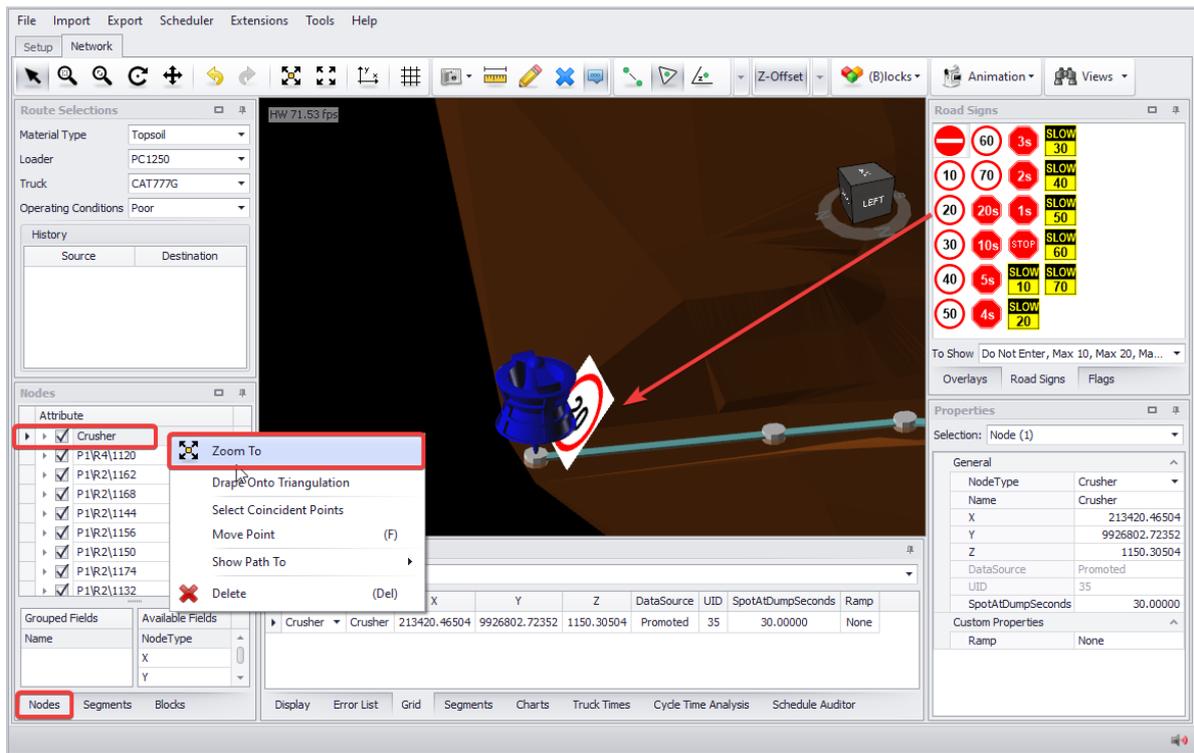
Speed signage is displayed where there is a change in speed between two segments, or at the end point of a road.

- ✓ Speed signs set the maximum forward and backward speeds across a segment.
- ✓ Slow points cause trucks to decelerate to that speed before they exit the segment.

There are different ways you can use to set speed limits on your project network.

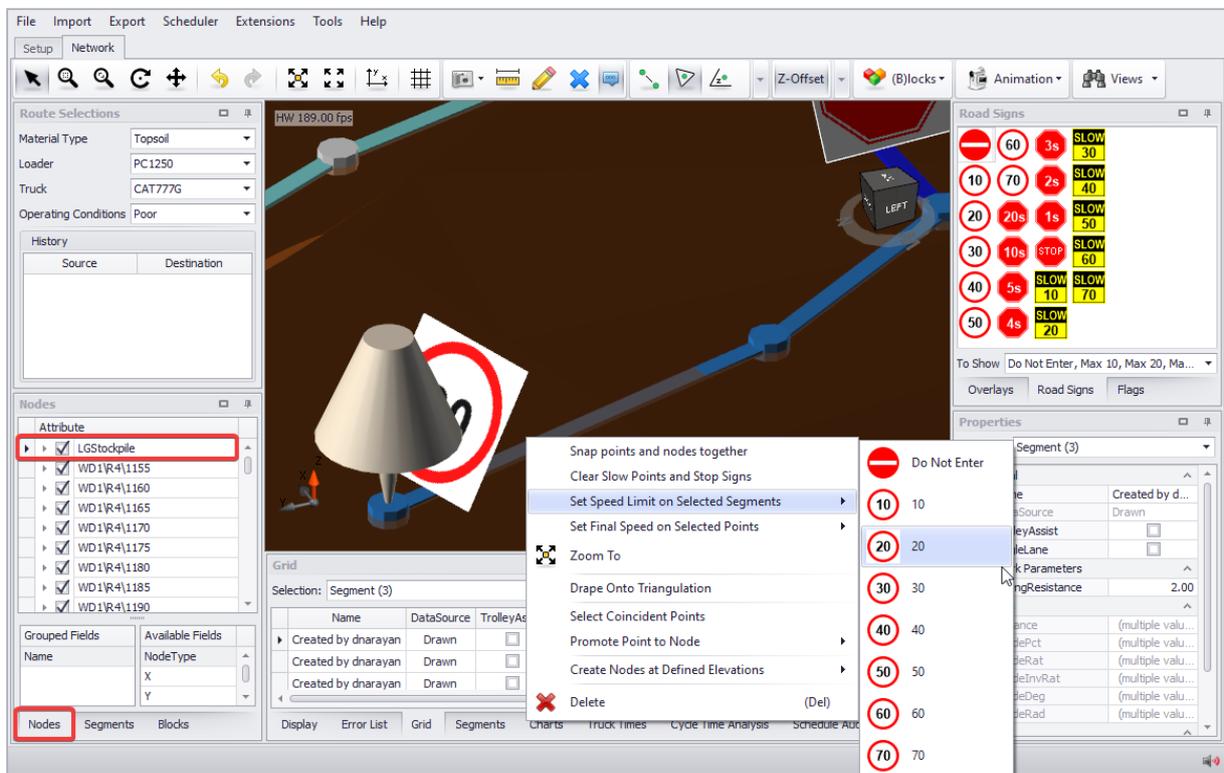
Dragging signs onto the network:

1. Go to the **Network** tab and in **Nodes** panel choose "Crusher", right click and press "Zoom To".
2. Locate the **Road Signs** panel to the right of the viewport
3. Select a 20 km/h sign and drag it onto the road approaching crusher.



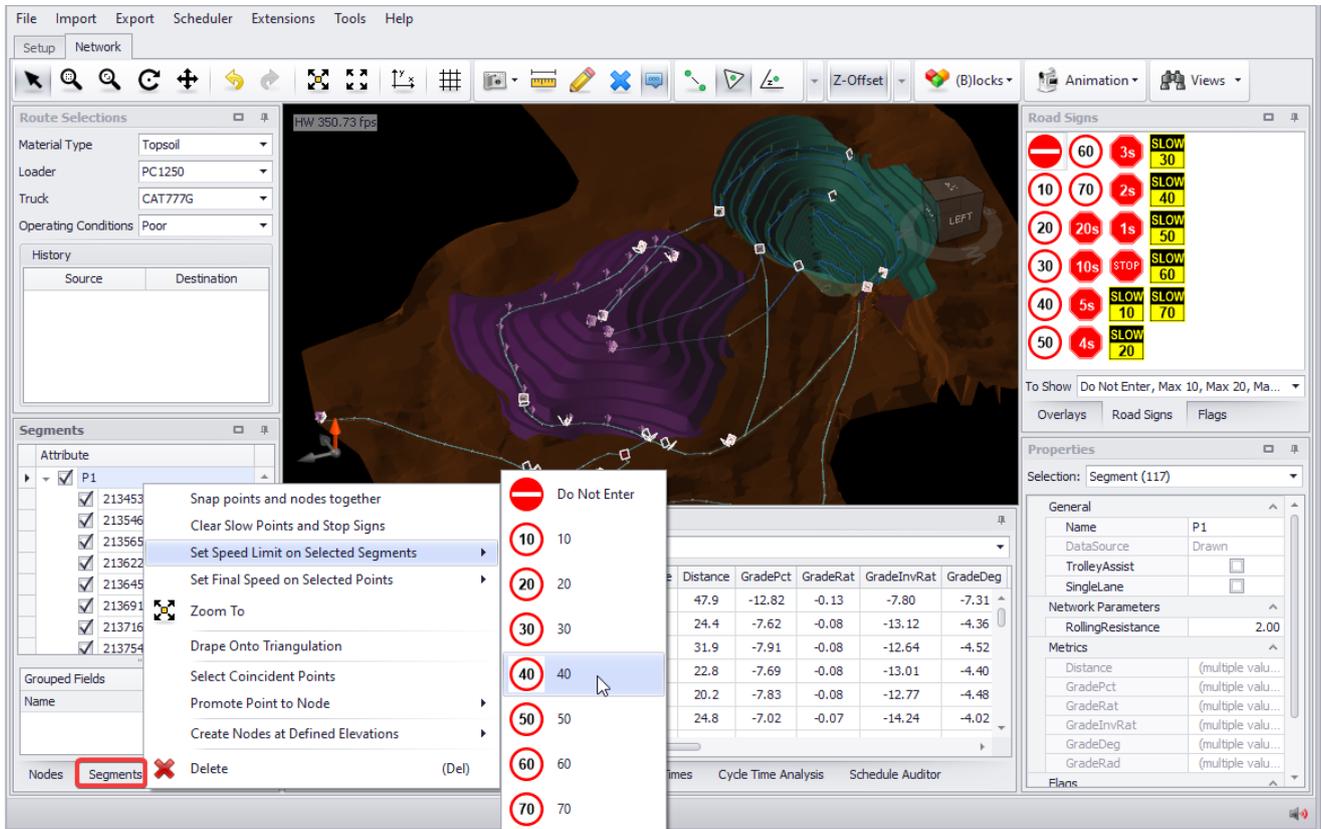
Assigning speed in the viewport via right click menu:

1. Go to **Network** tab and in **Nodes** panel choose "LGStockpile", right click and press "Zoom To".
2. Double click the entry road to the stockpile.
3. Right click > *Set Speed Limit on Selected Segments > 20 km/h.*



Assigning speed in the Segments panel via right click menu:

1. Go to **Network** tab and in **Segments** panel select roads by name (ie. "P1").
2. Right click > *Set Speed Limit on Selected Segments* > 40 km/h.



# Haul Infinity Calculation FAQ

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These notes are included as a reference for the cycle time calculations.

## Loader Load Time

The Loader Load Time is equal to the First Pass Delay added to the total bucket swing time. Any other delay becomes part of the Loader Idle Time.

$$\text{LoaderLoadTime} = \text{FirstPassDelay} + \text{NumPasses} * \text{BucketCycleTime}$$

## Truck Load Time

The Truck Load Time excludes the First Pass Delay and the first bucket swing (these fall into the queue and spot time).

$$\text{TruckLoadTime} = (\text{NumBuckets} - 1) * \text{BucketCycleTime}$$

## Truck Matching

The Nominal Number of Trucks is calculated as the nominal cycle time divided by the effective loader load time.

$$\text{NominalNumTrucks} = \text{NominalTruckCycleTime} / \text{EffectiveLoaderLoadTime}$$
$$\text{EffectiveLoaderLoadTime} = \text{Min}(\text{LoaderLoadTime}, \text{TruckPayload} / \text{LoaderRateOverride})$$

This number is then rounded or replaced according to the Truck Matching Method and the Truck Number Override.

## Truck Queue Time and Loader Idle Time

If the digger is over trucked, then there will be queue time.

$$\text{FinalQueueTime} = \text{Max}(\text{MinimumQueueTime}, \text{CalcQueueTime})$$
$$\text{CalcQueueTime} = \text{NumTrucks} * \text{EffectiveLoaderLoadTime} - \text{NominalCycleTime}$$

If the digger is under trucked, then there will be loader idle time.

$$\text{LoaderIdleTime} = \text{NominalTruckCycleTime} - \text{NumTrucks} * \text{EffectiveLoaderLoadTime}$$

## TKPH Delay

TKPH delays are calculated from the axle weights and truck speeds according to the formulas available in Michelin and Bridgestone handbooks.

Note that Michelin provides a temperature coefficient for calculating TKPH at different temperatures. This coefficient can sometimes be negative if the average haul speed is below 5 kilometres per hour. Essentially this means that there are no TKPH delays.

# Blocks Exercises

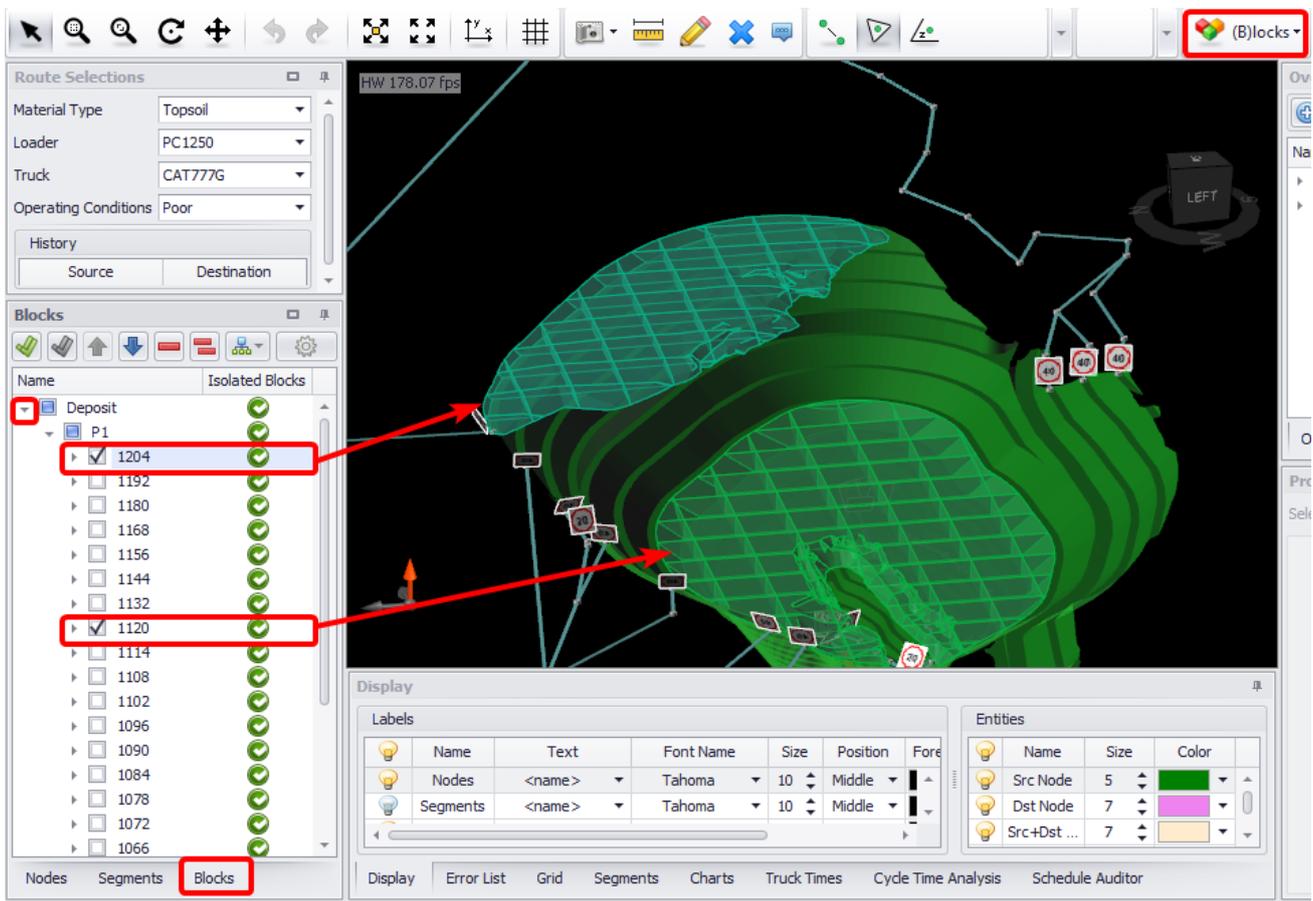
The following exercises focus on managing blocks, connecting them to the network and applying on-bench travel rules.

## Blocks Panel

The blocks panel is where blocks can be selected, hidden, and centred in the viewport.

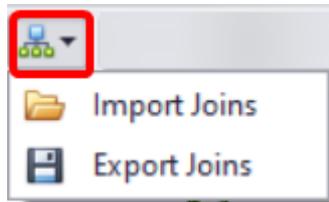
To use the blocks panel:

1. Select "Show Blocks" from the **Blocks** button in the top toolbar.
2. Open the **Blocks** panel in the bottom left of the **Network** tab.
3. Expand the block tree.
  - a. When you click on a row in the tree, that row should be **temporarily** visible in the viewport.
  - b. When you tick a row in the tree, that row should be **permanently** visible in the viewport.
  - c. When you double click a row, it should centre those blocks in the viewport.

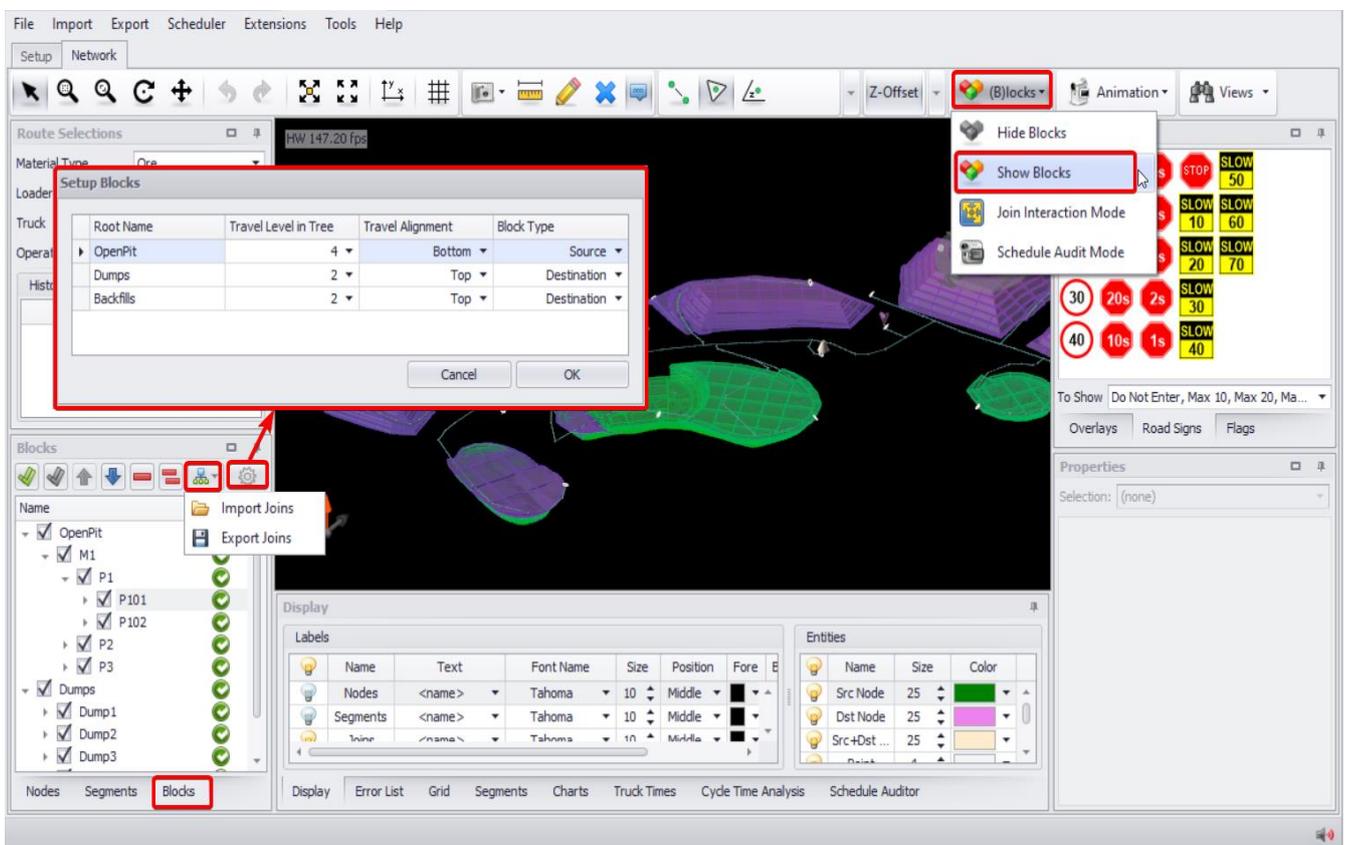


- Check all blocks with the green double-tick icon .
- Uncheck all blocks with the grey double-tick icon .
- Change the tree order with the blue arrow icons  .
- Remove a row with the single red minus icon. (This cannot be undone!) .

4. Remove all blocks with the double red minus icon. (This cannot be undone!) 
5. Import or export joins to the ".blockJoins" file by selecting the appropriate import/export options.



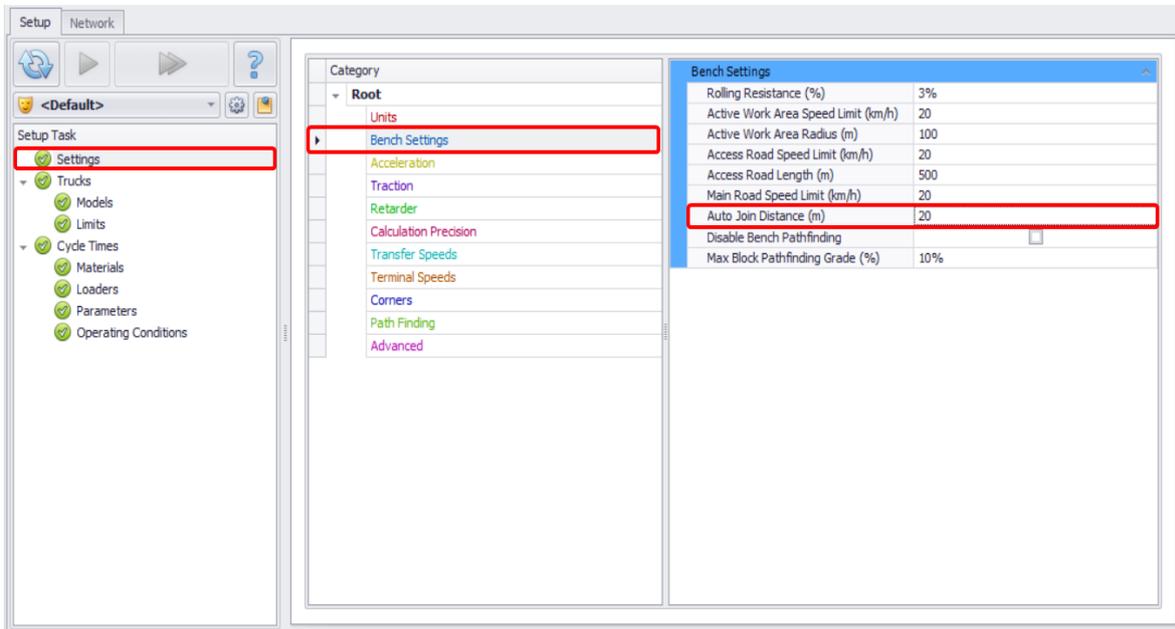
6. Press the cog icon to open the **Setup Blocks** menu.
  - a. Enter different values for the travel level, travel alignment, and block type.
  - b. Press OK to accept.



## Block Joins

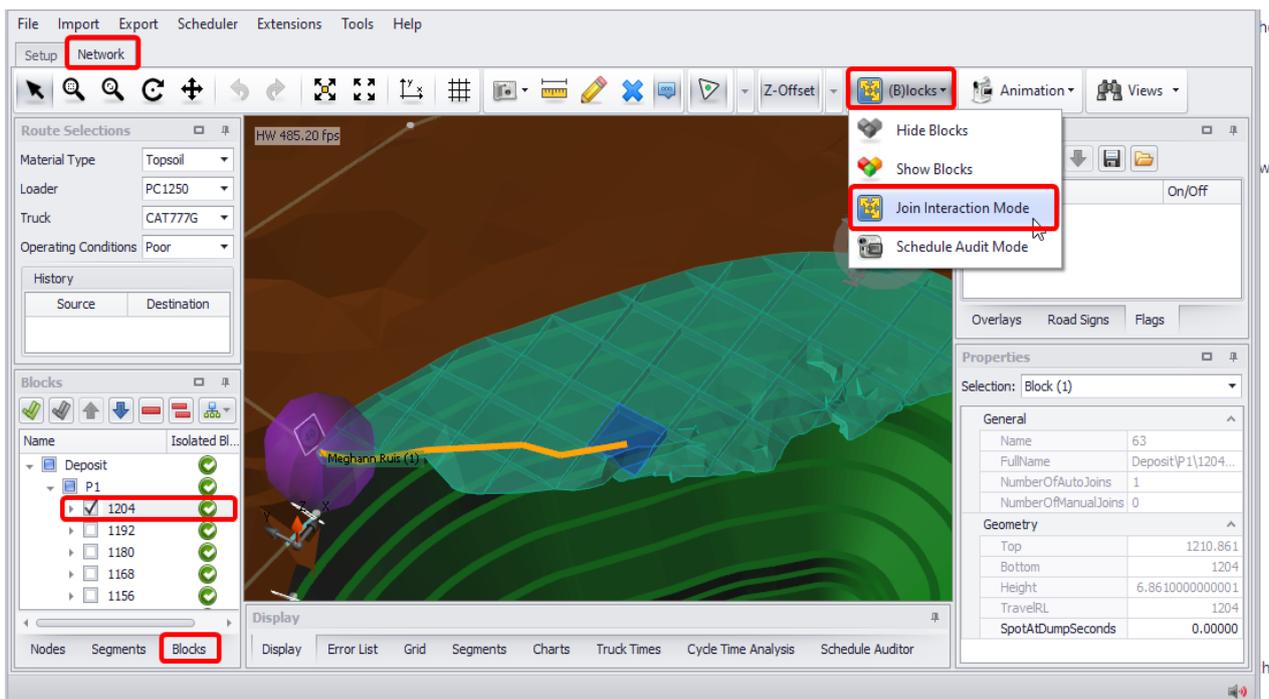
Blocks automatically join to roads that pass through their elevation and within the Auto Join Distance.

Auto-join distance can be set and changed at any time in the Setup > Settings > Bench Settings > Auto Join Distance.

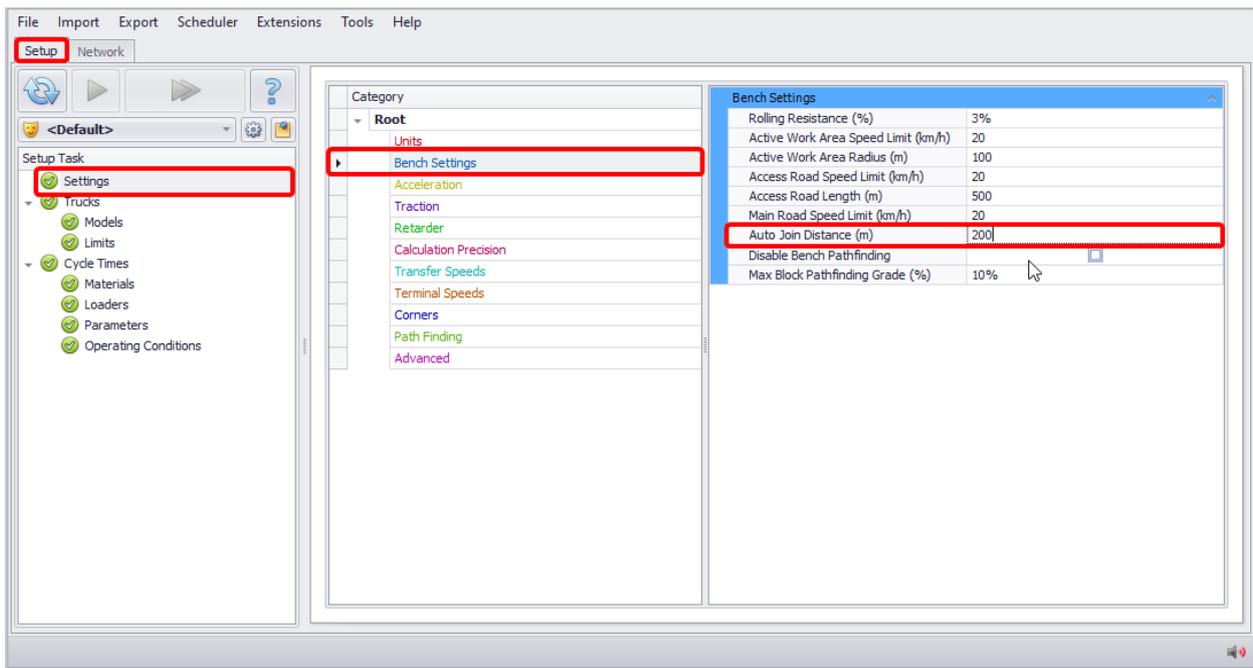


To choose and edit joins:

1. In the **Network** tab press the **Blocks** button in the top toolbar and select "Join Interaction Mode".
2. Go to the **Blocks** panel bottom left and select the 1204 bench from the tree structure.
3. Click on a block. You should see a connection to the ramp.



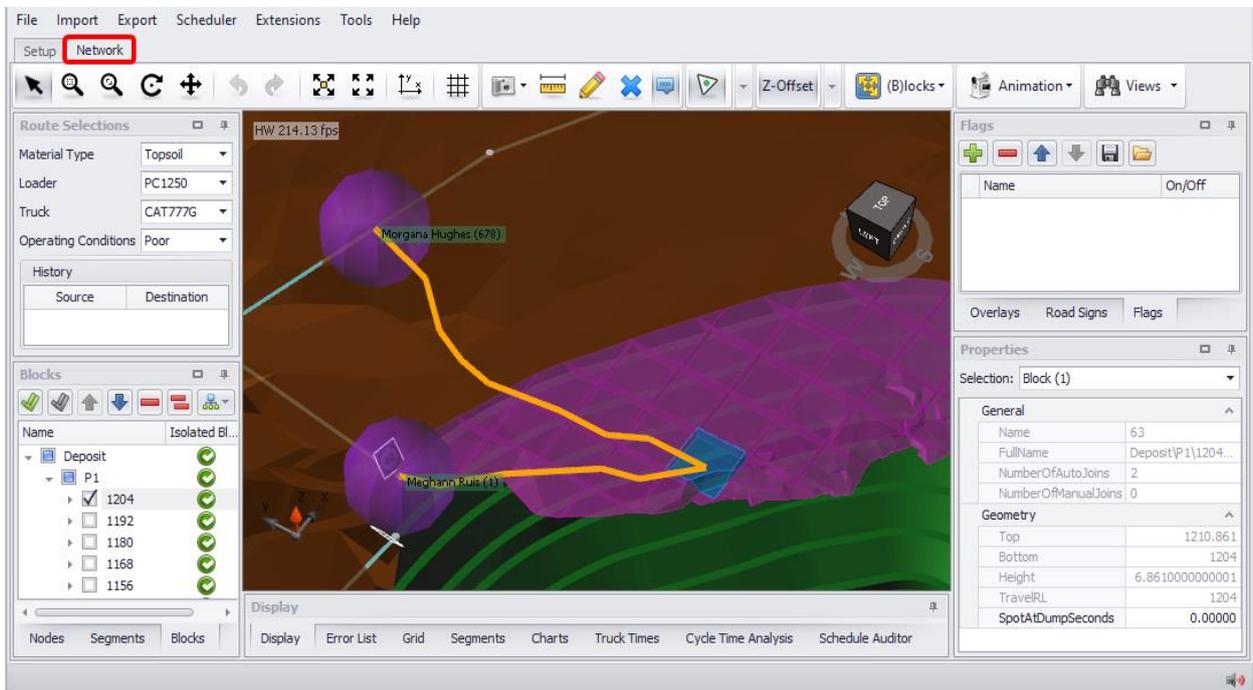
4. Go to *Setup > Settings > Bench Settings* and change the **Auto Join Distance** to 200.



✓ This means that blocks will be able to connect to any road that passes through their elevation with 200 metres.

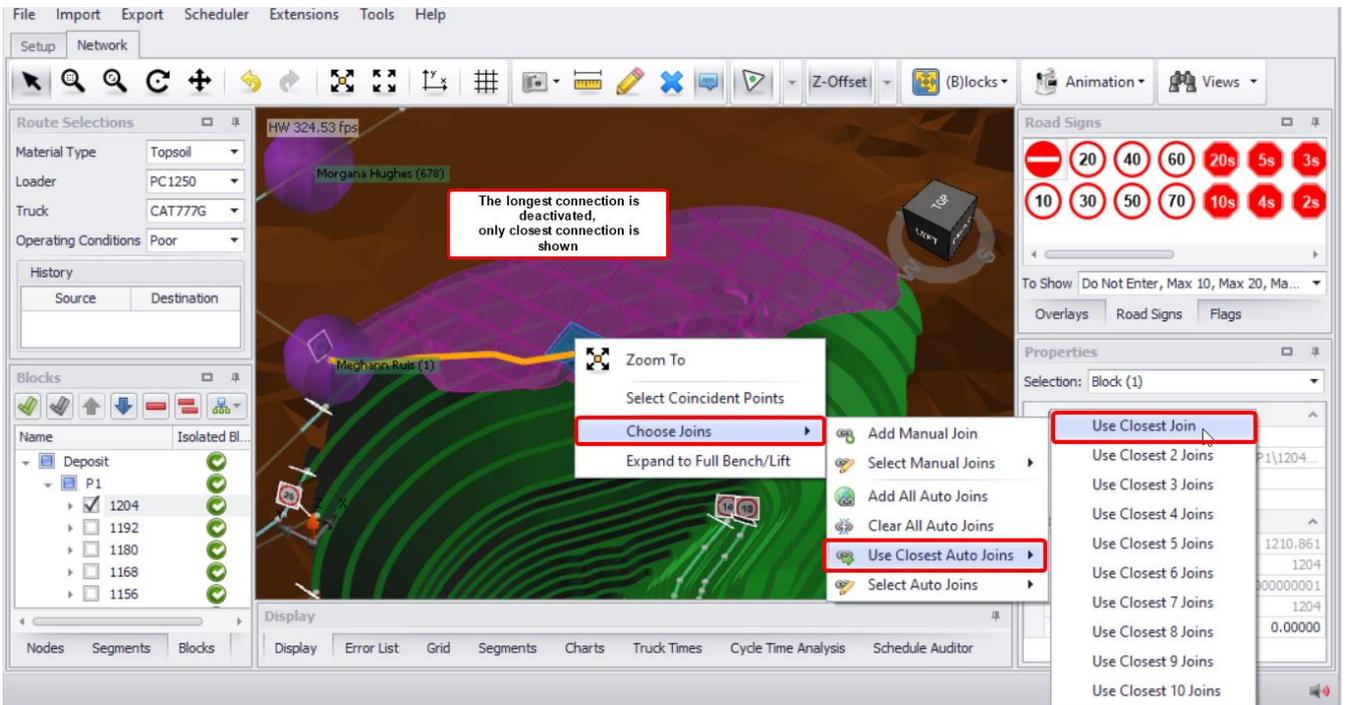
5. Run all steps and go back to the **Network** tab.

6. Click on the same bench block. Now you should now see two connections to the network.

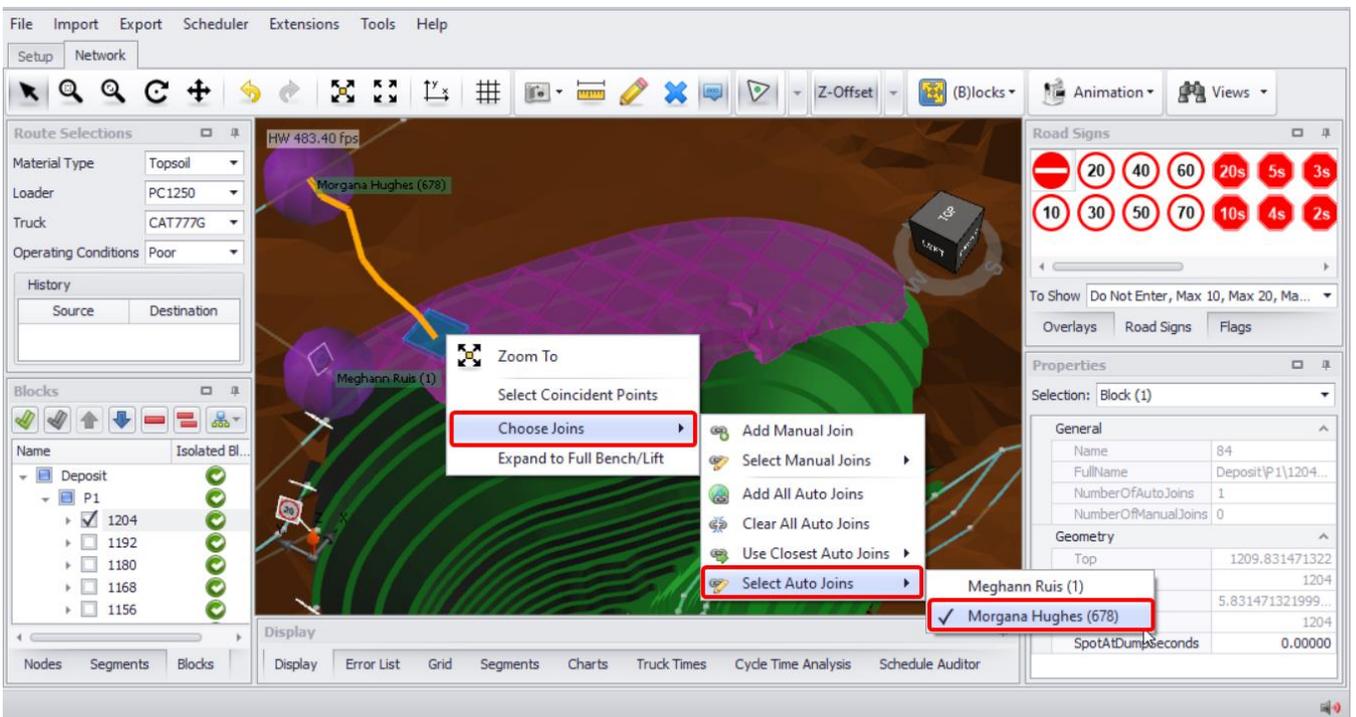


To select and deselect joins:

1. To choose the closest join, right click on the block and select “Choose Joins” > “Use Closest Auto Joins” > “Use Closest Join”. This should deactivate the longer connection.



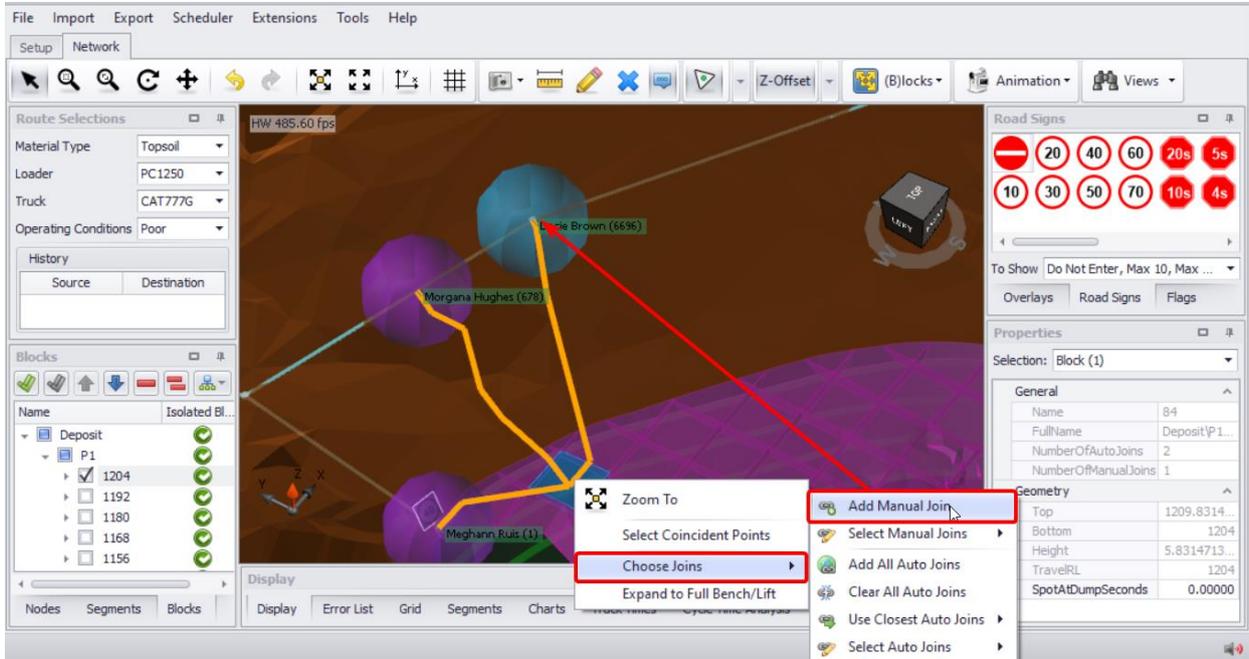
2. To select and deselect auto joins, right click on the block, and select “Choose Joins” > “Select Auto Joins”. This will open a list of the available joins, which you can activate or deactivate.



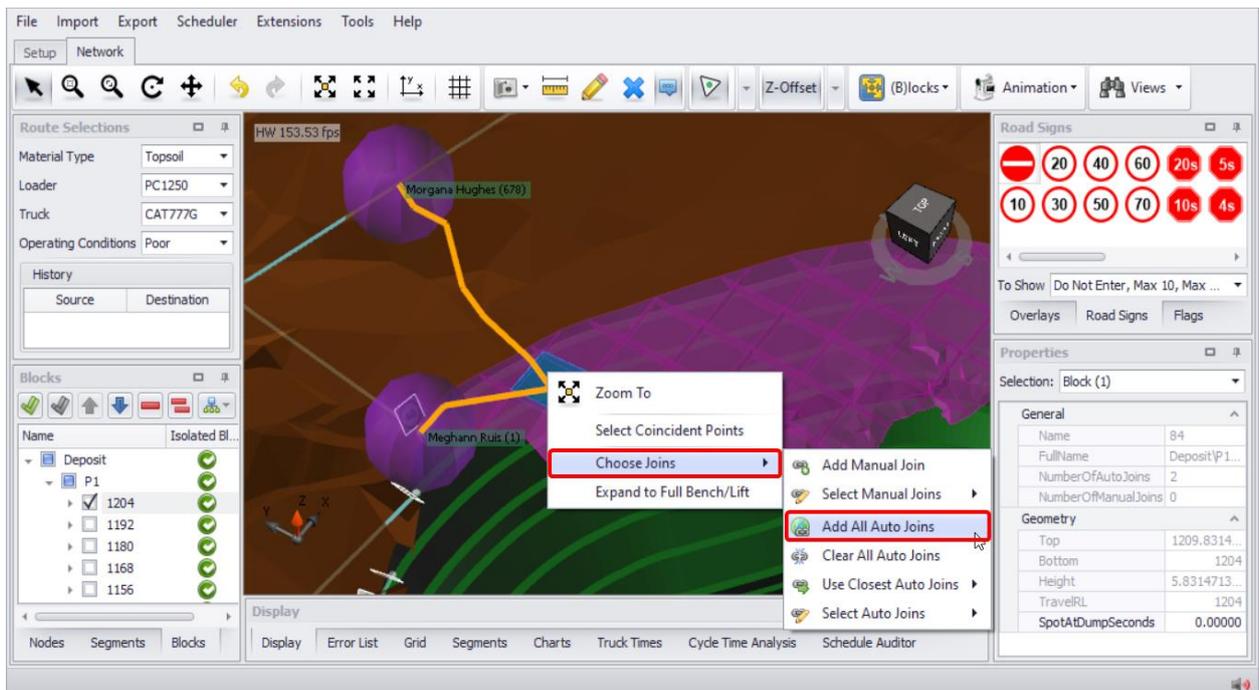
To create and remove new joins:

We can also add manual joins by picking a connection point on the network.

1. Right click on the block and select “Choose Joins” > “Add Manual Join”.
2. Click a point on the network to connect to. A new join should appear.



3. To remove a manual join right click on the block and select “Choose Joins” > “Select Manual Join” > deselect the manual join. The manual join should disappear.
4. To restore the default joins, right click on the blocks and select “Choose joins” > “Add All Auto Joins”.



Exercise:

1. Go to the **Blocks** panel and select a new bench near the bottom of the pit.
2. Create a manual join with a spiral as shown below.
3. Go to **Setup** tab > **Settings** step > **Max Block Pathfinding Grade** and lower the gradient.



Bench Settings	
Rolling Resistance (%)	3%
Active Work Area Speed Limit (km/h)	20
Active Work Area Radius (m)	100
Access Road Speed Limit (km/h)	20
Access Road Length (m)	500
Main Road Speed Limit (km/h)	20
Auto Join Distance (m)	200
Disable Bench Pathfinding	
Max Block Pathfinding Grade (%)	10%

**Lower Pathfinding grade = wider ramp spiral**



Bench Settings	
Rolling Resistance (%)	3%
Active Work Area Speed Limit (km/h)	20
Active Work Area Radius (m)	100
Access Road Speed Limit (km/h)	20
Access Road Length (m)	500
Main Road Speed Limit (km/h)	20
Auto Join Distance (m)	200
Disable Bench Pathfinding	
Max Block Pathfinding Grade (%)	5%

## Assigning Joins based on Segment Names

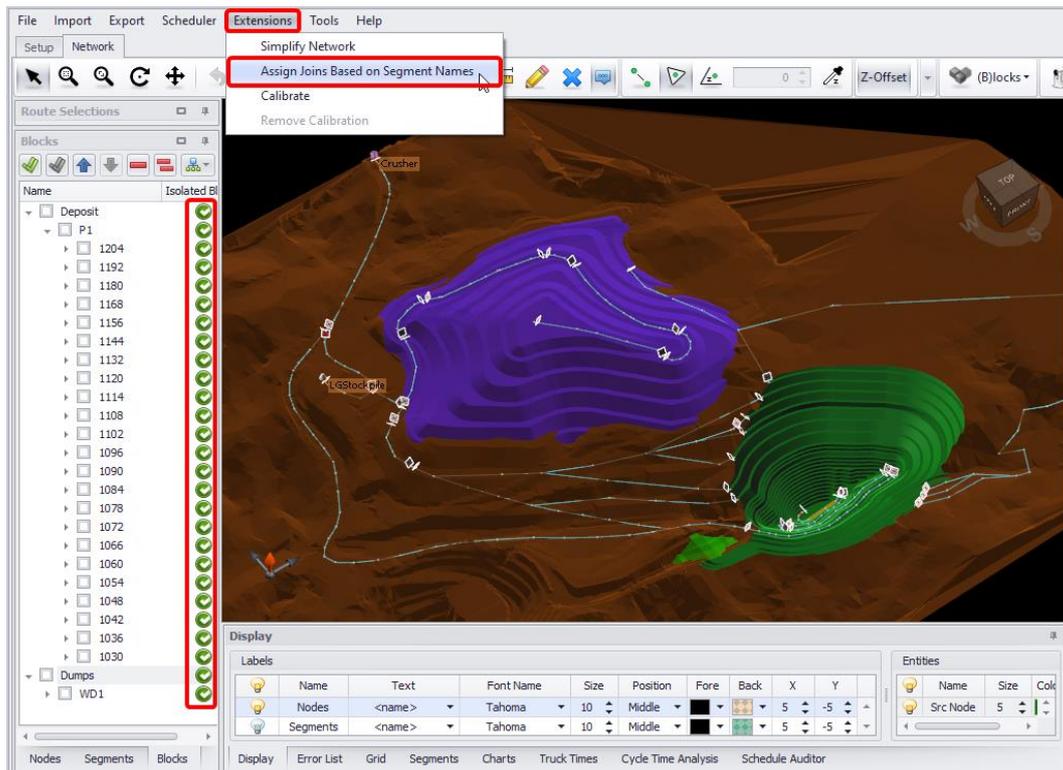
The ramp locking script limits auto joins so that blocks may only connect to road segments that share the same name. For instance, if there is a ramp named Reserves/Pit/Stage1 then only the blocks in Mine\Pit\Stage1 (or lower) will be able to connect to it.

- All blocks in Reserves may connect to a road named "Reserves".
- All blocks in Reserves/Mine1/Pit1 may connect to a road named "Reserves/Mine1/Pit1/Stage1/630".
- All blocks in Reserves/Mine1/Pit1/Stage1/630 may connect to a road named "Reserves/Mine1/Pit1/Stage1/630".

The function is calculated once and must be manually updated if you make changes to the network. It can be run from **Extensions** top toolbar tab > "Assign Joins Based on Segment Names" option.

To apply this function:

1. Open SampleModelWithBlocks.hinf.
2. Double click the ramp in the pit.
3. Go to the **Properties** panel and rename the ramp to "Deposit\P1".
4. Double click the ramp to the dump.
5. Go to the **Properties** panel and rename the ramp to "Dumps".
6. Press **Extensions** > "Assign Joins Based On Segment Names".
7. Expand the **Blocks** menu in the bottom left of the screen.
8. The pit benches 1030 to 1120 should be green, and all the dump levels should be green.



You may have noticed that benches 1132 to 1204 did not connect to any ramps. This is because the roads that pass nearby to those benches still have arbitrary names. To make those roads generally accessible, try renaming them to "Deposit" and run the ramp locking script again.

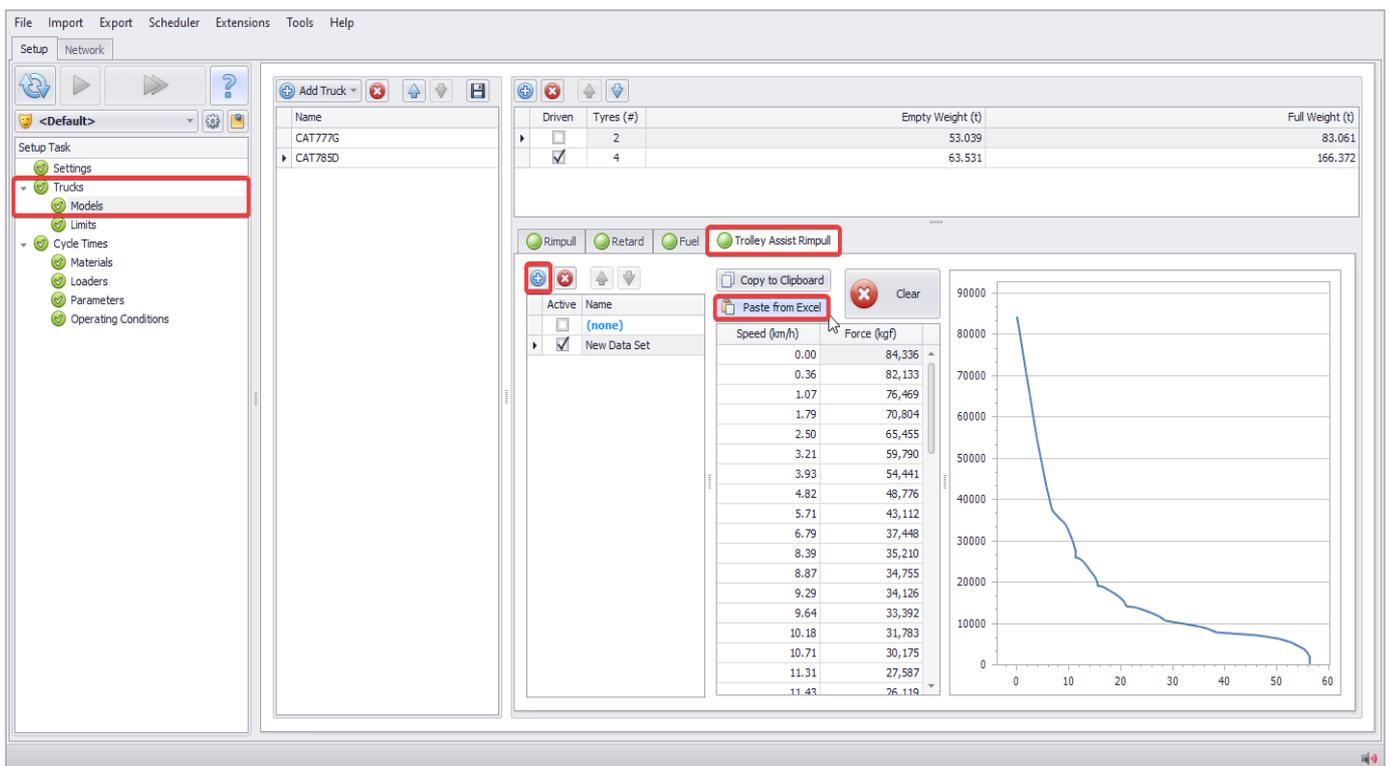
# Trolley Assist

Trolley assisted haulage involves feeding power to haul trucks from overhead lines.

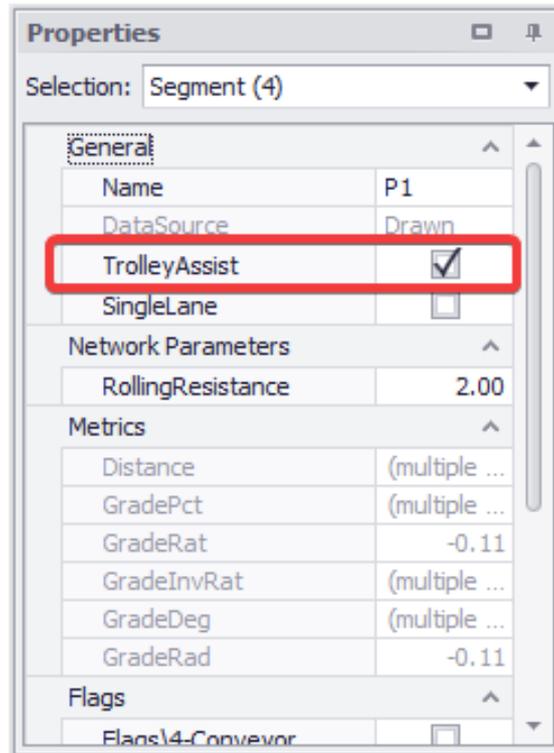
- Trolley assist performance is defined by a separate Trolley Assist Rimpull curve in the **Trucks** > **Models** step.
- Segments have a trolley property which can be toggled on or off for haul calculations.

To enable trolley assist:

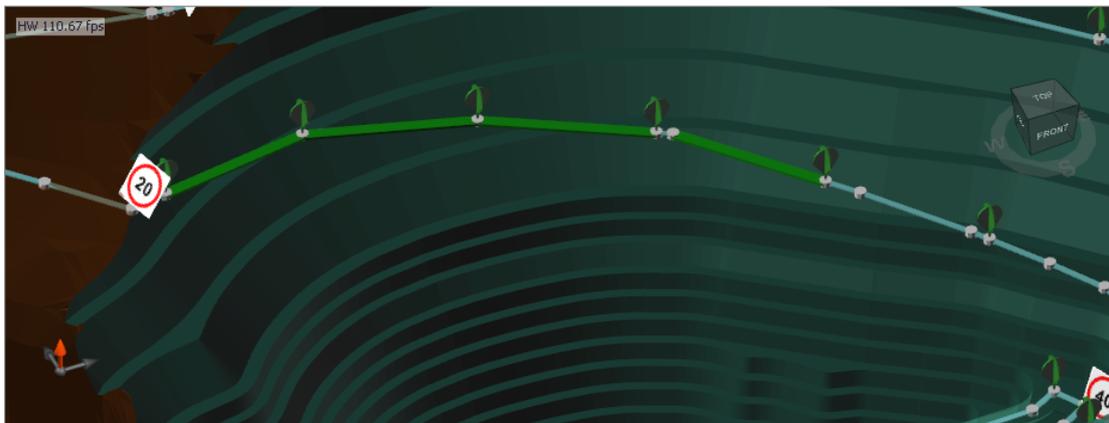
1. Go to the **Setup** tab > **Models** step and select the CAT785D.
2. In the **Rimpull** tab press **Copy to Clipboard** button.
3. Go to the **Trolley Assist Rimpull** tab and add a new data set by pressing the blue plus icon, toggle it as active and click **Paste from Excel**.



4. Go to the **Network** tab.
5. Select some segments near the crest of the pit ramp.
6. In the **Properties** tab, tick the "TrolleyAssist" property to true.



- ✓ The trolley assisted segments should now appear in green.



When the CAT785 travels over the trolley assisted segments, it will switch from its regular rimpull curve to the trolley assisted rimpull curve.



The trolley force must be enough to drive the truck up the ramp.  
As a rule of thumb, it should be comparable to the engine-driven force.

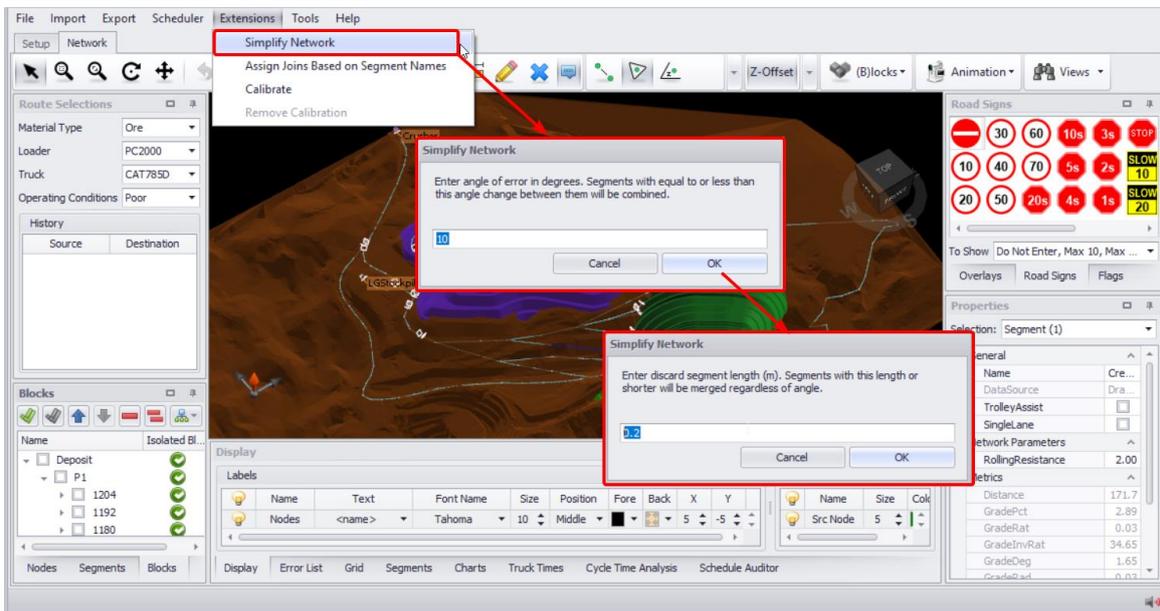
# Extensions

## Simplify Network

The “Simplify Network” extension is used to remove excess points from the network. If the next point is within the specified distance and angle, it will be removed from the network.

To simplify the network:

1. In the **Extensions** tab select “Simplify Network” option.
2. Enter an angle of 10 and press OK.
3. Enter a length of 5 and press OK.
4. Inspect the network.



- ✓ Calculation time will be faster with less segments in the network.

## Assign Joins Based on Segment Names

This function is used to force blocks to only connect to certain roads. Detailed explanation and examples see under the Blocks exercises.

## Calibrate and Remove Calibration

The Haul Infinity also has a model calibration function based on data imported from the FMS (Fleet Management System).

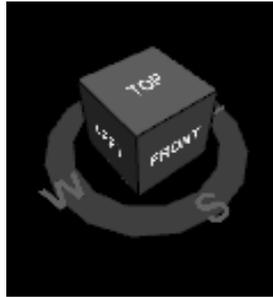
# Navigation and Display

## Grids

Grids are shown by default in new projects.

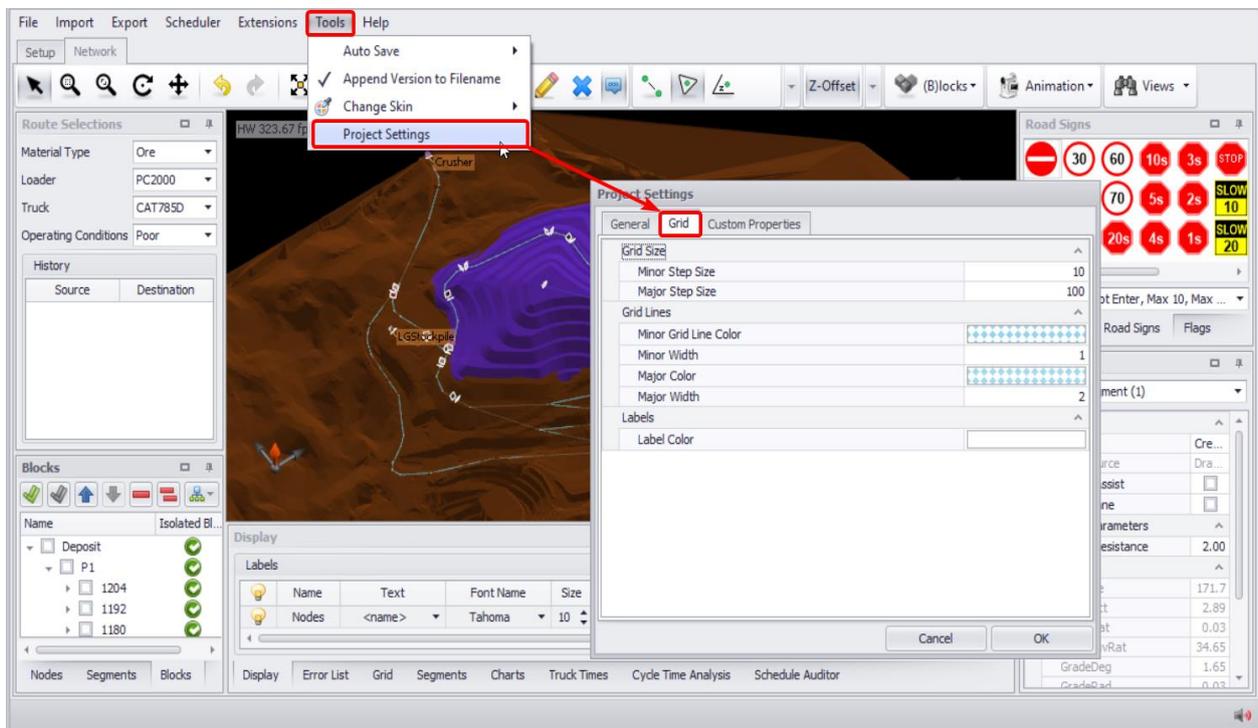
To toggle grids:

1. Hit the "TOP" text on the 3D compass.



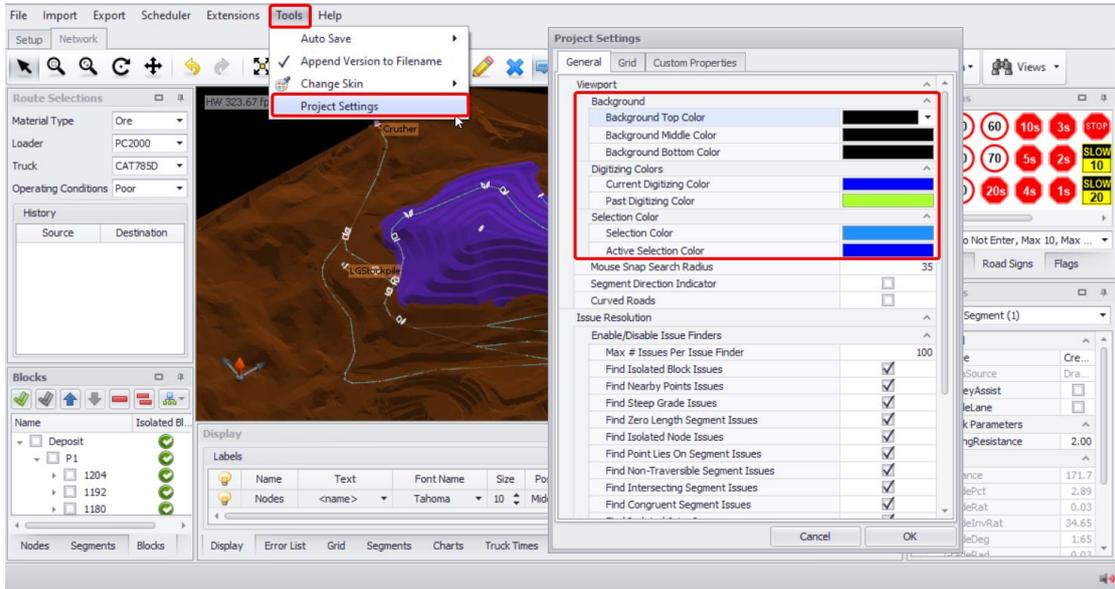
2. Press the grid icon  in the toolbar or keyboard shortcut <G>.

Grid size, colour and labelling can be set in *Tools > Project Settings > Grid*.



## Background

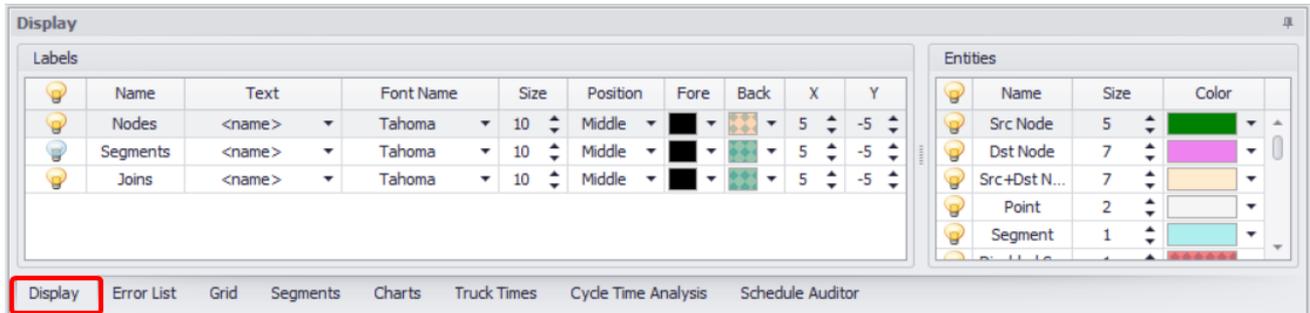
The viewport background colours can be customised in *Tools > Project Settings > General > Background*.



Change the background color of the viewport to suit your preferences. The default background color is **black**. Use the dropdown to select top, middle, and bottom colors.

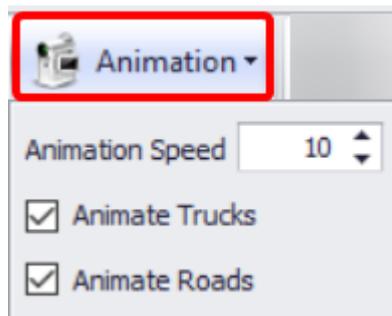
## Labels & Entities

The display properties of labels and entities can be customised in the **Display** tab below the viewport.



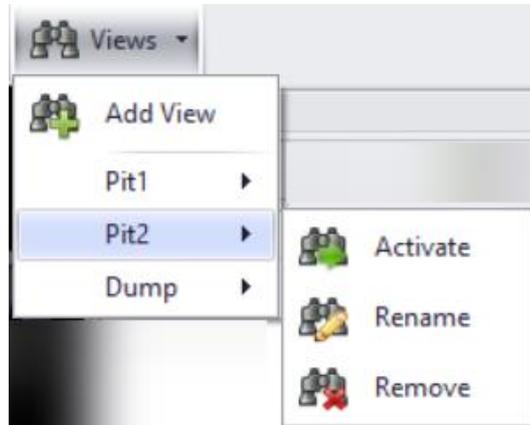
## Animations

Road and fleet animations can be toggled under the **Animation** button menu in the toolbar.



## Saved Views

Sometimes you may need to save particular view for consistent screenshots in your reports. To save the current view of any object in the viewport, click the **Views** button at the right end of the top toolbar and choose "Add View".

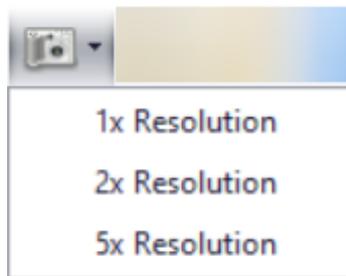


In the **Assign View Name** window that appears, enter a name for the view and click OK to save. The camera perspective will be saved for later viewing.

To return to the saved view of the viewport, click **Views** and select the appropriate one. You can move to the certain view ("Activate" option), edit its name ("Rename" option), or delete it ("Remove" option).

## Screenshot Tool

The screenshot tool saves the current view to clipboard for pasting into reports or presentations. Screenshots can be taken in 1x, 2x or 5x resolution so that you always have clear, crisp images to share.



## Multiple Screens

Panels and tabs can be dragged out of Haul Infinity and onto a second screen for easier viewing.

To use multiple screens:

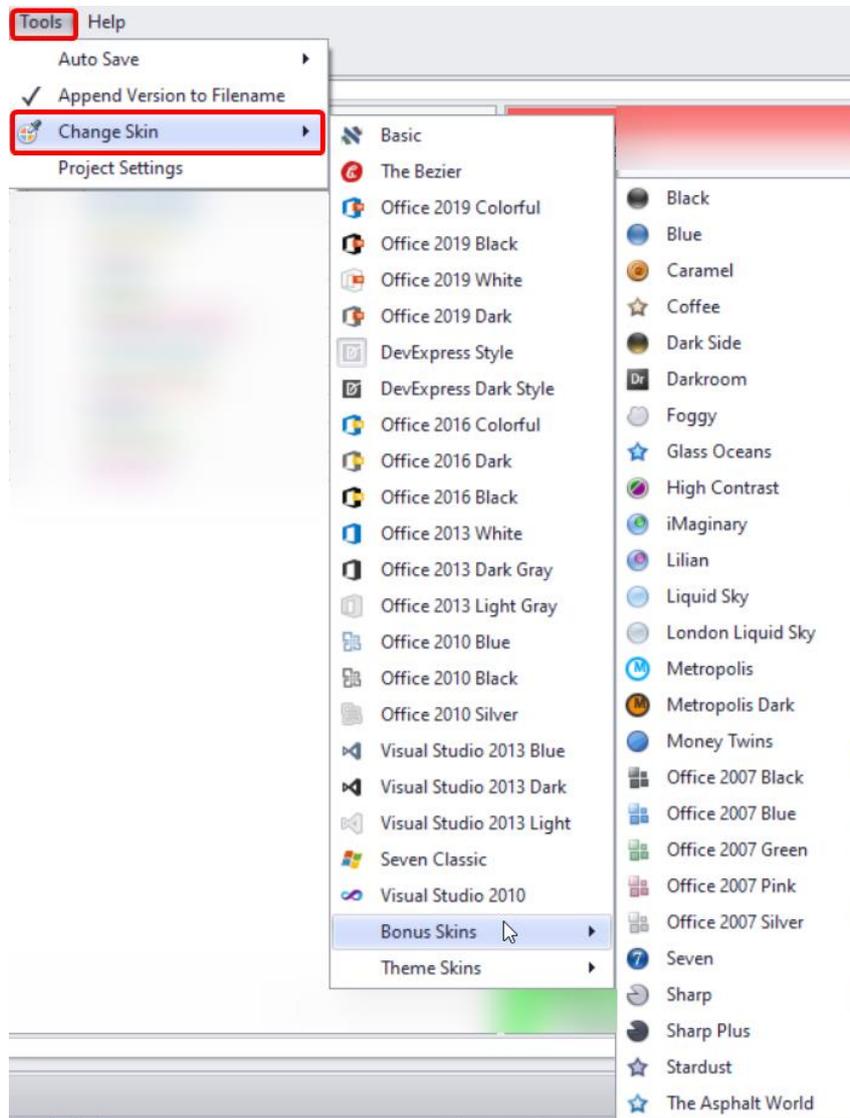
1. Go to the **Network** tab.
2. Select and drag the **Cycle Time Analysis** tab onto a new screen.
3. Select and drag the **Charts** tab onto a new screen.
4. To dock the tabs, double click on the header bar.

## Skin Themes

Haul Infinity is available in a variety of colours and contrasts, depending on what suits your tastes.

To change skin:

1. Click the **Tools** button located in the top bar of the app.
2. From its dropdown, select the "Change Skin" option.
3. An extensive list of available themes opens, including two tabs for bonus and special themes.
4. Select any theme you like depending on your preferences and wait for its downloading.



## Advanced Project Settings

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These are the advanced Project Settings user notes. These numbers should almost always be left at their defaults and should only be changed by a trained user. They can have significant effect on Haul Infinity calculations and accuracy.

## Engine Loads

The average engine loads during idle time, spotting, dumping, and trolley assist are used to calculate fuel consumption during the haul. These numbers can be calibrated using data from your Fleet Management System.

Truck CAT777G	
Engine Loads	
When Queuing	8%
When Spotting at Loader	20%
When Loading	8%
When Spotting at Dump	20%
When Dumping	50%
When Delaying for TKPH	8%
When on Trolley Assist	8%

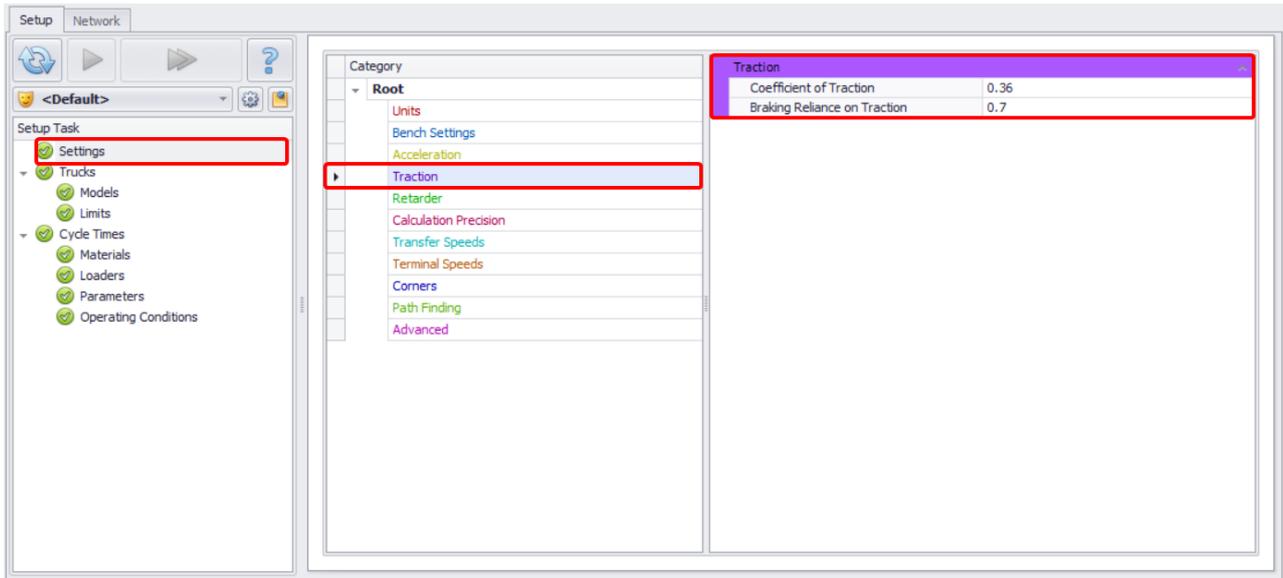
## Acceleration

The acceleration and deceleration forces provide an upper limit to the truck forces, even if the rimpull and braking curves can do more. This is based upon how the “average” operator drives the vehicle.

Acceleration	
Max Acceleration (km/h/s)	1.5
Max Unloaded Deceleration (km/h/s)	1.5
Max Unloaded Forced Deceleration (km/h/s)	0.416666666666667
Max Loaded Deceleration (km/h/s)	1
Max Loaded Forced Deceleration (km/h/s)	0.416666666666667

## Traction

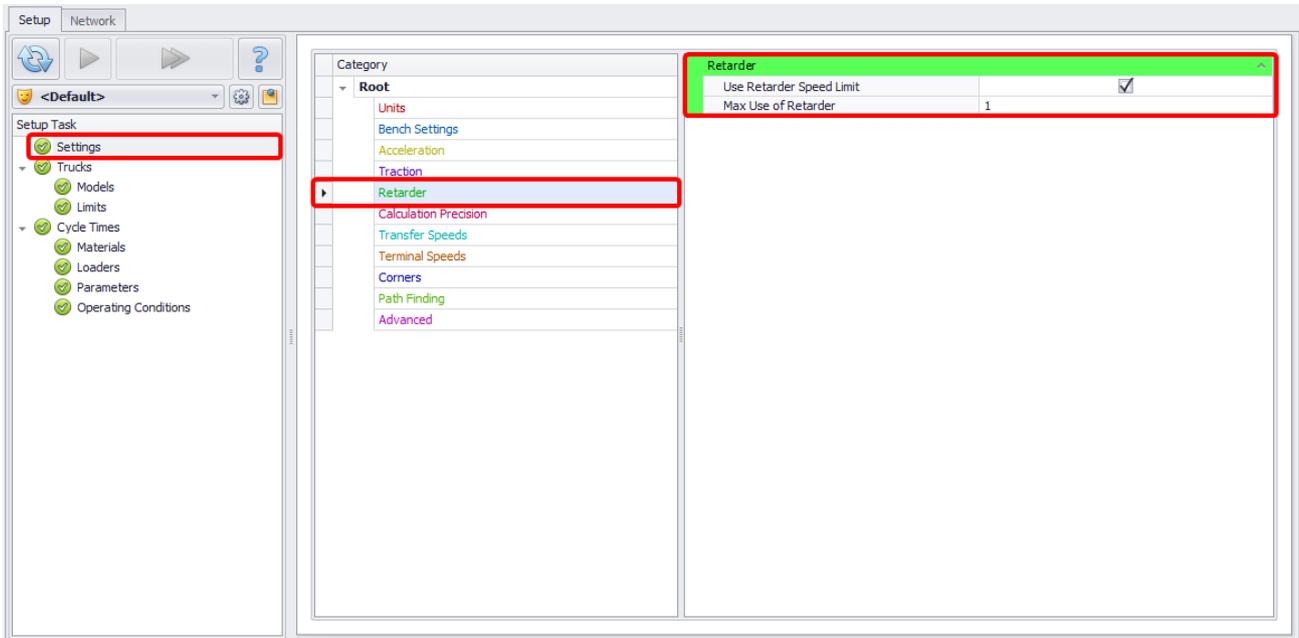
The traction constants are used for calculating tyre grip on the roads.



## Max Use of Retarder

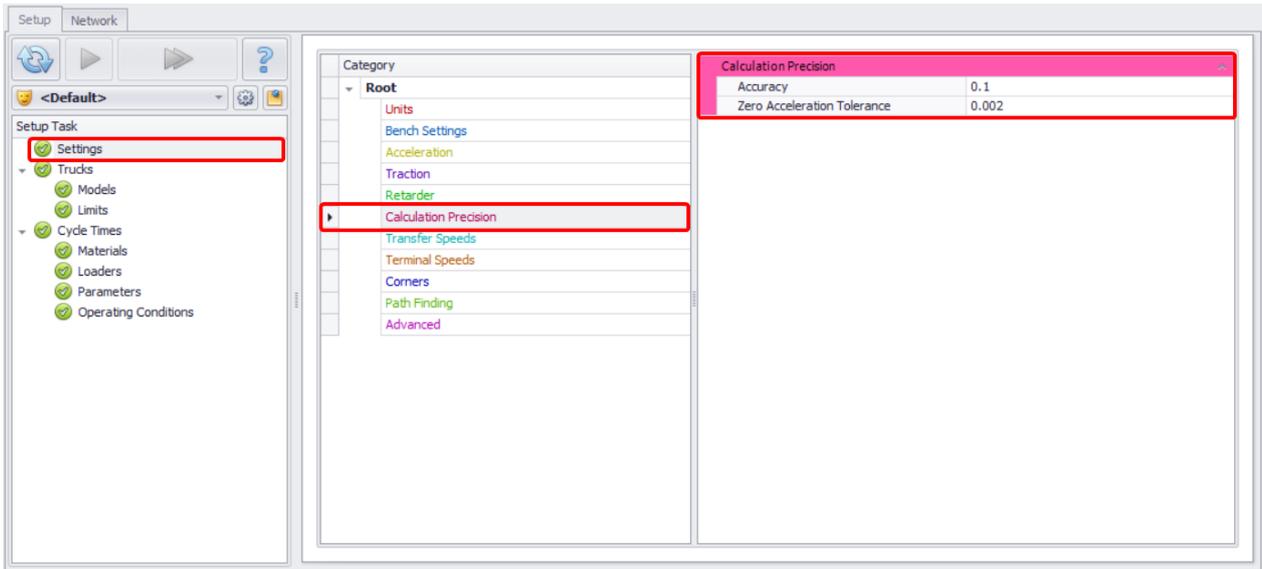
The max use of retarder is the amount of retard capacity actually used during operation. This is used to calculate the maximum speed limit from which the truck may safely brake.

The default is set to 0.7 (seventy percent). Increase this to 1.0 (one hundred percent) if using large trucks such as Komatsu 730E, 830E and 930E.



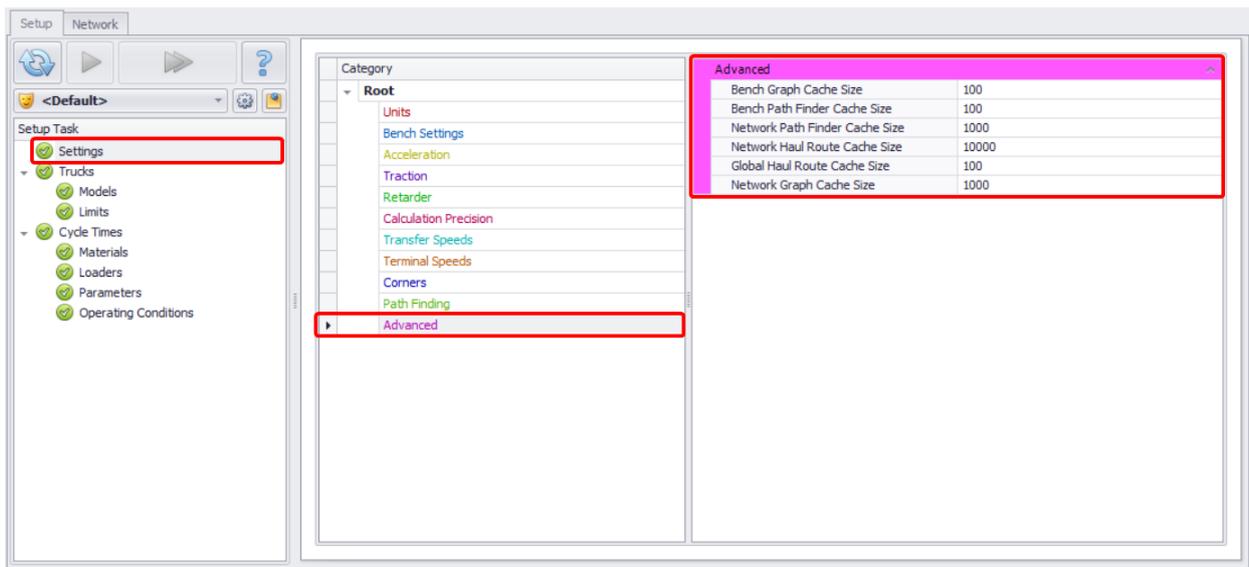
## Calculation Precision

These numbers tell Haul Infinity how precise it needs to be before being considered accurate. It is used to limit the number of calculations required on an asymptotic curve.



## Advanced > Cache Size

Cache size affects how much is stored in memory and how much is recalculated during haul queries. These numbers should be left untouched unless directed by an Alastri support representative.



## More Project Settings

Auto join distance.....	65	Grid properties	73
Background colours .....	74	Max block pathfinding grade .....	68
Curved roads	38	Michelin TKPH	54
Default rolling resistance .....	40	Segment direction indicator .....	21
Default speeds	54	Try return on same route .....	22

## Software Support

Our aim is to give great aftercare and support to all Alastri customers. If you have a problem, try searching by keyword in the online help documentation, asking a question in the user forums, learning from our video tutorials or by contacting an Alastri customer support representative.

<b>Documentation</b>	Extensive online documentation is accessible through the Help menu.
<b>Website</b>	Software updates are available at <a href="http://www.alastri.com.au">www.alastri.com.au</a>
<b>User Forum</b>	Learn from the experts at <a href="http://www.linkedin.com/groups/6788736">www.linkedin.com/groups/6788736</a>
<b>Video Tutorials</b>	Search for Alastri on <a href="http://www.youtube.com">www.youtube.com</a>
<b>Contact</b>	Send your support requests to <a href="mailto:support@alastri.com.au">support@alastri.com.au</a>

Sometimes we may link advanced users to preview releases on the Alastri website. It is possible that these unstable versions may crash, and if they do, we ask that you copy down the error message and send it to [support@alastri.com.au](mailto:support@alastri.com.au).