Use of OpenTrack for Large Freight Networks

IT015 The Industrialised Railway

Presented by Phillip Imrie

Phillip Imrie
Managing Director Plateway Pty Ltd

Experience

Over 30 years of railway industry experience.

Senior positions held include:

- Trackwork Renewals Manager RSA / FreightCorp involving management of 280 staff, operation of departmental wagon fleet of 120 wagons and delivery of an annual programme of in excess of 200 km of new rail per annum.
- Infrastructure Manager for Freight Australia managing budget of $30 - $45 million p.a. delivered by contract and 4200 km of network assets (track, bridges and signalling).
- Managing Director of Plateway international railway management consultancy.

Phillip Imrie
Managing Director Plateway Pty Ltd

Breadth of Experience

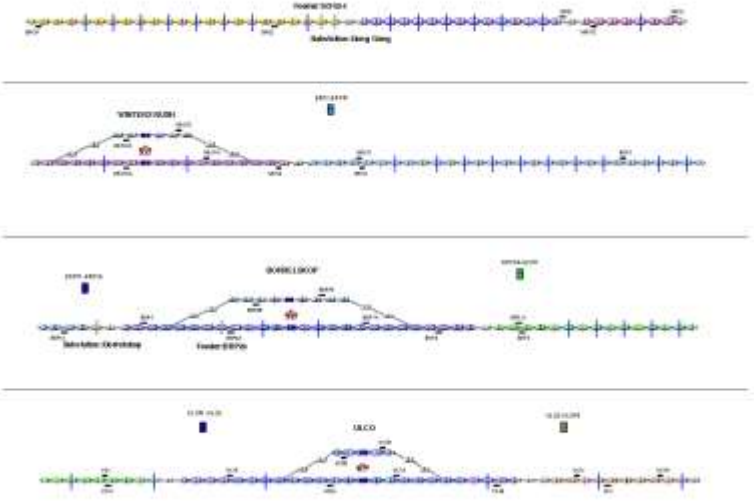
- Quality and Rail Safety Management System development.
- Railway capital and operating cost modelling.
- Railway track and civil engineering.
- Project management.
- Maintenance and operations management.
- Rail system and service planning.

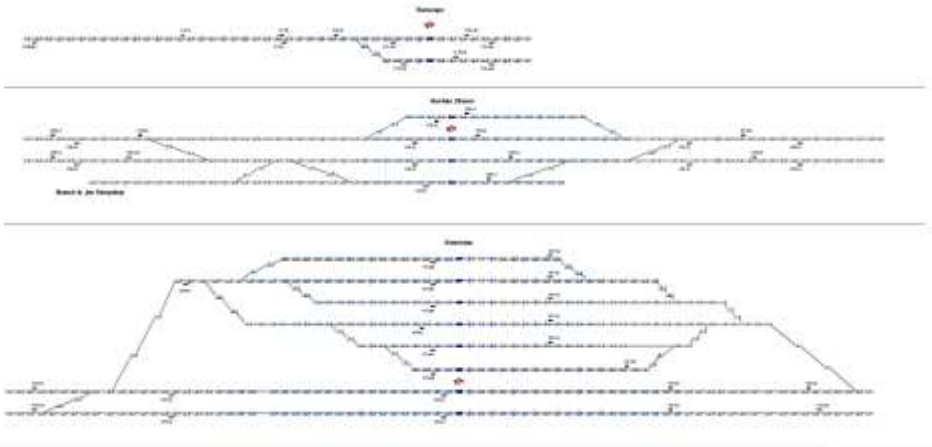
Plateway Service Streams

- Railway Engineering
- Railway Management Systems and Compliance
- Railway System Economics and Cost Modelling
- Railway Operational Simulation and Service Plan Development
- Railway Project and Operational Management

Plateway and OpenTrack

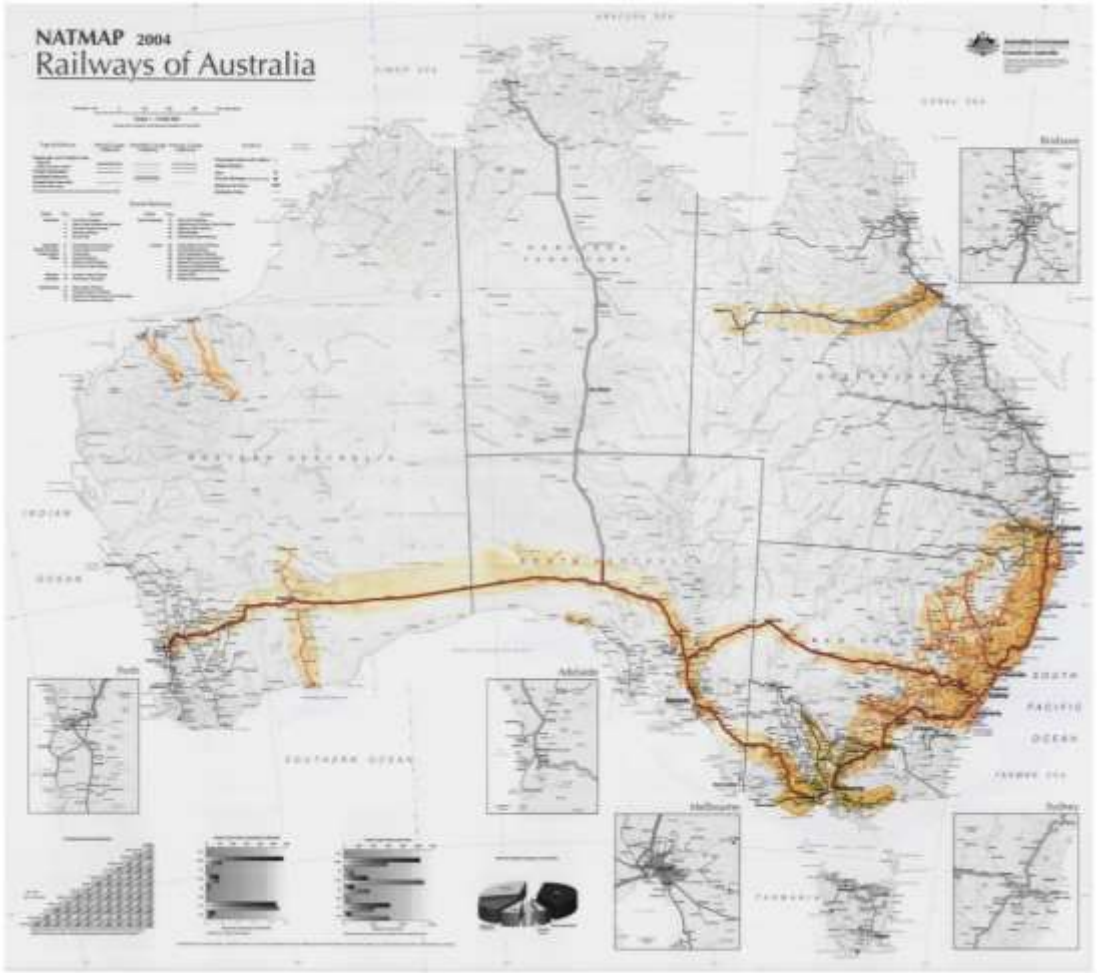
- Purchased first licence in 2001
- Australasian distributor of OpenTrack
- Started with single train runs to assess benefits of infrastructure changes.
- Model size and complexity expanded significantly over time since then.





Plateway and OpenTrack

- Sections modelled in OpenTrack by Plateway



Map source Australasian Railways Association

Plateway and OpenTrack

Project	Adelaide Timetable	Auckland Electrification 2012 Timetable	Adelaide Tram Extension	Cleveland Line Proof of Concept (with IFB) - Morning Peak Only	East West Intermodal	Maldon – Dombarton Feasibility	Adelaide Auslink Projects	Melbourne Freight Network Capacity	Orex Line (with Aurecon/ IFB)	Natcor (with LIFT/IFB)
Country	Australia	New Zealand	Australia	Australia	Australia	Australia	Australia	Australia	South Africa	South Africa
Year completed	2007	2012	2008	2012	2007	2010	2007	2010	2011	2014
Approx. Km of network in model	100	277	32	63	3775	1670	1600	541	970	2937
Simulated duration to produce a single data set.	24 hours	1 day	1 day	6 hours TT for 1 day	11 days	1 day	1 day	1 day	8 days	4 days
No. of trains run.	173	460	567	334	120	191	663	420	192	769
Variance Used	No	Yes	Yes	No	Yes	No	Yes	No	No	Yes

OpenTrack Freight Models

- Larger network areas than passenger models.
- Longer simulation durations.
- Fewer trains than passenger models.
- Similar numbers of trains operating at a given point of time in the simulation.
- Use of the variance functions in OpenTrack.

Railway Freight Network Characteristics

- Subject to competition both from multiple rail freight operators and alternative transport modes.
- Network owner does not always share the commercial drivers of the rail freight operator (sometimes favouring one operator over another).

Railway Freight Network Characteristics

System has a large amount of variability:

- Seasonal.
- Scale variability (large objects have a greater probability of variability than small ones).
- Business cycle variability.

Railway Freight Network Characteristics

Why OpenTrack?

- Handles trains of variable length and loading.
- Handles variability well.
- Includes the detail and if properly configured produces a far more realistic simulation than other tools.
- Able to look at the entire network / journey.
- OPN interface to model entire system.
- Can be processed to estimate fuel burn of single trains using notch settings.

Railway Freight Network Characteristics

- Train lengths 23 m (single locomotive)

  to 3600 m (the longer the better).
- Train handling critical for long trains.
- Desirable train handling based on preservation of momentum.
- Long haul distances.
- Long cycle times;
  - 11 hours – 96 hours - 160 hours.

Railway Freight Network Characteristics

Two basic types of services:

- Cyclic trains operate on a fixed cycle to feed export terminals or industrial processes.

- General freight services (intermodals) operate to meet customer demand (generally overnight delivery for the shorter viable hauls).

OpenTrack Adhesion Settings

- Not **adhesion** as calculated by rollingstock engineers.
- Function of control system in locomotive.
- Higher “adhesion” values used for more modern locomotives.

48 Class (1960’s)

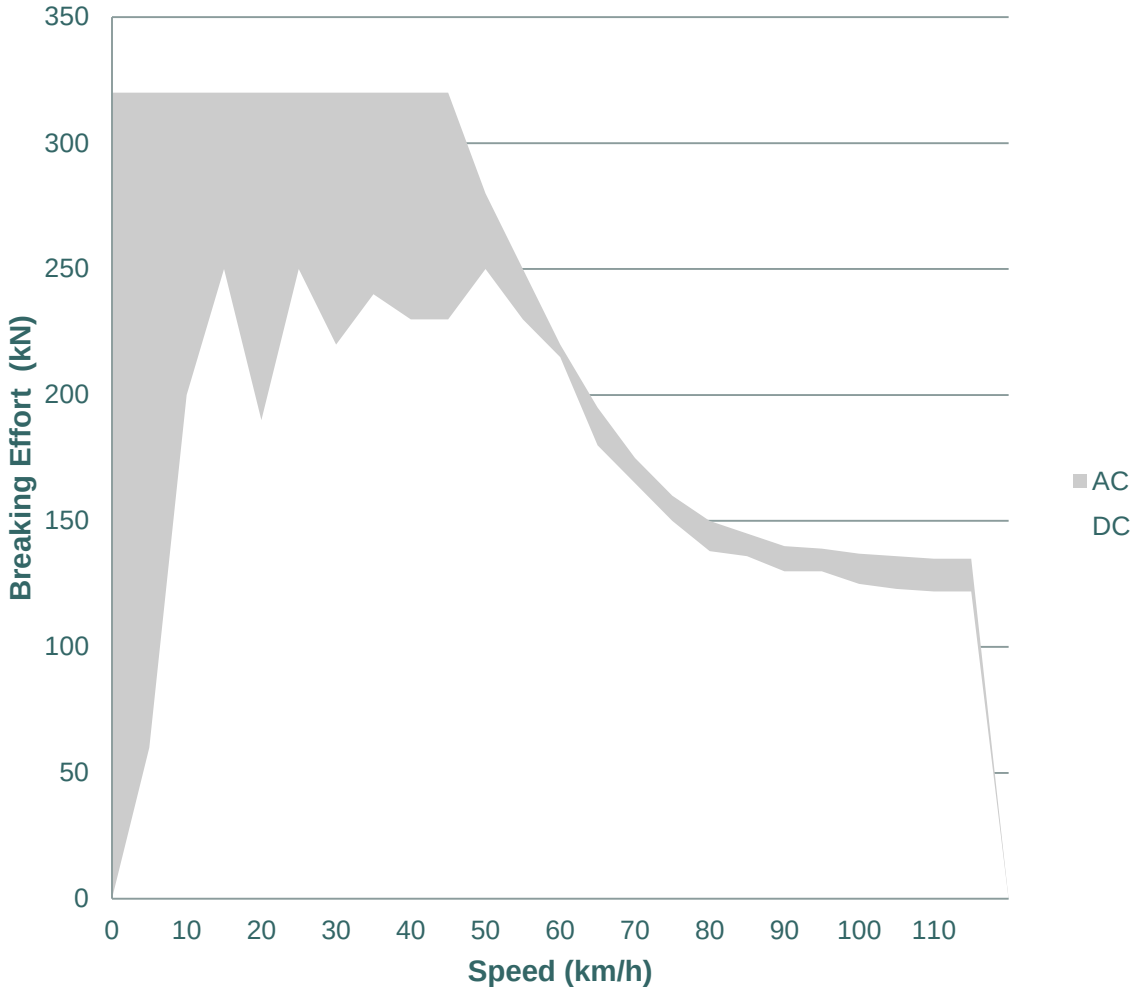
82 Class (1980’s)

TT Class (current)

OpenTrack Modelling Settings

- **“Driver” Performance**
  - Trains driven to avoid passing signals at danger (SPAD).
  - Variability ranges from 70% - 90%.
  - “Unhealthy” trains can be under 50%.
- **Braking setting**
  - Only time air brake is used to stop the train.
  - Dynamic brake is used to slow the train.
  - Very low braking rates such as – 0.1 m/s/s are used
  - Typical design service braking curves for longer freight trains -0.3 m/s/s to -0.4 m/s/s is used.
  - OpenTrack default – 0.6 m/s/s.

Dynamic Braking Performance



OpenTrack Modelling Settings

- **Train Performance**
  - Curve resistance ranges from 100% with head end only power performance to 50% with distributed power in a stress state managed environment.
  - Power shut off over crests to avoid breaking the train.
  - Data logger comparison 95-97%.

(N.B. This is within the accuracy of the rolling resistance equations.)

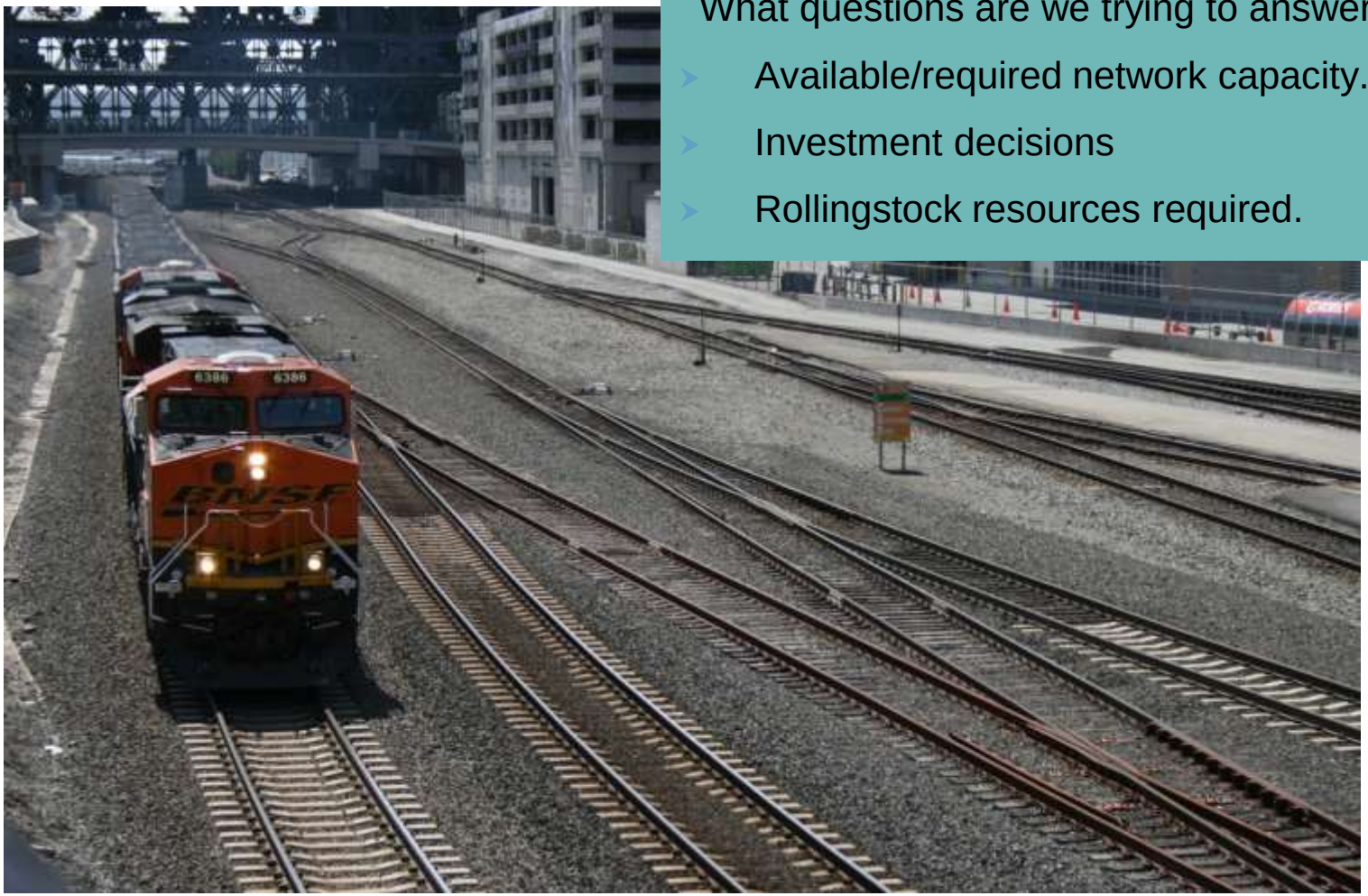
OpenTrack Modelling Settings

- **Boundary Conditions**
  - The model must have suitable boundaries so that trains can enter and leave the network as they do in real life.
  - A long period of time is required at the start and end of the simulation period to populate the model with trains (around 24 hours for the Transnet models).

OpenTrack Rolling Resistance Equations

- Davies is an Empirical formula
- Dates to 1926.
- No roller bearings.
- Most railways have arrived at the constants by empirical testing.
- Small start up organisations cannot afford to test in the same way that the larger railways did.

Railway Freight Network Characteristics



What questions are we trying to answer?

- Available/required network capacity.
- Investment decisions
- Rollingstock resources required.

Railway Freight Networks Modelling Approaches

- Historically timetables entered using Plateway's Viriato licence.
- This was limited due to the Plateway's lack of the calendar module in the previous Viriato version.
- On some projects to speed up the process Viriato used to map network capacity and OpenTrack only used to calculate single train times and "headways" through junctions.

Railway Freight Networks Modelling Approaches

- Hampered by the time and effort taken to input the model data.
- Most Plateway models built up job by job over a long period of time.
- Relies on co-operation over multiple customers.

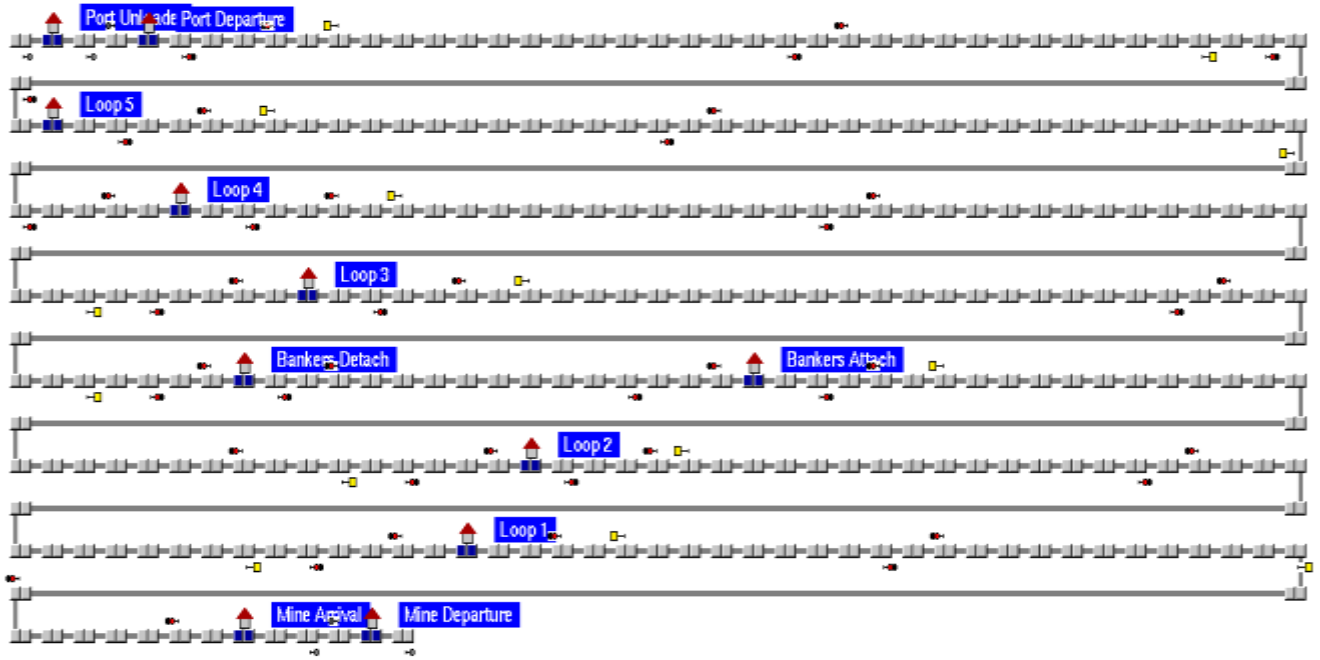
Railway Freight Networks Modelling Approaches

- Data input using Plateway's Complete Line Infrastructure Program (CLIP) add-on for OpenTrack speeds up process.
- Allows improved data control as the OpenTrack model can be created by electronic transfer from the source data of the network owner.
- Also loads data in a suitable format for OpenPowerNet.
- Allows a greater proportion of the customers budget to be spent using OpenTrack not just entering data.

Plateway's CLIP Add-on for OpenTrack

Why develop the CLIP code?

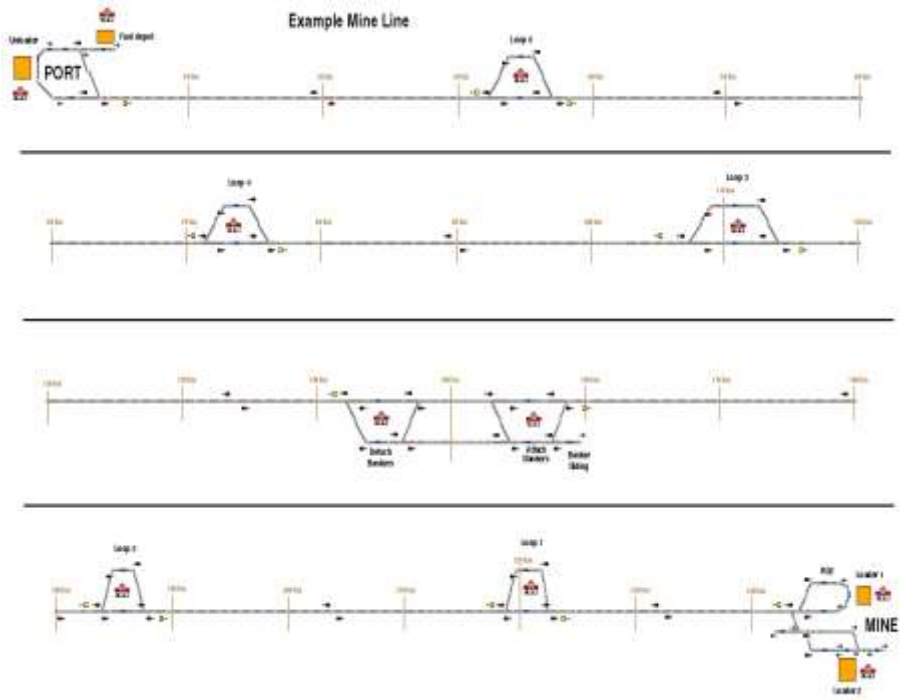
- An IVT file imported into OpenTrack will only produce a single track with no structure like this:



Plateway's CLIP Add-on for OpenTrack

Why develop the CLIP code?

- A lot of extra manual working and hence time is required to get the IVT imported file to look like this:



Plateway's CLIP Add-on for OpenTrack

Why develop the CLIP code?

When you have to build a large model very quickly time is something you are short of so it would be very nice if an OpenTrack import format allowed you to:

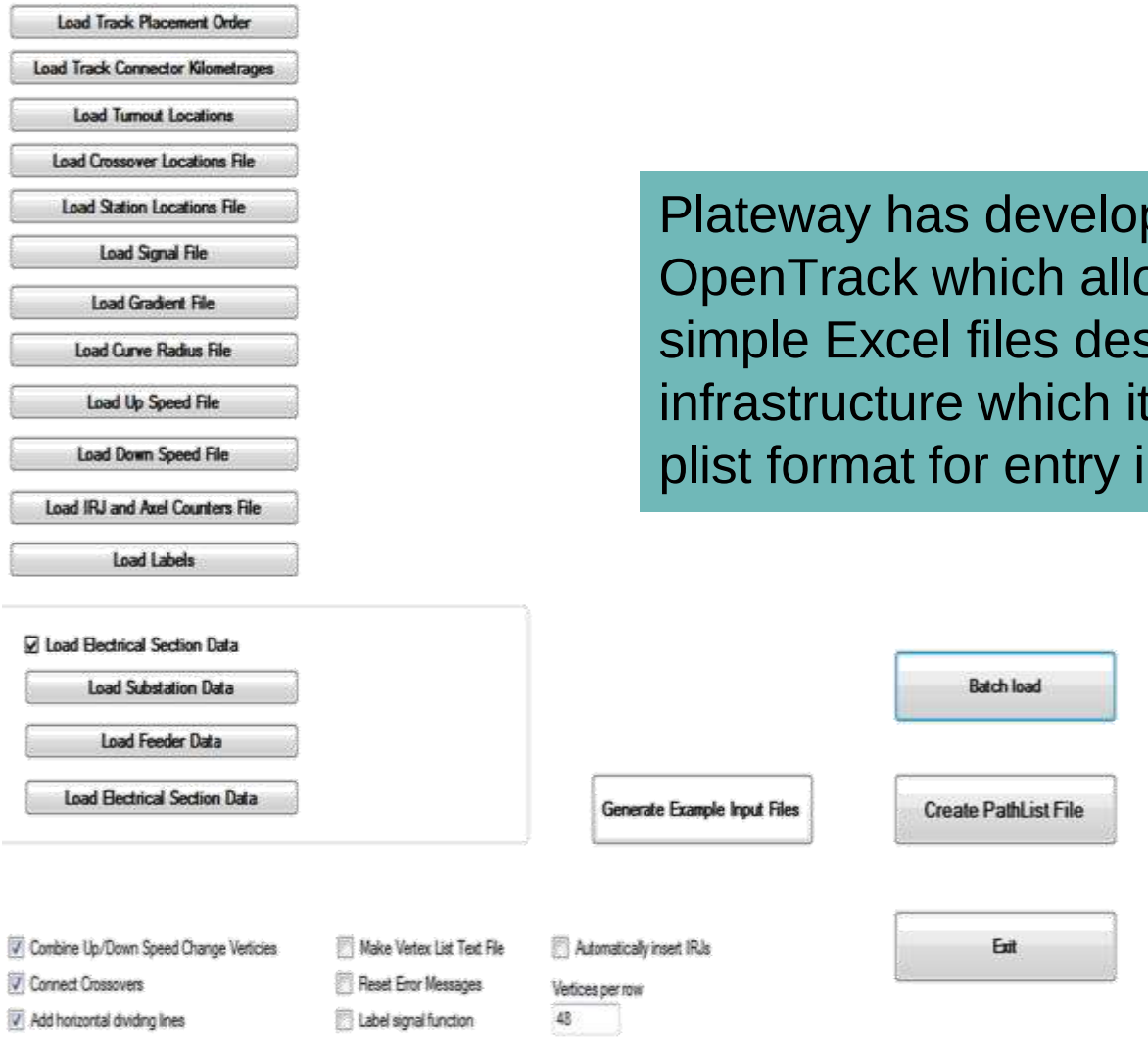
- Import multiple tracks and have them all correctly connected up.
- Import labels and graphics all set up and placed correctly.
- And it would be really good if it could all be imported with all routes and paths already in place.
- The OpenTrack plist input format allows us to do all this.

Plateway's CLIP Add-on for OpenTrack

Why develop the CLIP code?

- The CLIP format however does finally allow a complete error free input of even complicated infrastructure into OpenTrack.
- If it can be built in OpenTrack at all then it can be loaded into OpenTrack as a plist file, this also includes all routes, paths and itineraries.
- Changes the focus from data input to delivering the simulation objectives of the client.

Plateway's CLIP Add-on for OpenTrack

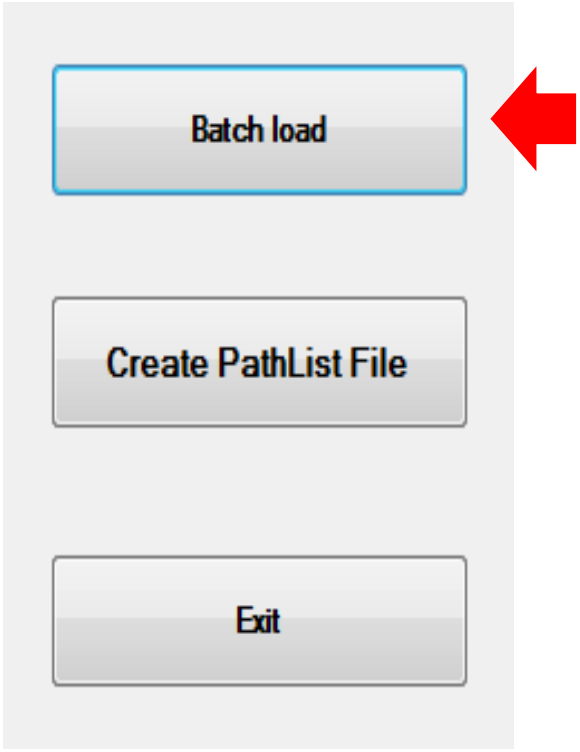


Plateway has developed a Add-on for OpenTrack which allows the user to write simple Excel files describing the rail infrastructure which it then converts into plist format for entry into OpenTrack.

Plateway's CLIP Add-on for OpenTrack

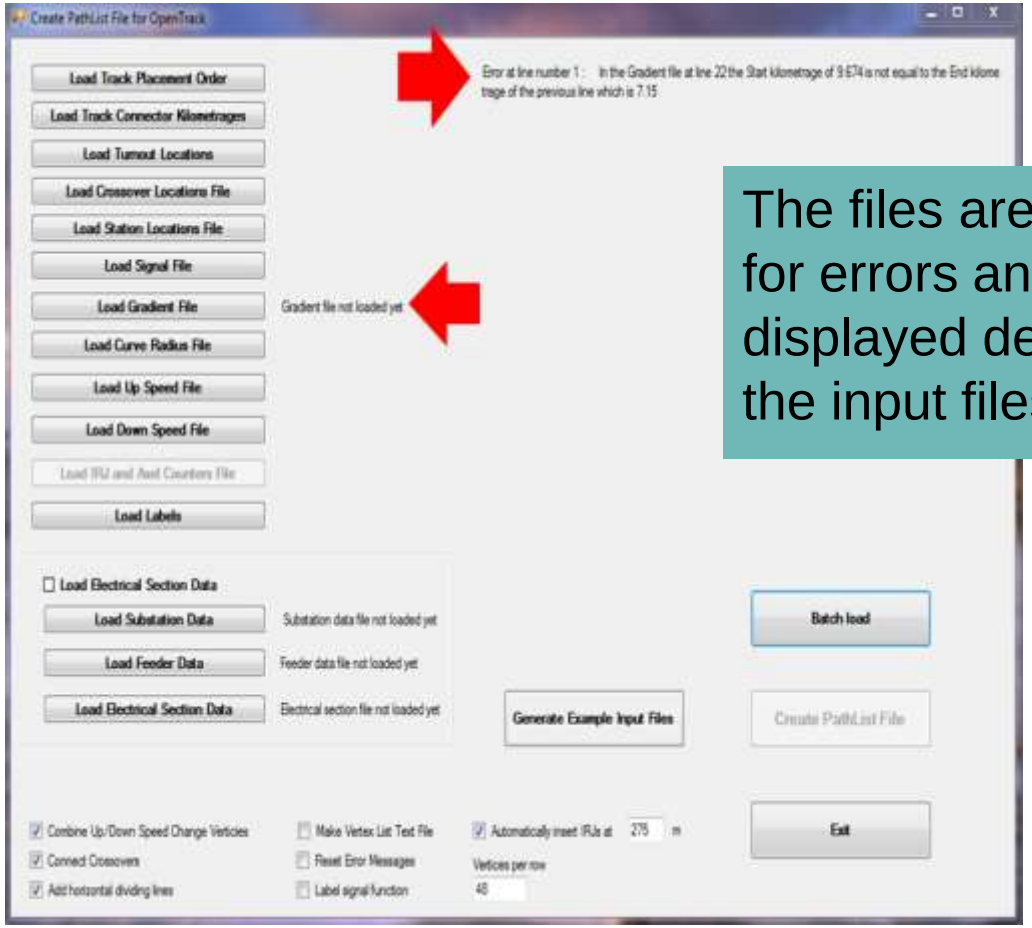
- The input to the CLIP program is 11 to 17 separate Excel files that contain data for track structure, turnouts, crossovers, stations, signals, gradients, curve radii, speed limits, IRJ and axle counters, graphical labels, substations, feeders, electrical sections, routes, paths and itineraries.
- Input files for electrical data and routes, paths and itineraries are optional.
- The large number of input files create an overhead that make CLIP less efficient for a very small and simple model. But for a big model in our own experience CLIP can reduce model building time to a quarter or less of what it would otherwise have taken.

Plateway's CLIP Add-on for OpenTrack



- In a big model such as Transnet's South Africa model you will be loading and reloading maps a number of times and that would be quite frustrating if you had to press 11-17 buttons and select files every time you wanted to reload the map.
- So we created an alternative way to load the data by just pressing the "Batch Load" button.

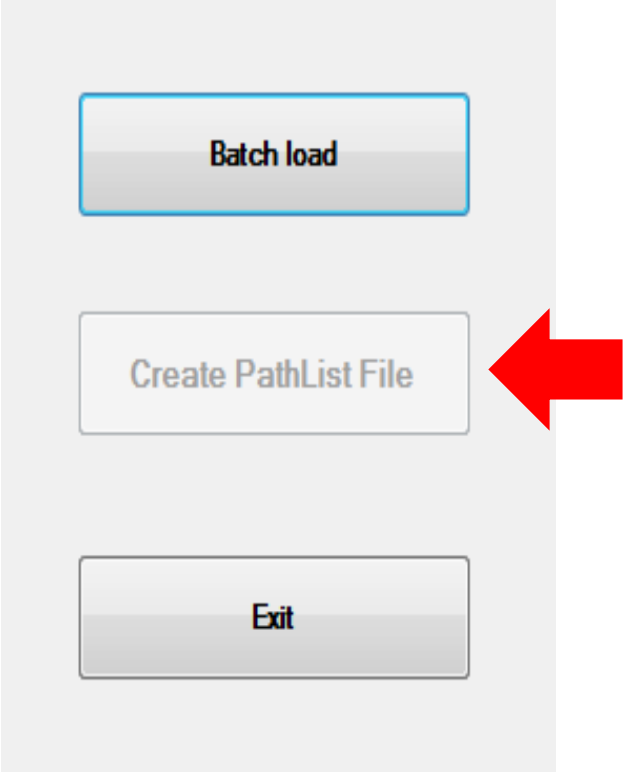
Plateway's CLIP Add-on for OpenTrack



The files are thoroughly checked for errors and an error message is displayed describing the errors in the input files if an error is found.

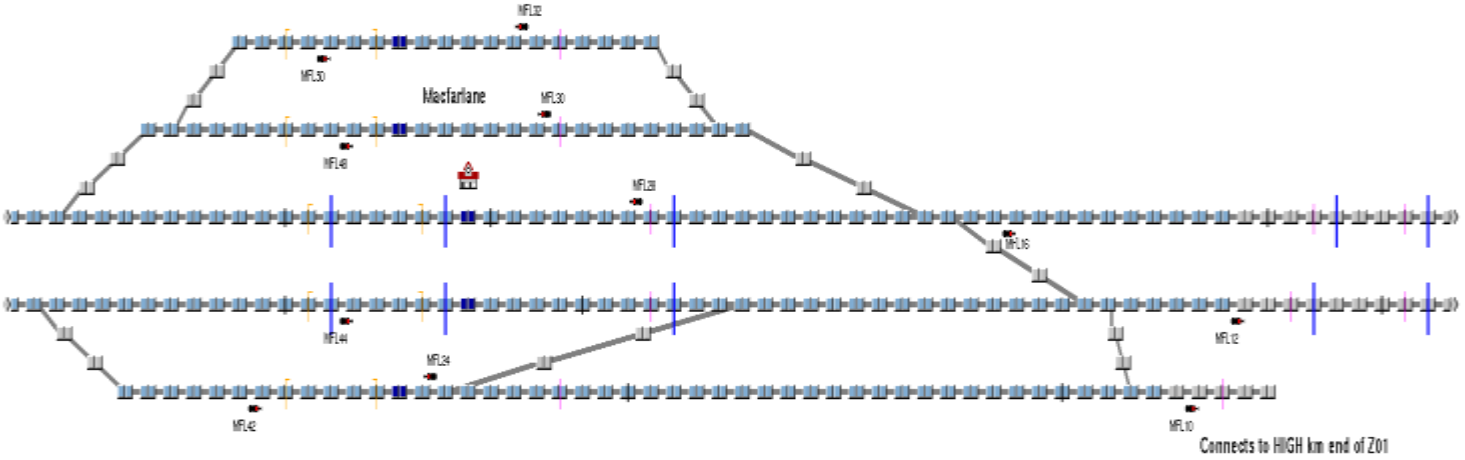
Plateway's CLIP Add-on for OpenTrack

The CLIP Add-on for OpenTrack disables the "*Create PathList file*" button until all required files are loaded and found to be error free.



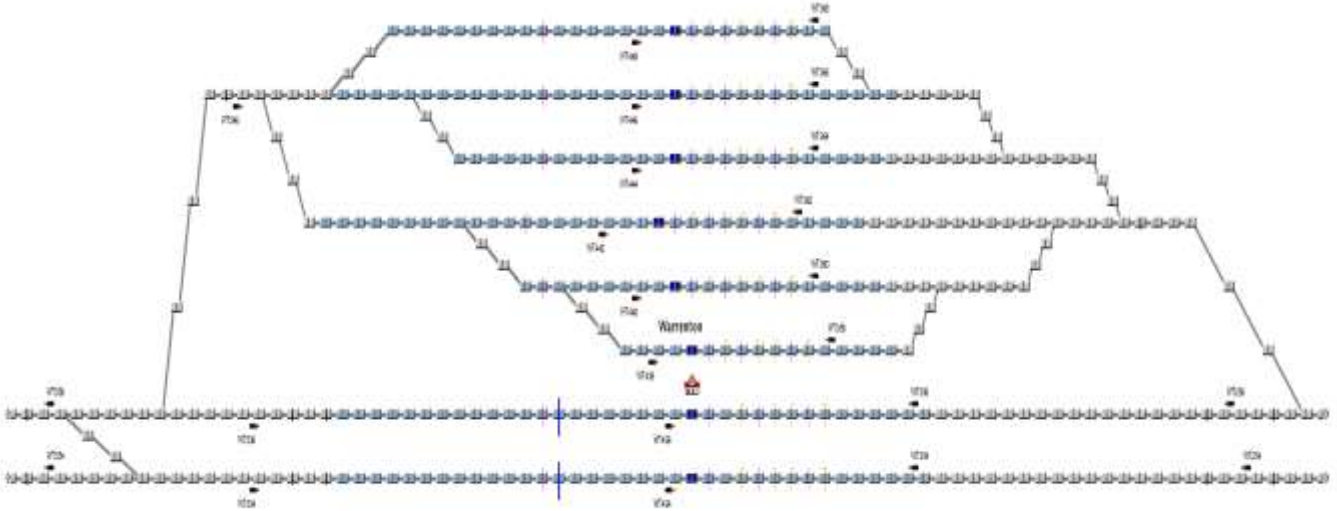
Plateway's CLIP Add-on for OpenTrack

- Here is an example of a Plateway CLIP generated infrastructure file from Plateway's Postmasburg to Durban model built for Transnet.
- The model here is shown as it loads straight from the CLIP file without any manual manipulation in OpenTrack.



Plateway's CLIP Add-on for OpenTrack

- Here is another bigger yard built 100% with the CLIP Add-on for OpenTrack and no OT manual involvement.
- At present padding with dummy vertices is used to make things line up. It does a good job but is not quite 100% perfect at alignment. In future we will improve the algorithm to perfect the display but it is only a minor graphical issue.



Plateway's CLIP Add-on for OpenTrack

Line name	Track name	Turnout name	Turnout kilometrage	Left side connects to same track (y/n)	Right side connects to same track (y/n)	Left side connects to crossover (y/n)	Right side connects to crossover (y/n)	Switch time (seconds)	Straight ahead is default position (y/n)
G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	Join to G07	0.000	n	y	n	n	15	y
G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	PMB229	0.344	y	y	y	n	15	y
G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	PMB129	0.777	y	y	Y	N	15	y
G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	PMB119	0.792	y	y	N	Y	15	y
G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	NPR761	2.921	y	y	y	n	15	y
G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	NPR711	2.930	y	y	n	y	15	y
G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	PNC659	4.752	y	y	n	y	15	y
G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	PNC669	4.817	y	y	y	n	15	y
G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	PNC631	4.993	y	y	n	y	15	y
G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	PNC301	6.018	y	y	y	n	15	y
G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	PNC219	6.411	y	y	n	y	15	y
G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	PNC229	6.554	y	y	y	n	15	y
G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	ASR619	14.671	y	y	n	y	15	y
G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	ASR629	14.812	y	y	y	n	15	y

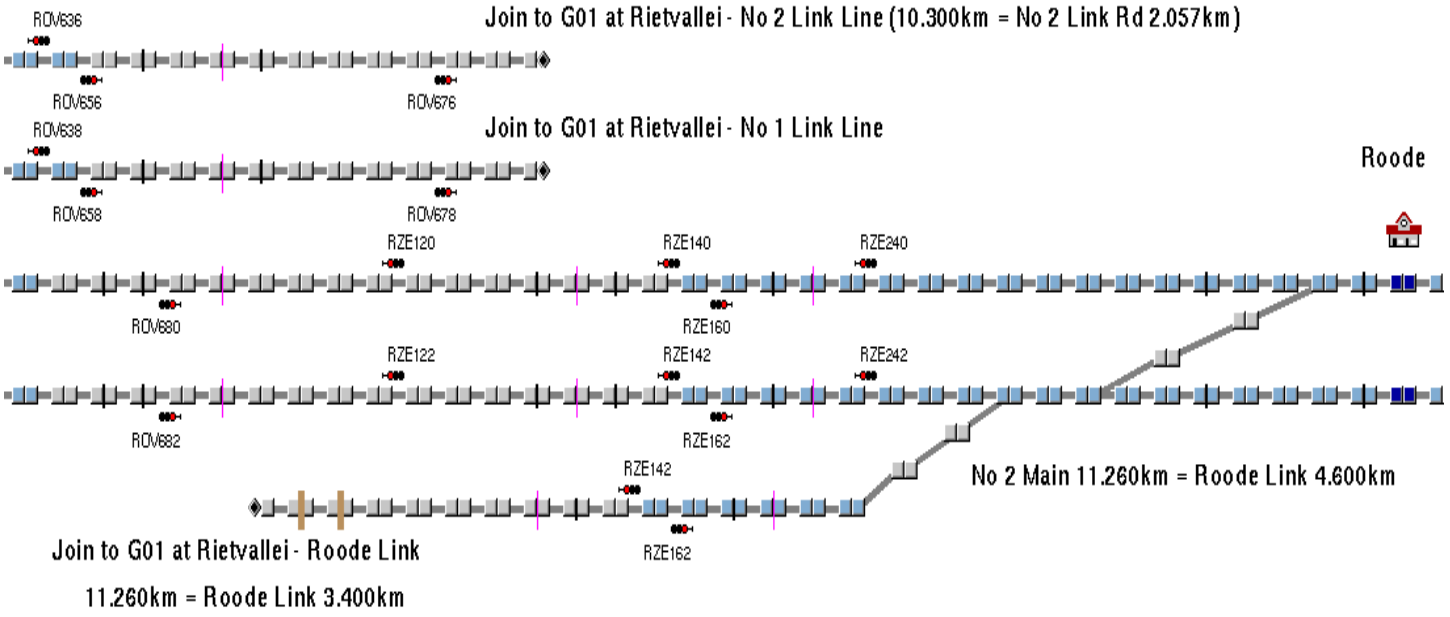
In our experience from building the South Africa PMG to Durban model it is quicker building a yard with the CLIP Add-on for OpenTrack than by hand (when the kilometrages are known).

However time is needed to work out;

- What the kilometrages of all your turnouts are
- What track they are on
- What their name is
- This needs to be typed into Excel for the CLIP Add-on for OpenTrack to read.

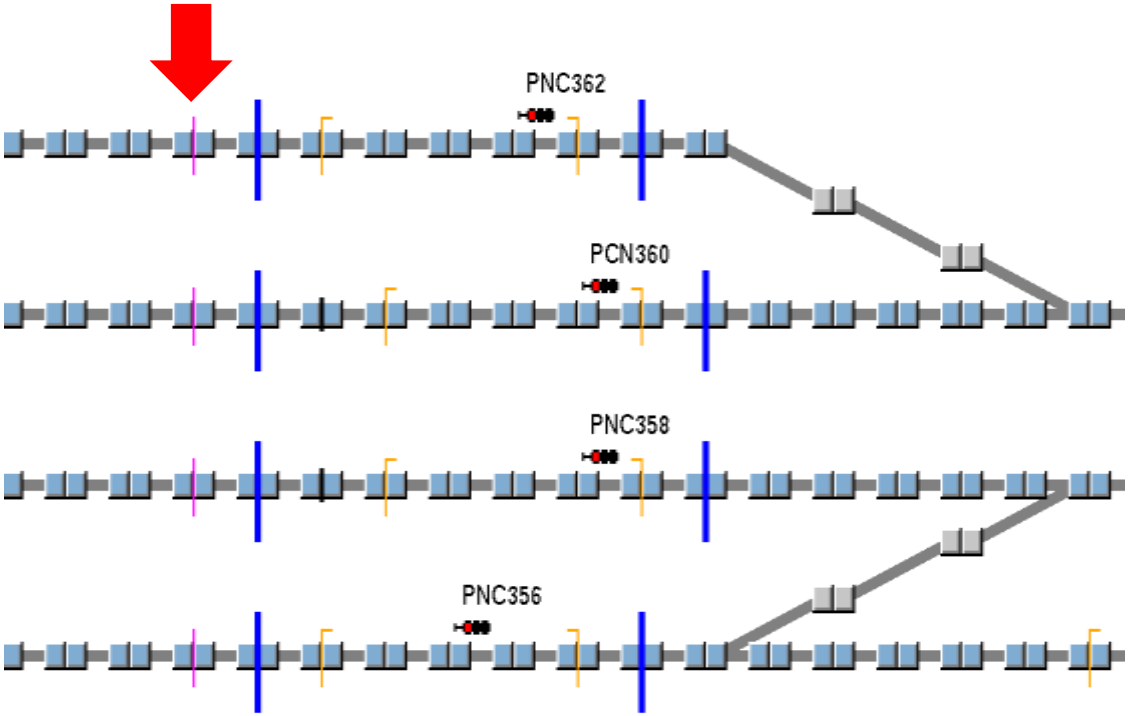
Plateway's CLIP Add-on for OpenTrack

- The Plateway CLIP Add-on for OpenTrack allows the specification of labels at any location. At present labels are all the same size but there is no reason we can't add other sizes or fonts later.



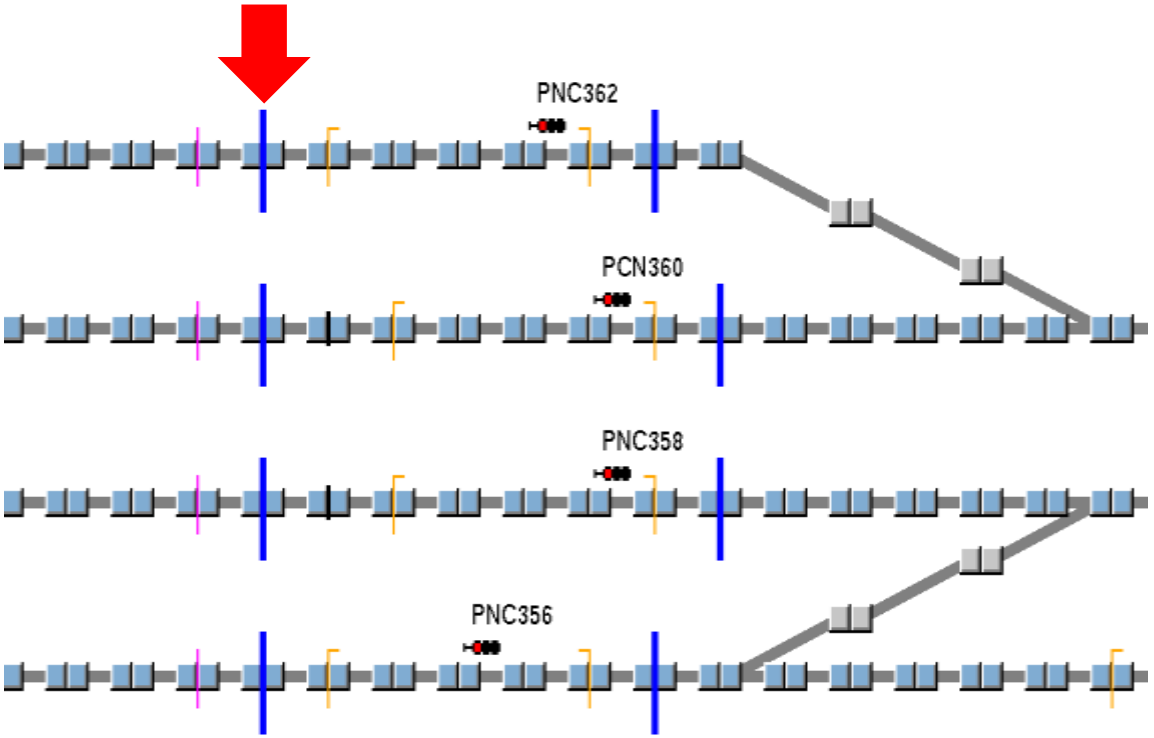
Plateway's CLIP Add-on for OpenTrack

- The Plateway CLIP Add-on for OpenTrack indicates gradient change vertices with a faint pink line.



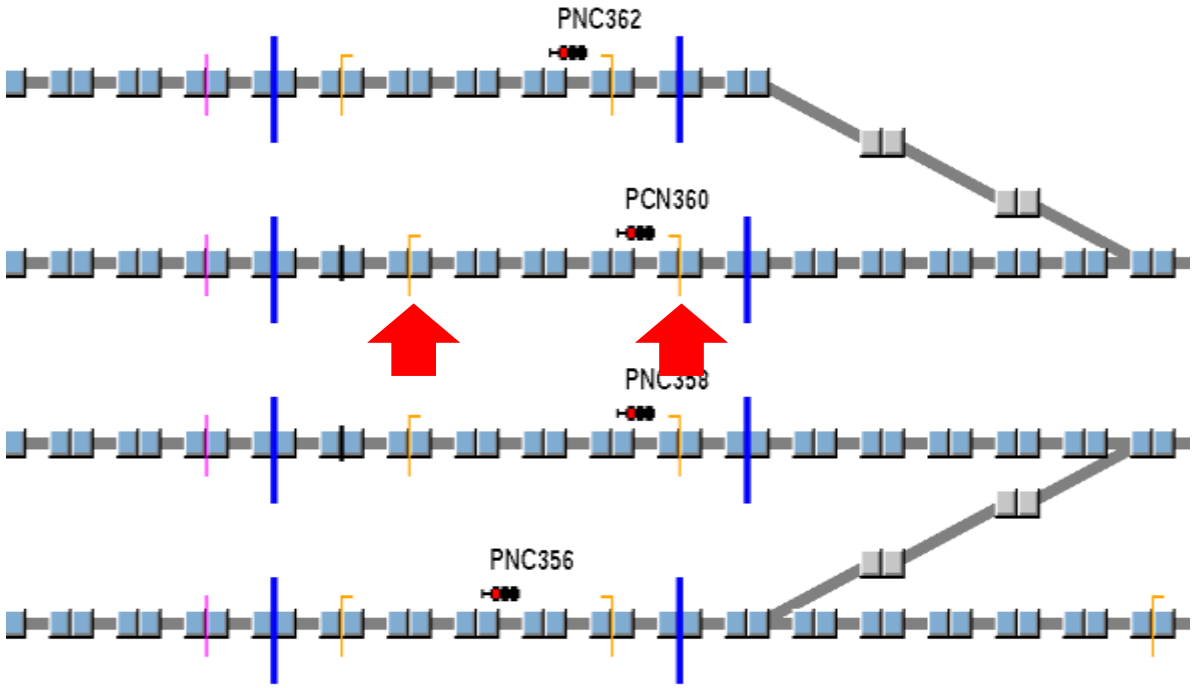
Plateway's CLIP Add-on for OpenTrack

- Speed changes are indicated with a thick blue line.



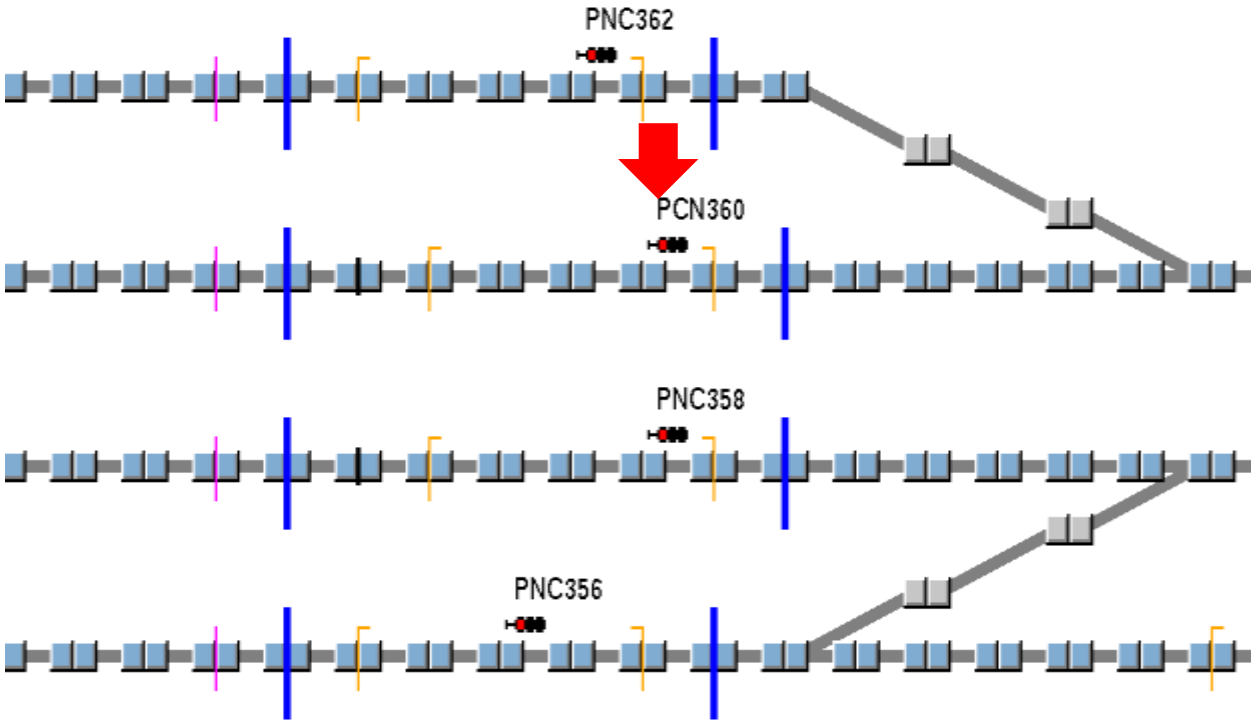
Plateway's CLIP Add-on for OpenTrack

- The start and end of a curve is indicated with upside down orange L shapes.



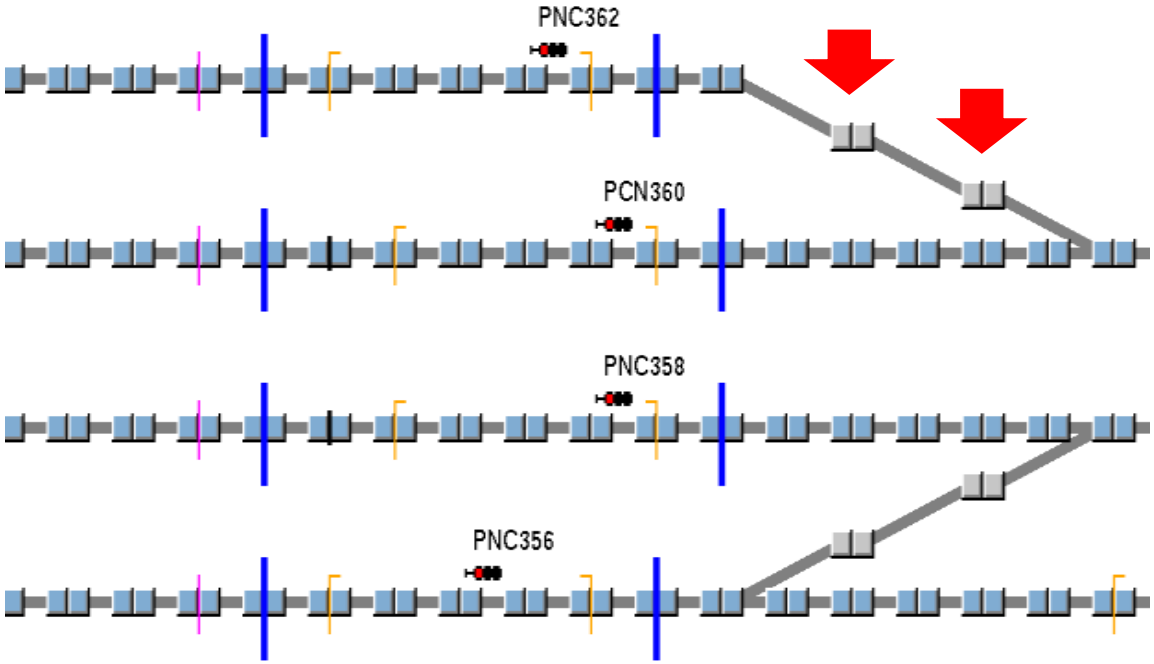
Plateway's CLIP Add-on for OpenTrack

- The CLIP Add-on for OpenTrack also labels all signals



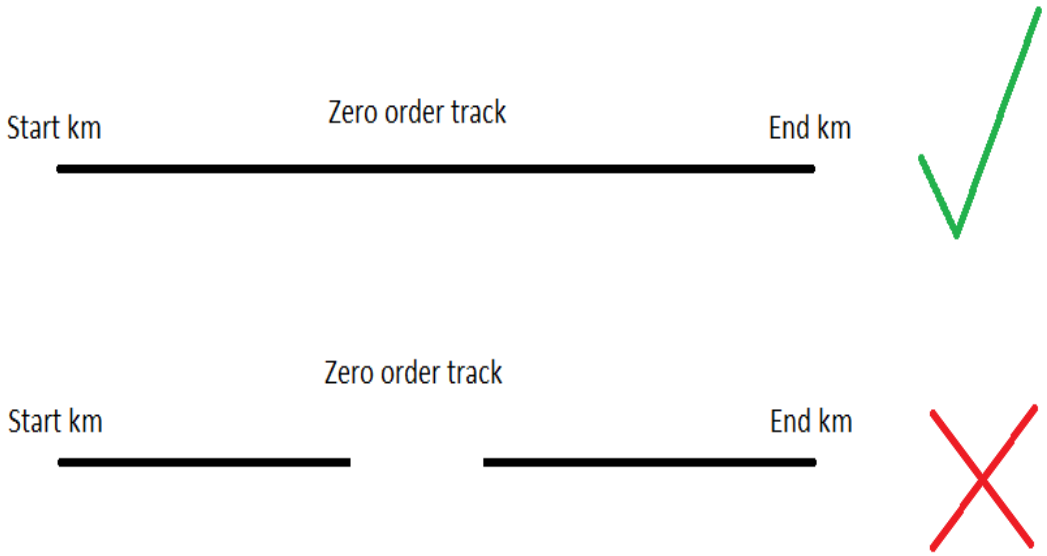
Plateway's CLIP Add-on for OpenTrack

- For compliance with OpenPowerNet The CLIP Add-on for OpenTrack puts two vertices on all crossovers.



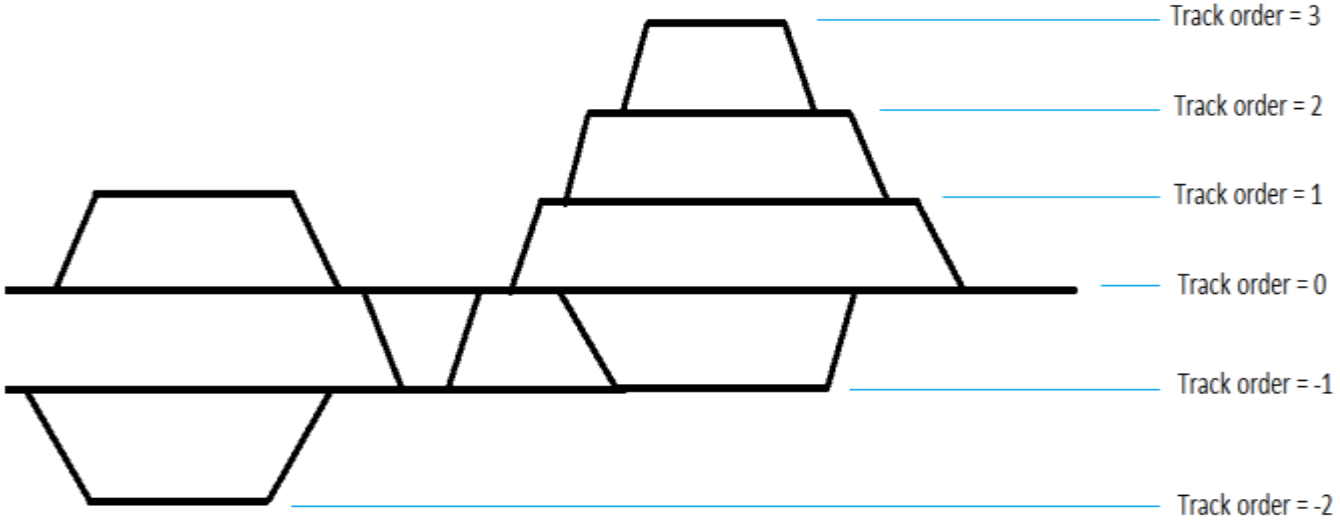
Plateway's CLIP Add-on for OpenTrack
Input files

- For the CLIP Add-on for OpenTrack the zero order track must be continuous and unbroken.



Plateway's CLIP Add-on for OpenTrack
Input files

- For plotting purposes each track is given a "track order number" which defines its relation to the zero order track as shown.



Plateway's CLIP Add-on for OpenTrack
Input files

- The "Track Order File" defines the horizontal order of every track.

	A	B	C
1	Line name	Track name	Track order number
2	G08 PIETERMARITZBURG - BAYHEAD	No 1 Main	0
3	G08 PIETERMARITZBURG - BAYHEAD	No 2 Main	-1
4	G08 PIETERMARITZBURG - BAYHEAD	PNC Up Goods	-3
5	G08 PIETERMARITZBURG - BAYHEAD	PNC Down Goods	-2
6	G08 PIETERMARITZBURG - BAYHEAD	ASR No 1 Loop	1
7	G08 PIETERMARITZBURG - BAYHEAD	ASR No 2 Loop	-2
8	G08 PIETERMARITZBURG - BAYHEAD	CFD No 1 Loop	1
9	G08 PIETERMARITZBURG - BAYHEAD	CFD No 2 Loop	-2
10	G08 PIETERMARITZBURG - BAYHEAD	COR No 1 Loop	1
11	G08 PIETERMARITZBURG - BAYHEAD	COR No 2 Loop	-2
12	G08 PIETERMARITZBURG - BAYHEAD	DAS No 1 Loop	1
13	G08 PIETERMARITZBURG - BAYHEAD	DAS No 2 Loop	-2
14	G08 PIETERMARITZBURG - BAYHEAD	GDL No 1 Loop	1
15	G08 PIETERMARITZBURG - BAYHEAD	GDL No 2 Loop	-2

Plateway's CLIP Add-on for OpenTrack
Input files

The electric substations file

- The only significance of the electrical substations file to OpenTrack is that it puts a label of the electrical feeder name next to the specified vertex.

	A	B	C	D	E
1	Line name	Track name	Kilometrage	Substation Name	Substation Code
2	C08 FENDYKE - MACFARLANE	No 1 Main	203.090	Veertien Strome	VSE
3	C08 FENDYKE - MACFARLANE	No 1 Main	209.580	Fendyke	FYX
4	C08 FENDYKE - MACFARLANE	No 1 Main	220.754	Honesty Substation	HSY
5	C08 FENDYKE - MACFARLANE	No 1 Main	242.188	Kareeput Substation	KAT
6	C08 FENDYKE - MACFARLANE	No 1 Main	252.775	Content	CNX
7	C08 FENDYKE - MACFARLANE	No 1 Main	262.920	Windsorton Road	WOW
8	C08 FENDYKE - MACFARLANE	No 1 Main	274.430	Slypklip	SLY
9	C08 FENDYKE - MACFARLANE	No 1 Main	285.534	Macfarlane	MFL
10	End of file				

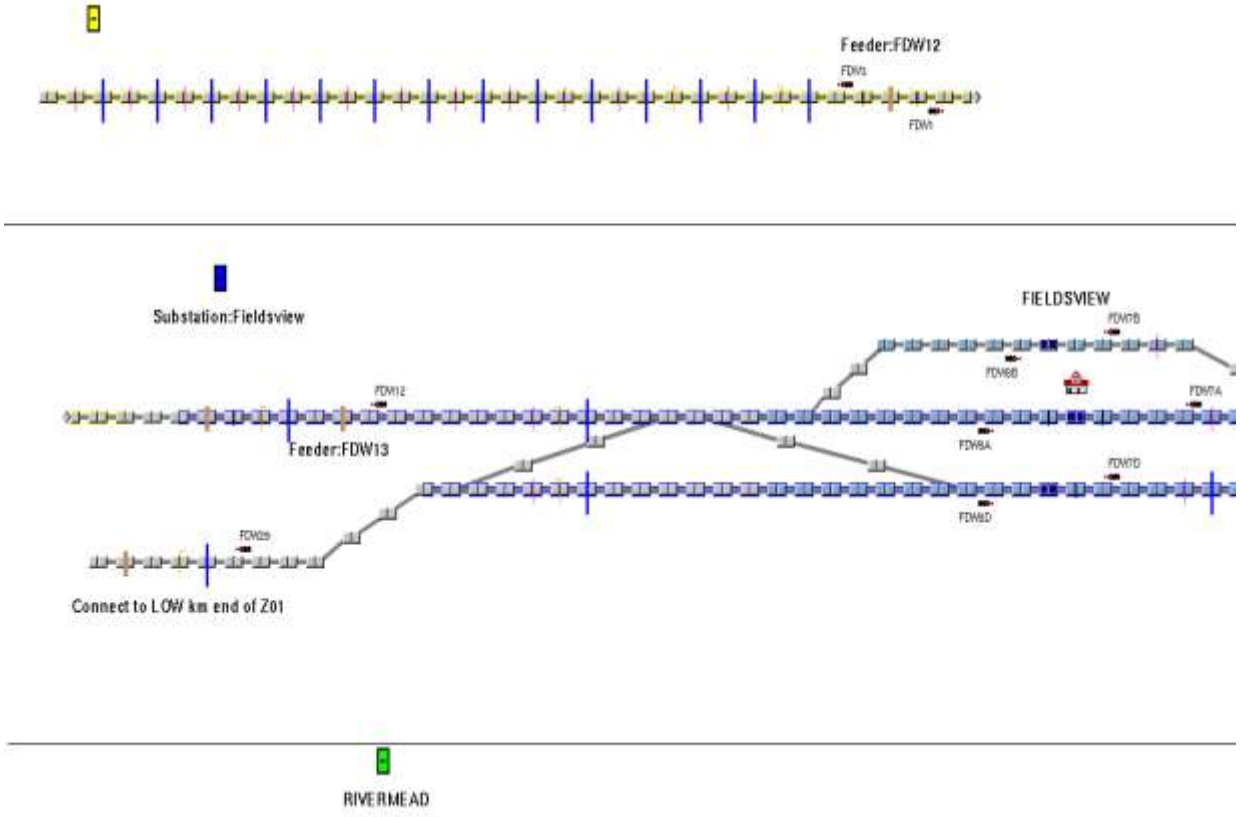
Plateway's CLIP Add-on for OpenTrack
Input files

The electric sections file

	A	B	C	D	E	F	G	H
1	Line name	Track name	Section start kilometrage	Section end kilometrage	Electrical section name	Electrical section color	Supply frequency (1 - DC, 2 - 16.6 Hz, 3 - 50 Hz)	Supply Voltage (kV)
2	Z03 FIELDSVIEW - KOOPMANSFONTEIN	No 1 Main	8.105	17.350	FDW2-FDWF1	Yellow	0	0
3	Z03 FIELDSVIEW - KOOPMANSFONTEIN	No 1 Main	17.350	20.381	FDWF2-FDW19	Dark Blue	0	0
4	Z03 FIELDSVIEW - KOOPMANSFONTEIN	No 1 Main	20.381	27.200	FDW19-WEI15	Green	0	0
5	Z03 FIELDSVIEW - KOOPMANSFONTEIN	No 1 Main	27.200	27.800	WEI15-WEIF1	Yellow	0	0
6	Z03 FIELDSVIEW - KOOPMANSFONTEIN	No 1 Main	27.800	28.939	WEIF1-WEI3	Purple	0	0
7	Z03 FIELDSVIEW - KOOPMANSFONTEIN	No 1 Main	28.939	32.381	WEI3-BKY8	Green	0	0

Plateway's CLIP Add-on for OpenTrack
Input files

- The electric sections file creates the standard OpenTrack electrical sections.



Plateway's CLIP Add-on for OpenTrack
Input files

- Just to recap on what data is needed for the tracks:
  - Every track that is to be found within the model must have its name appear in the track order, turnout, up and down speed limit and signal files.
  - If a track name is not found within the crossover, IRJ and axle or label files it will assume no such data is needed to be loaded for the track.
  - If a track name is not found within the gradient or curve radii file it will be automatically copied from the zero order track.

Plateway's CLIP Add-on for OpenTrack
Input files

- Things which the CLIP Add-on for OpenTrack can be made to do in the future but which it does not yet do and hence which you currently still have to do yourself include:
  - Set reserve with previous where necessary on single track sections.
  - Set up overlaps.
  - Set up release groups.
  - Connect documents to each other.

Typical Simulation Configuration

- Simulations usually run at 5 s intervals.

  (May be adjusted for OpenPowerNet).
- Fewer (typically 3-5), larger simulation runs are required to build a scenario.
- OpenTrack provides for 200 individually repeatable (on the same computer) disturbance simulations.

Typical Simulation Configuration

- Disturbance scenarios are discarded if they jam too soon and previous scenarios tested ran through.
- Judgement is required to make minor timetable adjustments which will enable a scenario to run.
- Typical simulation time is up to 3 hours per scenario.

Railway Freight Network Modelling Outputs

- Plateway uses Excel to manage and present the outputs.
- As each train category has different commercial drivers the outputs are divided into “traffic flows” which look at each service type and geographical flow.

Railway Freight Networks Modelling Approaches

Basic statistical analysis for each scenario to calculate:

- the mean end delay.
- the standard deviation (amount of variance).
- Number of trains simulated.
- Genuinely jammed runs included as a measure of network congestion.

Key Themes from Projects

A “planned” service operated to the “plan”:

- is always more reliable.
- has a higher level of throughput.
- uses fewer resources (trainsets, crews, yard tracks).
- satisfies the customer.

Key Themes from Projects

Network connectivity and access to terminals for is required to integrate the rail operations with the customers logistics chain.

Corporate Background

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