Visualising Early Stage Railway Development Through Simulation

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Big railway infrastructure projects are booming in many countries all over the world. And what all of these projects have in common is that at a very early stage a study will be conducted to analyse the benefits of the line to be constructed. This is to analyse and demonstrate the capabilities of such a new line, as well as to support early stage design.

A computer simulation of the operations will have to be run to demonstrate:

- What will be an expected journey time?
- Can the line handle the amount of trains expected?
- How many trainsets are required?
- Is the line capable of handling the mix of different train services?
- The number, size and location of stations and operational loops and sidings.

Looking into the Level of Detail

For a simulation, a computer model of the line has to be built. This needs detailed information about infrastructure and rolling stock. In general the more detailed data is available, the more detailed are the results.

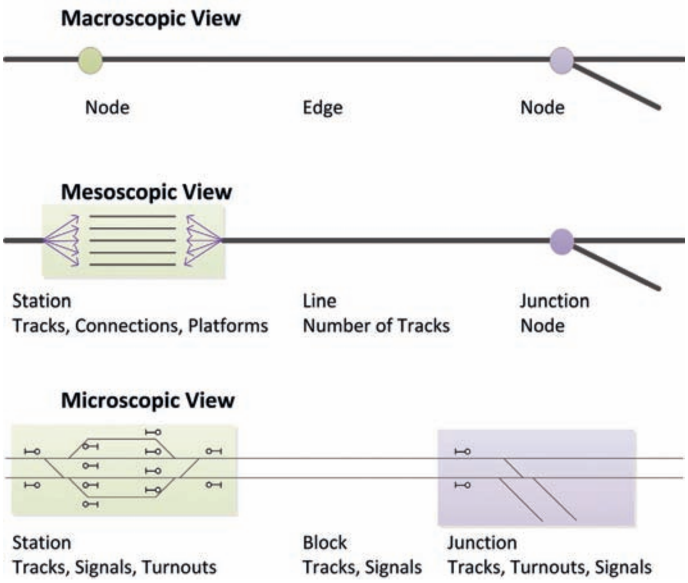
At this early stage not much detailed information is available, but for the task of an early stage simulation it is also not needed.

The level of detail is best described in a layer model: Macroscopic - Mesoscopic - Microscopic points of view. In all three views the same infrastructure is described, however, the levels of detail are changing from a little detail (macroscopic) to very detailed (microscopic).

Macroscopic point of view sees stations as nodes and tracks as edges of specific length.

Mesoscopic point of view adds more detailed parameters to the nodes and edges (like the number of tracks in stations or technical headways in block sections).

The microscopic view then takes every detail into account. Turnouts, signals, track sections, all is exactly positioned on the meter. Trains are run and analysed in steps of a second.



Sample Project

On the bases of a real project in Thailand, the Thai section of the standard gauge line form Kunming in China to the ports of Rayong, we will describe the development of a simulation.

The proposed line will enter Thailand at Nong Khai and will mainly run in parallel to the existing SRT line towards Bangkok. Later it will bypass Bangkok on the east going south to the ports (In the simulation for this report some data is modified from the real data for easy illustration).

Input Required and Available

At the first step we have to look at what input is needed for a simulation:

- Some track alignment data
- Traffic demand forecast data
- Proposal of type of train services and type of trains

At the very early stage of the project most likely, the alignment of the line is not known in detail. Further there is no specific rolling stock chosen to be used.

What data is available?:

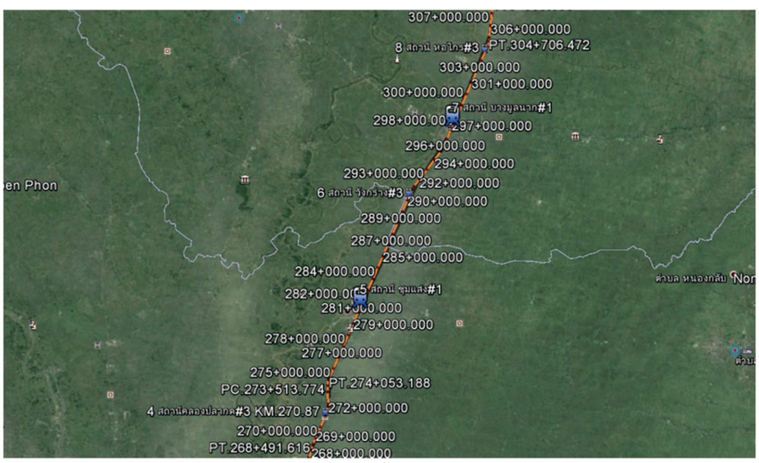
- Map of the line
- Basic technical data (gauge, electric/diesel, type of traffic)
- Proposal for services and speeds
- Demand forecast for passengers and freight

We are at a very early stage of the study. To do a simulation at this level, even data as simple as listed is enough for the start. We are looking from macroscopic and mesoscopic points of view.

Infrastructure Data

A good start to build up the infrastructure model is a map on google earth. In a simple '.KML' file, stations and track alignment can be shown. No great detail is needed, but basic alignment data (distances or even gradients) can be read out. Information, like line speed, is given by the track design. But in this early stage this design is not yet available.

For the simulation we use the proposed line speed as the basic data. Looking at the map will already indicate where speed restrictions might apply in the final design. It's therefore correct to make assumptions and apply speed restrictions based on experience. Once track design data is available the infrastructure model of the simulation will have to be updated accordingly.



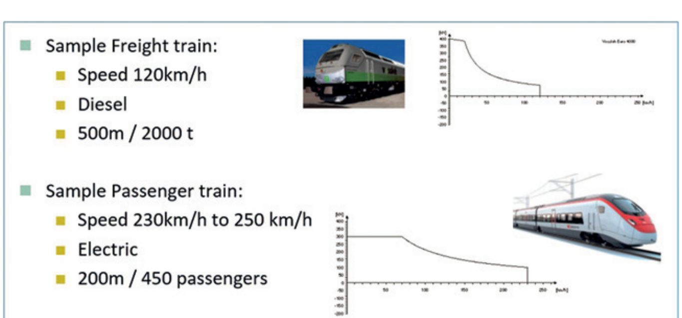
Rolling Stock

The detail of rolling stock data is not critical at this time of the project. The type of service (high speed, commuter, freight etc.) are defined in the project. The date of the opening of the line will most likely be years ahead anyway. Here the best available data is to take data from currently available rolling stock of similar technical specification.

In our sample project, passenger trains are expected to run at 220km/h. For passenger services this is not really a high speed train, but a fast standard train. Looking at the requirements of speeds, length, number of passengers etc, we chose a train from Stadler that is currently being developed for the Swiss Federal railways: 250km/h max, 200m long, 450 passengers, electric and standard gauge.

Freight trains will run at speeds upto 120km/h, diesel traction, with trains of 2000t. As a diesel loco for fast freight trains the Vossloh "Euro 4000 Freight" loco fits best for our purpose. Further Simulation will later show that in some cases double traction of these locos is needed.

General rolling stock data for a simultion is available on the internet.

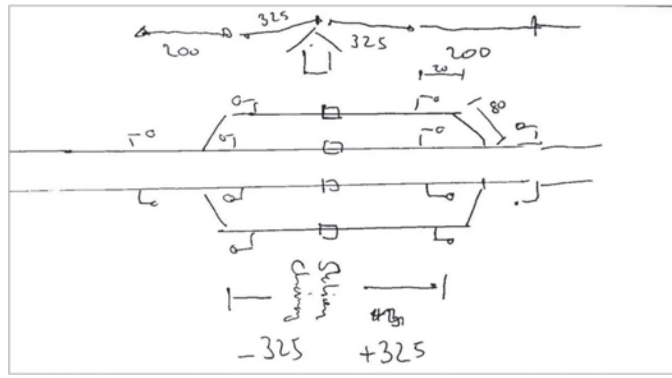


Station Layouts

At this time of the project a detailed station layout is not needed and most likely not available anyway. Some important information like the number of tracks and platforms, possibility for trains to stop and/or to overtake might still be missing.

The simulation will show where the stations and loop tracks are needed to allow for a train service as per our requirement (stopping of passenger trains, fast trains overtaking slower trains) and give input to the project design.

As input for our simulation model, a typical station layout, will do for the moment (the drawing is by hand on purpose, there is no need for a final design signalling plan).



Two or three types of stations will usually do, variations will include:

- Number of track and tracks with platforms
- Availability of crossovers (change from one track to the other used for reduced service)
- Loop tracks (for overtaking)

With the above simple station-data we can build up our simulation model. Actual station design will be different later, but for now only the number of tracks for mainline operations count. Shunting tracks or details of industrial sidings may also be left out for now.

Often stations can be replaced with halts. This will simplify the infrastructure. And simulation will show if this can be done without impacting on the operational requirements.

The simulation will also show if the choice of stations was correct. The simulation gives valuable input into the design of the line.

Plan a Timetable

With a macroscopic model based on above data we can run the simulation and plan operational services and timetables. From the demand forecast data (passengers per day and sections and freight tons per year) we determine the number of trains, per service, required.

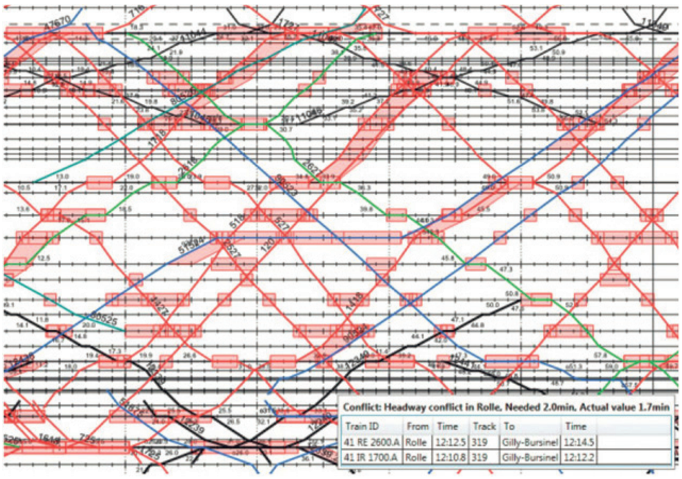
First we plan each service individually, then we combine all services. When planning each service individually, we get information about specific services, e.g. running times. A speed profile of the running train will help us check the reasonability of our infrastructure model and if the service will be attractive enough (running speeds, travel times etc).
For example, too long running times might indicate that the line would have to be built for higher speeds, trains not running to line speed might indicate that our trains are underpowered for the expected services.

The next timetable planning step will be to match all the individually planned services together. When combining all services, we have to plan the locations for overtaking, where faster passenger trains may overtake slower freight trains. This might be in existing locations, but if needed, we may have to propose new locations or new stations.

Modern simulation tools give us the help we need. The tool will highlight conflicts. In our timetable design possible conflicts are:

- Too many trains on a section of track
- Too short a headway of trains
- Sidings or platforms not long enough
- Locations of overtaking/loop tracks

The experienced eye of a timetable planner, with the support of today's tools, allows the construction a complete timetable that contains all the services needed, and at the same time highlight if the infrastructure is adequate or if, for example, additional overtaking loops have to be constructed.



What We Can See

The reason to do a simulation is not to plan a timetable. The timetable is the means of verifying the infrastructure or infrastructure proposal of the new line. It can be used to check if infrastructure and our operational requirements (type of services and number of trains etc.) match. A lot of detailed output gained at that time was used as valuable input into the design of the line.

What can we see in our final timetable: -

- Running times
- Can we reach the required capacity?
- Possibility and Reasonability of mixed service
  - Speed differences of services
  - Number of stations or loops
- Possible impact of external influences (geography, other operators)
- Where are passing stations/loop tracks needed
- Number of passing stations required

What's Next - More Details Needed

Once our initial simulation is done and the findings reported, work will not stop. Our initial simulation was done on a macroscopic level. Many assumptions were taken and for sure the trained eye of the engineer will highlight details that have to be looked at in more detail.

The findings have to be communicated with other parties involved in the projects. Infrastructure designers will have to take the findings of the simulation into account during the design process. Only the closed loop design – simulation – feedback will ensure the design is verified capable of handling the required traffic.

During the project design process (on a feasibility study level or during project construction) more and more accurate project data will be available.

Other Influences Affecting the Design More Than Simulation Feedback

Country or local regional politics will also have their say, and expected project costs will also have a great impact.

The simulation model should be updated according to the design process in reasonable stages. It's not reasonable to take every little design change to re-run the simulation. But waiting too long between steps might increase the risk of going the wrong way in design and corrections will be needed at a later stage.

Verification of Details

By doing a macroscopic and/or mesoscopic simulation we did have a look at the system from a higher level point of view. The trained eye of a planning engineer will spot constraints that have to be analysed in more detail.

In that case it will be necessary to simulate particular details (usually geographically limited areas) in a microscopic view.

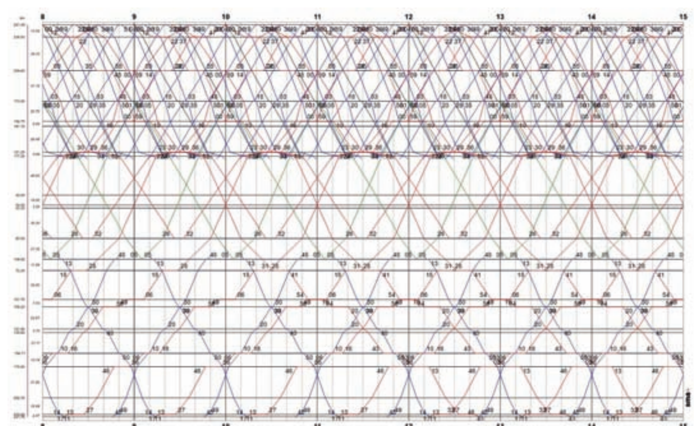
Building up a simulation model for microscopic simulation takes considerably more time. Doing microscopic simulation of the whole project area is at this early stage not necessary.

To analyse and verify specific details only, the particular area of concern needs to be modeled and looked at in detail.

In our particular example of a mixed traffic line a detailed look had to be taken in the locations where slow freight trains enter the mainline. The exact timings from freight trains to take their timeslot on the busy mainline is crucial so as not to interrupt the faster passenger trains.

For the section of track where high speed trains with 250km/h are to share track with the freight trains that run at 120km/h the overtaking of trains had to be looked at on microscopic level. Only then could the number of loop tracks be confirmed.

Further on, for a line that is partly elevated, it is important to look at the way heavy freight trains manage the gradient to the elevated track. This detail had to be looked at in greater detail. It also provided input for the freight loco performance requirements.



Final timetable

Conclusion

With very little data it's possible to plan the traffic for the future. A simulation gives us an exact output based on presentable data. On the other hand, we always have to be aware of the assumptions taken.

Using a macroscopic approach may not go into every detail, but at the early stage of a development, this approach may be detailed enough. A macroscopic simulation is usually cheaper and doesn't need as much time as a microscopic approach.

The simplicity of a macroscopic simulation (in effort and time) allows us to visualise the early stage of railway development at little cost. Even before doing a comprehensive feasibility study, simulation can be used as proof of an idea.

Simulation output is often in easy, understandable and presentable graphics. These graphics can readily be used to present the project or communicate the project status.

In this project the following tools were used:

- Macroscopic and Mesoscopic simulation and timetable planning: Viriato of SMA and Partners Ltd. in Switzerland.
- Microscopic simulation: Simulation tool OpenTrack of OpenTrack Ltd. Switzerland.

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