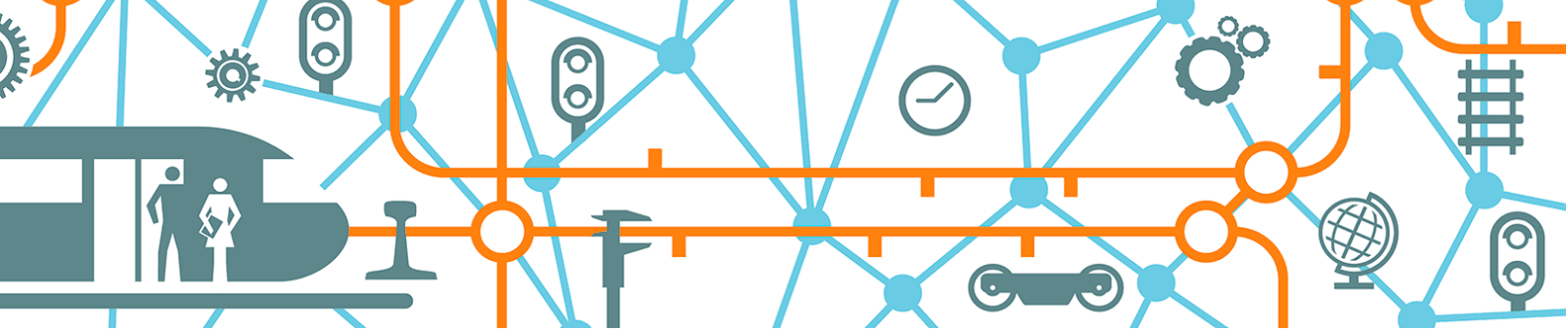

Railway Engineering: Real Time Operations

COURSE SYLLABUS

Week 1: Markets and stakeholders

The objective of railway systems is to facilitate and optimize the transport of people and goods. The system involves many different parties, but the passengers (and goods) have a central position. During this week, you will learn about the needs and demands of the passengers, shippers and other stakeholders.

1.1 An Integrated Approach

The first hour focuses on the interactions between the essential elements of railways by introducing the Cascade model. Integration is needed in the operations of infrastructure, rolling stock and staff, which all have different values. Now that you have discovered the railway markets and stakeholders, we will discuss the challenges and advantages of railway transport.

1.2 Stakeholders

Railway systems require the collaboration of many actors and stakeholders. This section dives deeper into which stakeholders are relevant for railway systems and what their needs and wishes are. Namely, the interests of the traveller, internal stakeholders and the governments will be discussed. This will be done through, for example, a video from the perspective of a selected expert in the field.

1.3 Freight Traffic

In the third hour, the focus will be on freight traffic. After an introduction, we will continue with the logistic chain of rail freight transport. Different kinds of freight trains will be named along with the advantages and disadvantages of each freight train. In addition, the organizations that are needed for freight traffic, and their roles will be discussed. With the information provided, you will learn how to create the most efficient and sustainable transportation plan in an entire network of different modes and routes.

1.4 Passenger Traffic

In most countries, the majority of train transportation operates to move passengers. In this section, you will learn what stages can be identified during the journey of a passenger and which variables contribute to the demands of passengers. Customer satisfaction is an important but complex variable in railway systems. Passenger demands are present in each stage, giving 7 basic needs of customers.

1.5 Forms of Governance

In the last hour of the week, more background on governance is given in the context of decision-making between various stakeholders. Literature makes a distinction between three different forms: markets, hierarchy, and networks. The processes and interaction between those will be given to provide some main guidelines.

Week 2: Timetable Design

Timetable design plays an important role in railway operations. This week, the purpose of timetables, planning stages and related processes will be covered. We will dive deeper into passenger demand, and how this can be translated in the optimal deployment of rolling stock on the available infrastructure.

2.1 Starting a Train Service

In the first hour, we will start by examining what is needed to connect two cities. Next, the market, infrastructure, operational staff and energy consumption will all be addressed. We will also consider the costs that this entails. The importance of the timetable will be explained through the Cascade Model that was introduced in the first week.

2.2 Purpose of a Timetable

Timetables not only guide railway parties, but also provide a way to convert market demand into supply for both passengers and transporters. In this hour, this and other purposes of timetables are covered. On top of design principles, components and attributes behind timetables, the concept of corridor drive will also be explained.

2.3 Frequency and Capacity

An important part of scheduling development is determining the investment necessary. In this hour, a method to make the timetable design choices more objective is proposed. Different levels of abstraction for capacity are covered and a focus is set on frequency. You will be asked to apply a provided method to a scenario where a city has decided to build a second station.

2.4 Structure and Design

When designing a timetable, different processes have to be considered. Processes like train running/driving, passenger dwelling, and train separation. In this hour, you will take a closer look at the timetable design's more technical aspects. The time-distance diagram plays an important role in this. A double-track bridge will be used as an example to illustrate the importance of an accurate definition of interval times and the buffer used for them. Finally, the influence of stakeholders on timetable is discussed.

2.5 Constructing a Timetable

The construction of timetables consists of different phases and processes. In this hour, we distinguish between short term focus and the long-time focus. Furthermore, we examine different approaches to making a timetable, and analyze the different phases within timetable design. If you want to know how your timetable design works in practice, whether your methods predict the punctuality or if you want to discover weak design spots, you will need to validate the timetable after running it. Several methods to validate timetable designs will be given.

Starting this week: Ask the Professor

Throughout the course, Professor Rolf Dollevoet will be available to answer any questions you have in fortnightly videos. He will give you feedback and counter-questions as well!

Week 3: Traffic control

This week, we identify the main principles and requirements of traffic-control and how to maintain the flow in case of a disruption. We will discuss how to best manage this complicated system to ensure the continuous movement of people and freight. What is the highest performance possible knowing that we have to deal with uncertain events which could cripple the 'perfect' traffic flow? How can we ensure a robust railway system?

3.1 Traffic Control Loops

Disruptions are often initiated without a warning, making it important to have solutions ready. To deal with disruptions, 5 control loops are available, ranging from solving minor disruptions to adjustments of the infrastructure. This unit focuses on the details of each control loop and how we can improve the current approaches. For this a controlled, structured and programmatic approach is presented.

3.2 Managing Delays and Disruptions

In this hour, we will dive deeper into the control loops mentioned in hour one. For handling small deviations, the train driver can solve the disruptions by adjusting speed. Can this be optimized by utilizing automatic train driving? After an analogy to explain minor delays, we will discuss the ideal follow-up time between trains to prevent the spreading of delays. Furthermore, the multiple stages of disruption as well as pre-defined solutions will be highlighted.

3.3 Design for Traffic Control

This section will focus on the control loops for disruptions on the long-term. For this, the timetable is evaluated and adjusted, in order to see how small changes in the timetable can make a big difference. Furthermore, the final control-loop will be elaborated upon. Here the focus is on strategic feedback and therewith pre-designed adjustments in the infrastructure to create flexibility. Finally, we will see how we can use models to predict the delays of trains and why this can be useful.

3.4 Functions

Even when timetables are already finished, some last-minute changes may need to be implemented. This unit explores what levels of last-minute changes exist and how the implementation of these can be facilitated. Is it possible to facilitate every unplanned action? Since train paths and routes play important roles in authorizing possibilities, each is considered with their own constraints. At the end, the elements of rail network will be clarified.

3.5 Organization

In the final hour of week three, the focus is on organizational aspects of solving the disruptions. The challenge to be solved is that three schedules (infrastructure, rolling stock and crew) always have to be in mutual accordance, fulfilling their dependencies. Animations of adjustable timetables show the extra level of complexity when rescheduling both rolling stock and staff.

Expert videos

Professor Rolf Dollevoet will answer questions from participants involved in the Rail MOOC through videos. They are both related to operations, but since many topics are discussed in this introductory course, also to other aspects of the railway system.

Week 4: Re-evaluating Decision-making

During the fourth week, we not only analyse the current situation but also reflect on why things are the way they are. By re-evaluating priorities, we aim to redefine and restate the main goal of railway infrastructure. Daring to question the system challenges us to re-evaluate priorities and reflect on the actual goal of having railway infrastructure. What solution would be best suited for the traveller?

4.1 Centralising the User

The priority of commuter trains is always the passenger; however, choices cannot always be made in favour of the passenger. Complex dilemmas need decisions, for example, when will the last train of the day run or how do we cope with freight transport through urban areas? In this hour, different aspects of centralising the user will be discussed and what considerations have to be made.

4.2 Questioning the System

In week 2, we came across a calculated academic approach. The actual goal is not to optimize the timetable, but to optimize the flow of traffic, in which the traveller is prioritized. In this hour, we will more closely inspect how complications in railway operations can best be addressed with the user's experience in mind. We learn how 'pre-defined' puzzle pieces are not always the best way to solve an issue, if the interests of the traveller are the priority.

4.3 Setting Priorities

In a very complex network of resources, logistics and stakeholders it is important to set priorities. Not only is it essential to focus on the very issue you are dealing with at that moment, but also understand the (in)direct consequences for the following trains and passengers. In this unit several main considerations are described and examples are given.

4.4 Learning form a Metro Network

Many factors are considered when constructing a timetable. Many of which have been covered in the previous hours. In this hour we see how existing timetables influence the creation of new timetables. We will consider short lines versus flexibility, delays and connections and schedules versus next trains.

4.5 Governance Dilemmas

In many countries, governance plays an important role in the rail industry. Often, dilemmas occur such as market versus hierarchy, private versus public, or state versus commercial. In the last part of week 4 we examine the influence of governance and what the alternatives are. Besides that, the concept of cooperative governance is covered.

Find our academic staff on the forum

During the course you will be invited to join us for problem-solving discussions on the complexity of railway systems engineering. Professor Rolf Dollevoet and colleagues will take part in these interactive sessions, responding to your answers in a forum.

Week 5: Optimizing Infra-capacity

ERTMS (European Rail Traffic Management System) aims to improve the capacity of tracks. In short, the main goal of ERTMS is to make optimal use of the existing railway infrastructure, with safe maximum traffic capacity and minimal use of energy, by means of a computerized system. We consider the opportunities of the system combined with the knowledge and developments of today. Besides that, we ask the question whether stakeholders can align towards an overall goal, rather than following their own interests.

5.1 Design dilemmas

To facilitate passenger transport in the best way possible, smart decisions have to be made to optimize the use of the available infrastructure. In this unit, we will focus on those decisions. It turns out that for different countries a different solution provides the best result. Amongst others, we determine the effect of the amount of stops and the coupling on lines on the railway network.

5.2 Signalling Systems

To allow trains to drive safely on the infrastructure, good signalling systems are required. In this unit, we will see how trains are detected, how signalling systems work and how trains are controlled. Furthermore, we will dig deeper into ERTMS and see how this operates on different levels. With this knowledge, we will have a look at the overall picture and the reality as it is today.

5.3 Development ERTMS

The issues with ERTMS as an extra system and the high costs of implementation has hindered any large scale ERTMS implementation in Europe so far, though it was the original intent from the 1990s behind the development of ERTMS. In this hour, we will focus on the difficulties we face when implementing ERTMS and investigate the implementation of ERTMS worldwide.

5.4 Implementation ERTMS

Based on the difficulties that we face when implementing ERTMS, in this hour, we will explore the necessary steps to implement ERTMS. What opportunities are available and what route is still ahead? It will become clear that this is a complex issue, and we invite you to share and discuss your views on this topic.

5.5 Rules and regulations

When stakeholders with different value prevalence have to work together it is to be expected that conflicts occur. Those conflicts are the reason we design governance. In this unit, the role of the government is studied and we see how we can deal with the different prevalences between stakeholders. This is done for multiple levels, namely on local, national and continental scale.

Week 6: Concluding case study

We challenge you to put your knowledge of the whole course together by analysing a final case study on railway operations and stakeholders, where you re-evaluate the use and position of Amsterdam Central Station in the Dutch railway system.

In this final assignment, you are given the opportunity to review a real case in order to master the following objectives:

- Analyse a real-world situation and its involved stakeholders
- Compare the current situation again possible alternative situations
- Conduct a SWOT analysis for the alternative solutions
- Dive into stakeholder involvement
- Develop additional adaptations