Introduction
Railways are complex systems. Infrastructure, rolling stock, operations and policy all need to be integrated. The rail network is one of the fastest and most reliable ways of transportation and used more than any other way of public transport worldwide. Keeping the system up and running brings many challenges each day. Anticipating on the changing demands asks for continuous innovation, co-operation and a long-term vision.

Our rail network facilitates passenger and freight transportation, within cities and on both national and international scale. To stay competitive to other ways of transportation, it must be fast, safe, reliable, comfortable and cost effective. Railway engineers can only address this permanent challenge when they are equipped with integral knowledge, covering all involved disciplines and aspects.

New Master Annotation
The annotation Railway Systems has been developed to provide the industry with scientifically trained engineers. Knowledge of the entire railway system is vital to deal with the challenges of today and tomorrow. Due to retirements, the railway sector is losing its skilled professionals rapidly. Therefore, a significant demand exists for well-trained engineers that can create, test and validate our future railway networks.

Delft University of Technology is well known for its wide range of railway education and research. This new rail annotation provides an opportunity for students of various Master's profiles to add a fundamental set of railway courses to their curriculum. From a systems approach, integrating operations and engineering, you will be prepared to become a certified railway expert.
To build a better, safer train system, starting one step ahead in railways is necessary. This is not based on just a good idea. The idea must be worked out in a research based environment and business case balanced. Also a stakeholder analysis needs to be carried out for technological innovation to be proved and implemented. Most people focus only at the technology on its own, but railway systems are more complicated. It takes time to develop, prove and implement new ideas in general. The aim for better rail transport starts with understanding the basics and relationship between the multiple assets in the railway system.

As a Master student, you will work on every day railway challenges. Our Railway Engineering group will guide you to find a scientifically based answer to solve such cases during your study, and thus bring knowledge into practice in an unique academic environment. Our leading researchers, rail laboratory and TU Delft measurement train (CTO) will facilitate you to bring out the best innovations and creative techniques. In close cooperation with the railway industry, our team works towards smarter railway systems to stay one step ahead of tomorrow’s demands. Develop an idea and challenge yourself. Create, test and validate; your ticket for a professional career in railways!
Compulsory Courses

Elements of Railway Engineering
Understanding of the basic principles of railway systems, which include both the railway track and rolling stock, is essential for all railway related activities, such as design of railway systems, management of railway asset, policy making etc. In this course the main elements of railway infrastructure and rolling stock, their functions and main features will be explained as well as the basics of track power supply and railway asset management.

Railway Operations and Control
This course gives the basics of railway signalling and its impact on the design and performance of railway operations. The course also analyses the coordination choices of the various railway subsystems from investments to operations to avoid potential misalignments and optimize overall performance. Implementing ERTMS is a main connecting example.

Operations Electives

Planning & Operations of Public Transport
This course introduces strategic, tactical and real-time operations planning of public transport systems. Topics include the characterization of public transport systems, networks and timetables, estimating railway capacity and reliability of services, and analysing service performance.

Railway Traffic Management
This course covers models and methods to design good railway timetables, energy-efficient train operations, and real-time traffic management. In addition, microscopic simulation is applied to analyze railway traffic performance under scheduled and disrupted traffic conditions.

Transport Safety
This course presents a systematic approach towards safety, with a focus on human factors, both in the design and operation phase. A systems perspective considers the effect of transport safety on society including accident analysis, while a bottom-up perspective considers risk analysis methods.

Engineering Electives

Structural Design of Railway Track
This course will provide deeper knowledge on the static and dynamic behaviour of railway tracks; hands-on experience with analytical, engineering and numerical methods like Finite Element and Multi-body based software. Finally, gained knowledge is applied to solve a given real-life railway track related problem.

Design & Maintenance of Railway Vehicles
The design and maintenance of vehicles have a direct impact on comfort of passengers, health conditions of tracks and vehicles, but also on operational safety. The course focuses on the vehicle dynamics; vibration, derailment and stability are discussed in relation to the railway track through wheel-rail contact.

Wheel-Rail Interface
This course concerns the theoretical and the practical aspects of wheel-rail interface. The course starts with everyday observations in the railway system that clarify what wheel-rail interface is, why it is so important and where the challenges lie in Railway Engineering.

Railway Assets: Performance by Design
Increasing demands on railways introduce a critical design challenge: from static design with functional specifications towards life-cycle performance based design. This course develops the engineering basis of such a design, with a focus on the interface between dynamics and material behaviour.

Capita Selecta
The main objective of this course is to bring students into contact with professionals from the railway industry who are involved in big infrastructural projects. The course consists of a series of guest lectures and discussions reflecting different topics and areas of expertise.

Railway Asset Management
Railway assets (infrastructure and rolling stock), have a long life expectation if well managed and monitored. By avoiding premature termination of assets, the life span of railway systems can be extended. The goal of this course is systematic and in-depth training on asset management.

"Hello! My name is Bojan Bogoević (Serbian roots), finishing a Bachelor’s degree in Civil Engineering at the TU Delft.

As a child I always had a strong interest for vehicles: buses, trucks, airplanes and also trains. Because of this strong interest, in 2015 I realised one of my dreams, to be a coach driver. Due my age of 19 years at that time, I was the youngest coach driver in The Netherlands.

Recently, I decided to do the minor ‘Bend and Break’, including a course about railway transition zones (e.g. between a bridge and regular track). Due to sloppy soil in The Netherlands, regular track is lowering all the time while bridges are well-founded. This results in a height difference, which causes big problems. During this course I learned that railways are complex dynamic systems, which was new and very interesting to me since civil structures are mostly static.

After the minor course, I became strongly interested in Railway Engineering. Since I already succeeded the railway course in the Bachelor, I decided to apply as a student-assistant for the railway department.

I got in touch with the TU Delft measurement train (CTO), assisting researchers with various tasks concerning different ways of monitoring tracks. Think about placing new sensors, executing measurements (while driving of course) and data processing. From this, I gain a lot of knowledge about railway systems, but also about measuring and data processing in general.

Because of the university having its own train, it is easily accessible for students. In this way, fundamental theories can be transformed into a hands-on experience, which I experienced as very important.

Next year I will start my Master’s in Rail. The new rail annotation is a great way to broaden my knowledge and learn more about this complex field of expertise."
**Objective, MSc integration and admission requirements**

**Objective of the Annotation**
The primarily goal of the annotation Railway Systems is to create MSc programmes that cover the complex challenges from both an Engineering and Operations stand, combining multidisciplinary aspects from subsystems of infrastructure, traffic management, safety and policy. The railway infrastructure (track, power supply, rolling stock, safety and signalling) should facilitate the desired railway operations (train services, traffic density, heterogeneity, synchronisation, speed) based on the transportation demands. Future railway engineers should have an integral knowledge on the whole system and interactions between subsystems.

**Cooperation with the industry**
The railway sector has a big demand for scientifically educated engineers with a broad knowledge of the whole railway system. With this rail annotation, graduates can easily find employment in the diverse railway sector; from railway administrator to railway operator, in urban rail transit, engineering and consultancy, at contractors and within the government. Various railway related companies are closely involved in the setup of our education, to make sure our lectures, projects and cases reflect reality.

**Leading in the world**
The railway engineering group at TU Delft is internationally renowned for its research and has strong connections with universities all over the world. A team of forty specialists continuously explores and investigates the railway infrastructure and rolling stock, to improve the train, tram and metro networks of today and tomorrow. By combining academic knowledge and practical experience we work towards innovations together.

**Integration within the MSc Curricula**
The annotation Railway Systems can be integrated within various MSc programmes. In consultation with our academic staff it is also possible to personalise your curriculum and follow our courses and annotation within Master degrees from other faculties.

The rail annotation is currently embedded primarily in four MSc programmes:
- MSc Civil Engineering track Structural Engineering (CEG/SE)
- MSc Civil Engineering track Transport & Planning (CEG/TP)
- MSc Transport, Infrastructure and Logistics (TIL)
- MSc TU Delft Flex (Faculties CEG, 3mE) flexible track (consult railway staff)

Students will be qualified for this annotation if they successfully have accomplished the following requirements:
- Compulsory courses (8 ECTS)
- Elective courses (14 ECTS or more)
- Graduation thesis (30-40 ECTS)

The graduation project and thesis must have a close relation to the field of railways.

**MSc Road and Rail**
For students following the Road and Rail specialization within the MSc-track Structural Engineering (CEG), all Railway Engineering electives, mentioned in the centre fold of this brochure, will become part of the set curriculum. This track is focussed on the essential technical aspects of railway infrastructure, vehicles and the different interfaces. Combined with the two compulsory annotation courses, students can also obtain the certificate Railway Systems.

**General TU Delft admission**
If you hold a Dutch BSc degree (WO) closely related to the Master’s programme, you will be admitted directly. However, if your undergraduate programme is not, you will be required to take additional courses in what is called a bridging programme. This may be a standard programme or it may be tailored to your specific situation.

An HBO Bachelor’s degree does not qualify for direct admission to a TU Delft Master’s programme. You must first complete a supplementary programme to bring your knowledge to the required level. You can do this during your HBO programme by completing a bridging minor, or through a bridging programme upon completion of your HBO degree.

**Applications through Studielink:**
www.tudelft.studielink.nl

**International applicants**
To be considered for admission to an MSc programme you will need to meet TU Delft's general admission requirements.

1. A University Bachelor’s degree (or proof that you have nearly completed a Bachelor’s programme) in a main subject closely related to the MSc programme to which you are applying, with good grades on the key courses.
2. A BSc Cumulative Grade Point Average (CGPA) of at least 75% of the scale maximum.

For more information about the application procedure, requirements and studying at TU Delft, visit: www.admissions.tudelft.nl

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**Further information**
For more details, complete requirements, deadlines and contact information, visit: www.rail.tudelft.nl

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