Railway systems and their transition.

Lecture 1

Peter Kummer
EPFL, Autumn Semester 2025

September 09, 2025

Agenda.

1. Intro & What to expect the next 14 weeks
2. Who am I, who are you?
3. What to know about our course
4. Railways: Past – Present – Future

Current challenges.

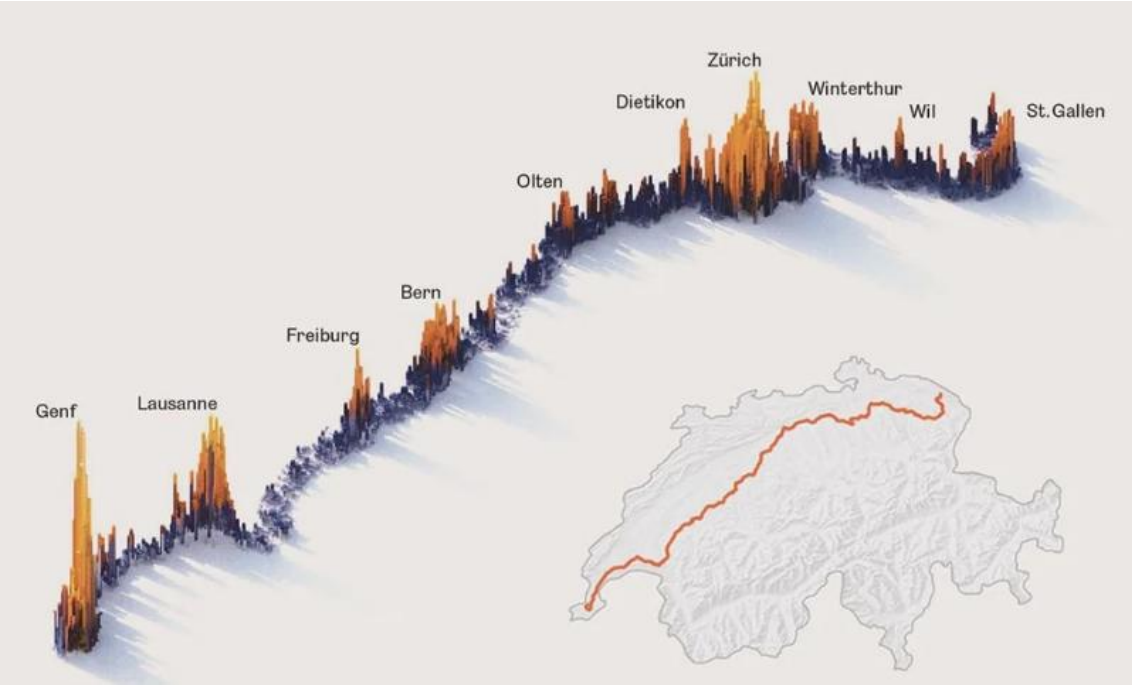
???

Railway systems and their transition
Lecture 1

Introduction & What to know about our course.

Peter Kummer
EPFL, Autumn Semester 2025
September 09, 2025

Railway systems and their transition – Lecture plan.



NZZ

You will get a **basic knowledge of transport and rail systems** and **learn** about their **strengths and weaknesses**. The goal is to obtain an understanding of railways' **contribution to the mobility sector.**

Topics of the course include:

- Railway Past – Present – Future
- Transport systems and role of railway
- Railway assets
- Customers
- Planning and development
- Safety and Security
- Financial and regulatory landscape
- Sustainability and climate goals

Content of this course.

- Railways: Past - Present – Future
- Transport systems and role of railway
- Railway assets
- Customers
- Planning and development
- Safety and security
- Financial and regulatory landscape
- Sustainability and climate goals

From railroad tycoons to “Taktfahrplan” and today’s challenges.
Evolution of railway in Switzerland and internationally also considering upcoming automobiles and trucks, climate challenge, …

Key strengths and weaknesses: Why is railway efficient in land- and energy-usage and limitations due to infrastructure / rolling stocks, transportation hubs etc.

Learn about **fundamental technologies required for a railway system** such as track, power supply, signalling, rolling stock. How to manage these assets focusing on life-cycle costs.

Changing needs and demands, including the future of „ticketing“ (mobility as a service). Understand cargo and real estate customers.

Understand the **basics of planning and developing** the transportation offer, infrastructure and rolling stock considering customer needs and capacity optimisation. Also learn about capacity usage and mixed-traffic capacity.

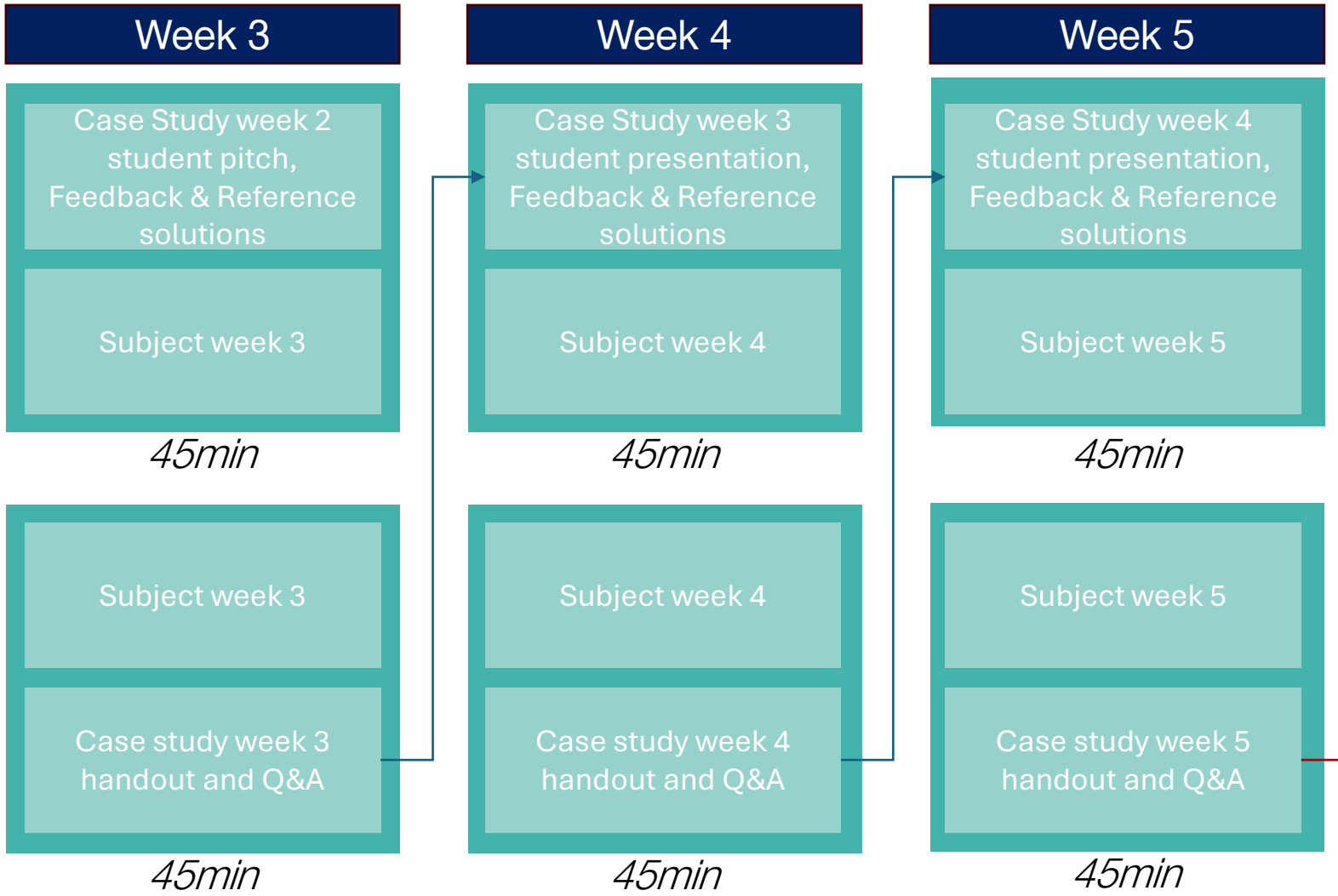
Threats from the outside for our system and our system as a threat to the outside & users. Challenges, strategies and solutions.

Efficiency in a **complex system** and how to generate revenue. The role of **public funds** for regional offers as well development and maintenance of infrastructure.

Railway and the role of transport, today and outlook on hydroelectric power, independent energy production, efficiency, net-zero, circular economy, embodied (grey) energy and more.

Lecture structure.

Case studies will allow a hands-on discussion about challenges in railways.



Case study methodology:

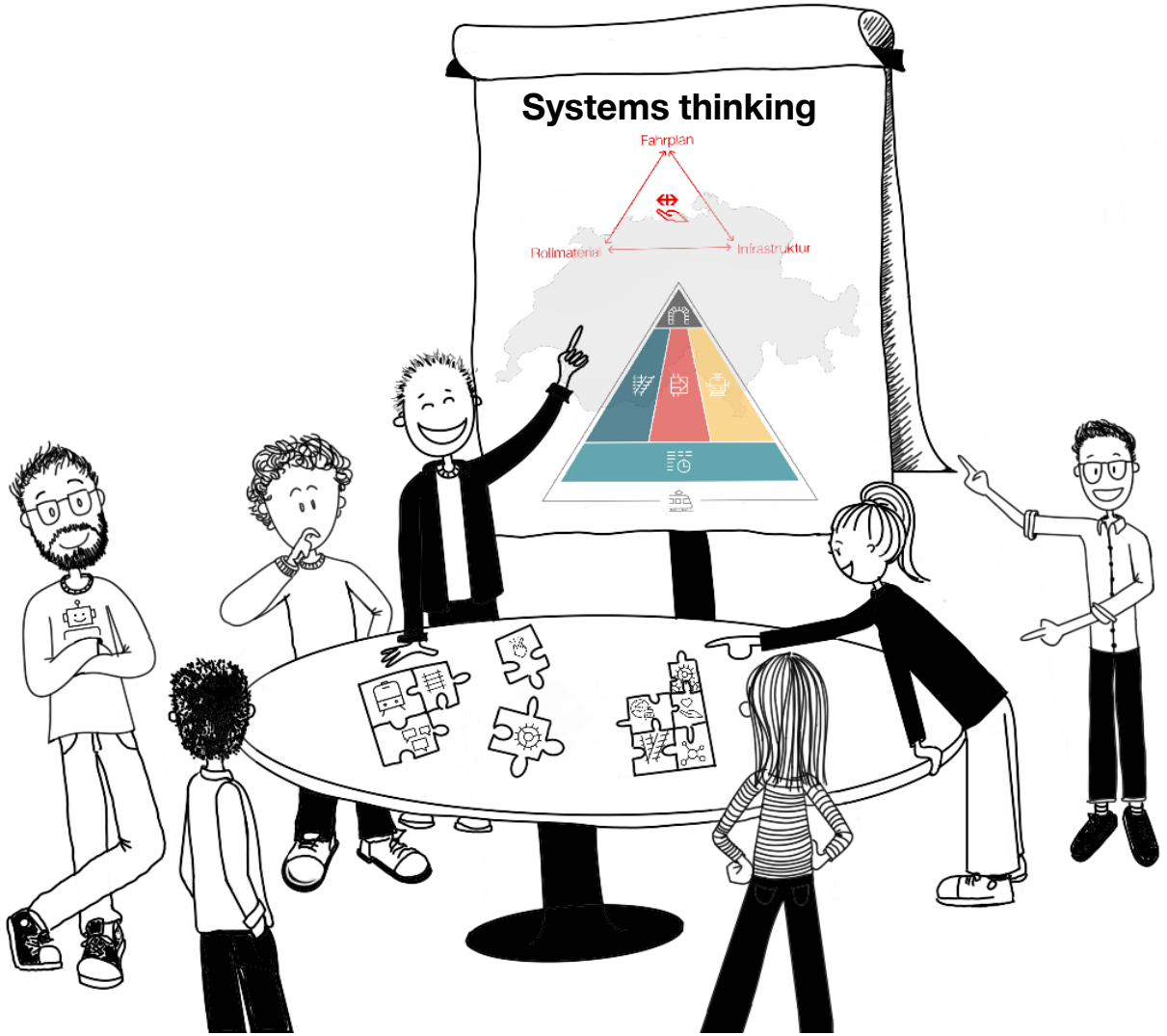
Each week some students will make a short pitch about their solution ideas to the case study of the week before.

We will provide feedback on their solutions and talk about real-case solutions we implemented within SBB for these problems.

After presentation of the new topic each week there will be a new case study question handed out and some time for Q&A.

The exercise lesson can be used for the preparation.

Student evaluation.



The evaluation will consist of multiple parts: a group project over the course of the whole semester and an individual exam.

Group project (40%)

- 3 to 4 students
- written report

Individual oral exam (60%)

- In the winter exam period
- Will also refer to the group project

Please refer to the moodle information sheet!

moodle

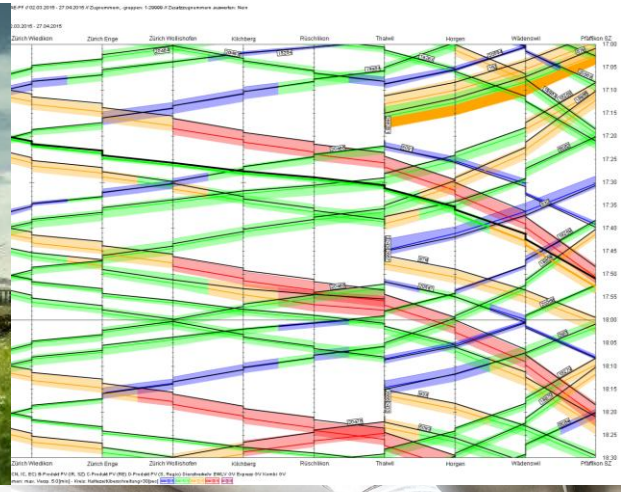
Information on group project.

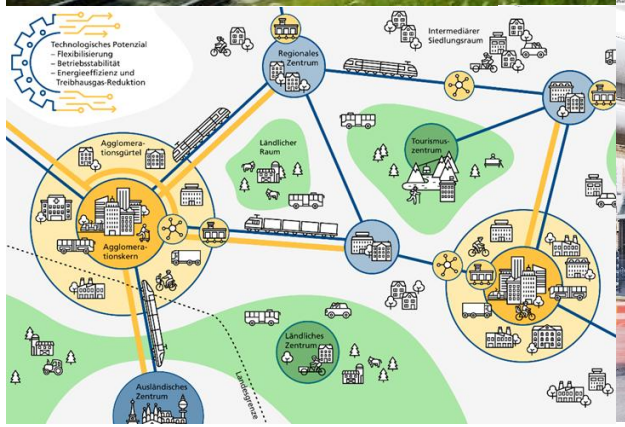
- Study a specific question related to transport systems and produce a final **report of 15 pages**.
- The groups will consist of **3 to 4 students** each.
- We will **provide topics** and possible questions.
- No more than two groups can work on the same topic.
- There is no presentation of your work. But questions regarding your report **will be part of the final oral exam.**

- **Tuesday 16.09.2025 Discussion of research questions possible during the exercise hour.**
- **Monday 23.09.2025: Groups sign up on Moodle with defined research topic question.**
- **Tuesday 07.10.2025: Deadline for the validation of the table of content.**
- **Tuesday 16.12.2025: Final report delivery.**

Please refer to the moodle information sheet!

Group project – possible topics.
Details will be provided in the 2nd lecture on September 16.





- **Sustainability in the Rail System:** Opportunities & Challenges by 2050
- **Energy efficiency in passenger and freight transport:** technical and operational measures
- **City logistics and (rail) freight:** from parcels to supermarket products and construction material
- **Freight transport in Switzerland:** Railway's role and alternatives?
- **Maintaining the Railway Network 2050 –** Regulation, finances, resources and communication strategies.
- **Swiss-European connection:** Trains instead of flights
- **Domestic and international nightly train travel chains**
- **Increasing attractivity of public transportation:** focus on pricing, customer interaction and integration of add. mobility offers
- **Safety and security:** continuous rail operations
- **Real estate and area development:** beyond mobility hubs

Individual oral exam in the January exam period. 20’

The oral exam will be an interview in the style of for example:

1. In a job interview for a senior management position at a Railway Company, you will discuss current challenges, opportunities, risks, and mitigation strategies, focusing on trade-offs rather than detailed technical expertise.

2. As a subject matter expert, you need to present information to a non-expert audience, such as in a public session, a media briefing or something similar.

3. You will evaluate an innovative idea for the railway system, analysing its relevance through a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis.

Please refer to the moodle information sheet!

moodle

Excursion on October 7th 2025.

Operational Asset Management live.

What
- Experience a live inspection of concrete sleepers on a SBB track specifically closed for this event.
- Learn more about the connection between manual and machine inspection of the rails and the impact on asset management.

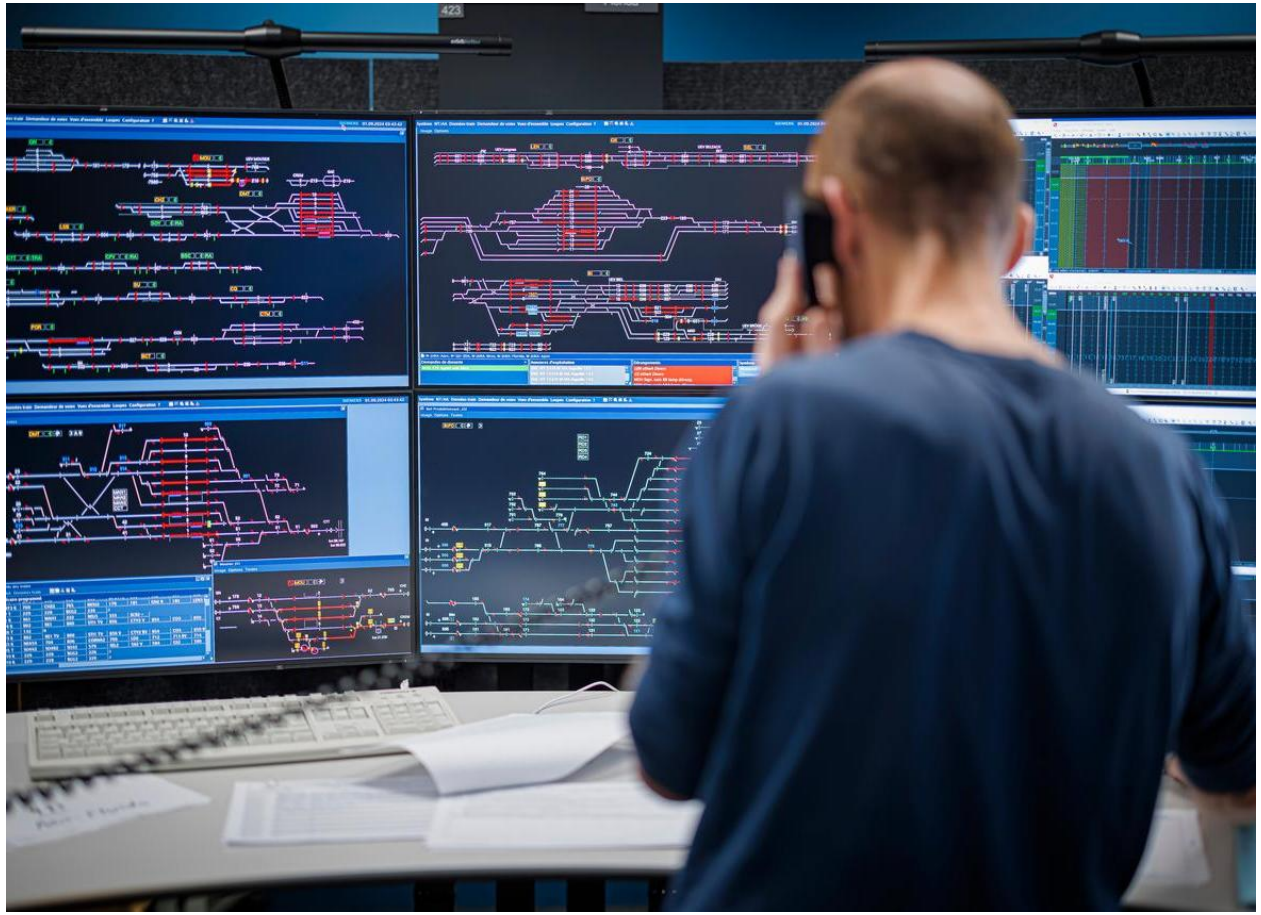
Where
- First, some theory in building A3 of SBB Simplonpark in Renens.
- Then, a field-trip to SBB track 925 just before Renens station.

When
- On 7 October 2025, 13:30-16:00, instead of lecture.

Specifics
- Sturdy footwear must be worn while out on the tracks.
- Before the trip, everyone is provided with a high-visibility vest and a helmet, which must be worn at all times.

Excursion on December 2nd 2025.

Train-control centre – from theory to real life application.



What

- You will get a unique opportunity to gain insights into real life railway operation and management.
- First hand experience of how the daily management of trains works.

When / Where

- December 2, from 13:30 until 16:00 instead of lecture, meet at Renens train station.

Remarks

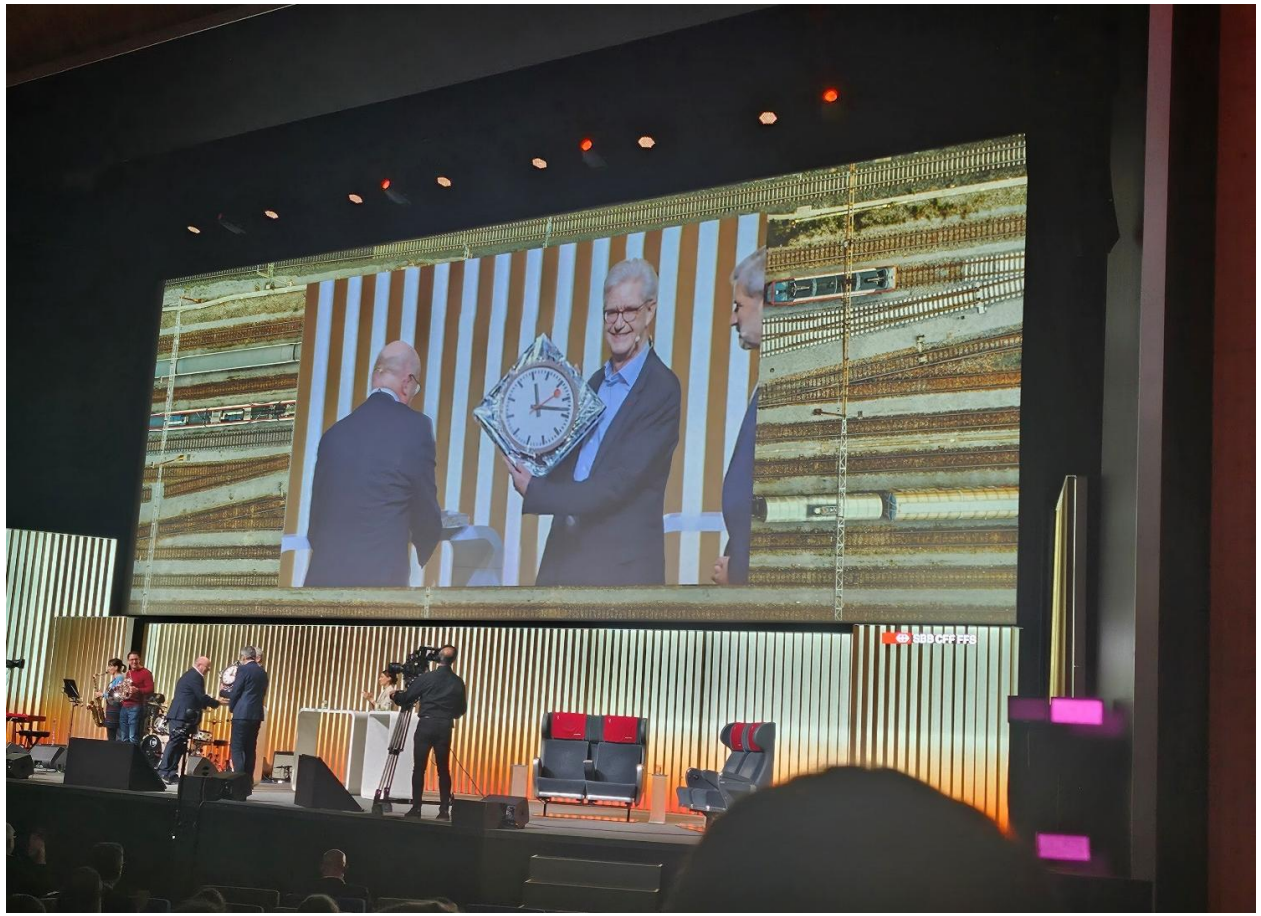
- Use this opportunity to address questions to experts.
- Mandatory participation.


SBB CFF FFS
B
7
Questions?

Introduction round.

Why am I speaking here in front of you?

Who am I?



- 15 years member of the executive board at SBB
  - 2020 - 2025: Head of Infrastructure
  - 2010 - 2020: CIO (Chief Information Officer)

- responsibilities:
  - As Head of Infrastructure: responsible for the Infrastructure division with it's 10'000 employes. The Infrastructure division guarantees optimal capacity utilisation for passenger and freight services thanks to professional train path management, efficient running, maintaining, and operating of the infrastructure and fixed railway installations. SBB Infrastructure is also responsible for developing and expanding SBB's electricity and rail network.
  - As CIO: leading SBB's entire IT department and responsible for the successful digital transformation of the company.

Who am I?

Professional Experience

- 30 years of leadership experience in the fields of Mobility, Railway, IT and Insurance
- Member of the executive board at SBB
  - 2020 – 2025: Head of Infrastructure
  - 2010 – 2020: CIO (Chief Information Officer)

Education

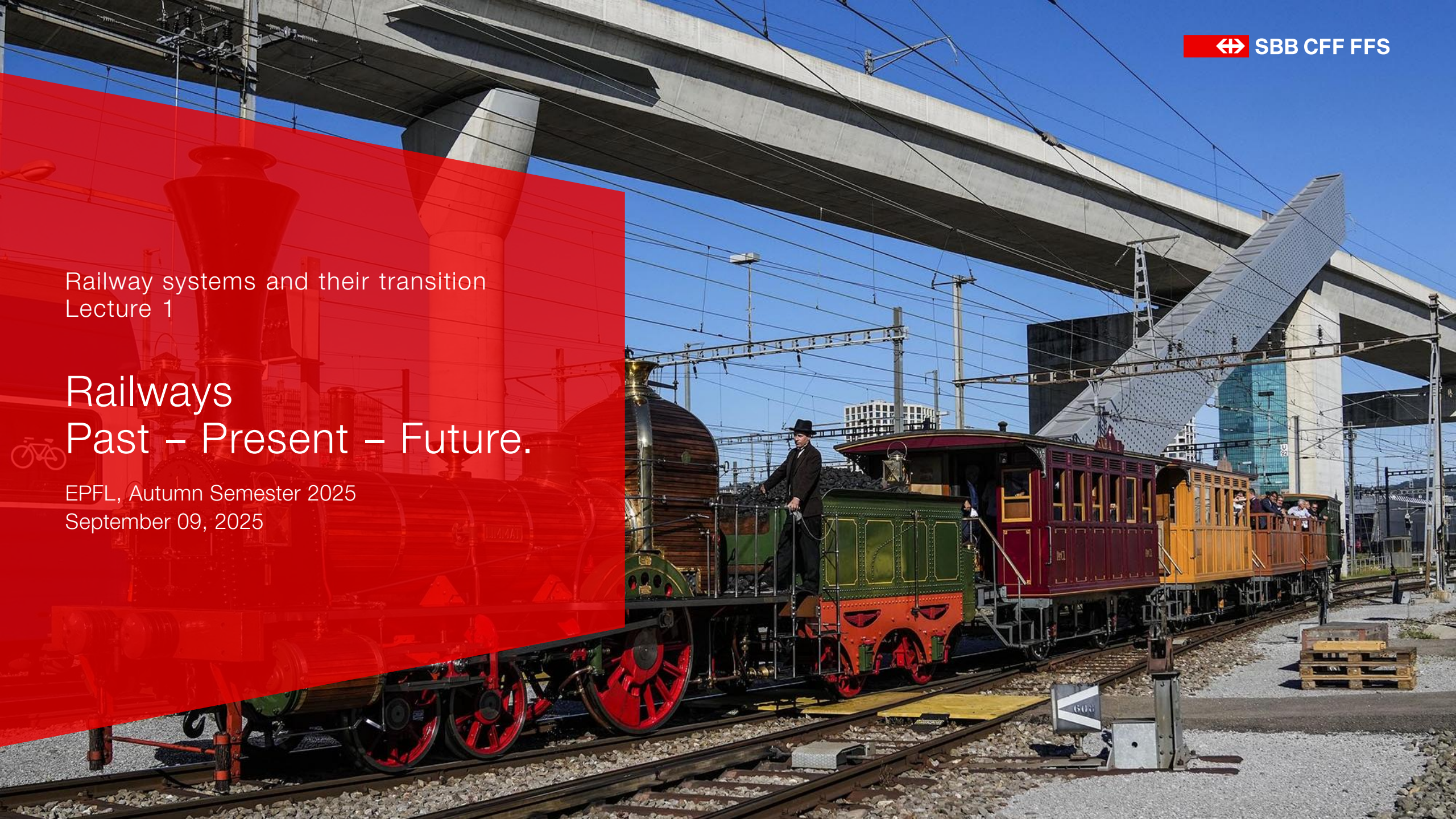
- Business Administration, lic.rer.pol. University of Bern
- Further education at University of St. Gallen (Corporate Governance) and IMD Lausanne

Personal

- Married and father of four daughters (2000, 2002, 2005, 2007)
- Living near Biel/Bienne

Who are you.

- **Name**
- **Coming from**
- **Educational Background**



SBB CFF FFS

Railway systems and their transition
Lecture 1

Railways
Past – Present – Future.

EPFL, Autumn Semester 2025
September 09, 2025

Today’s objectives

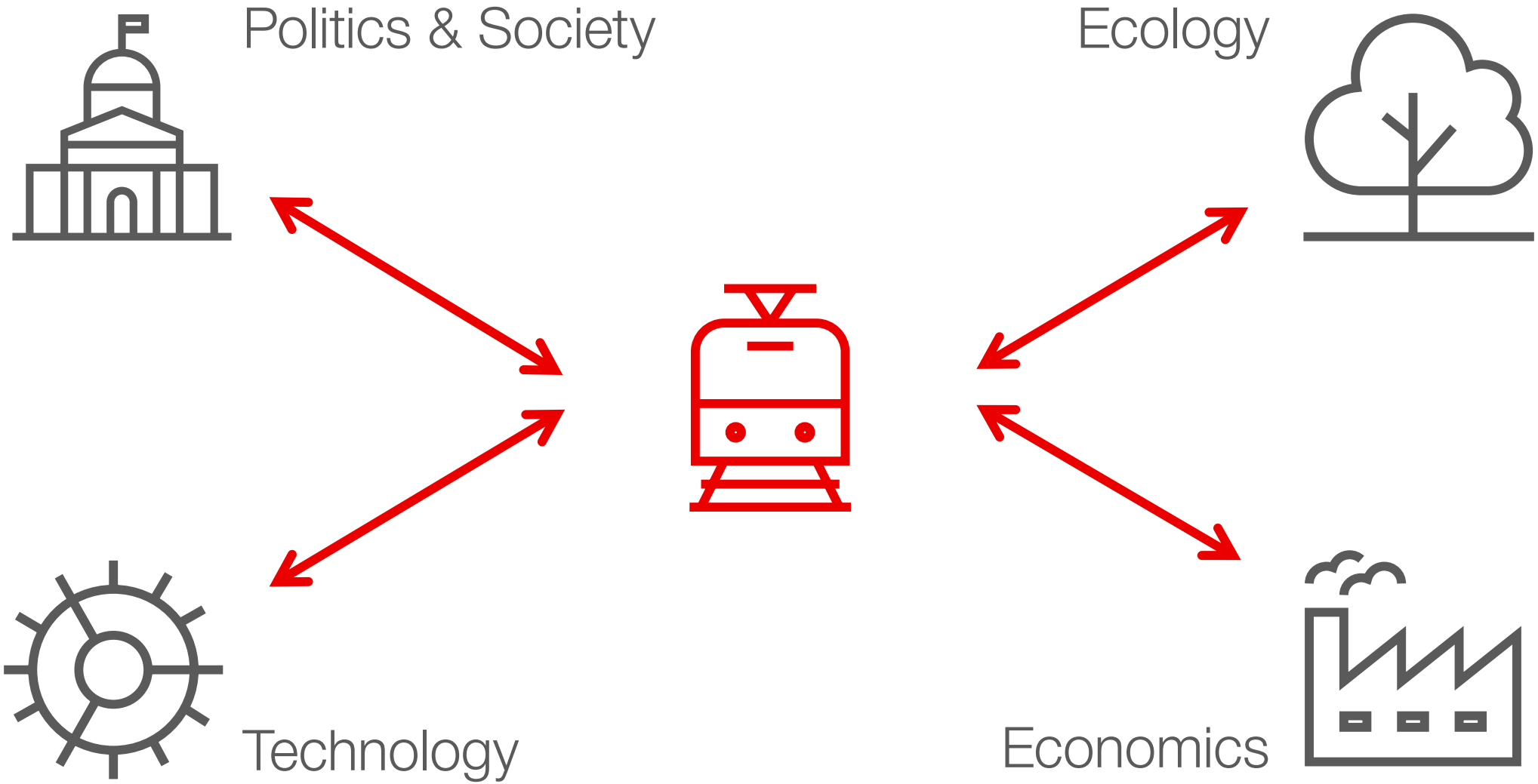
Expertise to be acquired:

Immerse yourself in the historical development of the railway in Switzerland and internationally. Discover the interactions between the railway system and its environment. Be able to analyse and find solutions to today’s challenges in mobility in the context of legacy development.

Agenda.

1. Railroad Tycoons.
2. Optimise instead of maximise.
3. Railway under pressure
4. Ongoing Optimisation.

Ecosystem.



Railroad Tycoons.

From the first Swiss railway to the founding of SBB.

Railroad Tycoons.

A license to print money.

Railroad Tycoons.

The first Swiss railway line opened in 1847, during the birth of "modern" Switzerland.

From confederation to federal state, 1848

- Industrialization began early in Switzerland.
- However, Germany, France and other countries were far ahead of Switzerland’s railway development.
- At that time, England had a railway network of around 12,000 miles.
- Alfred Escher was a Swiss pioneer aiming to close the gap with other European railways.

Railroad Tycoons.

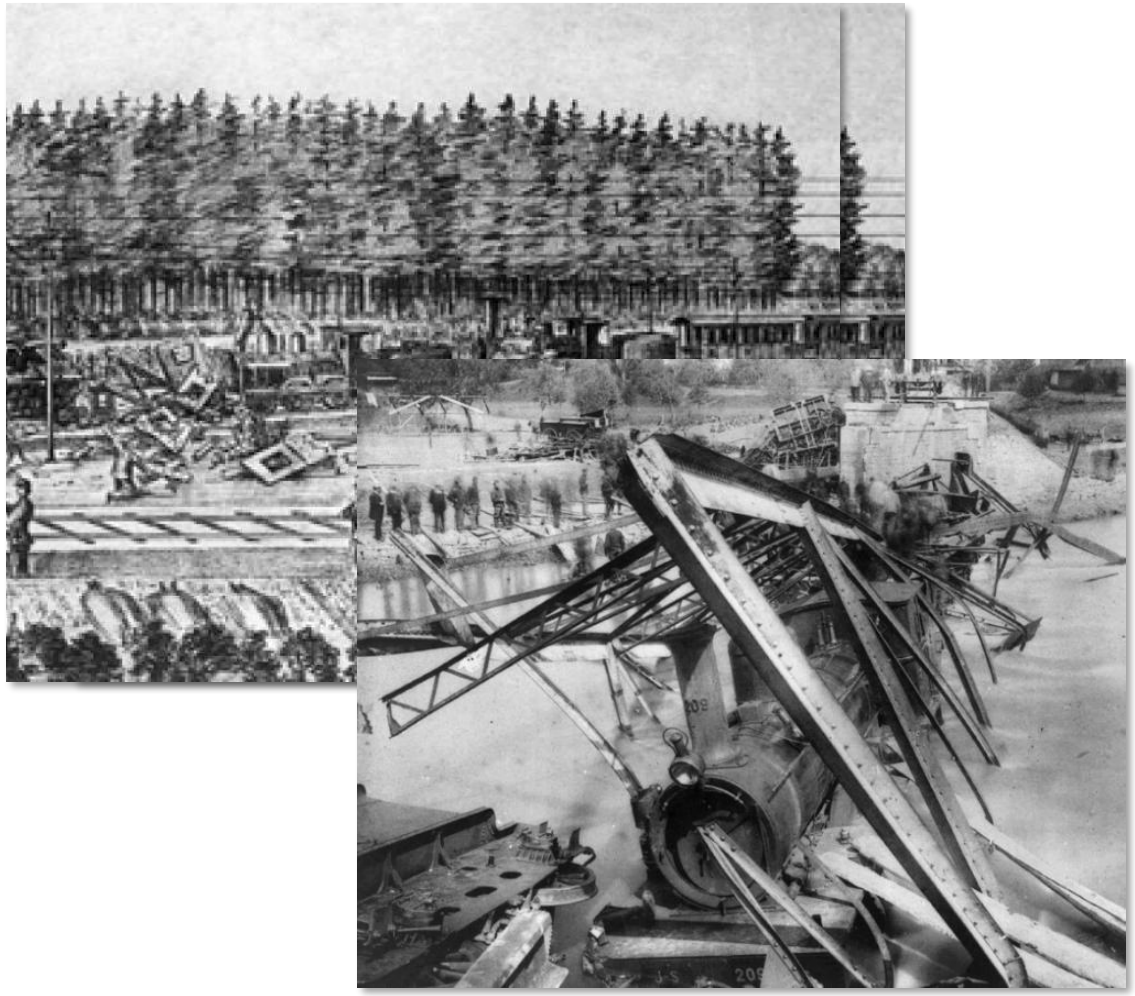
The Zurich railway war during the 1870s and other blossoms of the market economy.

The Zurich railway war and other blossoms of the market economy

- Escher and his colleagues built new railway lines prolifically and unsystematically, had to borrow abroad and entered into obligations to the cantons in exchange for railway concessions that they were unable to fulfil.
- The NOB and SNB fought each other with all fair and foul means, ending up in the Federal court several times.
- The **NOB only narrowly avoided bankruptcy, while the SNB went bankrupt.** Its legacy: barely utilised branch lines, but ultra-modern and innovative rolling stock, for example the first shell-cast wheels!
- The **financial difficulties were fuelled by the Great Depression**, which spread across Europe from the Vienna stock market crash in the late 1870s.

Railroad Tycoons.

End of the private railways.

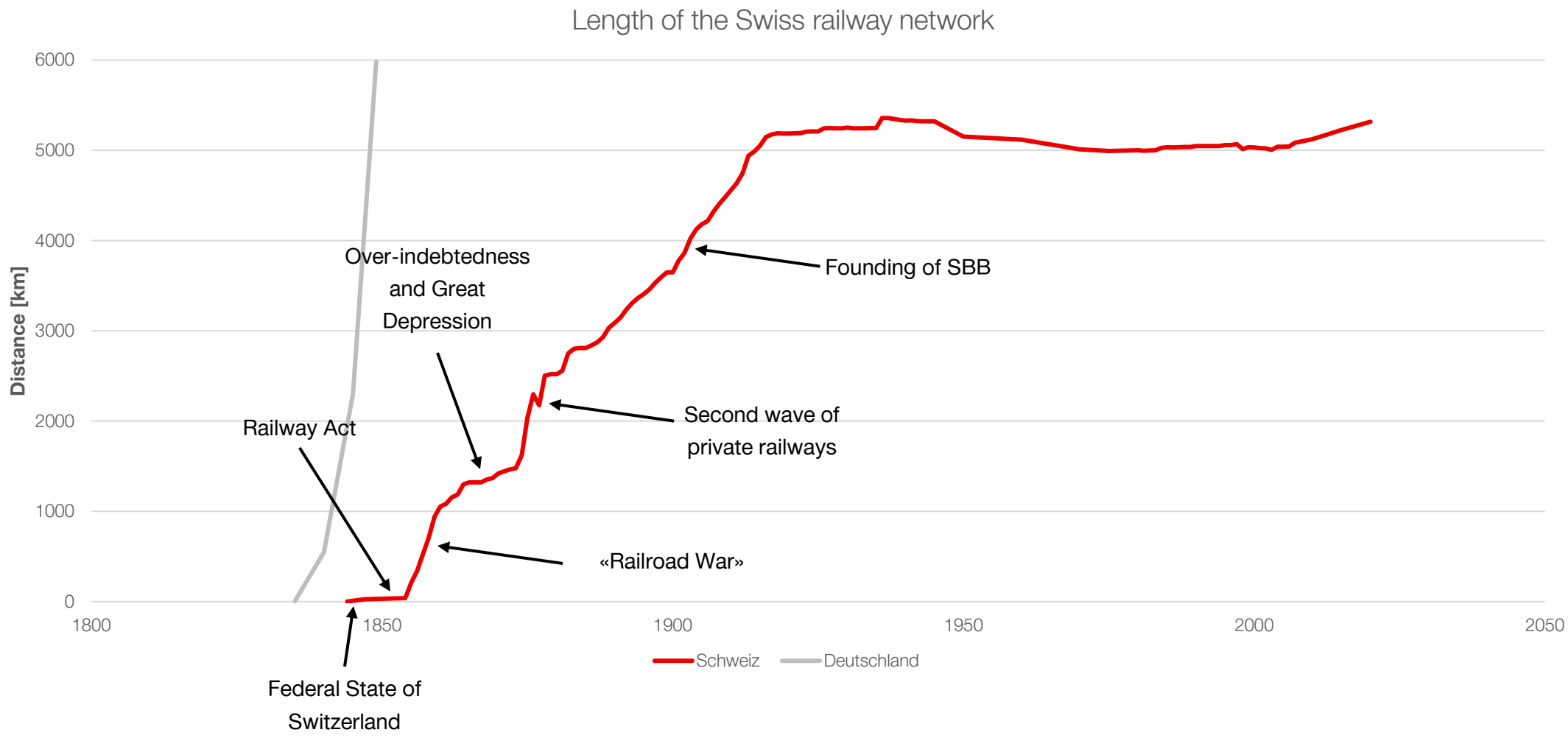


Accidents in Münchenstein 1891 and Zollikofen

- Ruthless business practices, **false incentives and accidents** led to a change of opinion.
- The politicians wanted change and to stop the investors from just withdrawing the profits whilst neglecting safety or substance (maintenance) just because it was expensive.
- The national vote (1899) and the **foundation (1902) of the Swiss national railways, SBB,** took place.
- SBB took responsibility for the operation of the national rail network and **ensured that the standards and regulations of the Act on the Construction and Operation of Railways in Switzerland were follwed**.

Railroad Tycoons.

The main network was almost finished in 1902.

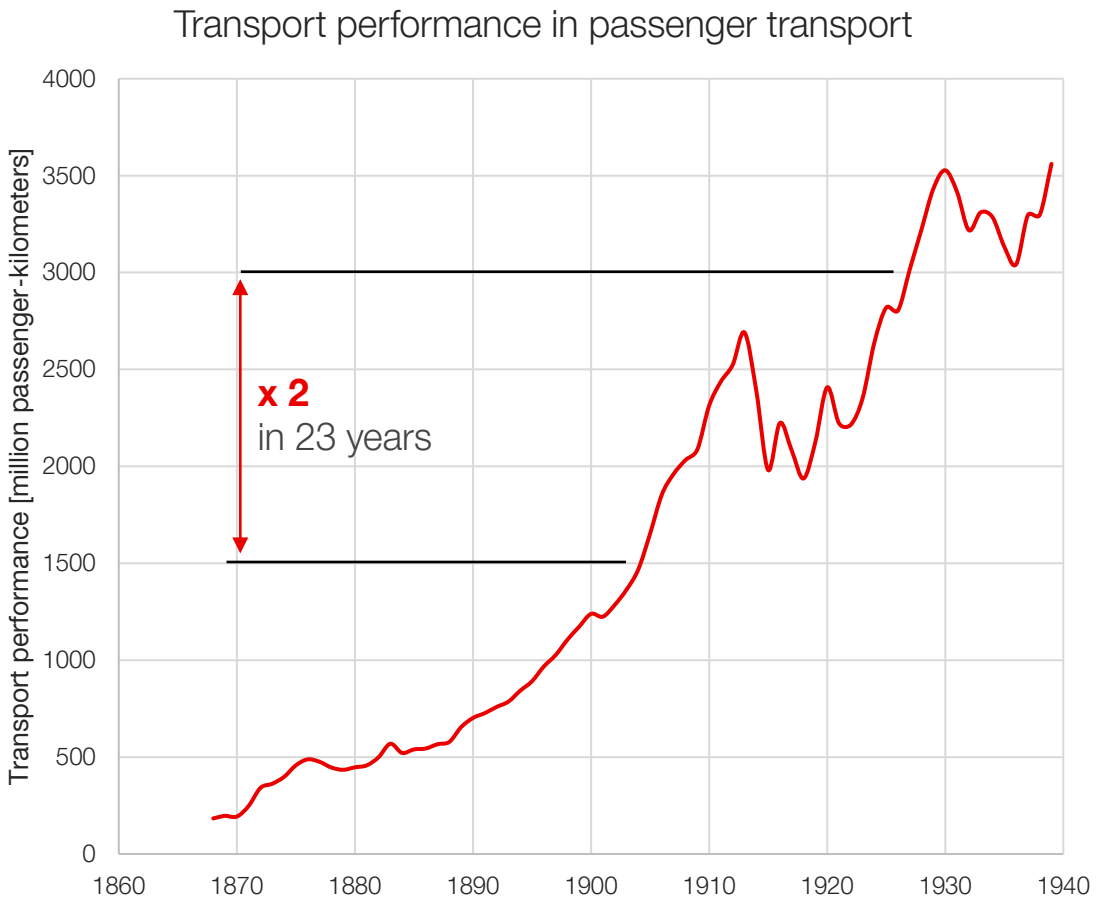


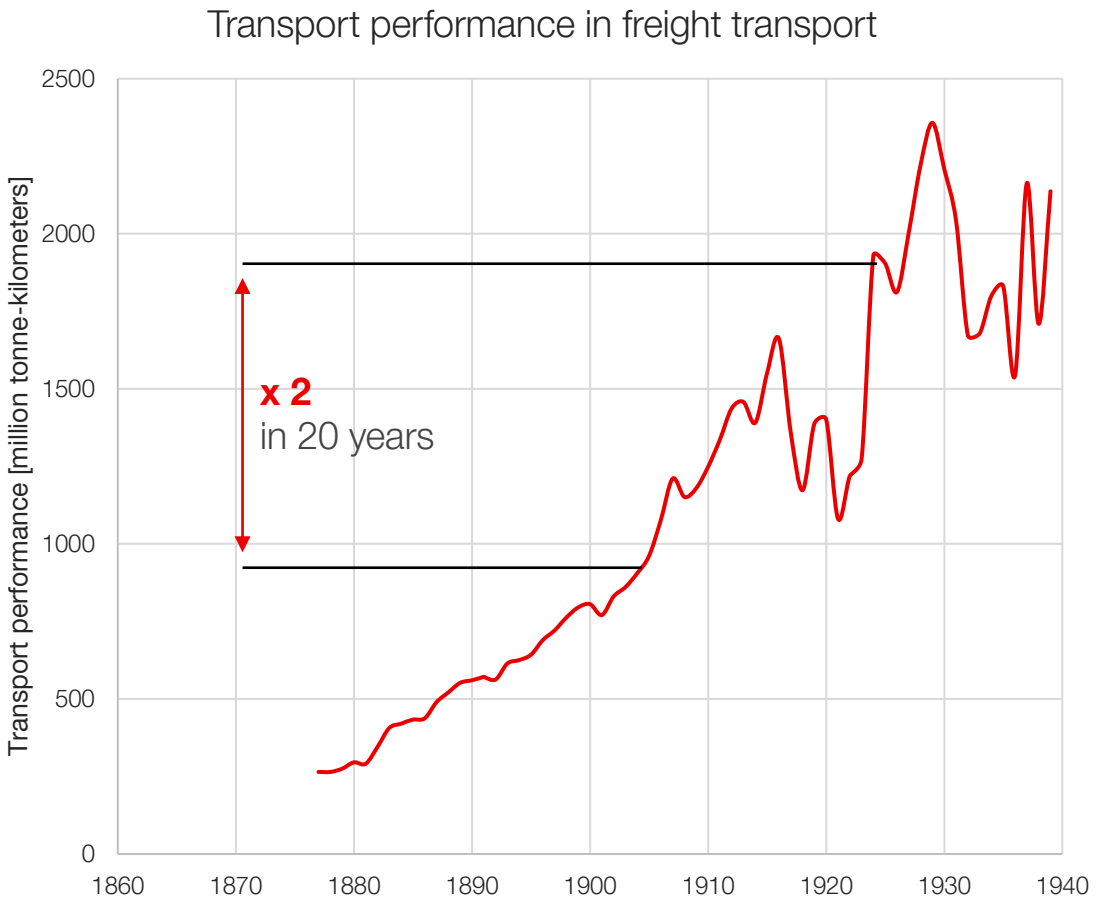
Optimise instead of maximise.

From the founding of SBB until after the second world war
1902 – 1950.

Optimise instead of maximise.

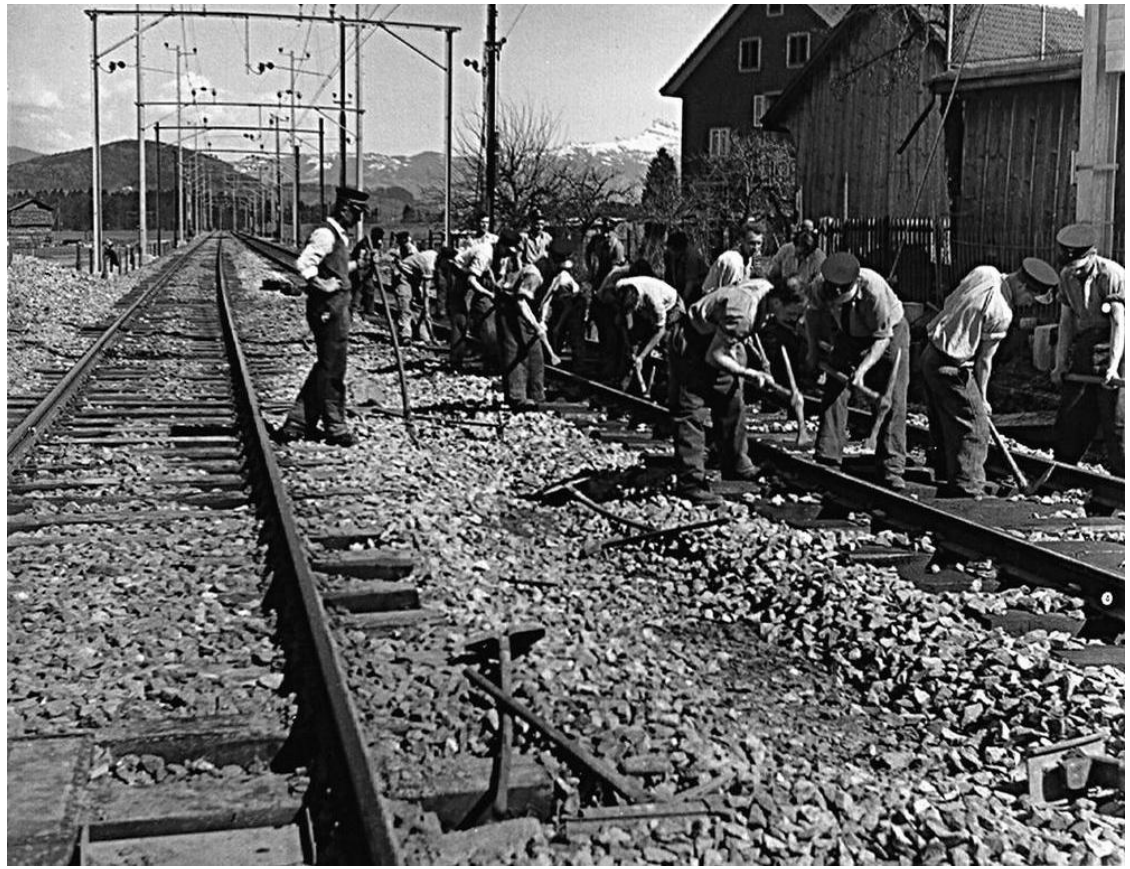
The first capacity issues.

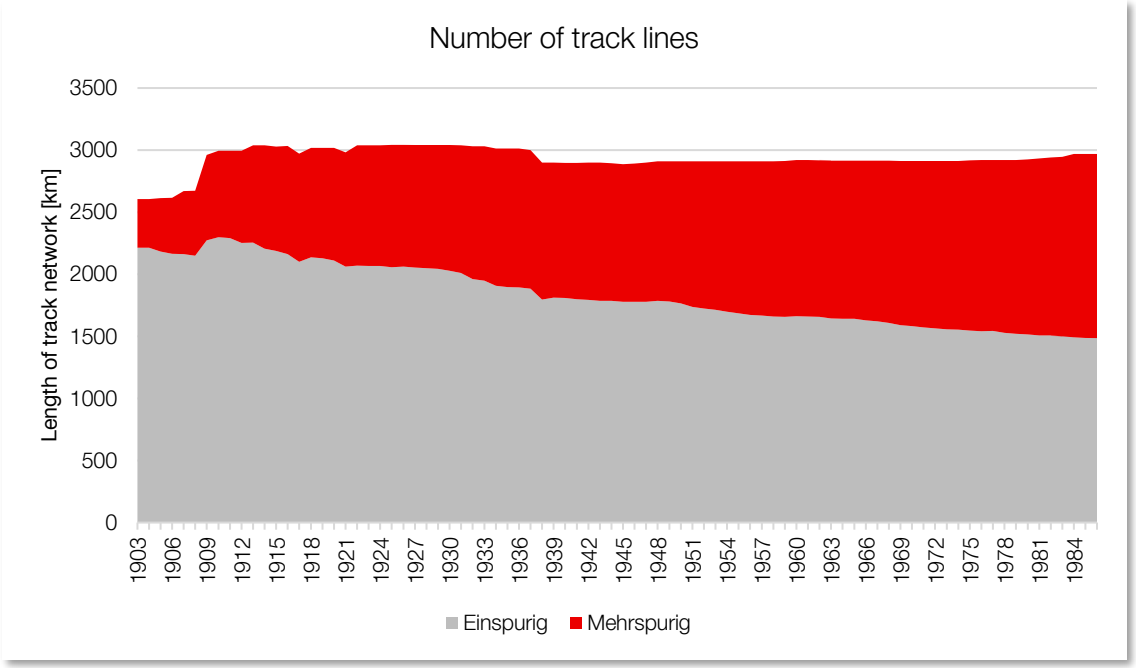




Optimise instead of maximise.

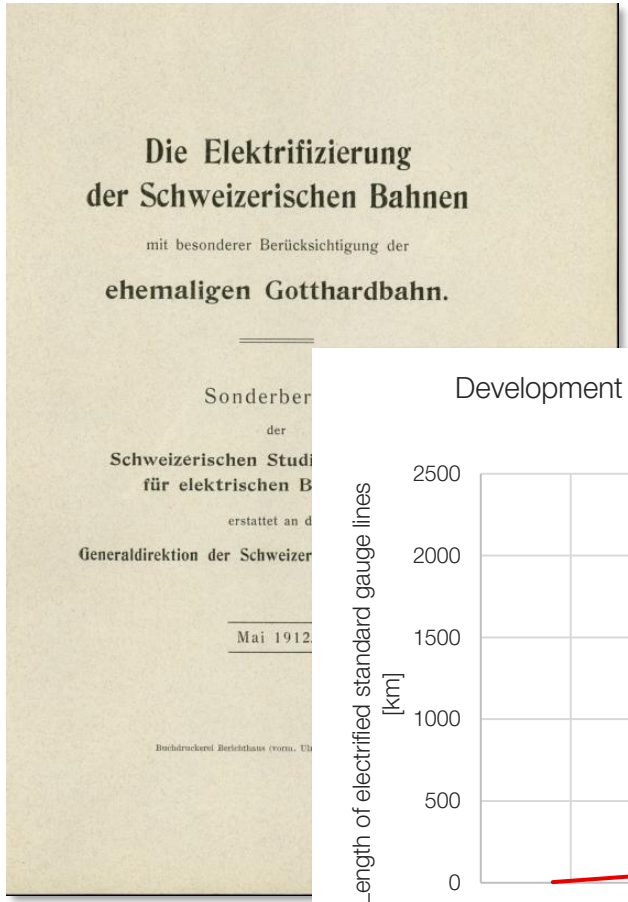
Enhance capacity in the existing network with upgrading of lines.



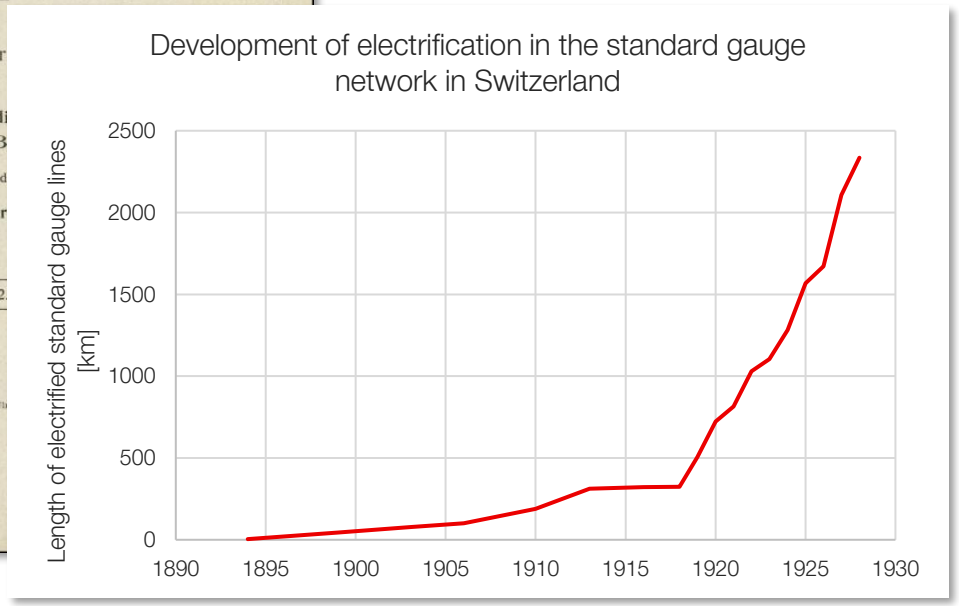


Optimise instead of maximise.

Enhance capacity in the existing network.

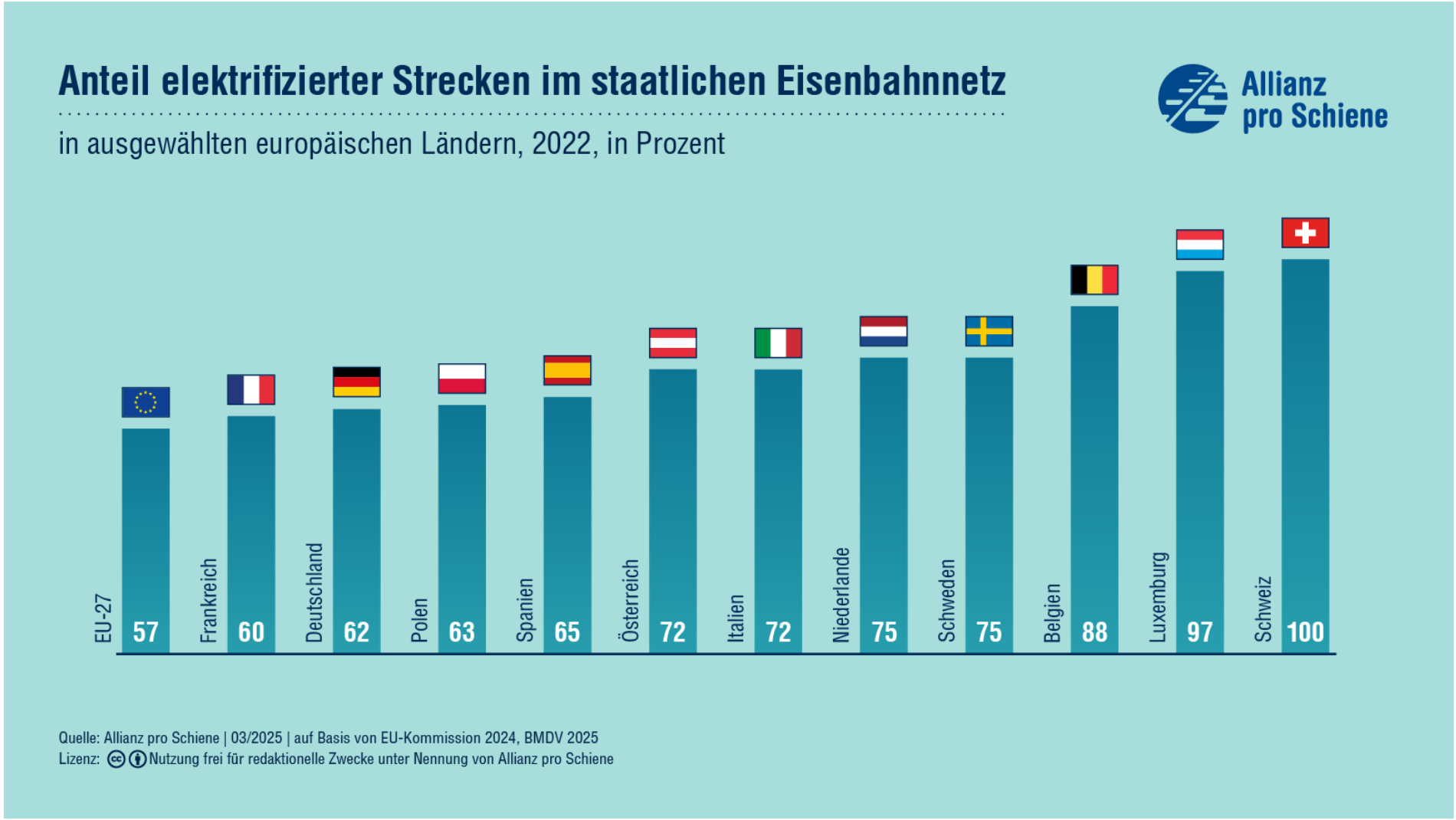


Electrification as an economic promotion and efficiency measures



- The industry represented by the Swiss Electrotechnical Association that finally convinced SBB and politicians to give serious **consideration to the electrification of the Swiss rail network.**
- **Pilot projects for the electrification** of railways in Switzerland tested the feasibility and effectiveness of electric traction systems before widespread implementation.
- Prediction of a transport capacity increase of up to 70% were made.
- Reasons for early electrification included topography, access to hydro power and the independence of fossil fuels.

Side note – electrification in Europe in modern times.



Optimise instead of maximise.

Enhance capacity in the existing network – Rolling Stock.

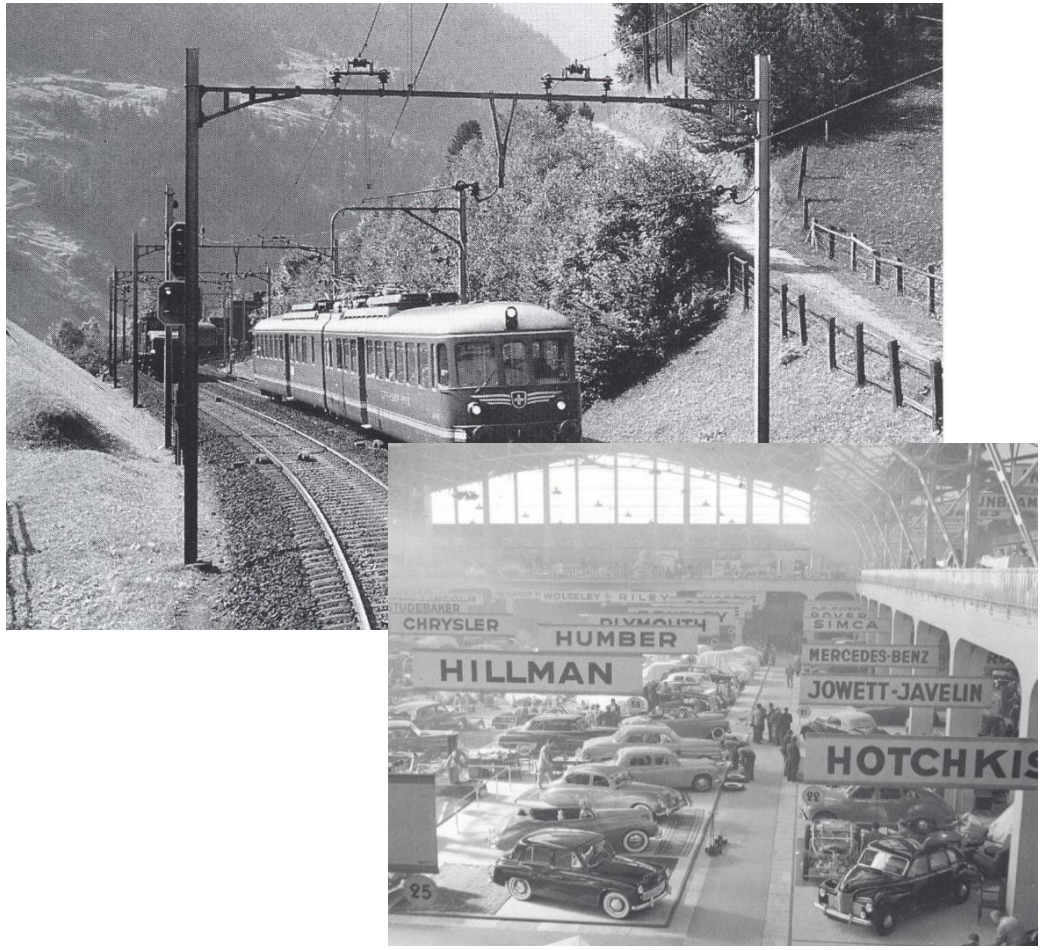
– These **trains were designed for faster travel times** and better performance on curves, allowing for higher speeds even on less-than-straight tracks.

– **Light express trains became** a key part of improving efficiency, as there was no focus on high-speed trains.

Railway under pressure.

1950s.

Economic upswing after the 2nd World War.



Car Show Geneva

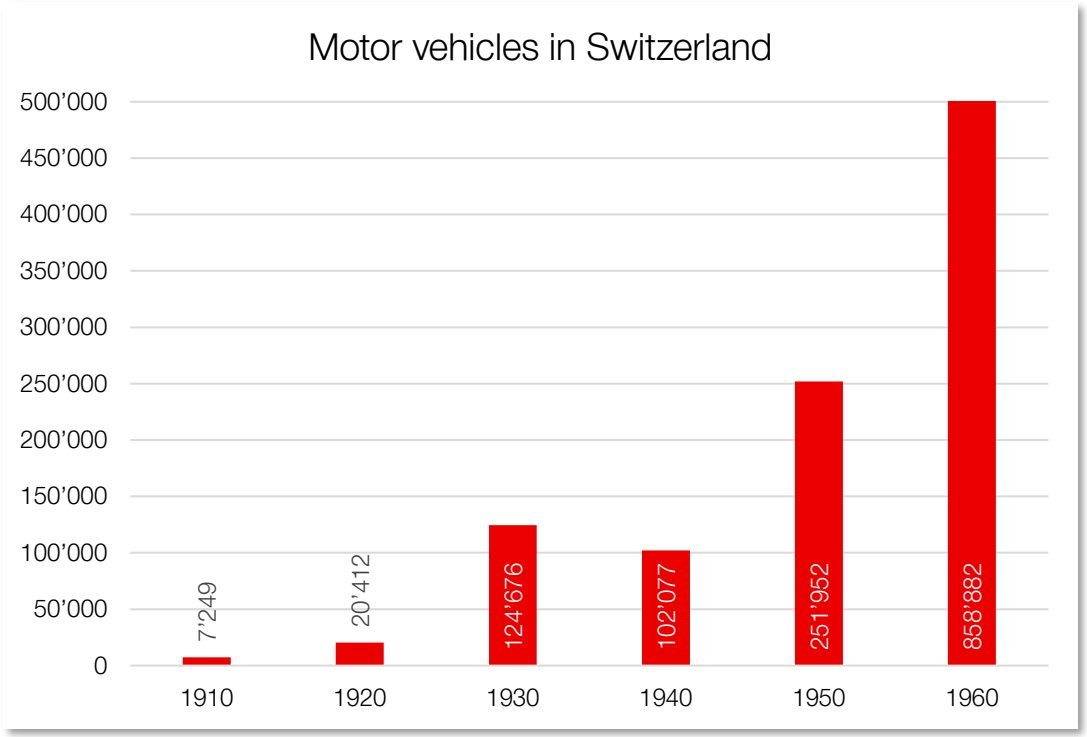
- **After WWII individual mobility** on the rise, **with investments in road.**

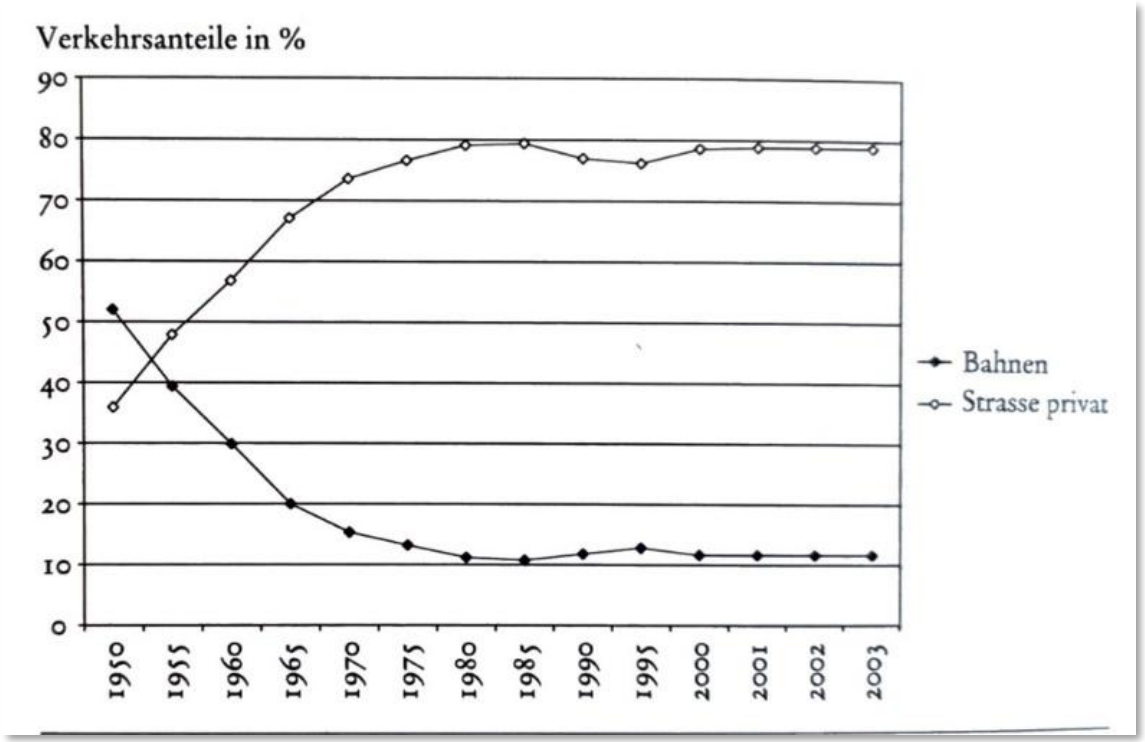
- Based on the decision regarding the motorway network in the 1950s, 1960s and 1970s, the road infrastructure began to receive more attention.

- Demand for Rail Travel was also high after World War II but there was **no major investment** in rail infrastructure.

Evolution of cars.

With increasing investments in road, cars gained momentum.

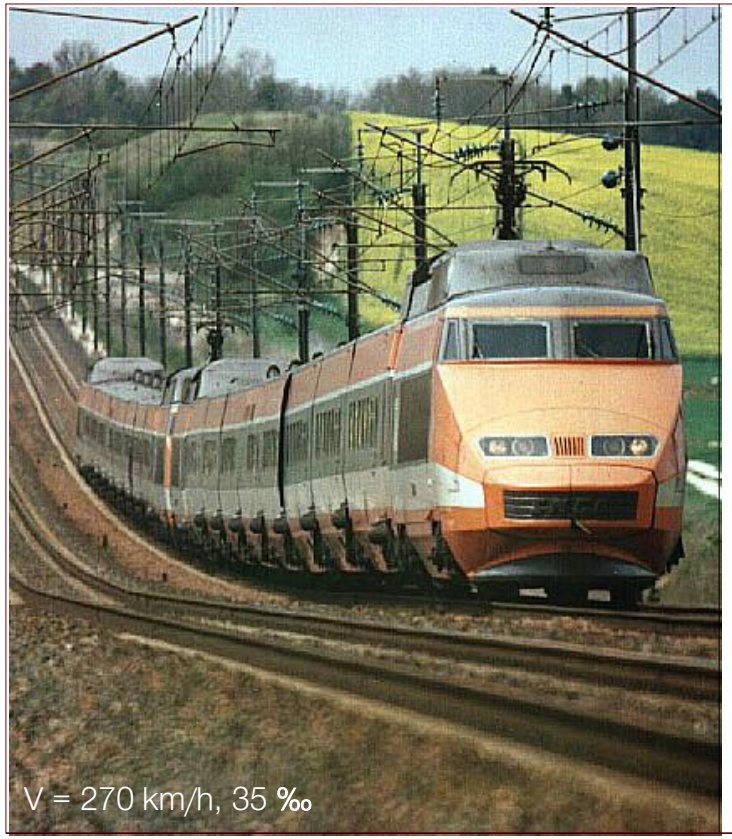


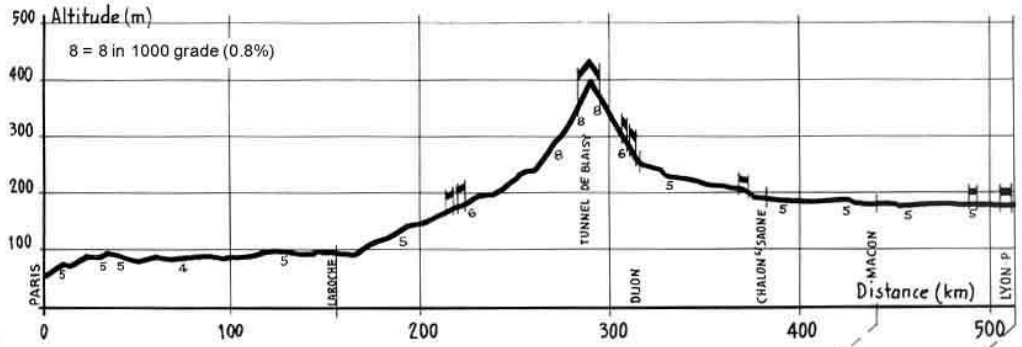


Reason for this development?

Competition from the road.

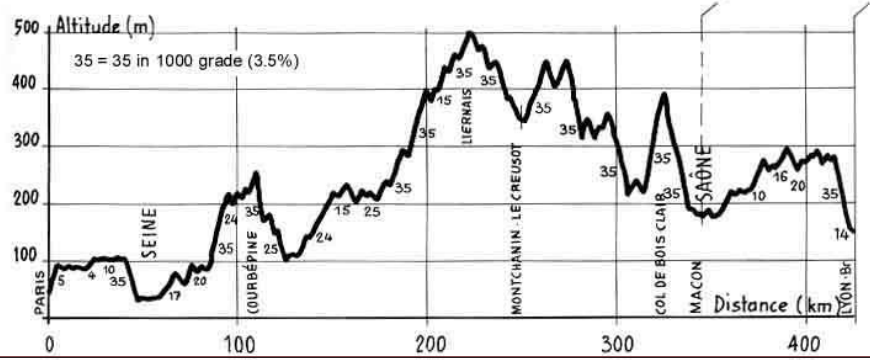
Beginning of the high-speed era in Europe in 1981 with TGV Paris – Lyon.





TOP: Paris - Lyon, profile along old PLM line

BOTTOM: Paris - Lyon, profile along LGV Paris Sud-Est



Paris - Marseille

Δ = 77 km

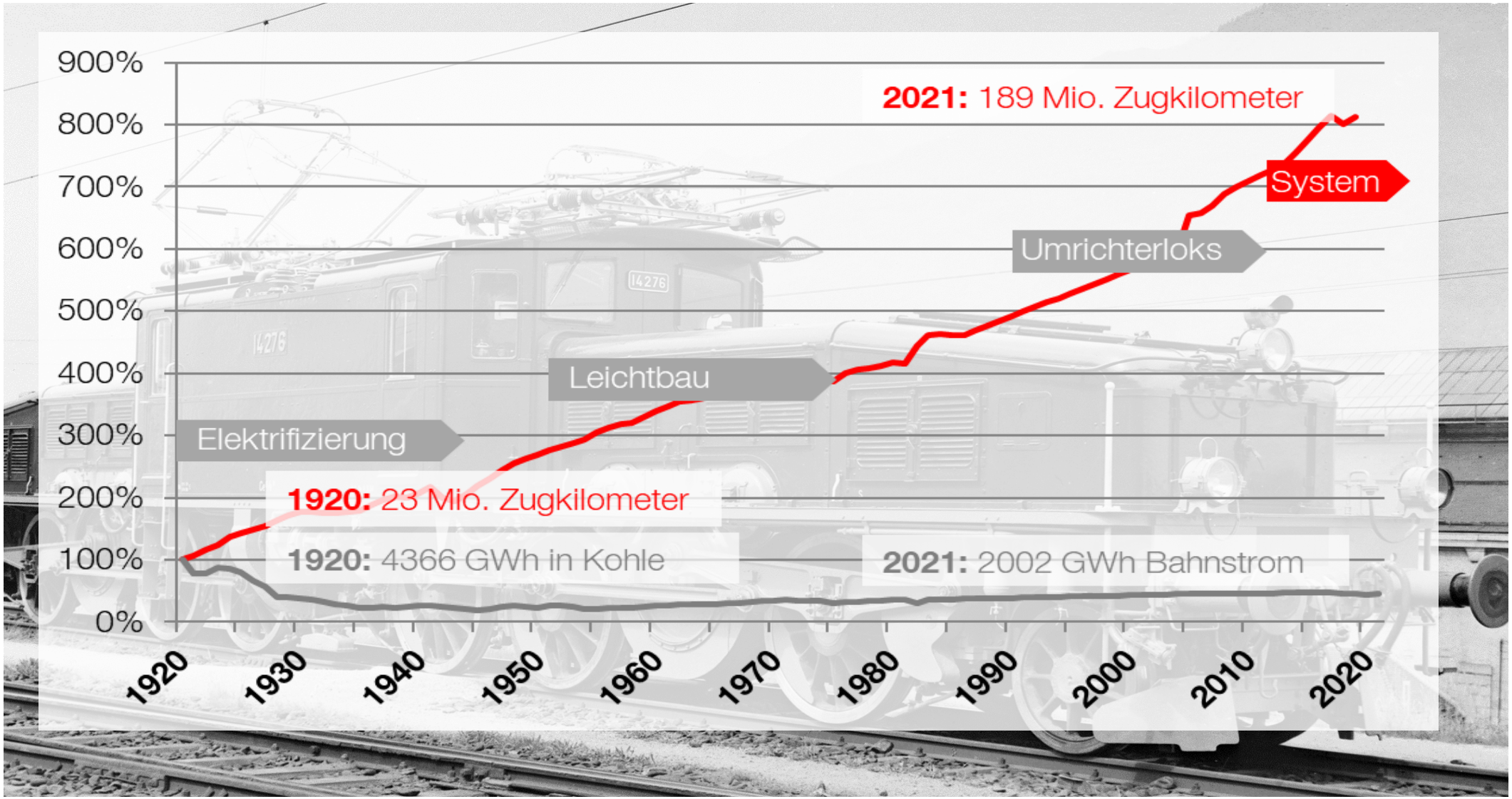
TGV 001

1973: Oil crisis -> Construction of nuclear power plants

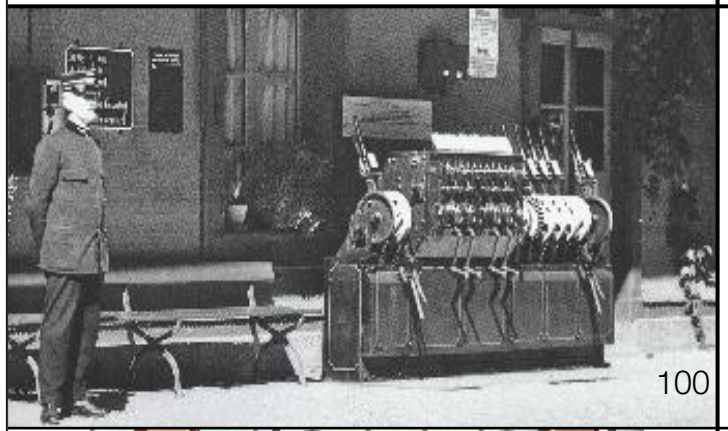
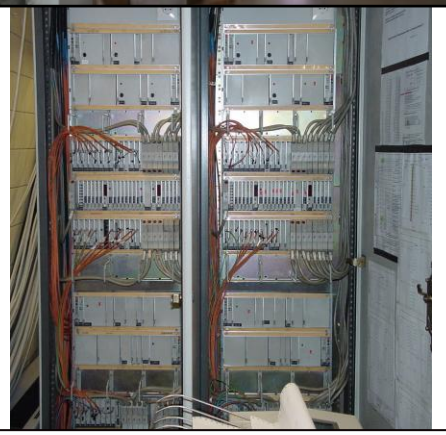
Photos Internet/ La Vie du Rail
Presentation by Urs Brotschi

Ongoing Optimisation.

Ten times more trains with half as much energy.



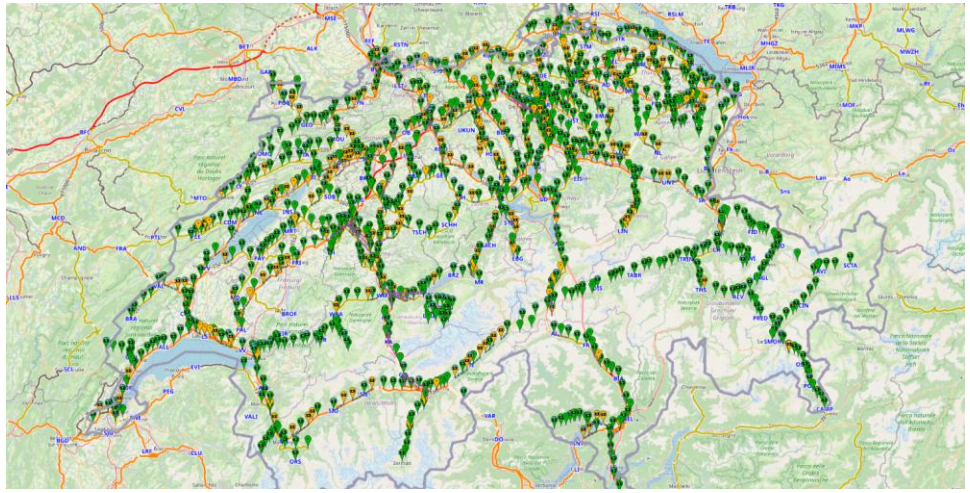
Safety technology.
Interlocking.

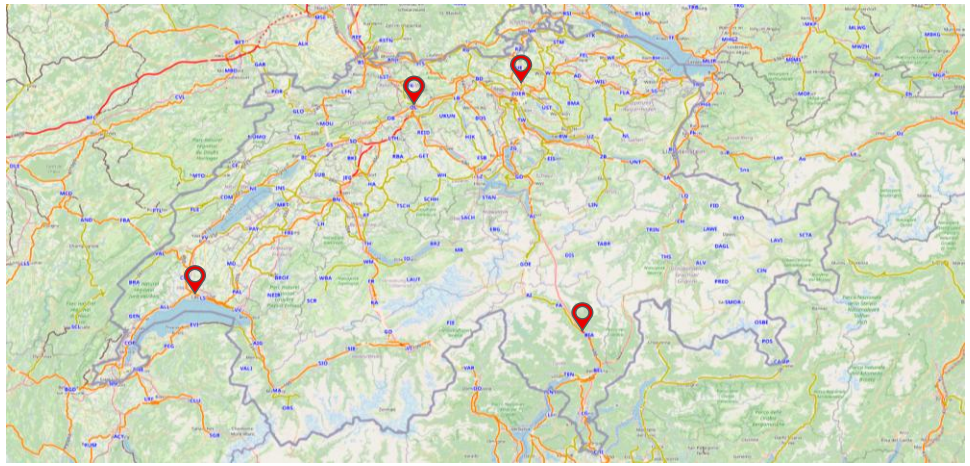
Mechanical Interlocking (1880 - ..)	Relais-Interlocking (1955 - ..)	Electronic Interlocking (1990 - ..)
 100	 50	 25
		

Fotos Internet/ Archiv
Darstellung Urs Brotschi

Production Yesterday and Today.

Transitioning from decentralised dispatching to a centralised system with four main Train Control Centres.





Source: stellwerke.info

1980

- Approximately **600 local dispatchers** at every major station manage operations.
- Introduction of the first remote control systems to manage multiple stations from one location.

2007

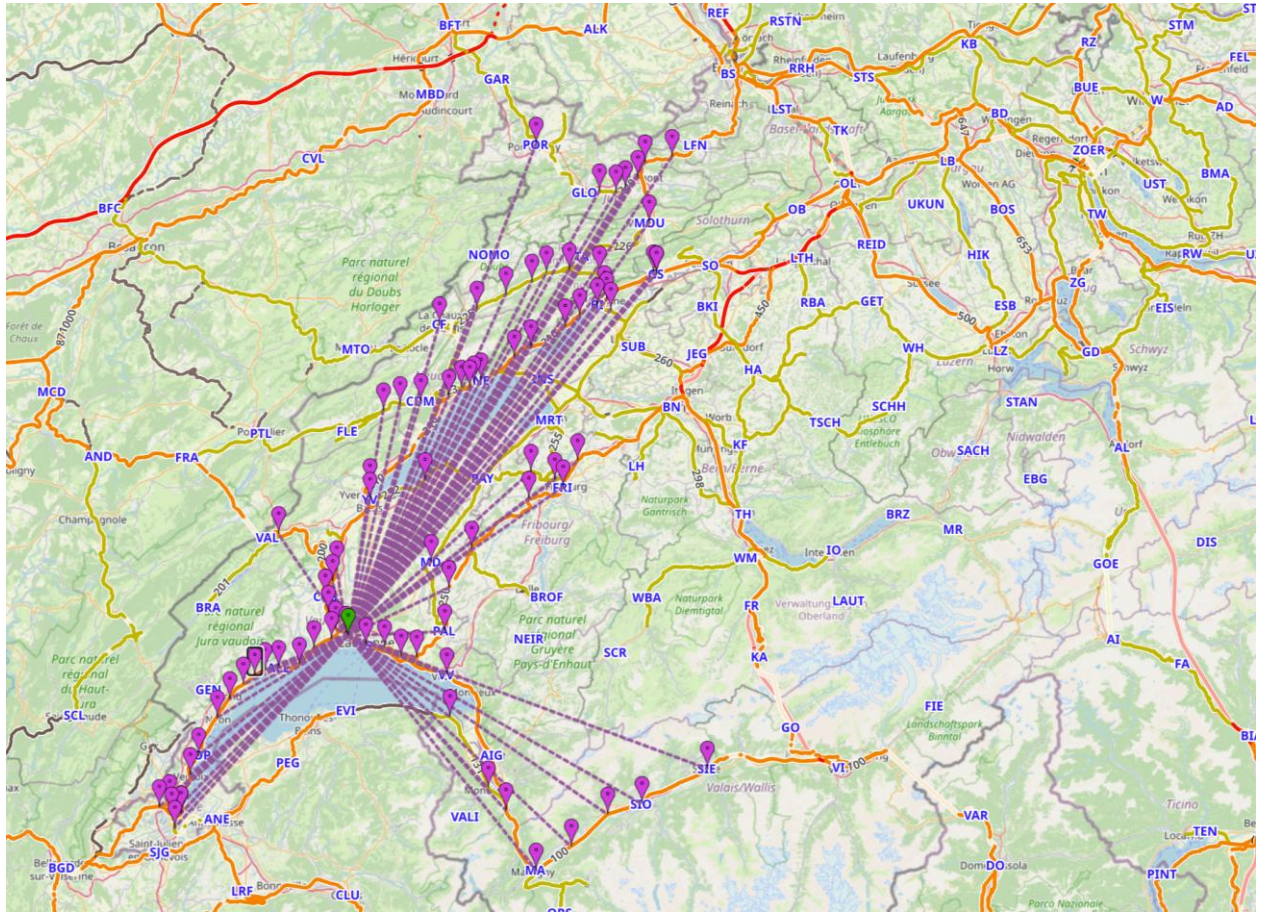
- Centralization and introduction of Train Control Centres.
- Only 25 remote control centres in operation.

2017

- **Four state-of-the-art Train Control Centres for the entire network.**

Production Yesterday and Today.

Transitioning from decentralised dispatching to a centralised system with four main Train Control Centres.



Overseeing the network of interlockings.

Source: stellwerke.info

Train Control Centre (TCC) Renens:

- Train Control Centre for the western region.
- Manages majority of rail traffic in western Switzerland.
- Ensures efficient monitoring and control of the network.

New Travel Concept '82 – interval timetable (Taktfahrplan).

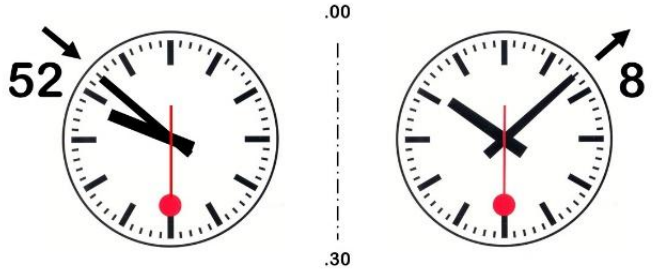
Synchronized timetable with frequent departures.

- Big Bang for Swiss public transport.
- Introduced in 1982.
- Synchronized timetable with frequent departures.
- Benefits:
  - Simplicity.
  - Efficiency: short transfer times.
  - Seamless connections between various modes of public transport.
  - Attractiveness: improved user experience.
- Economical: With an additional expenditure of 1.5%, 21% more pkm could be produced.

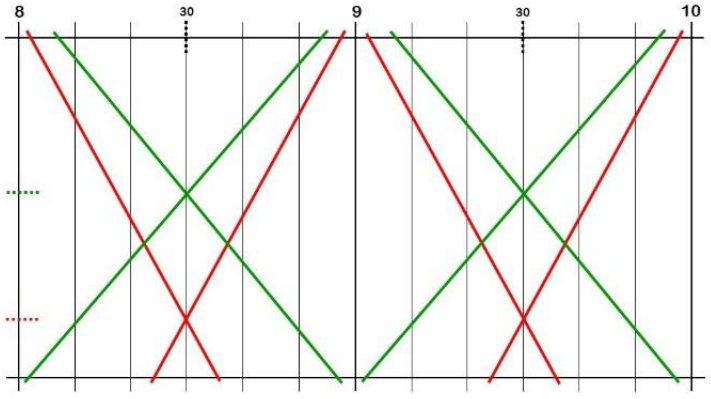
Railway 2000 (Bahn 2000).

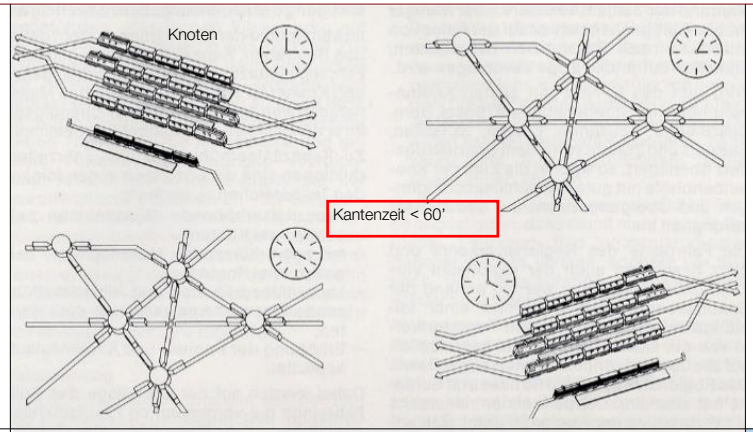
One of the most significant development programs. Key component: Knot principle.

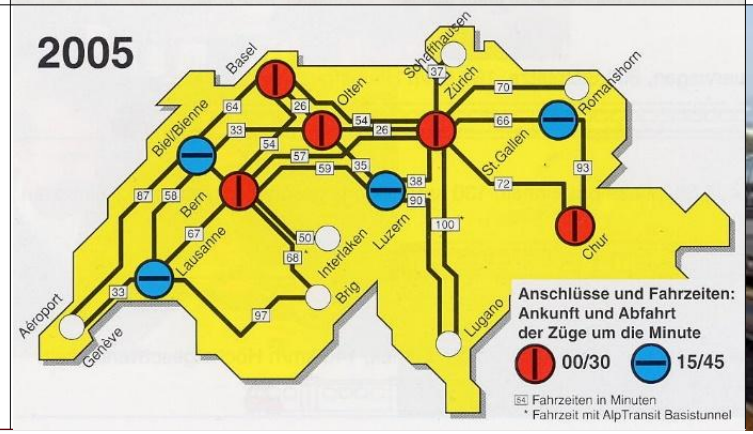
Interval timetable



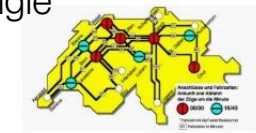
«Jede Stunde ein Zug»

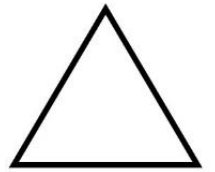






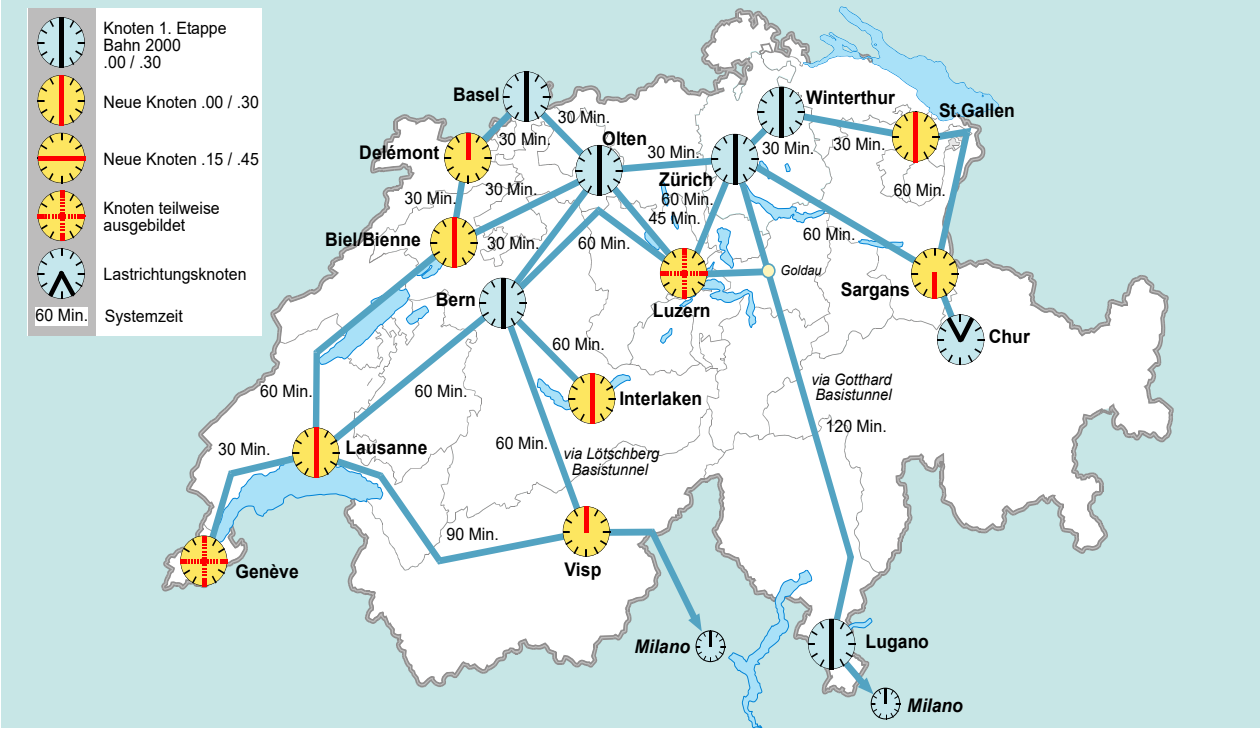
Planning Triangle





Railway 2000.

More than an infrastructure upgrade – systemic redesign of how railway services are delivered.



- **Infrastructure**
  - **New high-speed line Mattstetten–Rothrist** enables 200 km/h and cuts Bern–Zurich travel time below 60 minutes.
  - **Optimised hub stations** (e.g. Bern, Zurich, Lausanne) allow reliable transfers within 3–5 minutes.
  - **Double-tracking of key sections** improves frequency and operational stability across the network.

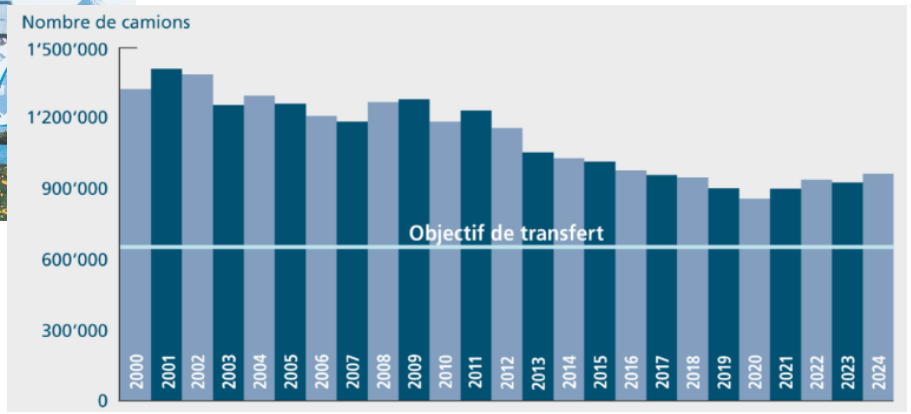
- **Benefits:**
  - **Shorter total travel times** thanks to well-timed transfers.
  - **More frequent and consistent connections** throughout the day.
  - **Increased attractiveness** of rail travel for commuters and leisure travellers.

New Rail Link through the Alps NRLA.

Swiss transport policy aims to shift goods traffic across the Alps from road to rail.

(Alptransit Portal)


(railway-technology.com)

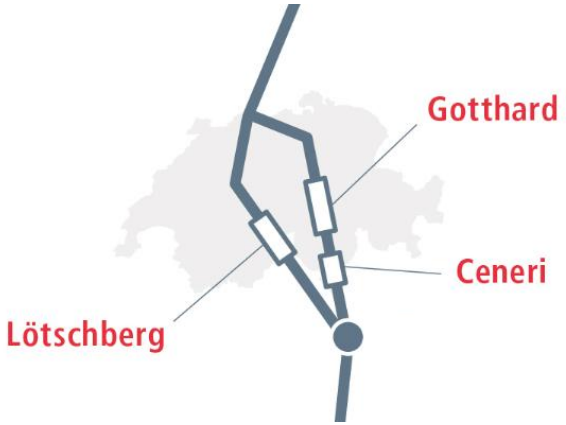


Number of goods trucks crossing the Alps. (Federal Office of Transport)

- In the **1990s**, the **Swiss population voted several times to shift goods transport across the Alps from road to rail**, responding to **growing traffic, environmental concerns, and European integration.**
  - In **1992**, approval of the building of a **New Rail Link through the Alps (NRLA).**
  - In **1994**, approval of the **constitutional article on the protection of the Alps.**
  - In **1998**, approval of a law on a heavy vehicle fee and the **financing plan for major railway projects**.
- The goal is to reach a maximum of **650,000 heavy goods vehicles crossing the Swiss Alps**.

New Rail Link through the Alps NRLA

A project involving three new base tunnels: Lötschberg, Gotthard and Ceneri



	Lötschberg	Gotthard	Ceneri
Length	34.6 km	57.1 km *World record !*	15.4 Km
Main tube excavation start	Sep. 2000	Nov. 2002	Mar. 2010
Commissioned	2007	2016	2020
Costs	5.3 Bil. CHF	12.2 Bil. CHF	3.6 Bil. CHF

Between 2000 and 2020

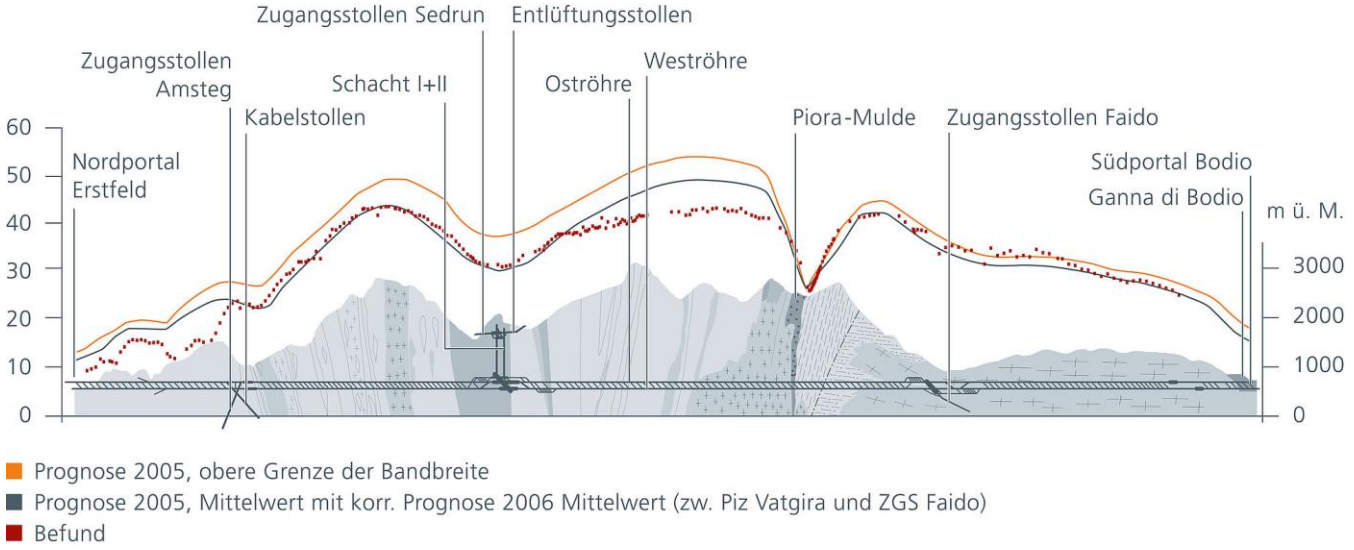
Whole project 22.8 Bil. CHF

(Federal Office of Transport)

Many challenges !
Examples for the Gotthard Base Tunnel:

- High **temperatures**
  Cf. Right Y-axis on the picture
- **High tickness** of the rock above the tunnel
  Cf. Left Y-axis on the picture
- Multiple **geological fault zones**
  Cf. Grey zones on the picture
- ...

More information: Video



Rock temperature in the Gotthard Base Tunnel (right Y-axis). (Alptransit Portal)

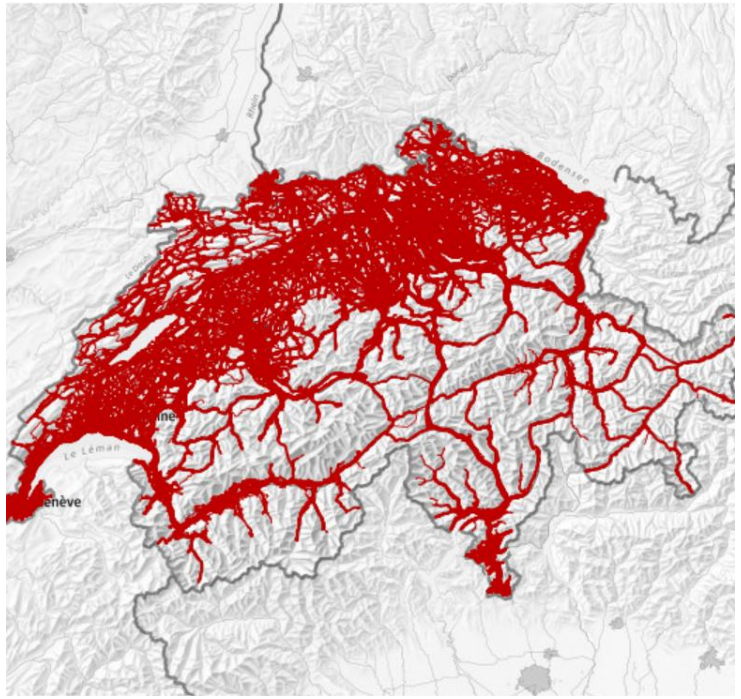
Is public transportation in Switzerland successful?

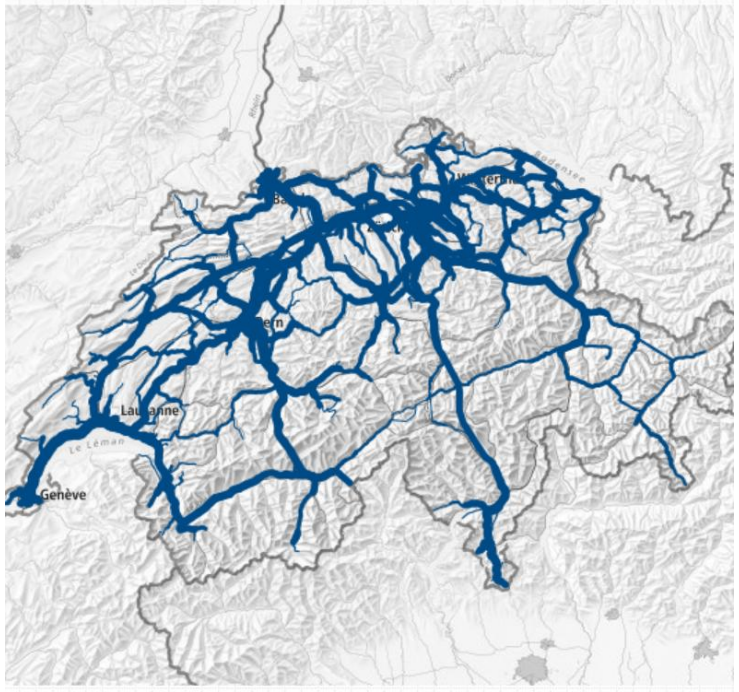
Öffentliches Verkehrsnetz	22 000 km
Davon	
SBB	3000 km
Privatbahnen	2000 km
Bergbahnen	1000 km
Nahverkehrsbetriebe	1500 km
Postautodienste	8500 km
Busunternehmen	5000 km
Schifffahrt	1000 km

5317 km

Is public transportation in Switzerland successful?

Switzerland is among the best-performing countries in terms of sustainable transport share, there is room for improvement in **active mobility**, particularly in cycling and suburban access.





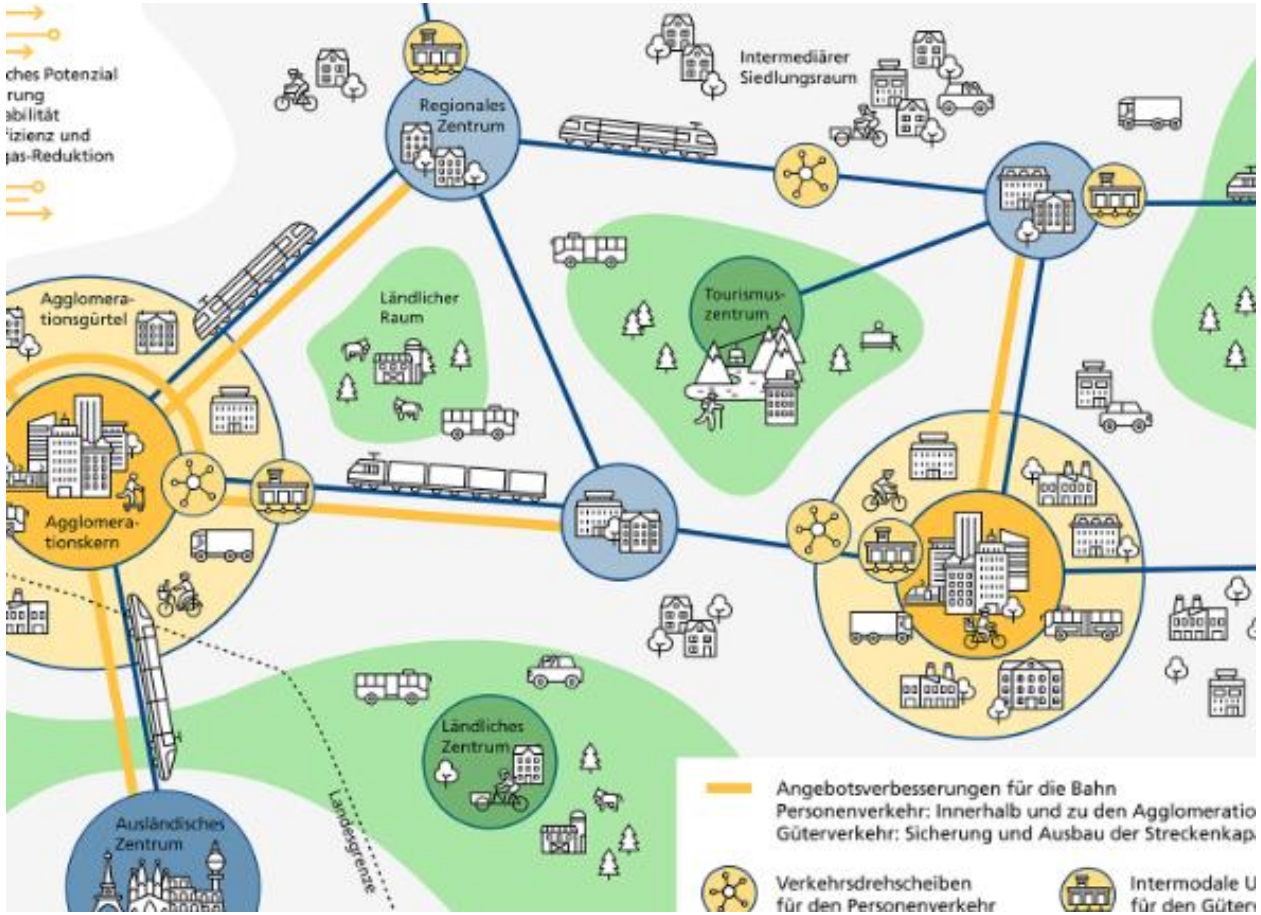
GIS ARE, Darstellung

- Car: 73%
- Public transport (rail, bus, tram): 21%
- Bike and walking: 6%

Source: Federal Statistical Office, Verkehrsleistungen im Personenverkehr 2023

Perspective “Bahn 2050”.

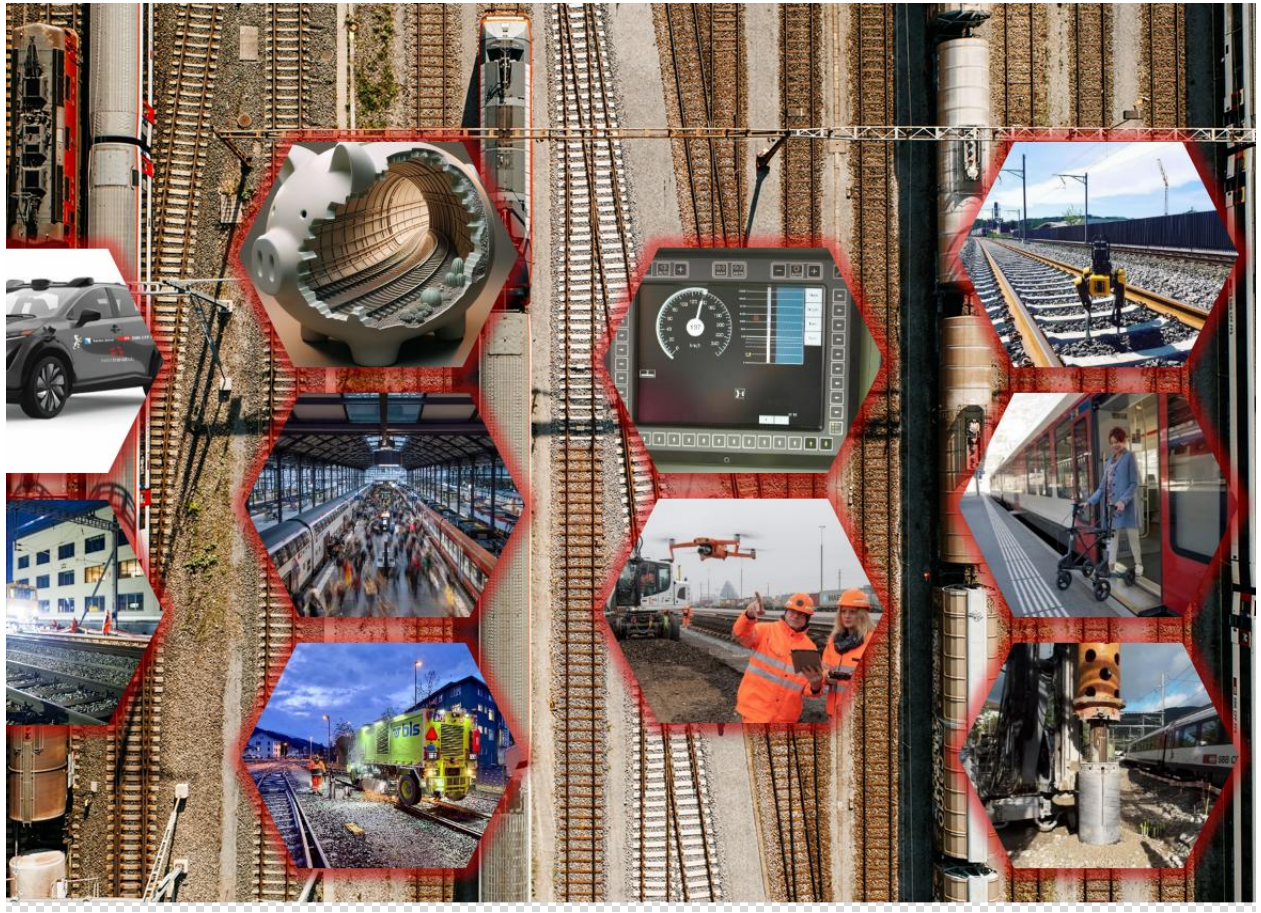
Vision: railways are making a major contribution to the 2050 climate target and strengthening Switzerland as a place to live and do business.



- The development of the railway is **coordinated** with the objectives of **spatial development**.
- The rail service is part of overall mobility. It is **flexible** and **optimally integrated** with **other transport** services and modes.
- **The rail share of the modal split** in passenger and freight transport **will increase** noticeably.
- **Rail operations are climate-neutral, with** new railway infrastructure being designed to conserve soil and resources and are well integrate well into the landscape and urban development.
- Rail operations are **safe, punctual, reliable and flexible**.
- **Efficiency** gains through **automation** and **new technologies** are consistently exploited.

Source: Perspektive Bahn 2050, BAV 2024)

Wrap up of today’s lecture.



- The **system is built an** we have to **deal with the legacy, innovation and new technology are crucial**.
- We can **learn from** developments in the **past** for the future.
- The system is becoming **more and more complex**.
- **Increasing the modal split is key to sustainable development**.

Outlook for next week and reading task.

Transport systems and the role of railway.

Content:
Efficiency of Rail-Based Mass Transit Systems and Modal Split

Preparatory reading:
Rail Perspective 2050 of the Swiss Federal Government.
Short version on moodle

More information (voluntary reading)
In German:
Perspektive BAHN 2050 - BAV

In French:
Perspective RAIL 2050 - OFT


SBB CFF FFS
Thank you!