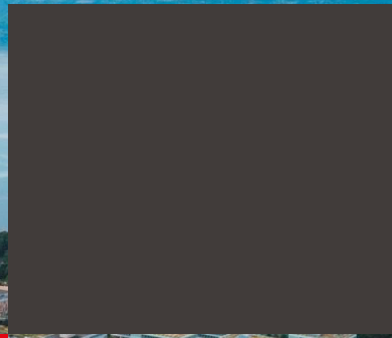


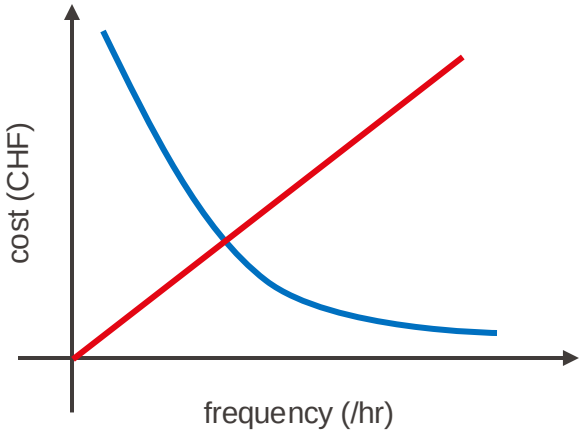
01 Introduction

CIVIL-324 Urban public transport systems

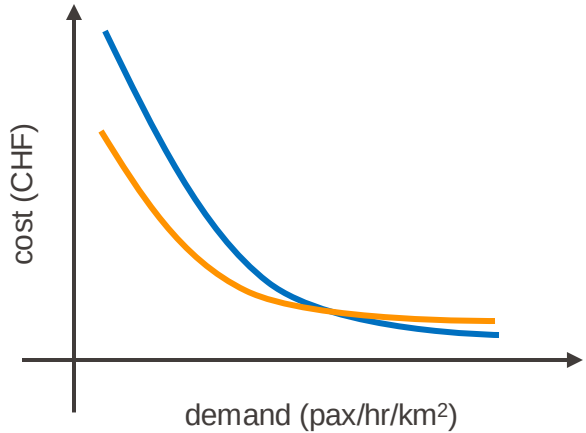
École
polytechnique
fédérale
de Lausanne

About this course

- Overview
  - An introduction urban public transport system ***planning***, operations, and management.
    - More focus on “planning” because it features more general rules and trade-offs



user cost vs **operation cost**



fixed-route vs **flexible-route** transit

About this course

- Overview
  - An introduction urban public transport system ***planning***, operations, and management.
    - More focus on “planning” because it features more general rules and trade-offs
  - Cover main characteristics and design problems of different public transport services

Characteristics

- Quality
  - travel, waiting, transfer
  - reliability, connectivity
- Cost
  - capital cost, operation cost
- Profitability
  - ridership, revenue

Design variables

- Strategic (long-term)
  - area, mode
  - stop, line
- Tactical
  - schedule, capacity
- Operational
  - pricing
  - delay management

About this course

- Modules and topics
  - Regular transit
    - Shuttle
    - Bus corridor
    - Fixed-route transit
    - Railway
    - Flexible-route transit
  - On-demand mobility
    - Taxi
    - Ride-hailing/sharing
    - Micromobility
  - Integrated transport system
    - Park & ride
    - First/last-mile service
    - Mobility-as-a-service
    - Co-modality

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- Modules and topics
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    - Co-modality

classic **modern** **emerging**

About this course

- Schedule

Week	Date	Topic
1	17.02	Introduction; Shuttle system
2	24.02	Bus corridor
3	03.03	Transit network I: Stop location and line planning
4	10.03	Transit network II: Scheduling and pricing
5	17.03	Transit network III: Operations
6	24.03	Railway system and operations
7	31.03	Flexible-route transit
8	07.04	Taxi and ride-hailing/sharing
9	14.04	Micromobility
10	21.04	*Easter break*
11	28.04	Project: proposal presentation
12	05.05	Intermodel 1: Park & ride; First/last-mile service
13	12.05	Intermodel 2: Mobility-as-a-service; Co-modality
14	19.05	*(TBD)*
15	26.05	Project: final presentation

Module 1: Regular transit

Module 2: On-demand mobility

Module 3: Integrated transport

About this course

- Lecturers
  - Kenan Zhang
    - Director of HOMES
    - Assistant professor since Sep. 2023
    - PhD from Northwestern University
    - Born and grew up in Beijing, China
    - Contact: kenan.zhang@epfl.ch

  - Rui Yao
    - Postdoc at HOMES
    - PhD from Technion
    - Born and grew up in Guangdong, China
    - Contact: rui.yao@epfl.ch

About this course

- Assistants
  - Pablo Vallbona Fernandez
    - GC BA6
    - Contact: pablo.vallbonafernandez@epfl.ch

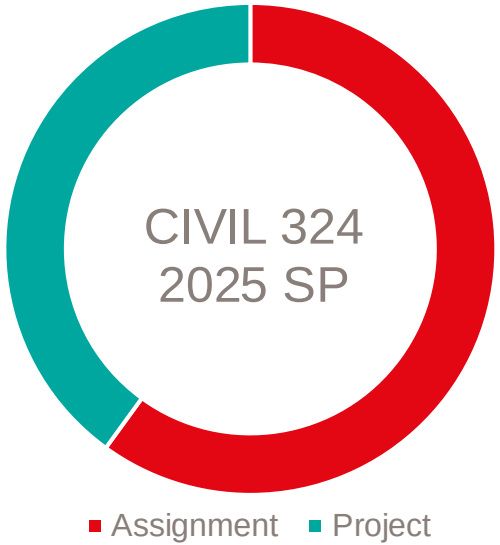
"Hello, I'm Pablo and I'm a third year student. I'm Spanish but I've grown up here in Switzerland near Geneva. I will gladly answer your questions in English, French or even Spanish. I'm looking forward to helping you throughout the course, so feel free to reach out if you need any assistance and I'll help you as best as I can."

  - Luca Liuzzi
    - GC MA2
    - Contact: luca.liuzzi@epfl.ch

"I am Luca, I am 24, and I was born and grew up in Lugano (Canton Ticino). I graduated last year, and now I am in MA2 with a specialization in Mobility & Transport and a minor in Territories in Transformation and Climate (TTC). With me, you can speak Italian, French, and English. During my free time, I like football, reading books, and cycling. I hope I can help you, and I wish you a good semester."

About this course

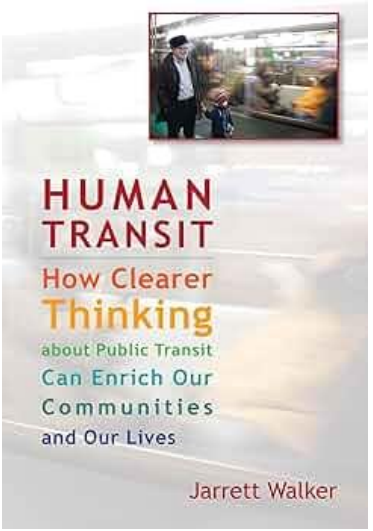
- Grading
  - Assignment (60%)
    - individual work, each amounts 20%
    - two cover Module 1 and one covers Modules 2 & 3
    - published at least 2 weeks before deadline, tentative schedule on syllabus
    - one Q&A session before each deadline, no late submission accepted
    - discussion with other students and ChatGPT is allowed but must be declared
  - Project (40%)
    - group work, proposal (10%), presentation (15%) and report (15%)
    - 3-4 persons per group
    - topic selected from a candidate list or self-proposed
      - tip: the smaller scale and more specific, the better



Questions?

What is public transport?

- Definition by J. Walker
  - Regularly scheduled vehicle trips
    - or at least predictable (e.g., on-demand mobility)
  - Open to all paying passengers
    - open to the entire public
  - With the capacity to carry multiple passengers
    - vehicle space is shared either simultaneously or non-synchronous
  - Trips may have different origin, destinations, and purposes



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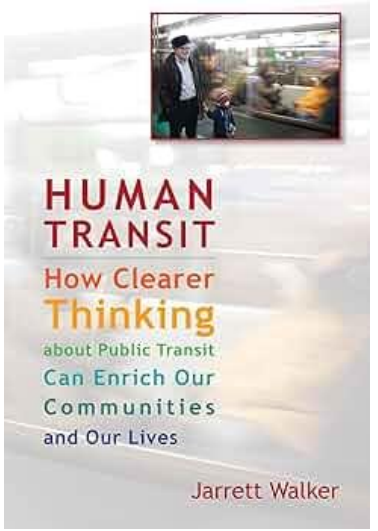
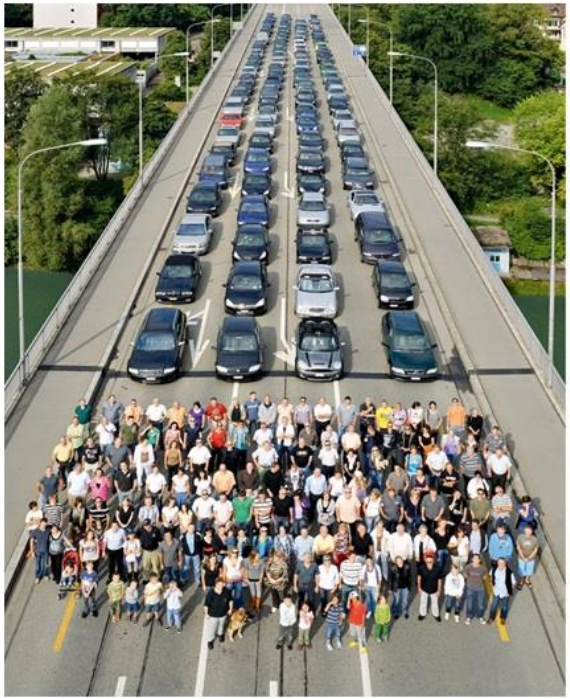
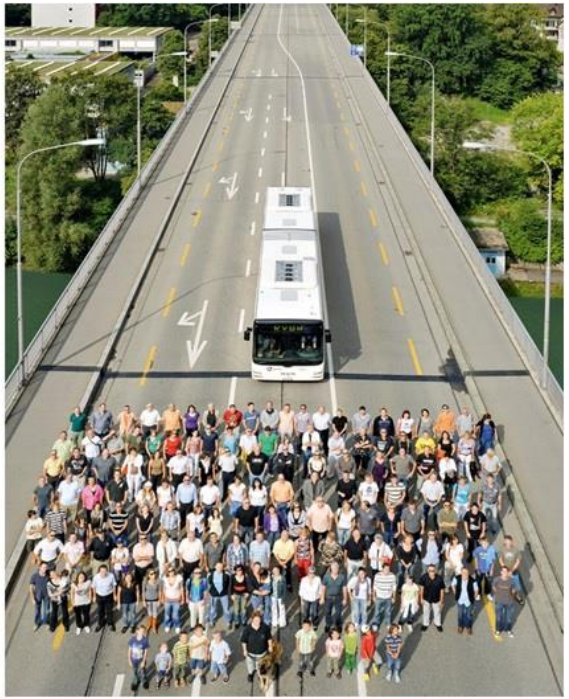
    - vehicle space is shared either simultaneously or non-synchronous
  - Trips may have different origin, destinations, and purposes
  - ***Provided as a service***
    - e.g., “hitchhike” is not public transport



Why public transport is needed?

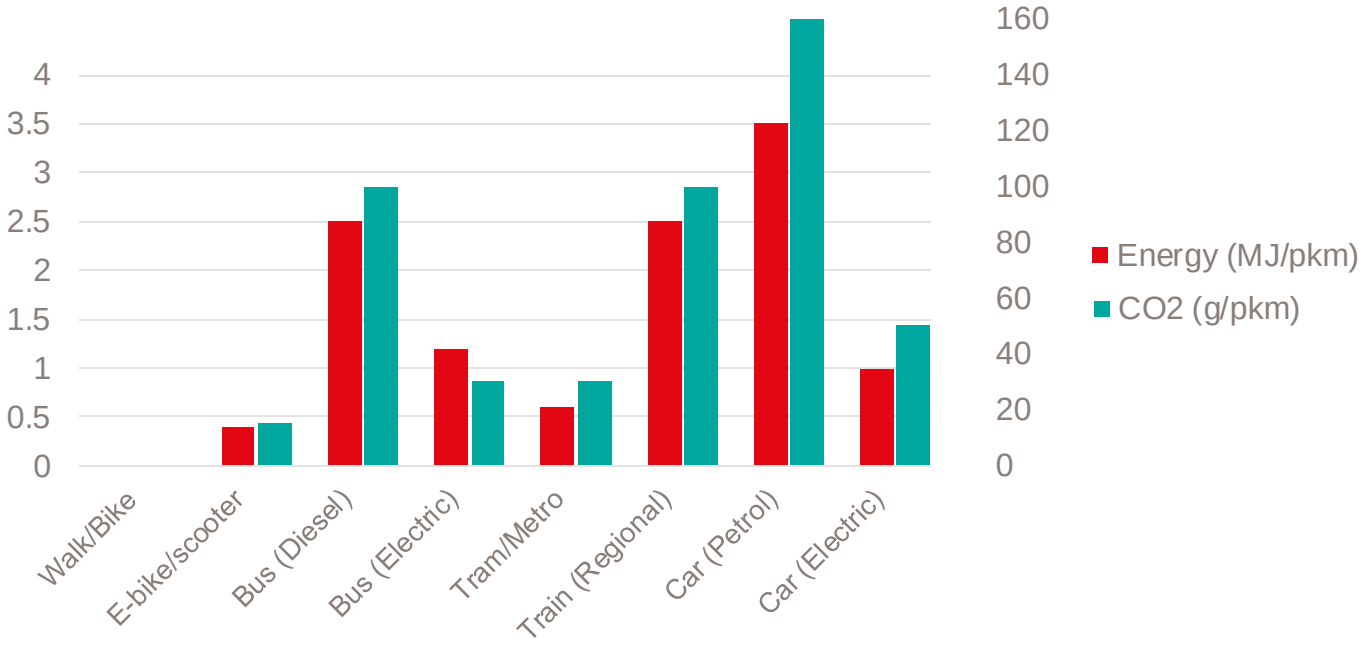
- Transport more people using less space
  - Vehicle and infrastructure





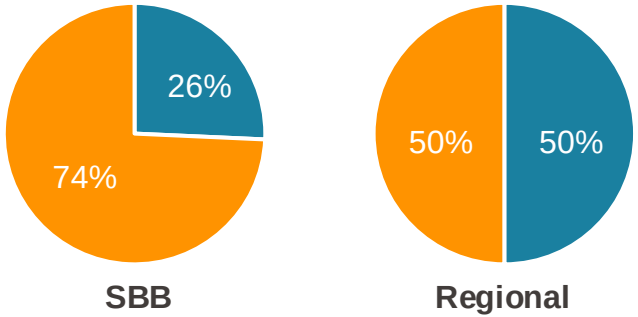
Why public transport is needed?

- Transport more people using less space
  - Vehicle and infrastructure
- Serve more travel demand with less energy
  - Fewer emissions and negative environmental impacts

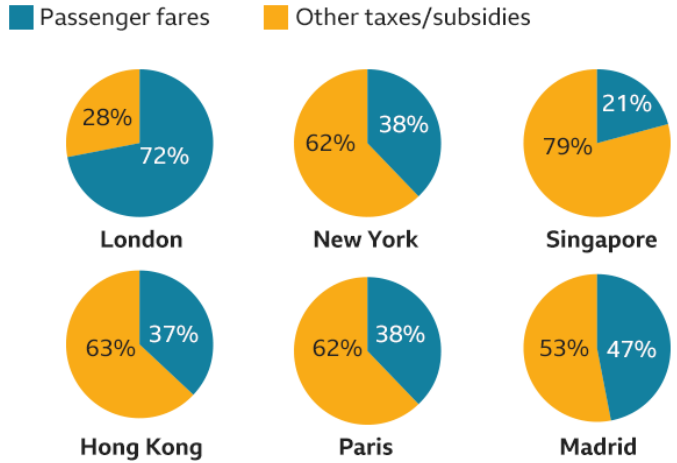


Why public transport is needed?

- Transport more people using less space
  - Vehicle and infrastructure
- Serve more travel demand with less energy
  - Fewer emissions and negative environmental impacts
- Treat passengers equally at low costs
  - Mobility and accessibility guarantee



Source: LE NEWS



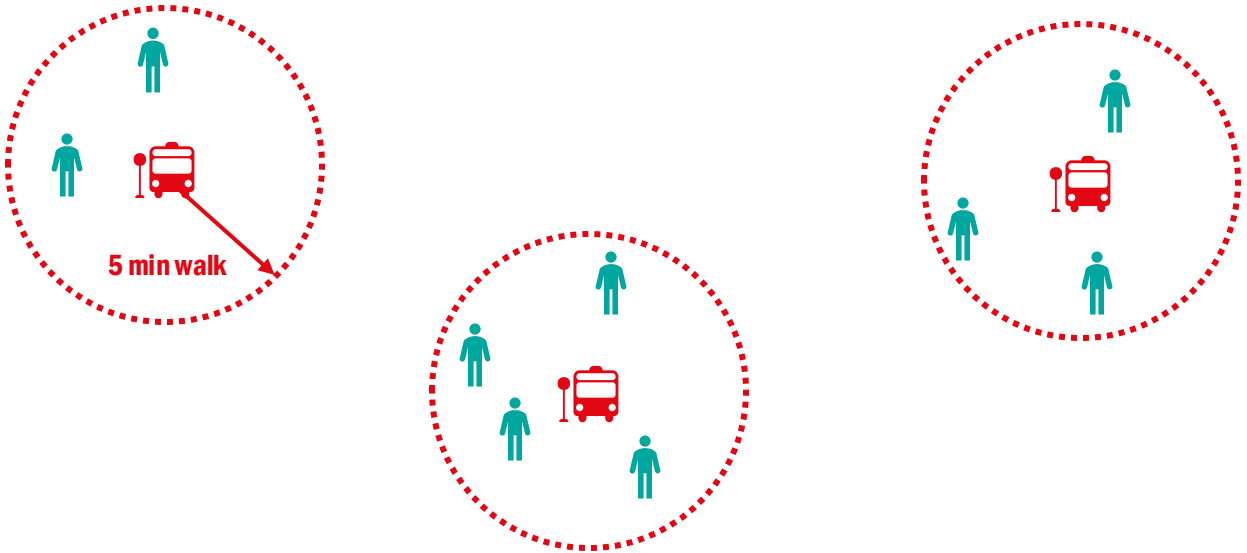
Figures are approximate as funding models vary in their scope

Source: TfL

BBC

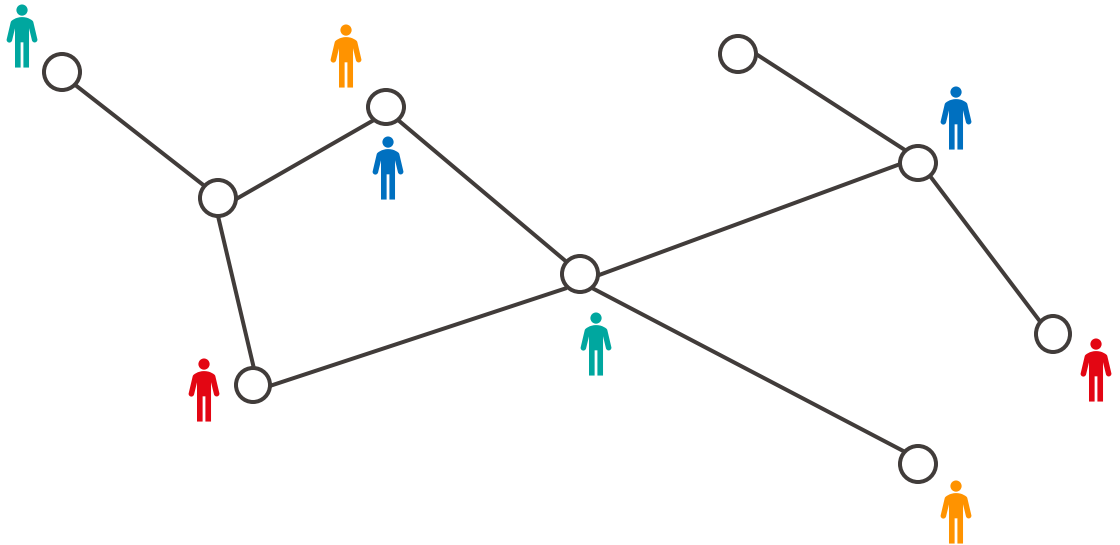
How to design a public transport?

- Fixed-route transit as an example
  - Stop location
    - estimate demand and locate stops to ensure an easy access
    - max service coverage while min stop number



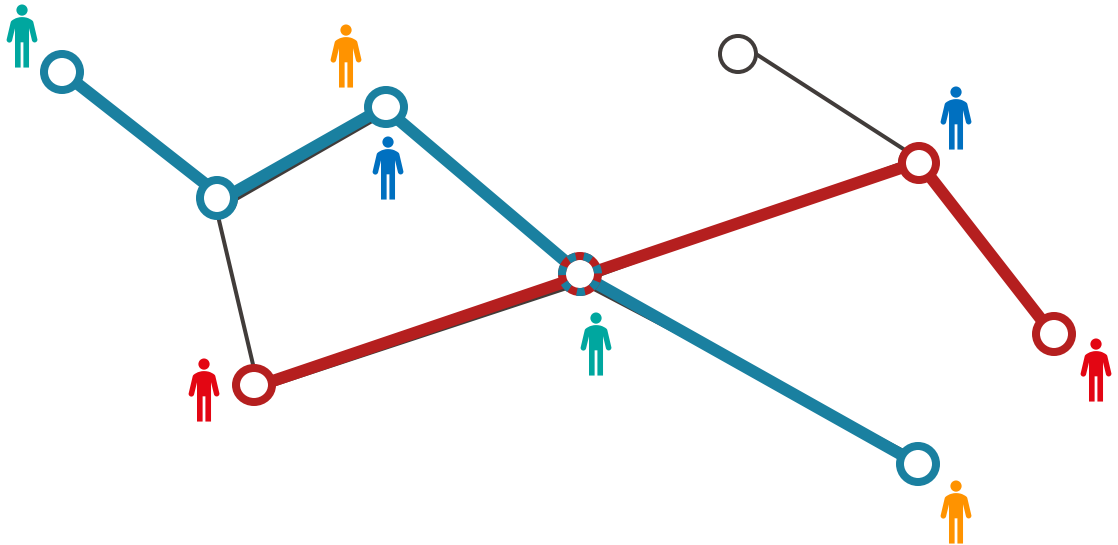
How to design a public transport?

- Fixed-route transit as an example
  - Stop location
  - Line planning
    - analyze trip origin-destination (OD) and connect OD pairs with lines



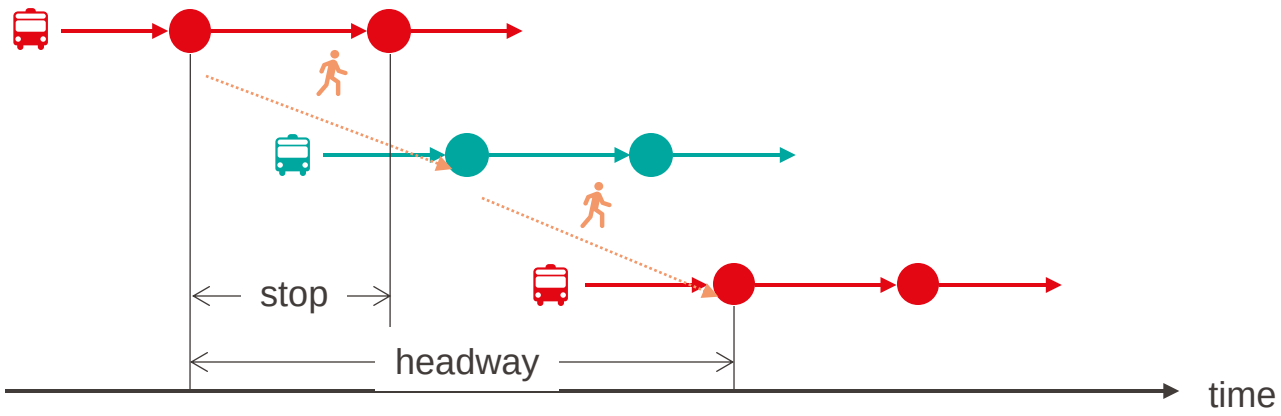
How to design a public transport?

- Fixed-route transit as an example
  - Stop location
  - Line planning
    - analyze trip origin-destination (OD) and connect OD pairs with lines
    - min travel time and transfer while min line number



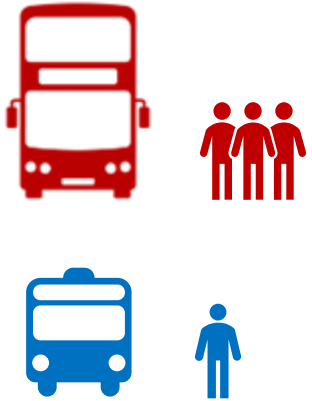
How to design a public transport?

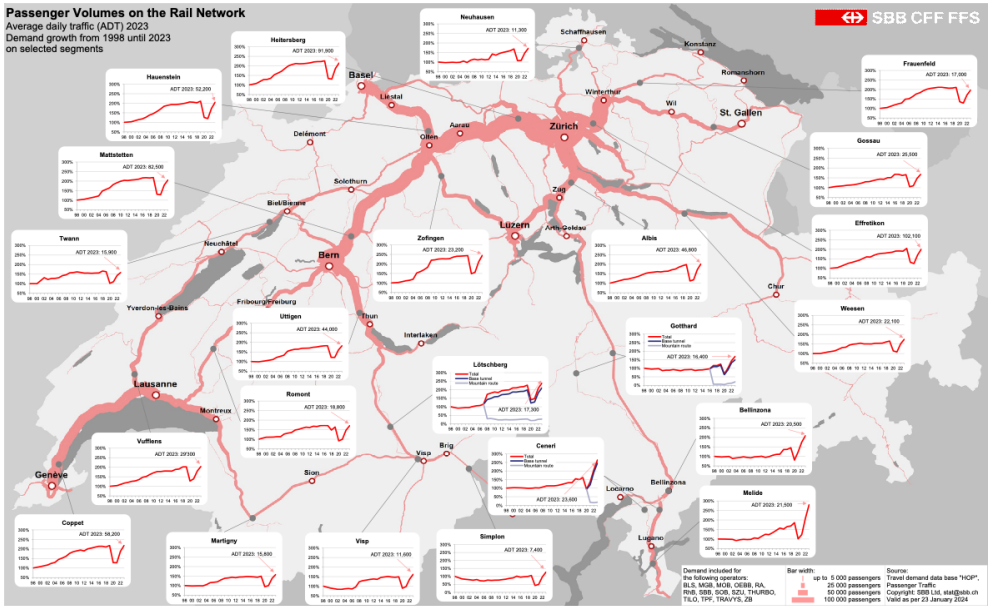
- Fixed-route transit as an example
  - Stop location
  - Line planning
  - Scheduling
    - frequency (tactical): average headway
    - timetable (operational): detailed arrival and departure times



How to design a public transport?

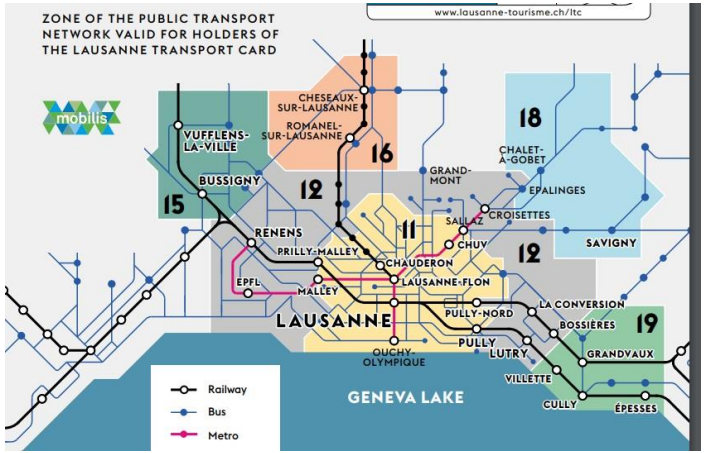
- Fixed-route transit as an example
  - Stop location
  - Line planning
  - Scheduling
  - Capacity planning
    - adapt to dynamic demand
    - vehicle dispatch

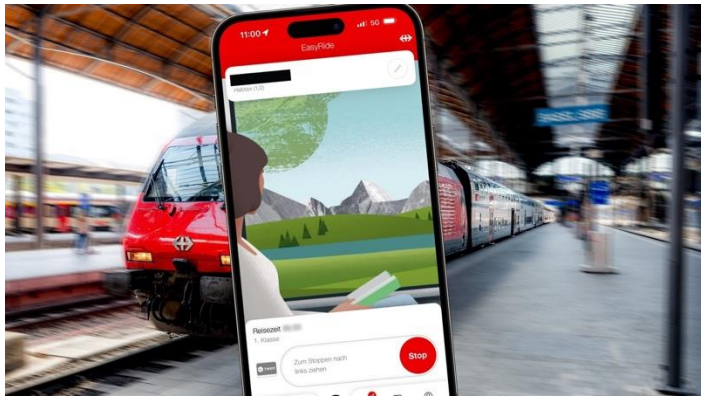




How to design a public transport?

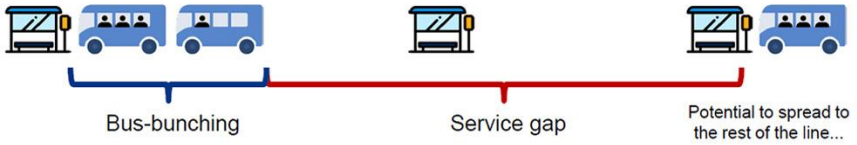
- Fixed-route transit as an example
  - Stop location
  - Line planning
  - Scheduling
  - Capacity planning
  - Pricing
    - flat, distance-based, zone-based
    - modal-specific vs modal-free
    - surge price vs discount
    - single-trip vs subscription

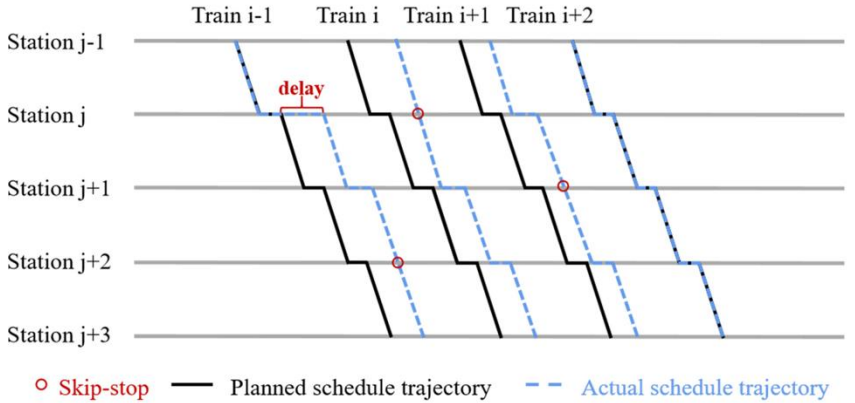




How to design a public transport?

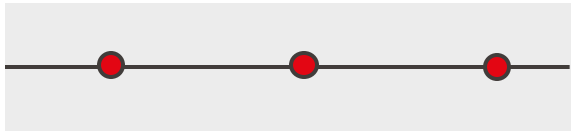
- Fixed-route transit as an example
  - Stop location
  - Line planning
  - Scheduling
  - Capacity planning
  - Pricing
  - Operations
    - delay management
    - rescheduling

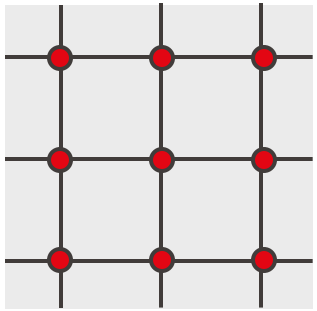




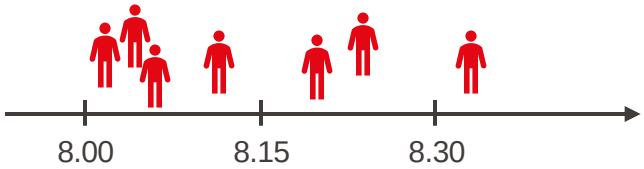
Methodology of this course

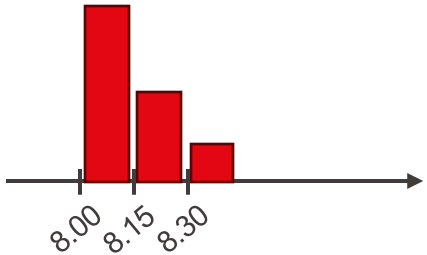
- Generic model by transport mode





- Aggregate and homogenous representation of demand





- Deterministic optimization of key design variables

$$\max_{x} \; F(x;\theta)$$

$$s.t.\; g(x) \leq 0, x \in X$$

x: design variable
θ: parameters

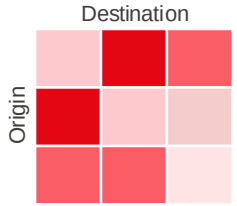
$F(\cdot)$: objective function
$g(\cdot)$: constraint
X: feasible set of x

Methodology of this course

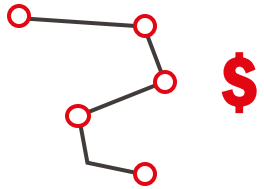
- How to use it in real-world problems?
  - Design a new service in a region

Household travel survey → **Demand pattern** → **Mode selection** ↔ **Service design**

id	Type	From	To	Mode
1	Work	A	B	Train
2	Leisure	B	C	Car
…	…	…	…	…



- Tram
- Bus
- Micro-transit
- …

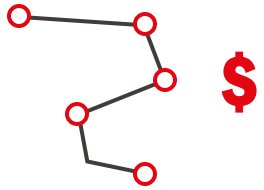


  - Improve an existing service in a region

Current demand & operation → **Alternative modes** → **Service design**

id	Arrival	Departure	Avg. pax
1	8.00	8.02	10
2	8.06	8.08	15
…	…	…	…

OD	Mode	Time (min)	Cost (CHF)	Avg. pax
1	Car	20	20	300
1	Train	30	15	150
…	…	…	…	



$$q_i = D(x_i, \theta_i; \mathbf{x}_{-i}, \boldsymbol{\theta}_{-i})$$

Questions?