Automatic Passenger Counting System in S-trains – how?

dsk.2022

Maja Kamstrup-Nielsen – majka@dsb.dk

03-11-2022

AGENDA

1. Why do we count passengers?
2. Data collection: How do we count?
3. Data handling: How are data handled and processed?
4. Data use: Two examples

1

Why do we count passengers?

Why count passengers?

- Development of number of journeys
- Determining travel patterns
- Estimation of loss of journeys due to incidents
- Distribution of rolling stock
- Contractual obligations to the ministry of transportation
- Revenue sharing in the capital area
- Budgets and accounting
- …

2

Data collection: How do we count?

S-train chart

- 135 trains
- 86 stations
- 8 routes

The counting system APS

- APS: **A**utomatic **P**assenger counting **S**ystem
- The system applies data from a number of different sources of varying quality
- Output is a modelled number of journeys and their travel pattern

Input data – multivariate?

Weights

- All litra units are weighed after departure from a station, when the velocity reaches 5 km/h
- The weighing cell is part of the braking system
- The weighing cell has an accuracy that makes it possible to compute the number of journeys

IR countings

- Installed in 16 litra units (12% of all litra units)
- IR counting bars in all door ways
- Register all passengers boarding and alighting the train

Manual countings

- Converting weights to passengers
- The weighings include luggage, animals, clothes etc.
- Few of the departures are counted manually, but are essential for converting weights to a veritable number of passengers
- In case of extensive replcement busses, the number of passengers are counted manually here as well

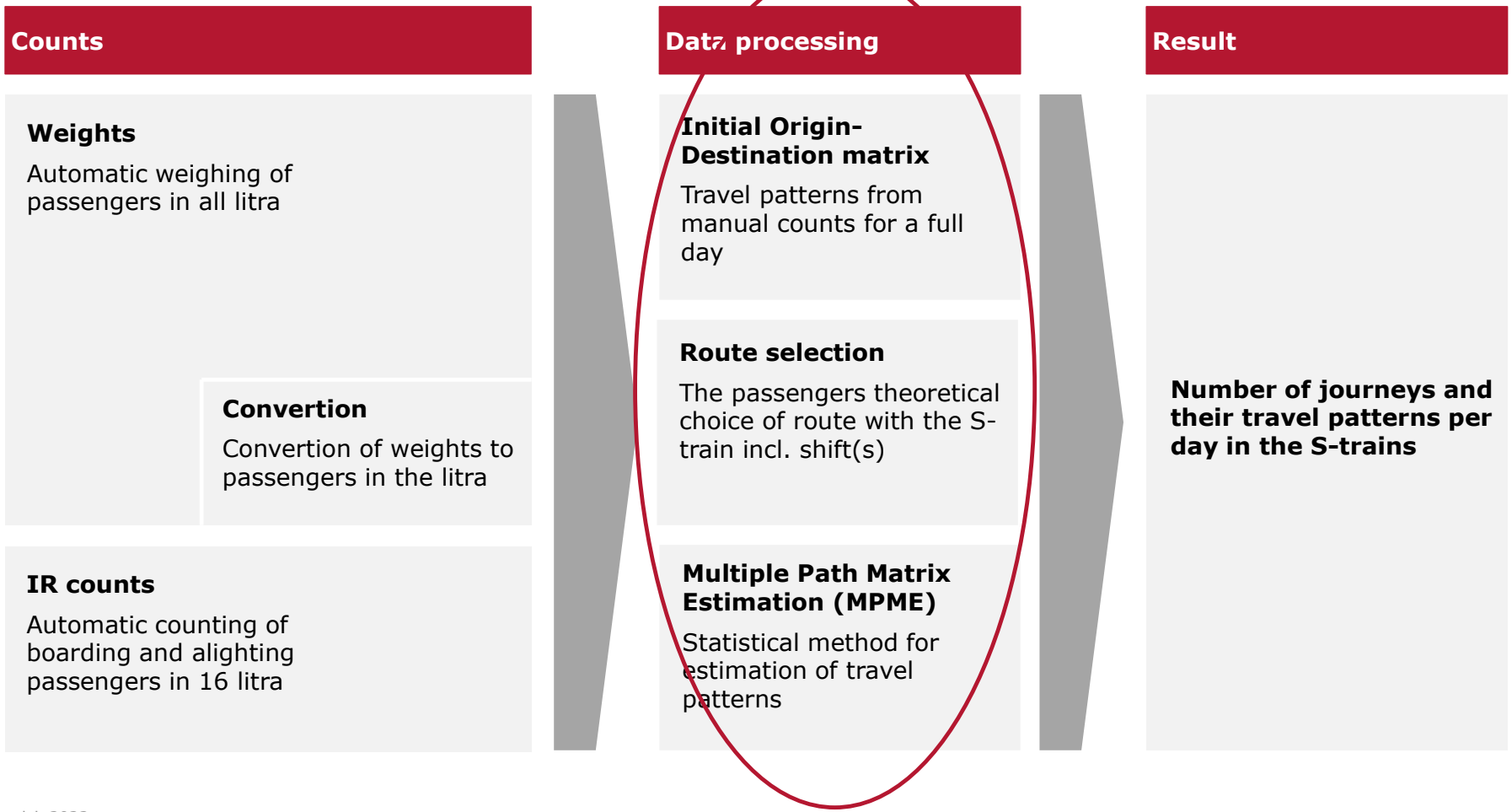
Additional data

- Origin-Destination (OD)-matrix – basic travel pattern
- Planned and actual train schedule (incl. replacements busses)
- Rolling stock schedule – which litra units run on which train numbers
- Litra unit coupling – which litra units are coupled to each other
- Positioning – where are the trains located

3

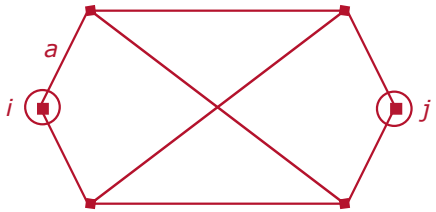
Data handling: How are data handled and processed?

The overall data process



Data processing

- The *route selection* model is applied on the *initial OD matrix*, which is spread out on the actual time table of the day
  - Determines which travel route the passengers are most likely to choose
  - Initial result: A modelled number of passengers between all stations
- Then each element is adjusted using the weights and counts – the *MPME adjustment*



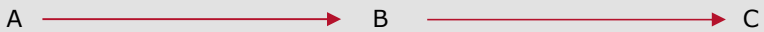
- The MPME adjustment can be expressed as:

$$T_{(E)ija} = \frac{V_a}{T_a} \cdot T_{ij}$$

- $T_{(E)ija}$ is the expected number of passengers from stations *i* to *j* on edge *a*
- V_a is the weight on edge *a*
- T_a is the modelled number of passengers on edge *a*
- T_{ij} is the initial number of passengers from stations *i* to *j*

Data processing – a simple example

Initial OD matrix:



From stat -> to stat	Traffic
A -> B	13
A -> C	42
B -> C	10

MPME adjustment:

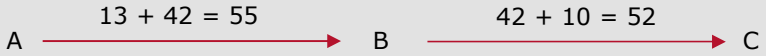
$$T_{(E)ij} = \frac{1}{N}\sum_{a=1}^{N}\frac{V_a}{T_a}\cdot T_{ij}$$

$$T_{A\to B} = \frac{42}{55}\cdot 13 = 9{,}93 \cong 10$$

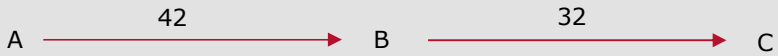
$$T_{A\to C} = \frac{1}{2}\cdot\left(\frac{42}{55}\cdot 42 + \frac{32}{52}\cdot 42\right) = 28{,}96 \cong 29$$

$$T_{B\to C} = \frac{32}{52}\cdot 10 = 6{,}15 \cong 6$$

From the initial OD matrix and the route selection – only one train:



Weights from the train converted to the number of passengers:



Results:

How many passengers are sitting in the train between stations?

A and B: 10 + 29 = **39**

B and C: 29 + 6 = **35**

Total number of passengers?

All "between stations" are summed: 10 + 29 + 6 = **45**

About the MPME method

- The idea is to adjust the number of passengers between all pairs of stations (ODs)
  - Approximately 120.000 OD combinations in the initial OD matrix
- The adjustment is performed based on weights and IR countings
  - On a single day the S-trains are weighed app. 25.000 times
- The solution of the method approaches the minimized squared deviation between the measured and modelled traffic:

$$min\left[\sum_{a}\frac{(T_a - V_a)^2}{V_a}\right]$$

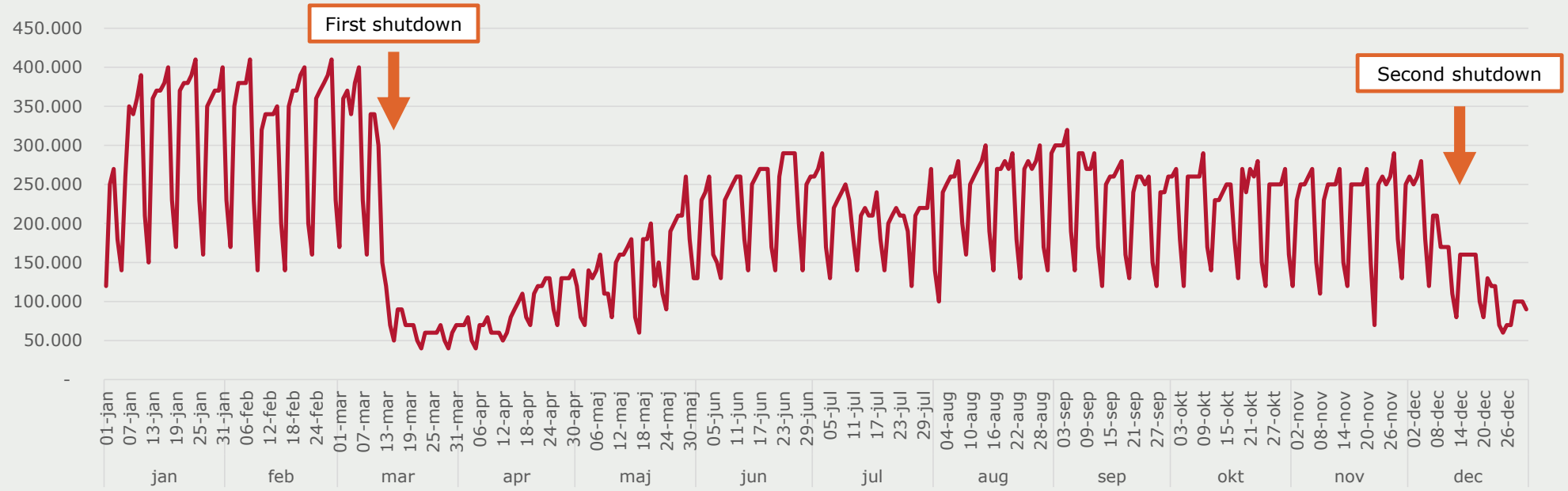
4

Data use: What can we use data for?

An example

Daily number of journeys

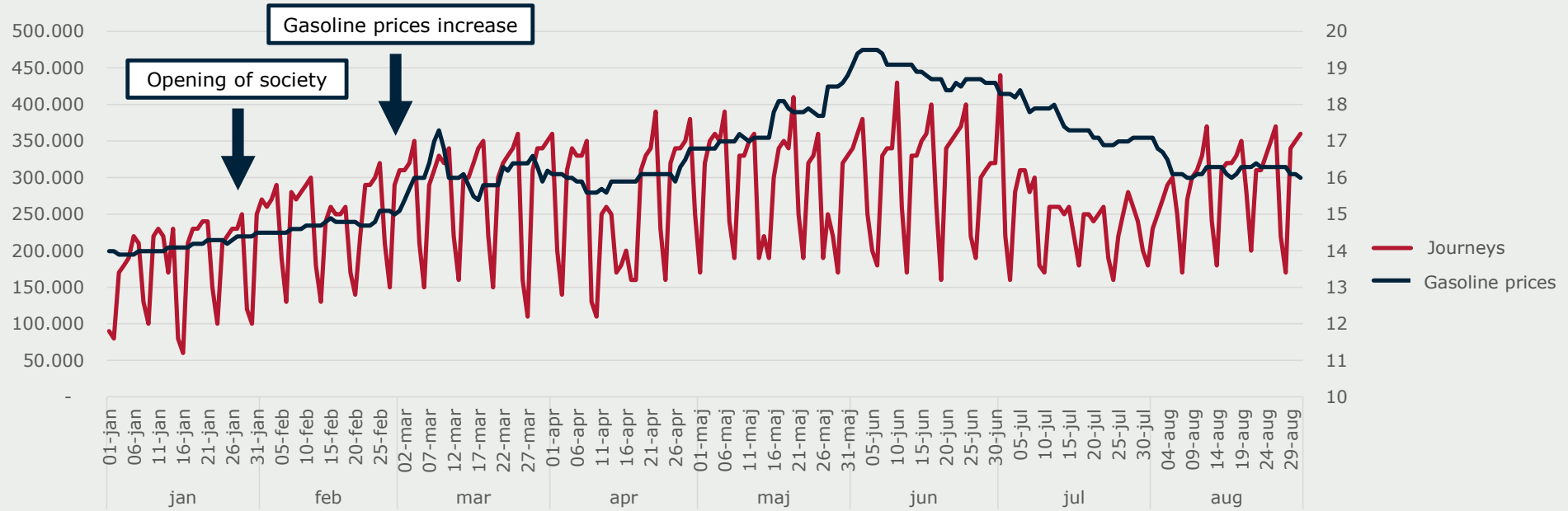
In 2020 when COVID-19 hit – how did APS perform?



An example – watch out!

Daily number of journeys vs. gasoline prices

In 2022 people came back to work and the gasoline prices exploded



Gasoline prices found on [Benzinpriser udvikling → Se prisudviklingen siden 1993 | OK]

Aspects to take into account

- Infrastructual work
- Gasoline prices
- Restrictions during COVID-19 – safe distances, use of mouth guard in public transport
- Strike of front personnel
- Opening of the Metro City Ring
- Increased possibilities of working from home
- Tour de France Grand Départ au Copenhauge
- IT breakdown
- …


DSB