Passenger Flow Analysis

UNECE Working Party on Transport Statistics

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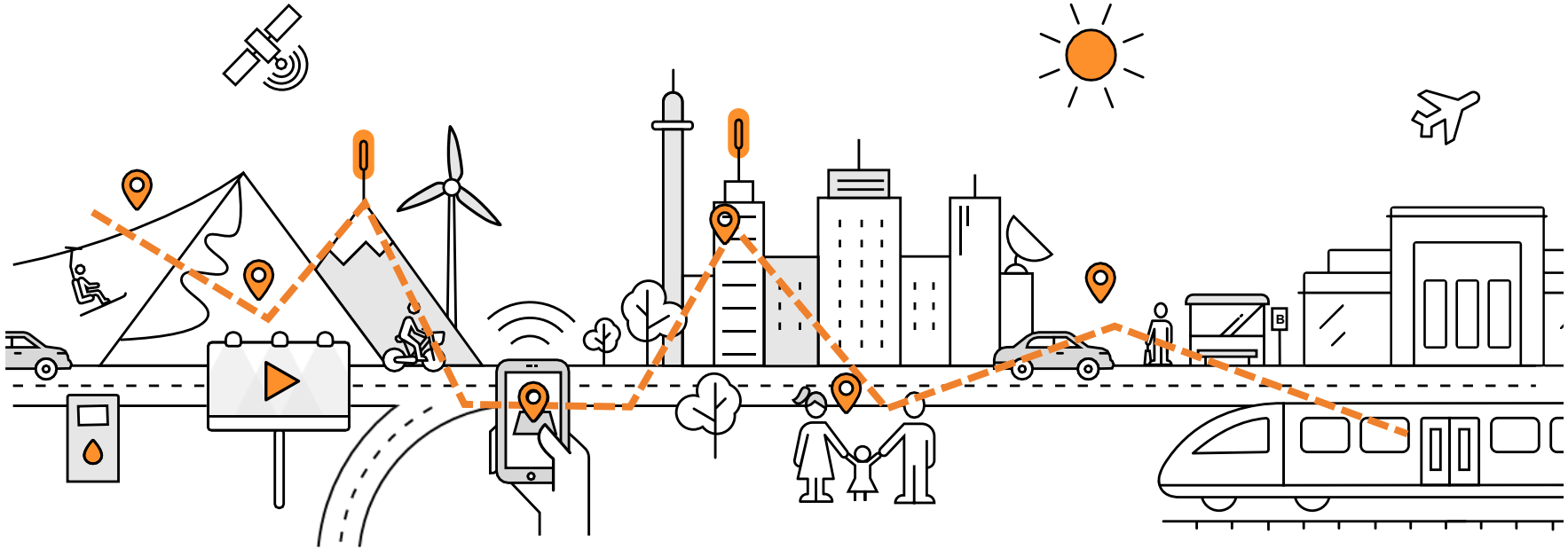
A1

INVENIUM
DATA INSIGHTS

Asset Management Bahninfrastruktur

Invenium in a Nutshell – What do we do?



Daily 3,2 Mio devices within the A1 Network with 7000+ base stations

Turning data into Insights

With Invenium Mobility Insights, we answer a wide variety of questions from our customers in business, tourism, transport and many more. Join us in exploring human mobility and gain valuable insights into the behaviour of your customers.

In compliance with the strictest data protection guidelines

TÜV SAARLAND Geprüfter Datenschutz

Collect data

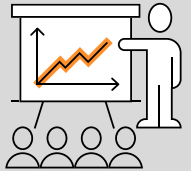
We collect completely anonymized data generated during the communication of mobile devices with cell towers.

Analyze Data

We rely on modern statistical methods and state-of-the-art machine learning approaches to turn millions of data points into insights.

Visualize data

Get an overview of analysis results with our daily PDF reports or go deeper with our interactive dashboards. We have the right solution for every requirement.

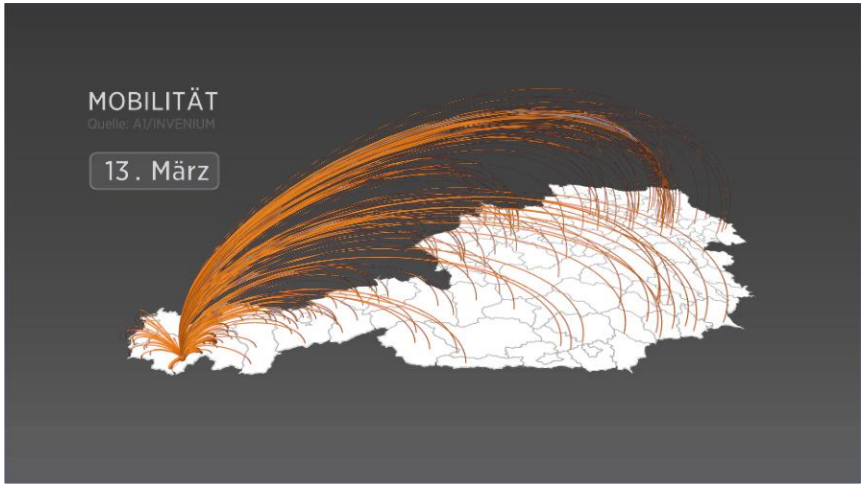


Answer questions

Human movement influences everything. We help you find answers to your questions and thus transform the way you make decisions.

Providing governments with lockdown analysis

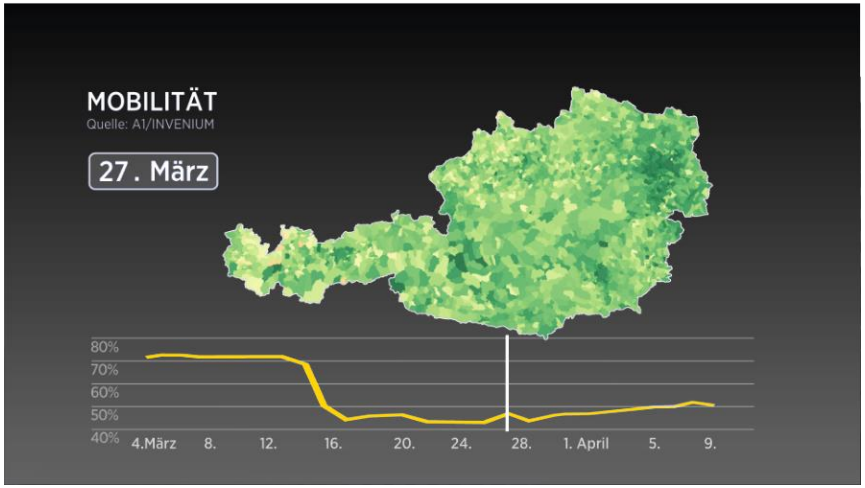
Examples of Austrian mobility analyses



Departure of tourists from Ischgl on the day of the lockdown start

Who is talking about us?

Bloomberg Law · REUTERS · WSJ



Mobility change for each municipality during the lockdown

What are the objectives and partners?

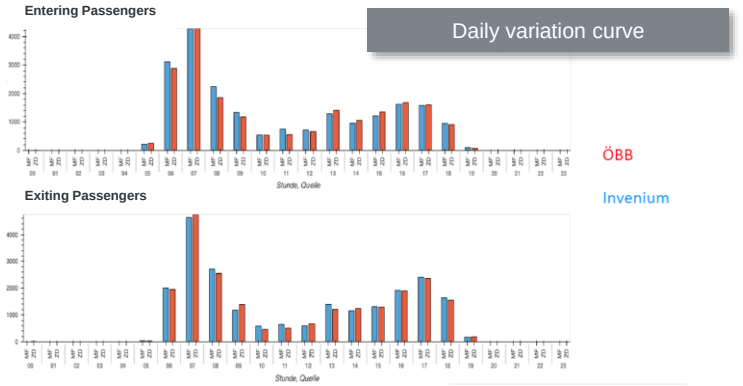
Cooperation Project

- Project **Passenger Flow Analysis** with the **goal:**
  - analyzing passenger demand using anonymous Floating Phone Data for 6 different use cases
  - provide the basis for internal planning purposes
  - develop internal analytic tools
- Telco provider **A1 Telekom Austria** provides **anonymized floating phone data** (market share in Austria Q1/2021 ~ 38%)
- **Invenium** creates, maintains and enhances the **algorithm platform**
- **ÖBB Infrastruktur** provides the **actual train timetable** on a daily basis using the Advanced Railway Automation Management Information System (ARAMIS)

What are the different use cases?

Use Cases

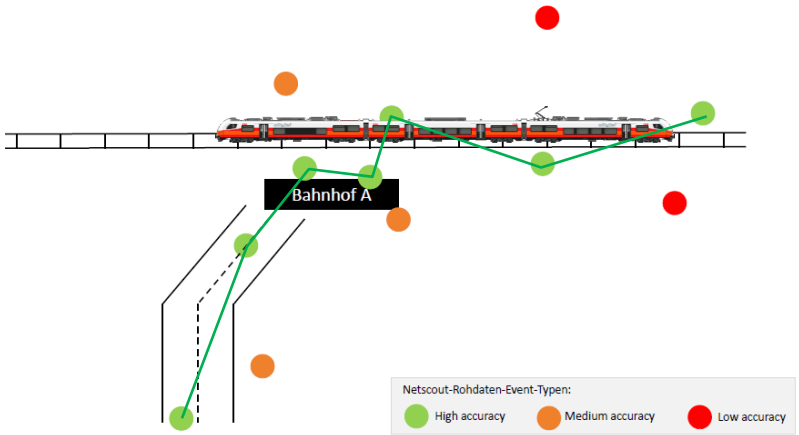
- **Entering** and **exiting passengers** per station
- Station based **Origin-Destination-Matrix** (including transfer passengers)
- **Loads of passengers** on defined cross sections
- Analysis of **delays**
- **Origin-Destination-Matrix** in zonal structure of the National Austrian Transport Demand Model (VMÖ)
- **Catchment areas** of stations (based on Home-Activity)
- **Special analysis**, e.g. demand peaks



How is the data determined?

Method

- **Anonymous mobile network events** are used to create **trajectories** over the day
- A **probabilistic model** is built based on **Machine Learning Algorithms** incl. trajectories combined with the track coordinates and the ÖBB train timetable
- Using this underlying principle, several algorithms are used to **estimate the total (passenger) demand**
- This procedure is **in compliance with all data privacy regulations** and has the appropriate certification



Processing of Data

- **A1** provides the anonymized raw Floating phone data including sociodemographic data. Each of the 3.2 million A1 **clients** generates (on average) 1000 mobile phone events per day
- **Invenium** extrapolates the A1 data to calculate the total transport demand. Quality control measures accompany the process
- **ÖBB** verifies, manages, uses and provides the results

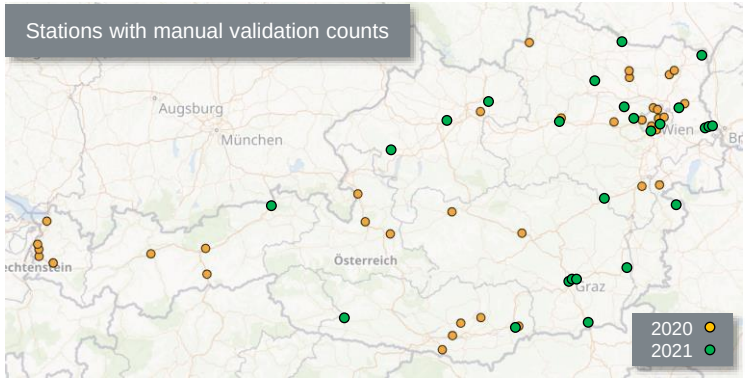
Process (from raw data to results)

A1		User	Invenium	ÖBB
Anonymized floating phone data from A1	Monitoring-system incl. triangulation	Use-Activity on End-User device	Algorithms to calculate Entering / Exiting passengers (per train)	Calculated results

How do we validate? (1)

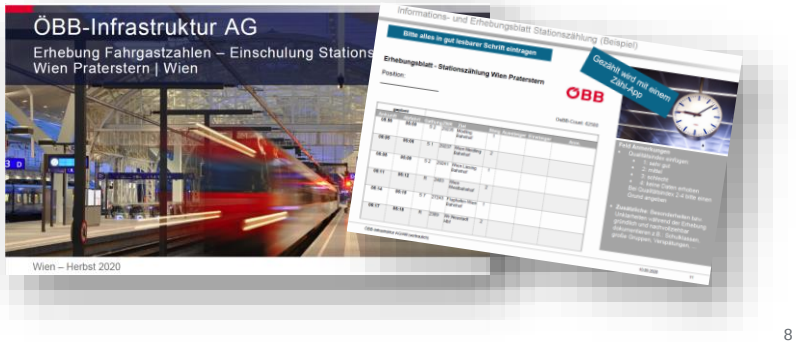
Empirical Reference Data

- **Manually performed counts** to validate the model
- Establishment of **high-quality** assured **empirical passenger counts**. Design, organization, implementation, and validation by the ÖBB
- **120 stations** of different size categories, locations, features etc... were **manually validated since 2019**
- ÖBB-Werbung supported with supplying the counting staff



Counting Method and Validation

- Counting of **entering** and **exiting** passengers **per train**
- The counting **staff** was **specifically trained** to ensure **reliable** and **consistent counts**
- For each count, one person was tasked with managing the counting team. **Only high-confidence counts** were **used** to validate the model



How do we validate? (2)

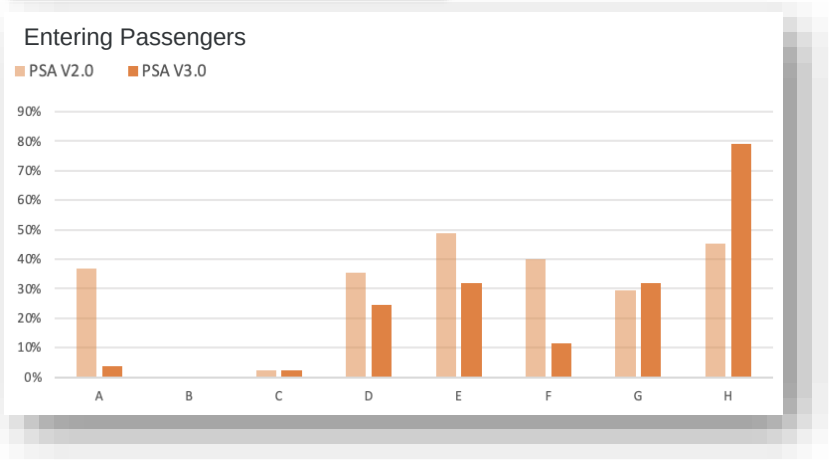
Status of Quality

- Since 2019, the **quality** of the algorithm was **continuously improved** (from version 1 to version 5):
  - **New Monitoring-System** at A1 Telekom Austria
  - **Individual parameters** for **urban areas**
  - **Improved accuracy** in **rural areas** with low cellular network coverage
  - **Focus** on the **“Vienna Main-Line"**
- **Slightly higher variance** still exists on **smaller** and **less used** train **stations**

Outlook

- **Improvement** in the **raw-data quality** from the monitoring system from the A1 cellular network
- **Automated validation** of the actual train schedule (ARAMIS)
- **Optimization** of the **algorithm** in version 5 (current roll-out)
- **5G expansion** will further **improve the quality** in the future

Validation Example



How is the progress?

Strengths

- Passenger demand is **continually calculated** for the entire Austrian railway network using a **consistent method**
- Comprises **entire journey** (from origin to destination)
- The results are available for **different time aggregations** (weekends, events, yearly variation curve, etc.)
- Distinction of **train categories**
- **Pandemic-proof method**, fully automated
- **High quality** results for **medium** and **high categorized stations**

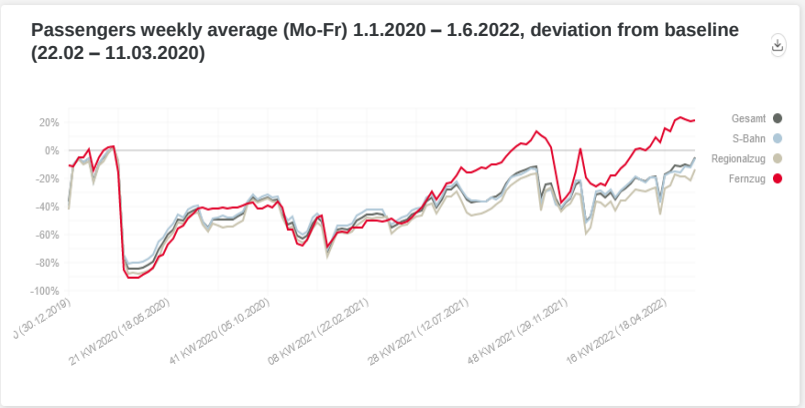
Weaknesses

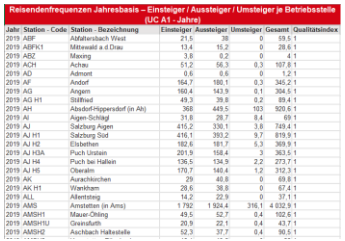
- **Quality improvements** dependent on **cellular network expansions**
- **Difficulty** in differentiating **parallel traffic flows** (affects some stations with nearby roads)
- **Validation counts** still **necessary** for future algorithm improvement
- **Low quality** results for **low categorized stations** (especially less than 200 passengers per day)

How is the data used?

Practical Applications

- **Statistics of passenger numbers** throughout the pandemic - necessary information for the **ÖBB Management** and CEO
- The line **Vienna - Salzburg**, which normally operates without public funding, urgently **needed public funding** to ensure continued operation during the pandemic. The project **provided** the **necessary data** for this political decision
- Aggregated data (for an average workday) are used as a **basis** for **internal planning purposes**
- **Individualized reports** are supplied to other departments within ÖBB
- Data is used as an **input factor** for the **National Austrian Transport Demand Model** (Verkehrsmodell Österreich - VMÖ)
- **Pilot project** to supply digital passenger data to **rail operating companies**





Reisendenfrequenzen Jahresbasis – Einsteiger / Aussteiger / Umsteiger je Betriebsstelle (UC A1 - Jahre)

Jahr	Station - Code	Station - Bezeichnung	Einsteiger	Aussteiger	Umsteiger	Gesamt	Qualitätsindex
2019	ABF	Abfahrtsbach West	21,5	38	0	59,5	1
2019	ABFK1	Mittewald a.d.Drau	13,4	15,2	0	28,6	1
2019	ABZ	Maxing	3,8	0,2	0	4	1
2019	ACH	Achau	51,2	56,3	0,3	107,8	1
2019	AD	Admont	0,6	0,6	0	1,2	1
2019	AF	Andorf	164,7	180,1	0,3	345,2	1
2019	AG	Angern	160,4	143,9	0,1	304,5	1
2019	AG H1	Stillfried	49,3	39,8	0,2	89,4	1
2019	AH	Absdorf-Hippersdorf (in Ah)	368	449,5	103	920,6	1
2019	AI	Aigen-Schlägl	31,8	28,7	8,4	69,1	
2019	AJ	Salzburg Aigen	415,2	330,1	3,8	749,4	1
2019	AJ H1	Salzburg Süd	416,1	393,2	9,7	819,9	1
2019	AJ H2	Elsbethen	182,6	181,7	5,3	369,9	1
2019	AJ H3A	Puch Urstein	201,9	158,4	3	363,5	1
2019	AJ H4	Puch bei Hallein	136,5	134,9	2,2	273,7	1
2019	AJ H5	Oberalm	170,7	140,4	1,2	312,3	1
2019	AK	Aurachkirchen	29	40,8	0	69,8	1
2019	AK H1	Wankham	28,6	38,8	0	67,4	1
2019	ALL	Allentsteig	14,2	22,9	0	37,1	1
2019	AMS	Amstetten (in Ams)	1 792	1 924,4	316,1	4 032,9	1
2019	AMSH1	Mauer-Öhling	49,5	52,7	0,4	102,6	1
2019	AMSH1U	Greinsfurth	20,9	22,1	0,4	43,7	1
2019	AMSH2	Aschbach-Haltestelle	52,3	37,7	0,4	90,5	1