The Activity-based Incremental Model (ABIT)

Modeling 24 hours, 7 days per week

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1. Background and Motivation
2. Simulating Weekly Demand
3. Simulating Year-to-year Incremental Updates
Activity-based Modelling

- Travel represented **the need to change location between activities**

- People (and their vehicle) can only be in one place at a time

- More behaviorally realistic

- Easier to explain to policymakers and stakeholders

- Expands modelling possibilities & potential scenarios, e.g.,:
  - EV charging infrastructure
  - Impacts of telework on other activities
  - Pricing studies
  - Autonomous vehicles
  - Ride-hailing
  - Health
Activity schedule
Trip based vs. Activity-based consistency

Temporal and spatial representations in TDM: Home->Work->Shopping->Home

**Trip-based**

**Activity-based**
The MATSim Transport Model

- “Multi-agent Transport Simulation”
- Open source
- [https://www.matsim.org](https://www.matsim.org)
- Activity-based simulation framework
Habits and Day-to-day Stability

Travel demand is typically modelled for a typical “hour” or “day”

Not always sufficient to model a peak “hour” or “day”, e.g.,
  - Person-centric policy assessments (Jones and Clarke, 1988)
  - Environmental exposures
  - Health (Staves, 2020)

Longer-term models create challenges in capturing **stability** and **variability** in people’s behavior.

**Example:** You have a 1-day model, but needed a 7-day result (e.g., weekly physical activity)
  - Run the 1-day simulation, multiply outputs by 7 → Too much **stability**
  - Run the 1-day simulation 7 separate times → Too much **variation**
Simulating Weekly Physical Activity with a 1-day Model

Cumulative density

Physical Activity (mMET-hours per week)

Model structure
- RED REFERENCE
- Blue Run once, multiply by 7
- Green Run 7 times
Beyond 7 Days: Longer-term stability

- Travel behaviour differs from day to day (Raux et al. 2016) but does not change dramatically from year to year (McCarthy 1982, Kitamura 1987).

- Life events, such as household relocation, graduation from school, change of job, birth of a child, etc., may change travel behaviour fundamentally.

- But for most people, such changes are rare, and travel behaviour changes marginally if at all.

By contrast, transport models tend to recreate travel behavior from scratch every time the model runs! Habitual behavior and attitudes are typically ignored.
The Activity-based incremental model (ABIT) aims to:

- **Integrate** within a land-use and transport model
- Simulate a **full week** of activity-travel behavior for each agent
- Simulate **incremental updates each year** with changes to life events
Development of the Activity-based Incremental Model (ABIT)
Data

- **German Mobility Panel** data (2010 - 2019):
  - Respondents were asked to participate in 3 consecutive years
  - Each year, participants provide:
    - A 7-day trip diary
    - Socio-demographic attributes
    - Mobility resources
  - Raw data: 589,357 trips of **25,449 individuals**

- Data were reduced to obtain:
  - Active days by purpose
  - Life events

Final sample: **9645 individuals, 220440 activities**
Munich metropolitan region

- Municipalities where at least 25% of workers commute to Munich, Augsburg, Ingolstadt, Rosenheim or Landshut

4,4 million inhabitants
444 municipalities
1,7 million jobs
14 million trips/day
~ 5,000 Zones
Households

Persons

2. Mandatory activities
   [work, education]
   - Frequency
   - Select weekdays
   - 5. Start time & duration

3. Discretionary activities
   [hierarchy: accompany, shop, recreational, other]
   - Frequency
   - Add to mandatory tour
   - Create new discretionary tour
   - Add to discretionary tour
   - 5. Start time & Duration
   - 6. Destination choice

4. Subtours
   [at work or education]
   - Frequency
   - Add to mandatory tour
   - 5. Start time & duration
   - 6. Destination choice

7. Vehicle allocation to household members by time of day

Tour

8. Tour mode choice and trip leg mode choice

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Example output (1 day)

**Work**
8:00–17:00

**Lunch**
12:00–13:00

**Leisure Ride**
20:30–21:00

- **Leg 1**: 45min
  - Work 8:00–17:00
  - Shopping 30 minutes

- **Leg 2**: 40 min
  - Lunch 12:00–13:00

- **Leg 3**: 15 min
  - Leisure Ride 20:30–21:00

**Legend:**
- ➔ Main tour
- ➔ Subtour
- ➔ Recreational roundtrip
1. Habitual mode choice

2. Mandatory activities
   [work, education]
   - Frequency
   - Select weekdays
   - 5. Start time & duration

3. Discretionary activities
   [hierarchy: accompany, shop, recreational, other]
   - Frequency
   - Add to mandatory tour
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8. Tour mode choice and trip leg mode choice

To assignment in MATSim...
Habitual mode: maintaining day-to-day stability

**Nested-logit** model estimated using 5601 records
- **Output:** mode used *the most often* for work tours
- **Input:** sociodemographic attributes, household & workplace location

Influences other decision-making, including:
- **Mode choice** for individual tours and legs
- **Trip chaining** of discretionary activities

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<th>Attribute</th>
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<th>CAR_PASSENGER</th>
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<td>No</td>
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Results: Differentiated by habitual commute mode
1. Habitual mode choice

2. Mandatory activities [work, education]
   - Frequency
   - Select weekdays
   - 5. Start time & duration

3. Discretionary activities [hierarchy: accompany, shop, recreational, other]
   - Frequency
   - Add to mandatory tour
   - Create new discretionary tour
   - Add to discretionary tour
   - 5. Start time & Duration
   - 6. Destination choice

4. Subtours [at work or education]
   - Frequency
   - Add to mandatory tour
   - 5. Start time & duration
   - 6. Destination choice

5. Start time & duration

6. Destination choice

7. Vehicle allocation to household members by time of day

8. Tour mode choice and trip leg mode choice

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Commute tour frequency

**Zero-inflated ordered logit**

- Estimates frequency of commute tours
- Every tour starts/ends at home
2. Mandatory activities [work, education]

3. Discretionary activities [hierarchy: accompany, shop, recreational, other]

4. Subtours [at work or education]

5. Start time & duration

6. Destination choice

7. Vehicle allocation to household members by time of day

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Discretionary Activities

Steps:
1. Frequency for each purpose (method: zero-inflated negative binomial models)
2. Decide where to put them:

Hierarchy:
1) Escort
2) Shopping
3) Other
4) Recreation
Subtours

**Definition:** a tour that starts and ends at the school or workplace

**Method:** Binary logit, for every commute tour
2. Mandatory activities [work, education]

3. Discretionary activities [hierarchy: accompany, shop, recreational, other]

4. Subtours [at work or education]

7. Vehicle allocation to household members by time of day

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To assignment in MATSim...
Activity-based travel demand model overview

Vehicle use consistency

Priority given to the user with **greatest benefit** of using car, considering

- Trip purpose
- Travel times
- Driver’s license
Simulating Year-to-year Incremental Changes

Empirical analyses have shown for a long time that travel behavior tends to be rather stable from year to year (Kitamura and Hoorn, 1987, Jones, 1988), unless some life event occurs.

- Strong association between changes commute mode and life events (Clark et al., 2014)
- Patterns of time use before and after key events differ by gender (Schneider, 2016)
- Changes in employment status triggers the largest difference in commute frequency (Moreno et al., 2023)

Discussed further in “Understanding the Impact of Life Events on Travel Behaviour Change via Machine Learning” (Moreno et al, Session 16)
ABIT: Activity-based travel demand model overview

68 million activities (9.6 million activities per day – 2.2 per person)
121 million legs (17 million legs per day – 3.9 per person)

- See further descriptions at: https://wiki.tum.de/display/msmmodels/abit
- Code: https://github.com/msmobility/abit (under development)
Thank you!