



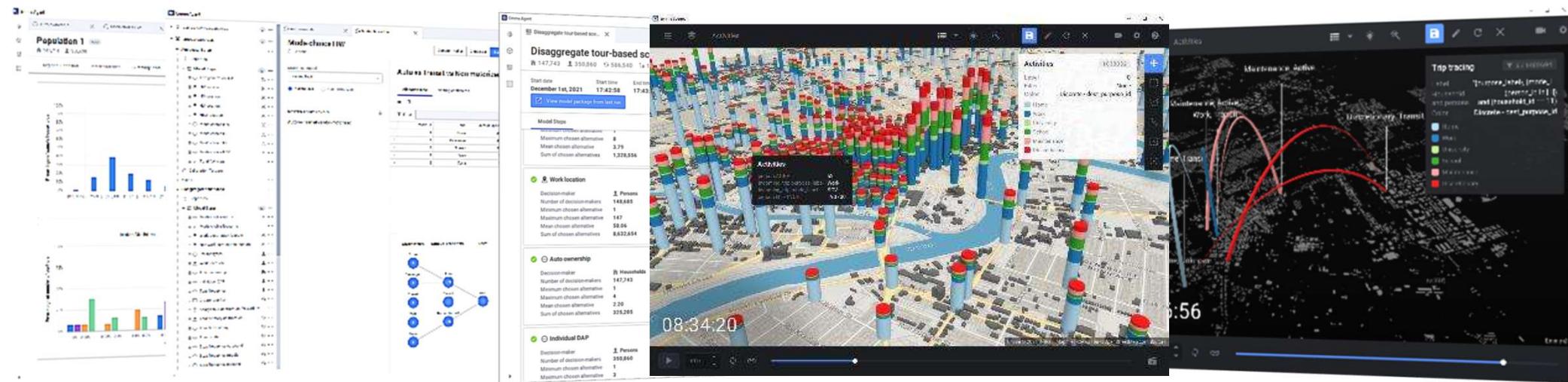
Recent applications of AGENT and new directions

Gaurav Vyas

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Bentley[®]

AGENT is a platform to assemble, calibrate and apply travel demand models



- Assemble virtually any travel demand model structure from 4-step to ABM
- Enjoy transparent access to a full travel demand model UI
- Maintain different model structures or versions in parallel
- Upgrade and advance models over time with new features

Four-step

This screenshot shows the 'Aggregate four-step' model structure. It includes a 'Properties' section and a 'Model Steps' section with the following items:

- Trip generation AM
- HW location
- HS location
- HU location
- HBO location
- Mode choice HW
- Mode choice HS
- Mode choice HU
- Mode choice HBO
- Total AM trips

At the bottom, there is a 'Calibration Targets' section.

Hybrid

This screenshot shows the 'Hybrid' model structure. It includes a 'Properties' section and a 'Model Steps' section with the following items:

- Mode choice utility
- Mode choice logsums
- Work destination logsum
- Non-work destination logsum
- Person types
- Auto ownership
- Individual DAP
- Home-based trip frequency
- Aggregate trips
- Trip distribution for work
- Trip distribution for university
- Trip distribution for school
- Trip distribution for maintenance
- Trip distribution for discretionary
- Mode choice for work
- Mode choice for university
- Mode choice for school
- Mode choice for maintenance
- Mode choice for discretionary
- Time-of-day split

At the bottom, there is a 'Calibration Targets' section.

Simple ABM

This screenshot shows the 'Disaggregate tour-based' model structure. It includes a 'Properties' section and a 'Model Steps' section with the following items:

- Mode choice utility
- Mode choice logsums
- Work destination logsum
- Non-work destination logsum
- Person types
- Work location
- Auto ownership
- Individual DAP
- Tour frequency
- Create tour list
- Assign tour destination for work to...
- Tour primary destination
- Tour time-of-day
- Tour mode
- Stop frequency outbound
- Stop frequency middle
- Stop frequency inbound
- First stop outbound purpose
- Second stop outbound purpose
- Third stop outbound purpose
- First stop middle purpose
- Second stop middle purpose
- First stop inbound purpose
- Second stop inbound purpose
- Third stop inbound purpose
- Create trip list
- Tag trip directions
- Trip destination with time-space co...
- Add origin zone id
- Trip mode
- Trip departure

ABM

This screenshot shows the 'MTC 1_5 Style' model structure. It includes a 'Properties' section and a 'Model Steps' section with the following items:

- Prep
- Calculate dc size terms
- Compute exponentiated utility
- Compute accessibility
- School location
- Work location
- Add OD relation for home to work
- Calculate person auto savings ratio
- Auto ownership
- Free parking
- COAP
- Mandatory tours models
- Add primary location to tours
- Mandatory tour scheduling
- Joint tour frequency
- Insert joint tours
- Joint tour composition
- Joint tour participation
- Delete non participants
- Joint tour destination
- Add OD relations to joint tours
- Joint tour scheduling
- Assign joint tour information to tours
- Non mandatory tour frequency adults
- Non mandatory tour frequency children
- Insert non-mandatory tours
- Non mandatory tour destination
- Add OD relations to tours
- Non mandatory tour scheduling
- Tour mode choice
- At work tour frequency
- Insert into sub-tours
- At work sub-tour destination
- Add OD relations to sub-tours
- At work scheduling
- At work tour mode choice
- Stop frequency on tours
- Stop frequency on at work tours
- Add frequency attributes for insert into tr...
- Insert into trips



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- Upgrade and advance models over time with new features

Input Schema

Agent Schema

Constants

Time of Day

THROUGH-SEGMENTS

Purposes

Modes

Person Types

Daily Activity Patterns

Modes

Person Types

Daily Activity Patterns

CONSTRAINTS

Person Types & Daily Activity Patterns

Purposes & Daily Activity Patterns

Modes & Person Types

Agent Schema

AGGREGATE

Zones

Network zones

O-D

TRAVEL

Tours

Sub-tours

Trips

TRAVEL

Tours

Sub-tours

Trips

VEHICLE

Cars

POPULATION

Households

Persons

JOINT TRAVEL

Fully joint tours

Joint tour participants

JOINT TRAVEL

Fully joint tours

Joint tour participants

- Assemble virtually any travel demand model structure from 4-step to ABM
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The screenshot shows the Emme Agent software interface. The main window title is "Disaggregate tour-based scenario". Below the title, there are statistics: 147,714 households, 350,607 persons, 587,470 trips, and 1,536,586 trips. The interface displays a data table with a filter set to "person". The table has 6 columns and 6 rows. The first row is labeled "househ" and the second row is labeled "Context person". The table shows numerical values for each row and column.

| househ | Context person | AGEP | constants | dap | dap ls | | | | | | | | |
|--------|----------------|------|-----------|-----|--------|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | |
| 6 | 4 | 1 | 66 | 0 | 0 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |

Disaggregate tour-based scenario
 147,714 350,607 587,470 1,536,586

Start date: December 14th, 2021
 Start time: 18:20:15
 End time: 18:21:56
 Duration: 00:01:40.73

Model Steps

- Work location**
 - Decision-maker: **Persons**
 - Number of decision-makers: 148,606
 - Minimum chosen alternative: 165
 - Maximum chosen alternative: 9,438
 - Mean chosen alternative: 709,81981
 - Sum of chosen alternatives: 105,483,483
- Auto ownership**
 - Decision-maker: **Households**
 - Number of decision-makers: 147,714
 - Minimum chosen alternative: 1
 - Maximum chosen alternative: 4
 - Mean chosen alternative: 2.21842
 - Sum of chosen alternatives: 327,692
- Individual DAP**
 - Decision-maker: **Persons**
 - Number of decision-makers: 350,607
 - Minimum chosen alternative: 1
 - Maximum chosen alternative: 3
 - Mean chosen alternative: 1.32967
 - Sum of chosen alternatives: 466,192
- Tour frequency**

Auto vs Transit vs Non motorized

Allocation table Nesting coefficients

| mode_id | label | default_speed |
|---------|-----------|---------------|
| 1 | Driver | 45 |
| 2 | Passenger | 45 |
| 3 | Transit | 35 |
| 4 | Walk | 3 |
| 5 | Cycle | 5 |

Alternatives Auto vs Transit vs... Root

```

  graph LR
    Driver((1)) --- Auto((0.9))
    Passenger((1)) --- Auto
    Transit((1)) --- Transit((1))
    Walk((1)) --- NonMotorized((0.5))
    Cycle((1)) --- NonMotorized
  
```

Daily Activity Pattern

Component expression: **dap_type_id**
 Utility specification type: **Wide**

Displaying 22 of 22 rows

| description | agent_filter | agent_expression | (dap_type_id) == 1 | (dap_type_id) == 2 | (dap_type_id) == 3 |
|------------------------|------------------|----------------------------------|--------------------|--------------------|--------------------|
| High income hhs | person_type == 7 | hh.HINCF > 75000 | 0.000000 | 0.000000 | -0.100000 |
| High income hhs | person_type == 8 | hh.HINCF > 75000 | 0.000000 | 0.000000 | -0.100000 |
| Number of cars | | hh.num_cars | 0.000000 | 0.000000 | -0.300000 |
| Linear age | | AGEP | 0.045000 | 0.000000 | 0.000000 |
| Age squared | | AGEP * JGEP | -0.000500 | 0.000000 | 0.000000 |
| non work accessibility | | hh.network_zone.non work dest 1s | 0.000000 | 0.150000 | 0.000000 |

Calibration Targets

Displaying 4 of 4 rows

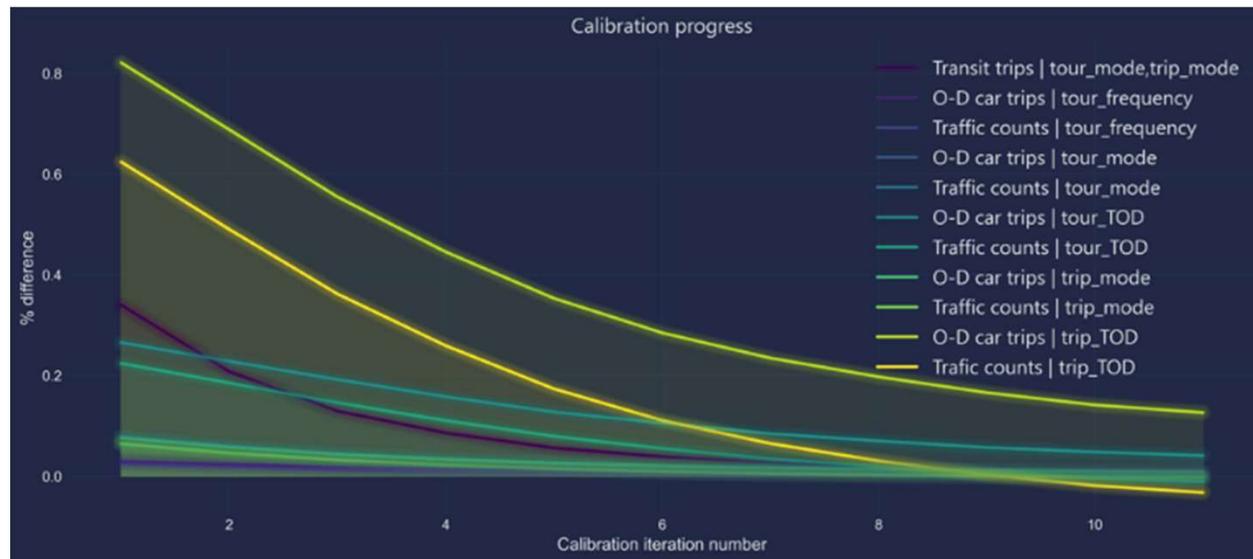
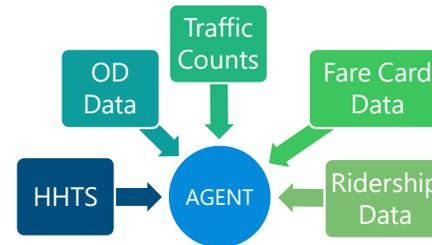
| name | description | table | filter_expression | value_expression | aggregation_function | target_min_value | target_max_value |
|-------------------|-----------------------|------------|-------------------|------------------------|----------------------|------------------|------------------|
| tot_cars | Total number of cars | Households | | num_cars * weight | Sum | 150000.000000 | 180000.000000 |
| tot_trips | Total number of trips | Trips | | tour.person.hh.weight | Sum | 1500000.000000 | 1600000.000000 |
| mean_distance | Mean trip distance | Trips | | od.autoDistanceOffPeak | Mean | 5.500000 | 6.000000 |
| rum_transit_trips | Total transit trips | Trips | mode_id == 3 | tour.person.hh.weight | Sum | 150000.000000 | 200000.000000 |

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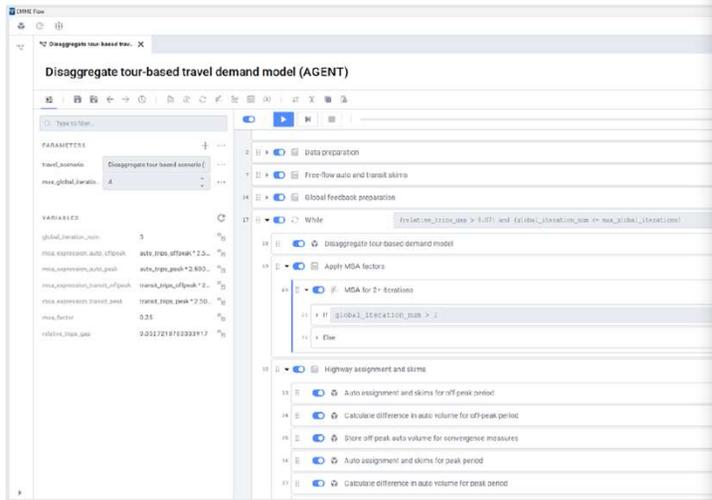
The screenshot displays the EMME AGENT software interface. On the left, a tree view under 'Disaggregate tour-based' shows a list of 'Model Steps'. The 'Stop frequency middle' step is highlighted with a green box. On the right, the 'Schema Browser' window shows a table of attributes for the 'Disaggregate tour-based' model. The table has columns for 'name', 'dtype', and 'sources'. The 'Stop frequency middle' attribute is highlighted in blue in the table.

| | name | dtype | sources |
|----|-----------------|-------|-------------------------|
| 9 | num_work_out | int64 | Stop frequency outbound |
| 10 | num_univ_out | int64 | Stop frequency outbound |
| 11 | num_disc_out | int64 | Stop frequency outbound |
| 12 | num_maint_out | int64 | Stop frequency outbound |
| 13 | to_prim_dest | int64 | Stop frequency outbound |
| 14 | total_outbound | int64 | Stop frequency outbound |
| 15 | tot_out_1 | int64 | Stop frequency outbound |
| 16 | tot_out_2 | int64 | Stop frequency outbound |
| 17 | tot_out_3 | int64 | Stop frequency outbound |
| 18 | num_work_mid | int64 | Stop frequency middle |
| 19 | num_disc_mid | int64 | Stop frequency middle |
| 20 | num_maint_mid | int64 | Stop frequency middle |
| 21 | total_mid_stops | int64 | Stop frequency middle |
| 22 | tot_mid_1 | int64 | Stop frequency middle |
| 23 | tot_mid_2 | int64 | Stop frequency middle |
| 24 | mid_exist | int64 | Stop frequency middle |
| 25 | num_work_in | int64 | Stop frequency inbound |
| 26 | num_univ_in | int64 | Stop frequency inbound |
| 27 | num_disc_in | int64 | Stop frequency inbound |
| 28 | num_maint_in | int64 | Stop frequency inbound |
| 29 | to_home | int64 | Stop frequency inbound |
| 30 | total_inbound | int64 | Stop frequency inbound |
| 31 | tot_in_1 | int64 | Stop frequency inbound |
| 32 | tot_in_2 | int64 | Stop frequency inbound |

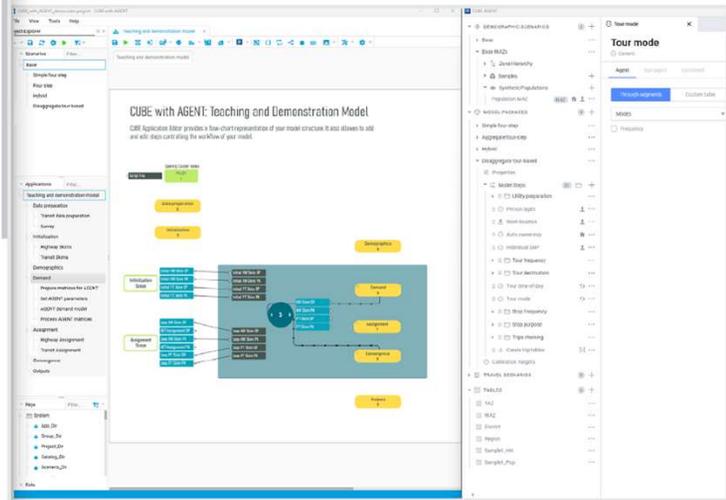
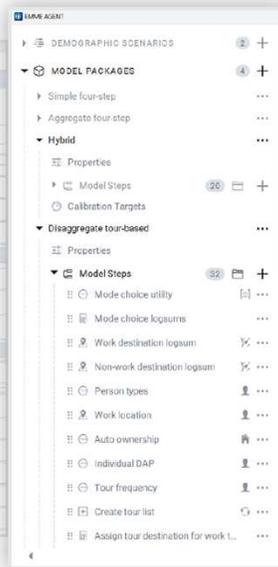
- Leverage automated calibration procedures
- Improve model calibration and validation results
- Minimize risks and costs associated with costly trial-and-error approaches to calibration
- Helps keep travel demand models up-to-date across mobility changes
- Incorporate all mobility data sources including big data



AGENT works with CUBE and EMME

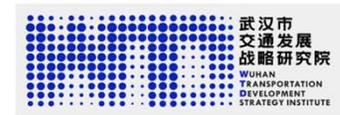


Leverage EMME features like Modeler, APIs, Notebooks, Scenes, and Flow with AGENT.



Leverage CUBE features like Application Manager, Scenario Manager, and Voyager with AGENT.

AGENT Users

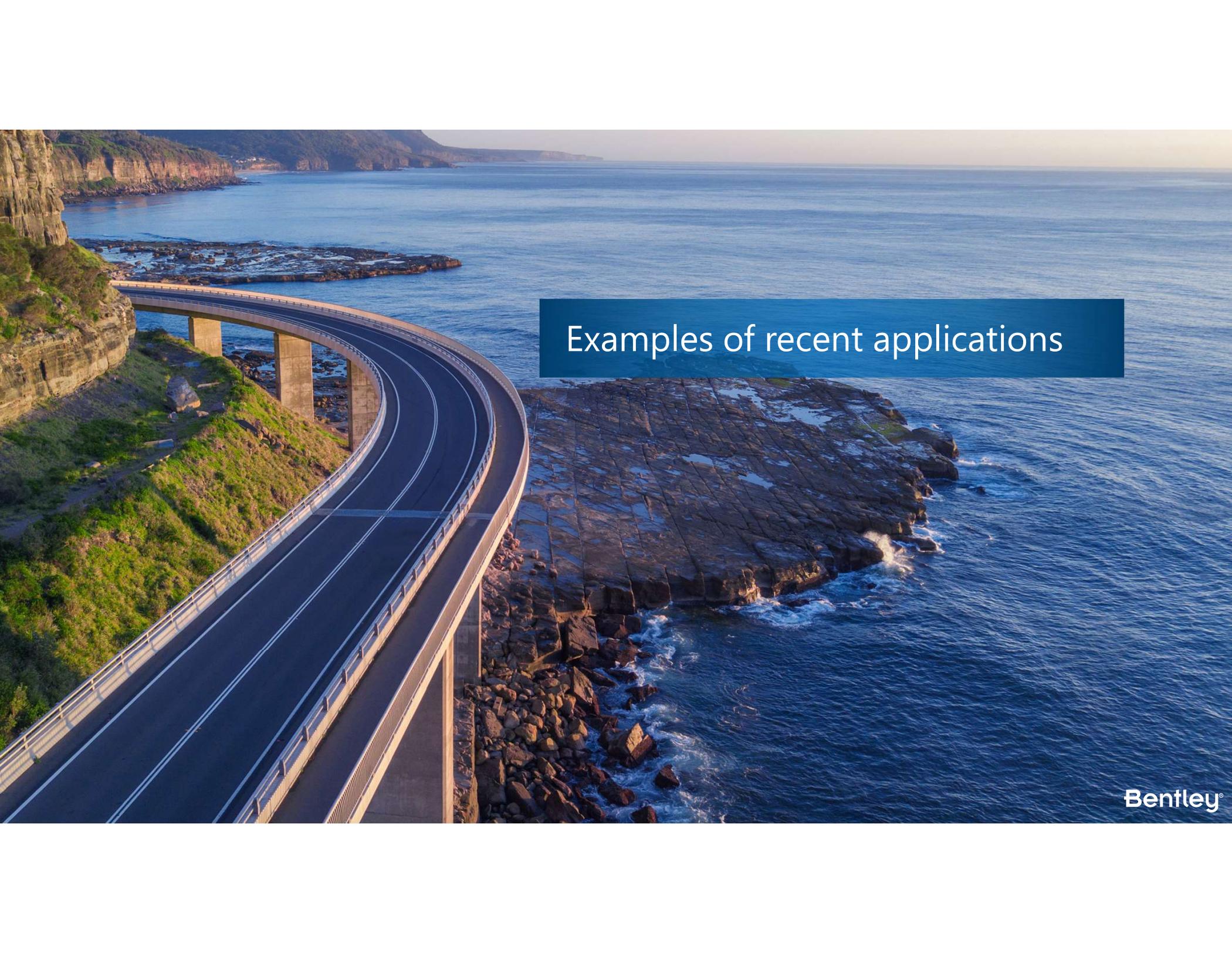


JERUSALEM TRANSPORTATION
MASTER PLAN TEAM



ARUP



An aerial photograph of a modern, curved coastal highway bridge. The bridge spans across a rocky coastline, supported by several concrete pillars. The ocean is a deep blue, and the sky is clear. The bridge has a dark asphalt surface with white lane markings and a metal guardrail. The surrounding landscape includes green grassy areas and rocky cliffs.

Examples of recent applications

National model: Sweden

- One model for 5 regions
 - Differential sampling weight to represent “halo” and external zones for each region
- Total population: 10M
 - Effective population after differential sampling: 3-5M

10,997 zones



682 zones



2,103 zones



3,110 zones



1,952 zones



2,982 zones

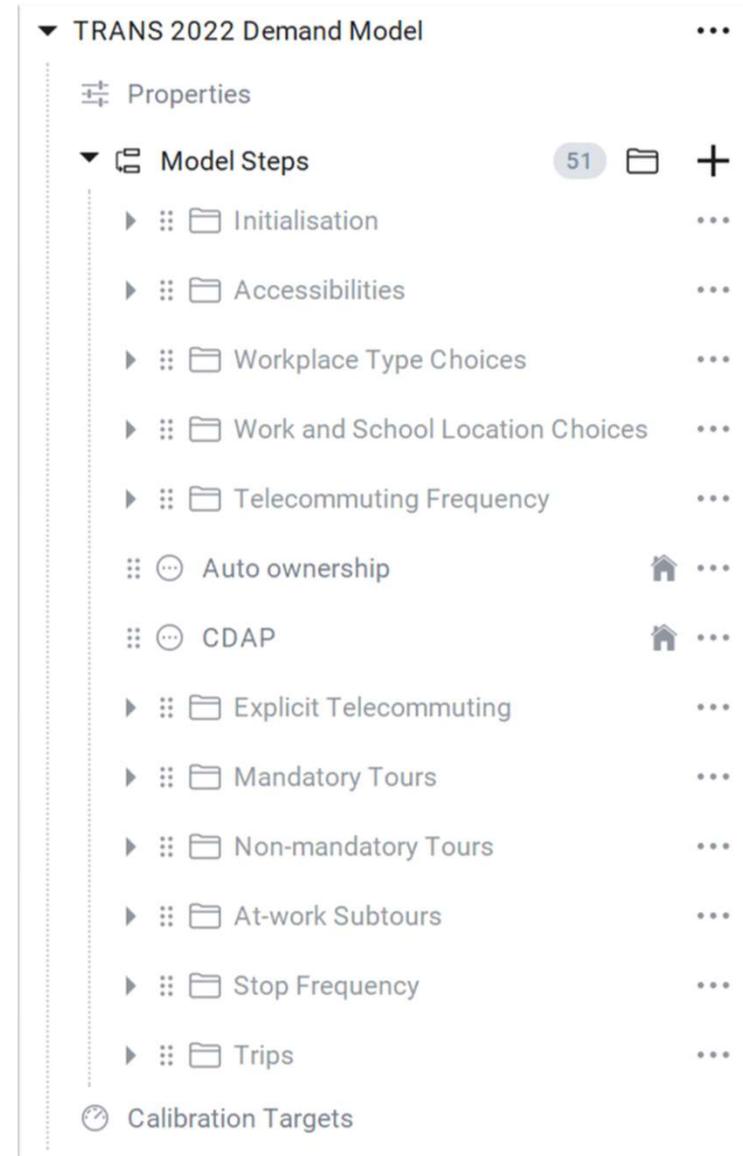


2,253 zones



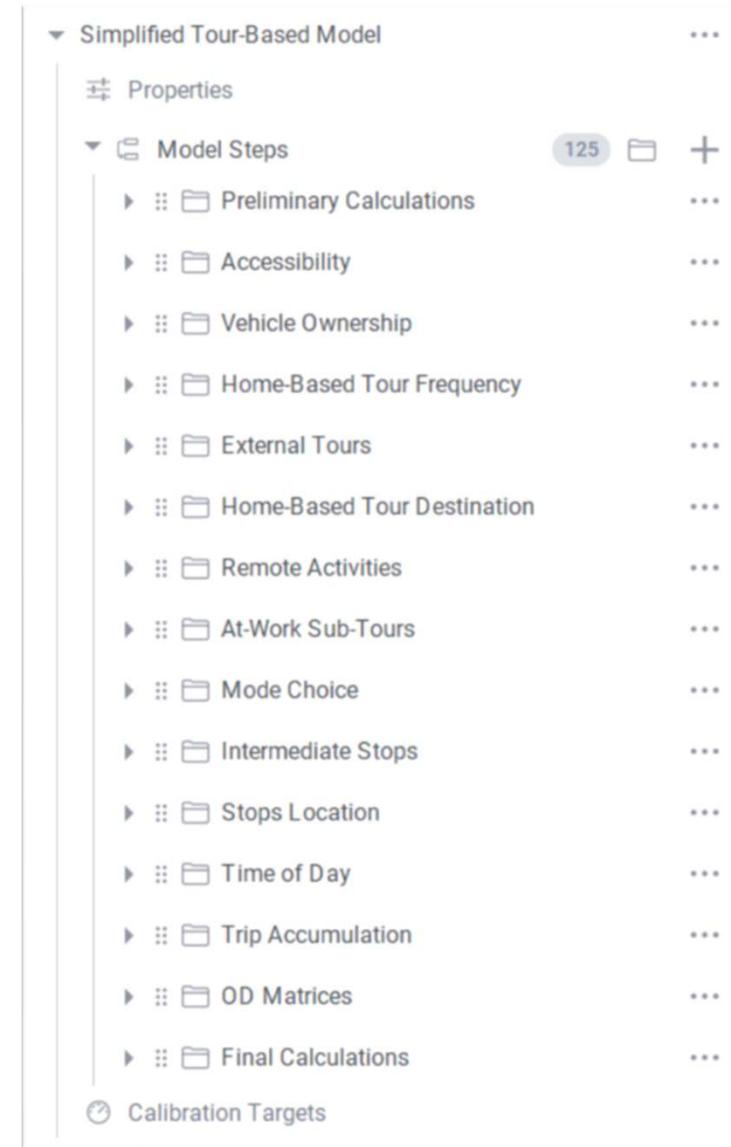
TRANS Model: Ottawa

- Development of new regional model in AGENT
- Population: 1.4M
- Calibration data sources:
 - Household travel survey
 - Traffic counts
 - Transit counts
- Runtime for 1 iteration of demand model
 - ~12 mins on Intel® 2.4GHz, 16 cores, 32 GB RAM



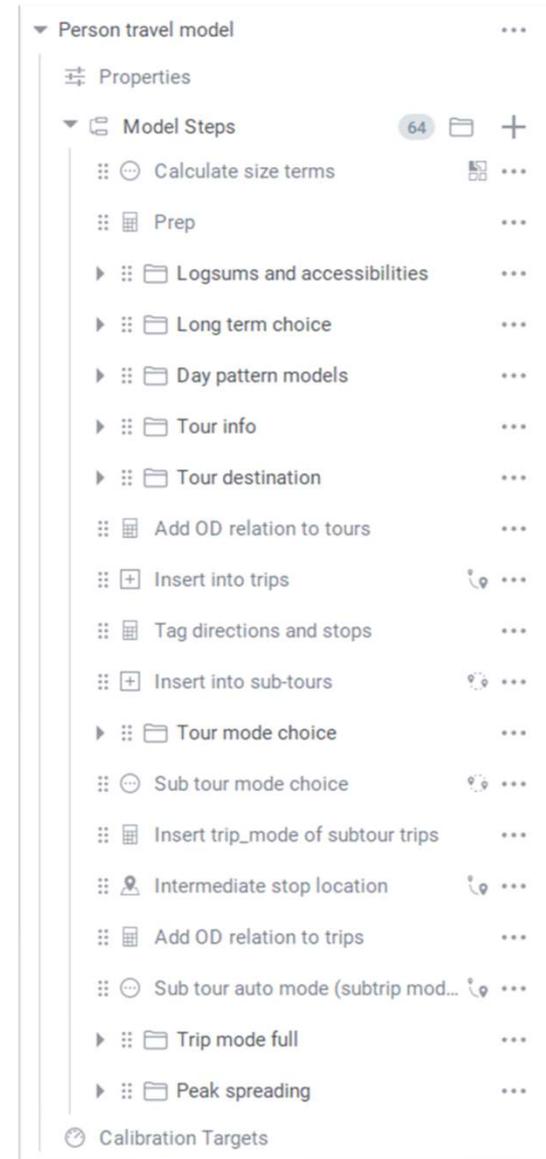
Simplified Tour-Based Model (STBM): Perth

- Re-platform demand model to AGENT and auto-calibrate
- Population: 2M
- Calibration data sources:
 - Household travel survey
 - Census
 - Traffic counts
 - Transit counts
- Runtime for 1 iteration of demand model
 - ~15 mins on Intel® 2.4GHz, 16 cores, 32 GB RAM



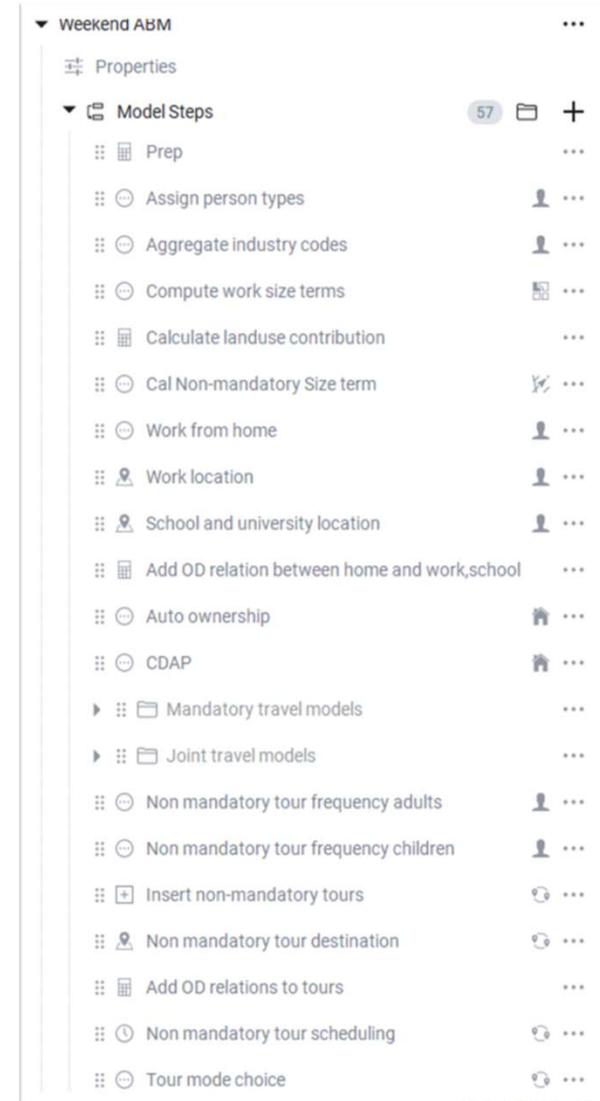
Person Travel Model (PTM): Edmonton

- Re-platform demand model to AGENT
- Data-driven day pattern model
- Population: 1.3M
- Runtime for 1 iteration of demand model
 - ~90 mins* on Intel® 2.8GHz, 32 cores, 128 GB RAM



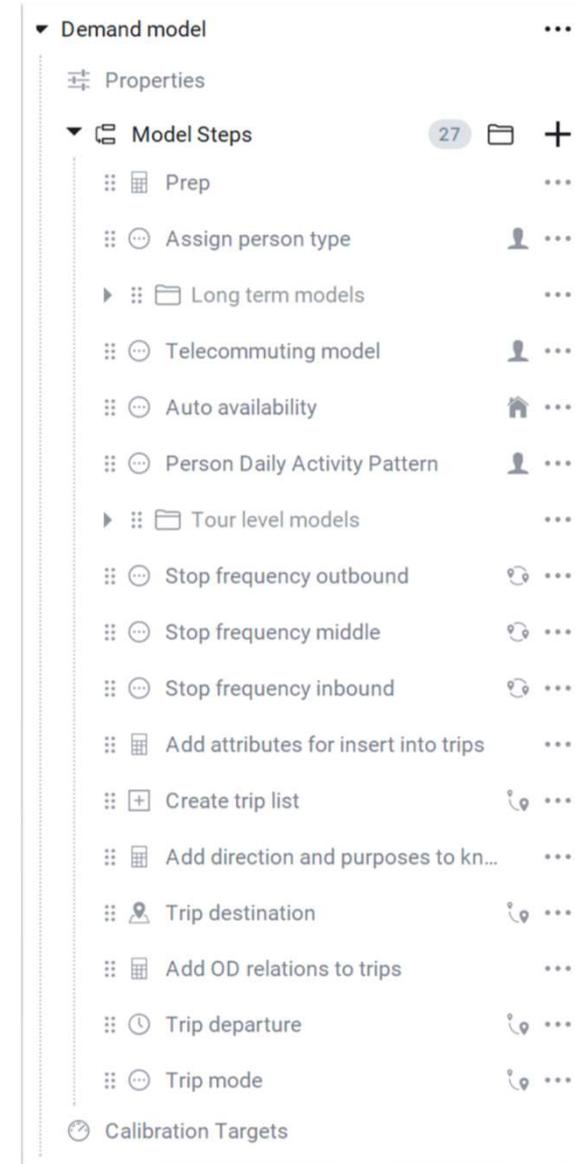
Weekend model: MAG

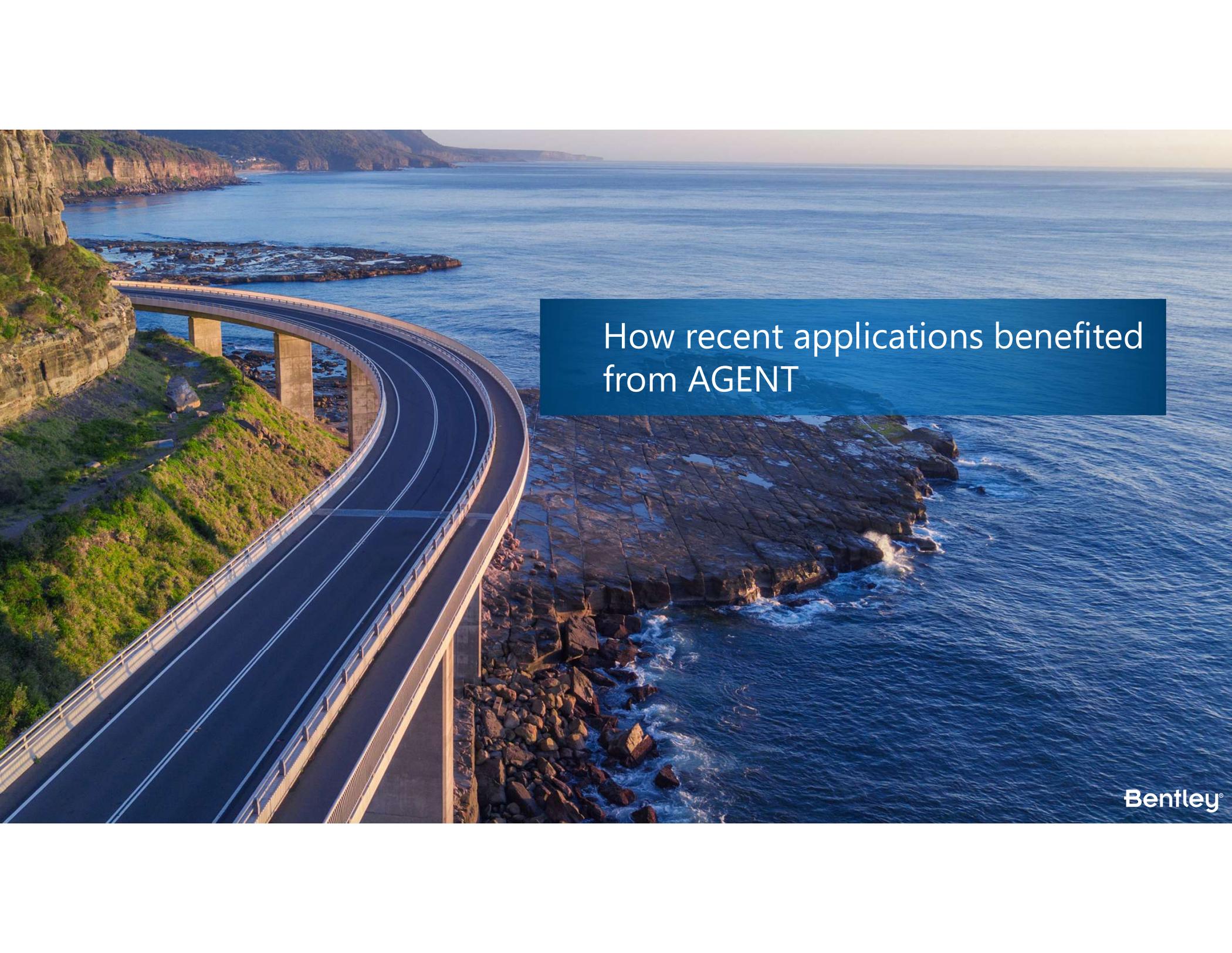
- ABM for new weekend travel demand model
- Population: 5M
- Transfer of weekday model to weekend:
 - No HTS for weekend travel behavior
 - Available data: AirSage data, traffic counts
- Runtime for 1 iteration of demand model
 - ~80 mins* on Intel® 2.8GHz, 32 cores, 128 GB RAM



Tour-Based Model: Hong Kong

- Development of new tour-based model for Hong Kong
- Population: 6.8M
- Calibration data sources:
 - Household travel survey
 - Traffic counts
 - Transit counts
- Runtime for 1 iteration of demand model
 - ~40 mins on Intel® 2.4GHz, 16 cores, 32 GB RAM





How recent applications benefited
from AGENT

Key benefits (1)



Shorter model configuration time

Examples:

Perth STBM → 4-5 weeks

TRANS Ottawa → 3-4 weeks

PTM Edmonton → 2-3 weeks



Easy to understand interface allowed collaboration

Everyone in the team could participate in model updates, QC and validation



Faster runtimes

Re-platformed models experienced substantial improvement in runtime:

- STBM Perth: 35 mins vs 15 mins in AGENT
- PTM Edmonton: 120 mins vs 90 mins in AGENT

Key benefits (2)



Automated calibration

Easier to transfer models from one region to another → Ex: Parts of MAG, ARC, GGHM, 3C for TRANS Ottawa

Accelerated model calibration → Ex: Calibration to HTS in less than a week for TRANS Ottawa

Leverage multiple data sources for model calibration → Ex: AirSage O-D data + traffic counts for MAG weekend Model

Demand model as a common denominator to understand multiple dataset



Managing stochasticity



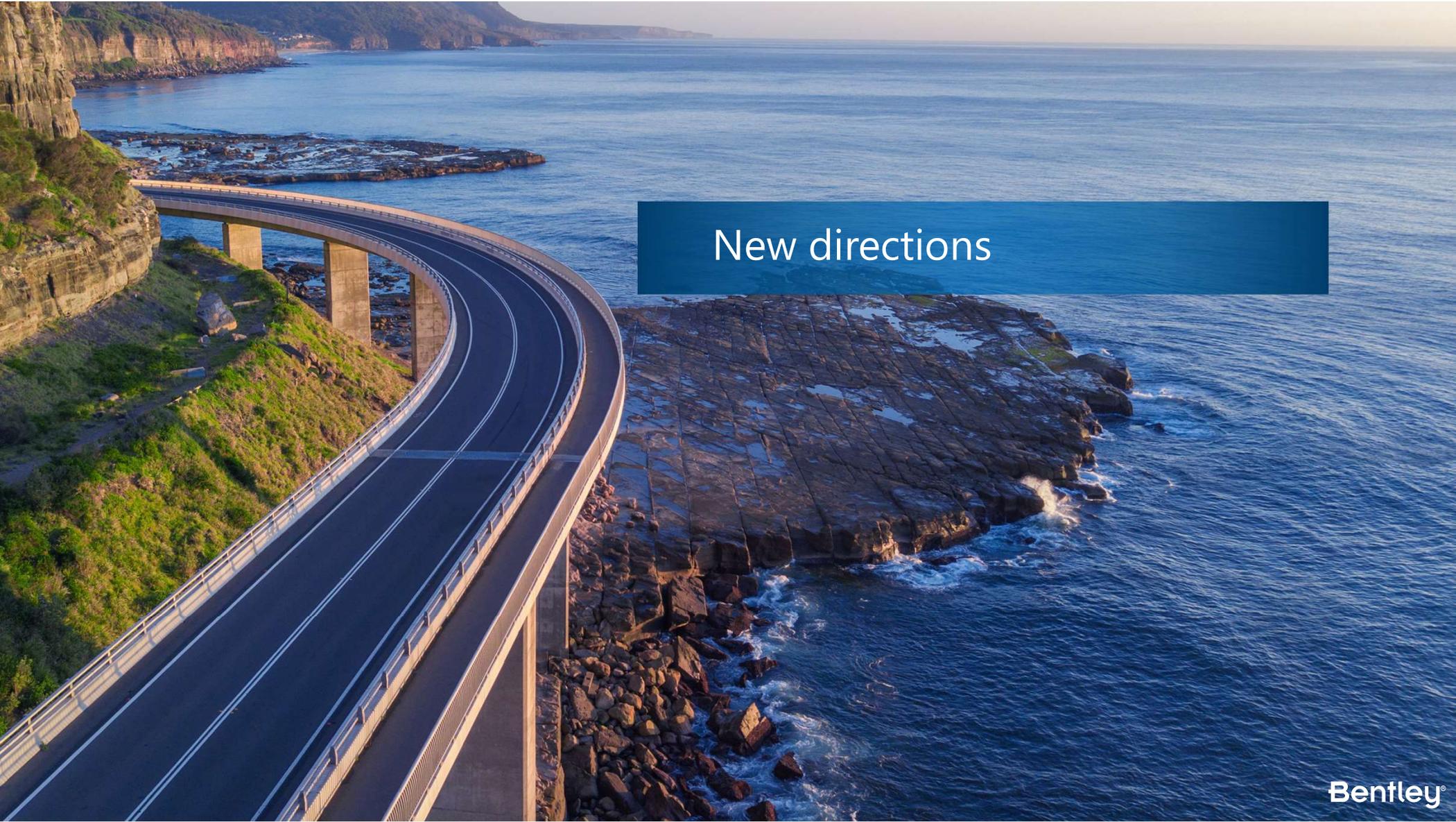
*AGENT provided us with a **transparent modelling environment** where the complete definition of utility functions, data and model results can be studied without ...specific programming skills. Our impression so far [of AGENT] is that we have a model with **low cost of maintenance** that can be further developed to address new questions.*

- Svante Berglund
Trafikverket, Sweden



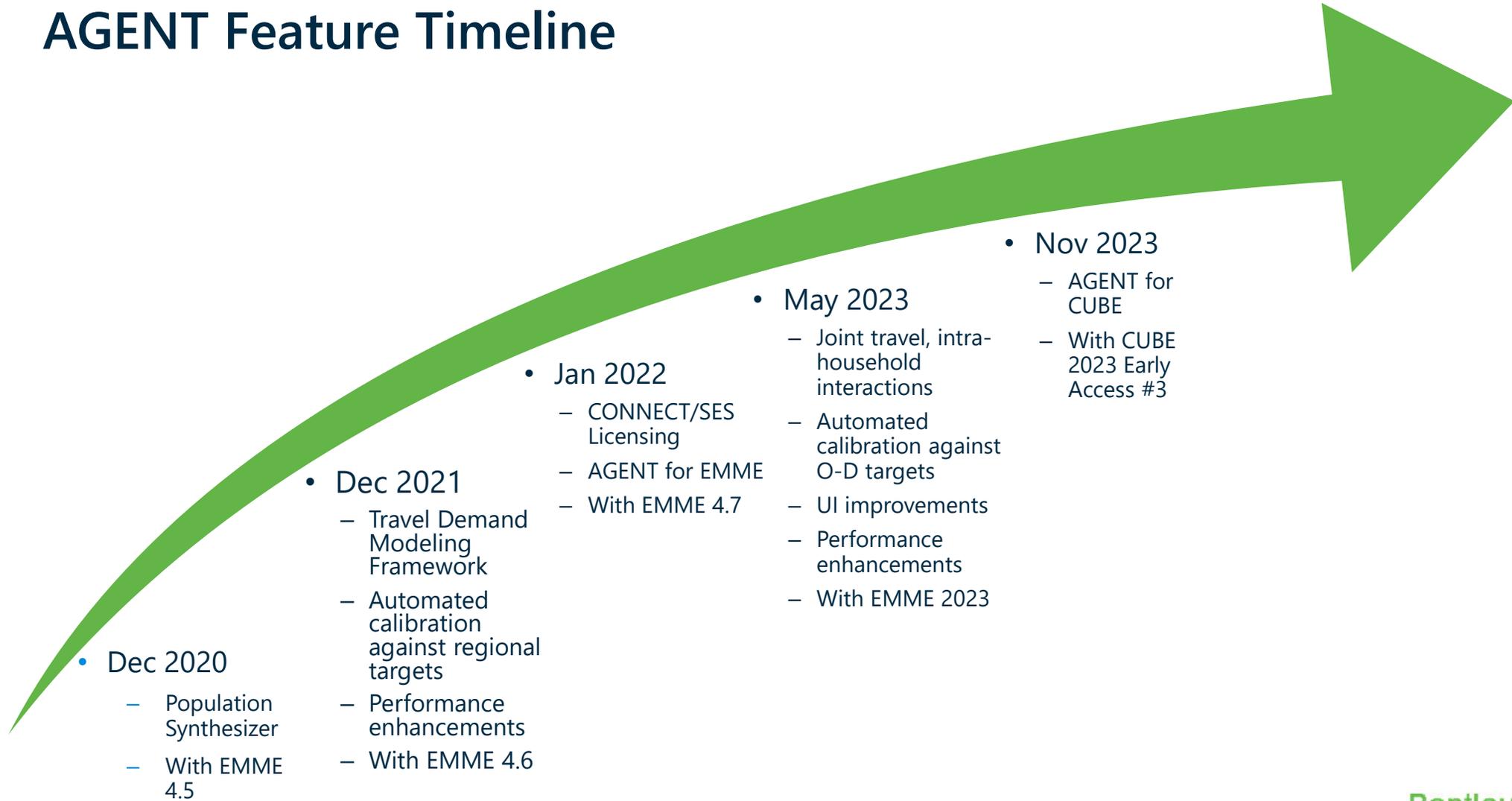
[AGENT's] easy to use interface, calibration frameworks, multi level and comprehensive use of big data sources, and pre-built modelling paradigms has provided practitioners and users flexibility and access to cutting edge ideas that was previously out-of-reach without a significant investment in time and resources.

- Mausam Duggal
National Director, Transportation Planning and Science,
WSP Canada



New directions

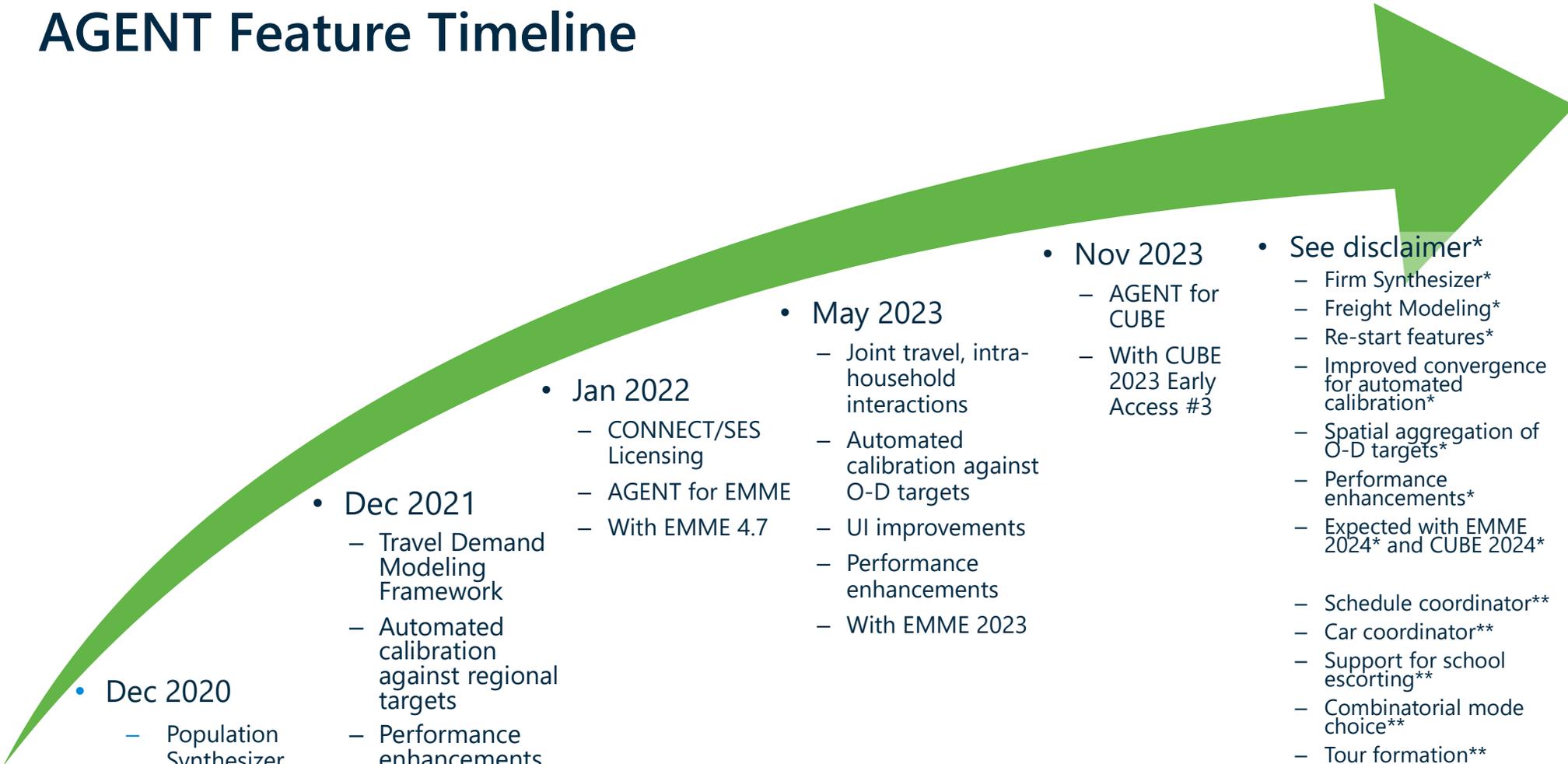
AGENT Feature Timeline



Disclaimer Statement

Release plans and timelines are forward-looking estimates and projections only. There can be no assurance that Bentley will be able to meet such estimates or projections by the dates specified, or at all. Do not make purchase decisions based on forward looking roadmaps.

AGENT Feature Timeline

- 
- Dec 2020
 - Population Synthesizer
 - With EMME 4.5
 - Dec 2021
 - Travel Demand Modeling Framework
 - Automated calibration against regional targets
 - Performance enhancements
 - With EMME 4.6
 - Jan 2022
 - CONNECT/SES Licensing
 - AGENT for EMME
 - With EMME 4.7
 - May 2023
 - Joint travel, intra-household interactions
 - Automated calibration against O-D targets
 - UI improvements
 - Performance enhancements
 - With EMME 2023
 - Nov 2023
 - AGENT for CUBE
 - With CUBE 2023 Early Access #3
 - See disclaimer*
 - Firm Synthesizer*
 - Freight Modeling*
 - Re-start features*
 - Improved convergence for automated calibration*
 - Spatial aggregation of O-D targets*
 - Performance enhancements*
 - Expected with EMME 2024* and CUBE 2024*
 - Schedule coordinator**
 - Car coordinator**
 - Support for school escorting**
 - Combinatorial mode choice**
 - Tour formation**

* Tentatively scheduled for next release

** In development

Time-space constraints

Location and temporal choice models have optional configuration for time-space constraints:

- Estimated/minimum activity duration
- Preliminary travel time

Preliminary travel time can be very different from mode/time-of-day specific travel time:

- Results in schedule inconsistencies

Choice models cannot fully incorporate all time-space constraints → Need an optimizer to resolve schedule inconsistencies

The image shows two screenshots of a software configuration interface. The top screenshot is titled "Tour time-of-day" and has tabs for "Decision-maker", "Choice set", "Statistical model", "Temporary attributes", "Time-space constraints" (selected), and "Utility exp". It is categorized as "Temporal". It features two main sections: "Persons" (AGENT) and "Tours" (SUB-AGENT). The "Persons" section has two input fields: "Window start time (minutes from day start)" and "Window end time (minutes from day start)". The "Tours" section has two input fields: "Minimum activity duration (minutes)" with the value "purpose.minimum_duration" and "Minimum travel time (minutes)" with the value "max((hp.autoDistanceOffPeak+ ph.autoDistanceOffPeak)*constants.". The bottom screenshot is titled "Trip destination with time-space constraints" and has tabs for "Decision-maker", "Choice set", "Statistical model", "Temporary attributes", and "Time-space constraints" (selected). It is categorized as "Location". It features two main sections: "Tours" (AGENT) and "Trips" (SUB-AGENT). The "Tours" section has four input fields: "Window start time (minutes from day start)" with "constants.tod_resolution * (start_time - 1)", "Window end time (minutes from day start)" with "constants.tod_resolution * end_time", "Minimum activity duration (minutes)" with "purpose.minimum_duration", and "Minimum travel time (minutes)" with "max((hp.autoDistanceOffPeak + ph.autoDistanceOffPeak) * constants.minutes_per_km, 0.1)". The "Trips" section has three input fields: "Minimum activity duration (minutes)" with "dest_purpose.minimum_duration", "Estimated travel time deviation (minutes)" with "constants.minutes_per_km * dest_purpose.distance_deviation", and "Actual travel time deviation (minutes)" with "max(constants.minutes_per_km * (orig_to_dest.autoDistanceOffPeak".

Schedule Coordinator

Creates a consistent individual schedule of activities and trips in continuous time given:

- Sequence of activities and trips for each individual
- Travel times from the time sensitive network model
- Original crude / inconsistent schedule coming from prior ABM choices
- Joint trips of HH members

Add Model Step

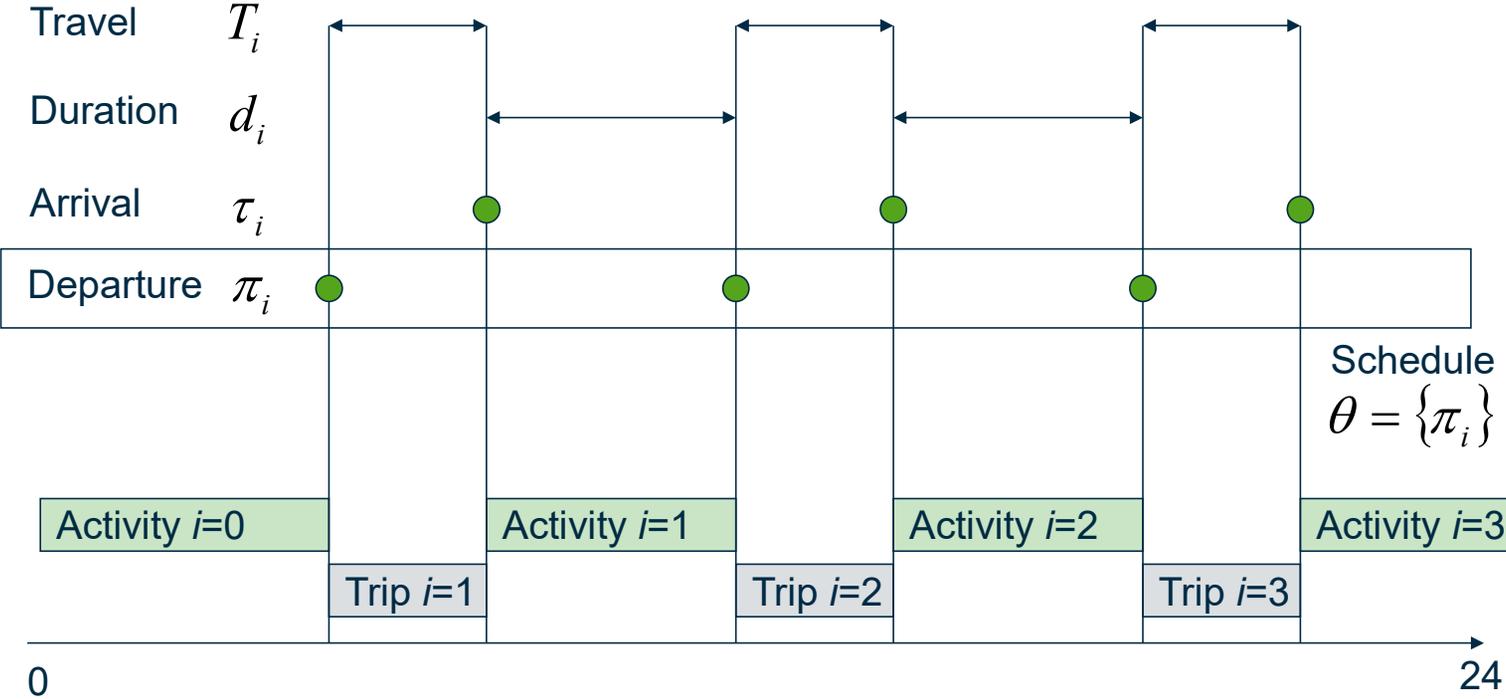
Create new Import from specification

Type

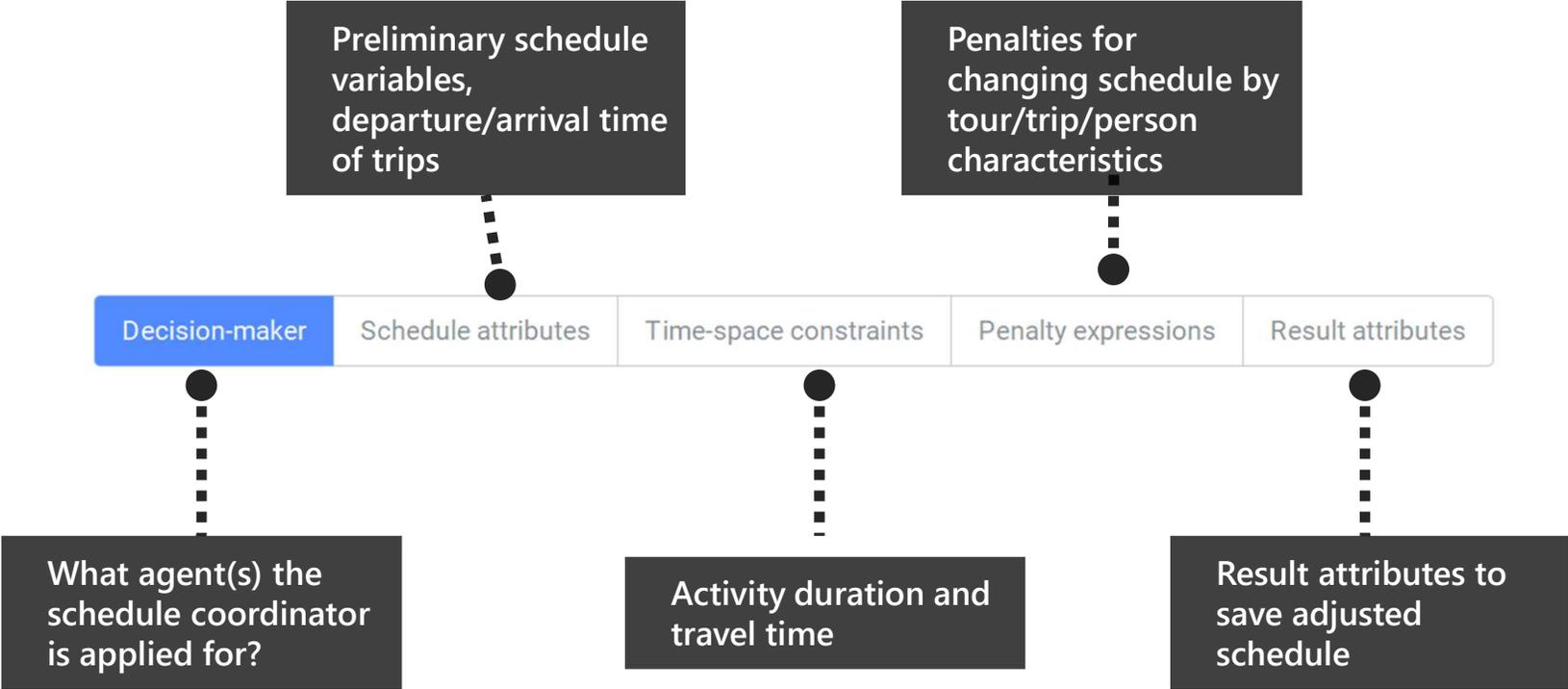
Select a type...

-  Generic Choice Model
-  Location Choice Model
-  Temporal Choice Model
-  Aggregate Table
-  Insert Into Table
-  Delete From Table
-  Table Calculator
-  Schedule Coordinator

Individual schedule consistency



Schedule coordinator interface



Car Coordinator

Allocates household cars to auto trips within household ensuring time-space constraints with following key considerations:

- Car size matching party size
- Car type preferences for trips (EV range)
- Car trips cannot overlap in time
- Close chain of consecutive trips for each car
- Car repositioning and parking options for autonomous vehicles

Add Model Step

Create new Import from specification

Type

Select a type...

- ⋮ Generic Choice Model
- 📍 Location Choice Model
- 🕒 Temporal Choice Model
- 🔗 Aggregate Table
- ⊕ Insert Into Table
- ⊖ Delete From Table
- 📊 Table Calculator
- 🚗 Car Coordinator

Specification of car type dimensions of interest: Example

3 fuel types



6 body types



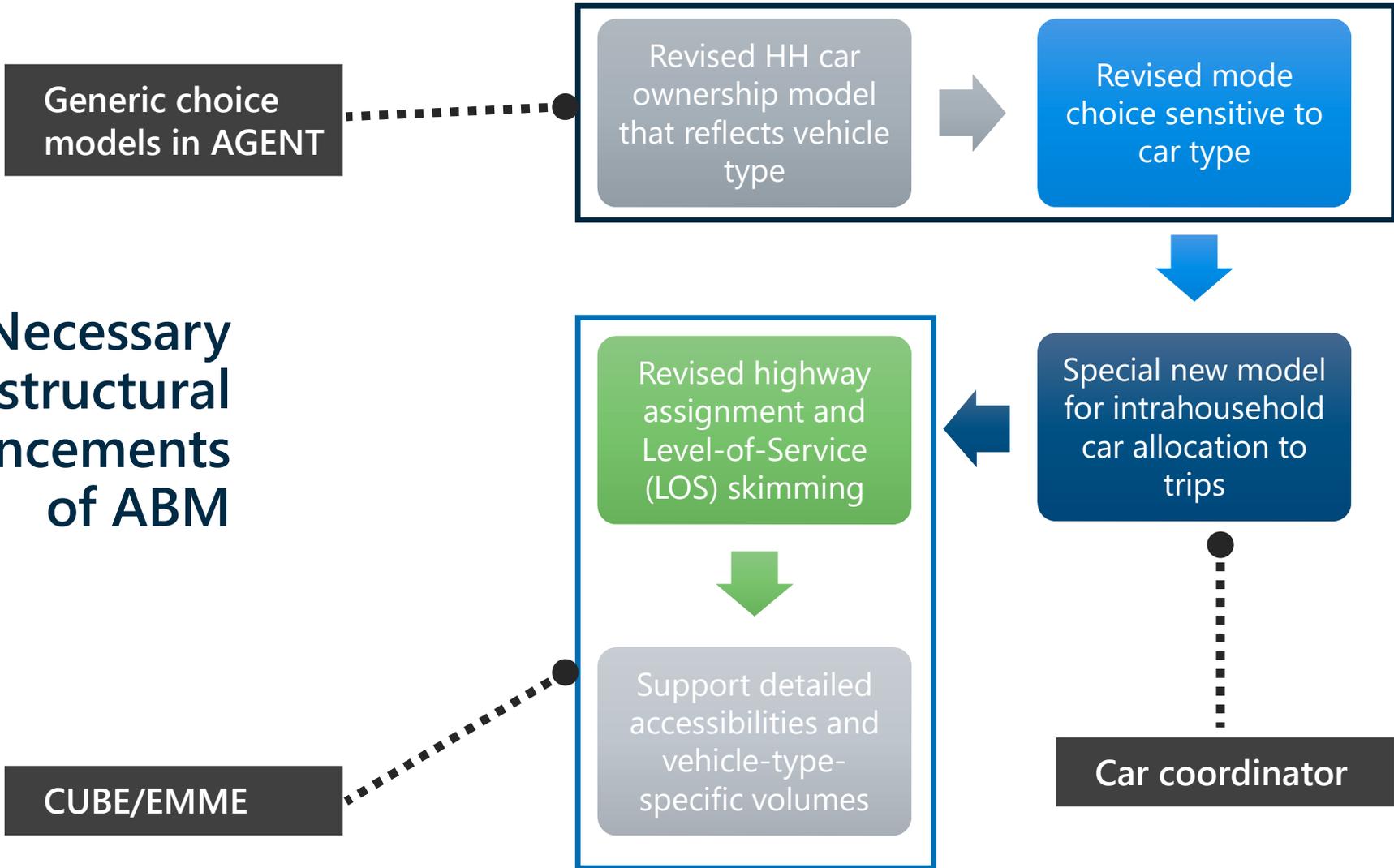
2 automation levels



18 car types for individual car segmentation

HH segmentation

Necessary structural enhancements of ABM



Why not conventional discrete choice?

- Infeasible choice set size for conventional discrete choice
- Choice models cannot incorporate (minor) adjustment in schedule to accommodate car allocation

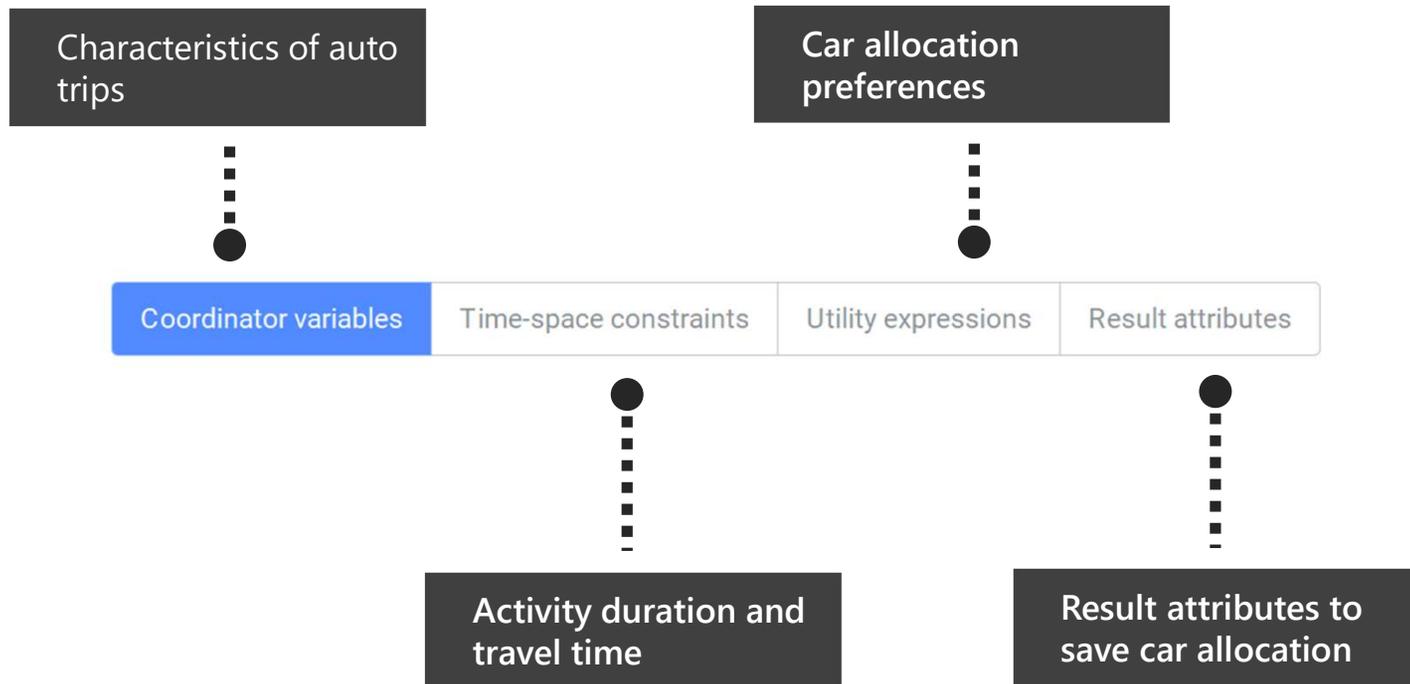


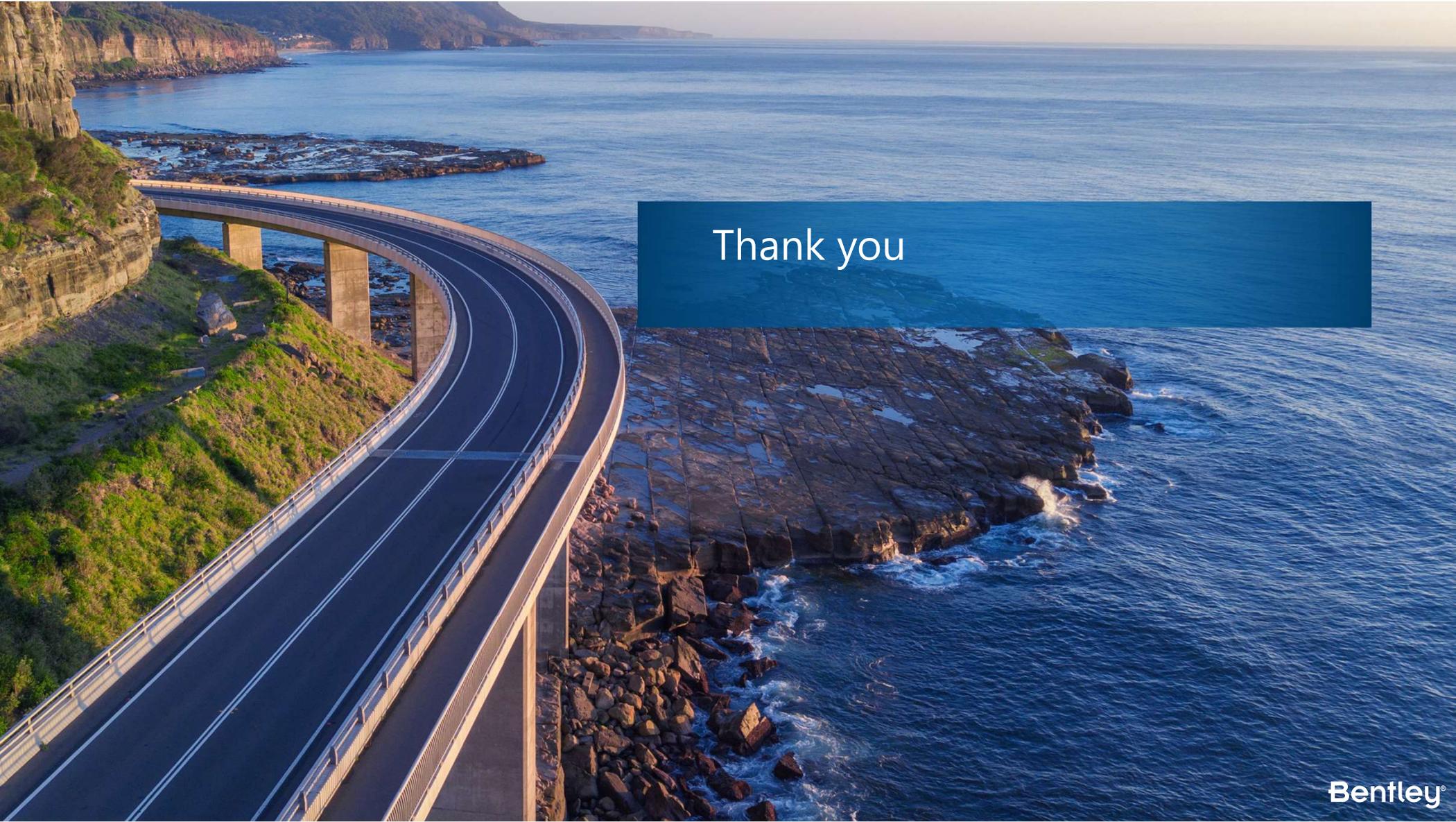
Person 1 and 2 cannot share a car without change in schedule



Car coordinator allows adjusting schedule to accommodate car allocation

Car coordinator interface





Thank you