Sample enumeration model for airport ground access

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"Cool model applications"

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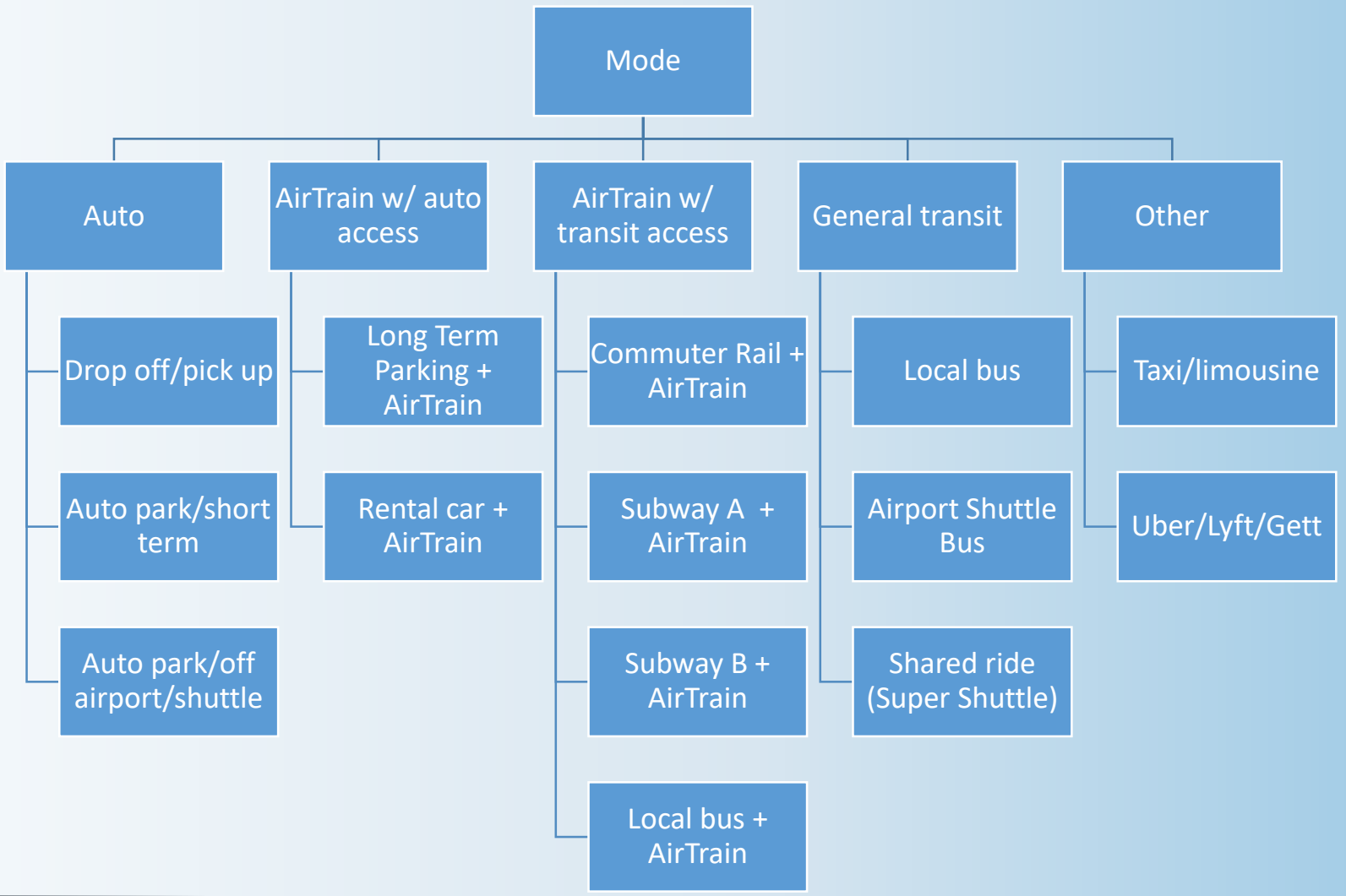
Sample enumeration model as example of data-driven approach

Use model to predict incremental changes pivoting off the observed data

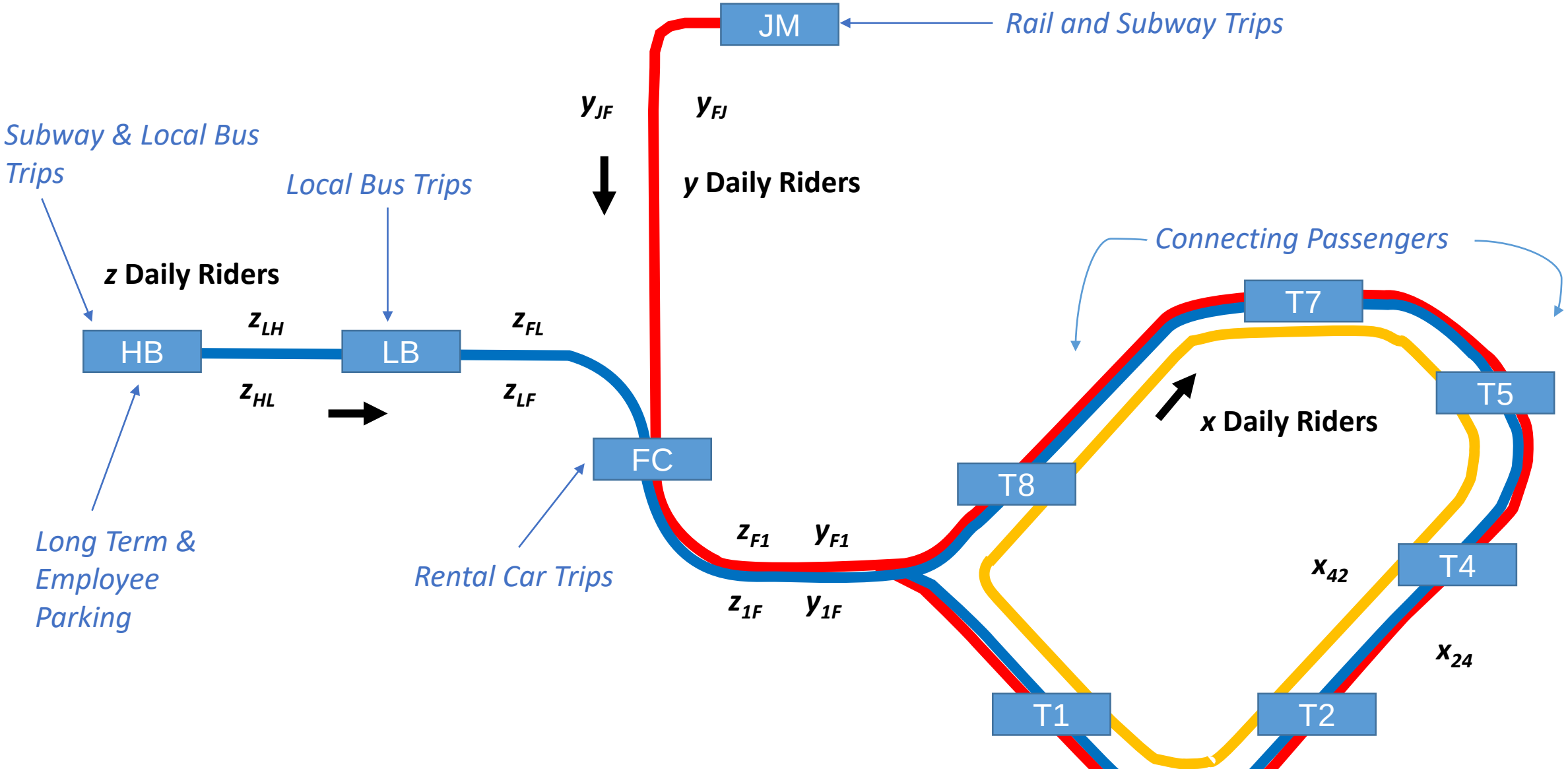
Airport and Ground Access Choice Modeling

- Airports are large, important generators of regional trips
- They also face many of their own important planning issues
- Air passengers have very different behavior from other travelers
- Questions:
  - What will the mode split of trips to my region's airport look like in the future?
  - What is the impact of adding rail transit service (AirTrain) to an airport on highway conditions around the airport?
  - How does changing the fare on transit service to the airport impact ridership? How does that impact transit conditions? Highway conditions?

Detailed ground access mode combinations, JFK



Model output for analysis of JFK AirTrain operations



Data-driven micro-model rather than special generator in regional model

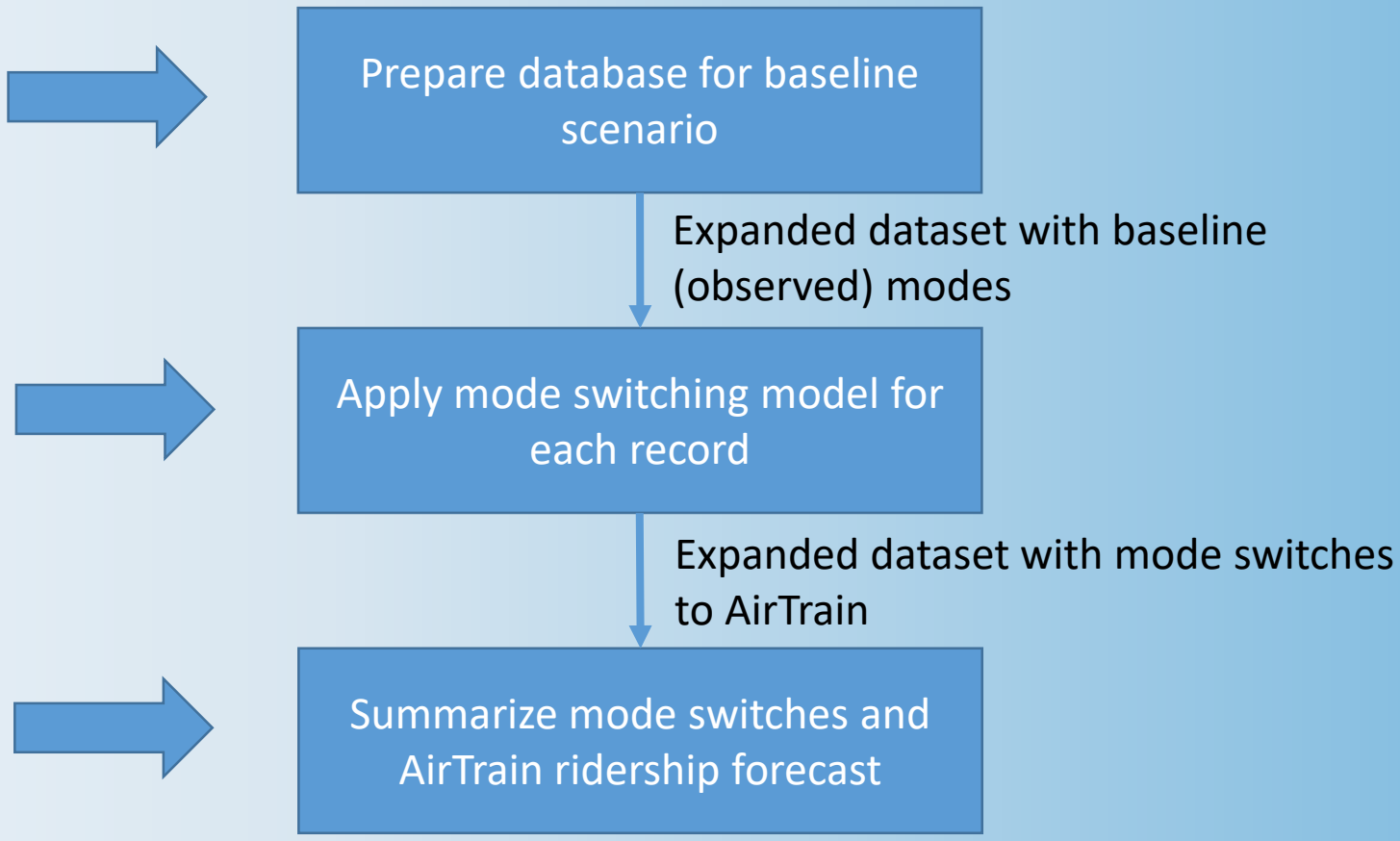
- Micro-model implemented in a micro-simulation fashion can have an unlimited segmentation with respect to air passengers
- Micro-model can be integrated with a detailed intra-airport network that represents all important trip generators and facilities and access options between them such as AirTrain, driving, walking, or using special modes such as shuttle buses
- Macro-model can be structurally different from the regional model (whether ABM or 4-step) and it can be built around specific data available for the airport:
  - For AirTrain ridership forecast for JFK and LGA, the micro-model was implemented using a disaggregate sample enumeration framework built upon special survey of the airport air passengers and employees.
- Micro-model can be conveniently run separately in a short period of time (with the fixed inputs from the regional model) for analysis and comparison of multiple alternatives:
  - It is more difficult to run an airport model by itself if it was implemented as a special generator embedded in the regional macro model.

Model flowchart for LGA AirTrain ridership forecasting

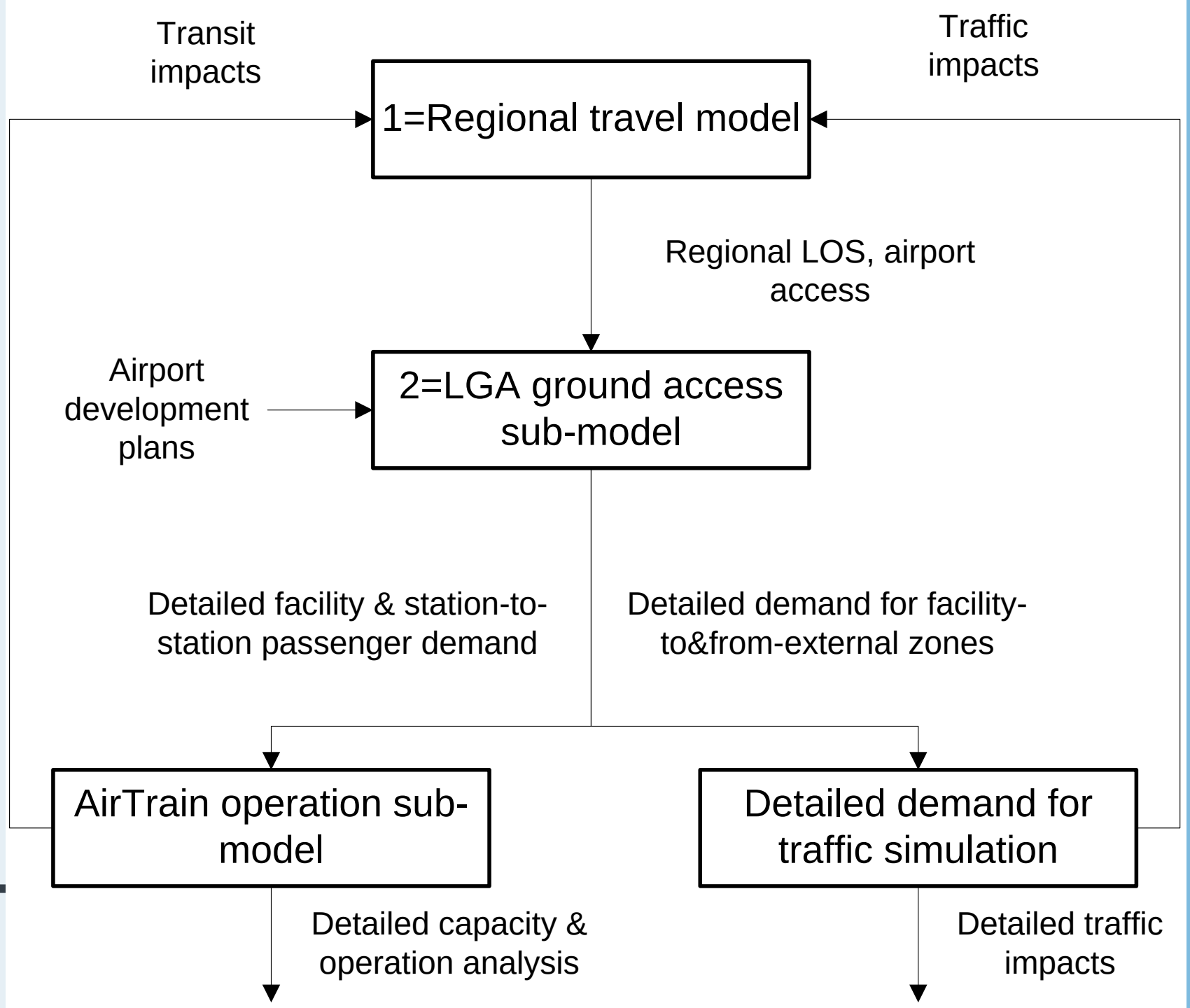
- Survey set of records
- Controls for expansion

- LOS (time, cost, reliability) for each record and mode / baseline scenario
- LOS (time, cost, reliability) for each record and mode / AirTrain scenario

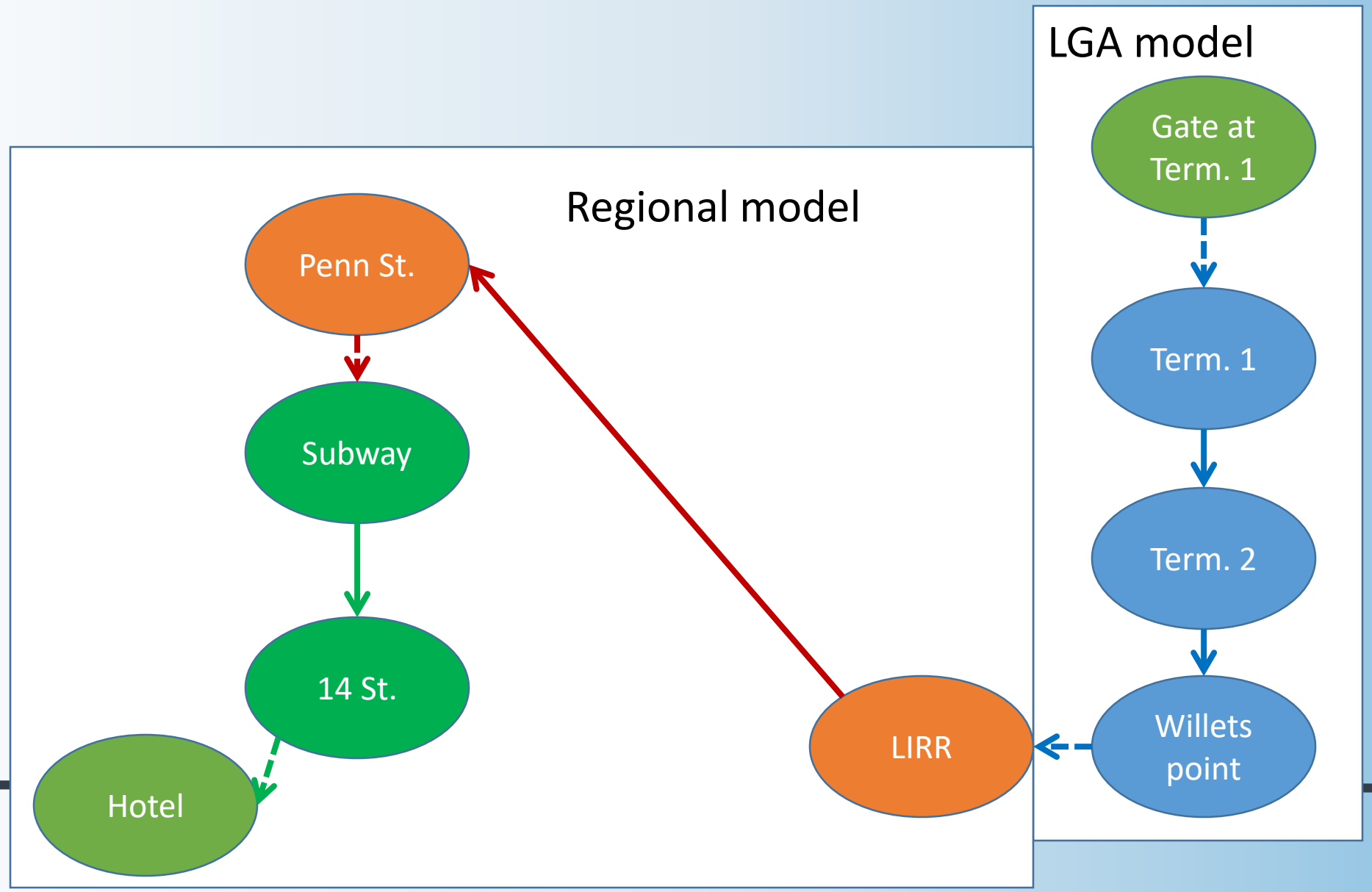
- Geographic aggregation for analysis



Overall model system structure for LGA: micro-macro relations



Construction of LOS for Entire Trip



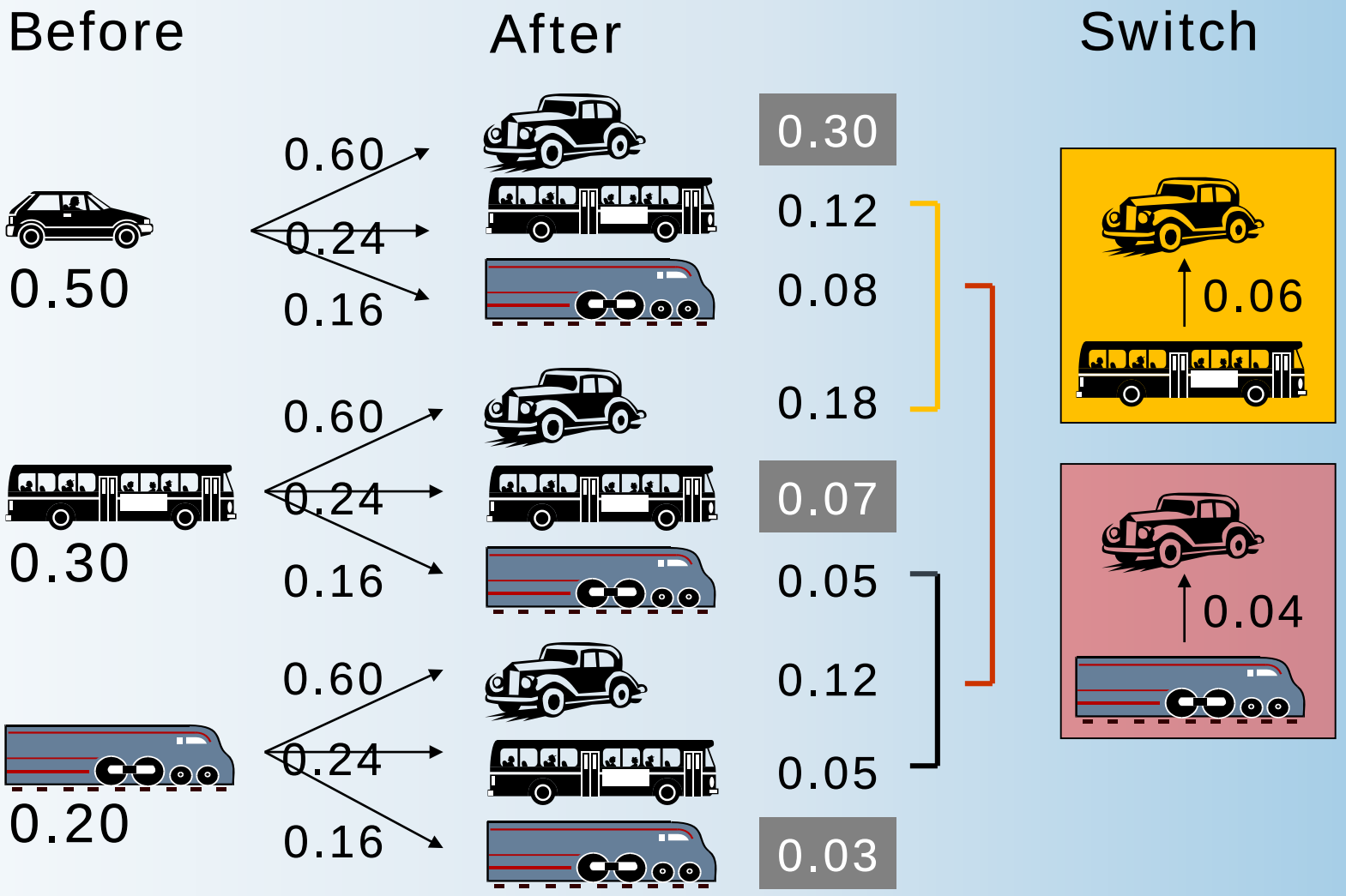
Switching model

Model structure to serve sample enumeration approach for policy analysis

Switching Logit Model

- Generalization of Incremental Logit:
  - No base case calibration
  - Standard Incremental Logit does not work with individual records
  - Switching Logit is a theoretically sound construct that does the trick
- Explicitly model mode switch:
  - Previous (observed) mode is known
  - Switching probabilities are consistent with the estimated core model
- Clarification:
  - Switching Logit is the way of model application
  - W/o transaction cost it is estimated as ordinary Logit

Switching Probability



Formal Expression

Switch from j to i *Probability after*

General: $$\Delta P(ij) = P(i)\times \tilde{P}(j) - P(j)\times \tilde{P}(i)$$

Probability before

Utility increment

MNL: $$\Delta P(ij) = \tilde{P}(i)\times \tilde{P}(j)\times \frac{\exp(\Delta V_i) - \exp(\Delta V_j)}{\sum_{k\in I} \tilde{P}(k)\times \exp(\Delta V_k)}$$

Nested Logit:

$$\Delta P(ij) = \tilde{P}(i)\times \tilde{P}(j)\times \frac{\exp(\Delta V_i)\times \exp\left[(\mu-1)\Delta U^{m(i)}\right] - \exp(\Delta V_j)\times \exp\left[(\mu-1)\Delta U^{n(j)}\right]}{\sum_{k\in I} \tilde{P}(k)\times \exp(\Delta V_k)\times \exp\left[(\mu-1)\Delta U^{r(k)}\right]}$$

Properties of Switching Model

- Pair-wise symmetry
- Total of switches equal to the modeled probability increment
  - Modeled probabilities match the parent model exactly
- No switch if alternatives have equal utility increments
  - Exact replication of observed choices for each individual record
  - Exact replication of probability shifts if only one alternative changes

Application rules for switching model

Individual Record with Observed Choice (Auto without Toll)

Individual Matrix of Switching Probabilities

		Modes After				Total Before
		Auto	Auto/Toll	Transit	P&R	
Modes Before	Auto	0.4	0.2	0.0	0.1	0.7
	Auto/Toll	0.0	0.0	0.0	0.0	0.0
	Transit	0.1	0.0	0.1	0.1	0.3
	P&R	0.0	0.0	0.0	0.0	0.0
Total After		0.5	0.2	0.1	0.2	1.0

Weight-Split Proportions

Auto	0.4/0.7	0.2/0.7	0.0/0.7	0.1/0.7

Airport ground access analysis with switching model

What makes data-driven approach in general and switching model in particular so attractive for practitioners

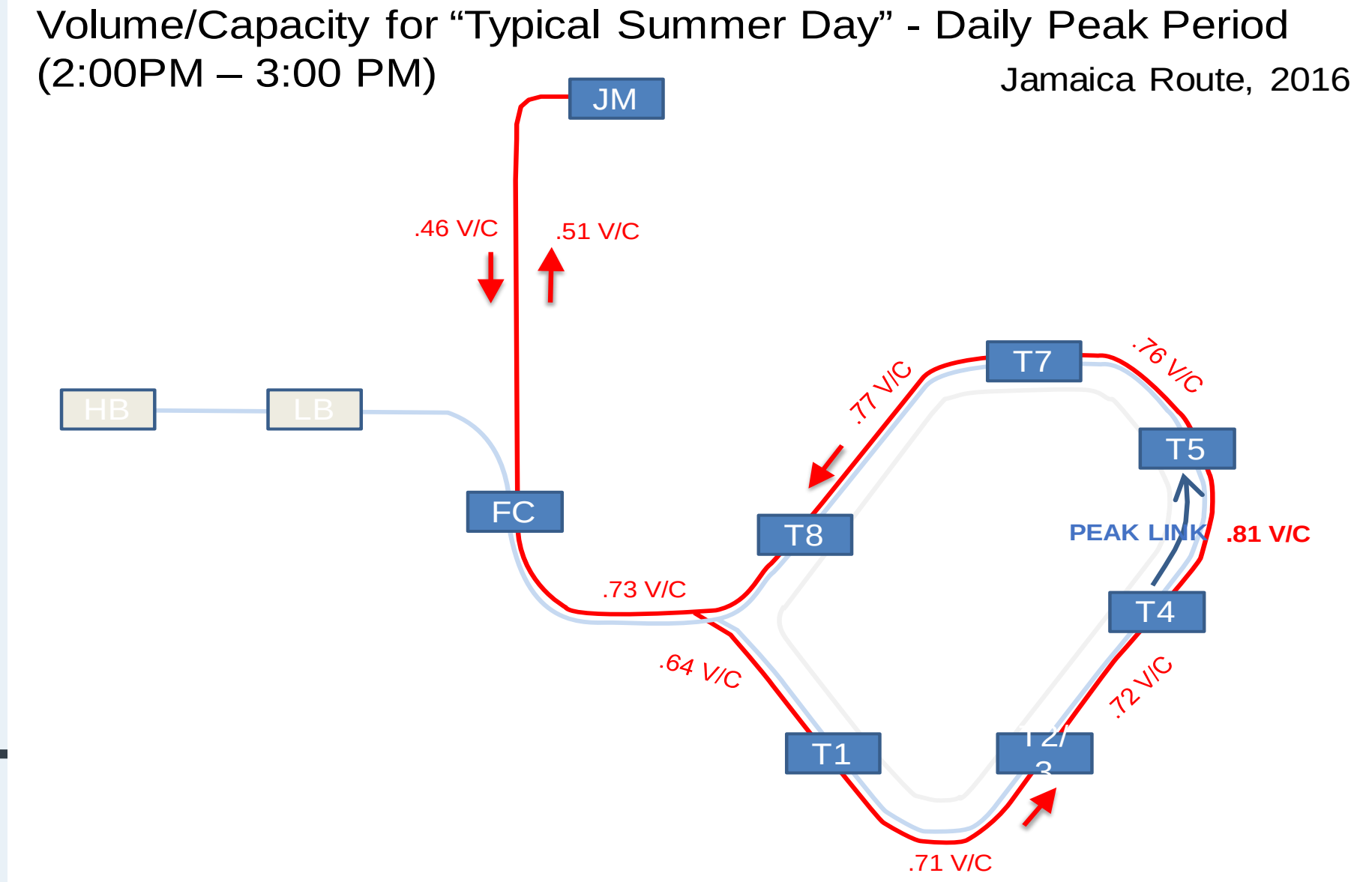
LGA Ground Access Mode Shares for Air Passengers for Baseline and Build Scenarios in 2025

Mode combinations	Air passengers		
	Baseline	Build	Difference
Auto Drop-off/pick-up	20.0%	16.5%	-3.5%
Auto Park - Short Term	5.6%	4.8%	-0.8%
Auto Park - Long Term	1.0%	1.0%	0.0%
Auto Park - Off Airport/ Shuttle	1.5%	1.0%	-0.4%
Rental Car - On airport	1.7%	1.7%	0.0%
Rental Car - Off airport	6.1%	6.1%	0.0%
Taxi/Limousine/FHVs	51.2%	44.9%	-6.3%
Shared Ride/Van	2.5%	1.1%	-1.4%
Hotel Courtesy	3.0%	3.0%	0.0%
NYC Airporter	1.1%	0.4%	-0.8%
Local bus	3.4%	2.0%	-1.3%
Subway + Bus	2.4%	1.1%	-1.3%
Rail +Bus	0.4%	0.1%	-0.2%
Auto Drop-off at Willets Point		1.2%	1.2%
Taxi/Limo/FHV at WP/ AirTrain		1.2%	1.2%
Subway to AirTrain		6.2%	6.2%
LIRR to AirTrain		7.6%	7.6%
Total	**100%**	**100%**	**0%**

Mode Switched from The Existing Modes to AirTrain for Air Passengers, 2025 Daily Trips

Existing Mode in Base Scenario	Total for Base	Existing Mode in Build Scenario													New Mode in Build Scenario			
		Auto Drop-off	Auto Short-Term Park	Auto Long-Term Park	Off-Airport Park	Rental Car - At Airport	Rental Car - Off Airport	Taxis/ FHVs	Hotel Courtesy Vehicle	Shared Ride Van/Shuttle	NYC Airporter	Bus	Subway + Bus	LIRR + Bus/Taxi	Auto Drop-off at WP/ AirTrain	Taxi/FHV at WP/ AirTrain	Subway to AirTrain	LIRR to AirTrain
Auto Drop-off	15,497	12,764	-	-	-	-	-	-	-	-	-	-	-	-	890	-	860	983
Auto Short-Term Park	4,369	-	3,730	-	-	-	-	-	-	-	-	-	-	-	-	-	306	334
Auto Long-Term Park	783	-	-	783	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Off-Airport Park	1,123	-	-	-	801	-	-	-	-	-	-	-	-	-	-	-	148	174
Rental Car - At Airport	1,296	-	-	-	-	1,296	-	-	-	-	-	-	-	-	-	-	-	-
Rental Car - Off Airport	4,735	-	-	-	-	-	4,735	-	-	-	-	-	-	-	-	-	-	-
Taxis/FHVs	39,612	-	-	-	-	-	-	34,729	-	-	-	-	-	-	-	929	1,729	2,226
Hotel Courtesy Vehicle	1,960	-	-	-	-	-	-	-	890	-	-	-	-	-	-	-	486	584
Shared Ride Van/Shuttle	2,352	-	-	-	-	-	-	-	-	2,352	-	-	-	-	-	-	-	-
NYC Airporter	876	-	-	-	-	-	-	-	-	-	289	-	-	-	-	1	249	337
Bus	2,616	-	-	-	-	-	-	-	-	-	-	1,579	-	-	-	0	443	593
Subway + Bus	1,885	-	-	-	-	-	-	-	-	-	-	-	848	-	-	-	514	523
LIRR + Bus/Taxi	272	-	-	-	-	-	-	-	-	-	-	-	-	96	-	-	46	131
Total for Build	77,377	12,764	3,730	783	801	1,296	4,735	34,729	890	2,352	289	1,579	848	96	890	930	4,781	5,885

Example of Volume-over-Capacity (V/C) analysis for JFK AirTrain



Conclusions

- Switching logit model applied in a sample enumeration fashion proved to be a useful innovative tool:
  - Practitioners have a better understanding of the impact of a project or policy if the results are presented in a switching fashion (i.e. for each mode it is known how many travelers will continue use it or switch to a different mode and why
- Sample enumeration model based on the trips that were actually observed, is trusted somewhat more by practitioners than conventional trip generation and distribution models
- Switching logit model is easy to estimate and apply
- Switching logit model allows for many interesting extensions:
  - Nested structure
  - Any other assumption core probability model
  - Explicit transaction cost
  - Dynamic effects if a panel type data is available
- A micro-model switching model based on sample enumeration suites well the task of modeling such special generators as airports

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