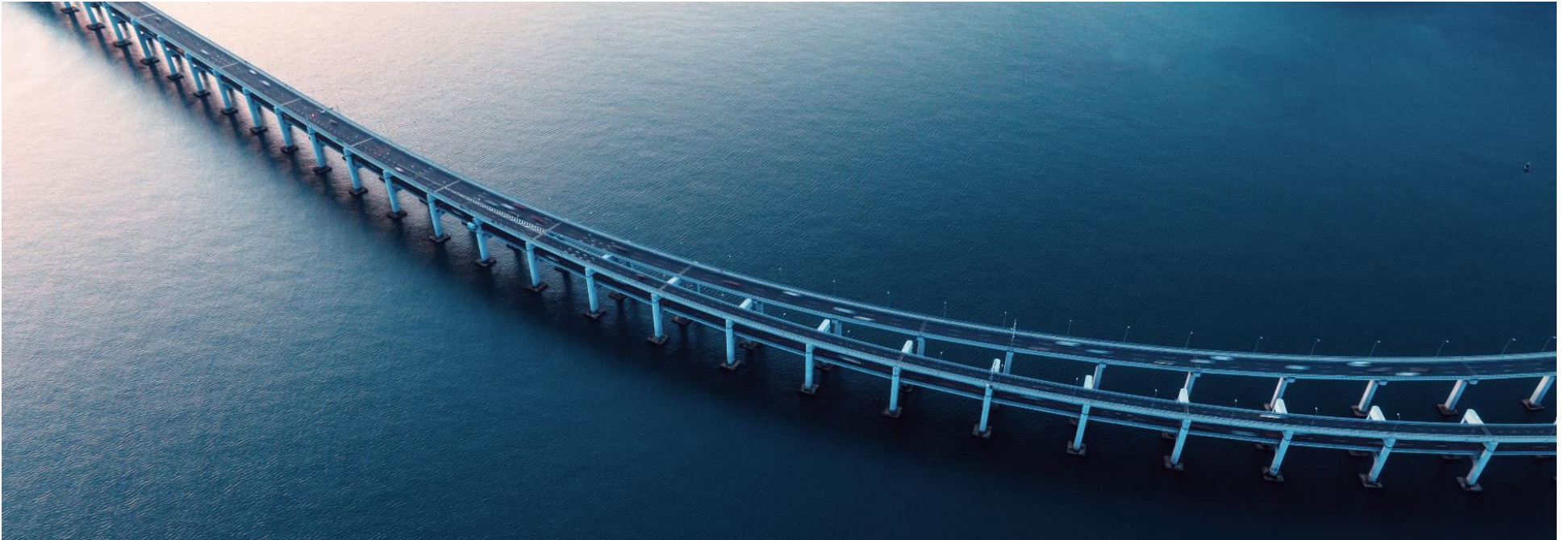


Systematic approach to travel model calibration



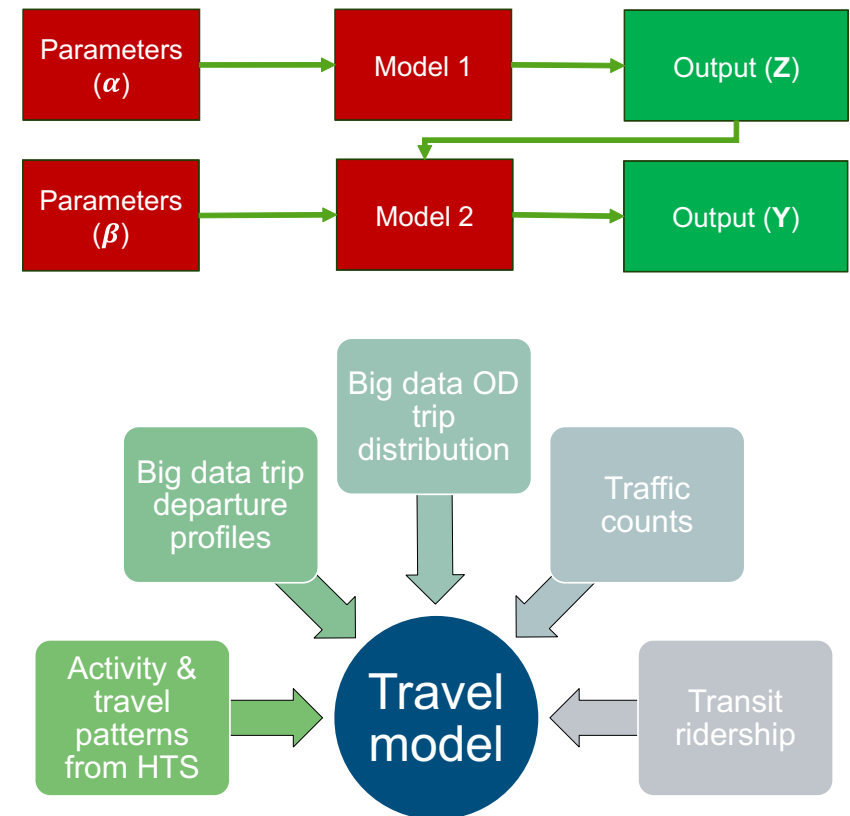
Peter Vovsha, Gaurav Vyas, Mehedi Hasnat, *Bentley Systems*

Bentley®

Two main objectives

Calibration of the *entire model system simultaneously* with interdependences between the constituent models, instead of calibration of one model at a time

Use of *multiple data sources* in model calibration in an integrated manner ("data consolidation")



Model calibration as optimization problem

Variables:

- Model parameters (constants α , time/cost and other coefficients β , etc.)
- No additional parameters, only original model specification

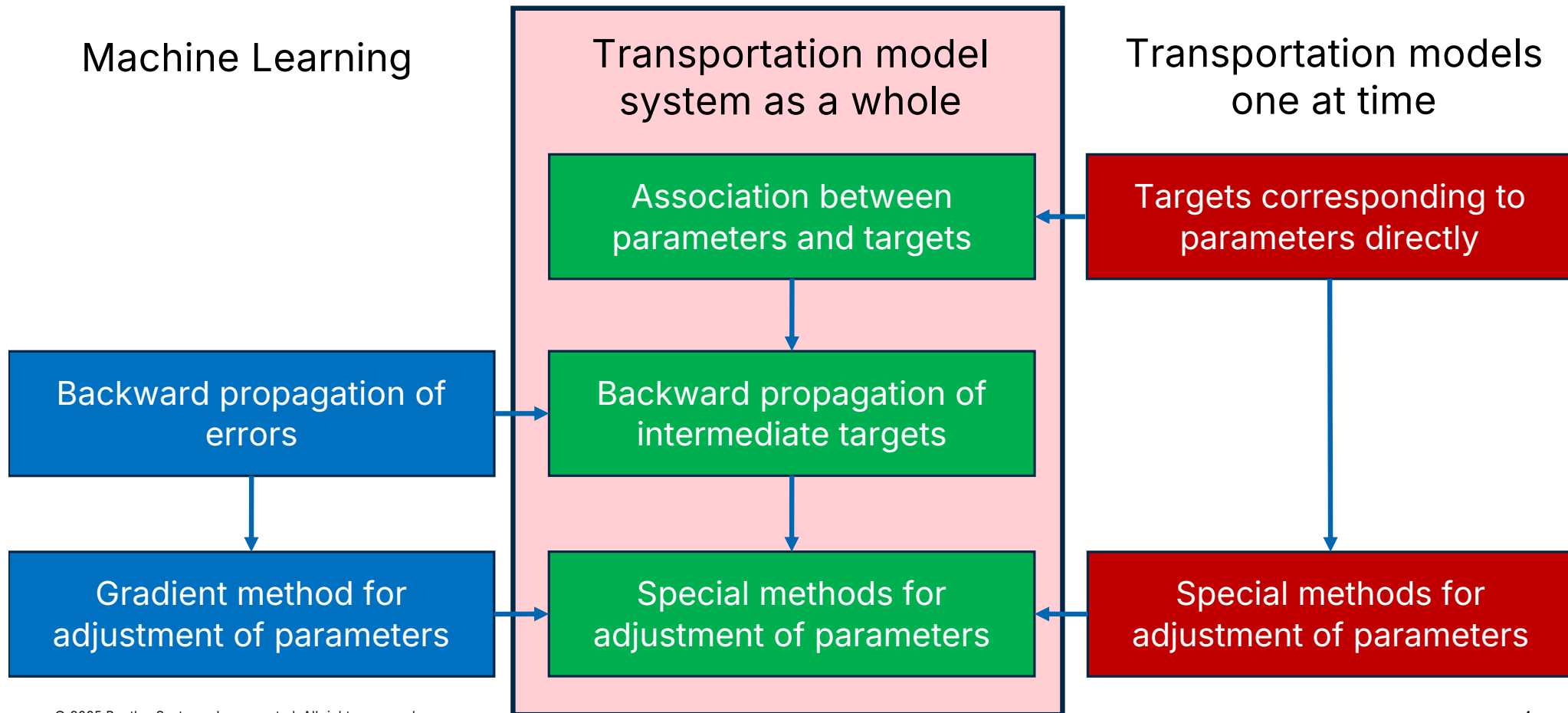
Objective function:

- Loss function as a weighted sum of deviations from the targets $\min_{(\alpha, \beta)} \sum w_s d_s[X_s(\alpha, \beta), T_s]$
- Max likelihood for discrete sub-models $d[X, T] = \sum_i x_i \frac{x_i}{t_i}$
- Least squares error for continuous sub-models $d[X, T] = \sum_i [x_i - t_i]^2$

Constraints:

- Dictated by the model structure and sequence of sub-models $s_1, s_2 \dots$
- Conditional dependence of sub-models $X_{s_2} = f(X_{s_1}, \dots)$
- Resource constraining through equilibration $g[X, R] \leq G$
- Priors $\min_{(\beta)} \sum_k w_k d_k(\beta_k, \hat{\beta}_k)$
- Too complex to express analytically but can be modeled by "forward pass" w/microsimulation

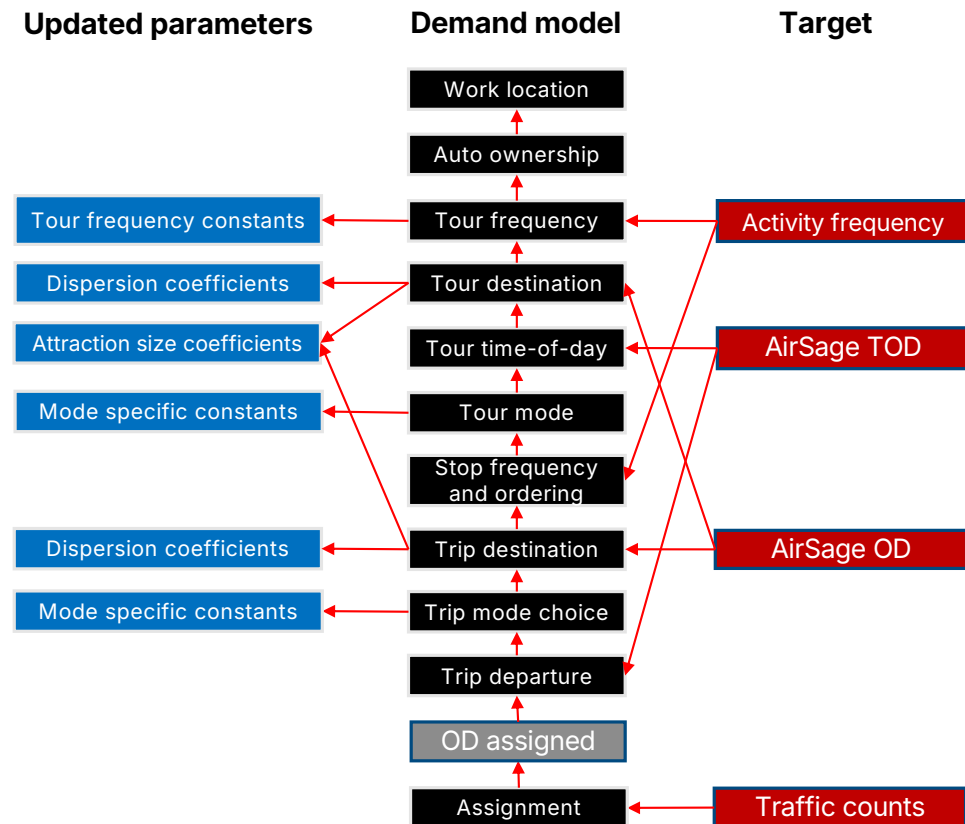
Relation to existing methods and innovations required for calibration of transportation model system



Example of calibration instrumentation in OpenPaths AGENT

Calibration accounts for interlinkages between sub-models

- Many-to-many relationship between targets and sub-models
- Different from conventional calibration of sub-models one-by-one



Examples of OpenPaths AGENT Automated Calibration Application

Application	Types of data sources			
	Big data	Transit ridership or counts	Household Travel Survey	Traffic counts
Phoenix AZ, weekend model	X (Airsage)			X
Singapore regional model	X (Planet)	X	X	X
Swedish National and regional models			X	
Lima, OH regional model	X (Streetlight)		X	X
Romania National model		X	X	
Nanaimo, BC regional model			X	
Ottawa, ON regional model			X	X
Edmonton person travel model		X		X
Perth ABM			X	
Perth TB-STEM		X	X	X
HGAC regional model	X (Replica)		X	X
Yorkshire Travel Model			X	
Queensland regional model		X		
Quebec City travel model		X		
Auckland, NZ	X	X		

Validation to traffic counts (Lima): % RMSE reduction/increase

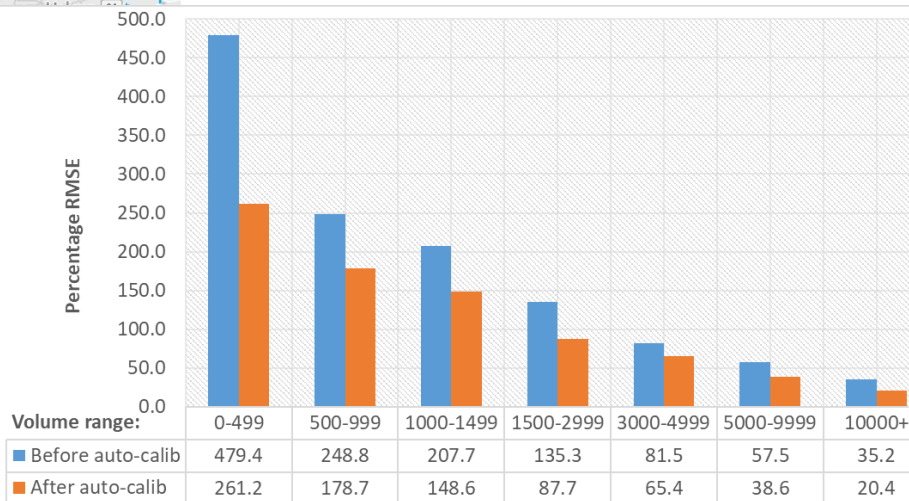
Importance of Big Data	Importance of traffic counts					
	0.0		0.5		1.0	
	MD	PM	MD	PM	MD	PM
0.0	-	-			-16%	-5%
0.5					-18%	-1%
1.0	-21%	15%	-19%	-1%	-22%	-3%

Validation to big O-D data (Lima): % RMSE reduction/increase

Importance of Big Data	Importance of traffic counts		
	0.0	0.5	1.0
0.0	-		10%
0.5			-50%
1.0	-56%	-59%	-53%

Perth TB-STEM: Calibration Results for Daily Traffic Counts

336 total count locations



Total Percentage RMSE:
 Before auto-calibration ~ **46%**
 After auto-calibration ~ **28%**

Calibration targets instrumented to:

- tour frequency
- tour attractions
- tour destination choice
- tour mode choice
- intermediate stops frequency
- intermediate stop location
- time of day

Conclusions

The described method is practical and useful

- Achieved level of calibration is substantially higher compared to traditional techniques
- Different data sources including household travel surveys, traffic and transit counts, and big data can be actively used for model calibration
- The automated calibration procedure is included in OpenPaths

New promising directions to explore

- Calibration of model sensitivity/elasticity on multiple scenarios ("before" and "after")
- Generative approach with strong priors

An aerial photograph of a multi-lane highway bridge that curves gracefully through a dense, lush green forest. The bridge is supported by several concrete pillars. The sun is shining from the upper left, creating a hazy, golden light over the scene. The text "Questions? Thank you!" is overlaid in white on the left side of the image.

Questions? Thank you!

Peter.Vovsha@Bentley.com

© 2023 Bentley Systems, Incorporated

Bentley®