

Innovative Assignment Process for a Statewide Model

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TRB Innovations in Travel
Modeling Conference
Atlanta

June 2018

New Statewide Travel Model for Kansas

- Conventional four-step model
- Estimates weekday travel by four periods on all roads of Collector and above
- Short- and long-distance travel by auto, transit, air
- Integrated goods movement model by truck and rail
 - ❖ Medium truck, heavy truck, light-duty commercial
- Calibrated using recent observed travel data
- Includes user-friendly application package and documentation
- Uses the Cube software platform

What Makes It So Special?

- Unique static assignment approach, combining
 - ❖ Stochastic assignment
 - ❖ Capacity-restraint with fixed iterations and weights
 - ❖ Embedded toll diversion model
- Probably the first time these techniques have been combined

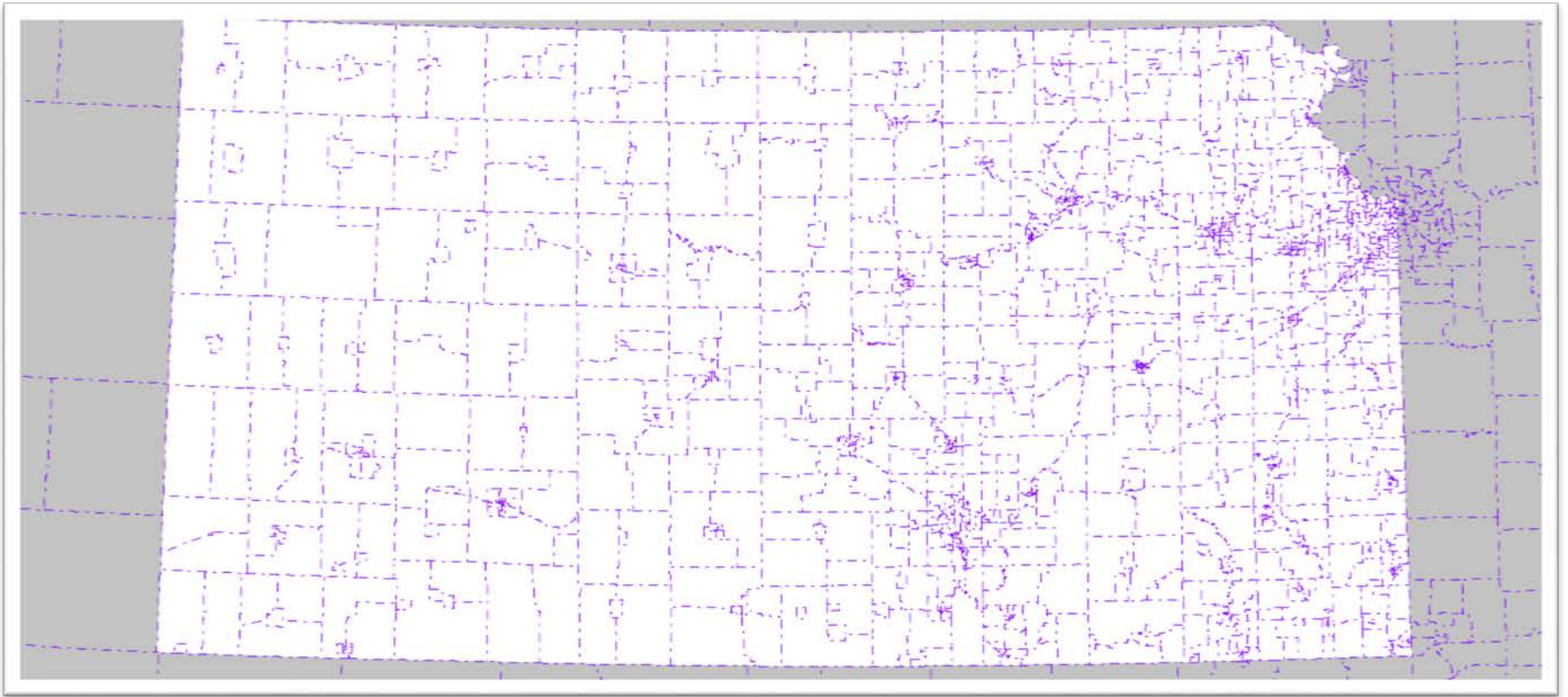
Key Motivations

- No prior statewide model existed
- Not a lot of congestion
- Keen interest in goods movement
- Major output: effect of economic growth, other factors on toll revenue
- Kansas Turnpike Authority was major project sponsor

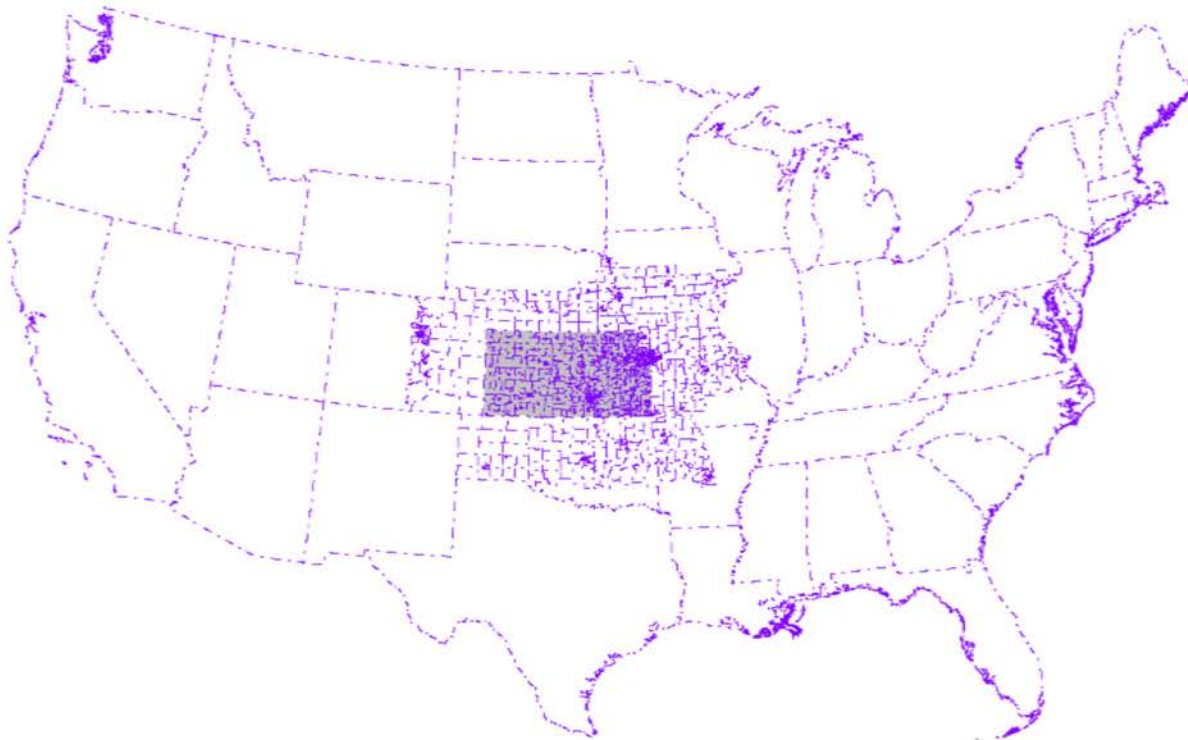
Calibration Data

- 2009 Nationwide Household Travel Survey data
 - ❖ Kansas: not enough records (189 HH)
 - ❖ West North Central US: 5,758 HHs
 - ❖ Iowa, Kansas, Missouri, Minnesota, North Dakota, Nebraska, South Dakota
- Observed vehicle trips derived from cell phone signals
 - ❖ AirSage nationwide tables by purpose, resident/non-resident
 - ❖ Spring 2016
- National freight databases
 - ❖ Transearch (IHS Markit)
 - ❖ Freight Analysis Framework (FAF4)
- Traffic counts in Kansas
 - ❖ Weekday (3,596 links)
 - ❖ Hourly classification counts (642 links)

State Zones



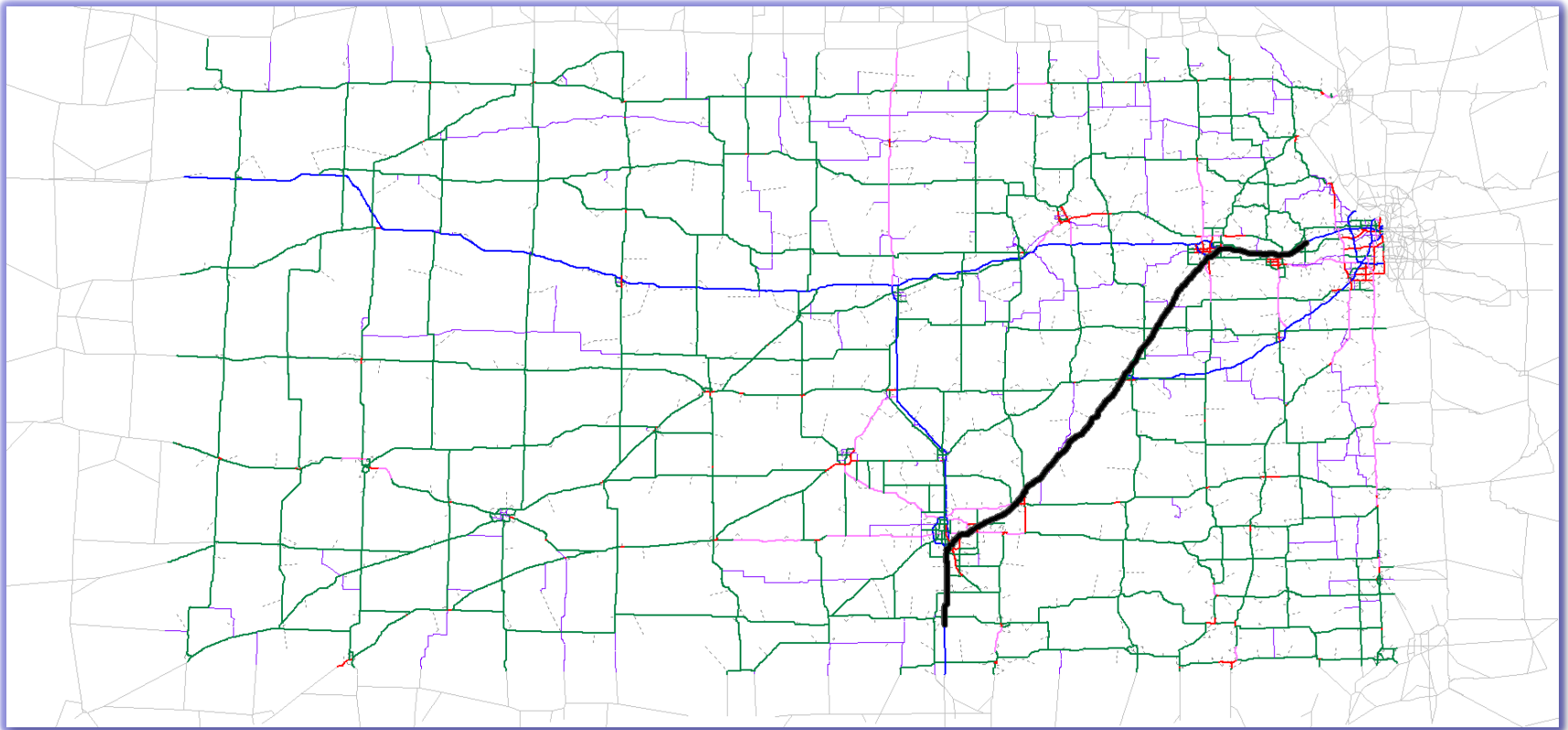
External Zones



Person Travel Model

- Standard four-step
- 1,258 zones in Kansas, 615 in “halo” area, 48 in rest of US
- Purposes: work, school, university, shop, other, NHB work, NHB other, long-distance business, long-distance personal, light-duty commercial, medium truck, heavy truck
 - ❖ Long-distance is over 50 miles
- Conventional highway network
- Typical socioeconomic data

Statewide Network

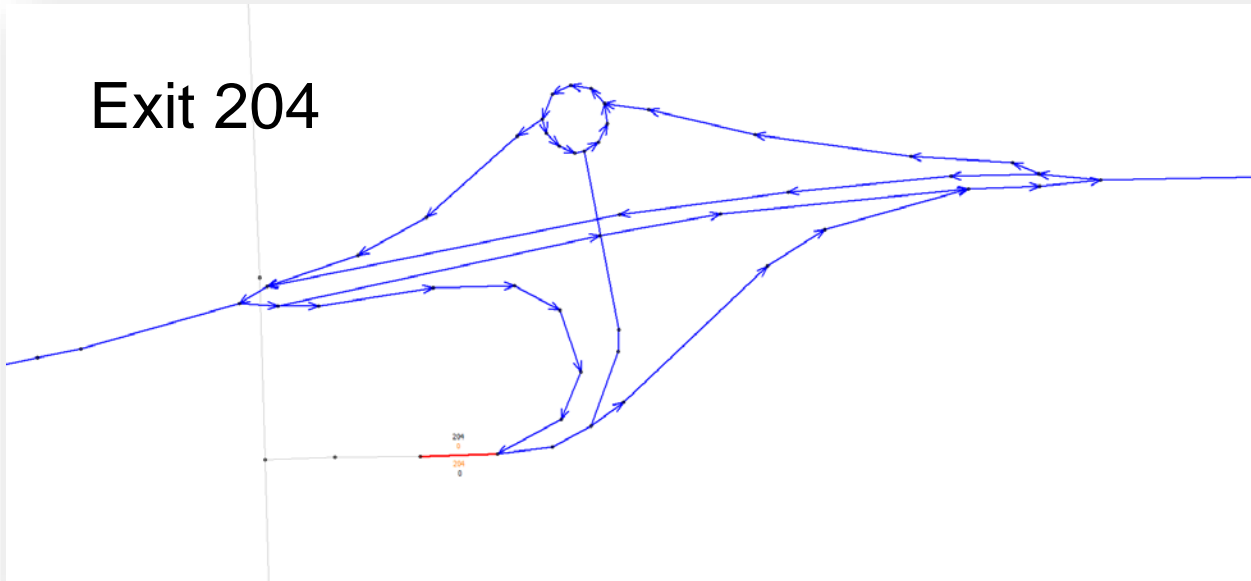


Toll Coding

- Different types of toll roads
 - ❖ Closed toll (Kansas Turnpike, Oklahoma turnpikes)
 - ❖ Barrier toll (E-470 Denver)
 - ❖ Distance-based tolls (future?)
- Toll options
 - ❖ Can vary by time period and vehicle occupancy
- Kansas Turnpike uses closed toll system
 - ❖ Coding is very elaborate
 - ❖ Interchanges are coded in detail
- Tolls represented in general
 - ❖ Cash toll only
 - ❖ Auto (2 axle) and semi-trailer (5 axle) tolls coded
 - ❖ Total toll revenue based on fixed factors

Toll Interchange Coding Example

Exit 204



Goods Movement Model

- Developed using Transearch and FAF4 data
- Conventional generation model by 8 commodity groups
 - ❖ Trip rates \propto employment by type, with dummy variables
 - ❖ Focus on agricultural goods
 - ❖ Wichita: aviation manufacturing
- Combined distribution/mode choice model
 - ❖ Truck vs. rail
 - ❖ Mode based on distance, time, and cost
 - ❖ Short, medium, and long distance groups
- Transport Logistics Nodes
 - ❖ 51 intermodal facilities, major warehousing/transfer points
- Vehicle model: converts payloads into trips
- Service model: light-duty commercial vehicles
- Implemented in Cube Cargo

Assignment Challenges

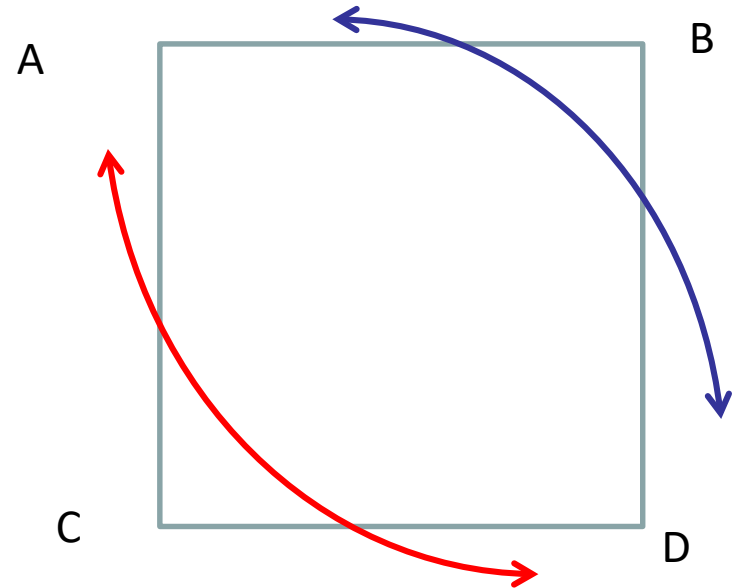
- Mostly uncongested grid network
- Problems finding alternative paths without congestion
- Questions about equilibrium volume averaging process
 - ❖ Issues with stability
 - ❖ Convergence feasibility
 - ❖ Wanted reasonable run time
- Needed toll diversion process to be incorporated in assignment
- Also wanted full assignment capabilities
 - ❖ Select link analysis
 - ❖ Multi-path, multi-class assignment

Proposed Solutions

- Uncongested grid: stochastic assignment
 - ❖ Finds alternative paths
- Equilibrium: capacity-restrained method with fixed iterations and weights
 - ❖ Improves stability
- Toll: logit toll model embedded within assignment
 - ❖ Turnpike traffic and revenue drove the project
- Can all of these be done at once?

The Grid Problem

- The real network looks a lot like this grid
- Path A-B-D looks very much like path A-C-D
- Real traffic uses both paths
- How to model that?



Stochastic Assignment

- Path-building uses a combination of time + distance
 - ❖ Toll is handled separately
- Create best path plus 3 more paths
- Use logit model to spread trips among paths
 - ❖ Split based on travel time difference
 - ❖ Coefficient developed from previous work
- Programmed in Cube

Equilibrium

- Good experience using fixed iterations and weights
- Run equilibrium (Frank-Wolfe) with reasonable convergence criterion to get the iterations and weights
 - ❖ Hold those constant for scenarios
 - ❖ One set for 2015, another for 2040
- Not clear that equilibrium theory is valid at the statewide level
- Stability of results is very important

Tolls

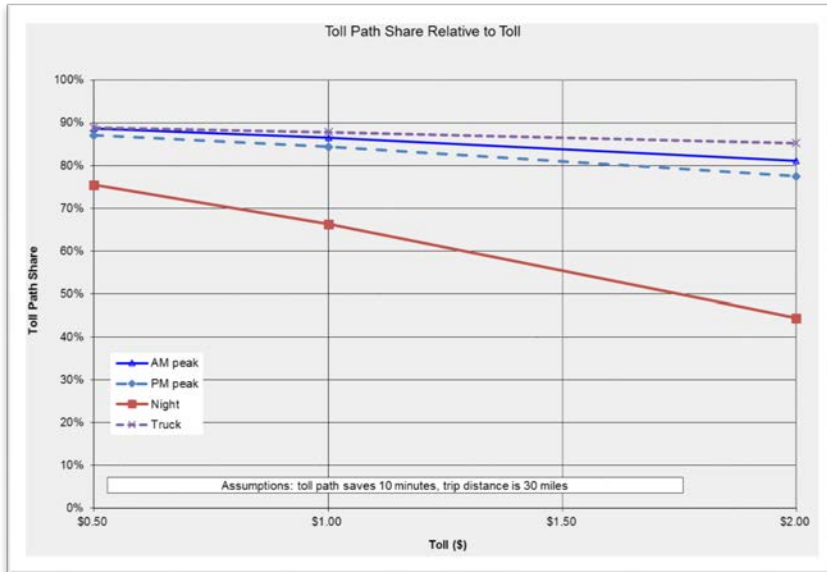
- Logit toll diversion model by period
 - ❖ Toll, time saved, log of trip distance
- Developed from prior work and surveys in other areas
 - ❖ No local survey data
- 8 paths built (4 toll, 4 free) for 4 periods and 3 vehicle types
 - ❖ AM peak, midday, PM peak, night
 - ❖ SOV, HOV, Truck
- Diversion is incorporated into the assignment
- Adjust bias coefficients based on Turnpike counts

Value of Time

- Implied by toll model coefficients
- Values asserted, based on prior work
- Peak has more work trips than off-peak
- AM peak has more work trips than PM
- Truck has a paid driver

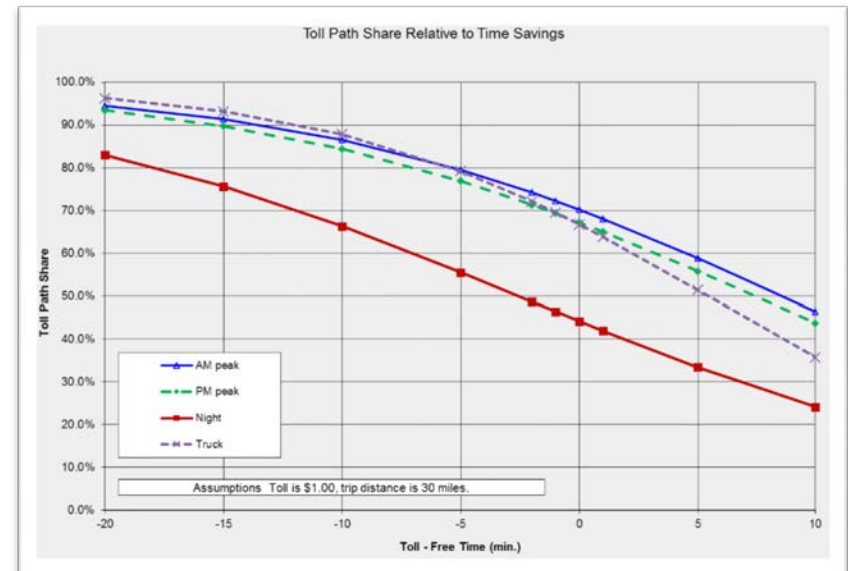
	AM Peak	Midday	PM Peak	Night
Auto	\$15.00	\$7.80	\$12.93	\$6.07
Truck	\$34.91	\$34.91	\$34.91	\$34.91

Toll Diversion



Effect of Toll

Effect of Time Savings



Implementation

- All 3 methods can be implemented at the same time, in Cube
- Probably the only time this has been done
- Cube Cluster used for multiprocessing (8 cores)
- Excellent match of volumes to counts
 - ❖ Overall volume/count difference = -0.9%
 - ❖ Volume/count on all facility types within $\pm 2\%$
 - ❖ RMSE = 25%
 - ❖ Link $r^2 = 0.992$
- Assignment run time (4 periods): 82 minutes

For More Information

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