# MARC Model Expansion
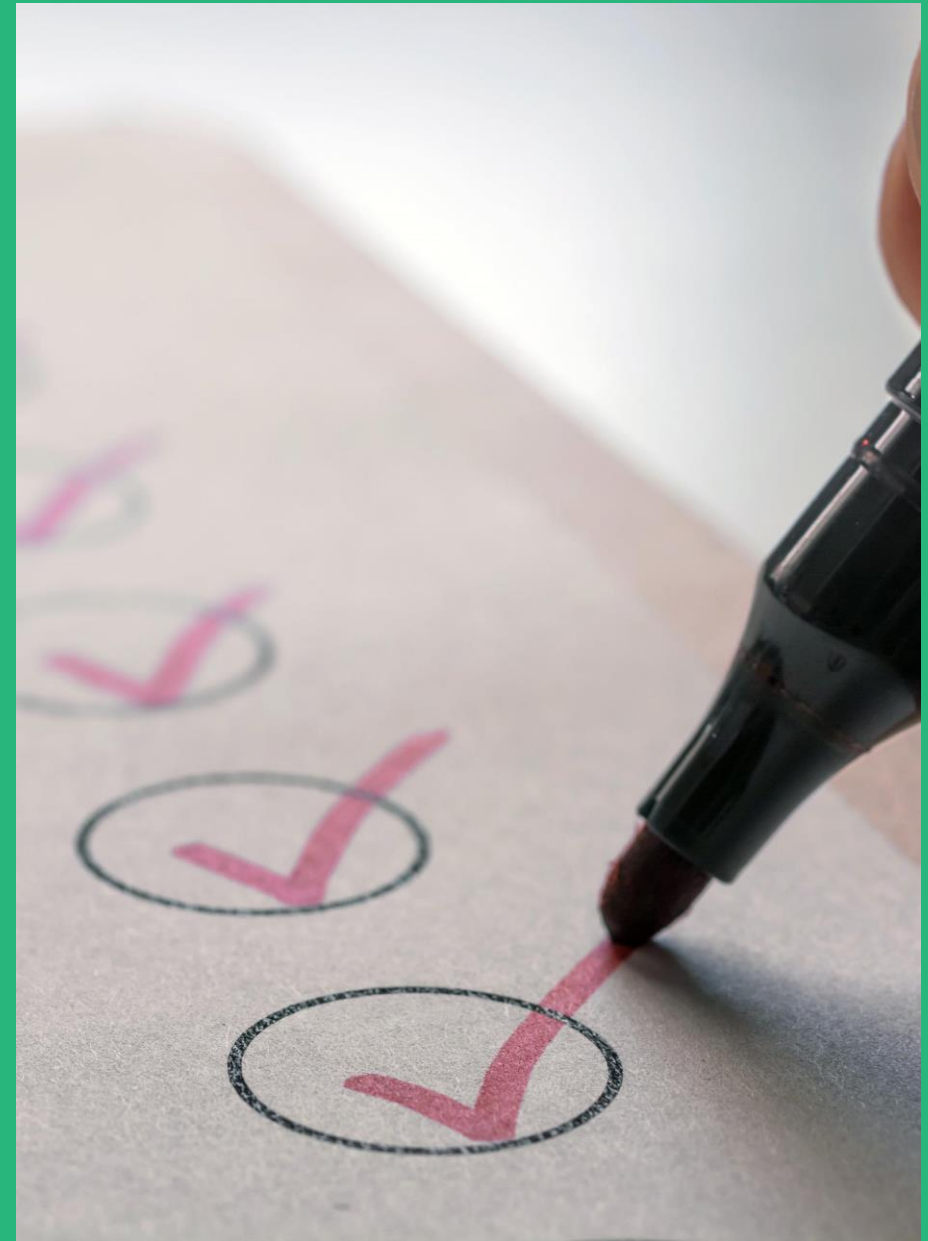
*presented to*

MARC Model User's Group

*presented by*

Cambridge Systematics, Inc.

December 12, 2024

# Project Objectives

- Expand the model coverage area
  - » Validate to expanded area counts
  - » Re-locate external stations

- User Improvements
  - » Master network system
  - » Faster run times
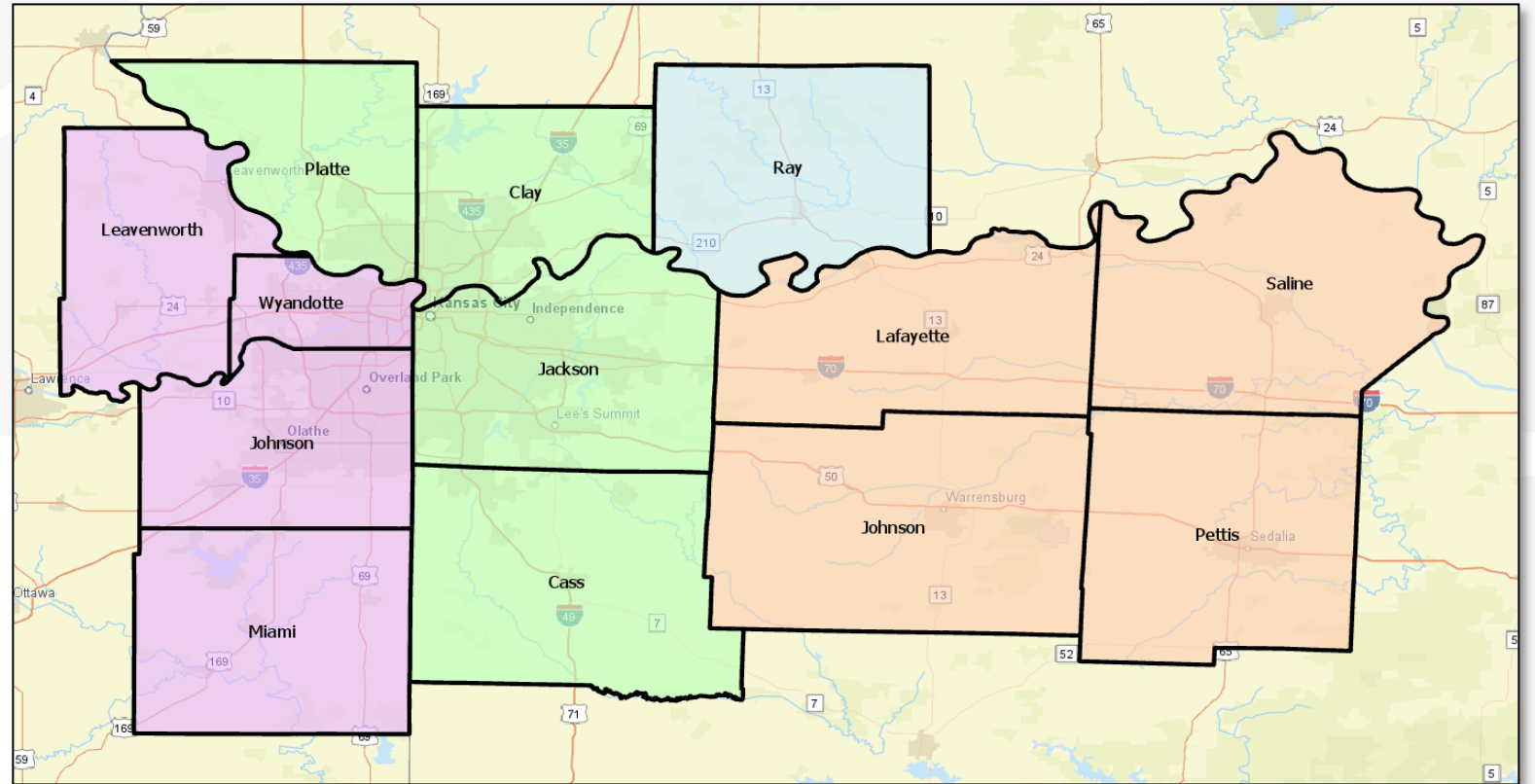  - » Model dashboard
  - » New software package

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# Core Model Updates

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# Model Expansion

- **Add 5 new counties to the model**
  - » Highway network,
  - » TAZs
  - » counts
  - » external stations
- **Updated scripts and calibration**

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# Software Package

- Implemented in TransCAD 9

- TransCAD GIS-based highway and transit networks

- User friendly run control and scenario management

- Python under the hood
  - » Demand Modeling steps
  - » Packaged with the model

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# Master Network



- Each highway project is coded individually

- Mix and match projects – or just select a year

- Efficient scenario testing

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# Fast Run Times

➤ Fully multi-threaded destination and mode choice

➤ Uses multiprocessing to make full use of resources in traffic assignment

| Run Type | Laptop (Core i7) | Server (Intel 32-core) Aws c7i.8xlarge |
|---|---|---|
| Single Loop | About 35 minutes | About 20 minutes |
| 5-Iteration Feedback | About 2.5 hours | About 1.5 hours |

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# Model Dashboard

➤ Quick access to maps, charts, and tables with model results

➤ Easily view select link/zone results, calibration statistics, etc.

➤ Maps accessed from the model software

➤ Tables and charts viewable from a web browser

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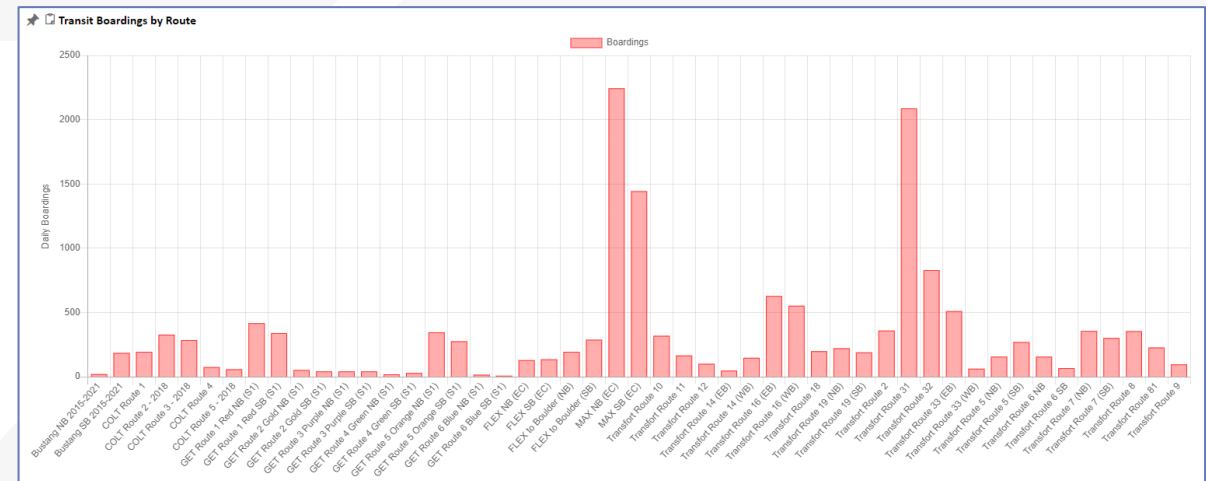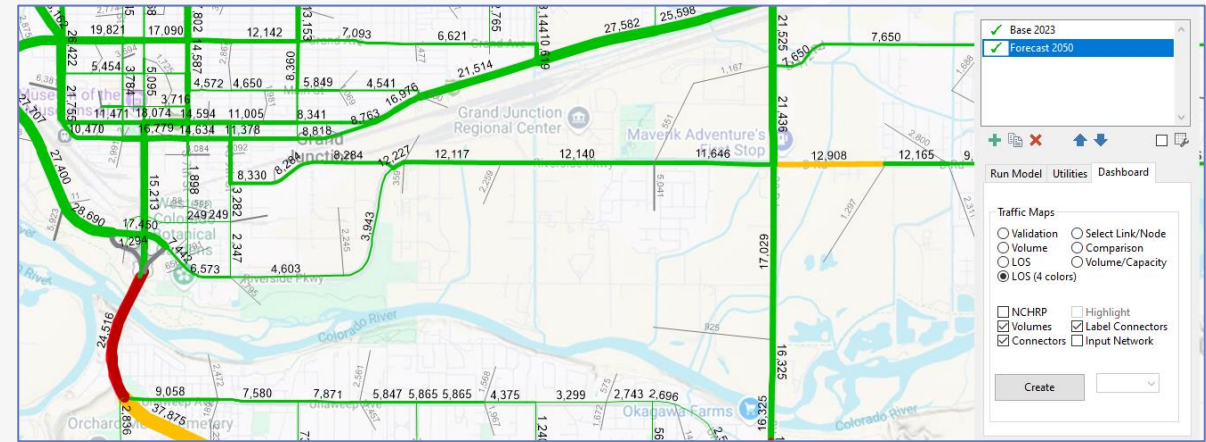
# Model Structure

- Retain the same model structure

- Continued 2019 base year

- Nested logit mode choice

- Destination choice

- Speed feedback



Transportation Networks → Trip Generation
Traffic Analysis Zones and Data → Trip Generation
Trip Generation → Destination Choice → Mode Choice → Trip Assignment
Feedback
Trip Assignment → Roadway and Transit Results
Trip Assignment → Reports
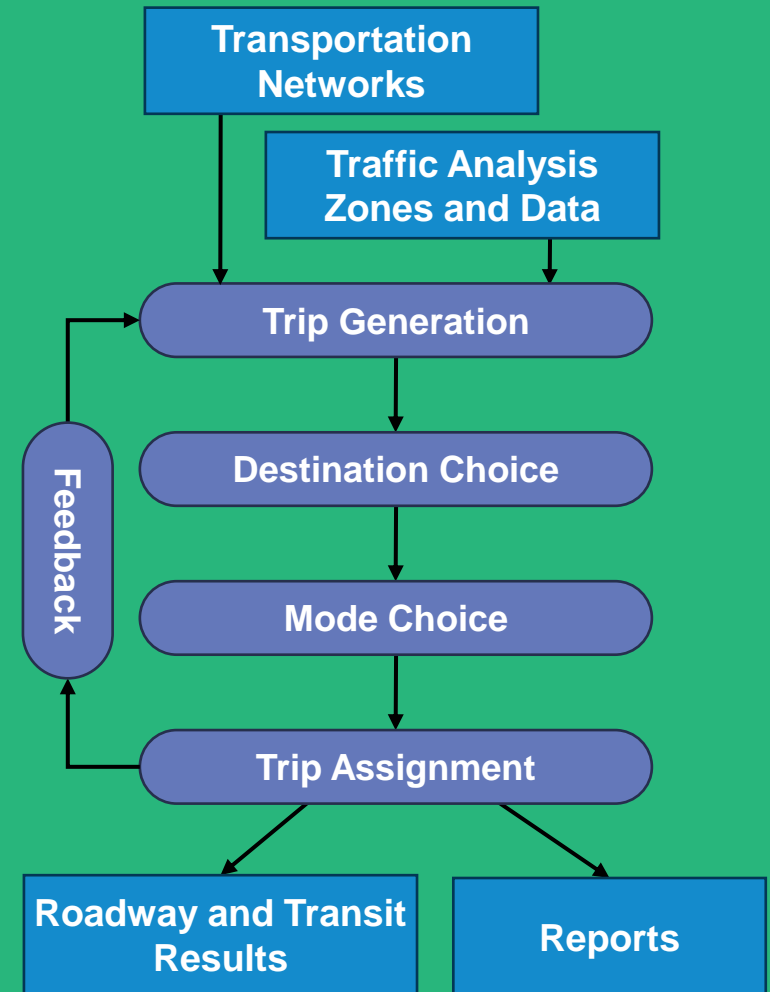
# Network Updates

- ➤ Converted to TransCAD GIS
- ➤ Expanded using street centerline data
- ➤ Updated Facility Type Coding
- ➤ Area Type
  - » Coded on the TAZ layer
  - » Attached to the network during the model run

| Functional Class | Updated | Previous |
|---|---|---|
| Freeways and Interstates | 1 | 1 |
| Expressways | 2 | 2 |
| Principal Arterials | 3 | 6 |
| Minor Arterials | 4 | 3 |
| Collectors | 5 | 7 |
| Minor Collectors (not used) | 6 | -- |
| Local Streets (not used) | 7 | -- |
| Freeway-to-Freeway Ramps | 8 | 9 |
| Other Ramps (Arterials) | 9 | 8 |
| Centroid Connectors | 10 | 5 |

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# Network Symbology

- Default Theme

- Roadway hierarchy

- Option to show centroids and nodes



**Facility Type**
- 1 - Freeway
- 2 - Expressway
- 3 - Principal Arterial
- 4 - Minor Arterial
- 5 - Collector
- 8 - Ramp
- 9 - Freeway Ramp
- 10 - Centroid Connector

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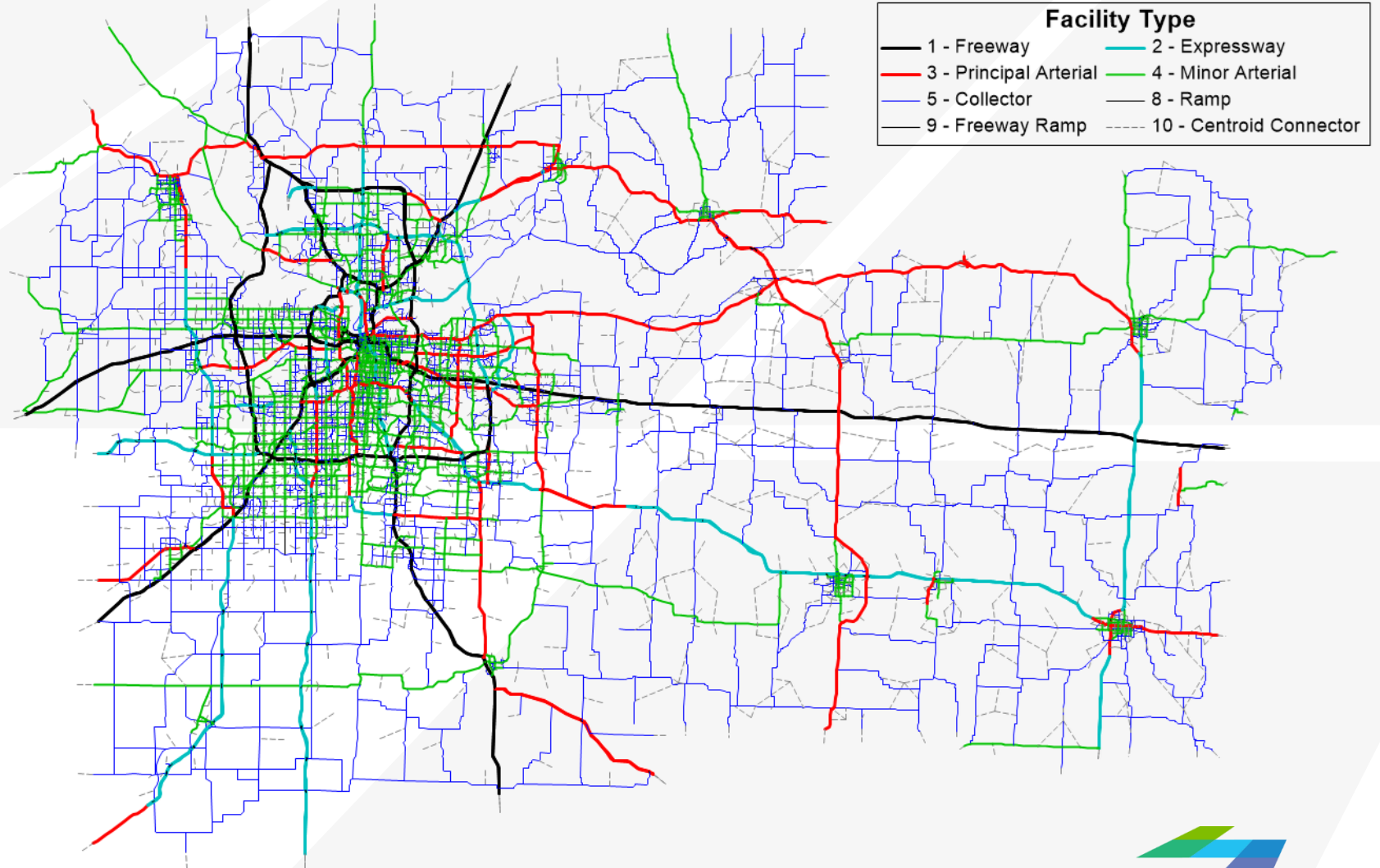
# Time Periods

- 4 primary periods
- AM and PM separated into peak and shoulder

| Time Period | | Definition |
|---|---|---|
| AM Peak Hour | | 7:00 – 8:00 AM |
| AM Shoulder | | 8:00 – 9:00 AM |
| Mid-Day | | 9:00 AM – 3:00 PM |
| PM Peak Hour | | 5:00 – 6:00 PM |
| PM Shoulder | | 3:00 PM – 5:00 PM & 6:00 – 7:00 PM |
| Overnight | | 7:00 PM – 7:00 AM |

CAMBRIDGE SYSTEMATICS
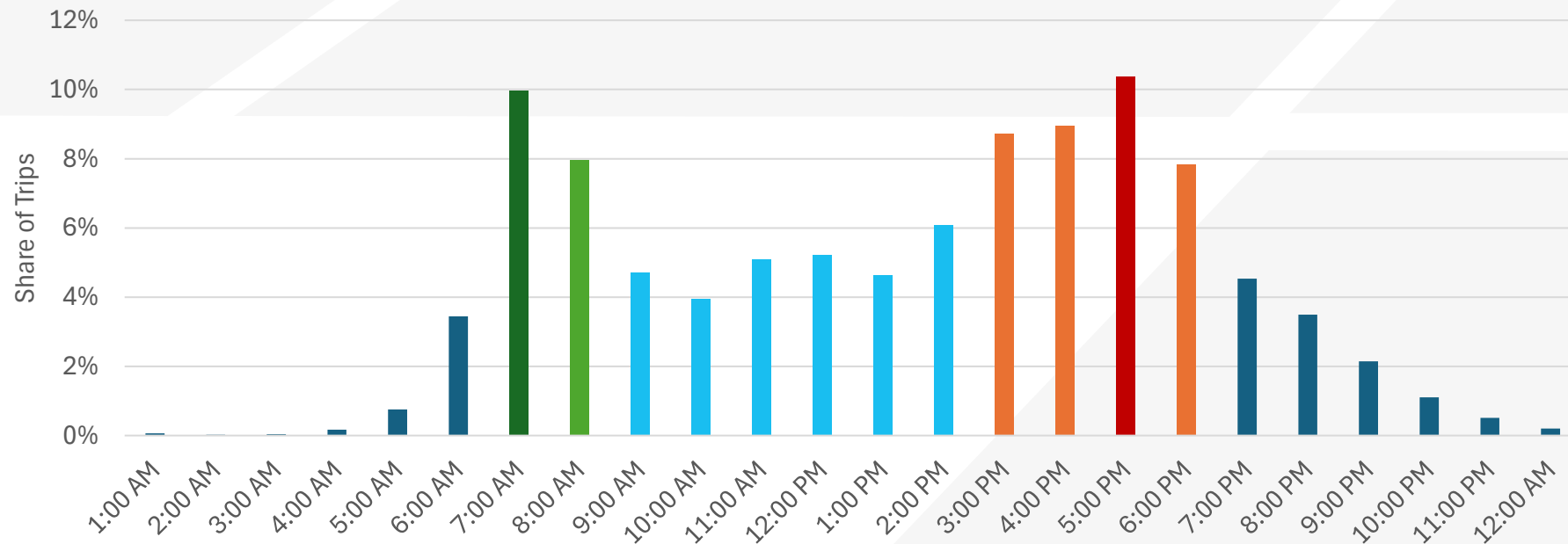
# Model Files

- Self contained AddIn with model scripts
- Shared inputs for all model scenarios
  - » Master Network for all years
  - » TAZ Data, external, and special generator files for each year
- One folder for each scenario



MARC Model

AddIn — Model Add-In files are stored here

Inputs — All model Input Data is stored here

Outputs
- Base
- Forecast — A separate output directory is created for each scenario
- Etc.

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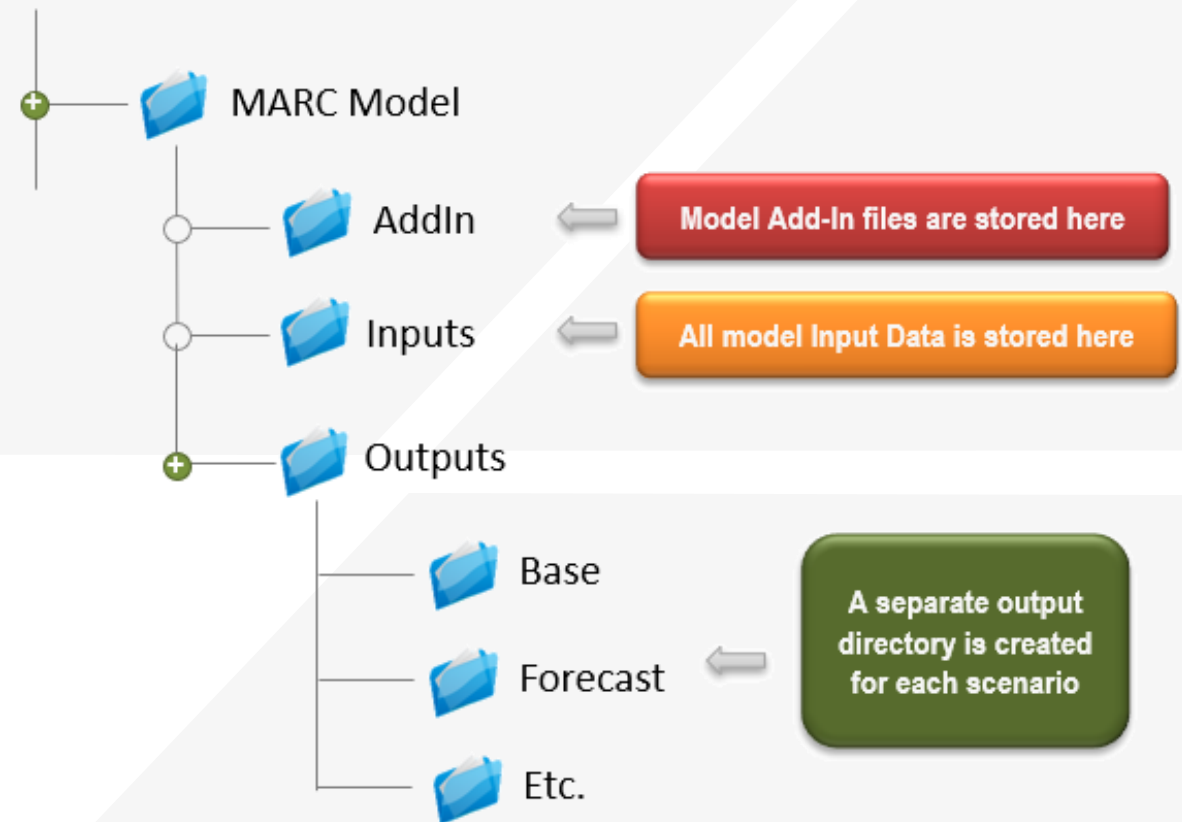
# Model Input Files

➤ **TAZ Data** is stored in CSV files

➤ Most **parameters** are in CSV files for easy editing or review

➤ Some parameters in TransCAD ".bin" format

➤ A small number of parameters are stored in the model interface

|  | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | taz | total_pop | total_hh | median_h | total_emp | retail_emp | service_er | other_emp |
| 2 | 1 | 0 | 0 | 80352 | 0 | 0 | 0 | 0 |
| 3 | 2 | 440 | 163 | 95642 | 51 | 0 | 26 | 25 |
| 4 | 3 | 1096 | 397 | 95642 | 222 | 24 | 140 | 58 |
| 5 | 4 | 2110 | 179 | 80352 | 855 | 47 | 805 | 3 |
| 6 | 5 | 959 | 418 | 48047 | 346 | 161 | 106 | 79 |
| 7 | 6 | 192 | 147 | 48047 | 8 | 0 | 5 | 3 |
| 8 | 7 | 1143 | 63 | 55940 | 681 | 317 | 282 | 82 |
| 9 | 8 | 69 | 29 | 55940 | 810 | 162 | 281 | 367 |

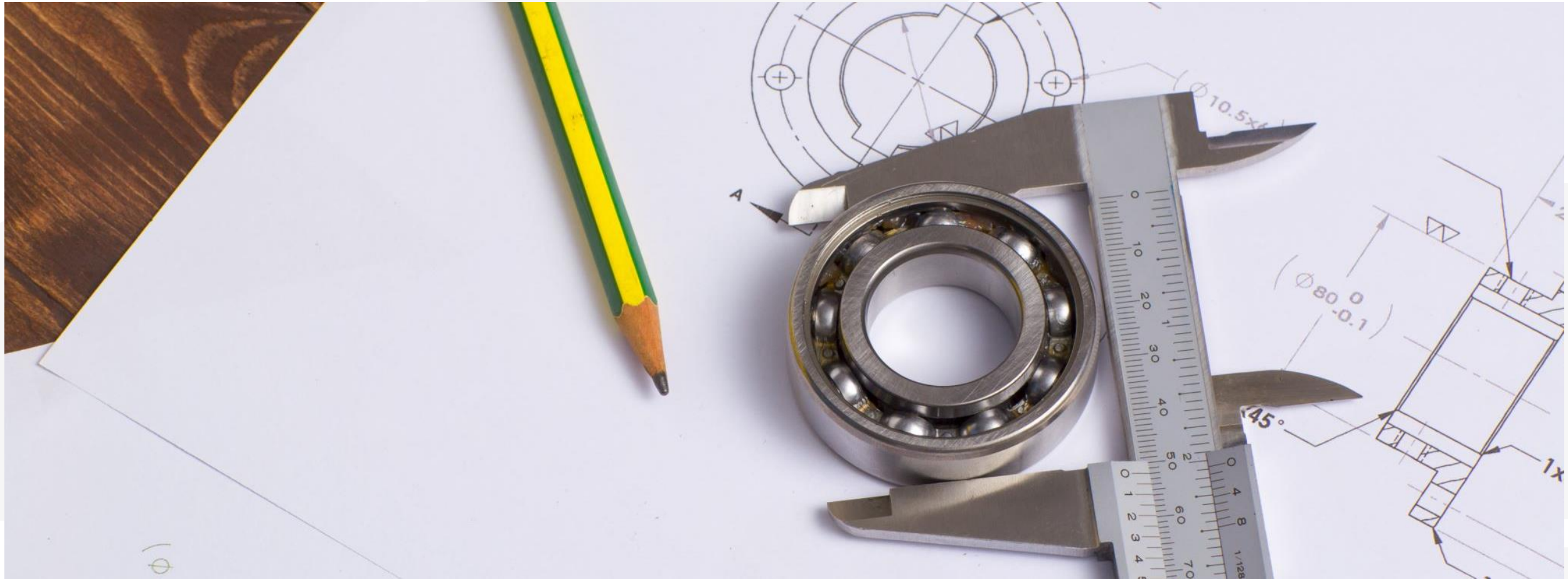|  | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | purpose | hh_incom | hh_size | A0 | A1 | A2 | A3 |
| 2 | HBW | 1 | 1 | 0.372272 | 0.696042 | 0.813444 | 0.813444 |
| 3 | HBW | 1 | 2 | 0.727472 | 1.22365 | 1.307087 | 1.521023 |
| 4 | HBW | 1 | 3 | 0.727472 | 1.357683 | 1.357683 | 2.300459 |
| 5 | HBW | 1 | 4 | 0.727472 | 1.357683 | 1.357683 | 2.300459 |
| 6 | HBW | 1 | 5 | 0.727472 | 1.357683 | 1.357683 | 2.300459 |

|  | A | B |
|---|---|---|
| 1 | VARIABLE | VALUE |
| 2 | DAILY_ENPLANEMENTS | 15779 |
| 3 | HB_INC1_SHARE | 0.192 |
| 4 | HB_INC2_SHARE | 0.556 |
| 5 | HB_INC3_SHARE | 0.252 |
| 6 | TRIPS_PER_ENPLANEMENT | 2.62 |
| 7 | HB_SHARE | 0.6 |
| 8 | NHBW_SHARE | 0.2 |
| 9 | NHBO_SHARE | 0.2 |
| 10 | AIRPORT_ZONE | 1021 |

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# Calibration and Validation

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# Trip Generation Review

➤ Retained trip generation rates from the 2019 calibration

➤ Based on the latest MARC Household Travel Survey

➤ Compared trip generation results to Replica with a focus on the expanded area

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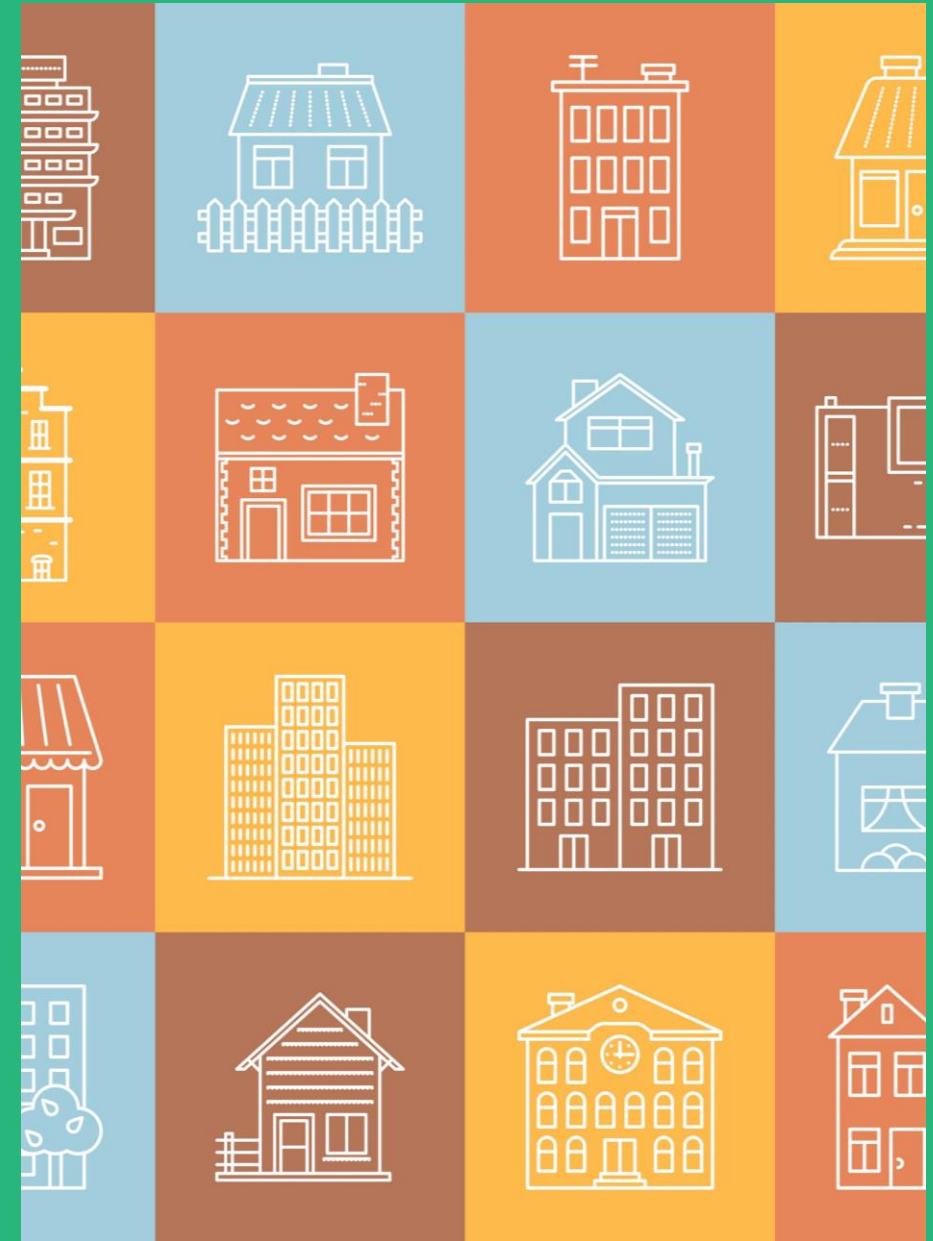
# Comparison to Replica – Trip Generation
## HBW Trips at the TAZ Level
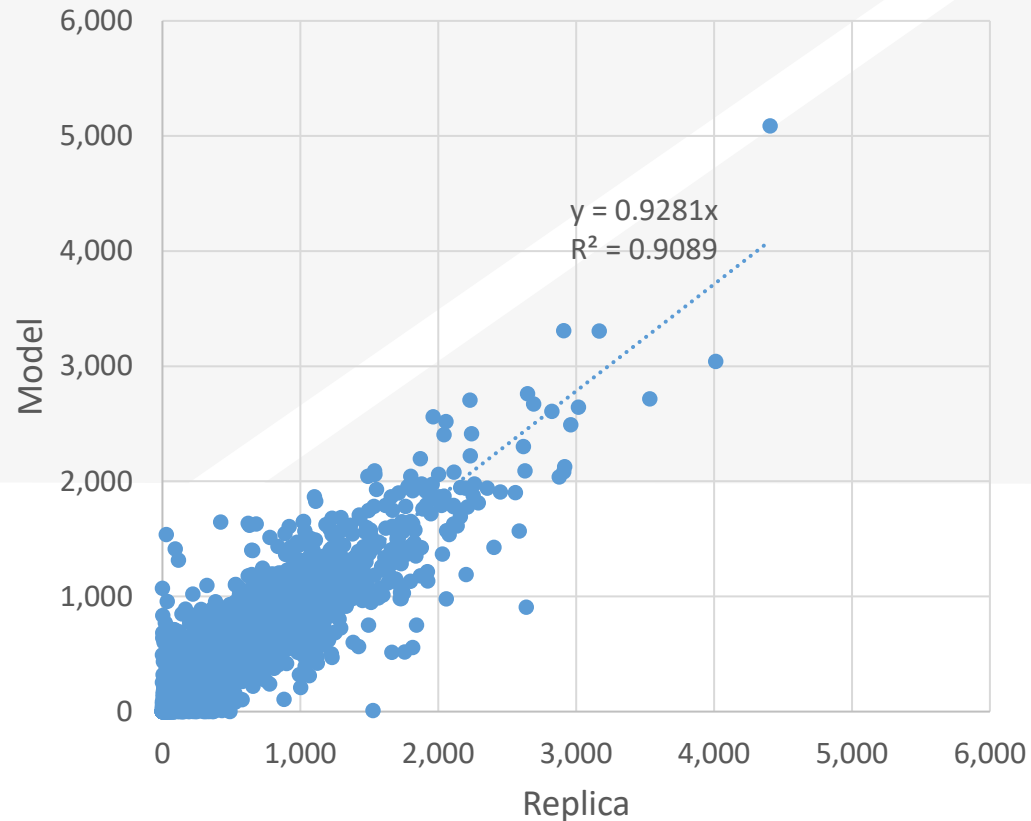
CAMBRIDGE SYSTEMATICS
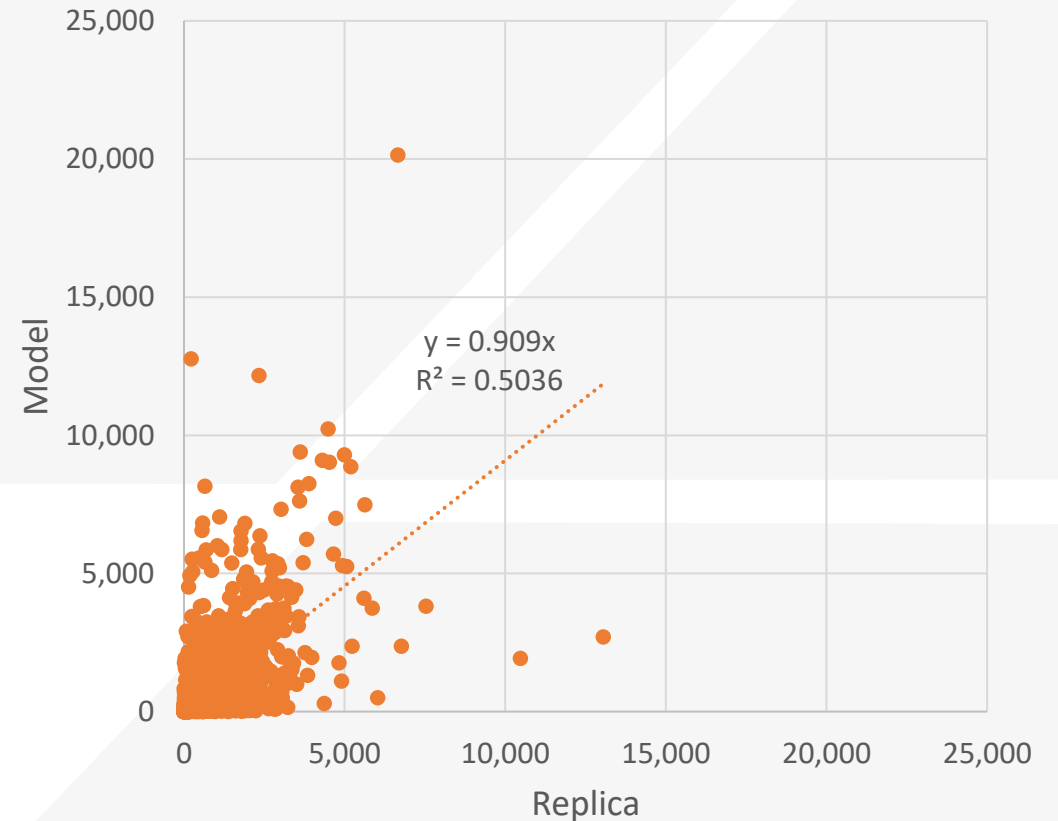
# Comparison to Replica – Trip Generation
## **All Trips** at the TAZ Level



Left chart: Productions — $y = 0.9342x$, $R^2 = 0.8801$. Axes: Model vs Replica. Legend: Productions, Linear (Productions).

Right chart: Attractions — $y = 0.7518x$, $R^2 = 0.742$. Axes: Model vs Replica. Legend: Attractions, Linear (Attractions).

CAMBRIDGE SYSTEMATICS
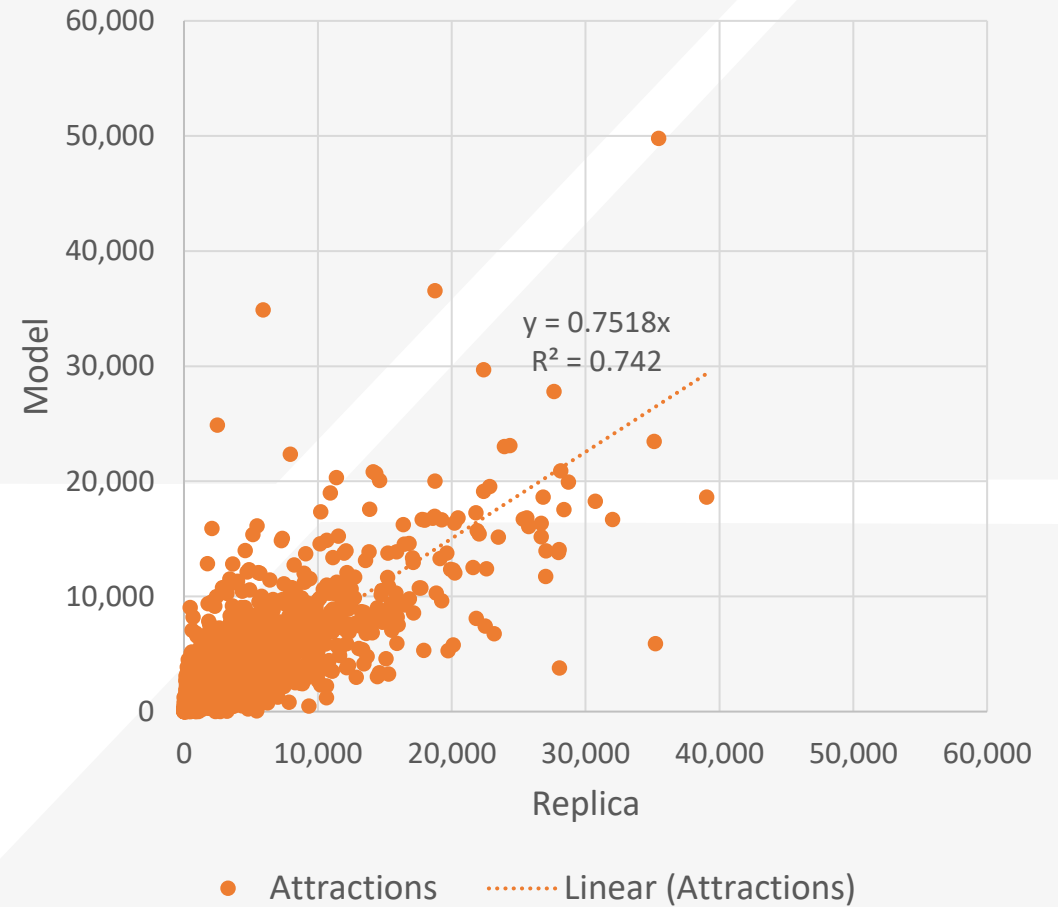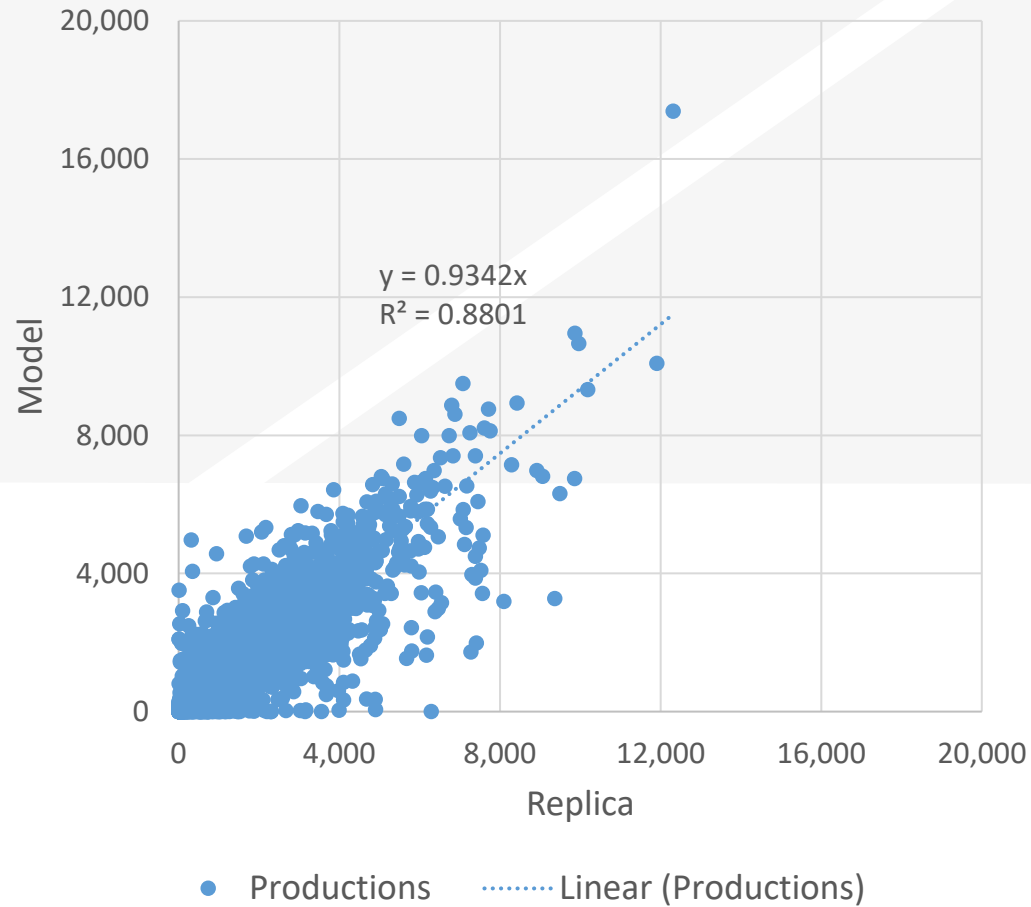
# Comparison to Replica – Trip Generation
## HBW Trips by County and Area Type
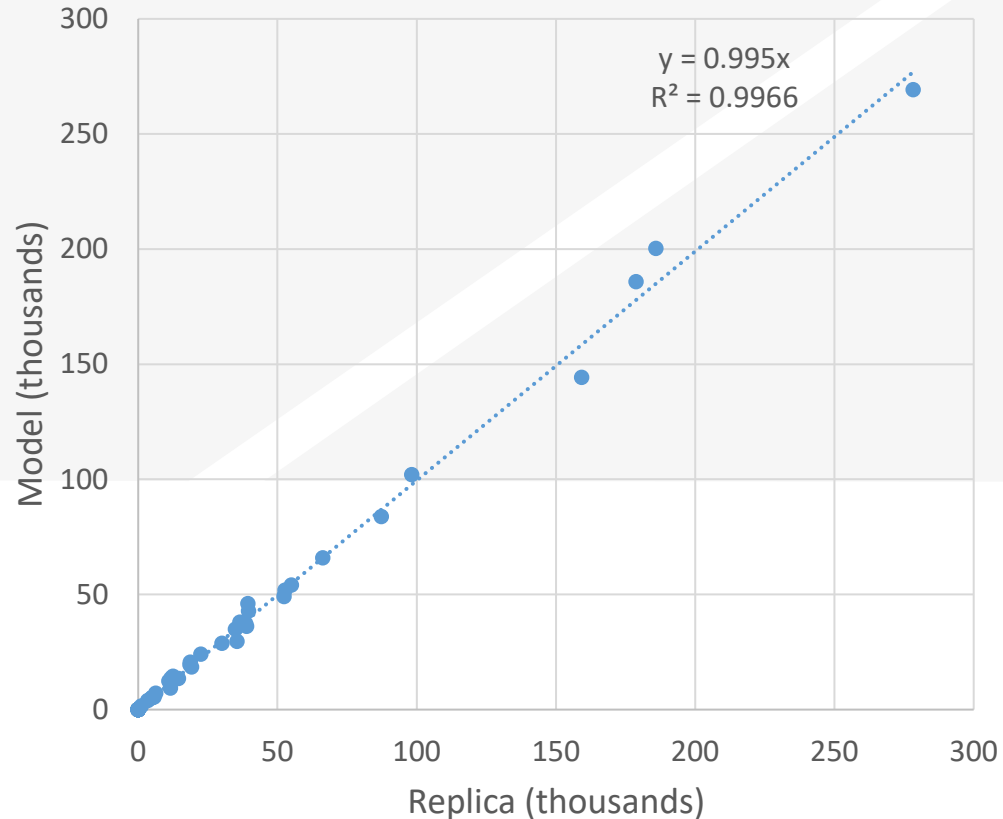
CAMBRIDGE SYSTEMATICS
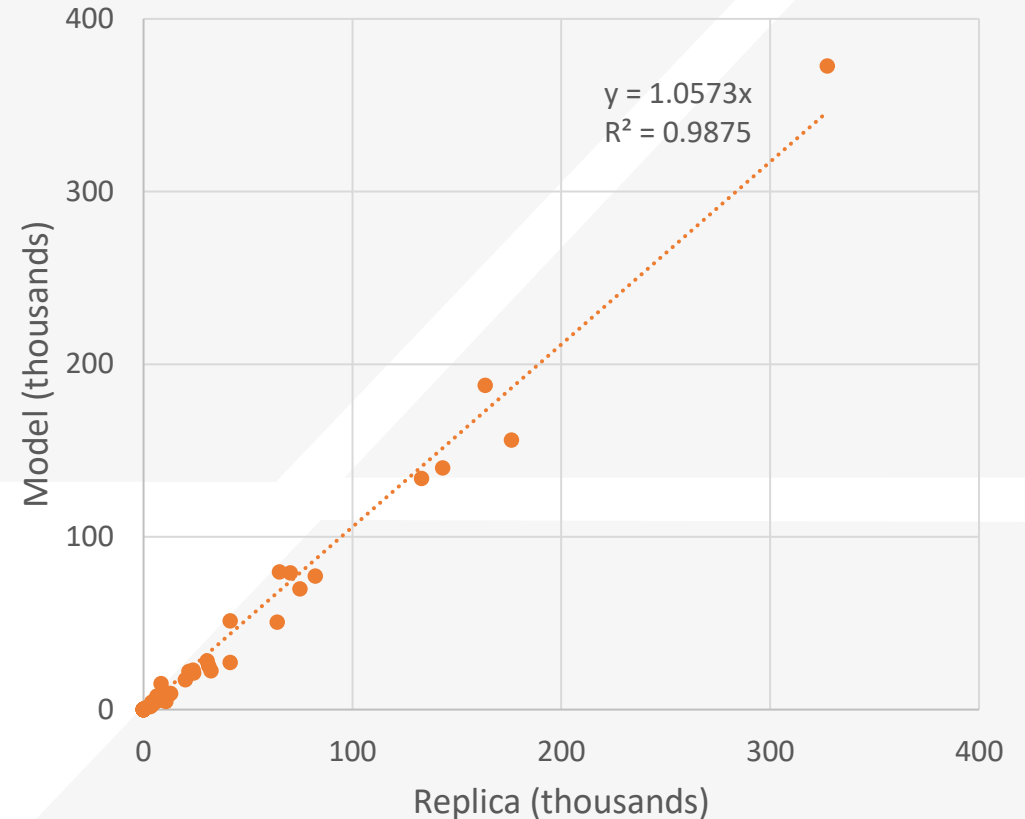
# Comparison to Replica – Trip Generation
## **All Trips** by County and Area Type
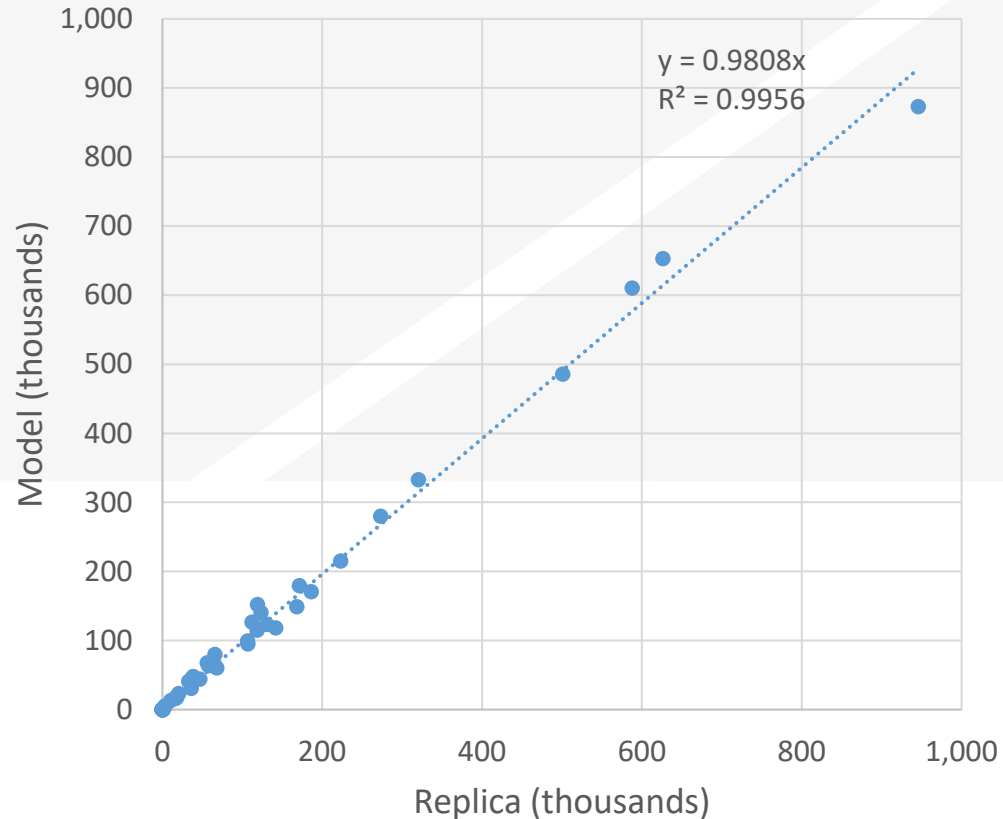
CAMBRIDGE SYSTEMATICS
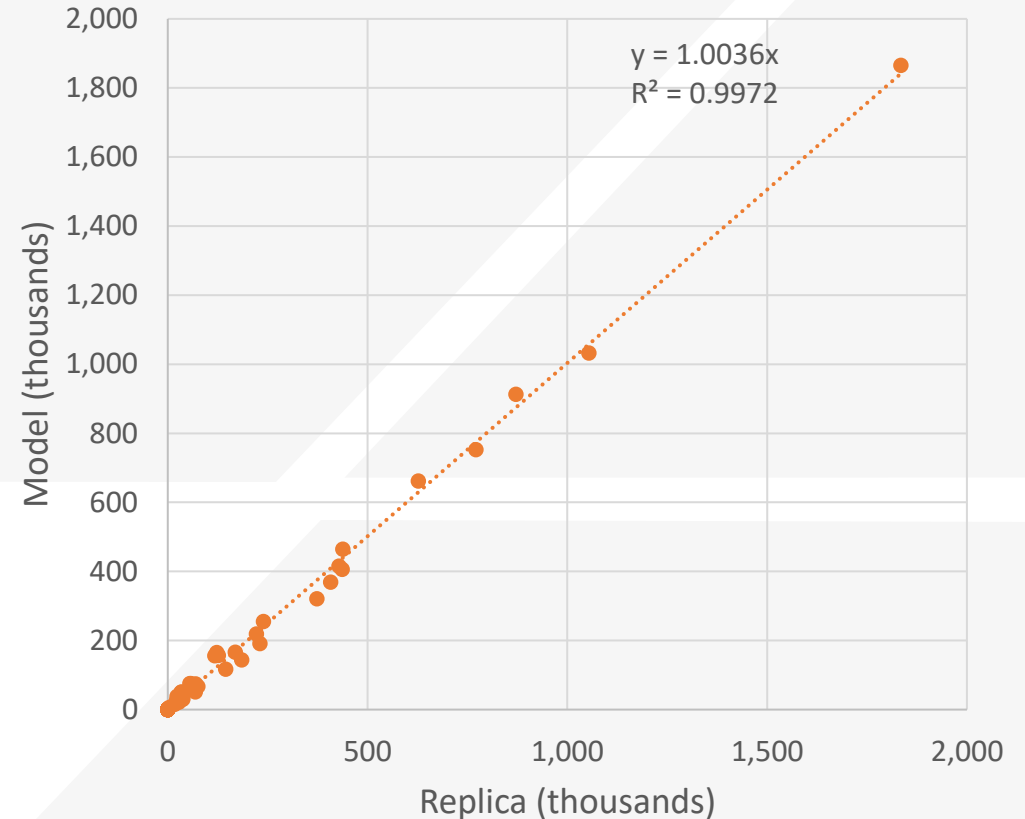
# Comparison to Replica – Trip Generation
## **HBW Trips** for Added Communities
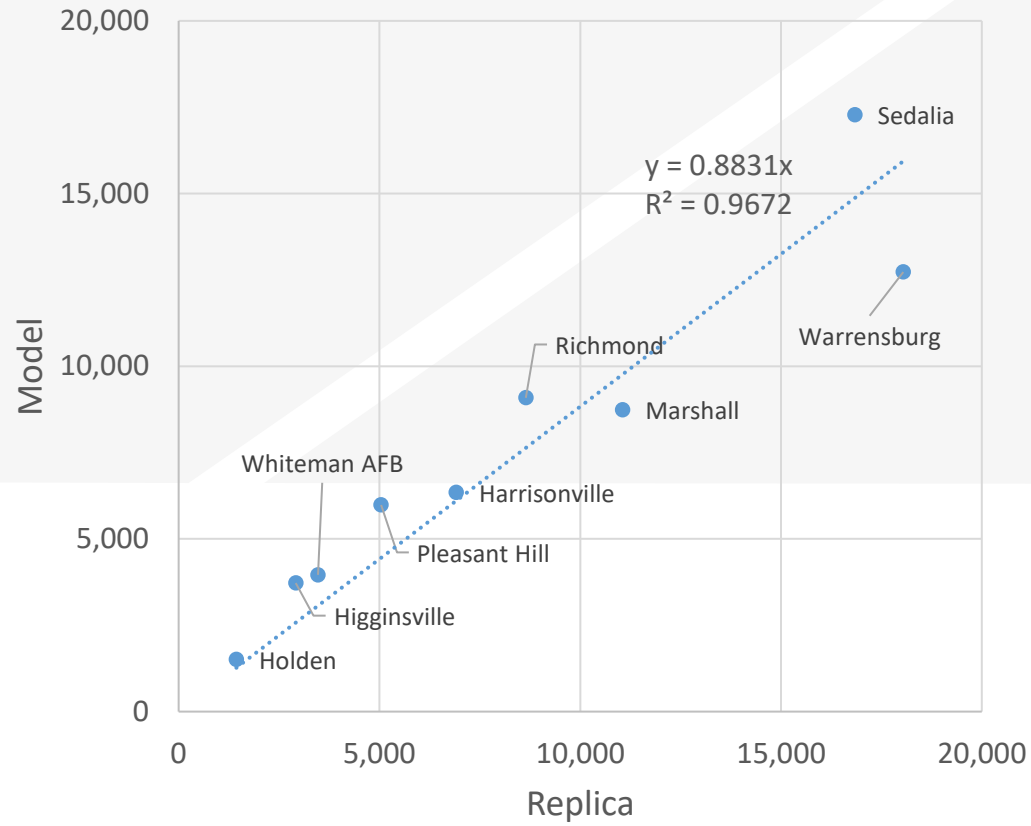


Left chart (Productions):
- y = 0.8831x
- R² = 0.9672
- Data points: Sedalia, Warrensburg, Richmond, Marshall, Whiteman AFB, Harrisonville, Pleasant Hill, Higginsville, Holden
- Axes: Model (y-axis) vs Replica (x-axis)
- Legend: ● Productions ····· Linear (Productions)

Right chart (Attractions):
- y = 0.6361x
- R² = 0.8977
- Data points: Sedalia, Warrensburg, Pleasant Hill, Whiteman AFB, Marshall, Harrisonville, Richmond, Higginsville, Holden
- Axes: Model (y-axis) vs Replica (x-axis)
- Legend: ● Attractions ····· Linear (Attractions)

CAMBRIDGE SYSTEMATICS
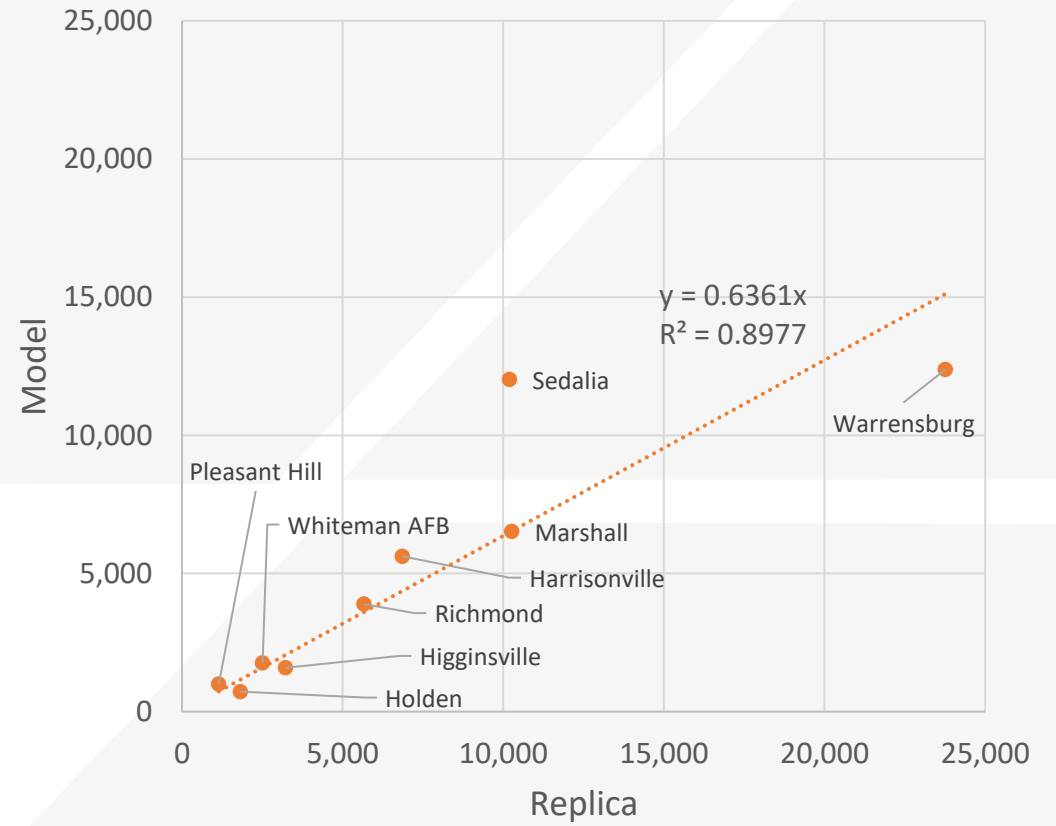
# Comparison to Replica – Trip Generation
## **All Trips** for Added Communities



Left chart — Productions:
y = 0.9487x
R² = 0.9759

Data points: Sedalia, Warrensburg, Richmond, Marshall, Whiteman AFB, Harrisonville, Pleasant Hill, Higginsville, Holden

Axes: Replica (x), Model (y)

Legend: Productions · · · · Linear (Productions)

Right chart — Attractions:
y = 0.7975x
R² = 0.9319

Data points: Pleasant Hill, Richmond, Sedalia, Warrensburg, Marshall, Whiteman AFB, Harrisonville, Higginsville, Holden

Axes: Replica (x), Model (y)
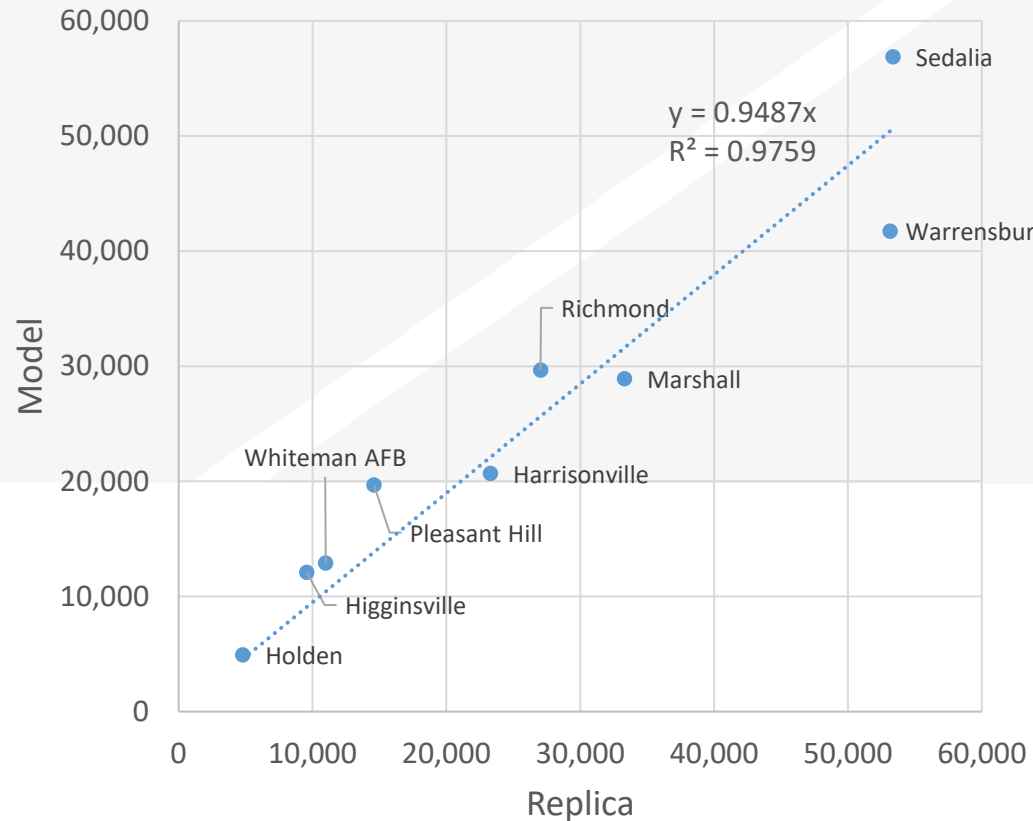
Legend: Attractions · · · · Linear (Attractions)
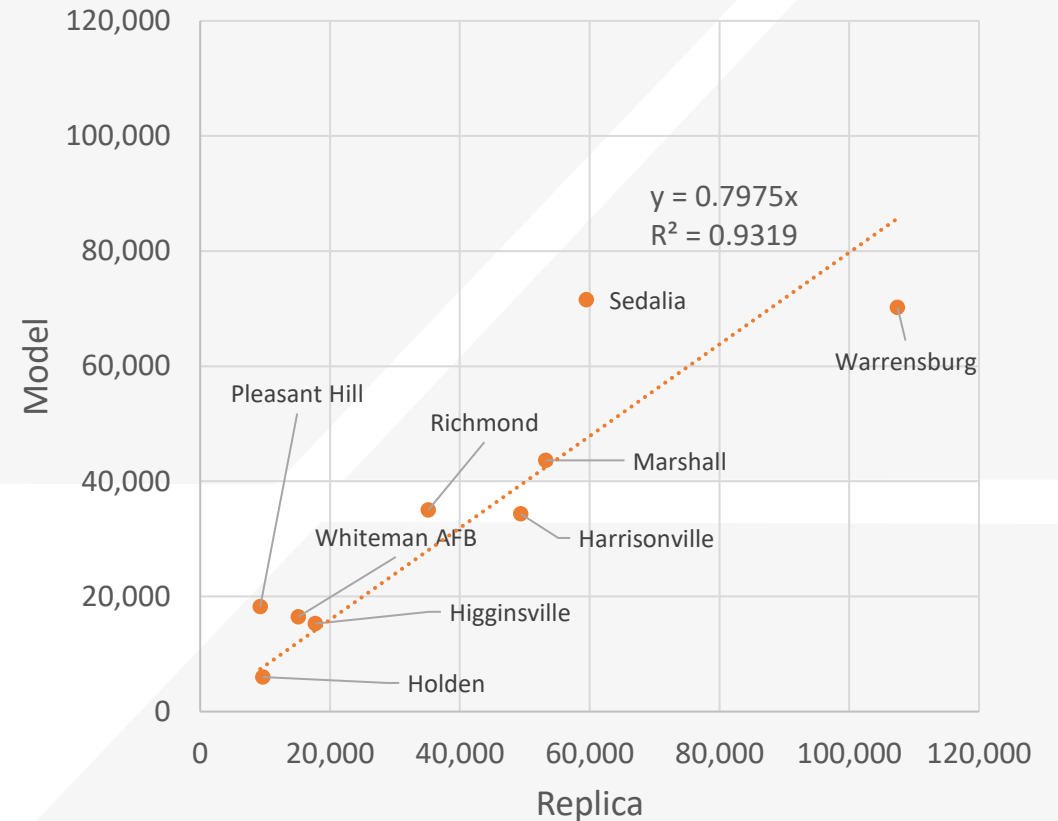
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# What's going on in **Sedalia**?

➤ Too much trip generation?

➤ Traffic counts match quite well

➤ Volumes were too low until we adjusted trip distribution for small communities



Volume (count)
*in thousands*

Model too high

Model about right

Model too low

# What's going on in **Warrensburg**?

- Not enough trip generation?
- Traffic counts match reasonably well
- University of Central Missouri



Volume (count) *in thousands*
Model too high
Model about right
Model too low
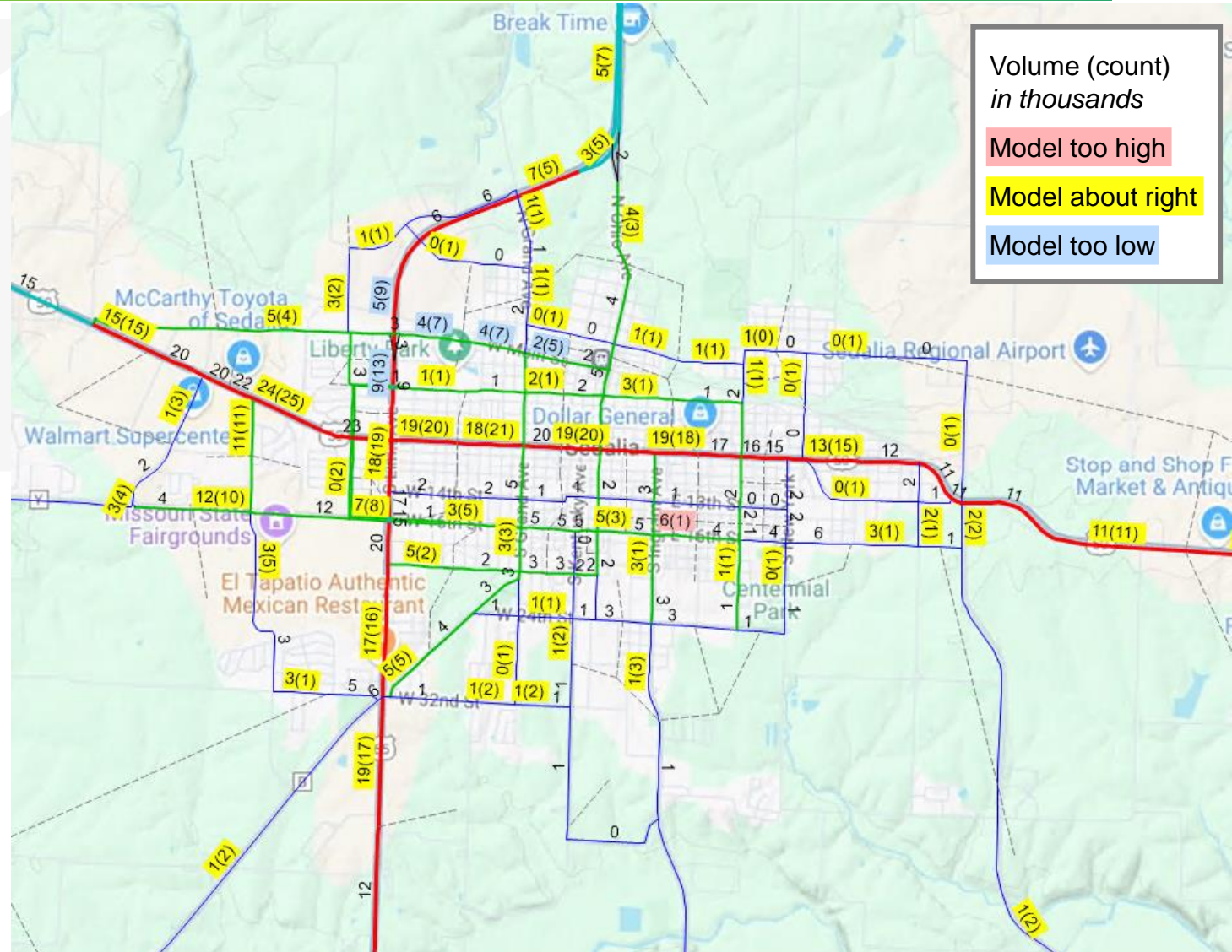
# Trip Distribution Review
# **HBW Trips** in the non-MPO Counties

- ➤ Replica reports home to regular activity

- ➤ Balanced match to counts vs. Replica

- ➤ Matching Replica more closely wouldn't match counts
  - » Too many long / freeway trips
  - » Not enough in-town travel



Trip Distance (miles)

Model  Replica

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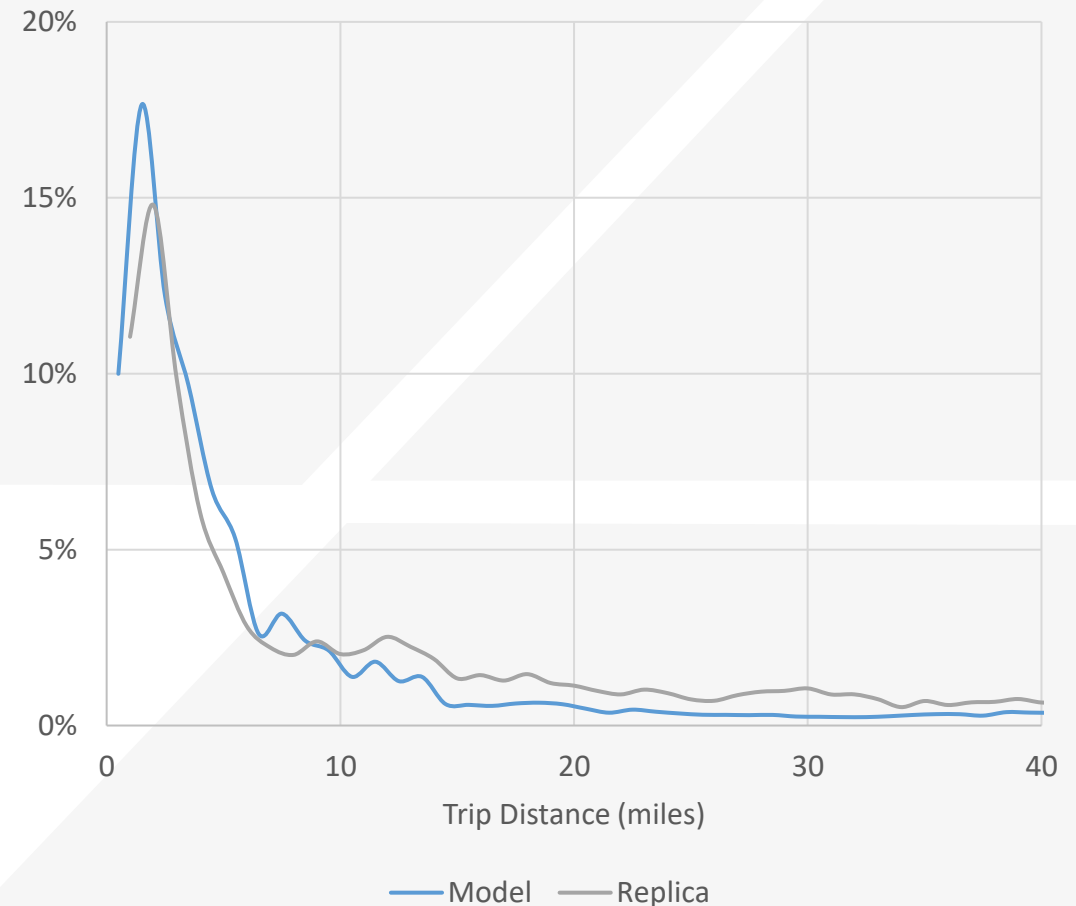
# Trip Distribution Review
## **HBNW Trips** in the non-MPO Counties

- Replica reports home to non-regular activity

- Similar patterns – adjusted trip lengths to better match counts

- Paid particular attention to the old/new boundary

CAMBRIDGE SYSTEMATICS
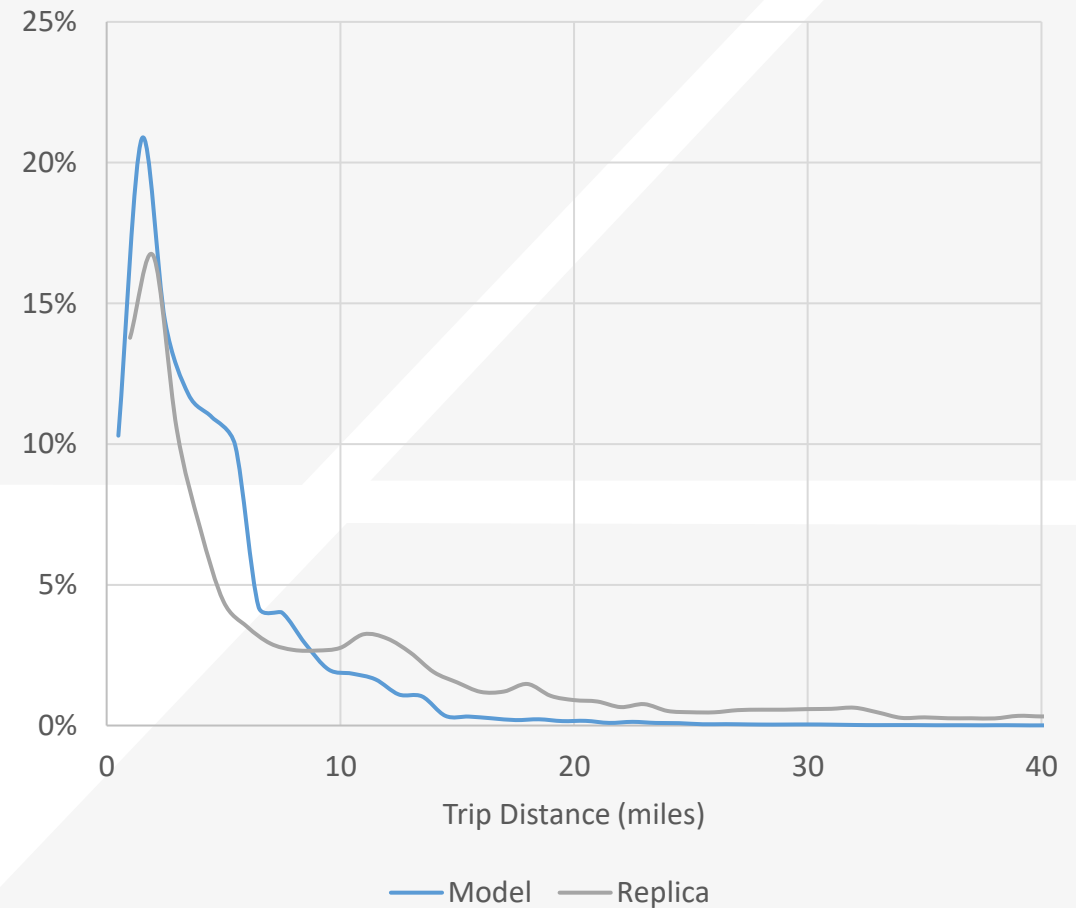
# Trip Distribution Review
# **HBW Trips** for the whole region

➤ Previously validated to Household Survey Data

➤ Compared to Replica and the previous model

➤ Left parameters un-changed for MPO Counties



Trip Distance (miles)

— Model — Replica

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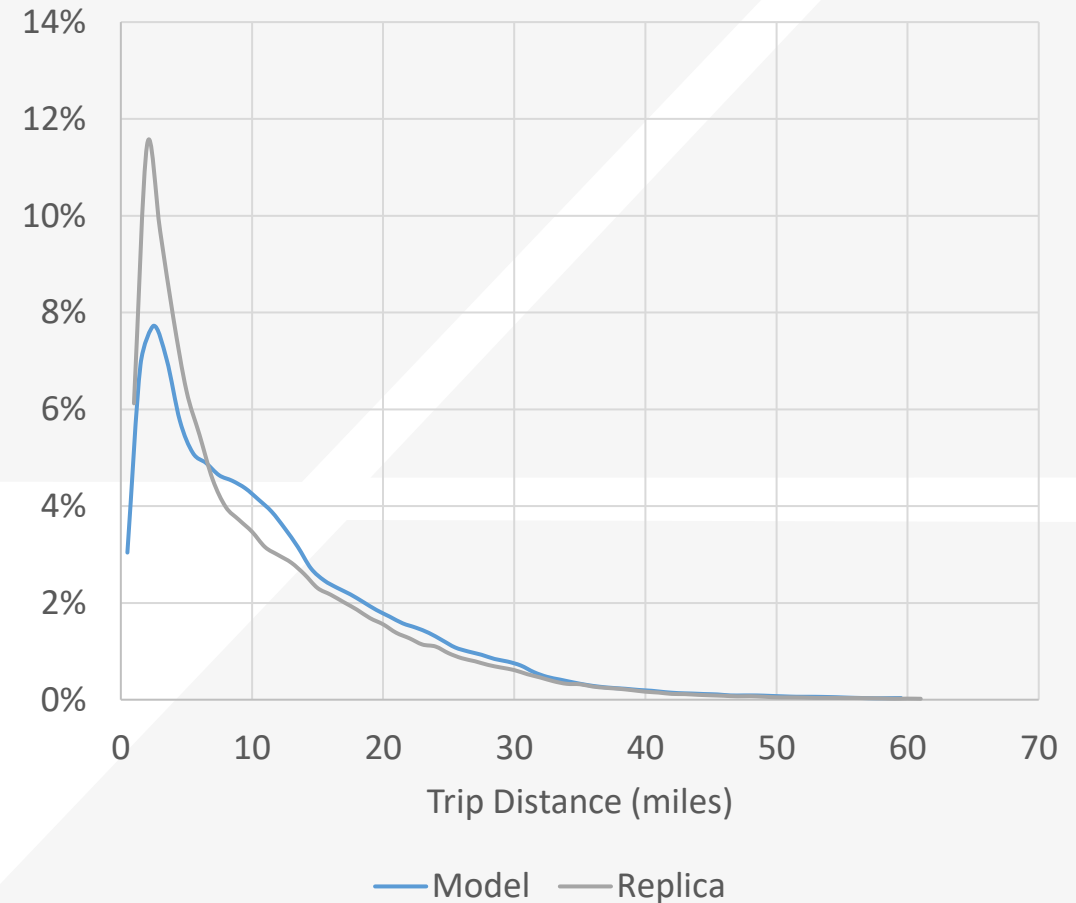
# Mode Choice Review

- Preliminary Calibration
- Pending updates after the latest adjustments
  - » Re-sync MPO transit results to targets
  - » No fixed route service in the expanded counties

| Mode | Target | Model |
|---|---|---|
| DA | 52% | 53% |
| SR | 43% | 40% |
| Auto Subtotal | 95% | 92% |
| Transit | 0.2% | 1.0% |
| Non-Motorized | 5.3% | 6.5% |

# Model Validation Results - Overall

| | VMT /<br>Count VMT | RMSE | % RMSE |
|---|---|---|---|
| Freeway | 98.5% | 6,911 | 19.4% |
| Expressway | 97.3% | 5,143 | 28.6% |
| Principal Arterial | 95.6% | 5,195 | 40.1% |
| Minor Arterial | 99.8% | 4,339 | 52.7% |
| Collector | 117.4% | 2,686 | 96.2% |
| CBD | 96.1% | 4,864 | 43.6% |
| Fringe | 92.0% | 5,737 | 34.3% |
| Urban | 100.9% | 5,017 | 36.2% |
| Suburban | 100.0% | 4,115 | 39.1% |
| Rural | 108.5% | 2,426 | 55.0% |
| **Total** | **99.8%** | **4,436** | **40.3%** |
| **Total*** | **98.1%** | **5,145** | **33.3%** |

*Excluding collectors*

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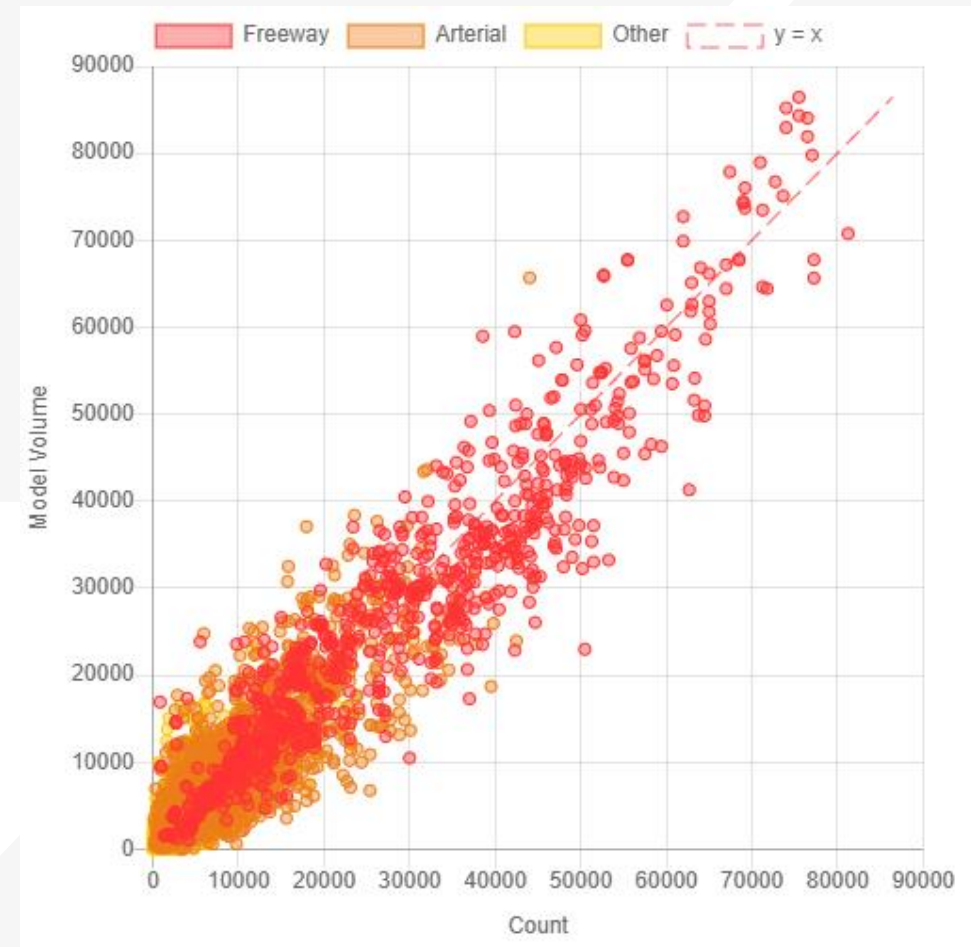
# Model Validation Results - MPO

| | VMT / Count VMT | RMSE | % RMSE |
|---|---|---|---|
| Freeway | 96.8% | 7,074 | 19.2% |
| Expressway | 98.7% | 5,561 | 27.8% |
| Principal Arterial | 95.8% | 5,723 | 39.6% |
| Minor Arterial | 100.2% | 4,595 | 51.3% |
| Collector | 127.0% | 2,984 | 91.4% |
| CBD | 96.1% | 4,864 | 43.6% |
| Fringe | 92.0% | 5,737 | 34.3% |
| Urban | 100.9% | 5,017 | 36.2% |
| Suburban | 100.7% | 4,592 | 36.7% |
| Rural | 113.2% | 2,824 | 54.4% |
| **Total** | **100.1%** | **4,806** | **38.4%** |
| **Total*** | **97.9%** | **5,473** | **32.3%** |

*Excluding collectors*

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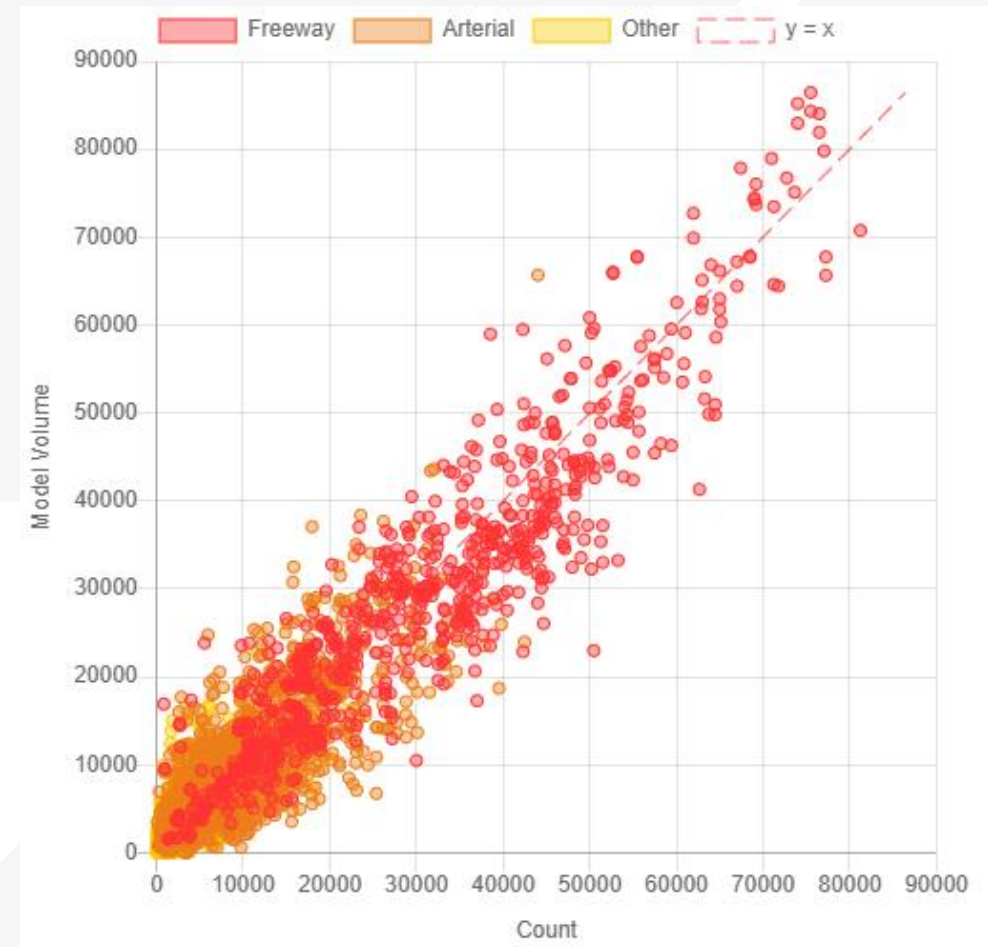
# Model Validation Results - Extended

| VMT / Count | VMT | RMSE | % RMSE |
|---|---|---|---|
| Freeway | 113.9% | 2,818 | 19.5% |
| Expressway | 90.9% | 1,449 | 20.5% |
| Principal Arterial | 94.3% | 2,122 | 30.0% |
| Minor Arterial | 94.6% | 2,151 | 57.8% |
| Collector | 78.2% | 1,300 | 104.7% |
| CBD | -- | -- | -- |
| Fringe | -- | -- | -- |
| Urban | -- | -- | -- |
| **Suburban** | **89.7%** | **2,020** | **46.5%** |
| Rural | **99.7%** | **1,505** | **49.1%** |
| **Total** | **98.2%** | **1,747** | **48.2%** |
| **Total*** | **101.5%** | **2,082** | **35.5%** |

*Excluding collectors*
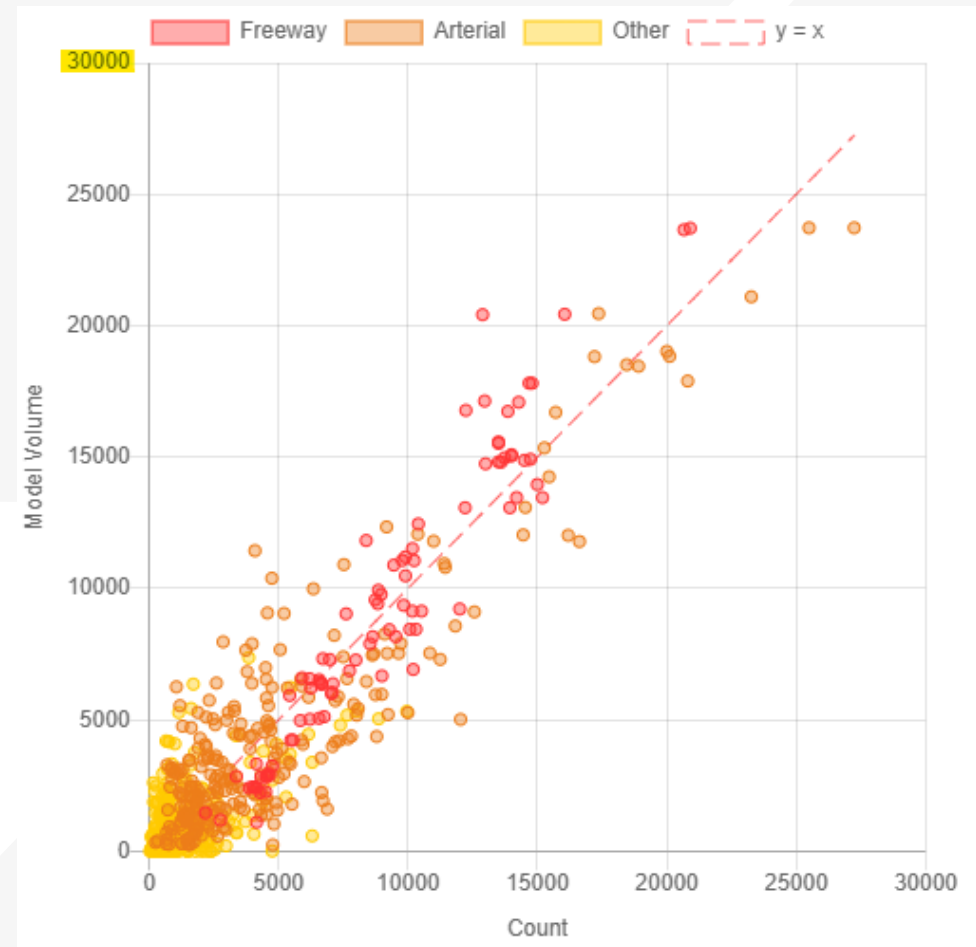
# Model Validation Results – Vs. Previous

| VMT / Count | VMT | RMSE | % RMSE |
|---|---|---|---|
| Freeway | 94.9% | 5,072 | 13.8% |
| Expressway | 98.5% | 2,856 | 14.1% |
| Principal Arterial | 103.3% | 3,338 | 22.1% |
| Minor Arterial | 116.9% | 2,479 | 28.2% |
| Collector | 136.7% | 2,270 | 59.2% |
| CBD | 101.8% | 2,687 | 33.5% |
| Fringe | 97.6% | 2,632 | 24.3% |
| Urban | 102.7% | 2,463 | 24.0% |
| Suburban | 101.9% | 2,567 | 26.3% |
| Rural | 124.6% | 2,380 | 54.1% |
| **Total** | **104.6%** | **2,568** | **27.6%** |

CAMBRIDGE SYSTEMATICS
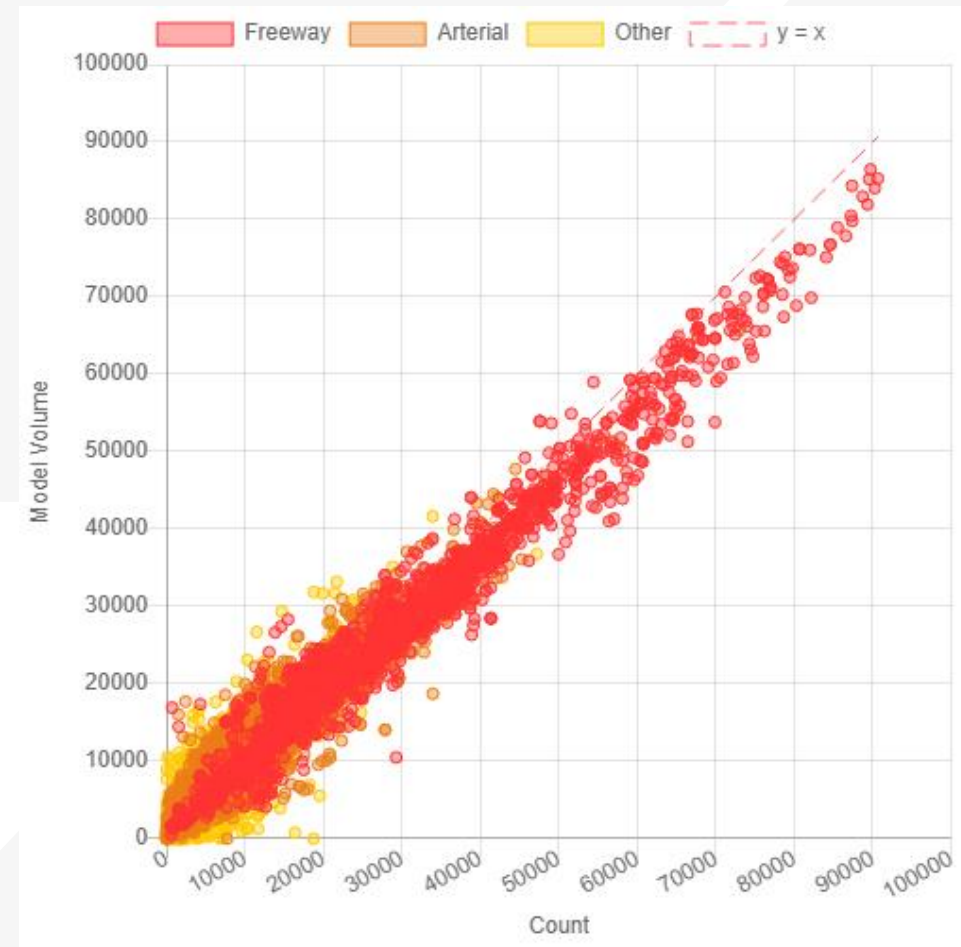
# Sensitivity Test – Forecast Data

- Rough forecast year assumptions

- Base year highway network

- Assume 35% external station growth

- No growth assumed in the expanded counties

| Metric | 2019 | 2050 | % Growth |
|---|---|---|---|
| Households | 891,685 | 1,098,538 | 23% |
| Population | 2,256,735 | 2,622,430 | 16% |
| Employment | 1,113,970 | 1,306,032 | 17% |
| Trips | 9,401,278 | 10,955,953 | 17% |
| Auto Trips | 7,185,629 | 8,547,813 | 19% |
| Truck Trips | 412,937 | 486,874 | 18% |
| Transit Trips | 53,583 | 68,664 | 28% |
| VMT | 60,853,743 | 75,247,221 | 24% |
| VHT | 1,688,291 | 2,309,062 | 37% |

*Preliminary Values – for sensitivity testing only*

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# Sensitivity Test – Road Closure
## Close I-70 just west of Oak Grove

- Remove I-70 and frontage road links
- Traffic diversion seems reasonable
  - » Localized diversion
  - » Longer trip diversion



**— Less Traffic**

**— More Traffic**

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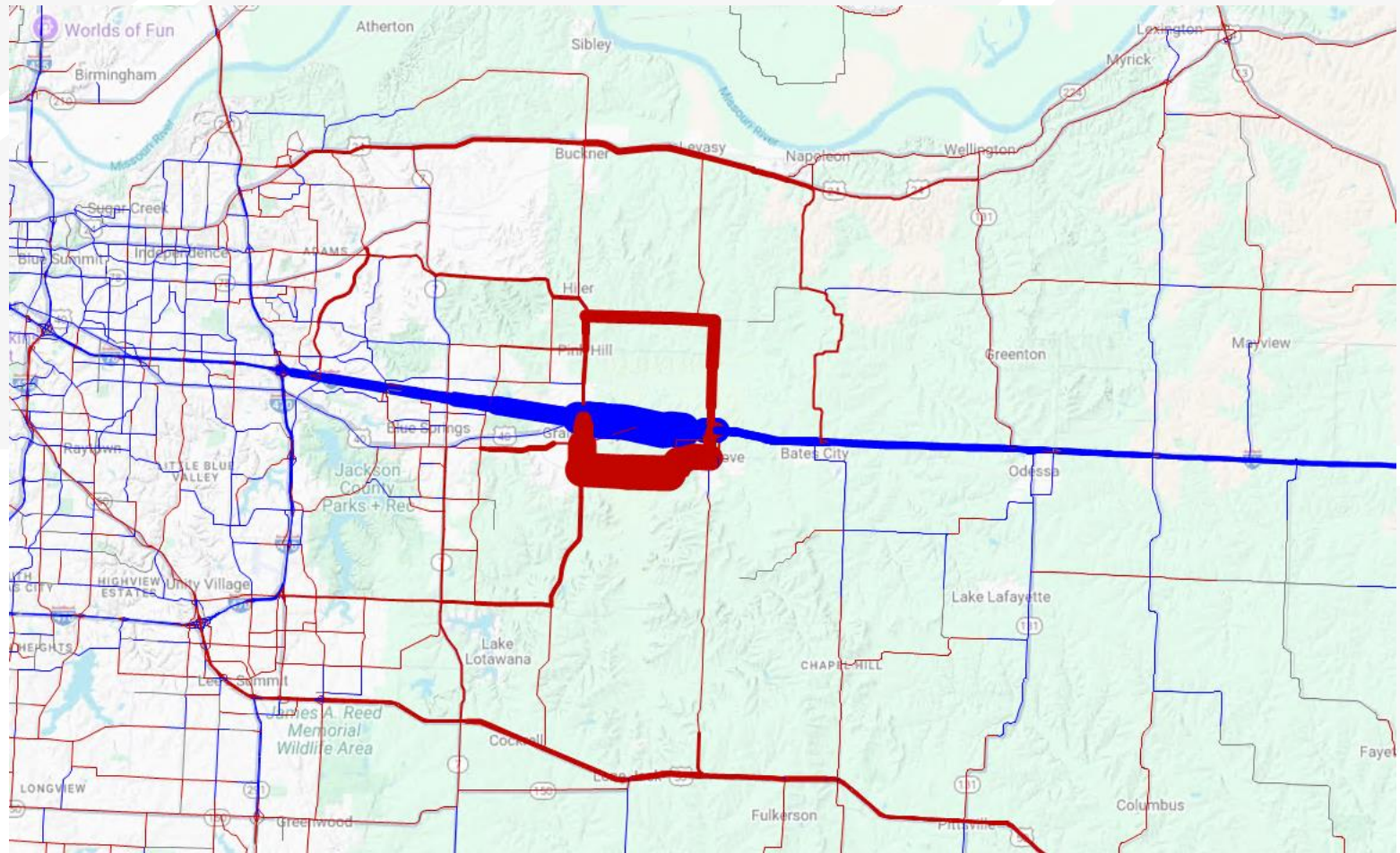
# Status and Schedule

| Task | Status / Schedule |
|------|-------------------|
| Expanded Database Development | Complete |
| External Station Revision | Complete |
| Count Data Processing | Complete |
| Big Data Processing / Review | Complete |
| Expanded Model Implementation | Complete |
| Model Calibration and Validation | Under Review |
| Testing by MARC Staff | Ongoing |
| Initial Release | End of 2024 / Early 2025 |

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# Questions and Discussion

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