QTP
Quality Transport Planning

# NZMUGS Conference 2022

Model Measure $R^2$ Premonitions

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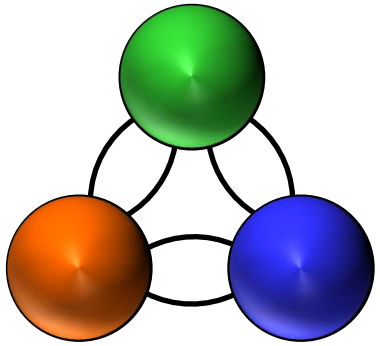

# Disclaimer

- “The views and opinions expressed in this presentation belong solely to the presenter, and do not necessarily reflect the views of the presenter’s employer, NZMUGs, the NZMUGs Committee or any other group or individual.”

# The Story Begins…

- Back in 2014, presented to MUGS on model measures adopted in TMDG and formerly in EEM…
- …Presented an interpretation of three measures, questioned their applicability to model vs count comparisons and suggested some improvements…

# 2014 Presentation Conclusions

- Is GnT a better indicator of potential issues with models than GEH ?
- Is $R^2$ appropriate to our purpose or should this be modified ?
- %RMSE not intuitive and of dubious value. Suggest replacing with %MAD
- Preference is to investigate & document reasons for all significant model vs. data discrepancies prior to and after any ME, rather than focussing on achieving a raft of arbitrary criteria.

# The Story Begins…

- Back in 2
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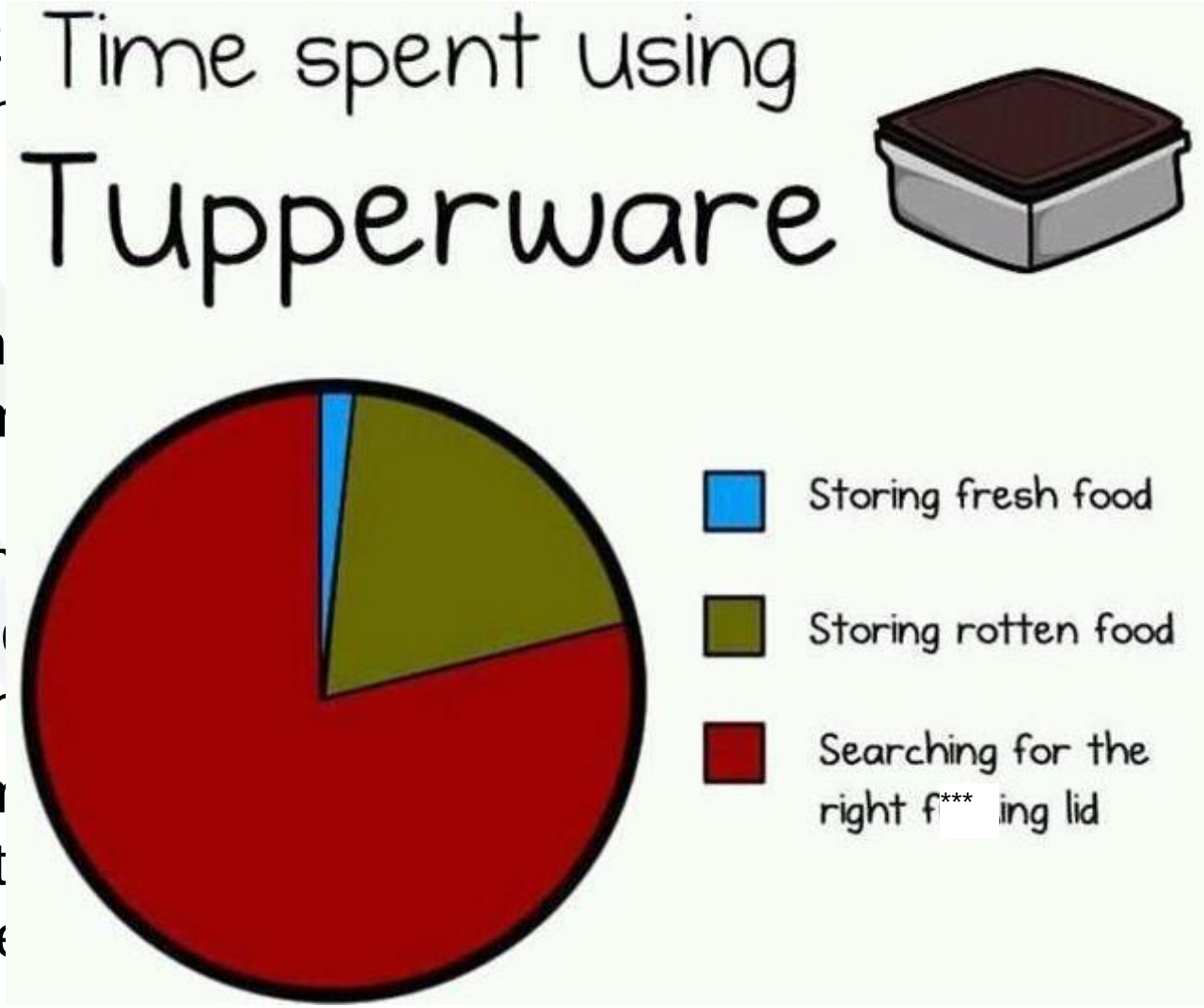
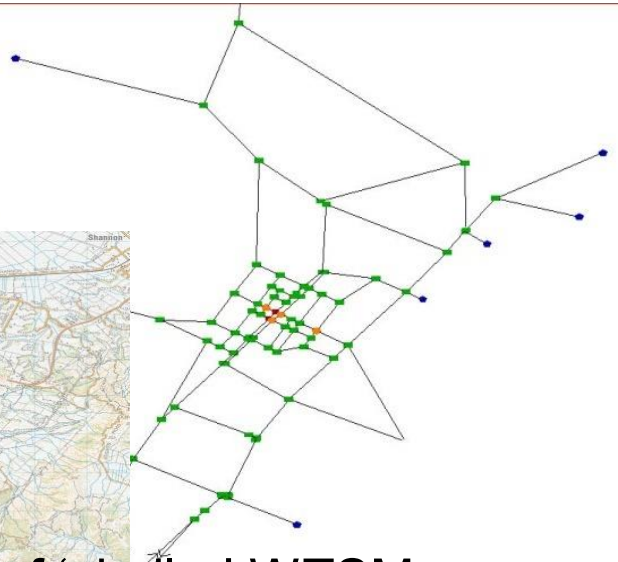


# The Story Continues…



- My first involvement was around 2015…
- …and then between 2016 and 2018 in refining the model…
- Key Features:
  - 3 Step SATURN Model
  - Trip generation based on linear regression of ‘similar’ WTSM zone demands to population, employment types and school role
  - Lights and Heavies Trip Ends estimated separately
  - Trip Distribution based on a simple gravity model
  - Subject to constrained ME
- In mine (and the Peer Reviewer’s) view the enhanced model was generally fit for its intended purpose.

# ….The Twist in the Story

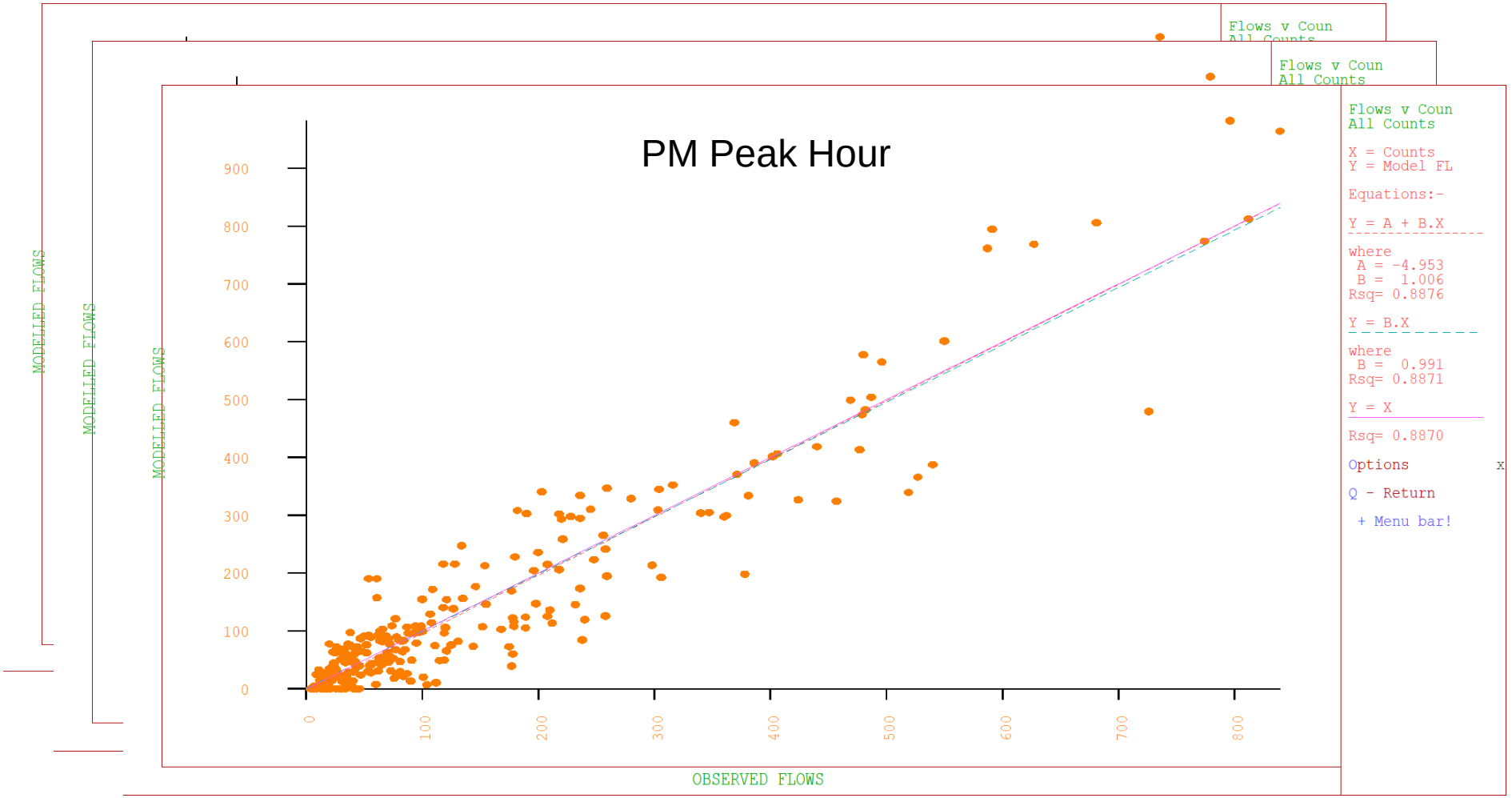
- In 2019, the local authority expressed an interest in further refining the model to be able to apply it for general transport planning purposes within their District
- Hence for the model update in 2020, scope included considering the benefits of segmentation of the demand model to include purpose-based demands

# Non-Segmented Demands

| Period & Direction | Population | Jobs | | | School Roll |
|---|---|---|---|---|---|
| | | Retail | Health | Other | |
| AM_L Frm | 0.12 | 0.77 | 0.34 | 0.21 | 0.16 |
| AM_L To | 0.02 | 1.86 | 0.97 | 0.42 | 0.16 |

- 'Trip Rates' Initially based on linear regression of peak Light & Heavy demands vs demographics for 'similar' WTSM model zones
- Example Trip Rates for **AM Peak Hour**
- Some small adjustments during model validation and consideration of TDB trip rates and other models
- Simple gravity model applied to resulting zonal trip ends
  - Comparison to impedance function parameters used in other models
  - Trip length validation / calibration against very limited MoT HH travel surveys for the District
- Multi-class assignments – Lights (all) & Heavies

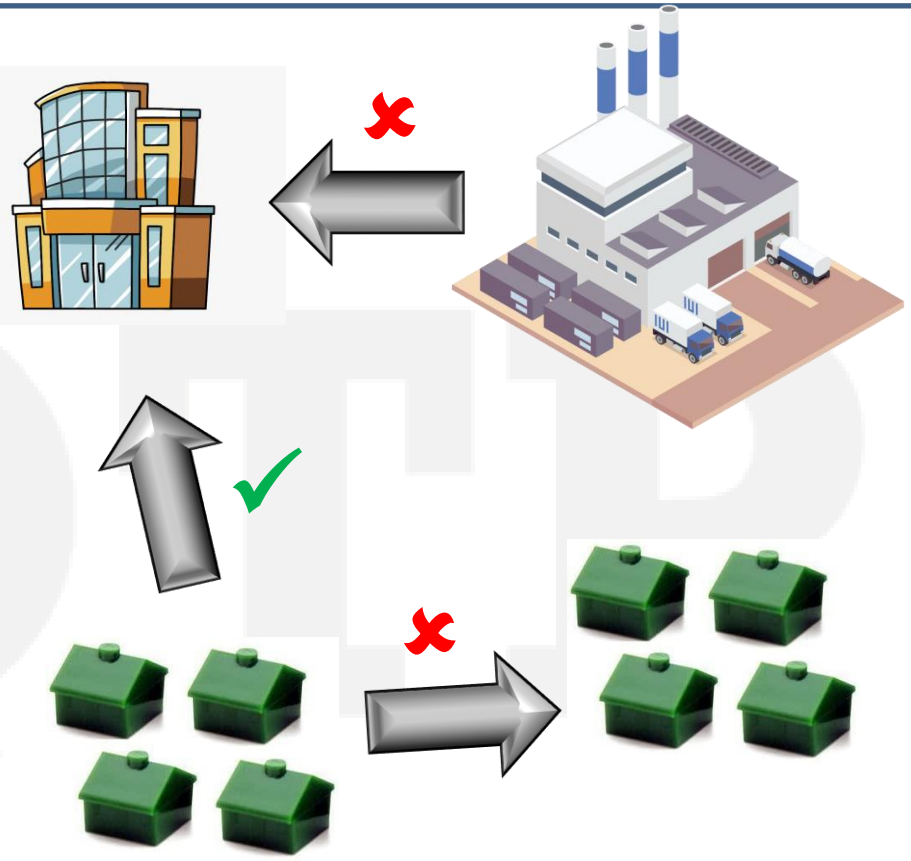
# Non-Segmented Assignments




- Reasonable validation of flows to counts ($R^2$ ~ 0.89)
- Demands subject to subsequent constrained ME

# The Concern…

- Arising from Peer Review, main concern was around trip distribution
- Could, for example, actual location of Home to Work trips (suburbs to CBD) be inaccurately occurring for, say, work to work locations ?
- Could some Home to Work trips be distributed as locations of Home to Home trips ?



# Initial Thinking…

- Highly simplified reflection of Model to consider implications of ‘all-purpose’ light-vehicle trips on trip distribution

**Zone Names**

| | | |
|---|---|---|
| 8 | 1 | 2 |
| 7 | 9 | 3 |
| 6 | 5 | 4 |

**Landuse Types**

| | | |
|---|---|---|
| Res | Res | Low Res |
| Res+Sch | CBD | Retail |
| Industrial | Res | High Res |

**% Population**

| | | |
|---|---|---|
| 15% | 15% | 10% |
| 15% | 1% | 2% |
| 2% | 10% | 30% |

**% Jobs**

| | | |
|---|---|---|
| 2% | 2% | 1% |
| 4% | 60% | 10% |
| 15% | 2% | 4% |

**Trips (AM Lights)**

| | | Trip Rates | | Trips | |
|---|---|---|---|---|---|
| | | From | To | From | To |
| Total Pop | 4000 | 0.13 | 0.03 | 536 | 101 |
| Total Jobs | 1160 | 0.35 | 0.72 | 401 | 835 |
| | | **Totals:** | | **937** | **936** |

**Trip Generation**

| Zone | Pop% | Jobs% | Pop | Jobs | Trips Frm | Trips To |
|---|---|---|---|---|---|---|
| 1 | 15% | 2% | 600 | 23 | 88 | 32 |
| 2 | 10% | 1% | 400 | 12 | 58 | 18 |
| 3 | 2% | 10% | 80 | 116 | 51 | 86 |
| 4 | 30% | 4% | 1200 | 46 | 177 | 64 |
| 5 | 10% | 2% | 400 | 23 | 62 | 27 |
| 6 | 2% | 15% | 80 | 174 | 71 | 127 |
| 7 | 15% | 4% | 600 | 46 | 96 | 49 |
| 8 | 15% | 2% | 600 | 23 | 88 | 32 |
| 9 | 1% | 60% | 40 | 696 | 246 | 502 |
| **Totals:** | **100%** | **100%** | **4000** | **1160** | **937** | **936** |

**Resulting Trips (Furnessed Gravity Model)**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 0 | 1 | 5 | 4 | 1 | 7 | 3 | 2 | 65 | **88** |
| **2** | 2 | 0 | 4 | 3 | 1 | 5 | 2 | 1 | 40 | **58** |
| **3** | 1 | 1 | 0 | 3 | 1 | 4 | 2 | 1 | 39 | **51** |
| **4** | 4 | 3 | 13 | 0 | 4 | 18 | 6 | 4 | 127 | **177** |
| **5** | 1 | 1 | 3 | 3 | 0 | 6 | 2 | 1 | 44 | **62** |
| **6** | 2 | 1 | 4 | 4 | 2 | 0 | 3 | 2 | 54 | **71** |
| **7** | 2 | 1 | 4 | 4 | 2 | 10 | 0 | 3 | 71 | **96** |
| **8** | 2 | 1 | 5 | 4 | 1 | 9 | 4 | 0 | 62 | **88** |
| **9** | 19 | 10 | 49 | 38 | 15 | 69 | 28 | 18 | 0 | **245** |
| **Total:** | **32** | **18** | **86** | **64** | **27** | **127** | **49** | **32** | **502** | **936** |

# Segmentation to Quasi-Purposes

- Trip generation regression analysis identified 5 variables:
  - Population
  - Retail Jobs
  - Health Jobs
  - Other (General) Jobs
  - School Roll
- Why not use these as the basis of trip types or ‘quasi-purposes’ ?
  - Population ~ Home-based trips
  - Retail Jobs ~ Shopping trips (but include employees)
  - Health Jobs ~ all Health-related trips (including employees)
  - General Jobs ~ Work trips (except retail and health workers)
  - School Roll ~ Education trips (excluding employees)

# Segmentation: What We Need

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Estimate Proportions From | | | | | | Total Trip |
| | **AM From** | Home | Work | Shops | Health | Education | **Rate From** |
| | **Home** | ? | ? | ? | ? | ? | **0.12** |
| | **Work** | ? | ? | ? | ? | ? | **0.21** |
| | **Shops** | ? | ? | ? | ? | ? | **0.77** |
| | **Health** | ? | ? | ? | ? | ? | **0.34** |
| | **Education** | ? | ? | ? | ? | ? | **0.16** |
| | | | | | | | |
| | Estimate Proportions To | | | | | | |
| | **AM To** | **Home** | **Work** | **Shops** | **Health** | **Education** | |
| | Home | ? | ? | ? | ? | ? | |
| | Work | ? | ? | ? | ? | ? | |
| | Shops | ? | ? | ? | ? | ? | |
| | Health | ? | ? | ? | ? | ? | |
| | Education | ? | ? | ? | ? | ? | |
| | | | | | | | |
| **Total Trip Rate To:** | | **0.02** | **0.42** | **1.86** | **0.97** | **0.16** | |

# Segmentation: Constrained Guesstimates

Estimate Proportions From

| AM From | Home | Work | Shops | Health | Educ'n | | Tot |
|---|---|---|---|---|---|---|---|
| **Home** | 5% | 50% | 15% | 10% | 20% | 100% | **0.12** |
| **Work** | 19% | 50% | 15% | 15% | 1% | 100% | **0.21** |
| **Shops** | 4% | 45% | 45% | 5% | 1% | 100% | **0.77** |
| **Health** | 28% | 35% | 1% | 35% | 1% | 100% | **0.34** |
| **Educ'n** | 10% | 50% | 20% | 10% | 10% | 100% | **0.16** |

Initial Trips Based on Froms

| | Home | Work | Shops | Health | Educ'n | Tot |
|---|---|---|---|---|---|---|
| | 151 | 1514 | 454 | 303 | 605 | **3027** |
| | 278 | 731 | 219 | 219 | 15 | **1462** |
| | 23 | 263 | 263 | 29 | 6 | **584** |
| | 94 | 118 | 3 | 118 | 3 | **337** |
| | 49 | 247 | 99 | 49 | 49 | **494** |
| | 596 | 2872 | 1038 | 719 | 679 | **5904** |

Estimate Proportions To

| AM To | Home | Work | Shops | Health | Education |
|---|---|---|---|---|---|
| Home | 20% | 55% | 44% | 50% | 87% |
| Work | 50% | 20% | 25% | 20% | 1% |
| Shops | 5% | 10% | 20% | 5% | 1% |
| Health | 15% | 5% | 1% | 15% | 1% |
| Educ'n | 10% | 10% | 10% | 10% | 10% |
| | 100% | 100% | 100% | 100% | 100% |
| **Tot** | **0.02** | **0.42** | **1.86** | **0.97** | **0.16** |

Initial Trips Based on To's

| | Home | Work | Shops | Health | Educ'n | |
|---|---|---|---|---|---|---|
| | 114 | 1592 | 618 | 479 | 429 | 3233 |
| | 284 | 579 | 351 | 192 | 5 | 1412 |
| | 28 | 290 | 281 | 48 | 5 | 652 |
| | 85 | 145 | 14 | 144 | 5 | 393 |
| | 57 | 290 | 141 | 96 | 49 | 632 |
| **Tot** | **569** | **2895** | **1406** | **959** | **494** | **6322** |

# Segmentation – "Bung it in the Furness"

Estimate Proportions From

| AM From | Home | Work | Shops | Health | Educ'n | |
|---|---|---|---|---|---|---|
| **Home** | 5% | 50% | 15% | 10% | 20% | 100% |
| **Work** | 19% | 50% | 15% | 15% | 1% | 100% |
| **Shops** | 4% | 45% | 45% | 5% | 1% | 100% |
| **Health** | 28% | 35% | 1% | 35% | 1% | 100% |
| **Educ'n** | 10% | 50% | 20% | 10% | 10% | 100% |

Post-Furness Proportions From

| AM From | Home | Work | Shops | Health | Educ'n | |
|---|---|---|---|---|---|---|
| **Home** | 4% | 49% | 19% | 14% | 14% | 100% |
| **Work** | 18% | 44% | 22% | 16% | 1% | 100% |
| **Shops** | 4% | 42% | 47% | 7% | 1% | 100% |
| **Health** | 23% | 34% | 3% | 39% | 1% | 100% |
| **Educ'n** | 9% | 46% | 24% | 14% | 7% | 100% |

Estimate Proportions To

| AM To | Home | Work | Shops | Health | Educ'n |
|---|---|---|---|---|---|
| Home | 20% | 55% | 44% | 50% | 87% |
| Work | 50% | 20% | 25% | 20% | 1% |
| Shops | 5% | 10% | 20% | 5% | 1% |
| Health | 15% | 5% | 1% | 15% | 1% |
| Educ'n | 10% | 10% | 10% | 10% | 10% |
| | 100% | 100% | 100% | 100% | 100% |

Post-Furness Proportions To

| AM To | Home | Work | Shops | Health | Educ'n |
|---|---|---|---|---|---|
| Home | 23% | 55% | 45% | 48% | 89% |
| Work | 50% | 24% | 24% | 26% | 2% |
| Shops | 4% | 9% | 21% | 4% | 1% |
| Health | 15% | 4% | 1% | 15% | 1% |
| Educ'n | 8% | 8% | 9% | 8% | 8% |
| | 100% | 100% | 100% | 100% | 100% |

# Resulting Quasi-Purpose Trip Rates

| Furnessed Segmented Trip Rates | | | | | | |
|---|---|---|---|---|---|---|
| **AM From** | Home | Work | Shops | Health | Education | |
| **Home** | 0.005 | 0.061 | 0.024 | 0.018 | 0.017 | **0.12** |
| **Work** | 0.038 | 0.092 | 0.046 | 0.033 | 0.001 | **0.21** |
| **Shops** | 0.029 | 0.321 | 0.365 | 0.051 | 0.005 | **0.77** |
| **Health** | 0.078 | 0.117 | 0.009 | 0.133 | 0.003 | **0.34** |
| **Educatio** | 0.014 | 0.074 | 0.038 | 0.023 | 0.011 | **0.16** |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **AM To** | **Home** | **Work** | **Shops** | **Health** | **Education** | |
| Home | 0.005 | 0.229 | 0.834 | 0.459 | 0.143 | |
| Work | 0.012 | 0.099 | 0.454 | 0.247 | 0.003 | |
| Shops | 0.001 | 0.038 | 0.391 | 0.042 | 0.001 | |
| Health | 0.003 | 0.018 | 0.013 | 0.143 | 0.001 | |
| Educatior | 0.002 | 0.035 | 0.166 | 0.076 | 0.012 | |
| | **0.02** | **0.42** | **1.86** | **0.97** | **0.16** | |

# Quasi-Purpose Os and Ds

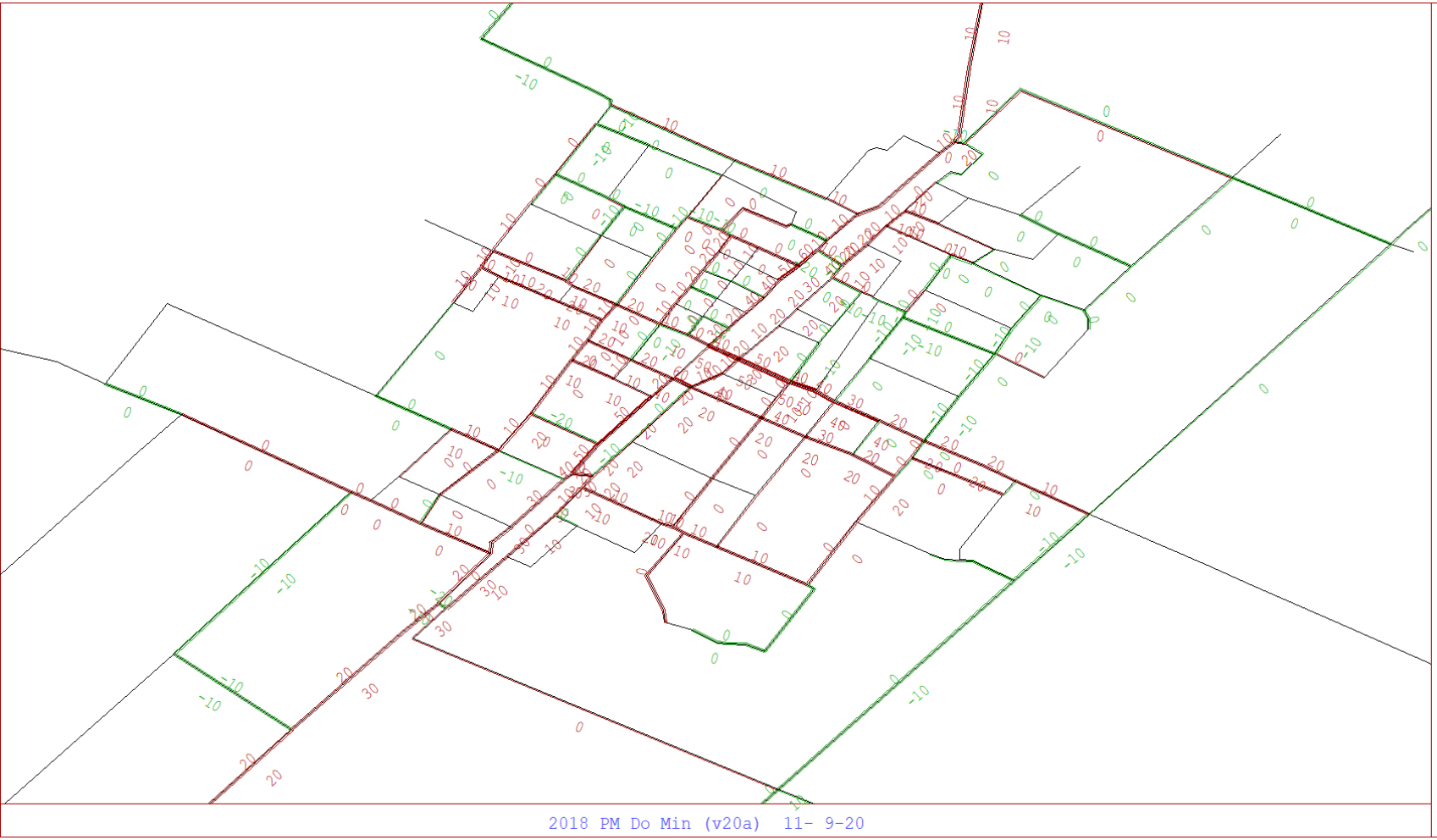
| Purpose: | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | | 11 | | 12 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone | HH_O | HH_D | HW_O | HW_D | HS_O | HS_D | HL_O | HL_D | HE_O | HE_D | WH_O | WH_D | WW_O | WW_D | WS_O | WS_D | WL_O | WL_D | WE_O | WE_D | SH_O | SH_D | SW_O | SW_D |
| 8 | 4 | 5 | 42 | 58 | 17 | 23 | 12 | 17 | 12 | 16 | 8 | 11 | 19 | 26 | 9 | 13 | 7 | 9 | 0 | 0 | 1 | 1 | 7 | 10 |
| 9 | 3 | 2 | 33 | 24 | 13 | 10 | 10 | 7 | 9 | 7 | 6 | 5 | 15 | 11 | 7 | 5 | 5 | 4 | 0 | 0 | 1 | 0 | 6 | 4 |
| 10 | 3 | 2 | 33 | 25 | 13 | 10 | 9 | 7 | 9 | 7 | 6 | 5 | 15 | 11 | 7 | 6 | 5 | 4 | 0 | 0 | 1 | 0 | 6 | 4 |
| 11 | 5 | 5 | 61 | 38 | 24 | 11 | 17 | 0 | 17 | 0 | 6 | 12 | 15 | 16 | 8 | 6 | 6 | 0 | 0 | 0 | 0 | 1 | 4 | 6 |
| 12 | 2 | 2 | 21 | 12 | 8 | 0 | 6 | 0 | 6 | 0 | 2 | 4 | 5 | 5 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 13 | 1 | 1 | 9 | 9 | 4 | 0 | 3 | 0 | 3 | 0 | 2 | 2 | 4 | 4 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 16 | 1 | 1 | 11 | 17 | 4 | 0 | 3 | 0 | 3 | 0 | 3 | 2 | 7 | 7 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 21 | 1 | 1 | 10 | 7 | 4 | 0 | 3 | 0 | 3 | 0 | 1 | 2 | 3 | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 23 | 1 | 1 | 7 | 8 | 3 | 0 | 2 | 0 | 2 | 0 | 1 | 1 | 3 | 4 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 24 | 0 | 1 | 6 | 7 | 2 | 0 | 2 | 0 | 2 | 0 | 1 | 1 | 3 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 26 | 1 | 1 | 10 | 74 | 4 | 0 | 3 | 0 | 3 | 0 | 13 | 2 | 30 | 32 | 15 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| 27 | 1 | 1 | 10 | 12 | 4 | 0 | 3 | 0 | 3 | 0 | 2 | 2 | 5 | 5 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 32 | 2 | 3 | 30 | 47 | 12 | 0 | 9 | 0 | 8 | 44 | 8 | 6 | 19 | 20 | 9 | 0 | 7 | 0 | 0 | 1 | 0 | 0 | 0 | 8 |
| 34 | 2 | 2 | 23 | 23 | 9 | 0 | 7 | 0 | 6 | 0 | 4 | 4 | 9 | 10 | 5 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 49 | 1 | 1 | 11 | 23 | 4 | 49 | 3 | 42 | 3 | 0 | 4 | 2 | 9 | 10 | 5 | 27 | 3 | 22 | 0 | 0 | 2 | 0 | 19 | 4 |
| 482 | 2 | 2 | 28 | 4 | 11 | 0 | 8 | 0 | 8 | 0 | 1 | 5 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 483 | 1 | 1 | 16 | 4 | 7 | 0 | 5 | 15 | 5 | 0 | 1 | 3 | 2 | 2 | 1 | 0 | 1 | 8 | 0 | 0 | 0 | 0 | 0 | 1 |
| 511 | 1 | 1 | 8 | 7 | 3 | 0 | 2 | 6 | 2 | 0 | 1 | 2 | 3 | 3 | 1 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 1 |
| 512 | 1 | 1 | 15 | 3 | 6 | 0 | 4 | 16 | 4 | 0 | 1 | 3 | 1 | 1 | 1 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 513 | 2 | 2 | 21 | 22 | 8 | 0 | 6 | 0 | 6 | 0 | 4 | 4 | 9 | 9 | 4 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 521 | 1 | 1 | 13 | 13 | 5 | 0 | 4 | 0 | 4 | 0 | 2 | 2 | 5 | 6 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 522 | 1 | 1 | 14 | 0 | 5 | 0 | 4 | 0 | 4 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 531 | 2 | 2 | 19 | 0 | 8 | 0 | 6 | 0 | 5 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 532 | 1 | 2 | 17 | 0 | 7 | 0 | 5 | 0 | 5 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 541 | 1 | 1 | 7 | 37 | 3 | 0 | 2 | 0 | 2 | 85 | 6 | 1 | 15 | 16 | 8 | 0 | 5 | 0 | 0 | 2 | 0 | 0 | 0 | 6 |
| 542 | 3 | 3 | 33 | 8 | 13 | 0 | 10 | 20 | 9 | 0 | 1 | 6 | 3 | 3 | 2 | 0 | 1 | 11 | 0 | 0 | 0 | 1 | 0 | 1 |
| 543 | 1 | 1 | 11 | 2 | 4 | 0 | 3 | 0 | 3 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 544 | 3 | 3 | 35 | 2 | 14 | 0 | 10 | 0 | 10 | 0 | 0 | 7 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 551 | 1 | 1 | 15 | 38 | 6 | 0 | 4 | 25 | 4 | 0 | 6 | 3 | 15 | 16 | 8 | 0 | 5 | 13 | 0 | 0 | 0 | 0 | 0 | 6 |
| 552 | 1 | 1 | 12 | 5 | 5 | 11 | 3 | 75 | 3 | 0 | 1 | 2 | 2 | 2 | 1 | 6 | 1 | 40 | 0 | 0 | 0 | 0 | 4 | 1 |
| 553 | 2 | 3 | 28 | 7 | 11 | 0 | 8 | 0 | 8 | 0 | 1 | 5 | 3 | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 554 | 5 | 6 | 66 | 5 | 26 | 0 | 19 | 0 | 18 | 30 | 1 | 13 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| Total: | **123** | **131** | **1,479** | **1,583** | **589** | **631** | **425** | **456** | **411** | **440** | **266** | **285** | **638** | **683** | **321** | **344** | **229** | **245** | **8** | **9** | **22** | **24** | **243** | **260** |
| Scale To: | **127** | | **1,479** | | **589** | | **425** | | **411** | | **285** | | **661** | | **332** | | **237** | | **8** | | **24** | | **252** | |

# Lots of Demand Matrices

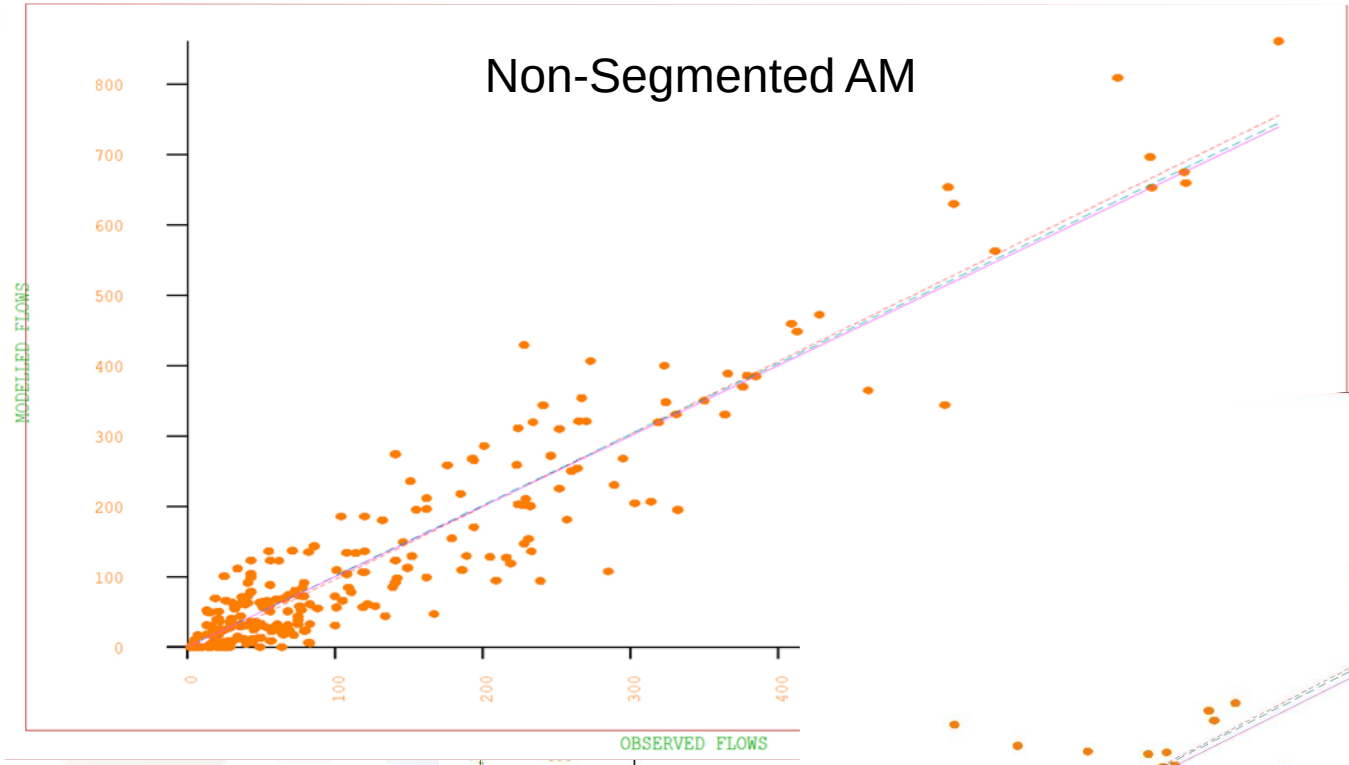
# Assignment

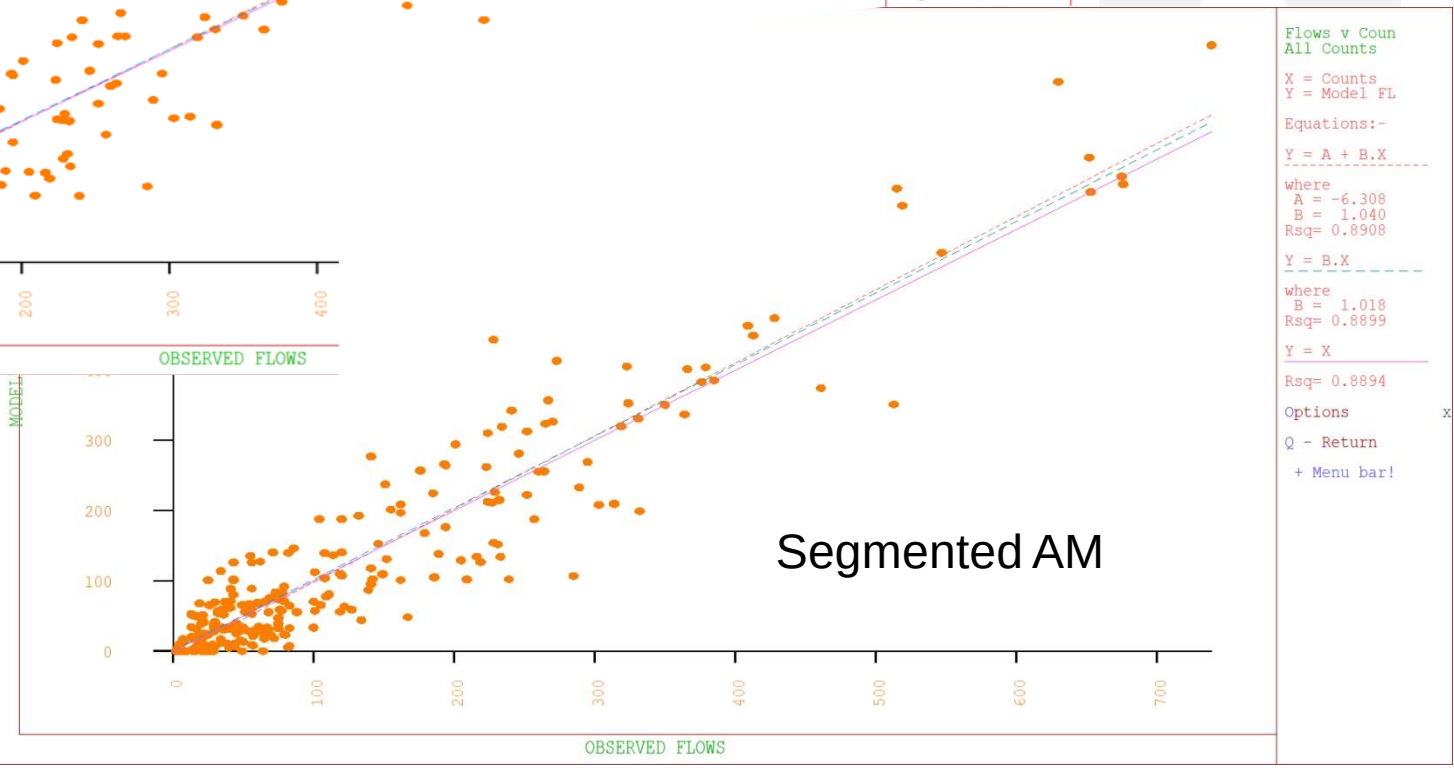
- All 26 light vehicle matrices summed post-distribution
- 2 Heavy matrices (internals and externals) summed post distribution
- Summed Light and Heavies assigned separately, as per original single-purpose demand matrices

# Effects of Demand Segmentation on Assigned Traffic (in Kiwiville)



# Effects of Demand Segmentation on Flow Validation




| Period | Non-Segmented | Segmented |
|---|---|---|
| AM | 0.888 | 0.889 |
| IP | 0.894 | 0.901 |
| PM | 0.887 | 0.899 |

# Summing-Up

- Models based on period-level trip rates applied to simplified demographic variables can provide reasonably accurate demand estimates, suitable as an input to a constrained ME process to forecast demands and network flows
- There is potential for some inaccuracies in trip distribution, dependent on the geographical and demographic nature of the model
- Subsequent segmentation of the trips to Quasi-Purposes can overcome such limitations
- In some ways, this bottom-up approach has an advantage over traditional models as there is greater control in the trip distribution over a larger number of trip types for each model period, meaning trip tours are implicitly modelled

# Summing-Up (Continued, your Honour)

- The bottom-up approach also has the benefits of:
  - not having to deal with unintuitive concept of productions and attractions
  - No directionality factoring of Ps&As to Os&Ds (inaccuracies)
  - No period factoring from daily to period levels (inaccuracies)
- In-practice, the effects of segmentation for this test-case have been shown to have a very modest impact on modelled flow accuracy
- However, the segmentation approach is considered worth pursuing as intuitively it should result in improved trip distribution and lower risk of inaccurate trip distribution in some circumstances
- The relative simplicity and intuitive nature of this bottom-up approach to developing trip generation and distribution models is considered worthy of consideration for other model-builds

# The End.

Bottoms Up to Quasi-Purposes

Tim Wright