Transit Modeling Update

presented to

MTF Transit & Rail Committee

presented by

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Objectives

- Improve the preparation of transit demand forecasts in Florida to a point consistent with federal expectations
- Incorporate state of the practice techniques and tools in FSUTMS through a prototype model application

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Transit Working Group

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Presentation Overview

- Project Overview
- PT Improvements
- Model Design and Development Guidelines
  - Auto Ownership and Trip Generation Model
  - Time of Day Segmentation
  - Trip Distribution Model
  - Transit Network Coding & Path Building
  - Mode Choice Model
- Prototype Application
- Concluding Remarks & Discussion

Project Overview

- On-Board Rider Survey – Synthesis of Practice
- Model Design & Development Guidelines
- Principles of Model Calibration and Validation
- Use of User Benefits Analysis Tools
- New Starts: Building a Case for the Project

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On-Board Rider Survey Synthesis of Practice

- Understanding Markets
- Build on FTA Guidelines
- Topics
  - Fielding Surveys
    - Self Administered
  - Selected Data Items – Lessons Learned
  - Expansion Methodologies
  - Emerging Use of APC Data
  - File Manipulation & Preparation
  - Survey Assignment

Principles of Model Calibration and Validation

- Transit Travel Time Functions
- Upper Level Model Influences
- Model Assessment
- Model Calibration
- Forecasting Testing
- Documentation Recommendations

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User Benefit Analysis Tools

- User Benefit Analysis Guidelines
  - Builds upon SUMMIT Program User's Guide
- UserbenC Program
- Quality Control Guidelines & Procedures
  - Basic Quality Control Comparisons
  - Standard SUMMIT Outputs
  - Understanding Service Level Changes
  - Capped Benefits
  - Understanding the Source of User Benefits
  - User Benefits per Project Trip

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Case for the Project Workshop

- Pilot held in Miami – November 15th and 16th
- 12 Sessions
  - Including 3 Mini-Workshops for Participants
- Framing the Benefits of the Project
  - Important Principles
  - Example Test Cases
  - Uncertainty Analysis
  - Defining the Problem
  - Implications for Practice
- Next Offering – May 2012 in Orlando

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Transit Modeling Update

NEW PT FEATURES IN CUBE VOYAGER 6.0

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New PT Features in Cube Voyager 6.0

- Enhanced Drive-Access Generation
- Enhanced Fares along with BestPathOnly
- Enhanced Transit Line Keywords

Enhanced Drive-Access Generation

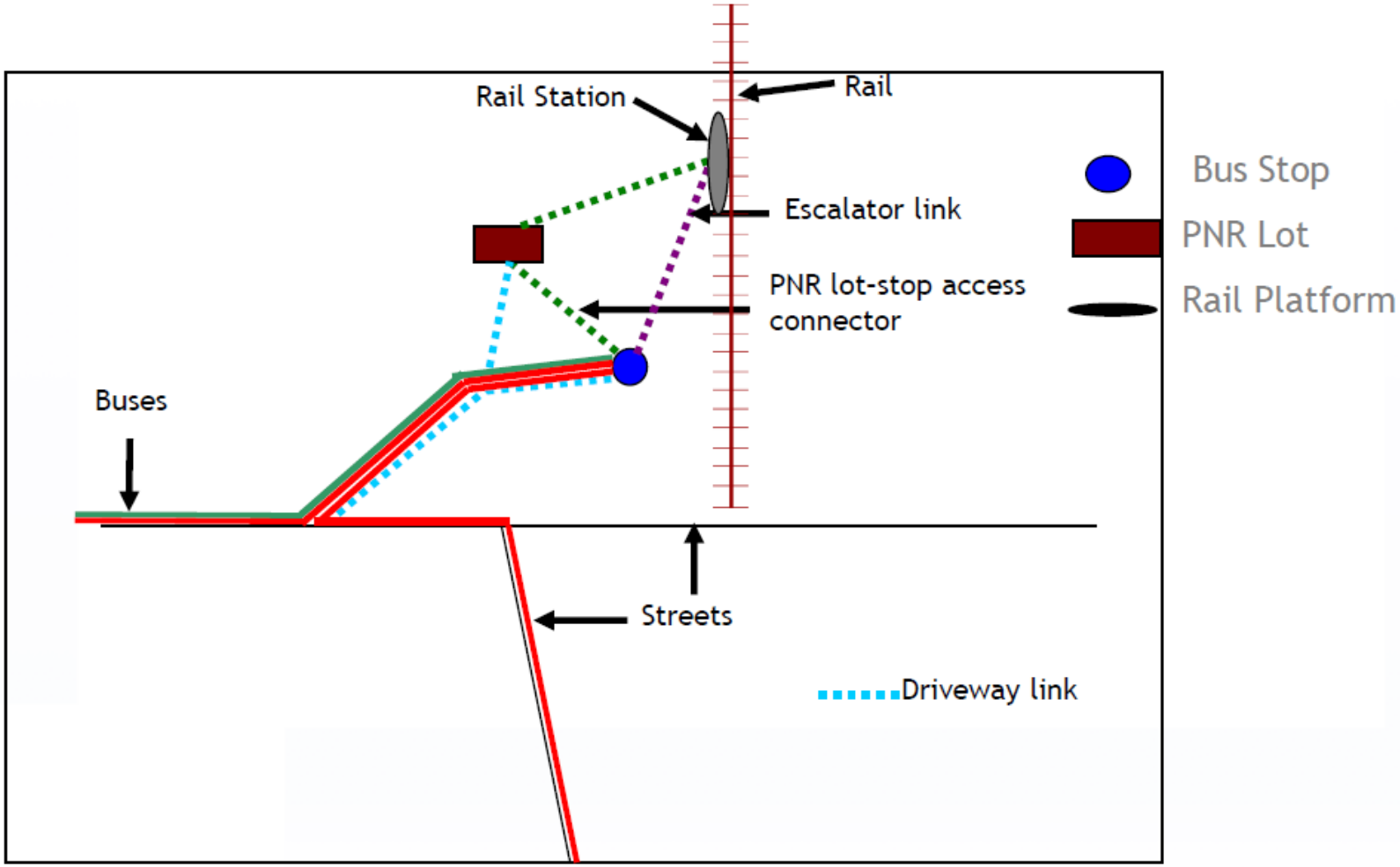
- Enhanced Drive-Access Generation
- Drive-Access Generation in 5.x
- Drive-Access Generation Examples in 5.x
- Drive-Access Generation in 6.x
- Enhanced Drive-Access Generation Example

Examples of Drive-Access Coding

- **Aerial photograph for parking lot & transit stops**

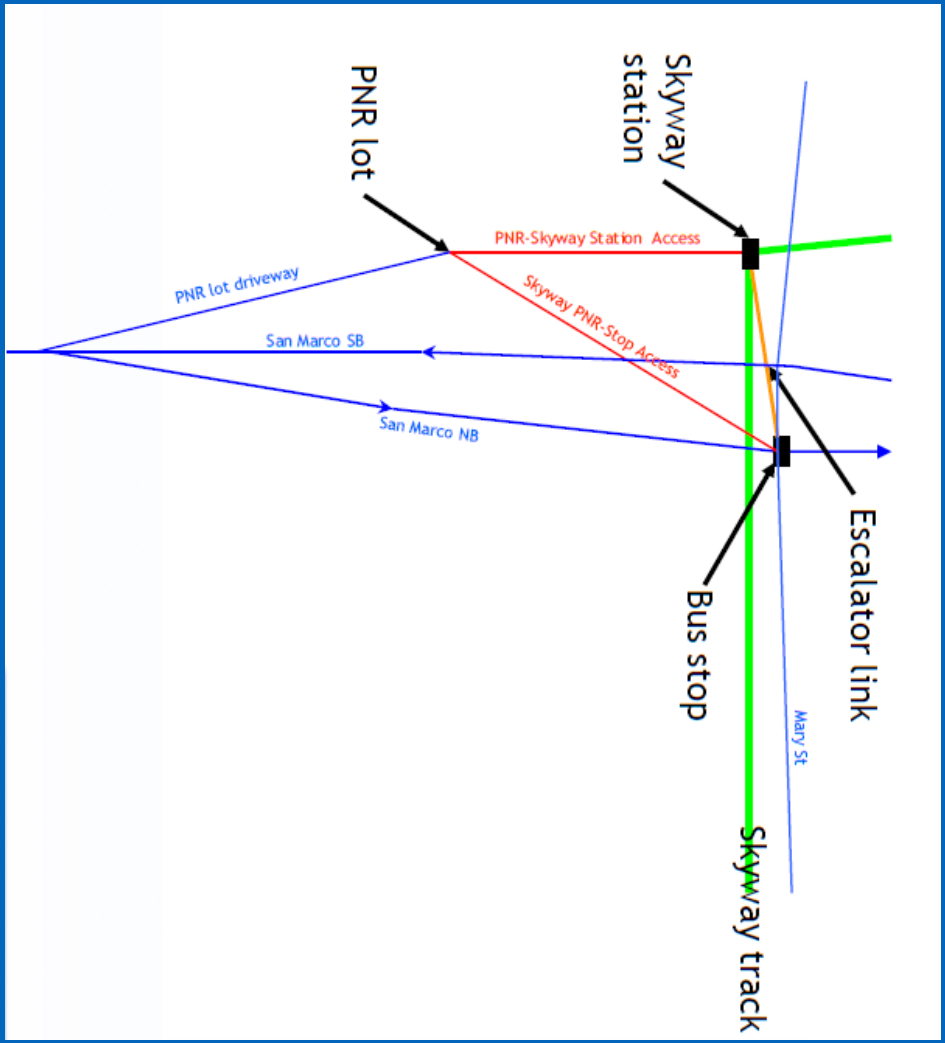
Examples of Drive-Access Coding

- **Schematic diagram**



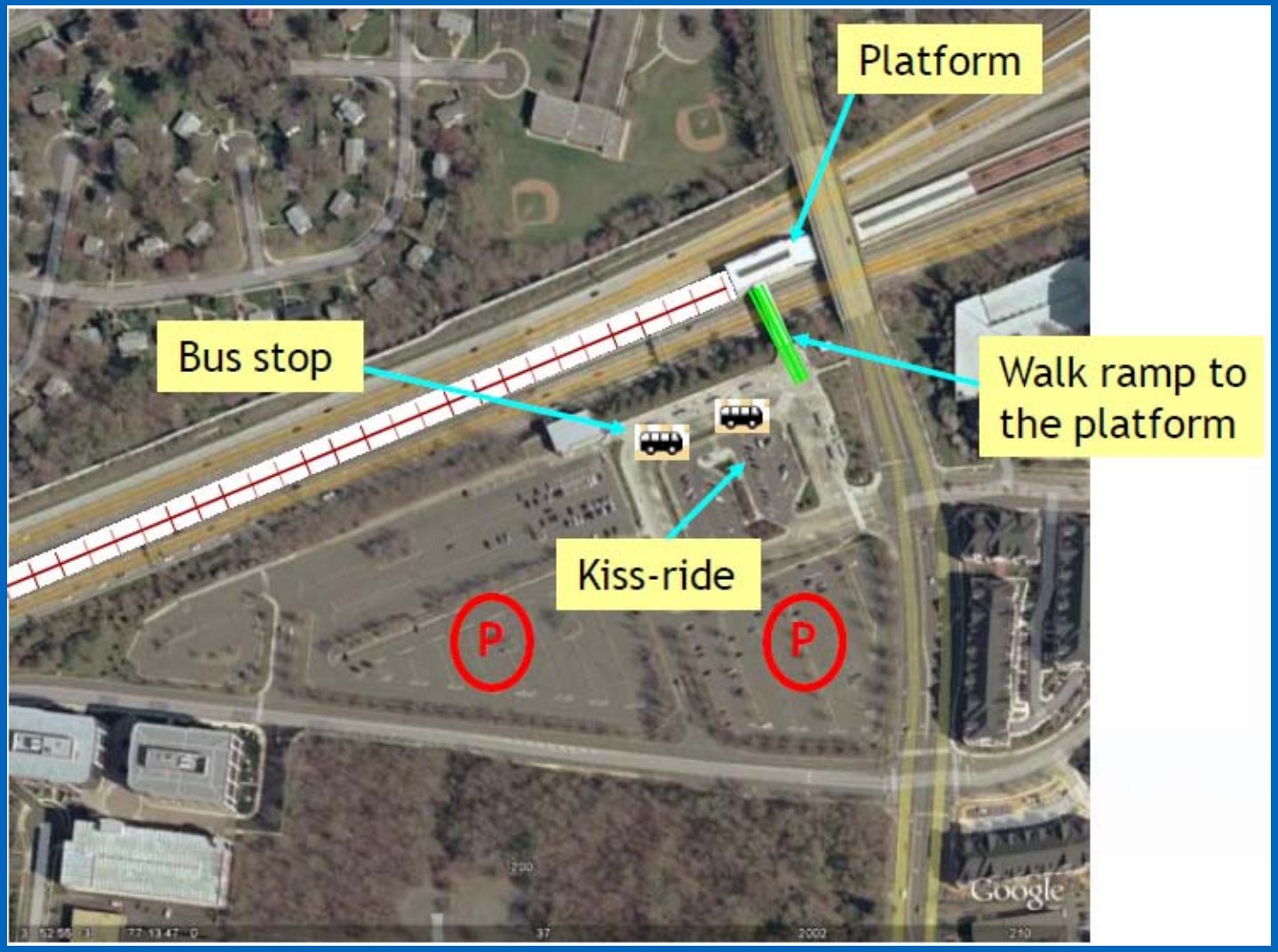
Examples of Drive-Access Coding

- **Network with transit lines and non-transit access links**



Examples of Drive-Access Coding

- **Example for kiss-ride facility with bus stop**



Drive-Access Generation in 5.x

- **Historically Cube Voyager has been very strong in allowing users to automatically generate PT access connectors.**

- **The user was able to consider many factors including:**

Name	Description
FROMNODE / TONODE	Defines nodes that will be considered as "beginning" and "ending" nodes
COST	Variable/equation that determines the minimum path
DIRECTION	Direction of the generated non-transit legs 1 - from -> to node 2 - to -> from node 3 - both directions
EXTRACTCOST	Skimmed variable/equation
INCLUDELINK / EXCLUDELINK	INCLUDE - Defines links that should only be used in generating non-transit legs; all links not listed are excluded EXCLUDE - Defines links that should not be used in generating non-transit legs; all links not listed are included
ACCESSLINK	One or more access links from park-and-ride facilities to stop nodes. If the link does not exist in the network, the program generates the link

Drive-Access Generation in 5.x

Name	Description
MAXCOST	Maximum value of COST (vector by mode)
MAXNTLEGS	Maximum number of non-transit legs per mode (vector by mode)
MINCOST	Minimum value of COST
NTLEGMODE	Mode for the non-transit leg
ONEWAY	Determines whether to use one-way links in the network in one direction or in both If true, use only A→B direction If false, use both directions
READNTLEGI	Index number of the input non-transit leg file
DIRECTLINK	Maximum number of network links a non-transit leg can traverse
SLACK	Amount added to the best cost non-transit leg to determine the maximum cost of legs saved. Specified for each mode

Drive-Access Generation Examples in 5.x

- Potential GENERATE keyword values

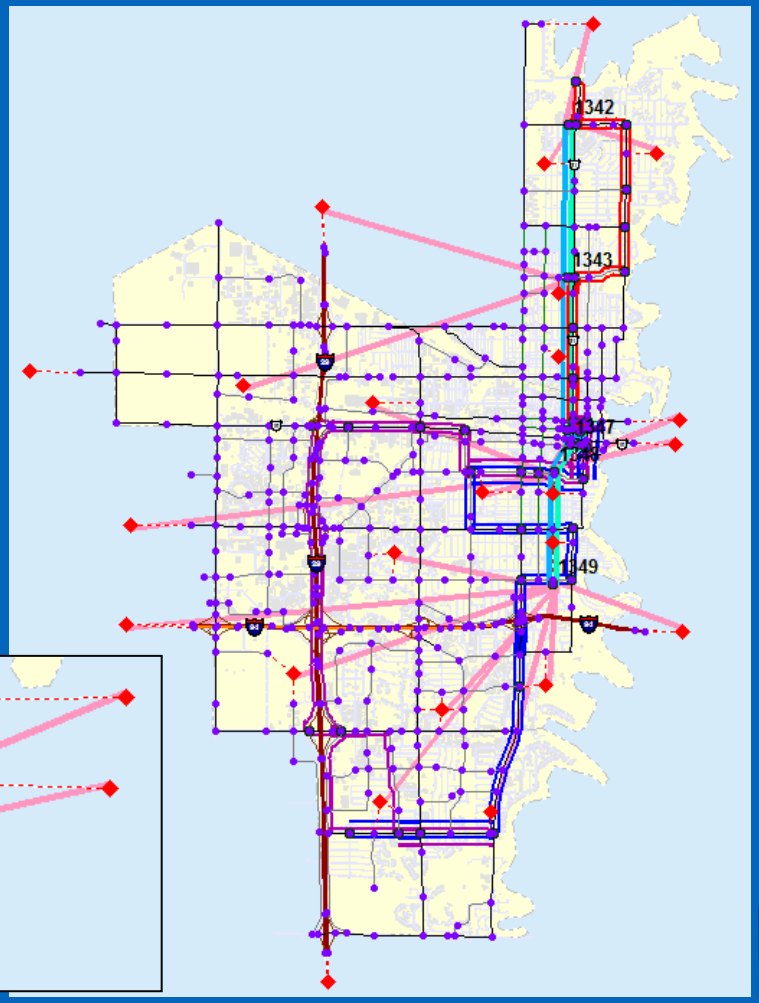
Keyword	Values (Example)
FROMNODE	Zones
TONODE	All station nodes with park-ride facility
COST	LI.DISTANCE
MAXCOST	10 miles
EXTRACTCOST	Time + time equivalent of toll
EXCLUDELINK	Transit guideways
NTLEGMODE	2
MAXNTLEGS	2
DIRECTION	1
ONEWAY	T

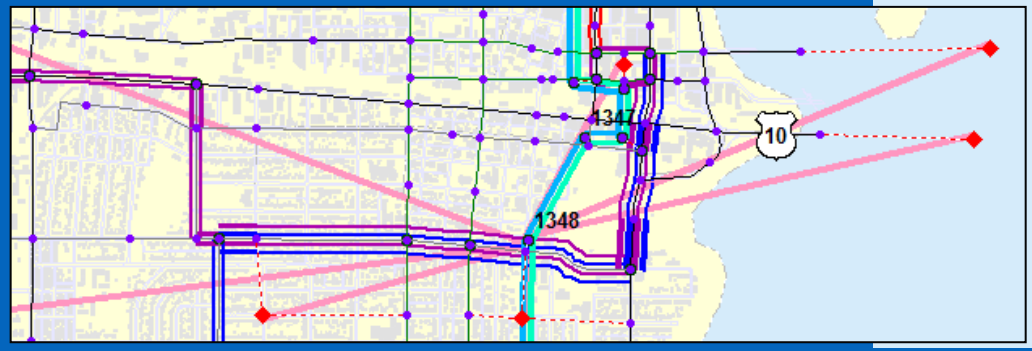
Drive-Access Generation Examples in 5.x

- Direct drive-access connection without parking nodes

```
PROCESS PHASE = LINKREAD
    LW.WALKSPEED= 2.5
    LW.TRANTIME = 0.80*(li.DISTANCE*60/li.SPEED)
    LW.AUTOTIME = 1.00*(li.DISTANCE*60/li.SPEED)
    LW.WALKTIME = 1.00*(li.DISTANCE*60/LW.WALKSPEED)
ENDPROCESS

PROCESS PHASE = DATAPREP
   GENERATE,
    COST=LI.DISTANCE,
    EXTRACTCOST=LW.AUTOTIME,
    MAXNTLEGS=1,
    MAXCOST=999*3.0,
    LIST=T,
    NTLEGMODE=201,
    DIRECTION=1,
    FROMNODE=1-25, TONODE=1342-1343,1347-1349
                   ; RAIL SYSTEM ONLY
ENDPROCESS
```





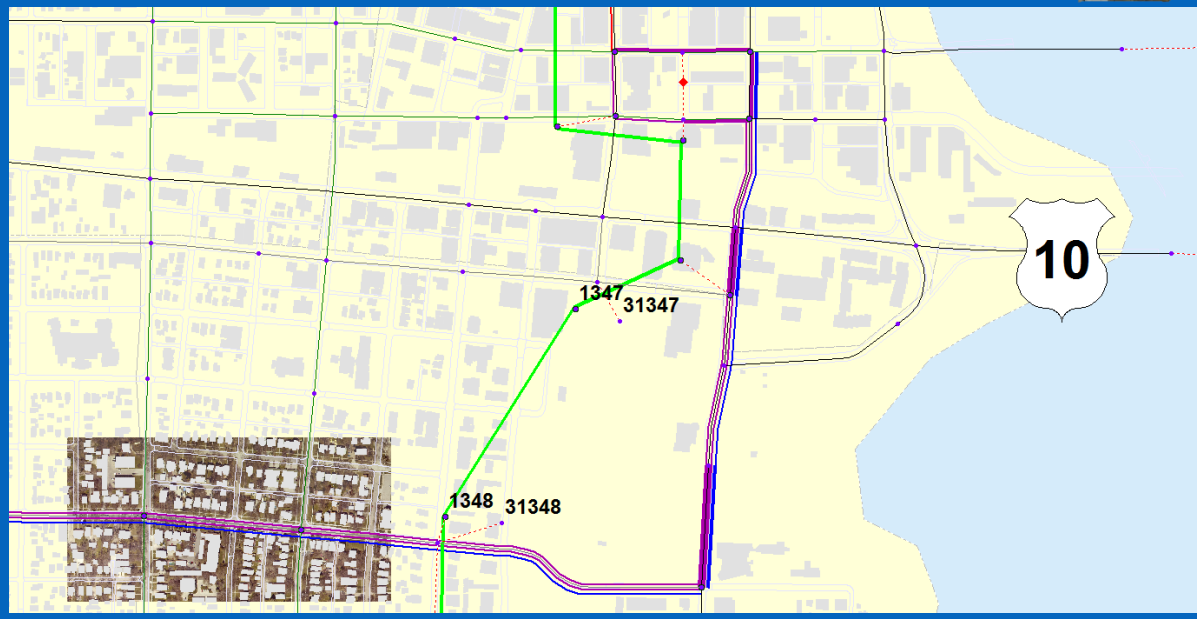
Drive-Access Generation Examples in 5.x

- **Using ACCESSLINK with GENERATE**
  - Optional keyword that provides a link connection from the park-ride facilities to stop nodes
  - An access link is specified as ACCESSLINK = A-S, cost, distance where:
    - A–Surrogate access point
    - S–Stop node
    - Cost–cost of using the access link
    - Distance–distance traveled on the access link
  - TONODE is ignored and the connectors are generated to the stop node S
  - If the accesslink does not exist in the network, PT generates it

Drive-Access Generation Examples in 5.x

- Drive-access connection with parking nodes

```
PROCESS PHASE = DATAPREP
   GENERATE,
    COST=LI.DISTANCE,
    EXTRACTCOST=LW.AUTOTIME,
    MAXNTLEGS=1,
    MAXCOST=999*3.0,
    LIST=T,
    NTLEGMODE=201,
    DIRECTION=1,
    ONEWAY=T,
    FROMNODE=1-25,
    ACCESSLINK= 31342-1342, 0.20, 0.01,
                31343-1343, 0.20, 0.01,
                31347-1347, 0.20, 0.01,
                31348-1348, 0.20, 0.01,
                31349-1349, 0.20, 0.01
                ; RAIL SYSTEM ONLY
ENDPROCESS
```




```
;;<<PT>>;;
NT LEG=1-1342 MODE=201 COST=1.75 DIST=0.63 ONEWAY=T XN=1153 1069 1175 1152 804 31342
NT LEG=2-1342 MODE=201 COST=1.24 DIST=0.42 ONEWAY=T XN=954 804 31342
NT LEG=3-1343 MODE=201 COST=0.53 DIST=0.13 ONEWAY=T XN=1266 31343
NT LEG=4-1347 MODE=201 COST=1.52 DIST=0.54 ONEWAY=T XN=962 766 966 974 975 758 759 750 751 31347
NT LEG=5-1347 MODE=201 COST=2.89 DIST=1.22 ONEWAY=T XN=1012 770 735 738 1238 739 740 1239 752 1010 751 31347
NT LEG=6-1347 MODE=201 COST=0.72 DIST=0.22 ONEWAY=T XN=976 758 759 750 751 31347
NT LEG=7-1348 MODE=201 COST=0.58 DIST=0.14 ONEWAY=T XN=1015 31348
NT LEG=8-1348 MODE=201 COST=1.52 DIST=0.54 ONEWAY=T XN=1014 741 744 1015 31348
NT LEG=9-1349 MODE=201 COST=0.81 DIST=0.24 ONEWAY=T XN=1021 31349
NT LEG=10-1349 MODE=201 COST=2.68 DIST=1.02 ONEWAY=T XN=1276 725 1145 723 1020 721 720 1021 31349
```

Drive-Access Generation in 6.x

- **Cube Voyager 6.0 has built upon the features of the existing Generate command to now consider:**

Name		Description	Default
PT	AUTOCON		
AATRATIO	AATRATIO	to specify the ratio of drive-access time to IVT mode choice coefficients	
AOC	AOC	to specify the auto operating cost	
AUTOCCPNR	AUTOCCPNR	to specify the auto occupancy for PNR	
AUTOCCKNR	AUTOCCKNR	to specify the auto occupancy for KNR	
AUTOMATCH		to indicate if using original AUTOCON logic or enhanced AUTOCON logic	True (=original)
AUTOMODE		to allow user specify the mode for auto access connectors (for AUTODAT file)	
CBDZONE	CBDZONE	to Specify the CBD area	
CHECKRELEVANCE	NOPT	flag to indicate whether to check relevance of the connectors	
CHECKBACKTRACT	BACK	flag to indicate whether to check backtracking of the connectors	
CONNREPORT	ACONLIST	to specify the PRINTO number for connector list	
DEFDRIVETIME	DEF	to specify default drive-access time used if time from matrix is zero	
DISTANCEFACTOR	UNITS	to specify the factor to convert distance to coordinate	
DISTMAT		numerical expression used to get the distance skim matrix	
GENREPORT	AUTOCONRPT	to specify the PRINTO number for AUTOCON report	
INFLTRANSITFARE	INFLTRANSITFARE	to specify inflation factor for transit fare	
INFLAOC	INFLAOC	to specify inflation factor for auto operating cost	

Drive-Access Generation in 6.x

Name		Description	Default
PT	AUTOCON		
INFLPARKINGCOST	INFLPARKINGCOST	to specify inflation factor for parking cost	
INTERNALZONES	ZONESI	to specify the internal zones to process	
KNR		flag indicating whether to turn on the additional Kiss and Ride generation	False
KNRMODE		to allow user specify the mode for KNR connectors	
MAXBACKDIST	BACKD	to specify the maximum backtracking distance allowed	
MAXBACKFACTOR	BACKPC	to specify the maximum backtracking factor allowed	
MAXCHECK		to specify the maximum connectors to consider	
MAXCONN		to specify the maximum connectors to use	
MODEPRIORITY	PRIORITY[M]	to indicate priority by mode	999
ORIGINTERMTIME	TERM	to specify the terminal time for origin	
OVTRATIO	OVTRATIOAM OVTRATIOPM	to specify the ratio of OVT/IVT mode choice coefficients	
PERIOD		to indicate the AUTOCON process period (0 - Off-peak, 1 - peak)	
PNR		flag indicating whether to turn on the enhanced AUTOCON process	False
PNRMODE		to allow user specify the mode for PNR connectors	
PREMIUMMODE	PRFLAG[M]	to indicate premium service by mode (0 - not premium, 1 - premium)	
SKIPZONES		to specify the zones should not be considered in the AUTOCON process	no skip zones
TIMEMAT	TIMEMAT	numerical expression used to get the time skim matrix	
VOT	VOT	to specify the value of time in $/hour	
XTRAAUTONTLEGI		to specify the NTLEGI file number to use	no override

Enhanced Drive-Access Generation Example

- AUTOCON process in NERPM

< Original Control >

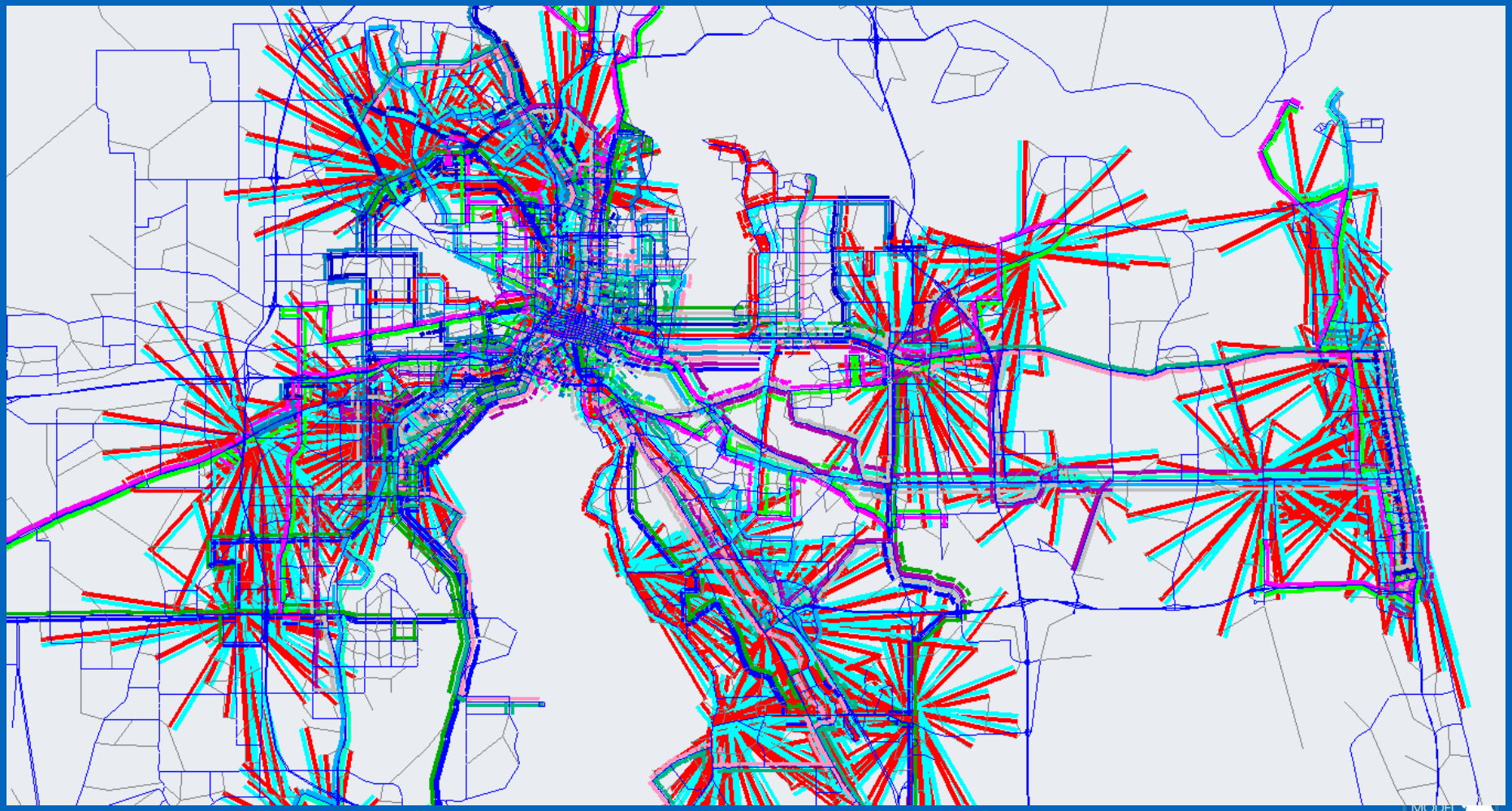
```
; Output
AUTOCONRPT                    C:\Cube_PT_Updates_NERPM
PNRAUTOAM                     C:\Cube_PT_Updates_NERPM
PNRAUTOMD                     C:\Cube_PT_Updates_NERPM
KNRAUTOAM                     C:\Cube_PT_Updates_NERPM
KNRAUTOMD                     C:\Cube_PT_Updates_NERPM
; AutoCon Parameters
AUTOCONVERSION                2
ZONESI                        2494
CBDZONE                       730
TERM                          2.00
DEF                           2.00
NOPT                          1
BACK                          1
BACKD                         4.0
BACKPC                        0.30
UNITS                         5280
MAXMODE                       27
MODENUM (not used)             21 22 23 24 25 26 27
PREMIUMFLAG                     0  1  0  1  1  1  1
MODEPRIORITY                    7  5  7  2  1  4  3
VOTAM                         6.00
VOTMD                         3.00
OVTRATIOAM                    2.00
OVTRATIOMD                    2.00
AATRATIOAM                    1.50
AATRATIOMD                    1.50
AUTOCCPNR                     1.2
AUTOCCKNR                     1.2
AOC                           9.5
InflTransitFare               0.9487
InflAOC                       1
InflParkingCost               1.1976
AUTODATAM                     C:\Cube_PT_Updates_NERPM
AUTODATMD                     C:\Cube_PT_Updates_NERPM
ACONLISTAM                    C:\Cube_PT_Updates_NERPM
ACONLISTMD                    C:\Cube_PT_Updates_NERPM
```

< PT Script >

```
PROCESS PHASE=DATAPREP
   ; GENERATE AUTO CONNECTORS FOR PNR AND KNR
   list='\nGenerate Zone Access/Egress Legs'
   GENERATE,
     PNR=T,
      KNR=T,
      PERIOD=1,
      PNRMODE=2,
      KNRMODE=3,
      INTERNALZONES=1-2494,
      CBDZONE=730,
      ORIGINTERMTIME=2.0,
      DEFDRIVETIME=2.0,
      CHECKRELEVANCE=1,
      CHECKBACKTRACK=1,
      MAXBACKDIST=4.0,
      MAXBACKFACTOR=0.30,
      DISTANCEFACTOR=5280,
      PREMIUMMODE=0,1,0,1,1,1,1,
      MODEPRIORITY=7,5,7,2,1,4,3,
      VOT=6,3,
      OVTRATIO=2,2,
      AATRATIO=1.5,1.5,
      AUTOCCPNR=1.2,
      AUTOCCKNR=1.2,
      AOC=9.5,
      INFLTRANSITFARE=0.9487,
      INFLAOC=1,
      INFLPARKINGCOST=1.1976,
      MAXCHECK = 2,
      MAXCONN = 2,
      CONNREPORT=1,
      GENREPORT=2,
      TIMEMAT=MI.1.4,
      DISTMAT=MI.1.2,
      AUTOMATCH=T       ; T=original logic, F=Enhanced logic
ENDPROCESS
```

Output Files by PT AUTOCON Process

- Network with transit & non-transit links



Output Files by PT AUTOCON Process

- Non-transit links (e.g. ‘PNRAUTOAM’ & ‘KNRAUTOAM’ in original AUTOCON)

```
;;<<PT>>;;
NT LEG=188-28469 MODE=2 COST=69.18 DIST=4.38 ONEWAY=T
NT LEG=188-28469 MODE=3 COST=66.18 DIST=4.38 ONEWAY=T
NT LEG=191-37148 MODE=2 COST=96.05 DIST=4.44 ONEWAY=T
NT LEG=191-37148 MODE=3 COST=93.05 DIST=4.44 ONEWAY=T
NT LEG=197-37148 MODE=2 COST=84.59 DIST=4.38 ONEWAY=T
NT LEG=197-37148 MODE=3 COST=81.59 DIST=4.38 ONEWAY=T
NT LEG=198-37148 MODE=2 COST=46.54 DIST=3.82 ONEWAY=T
NT LEG=198-37148 MODE=3 COST=43.54 DIST=3.82 ONEWAY=T
NT LEG=200-28469 MODE=2 COST=59.66 DIST=4.26 ONEWAY=T
NT LEG=200-28469 MODE=3 COST=56.66 DIST=4.26 ONEWAY=T
```

- Additional information for drive-access links (e.g. ‘ACONLISTAM’ in original AUTOCON)

```
188,  28469,   3.00,   4.38,   4.85,   2.22,  33.63,  38.47,   1.50,  57.70,   9.50,  41.62,
191,  37148,   3.00,   4.44,   5.63,   2.70,  50.72,  56.35,   1.50,  84.53,   9.50,  42.19,
197,  37148,   3.00,   4.38,   5.46,   2.51,  43.29,  48.75,   1.50,  73.12,   9.50,  41.62,
198,  37148,   3.00,   3.82,   5.90,   1.60,  17.78,  23.67,   1.50,  35.51,   9.50,  36.30,
200,  28469,   3.00,   4.26,   4.80,   2.01,  27.39,  32.19,   1.50,  48.28,   9.50,  40.48,
202,  37148,   3.00,   3.45,   5.10,   0.76,   5.50,  10.59,   1.50,  15.89,   9.50,  32.78,
227,  64893,   3.00,   3.38,   6.44,   0.81,   5.98,  12.42,   1.50,  18.63,   9.50,  32.12,
228,  64893,   3.00,   2.61,   3.93,   0.00,   0.00,   3.93,   1.50,   5.90,   9.50,  24.80,
229,  58551,   3.00,   3.40,   7.00,   0.93,   7.23,  14.22,   1.50,  21.34,   9.50,  32.31,
230,  58551,   3.00,   3.91,   6.92,   2.09,  29.71,  36.62,   1.50,  54.93,   9.50,  37.15,
233,  64893,   3.00,   1.59,   3.36,   0.00,   0.00,   3.36,   1.50,   5.04,   9.50,  15.11,
233,  65945,   3.00,   3.98,   5.31,   1.73,  20.43,  25.74,   1.50,  38.60,   9.50,  37.81,
234,  58551,   3.00,   2.50,   6.61,   0.00,   0.00,   6.61,   1.50,   9.92,   9.50,  23.75,
```

Output Files by PT AUTOCON Process

- Report (e.g. ‘AUTOCONRPT’ in original AUTOCON

```
NUMBER OF STATIONS:     32
STA     NODE     ZONE     MAXD     USE     RTE
   1,       19503, 2270,          300,    1,      210002
   2,       20242, 2203,          300,    1,      210045
   3,       23981, 2296,          300,    1,      210072
   4,       27395, 2224,          300,    1,      210056
   5,       28469,  841,          300,    1,      210067
  21,       35753,  677,          300,    0,           0
  22,       35792,  677,          300,    0,           0
   6,       37144,  738,          300,    0,           0
   7,       37148,  843,          300,    1,      210068
   8,       37203,  729,          300,    0,           0
   9,       37231,  719,          300,    0,           0
  26,       37705,  766,          300,    0,           0
  10,       38041,  665,          300,    0,           0
  24,       38942,  767,          300,    0,           0
  11,       40458,  482,          300,    1,      210003
  12,       46281, 2064,          300,    1,      210018
  13,       55419,  298,          300,    1,      210055
  14,       55718, 2065,          300,    1,      210058
  30,       58551, 1952,          300,    1,      210019
  15,       59392,  328,          300,    1,      210056
  16,       64141,  437,          300,    1,      210021
  29,       64893,  243,          300,    1,      210050
  17,       65945,  371,          300,    1,      210053
  18,       66285,  392,          300,    1,      210047
  19,       68036,  396,          300,    1,      210053
  31,       79001,  470,          300,    1,      210024
  28,       79003,  552,          300,    1,      210080
  20,       80001,  665,          300,    0,           0
  23,       80005,  677,          300,    0,           0
  27,       80006,  766,          300,    0,           0
  25,       80008,  767,          300,    0,           0
  32,       80025,  716,          300,    0,           0
    1,    4867.00000,      3.0000000000,  6570.00000,      4.0497226217
19503, 245909.9755098377
    1,    4525.00000,      3.0000000000,  6161.00000,      4.0846408840
```

Enhanced Fares along with BestPathOnly

- Fare Process in 5.x
- Enhanced Fare Process in 6.x

Fare Process in 5.x

- Fares for PT modeling are generally evaluated after the routes have been built. This is because for many fare systems, the cost is not known until the complete route is known.

- Especially, the fares are not included into the generalized cost during enumerating/evaluating the routes with BestPathPath=T.

Fare Process in 5.x

- **Output example of route-evaluation process with BestPathOnly=T . Note that the route doesn't include the fare in cost.**

```
REval Route(s) from Origin 194 to Destination 2204

194 -> 32376
32376 -> 22080 -> 2204 lines L8 WB
Cost= 107.703 Probability=1.0000


REval Route(s) from Origin 194 to Destination 2204

N:    194 Mode  WaitA  TimeA Actual B/XPen Percvd   Dist  Total  Lines(weight)
-> 32376    1      -   5.59   5.59      -  11.18   0.23   0.23
-> 22080   21  15.00  55.34  75.93   2.00  98.52  17.06  17.29  L8 WB(1.000)
->  2204    1      -   4.59  80.52      - 107.70   0.19  17.48
Mode  TimeA   Dist IWaitA XWaitA
  21  55.34  17.06  15.00   0.00
   1  10.18   0.42
Fare=   0.90
```

Enhanced Fare Process in 6.x

- The user may specify a simple fare structure during while enumerating the routes to enhance the path building process.

- Cube Voyager 6.0 includes additional fare keywords along with BestPathOnly:
  - ENUMFARE: if set to True, we allow a subset of fare systems to be considered in the best path enumeration process.
  - EVALFARE: if set to True, we allow fare to be calculated in the best path evaluation and skimming process.
  - EFARE: flag indicating whether to input descriptions of fare systems. If ENUMFARE=T and no fare skimming and route evaluation required, EFARE must be set to True to allow fares to be considered during the BESTPATHONLY route enumeration process.

Enhanced Fare Process in 6.x

- **Example 1: Input fare settings for EVALFARE=T**

```
*** INPUT FACTOR FILE ***
;Global Settings              ; fare to be calculated in the best
 BESTPATHONLY=T, EVALFARE=T   ; path evaluation process

*** SCRIPT PROGRAM ***
PARAMETERS FARE=T

*** ORIGINAL FARE FILE ***
FARESYSTEM NUMBER=1 LONGNAME="Local Buses" NAME="LB" STRUCTURE=FLAT
SAME=CUMULATIVE,
IBOARDFARE=0.90,FAREFROMFS=0.00,0.00,0.00,0.00,0.00,0.90,0.00
```

- **Example 1: Output report for EVALFARE=T**

```
REval Route(s) from Origin 194 to Destination 2204

194 -> 32376
32376 -> 22080 -> 2204 lines L8 WB
Cost= 117.521 Probability=1.0000


REval Route(s) from Origin 194 to Destination 2204

N:    194 Mode  WaitA  TimeA Actual B/XPen Percvd   Dist  Total  Lines(weight)
-> 32376    1      -   5.59   5.59      -  11.18   0.23   0.23
-> 22080   21  15.00  55.34  75.93   2.00  98.52  17.06  17.29  L8 WB(1.000)
->  2204    1      -   4.59  80.52      - 107.70   0.19  17.48
Mode  TimeA   Dist IWaitA XWaitA
  21  55.34  17.06  15.00   0.00
   1  10.18   0.42
Fare=   0.90
```

Enhanced Fare Process in 6.x

- **Example 2: Input fare settings for EVALFARE=T & ENUMFARE=T**

```
*** INPUT FACTOR FILE ***
;Global Settings                          ; to be calculated in the best
 BESTPATHONLY=T, EVALFARE=T, ENUMFARE=T   ; path enumeration & evaluation

*** SCRIPT PROGRAM ***
PARAMETERS FARE=T

*** REVISED FARE FILE ***
FARESYSTEM NUMBER=1 LONGNAME="Local Buses" NAME="LB" STRUCTURE=FLAT
SAME=CUMULATIVE,
IBOARDFARE=5.00,FAREFROMFS=0.00,0.00,0.00,0.00,0.00,0.90,0.00
```

- **Example 2: Output report for EVALFARE=T & ENUMFARE=T**

```
REval Route(s) from Origin 194 to Destination 2204

194 -> 32376
32376 -> 22080 -> 2204 lines L8 WB
Cost= 162.248 Probability=1.0000


REval Route(s) from Origin 194 to Destination 2204

N:    194 Mode  WaitA  TimeA Actual B/XPen Percvd   Dist  Total  Lines(weight)
-> 32376    1      -   5.59   5.59      -  11.18   0.23   0.23
-> 22080   21  15.00  55.34  75.93   2.00  98.52  17.06  17.29  L8 WB(1.000)
->  2204    1      -   4.59  80.52      - 107.70   0.19  17.48
Mode  TimeA   Dist IWaitA XWaitA
  21  55.34  17.06  15.00   0.00
   1  10.18   0.42
Fare=   5.00
```

Enhanced Fare Process in 6.x

- **Example 3: Input fare settings for ENUMFARE=T & EFARE=T**

```
*** INPUT FACTOR FILE ***
;Global Settings              ; fare to be calculated in the best
 BESTPATHONLY=T, ENUMFARE=T   ; path evaluation process

*** SCRIPT PROGRAM ***
PARAMETERS EFARE=T

*** ORIGINAL FARE FILE ***
FARESYSTEM NUMBER=1 LONGNAME="Local Buses" NAME="LB" STRUCTURE=FLAT
SAME=CUMULATIVE,
IBOARDFARE=0.90,FAREFROMFS=0.00,0.00,0.00,0.00,0.00,0.90,0.00
```

- **Example 3: Output report for ENUMFARE=T & EFARE=T**

```
REnum Route(s) from Origin 194 to Destination 2204

194 -> 32376
32376 -> 22080 -> 2204 lines L8 WB
```

Enhanced Transit Line Keywords in 6.x

- Cube Voyager's PT program uses a series of keywords embedded in the description of the public transport line data to save information.

- In order to provide better ways to calibrate and adjust transit travel times, some of the node specific keywords (specifically DWELL and DELAY) have also been made available as a line level keyword :
  - DWELL_DEFAULT: dwell time, in minutes, the line spends at all stop nodes for the line until one specifies a DWELL_C or DWELL sub-keyword.
  - DELAY_DEFAULT: additional time delay added to all link times for the line until one specifies a DELAY_C or DELAY sub-keyword.
  - TIMEFAC: time factor applied to the travel time of all links the line traverses.

Enhanced Transit Line Keywords in 6.x

- **Example 1: Transit line setting using DWELL_DEFAULT**

```
LINE NAME="B6 EB", LONGNAME="Stockton-Wilson EB", HEADWAY[1]=60,
     HEADWAY[2]=60, MODE=21, ONEWAY=T, OPERATOR=1, CIRCULAR=F,
     DWELL_DEFAULT[1]=2, DWELL_DEFAULT[2]=1,
     USERA3="Line 026", USERA2="B6", USERA1="LOCAL", N=11964,
     -11967, -11960, -11965, -11962, -11966, -11963, -11969,
     DELAY=5, N=11961, -11968, -11972, -11959, -11958, -11956,
```

- **Example 1: Comparison of run times in link level**

NAME	A	B	MODE	LINKSEQ	STOPA	DIST	TIME_ORG	TIME_TEST1	TIME_DIFF
B6 EB	11964	11967	21	1	1	0.08	0.21	0.21	0
B6 EB	11967	11960	21	2	0	0.07	0.2	0.2	0
B6 EB	11960	11965	21	3	0	0.04	0.11	0.11	0
B6 EB	11965	11962	21	4	0	0.09	0.23	0.23	0
B6 EB	11962	11966	21	5	0	0.09	0.24	0.24	0
B6 EB	11966	11963	21	6	0	0.03	0.08	0.08	0
B6 EB	11963	11969	21	7	0	0.06	0.16	0.16	0
B6 EB	11969	11961	21	8	0	0.1	5.27	5.27	0
B6 EB	11961	11968	21	9	1	0.07	0.18	2.18	2
B6 EB	11968	11972	21	10	0	0.14	0.37	0.37	0
B6 EB	11972	11959	21	11	0	0.08	0.21	0.21	0
B6 EB	11959	11958	21	12	0	0.17	0.47	0.47	0
B6 EB	11958	11956	21	13	0	0.33	0.9	0.9	0
B6 EB	11956	11952	21	14	0	0.07	0.19	0.19	0
B6 EB	11952	12111	21	15	1	0.19	0.44	2.44	2
B6 EB	12111	12135	21	16	0	0.02	0.05	0.05	0

Enhanced Transit Line Keywords in 6.x

- **Example 1: Comparison of run times in transit line ('B6 EB')**

PERIOD	DISTANCE (mile)	ORIGINAL (min)	TEST 1 (min)	DIFF (min)	DIFF (%)
PEAK	22.1	77.9	269.9	192.0	246.5
OFF-PEAK	22.1	72.7	168.7	96.0	132.1

Enhanced Transit Line Keywords in 6.x

- **Example 2: Transit line setting using DELAY_DEFAULT**

```
LINE NAME="B6 EB", LONGNAME="Stockton-Wilson EB", HEADWAY[1]=60,
     HEADWAY[2]=60, MODE=21, ONEWAY=T, OPERATOR=1, CIRCULAR=F,
     DELAY_DEFAULT[1]=1, DELAY_DEFAULT[2]=0.5,
     USERA3="Line 026", USERA2="B6", USERA1="LOCAL", N=11964,
     -11967, -11960, -11965, -11962, -11966, -11963, -11969,
     DELAY=5, N=11961, -11968, -11972, -11959, -11958, -11956,
```

- **Example 2: Comparison of run times in link level**

NAME	A	B	MODE	LINKSEQ	STOPA	DIST	TIME_ORG	TIME_TEST1	TIME_DIFF
B6 EB	11964	11967	21	1	1	0.08	0.21	1.21	1
B6 EB	11967	11960	21	2	0	0.07	0.2	1.2	1
B6 EB	11960	11965	21	3	0	0.04	0.11	1.11	1
B6 EB	11965	11962	21	4	0	0.09	0.23	1.23	1
B6 EB	11962	11966	21	5	0	0.09	0.24	1.24	1
B6 EB	11966	11963	21	6	0	0.03	0.08	1.08	1
B6 EB	11963	11969	21	7	0	0.06	0.16	1.16	1
B6 EB	11969	11961	21	8	0	0.1	5.27	5.27	0
B6 EB	11961	11968	21	9	1	0.07	0.18	1.18	1
B6 EB	11968	11972	21	10	0	0.14	0.37	1.37	1
B6 EB	11972	11959	21	11	0	0.08	0.21	1.21	1
B6 EB	11959	11958	21	12	0	0.17	0.47	1.47	1
B6 EB	11958	11956	21	13	0	0.33	0.9	1.9	1
B6 EB	11956	11952	21	14	0	0.07	0.19	1.19	1
B6 EB	11952	12111	21	15	1	0.19	0.44	1.44	1
B6 EB	12111	12135	21	16	0	0.02	0.05	1.05	1

Enhanced Transit Line Keywords in 6.x

- **Example 2: Comparison of run times in transit line ('B6 EB')**

PERIOD	DISTANCE (mile)	ORIGINAL (min)	TEST 3 (min)	DIFF (min)	DIFF (%)
PEAK	22.1	77.9	187.2	109.3	140.4
OFF-PEAK	22.1	72.7	106.5	33.8	46.5

Enhanced Transit Line Keywords in 6.x

- **Example 3: Transit line setting using TIMEFAC**

```
LINE  NAME="B6 EB", LONGNAME="Stockton-Wilson EB", HEADWAY[1]=60,
      HEADWAY[2]=60, MODE=21, ONEWAY=T, OPERATOR=1, CIRCULAR=F,
      TIMEFAC[1]=2.0, TIMEFAC[2]=1.5,
      USERA3="Line 026", USERA2="B6", USERA1="LOCAL", N=11964,
      -11967, -11960, -11965, -11962, -11966, -11963, -11969,
      DELAY=5, N=11961, -11968, -11972, -11959, -11958, -11956,
```

- **Example 3: Comparison of run times in link level**

NAME	A	B	MODE	LINKSEQ	STOPA	DIST	TIME_ORG	TIME_TEST1	TIME_DIFF	TIME_PROP
B6 EB	11964	11967	21	1	1	0.08	0.21	0.42	0.21	2
B6 EB	11967	11960	21	2	0	0.07	0.2	0.39	0.19	1.95
B6 EB	11960	11965	21	3	0	0.04	0.11	0.23	0.12	2.09
B6 EB	11965	11962	21	4	0	0.09	0.23	0.47	0.24	2.04
B6 EB	11962	11966	21	5	0	0.09	0.24	0.49	0.25	2.04
B6 EB	11966	11963	21	6	0	0.03	0.08	0.16	0.08	2
B6 EB	11963	11969	21	7	0	0.06	0.16	0.33	0.17	2.06
B6 EB	11969	11961	21	8	0	0.1	5.27	5.53	0.26	1.05
B6 EB	11961	11968	21	9	1	0.07	0.18	0.37	0.19	2.06
B6 EB	11968	11972	21	10	0	0.14	0.37	0.73	0.36	1.97
B6 EB	11972	11959	21	11	0	0.08	0.21	0.43	0.22	2.05
B6 EB	11959	11958	21	12	0	0.17	0.47	0.93	0.46	1.98
B6 EB	11958	11956	21	13	0	0.33	0.9	1.79	0.89	1.99
B6 EB	11956	11952	21	14	0	0.07	0.19	0.38	0.19	2
B6 EB	11952	12111	21	15	1	0.19	0.44	0.88	0.44	2
B6 EB	12111	12135	21	16	0	0.02	0.05	0.09	0.04	1.8

Enhanced Transit Line Keywords in 6.x

- **Example 3: Comparison of run times in transit line ('B6 EB')**

PERIOD	DISTANCE (mile)	ORIGINAL (min)	TEST 3 (min)	DIFF (min)	PROPORTION
PEAK	22.1	77.9	150.8	73.0	1.9
OFF-PEAK	22.1	72.7	106.5	33.8	1.5

Transit Modeling Update

TRIP MARKET SEGMENTATION

FLORIDA MODEL TASK FORCE

Key Travel Market Attributes

Trip Purpose	
Current	Proposed
Home-Based Work	Home-Based Work
Home-Based Shop	Home-Based Shop
Home-Based Social/Recreation	Home-Based Social/Recreation
Home-Based Other	Home-Based Other
	Home-Based College/University
	Home-Based School
Non-Home-Based	Non-Home-Based Work
	Non-Home Based Other

FLORIDA MODEL TASK FORCE

Proposed New Trip Purposes

- HB College/University
  - An important transit market in some regions
  - Comprised of several different subpopulations, each with distinct travel behavior characteristics
  - Well-identified destinations, less information available about place of residence
  - Mode split related to residence type, proximity to campus, transportation options

Proposed New Trip Purposes

- HB School
  - May comprise a large fraction of the transit riders in some cities
  - Possibly transit-dependent population
  - Often entitled to discounted fares
  - More likely observed on local buses
  - Short trips with distinct time-of-day patterns

Proposed New Trip Purposes

- **NHB Work**
  - **Different diurnal patterns and transit mode shares than NHB Other**
  - **May comprise a large share of midday, downtown transit trips**
  - **May be forecasted with direct demand models**

Key Travel Market Attributes

FSUTMS Household Markets	
Current	Proposed
Type of Dwelling Unit	Type of Dwelling Unit
Household Size	Household Size
Auto Ownership	Auto Ownership
	Workers in Household
	Household Income

Key Travel Market Attributes

		Model Step		
Household Attribute		**Trip Generation**	**Trip Distribution**	**Mode Choice**
Housing unit type		•		
Income		•	? •	? •
Workers		•	?	?
Size		•		
Auto ownership		•		
Car Sufficiency			•	•

FLORIDA MODEL TASK FORCE

Key Travel Market Attributes

Home-Based Work Car Competition	
Zero car households	
Car insufficient households:	fewer workers than autos
Car sufficient households:	equal or more workers than autos

Home-Based Non-Work Car Competition	
Zero car households	
Car insufficient households:	1 auto, 2+ persons
Car sufficient households:	1 auto, 1 person
	1+ autos, 2+ persons

FLORIDA MODEL TASK FORCE

Key Travel Market Attributes

FTA Recommended Mode Choice Stratification

	Zero Cars	Car Insufficient	Car Sufficient
Low Income	●	●	●
Medium Income		●	●
High Income		●	●

FLORIDA MODEL TASK FORCE

Building the Household Classification

- Number of proposed household strata is too large to obtain directly from observed data for each TAZ
  - Housing unit type (2)
  - Income (3)
  - Workers (4)
  - Size (4)
  - Autos (4)

  2 x 3 x 4 x 4 x 4 = 384 Strata!

- Proposed method is to apply household classification models combined with an auto ownership model

Building the Household Classification

Desired outcome:
number of households in each feasible combination,
for each TAZ

Income 3

	S1	S2	S3	S4+
W0				

Income 2

	S1	S2	S3	S4+
W0				

Income 1

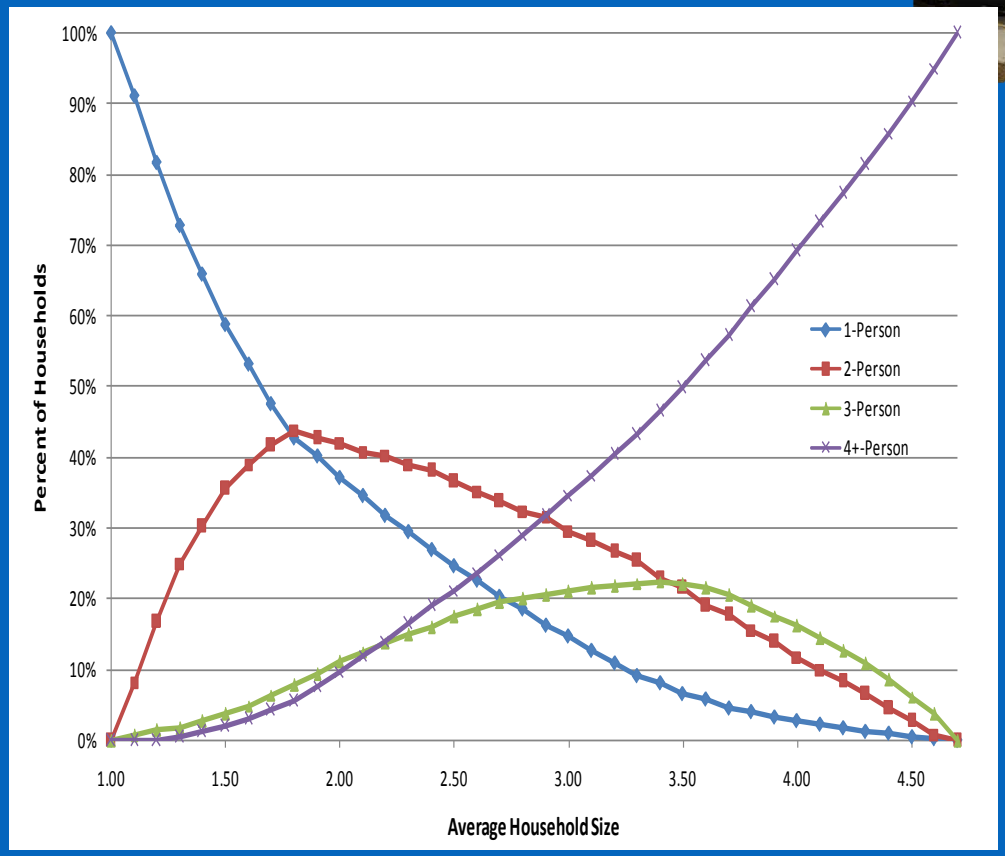
	S1	S2	S3	S4+
W0	2	1	1	0
W1	4	2	1	1
W2	-	7	5	3
W3+	-	-	2	1

Building the Household Classification

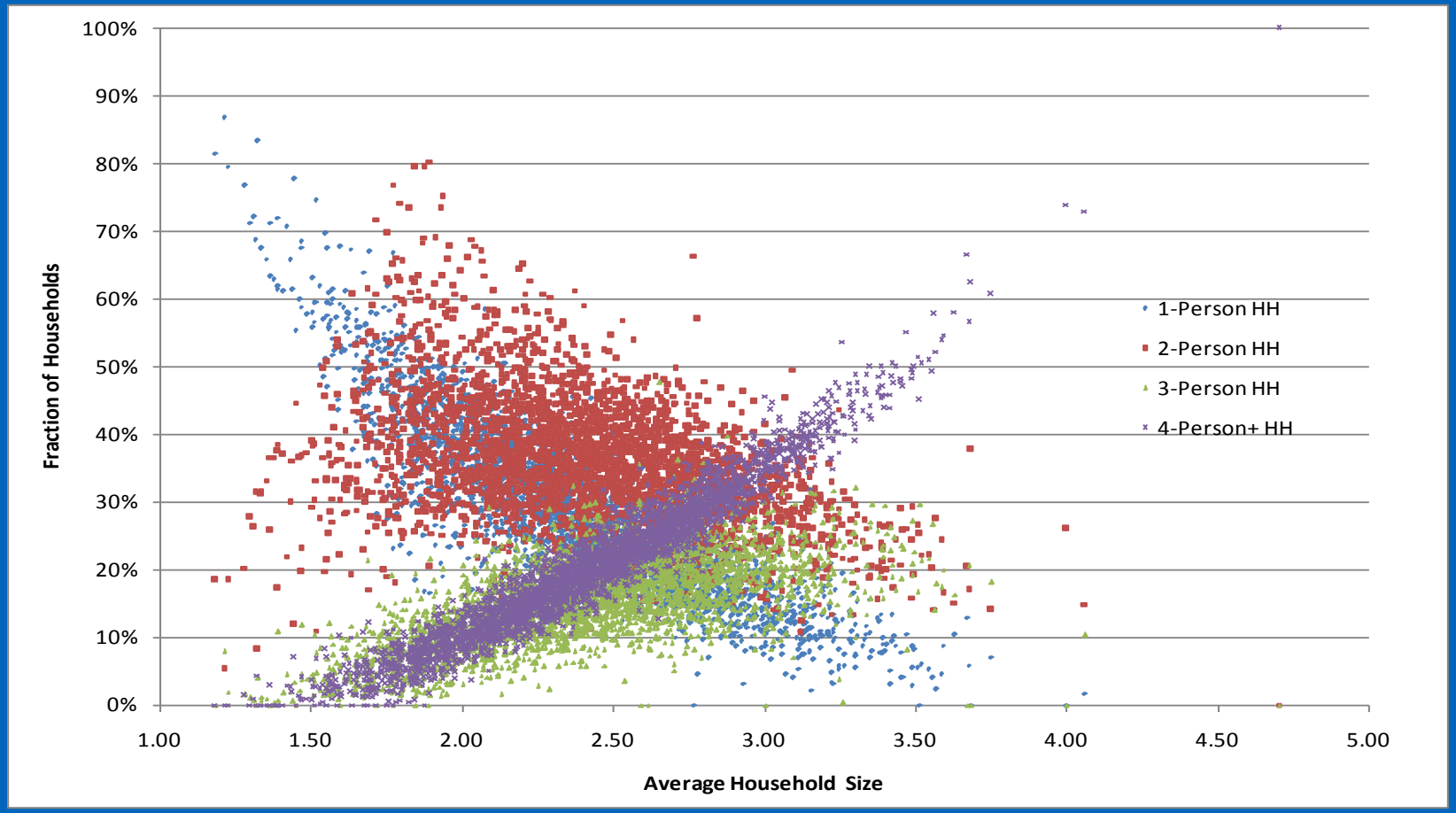
- Start with a *regional* distribution of households (seed)
- Find, for each TAZ, the *marginal* distributions:
  - Number of 1p, 2p, 3p, 4p+ households
  - Number of 0w, 1w, 2w, 3+w households
  - Number of low inc, med inc, high inc households
- Apply Iterative Proportional Fitting (IPF) to fit the seed distributions to the marginal distributions

Building the Household Classification

- Marginal distributions may be developed with a classification model,
- Or they can be prepared as a model input
- User-specified option

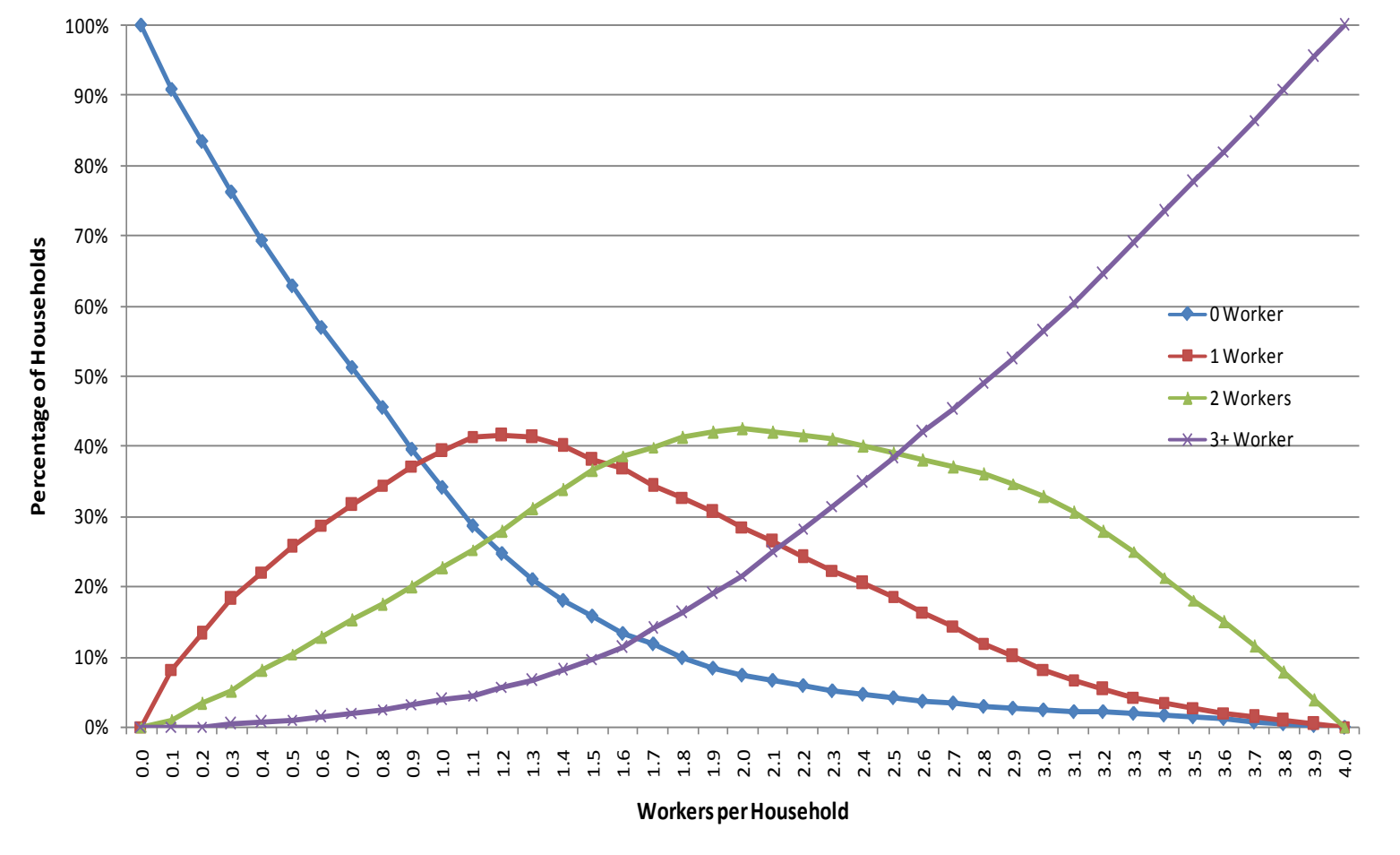


Household size classification model



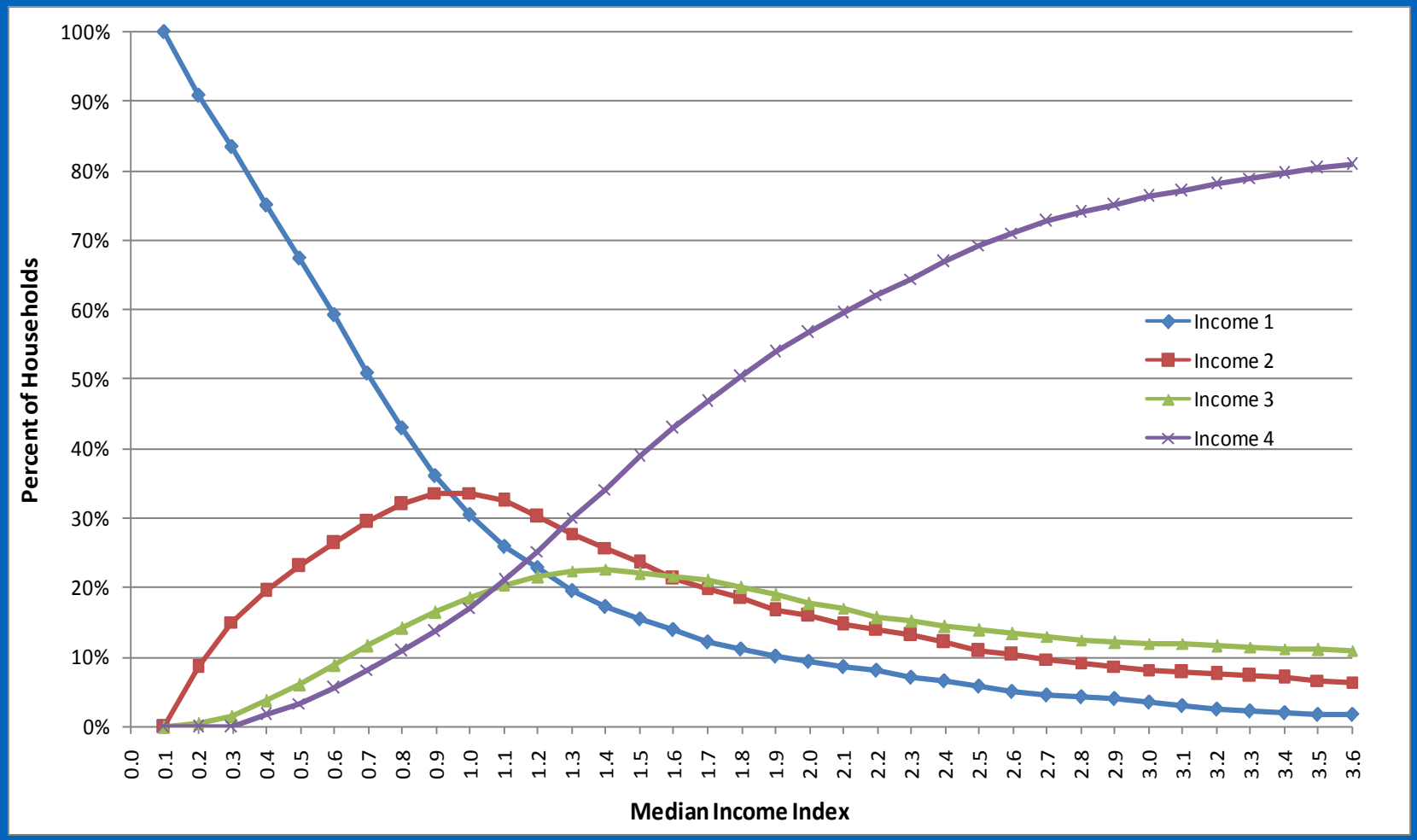
Source data: Florida 2008 NHTS Add-On Sample

Household Workers Classification Model



Source data: Florida 2008 NHTS Add-On Sample

Household Income Classification Model



Source Data: Florida 2008 NHTS Add-On Sample

Transit Modeling Update

AUTO OWNERSHIP MODEL

FLORIDA MODEL TASK FORCE

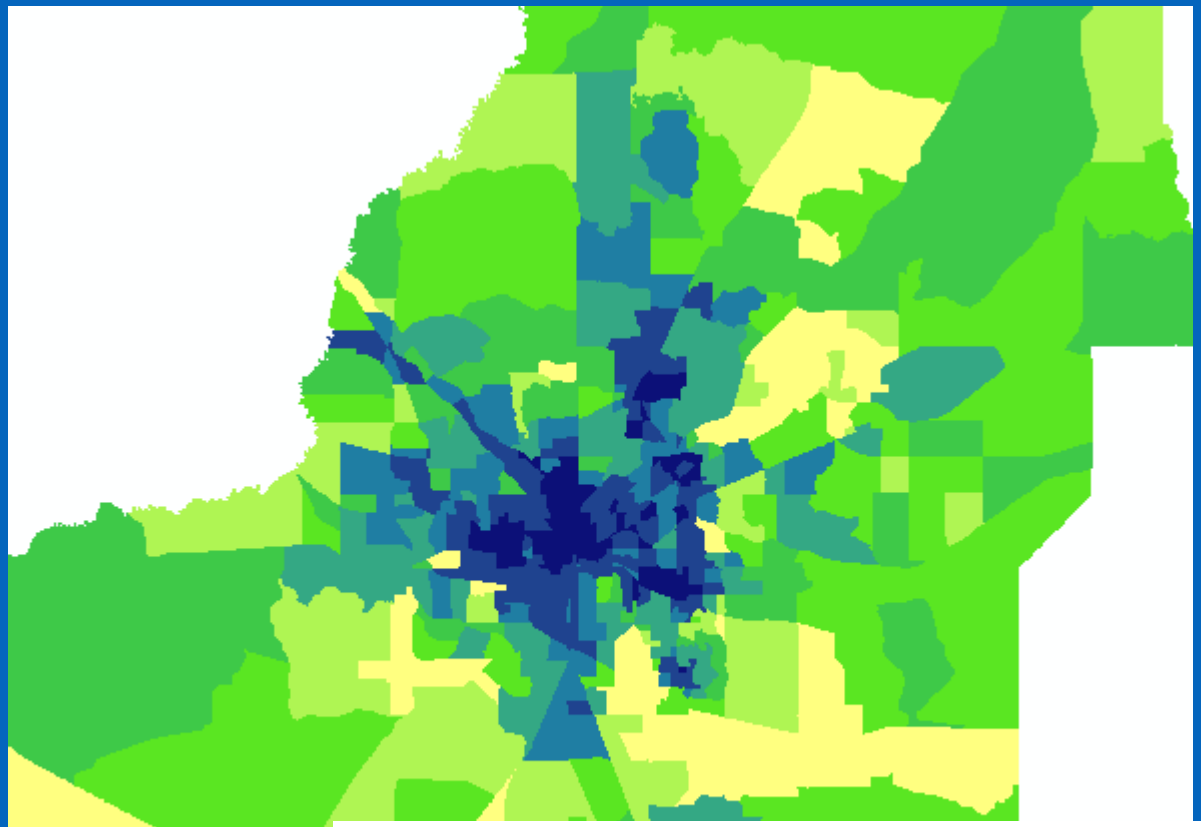
Why an Auto Ownership Model?

- Transit and non-motorized accessibility matters. An auto ownership model can be sensitive to accessibility, while a classification model is not.
- Can be estimated and validated from readily available data.
- Several effects are measurable: household size, workers, income and type of housing unit are good predictors of auto ownership.
- Reduces the number of IPF dimensions, which helps the household classification model to converge more quickly.

Proposed Auto Ownership Model

- Multinomial logit
- Choice set: 0,1,2,3,4+ autos per household
- Explanatory variables:
  - Household size, income, workers
  - Type of housing unit
  - Household and employment density
  - Transit and non-motorized accessibility

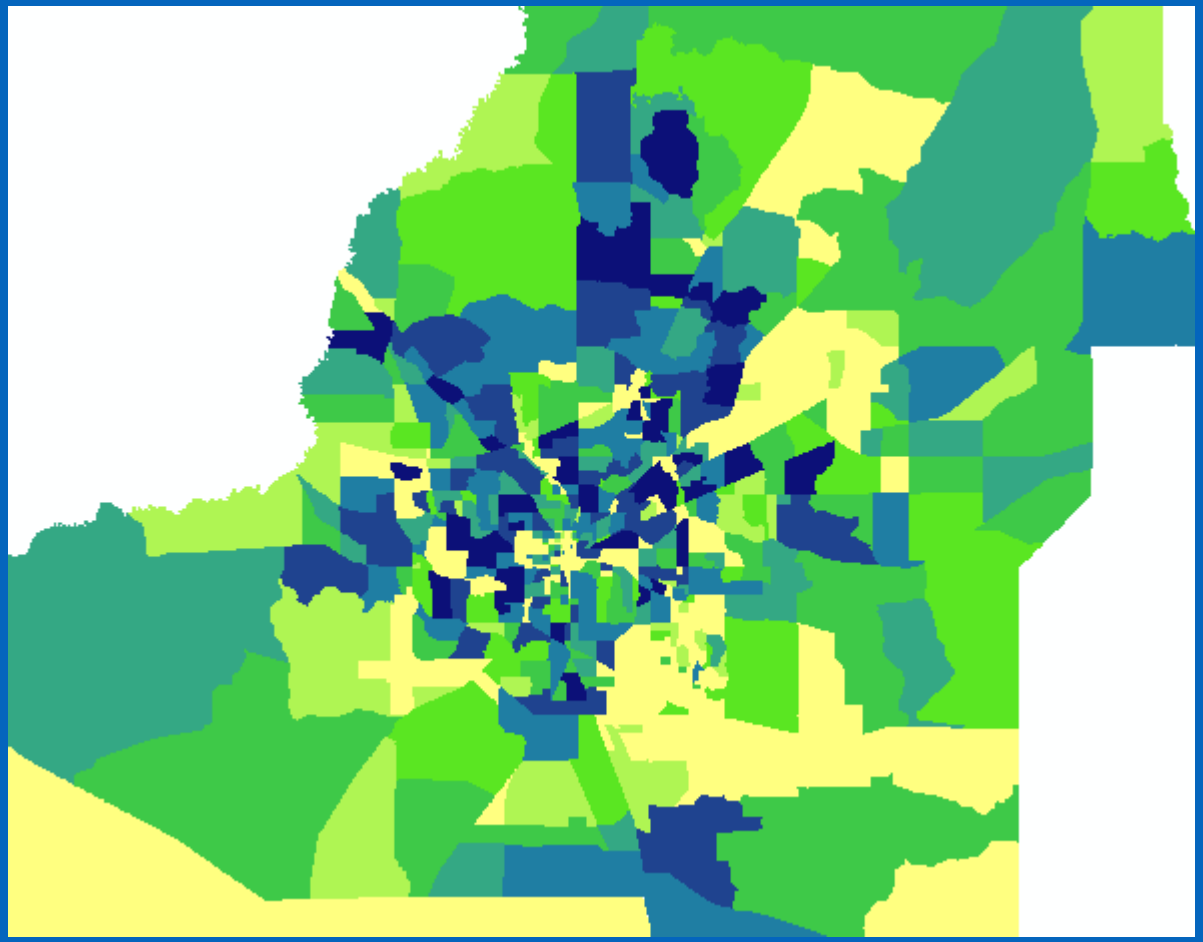
Mixed Household / Employment Density



$$Mixed\ \ Density = \ln\left[\frac{Intersections \times (a \times Households) \times (b \times Employment)}{Intersections + (a \times Households) + (b \times Employment)}\right]$$

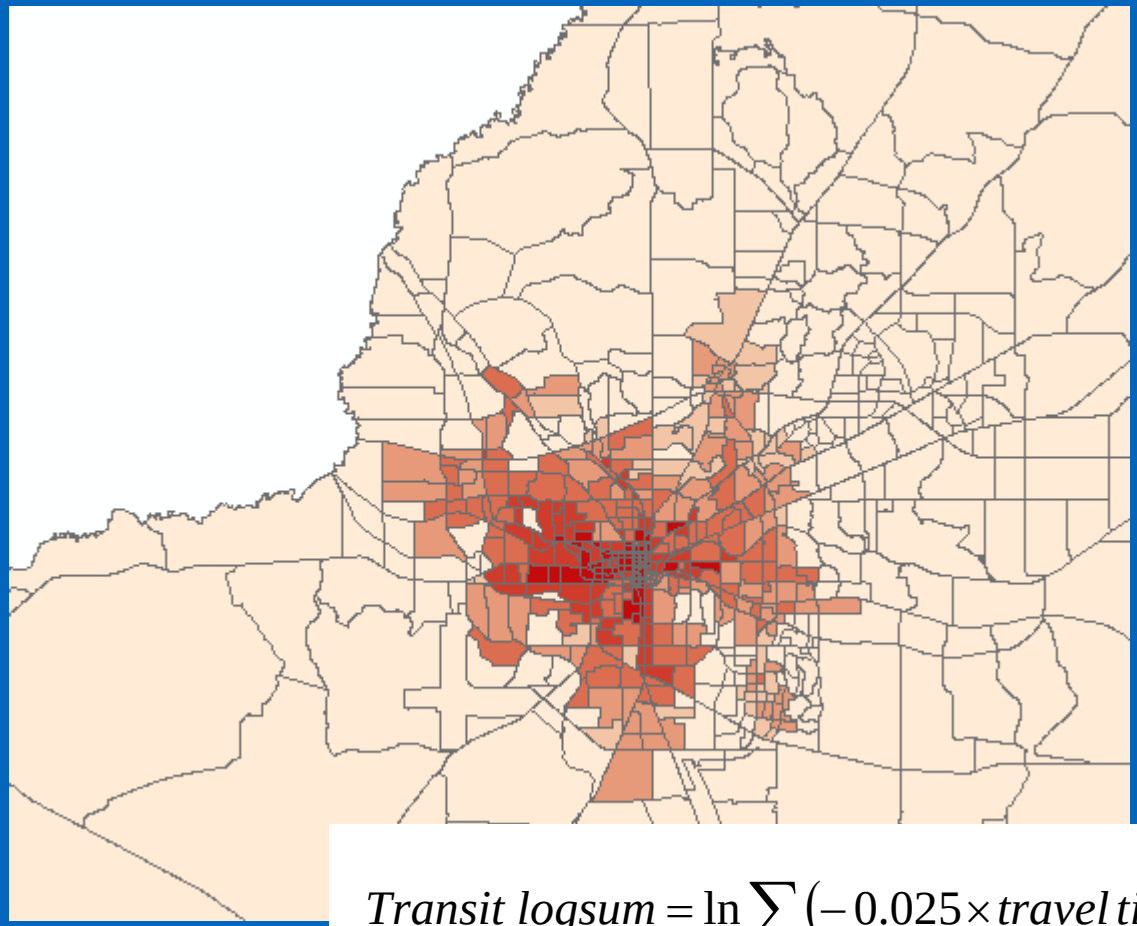
Calculated as floating densities!!

Mixed Household / Employment Density



Traditional zonal-based densities do not capture neighborhood effects as well as floating densities

Transit Accessibility to Employment



$$Transit\ logsum = \ln \sum \left(-0.025 \times travel\ time + \ln(employment) \right)$$

Sample Auto Ownership Coefficients

	1 Car		2 Cars		3 Cars		4+ Cars	
	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat
Household Income								
Low	-2.78	-6.7	-4.67	-11.2	-5.50	-12.8	-5.81	-12.4
Medium	-1.31	-3.1	-2.54	-6.0	-2.98	-7.0	-3.40	-7.7
High	-0.29	-0.7	-0.72	-1.6	-0.90	-2.0	-0.91	-2.0
Household Size								
2 Person HH	--	--	+2.02	+33.1	+1.99	+18.5	+1.68	+8.3
3 Person HH	--	--	+1.80	+22.5	+2.40	+19.7	+1.93	+8.8
4+ Person HH	--	--	+2.09	+27.7	+2.34	+19.5	+2.61	+12.6
Workers in HH								
1 Worker HH	+0.89	+10.6	+1.06	+11.0	+1.14	+9.2	+1.37	+6.4
2 Workers HH	+0.51	+3.6	+1.61	+11.0	+1.86	+11.2	+2.15	+8.9
3+ Workers HH	--	--	+0.76	+4.2	+2.72	+14.2	+3.65	+13.7
Multi-Family Housing Unit	-0.34	-4.0	-1.08	-11.8	-1.80	-15.7	-2.08	-11.6
Mixed Density	-0.0325	-1.4	-0.0534	-2.3	-0.0916	-3.7	-0.0733	-2.5
Walk Accessibility	--	--	--	--	-0.5760	-2.7	-1.4000	-2.8
Transit Accessibility	-0.0801	-7.9	-0.0927	-8.6	-0.0927	-8.6	-0.0927	-8.6

FLORIDA MODEL TASK FORCE

Transit Modeling Update

TRIP PRODUCTION MODEL

FLORIDA MODEL TASK FORCE

Trip Production Model

Home-Based Work Trip Rates

Household Income	Household Autos	Number of Workers in Household			
		Wrks0	Wrks1	Wrks2	Wrks3+
$0-$24999	Veh0	0.000	1.000	1.783	3.500
$25000-$49999		0.000	1.000	1.783	3.500
$50000-$74999		0.000	1.000	1.783	3.500
$75000+		0.000	1.000	1.783	3.500
$0-$24999	Veh1	0.000	1.085	2.272	4.389
$25000-$49999		0.000	1.332	3.145	4.389
$50000-$74999		0.000	1.145	2.172	4.389
$75000+		0.000	0.954	2.094	4.389
$0-$24999	Veh2	0.000	1.581	2.974	4.102
$25000-$49999		0.000	1.604	3.171	4.102
$50000-$74999		0.000	1.572	2.863	4.102
$75000+		0.000	1.330	3.111	4.102
$0-$24999	Veh3+	0.000	1.595	3.130	5.075
$25000-$49999		0.000	2.297	3.109	5.075
$50000-$74999		0.000	1.967	3.247	5.799
$75000+		0.000	1.551	3.119	5.799

Data Source: Florida 2008 NHTS Add-On Sample

FLORIDA MODEL TASK FORCE

Trip Productions Model

Home-Based Other Trip Rates

Household Income	Household Autos	Household Size			
		Size1	Size2	Size3	Size4+
$0-$24999	Veh0	0.535	1.057	1.310	3.719
$25000-$49999		0.535	1.057	1.310	3.719
$50000-$74999		0.535	1.057	1.310	3.719
$75000+		0.535	1.057	1.310	3.719
$0-$24999	Veh1	0.611	1.451	2.946	3.155
$25000-$49999		0.577	1.581	2.542	3.155
$50000-$74999		0.696	1.877	2.438	3.155
$75000+		0.936	2.011	4.455	3.155
$0-$24999	Veh2	0.630	1.181	2.823	4.000
$25000-$49999		0.717	1.368	2.168	4.151
$50000-$74999		0.768	1.330	2.160	4.839
$75000+		1.277	1.605	2.772	4.989
$0-$24999	Veh3+	1.175	0.973	1.832	4.216
$25000-$49999		1.175	1.310	2.375	4.563
$50000-$74999		1.175	1.443	2.347	4.285
$75000+		1.175	1.319	2.039	4.813

Data Source: Florida 2008 NHTS Add-On Sample

FLORIDA MODEL TASK FORCE

Transit Modeling Update

TRIP ATTRACTION MODEL

FLORIDA MODEL TASK FORCE

Trip Attraction Model Alternatives

- Logit share model
  - Estimates the share of workers in each income group, at place of work, as a function of type of employment
  - Requires CTPP place of work data - 2012
- Cross-classification model
  - Similar to a trip production model
  - Requires establishment survey

Trip Attraction Model

- **Linear regression model**
  - **Attractions stratified by income**

Trip Purpose	Common Trip Rate	Trip Rate Employment Multiplier		
		Industrial Employment	Service Employment	Commercial Employment
HBW Inc1	0.0910	0.728	1.000	2.437
HBW Inc2	0.1943	2.452	1.000	1.874
HBW Inc3	0.1932	0.754	1.000	1.325
HBW Inc4	0.4225	1.231	1.000	0.741

Trip Attraction Model

- Trip attraction models are optional when the distribution model is a destination choice model
- The destination choice “size term” replaces the attraction model

Transit Modeling Update

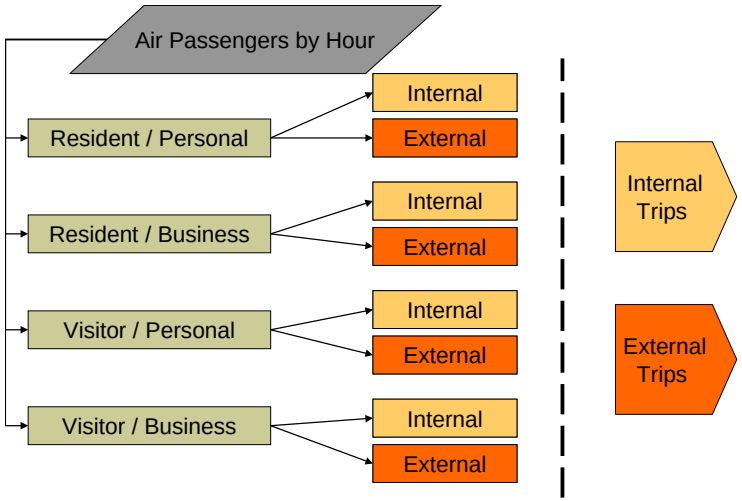
SPECIAL TRIP MARKETS

FLORIDA MODEL TASK FORCE

Special Trip Markets

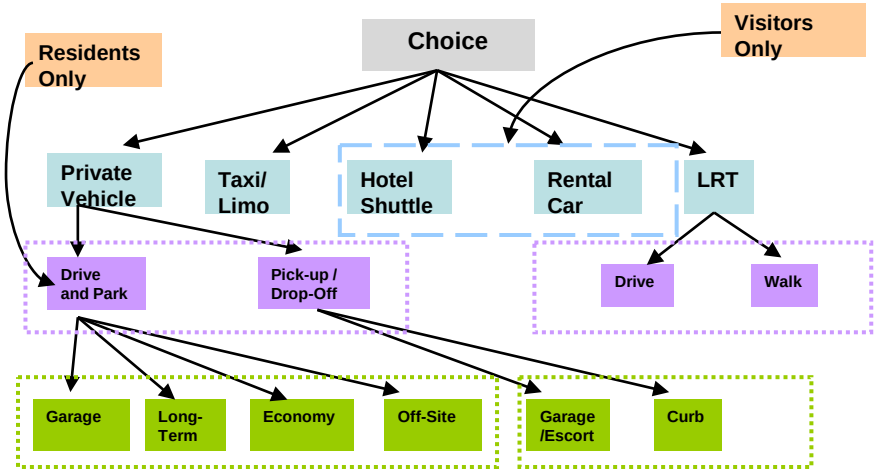
- Seasonal Residents
- Visitors
- External Workers
- Air Passengers
- Other Special Generators
- Special Events

Example 1: Portland Air Passenger Trip Model

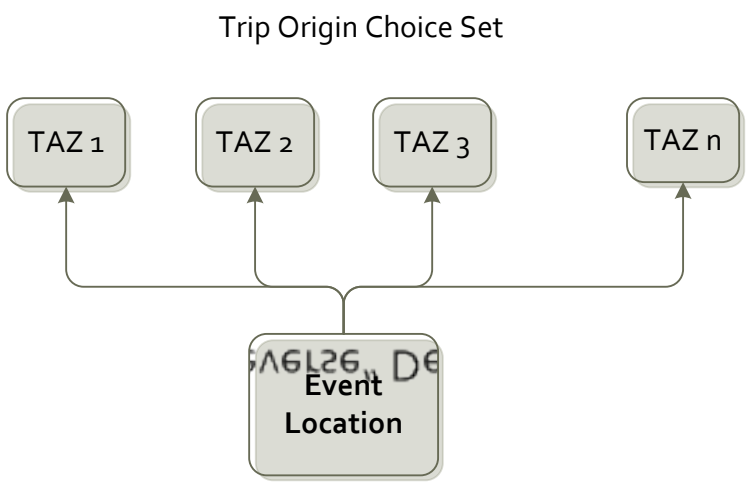


Portland Ground Access
Air Trip Generation

Portland Ground Access
Mode Choice

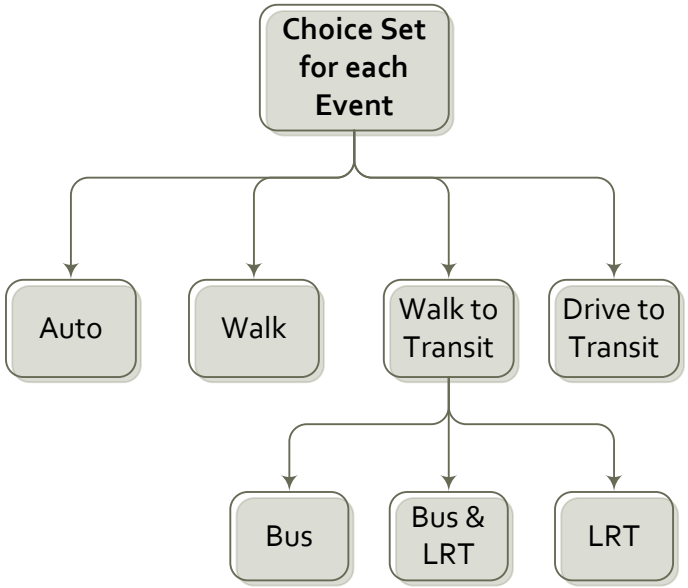


Example 2: Phoenix Event Model



Event "Reverse" Destination Choice Model

Event Mode Choice



Transit Modeling Update

TIME OF DAY STRATIFICATION

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Why Time of Day Stratification?

- Account for and represent time-of-day differences in transit levels of service:
  - frequency of service
  - fare
  - speed
  - routing
- Account for differences in travel markets:
  - peak period commute market
  - midday circulation market
  - off-peak period market(s)

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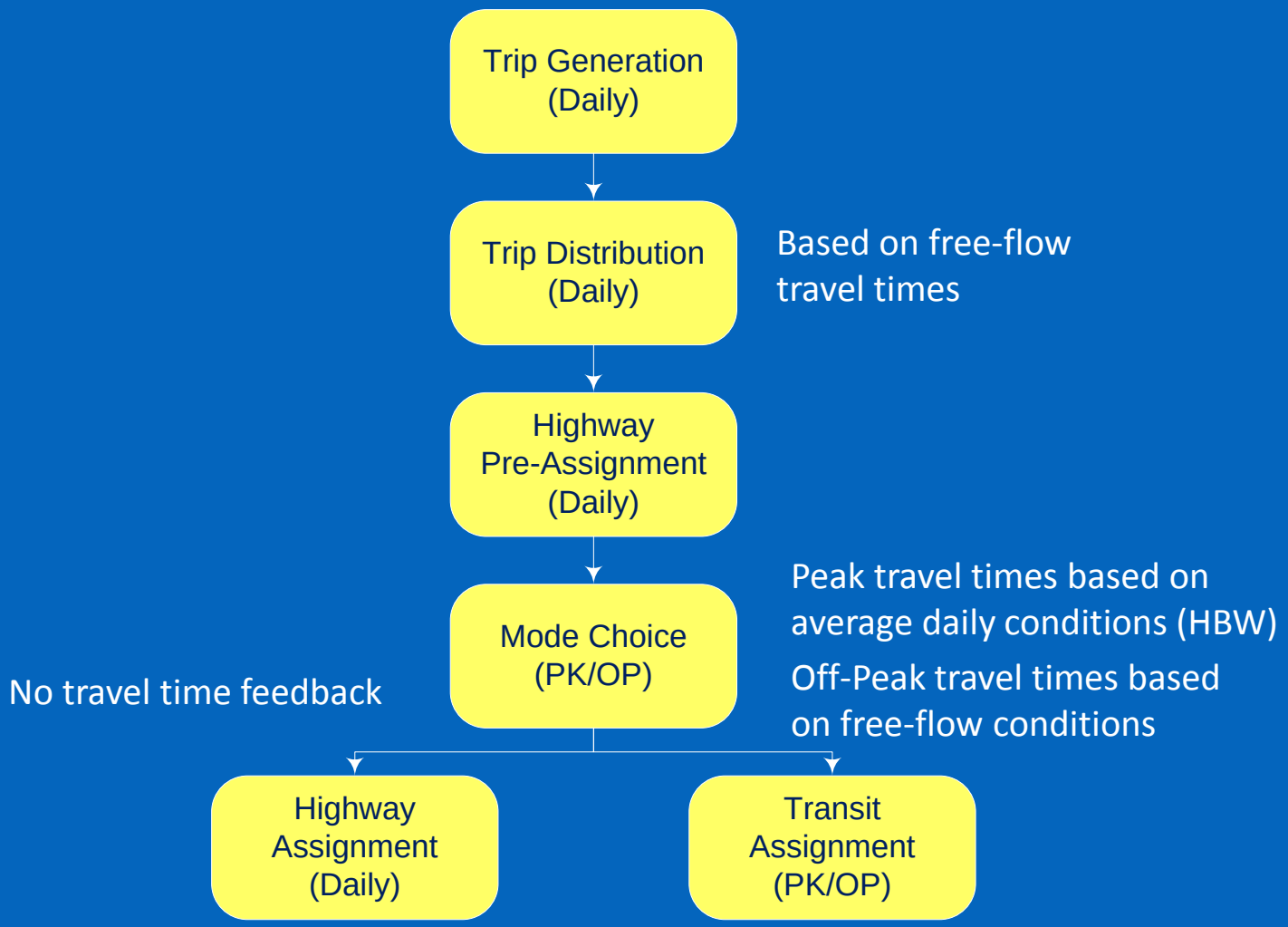
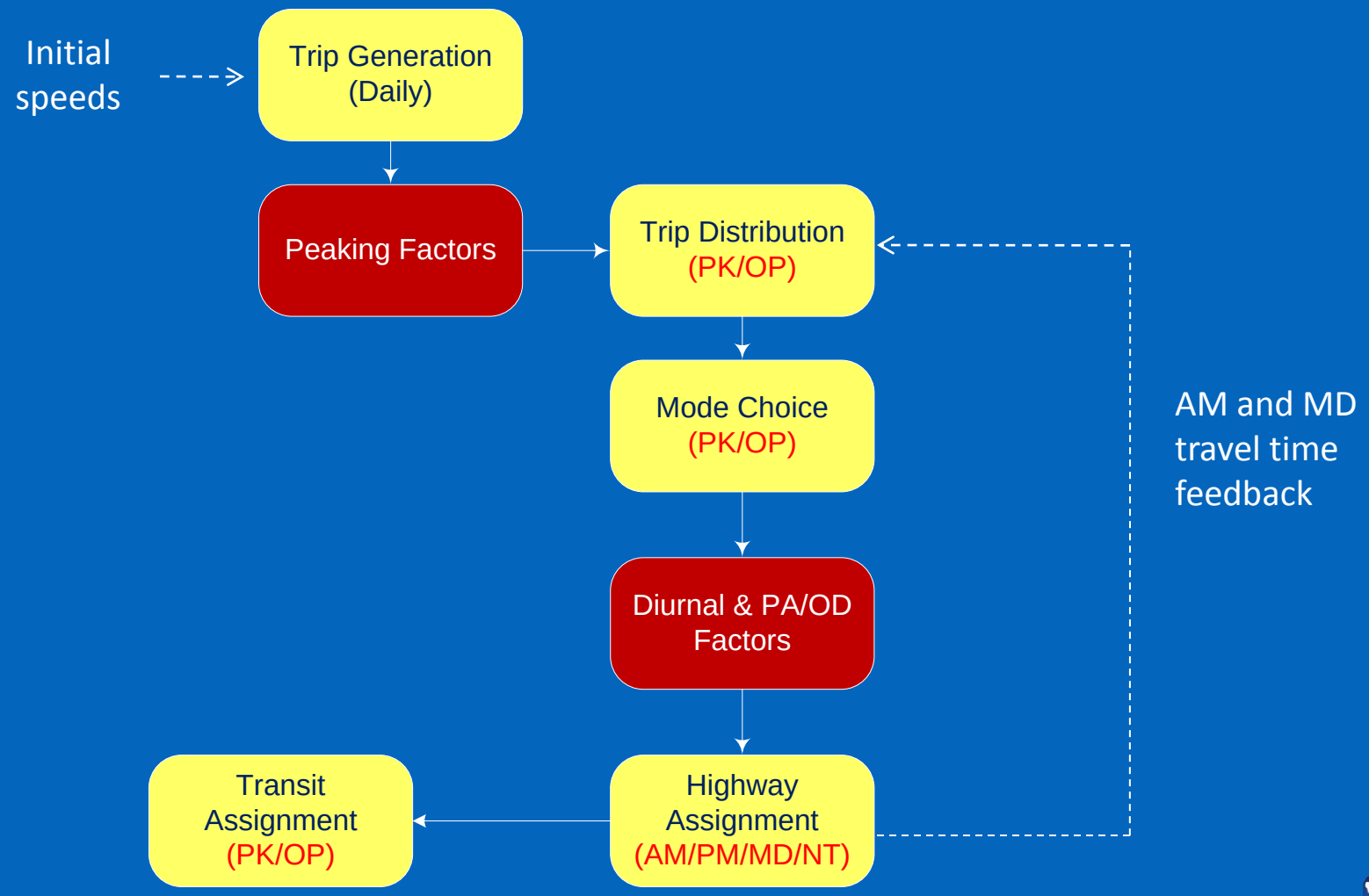
FSUTMS Approach to Time of Day Effects



Recommended Approach



Implications for other model components

- Modifies the definition of peak and off-peak times
  - Peak conditions –AM peak, PM peak, mixed?
  - Off-peak conditions – assume midday (not free-flow)
- Requires period-specific networks:
  - Transit – peak & midday service levels
  - Highway -- AM / MD / PM / NT capacity factors
- True diurnal stratification of trip distribution and mode choice models
- Requires performing more highway assignments
  - More time periods
  - More feedback loops

FLORIDA MODEL TASK FORCE

Time of Day Periods

- Allow for region-specific definitions of the peak period
  - Longer peak periods observed in urban areas
- Define periods on the basis of:
  - Observed diurnal patterns (surveys, traffic counts)
  - Transit levels of service
  - Levels of congestion (today)
  - Levels of congestion (future) – leave room for peak spreading

FSUTMS Diurnal Factors

- Developed from 2008 NHTS Add-On data, for these periods:
  - AM Peak: 7:00 AM to 8:59 AM
  - Midday: 9:00 AM to 2:59 PM
  - PM Peak: 3:00 PM to 5:59 PM
  - Night: 6:00 PM to 6:59 AM
- Stratified by trip purpose (standard practice)
- Also stratified by household income and region

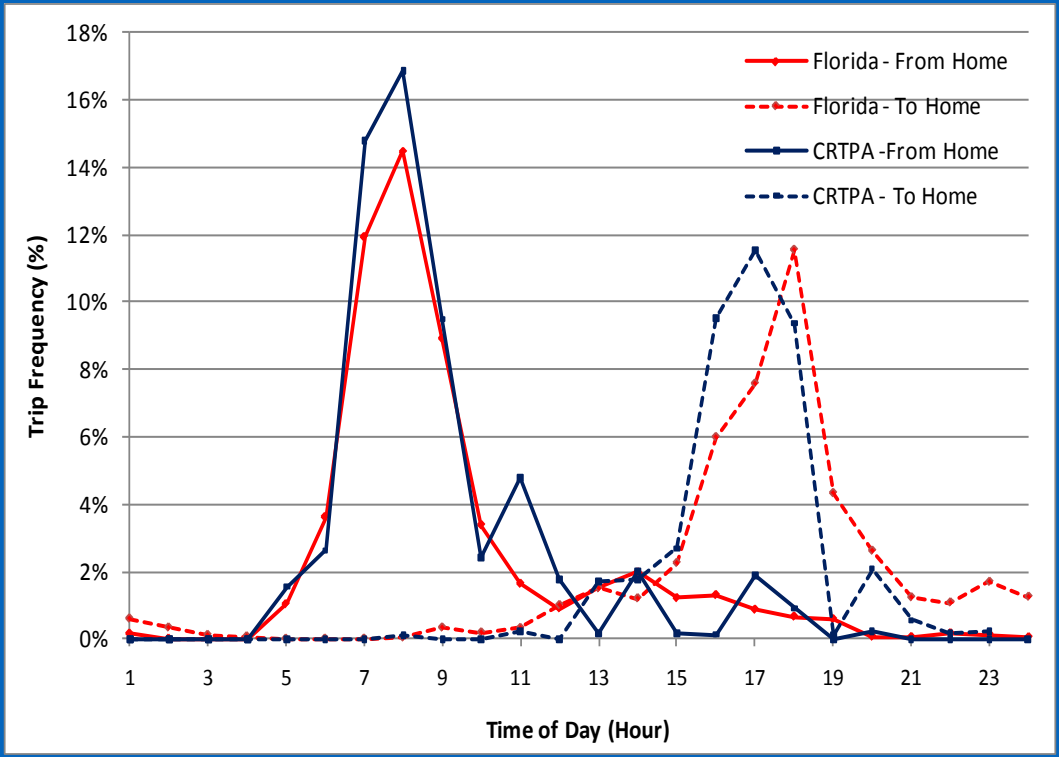
HBW Peaking & Diurnal Factors

HBW Peak Factors

Period	CRTPA Region	Florida
Peak	0.773	0.420
Off-Peak	0.227	0.580
	1.000	1.000

HBW Diurnal Factors

	CRTPA		Florida	
Period	P/A	A/P	P/A	A/P
AM	0.418	0.000	0.354	0.004
MD	0.108	0.039	0.106	0.065
PM	0.031	0.325	0.034	0.294
NT	0.046	0.033	0.053	0.090
	1.000		1.000	



Travel Time Feedback: Why?

- **Ensure consistency of supply and demand assumptions and outcomes in the forecast**

Travel Times derived from Link Flows
Output from highway assignment

=

Travel Times that yield the assigned Trips
Input to distribution & mode choice

Travel Time Feedback: How?

- **Combine link volumes of previous feedback loops with a decreasing weight (to ensure convergence)**

$$Link\,Flow^{n+1} = Link\,Flow^{n} \times (1 - 1/n) + Link\,Flow^{n-1} \times (1/n)$$

Method of successive averages

- **Compute new travel time by applying the speed-delay functions to the "averaged" volume**

- **Exit feedback loop when the relative change in link volumes and/or travel times is small**

Transit Modeling Update

TRIP DISTRIBUTION MODEL

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Trip Distribution Model

- **Proposed changes to FSUTMS discussed so far affect the specification and calibration of the distribution model:**

	Current	Proposed
Levels of Service	Free-flow	Peak Off-Peak
Household markets	None	Income & Car Sufficiency
Input/output travel time consistency	No	Yes
Model Structure	**Gravity**	**Destination Choice**

Destination Choice Advantages

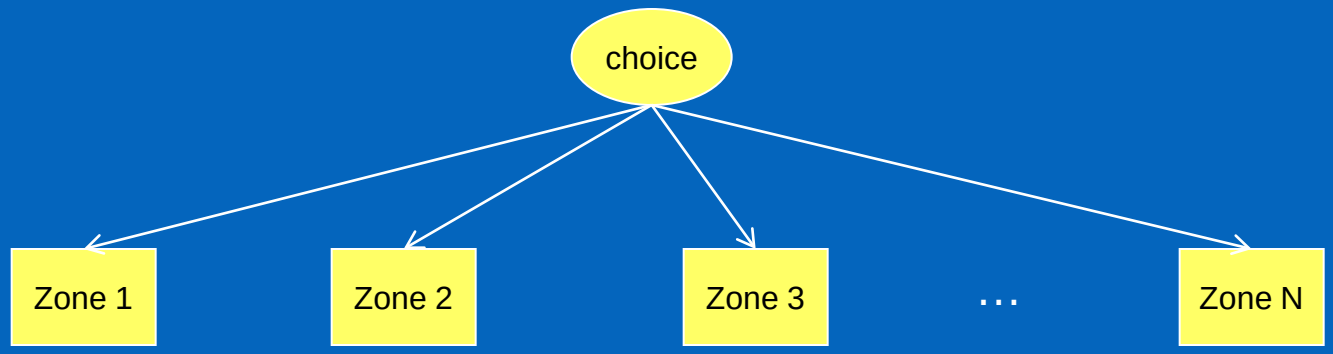
- **Sensitive to changes in highway and transit levels of service *commensurate* with their share of the travel market.**
  - **No more illogical changes to transit or auto trips!**
  - **e.g., when total person trips between two zones increase because of better travel times, the additional demand is allocated to the improved modes.**
  - **Total person trips respond to changes in transit or non-motorized accessibilities**

Destination Choice Advantages

- Very flexible model form
  - Can accommodate multi-modal impedances and many other variables
  - Allows generic and market-specific variables, which result in parsimonious specifications that capture key market differences
  - Can be calibrated to match observed trip length frequencies and other calibration measures
  - Could even be used to apply the current gravity models!

Destination Choice Model

- **Multinomial logit formulation**



choice set contains all TAZs in the region

- **Utility:**

$$U_{ijm} = \sum_k \beta^k \times X_{ij}^k + ln \sum_m \gamma^n \times S_j^m$$

"quality" variables:
travel time, travel distance, etc.

"quantity" variables
employment, households

Utility Function Variables

Mode choice logsum	• Impedance measure • Considers travel times, costs and preferences for all modes
Distance	• Used to reproduce observed trip length frequencies
Trip market attributes	• Provide additional sensitivity to attributes such as urban form or household income • May be interacted with one or more distance terms
Location attributes	• Represent barriers to travel, natural or perceived • Conceptually equivalent to a bridge time penalty
Size terms	• Represent activity opportunities at the destination • Often times consists of a weighted sum of employment by industry

FLORIDA MODEL TASK FORCE

Trip Market Stratification

- At least as many market segments as required by the mode choice model:
  - Trip purpose
  - Time period (peak & off-peak)
  - Household income & Car sufficiency
- Full segmentation is not required - some parameters are common across market segments
- Market segmentation helps to get the right workers to the right jobs, and exposes trips to accessibilities consistent with mode choice

Attraction Balancing

- The home-based work model is constrained so that attractions are proportional to employment at the destination zone

- A shadow price is added to each destination zone to increase or decrease its attractiveness

$$U'_{ijm} = U_{ijm} + sp_j$$

- The HBW destination choice model is applied iteratively until the shadow price, sp_j, converges

$$sp_j^{n+1} = sp_j^n + ln\left(\alpha\, Emp_j \Big/ \sum_i T_{ij}^n\right)$$

Attraction Balancing

- Whether to shadow price hinges on the level of confidence in the attractions forecast
  - Usually not very high confidence, except for HBW
- Recommended approach is to only constrain the HBW trips
  - Zonal employment is known
  - Compute shadow price for all household & car sufficiency segments ***combined***.

Specifying a Destination Choice Model

- Unlike a gravity model, that only requires calibration, a destination choice model has parameters that need to be specified
- Model parameters are specified via model estimation and model calibration
- Some parameters may be transferred, but others must at least be calibrated

Destination Choice Estimation

- Requires commercially-available econometric software (Alogit, Biogene, Stata, etc.),
- … a sample of trip records from NHTS or local household travel survey:
  - Trip Id
  - Trip purpose
  - Production zone
  - Attraction zone (choice)
  - Household income (& other trip or hh. variables)
- … employment data, skims, and mode choice logsums

Destination Choice Estimation

- Sample the region's zones to construct the destination choice set for each trip record
- Attach logsum, distance and employment information to each zone in the destination choice set

Destination Choice Estimation

- **Sampling-by-importance:**
  - **Define an 'importance' function:**

$$W_{ij} = exp(D_{ij}^{-\alpha}) \times S_j$$

$$P_{ij} = \frac{W_{ij}}{\sum_j W_{ij}}$$

  - **Importance function gives the probability of being selected as the destination zone**
  - **Sample from this probability distribution to select the destination choice set (20 – 40 draws) for each observed trip record**

Destination Choice Estimation

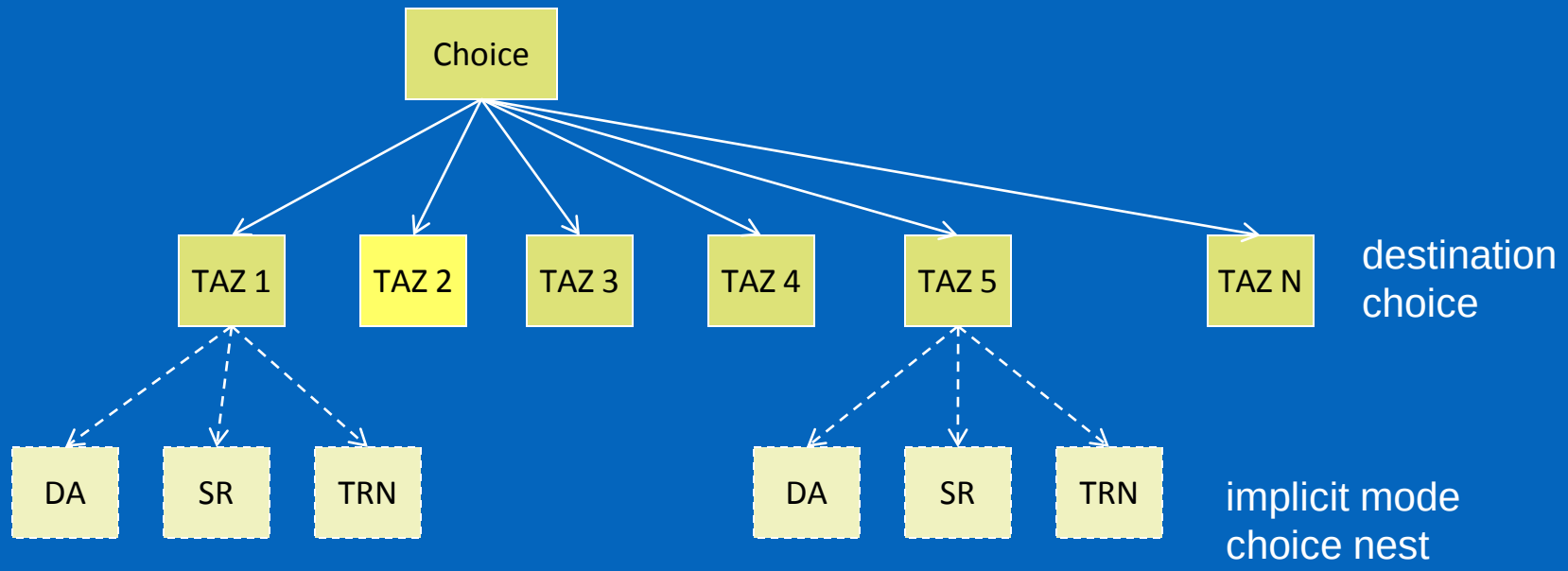
- Optionally, explode the sample
  - Reproduce each trip record k times, and choose a different destination set for each ‘exploded’ record
- Approximately statistically equivalent to choosing a destination set of 10 x k for each original trip record
- Apply weights (1/k) and sampling correction factor during estimation

$$U''_{ijm} = U_{ijm} + C_{jm}$$

Destination Choice Estimation

- Size variable coefficients may be estimated simultaneously, or pre-calculated
- Size variable pre-calculation options:
  - Use representative employment
    - HBW - total employment
    - HBSH - retail employment
    - HBU – college enrollment
  - Estimate coefficients using linear regression, similar to attraction model estimation
  - Tabulate workers by household income and industry (provides HBW income stratification)

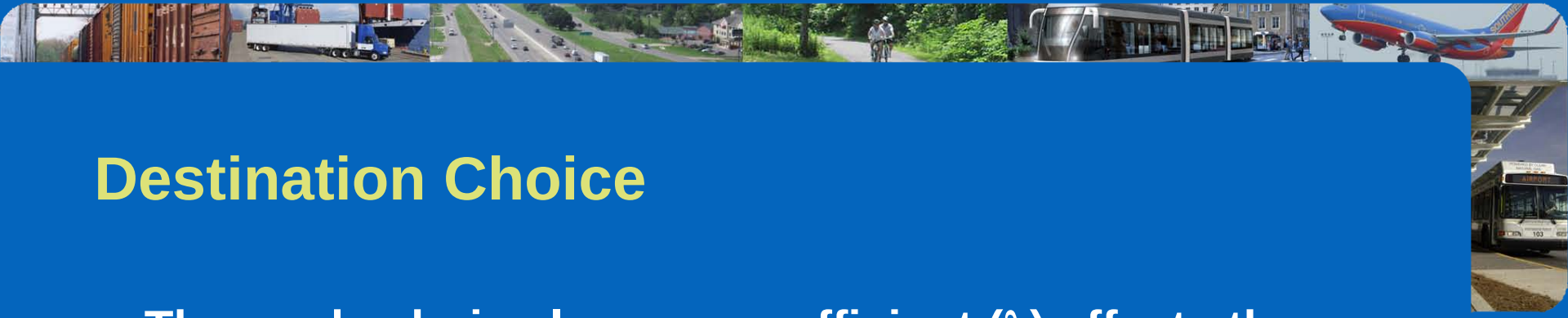
Linking Destination & Mode Choice



$$U_{ij} = \lambda \times L_{ij} + \sum_k \beta^k \times X_{ij}^k + ln \sum_m \gamma^m S_j^m$$

mode choice logsum

nesting coefficient



Destination Choice

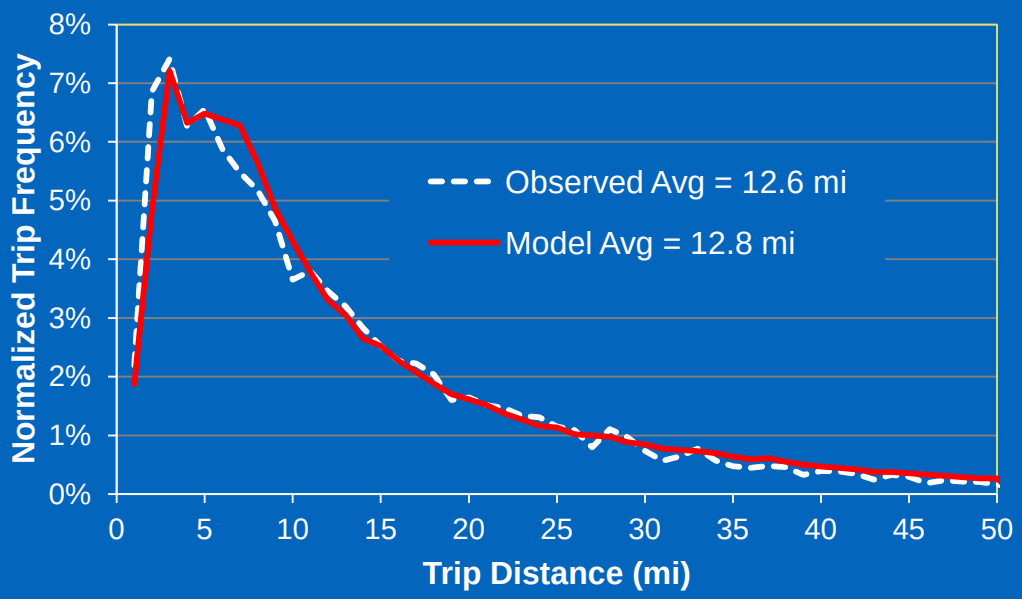
- The mode choice logsum coefficient (λ) affects the sensitivity of the distribution model to level-of-service attributes (time, cost, etc.)
  - When $\lambda << 1$, the destination choice model is relatively insensitive to changes in travel time or cost
    - HBW models: $0.5 \leq \lambda \leq 0.8$
    - HBO & NHB models: $0.7 \leq \lambda \leq 1.0$
- What happens when $\lambda > 1$?

Destination Choice Calibration

- **Calibration consists of adjusting the distance term(s) coefficients**

- **Similar calibration measures as a gravity model**

Estimated/Observed Work Trip Flows by Origin and Destination District									
	Destination								
Origin	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Row Totals**
1	1.1	0.5	1.0	0.6	0.2	0.0	0.0	0.0	**1.0**
2	0.1	1.3	0.1	0.7	0.0	0.1	0.0	0.0	**1.0**
		1.1	1.0	1.2	0.4	0.3	0.2	0.0	**1.0**
		1.2	0.8	1.0	0.3	0.5	0.1	0.1	**1.0**
		1.0	1.4	1.1	0.9	1.4	0.0	0.2	**1.0**
		1.2	0.6	1.1	2.6	1.0	0.4	0.4	**1.0**
		1.7	0.7	2.1	0.0	1.0	0.8	1.0	**1.0**
		0.4	0.0	0.8	0.7	0.8	0.7	1.1	**1.0**
		1.3	**0.9**	**1.0**	**0.7**	**0.7**	**0.7**	**0.8**	**1.0**



Transit Modeling Update

TRANSIT NETWORK CODING AND PATH BUILDING

FLORIDA MODEL TASK FORCE

Many good practices already applied …

Route and Stop/Station Location

Follows actual routing and exact stop location as accurately as allowed by the model's representation of the highway system. Recommend using transit agencies electronic records to obtain stop (lat, long) coordinates.

- ⇨ Improves estimation of in-vehicle travel times, walk distances and transfer opportunities

Applies *faithful* station coding (station micro-coding)

- ⇨ Faithfully represents street-to-station, PNR-to-station, platform-to-platform separation (horizontal & vertical).

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Good transit coding practices …

Route attributes: Mode

Defined on the basis of differences in operating characteristics and attributes not included in the model (reliability, comfort, etc.).

- ⇨ **Can be more detailed than required by the mode choice model**
- ⇨ **Used to create in-vehicle time skims**

FSUTMS Transit Modes
Local Bus
Premium Bus
Circulators (Skyway and Trolley)
Urban Rail
Commuter Rail
Other
Project

Additional Transit Mode
Bus Rapid Transit

Good transit coding practices …

Route attributes: Fare & Operator

Applies the prevalent fare system(s) as faithfully as possible.

- ⇨ **Each fare system is assigned a unique operator code**
- ⇨ **A given transit agency may be given more than one operator code, and conversely multiple transit agencies may share the operator code**
- ⇨ **Coded fare represents average fare cost per boarding or transfer**

FSUTMS Operators
Local Service
Circulator
Commuter Rail

Revised Operators?
Local Service
Premium Service
Circulator
BRT
Urban Rail
Commuter Rail
Other
Project

Good transit coding practices …

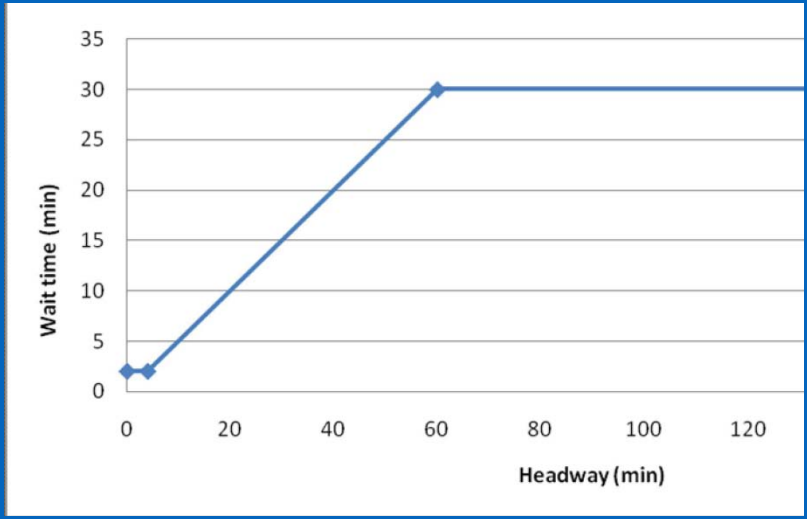
Route attributes: Headway and Wait Time

Compute time-period representative headways

- ⇨ May require coding 'short routes' separately from regular runs

Compute wait time as ½ of the headway

- ⇨ Remove current 30 minute cap
- ⇨ Cap makes the model insensitive to some headway improvements
- ⇨ In mode choice model, apply lower weight to first wait times higher than 5 minutes, in recognition that arrivals are not random



Transit network coding

Transit speed

Mode	Current Method	Proposed Method
Fixed-guideway	Coded station-to-station travel time	(same)
Buses	Proportional to auto travel time	Auto travel time + delay per stop

Transit network coding

Access Connectors

	Walk Access	Drive Access
Connector generation	Shortest distance from TAZ to stop	Generalized cost from TAZ to PNR/KNR node
Generalized cost components		Drive time, terminal time operating cost, parking cost
Access time	Based on highway distance and assumed walk speed	Based on volume-dependent travel times
Maximum length	0.6 miles	3.0 miles, lot specific
Maximum connections	99 per TAZ	3 per TAZ

May not be long enough, depending on average TAZ size and local behavior

Transit network coding

Access Connectors: REWALK program

Proceed with caution; unclear whether REWALK may have un-intended consequences (gains/loses in coverage unrelated to the project)

Useful network coding diagnostic tool

If the following condition exists,	Then:
No connectors were generated	Reset % walk to zero
No transit stop at centroid connectors, % walk < 95%	Reset all % walks to zero and delete all connectors
No transit stop at centroid connector, % walk greater than or equal to 95% and shortest connector is less than ½ mi.	None (CBD exception)
No transit stop at centroid connector, % walk greater than or equal to 95% and shortest connector greater than ½ mi.	Reset all % walks to zero and delete all connectors
Transit stop(s) at centroid connector and zone is 100% walk	None
Transit stop(s) at centroid connector and % walk is between minimum threshold and 100%	Adjust all connector times to ½ mile walk
Transit stop(s) at centroid connector and % walk is less than minimum threshold	Reset all % walks to zero and delete all connectors

Path building and skimming

Path Building Weights – Tier B Cities

	FSUTMS		Recommended	
Path Attribute	**Local Bus**	**Project**	**Local Bus**	**Project**
Walk access time	2.0	2.0	2.0	2.0
Drive access time	1.0	1.0	1.0	1.0
All walk time	10	10	-	-
Transfer walk time	2.0	2.0	2.0	2.0
Initial and transfer wait	2.0	2.0	2.0	2.0
Transfers	10	10	10	10
Local Bus IVTT	1.0	1.3	1.0	**1.1 – 1.2**
Premium Bus IVTT	10	1.0	-	1.0
Circulator IVTT	1.0	1.3	1.0	**1.1 – 1.2**
Urban Rail IVTT	10	1.0	-	1.0
Commuter Rail IVTT	10	1.0	-	1.0
Project IVTT	10	1.0	-	1.0

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Path building and skimming

Path Conditioning

Removes irrelevant paths from the skim matrices:

- all walk paths
- paths that do not use relevant line-haul mode

Recommendation:
Implement logic directly in mode choice program

Transit Modeling Update

MODE CHOICE MODEL

FLORIDA MODEL TASK FORCE

Trip market segmentation

Walk Market Segmentation

Recommendation: Implement short & long walk market segmentation

Short walk: ¼ mile buffer around stops & stations
Long walk: ½ mile buffer around stops and stations

… or as established by analysis of on-board survey data

		Egress	
Access		Short Walk	Long Walk
	Short Walk	1	2
	Long Walk	3	4
	Drive	5	6
	No Transit	7	

FLORIDA MODEL TASK FORCE

Trip market segmentation

Household Market Segmentation

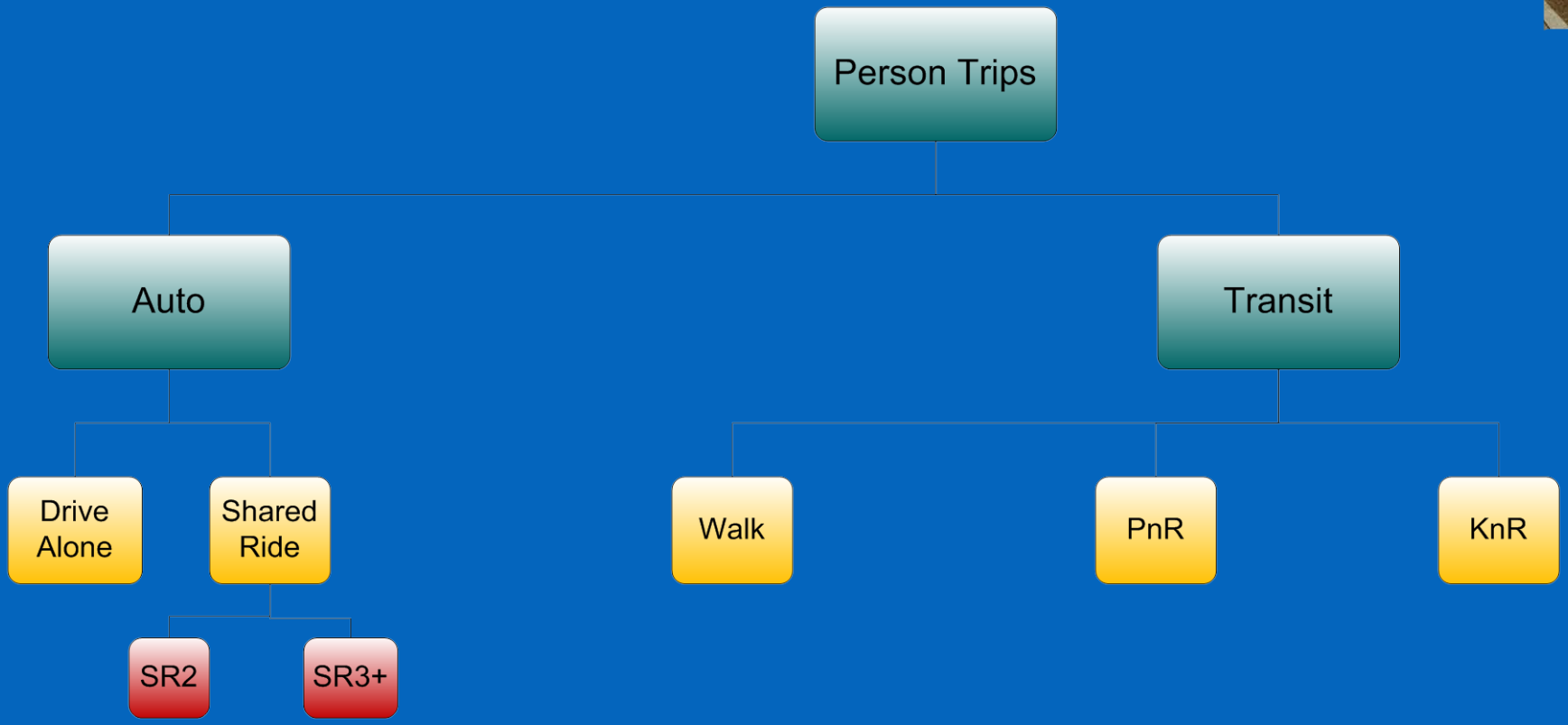
FTA Recommended Mode Choice Stratification

	Zero Cars	Car Insufficient	Car Sufficient
Low Income	●	●	●
Medium Income		●	●
High Income		●	●

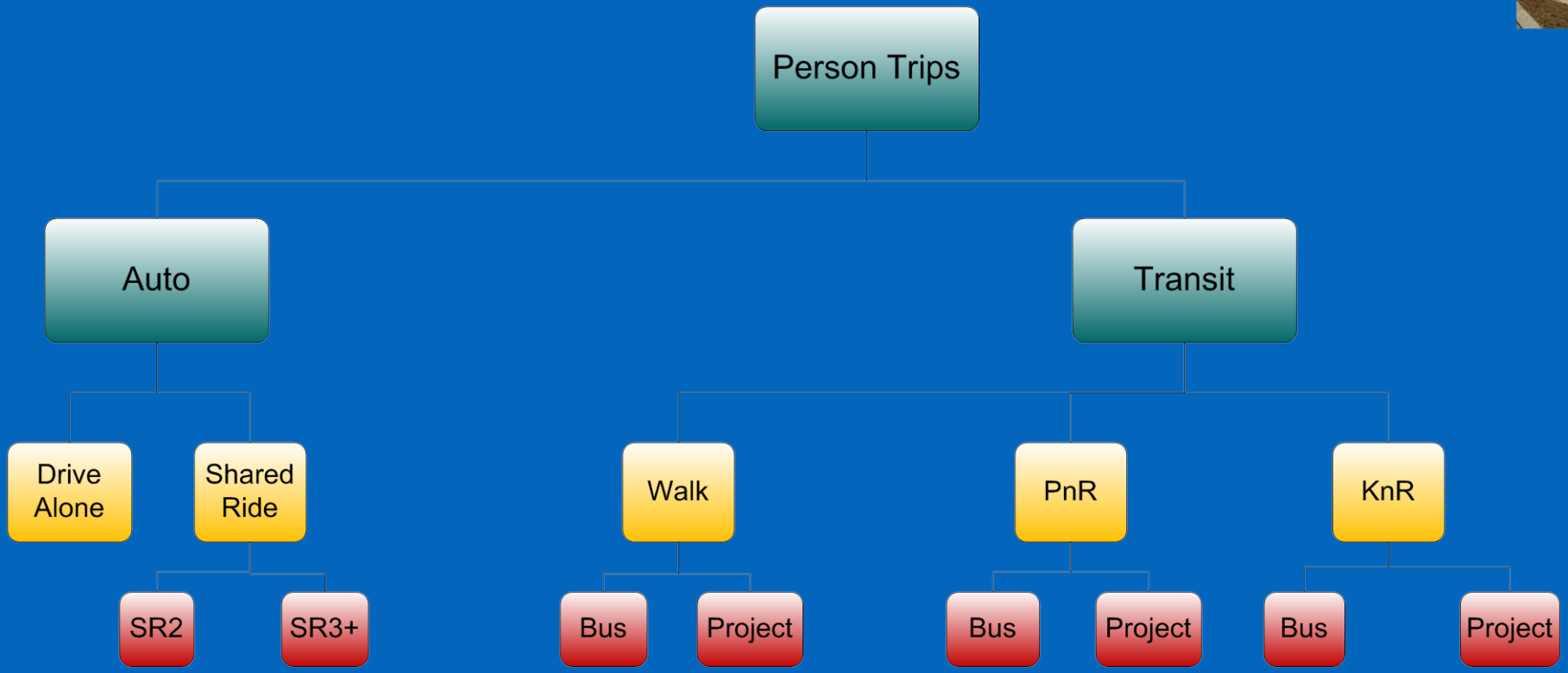
Time Period Segmentation

Stratify all purposes by peak and off-peak periods

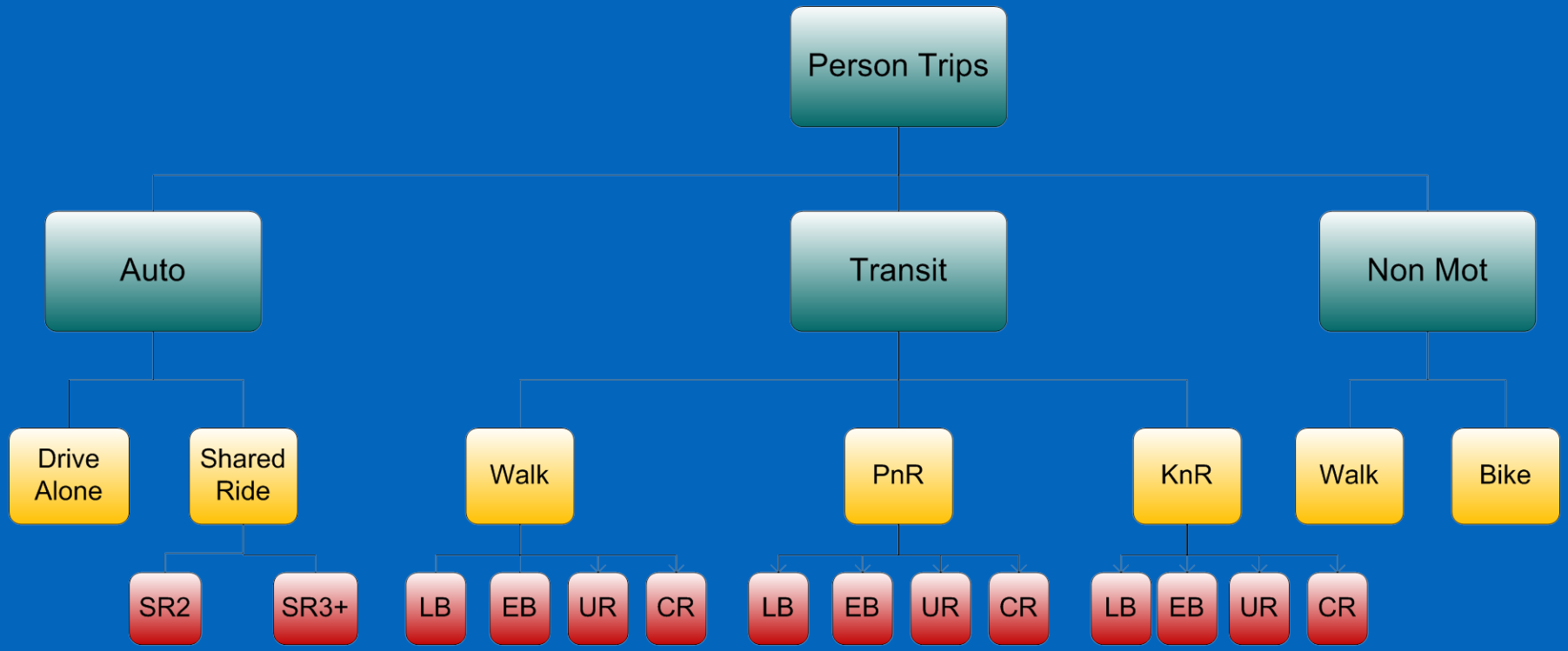
Tier A Mode Choice Nesting Structure



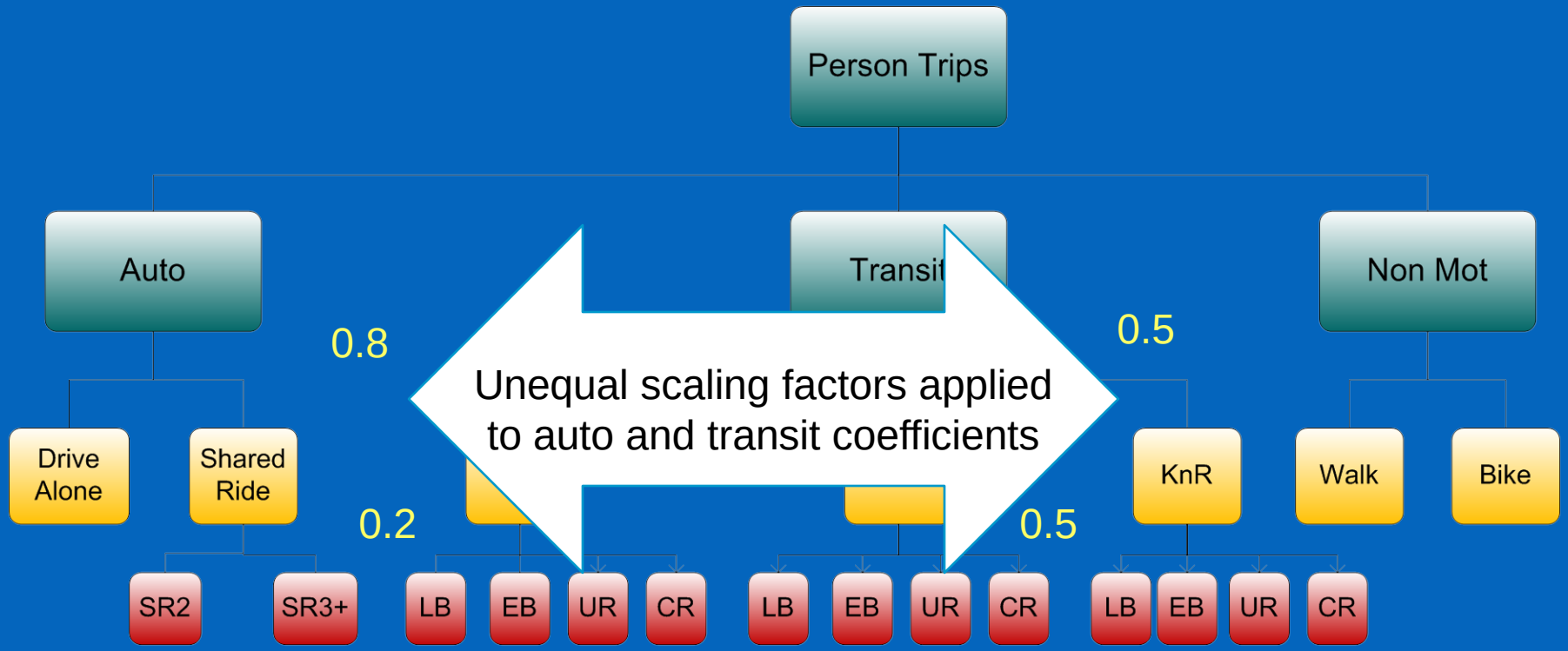
Tier B/C Cities Mode Choice Nesting Structure



Proposed Choice Set and Nesting Structure



FSUTMS Nesting Coefficients

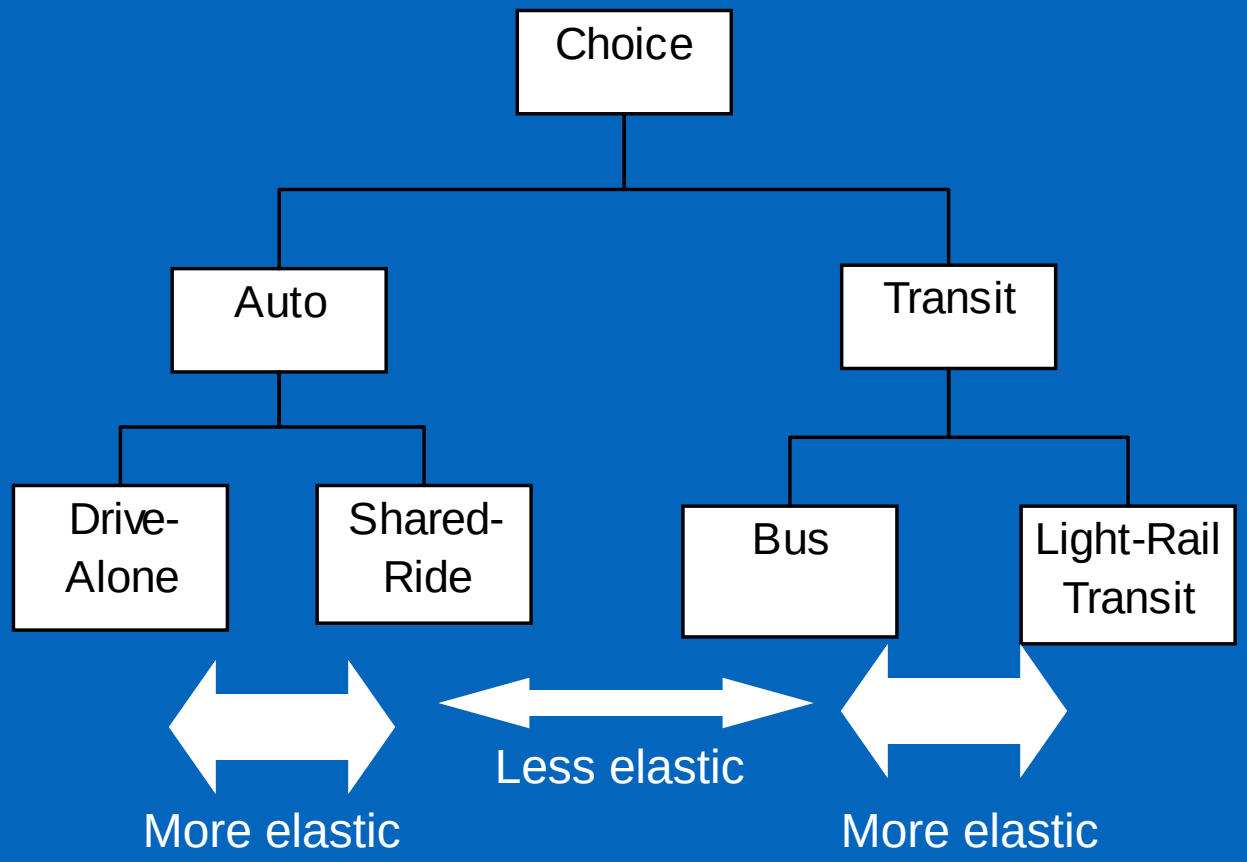


Nesting coefficient: what is it?

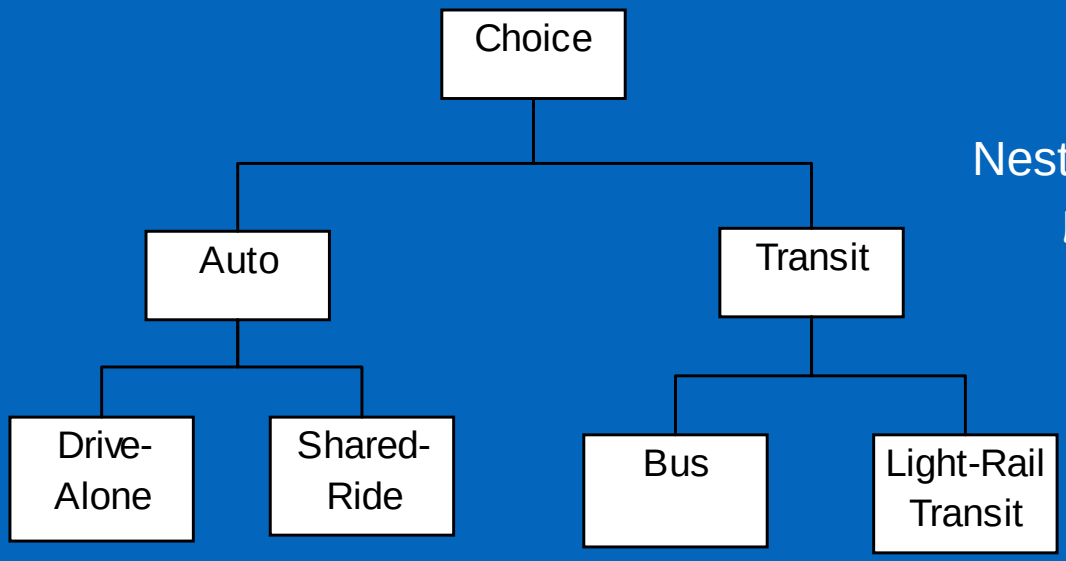
A measure of the correlation between alternatives

$0 < \mu < 1$

$1 - \mu \sim$ correlation



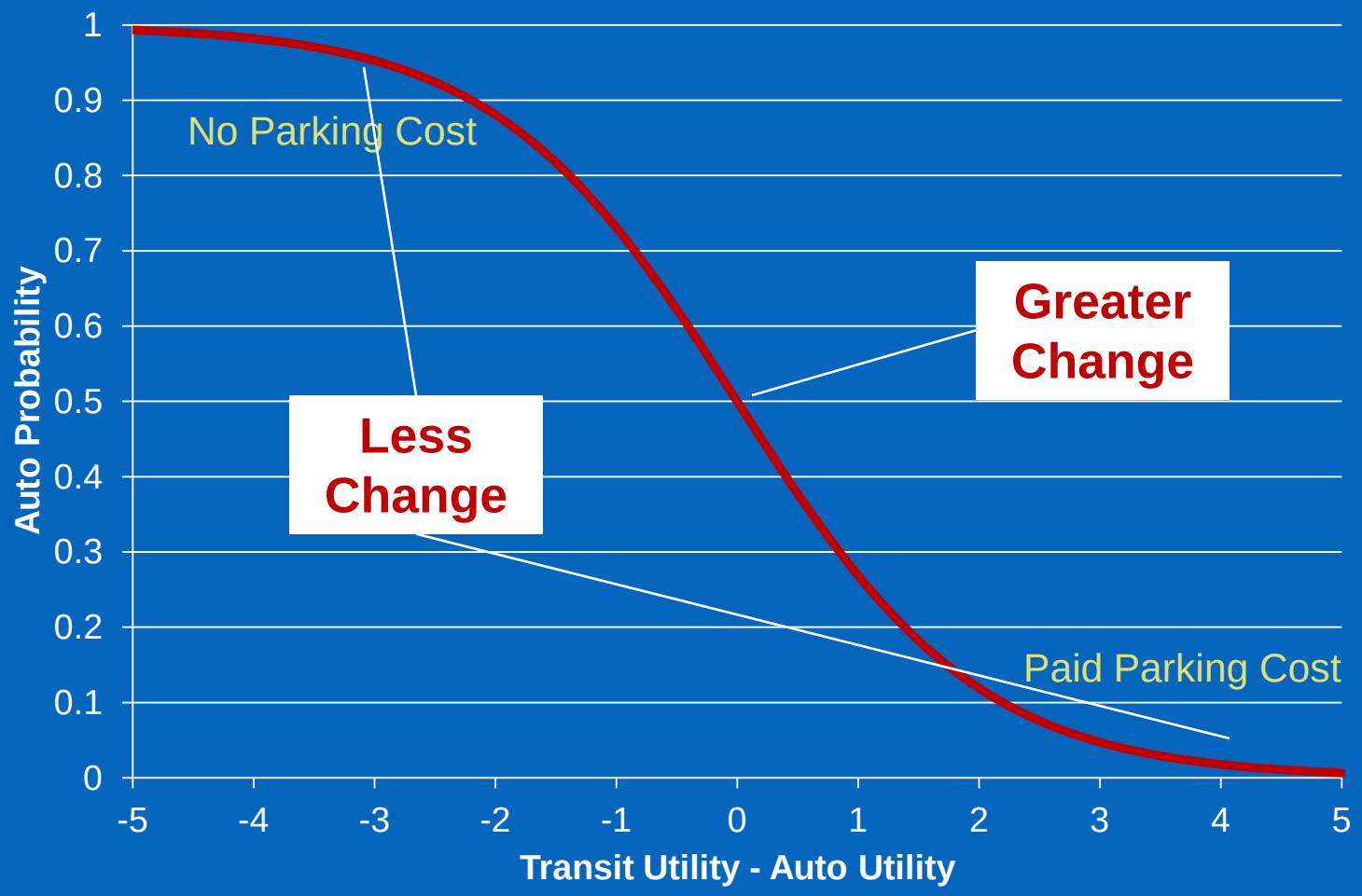
Nested Logit Model: How?



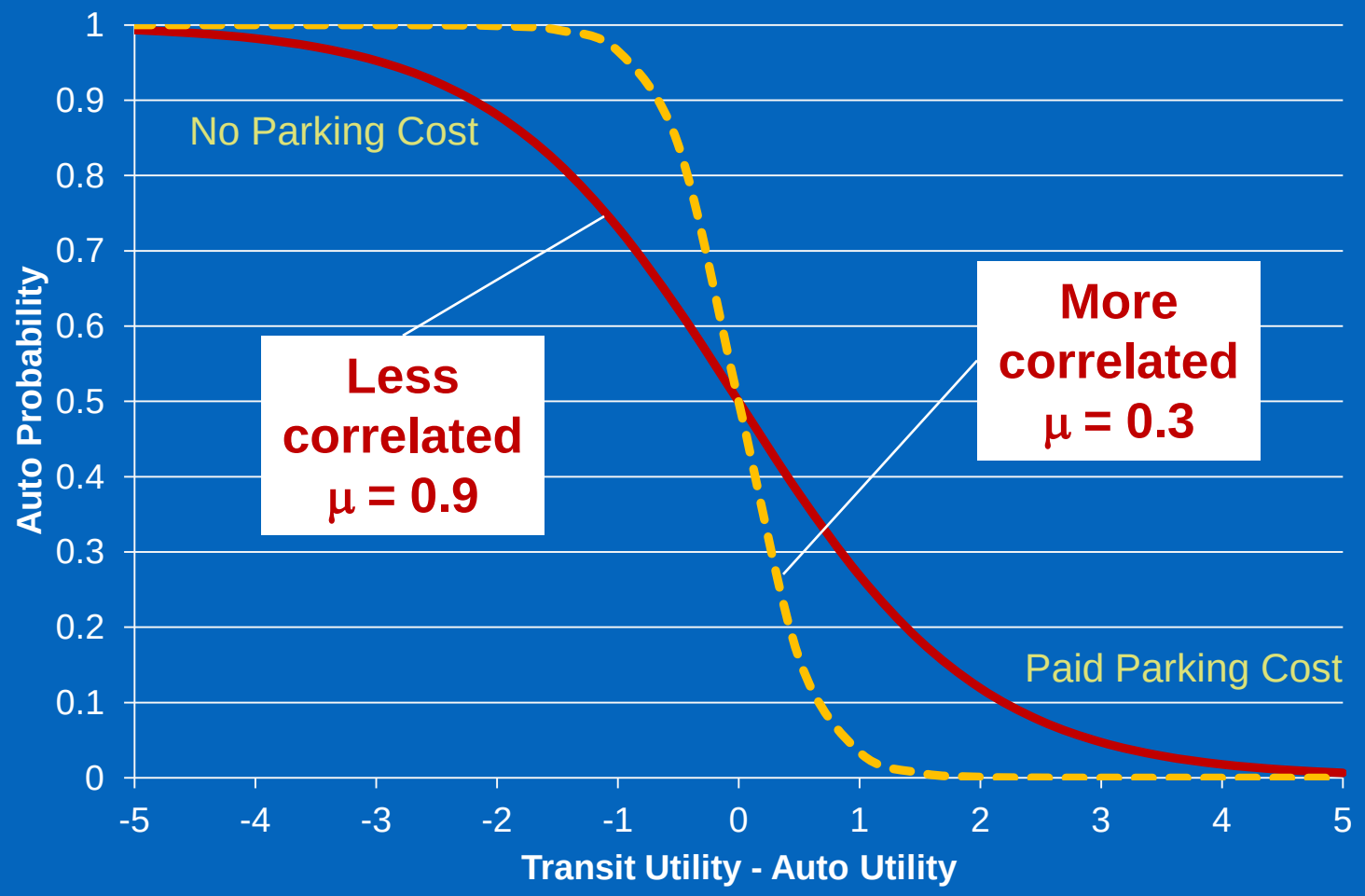
Nest coefficient
$\mu = 0.3$

- Nesting coefficients scale the utilities: $U^N(\text{bus}) = U(\text{bus}) / \mu$
- Nesting coefficients take values between 0 and 1
  - Steeper diversion curve between nested alternatives
  - Smaller the nesting coefficient, the more similar the nested alternatives
  - When $\mu = 1$, the model becomes multinomial logit (MNL)
  - When $\mu << 1$, the choice is practically all-or-nothing

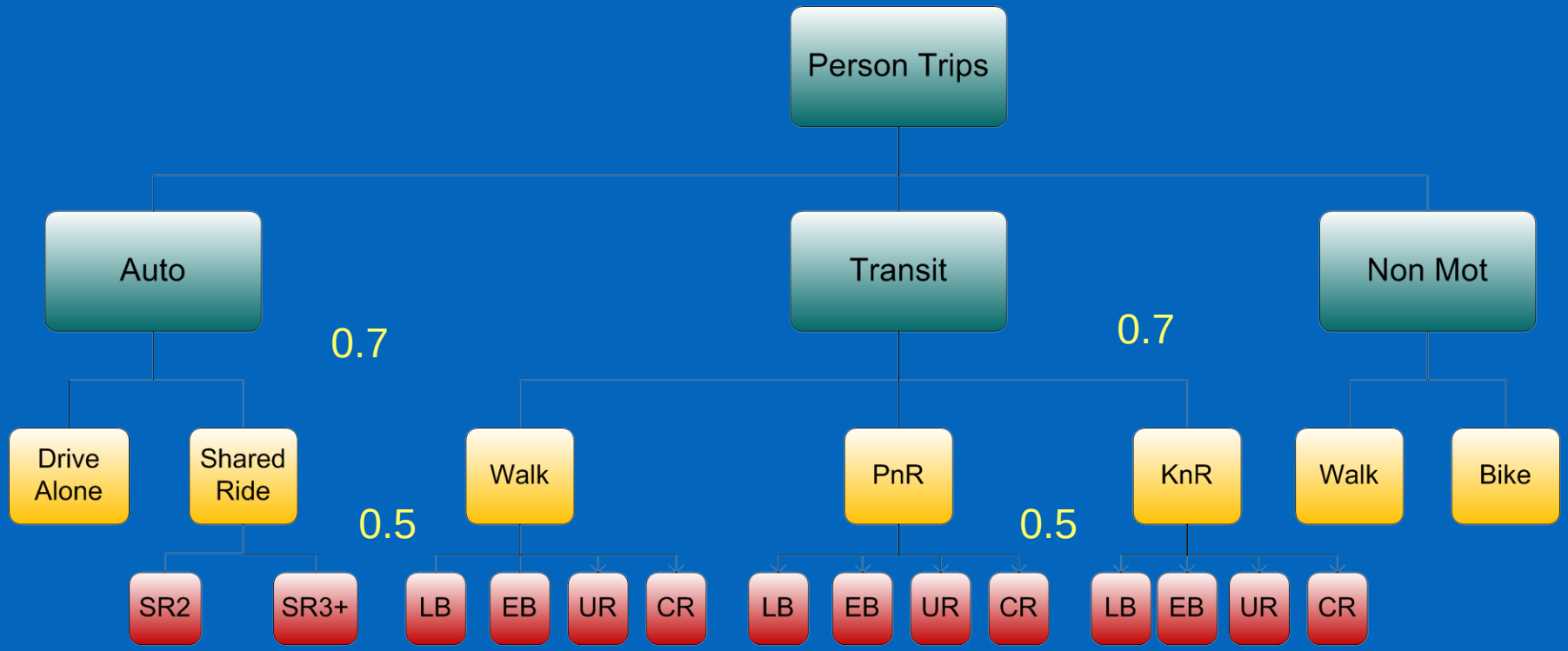
Logit Model Curve



Logit Model Curve

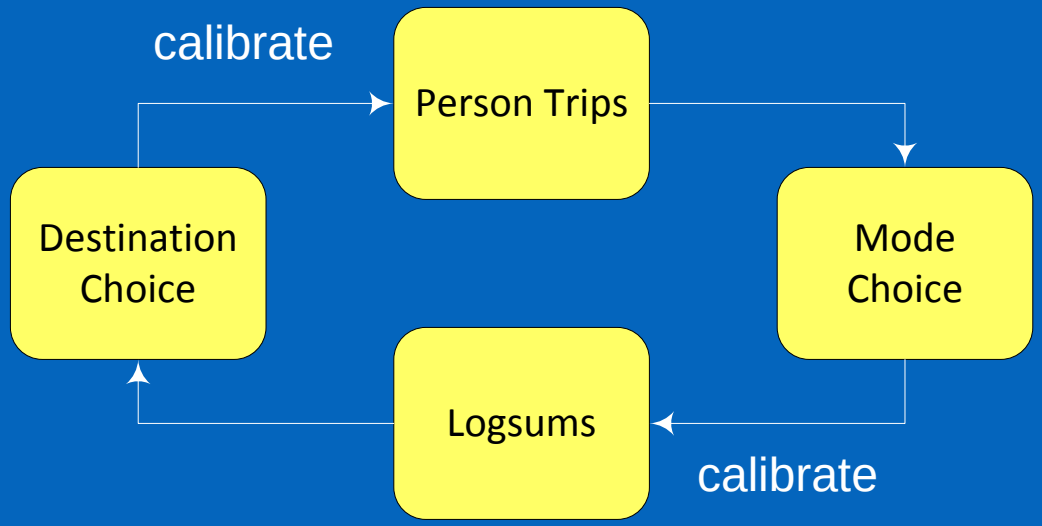


Proposed Nesting Coefficients



Coordinating DC and MC Calibration

If confident of soundness of mode choice model, use logsums ‘as is’ for destination choice estimation



If confident of soundness of person trip tables, start by calibrating mode choice

Transit Modeling Update

PROTOTYPE APPLICATION

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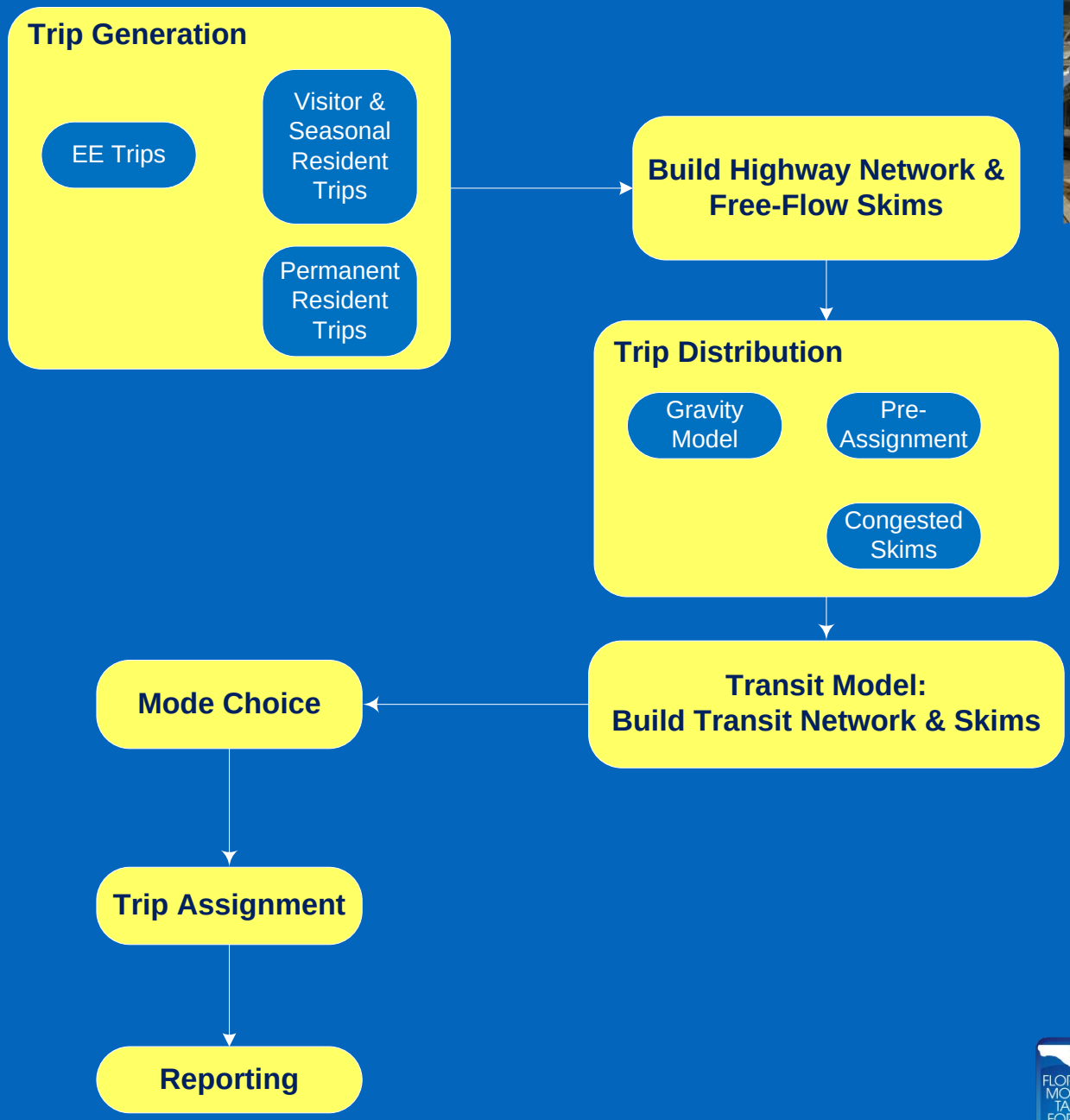
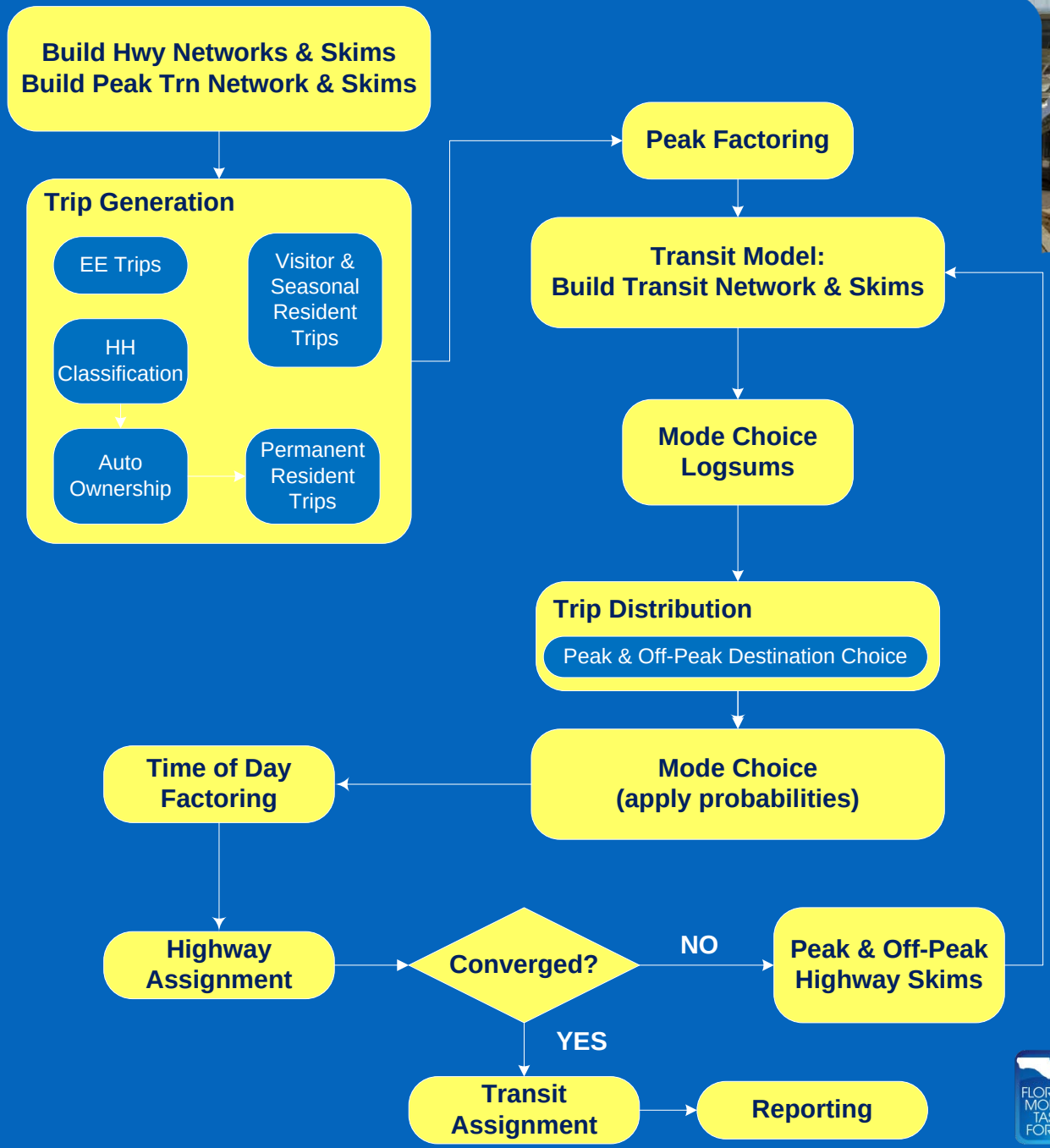
Current CRTPA Program Flow

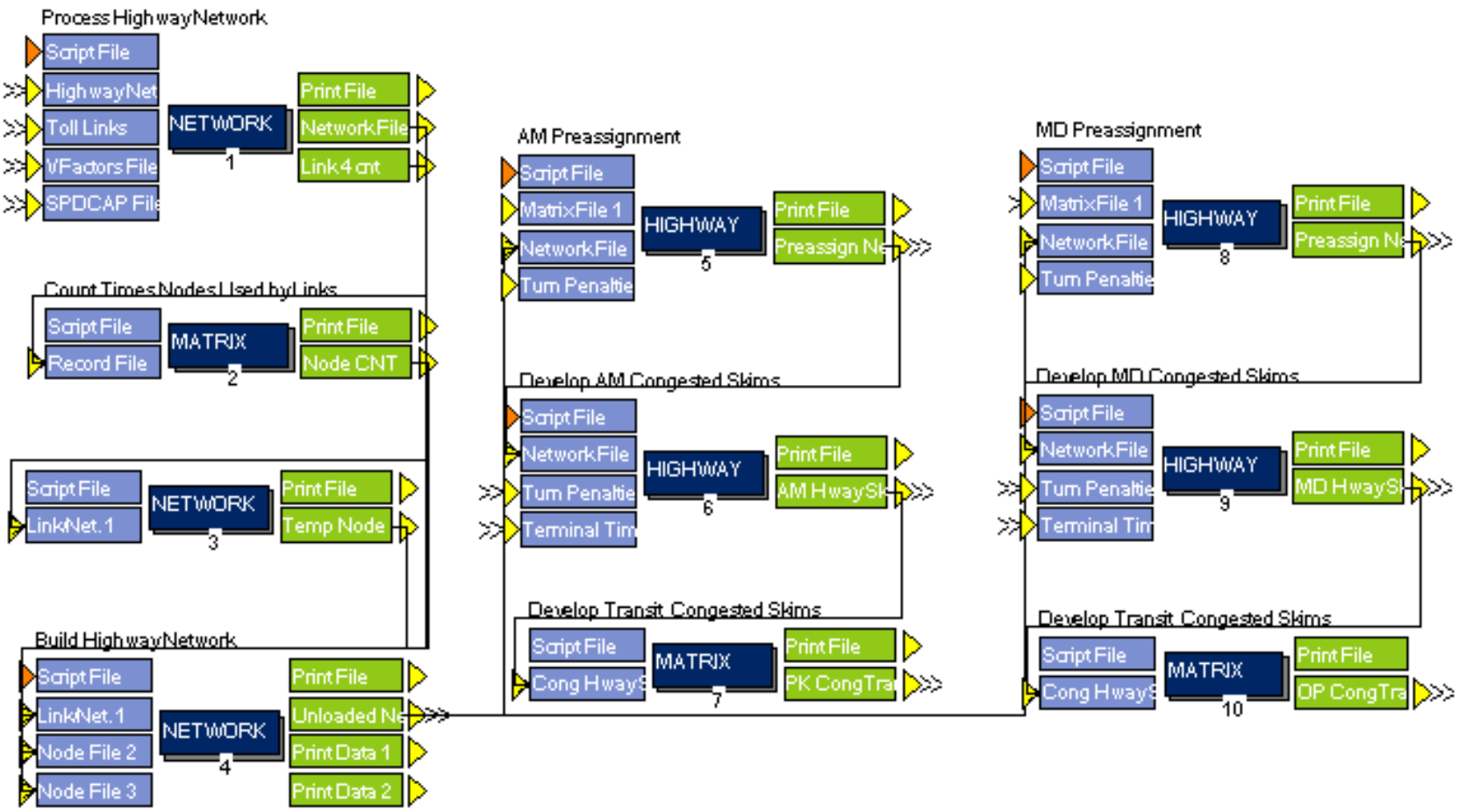


Demo CRTPA Transit Update Program Flow



Build Hwy Networks & Skims
Build Peak Trn Network & Skims

Develop initial highway skims



Build Hwy Networks & Skims
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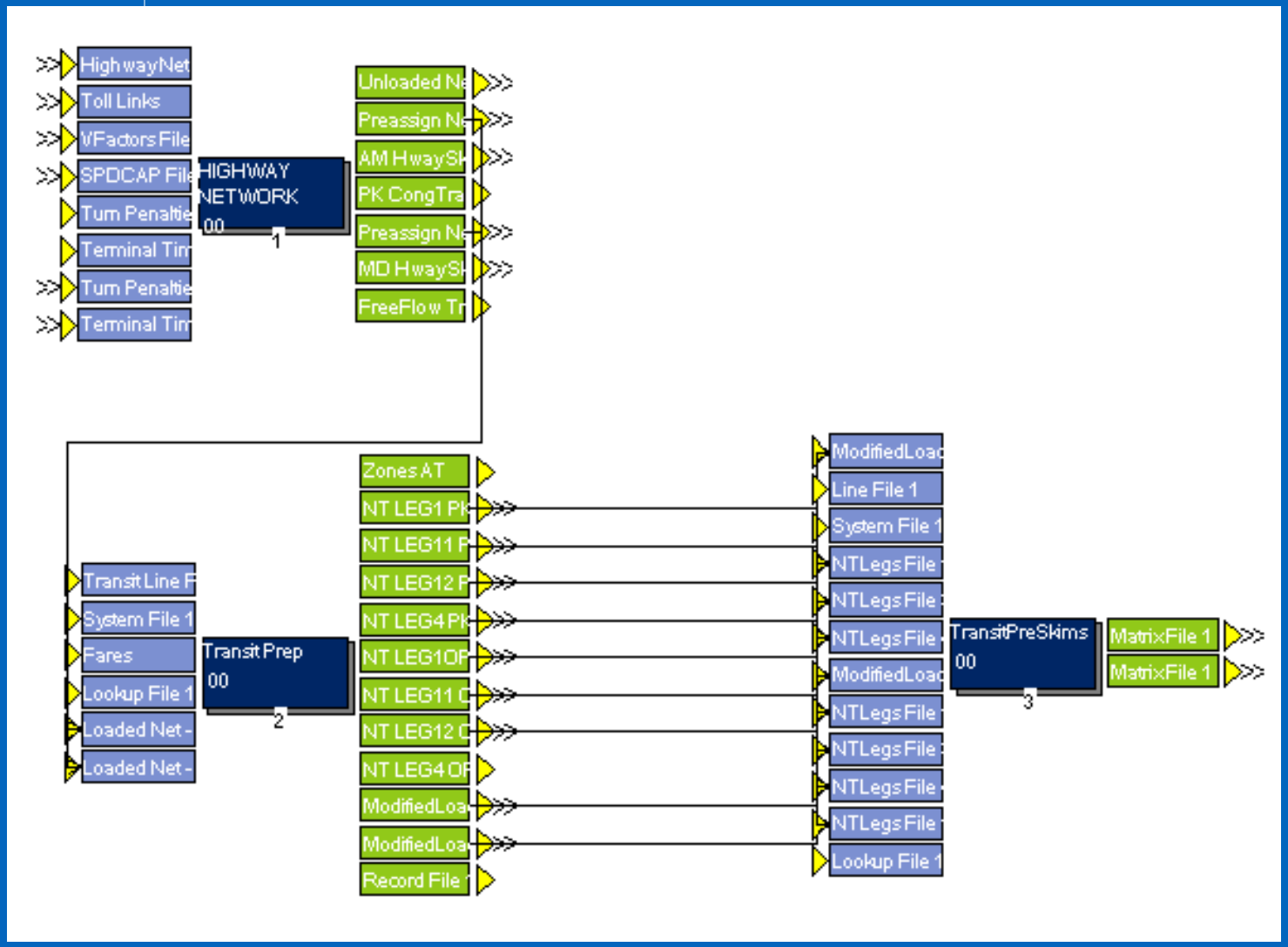
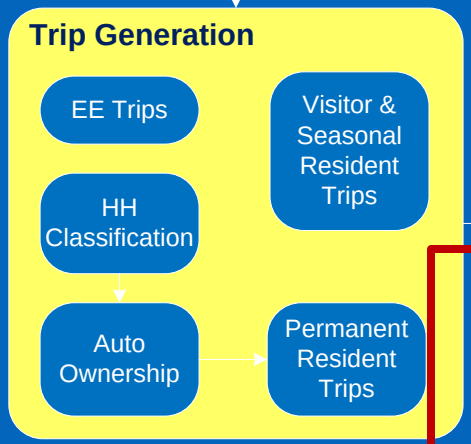
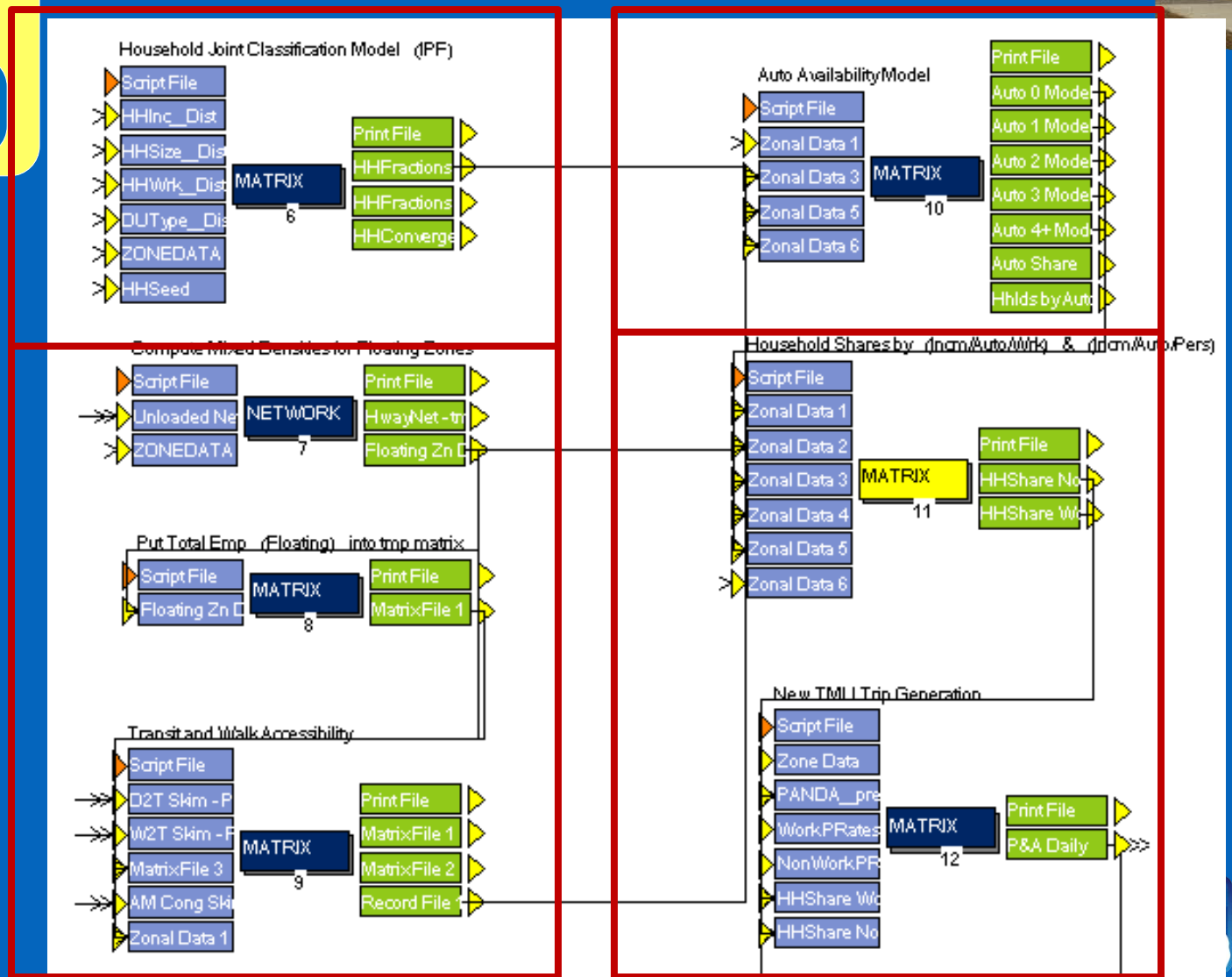
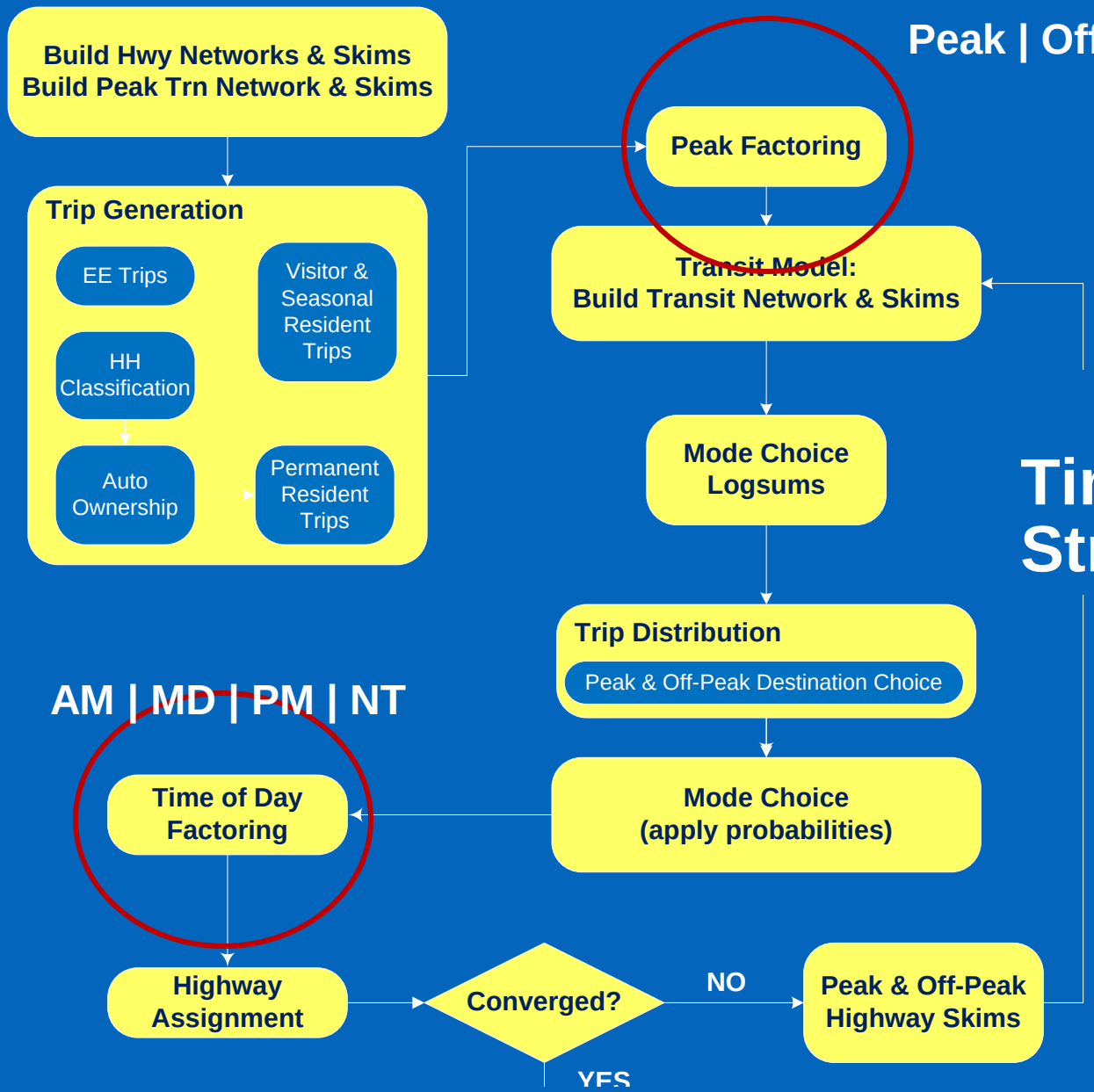


Household Classification Model
Auto Ownership Model
Updated Trip Generation Model

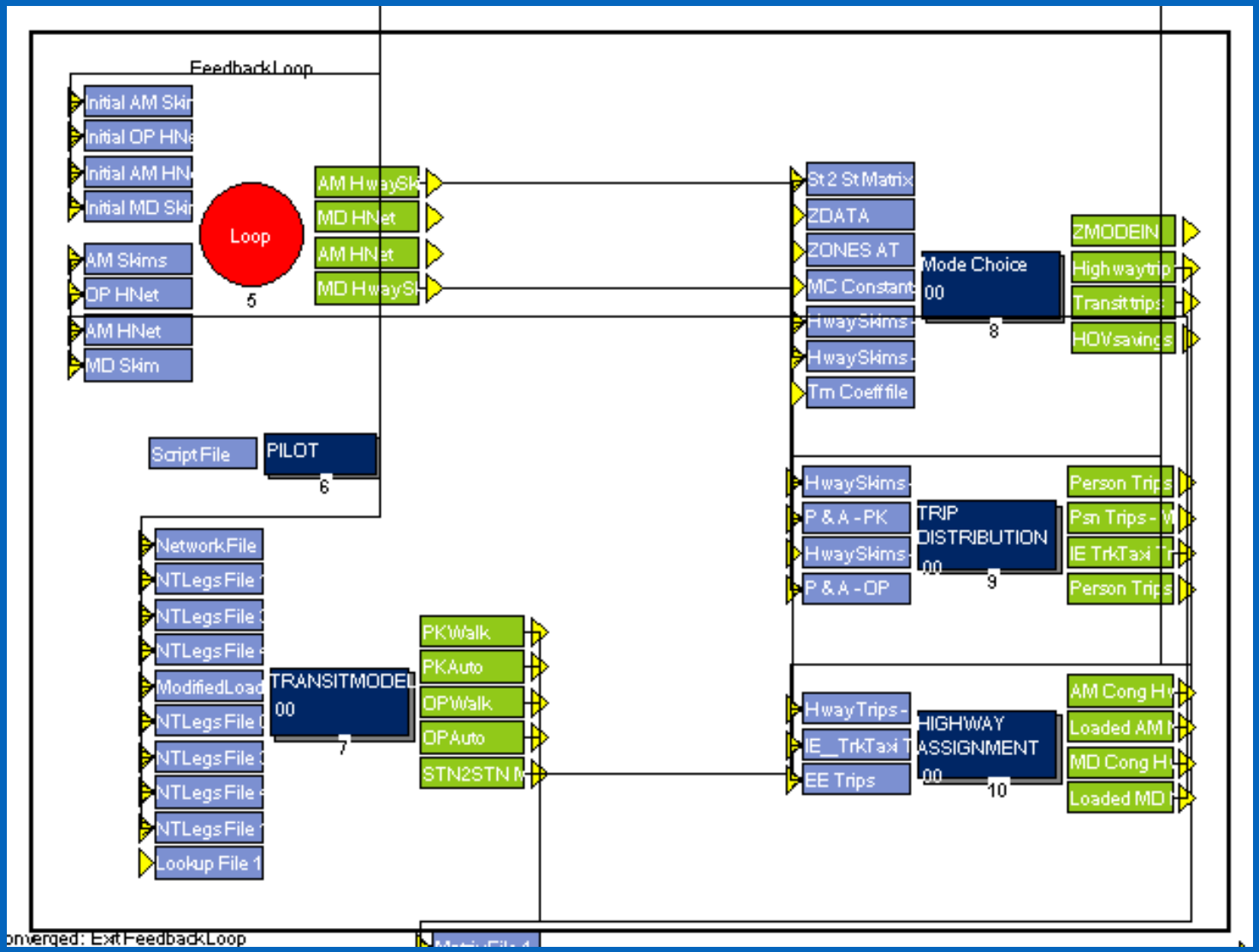




Time of Day Stratification



Travel time feedback



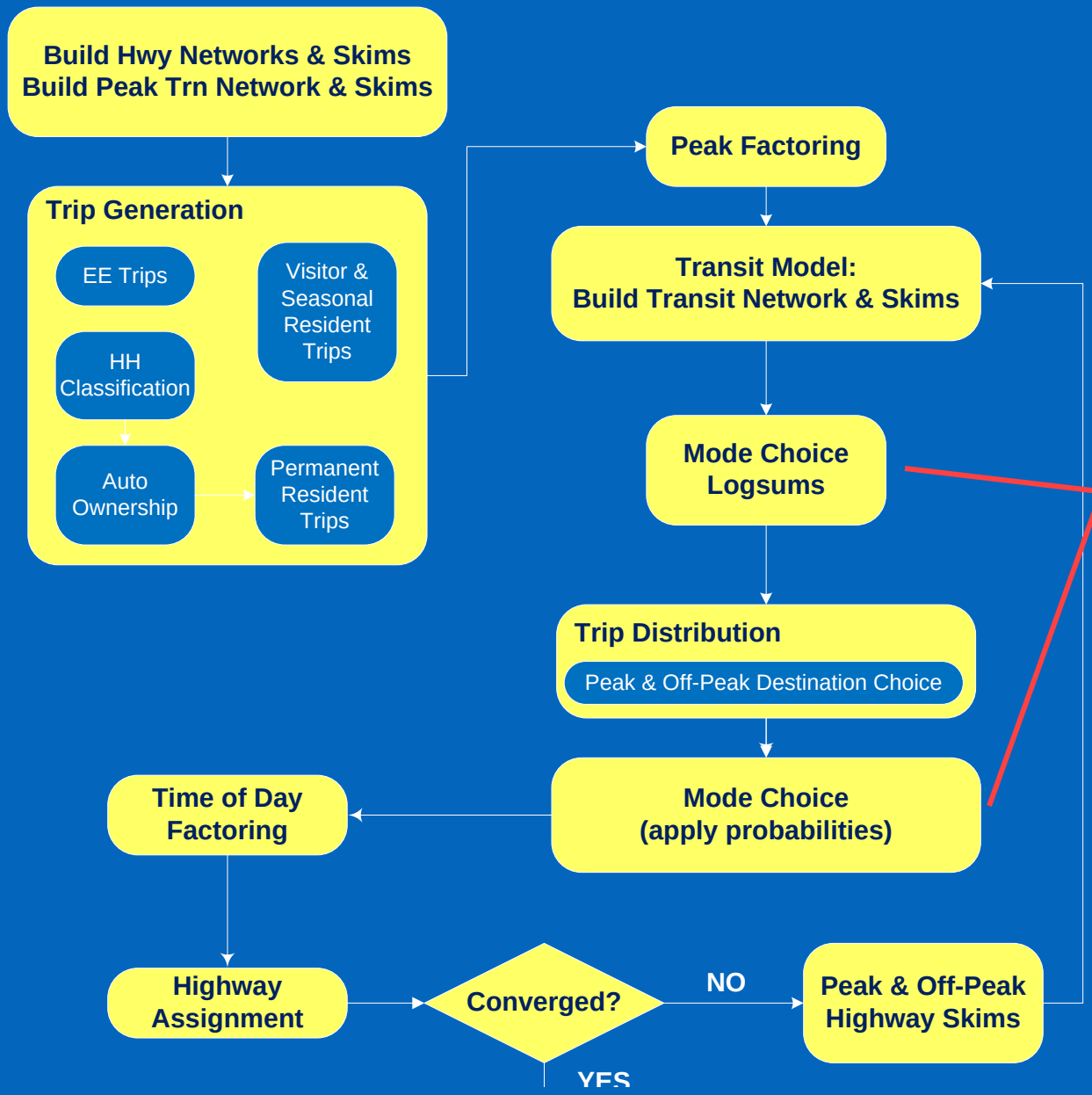
Feedback loop control

- Model exits the travel time feedback loop when it reaches convergence or performs the maximum number of loops
  - Convergence is measured by travel time and link volume average percent change
  - Convergence threshold is a user-input
  - Maximum number of loops is a user input
- Successive averages are used to compute the feedback volumes

Trip Distribution

- Destination choice models replace the current gravity models
- Stratified by trip purpose, household market and time period
- Completely scripted in Cube/Voyager
- Parameter file includes “place-holders” to allow for more detailed specifications

Mode Choice



FLORIDA MODEL TASK FORCE

Model Inputs: What's New?

Zonal Data

Variable	Description
ACRES	Area of the TAZ (in acres).
ST_CNTY	State/County code.
RESDHHLD	Permanent resident households.
RESDPOP	Permanent resident population.
HHINCINDEX	Median household income index: ratio of the median household income of the TAZ to the median household income of the region.
WRKRPHHLD	Average number of workers per household.
UNV_ENROL	Number of student enrolled at university and college institutions

FLORIDA MODEL TASK FORCE

Model Inputs: What's New?

- Initial AM and MD person trip tables
  - For generating first loop peak and off-peak travel times
  - Derived from an existing model run
- Seed household classification table
  - Obtained from 2010 PUMS
- Percent walk file
  - Percent of a TAZ that has short and long walk access to transit (new to Tier A model)

Model Parameters: What's New?

- Peaking factors & diurnal factors
- Household classification curves
- Updated trip production rates
- Destination choice parameters
- Updated mode choice nesting coefficients

Model Outputs: What's New?

- Trip productions by trip purpose, revised household markets, and time of day split
- Person trips by trip purpose, revised household markets, and time of day split
- Auto trips by four time periods
- Loaded highway networks for four time periods

Catalog Keys: What's New?

- Auto occupancy factors by trip purpose
- Highway capacity factors
- IPF control parameters (convergence & iterations)
- Travel time feedback control parameters
- Select zone – for debugging purposes

Transit Modeling Updates

PROJECT DELIVERABLES

FLORIDA MODEL TASK FORCE

Deliverables

- Technical Memoranda
  - Trip Generation Review and Recommendations
  - Time of Day Stratification
  - Trip Distribution Review and Recommendations
  - Mode Choice Review and Recommendations
  - AUTOCON Development
  - Additional PT Functionality
  - On-Board Rider Survey Synthesis of Practice
  - Principles of Model Calibration and Validation
  - User Benefit Analysis Guidelines
  - Quality Control Guidelines

FLORIDA MODEL TASK FORCE

Deliverables

- Powerpoint Presentations
  - Trip Generation Review and Recommendations
  - Time of Day Stratification
  - Trip Distribution Review and Recommendations
  - Mode Choice Review and Recommendations
  - Logit Model Primer
  - User Benefits

Deliverables

- Workshops
  - Case for the Project – Miami Pilot
- Software & Applications
  - UserBenC
  - Transit Update Prototype Model
  - Additional PT functionality (Cube 6.0)