Evolutionary Development of Revolutionary Models

The experience of Ohio DOT in the development of an advanced practice model

Presented at the TRB Conference on Meeting Federal Surface Transportation Requirements in Statewide Metropolitan Transportation Planning

September 3, 2008

Presentation Overview

- Motivation Behind Building a Statewide Model
- What do We Need it for?: A User Needs Study
- Holy Cow That's a Big Model!
- Taking the First Steps: Version 1 "Interim" Model
- Enhancements While We Wait: Version 1.1 Model
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- A Side by Side Comparison of Versions 2 and 3
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- Other Stuff We Want: Versions 2.1, 3.1 etc.

Motivation Behind Building a Statewide Model

- Staff made an attempt to begin a model in the 1970's (which failed)
- With transition to microcomputers and the advent of new planning requirements with ISTEA, modeling staff begins thinking about a statewide model again in the early 1990's
- Initial thought is a simple OD trip table/growth rate model developed in house based largely upon road-side surveys being conducted by ODOT for MPO model updates

What do We Need it for?: A User Needs Study

- Before pursuing this option, decided to find out if a statewide model was even needed and if so for what

- Identified customers and asked them about their traffic forecast needs

- Identified 3 Priorities:
    1. Truck/Freight Flow
    2. Economic Vitality
    3. Traditional Congestion Measures

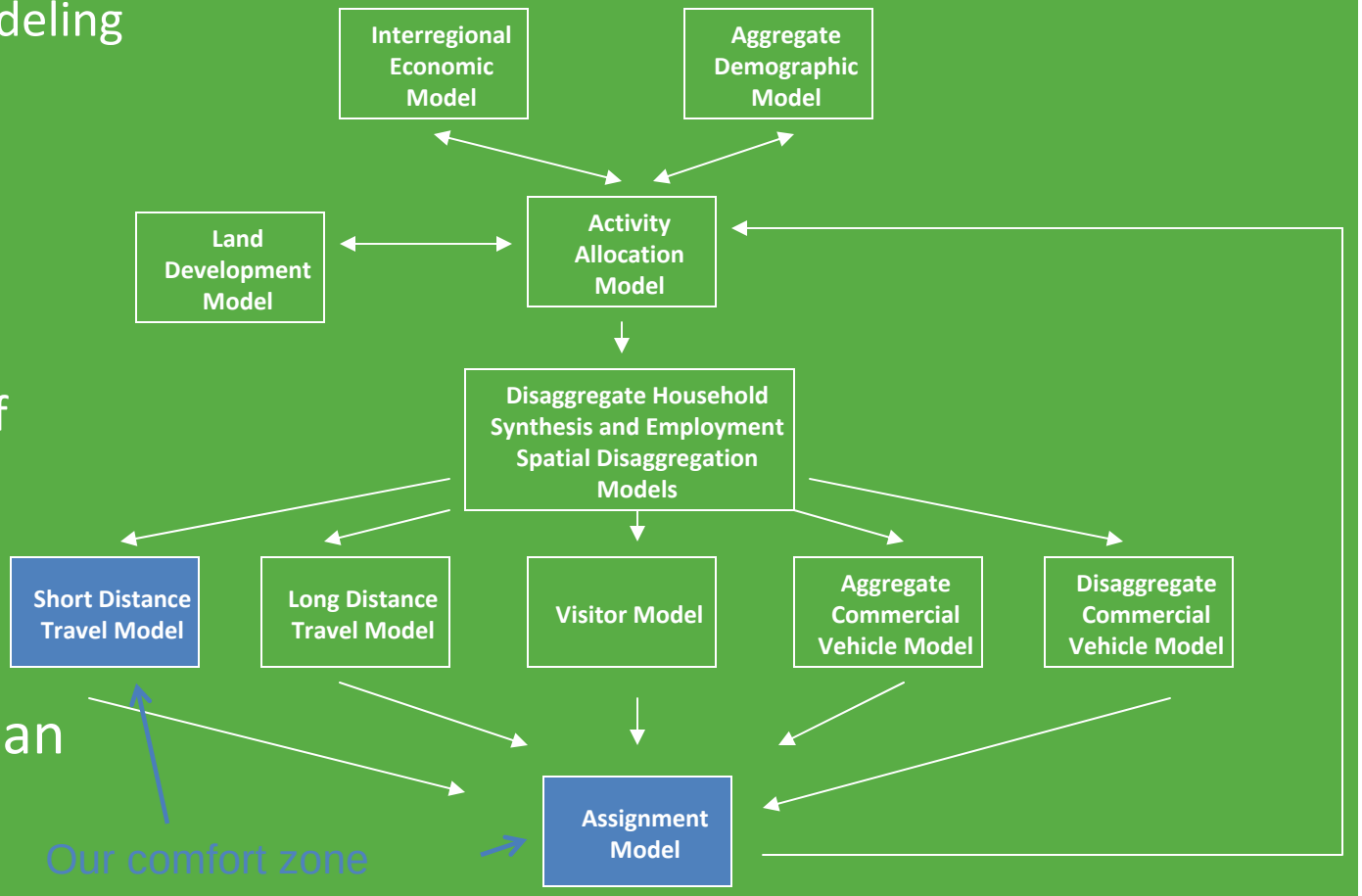
- The growth factor model would not handle the first 2 priorities, however, increased management support and sudden availability of funds provided more options

Holy Cow That's a Big Model!

- Therefore, an advanced model was proposed incorporating:
  - Econometric Models
  - Demand Microsimulation
  - Land Use Modeling

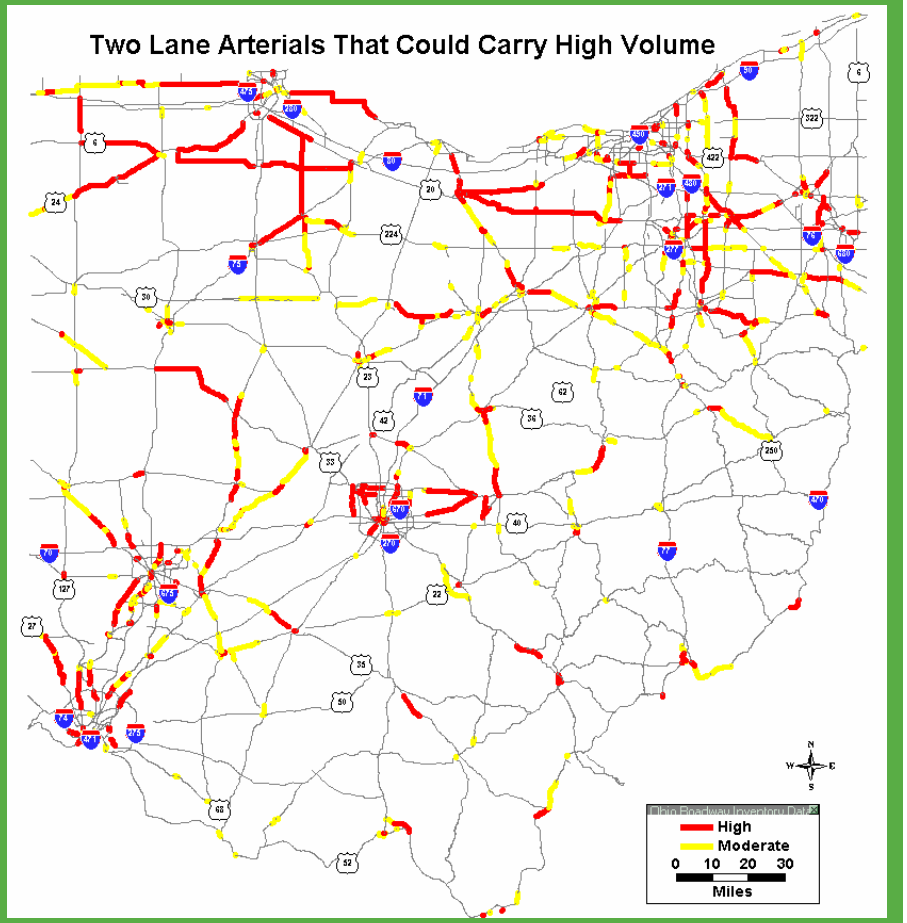
- This model would require:
  - Consultant assistance
  - Large volumes of data
  - Over 5 years to complete

- This necessitated an interim capability



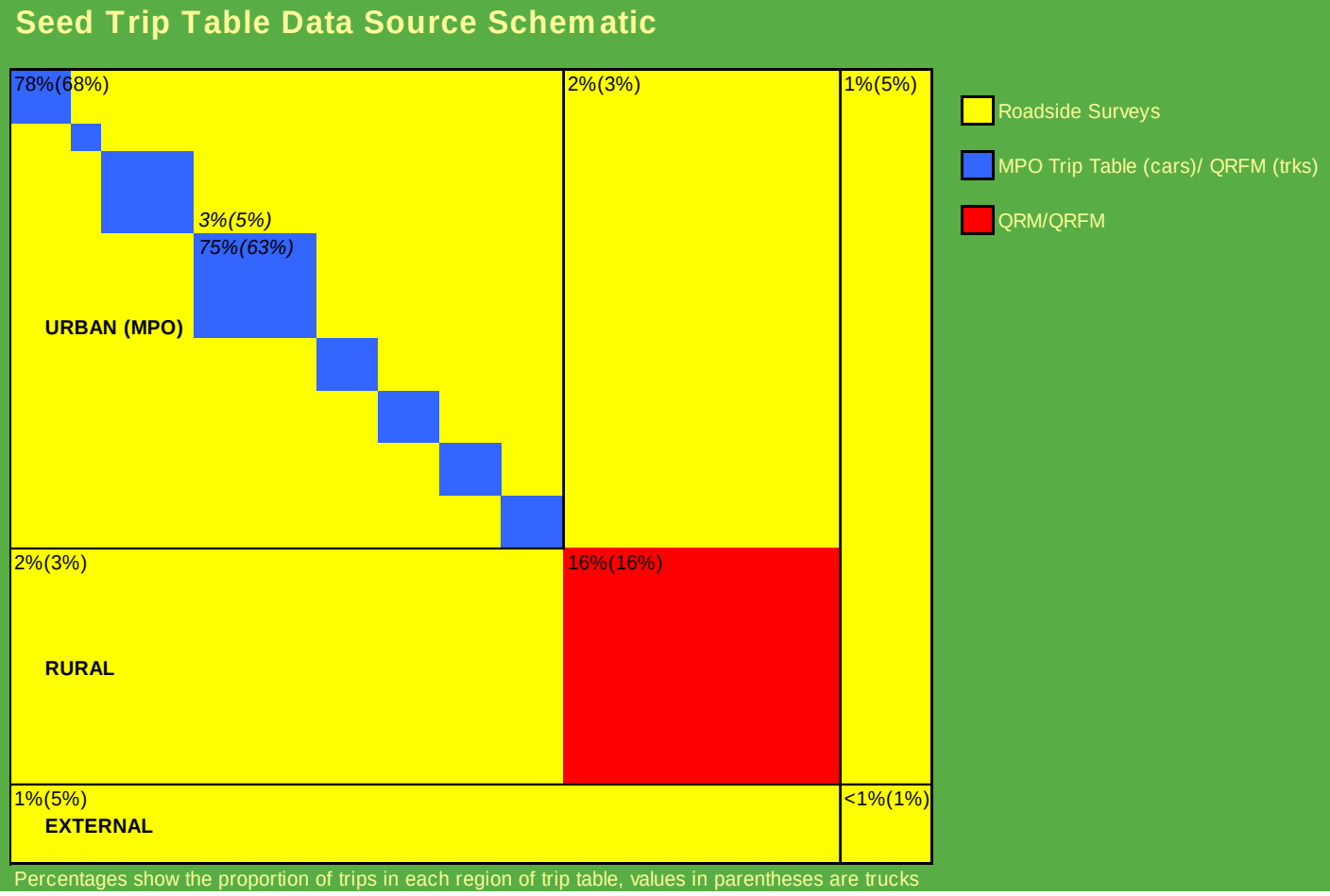
Taking the First Steps: Version 1 “Interim” Model

- Developed largely in house using the initial concept of a growth factoring “model”
- Operational in 2003
- Highway network developed from ODOT Roadway Information Database is a subset of the final model’s network



Taking the First Steps: Version 1 “Interim” Model

- Base year car & truck trip tables constructed from 700 roadside survey locations, MPO trip tables, QRM methods and then reconciled to counts with matrix estimation



Taking the First Steps: Version 1 "Interim" Model

- Simple growth factoring for forecasts using population & employment forecasts

Population and Employment forecasts based on MPO forecasts and Ohio Dept of Development County forecasts

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Regression analysis of base year trip table versus base year Pop./Emp. Provides a trip generation model applied to difference in Pop./Emp. from base year

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Differential zonal trip ends establish growth rates (Fratar Factors)

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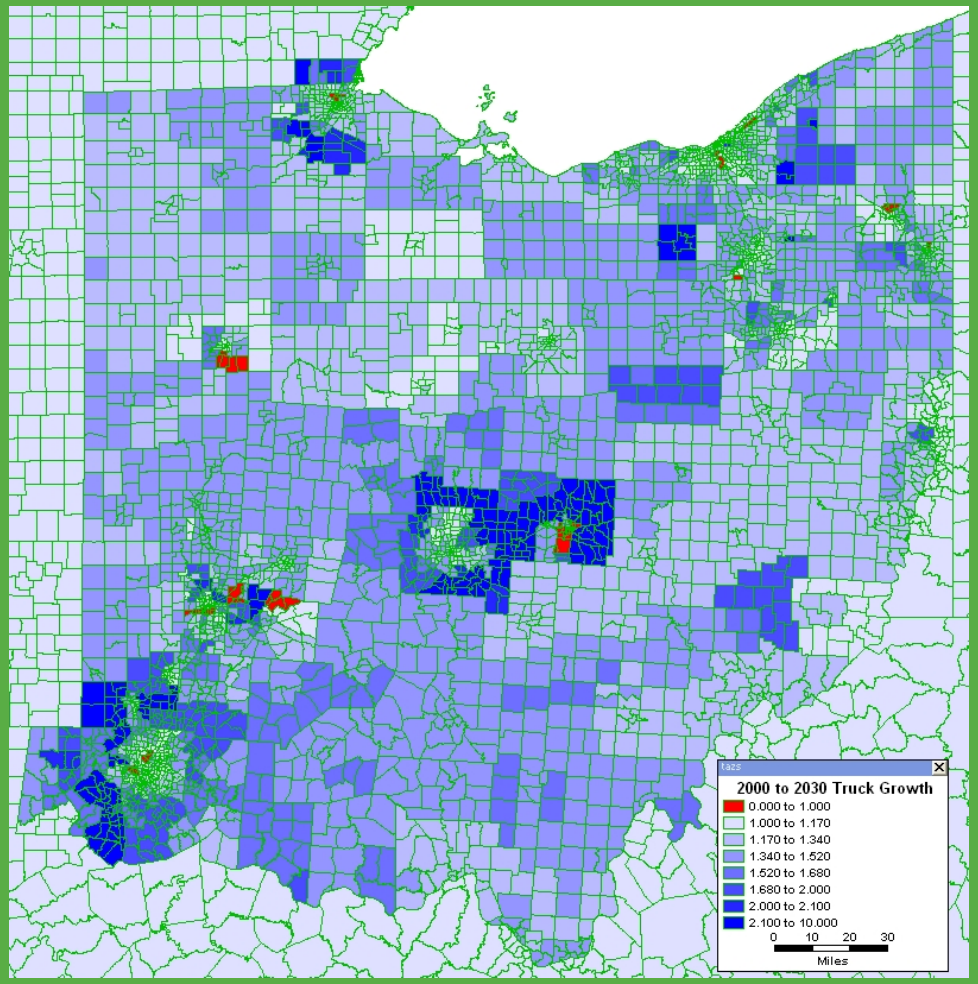
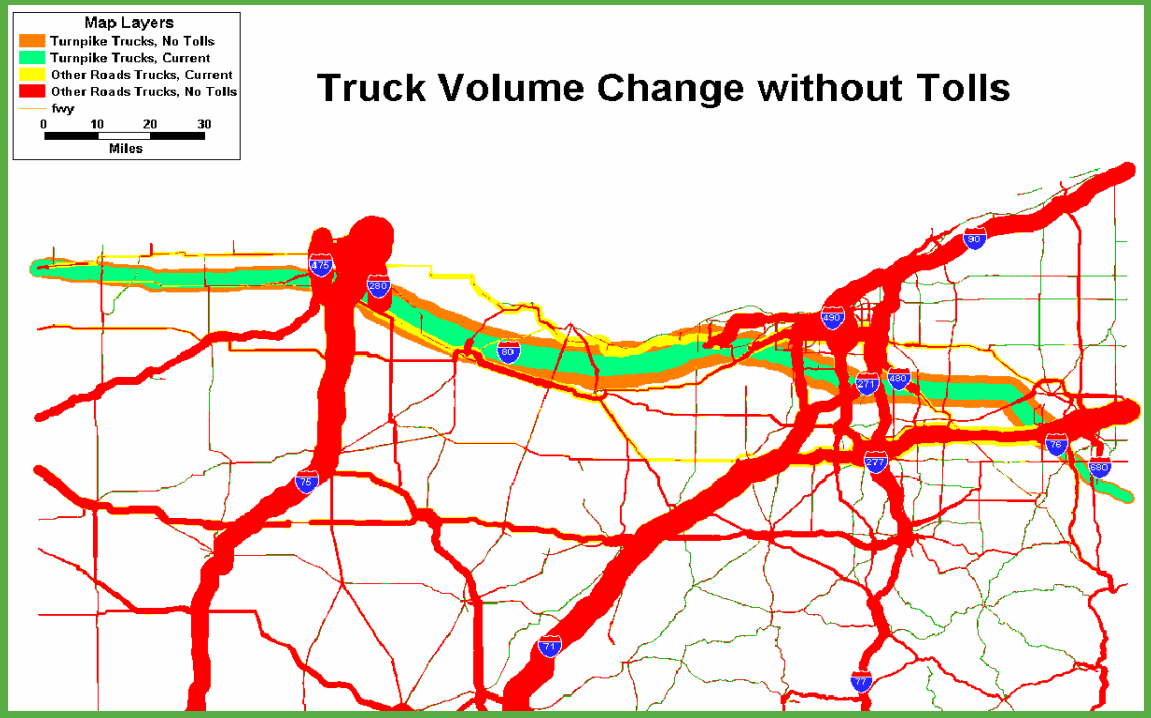
These are adjusted to match independent projections of county wide VMT and average trip lengths



Taking the First Steps: Version 1 “Interim” Model

- Model used to provide forecasts for many ODOT projects and studies building interest and support for effort
  - Statewide long range plan prioritization
  - Ohio Turnpike toll analysis
  - External station forecasts for MPO models and bypass studies
  - Numerous corridor and project forecasts



Enhancements While We Wait: Version 1.1 Model

- Delay with development of version 2.0 model due to its complexity leads to development of version 1.1 which enhances version 1 by moving from 1200 to 4000 zones

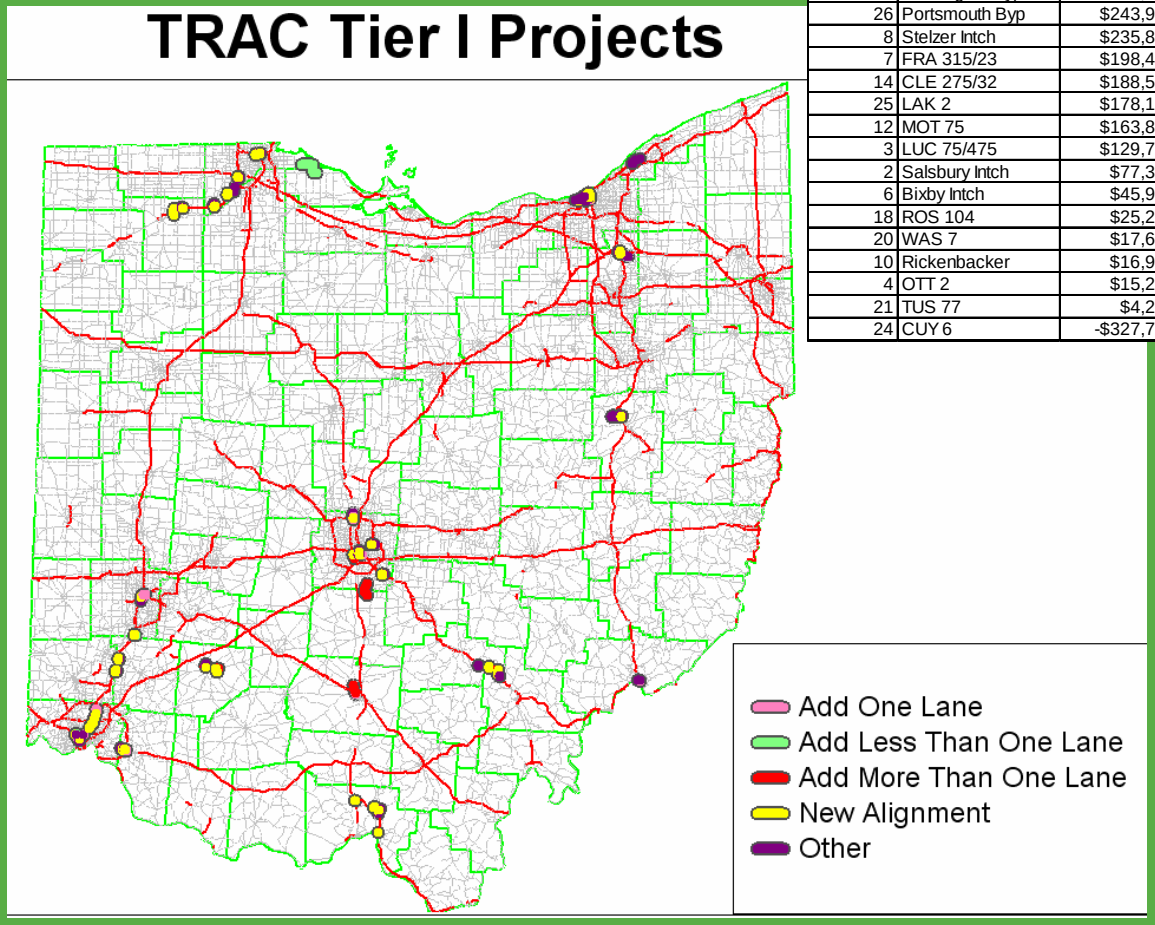
Side by Side Comparison of Versions 1.0 and 1.1

Version 1.0	Version 1.1
About 1200 zones cover Ohio plus small amount of KY, IN, MI near Cincinnati and Toledo	About 4000 zones cover Ohio and a 50 mile buffer, uses same zones in the model area as higher versions excluding about 1000 external zones
Network consists of arterials and freeways	Network the same as higher versions including collectors, arterials and freeways
Trip table in the native zone system used to geocode road side surveys which serve as its primary source	Trip table disaggregated based on population and employment totals with special processing to capture short trip VMT which was missing from version 1.0 intrazonals
Operational 2003	Operational 2007

Enhancements While We Wait: Version 1.1 Model

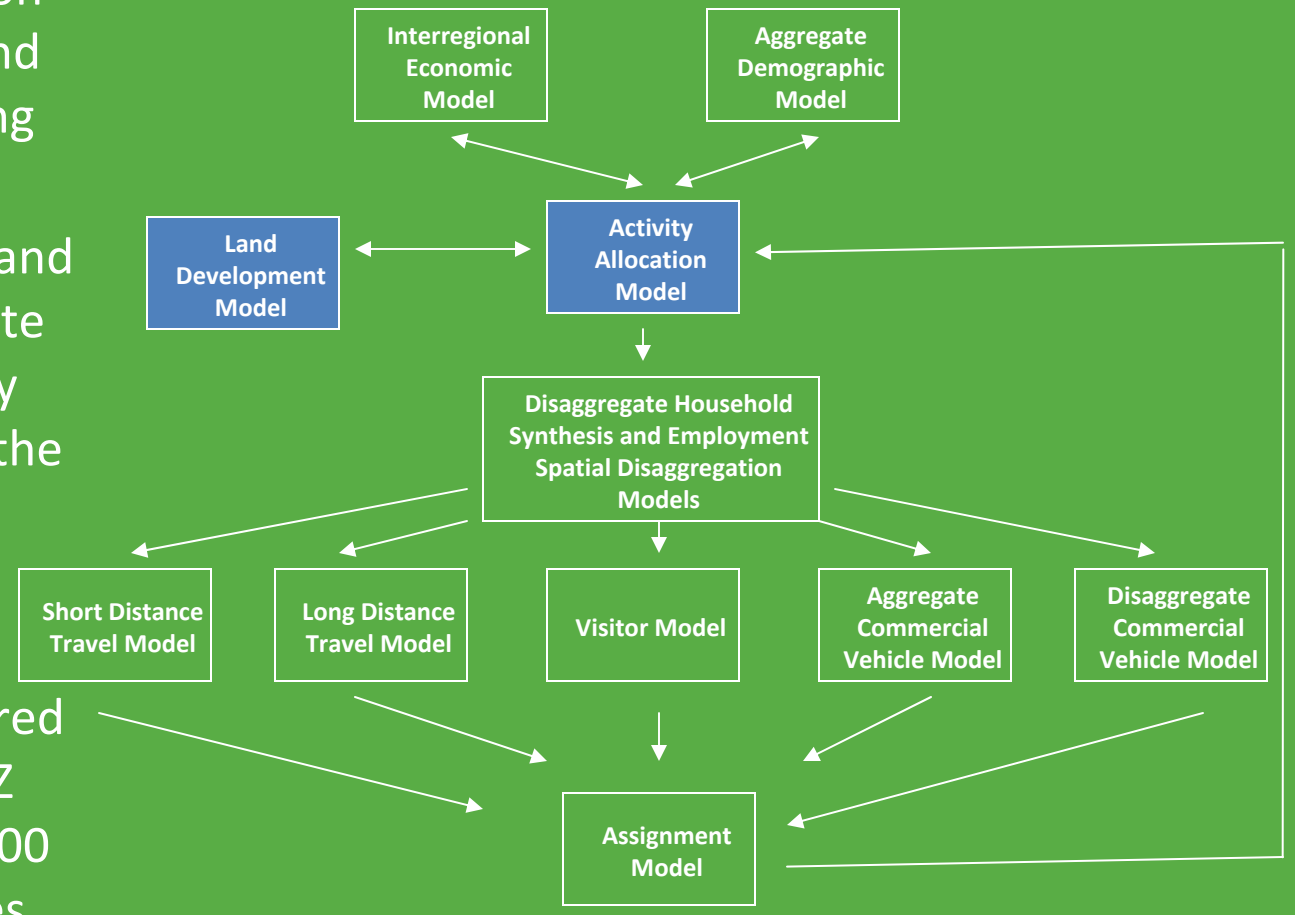
- This version primarily motivated by the need to provide detailed benefit-cost information for all ODOT projects over $5 million (version 1.0 was simply too coarse to handle many of these projects)
- Once in production, model replaces version 1.0 and is then used for other projects such as:
  - Five county Appalachian corridor study
  - Cincinnati eastern bypass study
  - Project level traffic forecasts

Project Number	Project Description	Project Benefits
16	HAM 75 (excl. BSB)	$1,100,331,431
9	FRA 71/70	$956,466,312
23	CUY 77	$912,827,463
1	US 24 (east 1/3 only	$676,360,955
5	SUM 8	$586,975,542
22	Innerbelt	$457,529,189
11	CLA 70	$422,564,201
19	Nelsonville Byp	$369,285,259
17	WAR 75	$305,840,158
13	BUT/WAR 75	$286,008,080
15	Wilmington Byp	$251,283,357
26	Portsmouth Byp	$243,949,486
8	Stelzer Intch	$235,830,465
7	FRA 315/23	$198,432,505
14	CLE 275/32	$188,533,864
25	LAK 2	$178,127,333
12	MOT 75	$163,870,500
3	LUC 75/475	$129,729,725
2	Salsbury Intch	$77,331,836
6	Bixby Intch	$45,957,909
18	ROS 104	$25,203,480
20	WAS 7	$17,609,446
10	Rickenbacker	$16,967,915
4	OTT 2	$15,266,360
21	TUS 77	$4,222,174
24	CUY 6	-$327,705,331



Scaling Back the Initial Vision: Version 2.0 model

- The final version of the model is to include a land use/activity allocation microsimulation similar to PECAS, however, this was replaced in version 2.0 because of difficulties associated with:
  - Lack of actual data on floor space, rents and vacancy rates making calibration difficult
  - Problems with the land use models aggregate treatment of activity coming into/out of the study area
  - Long model run times/resource requirements required an intermediate TAZ level consisting of 700 Activity Model Zones



The Final Destination: Version 3.0 model

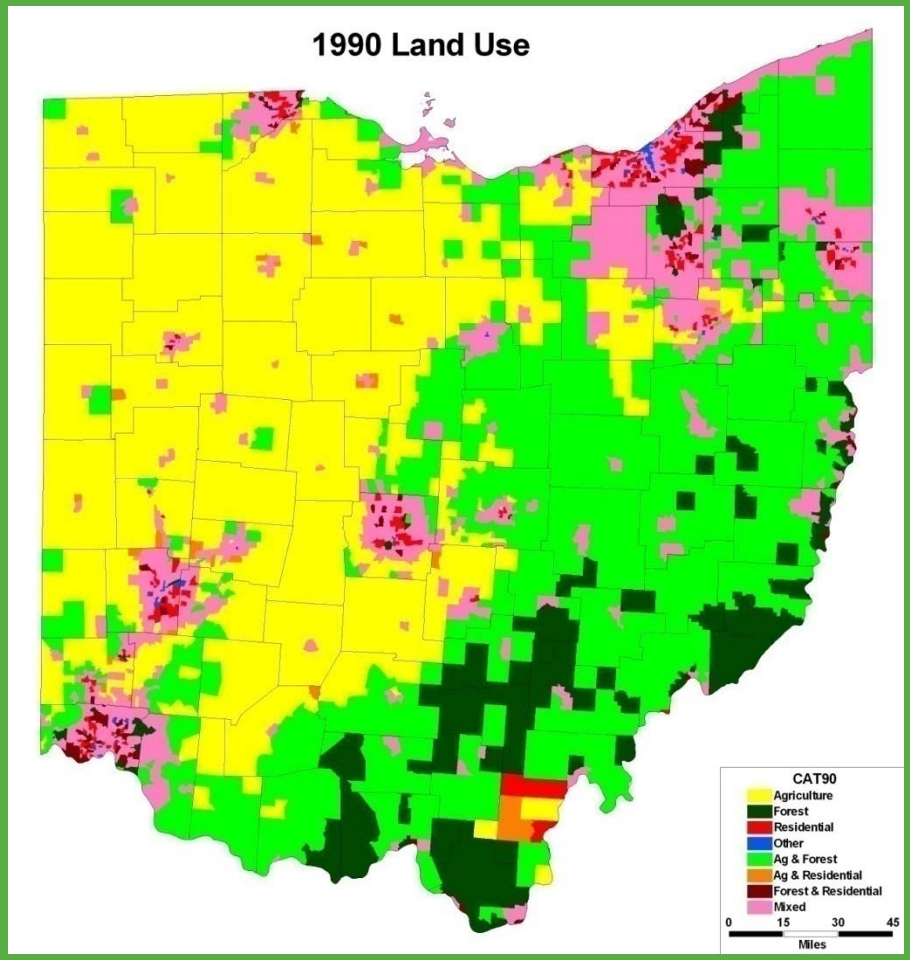
- Version 3.0 will reinstate the original land use and activity allocation models
- With more time and better data becoming available, the initial vision should be achievable
- It is hoped this will give:
  - A more sound theoretical formulation
  - Better policy sensitivity
  - More robust forecasts
  - More realistic economic/market signal response
  - Less dependence on exogenous control totals

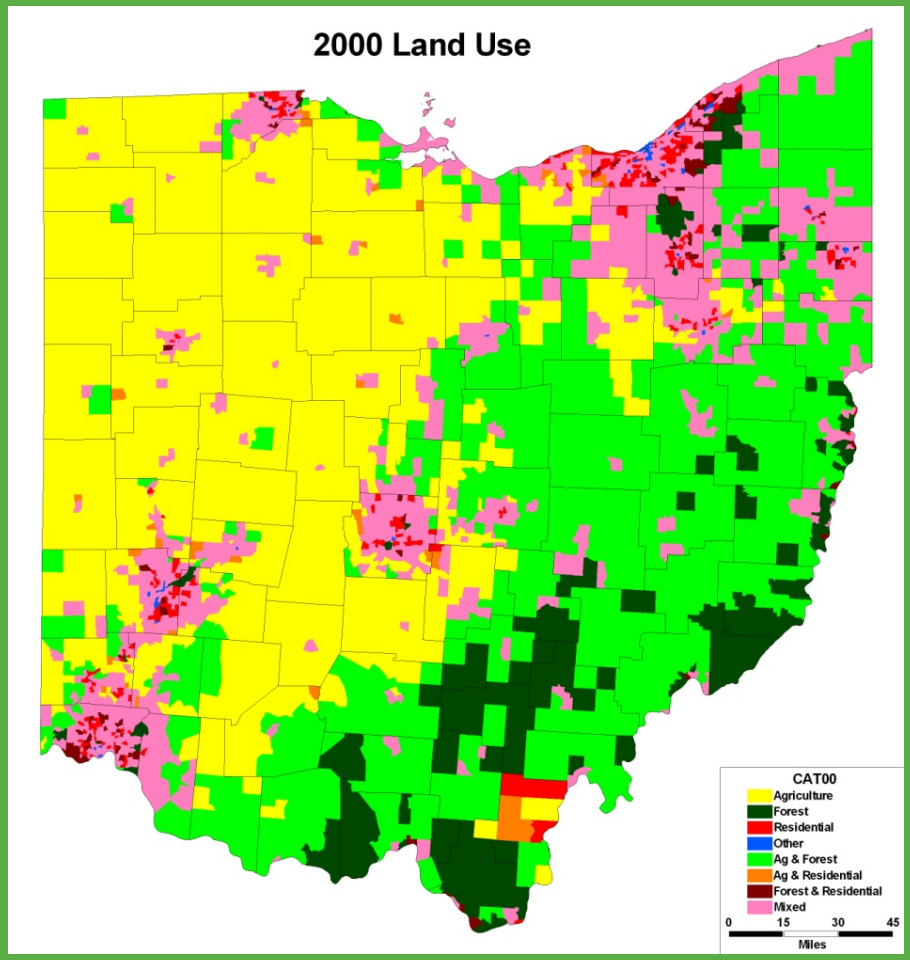
A Side by Side Comparison of Versions 2 and 3

Land Use Models

Version 2.0 Simplified Land Use Model (SLUM)	Version 3.0 Land Development Model (LD)
Base year land use inventory synthesized by developing land consumption rates for different types of employment and population in those few counties having land use inventories	Base year land use inventory synthesized by developing land consumption rates for different types of employment and population in those few counties having land use inventories
Aggregate zonal based model depending on previous development density and county control totals	Microsimulation of developer actions on 4 acre grids responding to price signals (rents) from previous round of activity allocation
•Simple functions fit to 1990-2000 transitions with respect to density relate transition of some types of land (mostly vacant/ag.) to other uses in fixed proportions •This potentially transitioned land is then compared to control totals which are allocated proportionally to get actually transitioned land •Floor space consumption rates (which vary by density) are then used to translate this into new floor space by type by zone	•Discrete choice model (logit) operates on grids allowing any land to transition to other types (depending on zoning) •Continuous choice model selects the intensity of development within a category, thus with favorable rents, an existing land use can be more intensely developed • Besides rents from AA, model is sensitive to construction/demolition costs and land prep costs conditioned by zoning which can be made to reflect added costs from slopes, flood plains, etc.

1990 and 2000 Land Use Data





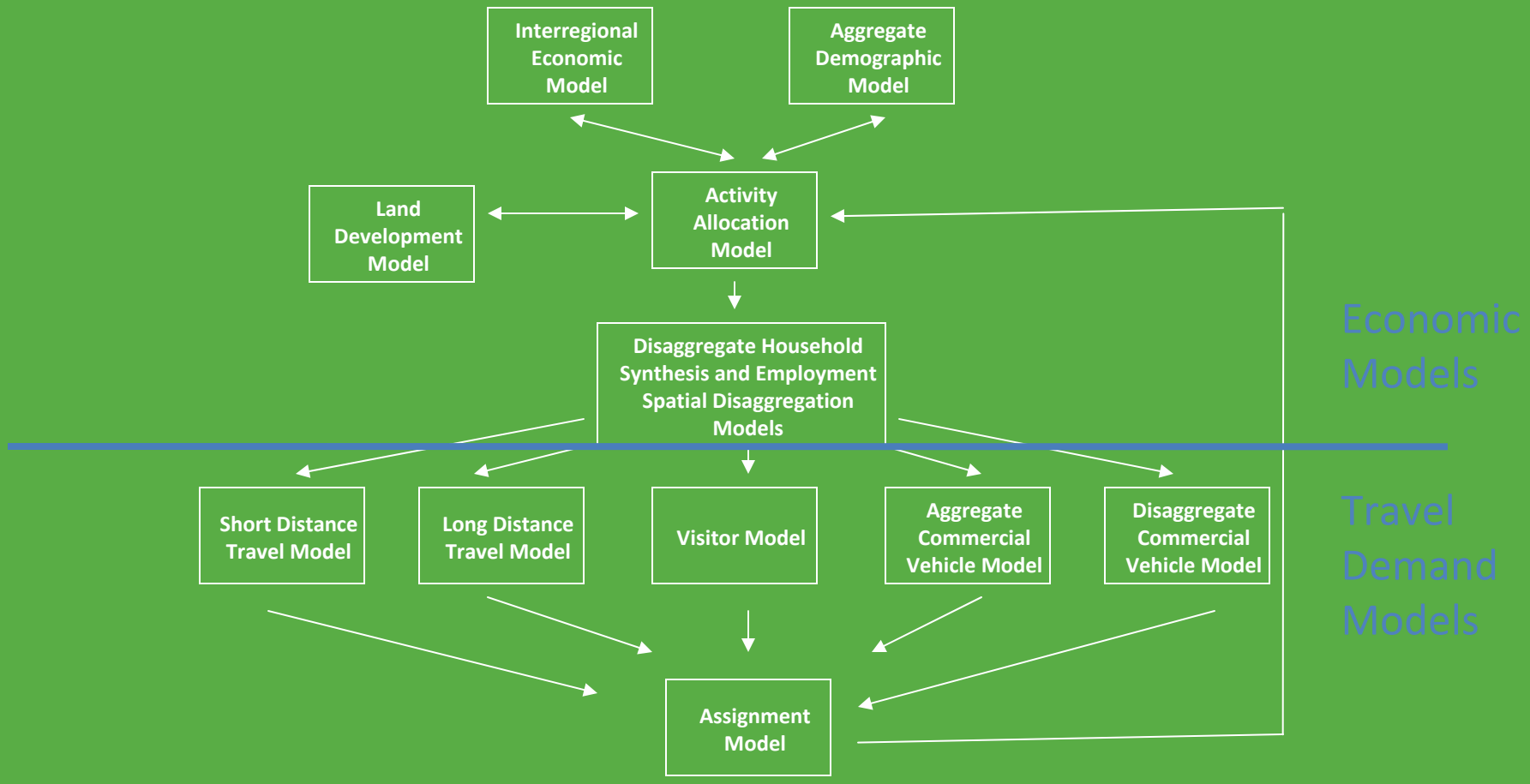
A Side by Side Comparison of Versions 2 and 3

Activity Allocation Models

Version 2.0 Simplified Economic Activity Model (SEAM)	Version 3.0 Activity Allocation Model (AA)
Inputs include: •County population control totals, HH types from aggregate demographic model •Employment control totals from ISAM model •Transport costs from previous year •Floor space from land use model	Inputs include: •Population distribution from aggregate demographic model •Regional flows (goods, labor etc.) from ISAM model •Transport costs from previous year
•Aggregate TAZ (5000+) based model relying on zonal accessibilities and matrix to synthesize pop./emp. distributions and labor/commodity flows	•Microsimulation using logit choice model of the AMZ (700+) location of industries, who they will sell to and how much and what they will produce
•Population and employment distributions created by forming matrices of utilities and then using IPF to adjust these matrices to county control totals •Utilities include terms for floor space (from LD model), and accessibility to various types of employment and labor •A gravity type formulation is then used to create labor and commodity flows between these activities •Has no explicit inertia terms so model is disjoint from the initial conditions. Rectified by applying differences from model to the initial conditions	•Utility in logit models includes size term, inertia term (based on previous years location etc.), buying/selling utilities, business travel costs, taxes/subsidies and zone constants •Buying/selling utilities depend on transport costs and prices from previous year •Relocations constrained by available developed floor space and minimum threshold sizes by industry •Supply and demand is then equilibrated iteratively using a Newton optimization algorithm

Components in Common Between Versions 2 and 3

- Despite the differences in the land use/activity allocation models, versions 2 and 3 share most components including the remaining elements of the economic models and all of the travel demand models



Components in Common Between Versions 2 and 3

- **Interregional economic model (ISAM)** of production & consumption by economic sector reflecting national forecasts
  - Establishes forecast flows of goods, services and labor (in $) between 14 regions of North America
  - Employs an inter-regional social accounting matrix based upon IMPLAN
  - "Inter-regional" part is the innovative feature since industries are related not only by their production and consumption but also by where they obtain/send factors
- **Demographic models** tied to economic activity reflecting migration and changes in population & household composition

Components in Common Between Versions 2 and 3

- **Travel demand models** are the same in both versions and include:
  - Short Distance Personal Travel Model (SDT) analogous to urban area models
  - Long Distance Personal Travel Model (LDT) models low frequency travel over 50 miles
  - Visitor Model models travel into/within Ohio by non-residents
  - Aggregate Commercial Vehicle Model (ACOM) covers long distance freight hauling
  - Disaggregate Commercial Vehicle Model (DCOM) covers local service/delivery and business travel not captured by the previous models

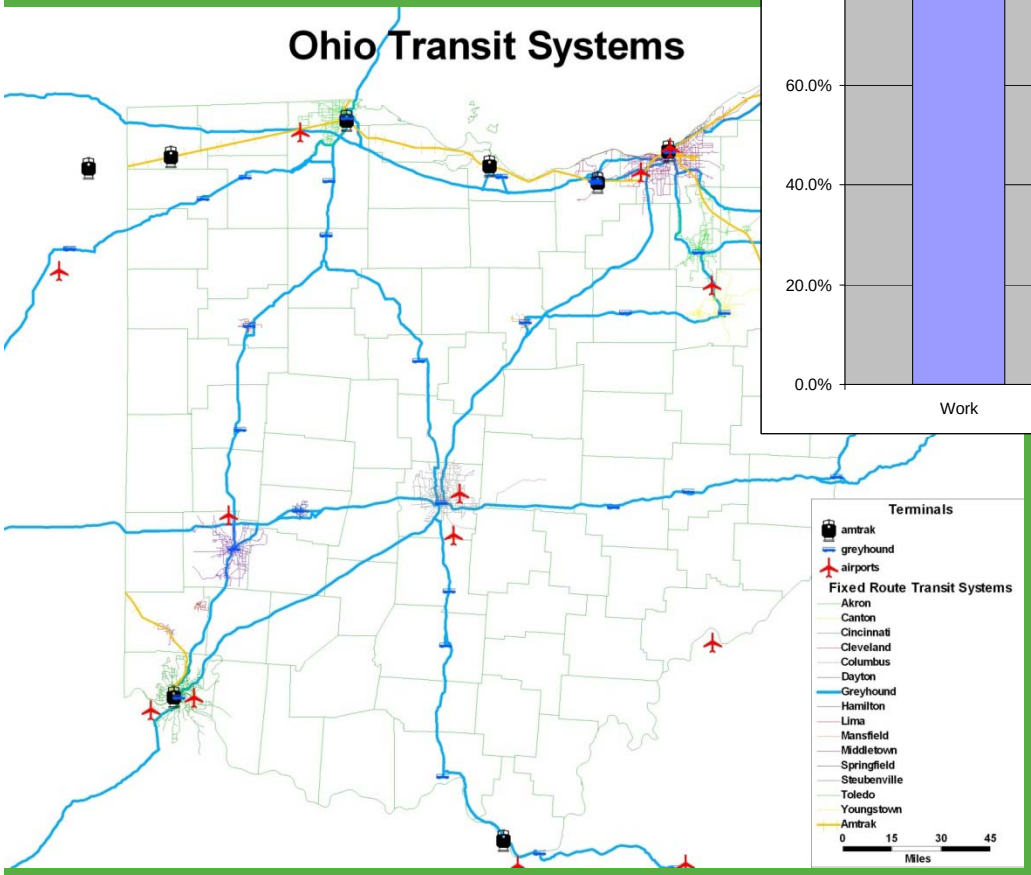
Components in Common Between Versions 2 and 3

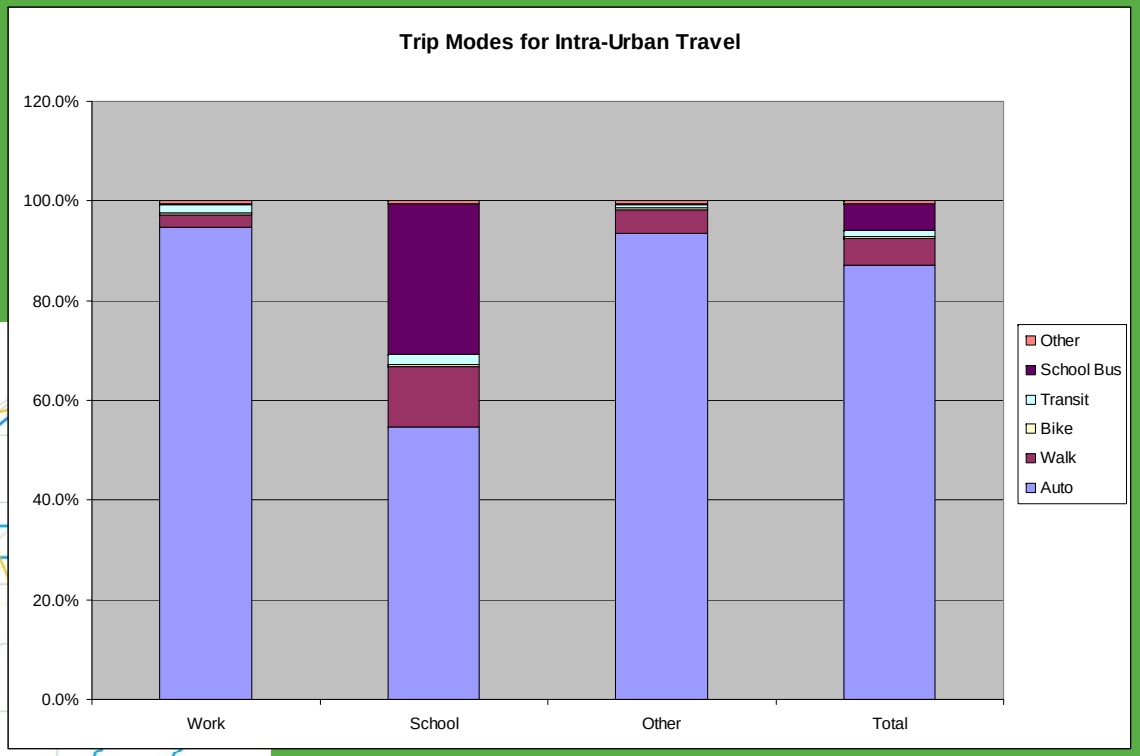
- **Short Distance Travel Model (SDT)**
  - Tour based microsimulation with logit choice models based on standard HH surveys
  - Simpler version than used with MORPC with no intra-household joint travel
  - Choices made of auto ownership, daily activity pattern, tour scheduling, tour patterns, tour destination, tour mode and intermediate stops
  - Purposes include Work, School, Shop, Social/Rec., Other
  - Work tours are conditioned by the labor flows from economic models
  - Work sub-tours are also possible

Components in Common Between Versions 2 and 3

- **Long Distance Travel Model**
  - Tour based microsimulation with logit choice models of infrequent travel over 50 miles based on a special 6 week long distance travel survey
  - Current implementation does not allow stops on the tours, so in essence they are trips
  - Linked to SDT, choice to make LD tour conditioned by short distance accessibilities, ability to make short distance tours linked to decision to make a long distance tour
  - Tours categorized by whether the entire tour occurs on model day or not
  - Purposes include work, other or entire household travel (work and other can include more than 1 person but not the entire household)

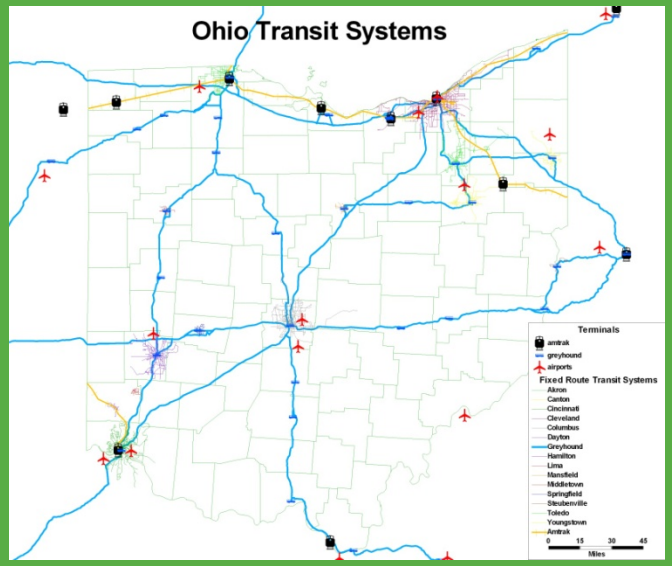
Urban Passenger Travel Mode Shares



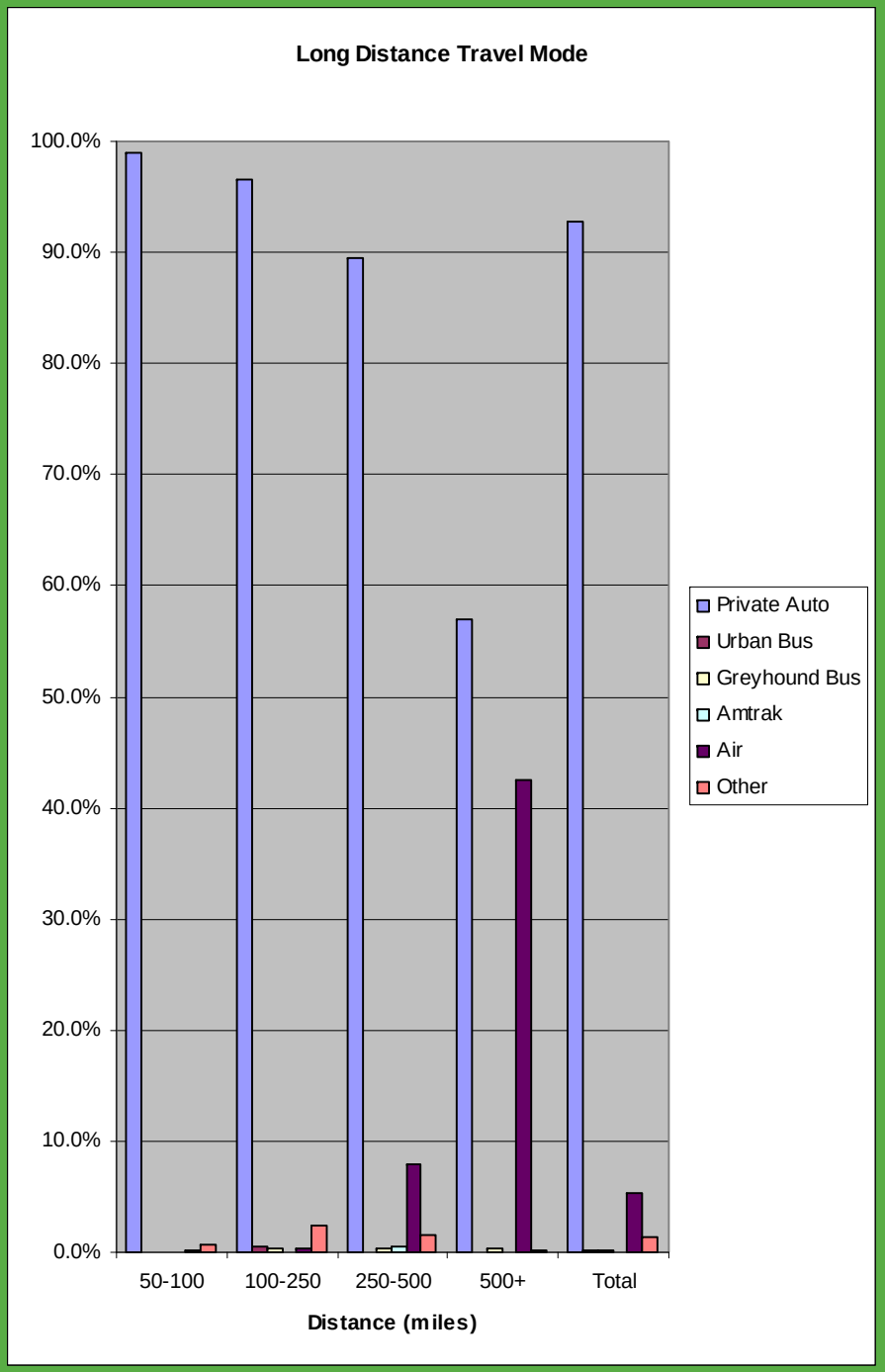


Trip Modes for Intra-Urban Travel				
Percent				
	Work	School	Other	Total
Auto	94.7%	54.6%	93.5%	87.2%
Walk	2.4%	12.2%	4.6%	5.3%
Bike	0.5%	0.4%	0.5%	0.5%
Transit	1.7%	2.1%	0.6%	1.2%
School Bus	0.1%	30.1%	0.2%	5.3%
Other	0.5%	0.6%	0.6%	0.6%

Long Distance Passenger Trip Mode Shares



Ohio Long Distance Travel Mode Summary					
	Distance				
Mode	50-100	100-250	250-500	500+	Total
Private Auto	99.0%	96.5%	89.5%	56.9%	92.7%
Urban Bus	0.0%	0.5%	0.0%	0.0%	0.2%
Greyhound Bus	0.0%	0.3%	0.4%	0.4%	0.2%
Amtrak	0.0%	0.0%	0.6%	0.0%	0.1%
Air	0.2%	0.3%	7.9%	42.6%	5.3%
Other	0.8%	2.4%	1.6%	0.1%	1.5%



Components in Common Between Versions 2 and 3

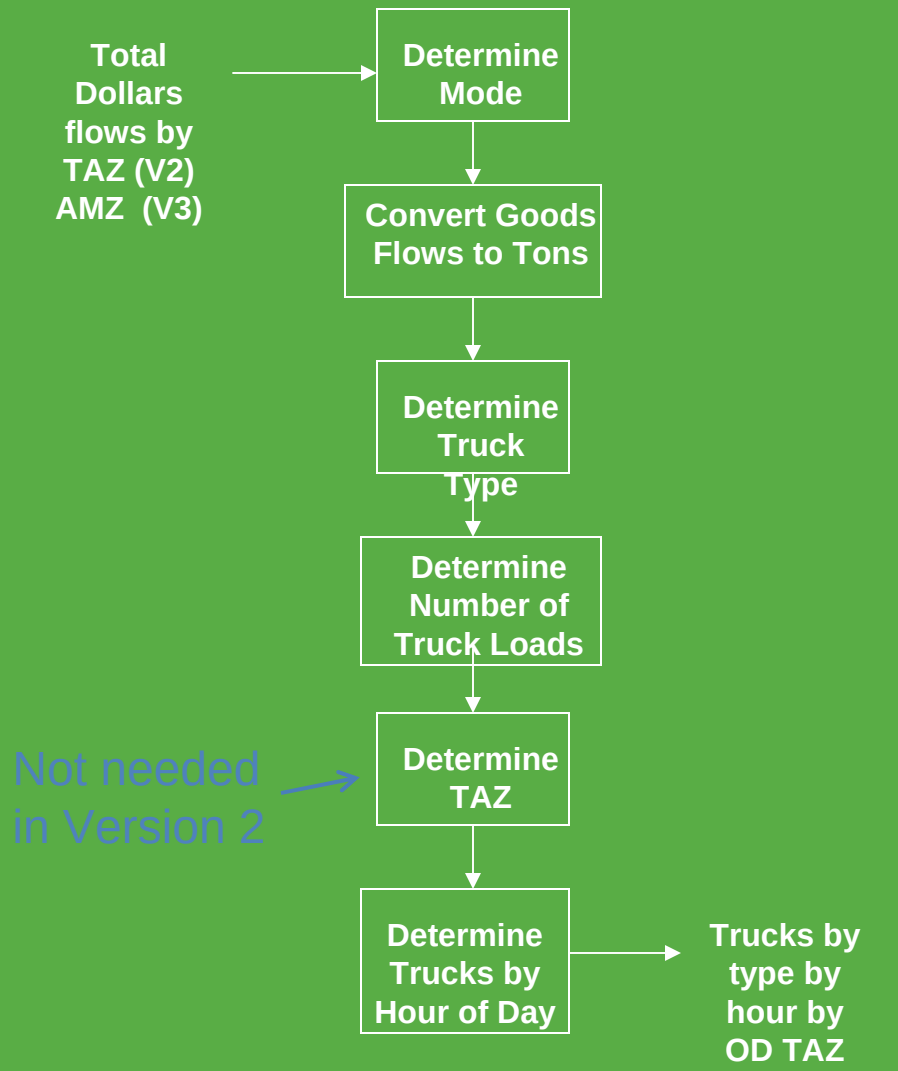
- **Visitor Model**
  - Based on a visitor and tourism survey conducted by another agency
  - Results in IE trips as well as additional synthetic households at hotels, camp grounds and households which are sent to SDT
  - Trip purposes for commute, business, visiting friends/relatives, leisure and camping
  - Trips also segmented based on whether it is an arrival day, departure day, both arrival and departure or an activity day

Components in Common Between Versions 2 and 3

- **Aggregate Commercial Vehicle Model (ACOM)**
  - Aggregate model for converting dollar flows of goods from economic models to trucks
  - Output is flows of trucks between Traffic Analysis zones (TAZ)
  - Uses information from CFS, VIUS and traffic counts to determine mode (truck/rail vs. other), convert dollars to tons, determine truck type and truck loads, all by commodity and distance shipped
  - Truck and rail mode choice model uses rail/highway skim comparisons to split “intermodal” type commodities while bulk commodities use CFS based factors if rail access is available (bulk rail too difficult to model at network level)

Components in Common Between Versions 2 and 3

ACOM Flow Diagram



Factors by commodity class, by distance, between air, water, bulk rail and truck/intermodal rail, rail only chosen if rail access available, mode choice model to split intermodal rail from truck

By commodity class and distance, from CFS

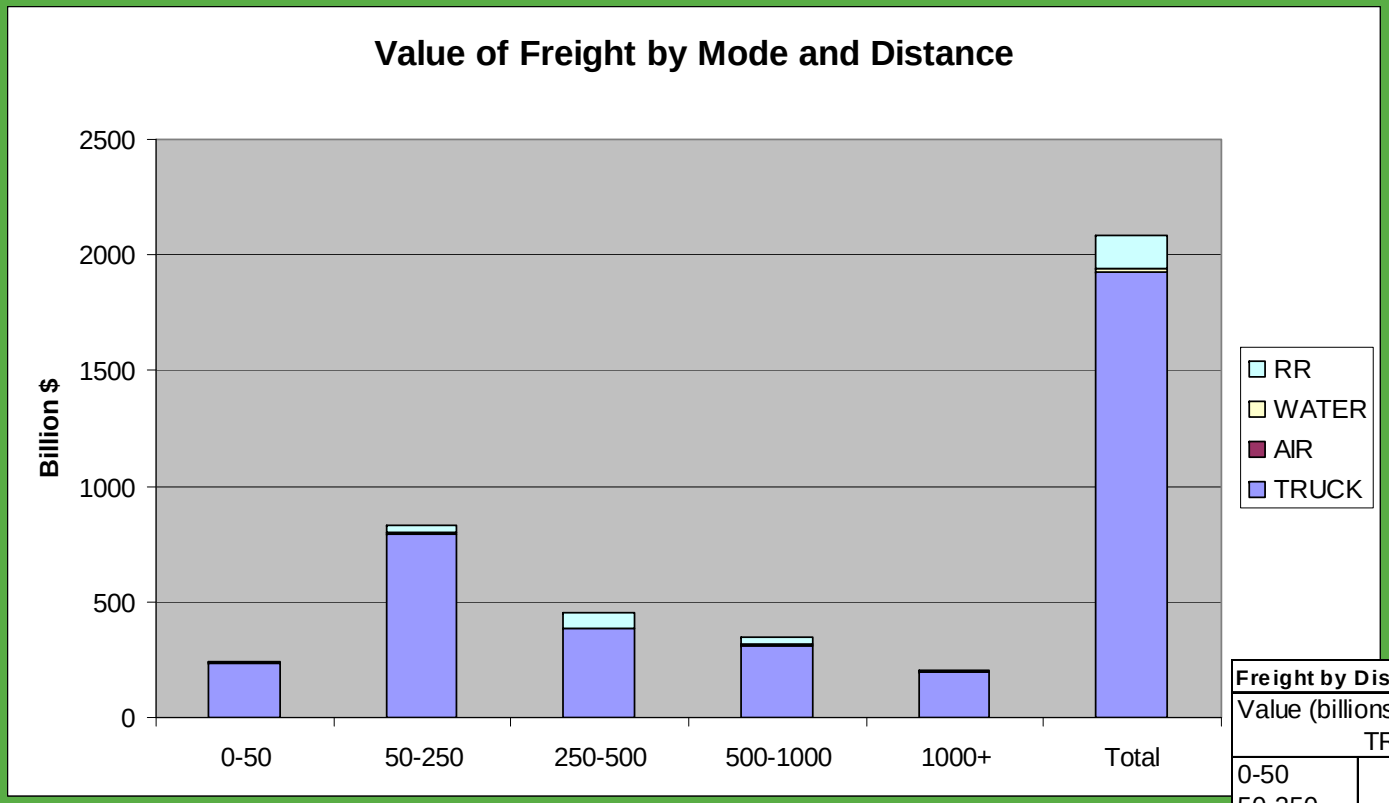
By commodity class and distance, from VIUS

By commodity class and truck type, from VIUS

Based on employment levels by industry class

Based on traffic counts, conversion from annual to weekday assumes 300 equivalent week days per year. This value is obtained as follows: (52 * 5) weekdays plus (52 * 2 * 0.44) weekday equivalents for weekends minus 6 holidays.

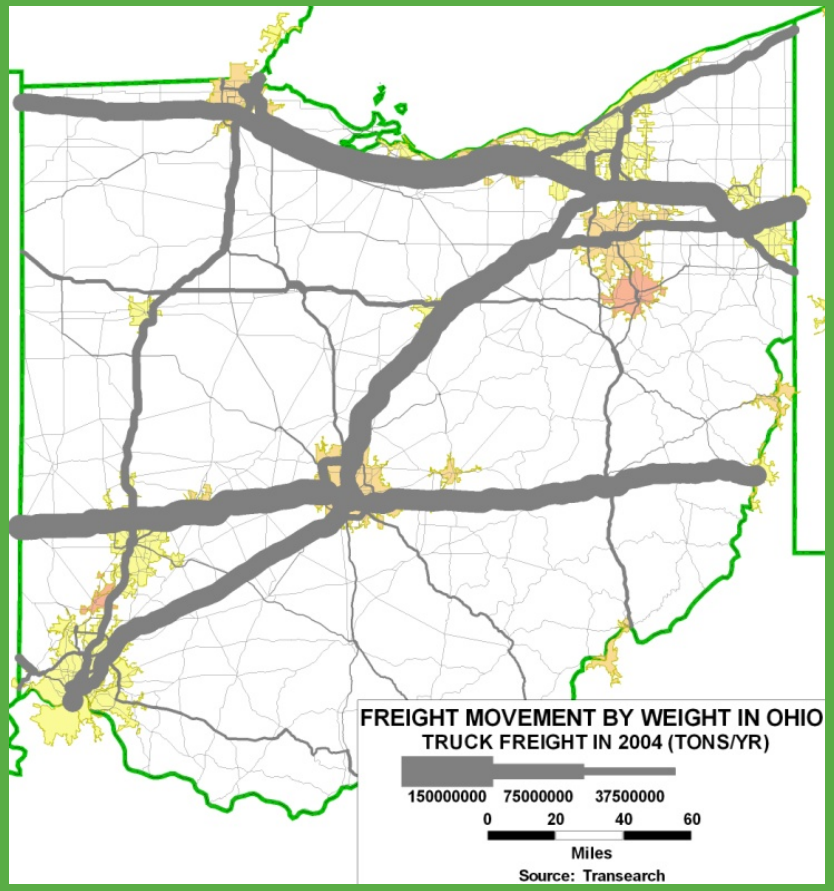
Freight Mode Shares



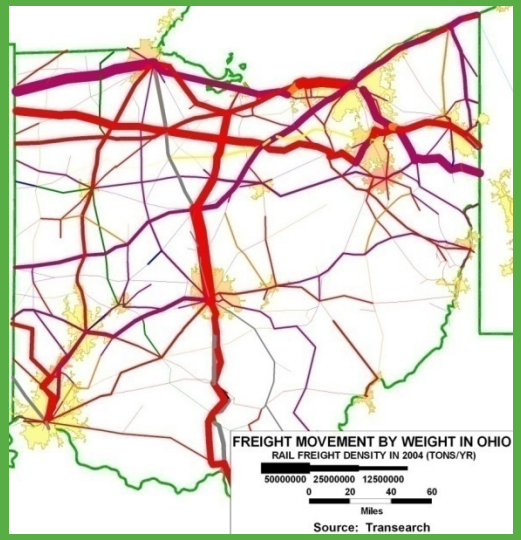
Freight by Distance					
Value (billions $)					
	TRUCK	AIR	WATER	RR	TOT
0-50	232	0	1	8	241
50-250	795	0	2	33	831
250-500	384	2	2	67	455
500-1000	313	2	4	30	349
1000+	198	1	2	6	207
Total	1923	6	12	144	2084

Percentage					
	TRUCK	AIR	WATER	RR	TOT
0-50	96.2%	0.0%	0.3%	3.4%	
50-250	95.7%	0.0%	0.3%	4.0%	
250-500	84.3%	0.5%	0.5%	14.7%	
500-1000	89.6%	0.7%	1.1%	8.6%	
1000+	95.6%	0.6%	1.0%	2.8%	
Total	92.2%	0.3%	0.6%	6.9%	

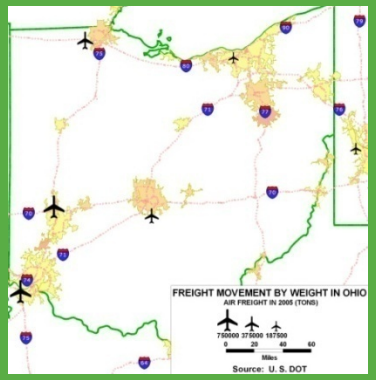
Freight Flows



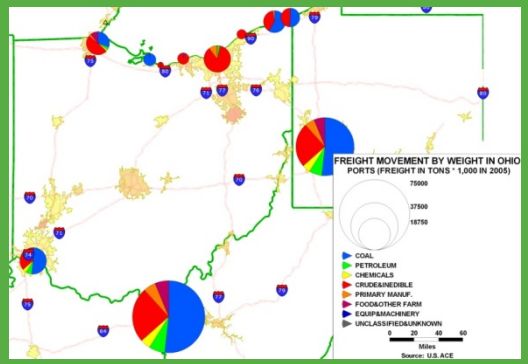
Truck



Rail



Air



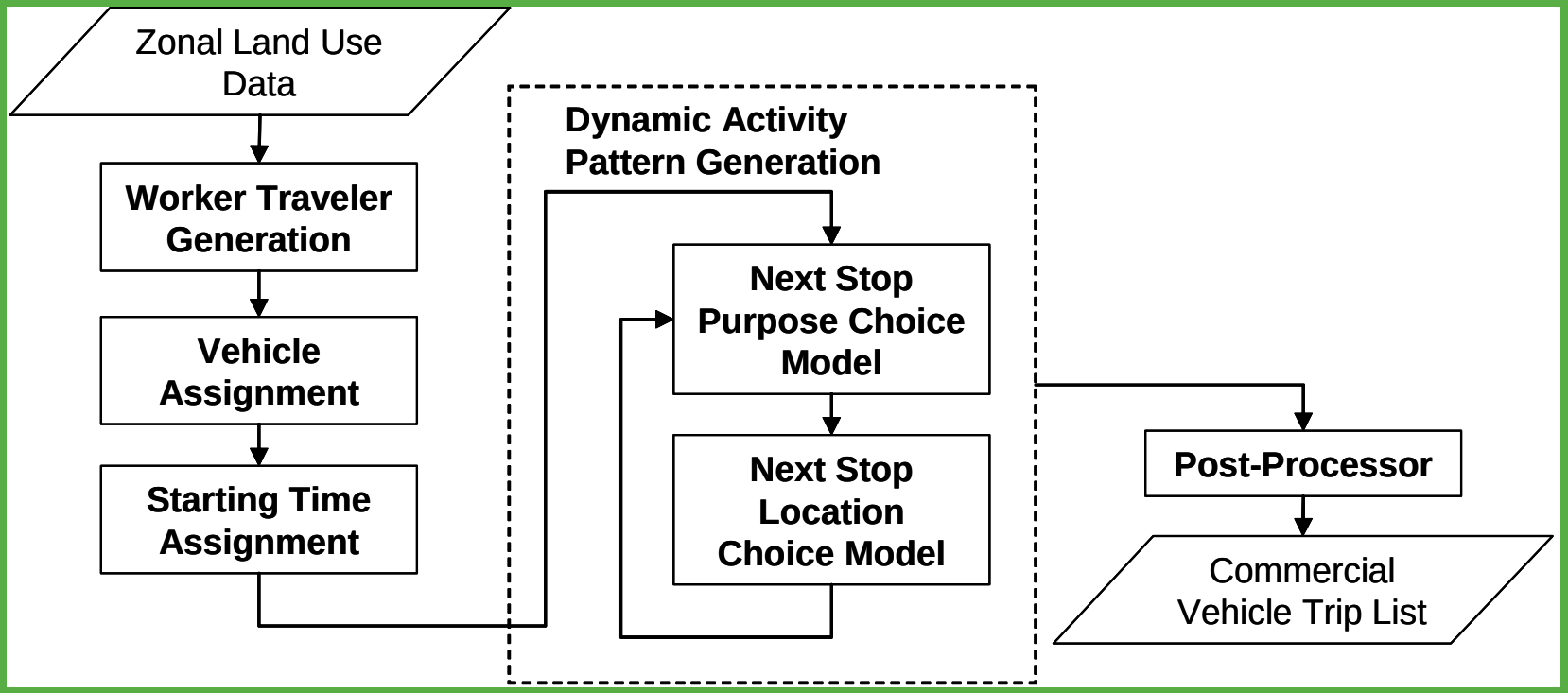
Water

Components in Common Between Versions 2 and 3

- **<u>Disaggregate Commercial Vehicle Model (DCOM)</u>**
  - Tour based microsimulation using logit choice models based on a survey of some 500 business establishments
  - Covers business/commercial vehicle travel not covered by other models including that related to management functions, sales & support activities, provision of services and short distance goods delivery
  - Note that long distance business travel is included in LDT
  - Unlike the passenger transport models, rather than choosing patterns, tours are built dynamically with duration of tour, purpose and location of the next stop chosen at each destination
  - Trip purposes include Provide Service, Attend Meeting, Deliver Goods, Other (such as stopping for lunch or fuel), note that this last purpose would only be for stops made in the course of other business activity since SDT includes a work sub-tour model for specific tours of this type

Components in Common Between Versions 2 and 3

- **Disaggregate Commercial Vehicle Model (DCOM)**



Components in Common Between Versions 2 and 3

- **<u>Disaggregate Commercial Vehicle Model (DCOM)</u>**

Truck volumes showing freight trucks (black) and non-freight commercial vehicles (gray)

Other Stuff We Want: Versions 2.1, 3.1 etc.

- Current model has over 5000 zones, however, this is not enough to do project level planning so current model has an underlying set of 20000 zones with associated networks for use in focusing, when computers are fast enough would like to perform all demand modeling at this scale

- Current model uses a static equilibrium assignment, again based on computer speeds, are adding dynamic intersection based delays to the static model

- AND would like to add dynamic traffic assignment partly to take care of problems associated with long distance trips traversing model periods

Other Stuff We Want: Versions 2.1, 3.1 etc.

- Obtain better data so we can calibrate and implement version 3.0
- Once implemented, want to add geographic specificity to land use grids so that they maintain the proper relationships between their attributes (such as zoning, flood plain, slope, water service etc) which will also make them mapable (currently randomly select each attribute based on TAZ proportions)
- Currently adding an economic benefit post processor which will feed the transport model accessibilities back to an economic engine to quantify the indirect and induced economic benefits of projects