



Introduction to **IN**tegrated
TRansportation **LU**sage **DE**mand
Model for Indiana (**INTRLUDE**)

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PURDUE
UNIVERSITY

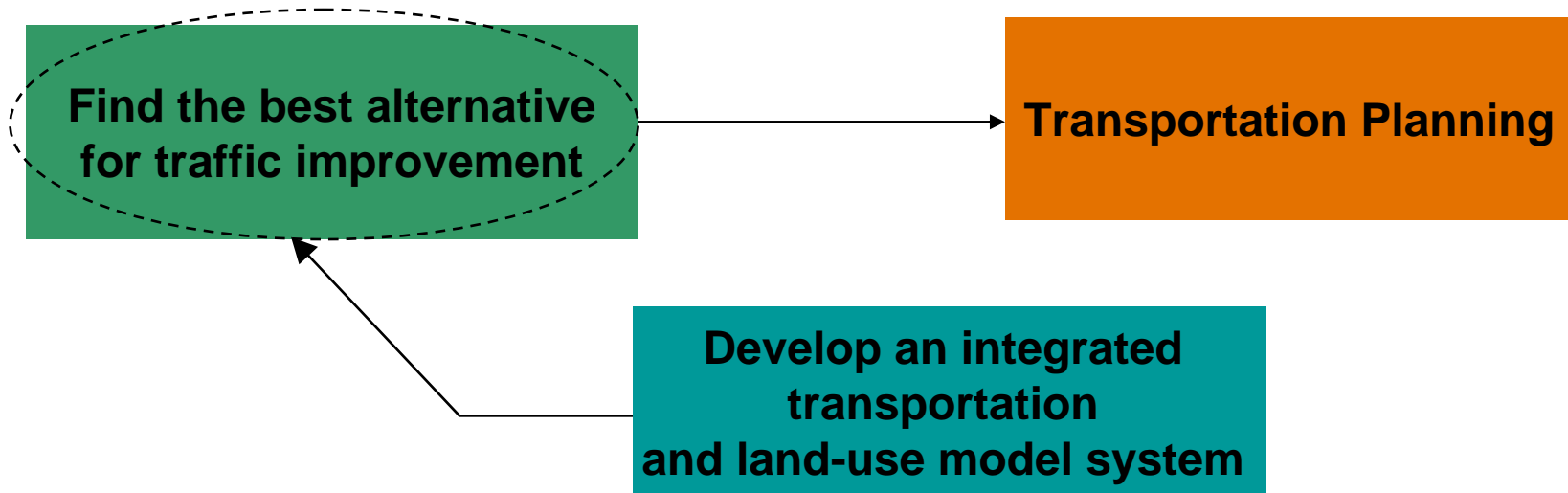


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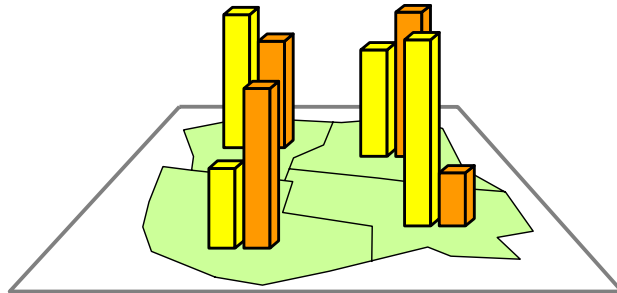
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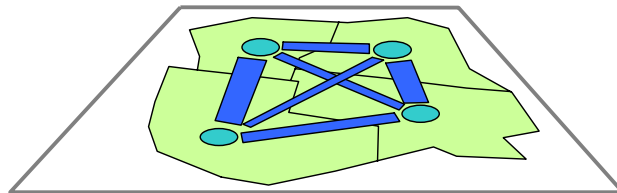
Background



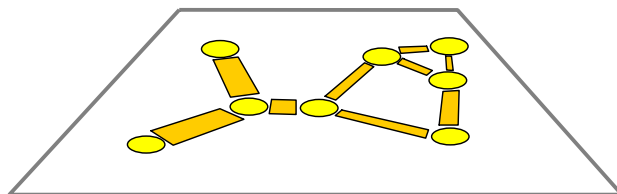
Background



- Spatial Accumulation (demand)**
- Economic base theory
 - Location theory
 - Traffic generation and attraction models



- Friction of Space**
- Spatial interaction models
 - Distance decay parameters
 - Modal split

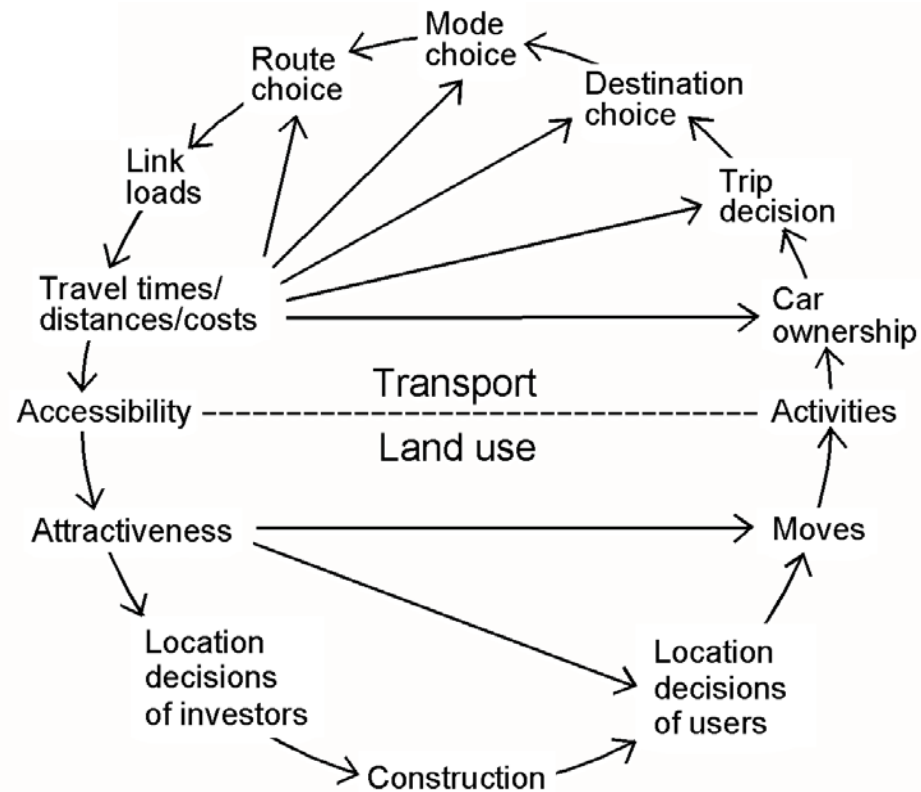


- Transport Infrastructures (supply)**
- Accessibility
 - Traffic assignment models
 - Transport capacity

Components of transportation and land-use system (Source: Rodrigue, 2006)



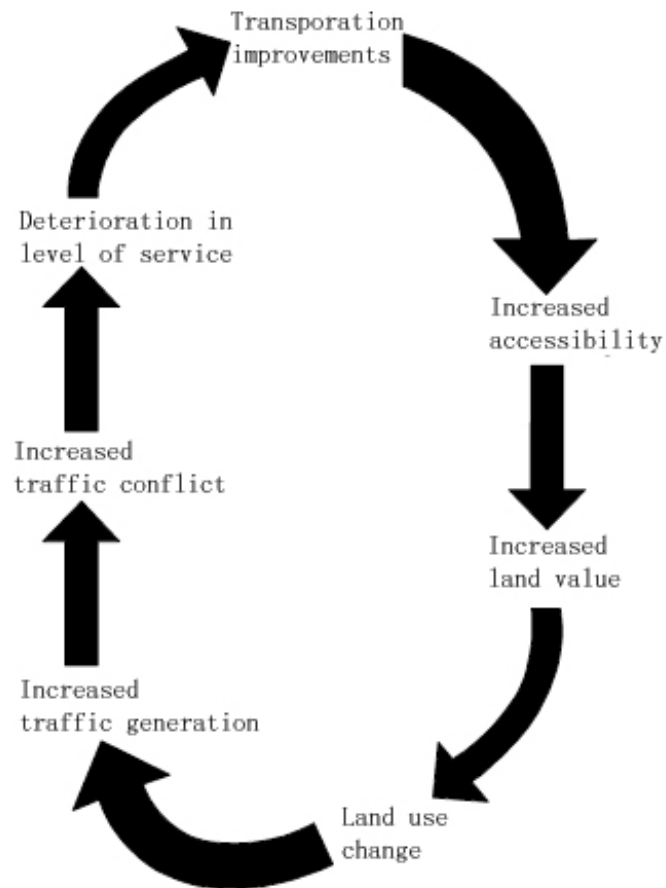
Background



Transportation and land-use cycle (Wegener and Fuerst, 2004)



Background



Transportation and land-use cycle (FDOT Site Impact handbook, 1997)



Background

- **Travel demand models focus on transportation side, which causes the difficulty in capturing the two-way interactions between transportation and land-use system.**



Background

- **Two major trends in transportation and land-use modeling from the existing literature (Pfaffenbichler, 2003):**
 - **Using a disaggregate approach;**
 - **The integration of GIS system.**



Background

- **The Indiana statewide travel demand and land-use models have an extremely large scope.**
- **Data limitations and resource availability made the development of a disaggregate approach impractical.**
- **Linking the two existing models was thought to be a feasible approach for Indiana.**



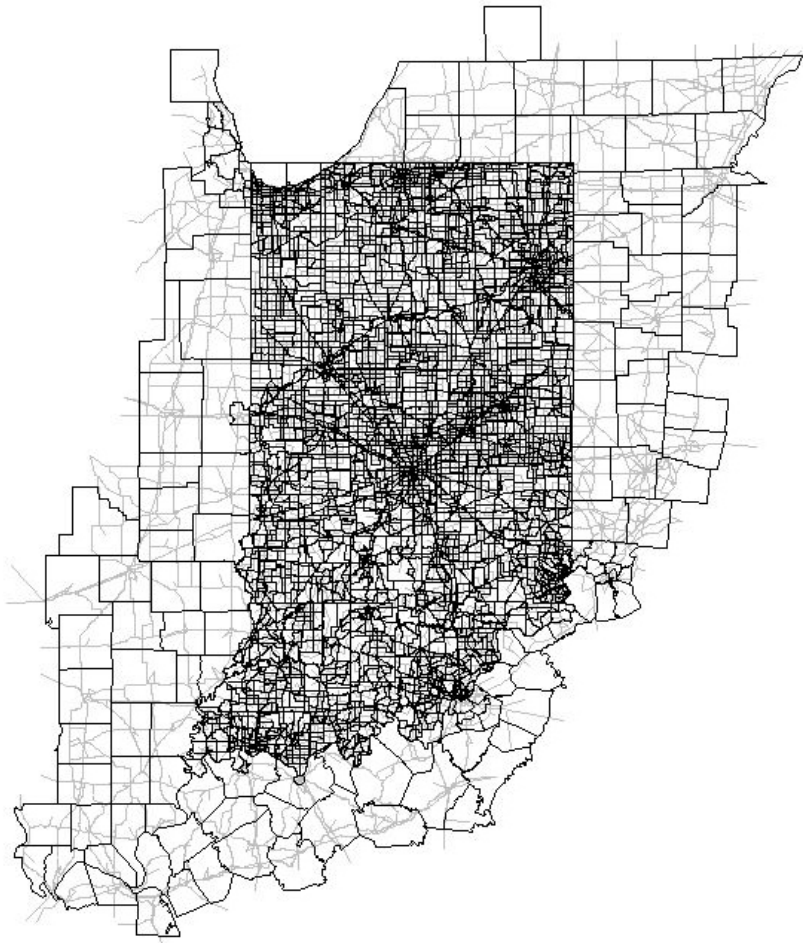
Background

- **Indiana Department of transportation (INDOT) has an operational statewide travel demand model (ISTDM v.4).**
- **INDOT has operational Land Use in Central Indiana (LUCI) model.**
- **The LUCI2 statewide model was integrated with the ISTDM v.4.**



ISTDM v.4

- **Over 20,000 links for state jurisdictional highways and over 11,900 links for local roads.**
- **4720 TAZs (including 141 external TAZs).**



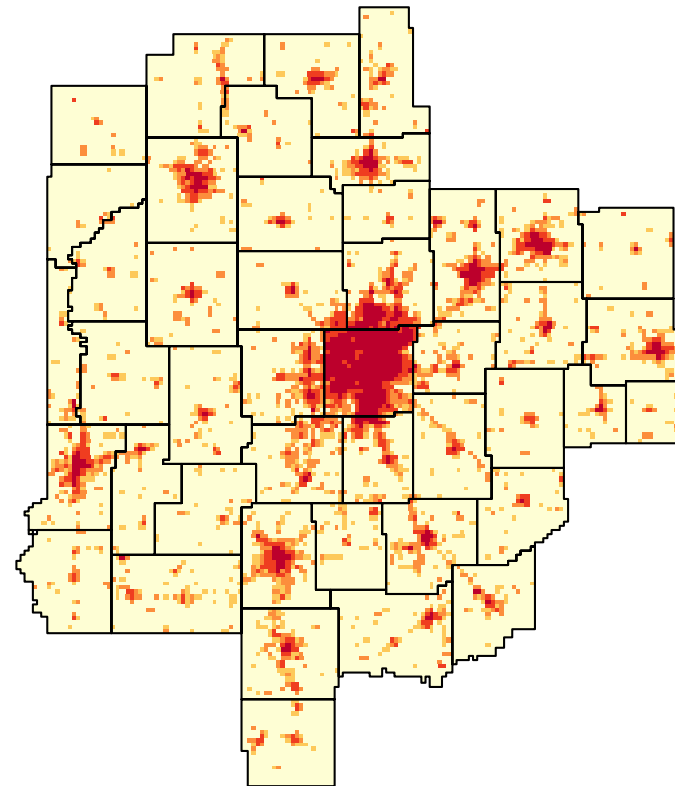
ISTDM v.4

- **A traditional four-step model;**
- **Implemented in TransCAD;**
- **A master network or “multinet” file that includes multiple year/improvement scenarios was used;**
- **Models were developed based on the data from 1995 Indiana Household Survey and the 2001 NHTS.**



LUCI model

- **Land Use in Central Indiana (LUCI) model first simulated conversion of land to urban use in 44-county region in Central Indiana.**
- **Used data on urban land derived from Landsat satellite imagery.**



LUCI model

- **Accessibility to employment (using distance);**
- **Availability of water and sewer;**
- **Distance to interstates and 4-lane highways;**
- **Level of urban development in area;**
- **Urban development in prior period;**
- **The Indiana Statewide Test of Educational Progress (ISTEP) scores for school district.**



LUCI2 Statewide model

- **Integrated with the ISTDM v.4;**
- **Simulates residential and employment-related development and provides the option to additionally simulate the change in local-service employment;**
- **Operates in five-year simulation periods, beginning in 2000;**
- **Using random utility theory and aggregated discrete choice models of the decisions.**



LUCI2 Statewide model

- **Probability of Residential Development Model**

$$\text{logit}(p_i) = \log\left(\frac{p_i}{1-p_i}\right)$$

$$\text{logit}(p_i) = \beta_0 + \sum_k \beta_k X_{ik}$$

p_i is the proportion of land converted to residential use. This starts with the increase in the amount of residential land from 1995 to 2000.

X_{ik} includes accessibility to employment change from 1995 to 2000 and a sewer service dummy.



LUCI2 Statewide model

Accessibility to employment change by TAZ from 1995 to 2000 as estimated from the ES-202 ZIP code employment data is calculated using the following formula:

$$A_i = \sum_j \Delta E_j e^{\beta T_{ij}}$$

ΔE_j is the employment change in TAZ j .

T_{ij} is the congested travel time from TAZ i to TAZ j .

β is an empirically-determined accessibility coefficient.



LUCI2 Statewide model

- **Density of Residential Development Model**

$$\ln(D_i) = \beta_0 + \sum_k \beta_k X_{ik}$$

$\ln(D_i)$ is the natural logarithm of net population density in 2000.

X_{ik} includes log accessibility to employment and a sewer service dummy.



LUCI2 Statewide model

- **Local-Service Employment Change Model**

- Local service employment is defined as employment in the construction, retail trade, service, and public administration industries.
- Employment in the basic industries is predicted by interpolating from the INDOT forecasts of employment change for those industries.



LUCI2 Statewide model

- **Local-Service Employment Change Model**

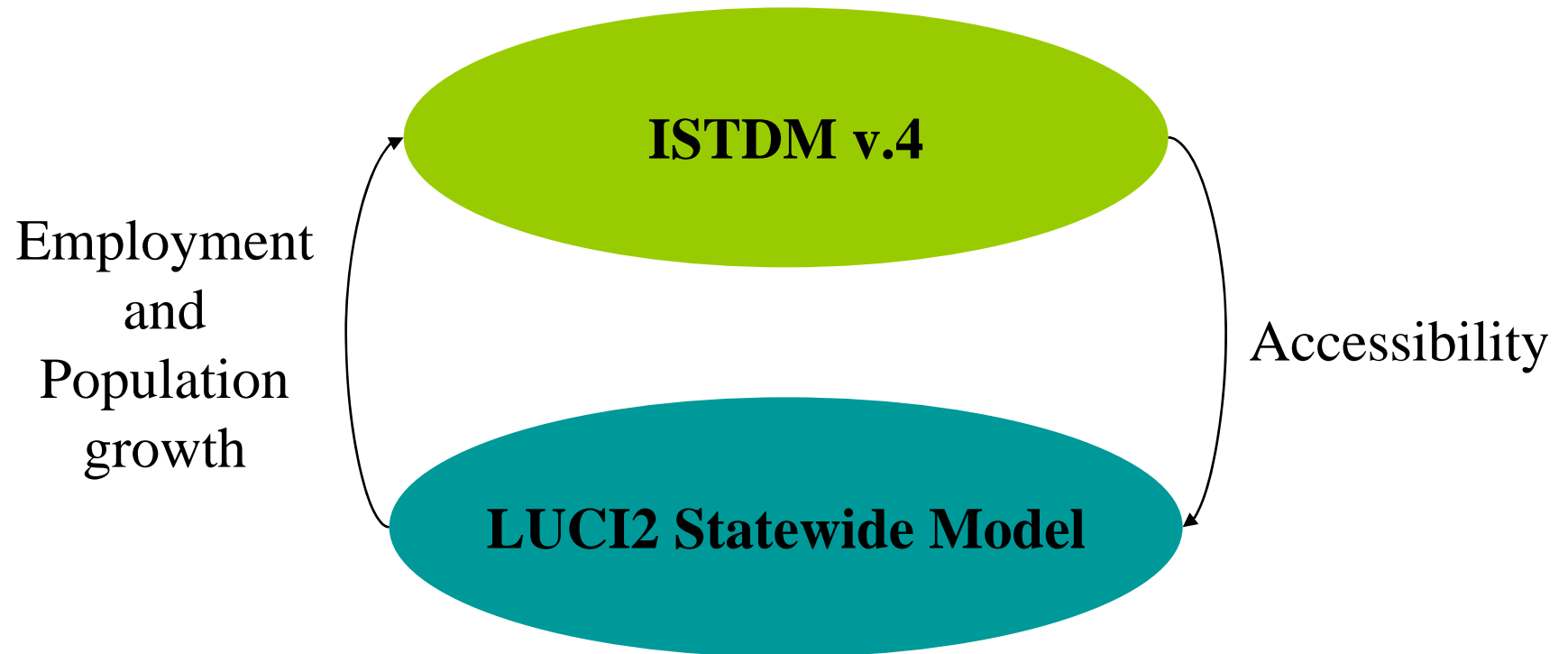
$$\ln(D_i) = \beta_0 + \sum_k \beta_k X_{ik}$$

$\ln(D_i)$ is the natural logarithm of Local-service employment change from 1995 and 2000.

X_{ik} is the Log accessibility to population change and change in urban land from 1995 and 2000.



INTRLUDE Model



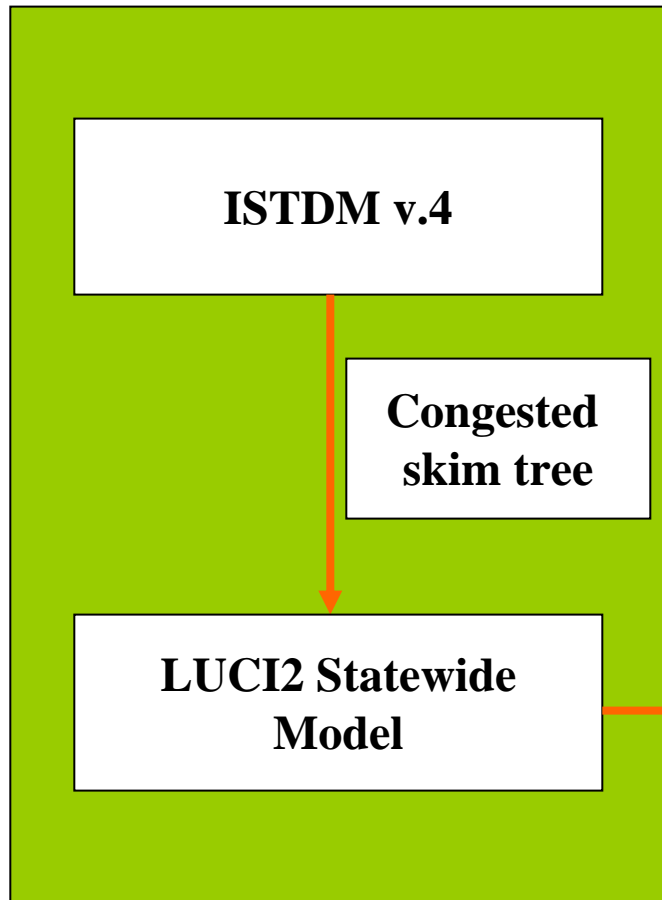
INTRLUDE Model

- **A five-year exchange simulation period.**
- **The LUCI2 statewide model runs as a program that is separate from the ISTDM v.4 during each five-year period.**
- **The LUCI2 statewide model uses congested travel times between each zone pair for measuring accessibility.**



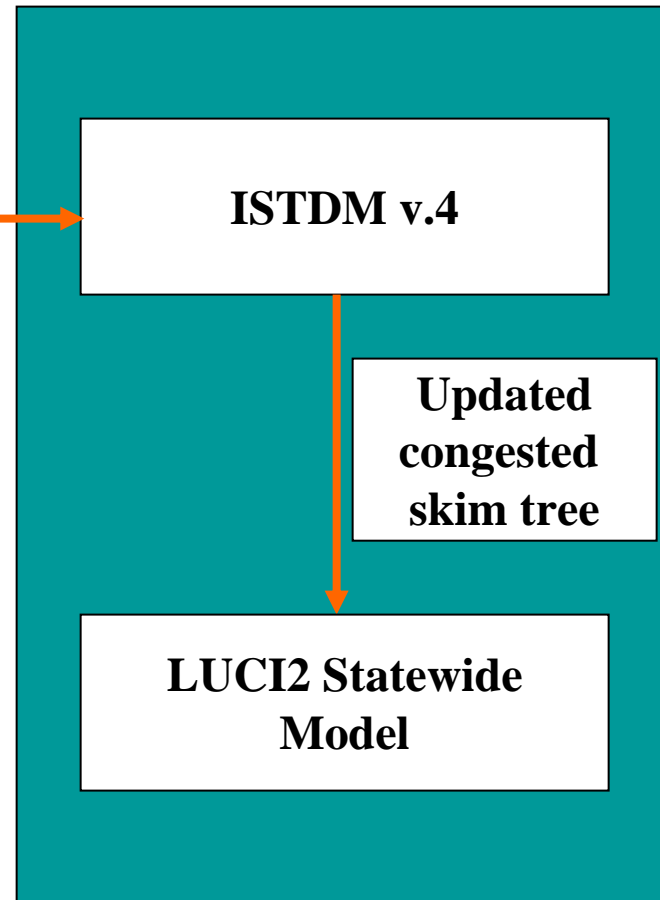
INTRLUDE Model

Year 2000-2005



**Population
and
employment
growth for
5-year period**

Year 2005-2010

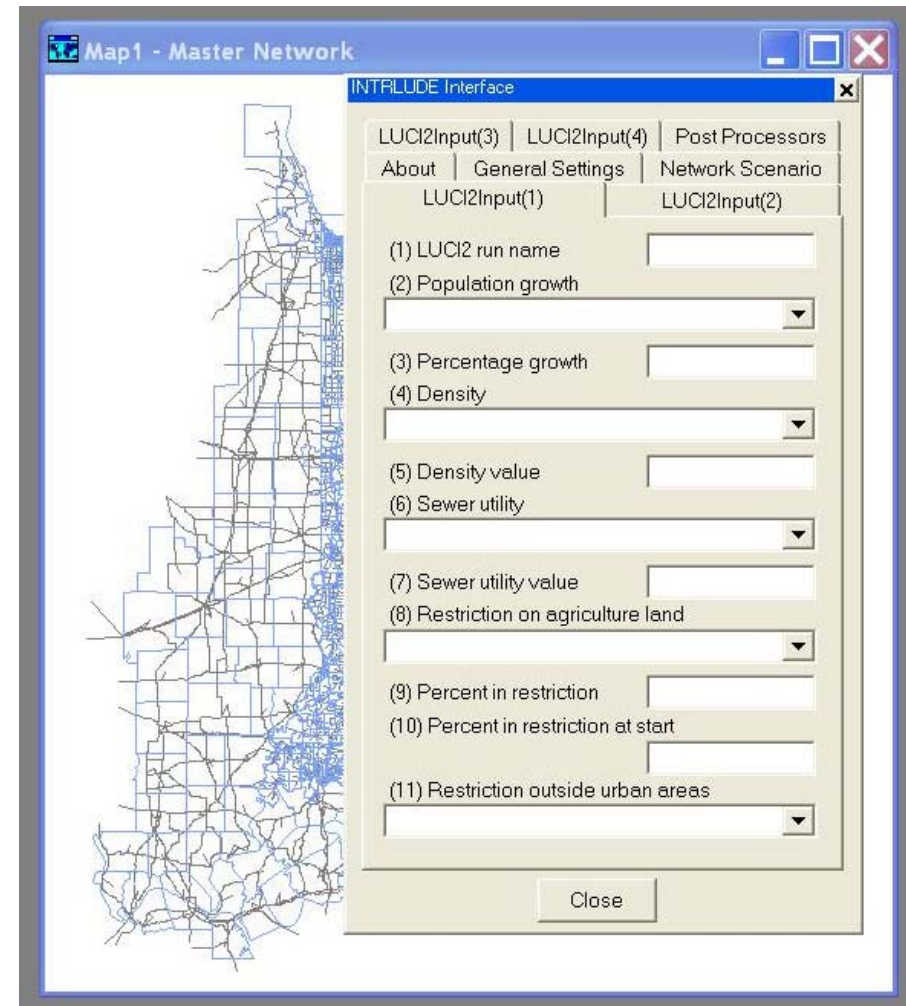


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INTRLUDE Interface

- **The interface lets users specify multiple ISTDM v.4 scenarios and LUCI2 statewide model options and then run INTRLUDE.**
- **It is a fully automated process.**



INTRLUDE Interface

- **The INTRLUDE model can allow users to specify changes to the statewide roadway network that is proposed at certain years before the horizon year.**
- **The INTRLUDE model can also allow users to specify employment changes to TAZs that is proposed at certain years before the horizon year.**



INTRLUDE Interface

- **In the INTRLUDE model interface, different land use policy scenarios can be tested for future years.**
 - Target year;
 - Population growth;
 - Population density;
 - Utilities;
 - Agricultural land;
 - Urban growth boundaries;
 - Dispersal of development;
 - Accessibility to employment;
 - Employment forecast;
 - Employment changes.

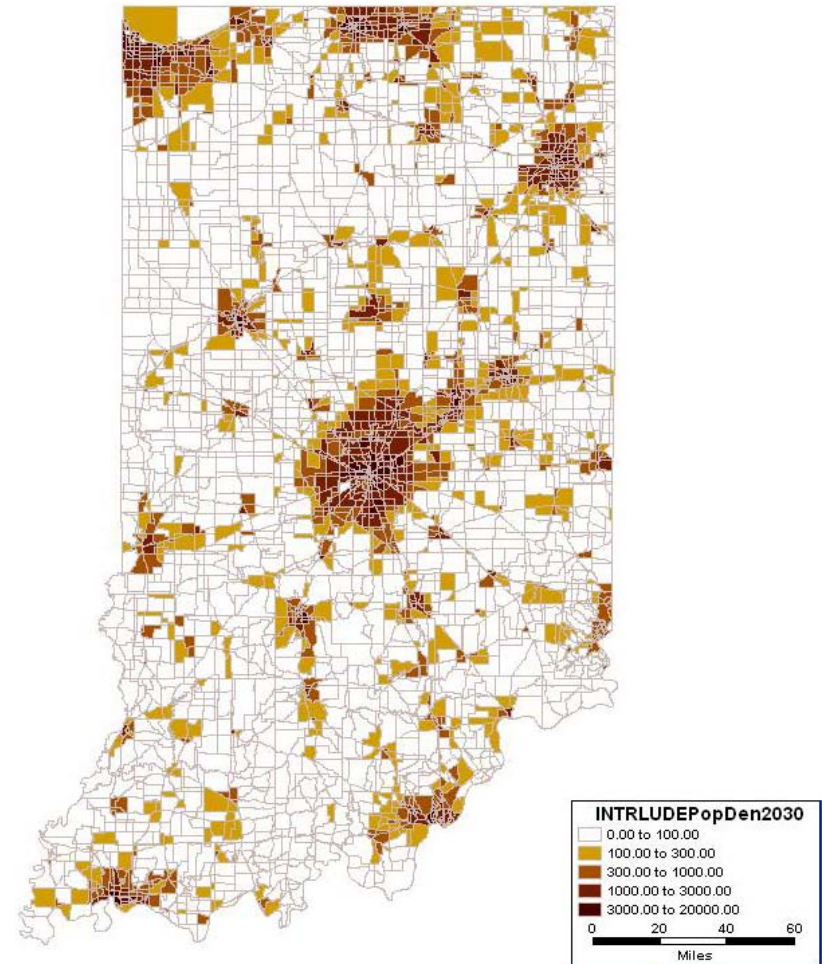
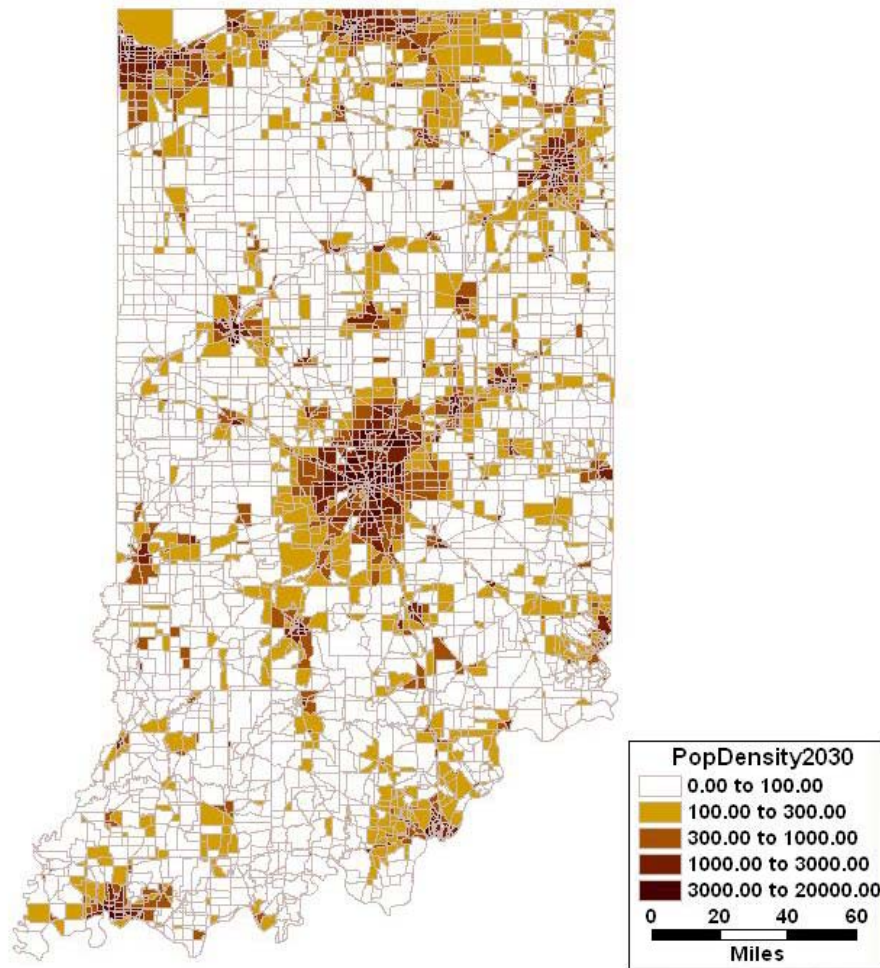


Comparison of the ISTDM v.4 and the INTRLUDE Approach

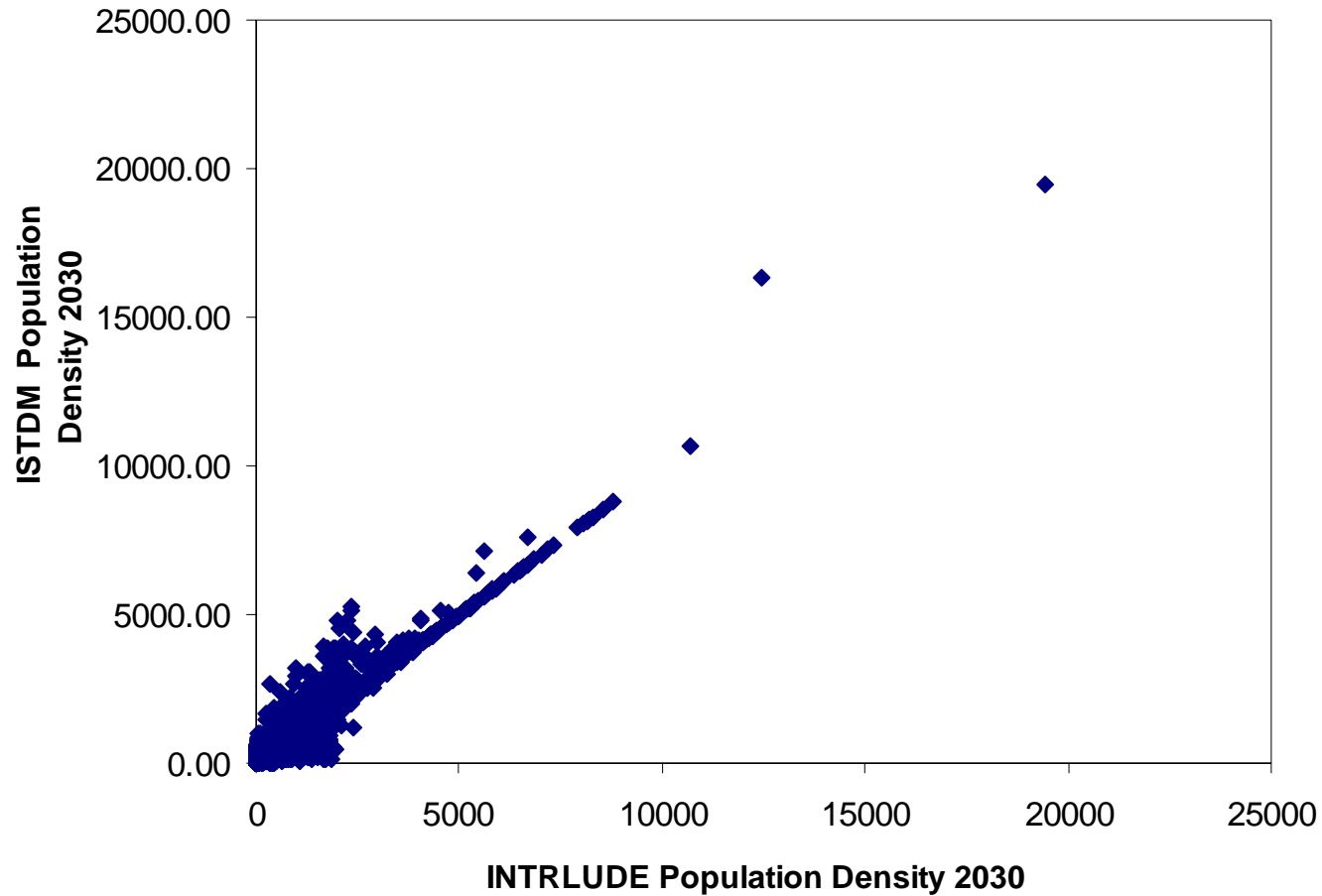
- **Both the ISTDM and the INTRLUDE approaches provide predictions of zonal population and employment in year 2030.**
- **The 2030 predictions of population for each TAZ are compared.**



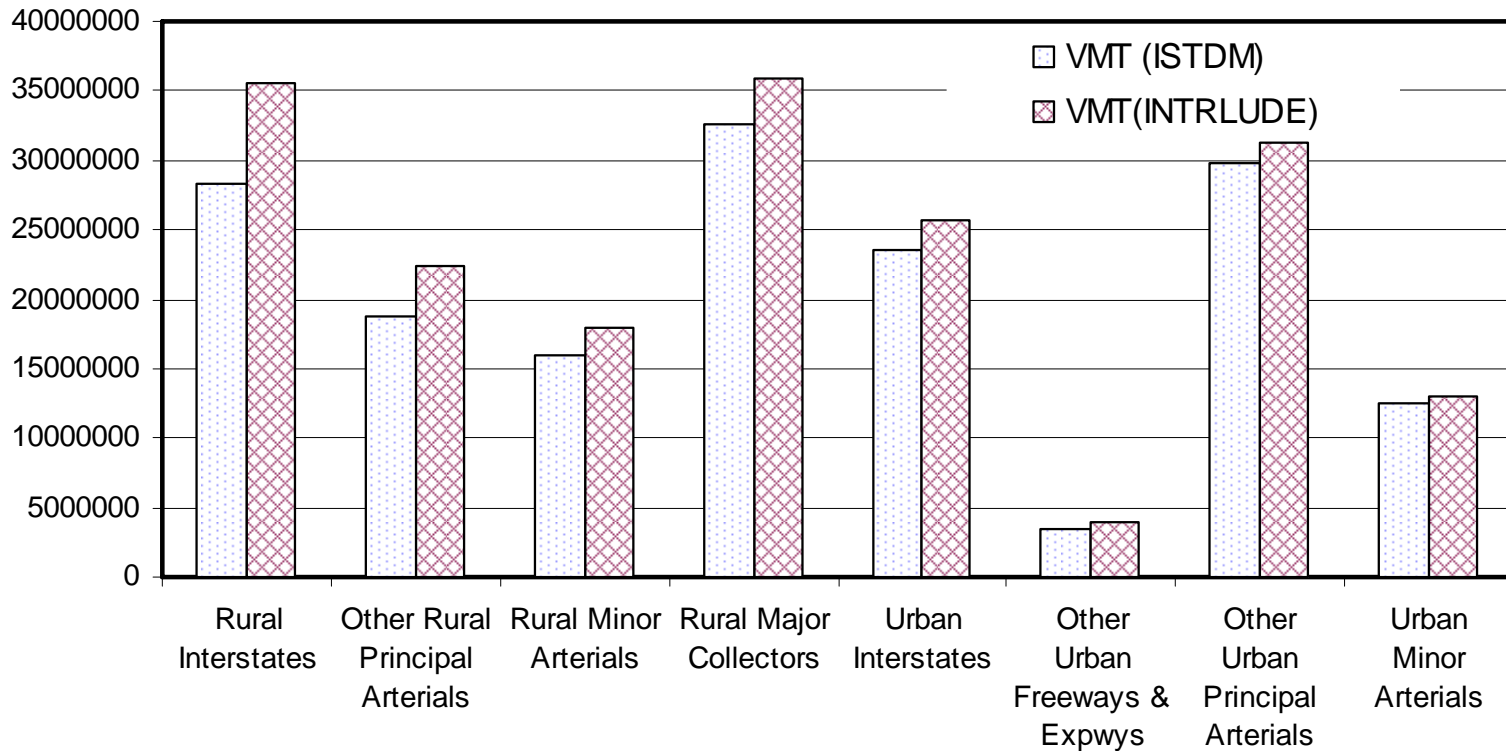
Comparison of the ISTDM v.4 and the INTRLUDE Approach



Comparison of the ISTDM v.4 and the INTRLUDE Approach



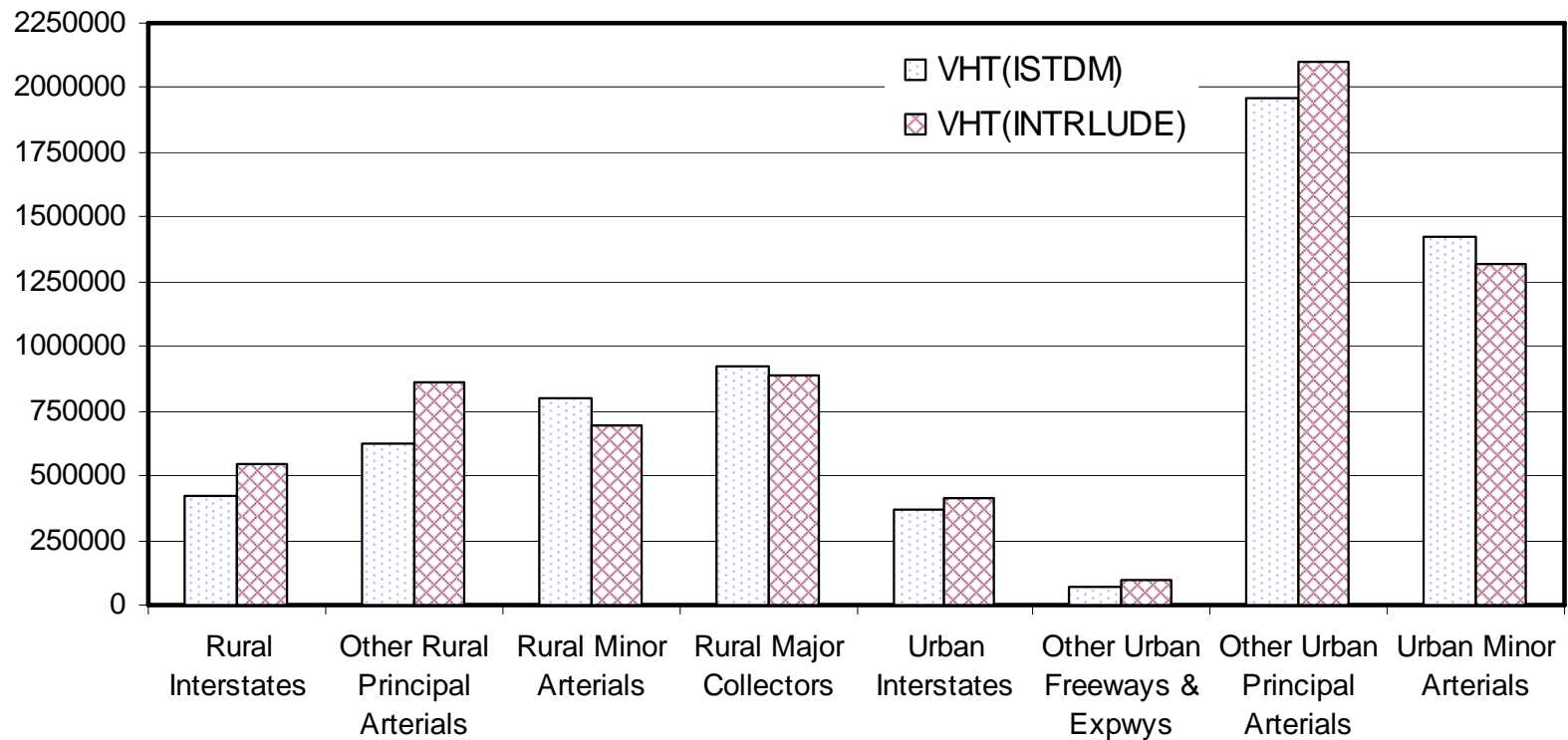
Comparison of the ISTDM v.4 and the INTRLUDE Approach



VMT forecasts in 2030



Comparison of the ISTDM v.4 and the INTRLUDE Approach



VHT forecasts in 2030



CONCLUSIONS

- **This research project integrated the LUCI2 statewide land use model with the ISTDM v.4.**
- **A user-friendly interface was built to implement the model process.**
- **INTRLUDE model allows forecasts of land use and travel patterns for any specified horizon year, with intermediate reports for each intervening 5-year period.**



CONCLUSIONS

- **INTRLUDE allows users to test options that will affect transportation and land-use development, including statewide network and employment changes that may be proposed at certain years before the horizon year.**

