Data exchange and communication between existing spatio-temporal urban models

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Strategic Planning Support

• Model integration
  – Managing complexity and complex systems models
  – Deep uncertainty in urban systems science

• Model value - Tara
  – Logical story
  – Communication and consensus
  – Identify tradeoffs
  – Magnitude and direction

• Backcasting – Brian G.
  – Learning
  – Systems understanding
  – Consensus
  – Managing scenarios

• Systems modeling and Evolving understanding
  – Simplification to increase understanding
  – Contextual experts vs modelers
Urban Systems Science
Modeling

Integrated modeling
• Economic Drivers
• LUC Model (LEAM)
  – Modular (sub models)
  – Process
    • Driver identification
    • Scenario identification
    • Buy in
• Implications
  – Coupled models
  – feedback
• Decision making context
  – Information vs data

• Iterative and evolutionary
  • Evolve models and information systems

• Managing uncertainty
  • By managing models
LEAM-2010
LEAM-2020
LEAM-2025
LEAM-2030
Viewing Change Over Time

- LEAM simulates annual growth.
- When viewed as a dynamic map or a graph the future is described in a much richer fashion.
Managing Deep Uncertainty

- Calibration
  - Scenarios?

Study Area initial land use map 1993

Actual developed areas 2000-2010

LEAM Probability Map using monte carlo
$R^2 = .5$
so what?
Implications?
What do we want to know?

Growth by watershed
Future Demand for Water by Watershed
Growth by ...
Stress Analysis
Green Infrastructure

Policy context – where to focus attention
decision support
Decision Support

• To affect decisions....
• Data must become useful information
  – Understandable
  – Rational
  – And sentient

• Does accuracy affect decisions?
  – If information is trusted

• Do implications affect?
  – If they are things the community wants to know

• What do we want and how do we help it happen?
LEAM-NCSGRE Maryland Modeling Project

Welcome!

The National Center for Smart Growth Research and Education (NCSGRE) at the University of Maryland, College Park and Land Use (Walkability and Impact Assessment) Modeling (LEAM) laboratory at the University of Illinois at Urbana-Champaign have joined forces to develop a comprehensive strategy for evaluating short and long-term development related changes in the state of Maryland. This collaborative effort will provide an opportunity to engage the federal, state, regional and local organizations in deliberations on relevant policy questions, including DOD centered issues of base closure and realignment, the implications of urbanization on the Chesapeake Bay, and related sustainability issues of economic, environmental, practical and social concern.

Discussions have been taking place between LEAM and NCSGRE in an effort to develop a land use model that can tightly couple with the transportation and economic frameworks jointly developed by the NCSGRE and the Maryland State Highway Administration (MDOT). This collaborative effort between the National Center for Smart Growth Research and Education and University of Illinois LEAM Laboratory will deliver a powerful integration of economic, transportation, and land use modeling capabilities to the state of Maryland. This integrated scenario and impact modeling tool will provide a unique opportunity to engage a wide variety of constituent groups in a myriad of policy related questions and will offer specific and tangible improvements and information that will empower local, regional, state, and federal decision makers toward a more sustainable future for the state of Maryland.
Cloud Computing

- Users run models through web services
- Model inputs are automatically organized, documented, and reviewable
- Long running models executed “in the cloud”
  - As opposed to embedded models
- Planning Portal allows for immediate review
McHenry County Planning Scenarios

Scenarios

Maps and data of the results of each simulation scenarios analysis.

- **Reference**
  The reference scenario illustrates the land use changes expected if current policies continue unchanged to 2030.

- **ETI (1.5mi)**
  The Extra-Territorial Jurisdiction scenario illustrates potential development patterns resulting from limiting new growth to within a one-and-a-half mile ETI buffer around municipalities.

- **Green Infrastructure**
  The green infrastructure scenario limits development in areas as defined by the Chicago Wilderness Green Infrastructure Vision plan and by the Illinois Department of Natural Resources Natural History Survey Green Infrastructure methodology.

- **Ag Pres Dist**
  Agricultural Preservation Districts are derived from National Resources Conservation Service (NRCS)’s STATSGO soil and designated as no-growth areas.

- **40 Acre Ag Zoning**
  This scenario limits development to 40-acre blocks in areas identified as prime agricultural lands (as defined in Ag Districts scenario). Once any cell within a 40-acre block is developed, that block is closed to further development.

- **Compact Contiguous Growth**
  This strategy examines the use of dynamic boundaries as a means of guiding development in McHenry County and encouraging compact and contiguous growth. The boundaries are used to encourage compact and contiguous growth by requiring development to occur within a defined area before other vacant or developable areas in the County. Areas inside the boundary are made more attractive for urban development while restricting development outside of the boundary.

- **Groundwater Protection**
  In this scenario a mask of groundwater recharge areas based on permeability, class III groundwater recharge areas and potential for aquifer contamination is created; the undeveloped areas are designated as no-growth.

- **Short-term Transportation Projects**
  This scenario projects the changes in development patterns resulting from short term road projects (those being completed by 2012) identified in the McHenry County 2020 Long Range Transportation plan.

- **Finacially Const Trans Projects**
  This scenario projects the changes in development patterns resulting from road projects identified as ‘fiscally constrained’ in the McHenry County 2020 Long...
Scenario Details

Details

Reference Scenario

Development occurs in the reference scenario unimpeded by policy interventions other than those already in place at the beginning of the analysis. Therefore, this simulation represents a baseline for potential future development patterns in the County to the year 2030. This 'business as usual' simulation will be used for comparison to each policy or investment scenario tested. Maps showing growth and stress resulting from business-as-usual can be viewed interactively or downloaded as JPEGs or shapefiles.

Data tables and graphs describing this scenario can be viewed here Reference LUCA.

Spatial Data Maps

Existing Development Map

The existing land use layer was derived from 2001 NLCD landcover data, digitally updated from 2005 Digital Ortho-Quadrangles (DOQs) from the ISCS and land use parcel data.

Reference Change Map

The reference change map shows expected growth resulting from a continuation of current trends and policies. It is based on population and employment projections as well as attractor values of the updated County road network and existing development and land cover in 2005.

Reference Summary Map

The reference summary map shows growth over time in five year intervals, from 2005 to 2030. Like the reference change map, it is based on population and employment projections as well as attractor values of the updated County road network and existing development and land cover in 2005.

Urban Open Space Map

As identified by 2001 NLCD landcover data.

Forest Map

As identified by 2001 NLCD landcover data.

Water Map

As identified by 2001 NLCD landcover data.

ETJ Mask

Extra Territorial Jurisdictions. A map describing the 1.5 mile buffer surrounding County Municipalities.

Scenario Stress Maps

Stress Analysis assesses potential urban land use development stresses on critically identified resource areas.
Summary Maps

Map Info in Detail
Map Info in (More) Detail
Scenario Comparisons
Policy Analysis
Impact Analysis

Impact analyses add value to McHenry County LEAM simulation results by revealing the potential impacts that future growth may have on County assets.

- **Land Use Change Analysis** — by admin — last modified Jan 23, 2009 11:00 AM
  The Land Use Change Analysis provides residential, household, commercial and agricultural land use change data by township in table and graph form.

- **Stress Analyses** — by admin — last modified Apr 21, 2009 02:27 PM
  Stress Analysis assesses potential urban land use development stresses on critically identified resource areas.

- **LEAMwoq — Water Quality Analysis** — by admin — last modified Jan 27, 2009 04:50 PM
  LEAMwoq assesses the potential impacts of land use changes on surface water runoff and NPS pollutant loading, using LEAM output and the Long-Term Hydrologic Impact Assessment (L-THA) model.

- **Water Demand** — by admin — last modified Jan 23, 2009 11:00 AM
  The Water Demand analysis attempts to estimate the changes in potable water use for each of the policy scenarios tested.

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Scenario Planning
Projected Development with Groundwater Protection
Stress Analysis
Integrated System of Plans (ISoP)

Why recreate what's already been made?

First Street has a number of existing plans that were developed to promote and guide the area's future growth. These plans include:

- City of Champaign Master Plan
- City of Champaign Downtown Plan
- City of Champaign Transit Plan
- Champaign County Comprehensive Plan
- Champaign County Land Use Plan

These plans are integrated into the ISoP system to provide a comprehensive view of the area's future growth.
Next Next Generation

• Sentient systems
• A sentient planning system is a decision support environment that has an evolving self-awareness about its basic data, models that process this data, and the subsequent information sets produced.
  - It knows me
  - It knows where I am
  - What device I am using
  - How I look at things
Managing Integration

Distributed Management Approach
Loosely Coupled Models
Tightly Coupled Models
• Managing multiple models

  - Transportation – tightly coupled
  - Water quality – 1st order embedded
  - Water quality and quantity – coupled
  - Socio-economic implications – coupled
  - Green infrastructure
    • Ecosystems services – loosely coupled
  - Others
    • Depending on project
      - Ex. Rural development implications in Korea...
      - Climate models
Model Coupling

Population
Households
Employee's
Employers
School Enrollment...

Network
Travel Times
Congestion
Accessability...

LEAM

Northeastern Illinois Region
2030 Landuse Change Business as Usual

CMAP

CMAP Master Network
2007 Congested Travel Speed 7-9 a.m.

SPEED (mph)

- Less Than 15
- 15 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- Greater Than 80

Illinois
Network Differences

LEAM (TIGER Line)

CMAP Master Network
CMAP Network Speed Differences

CMAP Network Posted Speeds

CMAP Master Network
Posted Speeds

SPEED (mph)
- slower than 15
- 15 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- faster than 60

CMAP Network Congested Speeds (7-9 AM)

CMAP Master Network
2007 Congested Travel Speed 7-9 a.m.

SPEED (mph)
- slower than 15
- 15 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- faster than 60
CMAP Posted Speeds
2035 LEAM Projection

Projection Result. using CMAP Posted Speeds

Projection Comparison. LEAM baseline with no redevelopment vs. CMAP posted speeds
CMAP Congested Speeds
2035 LEAM Projection

Projection Result. CMAP congested speeds

Projection Comparison. LEAM baseline with redevelopment vs. CMAP congested speeds
Drivers: Regional Economics

- Regional economy captured in a two-part model
  - An input-output model
  - Tied to national econometric models
  - Forecast change over time by sector
Spatial Allocation
Frequency Calculations

- City accessibility
- Existing development
- City accessibility score map
- Residential frequency -- Cities Attractor
- Existing development relative to accessibility
Probability Surface
Nearest Neighbor Driver

dynamic cell drivers

- Works on the principle of adjacency
  - Existing urbanized cells embody access to utility infrastructure and are easier and cheaper to develop.

\[
N_{pr,i} = \frac{1}{8} \sum_{j=1}^{8} (N_{pr} + \sigma_j)
\]

- The determination of the at any given time step for any given cell requires a summation of the neighboring cell characteristics with a spread coefficient \( \sigma_j \) over the total surrounding cells.
Random Number Generator

Development Score

0 1

Residential  | Commercial  | No Change

0 1

Commercial

Residential

No Change
Calculate Congested Speed

Detail of the CMAP master network with congested speeds

Calculate congested speed using travel minute and node length in CMAP output
Create Travel Speed Zone

- Travel Speed Zone can be conceptualized as a vehicle shed, much like a watershed
  - Referring to the area from which the majority of trips originate for that segment
- Each network segment has its own zone with information about the link speed
Project CMAP TDM Speeds to LEAM network

- Superimpose LEAM network to Travel Speed Zone
- Project the linked speed information to the LEAM geo-referenced network
New Simulation Network Congested Speeds

- LEAM network with projected congested speeds for creating LEAM cost surface map
- Some link speeds exceed posted speeds
  - Posted speeds are used as limits
TGZ Estimation

Discrepancy between Census data boundaries and TGZ boundary.
TGZ Estimation – Base Year

Logic of the Estimation
- Based on the location of the developed cells
- Assuming that each cell represents a particular demographic or economic attribute
- Based on its census block membership

Developed Cells
TGZ Estimation – Projected

The same logic is applied to the newly developed cells as well, with the consideration of few qualitative changes such as overall household density declines.