When GIS meets LUTI: Enhanced version of the MARS simulation model through local accessibility coefficients

M. H. Salas-Olmedo, Y. Wang, A. Alonso, A. Monzón, J.C. García-Palomares
Accessibility: Desired vs. Actual system

- Jobs
- Population
- Land use
- Transport
- Nature
- Services
- Health issues
The effect of the economic crisis on Madrid’s land use and transport system
The tool - MARS model

MARS is the product of 5th framework research project **PROSPECTS**. The main designer is **P. C. Pfaffenbichler (2003)**.

MARS model is constructed in a dynamical system software known as **VENSIM®**.

- Sketch planning model (SPM)
- System Dynamic (SD)
- Causal loop diagrams (CLD)
- Spatial aggregation
- Long term assessment
- Optimisation
MARS model - Framework

External Scenario
- Demographic transition and economic
- Mobility data

Policy Measures
- Land use measures
- Transport measures

Transport Sub-model
- Trip generation
- Trip distribution and modal split

Land use Sub-model
- Household location model
- Workplace location model

Relocation
- Accessibility

Assessment
- Cost-benefit analysis
- Multi-criteria analysis

Input

Calibration

Output
Accessibility definition

Figure 9. Simplified Causal Loop Diagram of accessibility indicators in the MARS model

Accessibility re-definition

**General local potential accessibility indicator:**

\[
GACC_j(t) = \sum_t \sum_m \left( a_j \cdot W_{jm}(t) \cdot F(t_{ijm}, c_{ijm})_{work} + b_j \cdot Edu_{jm}(t) \cdot F(t_{ijm}, c_{ijm})_{edu} + c_j \cdot Hea_{jm}(t) \cdot F(t_{ijm}, c_{ijm})_{health} + d_j \cdot Park_{jm}(t) \cdot F(t_{ijm}, c_{ijm})_{park} + e_j \cdot Shop_{jm}(t) \cdot F(t_{ijm}, c_{ijm})_{shop} \right)
\]

Where:

- \( W_{jm}(t) \) is the number of jobs in the destination zone \( j \) by mode \( m \) in year \( t \);
- \( Edu_{jm}(t) \) is the number of schools in the destination zone \( j \) by mode \( m \) in year \( t \);
- \( Hea_{jm}(t) \) is the number of hospitals and health centers in the destination zone \( j \) by mode \( m \) in year \( t \);
- \( Park_{jm}(t) \) is the number of parks in the destination zone \( j \) by mode \( m \) in year \( t \);
- \( Shop_{jm}(t) \) is the number of shops in the destination zone \( j \) by mode \( m \) in year \( t \),
- \( F(t_{ijm}, c_{ijm})_x \) is the generalized cost to reach jobs or the respective public service.

\( a_j, b_j, c_j, d_j, e_j \): coefficients for zone \( j \), weighting the importance of accessibility to each activity, the sum of them equals to 1.
Local coefficient estimation | Geographically Weighted Regression (GWR)

Our final GWR model after the variable selection process is:

\[ P = \beta_0(u) + \beta_1(u)W + \beta_2(u)E + \beta_3(u)R + \epsilon \]

Where \( P \) is population

\( W \) is number of workplace centres

\( E \) is number of education centres

\( R \) is the number of retail shops.

The general formula for GWR (one predictor variable) is set in equation 2 and subsequent (Fotheringham et al., 2002):

\[ Y = \beta_0(u) + \beta_1(u)X + \epsilon, \]

where \( u \) are the geographical coordinates and \( \beta(u) = (\beta_0(u), \beta_1(u)) \) is the regression coefficient at the idd location \( (u) \)

The vector of parameters \( \beta(u) \) is estimated by \( \hat{\beta}(u) = CY \), where:

\[ C = (X^TW(u)X)^{-1}X^TW(u), \]

where \( W(u) \) is an \( n \times n \) diagonal matrix whose diagonal elements denotes the geographical weighting of each of the \( n \) observed data for the regression point at location \( (u) \).
Local coefficients
Results: global v. local accessibility in the MARS model

Figure 3. Comparison of Nº of workplaces using new and old accessibility indicator.

Figure 4. Comparison of Nº of Residents using new and old accessibility indicator.
Conclusions

- Three single accessibility indicators have been combined using the estimated weights and integrated into transport and land use sub-model of MARS respectively. The new indicator includes the accessibility to jobs, schools and shops.

- The analysis evidences the convenience of GIS and LUTI combination to improve model accuracy and precision. Using the new accessibility indicator based on local coefficients, MARS model fits better with the real data in respect of the number of workplaces and residents, which are the key representatives of the land use sub-model.

- The general accessibility indicator combining the accessibility to jobs as well as to other public services complements the MARS model that now includes the public service choice.

- At the same time, calculating the weights of different public services in different urban areas is important in order to identify potential people preference that can contribute to the manifestation of public services imbalances.

- This innovation is useful for other LUTI model to improve their accessibility definition in order to better relate to the interaction between the two systems.

- This research is also one of the first outcomes to integrate the knowledge of geographers and transport planners. The work provides a new viewpoint for transport and urban planners for further cooperation.
Thanks for your attention!

When GIS meets LUTI: Enhanced version of the MARS simulation model through local accessibility coefficients

M. H. Salas-Olmedo, Y. Wang, A. Alonso, A. Monzón, J.C. García-Palomares

tGIS | Transport, Infrastructure & Territory
Faculty of Geography and History
Universidad Complutense Madrid
msalas01@ucm.es

TRANSyT | The transport Research Centre
School of Civil Engineering
Universidad Politécnica Madrid
yang.wang@upm.es