Urban Informatics for Sustainable Growth

By Eric J. Miller, Judy Farvolden, Sara Diamond & Mark Fox

The *iCity* research platform is the creation of a team of multidisciplinary researchers, including transportation engineers, urban planners, computer scientists and experts in digital media. It supports an ambitious research program, combining an emerging new "science of cities" with informatics and visualization. The *iCity* platform will provide improved tools for policy analysis and decision-support with respect to the transportation infrastructure investment required if our cities are to meet current and future demands.

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Some researchers in the emerging new city science believe big data, coupled with the tools of mathematics and computer science, will lead to a new theory of cities and a roadmap to optimal efficiency and productivity. By contrast, *iCity* researchers see cities as enormously complicated "systems of systems"—Jane Jacobs' famous "problems in organized complexity" (Jacobs, 1961). We believe mathematical models of this complexity are useful but they must be applied in the context of the knowledge evolved by urban planners over the past decades.

In this context, models help us to analyze how the design of any one component of the urban system, such as transportation, affects the urban system and all the other components with which it interacts: housing, the regional economy, etc. These systems, in turn have feedback effects on transportation demand. For example, shifts in population affect travel demand and transportation system performance.

The goal of *iCity* research is to provide improved tools, based on integrated models and analytics, which will enable policy experts to navigate this complexity with "what-if" analyses that untangle the intricate webs of cause-and-effect within our urban regions. This will help decision-makers understand the benefits and costs of alternative policies, particularly with respect to the infrastructure investment required if our cities are to meet current and future demands.

Informatics involves information processing, the acquisition, storage, management, curation, and analysis of data. A key aspect of iCity is the integration of datasets from numerous sources, including big data—the new, massive datasets gathered via smartphones, smartcards, and ever more ubiquitous sensor networks. Pervasive connectivity across social systems, allowing people to share their experiences in almost real time, and real-time sensor observations from the physical world are exponentially increasing, creating unprecedented opportunities for innovation.

This raises the problem of ensuring "semantic interoperability," that is that different models and analytics exchange data with unambiguous, shared meaning. Computer scientists address this with ontologies, models that describe the world in terms of types, properties and relationships among entities, ideas and events, with fixed vocabulary and definitions. A core component of *iCity* is the development of a transportation ontology that spans and integrates the many, many types of transportation data.

Visualization enables us to recognize patterns in these numerous and massive datasets and to understand the intermediate and final solutions produced by the integrated models and analytics. Most importantly, visualization of the "what-if" outcomes will communicate model results and policy analyses to the public and decision makers in understandable, compelling and impactful ways, thereby effecting a profound improvement in public policy making. Innovative visualization tools used to engage with citizens will improve governance and citizens' satisfaction. Integrated dash boards, combined with two and three-dimensional modelling can provide tools for planners, while visualization apps can support residents and travellers.

The ICIty approach

Taken together, *iCity* provides a computational virtual lab for analysis and design in which powerful, comprehensive computer models simulate the evolution of urban spatial socio-economic systems (transportation, the regional economy, etc.) in response to a wide variety of scenarios and policies. Combined

with equally advanced visualization capabilities, it provides the analytical environment needed to develop and test:

Practical solutions to specific problems that begin with the current metropolis and recognize that getting to a more resilient and sustainable place requires finding feasible pathways into the future.

A rich suite of performance measures, detailed benefit/cost distributions, etc., for comprehensively understanding the impacts of alternative policies.

Compelling, readily transmittable stories demonstrating the feasibility and efficacy of the solutions developed: why they are better than the status quo and how they can feasibly be realized.

Multidisciplinary teams performing the analyses ensure they are behaviourally sound and policy sensitive and that the designs tested are comprehensive and impactful.

The *iCity* platform is extendable to other urban systems (such as public health, water and waste systems) but the initial focus is on the modelling and design of urban transportation systems and closely-linked questions of urban-physical design.

Timeliness & relevance

Ontario's economic, environmental and social sustainability is intertwined with the design and functioning of our cities. It is not an exaggeration to say that Ontario has reached a near-crisis with respect to its transportation systems. The economy is already losing billions annually to the costs of congestion, which is experienced by people trapped in traffic and industries moving goods to market. And yet, our cities must grow to accommodate the rapid population expansion of the Greater Golden Horseshoe, Ontario's economic heartland. Transportation infrastructure investment on a large scale is required to support this growth if our urban regions are to remain productive and provide residents with a high quality of life

Moving Ontario Forward, the Province of Ontario's plan to implement the largest infrastructure program in Ontario's history, is an important opportunity to enhance Ontario's prosperity and quality of life. In its investment decisions, Ontario is committed to being guided by evidence-based, strategic planning. The evidence will be the result of research and analysis that demonstrate the impacts of investments on jobs and prosperity, as well as consideration of environmental protection and social benefits. Investments in public transit and transportation are among the priorities of this plan.

The *iCity* work is therefore timely and relevant. The holistic, comprehensive approach to urban system design, as envisioned by the *iCity* program, will support the Government of Ontario's stated need for evidence-based decision making. Our ability to collect and analyze data on every aspect of urban life has never been greater, and the analytical power of modern high performance computers to discover new patterns and connections within these data offers boundless potential for understanding the complex dynamics of modern cities. While many groups worldwide are exploring big data opportunities, the *iCity* program is unique in its focus to merge these promising new datasets with cutting-edge simulation modelling, and the urban systems simulation models developed by *iCity* researchers are among the most advanced globally. System planners, designers and policy experts seeking advice on appropriate transportation infrastructure investments can use the what-if analyses to visualize and understand the impacts of candidate transportation infrastructure investments. The combination of advanced modelling methods, promising new big datasets, and sound strengths in urban design and economic analysis hold the promise to significantly improve urban transportation planning in Ontario and elsewhere.

The *iCity* program represents a critical contribution to growing Ontario's "urban informatics" industry. This is an emerging multi-billion dollar industry in which we have the skills and capabilities to be leaders.

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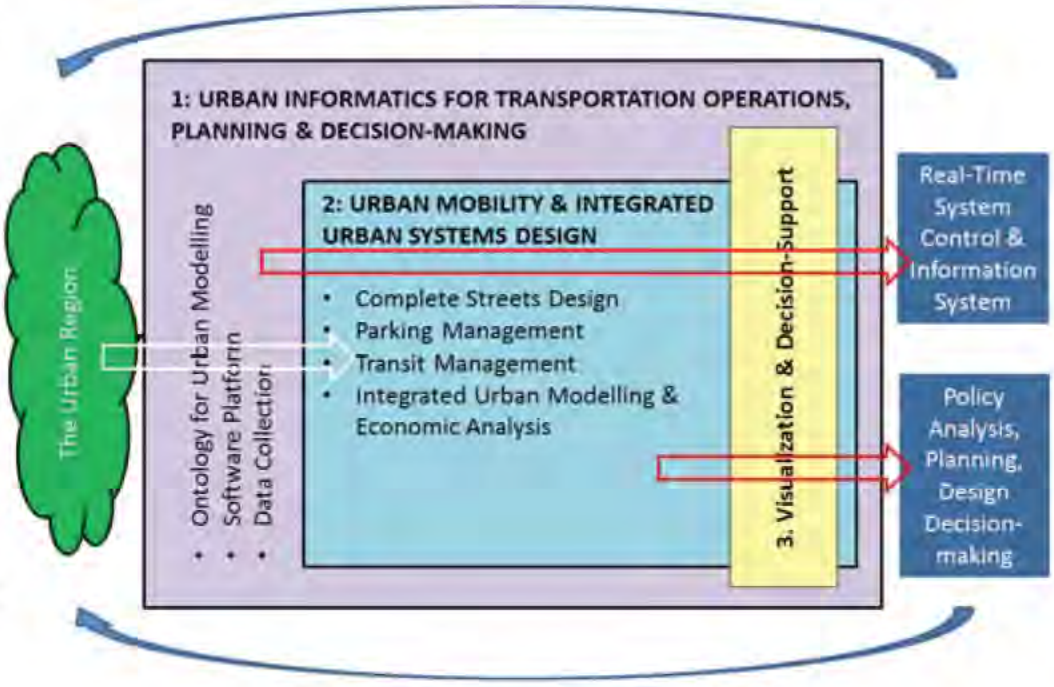

Integration of iCity research themes IMAGE COURTESY OF THE AUTHORS