2017 Canadian Consulting Engineering Awards
Category F | Special Projects

Development of a Strategic Accessibility Toolkit

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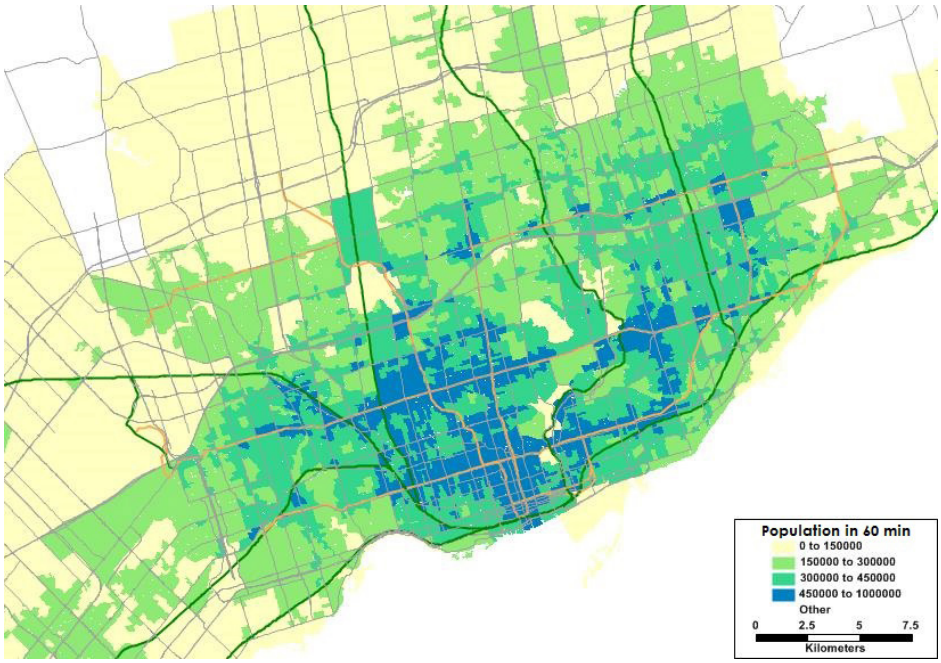
ARUP



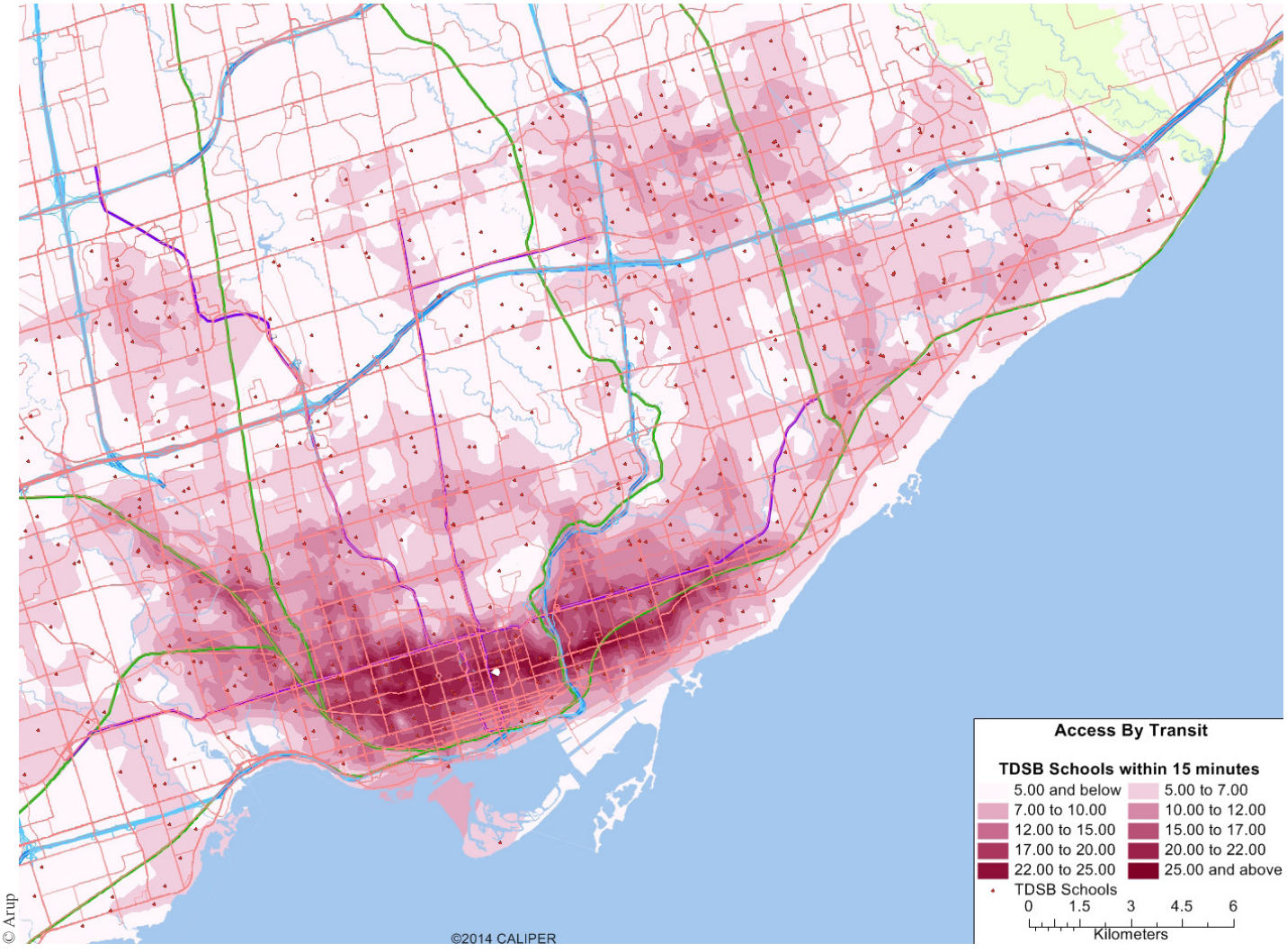
Contents

Project Information

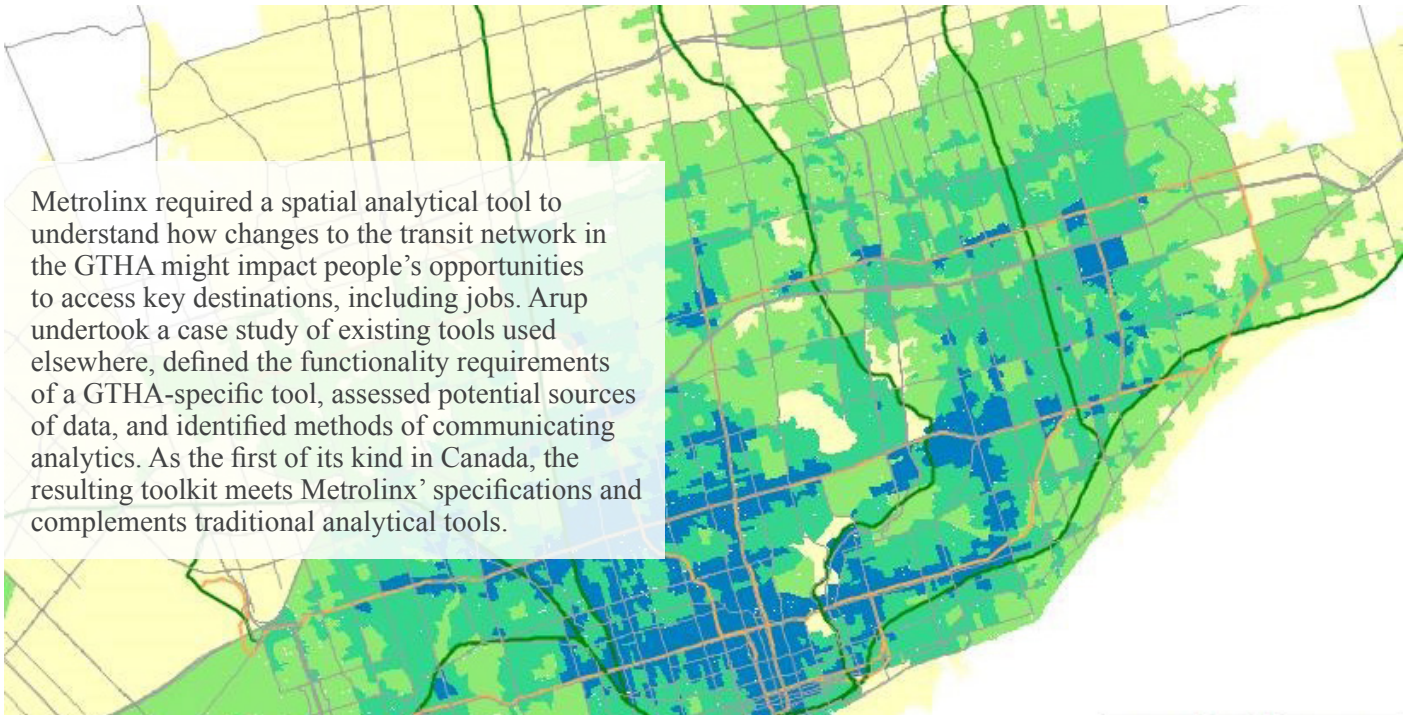
Project Name	Development of a Strategic Accessibility Toolkit
Project Location	Toronto, Ontario
Project Size	N/A
Year Completed	2016
Entering Firm	Arup
Project Partners	Metrolinx

Arup Contacts

Project Manger: Rishi Lukka | 647 462 1167 | rishi.lukka@arup.com
Project Director: Ryan Falconer | 647 260 3495 | ryan.falconer@arup.com
Marketing Contact: Graziela Palma | 416 646 5375 | graziela.palma@arup.com



Project Summary



Metrolinx required a spatial analytical tool to understand how changes to the transit network in the GTHA might impact people's opportunities to access key destinations, including jobs. Arup undertook a case study of existing tools used elsewhere, defined the functionality requirements of a GTHA-specific tool, assessed potential sources of data, and identified methods of communicating analytics. As the first of its kind in Canada, the resulting toolkit meets Metrolinx' specifications and complements traditional analytical tools.

Complexity

The concept for the toolkit resulted from this process: it would be composed of two main components, a 'transit network builder', which is used to import publicly available General Transit Feed Specification (GTFS) files and to aid in the creation of future year networks; and a 'transit accessibility calculator' which enables the user to estimate statistics regarding transit coverage and connectivity between sets of points:

- Transit Network Builder: Used to automate the manual tasks required to build a transit network from GTFS format files. This involves importing a number of files, combining them, extracting specific information (service frequencies, speeds, etc.), undertaking basic quality checks (e.g. ensuring that there are no abnormal speeds, excessively long or short routes, etc.) and generating a summary report of the process.
- Transit Accessibility Calculator: Component of the tool that calculates, for a set of user defined points, two metrics:
  - Access to transit. A score that represents transit service density taking into account the proximity of stops and the frequency of transit service.
  - Access to destinations. Estimates travel times on the network and calculates the number of destinations that are accessible from each origin.

GTFS data import tools exist in various software packages, including TransCAD. However, the majority of these tools can only process one agency at a time and the combination of agencies can involve a significant amount of time. In the GTHA, for example, there are ten separate transit operators, each generating its own GTFS file. To be able to overcome this, the Transit Network Builder developed by Arup as part of the Toolkit can import and combine up to 15 GTFS files, extracting routes, stopping patterns, travel times and service frequencies for six predefined time periods and up to three user-defined time periods.

Innovations

"I want to thank you and your team for all your hard work undertaking the accessibility modelling which allowed us to shed light on the possibilities of new solutions and made the benefits of the optimized plan clear for all to see." Hilary Holden, Director of Transit & Sustainable Transportation City of Toronto

The toolkit was developed as an add-in for the TransCAD transportation planning software, which includes many network processing facilities as well as a powerful GIS engine. The software can also integrate well with Microsoft applications.

The toolkit takes advantage of the GTFS standard which is quickly becoming a universal format for electronic time tables. This standard was originally developed by Portland's TriMet and is now used by Google as the common format for transit schedule sharing with service providers – the transit information available in Google Maps that allows users to find routes between points is provided to Google by transit agencies as GTFS files.

Access to Transit, is a score that represents the level of transit service available. This is based on walking distance to transit stops as well as the wait time for transit vehicles (frequency of service). The results are two numbers for each origin point: the first is an Accessibility Index (AI), which represents the equivalent doorstop frequency of transit service at a point, with a high AI representing a frequent, nearby transit service. There is no upper limit to this number. The second result translates the AI index into a score between 1 and 10, based on a logarithmic scale, with the maximum score of 10 defined by the user. For the evaluation of interventions, Metrolinx has defined what the score of 10 represents in order to obtain consistent results when comparing various alternatives.

Access to Destinations, uses the travel cost on the network to calculate how many destinations are accessible from each origin as well as the sum of a destination-based variable (e.g. number of beds at hospitals or jobs by zone) chosen by the user. The travel time includes walk time, wait time, and transfers. The origins and destinations are specified by the user. For each origin, two results relating to the accessibility to destinations are calculated:

- The first is a count total number of destinations accessible within a given maximum travel cost – this is known as a 'cumulative' calculation;
- the second is an estimate of the number of destinations in which each destination point is weighted based on its distance for them origin point using distance decay function, which in the toolkit can be selected from a linear, inverse power and inverse exponential – this is known as a 'gravity-based' calculation.

In addition to the count of features metric that the Access to Destinations generates, it also sums a variable related to each of the features, and applies the gravity-based weighting factor to it. This variable can be any numerical attribute of the destination and can be used to, for example, estimate the number of jobs available within 30 minutes by transit of a set of origin points, which could represent people's residences, for instance.

The travel costs in the calculation can be estimated as one of the following:

- Elapsed time – this is the actual time estimated based on walk distances and transit wait and in-vehicle times
- Generalized time – this is estimated using the elapsed times, with each component (walk, wait, in-vehicle) being weighted to represent users' perceptions of each of these and can include a penalty to represent people's dislike of transfers
- Generalized cost – similar to generalized time, but including the fare in addition to time
- Fare only

In addition to the final metrics of the Access to Transit and Access to Destinations (i.e. a score, count of features and sum of a variable), the toolkit generates a large amount of intermediate tables that can be used to complement the analyses. Information regarding each component of the travel time and fares are generated for every origin-destination pair, which combined with the final results provides a comprehensive set of results that can be used to generate contour layers which can be overlaid with census information to analyze the impacts of transit interventions in relation to socioeconomic characteristics of the population.

The Accessibility Toolkit builds on best practice from around the world, but is the first of its kind in Canada. Throughout the stages of development of the Toolkit various members of Arup and Metrolinx staff were involved, helping solve technical challenges that arose. The team involved Arup transportation planners based in Toronto with international (Canada, UK, Australia) experience on GIS, accessibility modelling, demand modelling and automation.

The use of publicly available datasets in combination with the use of a proven engine and simple, yet powerful outputs, makes the Toolkit a very valuable asset for the region that has the possibility of being enhanced to include more sophisticated analyses that may include items such as the consideration of service reliability and differential appreciation of accessibility by person types.

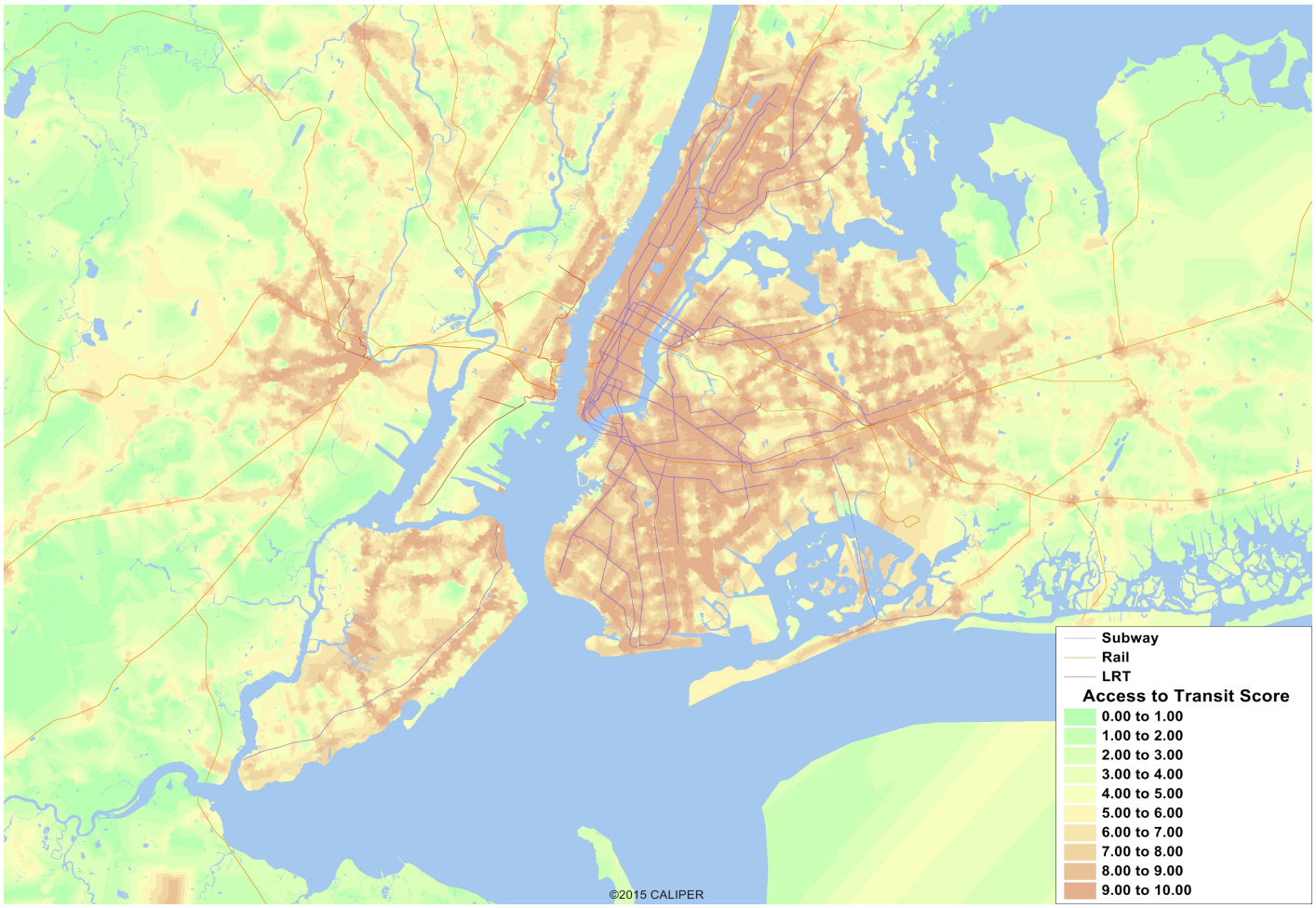
Social and/ or Economic Benefits

The toolkit allows planners to understand the impact of changes in transportation networks on opportunities to travel and helps generate statistics that can be used to support evidence-based decision making processes. It complements other tools, such as traditional demand forecasting models, providing an additional layer of information at a higher level of detail.

The application of the toolkit has had an important, positive impact on Metrolinx and the City of Toronto's City Planning teams, which are now using accessibility metrics and analyses as keys components of their project evaluation and consultation processes. Additionally, the toolkit is available to be used by all planning agencies in the GTHA.

In particular, the objective data that the toolkit yields enables more transparent and reliable monetisation of value of transit projects, and comparison of different transit investment options. This is a key input to business case assessments. Extensions to the basic toolkit – such as differential analyses based on target population (defined, perhaps, by socio-economic variables) – will allow for assessment of social equity impacts of transit investment proposals, a major focus for government in Ontario.

Furthermore, the data generated by the toolkit can be applied further to forecast possible changes to land use and travel behaviour that result from transit projects. This facilitates a more comprehensive economic and social impact assessment than enabled by traditional, trip-based transportation model packages.



Access to Transit Score in the New York Metropolitan Area (green = low, brown = high)©Arup

Environmental Benefits

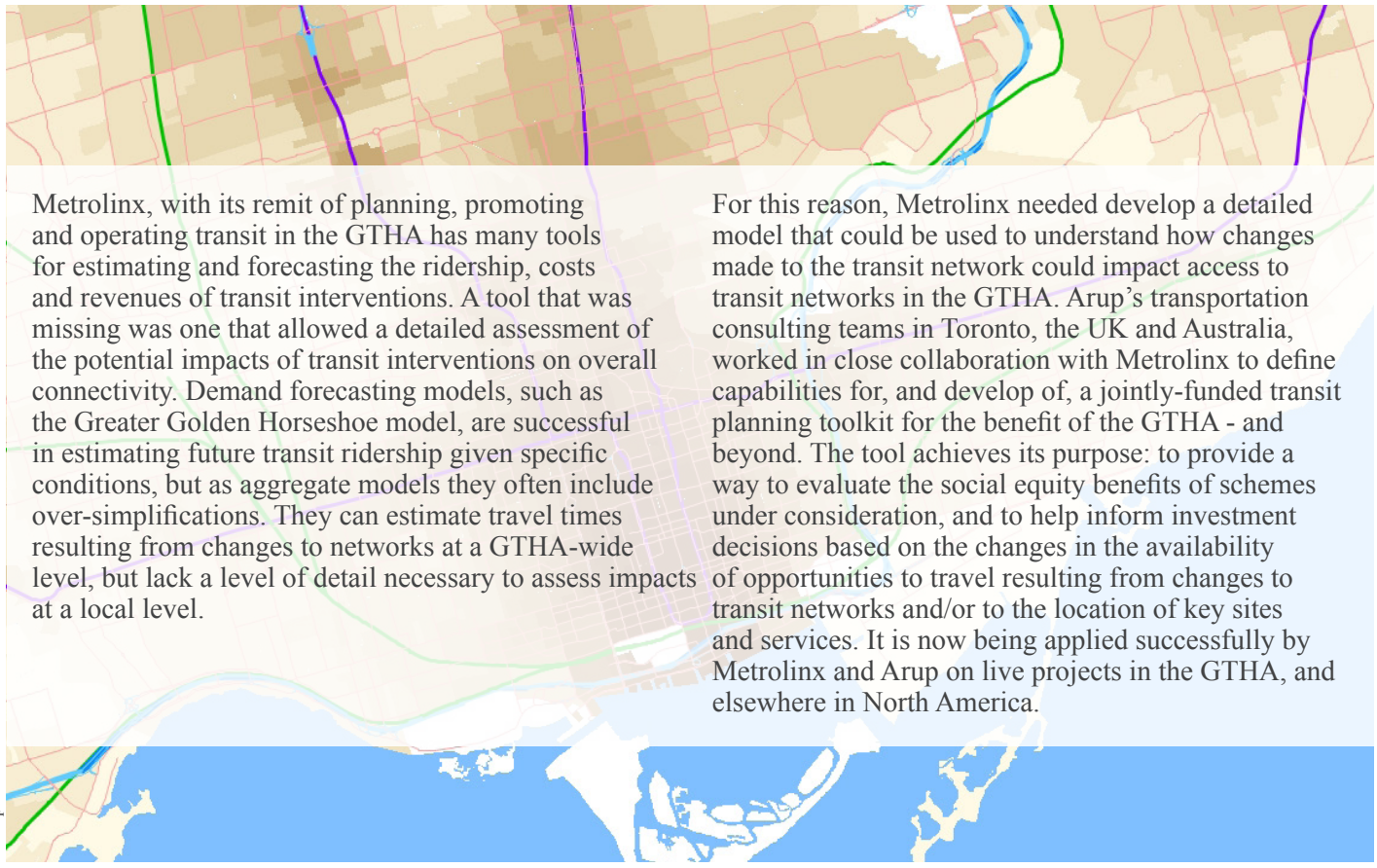
The Accessibility Toolkit allows planners to better understand the likely impacts of changes to the transit system, location of facilities and changes in land use on users. This enables more informed decision-making and better understandings of projects that can yield the best value-for-money, depending on policy priorities.

Analyses using the toolkit can be calibrated to focus on socio-economic variables (see 3). These have inferred environmental benefits as well, as improved accessibility via the transit network can reduce the use and impacts of private vehicles, lowering greenhouse gas emissions, energy consumption and traffic accident risks. By implication, reduced reliance on and use of private vehicles can reduce demands on transportation infrastructure, which lessens impacts on natural habitats.

More directly, application of the tool as part of a comprehensive urban growth and network planning process allows the value of transit projects to be evaluated against alternative options – such as highway projects – which can mean a more environmentally-responsible and sustainable infrastructure investment pipelines for government.

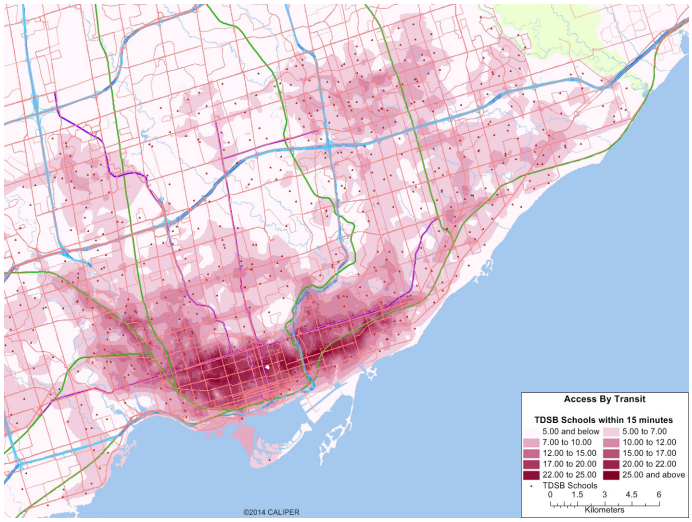
In the present political climate, there is emphasis on evidence-based decision-making. The toolkit makes a key contribution and significantly, allows generation of data that can be compared back to explicit policy requirements, such as Feeling Congested? criteria published by the City of Toronto and Metrolinx's Regional Transportation Plan.

Meeting Client's Needs

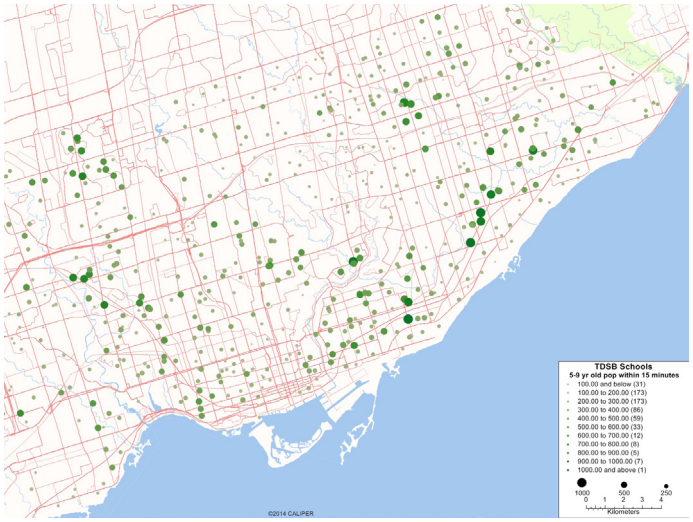


Metrolinx, with its remit of planning, promoting and operating transit in the GTHA has many tools for estimating and forecasting the ridership, costs and revenues of transit interventions. A tool that was missing was one that allowed a detailed assessment of the potential impacts of transit interventions on overall connectivity. Demand forecasting models, such as the Greater Golden Horseshoe model, are successful in estimating future transit ridership given specific conditions, but as aggregate models they often include over-simplifications. They can estimate travel times resulting from changes to networks at a GTHA-wide level, but lack a level of detail necessary to assess impacts at a local level.

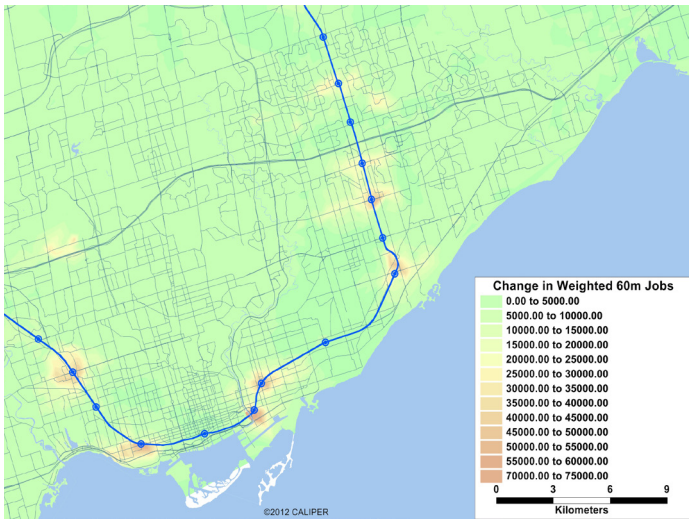
For this reason, Metrolinx needed develop a detailed model that could be used to understand how changes made to the transit network could impact access to transit networks in the GTHA. Arup's transportation consulting teams in Toronto, the UK and Australia, worked in close collaboration with Metrolinx to define capabilities for, and develop of, a jointly-funded transit planning toolkit for the benefit of the GTHA - and beyond. The tool achieves its purpose: to provide a way to evaluate the social equity benefits of schemes under consideration, and to help inform investment decisions based on the changes in the availability of opportunities to travel resulting from changes to transit networks and/or to the location of key sites and services. It is now being applied successfully by Metrolinx and Arup on live projects in the GTHA, and elsewhere in North America.



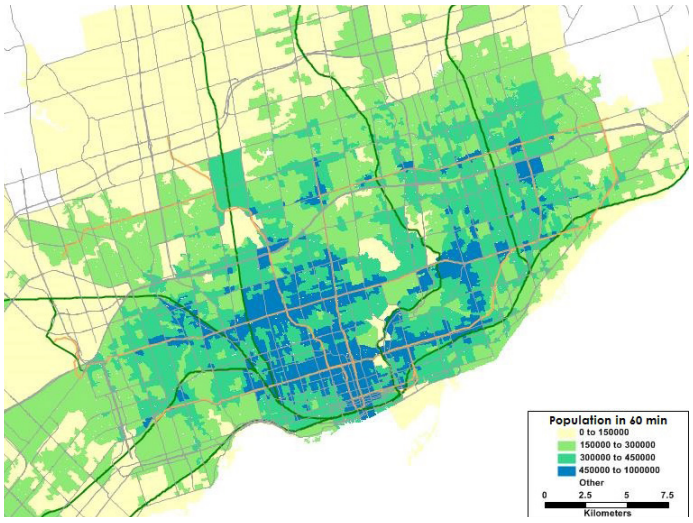
Access to Destinations Example – Number of Toronto District School Board elementary schools within 15 minutes of transit travel time of any point in Toronto ©Arup



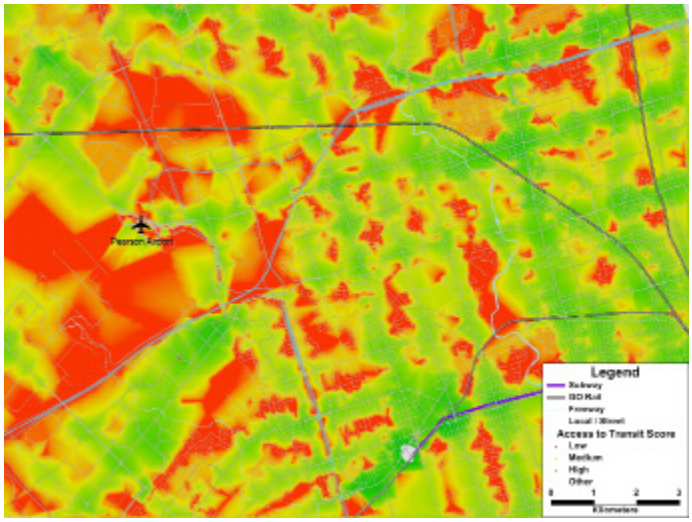
Access to Destinations Example – Number of 5-9 year old children within 15 minutes of transit travel time of Toronto District School Board elementary ©Arup



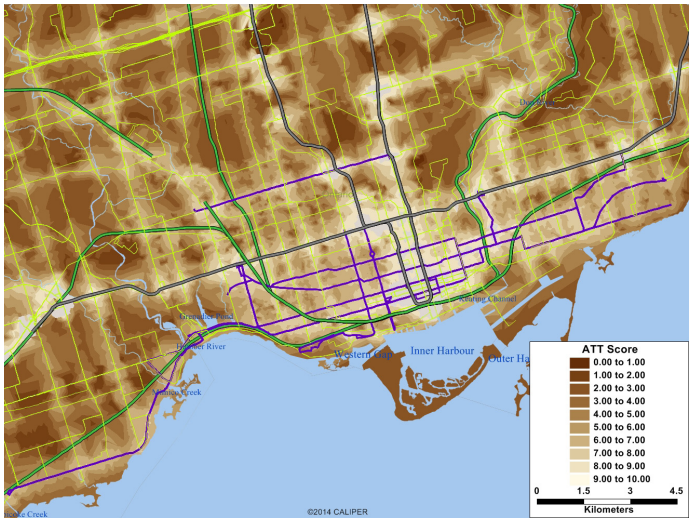
Access to Destinations Example – Change in the number of jobs within 60 minutes of any point in the GTA, between two hypothetical transit network scenarios ©Arup



Access to Destinations Example – Total population with 60 minutes of transit travel time of Census Dissemination Areas in the Greater Toronto Area ©Arup

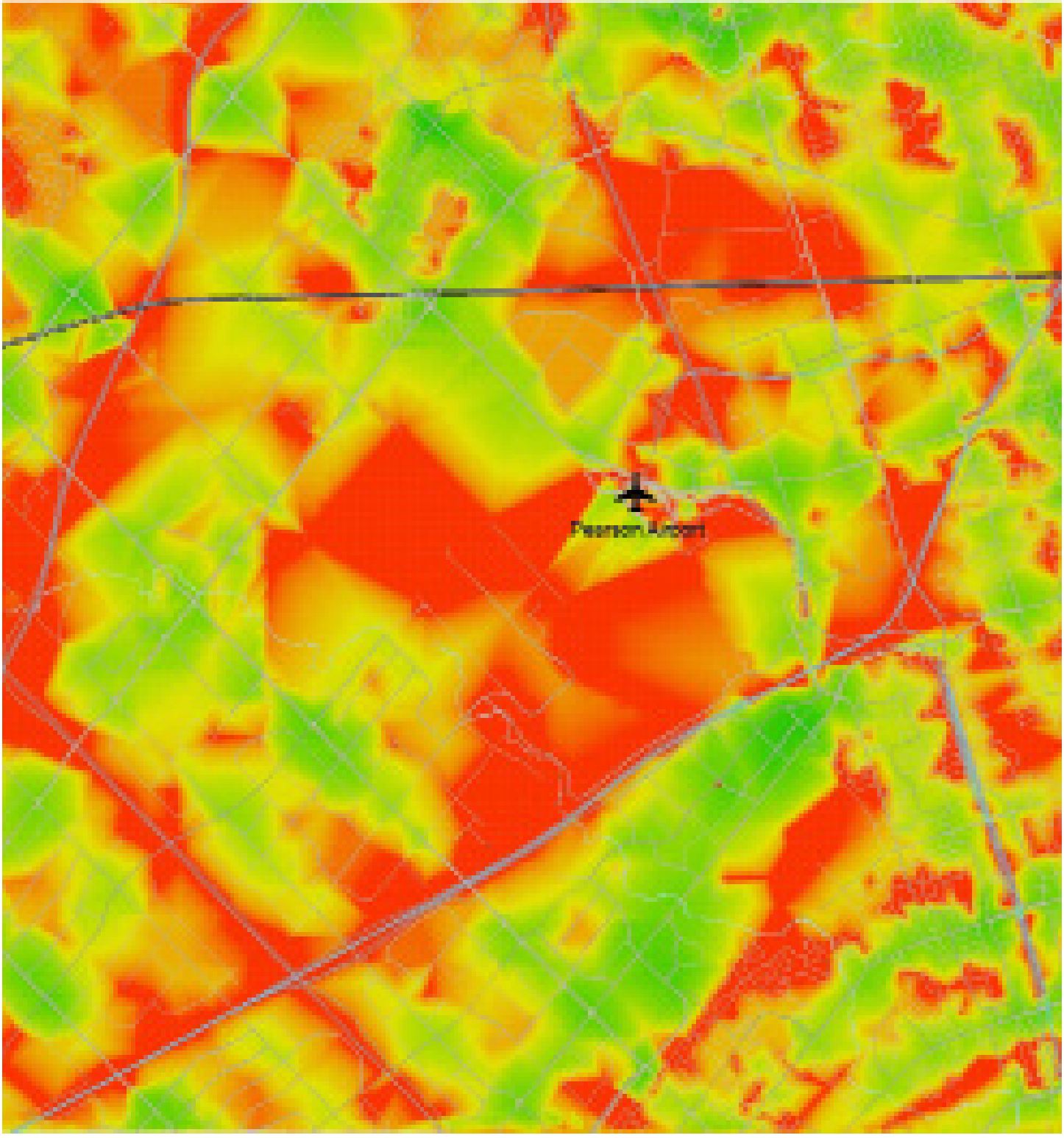


Access to Transit Score in the area around Pearson International Airport (red = low, green = high)©Arup



Access to Transit Score in the City of Toronto (Brown = low, white = high)©Arup

Front Cover/ Access to Transit Score in the New York Metropolitan Area ©Arup
Back Cover/ Access to Transit Score Pearson International Airport ©Arup



Graziela Palma (Marketing Contact)
T + 1 416 646 5375
E graziela.palma@arup.com

Rishi Lukka
T +1 647.462.1167
E rishi.lukka@arup.com

ARUP