MODELLING NETWORK RESILIENCY

Preparing for Climate Change

Presented by
Rhys Wolff & Elli Papaioannou

01 MEET RHYS & ELLI AT HDR

THE PRESENTERS

Meet Rhys…

- Project Manager and Lead Modeller at HDR with 12 years of experience
- Works on Transportation Master Plans and all sorts of modelling projects

Meet Elli…

- Transportation Planner at HDR with 4 years of experience
- Works on MTO's Greater Golden Horseshoe Plan and thinks every day of the grim future

A BIT ABOUT HDR

- HDR offers Engineering, Architecture, Environmental and Construction Services in Canada, US and worldwide
- 10,000 employees in 225 offices worldwide
- 250 employees in Toronto and Richmond Hill Offices
- Currently working across the GTA with MTO, Metrolinx, Upper and Lower Tier municipalities and transit agencies

TRANSPORTATION PLANNING
- Master Planning • Functional Planning
- Corridor planning • Complete Streets
- Macro-Modelling • Micro-Modelling
- Microsimulation • Pedestrian Simulation

TRANSIT PLANNING
- Transit Service Planning • Signal Priority
- Operational Reviews • Value Analysis
- Higher-order Transit Planning

DECISION ECONOMICS
- Funding Analysis • Risk Management
- Statistics and Data Analytics
- Sustainable Return on Investment

FREIGHT RAIL
- Bridge Inspection • Rail Modelling
- Cost-Benefit Analysis • Facility Design

TRANSIT ARCHITECTURE
- Sustainable Design • Structural Engineering
- Electrical Engineering • Design-Build
- Bus Service and Facility Planning

ROADWAY DESIGN
- Value Engineering • Utilities • Civil Engineering
- Construction Administration

PUBLIC ENGAGEMENT
- Facilitation • Media Strategy • Branding

Reconfiguration of Six Points Interchange

Calgary North Crosstown BRT

02 A CHANGING WORLD

CLIMATE CHANGE

"Extreme" Weather Events

- Increasing frequency of catastrophic weather events
- Rainfalls of 2013 left a GO commuter train submerged in water
- Ice storm of the same year blocked the transit network and left houses without power
- Many other similar events, floods, and extreme heat conditions in Canada and worldwide

03 LONG RANGE PLANNING AND RESILIENCY

WHAT ARE WE DOING IN SOUTHERN ONTARIO?

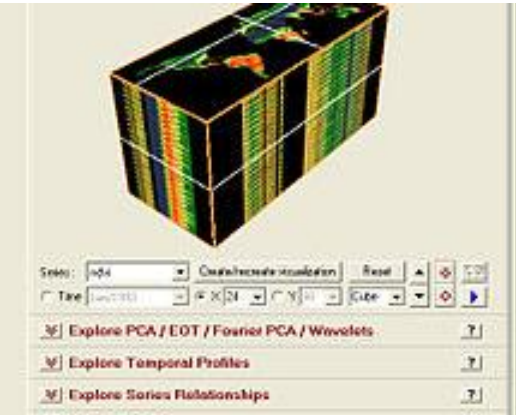
- Greater Golden Horseshoe (GGH)
  - Over 31,500 km^2
  - Over 9 million people in 2016
  - Over 3 million jobs
  - Projected to grow to over 14 million by 2041
  - Is the economic engine of Ontario
- Ministry of Transportation of Ontario is developing a long range multimodal transportation plan for the GGH
- The Plan is building infrastructure resiliency in our transportation planning

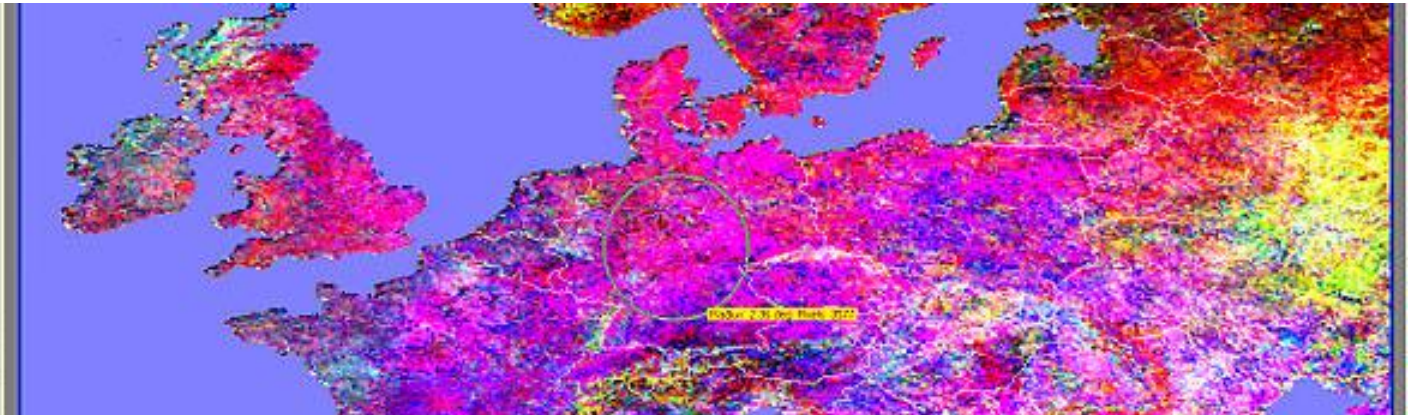
“STRETCHING” THE FUTURE

- The GGH Plan looked at 5 distinct stretch futures as part of resiliency planning
- The futures were not ideal conditions but plausible scenarios influenced by the environment, technology, economy and the volatile geopolitical conditions
- Each future had different urban structure, population and employment distribution
- Scenarios were tested using a custom-developed tool to identify important demand connections
- This exercise provided valuable information about which connections are essential or too stressed in a variable future set

USING THE RIGHT TOOLS

- Different tools can help long range planning
- Travel Demand Forecasting Models are commonly to simulate travel demand conditions
- Provide key forecast metrics such as congestion, delay, trip lengths and mode choices
- Represent typical conditions and assess the ability of the network to meet projected peak-period demand
- GIS applications can help quantify infrastructure that is at risk





LONG RANGE PLANNING AND RESILIENCY

- The same tools can be used to assess both extreme and recurring events

Identifying at-risk areas

Identifying appropriate scenarios and performance metrics

Running the forecasting model

Evaluating each scenario accordingly

04 AT RISK AREAS

WHY DOES IT MATTER?

- Transportation infrastructure is a valuable capital asset
- Contributes to a productive economy
- The infrastructure and the contribution to productivity are often undermined by inclement weather events
- Changing climate reality contributes to enormous costs for maintaining and rebuilding pieces of the infrastructure

AT RISK AREAS

- **Ongoing and plannable considerations** of known effects and cumulative results of climate change that are being documented and categorized
  - Examples include urban heat areas, floodplains, or areas at risk of blowing snow
- Cities, agencies and authorities document such areas and make datasets (in GIS or other format) available openly or upon request

- **Emergency considerations** of abrupt conditions that need to be examined in order to build a resilient and adaptable network
  - Examples include ice storms, floods and infrastructure failure/closure of critical network elements
- Are more difficult to predict
- Require the identification of critical network elements that would be under the highest stress in an emergency situation

ONGOING AND PLANNABLE CONSIDERATIONS

- **Floodplains**
  - A spatial representation of areas that are in high risk of being flooded if a river/watercourse experiences extreme flows because of heavy rain or snowmelt
- **Extreme Heat**
  - considerable spatial heterogeneity and there are multiple factors that contribute to heat vulnerability, including the topography, vegetation, and settlement density
- **Other**
  - Areas susceptible to blowing snow place more stress on infrastructure and pose higher risks to people/goods travelling through them

HOW TO ACCOUNT FOR ONGOING AND PLANNABLE CONSIDERATIONS

- **Looking at future infrastructure alternatives**
  - Alternative transportation infrastructure can be cross-referenced with the location of floodplains and urban heat areas
  - Length of each route (route km or route lane km/ rail length or number of tracks) that passes through them
  - Road and rail infrastructure can be ranked based on the passenger volumes or value of goods that they carry daily
  - Help avoid or view unfavorably infrastructure alternatives that traverse through at risk areas
  - Determine project cost estimates

- **Assessing existing infrastructure**
  - Areas that are exposed to higher risk should help inform the need for redundant routes in an effort to build a resilient region and.

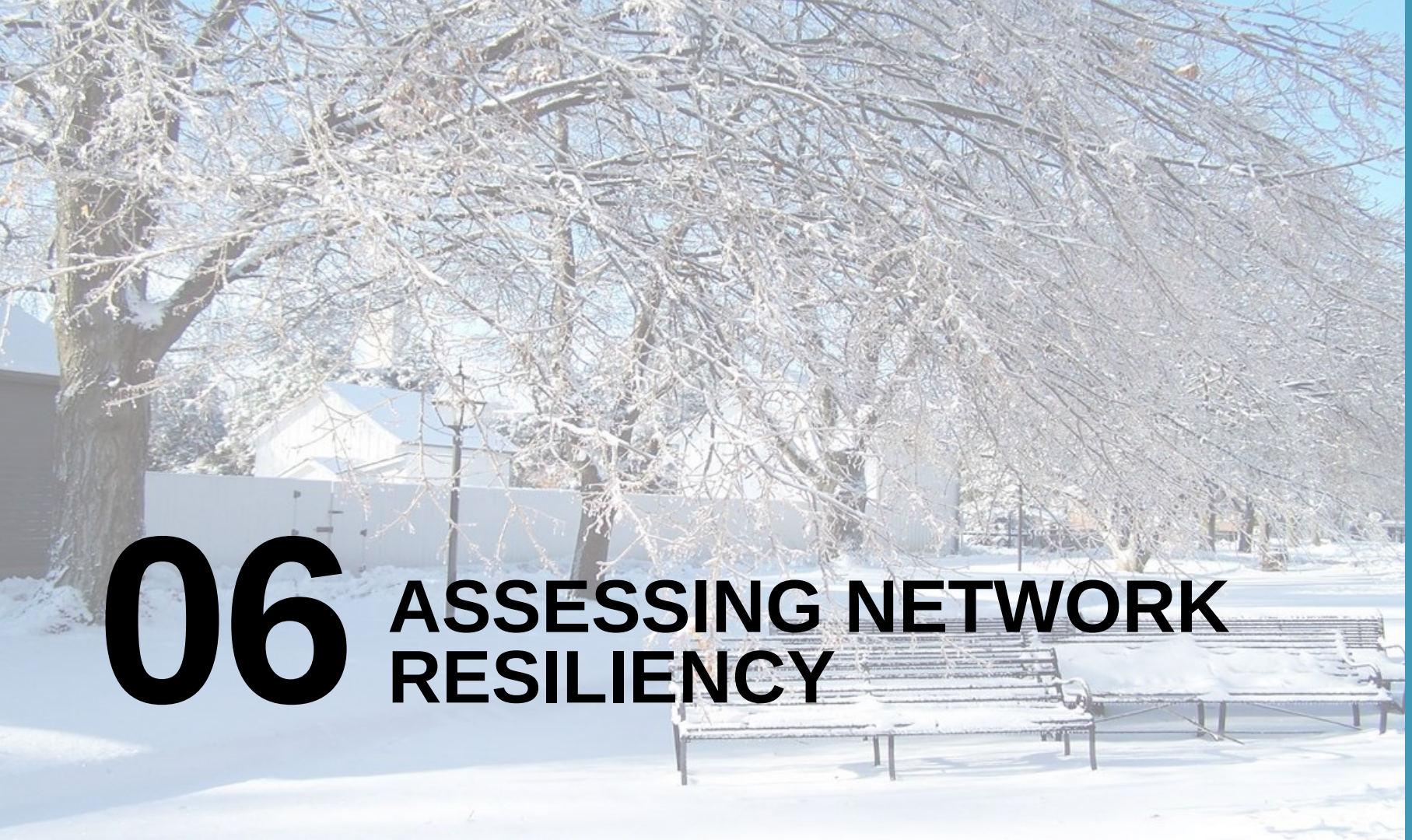
EMERGENCY CONSIDERATIONS

- Focuses on emergency management situations that cannot be planned for
  - Examples include evacuation, failure of critical components of the network, such as freeway interchanges or central train station
- Test and determine the impact to the system
- Identify proposed solutions to alleviate the pressure.

05 QUANTIFYING RISKS

QUANTIFYING THE RISK

Metric	Example	Question
Evacuation time	Percentage of residents who are able to exit the region within 45 minutes	How effective is the network at facilitating evacuation (one-way flows)
Risk areas	Km through areas susceptible to blowing snow	How susceptible is the network to extreme weather events?
	Km of network in flood-risk areas	
	Km of network through urban heat islands	
Infrastructure closure	Station removed: impact on travel times and congestion levels	How does the network respond if a key facility is unavailable?
	Major facility (highway or transit line) removed: impact on travel times and congestion levels	How does the network respond if a key link is unavailable?



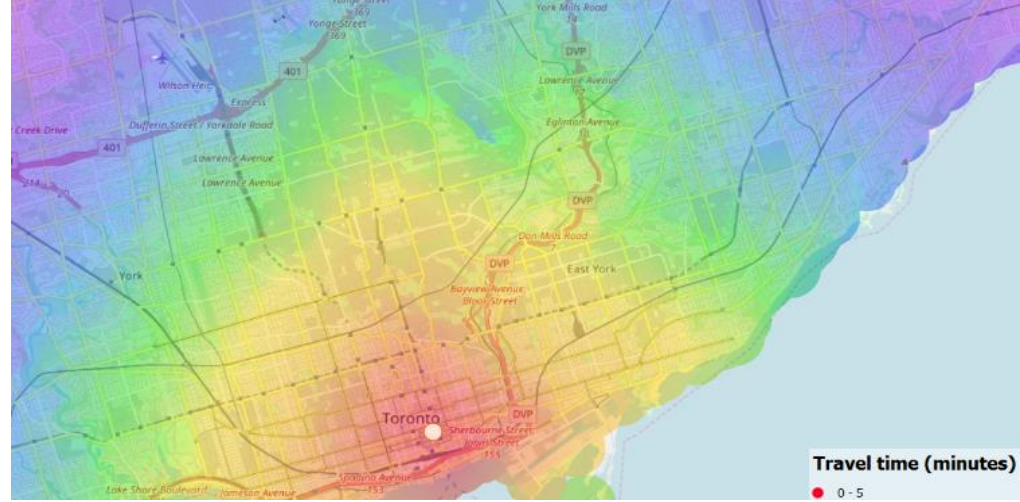
06 ASSESSING NETWORK RESILIENCY

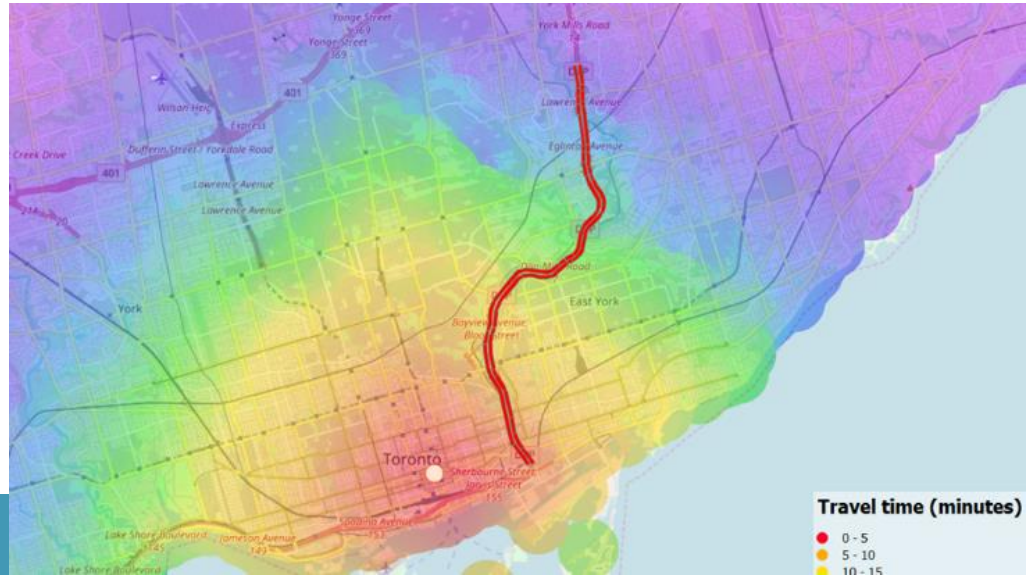
ASSESSING NETWORK RESILIENCY

- Network performance and the need for enhanced capacity is typically based on projections of recurring demand
- Develop alternative scenarios
- Use different ways to identify impact of alternative scenarios
- Hours of delay, % of network that is susceptible to extreme weather events, % of population that can be evacuated within a specific interval

EXAMPLE

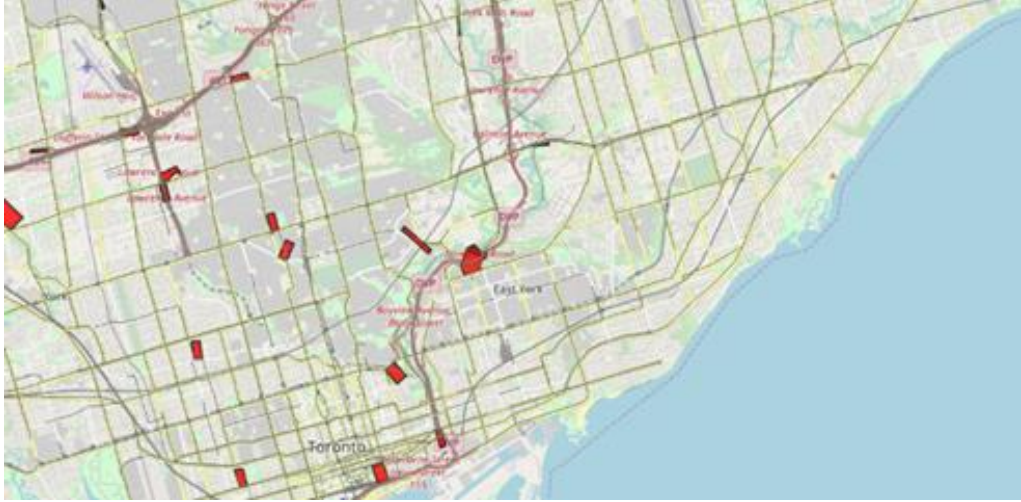
- Shows the impact of how travel times out of the core will be affected if a key highway is unavailable.





EXAMPLE

- Shows the impact of how congestion out of the core will be affected if a key highway is unavailable
- These results provide at a glance comparisons of the impact of closures and the facilities that would be most greatly affected



07 FORWARD

MOVING FORWARD

- Realize the impacts and threats of climate change
- Create detailed and consistent mapping
- At risk areas should be made openly available and should be updated frequently
- Resilience-testing should be part of all transportation plans
- Long range planning should examine extreme events beyond the peak
- Critical components of the network should be identified and stress-tested

Thank you for listening!

Rhys Wolff
Rhys.Wolff@hdrinc.com

Elli Papaioannou
Elli.Papaioannou@hdrinc.com