A Network Centric Spatial Decision Support System Approach for Modeling Infrastructure Interdependency

Vincent Tao, PhD, PEng
Canada Research Chair in Geomatics
Director, GeoICT Lab, York University

Rifaat Abdalla, PhD Candidate
Project Coordinator, York GeoICT Lab

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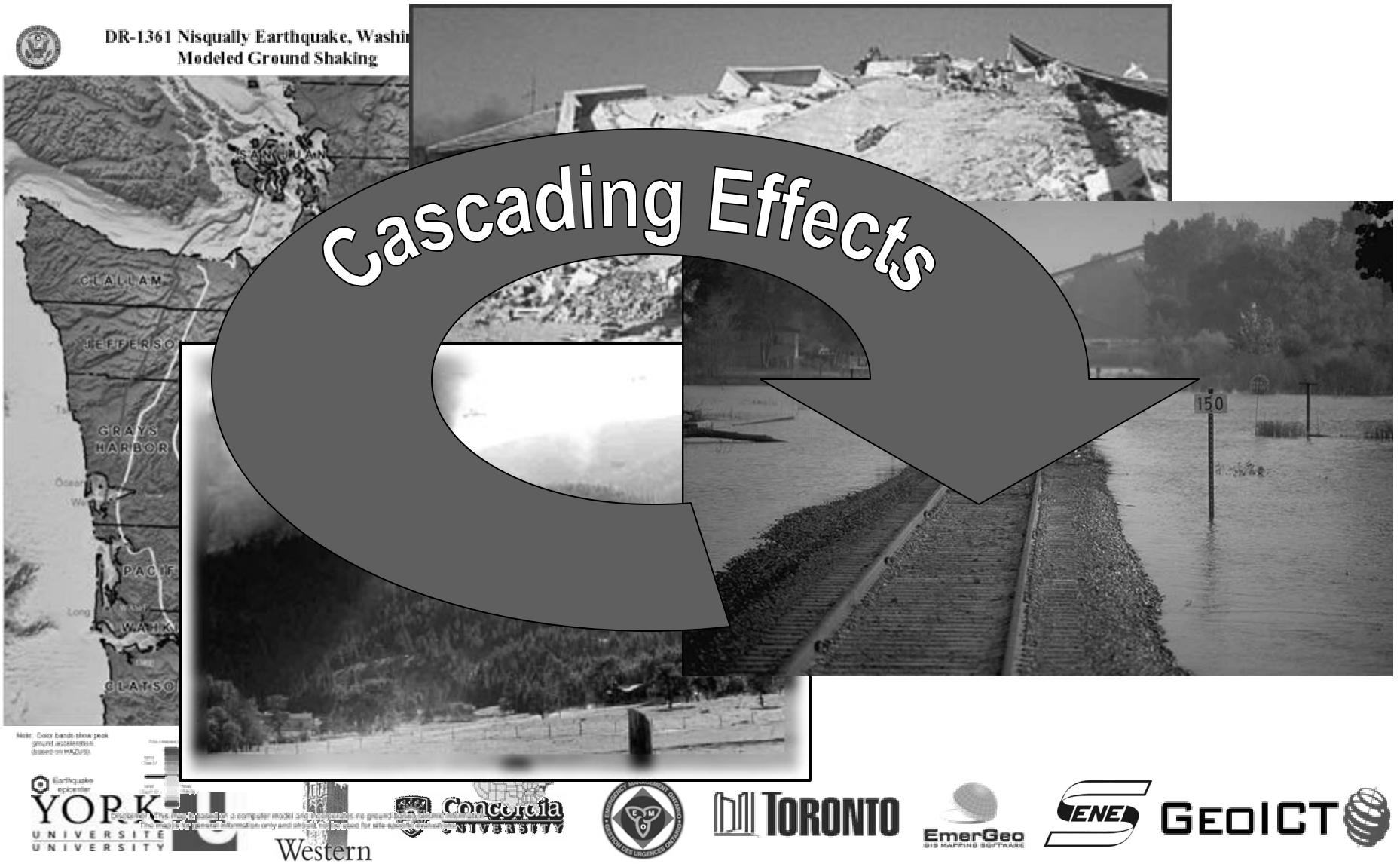
Project Team

- Prof. Vincent Tao, York U
- Prof. Slobodan Simonovic, U Western Ontario
- Prof. Zhi Chen, Concordia U
- Prof. Mary Ann Jenkins, York U
- Mr. M. John Galea, Emergence Management Ontario
- Mr. Bob Gaspirc, City of Toronto
- Mr. Mike Morrow, EmerGeo
- Dr. Rafik Djouad, SENES Consultants

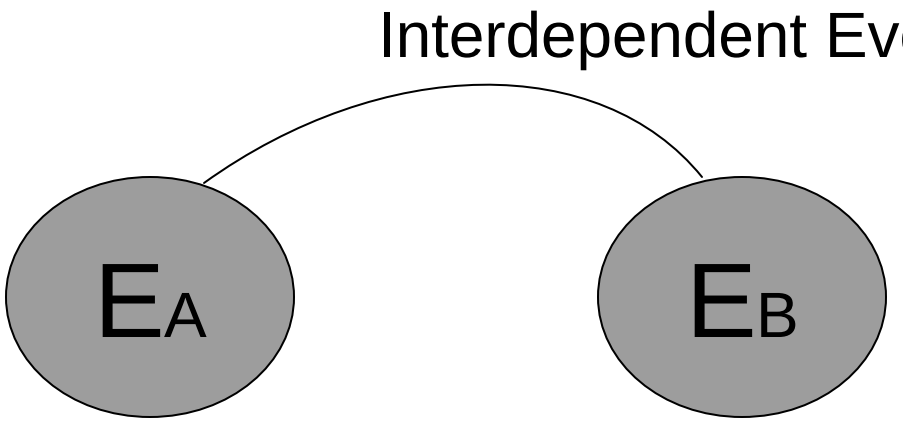
Infrastructure Interdependency ....



Aircraft Crash Scenario

Interdependency

Event



e.g. Earthquake

e.g. Power sector

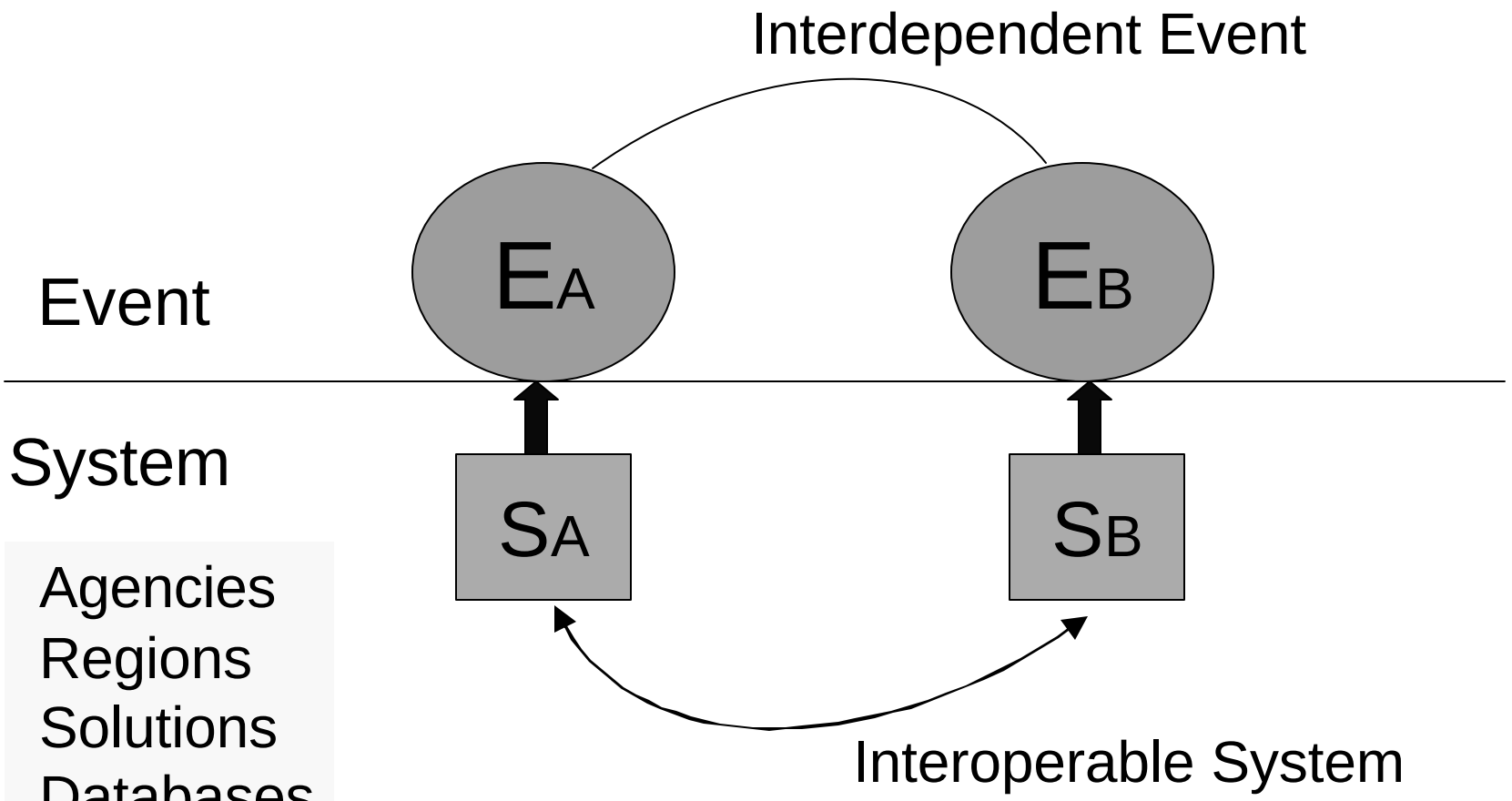
e.g. Ontario

e.g. Flooding

e.g. Transportation sector

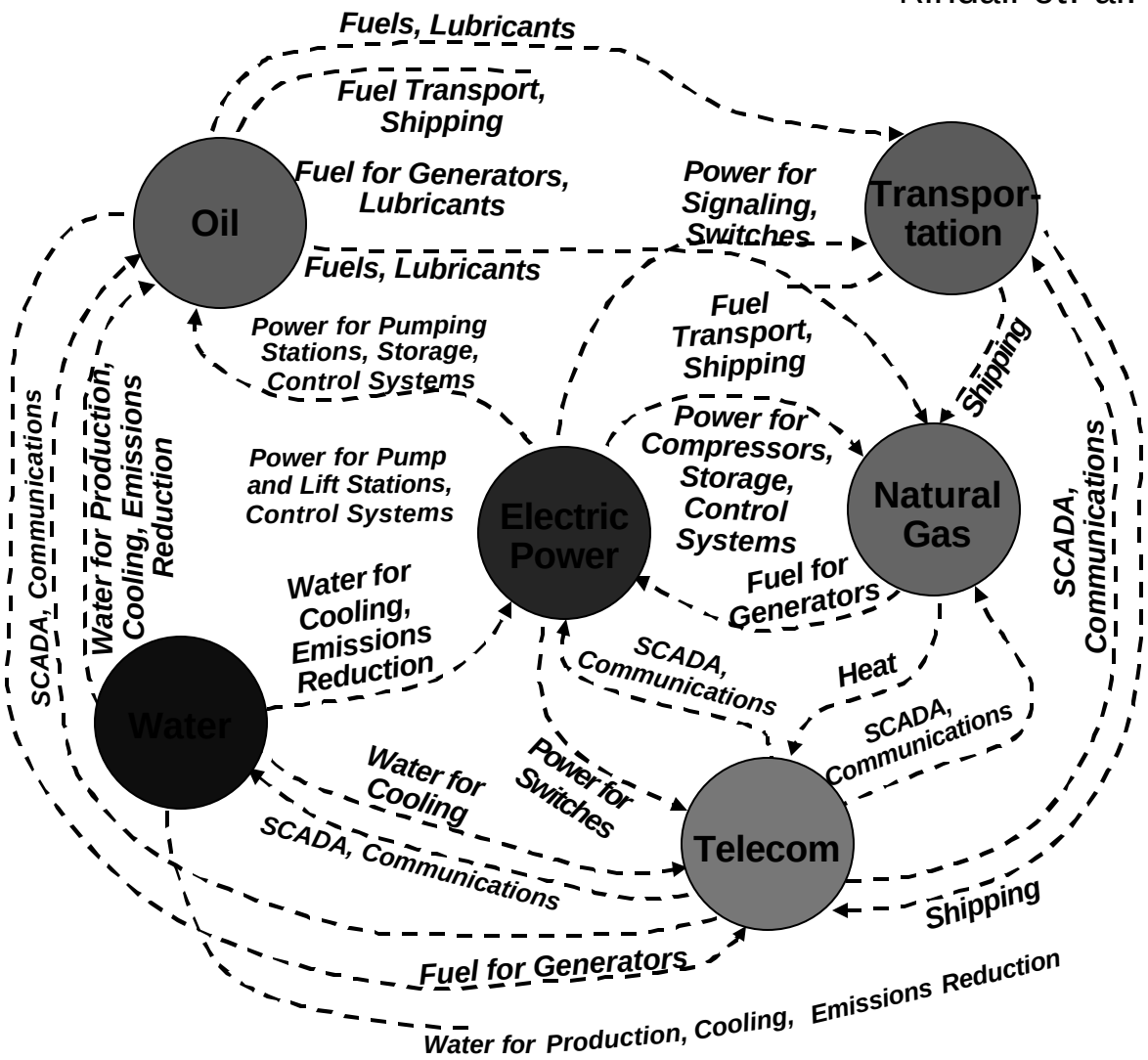
e.g. Quebec

Interdependency vs. Interoperability



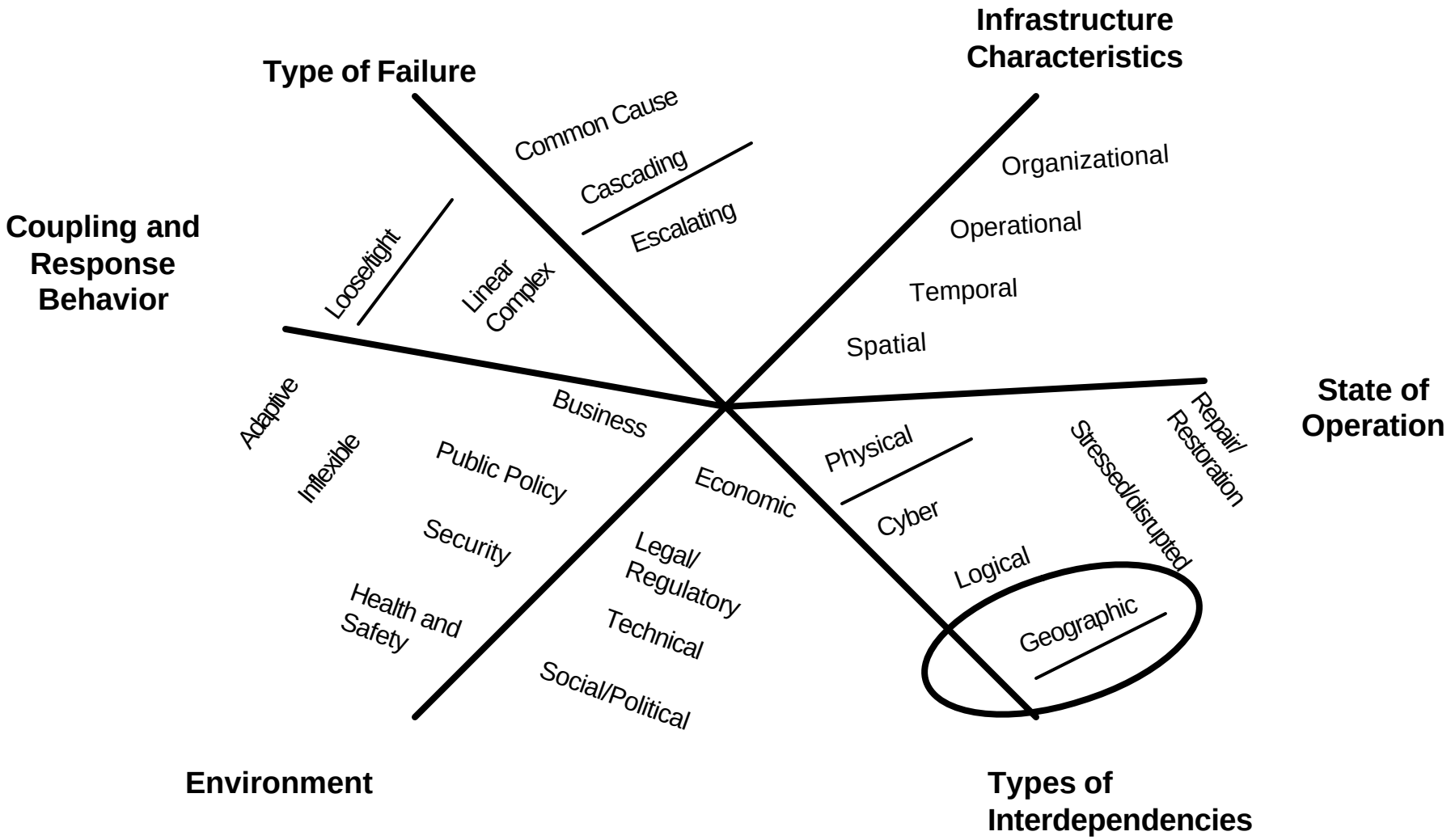
A “System of Systems” Perspective

Rindali et. al. 2003



Dimensions of Infrastructure Interdependencies

Rindali et. al. 2003



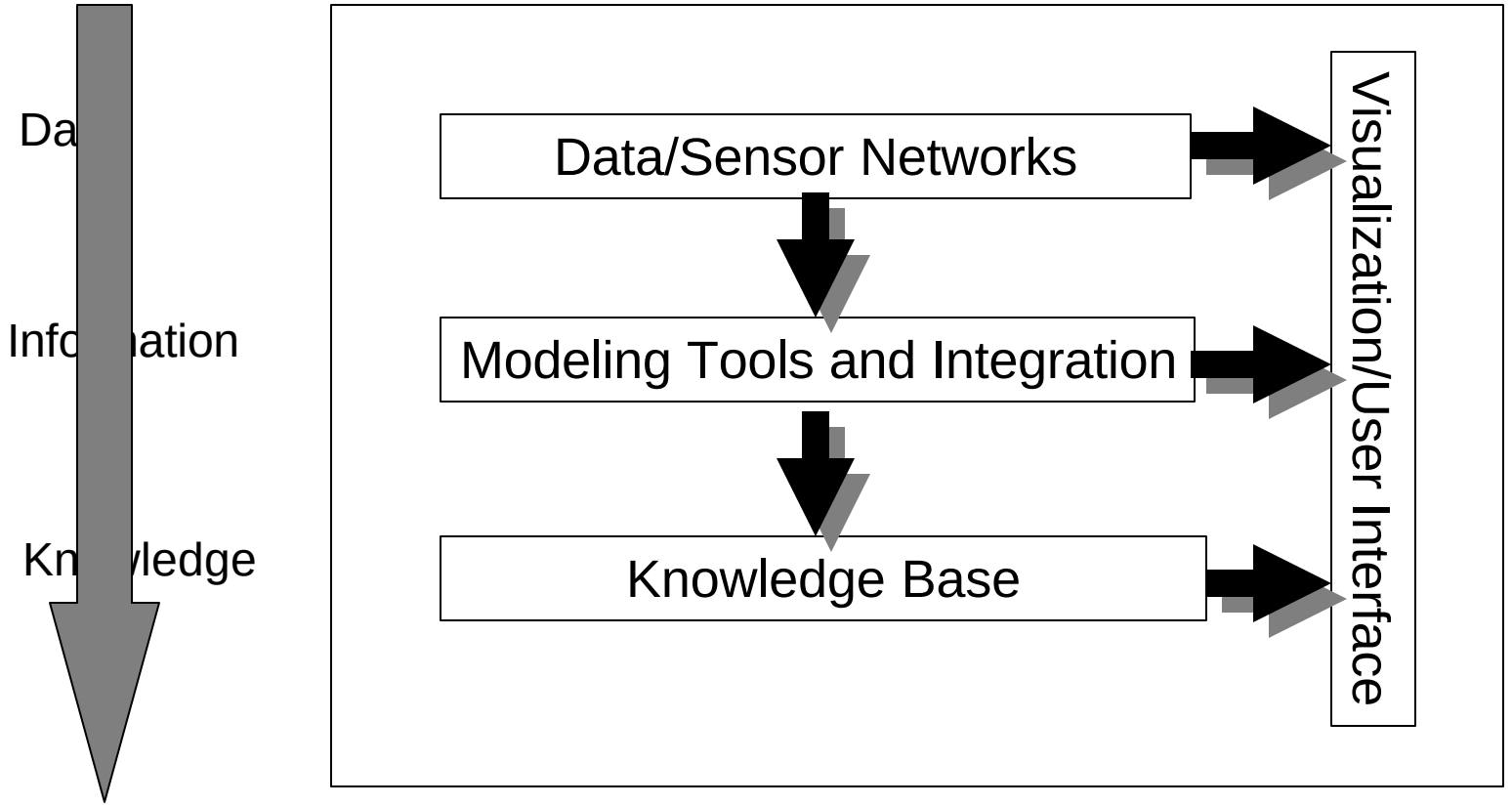
Research Objectives

1. Investigate the location based infrastructure interdependency (LBII)
2. Investigate the system interoperability for emergency responses
3. Use of the scenario driven approach for analysis and experiment
4. Develop a spatial decision support system prototype

LBII – An Interoperability Perspective

- Data Level
  - Data/Sensor networks for data collection
- Information Level
  - Modeling tools as well as their integration
- Knowledge Level
  - Knowledge base construction
- System Level
  - distributed spatial decision support system

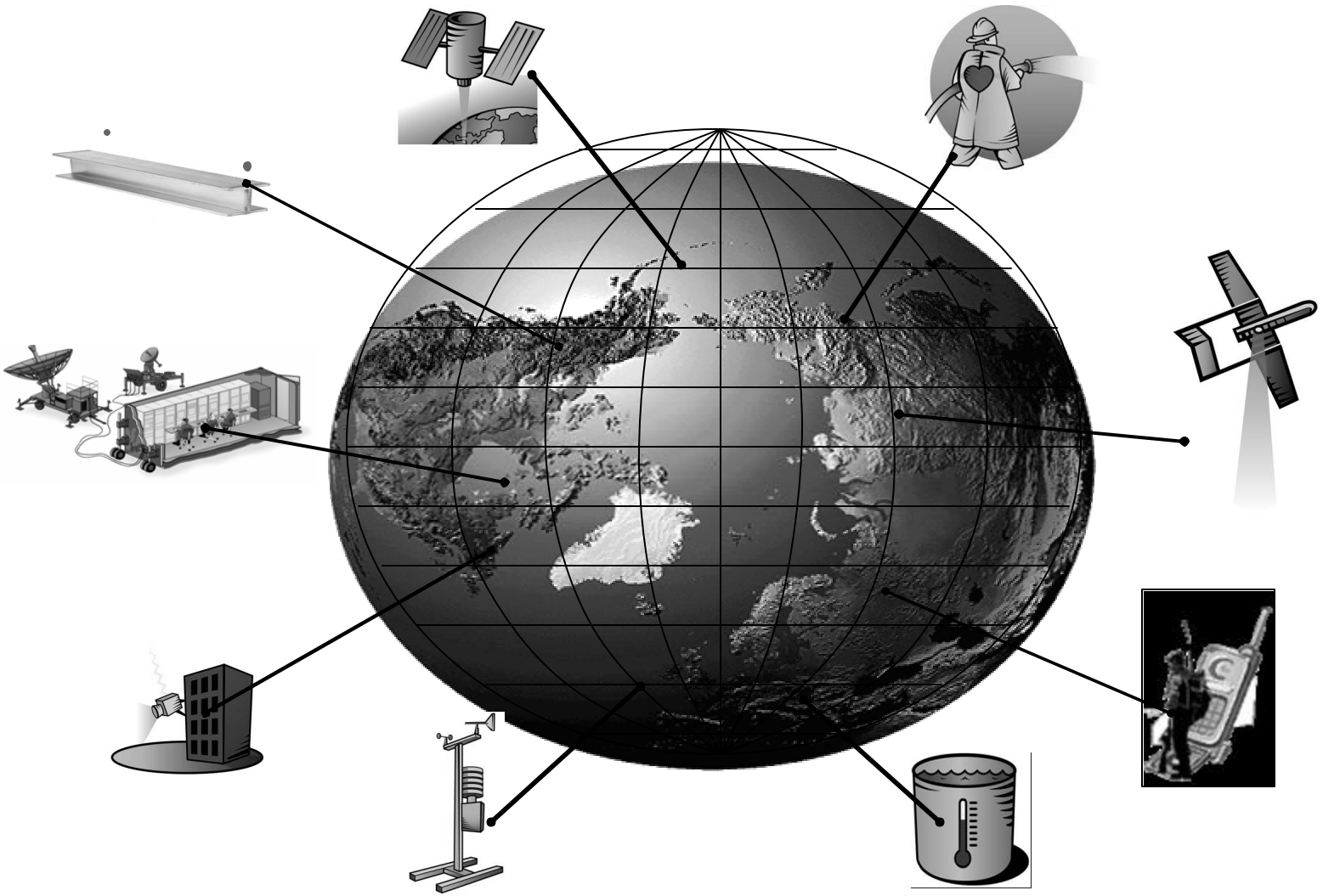
Spatial Decision Support System



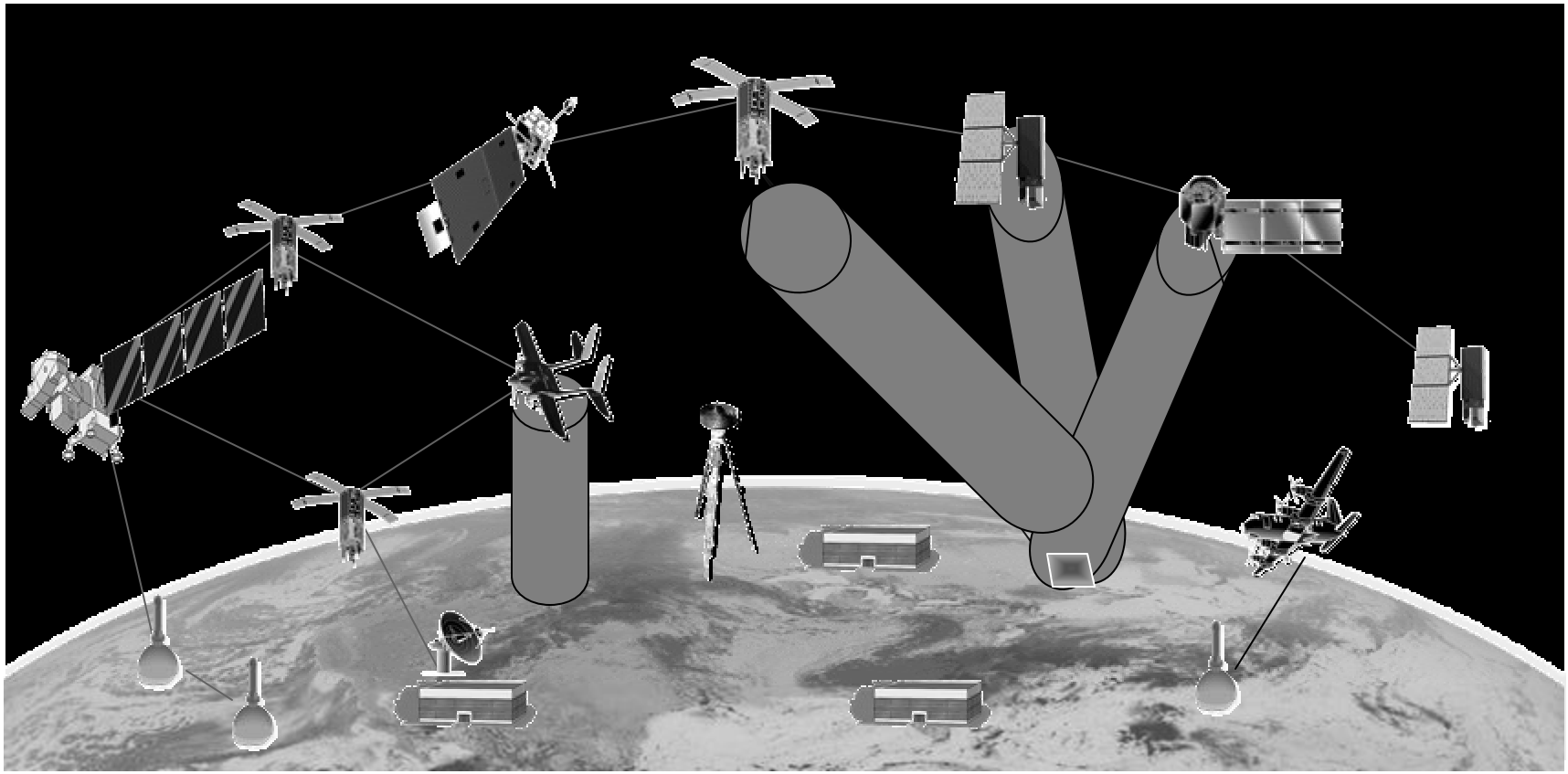
LBII – Tools

- Sensor Network Tools
- Event Modeling Tools
- Knowledge Construction Tools
- Spatial Visualization and Integration

Sensor Network Concept



Sensor Networks
- Integrated sensing approach



Sensor Web Concept: ***NASA/GSFC: 2000 Survey of Distributed Spacecraft Technologies and Architectures for NASA's Earth Science Enterprise in the 2010-2025 Timeframe***

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ISIES Sensor Web Project

YORK UNIVERSITÉ UNIVERSITY

Western

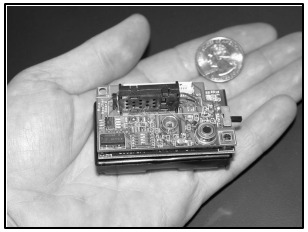
Concordia UNIVERSITY

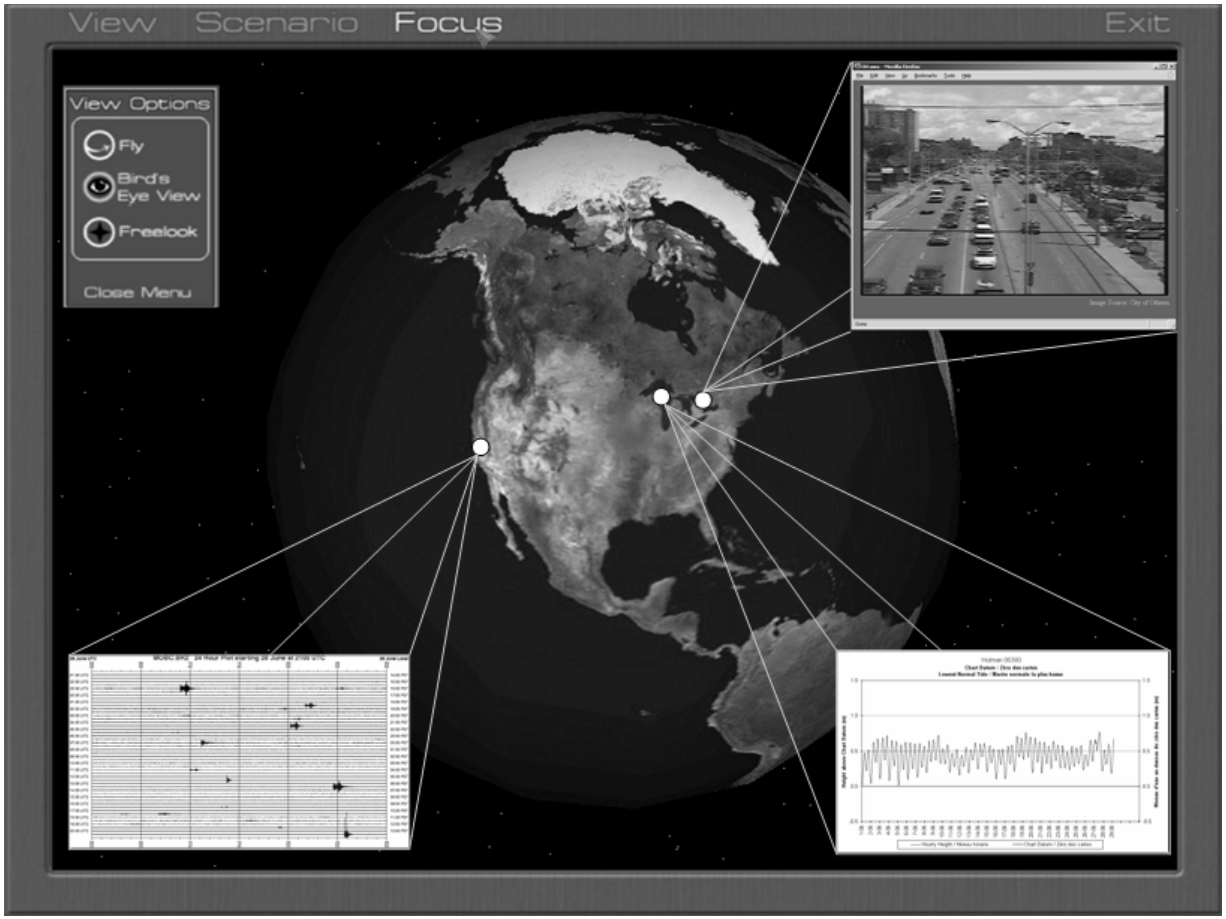
TORONTO

EmerGeo

Developed by NRCan

GeoSWIFT: **Sensor Web Information System**





YORK UNIVERSITÉ UNIVERSITY

Western

Concordia UNIVERSITY

TORONTO

EmerGeo

ENEL

GeoICT

LBII – Tools

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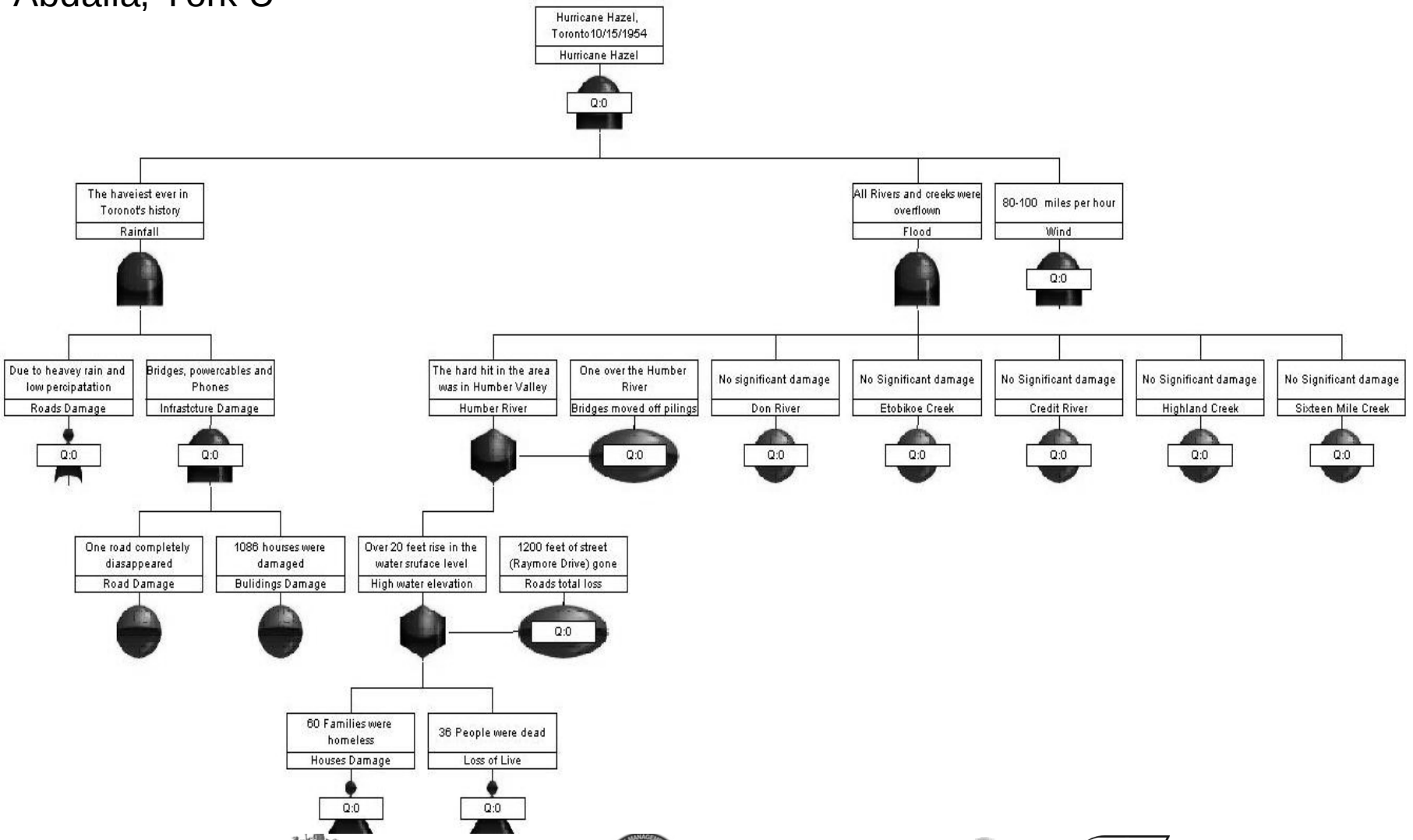
Scenario – Flooding

- On October 15 and 16, 1954, Hurricane Hazel struck the Toronto area.
- Extreme event with wind of up to 80 miles per hour and heavy rain.
- 81 people died and over 4,000 families were left homeless in Ontario.
- The total cost of the destruction in Canada was estimated at $100 million, the equivalent of about one billion dollars today.
- Recorded as the most devastating event in the City's history.

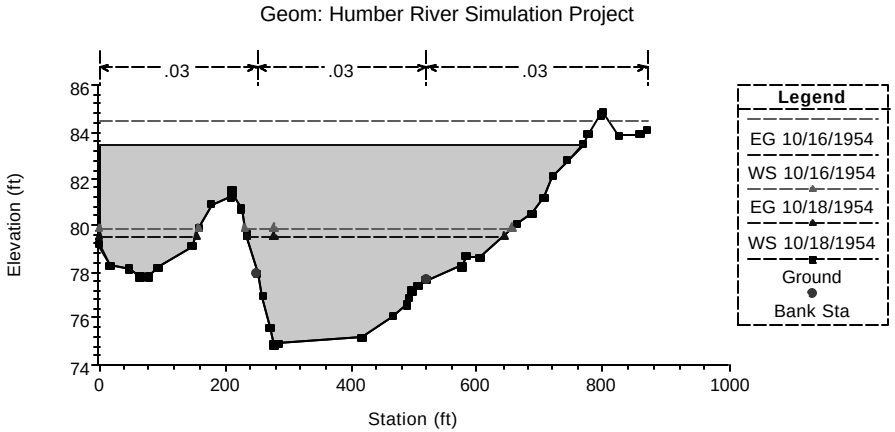
Event Tree Analysis

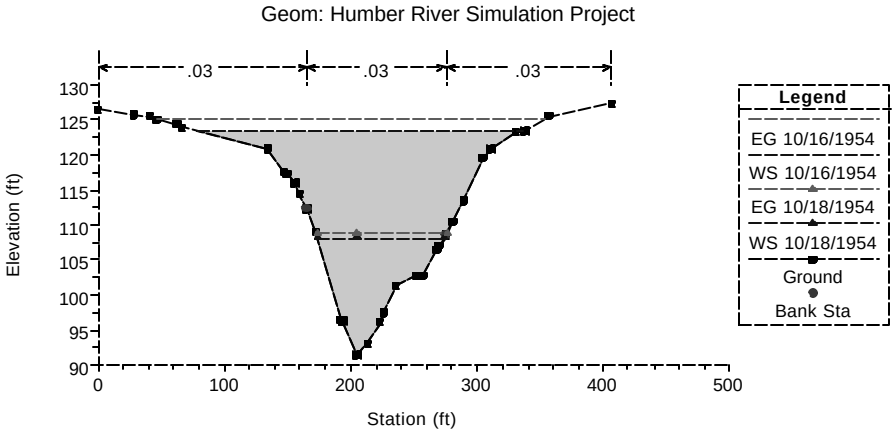
Abdalla, York U

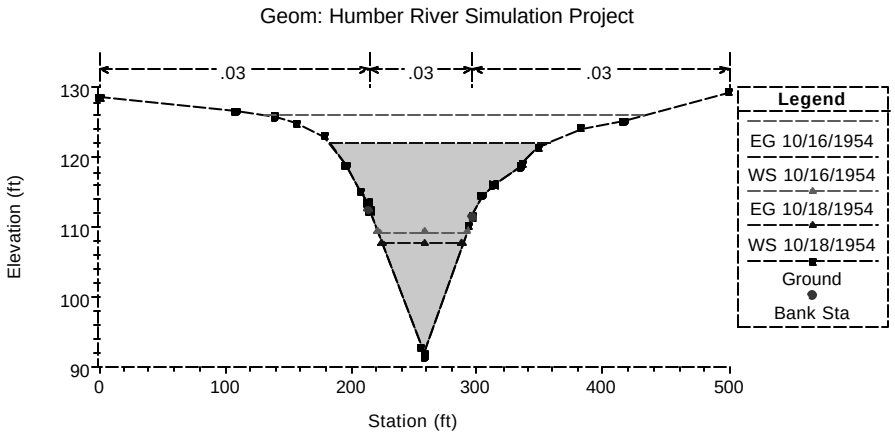


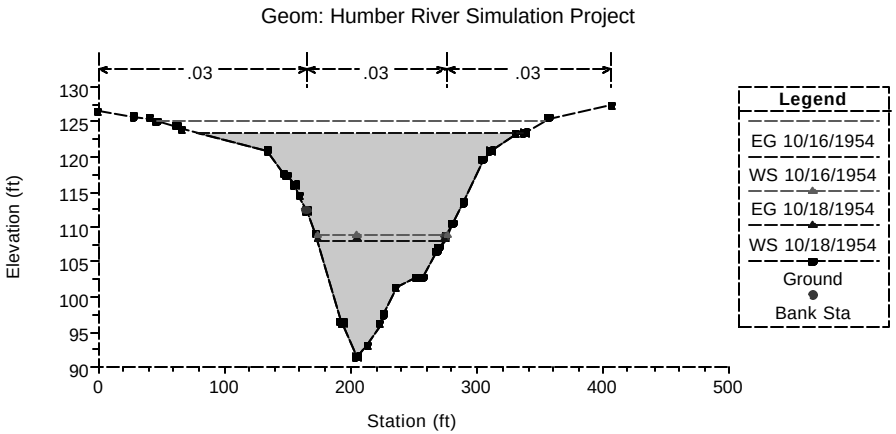
Hydraulics Modeling - HEC-RAS

Abdalla, York U









Hydraulics Modeling - HEC-RAS

Abdalla, York U

Bank Stations Table

River: Humber Edit Interpolated XS's

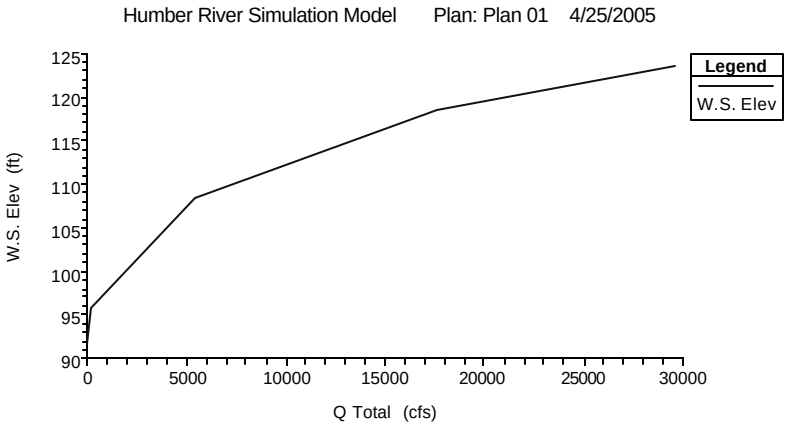
Reach: Main

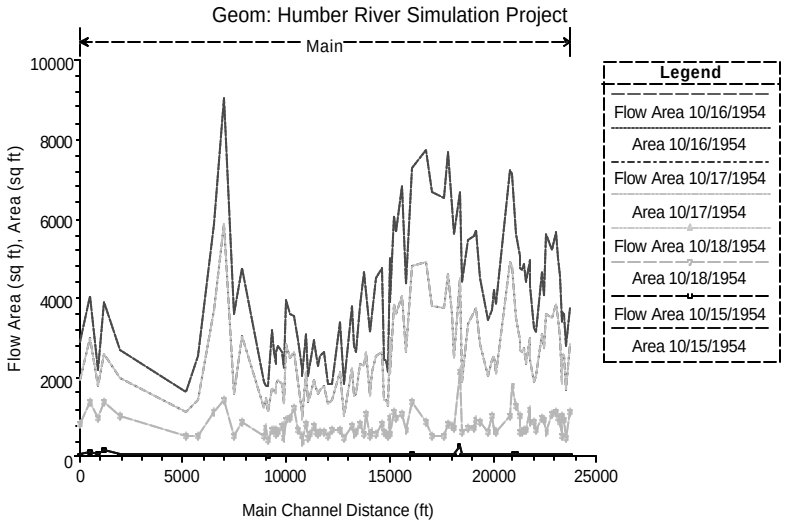
Selected Area Global Edits

Add Constant ... | Multiply Factor ... | Set Values ... | Replace ...

	River Station	Left Bank Sta	Right Bank Sta
1	24056.27	128.93	227.98
2	23897.72	214.52	265.64
3	23805.74	164.81	262.1
4	23695.58	180.35	274.3
5	23619.75	213.35	273.42
6	23554.63	203.49	293.71
7	23474.93	188.48	304.45
8	23396.98	254.02	327.03
9	23230.02	200.15	286.92
10	22999.37	153.2	226.08
11	22765.26	252.17	335.7
12	22678.48	291.05	408.87
13	22422.45	187.5	259.95
14	22316.87	157.87	244.24
15	22177.18	170.4	276.43
16	22046.60	233.94	317.57
17	21931.24	244	314.96
18	21856.70	223.87	307.89
19	21774.27	264.92	329.07
20	21697.13	231.48	303.35
21	21623.59	259.69	346.82
22	21438.17	323.04	376.52

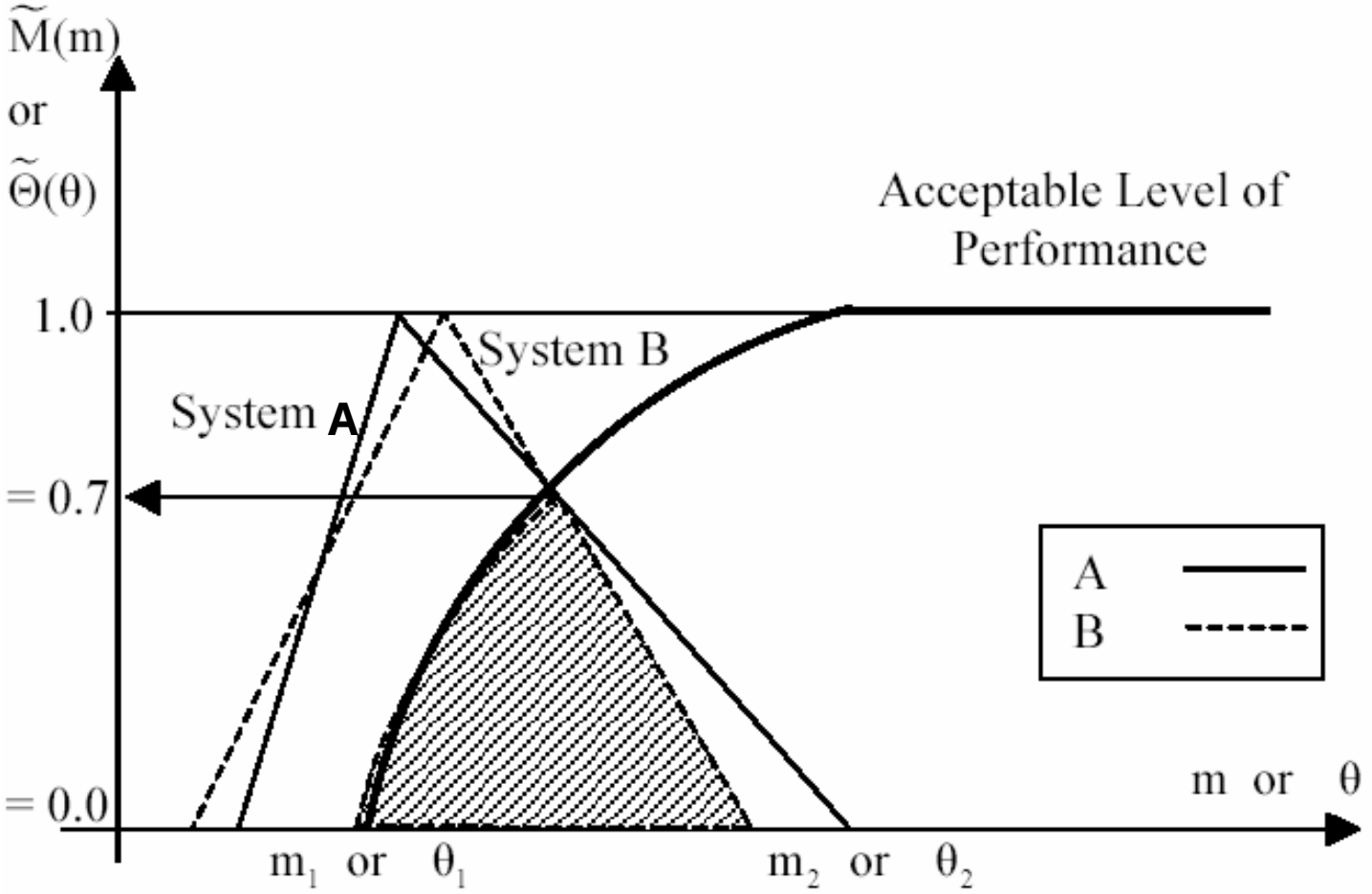
OK | Cancel | Help



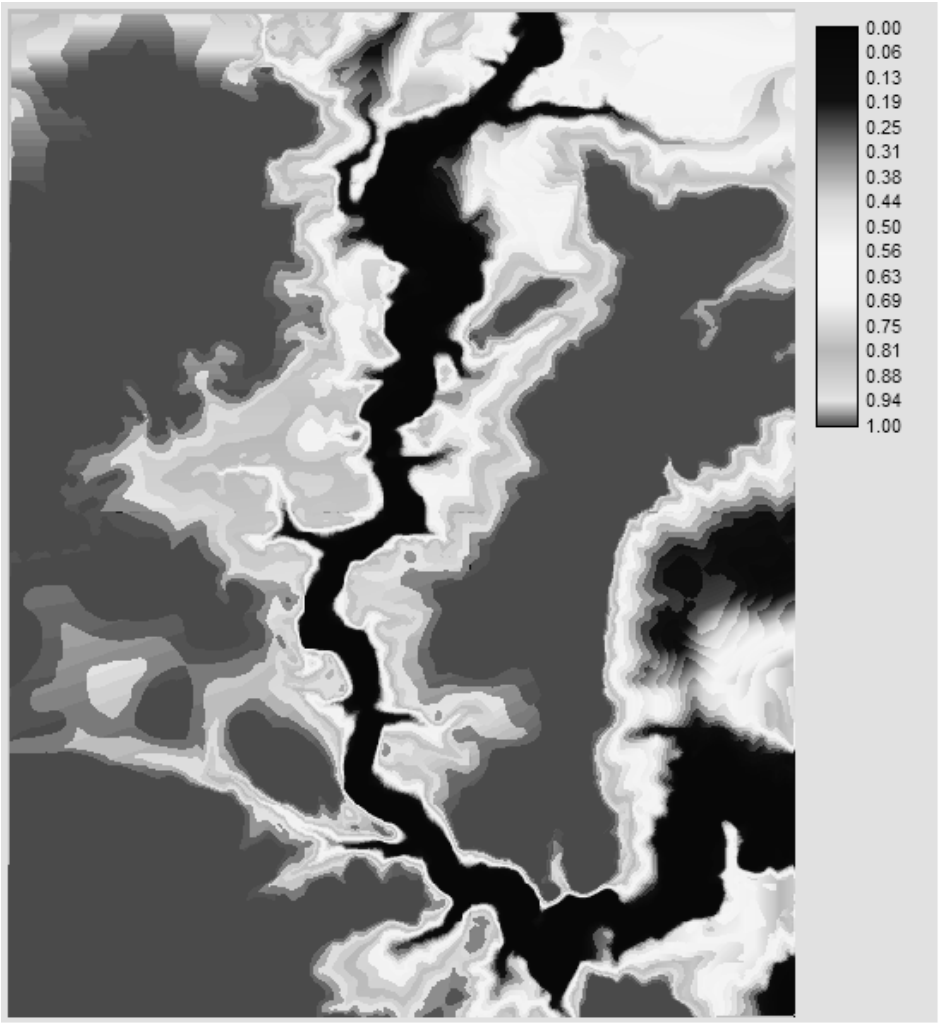


Fuzzy Logic based Flood Modeling

Simonovic, UWO

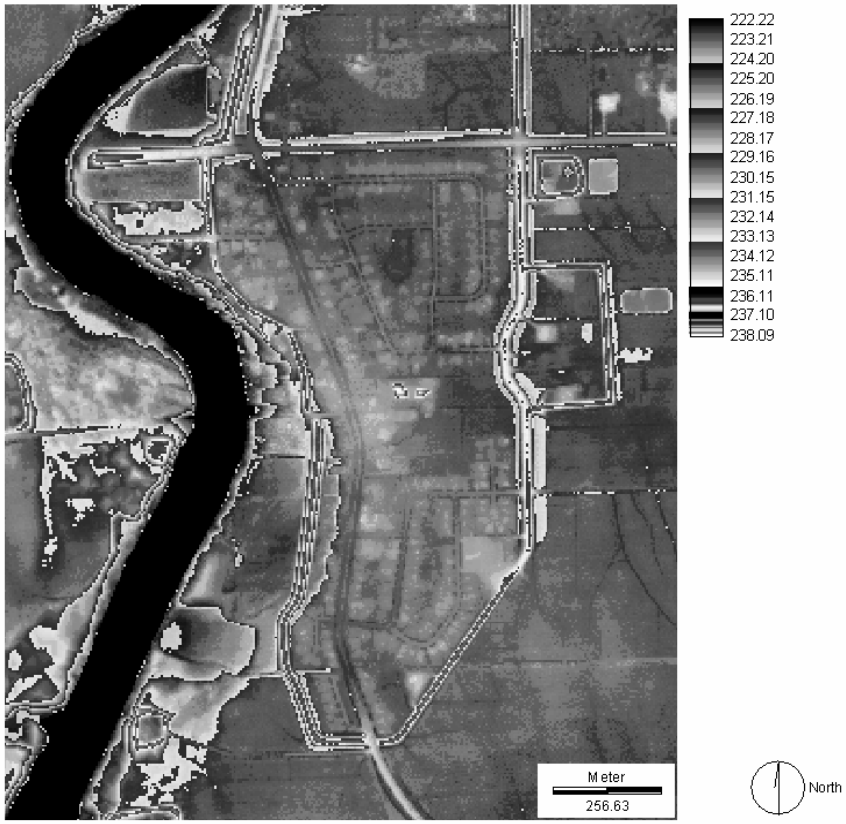


Medway Creek – 500 yr flood

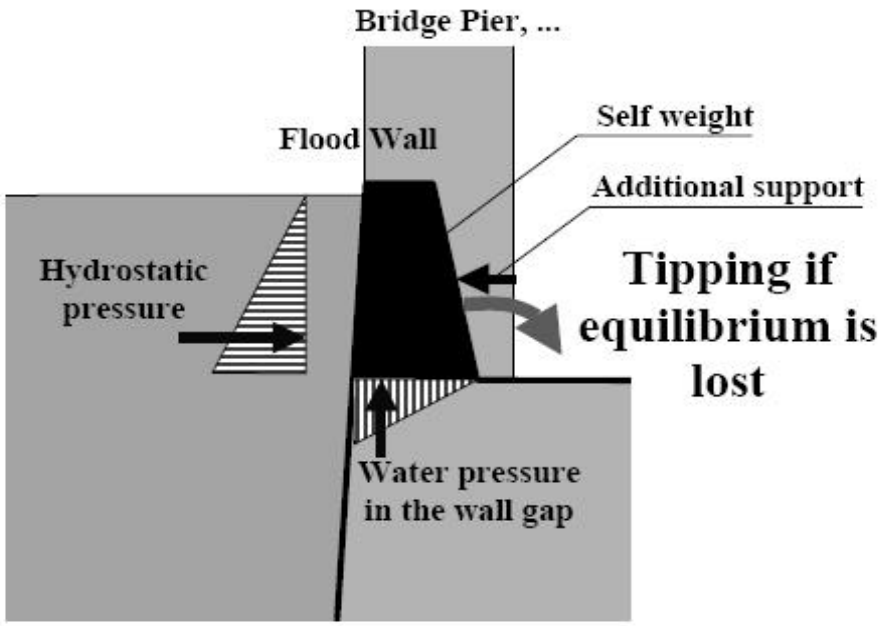


Flood Impact to Housing

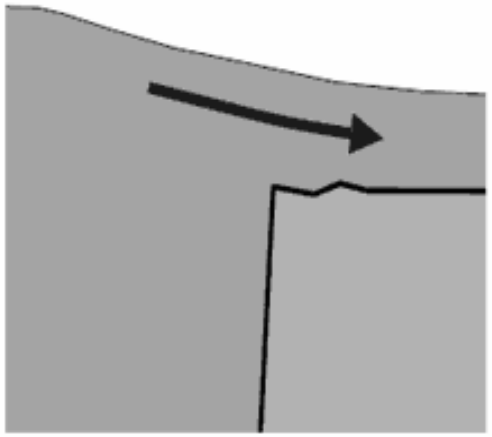
Simonovic, UWO



Modeling of flood impact to civil infrastructure (roads, dams and dikes etc) – Prof Chen, CU

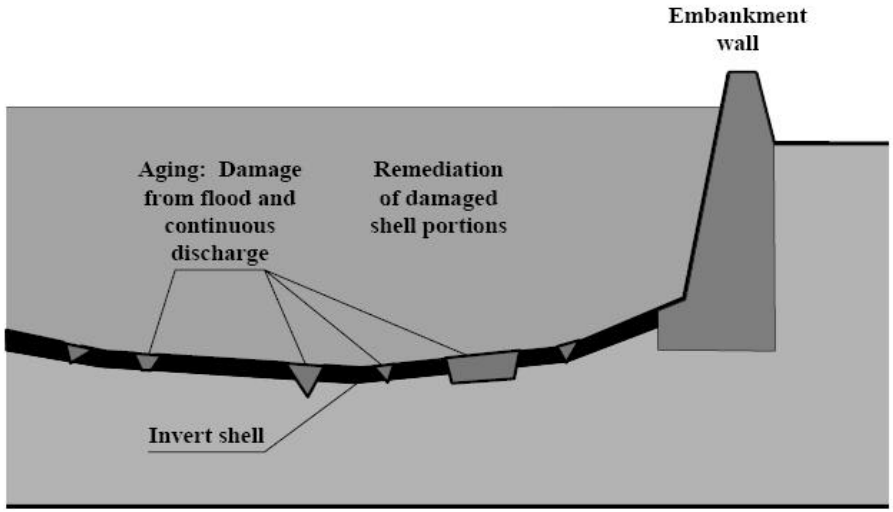


Wall tipping failure

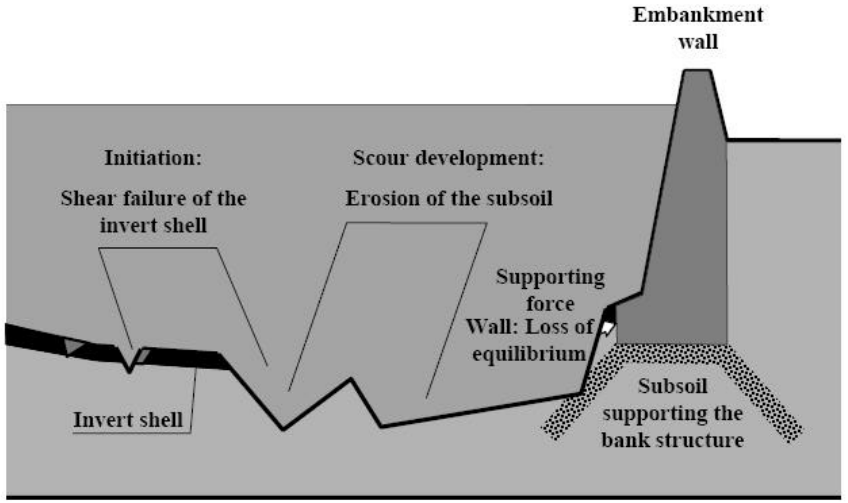


Consequence of failure as inundation of area

Modeling of flood impact to civil infrastructure (roads, dams and dikes etc) – Prof Chen, CU



Initiation of the scouring



Scouring process during an extreme event

Dispersion Modeling

- Prof Jenkins, York U

Urban Fire Modeling

- Geographic factors
- Atmospheric parameters
- Environmental parameters

Examples:

1. Fire Modeling Fire Model
2. Tree Burning Tree Fire
3. Forest Fire Modeling Forest Fire

LBII – Tools

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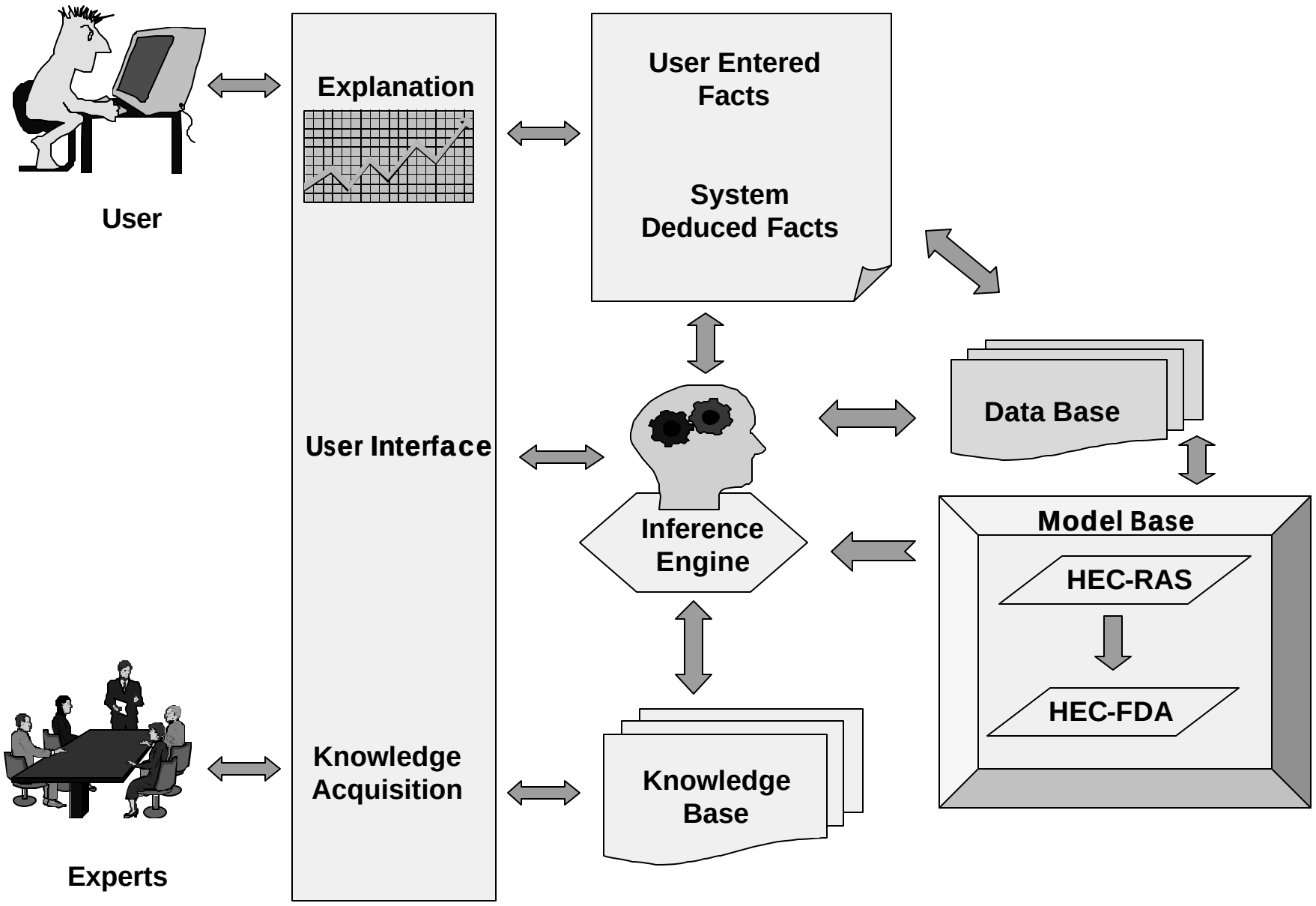

Knowledge Base Construction Process

LBII – Tools

- Sensor Network Tools
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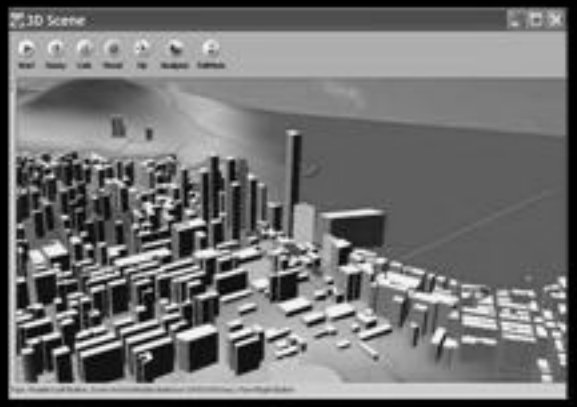
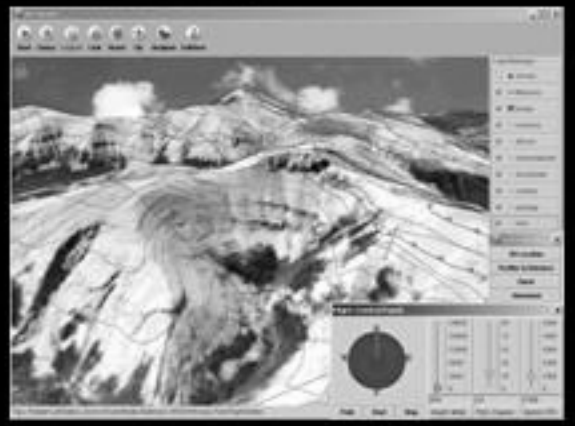
An Overview

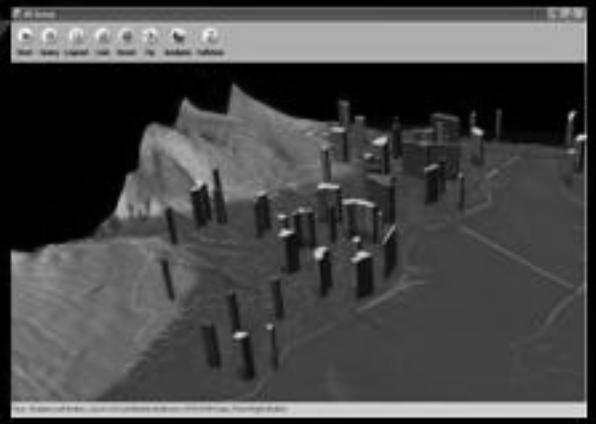


Downtown
3D Modeling

Geological
Analysis

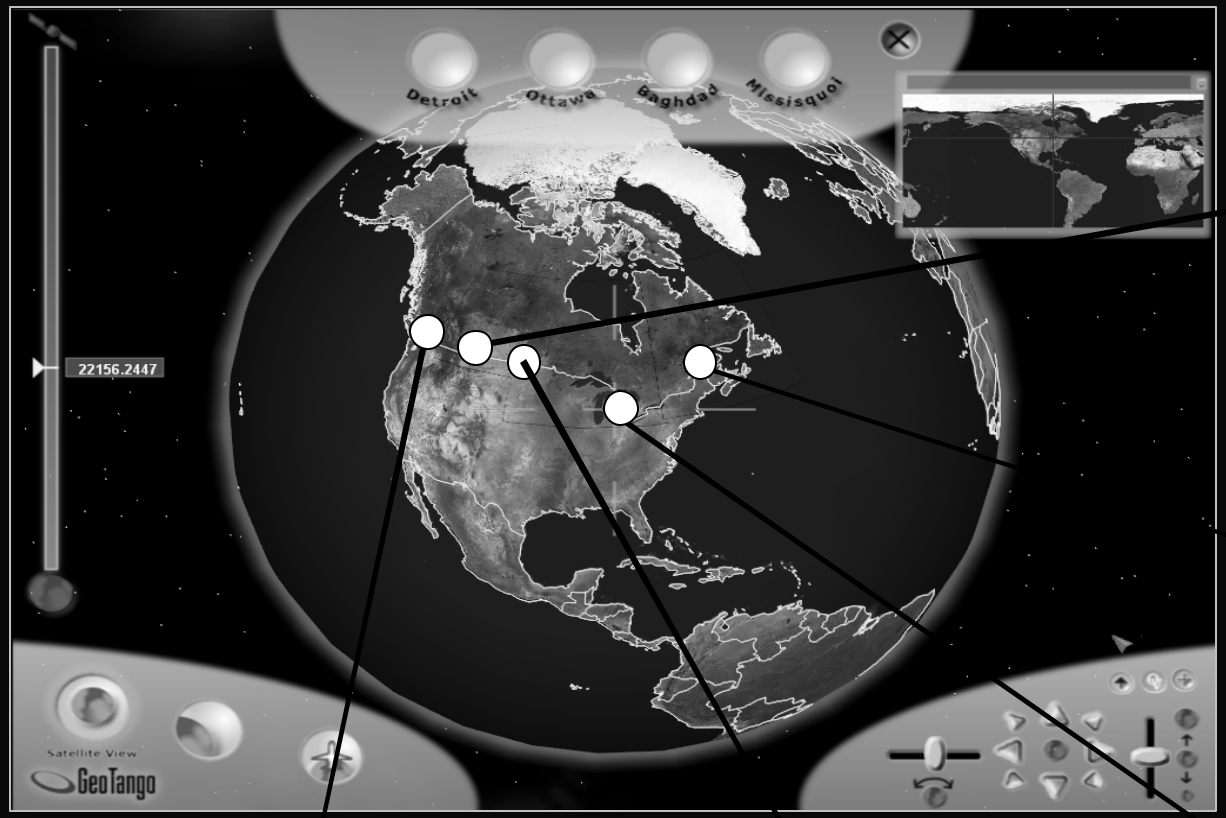


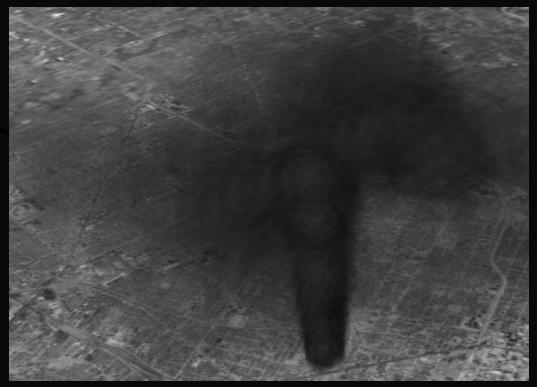
A Map View: Vancouver Earthquake Scenario

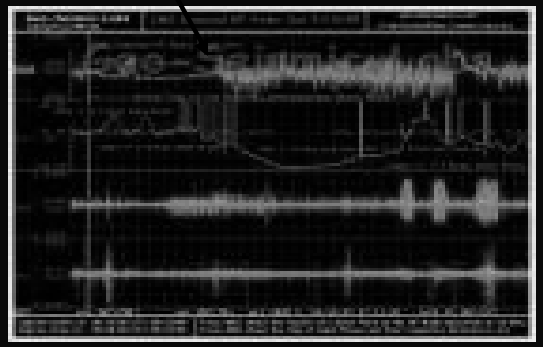


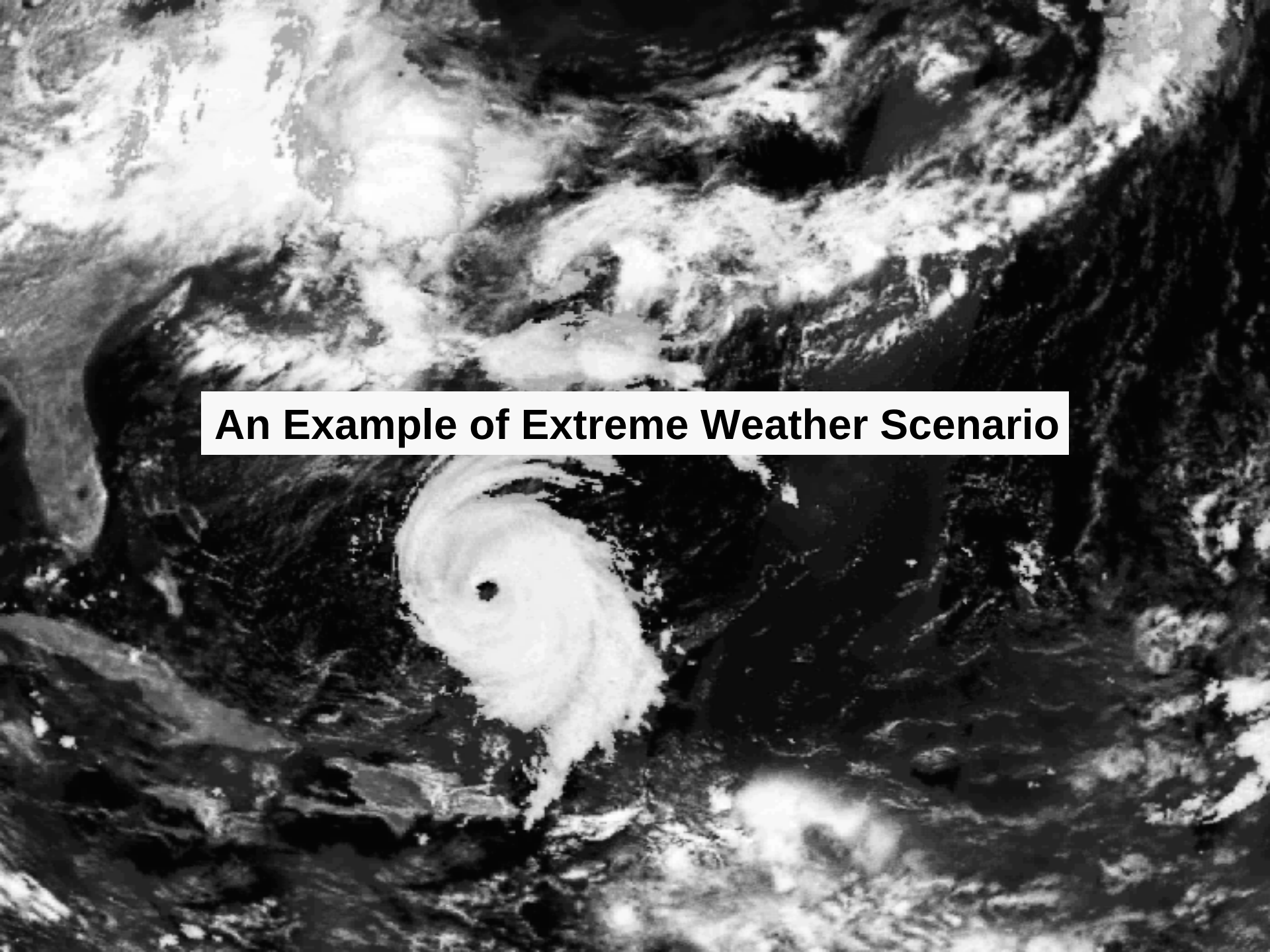
Flood
Simulation

Network-based 3D GlobeView User Interface









An Example of Extreme Weather Scenario

Who Should I Call ?

Acknowledgement

- The City of Toronto has provided value data sets for the city water and sewer system as well as geographic data.
- EMO provided technical and consultative assistance with all aspects of the project so far.
- PSPEC/NSERC JIIRP financial support.

For more information about our project,

www.geoict.net/JIIRP/JIIRP.htm