Joint Infrastructure Interdependencies Research Program (JIIRP) Symposium

Hosted by the Department of Public Safety and Emergency Preparedness Canada (PSEPC)

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Symposium Report

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1-Introduction

On November 10th, 2005 the Department of Public Safety and Emergency Preparedness Canada (PSEPC) hosted the first annual symposium of the Joint Infrastructure Interdependencies Research Program (JIIRP). The objective of the Symposium was to present high-level summaries of the purpose, scope, timetable and status of the six research projects that make up JIIRP.

The Joint Infrastructure Interdependencies Research Program is a part of a national effort to ensure Canada is secure from threats and vulnerabilities that have increased due to the evolving complexity and interconnectedness of its critical infrastructure. The Program is jointly funded by PSEPC and the National Sciences and Engineering Research Council (NSERC). The symposium brought together researchers, academics, government officials and other stakeholders to give them the opportunity to become acquainted with the research program and to meet and network with others who share similar research interests.

This document summarizes the key points that were made by the researchers during their presentations to the symposium participants. It also captures the introductory remarks made by the symposium's co-hosts, Janet Walden, Vice President of Research Partnerships Programs at NSERC, and Janet Bax, Senior Director, Infrastructure Assurance Program, Public Safety and Emergency Preparedness Canada. In addition, the report details the comments and discussion points that were raised during the question and answer periods.

(Note: For further information on the content of the researchers' presentations, please refer to PSEPC's web site to view the PowerPoint slides each researcher assembled for the symposium.)

2-Opening Remarks

In their opening remarks, Janet Walden and Janet Bax discussed the value of researchers and their partners coming together to share knowledge and explore the challenges that lie ahead as the JIIRP moves forward. Listed below are the key messages that were shared during this opening session of the symposium.

Janet Walden, Vice President of Research Partnerships Programs at NSERC

- This symposium is in essence about partnerships: it is an opportunity for the research community to come together to see how it can provide assistance to Canada's infrastructure issues.
- A key goal of the symposium is to understand and discover what new linkages exist in Canadian infrastructures.
- The six research projects that are being presented here will unearth many challenges that lie ahead of us.
- This initiative is new for NSERC so we are working closely with PSEPC to help define this area of research more clearly.
- It important to keep in mind that the synergies that develop in symposiums, such as these, will continue to influence research programs that will take place in the coming years.

Janet Bax, Senior Director, Infrastructure Assurance Program, Public Safety and Emergency Preparedness Canada

- Government, typically, does not do a good job of working horizontally yet it is key to the success of JIIRP.
- Building a national critical infrastructure will succeed if researchers and partners work well horizontally. This symposium represents an attempt to do this.
- There is a need to persuade politicians of the importance of research and that quality research is being undertaken.
- To make an impact on politicians, it is important to illustrate how the research that is being done is useful.
- There is also a need to find ways to share the research and to apply it to real world problems.
- A key way to apply the research to real world problems is to apply it to the national critical infrastructure.

3-Presentations

3.1-Decision Making For Critical Linkages in Infrastructure Network

Jose Marti, University of British Columbia

The focus of Dr. Marti's presentation was on how to effectively make critical infrastructure decisions during emergencies. The following items outline the key points that were raised during his presentation.

Overview of the Project

- The key goal of the project is to use systems theory to help save human lives.
- The main objective and first priority of managing disasters is to maximize human survival rates.
- The key problem that exists during a disaster is that when one critical infrastructure goes down, others come down simultaneously. When this happens infrastructures start "stepping on each other's toes" when they try to recover.
- Since each infrastructure (power, water, etc) knows best how to recover its own system, the goal of this project is focussed solely on the *coordination* of the recovery.
- Ensuring effective coordination is dependent on having a clear understanding of how one system's decision affects all of the other systems.

The Requirements of Survival

- Action needs to be taken on the ground quickly and effectively in the event of an emergency.
- To do so it is essential that support systems have a clear understanding of what the needs of the victims are.
- There are a number of items that are vital to ensure that as many people as possible survive during a disaster. These items or "vital survival tokens" include things such as food, water, shelter, personal communication, panic control, medical care, sanitation, individual preparedness and civil order.
- Panic control is a very important vital survival token. This is because it is much harder to recover from and manage a disaster when people panic. Panic control is also important since civil order decays when panic sets in.
- During an emergency it is critical that survival tokens are delivered quickly from repositories to victims and first responders.
- In such a system it is critical that the location of the survivors be clearly identified.

Delivering Survival Tokens

- There are numerous points in a critical infrastructure that depend on each other. (For example, water systems will not work without power.)

- In order to ensure that survivors receive survival tokens, interdependent infrastructures must work in a coordinated manner.
- This “survival network” is a multi-token system that involves multiple interdependent infrastructures working together to maximize survival rates.
- The tokens that are required to be delivered in the survival network can be categorized as physical (e.g. electricity, food, water, medicines) and professional (e.g. education, nurses, doctors, firefighters and police officers).

Decision Making and Coordination

- The transportation network required to deliver tokens consists of a number of “layers”.
- The human layer is very important since a lot of decision-making and coordination must be done at infrastructure interdependency points during an emergency.
- An example of decision making that would have to be done during an emergency would be when all of the power required to run a system could not be restored. In such a case a decision maker would need to prioritize which areas in an infrastructure should receive power.
- The key for the decision maker is to coordinate the sequence of actions that result in maximizing the saving of people's lives.
- A transmission matrix is a useful tool that allows one to see interdependency links that exist between different systems.
- The matrix can incorporate all of the information required to assess a system’s survivability index and can dynamically coordinate disaster survival actions.

Islanding

- Another technique for increasing a system’s survivability index is using the idea of islanding. This idea can be used during a disaster’s first-moments to prevent panic and other dangerous cascading events.
- Islanding is a well-known and effective strategy for segmenting networks and preventing cascading effects.
- An island can survive on its own for a limited period of time. Beyond this period, help needs to be coordinated and delivered from the external world
- Islanding also allows for more opportunity for outside help to reach each sub-region.
- Doing this works to control panic and helps speed up the process of getting vital tokens to survivors.

Simulations and Disaster Management

- To effectively manage large scales emergencies, infrastructure managers must get together in a “disaster coordination room” to coordinate interdependency actions.
- A faster than real time simulator (the DNSIM) would be available to the infrastructure managers for testing out actions before applying them to real world situations.
- The DNSIM simulator implements the concept of individual infrastructure subsystems interconnected through interdependency links.
- The simulator would function as a key mechanism for getting ideas on how to deal with disasters.

Question and Answer Session

Following are the key discussion points that were raised during the question and answer period.

GIS

- The team is in the process of taking a survey to see how to effectively use the GIS system.
- In the future, GIS will be an important visualization tool for the project.
- GIS will be used to define the sensitivity of the simulator they will develop.

Communication During an Emergency

- It is possible to have island-to-island communication during an emergency. Communication, of course, may not be optimal.
- Before a disaster happens, the infrastructure has to be as strong as possible to minimize communication breakdowns.

Prioritization When Recovering a From an Emergency

- The key to prioritization is to identify the critical feeders before a disaster happens
- Any major sub-stations will be the first to have their power restored.
- The system has to be set up so priorities can evolve as a disaster unfolds.
- When restoring power, the key priority is to get the grid up and running as fast as possible. It is important to note, however, that even if the grid is up it still doesn't mean power will be available to all places.
- When trying to establish priorities in an emergency, every problem and every situation is different.
- Ontario Hydro does work to take into consideration other groups when it is recovering from an emergency.

Simulations

- Any simulations must always be done in real time during an emergency. Decisions made during an emergency will always be the best ones possible at any given moment.
- The simulator is dynamic and local.
- The more the simulator is used with different scenarios the more effective it becomes at identifying how to respond during an emergency.

3.2-Modelling Interdependencies for Emergency Management

Vincent Tao, York University

Dr. Tao focused on the modelling of interdependencies for emergency management using geographic decision support systems. The items listed below capture the key elements of his presentation and outline the discussion items that were raised during the question and answer session.

Overview of the Project

- The project looks at the issue of emergency management from a geometrics (Geomatics) perspective.
- The key objectives of the project are to:
  - study location based infrastructure interdependency (LBII);
  - study the interoperability of systems during emergencies;
  - use scenario-based approach to analyze interdependencies; and
  - Develop and design a prototype for supporting decision making.

Infrastructure Interdependency

- An emergency event can cause “cascading effects”. For example, a failure in the power sector will affect many other critical infrastructure functions.
- This project focuses on the relationship between infrastructure interdependency and emergency response planning.
- The dimension of infrastructure interdependency and interoperability is very complex since many different systems (e.g. power and water) work together as integrated functions.
- Since a lot of knowledge exists with respect to how systems work together, a key challenge of the project is to effectively use this knowledge to ensure dependencies are clearly identified.

The Four Components of the Project

- The four key components of this project include using sensor networks to collect data, integrating modeling tools that can utilize the data, constructing a knowledge base and design and development of a distributed decision support system.
- In order successfully complete these components of the project it is important to note the following:
  - The integration of tools is essential when constructing a knowledge base.
  - Integrating modelling tools means that the interoperability of systems must be thoroughly understood.
  - It is essential that the knowledge base is built so information can be effectively shared.
  - The information in the knowledge base must be presented using a powerful user-interface and GIS.

The Sensor Network Tool

- To utilize a "sensor network" it is important to link massively deployed sensors that will collect and integrate data from a variety of sources.
- GeoSWIFT allows for the real time integration of many different systems, using over 100 connected sensors.

Event Modeling Tools

- A key goal of modelling is to analyze the threshold of what will trigger problems (e.g. what flood levels will trigger problems for the infrastructure).
- One can also use event trees to analyse the logical flow of what will happen if a dangerous event, such a hurricane, takes place.
- On October 15 and 16, 1954, hurricane Hazel struck the Toronto area. The downpour caused flooding of the Humber River and did significant damage to the city. The cost estimate of the disaster was $100 million.
- Different sections of the Humber River and various other vulnerable sites are now being analysed using tools such as hydraulics modelling, dispersion modelling and fuzzy logic based modelling,
- It is important to note that there is uncertainty when developing models for interdependency analysis. As such, tools such as fuzzy logic modelling are very useful.
- Additionally, dispersion modelling allows one to see how much time one would have before a huge amount of damage is done during an emergency event.

Knowledge Construction Tools

- The research team is in the early stages of the development of the knowledge base.
- The knowledge base will be built using accumulated information from many sectors.
- A key component of the knowledge base will be a rule-based inference engine. It will help answer the question "if event x occurs, what subsequent actions will happen next?"

Spatial Visualization and Integration Tool

- This tool will combine visualization applications with models and data in to generate an interface that will support decision makers.
- The tool will also allow users to run models to identify infrastructure vulnerabilities.

Key Points from the Question and Answer Period

Telecommunications

- Since it is becoming a key system for controlling vital sectors, it is important to look more closely at the dependencies and vulnerabilities of telecommunication networks.
- There are reports that are available from the telecommunications sector that give more insight into the relationship between telecom and infrastructure interdependency.

Other Comments

- The same models are being used for both data analysis and synthesis.
- The knowledge base that will be develop will help decision makers make decisions. The system is a decision *supporter* and not a decision *maker*.

3.3-Interdependencies and Domino Effects in Life-Supporting Network

Benoit Robert and Luciano Morabito, École Polytechnique de Montréal

The next presentation, given by Benoit Robert and Luciano Morabito, focused on the study of interdependencies, relationships and vulnerabilities in critical infrastructure life-supporting networks in the city of Montréal. The following points capture the key elements of their presentation and outline the discussion items that were raised during the question and answer period.

Overview of the Project

- The focus of the study is on the vulnerability of infrastructures.
- This study is concentrated in a small area in Montreal to ensure that the research team would be able to get detailed knowledge of how the infrastructure functions.
- The core principle behind the project is to ensure that entities (organizations, agencies, etc) work in cooperation to maintain a principal of good faith and communication between all partners and stakeholders.
- There are three key objectives of the research:
    - to develop a new methodology of risk management based on the interdependences between Lifeline Networks;
    - to develop concrete risk management tools to prevent domino effects regardless of the events likely to generate failures; and
    - to increase the team's knowledge of problematic areas related to interdependent infrastructures.

Partners in the Project

- This research group is working with many partners in the project including all levels of government and several private sector companies.
- Workshops have been conducted with partners to find ways of studying interdependencies between different systems in Montréal.

Reducing Complexity

- The links and interdependencies between entities can become an incredibly complex system.
- Such complexity makes it nearly impossible to model all of the effects and interactions between entity relationships.
- The project is working towards reducing the complexity of these relationships.

Representing Interdependencies

- Organizations or entities can be represented as having functions, operations and internal resources. These entities also use external resources and furnish resources for other entities to use.

- In order to evaluate the interdependencies between Lifeline Networks, the way each entity uses the resources of other entities has to be clearly defined.
- Doing this will also help to identify any vulnerabilities that may exist in the interdependency relationships.
- All of this interdependency information is currently being collected and will allow for a detailed description of all entity relationships.

Dependency and Consequence Curves
- A key goal of the project is also to evaluate the dependency curves between entities.
- Dependency curves describe how much of a particular resource is required for the user of a resource to perform optimally.
- Identifying these curves helps to clearly define the risks and vulnerabilities involved in a particular entity relationship.
- Similarly, consequence curves detail the negative outcomes that result if an entity is unable to supply other entities with resources.

Example Interdependency
- An example of how interdependencies work together can be illustrated by describing the relationship between Hydro Québec and GazMétro.
- Hydro Québec's key mission is to produce electricity. Hydro Québec's internal resources use natural gas from GazMétro to power its transportation functions which in turn allow it to produce electricity. This relationship indicates that there is a potential vulnerability with respect to Hydro Québec's dependency on GazMétro's resources.

Interdependency Matrix
- This project is focussed on clearly identifying Lifeline Networks (e.g. Hydro, etc) and sensible infrastructures (police stations and fires stations) that exist in Montréal.
- All of these interdependencies in Montréal can be illustrated using a matrix. The matrix can show how two entities are operationally dependent upon each other.
- The goal is to review each interdependency in the matrix and to determine the resource vulnerabilities and dependency/consequence curves.

Status of the Project
- Approximately 50% of the interdependencies have been identified and approximately 25% of the entire project has been completed.

Question and Answer Session

The following items list key discussion points that were raised during the question and answer period.

Relationship with Partners
- The group has excellent collaboration with partners.

- The partners gave interdependency data only when they saw that the project was important to them.
- The more a partner sees how useful the project is to them the more they are willing to cooperate.
- When partners see that a project is important to them and they see that the system operates like one giant network, they cooperate with greater enthusiasm.
- The issue of creating a sense of trust with partners is very important.
- The dialogue between partners always gets richer when more information is shared.

Other Key Discussion Points

- Managing the vulnerability risks is very important to the success of the project.
- There is a need to identify the high and low probability causes of failure. Natural causes may be of a low probability but deliberate (i.e. human) causes may be high.
- Currently, there is a researcher looking at the impact of human failure. The work is focussed on human failure and its impact on disasters.

3.4-Developing a Model of Infrastructure Interdependencies

Tamer El-Diraby, University of Toronto

Tamer El-Diraby presented a talk on the how his research group is developing a model of infrastructure interdependencies through an analysis of stakeholder needs, risks and competencies. The points listed below describe the key items that were discussed during his presentation and the comments that were made during the question and answer period.

Overview of the Project

- The focus of this project is on making critical infrastructures stronger by addressing interdependency issues at the design stage.
- The project is a way of understanding how to help engineers design a product by making them fully aware of the critical linkages to other systems.
- The project deals with exchanging knowledge about engineering and working towards integrating design decision-making.
- This work is different from that being done by others such as Jose Marti and Vincent Tao. The key difference is that their projects are focussed on improving interdependency robustness at the "decisions making" or "managerial" level.
- The work of this project, however, focuses on the representation of knowledge at the engineering or design level.

Introduction to Ontologies

- The model that is being developed, to represent interdependencies at the design level, does not focus on any particular engineering sector—the model is strictly a generalized schema.
- At the root of the model is the concept of an ontology.
- An ontology is focussed on creating a common language that will give designers the ability to share information. Some of the key features of an ontological model are that:
    - it exploits the fact that there is a common thread between all systems;
    - it provides an effective way of facilitating interoperability and data exchange;
    - it is object oriented and provides excellent scalability; and
    - it is a powerful tool for representing knowledge that is important to humans.

The Basic Ontology

- The basic ontology describes the interaction of processes, actors and resources to produce a particular output.
- It also describes constraints and mechanisms that intersect with the process, actors, resources and products.
- Mechanisms are used to support the process, product and projects and include items such as parameters, attributes and performance measures.

- Constraints, on the other hand, are used to control resources, products and processes and may include such things as laws, user requirements and environmental codes.

Ontological Management

- The various components in an ontology can be classified in an ordered “tree” diagram to indicate natural relationships. These relationships are important when understanding how the various components of a system interact with one another.
- A key characteristic of an ontology is that it starts with a set of entities and then supporting components are added to it.
- The beauty of the system is that it allows each specific component of a structure to fit into the overall ontology.

Other Components of an Ontology

- Ontologies can also be created for:
    - products;
    - product development constraints;
    - the attributes of products; and
    - actors working in a system.
- An ontology can also be developed for the infrastructure codes that affect the engineering design process. Modelling the codes make it possible to look at a paragraph in the code and see what design functions it impacts.
- Part of this project involves studying the regulatory structure of the energy industry to analyse the impact of infrastructure codes.

Collaborative Design

- All of the stakeholders that use the ontology will be represented by software agents.
- These agents will be able to roam the “agent space” and will be able to access the information in the ontology.
- A key to successfully building the ontology is to take the information companies are willing to share and add it to the ontology. Companies can remain anonymous and can continue to add to the ontology as they see fit.
- The aim is for companies to be able to share information with other groups that have a common goal.
- Given the results of these collaborations, designers may change their products to ensure the overall good is being served.

Question and Answer

The following items list key discussion points that were raised during the question and answer period.

- There will never be a time when all users of the ontology standardize their design processes and systems. This is because each user is an expert in their own domain. The goal in this project, however, is not to create a standardized system but to create a common language for communication and information sharing.

- A common model for performance measurement is being created in this project. This is a key way of showing how the overall performance of one system will impact all others.

3.5-Models that Simulate Critical Infrastructure Networks

Wenjum Zhang, University of Saskatchewan

Following the presentation of Tamer El-Diraby, Dr. Zhang presented a talk on his project to develop models that simulate critical infrastructure networks. The following outlines the key points and discussion items that were raised during his presentation.

Overview of the Project

- The potential users of the tool that will come out of this project will be key decision makers in government agencies.
- There are two key components to the project:
    - The first is to develop a model that will capture all interdependent relations in a critical infrastructure (CI).
    - The second is to create a simulation of the CI interdependencies.
- To help develop the model, researchers took past data, developed a model based on the data and then generalized the model.

What does the Model represent?

- CIs are at the heart of the model.
- A CI can be defined as physical system that, if disrupted, can seriously affect the health, safety and security of citizens.
- Within any CI there are dependencies. Some of these dependencies exist between people and the systems.
- The focus of the project, however, is on the relationship between CI systems and not the human-CI system.
- Interdependencies in a CI model can be represented using entities and entity flows.
- An entity may be thought of as a material, energy, people or information/knowledge.
- If a dependency exists between two systems then this relationship must be represented by an entity flow.
- The flow between entities can be very complex.
- The process dynamics between entities can be concurrent, asynchronous, distributed, parallel or stochastic.
- Any process relationship can be classified using one of these 5 dynamics.
- If a model is to be successful, it must be able to reflect these process dynamics.

Why build a Model?

- Identifying the vulnerabilities in the infrastructure is a key reason for creating the model.
- In order to address and study interdependencies in CIs, the use of simulations is essential.
- Simulations make it possible to see where potential problems in a CI may exist.
- A model is a good way of validating decisions when preparing for emergencies and when an emergency occurs.

- Making decisions with respect to the CI is very complex and there are many uncertainties. Simulations are a good way to reduce the uncertainties.
- Models and simulations are a good way of determining what enhancements are required of the CI.
- If a problem occurs in the CI, models and simulations are an effective way of determining the root of the problem.
- Since the networked CI system is a human-machine system, using simulations is the only way to predict its behaviour, function and performance. Also note that a networked CI system is a dynamic system and as such any simulations must also be dynamic.

How does one build the Model?

- A Petri-Net is a powerful tool for modelling concurrent, asynchronous, distributed, parallel and stochastic process such as a networked CI.
- Petri-nets are also good for use in non-deterministic systems such as CIs.

Simulations--Case Study

- A case study shows the feasibility of using the model and using simulations.
- In the case study presented here there are three CIs involved: a petrol processing plant, the transportation system and the hospital.
- The case study consists of an accident occurring at a plant wherein toxic gas leaks into a community. The victims of the accident are transported to the hospital using the transportation system.
- The goal with respect to the case study is to use the simulation to determine how effective the hospital is at handling victims.
- A secondary goal is to examine the effectiveness of the transportation system.
- We can determine how the hospitals will be able to respond to the emergency by seeing how the simulation fills up the hospital's capacity over a period of time.
- As time continues, the number of victims affected by the accident increases as does the number patients at the hospitals.
- The simulation is an effective tool to reveal how well these CIs function when there is an emergency.

Usefulness of Simulations

- Clearly, simulations of how a networked CI operates are possible using the modelling tools stated above.
- Simulations help to clarify at what point the workload in a CI reaches its capacity.
- Simulations promise to be a valuable tool in assisting and supporting decision makers.

Current Work in Progress

- The research that is currently in progress includes:
    - dealing with the scalability of the models and simulations;
    - making the tool an effective decision support mechanism;
    - developing the fault diagnosis functionality;
    - developing the tool's ability to identify vulnerable areas in the CI; and

  - working on the human-machine dependency component of the CI.

Question and Answer Session

- The key partners for this project include a team of academic researchers, individuals from industry and individuals from government agencies.
- There is a demo that is available for anyone interested.
- When trying to simulate how a CI will function in an emergency the key problem is getting information that is timely. Petri-Nets are capable of capturing fuzzy information and it is possible to create useful models using such information.
- One has to be very careful with how a model is used. The modelled system does not tell one how to make decisions. Decision-making is not a part of the project. The model is to be used to *support* decision-making. The project is geared towards simulating the consequences of a decision but do not actually make the decision.

3.6-Improving the Resilience of Water System Infrastructures

Edward McBean and Corinne Schuster, University of Guelph

The final presentation, given by Edward McBean and Corinne Schuster, focused on ways to improve the resilience of water infrastructures and the health systems that respond to waterborne disease. The following points capture the key elements of their presentation and outline the discussion items that were raised during the question and answer session.

Overview of the Project

- The project is much narrower than the work being done by the other research groups.
- The focus of the project is on studying ways to improve the resilience of the water systems infrastructure and the health response systems to waterborne diseases.
- The project deals with how systems fail, the communications between systems and how key players must respond in the event of a failure.
- A goal of the project is to make sure that things happen the way they are supposed to, with respect to emergency management and prevention.

Partners

- Some of the key partners involved in the research include municipalities such as the Cities of Guelph, Peterborough, Goderich and Toronto. These groups are important to have on board since they represent the eventual users of the research.
- Other key partners include government organizations such as Environment Canada. This group of partners are important since they provide the regulatory framework for the issues which this project is addressing.

Background

- The water management system in Ontario is an aging infrastructure.
- Pipe breaks regularly happen in many different locations across the province.
- A number of outbreaks of diseases related to water contamination have occurred recently. These include the Cryptosporidium outbreak in Milwaukee (1993) and the Walkerton E. coli outbreak in 2000.
- The most recent example of illness related to potable water occurred in Kashechewan. In this case the key problems were isolation and poor design and operation of the water system.
- Beyond outbreaks, there also exist the potential for accidents and intentional acts that can cause contamination for which planning and action must be undertaken.

Strategies and Direction

- A key strategy of the research group is to get a clear idea about what is causing the failures of the water system and health response system.
- Some of the factors that raise the risk illness include the following:
    - There has been an increase in precipitation and in the intensity of storms.

  - Research indicates that pathogens are prevalent in the ecosystem and as such increase the likelihood of contamination.
  - Cryptospiridium has been a very successful pathogen and is extremely resilient.
- Another key strategy is to clearly define the infrastructure interdependencies as they relate to water systems.
  - An example of this is defining the infrastructure involved in a "boil water advisory" - how should such an advisory be promulgated and when should it be removed?
- Flowcharting is an effective tool to identify the water system's interdependencies. It also helps to determine when such things as additional monitoring, etc. should be implemented.

Examples of Preliminary Research Findings--The Aging Infrastructure

- A key finding is that the water system infrastructure is aging and it will only get worse.
- Because of aging of the infrastructure and population growth, there will be continued pressure on the water supply system.
- The research group is looking at different watermain breakage rates of the aging system to produce a model that predicts which pipes are at risk of breaking.
- The group is also studying the effects of chlorine decay on the water system. (A water distribution system model for Goderich has been developed to study this more closely.)

Future Directions

- It is critical to have effective mechanisms for communication in the event of a failure in the water system.
- The problems of communication and redundancies are not just ones felt by small systems.
- "Learning protocols" need to be put in place that will give all players involved in operating the water system, the knowledge to respond effectively to issues.
- Without effective legislation there is resistance from municipalities to start improving their water systems as they do not have extra money to spend. There is some reluctance to initiate unnecessary reviews or monitoring as this can increase the burden of reporting.
- Currently the research group is conducting interviews to improve the understanding as to how water systems and related infrastructure systems work on an operational level.
- Additionally, the group is developing a greater understanding of the reasons for water quality failures.
- Another future initiative will be to look at the interdependencies between water and health. A problem exists due to the fact that it can be very difficult to identify the source of an outbreak, especially when dealing with small numbers of cases.

Question and Answer Discussion

- It is shocking to see how many departments are engaged in the issue of water.
- There is a student working on this project that is pulling together the linkages between various levels of government. The goal is to get to a point where a tool can be used in municipalities to help deal with water system infrastructure issues. Trying to bring together all of the different groups to deal with these issues is very important.
- More attention needs to be given to accountability and empowerment when things go wrong.
- It is very difficult to determine what outbreaks are food related and what are water related. (Note: This is not their focus of this study.)
- A key issue is controlling the number of false positives. Too many false positives are very dangerous and should avoided (i.e. if one “cries wolf” too many times people will stop listening).

4-General Discussion Period

At the conclusion of the presentations an open question and answer period was held. Listed below are the key points that were discussed during this session.

Comments on Data Sharing

- A lot of issues are centred on data acquisition and the communication of data.
- A key priority for many groups is getting real data that they can use in their models.
- It is difficult to get real data from the industry.
- Bell Canada has begun the process of sharing data but not a lot of progress has been made.
- At Ontario Hydro, there have been problems in the past sharing their data with law enforcement agencies.
- Ontario Hydro in general, does not like to share its data because it doesn't like to share its vulnerabilities.
- There has been a movement towards companies sharing data anonymously.
- It is not easy for an organization to have all of the data that the research groups require. Even if organizations were willing to share data, they may not have it available.
- It is important to be practical and very precise when dealing with a partner to get data from them.
- There are protocols to help with anonymity if an organization wants to share data.
- Researchers should look to Europe to get good data.
- There is also a lot of protection of information with respect to water systems in the US.

The Symposium

- The symposium was an important step in bringing researchers together. It is important to bring people together in a forum such as this to help all stakeholders get more precise about what is trying to be achieved.
- There should be more people who have an emergency preparedness background at these conferences. These people should be involved so we can get a real world perspective on the issues being discussed.
- Some of the presentations are too technical.

Funding

- The work being done on the projects are just beginning. The problems are extremely complex so the researchers need to know they have a commitment to long term funding.
- Canada does a lot with the little resources it has.

Other Comments

- There is a lot of communication with colleagues in the US.
- The communication channels in academia are very good.
- Researchers in industry should be approached to see if they are interested in being potential partnerships.
- It is important to know what language the researchers need to use when working on their projects so that it will help in communications with government.
- The more precise we get with respect to defining the infrastructure problems the better the solutions will be.