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Designing an Intelligent Infrastructure for River Ice Floods

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There have been 700 reported "ice-related incidents" in the province of Quebec since 2000 (i.e. about 50 per year, and, by extrapolation, about 300 per year across Canada). An 'incident' usually involves flooding that is significant enough to be preceded by preventive evacuations or to cause damages. Damages can be substantial (a whole town flooded or a road washed out) or minor (a few flooded cottages). Generally speaking, virtually all those touched by river ice events are powerless. Having no warning, no plans, no understanding of what is happening, no expertize, no tools, in fact, having virtually no resources, the 'victims' often suffer in isolation.

As civil engineers, our job is to provide infrastructure to respond to public needs. While Mother Nature will always send her runoff and breakup events, we can make a difference. Damages can be limited, victims can break their isolation and some level of community sustainability can be achieved. Building primarily on existing resources, we need to design and build intelligent river ice infrastructure (*IRII*) to respond to river ice events.

According to Fulmer (2009), infrastructure is "the physical component of interrelated systems providing commodities and services essential to enable, sustain, or enhance societal living conditions". We believe that the designed infrastructure must be primarily 'intelligent'. Intelligent infrastructure systems are "world-class applications of the most reliable monitoring, modeling and decision tools and technologies, together with the engineering support and experience of highly respected practicing engineers" (www.pennoni.com/services/service.aspx?id=201). In other words, the infrastructure should be organic. It must have instruments that monitor, networks that transmit, software that integrates data into information and people that can interpret information, make decisions, and mobilize resources.

Some components and services of a good *IRII* would be:

- Site-specific and accessible documentation of river ice processes and vulnerabilities,
- Education of local emergency management teams about the river's history and possible river ice flooding scenarios,
- Contact lists and contact protocols for local knowledgeable people and river ice experts,
- Early detection and warning systems,
- River ice numerical models tied in to local GIS,
- An annotated weather and hydrological forecast service,
- An annotated database (e.g., Carr et al. 2015),
- Contingency plans including river ice interventions, evacuations, etc.

In designing the *IRII*, we have to identify allies and ask ourselves how each actor can best contribute (e.g., local public works, local engineering firms, local watershed-based organizations, schools, each level of government, their ministries, their resources, their programs, etc.).

Despite its severe inadequacy, here is an extreme example of intelligent infrastructure from the Philippines. The sun was shining and the 2013 Christmas celebrations were well underway in Cagayan de Oro when a young professor got a call on December 18th from one of his students who lived up in the mountains. He said 'professor, it's raining here and I have never seen anything like it - the river has become a wall of water'. The professor was closely tied into the. He got on the phone and because a phone chain list had already been developed the word got out on the street very quickly and thousands and thousands of people evacuated the low-lying regions in the next few hours in rain and under darkness. Their 'social media' worked. These actions were able to limit the number of deaths to about 2500 people only. Without that phone call the flash flood would surely have killed most of the 150,000 living in the floodplain times more. Obviously, the infrastructure had terrible weaknesses. On the other hand, it shows what is possible when simple links are forged and are trusted. There was a sensor (the student0, a data transmitted ('wall of water'), converted into information by an expert (professor) and relayed through an established (though completely informal) network where people had sufficient leadership and trust to enable them to act.

Translating this experience into a Canadian context, should the monitoring of Twitter conversations for key words such as 'flood' be an important part of the infrastructure? Should GPS traffic patterns of cell phone movements be part of the infrastructure to tell us where people are fleeing or where they are detouring?

In our experience, it is very difficult to understand what is happening during a river ice flood event. It is difficult to access the river, to get hard data, to know the governing processes in time and space, and to know what will happen next. Is the use of drones during events the most important vehicle to understand what is happening and should they be part of the infrastructure? Drones are powerful tools that can relay 3D terrain digital data as well as visual images.

Given the chaotic nature (i.e., the complexity, infrequency, time-space indeterminacy and random amplitude) of river ice events; given the number of ways they can impact (e.g., flooding, ice damage, freezing damage, etc.); given the elements at risk (roads, bridges, railways, historic buildings, residences, industries, etc.), the *IRII* must be particularly agile, versatile, responsive, and adaptive.

The damages caused by river ice are grossly underestimated. Given that individual events are often viewed as isolated anomalies, investing in river ice infrastructure is not now on the political radar so funds are scarce. Therefore, *IRII* must leverage existing resources rather than being, in itself, a heavy, costly, homogeneous and monolithic entity. It also needs champions.

Warren Buffett (the all-time greatest Wall-Street investor) is quoted as saying that '*predicting rain doesn't count; building arks does'.* The purpose of this presentation is to initiate a dialogue. Are we going to continue to watch on the sidelines or, as civil engineers, how can we design a river ice intelligent infrastructure and how can we build it?

No project ever gets done without a champion. Are you feeling like Noah today?

References:

Carr, Gaughan, George and Mason. 2015. CRREL's Ice Jam Database: Improvements and Updates. CRIPE 2015. Quebec. QC.

Fulmer, Jeffrey (2009). "What in the world is infrastructure?". *PEI Infrastructure Investor* (July/August): 30–32.