Making Resilience Accessible

ACCESS: AN ENABLER OF COMMUNITY RESILIENCE

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FUTURE READY

Abstract

Services are a big part of the conversation around resilience. How quickly can we get the power grid up and running? What about the water supply? What do businesses need to maintain operations? Not surprisingly, many municipal planners believe that if you can answer those questions adequately, you are resilient. You will be able to bounce back after a blow.

But there's missing piece of the puzzle in all this: people. If a municipality is going to be able to withstand a shock, don't its people have to be resilient, too?

When a natural disaster turns daily life into chaos, people need to be able to implement their own personal resilience plan. They need take charge of themselves, to shelter in place, for up to 72 hours. Why? Because if they do, municipal efforts can focus squarely on recovery.

The Canadian government has been promoting this kind of emergency preparedness for years. How-to pamphlets get mailed out across the country. Detailed websites get launched. The only problem is, no one listens. Only a tiny percentage of Canadians say they are ready for the next disaster.

But there is a solution. The smartest planners are sidestepping the whole issue of people and emergency preparedness by ensuring people have access instead. Access to those items they will need most in an emergency, like food, cash and fuel. Access to reliable communications and supportive communities. If they have all these things, research shows, people can safely and securely shelter in place, with or without that government-mandated emergency kit, while efforts are underway to reboot an entire city.

Unfortunately, access is the seldom-mentioned enabler of resilience. This paper intends to change that.

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Introduction

For Southern Ontario's 12.1 million inhabitants, freezing rain in December is not unusual. But the severe storm that swept through the region on December, 21, 2013, brought with it the kind of damaging ice accumulation that can force even the largest cities to a grinding halt. By the time the storm had ended, up to 30mm of ice had downed trees and power lines, made roads impassable and hamstrung public transit systems in some of the country's most densely populated areas. As many as 830,000 hydro customers were without power for several days, or longer. Power was only restored to most residences and businesses on January 1, 2014.[1]

The storm was definitely a shock, but was it a freak occurrence? Not anymore.

In fact, natural disasters, driven by our changing climate, are on the rise. Canada's insurance industry has said they are now three times more frequent than just five years ago. (ACI 2016) Losses are also increasing every year. (IBC 2015)

If extreme events are the new normal, planning for them has to be the new normal, too. That planning often revolves around the idea of resilience, or the ability of an operation, or for the purposes of this discussion, a city, to absorb, adapt, respond to and rapidly recover from a catastrophic event.[2]

Resilience is certainly part of the answer. But a careful review of the fundamentals of resilience reveals an important fact, a fact that can be overlooked by planners: in an extreme event, individual citizens need to be able to self-recover. They must be able to meet their needs for food, water and other essentials for the first 72 hours after a shock without relying on the municipality. Why? Simply put, if individuals have prepared for an emergency and can look after themselves, then the city as a whole is much more likely to survive.

A Word About Sustainability

Work by the UN (UNISDR 2013)(UNECE 2016) and University of Toronto increasingly points towards a symbiotic relationship between resilience and sustainability. Reducing our demand footprint to levels that do not compromise future resource demands (UN 1987), enables effective dependency management and so resilience. (Hay 2016a) Similarly, resilience is the pre-requisite of sustainability (UNISDR 2013).

EMERGENCY PREPAREDNESS: MESSAGE NOT RECEIVED

For years, various levels of governments have been trying to get Canadians to buy into the idea of emergency preparedness. Know the risks, make a plan, get an emergency kit, they urge. Unfortunately, the message does not seem to be getting through. In fact, recent estimates suggest that just five per cent of Canadians have readied for a natural disaster and would be able to safely and securely shelter in place for those crucial first 72 hours.

With adoption numbers that low, it may be time to acknowledge that, despite the government's best efforts, most people are not going to prepare for an extreme event.

While this certainly sounds like an obstacle for municipal officials, shifting the focus away from individual emergency preparedness could actually allow for a deeper discussion around another, potentially more important resilience enabler: access.

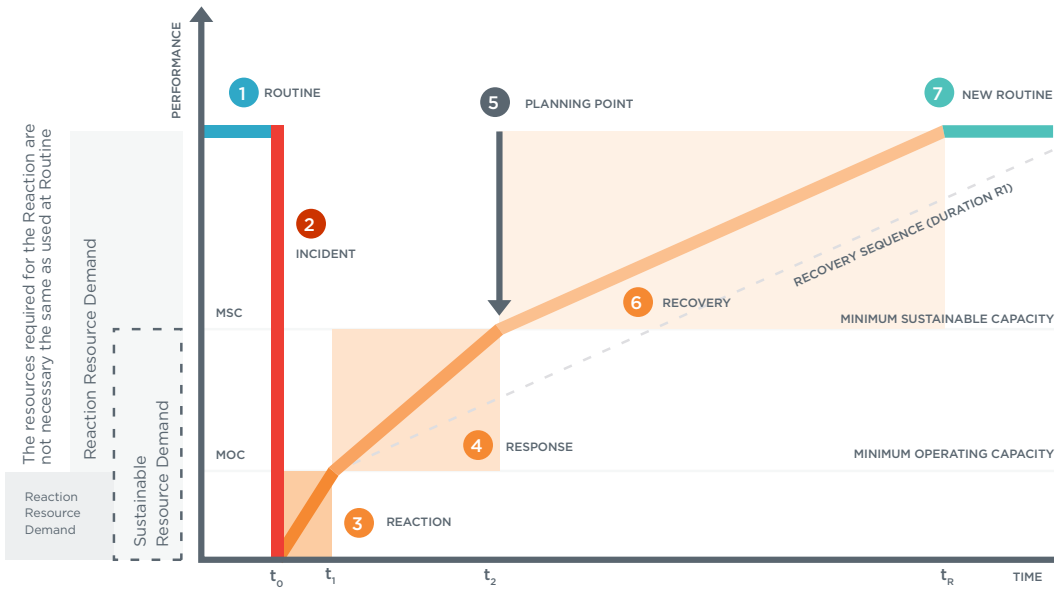
[1] An ice storm hit Toronto 22/23 December 2013 with after effects to 27 December. 250,000 residents lost power for up to two weeks. The Insurance Bureau of Canada estimated the property losses from this event at $200,000,000 in insured damage.

[2] The University of Toronto Centre for Resilience of Critical Infrastructure defines Operational Resilience as "... that essential ability of an operation to respond to and absorb the effects of shocks and stresses and to recover as rapidly as possible normal capacity and efficiency." www.crci.utoronto.ca

ROUTINE, REACTION AND RESPONSE: THE IDEAL RESILIENCE SCENARIO

Before we look more closely at access and its important connections to resilience, it may be helpful to get a clearer understanding of how effective resilience planning functions in the face of an extreme event. We can do that by reviewing an incident sequence in more detail.

It is often best to think of resilience as capability at each stage in the sequence of an incident, (Hay 2016b) starting from the Routine phase through to the Reaction and Response phases, then on to Recovery, and finally a New Routine.



1. **ROUTINE** | Capability absorbs the effects of the event to prevent harm coming to the operation.
2. **INCIDENT**
3. **REACTION** | Capability minimises the magnitude of the operational failure and provides an automatic reaction to restore essential life support.
4. **RESPONSE** | Capability provides city officials with the right situational awareness to make decisions and the necessary minimum resources to implement them.
5. **PLANNING POINT**
6. **RECOVERY** | The pre-set capabilities during the recovery phase enable a pre-defined sequence of functional restoration back to a routine level of performance.
7. **NEW ROUTINE** | The lessons learned from the event are incorporated into the new routine practices.

A MORE DETAILED INCIDENT VIEW

REACTION PHASE

At the point that an incident like the 2013 ice storm occurs, time t_0, performance can drop to zero. Here a municipality enters the Reaction phase, when essential and critical functions are immediately and automatically restored to bring overall performance up to the Minimum Operational Capability (MOC).

MOC is the absolute minimum survival level of performance for operation-defining functions and must be achieved by t_1, within the tolerances of the operation. Without MOC, further restoration of function is not possible.

RESPONSE PHASE

The Response phase begins once MOC is achieved. It is also the situation-specific functional restoration necessary to achieve a Minimum Sustainable Capability (MSC). This is the level of performance at which the operation is sustainable; if the operation is a business, it may not be making money, but it's not failing either.

The time taken to achieve a level of performance at MSC is known as the Planning Point and reflects market tolerance of operation interruption. In Canada, the market tolerance is typically 8 a.m. the following business day, even if the cause of the interruption is ongoing. (BOMA Toronto 2015) This tolerance will be different for more time-sensitive applications, for example the tolerance for elevator failure will be limited when the elevators are the principal access to food or for emergency services.

RECOVERY PHASE

The Recovery phase is a strictly sequenced restoration process that is planned as if from MOC at t_1 through to the achievement of the New Routine. This new routine level of performance is not the same as the pre-incident routine, as the municipality will have learned from the incident and adapted to become more efficient.

The Recovery phase begins from MSC. During this restoration sequence, each function is assessed and, if necessary, restored. Since not every function will need restoring, the Time to Recovery, t_R, should be less than the calculated Recovery Time, RT, which assumes that every function must be restored. RT can be used to derive the maximum income loss exposure for insurance valuation and the risk exposure for assets and vulnerable populations.

Measuring Resilience

It is a municipality's capability to absorb, adapt, respond and recover that defines how resilient or fragile it might be. Historically though, measuring that capability has not been an easy task. Performance metrics are not consistent or relatable between organisations, nations or communities. Culture and risk criteria will be different, geography, politics and jurisdictional responsibilities will be different, and hazards will manifest in different ways. In the same way that best practice can't truly be transferred from one city to the next, the assumptions and contextual definition of performance cannot be compared between cities.

Measurements of performance are measurement of what is, not what would be. This also reflects another misconception about resilience. Inanimate objects cannot be resilient. They can't respond and self-recover. Therefore, it is more correct to say that a bridge is robust, but a transportation system can be resilient. It's really a question of systems.

INFRASTRUCTURE: PLANNING TODAY FOR THE FUTURE

If we think of the operations and functions that make up our lives, individually and as communities, we will quickly see that each relies upon an intricate network of enabling infrastructure and services, which in turn rely on other things. These are the systems that define our ability to do something, whether it is withdrawing cash from an ATM or a fire crew responding to a fire. Each of these systems is interconnected and together, they enable our lives.

This holistic construct is known as a vitae system of systems (Hippel, 2011) (Okada, 2006) that is often represented as a holarchy (Bristow 2015a) (Bristow et al 2013) (Maier, 1998) with each higher capability enabled by others. The purpose is simply to enable convivial and vital communities that survive. (Okada, 2006)

Underlying the whole is a network of infrastructure systems that supports each component capability and frames both our perspective and our behaviours. If we overtax it – through intensification, say – the systems can't support continued occupancy, even under routine conditions. (Hay 2014) (BOMA Toronto 2015) These failures result in a loss of confidence, depopulation and divestment, and finally reduced tax receipts. (Hay 2016a)

As infrastructure takes a long time to realise and often serves far longer than the communities it supports, we need to define that infrastructure purpose not by today's needs but rather by the capability that we wish to have in the future. (Hay 2016a) Infrastructure is a statement of future intent. It says that the municipality has a vision of what it will be in 25 and 50 years' time and this infrastructure will support that vision. Some describe infrastructure as the enabler of the next generation's prosperity. More immediately, it is a constraint to how we can live today. It defines not only capability, but inherent risk exposure.

ADVANCES IN SYSTEM MODELLING AND THE SAFE-TO-FAIL PRINCIPLE

The 2012 City of Toronto Infrastructure Resilience Study (TEO 2012) (Bristow 2015a) was the first time that a large-scale, complex operation was successfully mapped. It was conducted manually using three iterations of dependency. Since then, capabilities and tools have advanced significantly, with no apparent limit to the degrees of dependency anymore.

Dependency modelling is now faster, geo-enabled and repeatable using directed path graph modelling and without compromising the evidence-based objective and fully auditable analysis of the core approach.[3] This means that we can now see how failure affects entire systems, and so the actual capability of the whole. It allows us to see clearly what the operational and cost consequences of an incident are and test various mitigation strategies. More importantly, it allows us to see how much inherent risk the systems are carrying; how much background stress they are subjected to and therefore how little applied stress could cause failure. Simply put, this new advanced dependency modelling allows us to holistically pursue a principle of Safe-to-Fail. (Hay 2016a)

Location Risk Assessment

Manual mapping tools like Location Risk Assessment remain highly relevant today because they show how our little patch of paradise is directly and indirectly affected by an event – like how the flood that doesn't reach us still shuts down the substation that provides us with power. Location Risk Assessment allows us to look at infrastructure and see whether it is vulnerable to failing in a particular event. Similarly, if we are planning infrastructure, we can see what the consequences of a failure would be.

A Safe-to-Fail network allows for the failure of one system in the design of related systems. Across the system of systems there is absorption of the consequences of failure so they do not lead to a catastrophe. For example, are houses able to maintain a manageable temperature during a prolonged power failure, like the one experienced during the ice storm? If not, the occupants will need to shelter elsewhere. Water systems in the house could freeze and rupture. Being able to continue in the event of a massive service failure – even if only for a graduated slow decline in function – allows one to manage and limit the consequences of that failure. It is managing exposure to loss.

The Safe-to-Fail principle requires that city planners assume that part of the infrastructure system will fail and then build in access to the service it represents. Dependency modelling can help us achieve that by providing a whole cross-system understanding of failure.

An understanding of the shared use of infrastructure as well as how and why it is used, rather than simply how much and where, provides us with a level of understanding about requirements that helps define our relationship with our neighbours and the infrastructure itself. (Hay 2014) At a regional level, this may be the relationship between neighbouring municipalities and with the provincial infrastructure that enables them. This is known as Equilibrium (Hay 2014) and is a development of Elinor Ostroms' "Governing the Commons." (Ostrom, 1990)

[3] RiskLogik risk mapping software is one such example. www.risklogik.com

Our understanding of infrastructure's performance and connectivity allows us to specify its role more closely at all stages of an incident. Specifying the capability that the infrastructure should enable during Reaction, Response and Recovery means that we can fully enable Emergency Management preparation for disasters, mitigate the effects of system failure and more broadly enable the municipality's management of resources during a crisis.

For example, in a prolonged power failure like the one that occurred during the 2013 ice storm, community housing blocks could be without heat during freezing temperatures. In such a situation, the municipality will need to allocate resources to keep the residents alive. These might include school buses to keep people warm, staff to go unit to unit and help the elderly and infirm negotiate a couple of dozen flights of stairs. Then there are the attendant sanitation, water and feeding issues to deal with. Before long, the logistics tail and the ensuing administrative burden on the municipality becomes a significant resource burden.

How much simpler and preferable for both the municipality and all involved if the occupants could remain in place with a minimum of assistance? What if essential services could be maintained even during a major power failure? By investing in essential functionality, we not only save a significant amount of money, but municipalities can focus on the all-important Response phase of the incident, because the population safely shelters in place during with the Reaction phase.

An Access Success Story

The regional municipality of Tirol recognized the need for enabling the shelter-in-place principle and redeveloped community and affordable housing into dispersed medium rise properties designed to passive house standards. It meant that during a winter power failure in the -30oC Austrian Alps, the municipality's resources could be focused on recovery of the community as a whole, not basic survival needs.

Applying Resilience

While we may understand the logic of self-recovery, sheltering in place and the Safe-to-Fail principle, today's demands often divert focus from planning for tomorrow, much less for the next generation. As if to reinforce this point, we have so far, in Canada, always been able to buy our way out of trouble. It remains to be seen if the Fort McMurray wildfire losses will prove to be the event that changes that.[4]

Until now it has been simpler to stick with familiar planning models and leave disaster planning to the Emergency Managers in the expectation that it will never happen. That may have worked before climate change triggered an ever-increasing number of extreme events. But many of these familiar models are no longer valid. That increasing concentration of value and the rising cost and liability of failure will soon mean that we cannot buy ourselves out of a loss. For example, the City of Thunder Bay, Ontario is currently in court over liabilities arising from 2012 floods that damaged thousands of homes and interrupted gas and electricity services.[5] Further flooding in 2016 provides a stark reminder of the changing frequency of extreme events.

And yet, even as extreme weather events grow in frequency and impact, the biggest trend in municipal planning remains densification. This is happening through concentration in existing floor space, known as space optimisation, and through ever-taller building construction.

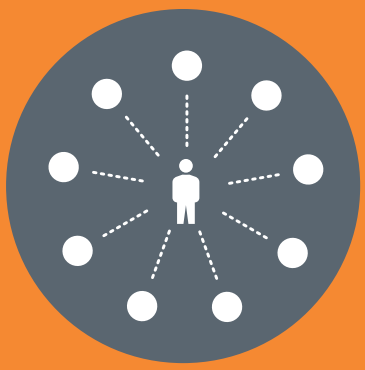
There are residents in these high rises who are, strictly speaking, in food deserts despite having a grocery store in the same block. There are increasing issues around emergency response when the elevators aren't working. How many flights of stairs can a paramedic climb to reach a patient in critical need of attention? This is a running frustration for many city staff, as it is for anyone who depends on an elevator for even the most basic forms of access.

When we consider space optimisation, do we also consider the time that it takes to evacuate in an emergency? If the fire code requires a two-hour rating and it takes five hours to evacuate, is that still safe? Questions over life safety and interruption of operational capability have become more pressing and vital as the built environment less resembles the world that the codes were based on. The changing demands of a life lived in a genuinely three-dimensional environment need to change the way we think about individual and community safety and survival. They need to change the way we need to think about Safe-to-Fail.

The common denominator in all of this is access and egress. Though no replacement for a properly conducted resilience assessment, if a property owner, developer or planner can address the access and egress of properties, we can collectively begin to enable self-reliance during the Reaction phase of an incident. It doesn't remove the need for insulation, ventilation and life support systems, but it does mean that individuals and businesses can access what they need, and emergency services can reach them, if necessary. Access and egress are not the whole answer, but they do also help prevent a sense of helplessness and isolation, particularly among the most vulnerable.

[4] Wildfire burned through the southern half of Fort McMurray during May 2016 destroying 2,400 plus buildings and 600,000 ha. It is anticipated to be the largest insurance loss in Canadian history.

[5] www.thunderbay.ca/city_government/news_and_strategic_initiatives/new_releases/update_on_2012_flood_class_action_proceedings_s_p21096.html accessed 17 August 2016.



Access to Amenities

When we talk about access, we're really talking about two things: access to resources like food, water and cash; and access to and from the places we live and the services we frequent, like the grocery store and the bank. After a shock, these two types of access are underpinned by a basic level of functional infrastructure, like backup power for elevators, ATMs and other essentials.

With that in mind, consider this common scenario: an elderly, infirm woman lives alone on the 20th floor of one of those community housing blocks affected by the ice storm. A lack of access planning means that the ensuing and prolonged power failure forces her to walk down 19 flights of stairs and then on to the grocery store, returning with two bags of groceries to climb back up those 19 flights of stairs. Is this how we would wish to treat our most vulnerable?

A power failure shouldn't mean a complete loss of power and certainly not a transition period of just two or four hours of elevator use for emergency crews. Elevators became critical infrastructure once we began building above the 7th storey, the height of a fire engine ladder. Similarly, the push upwards has been accompanied by a reduction in storage space, stimulating a greater reliance on day-to-day grocery shopping rather than the more typical weekly shop in medium- and low-rise dwellings.

We should be considering access to amenities of between seven and 15 minutes walking distance. This will be different by demographic group. A parent with an infant and/or toddler will not get as far as an able-bodied individual in their mid-thirties.

AMENITIES THAT ENABLE SELF-RECOVERY

The question then becomes, which amenities do we need to access? Maslow's observations about the needs of man are a useful start: food, water, warmth (or cooling) and shelter from the elements. Historically, we can also see a community need to access cash and, depending on the circumstances, fuel. Nowhere was this more obvious than in the wealthiest neighbourhoods in New Orleans where the land was so expensive that no one could support a grocery store, ATM or gas station. As a result, when Hurricane Katrina hit, the occupants of those neighbourhoods could not remain in place without assistance and resources that were desperately needed elsewhere.

Similarly, experiences of non-government organisations in catastrophe areas indicate that an effective communications structure, even if only SMS-text based, offers enough situational awareness to reassure populations. Ushahidi[6] is possibly the most widely recognised of these organisations and provides real-time updates of where different commodities can be had during a catastrophe. Municipality and regional-government use of text messaging and some social media platforms provides clear direction and general situational awareness.

[6] www.ushahidi.com

Building on that historical experience, we can say that there are eight essential amenities for residents:

Ensuring access to each essential amenity would mean that certain services must continue, even when there is a service failure. Referring back to the Incident Sequence discussed above, the resource demand for essential functions in the Reaction phase is significantly less than Routine or even MSC resource levels. The 2015 BOMA study (BOMA Toronto 2015) estimated typically 20 per cent of Routine resource demand is for essential services.

If essential services in a building were provided from a dedicated circuit, one could easily reduce overall demand in an emergency. The advent of smart meters makes this possible. In an emergency, a power utility could reduce the overall demand on its supply to within a more workable level if there is still any power available. It would mean that the utility would need to understand the customer needs, why and what the energy is for, rather than just quantities.

Similarly, property owners could provide their own standby generation connected to the essential circuits. For businesses, this means that servers could continue, as well as transmitter stations and water pumps. It means that the community services don't fail and that no one goes out of business. This is important, because if the community can prevent anyone falling below MOC, restoration to MSC within the Planning Point is not only possible, but probable.

One critical service in any urban setting would be elevators. Perhaps use of the essential circuit would mean that just three instead of six elevators are operational, but that maintains an acceptable level of access. Similarly, we maintain water pressure in the pipes for both drinking water and fire-fighting. Where this fails, access to standpipes at ground level has proven practicable in the past.

ACCESS TO AMENITIES ENABLES COMMUNITY ENABLES RESILIENCE

A 2012 study at the University of Toronto identified five characteristics that were common to all the communities that had demonstrated resilience by surviving a catastrophe. (Hay 2013) They are:

- Community identity
- Community focus
- Strategic framework, which defines the relationship of the community with its neighbours and the enabling infrastructure
- Infrastructure in balance with the demands of the community
- Confidence in leadership

Community makes people – and places – better able to withstand shock. In times of stress, that sense of community is bolstered through access. Here's how:

ACCESS ISSUE 1: SHELTER AND PROTECTION

Proper access to shelter and protection means adequately heated/cooled housing and barrier-free options for some demographic groups. Heating and cooling should be done with minimum dependency on active systems to reduce energy consumption, especially during operations under stress. Passive house concepts and on-site renewable energy sources can result in net-zero or even energy positive (e+) buildings and should be encouraged to break the energy dependence (UNEP 2016), which is especially critical in times of stress. Sufficient insulation and/or heating will also prevent secondary effects such as breaking water pipes from frost.

ACCESS ISSUE 2: WATER

This includes access to potable water as well as waste-water disposal. During regular operations, 24/7 access is expected in developed countries. During operations under stress, access still has to be guaranteed but can be more restricted by less convenient and less constant supply.

ACCESS ISSUE 3: FOOD

Access to food is another critical operation. High-density neighbourhoods with less in-home storage require daily food access while low- and medium-density neighbourhoods are generally less dependent on daily access. Food deserts are a growing concern, especially for low-income groups (Jiao J. et al. 2012) which affects all aspects of life, most notably health. The long-term goal for municipal planners should be to encourage access to food in walkable distances to break dependencies on cars and fuel. A lack of refrigeration due to reduced power in times of stress can also increase the need for daily food access.

ACCESS ISSUE 4: CASH

During normal times, cash is no longer king. In fact, the number of retail transactions conducted in cash continues to decrease (Fung et al. 2015) and daily access to it is no longer critical for most people. But in times of stress, cash is the main enabler for food and public-transportation access. This can be problematic as the population has reduced cash reserves on hand. As a result, developers should be encouraged to include bank machines with designated power options as part of housing developments.

ACCESS ISSUE 5: COMMUNICATION

Communication and Information and Communication Technology (ICT) have become an essential part of everyday life. Before, during and after an event, these technologies play a vital role as warning, organisational and reassuring tool (FEMA 2014). Trust in leadership is critical during times of stress, and communication is the key to develop and maintain this trust. Enhancing the robustness of communications through, for example, designated power to cell phone towers, providing recharging locations for cell phones and using social media to contact the public supports the resilience of the community.

ACCESS ISSUE 6: HEALTH CARE

Health care access is critical, especially for parts of the population with ongoing health issues. Health care can be divided into multiple categories, each requiring their own access:

- Emergency medicine, including first-aid response
- General health (family doctors, walk-in clinics and hospitals)
- Nursing care
- Medications, medical supplies

Each category will require access of the health-care provider to the patients or access of the patient to the health-care facility.

ACCESS ISSUE 7: CHILD CARE

Child care benefits the community during routine operations and especially during times of stress. In routine operations, access to affordable and quality child care benefits the social needs of parents, aids local employers and supports smart growth and sustainability within the community. During times of stress, child care, including child care provided by schools, will reassure critical personnel that their children are safe and allow them to contribute to the recovery of the community. To enable child-care centres to shelter children, they will have to be planned to operate with off-grid capabilities for up to 72 hours, this includes backup power sources (fossil and/or renewable). Buildings with low-energy footprint should be encouraged to reduce grid demand-dependency.

ACCESS ISSUE 8: TRANSPORTATION

Transportation both by car and/or public transportation remains critical in regular operations, with 74 per cent of Canadian commuters driving a vehicle and another 12 per cent taking public transit to work (Statistics Canada 2011-1). In operations under stress, access to transportation, including access to fuel or public transit, is essential to ensure that everyone required during the response time is available. The ultimate goal has to be to reduce the dependency on transportation by encouraging shorter commutes that can be done by walking or biking.

ACCESS ISSUE 9: COMMUNITY

Community is defined as access to common facilities such as community centres, libraries, schools or other organisations that create a sense of community and add to the identity of the community. Access to these operations is becoming more critical with increasing numbers of one-person households (Statistics Canada 2011-2). Isolation can be especially harmful for handicapped or infirm adults or seniors. Having a strong community identity helps create a self-supporting community that can organise itself, and therefore provide access to necessary operations such as transportation (e.g. carpooling), child care (e.g. emergency babysitting), food, water and shelter (sharing of resources).

ACCESS FOR ALL: AGE AND INFIRMITY SHOULD NOT MATTER

When planning for access, municipal officials need to remember that it is not just the able-bodied who will need to come and go without hindrance in times of stress. The elderly woman in that community housing high-rise or a mother pushing a stroller with a toddler in tow have to be taken into account as well. It is necessary to take a close look at essential operations for various demographic groups and rank them according to their needs.

Table 1 shows access needs to amenities in resilient communities by arranging demographic groups from most to least dependant. Daily Access is defined as walkable access within seven to 15 minutes, taking into account vertical elevation (stairs, elevator waiting times) and topography (hills). Based on a walking speed of about 4 km/h for a healthy adult this would result in a horizontal distance of about 0.5 to 1km. This number has to be reduced for elderly or families with small children to account for slower walking speeds. The distance would be the path length versus as-the-crow-flies.

Weekly access defines access that can include public transportation or longer walking distances. Infrequent access describes rare access, once a month or less, or access for emergencies only. Walkability Scores[7] can be a good starting point to look at access (Carr et al. 2011). Nevertheless, it is vital to include three-dimensional aspects, especially for neighbourhoods that include high-rise buildings.

[7] www.walkscore.com

TABLE 1.

DEMOGRAPHIC GROUP	SHELTER/ PROTECTION	WATER	FOOD	CASH
Handicapped or Infirm One-Person Households	24/7 barrier-free access (ramps, elevators...) Back-up power to elevators Heating or Cooling has to be maintained through back-up power or low-energy housing principles	Full access within housing /shelter Maintenance of water pressure	Barrier-free daily access or in-house delivery options	Barrier-free daily access Back-up power to ATM machines.
Families with Handicapped or Infirm Members				
Family With Young Children			Daily access, Measures against food deserts	
Healthy Senior Citizen(S)				
Family with Older Children	24/7 access Back-up power to elevators Heating or Cooling has to be maintained through back-up power or low-energy housing principles	Daily access, Maintenance of water pressure or stand-pipes		Barrier-free daily access Back-up power to ATM machines.
Healthy Adult(s) (No Children)				

COMMUNICATION	HEALTHCARE	CHILD CARE	TRANSPORTATION	COMMUNITY
24/7 access Back-up power to cell phone towers Usage of social media to inform public	Daily barrier-free access or in-home visits	Barrier-free daily access Facilities have to be robust (back-up power, heating, cooling...)	Daily access to accessible transportation services, Barrier-free access to public transportation Parking and fuel access	Barrier-free weekly access
	Daily Access		Daily, barrier-free access to public transit Parking and fuel access	
	Monthly access	Daily access Facilities have to be robust	Daily access to public transit Access to fuel and parking	Weekly access
	Infrequent access			

Conclusion

Climate change – and the increasing frequency of extreme weather events that it has triggered – has changed the game when it comes to municipal planning. This new reality means that the standard frameworks that have guided planning principles for decades are no longer valid. They do not incorporate the changed-risk context in which we now live.

Access as it enables resilience can help municipalities blunt the effects of a shock like the ice storm by making it possible for entire communities to shelter in place while city workers work through the Reaction and Response phases of an incident.

The concepts discussed above are not new, though the application has changed for our new urban environment. In 1948, the World Health Organization broadly defined health and identified what was needed for healthy humans and communities. What they identified then is consistent with this paper.

Planning resilience into community design is part of sustainability and healthy communities. Designing resilient developments that promote access does not cost more than is required for ordinary liability management. One wouldn't optimise office space if it meant that the building would then fail in an emergency evacuation. One wouldn't in good faith build a high-rise development that the water infrastructure can't support. One would risk a liability for the loss of businesses and individuals if it were reasonably foreseeable. Most of resilience planning in practice is simply good operational risk management, and not willful ignorance, blind compliance and insurance.

If we think about access to essential amenities and egress during all phases of an incident, we will address the primary causes of loss during catastrophes and provide our communities the very real prospect of timely response and rapid recovery.

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