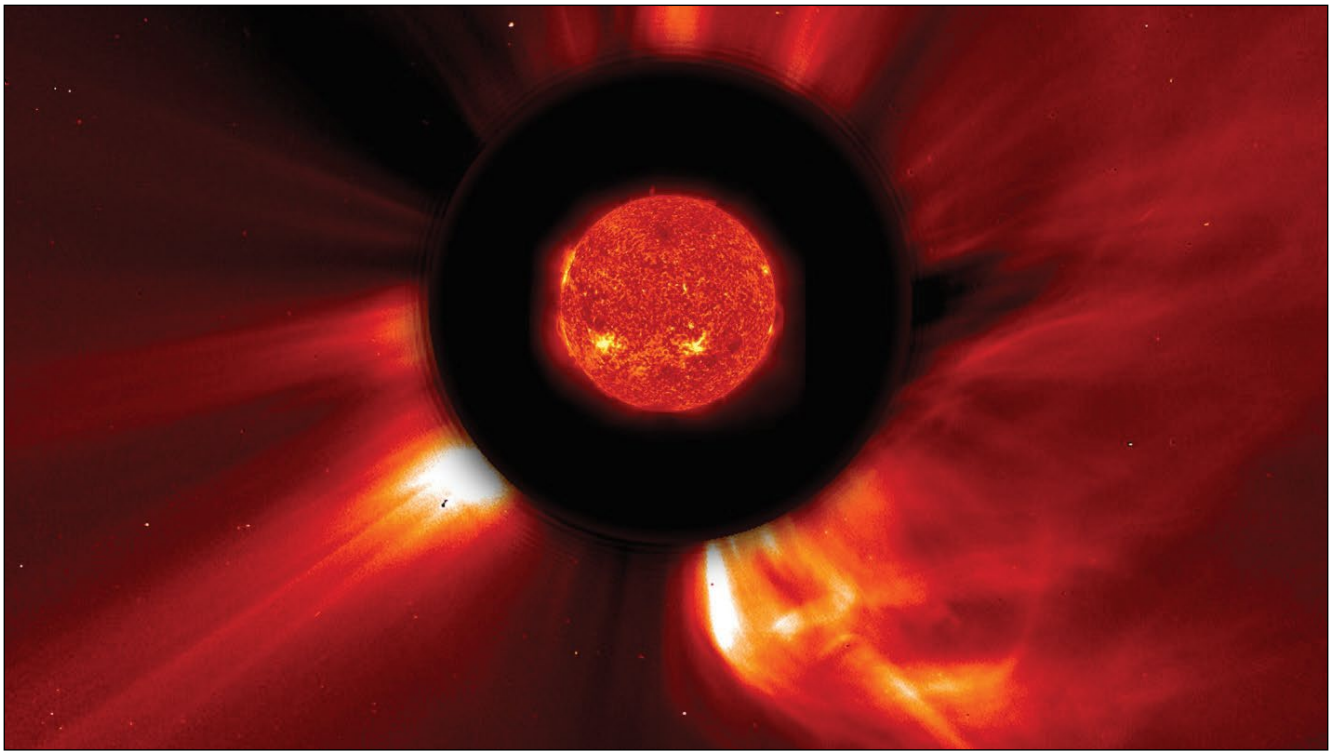

NASA/STEREO

Solar Terrestrial Relations Observatory's view of the 23 July 2012 coronal mass ejection. The event was the fastest-ever coronal mass ejection, leaving the sun at between 1,800-2,200 miles-per-second.

Reframing and Responding to Electromagnetic Pulse (EMP) Risk to Canada

by Simon D.H. Wells

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Introduction

Compared to the threat of chemical, biological, radiological, nuclear, and explosive (CBRNE) weapons, electromagnetic pulses (EMP) receive little attention. There is very little scholarship or public-facing government communication regarding this grave threat. Occasional news articles discussing possible scenarios can be found, but little else is said of the matter in Canada. That is surprising, given that the most effective delivery method in an attack would be through a nuclear warhead detonated at high altitudes in near-space. EMPs are contained within the nuclear threat. They can also occur naturally as a result of coronal mass ejections (solar flares), but a weaponized EMP would be faster, more intense, and highly destructive.[1] In a high-yield warhead detonation scenario, the pulse would exert three waves within fractions of a second of detonation: the first would disrupt electronic control systems and communications within a billionth of a second; the subsequent wave would follow within a second and overwhelm any remaining system protection measures (like surge protection); and the third would be a longer-duration pulse that disrupts or destroys electricity transmission lines and infrastructure.[2] The mechanism of an attack is through a weapon system, but the true weapons are the catastrophic consequences that would impact all of society. Vulnerabilities to natural incidents or human-caused events are unlimited. Depending upon the scale and intensity of the pulse, critical infrastructure could be permanently and irrevocably destroyed; office buildings shuttered; hospitals rendered inoperable with failing life support systems; stoves and ovens would not start; cell phones would not turn on; *et cetera ad infinitum*.

EMPs appear to be largely ignored because they are considered unlikely events. However, it is irresponsible to ignore the catastrophic effects of a natural or human-caused pulse. In order to reframe the severity of the EMP threat to Canada, the referential object of risk should be shifted to the *individual*, not *infrastructure*, and the focus should be shifted to *long-term impacts*, not *immediate outcomes*. Since there is not much literature openly available to scholars or planners and EMPs are comparably destructive weapons, this article will refer in part to CBRNE scholarship, assumptions and considerations, and planning. It will analyze the threats and impacts of EMPs and critique risk assessment and planning, recommending proactive capability-based planning.

Threat and Impact Analysis

There are robust international and national frameworks for *mitigation of* and *response to* CBRNE incidents, whether the incidents are accidental or intentional, but there appears to be very little public-facing discussion regarding the EMP threat. CBRNE and all other hazards to Canadians are planned for based almost exclusively upon their risk to infrastructure, with a focus upon business continuity[3] or upon a broad and nebulous hazard identification that does little to address scenario-specific concerns.[4] Neither basis is helpful when discussing EMPs. An EMP's effects will be markedly different from that of a chemical or biological attack. Therefore, specific assumptions and considerations should be developed. This section will examine threats in two categories: human-caused events, specifically terror and rogue state attacks; and naturally- occurring incidents.

Human-Caused Events

Human-caused EMPs are dangerously effective and subversive weapons. They are most often imagined as a nuclear warhead detonated at high altitude in order to destroy infrastructure in a large area, but they can also be employed locally with equally devastating effects. An emergent concern is the increasing access threat actors have to pulse weapons. Popular opinion is that the probability of an EMP attack upon Canada is low, but a survey of the threat environment shows that possibility is increasing.

The 'classic' EMP scenario renders large swaths of electrical infrastructure totally inoperable. Critical infrastructure would be destroyed by an EMP attack, but the long-term impacts upon Canadian citizens and forces are the real threat. The pulse itself is merely a mechanism through which enormous societal consequences are affected. One damage estimate brought to U.S. Congress by its now-unfunded EMP Commission maintained that "…a nationwide blackout lasting one year could kill up to 9 of 10 Americans by starvation, disease, and societal collapse."[5] The effects of a nationwide pulse incident would be apocalyptic. There is no comparable civilian body mandated to research EMPs in Canada.

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Technological advances have made it increasingly easy to obtain, move, and employ pulse-based weapons at a local level. Radio Frequency Weapons (RFWs), the smaller counterparts of EMP weapons, are capable of damaging and destroying electronics locally, with an effective range measured in kilometers, and are available on open markets in easy-to-produce models including briefcase packages.[6] Subversive weapon systems such as these pose significant risk: the probability of an RFW system being employed is much greater than a high-altitude nuclear warhead detonation, and the impact could be just as severe. Subject matter expert Dr. Peter Pry, a member of the U.S. Congress EMP Commission, quotes the U.S. Federal Energy Regulatory Commission's warning "…that a terrorist attack that destroys just 9 key extra-high voltage transformer substations (out of a total of 2,000) could cause a nationwide blackout of the United States lasting 18 months"[7] – fully six months longer than the Commission's one-year mortality estimate. Whether or not mortality rates would increase after the one-year estimate period and what aggravating factors exist is unclear.

Despite the extraordinary impacts of pulse weapons, the drivers and actors involved are not well understood. Past critical infrastructure threat analyses have only mentioned EMPs and RFWs

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North Korea's intercontinental ballistic missile *Hwasong-15* is displayed during a military parade in Pyongyang, 8 February 2018.

as potential threats to cyber targets,[8] although, in fact, they threaten every aspect of our lives in some manner. There appears to be little thought given to the increasing scope of the EMP threat environment: it is characterized by urbanization and globalization, which amplify individual vulnerability by increasing interdependencies in economies and technology, and accessibility to weapons materials for foreign and domestic terror actors and criminals.[9] As we become increasingly dependent upon interdependent systems, our vulnerability increases in correlation.

Non-state actors, rogue states, and to a lesser extent, nuclear power states pose EMP threats to Canada and its allies. There are a limited number of states that possess the pre-requisite ability to launch warheads into space, but the capability could be developed in the near future.[10] Rogue states, such as Iran or the Democratic People's Republic of Korea (North Korea), could potentially use pulse weapons to disrupt their enemy's command, control, and communication systems.[11] Middle powers and immature nuclear states, such as the aforementioned, benefit most from employing EMPs because they instantly gain significant strategic advantages (if not absolute victory) over enemies they might not normally be able to challenge.

In mid-2017, North Korea claimed to have conducted a "perfect hydrogen bomb test" with a 50-100 kiloton yield capable of delivering an EMP.[12] Iran reportedly conducted missile tests simulating EMP strikes in the 2000's.[13] At the time this article was written, the United States had recently withdrawn from the Joint Comprehensive Plan of Action with Iran and American allies (known popularly as "The Iran Deal"). The impacts to nuclear security are unclear, but it is reasonable to assume that nuclear and EMP risk will have increased as a result. As North Korea begins denuclearization discussions, monitoring and control becomes of paramount importance. Non-state actors could feasibly obtain unsecured nuclear weapons directly from the state or without its knowledge,[14] paralleling the Russian experience in the collapse of the Soviet Union. Canada may be a less likely target than the U.S. for an EMP attack, but our interconnected power grid in North America makes us intrinsically vulnerable to an attack upon the U.S. as well.[15]

Naturally-Occurring Incidents

Naturally-occurring EMP incidents are widely accepted as the more likely type of scenario to which governments will need to respond. Historical events have demonstrated the scale of natural EMP incidents can be enormous and just as destructive as a human-caused event. Natural incidents may not have a security-related cause, but security will be needed in their aftermath and military capabilities and assets will definitely be required to aid in recovery.

Natural incidents may have just as serious impacts as human-caused events. The Carrington Event, a solar flare observed on 1 September 1859 by English scientist Richard Carrington, was the first observed geomagnetic event and one of the largest in the last 150 years, comparable to a significant event on

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This image released by the North Korean Official News Service (KCNA) shows the launch of the intercontinental ballistic missile *Hwasong-14* during its second test-fire, 8 August 2017.

Jason Langley/Alamy Stock Photo/J29EJ1

London, Westminster Bridge, Palace of Westminster, and the clock tower of Big Ben at dawn.

4 November 2003.[16] The Carrington Event caused power surges through telegraph lines that set fire to papers and shocked operators; additional events in the past 50 years have caused power losses for millions, transformer failures, and threatened adverse health effects to those in affected areas.[17] One could extrapolate the added effect on modern telecommunications and electrical infrastructure if a comparable incident were to affect the globe today.

Between 23 July and 24 July 2012, Earth missed a titanic coronal mass ejection by only three days' orbit, narrowly avoiding globally-catastrophic consequences.[18] Researchers called that event a " 'shot across the bow' for policy makers and space weather professionals," noting that the storm's occurrence during a perceived period of minimal solar activity "makes the important point that incredibly powerful – even extreme – space weather events can occur even during times of weak or moderate sunspot cycles."[19] Just like the militant threat, the natural threat is unpredictable in timing and scale. The United Kingdom's House of Commons Defence Committee noted in 2012 that "the potential effects of space weather are growing rapidly in proportion to our dependence on technology,"[20] paralleling our interconnected vulnerability to attackers.

"Generally speaking, the ability of emergency responders and military forces to operate in an affected area after an EMP incident will be disrupted or totally destroyed."

Generally speaking, the ability of emergency responders and military forces to operate in an affected area after an EMP incident will be disrupted or totally destroyed. Automated control systems employed by companies and agencies responsible for recovery will be inoperable, and skilled professionals capable of manually repairing damage will have limited availability.[21] One can assume the same constraints will apply to military equipment that is not target-hardened, so whether human-caused or naturally occurring, capabilities can be expected to be dramatically reduced.

Refocusing Risk and Responding

Electromagnetic pulses and radio frequency weapons do not pose direct threats to individuals, except those who might wear pacemakers or use other biotechnology. As we have seen, the catastrophic threats to individuals and communities are the results of the EMP's or RFW's lingering effects. To fully understand the threat's risk, we must shift our focus from the *likelihood of attack* to the *likelihood of specific effects*.

The primary omission from Canada's EMP preparedness and mitigation is a fulsome risk assessment. *Impacts* are broadly understood, but *likelihood* is not. The general definition of risk employed by the Government of Canada is the product of a hazard's

impact and probability.[22] The Canadian Armed Forces (CAF) could use a risk assessment's results to prepare and update contingency plans, inform strategic stockpiling, determine pre-positioning of military resources during high readiness, or to constrain tasking of high readiness and Special Operations Forces units. Risk assessment of the EMP threat is not an entirely military or civilian intelligence responsibility: the whole-of-government should be responsible for contributing to such an assessment. Although it would be a lengthy and cumbersome process, there is support to be gleaned from the lessons learned with respect to the CBRNE spheres. The Royal Canadian Mounted Police's (RCMP) evaluation of the federal CBRNE response program supported early identification of lead organizations, and roles and responsibilities for mitigation and response; facilitation of information sharing between responsible organizations; and, proactively determining strategic objectives.[23]

In order to understand the risk of effects, one should refer to *individuals* as the object of risk, versus *infrastructure,* or through the use of generic scenarios. The *Federal Nuclear Emergency Plan* begins to address individual vulnerability by aiming to prevent or reduce health impacts, but it makes provincial and territorial governments responsible for sheltering, evacuation, food and water safety, and other local interventions.[24] It is an acceptable plan for the health portfolio's area of responsibility, but it is not comprehensive enough to serve as a plan for a combined federal response. For example, the Ontario Office of the Fire Marshal and Emergency Management's *Provincial Nuclear Emergency Response Plan* identifies more specific hazards and delivery mechanisms and sets planning zones around nuclear sites, based upon distance from the hazard's origin,[25] but it is intended for nuclear generating station disasters instead of an entire suite of nuclear emergencies. That plan more specifically addresses the factor of proximity in nuclear incident risk, whereas the federal plan does not. The Province of Ontario's plan still does not comprehensively respond to a wide range of social consequences vulnerable communities might be forced to endure in a nuclear or EMP event. In fact, both are more akin to frameworks than true plans, and they focus almost entirely on quelling the source of the emergency instead of transitioning to and facilitating long-term recovery.

An EMP will be a 'magnifying glass' for all hazards. It is an exponential force multiplier for every possible societal vulnerability. The North Atlantic Treaty Organization (NATO) understands consequence management for weapons of mass destruction as "…a multi-dimensional effort, requiring coordination within the Alliance at all levels, as well as with civilian emergency planning authorities" and other actors.[26] Military courses of action must be strategically coordinated with other government departments, non-governmental organizations, and international partners.

Recalling that very limited EMP scholarship and planning exists, it is necessary to refer to CBRNE response planning to determine probable courses of action and constraints. If the impacts of a natural or human-caused disaster rest upon the whole-of-society, then preparedness, response, and recovery must be coordinated across the whole-of-society as well. In the case of CBRNE weapons, NATO acknowledges that as the principal threat is terrorism, response and consequence management measures have primarily materialized from military perspectives.[27] A military response component will undoubtedly be critical, but just to apply a military perspective to consequence management is not comprehensive enough. It is imperative that Canadian Armed Forces leadership understand the whole-of-government response in order to effectively plan immediate and long-term recovery operations. Unfortunately, the whole-of-government collective body does not seem to fully comprehend the mitigation and response options available to it. Public Safety Canada has conceded to media that its guidance with respect to EMP mitigation to electricity infrastructure owner-operators was *generalized*, and it did not address *specific* measures, such as surge or pulse protection.[28] Even with respect to basic mitigation measures, we are unprepared.

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NATO Headquarters, Brussels, Belgium.

In Canada, the CAF is undoubtedly the best-equipped and best-trained organization to

respond to the initial effects of an EMP incident, but it is not prepared to manage community-specific needs, nor should it be asked to do so. The second objective of Canada's CBRNE Strategy is to "integrate CBRNE into an all-hazards risk management approach" using capability-based planning to reduce risk once sources are understood.[29] In accordance with this objective, and in order to ensure maintenance of its aim, the CAF should plan potential EMP response operations based upon its capabilities and mandate. It should also develop specific possible courses of action in order to be prepared to support incident-specific responses. An all-hazards approach, even including EMPs as a consideration, is too general to manage the chaos associated with an EMP's aftermath.

The CAF could potentially support business continuity of other government departments, but to rely solely upon military forces to support a response and recovery operation would be incorrect and inappropriate. Instead, military planners should focus upon contingency planning for distribution of aid and equipment, aid to the civil power, and upon occupying and securing spaces with no functional government infrastructure. Constraint to only these types of missions or other specific missions more appropriately reflect the military's role and allows lead government departments to maintain overall command and control of disaster recovery.

The CAF and the Department of National Defence has integrated research and development and target hardening into its CBRNE capability development. It requires new equipment designs to include hardening against potential CBRNE threats, and it needs research and development to be coordinated with international partners via Defence Research and Development Canada (DRDC).[30] This policy encompasses previous EMP protection direction, thereby supporting increased EMP resilience within the military and hopefully enabling recovery operations by conventional forces that will remain operable after an incident. The Canadian Joint Incident Response Unit (CJIRU) is the sole dedicated CAF contribution to the National CBRNE Response Team, which includes the RCMP and the Public Health Agency of Canada.[31] The concept of operations for force employment includes consequence management activities and use of force protection capabilities to support civilian authorities. However, without extensive preparation, a comprehensive response framework, or institutional knowledge and effective training, the CAF's ability to aid the National CBRNE Response Team is limited.[32] Capability-based planning must be conducted in order to identify resources available for an EMP/CBRNE event response and to determine specific and likely courses of action.

This article has argued that the object of EMP risk should be the *individual*, because EMP threats ultimately affect individuals, whereas conventional weapons and tactics *collaterally* affect them. It has also advocated for capability-based military planning in coordination with the Government of Canada. As the scale and scope of an incident will very likely be protracted, planners should consider a proposed updated capability-based planning process from Defence Research and Development Canada (DRDC). The updated process would include concurrent capabilities and capacity analyses resulting in outlined courses of action and defined force elements, linking results to the Joint Capability Framework, and identifying risks associated with specific capabilities, force elements, and objectives.[33] The capacity analysis is of particular interest because it is *capacity* that will become the greatest issue for responding forces. Independently from assessing the suitability of proposed course of actions, a capacity analysis will consider force elements, scenario likelihood, and other inputs to determine responding force generation, producing determinations on the effectiveness of force composition and effects.[34]

"The concept of operations for force employment includes consequence management activities and use of force protection capabilities to support civilian authorities."

With updated capabilities and capacities analyses tailored to the threat and risk environment, the CAF would be able to develop specific contingency plans to exercise specific functions. It must consider its priorities and objectives when it is called upon to distribute aid to civilians or equipment to security forces and government organizations. Will the Government of Canada identify priority recipients of aid, and will they be categorized by geographic location or demographic factors, such as age and health status? Or, will deployed officers and soldiers have to make those decisions when aid inevitably runs short during the catastrophe? What supplies or capabilities can it part with to support friendly actors? It must identify its rules of engagement when providing aid to civil power in a lawless and potentially anarchistic environment. Canadian service members could plausibly be asked to employ force to maintain order among a starving and terrified civilian population in the dystopian aftermath of an EMP attack.

Most significantly, the CAF must consider how it might use limited resources and capabilities to occupy and secure spaces and places, and it must identify those that are of strategic value. Clearly, there are not enough soldiers or vehicles to fully occupy Canadian territory. Additionally, it would almost certainly be impossible to protect all critical infrastructure sites and ensure continuity of government as well. Difficult considerations must be analyzed, such as the value of water treatment plants and power generating stations versus the continuity of the functions of government. There is no zero-sum answer to these problems.

Conclusion

Natural and human-caused electromagnetic pulses pose significant threats to Canada and its allies. While the threats and impacts are acknowledged, their risk has not been acknowledged. Shifting the focus of risk to the *consequences* of an event versus the *immediate outcomes* increases perceived risk and can better inform strategic and operational contingency planning. A concept of operations and recovery programming cannot be left solely to the military or to the public service. Dialogue is required to determine capabilities and objectives proactively, instead of during the aftermath of an unparalleled catastrophe, when there may be no means to communicate. Regardless of perceived likelihood or public or political appetite, coordination of mitigation and preparedness activities between all stakeholders needs to begin without delay.

The Canadian Press/J.P. Moczulski

An aerial view of the Bruce Power nuclear generating station in Kincardine, Ontario. An EMP event affecting this facility could have catastrophic consequences.

NOTES

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