



BRIEFING NOTES

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GLOBAL KEY ELEMENTS AND SECURITY CHALLENGES IN SPACE – A DAY WITHOUT SPACE

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SUMMARY

- ✚ In order to answer the big question regarding effects and risks of a “day without space” on Canada’s military force and public activities, and configuring of key pillars of public and industry policy to reduce effects of risks, it is crucial to have solid understanding of concepts and current challenges on security of space.
- ✚ In addition to the commercial sector, space is becoming the core of military activities such as missile warning systems, navigation, tracking and identifying attacks and adversarial activities. These advanced technologies in the military sector, prevents malicious adversarial countries to conduct undetected sensitive military activities. This is an advantage, as it ensures the world to be more peaceful.
- ✚ Our daily dependence on satellites and space is an obvious aspect of nowadays life that has increased vulnerabilities of the space. Accordingly, it is very essential and imperative to protect security of the space.
- ✚ Protection of space system components (i.e., satellites, ground station, data-link between satellites) is crucial to be ensured and guaranteed. The most vulnerable component as can be expected is the ground station. On the other hand, it is essential to prevent adversaries from through cyber or kinetic means attack space assets.
- ✚ The United States has over 25 years successful military experience through space capabilities. However, recently Russia and China and few other countries are trying to deny and challenge the US position in space.
- ✚ According to international agreements at United Nations that have been signed by all partners for space activities, nations are limited in weaponizing the space while they can still develop counterpace weapons. These agreements prohibit partners to place weapons on orbit or any other object in space purely for military purposes. Although all countries have signed these agreements, a few states are not following their signed agreement.
- ✚ The main motivation behind this research is to have a deep and full understanding that advancements in space and counter space technologies that are developed by other countries can support and facilitate Canada’s plan and initiatives to proliferate its space activities correspondingly to avoid any disaster which may be caused by a day without space.

CONTEXT

Key Elements of Space:

- ✚ Communication satellites [1], Intelligence, Surveillance, and Reconnaissance (ISR) satellites [2, 3], and Positioning, Navigation, and Timing (PNT) satellites [4] are three main types of satellites that exist in space.
- ✚ The manner that users control and communicate with satellites is presented by the Command and Control architecture through uplink and downlink channels that are used to transmit information from spacecraft to Earth [5].

- ✚ Relay satellites are used to enable communications between a satellite outside the reception area of the ground station and the ground station. All components of this structure are vulnerable to cyberattacks. Ground stations are prone to physical attacks and space vehicles and communication between satellites and stations are prone to electronic warfare.
- ✚ Since 2018, more than 1500 space objects are orbiting around the Earth [1]. Despite the fact that only US and former Soviet Union were capable of space activities 60 years ago, currently more than 50 countries are capable of space activities. Among them nine countries and an international organization are capable of launching a spacecraft independently namely China, India, Iran, Israel, Japan, North Korea, Russia, South Korea, US and the European Space Agency from French Guiana [2].
- ✚ These advancements have occurred during the past 6 decades due to the fact that cost and technological barriers are reduced. In addition, space is an important and strategic area for governments and nations to compete commercially and supply products. In other words, governments and nations can compete commercially by launching satellites or any other objects to space for communication, awareness, and remote sensing purposes.
- ✚ The above competition has resulted in exponential increase in the number of objects on the Earth's orbit. These objects can be active satellites or orbital debris.
- ✚ Thus, it is challenging for all participants in space activities to better track and identify objects and also, to avoid collision with other satellites and debris [4,5,6].
- ✚ According to an agreement signed by all partners in space activities, partners are prohibited to place weapons on orbit or any other object in space for military purposes. Although all countries have signed this agreement, some states are not strictly following this agreement [9,10].

CONSIDERATIONS

- ✚ There are five orbits around the Earth, namely the Low Earth Orbit (LEO) which is 2000km from the Earth that is used for communication, ISR, and astronaut spaceflights. The Medium Earth Orbit (MEO) which has altitudes of 2000 to 35000 km is used for communication, positioning, navigation, and timing. Highly Elliptical Orbit (HEO) contains communication, ISR and missile warning satellites. Finally, Geosynchronous Earth Orbit (GEO) which contains satellites as in the HEO [6].
- ✚ Three types of satellites exist in space. Communication satellites provide all types of personal communication, TV broadcasts, Internet, Mobile services, and any data transmission for civil, military and commercial users all over the world [13]. Intelligence, Surveillance, and Reconnaissance (ISR) satellites provide data information of Earth's land, air and sea through remote sensing for communication and civil purposes. ISR Satellites provide signal intelligence, warning of ballistic missile activities [14, 15]. Positioning, Navigation, and Timing (PNT) satellites, as it is obvious from the name provide precise

time and location and time information to the users. PNT satellites can be used in commercial, civil, and military purposes [16].

- ✚ Missile warning systems use space-based sensors to indicate the launch of a missile attack and use ground-based radars to follow them [6]. It can provide warning to countries regarding a missile attack and can enable defensive and offensive operations. To launch satellites to space is accomplished through space launch vehicles to serve commercial, civil, and military users [18].
- ✚ Counter space concepts that are used to attack space components by any means have a variety of types from cyberspace to electronic and kinetic energy. Below is a brief description of each.
- ✚ Cyberspace threats use partial knowledge of C2 architecture to apply offensive actions against space systems [19]. Direct Energy Weapons (DEW) are the ones that use a variety of waves such as laser, high power microwaves and radio frequency weapons to attack a satellite. One of the challenges in DEW is to determine the origin of the attack [20].
- ✚ Jamming and spoofing techniques can be used to control the communication between satellites and ground stations which is considered as electronic warfare (EW). Downlink jamming has a local effect while uplink jamming disrupts services for all users at the reception [21]. Kinetic energy threat is another type of counter space threat which destroys the satellite without placing any weapon into the orbit. Kinetic energy threats are also called anti-satellite missiles which consist of a fixed or mobile launched system, a missile, and a kinetic kill vehicle. The kinetic kill vehicle is used to identify the desired satellite. This type of missile is easier to launch and initiate than other types of means [6].
- ✚ Different kinds of satellites can be launched to the orbit that are considered as orbital threats. For instance, the satellite can have a kinetic kill vehicle, radio-frequency jammer, laser, high power microwave, and chemical sprayer to have temporary or permanent effect on the target satellite.
- ✚ Moreover, robotic mechanisms can be used in offensive operations while they are generally designed for repairing, servicing and removing debris from the space [6]. Finally, one of the necessary space operations is space situational awareness (SSA) given that it has the capability to know the exact location of an object in space and can predict its future location. However, it can be used to target a satellite and analyze the effectiveness of an attack. SSA can generate its data by using telescopes, radars, and various space-based sensors [22, 23].

NEXT STEPS

- ✚ Developing ethics and applying joint coordination among more than two countries to control satellites for preventing the blackout in the world is very important since only USA and Russia have the capability to launch and control satellites. However, due to political

issues and wars currently in the world, these two countries are able to shut down satellites and make a blackout in the world.

- ✚ It should be noted that certain countries are not sharing their counter space activities with the rest of the world community. Accordingly, ethics and public and defence policies should be developed in order to reveal the secrets behind their counter space activities by NATO Allies, NORAD, and 5 eyes countries.
- ✚ There is a competition between countries to achieve superiority in space activities that can result in space supremacy. It is observed that countries such as US and Russia are re-organizing their military forces to operate, train, and equip space forces. Thus, it is a critical research challenge one is faced with in developing and devising international policies among countries to equalize information sharing among allied countries.
- ✚ One needs to focus on counter space capabilities of China, Russia, US, and North Korea. The main motivation behind this research is to recognize advancements in space and counter space technologies that are developed by other countries so that they can provide support to Canada for proliferating its space activities that correspond to avoiding and prevention of any disaster that may cause by a day without space.

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