Space Technologies

Space technologies support critical functions in our daily lives. The range of space-enabled applications extends from communications and navigation to earth observation, weather forecasting, security and intelligence operations, and applications requiring precise timing/positioning. Thanks to technological advances and falling costs, more countries and commercial interests now participate in the space economy. However, space debris, spectrum congestion, communications jamming and complex governance may challenge our ability to operate in space.

Enabling Science and Technology

Optical communications

Optical communications feature fast data transmission rates and circumvent congestion and licensing issues related to conventional radio-frequency (RF) systems. Data transmitted in optical beams are more secure, with a lower probability of interception, than RF signals. Optical technologies are also well suited to deep space and inter-satellite communications. Among the issues to be resolved is the susceptibility of optical communications to interference caused by atmospheric conditions.

Intelligent autonomy

Autonomous and intelligent systems in space can improve efficiency, reduce personnel costs, and enable many operations required for deep space missions of long duration. On earth, automated methods based on learning systems can improve data handling, image classification and analytics. Fully automated and intelligent systems, however, still require considerable fundamental research.

Space debris: surveillance and mitigation

More than 500,000 pieces of space debris now orbit the earth and threaten to damage space assets. Technologies to track and mitigate debris include space-based optical sensors, phased array radars, tethers, nets, robotic arms, satellites dedicated to debris removal, cladding systems, and cataloguing/situational awareness platforms.

On-orbit servicing

On-orbit servicing can tackle tasks such as re-supply, inspection, repair, and debris removal. Servicing missions can extend the useful life of satellites and can also "save" missions threatened by damage or malfunction. Core servicing technologies are robotic manipulators and target motion prediction systems. The market for space infrastructure servicing is predicted to grow exponentially. Canada has been a pioneer in this field.

> ***Once an exclusive resource, space-based technologies and their applications are now increasingly available to governments, businesses and civil society organizations. From monitoring human rights violations and the impacts of climate change to helping people find the fastest way home, space technologies are being applied in unexpected and innovative ways.***
>
> – **World Economic Forum Global Agenda Council on Space Security,** Bringing Space Down to Earth, 2014

Canada

Signals

Academic

Chinese institutions have published extensively on robotics, attitude control and optical communications. American institutions such as the University of Maryland have expertise in environmental monitoring and instrument design. The University of Toronto specializes in spacecraft dynamics and robotic systems.

Government

National space agencies have extensive R&D portfolios and are important hubs for technology transfer.

Collaboration

The European Space Agency launched the Galileo satellite constellation for navigation support, and an international consortium is behind OneWeb, a constellation for broadband Internet delivery. An American industrial Consortium for Execution of Rendezvous and Servicing Operations will develop technology standards for servicing operations.

Non-governmental organization (NGO)

The United Nations Office of Outer Space Affairs advocates for peaceful cooperation in space use and exploration; oversees guidelines for debris mitigation; and promotes sustainable development in space.

> ***A variety of actors are involved in the creation and diffusion of knowledge in the space sector. Although business enterprises play a significant role in space programmes [...], public research institutions and universities still lead space innovation [...], with start-ups particularly active in downstream space applications.***
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> – **OECD**, Space and Innovation, 2016.

Corporate

Large aerospace firms are well-established participants in the space economy. The value chain also includes component and nanosatellite manufacturers, imagery and analytics firms, and commercial launch or transportation companies.

Impact

Social

Space research enables socio-economic benefits in telemedicine, search and rescue, emergency management, and navigation. International law is slow to respond to challenges such as debris removal, malicious signal jamming, exploitation of in-space resources, and space traffic management.

Policy

There has been a proliferation of national agencies dedicated to space activities. Many countries have recently developed strategies to link space more explicitly to the economy.

Economic

Prices for technologies and services are falling. New downstream industries are springing up, for instance in the areas of on-orbit servicing and data analytics.

Environmental

Rising traffic and the proliferation of “space junk” bring the sustainability of activity in space into question. Satellite imagery is critical to terrestrial applications in natural resource monitoring, meteorology, climatology, and precision agriculture.

Defence

Space-based data are a key component of intelligence; however, malicious jamming and weaponization are potential challenges. Nanosatellite constellations will complement traditional platforms, and unmanned vehicles will increasingly be consumers of precise positioning and navigation systems. In Canada, space-based services will continue to support national security, surveillance, and search and rescue.

> ***As the number of actors [in space] increase [sic], the space sector will likely see increased competition and overcrowding, both literally and metaphorically, which, in turn, serve as a driver for more products, services and governance structures that can support the needs of a growing sector.***
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> – **Institute for Defense Analyses**, Global Trends in Space, 2015

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Please provide feedback

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