How the war in Ukraine is affecting space activities: new challenges and opportunities

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Key messages

- Boosted by public and private investments and advances in digitalisation, space capacities have taken on a new role in crisis management, as demonstrated by the war in Ukraine.
- The Russian Federation's [hereafter 'Russia'] war of aggression against Ukraine shows how the improved availability of satellite data and signals is affecting quality and resilience of government systems in Ukraine (e.g. communication systems, military intelligence) and supporting new applications using space-based data (e.g. open-source intelligence for reporting).
- The war has also revealed space systems' vulnerabilities and unleashed a series of threats, notably: unanticipated third-party uses of data; the vulnerability of space infrastructure to malicious acts and orbital threats; as well as a concentrated and fragile global supply chain relying on a small number of key actors and highly specialised components.
- The current geopolitical situation raises questions about the future of international co-operation in space activities, in a time when it is urgently needed to collectively manage the use of orbital resources.
- Key policy responses include addressing the space sector's vulnerabilities (e.g. cyberattacks, signals jamming), managing access to and use of data and signals, managing further space sector commercialisation and ensuring long-term sustainability of space activities.
- The OECD is well positioned to support these discussions, providing evidence-based policy advice, guidelines and toolkits on data management, privacy, digital security of critical infrastructure and space sustainability, as well as a forum for convening further dialogue to inform future policy making in this important area.

Governments and industry rely ever-more on space systems

Governments have relied on space assets for decades. Beyond defence and national security applications, space technologies are particularly well suited to address different types of natural, technological and societal hazards and threats. They allow the acquisition of crucial data, provide early warning using earth observation applications, form back-up hubs for telecommunications when needed and offer precise navigation tools.

Over the last two decades, governments have made considerable investments in satellite earth observation systems. This includes large institutional programmes (e.g. the Copernicus earth observation programme by the European Union and the European Space Agency), the coming of age of new-generation satellites supporting decades-long missions such as the US Landsat programme , currently in its fourth iteration of sensors; or Canada's successive Radarsat missions. The availability and precision of signals from satellite navigation systems has also significantly increased, and will be even more precise by 2030, as governments are making important investments in global navigation satellites systems (GNSS) and satellite-based augmenting systems (SBAS). The OECD has just published a Handbook to better identify and track public and commercial space investments and their outcomes.

This considerable deployment has been accompanied by dedicated programmes and initiatives to encourage the use of satellite data and signals, which include open data policies and the development of specific services and applications to make data more accessible to the public, for example Digital Earth in Australia, satellittdata.no in Norway, or Satellite Data Portal in the Netherlands. In Canada, Radarsat data are accessible to the public through the Open Data and Information Portal and/or through the Earth Observation Data Management System. In Europe, data from the Copernicus programme are made available via Data and Information Access Services or the Open Access Hub. The Committee on Earth Observation Satellites (CEOS) and other partners supported the 2018 launch of Digital Earth Africa. Data from government missions are also available on popular commercial platforms, such as Earth on Amazon Web Service or the Google Earth Engine. Finally, the global initiative Open Data Cube, supported by government organisations in Australia, the United Kingdom and the United States as well as commercial partners and CEOS, provides an open and freely accessible tool to access a large range of satellite data.

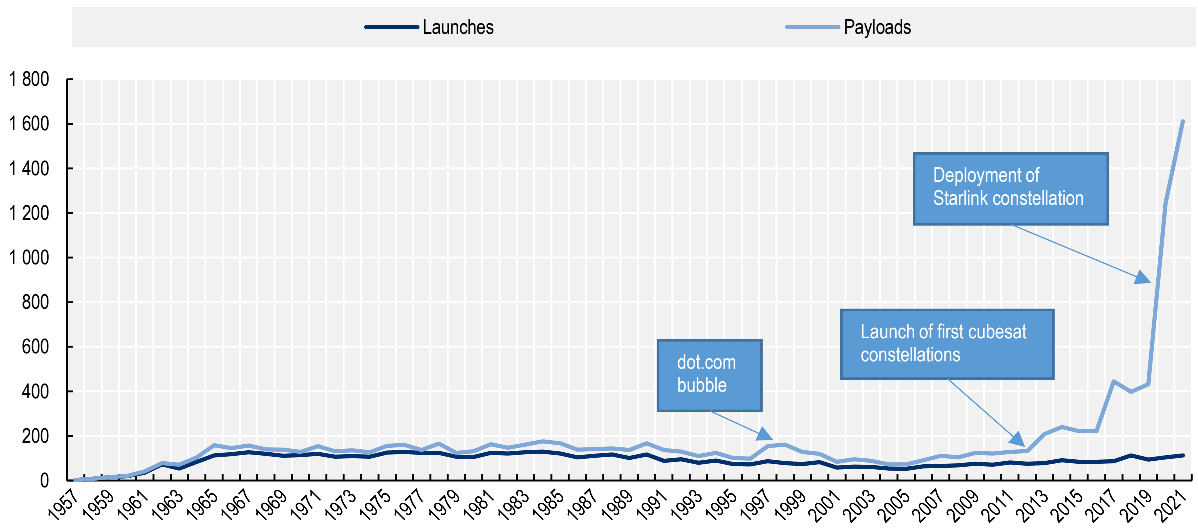
Private sector investments have also increased in the last decades. The first wave of space system commercialisation took place in the 1980s and 1990s, with the privatisation of satellite telecommunications services. Further commercial projects included public/private earth observation satellites. Commercial investments took off strongly in the early 2010s and accelerated in the past five years, boosted by miniaturised technology and increased usage of standardised and off-the-shelf products that considerably reduced satellite production and launch costs. The generalisation of small satellites in low-earth orbits, launched in batches, allow today the deployment of different types of commercial multi-satellite constellations.

The most recent jump in space launches as shown in **Figure 1** marks the deployment of Space X's Starlink constellation for satellite broadband. Satellite broadband is now the main driver of private investments in mega-constellations[1] projects in the low-earth orbit, dwarfing all other space launch activities. In early 2022, the satellites from only two commercial operators, SpaceX and OneWeb, accounted for almost half of all operational satellites in orbit.

[1] The term "mega-constellations" is used to describe projects under development for hundreds to several thousands of satellites in the low-earth orbit, mainly for the provision of satellite broadband services.

Figure 1. Orbital launch history

Number of launches and payloads. Activity as of 23 November 2021



Note: Payloads refer to space objects (e.g. satellites, space probes) designed to perform a specific function in space, excluding launch functionality. It is worth noting that the number of launches remains stable over the period, with an increased number of satellites per launch starting around 2012.
Source: US Space Force (2021), www.space-track.org.

Improved accessibility of satellite data and signals is supporting not only war efforts in Ukraine, but also monitoring of the situation

Supporting Ukrainian war efforts and resilience

The substantial use of commercial satellite services in Ukraine has rendered both civilian and military infrastructure more resilient and provided new services that were not available just a few years ago. Government officials have been able to communicate with the wider world since the Russian attack in February 2022, thwarting attempts to isolate the country. To keep broadband access online, SpaceX has reportedly sent thousands of Starlink terminals to Ukraine, paid for by private sources and selected governments. This satellite broadband access is intensively used by the Ukrainian military for tactical communications, for recreational purposes and conversations with family. Furthermore, commercial radio frequency spectrum monitoring, deployed on 15 kg satellites by the US company HawkEye 360, has contributed to detecting troop movements and GPS jamming attempts.

Commercial high-resolution and radar imagery contribute to map military activities and document developments on the ground almost at real time. The US National Geospatial-Intelligence Agency reports using data from more than 200 commercial satellites and some 100 different companies, leading to an “unprecedented” use of commercial geospatial intelligence. Other countries and private firms have also provided assistance. Canadian satellite operator MDA has provided Ukraine with near real-time satellite imagery to track troop movements and the European Union has also agreed to share classified satellite imagery. This comes in addition to more conventional space-based support for military systems, e.g. GPS-guided equipment.

Enabling monitoring of the situation from orbit

The ongoing war has revealed an exponential use of commercial satellite imagery in international media coverage. The use of non-classified satellite imagery in the media is not new for war coverage and crisis management (e.g. mapping refugee camps, large fires and destructions), but it has never been seen at such a scale, with many news outlets around the world getting access to these technologies for the first time. Some commentators compare this "explosion" in near-real-time data to the televised live war coverage during the 1991 Gulf War.

The breadth of commercial data allow also to monitor the situation and dispel disinformation, such as the pictures showing Russian troop build-ups along Ukraine's borders in February 2022 from the US company Maxar. The Centre for Disinformation Resilience has also launched the crowdsourced Russia-Ukraine monitor Map, an online archive of verified videos, photos or satellite imagery that can be used by ministries of justice, accountability and advocacy groups. For example, open-source satellite imagery from several operators are being used to document potential Russian war crimes in the Ukrainian city of Bucha.

Monitoring food supply

Finally, space assets are being used to monitor the global food supply – a critical area of international attention in the current geo-political context. Data analytics based on satellite imagery precipitation and temperature forecasts gives the Group on Earth Observations Global Agricultural Monitoring (GEOGLAM) continued coverage of crop conditions within the Russian Federation and Ukraine for wheat and corn crops, as well as any updates that may affect exports.

But the war has revealed vulnerabilities of space assets

Revealing vulnerabilities in space infrastructure…

Russia's war against Ukraine has demonstrated different vulnerabilities of space infrastructure components. Satellite signals have been exposed to both electronic attacks and cyberattacks. Jamming attacks have targeted commercial SpaceX terminals for satellite broadband, as well as GPS signals, including "spoofing" (i.e. when a radio transmitter is used to fake a GPS signal to bring confusion). More significantly, a cyberattack targeting Viasat's KA-SAT fixed broadband network led to widespread network outages in Central and Eastern Europe on the day of the invasion, as the attack knocked out thousands of modems communicating with the geostationary satellite.

Another type of vulnerability comes from the growing availability of satellite data online, as commercial applications track cell phone locations in real time. The US company Alphabet had to disable live traffic services for Ukraine in its Google Maps application, because traffic jams could be used to detect civilians on the move, who may become targets, and military troop movements.

Ensuring the resilience of space infrastructure has become strategically important for many countries. France and the United Kingdom have recently published military space strategies. The United States established the Space Force as a new branch of armed services in 2019. More regions and countries are building space tracking abilities, including for instance the European Space Surveillance and Tracking network (EUSST). Several countries have demonstrated anti-satellite capabilities, allowing disruption of signals and even destruction of space assets in orbit (e.g. People's Republic of China, India, the Russian Federation and the United States).

…and in global space supply chains

The war against Ukraine affects global supply chains in the space sector. In this high technology market, the Russian Federation and Ukraine have long been notable international actors (building on the USSR space programme) as trade partners and manufacturers of components and full space systems; as well as launch service providers. Two US launchers, the Atlas V heavy-lift launcher and the Antares launcher (which transports cargo to the International Space Station), rely on Russian engines, the Antares launchers also uses a Ukrainian-produced first-stage rocket. The upper stage of the European Vega launcher uses Ukrainian-built engines. The European Space Agency has also been using the Russian medium-class Soyuz launcher since 2011, e.g. for launching Copernicus and Galileo satellites.

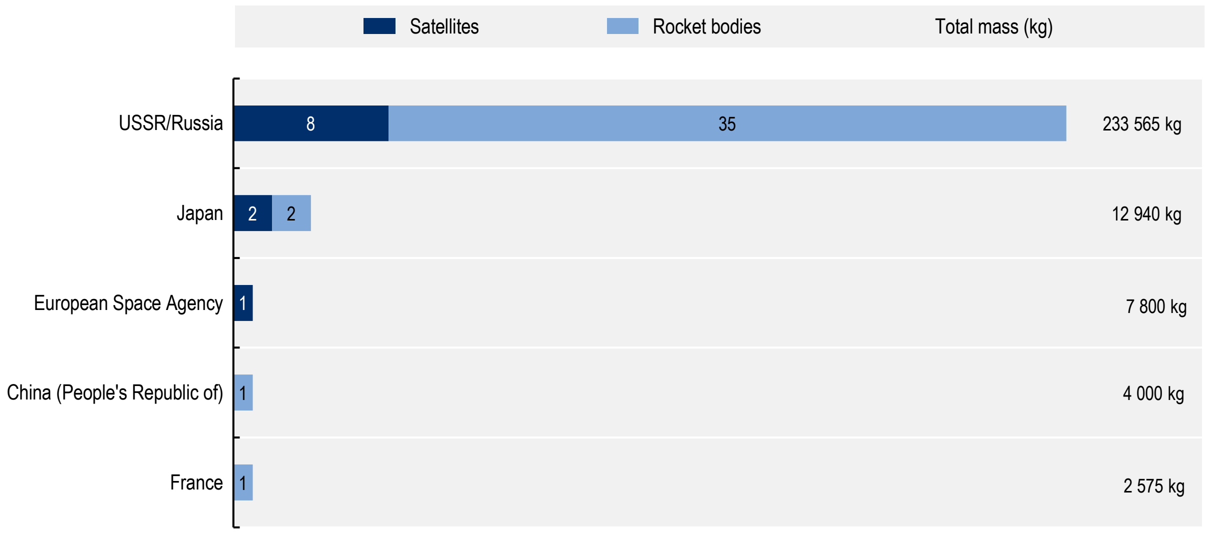
The Russian-operated Baikonur spaceport in Kazakhstan was until recently frequently used for international commercial launches. In early 2022, a batch of UK satellites for the OneWeb broadband constellations were temporarily grounded while looking for other launch opportunities, finally provided by their US competitor SpaceX. Baikonour was also for almost twenty years the only gateway to space for OECD partners of the International Space Station (Canada, European countries, Japan and the United States) after the dismantling of the Space Shuttle programme in 2011. This dependence for human spaceflight ended with the first crewed launch of the US commercial Dragon spacecraft in 2020.

Putting international co-operation at risk when this is urgently needed

Another area of concern is how the Russian large-scale aggression affects international co-operation and the management of shared global challenges, most notably the growing threat of space debris[2]. International co-operation is not only crucial for space science, meteorology, climate change research and space exploration, but for the sustainable future uses of the space environment. The Russian Federation is a space superpower together with the People's Republic of China and the United States in terms of military space capabilities, human spaceflight and orbital presence. The country operates a considerable number of satellites, and, importantly, accounts for the lion's share of catalogued space debris, including several hundred metric tonnes of particularly "concerning" orbital debris from a collision perspective – due to their size, inclination and/or orbit (McKnight et al., 2021[16]), as shown in (**Figure 2**).

Figure 2. Top 50 most "concerning" orbital debris from a collision perspective

Number of satellites and rocket bodies by launch country/institution, with associated total mass



Source: Based on McKnight et al. (2021, "Identifying the 50 statistically-most-concerning derelict objects in LEO", *Acta Astronautica*, issue 181, https://doi.org/10.1016/j.actaastro.2021.01.021.

[2] Currently tracked debris objects are mainly fragmentations from satellites and rockets, followed by defunct spacecraft, rocket bodies and mission-related debris such as lens caps and solid rocket firings.

Space debris is a growing threat for human activities in space. In the last 15 years, levels of debris have accelerated at a worrying pace, casting uncertainty about the long-term sustainability of current space activities. The underlying fear is that the debris population reaches such levels that collisions become self-generating and uncontrollable, leading to the so-called Kessler Syndrome. This could disrupt human activities in several valuable orbits.

Co-operation and co-ordination between all major space actors will therefore be key to addressing the growing problem of space debris and the overall sustainability of space infrastructure and related activities. The United Nations' Committee on the Peaceful Uses of Outer Space (UN COPUOS) 2019 agreement on guidelines for the "long-term sustainability of outer space activities", which reflects an increased awareness about the negative externalities surrounding activities in space and particularly of the unrestricted use of certain orbits of value to activities on Earth, should guide such efforts.

What are key considerations for policymakers?

The OECD has published extensive research on issues raised in this note including space infrastructure resilience, satellite data management and sustainability. Decision-makers are encouraged to take note of the following areas that would require further work.

Addressing the space sector's vulnerabilities

Policymakers are not necessarily aware of the scope and degree of the vulnerabilities that need to be mapped and addressed. Relevant OECD resources include:

- The OECD Recommendation on Digital Security of Critical Activities sets out a range of policy recommendations focused on strengthening the digital security of operators of critical activities.
- The OECD Policy Toolkit on Governance of Critical Infrastructure Resilience helps governments design their national critical infrastructure resilience policies and implement them through effective partnerships with operators.

Managing access to and use of satellite data and signals

Enhanced access to and sharing of space-based data and signals are associated with notable social and economic benefits, but they also raise a number of questions, e.g. in terms of private ownership of public-good data and unanticipated consequences on national security and privacy. Relevant policy tools to consider include:

- The OECD Recommendation on Enhancing Access to and Sharing of Data is the first internationally agreed upon set of principles and policy guidance on how governments can maximise the cross-sectoral benefits of all types of data – personal, non-personal, open, proprietary, public and private – while protecting the rights of individuals and organisations.
- The OECD Recommendation concerning Access to Research Data from Public Funding covers research data from public funding as well as other research-relevant digital objects, such as metadata and bespoke algorithms, workflows, models, and software (including code) and provide updated policy guidance.
- The OECD Guidelines Governing the Protection of Privacy and Transborder Flows of Personal Data provides useful guidance for the collection, processing, and sharing of personal data to safeguard privacy and individual liberties, including in times of crisis.

Ensuring long-term sustainability of space activities

It is crucial to make space infrastructure more resilient to natural and manmade threats and address negative externalities of space activities.

- Despite the challenges, countries must continue to pursue international co-operation for sustainability of space activities, while partnering constructively with the private sector. The OECD is well positioned to support these discussions, providing evidence-based policy advice, guidelines and toolkits, as well as The OECD Space Forum for convening further dialogue to inform future policy making in this important area.
- Economics of space debris identifies some of the shorter and longer-term costs associated with space debris and cluttered orbits and discusses possible policy actions. This is further elaborated in *Earth's Orbits at Risk: The Economics of Space Sustainability*.
- The OECD Space Forum has also launched a collaborative project on the economics of space sustainability involving universities and research centres from different parts of world, assessing the costs of space debris and value of space applications. The objective is to spur more research in that field and provide new evidence to support policy options.

Further reading

OECD (2022) *Earth's Orbits at Risk: The Economics of Space Sustainability*, OECD Publishing, Paris, https://doi.org/10.1787/16543990-en.

OECD (2022), *OECD Handbook on Measuring the Space Economy, 2nd Edition*, OECD Publishing, Paris, https://doi.org/10.1787/8bfef437-en.

OECD (2020), "The impacts of COVID-19 on the space industry", *OECD Policy Responses to Coronavirus (COVID-19)*, https://www.oecd.org/coronavirus/policy-responses/the-impacts-of-covid-19-on-the-space-industry-e727e36f/.

Undseth, M., C. Jolly and M. Olivari (2020), "Space sustainability: The economics of space debris in perspective", *OECD Science, Technology and Industry Policy Papers*, No. 87, OECD Publishing, Paris, https://doi.org/10.1787/a339de43-en.

OECD (2019), *The Space Economy in Figures: How Space Contributes to the Global Economy*, OECD Publishing, Paris, https://doi.org/10.1787/c5996201-en.