# UCL Space Policy Workshop: ‘Enabling Space’

# REPORT

Rapporteur: Dr Christoph Beischl

Organised by

UCL Space Domain[[1]](#footnote-1)

Wednesday, 15 May 2019

Christopher Ingold Building XLG1 Chemistry Lecture Theatre

University College London

20 Gordon Street, London WC1H 0AJ, United Kingdom

**Executive Summary**

This report provides a summary of the main points raised during the presentations and discussions at the UCL Space Policy Workshop titled ‘Enabling Space’ that took place during the 2nd UCL Space Week in 2019. The workshop, with particular consideration of policy aspects, explored how to better enable and facilitate space activities and services.

Invitees to the workshop (both speakers and audience participants) were chosen from government, industry and academia. A number of masters’ students from UCL studying related subjects also attended and made many useful contributions.

A general conclusion that can be drawn from the contributions during the workshop is that space-related policy-making, including in the UK and at the international level, has become more complex. The space sector has undergone many changes in recent times and has to tackle many concurrent challenges. Overall, the involvement of a broad number of public and private entities will be necessary to develop policies that address these changes and challenges effectively. A participant said at the end of the workshop: ‘Space is too important to leave decision-making solely up to the politicians’.

Overall,

* the first session noted that there are a number of different drivers that underlie space undertakings, and introduced some legal and political issues affecting the implementation of certain new measures;
* the second session looked at the UK Space Agency’s approach to international engagement, with a special view to its engagement with India, and indicated several political and legal challenges that should be taken into account in future UK space policy-making;
* the third session provided insight into political and legal intricacies that affected the development of the Space Industry Act, which might be considered in drafting national policies;
* in the fourth session the view was expressed that existing international space law does not hamper current space undertakings *per se* and provided a good framework for the further advancement of the use and exploration of outer space. Yet, it also indicated that there is a need for political and legal clarification of the potential scope of certain space undertakings within this international legal framework;
* the fifth session offered advice on how to persuade decision-makers to engage in space-related policy-making, and implied that positions can change and can be changed;
* the sixth and seventh session sought to illustrate the relevance of the further development of the UK space industry and economy, and proposed steps towards that end;
* the eighth session explored the importance of the heritage of space and public engagement in the space sector;
* the ninth session addressed the congestion of space and some of the challenges the space sector faces regarding the establishment of Space Traffic Management on an international level;
* the tenth and final session increased the participants’ knowledge of the potential impacts of space weather events, and indicated that this topic should receive more attention with respect to space policy.

# Workshop and report objective

While the theme of the 2nd UCL Space Week (2019) was ‘Space the Enabler’, the one-day Space Policy Workshop’s theme looked at the other side of this coin and so was titled ‘Enabling Space’. In this regard, the workshop aimed at exploring the question of how to better enable and facilitate space activities and services, particularly through policy development and change.

This report provides a summary of the core points presented and discussed in the various workshop sessions. The UCL Space Domain hopes that this report will assist UK decision-makers in developing and implementing practically useful and forward-looking space policies, as well as help other parties in the space sector, especially from the industry side and academia, but also the general public to understand the importance of having their voices heard throughout this process.

*Nota bene*: While the various presentations are – as far as the speaker have agreed – available via the UCL Space Domain webpage, the discussions followed the Chatham House rule.

# Programme overview

Co-chair (morning session): Professor Joanna Chataway (University College London, Director STEaPP)

Co-chair (afternoon session): Professor Jean-Jacques Dordain (Former ESA Director General)

|  |  |  |
| --- | --- | --- |
| **Time** | **Topic** | **Speaker** |
| 08:30 – 09:00 | *Morning**Coffee* |  |
| 09:00 – 13:00 | Opening | Alan Smith (UCL) |
| Past and Current Enablers of Space  | Serge Plattard (UCL) |
| India | Arfan Chaudhry (UKSA) |
| *Break* |  |
| Law | Martin Petto (UKSA) |
| Law | Sa’id Mosteshar (Institute of Space Policy and Law) |
| 13:00 – 14:00 | *Lunch**Break* |  |
| 14:00 – 17:50 | Policy | David Willetts (Former UK Minister of State for Universities and Science) |
| Capability, Capacity and Technology | Graham Peters (UKspace) |
| Capability, Capacity and Technology | James Cemmell (Inmarsat) |
| *Break* |  |
| Public Engagement | Doug Millard (London Science Museum) |
| Space traffic control | Peter Stubbe (Federal Ministry for Economic Affairs and Energy, Germany) |
| Space Weather | Lucie Green (UCL Mullard Space Science Laboratory) |
| 17:50 – 18:00 | Close | Jean-Jacques Dordain (Former ESA Director General) / Alan Smith (UCL) |

# Presentations and discussions

## Opening Morning session (*by Professor Alan Smith, UCL MSSL and Space Domain, and Professor Joanna Chataway, UCL STEaPP*)

Professor Smith welcomed the participants and the co-chairs. He also noted the importance for the broader space community to engage in space policy-making to “enable space”. To that end, he invited all workshop participants to engage fully in putting forward radical or controversial positions, and so to stimulate many fruitful discussions.

## Past and Current Enablers of Space (*by Professor Serge Plattard, UCL Space Domain*)

This session gave a overview of the myriad of existing and proposed domestic and international binding and non-binding space-related regulations and guidelines that have or might need to be considered to enable the various forms of current and planned space activities and services in the UK and internationally in a sustainable manner. Moreover, this session offered an overview of the general drivers that have underlain the development of the UK’s and other countries’ space capabilities and capacities over the past decades.

Most prominently, major drivers behind space undertakings over the past decades have arguably been:

* *National security*, e.g. in terms of space launcher development contributing to achieving/upholding nuclear deterrence, as well as the development of remote sensing, telecommunications and broadcasting, and navigation satellite systems to advance strategic support qualities;
* *Political motives*, e.g. in terms of engaging in national space capabilities as an attribute of power in geopolitical competitions (such as during the Cold War in the form of the US-Soviet race to the Moon), as well as using space undertakings as a symbol of or measure to foster international cooperation. For instance: during the US-Soviet policy of détente in the 1970s; the intergovernmental partnership towards creating and operating the ISS that commenced in the 1990s; and, with a view to the future, potentially establishing a multinational cis-lunar station and ‘Moon Village’);
* *Economic gains*, such as in terms of commercialising state-owned satellite and launch systems for financial profits. Furthermore, and assisted by the adoption of business-friendly national regulations and policies in many countries, more private actors, including billionaires, have become aware of the business potential of and commenced investing in the space sector (keyword: NewSpace), i.e. they work towards offering low-cost launch services, operating low-Earth orbit satellite mega-constellations for broadband internet and Earth observation, and exploiting space resources. Also, there are already some deliberations in the space sector about the potential to establish a sustainable Earth-space ecosystem[[2]](#footnote-2) involving private and public actors over the next decades. Notably, during the discussion, it was suggested that there is a particular need to clarify the legal issue of ownership of space resources considering the various planned private space mining initiatives and private lunar and Mars missions. Also, the discussion mentioned that these new entrepreneurs try to influence government policies and regulations to benefit their ambitions. Yet, these attempts to influence should not necessarily be seen as fostering fierce competition between the governments and entrepreneurs. Rather they should come together to find mutually beneficial solutions, to find win-win outcomes.

The session also highlighted that there are threats to the stable use of space associated with a more and more congested, contested and competed space environment, space weather events and near-Earth objects (NEOs). The first aspect creates new demand for establishing – including the relevant political and legal framework that allows for the use of – such capabilities as active debris removal, space tugs and in-orbit servicing. However, regarding in-orbit servicing the discussion added that the servicing system needs to be highly reliable and cost-efficient while future generations of spacecraft have to be constructed so that they can be serviced. Past attempts to implement an in-orbit maintenance approach have not proved to be cost effective. This is especially true for smaller satellites which might best be considered ‘disposable’ in economic terms. Furthermore, the discussion emphasised that the current priority for debris removal should be given to larger objects since through collisions and other processes they may become the source of numerous secondary objects (the Kessler effect refers to a situation where debris collisions multiply rapidly to a point that satellite operations at some altitudes becomes impossible). Foreseen satellite mega-constellations might make debris removal generally more prevalent in the future although the effective implementation of active space debris removal currently runs into various legal and political problems. For example, on the legal side, there will be situations when it is not possible to identify the debris owner, whether it is debris or just a currently inactive satellite, or when the owner of debris does not consent to its removal. While the Outer Space Treaty (1967) does offer some protection, the absence of a secure legal framework limits private enterprise in this area. On the political side, the dual-use potential of active debris removal capabilities is cause for strong security concerns among the states.

Lastly, the discussion noted that the topic of planetary protection should receive greater attention with a view to more and more missions aiming at landing on other planets/satellites, bringing back samples, mining space resources and building structures on other celestial bodies.

## India *(by Arfan Chaudhry, UK Space Agency)*

This session gave a general overview of the UK Space Agency’s (UKSA’s) approach to international engagement, with a special view to its engagement with India. In short, UKSA aims, in cooperation with other relevant government entities, academia and the domestic private sector, at delivering an excellent – bi- and multilaterally-based – collaborative space programme that provides maximum socioeconomic, scientific and political benefit for the UK. Economically, the UK attempts, in particular, to reach a 10% global (civil) space market share by 2030, including being a world leader in small launchers and small satellites. Cooperation-wise, the UK through UKSA gives considerable attention to continuing its strong engagement within ESA, maintaining active involvement in the United Nations Committee on the Peaceful Use of Outer Space (UNCOPUOS) and partnering bilaterally with major actors including the USA, as well as with developing countries, e.g. in the Latin American and African regions, that benefit considerably from access to space-related capabilities and capacities. The discussion suggested that UKSA works towards creating a coherent international bilateral space programme, including the fostering space science collaboration. It also explained that the intention behind UKSA’s International Partnership Programmes (IPPs) (152 M£ over 5 years) is ultimately to create a sustainable engagement between the respective host country and the involved UK key industry partner.

The UK interest in engaging in the space sector with India, especially through interaction of the UKSA-Indian Space Research Organisation (ISRO), both of which entered into a space-related MoU in 2011,[[3]](#footnote-3) is based on the perception that India is self-sufficient in terms of creating space data, yet India might benefit from further capabilities and capacities to interpret and utilise data in the downstream environment. Moreover, India seems to be commercialising its space sector more and more, including through increased involvement of private actors, and has already set up well-rounded domestic space launch and space exploration capabilities. This offers exciting collaborative opportunities to public and private space actors in the UK. Notably, ‘International Trade Secretary, Dr Liam Fox announced in 2018 that the UK will be promoting for the first time space exports worth up to £1.5bn in USA and India through a new marketing campaign.’[[4]](#footnote-4) The UK also presses for further ESA-Indian collaboration.

Examples of UK’s challenges in conducting domestic and cooperative space-related undertakings are to ensure sufficient funding, tackle (and have the capacity to tackle) the agency’s increasing range of tasks, deal with a complex domestic intra-governmental coordination processes and intergovernmental decision-making procedures within the ESA framework, take export restrictions into account, engage efficiently with industry and academia, and – on that background – create a coherent agency position. The discussion indicated that a formal approach to facilitate domestic intra-governmental coordination with regard to space is already under development.

The discussion further added that MoD personnel currently support UKSA in its assessment of establishing a UK GNSS to substitute for the likely lost secure operational access to the European Galileo GNSS after Brexit. Is there a compelling business case? What are the potential long-term benefits of a national solution?

Finally, the discussion highlighted that UKSA is aware of the importance and difficulty of regulating space debris management, as well as of detailing UK launch activity regulations, especially with regard to ascribing final responsibilities.

## Inside the sausage factory – Public policy lessons from the Space Industry Act (*by Martin Petto, UK Space Agency*)

This session, which built on the speaker’s personal views and should not be misinterpreted as the position of UKSA, provided some insights into the decision-making process behind the creation of the Space Industry Act (SIA) and highlighted some of the act’s content (which is not reported in detail here)[[5]](#footnote-5).

Seeking the right balance, there was a lot of discussion in parliament about the large number of delegated powers in the act. An act that is flexible and future proof in a constantly evolving space sector is required. Overall, the drafting of relevant secondary regulations based on the delegated powers in the adopted act, e.g. addressing operator fees, environmental issues and insurance, is still ongoing. Notably, at one point in the drafting of the act the proper way to address the use of drones and related security issues for spaceports in the UK became a challenging topic. Also, the government saw the public presentation of the act as an important issue, which, after taking up some time, ultimately led to the change of the act’s initially proposed name ‘Spaceflight Act’ to ‘Space Industry Act’. On the institutional side, the government had to decide during the drafting process which (of two) department should take on the responsibility of bringing the bill forward. In the end it was given to the Department of Transport.

Finally, the discussion noted that there was a strong case for creating this act even within a challenging legislative calendar at the time. Among others factors, decision-makers saw the danger of missing the window of opportunity to make the UK industry a player in the internationally growing launch market.

## Law (*by Professor Sa’id Mosteshar, Institute of Space Policy and Law*)

This session started with a reference to the great advancements in space technology development that have reduced the cost of access to and operation in space, as well as to the tremendous concentration of wealth that has made space activities more accessible to private entities. At the same time, it is often suggested that the development of international space law has not kept pace with technology developments. Yet, the latter assessment can be challenged. Indeed, the existing international space law does not hamper current space undertakings *per se* and provides a good framework for the further advancement of the use and exploration of outer space. Nevertheless there are areas that would benefit from better definition, such as ‘where does space start?’, and what is meant by ‘fault’ when applied to space activities.

For example, with regard to the extraction or mining of space resources in which some private companies want to engage, a close read of Art 6 Outer Space Treaty (OST) shows that states must authorise and supervise national space activities in accordance with the other treaty provisions. Therefore, the treaty arguably also covers domestic private entities’ space undertakings. This stands against the argument that developed over the years that the OST does not regulate the activities of private entities. Moreover, the current legislation already counters the arguments that the OST bans territorial appropriation and not the appropriation of resources, just as the fact that one is allowed to fish in the high seas suggests that you can exploit resources in outer space. Under the Convention of the High Seas, it merely reads that no state can claim sovereignty over high seas, while the OST forbids appropriation by sovereignty and any other means, making the OST much more restrictive regarding the appropriation of space resources. Also, the Convention of the High Seas directly includes four freedoms, namely navigation, fishing, laying submarine cables and pipelines, and overflight. The OST does not provide any such special cases for appropriation, which makes the fishing argument void. At the same time, international space law already offers a solution for the lawful extraction of space resources, including by private entities, namely through the so-called Moon Agreement (ratified by only 15 countries so far, none of them having significant space activities). State parties to this agreement can (allow their private entities to) engage in space resources extraction under the condition that they put a regime in place that makes sure that such extraction is conducted in an orderly manner and involves equitable sharing (fairness principle) of benefits by all states.

On a different note, current international space law does not stand against the engagement of states and private entities in topical activities such as Space Traffic Management, living off-worlds and Space Tourism. However, there are some legal obligations, including on the national level that (might) need clarification. For example, an important issue for Space Tourism is the scope of ‘informed consent’.

The discussion then noted that the OST does not govern potential interaction with alien life, but it determines that humanity must not contaminate the space environment and Earth through space undertakings. Additionally, the provisions of the OST can be interpreted to read that space actors should not leave space debris to threaten other actors’ endeavours. Finally, while there is no international or supranational agency enforcing international space law, states or private entities registered with them that do not abide by such law, even if they are not signatories, have to fear the reprimanded of states observing such law. So far, however, no country has ever been officially brought to account for violations of OST.

## Opening Afternoon Session *(by Jean-Jacques Dordain, ex ESA Director General)*

Space has become too important! We should note that by far the biggest spender on space is the US DoD, far exceeding NASA. Moreover, we are seeing and have seen breakthroughs in space transportation, solar energy production and local life support systems in space.

## Policy (*by Lord David Willetts, ex minister of Science and Technology*)

It was noted that the UK has been engaged in space from very early times and was the 3rd signatory to the 1967 Outer Space treaty (OST). In the run up to the OST’s 50th anniversary and following a recommendation by the Canada-UK Council Colloquium 2015[[6]](#footnote-6), the UK reached out to the USA and Russia as to whether there is an interest to convene and discuss updating the international space law framework. The responses from the US and Russian side were dispiriting and nothing happened. Currently the prospects are even less promising.

To persuade decision-makers to engage in space-related policy-making it is beneficial to be able to showcase (public and private sector) gaps and opportunities. Also, it is useful to be able to make the financial argument that public spending in the space sector can trigger private spend, as well as to raise awareness among departments about their current use of space capabilities. The importance of space is receiving increased government attention, indeed Space Weather was considered as one of the 6 top risks associated with the London 2012 Olympics. Notably, the Tim Peak mission to the ISS has already contributed to putting space more into the public eye.

In recent years there has been a change of attitude of the UK MoD to the EU. For example, the MoD has become interested in a security-related UK participation in the Galileo GNSS system. With Brexit however, such involvement will be hampered in the future, potentially necessitating the establishment of UK autonomous capabilities. Furthermore, over the past decade, the UK government has become more and more aware of the dangers of space weather events to life in the UK and the success of other elements of its political agenda.

On a different note, the session brought forward the opinion that UK space capabilities can help the developing world. For example, satellite imagery allows governments in developing states, especially those lacking a strong terrestrial infrastructure, to check whether various constructions projects are actually underway in more remote parts of their territory (e.g. Indian schools build programme). In this regard, the discussion added that training and education needs to be linked to providing technological aid, as well as selling space products.

The discussion touched once again on the political and legal difficulties of tackling the growing space debris issue. For example, there is the dual-use potential of active debris removal satellites, the potential of wrong-full removal of ‘debris’ that was not debris, and the transfer of space situational awareness data to countries with which one is not allied.

The session finished on an interesting and provocative question from the floor: How does space get political support without political interference?

## Capability, Capacity and Technology (*by Graham Peters, Chair UKspace*)

This session argued for the development of the UK space industry and proposed certain steps towards that end, especially with a view to the UK government’s plan to have the UK reach a 10% (civil) space market share by 2030.

Concerning the relevance of the development of the UK space industry, the presentation pointed out that daily life in the UK is dependent on space. Overall, an estimated 15% of the UK economic activity, in particular when it comes to digital infrastructure, is enabled by space-related capabilities and such dependence is expected to grow even further. In this regard, UK space policy-makers should consider the desirability of the UK’s dependency on foreign space infrastructure and industries, especially taking into account that Brexit might disrupt integrated supply chains and reduce the UK’s role in the development and operation of the European GNSS Galileo. Moreover, the discussion added that nowadays large companies, in contrast to SMEs, are typically transnational and there is no guarantee that they will always stay in the UK as they inevitably adapt to new economic conditions.

In terms of proposed steps to address these issues, the presentation highlighted the potential contribution of the already established Space Growth Partnership that aims at aligning space-related activities among the government and the industry to achieve domestic coherence. Moreover, UKSA’s IPPs are helpful as long as Oversees Development Assistance (ODA) benefits to the partnering countries are considered in concert with export opportunities to the industry. Furthermore, significant benefit can be envisaged from the currently debated creation of the ‘National Space Council’ and the establishment of an official space sector deal (or national space programme) that focusses on domestic space sector development while also driving its growth through bilateral and institutional programmes (e.g. ESA and Eumetsat), takes a long-term view, interlinks the space-related activities of the various government department and aligns well with the UK industrial strategy. Additionally, the government needs to consider operating as an anchor customer (especially for downstream applications) to help unlock investment by private investors, as well as to set up a business environment that reduces the financial risk. Lastly, the presentation and discussion introduced the argument that it is necessary to increase domestic investment in space-related education and training to advance the pool of skilled workers in the UK space sector. This might include the creation of something along the lines of a (virtual or physical) Space Skills and Trade Institute that not only brings more skilled people into the industry but also brings industry people up to speed with new technology. The sector must continue to address its poor gender balance.

## Capability, Capacity and Technology (*by James Cemmell, Inmarsat*)

This session started with the statement that over the past decades the overall social contract and political landscape in the UK as well as the UK space industry have undergone many changes, and continue to experience them. Concerning the space industry, examples of such change include the privatisation of previous public entities, commercialisation of services, the adoption of new space-related legislation and institutional transformations such as the setup of ‘catapults’ and the current discussion of establishing a National Space Council. With regard to changes to the space economy, major factors are:

* New sources of capital;
* Emergence of new markets;
* Big bets on technological developments;
* Insecurities in the GEO and launch sector;
* New satellite companies that want to be players in the Internet of Things;
* Interest of the US DoD in distributed resilience (including private space capabilities and capacities);
* Involvement of more states (e.g. Japan and China) in space and new space-related dynamics;
* Attempts to avoid space-related silos in government.

Overall, the session suggests that the UK space industry is vulnerable, especially due to Brexit, and the UK government is at risk of failing to sufficiently address the factors introduced above. There is a need for strong political leadership. One potentially important measure would be to establish a Minister for Space. Moreover, the discussion added that the science and technology-heavy space sector might benefit considerably from stable (bipartisan) long-term planning and investment strategies. Finally, the discussion suggested that there is a need to raise the awareness of policy-makers about the differences between policies and strategies to arrive at efficient political frameworks to address space-related issues.

## Public Engagement (*by Doug Millard, London Science Museum*)

This session and related discussion addressed space heritage and public engagement in the space sector. The workshop participants received a broad overview of the Science Museum’s space exhibitions and their success stories over the past decades. Moreover, they received some indication of potential upcoming exhibitions, as well as information about some private space-related archives collected by the museum. In recent years, the greatest contributor to space-related public engagement in the UK was probably the Principia mission on board the ISS involving the first British ESA astronaut, Tim Peake.

A notable point during the discussion was that the Science Museum has adapted to the changes in the UK space sector and engages with commercial companies in the UK, which have become major space-related actors, to get access to new exhibition material.

## Space traffic control (*by Dr Peter Stubbe, Federal Ministry for Economic Affairs and Energy, Germany*)

This session addressed the topic of Space Traffic Management (STM), which has gained an increasing attention in recent years, especially due to the growing number of space debris and the planned Low Earth Orbit (LEO) satellite mega-constellations. Projections suggest that active debris removal, in particular in LEO, will become necessary to ensure stable access to space.

In the German case, the government’s current space strategy cites sustainability as a guiding principle. Towards that end, and relating to STM, Germany set up a Space Situational Awareness (SSA) Centre (Weltraumlagezentrum) and works on improving its SSA capabilities and capacities, including, among others, through sensor development and modelling. Moreover, the country engages on an international level in the European Space Surveillance and Tracking (EUSST) Support Framework Consortium, cooperates in ESA programmes relating to, e.g., space weather and Near Earth Orbit (NEO) observation, participates in standardisation-related bodies like European Cooperation for Space Standardization (ECSS), and takes part in the relevant work and discussions in, e.g. UNCOPUOS, Prevention of an Arms Race in Outer Space (PAROS) and the Inter-Agency Space Debris Coordination Committee (IADC). Naturally, it takes note of developments in and potential for collaboration with other states such as the USA.

From a general perspective and to enable space in the future, the establishment of Global Space Governance is a reasonable next step in STM. So far, international space law is quite fragmented. It lacks a clear organisational framework, an institutionalised and flexible norm development process, as well as a coherent implementation. However, according to the discussion, the international space community seems not inclined to create internationally binding rules for STM. The development of soft law approaches might have the highest chances to succeed in this regard. Within such approaches, it makes sense to, among others, require end of life plans for satellites. Notably, the upcoming German national space law might outline general obligations for STM that then call for the establishment of more specific secondary regulation. Overall, it will never be enough to leave STM to private sector initiatives. Private actors will always need national and international regulations to have legal security.

In closing the session, the Chair added that it was first up to the USA and China to show the way forward agreeing on a concrete next step for STM.

## Space Weather (*by Professor Lucie Green, UCL, Mullard Space Science Laboratory*)

The session commenced with an overview of potential impacts of space weather events, e.g. the disruption to electricity disruption networks and the Global Navigation Satellite System’s (GNSS) signal and HF radio wave propagation, the damaging of micro-electronics in space and in aircraft , the shortening of satellite lifetime, and the disruption air traffic.

The March 1989 geomagnetic storm was a wake-up call about the dangers of space weather to space and terrestrial assets, and as a consequence to the economy and human life, particularly felt in the Province of Quebec. The Halloween solar storm event in 2003 was a strong reminder. Some effects of the latter were:

* 10 % of satellite experienced anomalies;
* 10 satellites lost operation service for more than one day;
* One scientific satellite was lost;
* Sweden had a partial grid blackout for 1hr affecting 50,000 people;
* High latitude flights had to be re-routed to avoid HF radio blackout;
* Some aircraft needed to land for several hours due to GNSS satellite problems;
* The International Space Station (ISS) crew had to take shelter from radiation.

The UK Met Office Space Weather Operations Centre issues tailored forecasts to specific industries, whereby different users might have different needs and priorities. The UK has already entered into a coordinated relationship with the USA to improve its space weather forecasting. Moreover, researchers collaborate internationally towards creating ever more sophisticated and accurate physical models, which is extremely challenging because of vast volume of space that needs to be observed, (the physical diameter of the Sun is 1.4 million km, the Earth’s is 12700 km, and the Sun-Earth distance is 150 million km). Notably, UCL engages in the study of space weather events and has published papers in learned journals. The discussion added that researchers elsewhere look at other sun-like stars to assess their activity and so better predict the risks of solar events. Besides that, the discussion suggested that modelling of radiation-particle interaction (fundamental to space weather prediction) is still extremely complex and challenging.

Overall, in the past decade has seen some notable milestones in the UK and European that addresses space weather, *vis*:

* 2000 EU directive on aviation and the radiation environment;
* 2009 ESA Space Situational Awareness programme launched;
* 2011 UK: Space Weather on the national risk assessment;
* 2014 UK: MET Office Space Weather Operations Centre opens;
* 2015 UK: UKSA International Partnership in Space (IPSP) funds a study socio-economic impact of space weather and a mission concept;
* 2017 ESA SSA phase 3 includes the development of the Lagrange mission concept, a satellite programme that the UK may well participate in.

# Closing remarks *(by Professor Jean-Jacques Dordain and Professor Alan Smith)*

The closing remarks pointed out that the domestic and international space sectors are currently undergoing a range of changes and have many competing priorities. To enable and facilitate space activities and services in this context, it is, policy-wise, essential to engage in collective international efforts and build bridges between the private-public space sectors and downstream-upstream industry, and to reconcile short and long-term objectives. Moreover, there is a need to establish laws and regulations that address and are able to handle this complex situation. All need to understand that the space sector has entered into a new era which warrants new solutions and so new policies. Space policy-making needs to be a collegiate affair. Space is too important to leave decision-making solely up to the politicians.

1. Official webpage: <https://www.ucl.ac.uk/mssl/space-domain> instead of www.uclspace.com? [↑](#footnote-ref-1)
2. See, for example: <https://www.nasaspaceflight.com/2018/03/ula-laying-foundations-econosphere-cislunar-space/> [↑](#footnote-ref-2)
3. For more information: <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/304227/isro-uksa-mou.pdf> [↑](#footnote-ref-3)
4. For more information: <https://www.export.org.uk/news/409750/DIT-launches-1.5bn-space-export-campaign.htm> [↑](#footnote-ref-4)
5. There are excellent papers addressing that, e.g.: <https://www.kluwerlawonline.com/abstract.php?id=AILA2019001> [↑](#footnote-ref-5)
6. https://munkschool.utoronto.ca/publicpolicy/2015-space-obstacles-and-opportunities/ [↑](#footnote-ref-6)