GLOBAL SPACE TRAFFIC MANAGEMENT WORKSHOP 2025

Summary Report

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The Edinburgh Global Space Traffic Management Workshop

This is a summary from the fifth in what has become an annual series of events that bring together invited groups of international participants with expertise in the range of topics that relate to the development of a global system for Space Traffic Management (STM). This is not a conference where attendees passively listen to presentations. Instead, our workshop is an immersive, interactive experience where participants engage in collaborative activities, share perspectives, and work together to develop common understandings and innovative solutions.

This workshop series started in 2016 when we first convened to explore the range of topics related to the development of a global system for Space Traffic Management (STM). The inaugural workshop undertook a tour d'horizon to identify the range of such topics, yielding a report - "The case for a commercial/civil space traffic management capability" - that set the agenda for subsequent discussions.

In 2017, we walked through a satellite operations scenario, from launch to orbit, to identify the information required for effective space traffic management. The third workshop focused on the network of data resources needed to support STM and the regulatory framework within which STM capabilities must operate. The fourth workshop in the series built upon this momentum, extending the regulatory theme by story-boarding a GEO debris collision scenario. This scenario formed the basis for a series of "Space Law Games," designed to provide a legal analogue to the operations scenario from the 2017 workshop.

The topic for this 5th year focused on stakeholder integration into the national, coalition and international military/civil space command and control framework. In past workshops we have examined the need for data sharing and the development of sense making analytics. There has been significant progress in the last four years in these areas. We want to build on this progress and consider how we as an international community, collaborate and interact operationally. This will be a highly interactive, scenario-based workshop with the goal to produce community guidance in R&D, policy development and evolution of operational frameworks.

We follow the Chatham House Rule. The Chatham House Rule helps create a trusted environment to understand and resolve complex problems. Its guiding spirit is: share the information you receive, but do not reveal the identity of who said it. A full compilation of notes was compiled by our team of student scribes from Northumbria University School of Law and is archived for reference by the workshop participants. This summary report is compiled from those notes and has been reviewed by participants for accuracy.

The summary report is free to distribute. We intend the workshop to benefit the global space community. We only ask that if the material is used in publications, the report is cited as a reference. For additional information and to contact the workshop team, please visit our website at: sites.google.com/view/space-traffic5.

Matthew Bold, Workshop Coordinator

Acknowledgements

Before we proceed, it is essential to recognize the remarkable individuals whose dedication and expertise have made this workshop possible.

- **Agata Rożek** – My trusted collaborator and the driving force behind every facet of the event. Agata's tireless commitment, strategic insight, and flawless execution were indispensable; none of the workshop's achievements would have been realized without her leadership.

- **Professors Andy Lawrence and Bob Mann** – From the workshop's inception, these distinguished scholars have served not only as gracious hosts but also as steadfast stewards of our program's direction. Their vision, mentorship, and unwavering support have kept the agenda on track and ensured a consistently high standard of quality.

- **Dinz Dinsley, Chris Newman, and Nik Smith** – Your enthusiasm and deep domain expertise have invigorated the workshop's discussions and sustained its momentum. The passion you bring to the space community enriches every session and inspires all participants.

- **Thea Dingwall, David Eagleson, and Molly Doyle** – Thank you for the countless hours you devoted to documenting the insights generated throughout the workshop. Your meticulous note-taking and skillful synthesis have produced this comprehensive summary report. As emerging scholars of space law at the University of Northumbria, you are poised to become the next generation of leaders shaping the future of the space industry.

Together, your collective efforts have not only ensured the success of this workshop but have also laid a strong foundation for continued collaboration and innovation in the global space community.

All the best, Matt

Introduction

The aim of the workshop was to identify problems in space domain awareness, establish clear definitions and frameworks and to share this with the wider space community. Over the course of the workshop, the group identified a critical capability gap:

> Stakeholders are separated by political boundaries and objectives (military, civil, commercial, regulatory, and legal) and lack access to operational information needed for safe space activities. This information disparity hinders effective coordination, risk management, and compliance with regulatory standards.

Group discussions were centred on breaking down this gap into smaller, digestible questions. This summary report summarises these key points of discussion and lays out the next steps to be taken by the workshop group. The summaries are not written in prose to ensure the scribes did not expand group discussions with their own thoughts and analysis during the write up. A disclaimer that Artificial Intelligence was used during the workshop for the purposes of transcription and producing summaries, but the entirety of this report was created by the scribes, and names have been manually scrubbed from the transcripts to ensure compliance with Chatham House Rule. Scribe notes and transcripts can be provided upon request.

a. Data

Data was identified by participants as a necessary element for an effective system of Space Traffic Management. The discussion centred on data acquisition and sharing, as well as the adoption of appropriate standards to allow for interoperability with different systems. Many operators do not currently know where to obtain data, or if they do, lack the financial or regulatory incentives to do so.

Topics of Discussion

- Need to find the optimal level of data sharing.
    - *Optimal outcomes depend on who you are and what your aims are (optimising profits vs security vs minimizing cost)*.
- Who can have access to optimal levels of data.
- Registration Convention lacks clarity and United Nations Register of Space Objects is incomplete and out of date.
    - *Poor compliance despite UN claims*.
    - *Countries fail to provide information or are years behind in registration*.
    - *Basic data is missing (designation, perigee and apogee, operator)*.
    - *Critical details frequently missing (orbits, materials, rotation, propulsion and contact information)*.
    - *Significant gaps in reporting*.

Critical Data Gaps

- Critical Data gaps can be seen listed on the Global Network on Sustainability in Space.
- Current tracking capabilities limited- only focus on objects 10cm or larger when the smaller debris can still cause catastrophic damage.
- Tracking sensors are predominantly in the Northern Hemisphere creating 'reflection bias'.
- Insufficient frequency of observations.
- Some debris have no identifiable origin- accountability issues.
- No standardisation sharing of area-to-mass ratios or spacecraft orientation details.
- Inaccurate collision avoidance messages: thousands of warnings a day but with very low accuracy. Needs improvements in capabilities for better data acquisition and processing.

Barriers to Data Acquisition:

Access to space data is uneven - while some data is theoretically available through systems like the Unified Data Library (UDL). There are practical barriers:

- National security concerns lead to a reluctance to share data.
- Military classification as a barrier to sharing useful information.
- International Traffic in Arms Regulations (ITAR).
- Proprietary data: Reluctance to share data which may reveal proprietary information about capabilities.
- Lack of unified licensing regime inhibits efficient data transfer.
- Data interoperability: Some data held on legacy systems or in accordance with different national standards or systems which make it different to combine.
    - *Including calibration issues and lack of curation*.
- Data processing bottlenecks: Enormous volume of tracking data with insufficient processing capabilities.
- Cost: Commercial data providers have financial incentives to limit access to high quality data. However, providing free data creates challenges for organisations to justify their actions to government oversight.

<u>Proposed Solutions</u>

- Establishment of Metadata standards: Establishing essential contextual information necessary for data retrieval and access, thus streamlining the combination of data from different sources.
- Propose UN conference room paper to highlight the challenges to data access.
- Gather support from UNCOPUOS Member States to provide further information than is required by the Registration Convention.
- Establish trusted agency to handle commercially sensitive information- including public health information.
- Leverage market-driven factors such as financial and insurance incentives for better compliance.

b. Communication and Information Sharing

Topics of Discussion

- Need for trusted entities to handle information sharing and coordination.
- Streamlining communication channels between operators.
- Breaking down siloed interactions to improve communication between different orbital regimes.

Current Challenges

- Knowledge disconnect: Widespread lack of understanding among diplomats, politicians, and government officials about space operations.
- Lack of contact details for operators in a centralised location.
- Reluctance of operators to share data.
- Lack of transparency in current space operations.
- Some States would be reluctant to cooperate.
- Communication breakdowns between tracking and operators, leading to lost objects increasing operational costs.

Proposed Solutions

- Development of standard messaging protocols - IVOA (International Virtual Observatory Alliance) and FITS (astronomical file format) were mentioned as examples.
- Create a trusted entity to facilitate information sharing.
- Create emergency contact protocols requiring States to share contact information about their licensed operators and update it accordingly.
- Implement Layered Access Control to make States or companies more comfortable with sharing data. Data shared only on a need-to-know basis.

c. Tragedy

Space Environment Concerns:

- Currently around 12,000 active satellites with projections of 70,000-100,000 in 2 years.
- Environmental degradation and incremental pollution rather than a catastrophic event.
- Most objects of concern are in LEO (350km-800km) with concerns for:
    - *Uncertainty in tracking, challenges for collision avoidance*.
    - *The higher the number of satellites the more avoidance manoeuvres required*.
    - *Some participants expressed concern over Kessler syndrome possibilities due to increasing risk of collisions (this was debated, with some expressing collision risks could be overstated due to vastness of space)*.
    - *Regular large constellation re-entries (and some concerns over the pollution this can cause even with a lack of consensus from scientific community so far)*.

Promotion of change:

- Is there a "need" for tragedy? Will it promote rapid change in the space sector?
- Tragedy and inconvenience are not interchangeable. Tragedy is specific and may inspire change, but inconvenience does not.
- There are issues defining a tragedy including the levels, extent and size.
- The more tragedies there are, the less impact they have – unpredictability is important in tragedies promoting shock.
- Concern that consequences are not apparent until critical services affected.
- When tragedy does eventually occur, we cannot be confident that we have sufficient data for attribution.

But – is there time to wait for tragedy? Pre-emptive efforts may be better than reactive ones

Potential Catastrophic Scenarios *(resulting from bad space operator / space user behaviour)*

- Nuclear detonation in LEO destroying a mega constellation, wiping out an orbital regime, significant destruction.
- Collisions causing damage to critical GEO satellites.
- Space Station debris casualties on Earth, particularly the example of a collision of the ISS into Chicago.
- Would the death of an astronaut be a significant enough tragedy to spur action?

"Tragedy" on The Public

- The media drives the impact of tragedy and this needs to be balanced.
- There may be a need for the public to be concerned about a risk to themself in a tragedy for it to spur meaningful change.
- There is growing public awareness of space pollution and the harm this may cause harm to people on Earth - still not a large enough percentage of population.
- Some debris has hit personal property and helped to raise awareness, but the news cycle moves quickly, and space often seems remote to the general public.
- Could human health become the tragedy? (impact of mercury in bodies?)

d. Standards and Best Practices

Participants did not reach a consensus on who should lead the development of standards and best practices. Some argued this responsibility lies with the government while others favoured an industry driven approach. However, there was agreement that coordination between government and industry will be essential in shaping the future standards and best practices landscape. Further concerns were raised regarding there being too many standards organisations in the space sector without adequate coordination between them.

The key aim which participants identified was to begin to categorise different mission and satellite types before identifying which standards need to apply to each.

<u>Legislative position</u>

- Law does not deal well with pre-emptively addressing issues, but instead works best when there are established principles which can be codified.
- Engineers and technical experts must establish these principles to guide lawyers and regulators.
- Need for processes and procedures to fill blanks where there is no established law.
- Current data standards make it difficult to prove fault, thus difficult to deal with legal causation.
    - *Iridium-cosmos incident: lack of sharing crucial information. But there was no legal reason for movement, law is lacking.*
- International law should be properly implemented and applied in national law.
- Legislation is for a generalised group. Standards are for specific functions and tasks.

<u>Current Challenges</u>

- Balancing transparency with security and proprietary concerns.
- Challenge of accurately quantifying reliability of space systems.
- Finding standards which are acceptable to all nations at varying levels of technological development.
- Too many standards organisations with a lack of coordination.
- Pace of technology vs pace of legislation.
- How to incentivise stakeholders to follow standards?
- Creating standards that can be adopted by emerging space actors and states.
- Implementing mechanisms for enforcement and compliance.
- Current moves to create Rating systems (bronze/silver/gold standards) that create feedback loops in design and engineering.

Current Standards Landscape

- The legal system cannot bindingly legislate when there is still a need for research.
- Standards will fill a gap where legal system is unready to regulate (especially emerging issues).
- There is a need to raise attention and raise this issue with government, science, industry, insurance, finance.
- ISO standards – Self-referential system which builds upon existing standards to create a complex framework.
- Standards need produced by the people who have the knowledge.
- High degree of involvement from industry.
- Governments and regulators play a supporting role.

Participants identified the following Gaps in Existing Standards

- Lack of space awareness: UK Government departments (DSIT) acknowledge they are 'policy people' not 'space people'.
- Unclear accountability and responsibility in government structure.
- Environmental impact and human health concerns.
- No standardised format for sharing owner/operator information, including contact information.

Potential Solutions

- Social pressure approaches like UK's drink driving campaigns of the 1980s.
- Work closely with insurers to set expectations for operators and provide markets with appropriate guidance on technical safety matters to ensure space remains insurable.
- Ensure developed standards are practical, workable, and accessible.
- Differentiate standards based on operator category (mega-constellations vs. small satellites) - although the point was made that agreement on such classification would be difficult to reach.
- Launching States can act as gatekeepers for standards enforcement – Reaching consensus amongst these key stakeholders is most critical.
- Start with best practice, morph into national then international standards.
- Need as a best practice communication to inform people (organisations, registration, licencing nations and launch providers) of the information they have for conducting safe operations.

e. Red Light / Green Light Discussion

Participants resolved to consider best practices for behaviour which could form the basis of a publication for further comment and discussion from industry representatives. Participants were also asked to consider incentives and penalties which may help to shape desirable behaviour. There was consensus on the position that progress on this issue will be incremental. It should be noted that participants recognised that a large portion of the red/green light discussions will already be reflected by national licensing regimes.

Purpose

- Set guidelines to ensure responsible space users.
- Ensure transparency and predictability.
- Encouraging responsible practices of operators and engineers.
- Solidify concept of a duty of care operators have towards other space users.
- Keeping space operationally efficient as there would be a clear line to be crossed.
- May allow for better operators as violations will be clearer.

Green Lights – Good Behaviour

Key Principles of Responsible Space Operators:

- Transparency and predictability are fundamental qualities for responsible operators.
- Being clear and open about current space capabilities and limitations. Including publishing updates on changes in capabilities.
- Practicing responsible engineering, minimizing space debris.
- Pro-active communication with STC centres and operators.
- Sharing data about non-manoeuvrable objects.
- Sharing data about proposed manoeuvres to allow for planning 3-4 months in advance.
- Post-manoeuvre communication of actions taken.

Red Lights – Rule Violations

Negative Behaviour which ought to be controlled

- Persistent proximity without explanation.
- Launching undisclosed satellites without sharing basic parameters (there is a need to identify basic level of information even for defence satellites).
- Transmitting signals using unassigned frequencies.
- Refusing to share relevant operational information.

Penalties:

- Situationally Dependant.
- There may be a requirement for a more universal sanction such as being able to hold States accountable for their actions or lack of action.

Suggestions of Penalties:

- Economic restrictions – may not be a good idea or feasible.
- Rating systems for space actors - actions or lack of action may result in reputational damage, with reference to existing standards such as the Space Sustainability Rating.

Challenges

- Achieving consensus on definitions:
    - *Criteria such as "reasonable expectations" may likely pose challenges to different operators.*
    - *Consistently defining 'space debris'.*
- Achieving balance between transparency and security.
- Requirement for a balance between incentives and penalties.
- Addressing diversity of operators- considering needs of large commercial entities as well as new emerging space actors (differing capabilities).
- Practically, national law and regulation is easier to enforce "red lights" as this considers commercial operators.
- Difficulty agreeing upon an international set of rules which can be implemented on a national level.
- Certain countries already have laws in place which penalise their actors.
- Enforcement challenges should some countries refuse to participate.
- Communicating standards to industry, public and government.

Incentive / Implementation Mechanisms:

- Positive economic and reputational incentives rather than punishments.
- Rating systems for space actors that create feedback loops between different divisions such as design and engineering.
- Social pressure approaches.
- Need for standards to consider operator classes (small satellites vs mega constellations).
    - *Such as a modified testing and certification process to reduce burden on smaller operators*
- Role of launch licencing vs launch vehicle industry: a gatekeeping mechanism for standards enforcement.
- Participants agreed on the need for governments to engage in diplomatic coalition building to secure agreement on standards.
- Prospect of integration of incentive mechanisms with existing legal structures, such as at the ITU, to enable tiered incentives and punishments based upon compliance with best practices.

f. Space Traffic Management or Organisation

Topics of Discussion

- Current challenges.
- Coordination perspectives.
- Regulatory considerations.
- Proposed models and solutions.

Current challenges

Current approach to STM is insufficient

- Inefficient systems with common disruptions (week-long disruptions to launch windows).
- LEO presents more complicated challenges compared to GEO.
- No centralized STC compared to air traffic control and maritime.
    - *Difficulty in comparing ATC and maritime with STC due to differences in domains- high risk of harm to humans and to Earth in air disasters, key differences in State sovereignty, unpredictability of space weather*.
- Need to improve data accuracy for collision warnings.
- Do we need management or coordination?
- Lack of catastrophic event means little incentive for commercial operators to pay for improved systems.
- Political 'games' posing a risk to space- other countries wanting their own version of Starlink.
- Dual-use conundrum: Governments needing commercial satellites to help in combat missions.
- Lack of consequences for poor space behaviour results in limited motivation for improvements.
- Universal rule: space debris has right of way.
- One view is that space is being used sufficiently because it is currently being used successfully. Counterpoint: sufficient use of space depends on acceptable risk tolerance.
- Different risk tolerances exist based on operator type (military, commercial, academic).
- Smaller companies may take greater risks due to limited liability exposure.

Satellite tracking and identification challenges

CubeSat confusion- difficulty identifying and communicating with small satellites after deployment.

- Differences between LEO vs GEO tracking: GEO is more known and predictable, LEO is more congested and the assumption that space is vast enough to avoid collisions will eventually fail.
- The launch COLA gap (period between launching and cataloguing) can be weeks or months.
- 8% of objects remain unidentified.
- Approximately 14% of all objects have been lost in transport.
- Misidentification lead to significantly increased operational costs.
- Emotional impact on teams who spend years working on satellite projects that fail or are lost.
- Wasted development time can be years.
- Industry Support Disparities.
    - *Large satellites (in GEO) come with manufacturer support.*
    - *Smaller satellite operators work on limited budgets.*
    - *Launch providers consider their responsibility complete once satellite is ejected into desired orbit.*

Considerations for STM

- Differences in stakeholder interest complicate coordination efforts.
- Using the ITU as a model for developing a developed air and space management system.
    - *Holds influence on end users.*
    - *Incorporated sustainability considerations into frameworks.*
- Maintain national-level responsibility (and sovereignty) with international coordination.
- Insurance industry likely won't drive STM developments due to limited number of insured satellites.
- Economic and market-driven factors ultimately determine participation.
- Current space industry evolved with military applications but needs civilian-led approaches (similar to Euro-control in Europe).
- Sustainability could be a driving factor for new regulatory frameworks, along with non-traditional influences like financers and insurers.
- Several possible solutions for satellite identification problems were identified:
    - *Satellite broadcasting identification information.*
    - *Laser reflectors to enable tracking even after satellite failure.*
    - *RFID-type technology that can be triggered by a signal.*
    - *Composite power sources that can 'paint on' power generation.*
    - *Self-powering identification technology that could last indefinitely.*
- Technical solutions should be selected based on mission requirements, budget and capabilities.

Proposed Solutions for STM

- International Visual Observatory Approach: using the international observatory approach as a medium for exchanging space information as this system already has hierarchical access controls.

- Credential Delegation Protocol: for machine-to-machine communication across systems, implementing protocols for passing authorisation credentials through a chain of software systems.

- Stakeholder communication: bringing astronomers who understand data standards with other space stakeholders to determine what extensions or alterations would need to be made to existing systems.

Action Items

- Enhance diplomatic approaches to create a framework for effective coordination.
- Clearly define the core information which must be shared about operational activities and location.
- Create 'flight plan' like filing system to complement SSA. Need for awareness not only surrounding what a satellite is currently doing but around what it will do next.

g. Public Awareness of the Space Industry and Role in the Media

Key Themes

- Everyone is a stakeholder: Space should belong to everyone, not just specific groups.
- Public outrage can precipitate government action.
- Concern surrounding atmospheric re-entry identified as a potential focal point for raising public awareness, linking in with existing public concern around climate change.
- Catastrophic impact disconnect from discussion surrounding risk: Potential for catastrophic economic and social impacts if satellite services were disrupted, but lack of awareness among decision-makers.
- Limited public awareness of dependence on space infrastructure.

Challenges to Engaging the Public

- Invisibility: Space feels removed from daily lives of many people.
- Scientific uncertainty: Scientific community hasn't reached definitive conclusions about health impacts, creating communication challenges.
- Budget allocation disconnect: People allocating budgets aren't interested without understanding space importance.
- Space Safety is a global PR challenge: Important to explain to people why government budgets should be directed towards this issue.

Potential Solutions for Raising Awareness

- Emergency scenario education: Using scenarios like "Day Without Satellites".
- Public seminars: Conduct seminars to educate the public about space infrastructure.
- Embed Space in the curriculum.

Possible Next Steps

- Drafting of a conference room paper/ position paper to take to UNCOPUOS and securing sponsorship of this paper by a Member State.

- Taking a position paper directly to relevant stakeholders as well to encourage best practice and communication.

- Work with ESSI under framework of BSI to develop a standard for space data sharing.

- Plan follow-up sessions around specific challenges to break down the challenge and enhance approach (roughly every 3 months).

- Consolidating information from this and previous workshops (since 2019) onto a webpage which is accessible for attendees.

- Create website that holds key information on standards, contact information for operators and any other relevant information and documentation (password protected).

- Take learning back to national agencies and regulators.

- Find volunteers for facilitators who are unbiased for participation as wide as geographically possible for future workshops.