Tuesday 27/08/2019 – Day 2 of the workshop

Morning session

Lockheed Martin, Royal Observatory of Edinburgh, NORSS and Northumbria University.

Academia should be in touch with industry, a network to connect the developments and thought processes between the two. Network as in a meeting place for the two groups.

Christopher Newman – The Legal Mechanics of STM

- Legal Dimensions of STM
- 1. Introduction, 2. The Assumptions of Regulation, 3. What should STM seek to do, 4. Taxonomy of STM, 5. Treaties, Codes of Conducts and Agreements, 6. State Liability & Fault, 7. Regulating STM

- Regulatory Assumptions, Space 2019 (2)
    - Environmental issues should be a factor
    - Substantial increase in change in composition in orbital population
    - Increased Launch Capacity with new launch nations with a diverse range of actors, Commercial – Military – Scientific.
    - ASAT tests – tacti acceptance? The impact they have on regulation.
- In space developments
    - On-orbit servicing/ Life extension
    - Increasing nomadic population which creates a difficult question for space regulation, how do we track them all?
    - Active Debris Removal
    - Boeing Starliner CST-100& Space X Dragon Crewed flights?
        - Who will be back in space? Not test pilots and astronauts but tourists and a new type of person in space. From military to civilians.
        - Sub Orbital Space Tourism to begin?
    - Rise of the 'very large constellations'
- Other Developments
    - State of the insurance market
        - Second largest insurer backed out, Swiss re?
    - Increased forum shopping posing regulatory challenges
- Increased Military tension space as a 'domain of war' and the duel use conundrum.
- Orbital debris will increase. Commercialisation and Sustainability tension?
    - A focus on the fact that the majority of the space population is debris for regulation.
        - Make the public aware of this situation to be able to influence regulation.
- Is enforcement limited? Loopholes in the current tool of enforcement via regulators as incorporated by the OST.
    - Mandatory is not the way, no Space Cop.
    - Sovereign authority allows enforcement to happen, but aside from that independently corroborated evidence to allow enforcement.
        - Independent verification of evidence required.
        - How can we start this independent evidence?
        - Will nations accept each other's estimation on evidence? For example, India with US' debris estimation. Standstill is common, but to override this we need independent verification.

- Be careful with verification as it is very loaded – because of militarisation aspect. Potentially corroborated? Confirmation? As Space is such a varied arena, words need to be picked carefully. Verification can have a different effect to different groups of people, for example engineers and diplomats.

Are these the main drivers on regulation?

- National policy
- Custody
- Continuous Supervision
- Very hard to verify/prove which satellite is which
- Economic development
    - Attracting Companies to your licensing state means a driver on regulation
    - But how is a responsible state defined?
    - Evidence is finite, it is important to use it but also to consider all factors involved
        - My own note: but what are the other factors? Evidence is a reliable start and in such an unknown arena I think it is the best start.
- The relevance it has with the public, if they aren't aware, regulation will be difficult
    - Create a relevance for the topic within the public and translate it for those who do are not as involved in the topic
- The critical importance of the utilisation of Space
    - The loss of GPS would have huge ramifications on modern society
- Space is 'out of sight out of mind'
    - Difficulty to conceptualise

What should STM be looking to do? (Looking at outcomes)

- Group 1 – An outcome that creates predictable and acceptable behaviours. It creates a foundation that we do not have. More will follow after a foundation is set. Another objective is avoiding the crash, the issue.
- Group ? – Certain norms in Space, should they be written down and documented? We do need a larger body of evidence to be aware of if the environment is severely at risk. The current system is not sufficient for sustainability.
- Group 4 – Compel traffic members to be safe, evaluate them as well to ensure they keep being safe. Enable an establishment of traffic norms. Coordinate Space Traffic events with other Space Traffic Checking organisations. Translate it for other organisations that do not understand the implications.
- Group 2 – Safety of flights, prefect scenario would be no accidents. But a body of accepted evidence with independent verification to deal with the worst-case scenario. While not being too restrictive on what we expect from all institutions. Should be scaled depending on the size of organisation, don't expect the same from a small one as we would from a large one.
- Proper standards of STM. Incentives that could be used to encourage STM. Reputation and inclusion of Space faring nations. A flight plan, similar to aircraft, if they don't stick to it they pay a fine, implement a similar system for space craft. A database for space debris to be used by all groups and improved upon by all.

- Compel traffic members to be predictable and safe

- Evaluate Traffic members performance in predictably/safety
- Enable inform regulatory feedback
- Balance environment preservation with commence optimisation
- Enable establishment of traffic norms/rules of the road
- Support evidence provision forensic reconstruction in event of
- Coordination space traffic with other traffic domains

Taxonomy of Space Governance

Dreadnaught and Lighthouse comment, big objects in space that need to work around each other.

International Space Law: The Baseline Rules (outlined in the powerpoint).

- Norms "a standard of appropriate behaviour for actors with a given identity"
- Key is widespread adherence (contrast OST with PAROS)

Guidelines & Codes of Practice: Instant norms?

- Outer Space Treaty isn't going to be changed and it shouldn't be changed either
- Discussion of changes to OST is "suicide"
- No formal treaty exists for combating the rise of Space Debris
- Prominent role of the US > UN Debris Mitigation Guidelines 2007

Advantages	Disadvantages
Flexible & Responsive to ambient changes in technology	No legal duty to obey – no compulsion or sanctions for overlooking
Less cumbersome to agree and states/actors more willing to get involved	

- No legislation for Space Traffic Management, no requirement for an operator to behave in a certain way
    - FCC uses the phrase "for the public good"
    - depends on how you define the regulation, they have a soft way of influencing behaviour in Australia (I think?)

State Practice Leading to International Norms

- Roles of states
- This enduring myth of the power of 'legally binding norms' is powerful but Debris mitigation shows how US can lead
- Transnational reach of regulators (working together) can also be used to consolidate best practices
- Could open the door for measures which occur this way to become customary international law (general & consistent state practice + a sense of legal obligation)
- Dynamics will change in Europe with new European directives that will affect the ESA.

State Liability: The Commercial Dimension

- If a satellite is damaged in orbit, the economic, political & Strategic implications could be significant.
- There has been no litigation as yet to test the limits of the existing liability regime.

- Under international space law, liability for damaged caused is assigned to the launching state on a fault basis.
- Usually in law, fault will be either because of lack of compliance with treaty obligation, breach of a duty of care or failure to comply with codes of conduct, norms or behaviour.
- In satellite operations there is little in the way…

If a satellite loses some capacity the insurance would pay the amount of capacity it lost, 10% for 10%

What is damage? Is no physical contact but behaviour causing loss of revenue, on board fuel ect. What deals with that?

The Liability convention focuses more on avoidance of conflict, that sort of business damage can be left to the court.

The amount of considerations required in liability, nature, human mistakes, malfunctions, dangerous environment of Space ect.

Establishing fault

- Fault = Negligence
- Negligence is proved by a four-stage test
- 1. Establish the existence of a duty of care
- The Defendant was in breach of the duty
- The breach of duty caused damage
- The damage was not too remote

A change in definitions for damages, potentially a degradation, lessening or change in the service could be a damage? Different definitions required for a new environment.

- The period of duty of care, what is it for Space? When does it begin for Space?
- We have 60 years of leaving stuff in Space, it has customary behaviour which is the problem.
- The duty of care is dependent on when the item collided with has launched, different rules or provisions for cube-sats to a vanguard module.
- Tort law often operates in areas where there aren't defined systems. For example, it requires me to behave in a reasonable prudent way towards you, if I threw my phone at you, id break that.
- With the iridium case we looked at the best industry practice at the time. It was completely unclear at the time what a best industry practice would be. Would continuation of litigation put the company at risk? Yes. But it is dependant upon what is available at the time and more is available now.
- Is there a duty to mitigate things? For example, asbestos, it was okay at the time but we mitigate it now, what about Space?
- A lot of our rules are limited to the human race and our capabilities.
- Ability to know where things are where they will be going is key, it is how we land aircraft every 30 seconds at the busiest airports.
- Planet Labs, possible direction? Intelsat has a long track record.
    - The focus is reasonable in the broad sense.
        - Use real life example of a way that we want everyone else to behave, set a standard.

UK Space Agency – Regulating and Licensing In-Orbit Servicing, Manufacturing and Active Debris Removal

IOSM/ADR (In-Orbit Servicing Missions/ Active Debris Removal)

- So many apply for IOSM, how do you decide who gets that? Whose judgement do you use?
    - Regulator does have a bit of scrutiny, but there is a reliance on how the company can persuade the regulator.
    - It is a learning process, we learn as we go along and try to mitigate risks as much as we can.
- "I feel as though the regulator could benefit from either the engineers or an independent evaluator of the capability of what has requested the IOSM" (quote from a member of the audience)
- Caution in the use of the phrase 'best practice' as it is very uncertain and mostly no practice, if a practice is labelled best practice it could limit the definition, when it is up to us to define the best practice rather than relying on what is done and accepting that as the best form.
- As a launching state you can decide what your own best practice is, it isn't as much about how much money they have, it's what they propose and the safety, viability and possibility of their propositions.

Lunch Break

- The idea of fault does not need to be binary, it does not need to be at fault or not at fault, a focus on statistics and how each contributing factor can be portioned fault.
    - Difficulty is convincing regulators and nations that this is a valid option.
- Mitigating liability by warning others of issues? If there is a break up of debris and you are warned yet launch and hit it, is that contributory negligence?
- Disclose as much as we can to ensure that the public can understand.
- Lack of information as a result of classification is a part of the causation of these accidents, we cannot act upon approximations.

<u>2019 International STM Workshop Space Law Game – GEO Debris Scenario</u>

The Limitations of Ground-Based Observations -ExoAnalytic

What needs to improve?

- Resolution
    - Temporal
        - Observe more often
    - Spatial
        - Observe from more places with detail
- System understanding
- Methods for understanding modern active spacecraft

Example for Discussion – Intelsat 29E Debris

- Because of the sheer volume it is hard to find the exact bit again or to re-visit past events
    - But Intelsat 29E was a real-time event

Debris paths develop in dynamic and unpredictable ways.

One piece of debris can affect many active satellites.

- Persistent observation and custody maintenance of debris generated by on-orbit anomalies is needed to support evidence provision in support of Space Traffic Management

- While the examples shown today represent some of the most complete bodies of evidence, we have identified areas where this evidence can be enhanced. How important are these enhancements in supporting future litigations?
- In what ways can evidence in the form we have presented support the development of legal and regulatory policy as it pertains to STM?
- What additional services does todays discussion motivate regarding enhancing future bodies of evidence for STM?

We lack root cause information which in STM, which is vital for finding a solution.

Bowtie Methodology

- A use of barrier risk models available to assist identification and management of risk
- The bowtie model consists of different elements that build up the risk picture
- This methodology will be implemented to ensure that threats and their consequences can be considered with on board servicing and Space Debris
- Both sides the threat and the consequence can have a mitigation incorporated
    - You may find that you can't find way to mitigate the threat, but you can mitigate the consequence or vice versa

The Visual Observatory and Space Traffic Management

To improve SSA data use and sharing capacity

- Multiwavelength astronomy
    - Different wavelengths probe different physical processes
        - Need all the data to understand all the physics
    - Data from different missions/telescopes reside in different data centres
        - Leave data in the care of those who understand it best
    - Multiwavelength data fusion requires a distributed system
- Observational data types
    - Observations characterised by coverage and sampling in (time, space, wavelength) – plus polarisation in some cases.
    - Native data types:
        - Images
        - Spectra
        - Time series
    - Much analysis is done with derived tabular datasets for objects
        - Position, time, flux ect.
- Astronomical Data
    - Distributed
        - 10-100 significant resoruces worldwide
    - Variety of types
        - Native – images, spectra, timeseries, ect.
        - Derived – e.g. object catalogues
    - Storage
        - Native – flat files (mostly FITS format)
        - Catalogues – mostly in relational databases
    - Most data ends up in open archives

IVOA Process

- W3C like process
    - Open discussion
        - Two face to face meetings per year
        - Aim for consensus then wide adoption
- Implementation
    - Two interoperable implementations for REC
    - Popular standards may have several implementations from different data centre

Major VO components

- Images
    - SIA
        - SIA = Simple Image Access Protocol
            - Client queries service for images of size S in region R taken at time T in waveband W
            - Service returns list of images (or links to cut outs it makes on the fly)
            - Client downloads desired images
- Tables
    - TAP
        - TAP = Table Access Protocol
            - Client issues query in ADQL (Astronomy Data Query Language)
            - Synchronous or Asynchronous
- Registry
    - VOResource – metadata schema for resources
        - Standard metadata components
        - Extensible to allow new resource types to be registered
        - Now implemented as tales in relational databases
- VOSI = VO Support Interface
    - Functional capabilities
    - Availability (reliability, ect)
- Model Data SIMDAL
- VOSpace
- VOEvent
    - Description of transient alert

VO Status

- Comprehensive set of standards
    - New projects (e.g. LSST) building VO in from start
    - Some protocols better exercised than others
        - Mostly implemented on open datasets, but Single SignOn and Credential Delegation standards exist
- Implemented using web services
    - REST-ful services now; many SOAP originally
    - Written by professionals, not grad students
        - But nobody dies or gets sued over astronomy data
    - “There is no RedHat for the Virtual Observatory”

Lessons Learnt

- Standards work takes time
    - It needs day-job time
    - Could a stronger steering hand have helped?
- Well-characterised data, not good data
    - “Data quality” is a function of use
- Don’t try and be too all-encompassing
    - Necessary data models will emerge
- Standardisation can follow implementation
    - Best standards generalise useful prototype services

Two possible next steps

- Paper Exercise
- Practical Exercise

Space Law Games – GEO SCENARIO STORY BOARD ON (IN) ORBIT SERVICING

Aims of the Law Games

1. How could the event have been avoided?
2. Identification of the roles and responsibilities in avoiding such outcomes.
3. When the event cannot be avoided, building on 1 & 2, what evidence is required in order to properly assign fault?
4. What are the issues (both theoretical and practical) of entering that evidence into legal proceedings?
5. Finally, what are the responsibilities to all parties for the continued existence of risk arising from the event?

Where do we start this event from?

Suggestion 1 – Repair and delay (2+ weeks) then satellite ‘breaks’

- Satellite at GEO operating normally.
- Starting to notice vibration in the spacecraft
- The vibration from independent sources is commensurate with a loose solar panel
- They pick a company to fix it.
- A loose bolt is tightened by the company.
- No damage in the servicing.
- But then a panel breaks off after time passes.
- Who is at fault?
    - Is there a guarantee from the fixing company?
    - Is there fault from the launching company?
    - Does this put other users under threat in the GEO area?
    - Servicer - The liability, unless there is gross negligence is with the launcher/operator
    - What constitutes gross negligence in this case?
        - If the operator of the servicing vehicle was drunk?

Suggestion 2

- 3 nation states involved
- A piece of the satellite breaks off and hits the third party = third party damage.
- Multiple parties giving conflicting pieces of evidence

Suggestion 3

- Normal satellite operating well (potentially with an undeclared issue?) from a well-established operator with good regulations.
- They sell to a third nation state with intermediate experience. Service company to extend life and change orbit.
- Degraded control of satellite puts other parties at risk.
- Who deals with what?

Suggestion 4

- Pre-license discussion stage (regulatory involvement?)
- Object license and registration and approval.
- Temporal location of the contract.
- Launch > RPO approval.

Suggestion 5

- Older but valuable satellite needs refuelling.
- The refuelling satellite goes to refuel.
- 'hostile' satellite goes to monitor activity.
- Operators unable to communicate with every satellite in that region (service, servicer and hostile).
- Observations show all Satellites slowly tumbling.