



# TOWARDS A GREEN TAXONOMY FOR SPACE SUSTAINABILITY

CNES, PARIS 6 APRIL 2023

Prof. Lucien Rapp  
*Chaire SIRIUS – University Toulouse-Capitole (France)*

# LAYING OUT

- STM
- Space Sustainable Rating (SSR)
- Going further ...
- EU Green Deal
- SIRIUS proposal for a Sustainable Space Taxonomy (SST)
- Implementing a SST



# ADDRESSING ENVIRONMENTAL CHALLENGES IN OUTERSPACE

- ***Space weather***: monitoring the Sun, solar wind, and Earth's magnetosphere, ionosphere, and thermosphere, which may affect space and ground infrastructure or endanger human life or health
- ***Near-Earth objects***: detect natural objects, such as asteroids and comets, that may impact the Earth
- ***Space surveillance***: tracking artificial satellites and active and **inactive space debris**



- **S.S.&C., Space Situation & Control**
- **SSA, Space Situational Awareness**
- **STM, Space Traffic Management**

# SPACE TRAFFIC MANAGEMENT

« Set of **technical and regulatory provisions** for promoting **safe access** into OuterSpace, **operations** in OuterSpace and **return** from OuterSpace to Earth» to Earth free of physical or radio-frequency interference »

(AIAA - American Institute of Aeronautics and Astronautics, Space Traffic Management – Towards a Roadmap for Implementation, 2018)

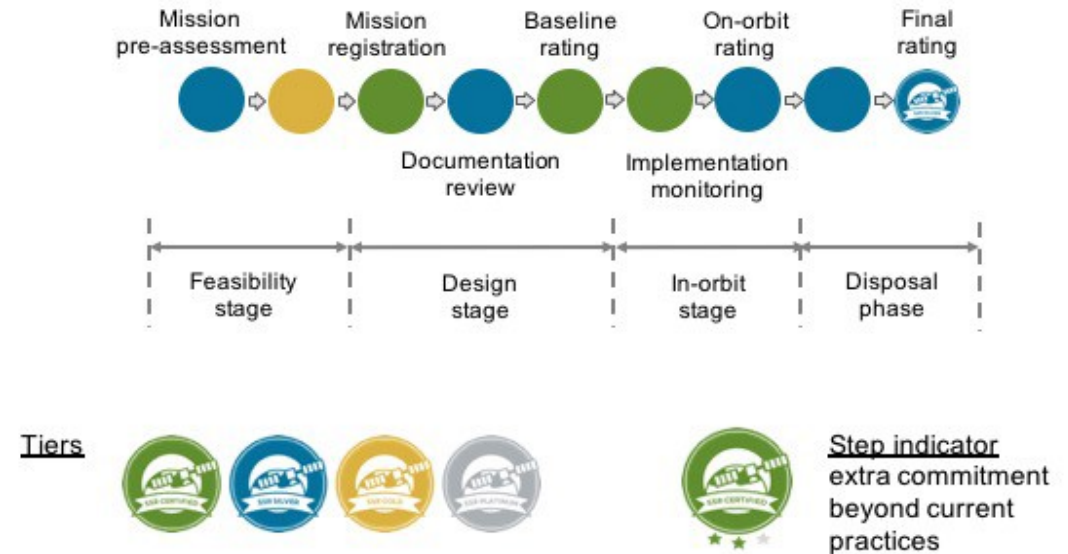
Scope	Launch	On-Orbit	Re-entry
Data (information)	X	X	X
SARPs (soft law) Standards and Recommended Practices – Guidelines	X	x	X
Rules (hard law) Licences/ Certifications/ Sanctions	X	X	X
<b>Rating</b> (Sustainable Corporate Finance)	?	?	?

“Satellite developers and owners should be thinking beyond **end-of-life disposal**. Satellites should be **designed** to ensure they do not fall apart when they get old or things happen aboard the satellites (...) Overall, the **entire lifecycle** the satellite has to be built with an emphasis on sustainability.”

Lt. Gen. John Shaw,, Aug. 9, 2021, U.S. Space Command deputy commander, keynote at the 35th Small Satellite conference

# FROM STM TO SSR (Space Sustainability Rating)

- Is a **composite indicator** that is a function of the Space Traffic Footprint measured through a mission index and compared to the so-called « Environment Capacity »
- Provides an innovative way to address the orbital challenge by **incentivising industry** and fostering voluntary actions to design missions compatible with sustainable and responsible operations
  - First conceptualised by World Economic Forum Global Future Council on Space Technologies*
  - Designed by an international transdisciplinary consortia*
  - Introduced at the IAC 2019, 2020*



*Mino Rathnasabapathy et alii. Space Sustainability Rating  
: Designing a Composite Indicator to Incentivise Satellite Operators  
to Pursue Long-term Sustainability of the Space Environment  
71st International Astronautical Congress (IAC)  
The CyberSpace Edition, 12-14 October 2020.*



# GOING FURTHER MORE ...

## Financial Context:

- Abundance of liquidity in search of RoI
- Don't miss the next industrial revolution
- Being ethical and investing in sustainable development

## Space Attractivity

Space industry is growing exponentially, fed by the fact that,

- access to space is becoming cheaper,
- technology is being miniaturized,
- new business cases are now enabled (SaaS, Space as a Service)

## Financial techniques

SPAC (Special Purpose Acquisition Company)

- 700 SPACs, \$227 billions (Redwire, Adcole Space, Deep Space Systems, Deployable Space Systems ...)

## Investors profile

Space investors become more and more « institutional »

Investors	Space Infrastructures
Fundamentalists	They believe that mega-constellations of small sats will generate new business models and a great deal of wealth
Tacticians	They reckon space activities value will rise as more people invest in it
Speculators	They want to gamble

*Adapted from Mohamed El-Erian (Allianz)'s taxonomy of bitcoin investors (The Economist, 7 Aug.2021)*

# SUSTAINABLE CORPORATE FINANCE AND SPACE ACTIVITIES

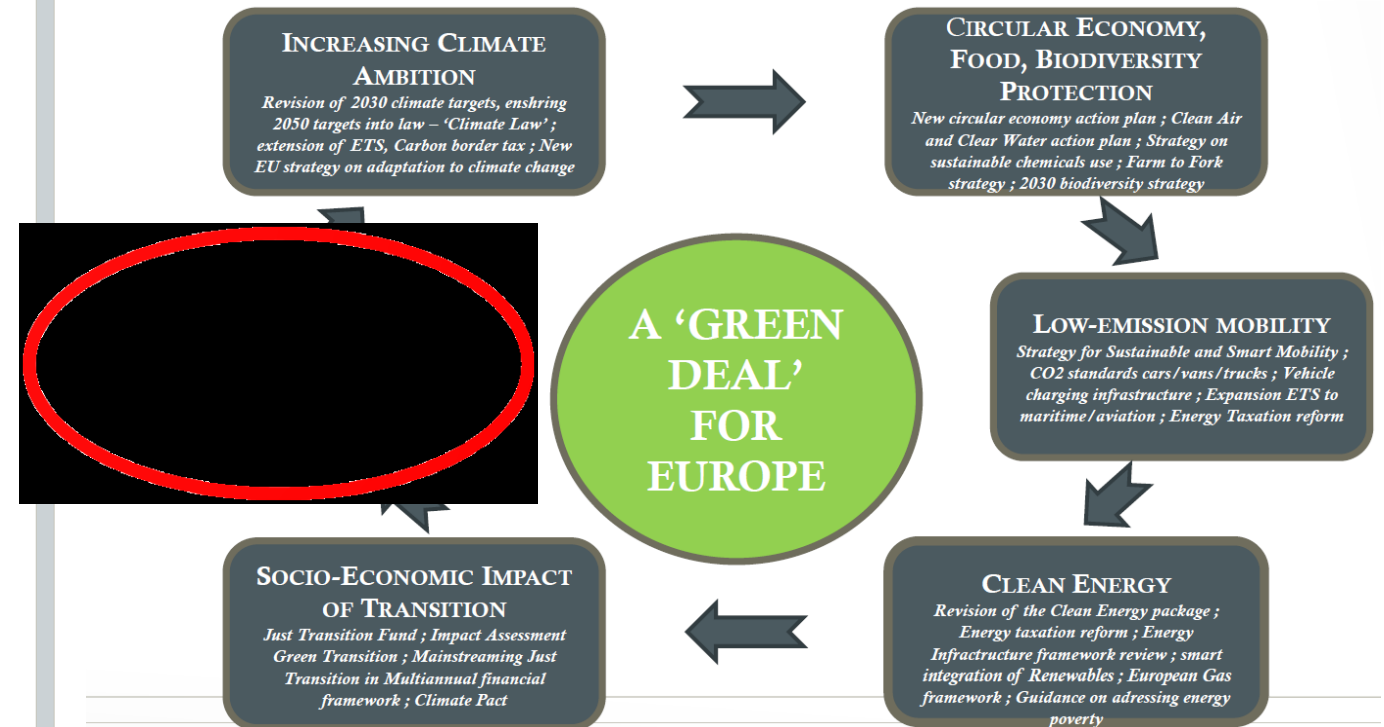
*We (SIRIUS) are currently  
working on a new concept : **Space  
Sustainability Taxonomy***

*This concept is decaled from the  
European Union's ongoing  
program named EU Green Deal  
whose Sustainable Finance is one  
of the master-pieces*

- *Step 1: Determination of specific environmental and sustainability objectives*
- *Step 2. Establishing a list of commercial space activities*
- *Step 3. Elaboration of performance and screening metrics*
- ***Step 4. Determination of thresholds***

# '50 EU Carbon Neutral

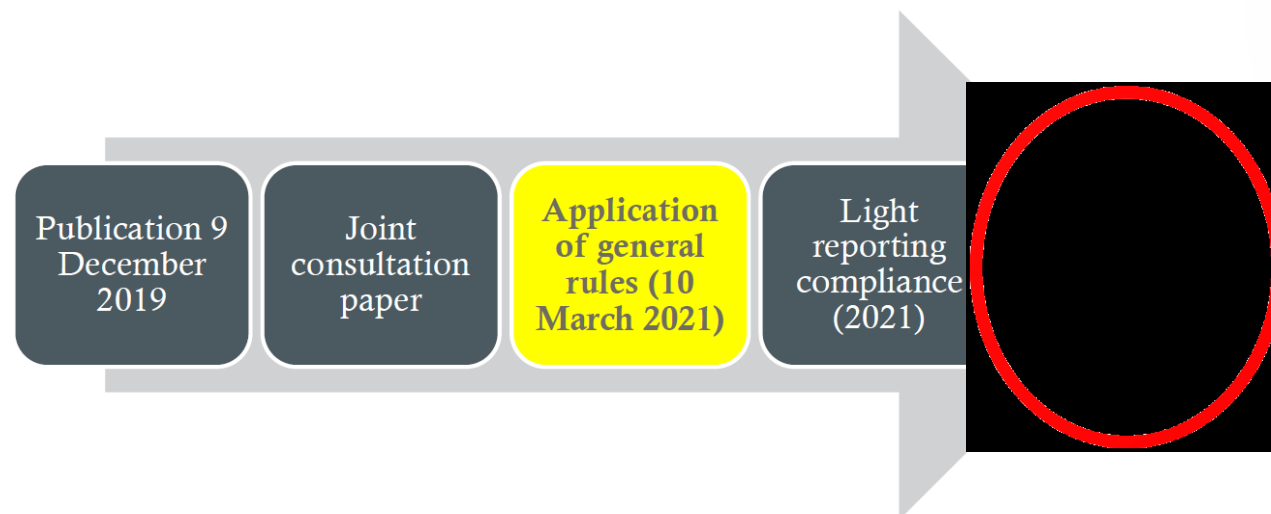
- Paris Agreement (2015)
- US Withdrawal (2017)
- EU SCF Package (2018)
- EU Call for a climate-neutral Europe by 2050 (2018)
- Europe's new Green Deal (2019)
- COVID-19 Crisis
- Disclosure Regulation





## DISCLOSURE REGULATION

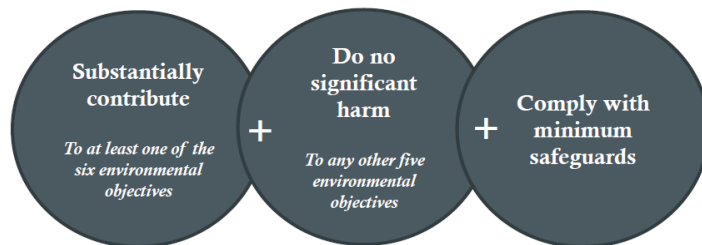
Regulation (EU) 2019/2088  
of the European Parliament  
and of the Council of 27  
November 2019 on  
sustainability-related  
disclosures in the financial  
services sector (Text with  
EEA relevance)



# HOW DOES IT WORK?

*Defining a common language for what can be considered an environmentally sustainable activity*

- Taxonomy
- Screening
- Indicators/Metrics



- Climate change mitigation
- Climate change adaptation
- Sustainable water and marine resources protection
- Circular economy and waste prevention
- Pollution prevention and control
- Protection of healthy ecosystems

**Substantially contribute**  
To one of the six objectives defined in the Disclosure Regulation

## Climate change mitigation

- Renewable energy
- Energy efficiency
- Clean or climate-neutral mobility
- Switching to sustainably sourced renewable materials
- Clean fuels from renewable or carbon-neutral sources
- Carbon capture and utilisation (CCU) and carbon capture and storage (CCS)
- Strengthening land carbon sinks (incl. regarding forests, croplands, grasslands and wetlands)
- Energy infrastructure required for enabling the decarbonization of energy systems;

## Climate change adaptation

- Reducing the risk of the adverse impact of the current climate and the expected future climate on that economic activity or substantially reducing that adverse impact, without increasing the risk of an adverse impact on people, nature or assets
- Reducing the risk of the adverse impact of the current climate and the expected future climate on people, nature or assets, without increasing the risk of an adverse impact on other people, nature or assets.

## Technical Screening Criteria (TSC)

TSC to be published as Delegated acts (DAs)

- Delegated legislation (DAs) process:
1. Platform on sustainable finance (incl. private sector stakeholders) advises
  2. European Commission consults and informs Member States
  3. European Commission drafts
  4. Co-legislators (EP and MS) scrutinise
  5. Application by 31 Dec 2021 for climate change mitigation and adaptation objectives, 31 Dec 2022 for other objectives



## Activity is considered transitional or enabling activity

Activity can be transitional if (to be revised every 3 years):

- There is no technologically or economically feasible low-carbon alternative
- GHG emission levels corresponds to the best performance in the sector or industry
- It does not hamper low-carbon alternatives
- It does not lead to carbon lock-in

Activity can be enabling if:

- It does not lead to a lock-in in assets that undermine long term environmental goals, considering economic lifetime of those assets
- It has a substantial positive impact on the basis of life cycle consideration

Adverse sustainability indicator	Scope	Metric (expressed in market value)	Impact n, n-1	Explanation
Greenhouse gas emissions	Carbon emissions, carbon footprint, solid fossil fuel sector exposure			
Energy performance	Total energy consumption from non renewable sources			
Biodiversity	Biosystem and ecosystem preservation practices			
Social and employees matters	Implementation of fundamental ILO Conventions, Gender pay gap, excessive CEO pay ratio, Board gender diversity	<ul style="list-style-type: none"> <li>• Average pay gap of investee companies,</li> <li>• Average ratio of female to male board members in investee companies</li> </ul>		
Human rights	Processes and measures for preventing trafficking in human beings			

# SECTOR MAPPING

*Defining a common language for what can be considered an environmentally sustainable space activity*

- **Sector Mapping**
- Objectives
- Metrics

Sector	Relevant activity
Transportation	Launch services (e.g. transporting satellites to orbit) Space tourism Recovery of spacecraft ...
ICT	Satellite-based internet Blockchain in space Satellite-based Internet of Things services Data processing, hosting and related activities ...
Data sharing	Earth observation and remote sensing data accrual and dissemination Navigation services Space Surveillance and Tracking (SST) data related services ...
Manufacturing and construction	Construction of space stations and outposts On-orbit assembly, manufacturing and servicing 3D printing in space ...
Energy generation and supply	Energy generation activities (through the use of He <sub>3</sub> /regolith, solar energy etc. ) Manufacture of Hydrogen Production of Electricity from Solar PV Transmission and Distribution of Electricity Storage of Energy ...

# SUSTAINABILITY OBJECTIVES

*Defining a common language for what can be considered an environmentally sustainable space activity*

- Sector Mapping
- **Objectives**
- Metrics

Sustainability Objectives For Space Activities	Indicators
Sustainable space traffic	Space debris generation avoidance measures Debris removal or deorbiting ...
Planetary protection	Backward contamination prevention measures Biological load / surface bioburden level (e.g. quantity of organisms present on a spacecraft) ....
Circular space economy	Efficient use of outer space resources Degree of reusability of systems Degree of resilience of systems Recycling of materials Percentage of electricity stemming from renewable energy sources (e.g. solar power) ....

# INDICATIVE METRICS

*Defining a common language for what can be considered an environmentally sustainable space activity*

- Sector Mapping
- Objectives
- **Metrics**



Adverse Sustainability Indicators		Indicative metrics to measure each indicator
Sustainable Investment Objective	Indicator	
Space Traffic	<div></div>	
Space Resources	Space Weather	<ol style="list-style-type: none"> <li>1. Space weather monitoring and risk assessment capabilities</li> <li>2. Space weather data sharing</li> <li>3. Design that ensures resilience / adaptability of systems to space weather events</li> </ol>
	Operational safety of mining operations	<ol style="list-style-type: none"> <li>1. Adherence to the Hague Space Resources Governance Working Group's "Building Blocks for the Development of an International Legal framework on Space Resources Activities"</li> <li>2. Establishment of safety zones around operations</li> <li>3. Space resources mining operations being undertaken sustainably (e.g. measures to prevent lunar dust from impacting other operations or entering into lunar orbit)</li> </ol>
	In-situ resource utilization	<ol style="list-style-type: none"> <li>1. Contributes to decrease of dependence on terrestrial supply chains (thus reducing the need to transport material from the Earth), e.g. creation of feedstock for 3D printing purposes</li> <li>2. Waste minimization processes</li> <li>3. Life support</li> </ol>
Planetary Protection	Exobiological contamination	<ol style="list-style-type: none"> <li>1. Adherence to the Planetary Protection Policy formulated by the Committee on Space Research (COSPAR)</li> <li>2. Bioburden reduction mechanisms</li> <li>3. Contamination control protocols and strategies</li> </ol>



## NEXT STEPS

- International cooperation mechanisms (UN OOSA/UN COPUOS, World Economic Forum)
- Industry self-regulation through international standards-setting (ISO)/industry-wide voluntary agreements
- Incorporating sustainable finance rules within a space traffic management framework (ex. EU Space Programme Regulation)
- **MAKING** Space Sustainable Taxonomy, a universal instrument, likely to cover all the issues of interest to the international space community, starting with debris. This work of finalization does not raise major difficulties as long as the methodology is clearly defined
- **TESTING** Space Sustainable Taxonomy with the industry and make sure that (i). it fits the reality of its activities, (ii). it is practicable and (iii). its implementation is not in contradiction with its industrial development.
- **DEPENING** the collaboration between industry and academia, to federate all the expertise and experiences, especially those that may result from the social sciences, and perhaps one day, create an international task force, likely to constitute a **Space Sustainable Institute**, to provide a viable dual use of SDA capability.

## The COST of Joining Legal Forces on a Celestial Body of Law and Beyond: Anticipating Future Clashes between *Corpus Juris Spatialis*, *Lex Mercatoria*, Antitrust and Ethics

Maria Lucas-Rhimbassen<sup>1</sup>

IDETCOM University of Toulouse 1 Capitole, 2 Doyen Gabriel Marty, Toulouse 31042, France

### ARTICLE INFO

Article history:  
Received 2 December 2020  
Received in revised form  
15 June 2021  
Accepted 22 July 2021  
Available online xxx

Keywords:  
Space law  
Commercialization  
Privatization  
Competition law  
Ethics

### ABSTRACT

The purpose of this paper is to address potential clashes in the future between different bodies of law pertaining to the space sector, such as space, commercial, competition, and transnational law, notably so within the given economic context currently characterized by the increasing privatization of space services in a "congested, contested, and competitive" space market. Furthermore, our analysis conveys rising tensions between higher ethics principles of space law – such as equality of opportunity and access to space, non-appropriation and province of all mankind – and commercial competition dynamics once the bargaining power will irreversibly shift towards the private sector. This transition is already taking place, and the space domain, which used to be considered under international space law as a "sanctuary", is now gradually considered as an ecosystem filled with business opportunities. However, for this new "blue ocean" ecosystem to become sustainable, business models would have to embrace creative and innovative ways in which they would comply with space ethics. Based on the results of the analysis, this paper concludes with a roadmap leading to interdisciplinary governance and sustainable solutions to help foster growing commercial activities and ethics compliance in a similar manner that Art. VI of the Outer Space Treaty opened the gates for nascent non-state activity while complying with the essence of international space law in the 1960s. Today, the challenge is to channel both the privatization of space activities and, most importantly, the privatization of space law per se in constructive ways to ensure a prosperous peaceful, ethical, and yet profitable ecosystem, and to determine whether a new "Commercial Outer Space Treaty" (COST) would help pave the way.

© 2021 Elsevier Ltd. All rights reserved.

Assessing a Mars Agreement Including Human Settlements (p 27-35) | Cite as

## On the Province of All Mankind

Authors: Maria Lucas-Rhimbassen

Chapter: First Online: 18 May 2021

Part of the *Studies in Space Policy* book series (STUDSPACE, volume 30)

### Abstract

The purpose of this article is to explore the challenging context surrounding the non-appropriation principle as recent developments in space law take an unexpected turn towards accelerated commercialization and blurring ethical principles. By analyzing the reinterpretation of the "res communis" regime of outer space, the reader understands that this regime is in transition and gradually slides towards private property rights and trends despite the non-appropriation principle. This raises questions as to competition law rights between private stakeholders (firstcomers vs newcomers) and potential monopolies restricting access to critical resources and services. Such commercial activity must further be closely monitored since it might involve modifying the core identity of a celestial body per se, as in the case of terraforming. Space ethics could provide guidance against such scenarios until an appropriate regulatory regime is agreed upon at the international level. Last, proper antitrust regulation is vital for a prosperous Mars settlement.

### Lucien RAPP

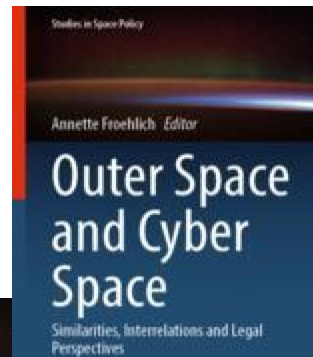
Professeur de droit public  
Membre de l'Institut du Droit de l'Espace, des Territoires,  
de la Culture et de la Communication (IDETCOM)  
Directeur scientifique de la Chaire SIRIUS (Space Institute for Research on Innovative  
Uses of Satellites), Université Toulouse Capitole

« From Space to SPAC ». Pourquoi ce titre de communication en anglais dans un colloque essentiellement francophone et pourquoi ces deux termes différents, que sépare une seule lettre, la lettre « e » ?

Deux termes différents en effet. L'un est un mot qui désigne ici l'espace extratmosphérique, sans autre précision puisque la frontière entre espace aérien, relevant de la « souveraineté complète et exclusive » des États et espace extratmosphérique, « apaisage de l'humanité tout entière » n'a jamais été juridiquement tracée<sup>1</sup>. L'autre est un sigle qui renvoie à l'une des techniques en vogue sur les marchés financiers américains : elle consiste à créer une société coquille que l'on cote en bourse avec la double promesse d'un investissement proche dans une société émergente et d'un important retour sur investissement ; quelque temps plus tard, la société cotée et la cible fusionnent, de telle sorte que la société cible se trouve *ipso facto* introduite en bourse. Sur les deux-cent-vingt-sept milliards de dollars levés de cette manière aux États-Unis au cours des mois écoulés<sup>2</sup>, un tiers environ aurait été investi de cette façon dans des sociétés du secteur spatial.

Le rapprochement de ces deux termes est à la fois le signe d'une révolution accomplie au cours des deux dernières décennies par les entreprises du secteur spatial et l'indice de leur niveau de maturité, qui ne peut plus laisser les juristes indifférents.

Dans quelques mois, quelques années tout au plus (2025), 1765 satellites nouveaux auront été lancés et mis en service par des opérateurs, essentiellement privés ; les technologies spatiales devenant de plus en plus accessibles, le nombre



## Outer Space and Cyber Space

Similarities, Interrelations and Legal Perspectives

Authors: Annette Froehlich

Chapter: First Online: 18 August 2021

Part of the *Studies in Space Policy* book series (STUDSPACE, volume 30)

### Abstract

The purpose of this chapter is to determine whether the private space industry can escape jurisdiction by dematerializing the space resources commerce processes and assets thanks to cyber technology. Investigated strategies include dematerialization of space resources into intangible assets (such as intellectual property rights and financial assets) before transferring them into digital or cyber resources via tokenization to be part of commercial transactions through smart contracts on a distributed ledger technology (DLT). This chapter asserts that pure code, devoid of legal contract and human orders, can indeed escape jurisdiction. However, if the smart contract is hybrid, contractual law applies and connecting factors have an increased chance to be moved to one of human arbitrators as orderlies. Nonetheless, to prevent further privatization of the law, opacity and anti-competitive behavior, transparency measures must be implemented at the contractual and arbitrators' level. The methodology behind this chapter's rationale is based on Pistor's "Code of Capital" which elaborates on the detrimental enclosure of knowledge and how it can be accelerated by decentralized technology, which in fact faces monopolistic ambitions. Last, this line of thinking is juxtaposed on Israel's Space 3.0 categorization of the contemporary space context to extrapolate Pistor's thinking to the space economy.

### Enter your search terms here

Home / Journals / Journal of Property, Planning and Environmental Law / Volume 13 Issue 2 / New space property age: at the crossroads of space commons, commodities and competition

Maria Lucas Rhimbassen, Lucien Rapp

Print & Feedback

ISSN: 2514-9407

Article publication date: 25 June 2021

Issue publication date: 17 August 2021

Open Access

Space Policy 56 (2021) 101413



Contents lists available at ScienceDirect

## Space Policy

journal homepage: [www.elsevier.com/locate/spacepol](http://www.elsevier.com/locate/spacepol)



## Which Jurisdiction for Private In-space Assembled Autonomous Platforms?

Lucien Rapp<sup>a,1</sup>, Maria Topka<sup>1</sup>, Lucas Mallowan<sup>1</sup>

Chaire SIRIUS, Faculté de droit, Université Toulouse-Capitole, F-31042, Toulouse, France

### ARTICLE INFO

Article history:  
Received 15 April 2020  
Received in revised form  
11 January 2021  
Accepted 12 January 2021  
Available online 20 February 2021

Keywords:  
Space law  
State's jurisdiction  
In-space assembly  
Artificial intelligence  
Private in-space assembled autonomous

Journal of Space Safety Engineering 8 (2021) 155–166

Contents lists available at ScienceDirect

## Journal of Space Safety Engineering

journal homepage: [www.elsevier.com/locate/jsspe](http://www.elsevier.com/locate/jsspe)

## Reinventing treaty compliant "safety zones" in the context of space sustainability

Lucas Mallowan, Lucien Rapp<sup>a</sup>, Maria Topka

Chaire SIRIUS, IDETCOM - Faculté de droit - Université Toulouse-Capitole, Toulouse F-31042, France

### ARTICLE INFO

Keywords:  
Safety zones  
New space  
Antenna access  
Definition of space activities  
OST  
Market entry  
Non-appropriation principle  
Space law  
Maritime law  
Aviation law  
State's jurisdiction  
Extra-territorial jurisdiction in outer space

Article history:  
Received 16 February 2020

### ABSTRACT

This paper questions the concept of safety zones, tracing it to maritime and military law, in order to unpack its potential legal uses, applications and implications in the current context of the New Space economy. To achieve this, it starts by investigating the historical foundations of safety zones rooted in the Cold-War-era legal literature and then move on to a larger discussion of how such zones can be balanced with the non-appropriation principle. Then, this paper examines a number of legal analogies, as they appear in maritime law, aviation law as well as relevant examples in outer-space law. Lastly, it attempts to sketch the outline of a "solution" that identifies the criteria, to be used in order to model a potential safety zone that strikes a balance between the industry's growing concerns and requirements on one hand, and the legal prohibitions that preclude sovereign claims on outer space on the other hand. Particular attention is given to the special case of the United States' extra-territorial jurisdiction in outer space.

Acta Astronautica 189 (2021) 235–240



Contents lists available at ScienceDirect

## Acta Astronautica

journal homepage: [www.elsevier.com/locate/actaastro](http://www.elsevier.com/locate/actaastro)



## Competitive space foresight: Incentivizing compliance through antitrust

Maria Lucas Rhimbassen<sup>a,\*</sup>, Lucien Rapp<sup>b</sup>

<sup>a</sup> Chaire SIRIUS (University of Toulouse), France

<sup>b</sup> Doyen, Gabriel Marty, Toulouse, 31000, France

### ARTICLE INFO

Keywords:  
STM  
Antitrust  
Compliance  
Governance  
Security

### ABSTRACT

The purpose of this paper is to address STM through an unconventional but pragmatic angle to help optimize efficient compliance governance. This paper proposes using antitrust mechanisms in space as a pragmatic and utilitarian tool for sustainable purposes with regards to STM within a sourcing space ecosystem. In the context of accelerated space commercialization and privatization, having a new space antitrust framework at the helm of such transition might indeed prove to be a flexible yet decisive tool into shaping the future of STM and ensuring perennial protection of higher space principles which are enshrined in the Outer Space Treaty and form the essence of space law.

On one hand, examples of antitrust key components include fair competition while, on the other hand, higher ethical principles of space law include non-discrimination and benefits sharing. Furthermore, in between these two extremes, security and commerce both rely, respectively on non-harmful interference and competitiveness.

To navigate through all these factors, a new space antitrust framework might indeed prove strategic and beneficial to incentivizing the creation of an adaptive, polycentric and action-oriented governance mechanism with great resonance among the commercial new space players and reaffirm the importance of sustainable space traffic management before return on investment, while still making a profit in the long run.

## Small Satellite Constellations, Infrastructure Shift and Space Market Regulation

Lucien Rapp and Maria Topka

**Abstract** With the commissioning of the first constellations of hundreds or even thousands of small satellites, we are witnessing today an infrastructure shift. While it has not completely distanced the exploration and use of outer space from the dramatic geopolitical and military implications they once entailed for States, it is undoubtedly transforming this realm into a new economic frontier of competition, with its predominant players, this time being private profit-driven actors sensitive to market forces. As the exploitation of outer space becomes more economically viable, new commercial services should emerge through the deployment of SmallSat constellations and the provision of services by means thereof, creating a risk of increased dependency of the services consumed on earth on these new infrastructures. Therefore, new legal challenges pertaining to competition, foreign investment and the global economy as a whole do arise.

# Questions ?

[lucien.rapp@ut-capitole.fr](mailto:lucien.rapp@ut-capitole.fr)  
[rapp@hec.fr](mailto:rapp@hec.fr)

[www.chaire-sirius.eu](http://www.chaire-sirius.eu)  
[www.spacelegaltech](http://www.spacelegaltech)