On Orbit Servicing as Space Resource

Liability Challenges

Dr. **Cristiana Santos**, Researcher at Chaire SIRIUS
Ms. **Maria Rhimbassen**, PhD Candidate at Chaire SIRIUS

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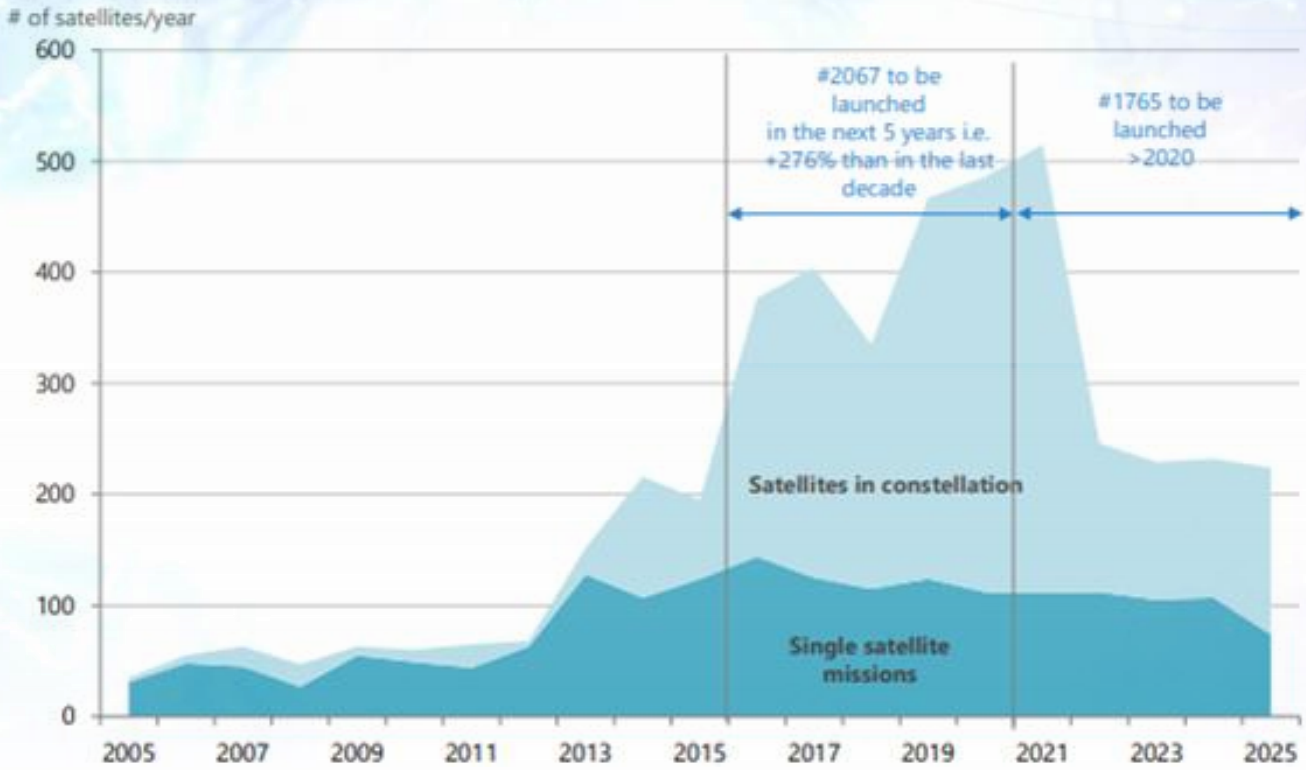
Introduction

- The developments of increasingly sophisticated **services provided on orbit (OOS)**, and the risks of increased debris due to the deployment of new **LEO Mega-Constellations** require an international reflection on the **existing space liability regime.**

- Therefore, **a compulsory in-orbit liability insurance** needs to be defined. Are current rules (Liability Convention 1972), and insurance policies adapted to the requirements of space services provided in orbit ?Insurance is weighing between "**service-or-replace trade-offs**", while seeking for in-orbit liability in case of damage to constellations (Swiss Re, 2018), but up to our knowledge, OOS is being already insured.

- **Our proposal on in-orbit liability insurance** provides for a sound legal regime amenable for mitigating risk amidst mega-constellation impact, and to optimize performance. Yet it requires:
  - Servicing-operator demonstrations and maturity of this industry (CONFERS consortium and DARPA will propose best practices and standards for commercial on-orbit activities like repairing and refueling satellites);
  - Clients aiming servicing in orbit for their constellations

1. Mega Constellations: circa 20K SmallSats (comms)



FUTURE MEGACONSTELLATIONS

1.	Laser Light (US)	12
2.	O3B (LUX)	27
3.	Viasat (US)	24
4.	Samsung (KR)	4600
5.	LeoSat (US)	108
6.	Astronome Technologies (IN)	600
7.	SpaceX Starlink (US)	4 425
8.	OneWeb (US,UK)	900
9.	Lucky Star (China)	156
10.	Hongyan (China)	300
11.	Xinwei (China)	32
12.	Boeing V-Band (US):	2 956
13.	Telesat LEO (CAN):	117
14.	Yaliy (RU)	135
15.	Commsat (China):	800

(LEO and MEO broadband constellations mega source of consternation by Caleb Henry — March 13, 2018; Divining what the stars hold in store for broadband megaconstellations); ESA CleanSpace Industrial days (2016)

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2. Context is changing into a new playing field

- **Privatization** (cost evolution, launches). Private sector leads 70% of space activity [UNOOSA, 2018]
- More actors, space **democratization** (spacefaring nations, private)
- New disruptive tech (**reusability, miniaturization**, disaggregation, constellations, electric sats vs propelled)
- **New business opportunities** (tourism, mining, 5G), **shrinking GEO market** (fear that MAXAR pulls out)
- **IoT, AI** (robotics) will change how businesses, consumers interact with insurers, leading to a **data-driven, usage-based insurance (UBI) and pay as-you-go** models market (2025)
- **Aggregation of policies** (e.g. XL Catlin, 2018)
- Space 4.0 Era of proactiveness, open-mindedness to both disruption and opportunity" [Baldesi, ERA]

"Technology evolution and insurance innovation are symbiotic"
[Satellite Evolution Group, 2016]

- **Such disruption alters risk management approaches, insurance products and value chains**
- **Space Insurance needs innovative solutions to:**
  - adapt and cope with New Space
  - avoid unsustainability

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3. Mega-constellation risks vs OOS insurance demands

- Launched into littered debris areas, leads to LEO congestion (~17k LEO catalogued objects)
- Difficult maneuverability, collision, damage, debris-generation loop, decrease of orbit utility
- Multiple launches and launchers
- Change in space systems and operations, likelihood of accidents due to operator error
- New operators relearning lessons create additional risk
- Deorbiting/reorbiting becoming practice
- Shorter orbital lifetime, replaceable smallsats
- CubeSats "plagued with issues related to partial and complete failures, power-on issues (latency, anomalies and unknown attitude dynamics)"

[Swiss Re, 2018]

AON

"Smallsats come from educational projects, tech demonstration to operational missions. Approaches that worked for a small number of large sats won't work with a large number of small ones"

*If different sats will be **replaced** by resilient new ones (tech or manufacturing process), which will be the **risk profile** for that same constellation?

*How to compare sats with a conventional liability risk-mitigation profile, to those with **OOS insurance**?

*How to define expected **performance, lifetime** when there is a need to deploy constellations over multiple launches?

*Will the constellation policy cover for each satellite lost, or up to some **contingency threshold** (loss criteria)?

*Insurance product is expected to respond to the sum of all sats that make up the whole constellation. Which will be the **trigger** for such coverage?

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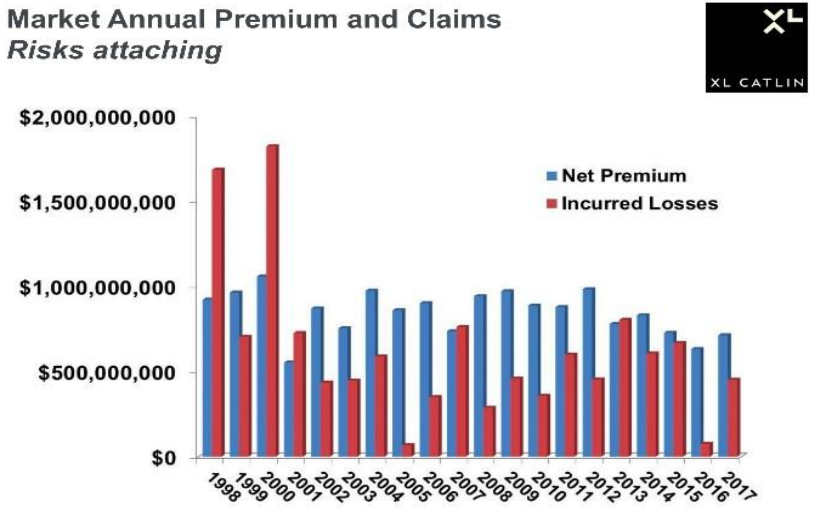
4. Space insurance: Key Figures



"The nature of this business is very volatile. You don't have many losses, but when you do, they're large"
Chris Kunstadter

Trend: historically low premium rates, with diminishing margins, making this very much a buyer's marketplace at present, due to high insurance capacity: USD 700+ M worldwide vs 150 M/ value per sat, resulting in supply & demand competitive market)

- **although New Space causing uprising claims trend.**

- **50 % of commercial sats**
- **5% OF LEO ("Space Insurance Update 2017)**
- **45% of GEO satellites fleet satellite launches**

Ratio to be maintained between the 560 commercial sats to be launched [AON Risk Solutions, 2016]

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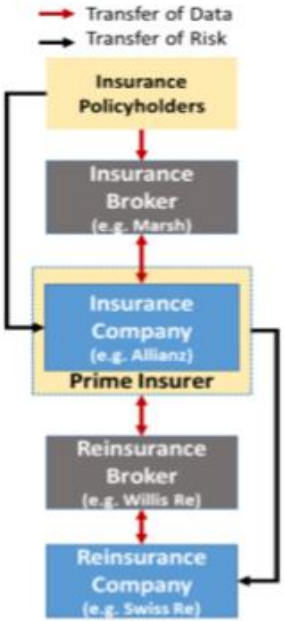
[Global Satellite Launch and Space Insurance Market 2018-2022]

5. Key vendors (space) per services



Generalised flow of data and risk in PC insurance

[Insurance Market Report, Satellite Applications Catapult, 2017]

CATAPULT Satellite Applications

Table 3: Top Global Insurance Industry Players

Insurers Brokers	Insurers	Reinsurance Brokers	Reinsurers
- Marsh & McLennan Cos. Inc. (US) - **Aon P.L.C. (UK)** - **Willis Towers Watson (UK)** - **Arthur J. Gallagher & Co. (UK)** - **Jardine Lloyd Thompson Group (UK)** - Wells Fargo Insurance Services (US)	- Berkshire Hathaway (US) - Allianz (DE) - Munich Re (DE) - People's Insurance Company of China (CHN) - Zurich Insurance (CH) - AIG(US) - **Aviva (UK)**	- **Aon Benfield (UK)** - Guy Carpenter (US) - **Willis Re (UK)** - **JLT Reinsurance Brokers (UK)** - **Cooper Gay Swett & Crawford (UK)** - **Miller Insurance Services (UK)**	- Munich Re (DE) - Swiss Re (CH) - Hannover Re (DE) - SCOR SE (FR) - Berkshire Hathaway (US) - **Lloyds of London (UK)**

*However this might **change** as the Asian market thrives rapidly: "Munich Re predicts that by **2025 more than one quarter** of global primary insurance premiums will come from **emerging economies (...)**"* a shift mainly led by China.

Key Vendors (Space) in alphabetical order

- Allianz Global Corporate & Specialty
- American International Group
- Atrium Underwriting Group
- Brit Group Services
- Elseco
- Global Aerospace
- Marsh & McLennan Companies (acquired JLT)
- Munich Re
- **XL Group, acquired by AXA in september 2018**

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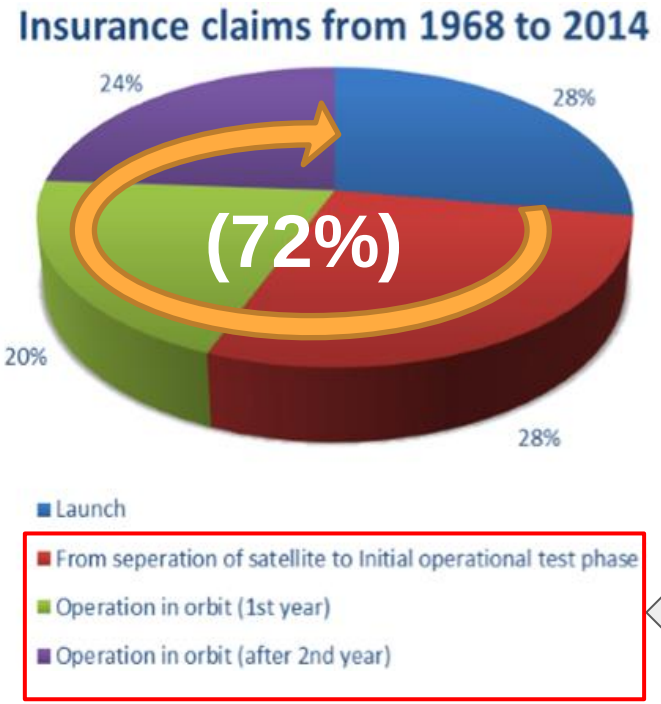
6. On-orbit Insurance: key figures as of today



1) Power
2) Altitude Control
3) Telemetry

[Swiss Re, 2018]

RISK OF FAILURE :

- **45% of failures during launch**
- **42% first 2 months in-orbit,**
- **13% 3rd until 12th month.**

However, as we shall see, space insurance is insufficient

[Euroconsult, 2016; Krishna, A. et al. (2016). In-Orbit Maintenance: The future of the satellite industry]

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7. Space Law: Liability convention (1972)

State responsibility for launch/in-orbit damages to third party (**On-orbit** liability, **based on fault, art III**)

Art III *: "In the event of **damage** being caused elsewhere than on the surface of the Earth to a **space object of one launching State** or to persons or property on board such a space object **by a space object of another launching State,** the latter shall be liable **only if the damage is due to its fault** or the fault of persons for whom it is responsible."*

- Some states require **mandatory private on-orbit liability insurance** (in order to **reimburse** the state against which there is a claim)
- Ceiling examples: UK and France: € 60 M, Japan, Hong Kong, Singapore USD 100 M
- Complemented (or not) by private insurance (for example, US- USD 500 M)
- States provide themselves further (un)limited insurance, depending on national legislation or common law.
- State acts as de facto reinsurers.

Need for changes …

8. Hypothesis 1 : Fault Based Liability

Third Party Liability VS **Performance, Property, Life**

- Mandatory (some States)
- Backed by some States, (un)limited

- Optional (all-risks, in-orbit)
- Volatile Market

In case of space debris damages, it covers financial damages of:

Owner of debris (exceptions) ⟷ Victim of debris

In case of On-Orbit Servicing (OOS), how would this apply?

Provider
(would be insured de facto)

Client
(buys insurance or relies on built-in redundancy)

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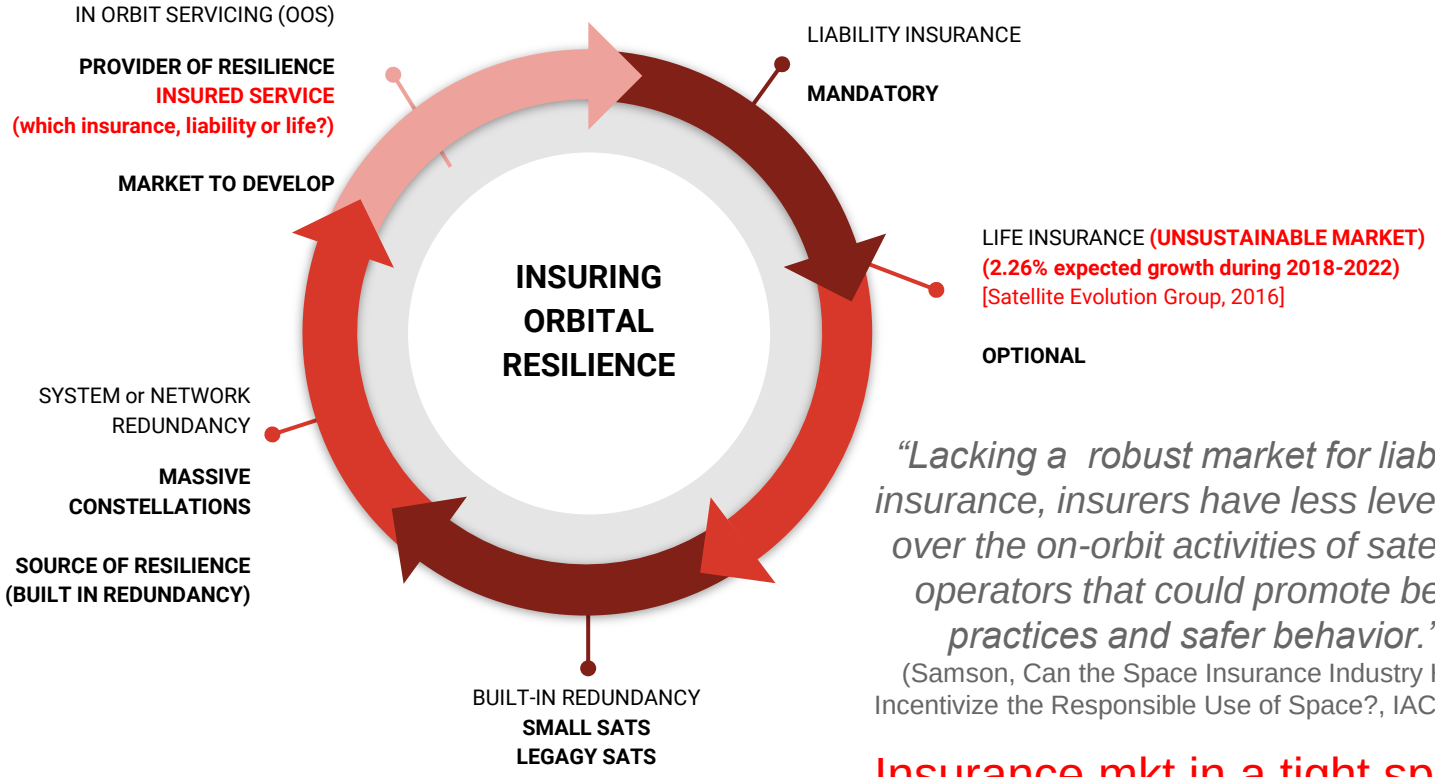
9. Hypothesis n°2 : Absolute Liability

Problem with fault

It should be noted that due to limited space monitoring (space surveillance) capability, especially on the part of a claimant State that is not a well-developed space-power, it will be difficult, if not impossible, to clearly and convincingly establish fault on the part of the State whose small satellite (including an untracked small piece of space debris) that will be believed to have caused the damage.

(Jakhu, IAASS, 2013)



"Lacking a robust market for liability insurance, insurers have less leverage over the on-orbit activities of satellite operators that could promote best practices and safer behavior."

(Samson, Can the Space Insurance Industry Help Incentivize the Responsible Use of Space?, IAC 2018)

Insurance mkt in a tight spot so no BONUS/MALUS

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10. Hypothesis n°3 : Compulsory Liability

No elements required in order to establish that a state is liable **in international law**.

"Every internationally wrongful act of a State entails the international responsibility of that State."
Article 1 of the International Law Commission's Draft Articles on Responsibility of States for Internationally Wrongful Acts)

*"Future actors might include **non-space** actors, relying not on space law but **on international law***

Need for compulsory liability
In order to reduce space debris, national regulatory and technical solutions would need to be developed and implemented. Perhaps, all the States that actually launch satellites should be enter into agreement for requiring (a) proper end-of-life disposal of satellites before their launch and (b) compulsory insurance against third party claims.
(Jakhu, IAASS, 2013)

- EXCEPTIONS in common law: Act of God, 3rd Party Act, Fault or **Consent of Plaintiff** (as would be applicable in OOS)

BENEFITS

- Extend earth and air coverage of absolute liability to space, Environmental sustainability and higher standards
- Strengthen volatile space insurance market (e.g. LEO, constellations, etc.)
- **thus incentivizing OOS, salvage clauses, and therefore resilience.**

11. Recommendations

Given that:

- *The space insurance industry is volatile and needs strengthening*
- *The space insurance industry foresees the business opportunity for OOS*
- *OOS is a source of resilience*
- *OOS will, inter alia, have the shape disaggregated constellations;*
- *Such constellations, themselves resilient*
- *That space debris are a significant collision risk*
- *That space is congested environment in need of sustainable development*

We recommend compulsory absolute in-orbit third party liability insurance for OOS, to protect its service towards clients and ensure a market stability.

Such **liability insurance premium** should:

- Be **affordable** to all
- **Customized**.
- **Not according to size, but to capability/service (e.g. smallsat, big service)**
- Revise exclusions (as context evolves)

12. Conclusion and Future Discussion

- **Footprint positioning from insurers** to underwrite this new line of OOS business, as heritage and reliability become established in new technologies. There is a need for expertise from the technical, legal and insurance disciplines to deliver metrics for risk assessment in order to underwrite risks for the new insurance programmes to come

- As for OOS, liability has to become absolute (strict), with premiums/caps accessible to all, customized, but not depending on size, rather on service (ie smallsat but big service).

- Absolute liability would incentivize to in-orbit servicing since the client (plaintiff) consents to service.

- **Our proposal** : if fault is established, then insurance is triggered to protect an uninsured client against fault at a minimum. If not, a client should better buy in-orbit property insurance (which only 50% of commercial GEO sats and 5% of LEO sats have).

- Strict liability might be a solution towards a sustainable space environment and mitigate debris on the long run. Can be a source of funding as well.

- Mega constellations will become subject to this, as OOS satlets will become disaggregated, with a resilient architecture. Built-in resilience might dissuade from extra in-orbit property insurance (reflecting today's constellations position - Planet, Spire, etc.), but this might change in the future, depending on mega-constellations services.

  - **For this reason, we recommend at least the standard of compulsory in-orbit absolute liability, <u>securing</u> both the stability of the space insurance industry and the OOS market.**

  - **France could join international discussion on OOS INSURANCE** :