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## Can the Space Insurance Industry Help Incentivize the Responsible Use of Space?

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### Abstract

Space is opening up to an increasing number of actors, which is sharing the benefits of space capabilities with more people and nations globally. However, there is a lack of clarity in regards to what constitutes responsible behavior in space. The international community is working at the nation-state and multilateral level to try and establish best practices. Yet the commercial sector is becoming more active and often taking on missions or providing capabilities that used to be solely the provenance of state actors. Industry must be included in seeking out solutions for ensuring the safe, secure, and sustainable use of space, and specifically, there may be a role for the space insurance industry to drive norms for responsible behavior in space.

This paper will start off by examining trends in commercial space and how the space domain is changing overall. It will then look at trends in space insurance, seeking out characteristics of the industry to see if there is the possibility of and interest in incentivizing good behavior. The paper will then look at other domains to see if insurance had any role in reducing risk. The paper will discuss the interplay between government and industry to see if there is a role that the government can play in this. Finally, the paper will discuss future opportunities for motivating responsible use of space by the commercial sector writ large and how those might be incorporated into state practice.

**Keywords:** space insurance, responsible use of space

### 1. Introduction

As the number of objects orbiting Earth continues to grow, both the opportunity for cascading collisions and the holistic cost of losing satellite capabilities grow as well. The number of operational satellites has increased to over 1,800 [1] and is projected to grow by an order of magnitude in the coming decade [2]. The amount of debris on-orbit has continued to increase as well, with the U.S. Strategic Command currently tracking over 19,000 pieces of debris, with the potential for further growth as space gets increasingly congested [3]. Space has also become much more commercialized and with the rise of megaconstellations, the very nature of space will shift from being primarily populated by state actors to being dominated by the commercial sector. Overall, there is an increase in new actors, with over 80 countries owning/operating satellites, and new uses of space assets (rendez-vous and proximity operations, active debris removal, and on-orbit servicing, to name a few) that test the boundaries of both the existing legal regime and established practices for activities on orbit. As well, the definition of a launching state is broad enough that there rises the potential for disputes over liability, should some sort of incident occur that requires an insurance claim to be paid.

The confusion surrounding applicable legal regimes has fostered a perception of legal uncertainty, particularly if there is a dispute over activities on orbit that cause damage to another actor. Determining liability on orbit is difficult because the relevant international treaties define liability differently depending on where the damage takes place. The 1971 Convention on International Liability for Damage Caused by Space Objects defined liability as absolute on the surface of the Earth or in the atmosphere, but “fault-based” on orbit [4]. At the great distance from Earth that satellites operate, precise situational awareness is often not accurate enough to ascertain the details necessary to assign fault. While many governments, international organizations, and private groups are working to develop guidelines for what constitutes responsible behavior in space, and increase the accuracy of space situational awareness, there is limited leverage to enforce such recommendations, or even to agree on universally applied definitions and standards.

Insurance of satellites is a major cost for owners/operators of satellites and thus theoretically could provide a path for encouraging behavior that would ensure that space is sustainable for all over the long-term. It raises the question of whether space

insurers could incentivize responsible behavior in space, whether it be by requiring industry-wide best practices, penalizing financially those who are not following established norms, or some other action entirely. In order to examine these possibilities, on Jan. 22, 2018, the Secure World Foundation (SWF) and the Stimson Center partnered to host a roundtable discussion on the relationship between space insurance and incentivizing responsible behavior in space operations and brought together space insurance companies, underwriters, satellite operators, and experts from non-space fields to discuss this issue [5]. The main takeaway was that given how competitive pricing is within the space insurance market, space insurance companies do not have the flexibility to use pricing as a way in which to encourage responsible behavior. It was suggested that perhaps another source of funding, like investors, might have more sway in encouraging newspace actors to follow existing rules of the road and promote responsible behavior in space.

## 2. Trends in the Commercial Space Sector

The roundtable discussion started off with an overview of trends in the commercial space sector. The satellite industry is comprised of different types of companies that produce products and services that relate in some way to orbiting satellites. Manufacturing of satellites and of launchers couple with launch services to create the “upstream” portion of the value chain. Satellite operators gather the data which is then used for services that feed through ground segments into the rest of the “downstream” value chain comprised of militaries, public civil organizations, businesses, and consumers. Both the upstream and downstream portions of the value chain generate revenue; of the \$250 billion in revenue from 2017, it was dominated by the downstream portion of the market (97%).

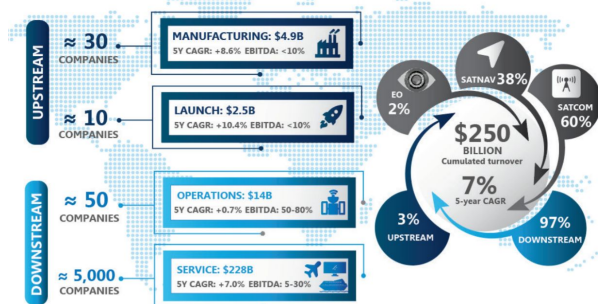


Fig. 1. Commercial satellite industry 2016 snapshot [6].

Outside of the value chain, space agencies, investors, insurers, and regulators act upon the value chain as a source of demand, to promote research and development, monetize risk, or to modulate behavior. Space insurers, in this context, are outside of the value chain because they do not generate demand for satellites, or use the data that come from them.

Much of the revenue from satellite operations and insurance comes from large school-bus sized satellites, mostly at geosynchronous orbit (GEO). These large satellites cost hundreds of millions of dollars and are expected to perform for upwards of 10-15 years, recouping their costs over time. However, the GEO market is currently experiencing a downturn as new satellite configurations and miniaturization are driving innovation and disruption. The U.S. Federal Aviation Administration’s (FAA) January 2018 Compendium of Commercial Space Transportation notes a decrease and flattening out of GEO launches that launch providers are feeling as well [7]. At the September 2018 World Satellite Business Week in Paris, France, United Launch Alliance CEO Tory Bruno, referencing low-Earth orbit constellations, said, “I also think that will eventually lead to a sort of reset in the GEO marketplace, with those constellations taking some, but not all, business away from GEO systems.” [8]. Smaller, less expensive, and possibly more replaceable satellites could change how the space industry seeks its profits and thus underline other trends in commercial space.

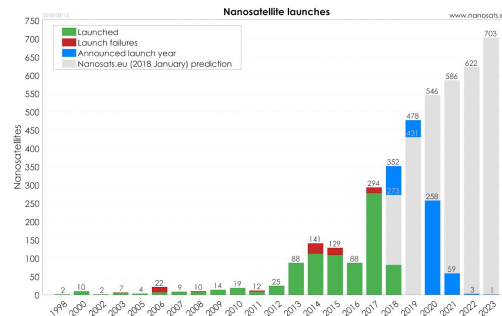


Fig. 2. Nanosatellite launches over time with future announced launches and projections [9].

One of those trends is the entrance of smaller satellites on the commercial market. 2017 alone saw more nanosatellites launched than all the years before 2012 combined. Companies can now fly constellations of satellites that had up until recently been considered too small to be commercially viable. Part of the draw of smaller satellites are that they cost less and can be replaced more easily, refreshing technology rapidly. Constellations of smaller satellites could be their own

form of insurance and resilience, expecting loss and replacing with other on-orbit assets in reserve. In any case, small satellites have proven to be a very attractive option and it is anticipated that tens of thousands could be launched over the next decade or so [10,11].

Another increasing trend is the rise of mega-constellations. For example, the California-based remote-sensing and analytics company Planet uses over 180 satellites to provide Earth observations, a constellation that as of a decade ago, would have been considered one of the biggest ones in the world; now, it is large but not unheard of, particularly given the plan of some companies to launch constellations with thousands of satellites. Seeing how there are about 1,800 active satellites at present, these plans for thousands upon thousands of new satellites is a huge jump in the number of satellites on orbit. Additionally, new actions like on-orbit servicing or satellite refueling could serve to extend the lifespan of many satellites. These changes to expectations of satellite longevity could significantly upset the space insurance market.

Beyond insurers, there is a balance of obligations among investors and lenders that can influence operator behavior. Investors and lenders are interested in reducing risk and have a theoretical interest in protecting their investment through responsible operations. However, any steps taken to reduce long-term risk also have the potential to increase short-term costs, so the commercial sector will regard any risk-reduction recommendations through that lens and this must be kept in mind when examining the appetite for self-regulation of the commercial sector.

### 3. Trends in the Space Insurance Industry

Next, there was a discussion about trends in the space insurance industry. The global insurance market is roughly \$5 trillion dollars per year, and space insurance represents between \$500 million to \$1 billion per year, or roughly \$750 million in 2017. It is a small but very competitive market. There is a lot of interest in space and also a lot of capital interested in space insurance. Currently, there are around 30-40 insurers for traditional western risk. They can compete on coverage terms and capacity, but due to the fierce competition, most are only competing on price and thus are loathe to try to raise prices out of worries that it would drive customers to their competitors.

Property (first party) and liability (third party) insurance are typically packaged together in most insurance products, but they are separate in space. Property insurance of a satellite insures against the failure of that satellite during launch or operation and will typically recoup only the cost of the satellite, not the loss of future revenue. Rocket failure happens about

5-6% of the time. Liability insurance of a satellite would insure against damage caused to a third-party by the operator's satellite.

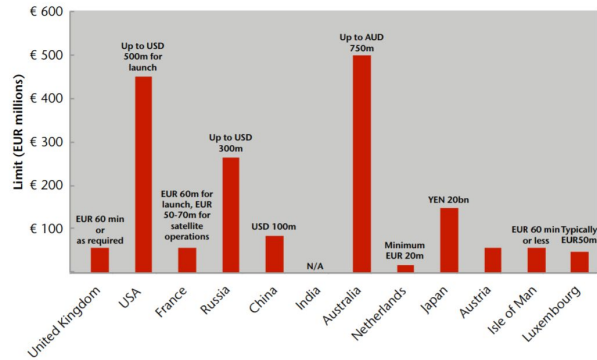


Fig. 3. International legal & regulatory requirements for third party liability insurance by state [12].

A small number of countries require on-orbit liability insurance as part of their regulatory oversight, but still only a handful of satellites carry liability insurance. On-orbit operations have not been typically insured. The vast majority of all satellite ventures carry property insurance, which is typically the third-largest expenditure behind launch and manufacture. 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. Historically, the thinking has been that insurers needed to look at the launch and the first three months on orbit, and after that, owner/operators would not have to worry so much about risk.

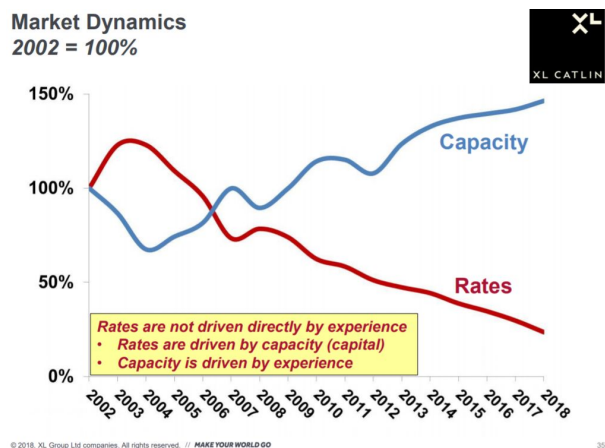


Fig. 4. Space insurance market prices and rates [13].

Pricing for insurance is not driven by operational experience. Even after the 2009 Iridium-Cosmos

collision, prices quickly fell back down, and are now even below pre-collision prices because traditionally-calculated collision risk is extremely low (ranging from close to zero to 1 in  $1 \times 10^4$  depending on orbital altitude) - it is an insignificant element in pricing on-orbit insurance. Orbital space is very large and the relative size of satellites are very small, so the possibility of a collision is one that has a very high severity of consequences with a very low frequency of occurrence, which makes a business case for insurance challenging. In any case, a true third-party liability claim could be catastrophic for the satellite operator at fault and potentially the space insurance market. But in the 60-plus years of satellites orbiting Earth, a true third-party liability lawsuit has not taken place, so there is no direct precedent for such an event.

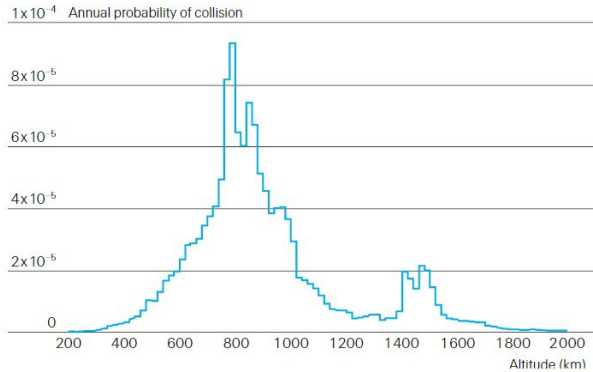


Fig. 5. Annual probability of a collision risk for a  $10 \text{ m}^2$  as a function of orbital altitude [14].

While precedent for on-orbit liability claims are lacking, liability for damage during launch is required for some parties and regulated through indemnification cross-waivers in the United States. The 1984 Commercial Space Launch Act (CSLA) sought to encourage private space industry by recognizing the hazards of launch and standardizing indemnification across all the parties involved in a launch [15]. Participants noted one of the impetus for the Act was the 1984 on-orbit malfunction of the Westar 6 and Palapa B2 satellites' payload assist modules (PAM). The Indonesian government, owners of Palapa B2, sued the manufacturer of the PAM and won a large settlement, a precedent that could inhibit future innovation [16,17] Participants noted that the CSLA enabled a lot of successful development and that it might be a good model to hold as a benchmark for future legislation on this issue.

Space insurers would like to reduce premiums for better actors, but the pricing challenge prohibits any meaningful action. Those selling insurance have very

little pricing power and very little direct interaction with their customers - most of it goes through brokers, who depend heavily on models to determine pricing. There is very little flexibility for space insurance pricing for the insurers. Collaboration between the insurers may help to develop best practices such as maintaining reserve propellant for end-of-life disposal. However, antitrust regulation may prohibit such collaboration. In the United States and European Union, colluding to influence pricing decisions among competitors quickly runs afoul of government regulators.

There is also the question as to what exactly is good behavior on orbit. There are the established best practices, but they often emerge only after years of trial and error by operators and are not entirely clear for emerging space technologies. Given that there is not universal (or even close to it) agreement as to what the rules of the road are or should be, it is hard to hold companies to standards or to punish them financially for not meeting those standards. Efforts are afoot to create agreed-upon norms of behavior, but in the interim, an insurance company/the insurance industry would have to take the initiative to create these actionable standards and that is unlikely to happen. Most likely, we would need to start seeing the national implementation of international guidelines for responsible behavior in space first.

It was also noted that a lot of risk of operating in space can be passed on, due to the established legal framework, to the government, raising the question of how you can incentivize good behavior when the bad behavior is not yours to worry about. Also, primary payloads can have different levels of insurance than secondary payloads, increasingly the complexity of using insurance to encourage good behavior.

It was argued that it is not helpful to regulate insurance rules until we know what we are trying to have happen - or more accurately, what we are trying to avoid. What problem are we trying to solve: are we trying to avoid collisions? Stop radiofrequency interference? Prevent satellites from having to maneuver and shorten their lifespans? There needs to be a discussion about the end-goal in order to determine the best way to reach it.

Having said that, there were some thoughts about possible ways in which responsible behavior could be encouraged, with the goal of it becoming the baseline and possibly having a surcharge levied on those who didn't carry them out. These could be as basic as becoming a member in a space situational awareness organization (and the sharing of information that that would entail), having pre-agreed upon policies for emergency maneuvers, incorporating end-of-life characteristics in satellite design and usage (saving

propellant for end-of-life maneuvers, building in redundancy for critical systems), ensuring cybersecurity strength, coordinate frequency and orbital slots, and sharing anomaly information in order promote any lessons that were learned.

#### **4. Lessons from Nuclear Power, Maritime, and Cyber Domains**

While space is very different from other domains, it does not mean that lessons cannot be learned from other models of insurance. The workshop thus brought experts with experience in nuclear power, maritime domain, and cybersecurity to see if insurance in those domains was able to give birth to best practices or encourage good behavior/punish bad behavior.

##### *4.1 Nuclear Power*

The nuclear power industry is subject to strict regulation after notable public disasters over their history of operation. Unlike satellite operators, nuclear operators are held hostage to each other in terms of reputation. If any nuclear operator has a catastrophe anywhere in the world, public and governmental opinion shifts very quickly to reevaluate all nuclear operators, which encourages sharing information about learned risks in the hopes of lifting the entire industry up and avoid punishing press. The creation of the World Institute of Nuclear Security (WINS) was noted as a way in which nuclear operators strive to share information in order to avoid future catastrophes and how governments might pay to incentivize best practices. In light of the danger posed by nuclear catastrophes, governments established antitrust waivers to encourage nuclear operators to collaborate in order to improve industry-wide safety. Lastly, governments have also become the backstop and guarantor of nuclear industry. Without this liability and established precedent, fear of lawsuits has not developed as a driver for better safety performance in the nuclear industry.

##### *4.2 Maritime Domain*

Maritime regulation, law, and conceptions of risk are often compared to space and the satellite industry because they share similar questions of jurisdiction ambiguity. Yet, the maritime domain has centuries of precedent among states, international bodies, and commercial interests that are much less developed in the space domain. For example, maritime vessels have to be verified to ISO standards, while there is no equivalent requirement for space vehicles. International laws establish mandatory minimum requirements on ships and operators that are then enforced and possibly enhanced by states and ports. It was noted that there are flags of convenience in the maritime world that are

well-regarded in terms of being responsible operators; could that be something that might be applicable eventually to space entities?

With requirements for not only property, but also liability insurance, there exists in the maritime domain a robust insurance market with high demand and the ability to differentiate premium pricing. Insurers assist in improving safety and best practices because it minimizes their exposure to risk. Also, maritime insurers have standardized liabilities in their contracts, which has been very important to the industry.

##### *4.3 Cybersecurity Domain*

The cybersecurity domain is distinct from space, nuclear, and maritime because it is not a stand-alone domain, as it is integrated into everything. The current economic incentives make attacking cyber networks much more feasible and profitable than defending. Regulation has run the gamut from laissez-faire to full-on government control with mixed results. Some of the best efforts may be in influencing the boards of companies to have a culture of cyber security that permeates the organization. Without top-down support, efforts to defend could continue to be futile. Cyber insurance does exist, but it is developing very slowly and only covers identifiable and foreseen risks. Monolithic insurance pricing may never be a driver of best practices, but maybe different insurance types, similar to health insurance, could adapt to the cyber environment. While technical standards may be helpful, best practices (such as public reporting of vulnerabilities) might be more productive and are becoming more common. Even with that, they are not fully adopted nor enforceable.

#### **5. Conclusions**

This event sought to elucidate the relationship between space insurance and incentivizing good behavior. Based on the information presented, it seems that the structure of the space insurance market currently precludes any incentivizing from the insurers onto the operators. While the insurance industry is not currently in a place to drive responsible behavior, it can be a supporting force.

Due to the current market complications, ensuring these best practices may fall to governments. While many governments are loathe to impose mandates upon private companies, without action and due to the nature of liability in space, governments could be holding much more risk than is currently assumed.

Government activity might be as simple as incentives such as fast-tracked licensing for spectrum allocation and earth-observation and antitrust waivers for space insurance companies to collaborate on safety

practices. A more complex approach would involve regulated standards, provision of robust public space situational awareness data, and mandated liability insurance.

In addition, those who can affect the immediate financial well-being of satellite operators might be better-placed to incentivize good behavior - namely, the investors. Examining their role in establishing norms for good behavior on orbit could be a productive follow-on discussion. Otherwise, it may take a catastrophic and costly event on-orbit to spur change.

### Acknowledgements

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