

# Insuring Space Activities

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# Introduction

From the first detailed account of a voyage beyond the terrestrial limits of planet Earth by Lucian of Samosata in AD140<sup>1</sup>, through the milestones achieved by the Sputnik I and Apollo XI missions in the sixties, to the satellite constellations which serve the world’s populations today, humankind’s long- held dream of exploring space has not only become reality but a critical hub of our modern-day society. The evolution of space technology has continually opened up new horizons, with a vast range of commercial, space-based applications turning the industry from a two-nation military “space race” between the U.S.A. and the Soviet Union to a global, multi-billion dollar enterprise. Indeed, recent figures released by the Satellite Industry Association show that the growth in the global satellite industry shows no sign of abating with cumulative industry revenue estimated at some USD208.3 billion, almost double the number recorded in 2006<sup>2</sup>. The buoyancy of the industry has coincided with the increased investment of private companies. Where Space activity was previously largely funded by governmental bodies and national space agencies, nowadays it is the very same state entities that are purchasing hardware and services from private companies who sell such services for commercial gain. Yet whilst the public marvels at the seemingly boundless possibilities offered by space-based technology and the companies who provide them, behind the curtain lies an industry which has played an important supporting role in enabling such technological advances to become reality: insurance. Coinciding with the growth in the commercial space industry,

space systems operators, launch vehicle providers, governments and national space agencies have increasingly purchased specialist insurance cover to protect their assets. When one considers the extreme physical risks involved – in the case of a satellite, subjecting a bespoke, fragile piece of electronic equipment to a high-pressure voyage to the harsh environment of outer space - in combination with the large monetary values at stake - a single satellite project can cost upward of USD 500 million and can take up to three years from the moment the manufacturing contract is agreed up until the moment of launch - it is no surprise that insurance is considered essential, especially for private entities. Indeed, external capital finance is often obtained from specialist banks such as the Export-Import Bank of America or COFACE, which require a covenant from the prospective operator to obtain comprehensive insurance as a condition. Mutually recognising the need to protect such valuable assets and services from the unique perils associated with space activities, insurance companies have been a key enabler in the development of the space industry, providing coverage for private and public entities alike since 1965<sup>3</sup> and continuing today. This chapter will consider the symbiotic relationship between insurance and the space industry, from its initial beginnings through to today, discussing the various players involved and the specialised insurance coverages available to operators, including an outlook on the role of insurance vis-à-vis the future.

<sup>1</sup> Lucian, of Samosata, *True History* (circa 2nd century, Francis Hickes tr, London, 1894)

<sup>2</sup> Satellite Industry Association, '2016 State of the Satellite Industry Report' (June 2016), <http://www.sia.org/wp-content/uploads/2016/06/SSIR16-Pdf-Copy-for-Website-Compressed.pdf>

<sup>3</sup> ACSC was the first company to obtain a space insurance policy for the first commercial satellite, *Early Bird*.

# What is insurance?

Modern-day insurance can be defined as a contractual relationship that exists when one party (the insurer), for a consideration (the premium), undertakes to reimburse another party (the insured) for loss to a specified subject (the risk) on the happening of a specific event (hazards or perils)<sup>4</sup>. Put simply, it is a form of risk management in which one party transfers the cost of a potential loss to another entity in exchange for a fee. By purchasing an insurance policy for a smaller, known premium, the insured individual, business or other entity removes the possibility of a much larger and potentially catastrophic loss by transferring risk to a more risk-neutral party. For many businesses, insurance is essential, providing protection against associated business risks and enabling them to obtain credit from banks in order to expand into new, unfamiliar territory. In this sense, insurance is critical for encouraging risk-taking and creating and ensuring economic growth.

An insurance company pools the premium it collects, along with the risks it insures, to distribute the financial impact of a loss made under one of the policies it insures, the basic principle behind insurance being the losses of the few are paid by the premiums of the many.

## What is space insurance?

'Space insurance' can broadly be defined as a highly specialised niche market into which fall all contracts of insurance designed for protecting against the financial consequences of losses occurring before, during and after the launch of an artificial satellite. This definition includes the legal liability to third parties that may be incurred by operators and launch vehicle services providers during the pre-launch and/or launch and/or in-orbit phases of a satellite's life. As a developing venture in its infancy, space tourism does not (yet) fall under the realm of space insurance, therefore discussion will predominantly be focused on the insurance of satellites.

The American Communication Satellite Corporation was the first company to obtain a space insurance policy for Early Bird in 1965. Whilst the early years of space insurance saw fewer than five insured satellites being launched on average, as the commercial industry truly took off from the 1980s onwards, this figure had increased to between 30 and 40 a year on average<sup>5</sup>.

As of 2016, of the 430 commercial satellites operating in-orbit, over 250 were insured, thus confirming the change in landscape and reflecting the symbiotic relationship between the commercial space and insurance industries. This shows no signs of changing with a total of 560 commercial satellites anticipated to launch over the next decade<sup>6</sup>.

**Fast fact:** The American Communication Satellite Corporation was the first company to obtain a space insurance policy for Early Bird in 1965.

# The insurance covers

Whilst commercial space activities have evolved over the 50 years since its birth, the basic risk categories and the corresponding forms of insurance cover have essentially remained the same. Broadly speaking, there are two main types of space insurance: one covering first-party property insurance and the second, third-party liability insurance.

## 1. Satellite/Launch Vehicle First Party Property Insurance

The usual forms of space first property cover are geared around the technical sequence of events, namely the pre-launch, launch and in-orbit phases of the typical space project.

In order to meet the unique requirements for space projects, space first party insurance policies are offered on the basis of "all-risks" coverage<sup>7</sup>. This means that unless specifically excluded, the insurance covers all forms and causes of damage, including incidents of an accidental nature and malfunctions, whether these result from premature wear and tear or faulty design. This extremely broad coverage is necessary since it is practically impossible to resolve incidents once launch has taken place.

It is important to note that space insurance policies include a waiver of subrogation rights in favour of all participants in the satellite contractual chain, so that, after having indemnified the insured for its loss, insurers contractually agree not to use their right of recourse against any party which could be responsible for the damage caused. This is unique as insurers' subrogation rights are an important principle of insurance law. This flows down from the 'reciprocal no-fault, no-subrogation, interparty waivers of liability' standard basis of the satellite manufacture and launch services contracts, under which no contracting party (at any level) may make any claims or initiate any proceedings based on any reason or event, regardless of where fault lies<sup>8</sup>. The scope of the waivers cover damage to property; bodily harm and death and all their consequences; launch mission failure and satellite mission failure. For example, if an accident causes damage to the satellite which originates from a faulty component or erroneous assembly by an employee of the launch service provider, the satellite owner may not bring a claim against the launch service provider or any of their contractors or subcontractors. This essentially transfers all risks to the operator<sup>9</sup> and therefore ultimately to insurers under the insurance contract.

"It is important to note that space insurance policies include a waiver of subrogation rights in favour of all participants in the satellite contractual chain, so that, after having indemnified the insured for its loss, insurers contractually agree not to use their right of recourse against any party which could be responsible for the damage caused"

<sup>4</sup> International Risk Management Institute (IRMI) <https://www.irmi.com/online/insurance-glossary/terms/i/insurance.aspx> accessed 1 August 2016

<sup>5</sup> 38 launches were insured in 2013 (some 46% of all launches)

<sup>6</sup> '\$250 Billion to Manufacture & Launch 1,450 Satellites over Next Ten Years' [http://www.euroconsultec.com/13\\_September\\_2016](http://www.euroconsultec.com/13_September_2016) accessed 13 September 2016

<sup>7</sup> This notion is opposed to a standard property risk policy based on 'named perils', under which insurers will only indemnify the policyholder for losses or damages specified under the policy.

<sup>8</sup> The objectives sought by the reciprocal waivers of liability are to limit the claims that might arise from a launch.

<sup>9</sup> It is more frequent that a launch vehicle causes of damages in the event of a failure rather than the satellite, for whom legal title rests with the operator.

## 1.1 Satellite/Launch Vehicle Pre-Launch insurance

Pre-launch insurance provides coverage against physical loss or damage of the satellite or launch vehicle whilst it is in its manufacturing and ground testing phase, including transportation to the launch site, assembly, integration and the various processing phases involved prior to launch. This cover is purchased by satellite manufacturers or launch service providers with whom title remains until Intentional Ignition or Launch.

The most common hazards which this policy provides cover against stem from the fragile and extremely lightweight constitution of the satellite or launch vehicle during construction and transportation,<sup>10</sup> as well as the particular perils encountered during assembly of the rocket stages and payload on the launch pad, such as fire or explosion, due to the quantities of propellant being handled<sup>11</sup>.

In virtually all pre-launch risks policies, coverage terminates when legal title to the satellite passes from the manufacturer to the purchaser, typically the point contractually defined as the intentional ignition of the launch vehicle. This is the point at which the launch is deemed irreversible, as the launch service is considered performed, whether successful or not. At this point, risk of loss will transfer the launch insurance policy, where this has been purchased.

The sum insured will typically comprise the replacement cost of a satellite and/or launch vehicle. In addition to the exclusions set out in 1.4 below, damages caused to the production facility and launch pad property are typically excluded under a pre-launch risks policy, these being covered under the facility owner's property insurance policy.

"In virtually all pre-launch risks policies, coverage terminates when legal title to the satellite passes from the manufacturer to the purchaser, typically the point contractually defined as the intentional ignition of the launch vehicle."

<sup>10</sup> For example, the Spainsat satellite was damaged in December 2003 during transportation to a testing facility

<sup>11</sup> For example, AMOS-6 was destroyed on 1 September 2016: Stephen Clark, 'SpaceX rocket and Israeli satellite destroyed in launch pad explosion' (Spaceflightnow, 1 September 2016) <https://spaceflightnow.com/2016/09/01/spacex-rocket-and-israeli-satellite-destroyed-in-launch-pad-explosion/>

## 1.2 Satellite Launch insurance

Launch insurance provides coverage for loss of, damage to or failure of the satellite occurring at any time between the beginning of the launch phase and typically one year thereafter,<sup>12</sup> although certain insurers may be willing to offer extended coverage periods of up to fifteen years. This policy is mainly purchased by the satellite operator, although any party with a legal insurable interest in the satellite may procure coverage. Whilst the value of the launch costs are included within the sum insured, the launch vehicle itself is not insured by launch service providers as the launch contract is deemed performed upon ignition of the launcher, regardless of whether the launch is successful or not.

The launch and early orbit phases constitute the most critical phases of a satellite's life. The satellite is exposed to a number of major hazards and a high risk of loss, especially during the launch mission. There is, on average, a 5.6% possibility that the launch vehicle will fail,<sup>13</sup> with the worst-case scenario entailing a total loss of the satellite through destruction or the attained orbit deviating from the planned orbit so that fuel is consumed in correcting the deviation, reducing its useful lifetime, or, at worst, stranding the satellite in a useless orbit.

If the launch is successful, the satellite will then be thoroughly tested to ascertain whether the satellite is free of design errors and manufacturing faults and will fulfil its operating requirements. Historically, occurrences of malfunctions are numerous during this phase (see fig.1).<sup>14</sup> If no faults are detected during positioning and in-orbit testing, then the probability of losses occurring during the operations phase depreciates appreciably<sup>15</sup>.

### Market insured losses: launch through first twelve months in orbit (since 2000)

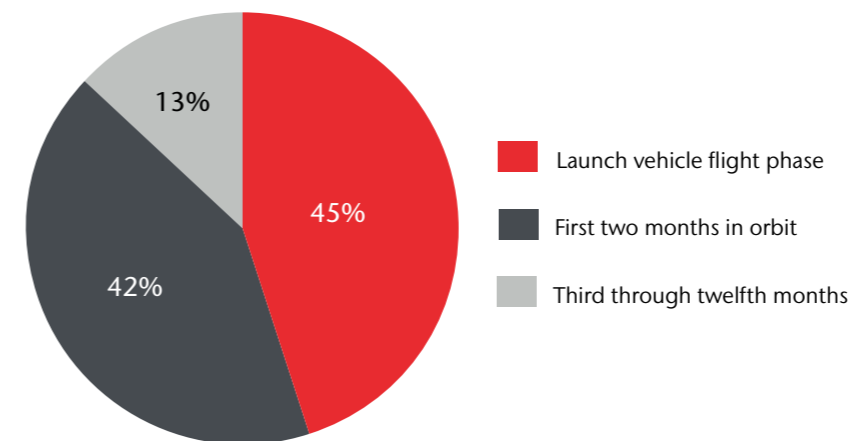


Figure 1: Market Insured Losses: Launch phase through first twelve months in orbit  
Source: XL Insurance<sup>16</sup>

<sup>12</sup> The standard is for coverage to terminate twelve months after launch for satellites which use chemical propellant or sixteen months for electric orbit-raising satellites.

<sup>13</sup> XL Insurance, 'Space Insurance Market Update', (XL Insurance, May 2014) available at [http://worldspaceriskforum.com/2014/wp-content/uploads/2014/05/1\\_MAR-KET-UPDATE\\_KUNSTADTER.pdf](http://worldspaceriskforum.com/2014/wp-content/uploads/2014/05/1_MAR-KET-UPDATE_KUNSTADTER.pdf) accessed 17 July 2016

<sup>14</sup> For example one of the two solar arrays could not be fully deployed on the Estrella do Sul satellite, leading to a large partial loss.

<sup>15</sup> Satellites have an average annual failure rate of just 1.5% in the second and subsequent operational years in orbit (XL Insurance, 'Space Insurance Market Update', (n 14)). <sup>16</sup> XL Insurance, 'Space Insurance Market Update', (n 14)

<sup>16</sup> XL Insurance, 'Space Insurance Market Update', (n 14)

The sum insured under a launch policy will usually comprise the cost of procuring a like-for-like replacement in case of a total loss. This includes the total value of the satellite, the launch services price and/or the insurance premium cost itself, however this is dependent on the insured's risk appetite and/or budget. Premium savings can be made by restricting the agreed value to be insured and retaining a portion of the risk. Whilst the average launch risks policy insures a value of approximately USD250 million, values can be as high as USD500 million and beyond.

Although coverage costs will vary depending on a number of factors,<sup>17</sup> launch insurance typically constitutes the third most expensive element of a space project after the launch vehicle and satellite manufacturing costs.

Reduction in a satellite's operational capability is compensated according to a predetermined, bespoke ratio of loss calculated in terms of the number of transponders on the spacecraft, the on-board electrical power, the reserves of fuel and designed satellite life. Risks are classified as either a total loss, constructive total loss or partial loss. In each case, in order for a loss to be indemnified, the satellite status must simultaneously meet two conditions: (1) the satellite does not perform in accordance with its technical specification so that the loss definitions are fulfilled; and (2) the satellite (or affected part thereof) cannot be used for its intended purposes.

Total loss would cover situations including the explosion of the launch vehicle or satellite following Launch or the satellite being inserted into an orbit which deviates so far from its intended one that correction cannot be achieved using the satellite's on-board propulsion system or the apogee motor so that the satellite is left 'stranded' in a useless orbit.

If a covered loss leads to a reduction of the lifetime or operational capacity of the insured satellite below a threshold, typically set between 75 per cent and 90 per cent, it will be declared a 'constructive total loss', in which case the satellite will be totally indemnified by the insurers. As a counterpart to such full indemnification, insurers may be entitled to the sole rights of salvage, a concept originating in maritime law under which title to the satellite will pass to the insurers, who are free to sell it on.

Thirdly, 'partial loss' of the satellite corresponds to a partial reduction of the lifetime or operational capacity of the satellite below the threshold used for the determination of the constructive total loss. In this case, the amount of indemnification will correspond to the actual loss of capacity and/or lifetime sustained by the satellite. As with constructive total loss, policies may also provide for salvage opportunities in the case of a partial loss, however the amount of salvage received by the insurers shall be limited to the indemnification paid for the respective loss.

**"Although coverage costs will vary depending on a number of factors, launch insurance typically constitutes the third most expensive element of a space project after the launch vehicle and satellite manufacturing costs."**

### 1.3 Satellite in-orbit insurance

Also known as "life" insurance, in-orbit cover offers protection against the risk of a satellite's complete or partial failure during its operational lifetime. This type of coverage commences upon expiration of the Launch insurance policy and is usually renewable on a yearly basis.

Provision of coverage is subject to a review of the health status of the satellite prior to commencement of each policy period. Depending on the state of health reported by the prospective policyholder, the insurers will decide what terms and conditions to offer. For example, if anomalies have occurred during the expiring policy period, exclusions or deductibles may be introduced by insurers or by the buyer in order to maintain coverage at a reasonable cost. Generic defects, i.e. particular issues affecting satellites that share a common manufacturer or components, are usually excluded from cover even where the buyer's satellite does not show any sign of suffering from the same defect.

As with launch insurance, the insured value is an agreed value, which at the beginning of the satellite's service life is based on the replacement value or the amount of loans required to finance the project. As the satellite ages and its operational lifetime declines, the value of the satellite will amortize correspondingly and the sum insured will decrease, usually on a linear basis.

The covered damages are total loss, constructive total loss or partial loss of the satellite, for the same causes and on the same bases as discussed for launch risks. The main risk during the in-orbit phase is of partial loss, statistically most likely to occur as a result of a malfunction in the electrical power systems.<sup>18</sup>

Besides the internal perils mentioned here, there are external influences which may affect the functioning of a satellite. Intense cosmic radiation resulting from solar flares can induce electronic discharges, causing satellites to malfunction.<sup>19</sup> Of increasing concern is a collision with orbital debris, particularly in the case of satellites operating in low earth orbit, where there is greater spatial density owing to the growth in population of satellites orbiting at this altitude and the presence of objects such as used upper rocket stages. Even though the risk has historically been considered very low – in part because there are a number of collisions warning systems in place – a collision with the smallest particle of debris could cause serious damage to a satellite.

Costs for in-orbit coverage in the second year of operation are typically much lower than the launch phase and first year in-orbit period, owing to the lower probability of failure. Indeed, satellites have an average annual failure rate of just 1.5% in the second and subsequent operational year in orbit.<sup>20</sup>

"As the satellite ages and its operational lifetime declines, the value of the satellite will amortize correspondingly and the sum insured will decrease, usually on a linear basis"

<sup>17</sup> See the Insurance Procurement Process section below (Risk Analysis, marketing and quotation) for a detailed discussion

<sup>18</sup> XL Insurance, 'Space Insurance Market Update', (n 14)

<sup>19</sup> During a solar storm in January 1997, communications to Telstar 401 failed, leading to a total loss.

<sup>20</sup> XL Insurance, 'Space Insurance Market Update', (n 14)

## 1.4 Exclusions

In addition to the specific exclusions already mentioned, pre-launch, launch and in-orbit insurance policies are subject to standard exclusions for damage caused by war risks, terrorism, radiation or nuclear effects. Damages for third party liability are also specifically excluded. Where a new or upgraded component forms part of the risk subject matter, insurers may request part of the risk be retained in the form of a deductible, impose a No Claims Bonus or alternatively, an additional premium may be imposed.

## 2. Third Party Liability insurance

Third party liability insurance protects operators and all other participants in space operations from claims from third parties for bodily injury and/or property damages arising due to their space-related activities, whether during the pre-launch, launch or in-orbit operations phases, up to the amount of insurance specified under the policy, commonly referred to as the Limit of Liability.

The Outer Space Treaty 1967 (OST) and the Space Liability Convention,<sup>21</sup> which provide the basic framework of international space law for space-faring nations, establish that 'launching states' will be liable for damage caused by its space objects on the surface of the Earth, in airspace and in outer space<sup>22</sup>.

Whilst there is no obligation to procure third party liability insurance imposed by the OST and the Space Liability Convention, since the potential cost that could be incurred by damage to a third party is limitless, many signatory States have implemented national laws under which any person or entity which falls under its jurisdiction seeking a license for space activities must obtain such coverage.

The scope and minimum level of liability insurance imposed varies from one State's legal regime to the next (Fig.2). For some States, the liability may be imposed on the launch operator only and not on the in-space operator, such as under the US Commercial Space Law Act, whereas for others, the liability will lay with all operators throughout the satellite's life, as is the case in UK<sup>23</sup> and French law<sup>24</sup>. Above the level of liability imposed, the State will generally guarantee protection on an unlimited basis or up to a specified amount.

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## International legal and regulatory requirements

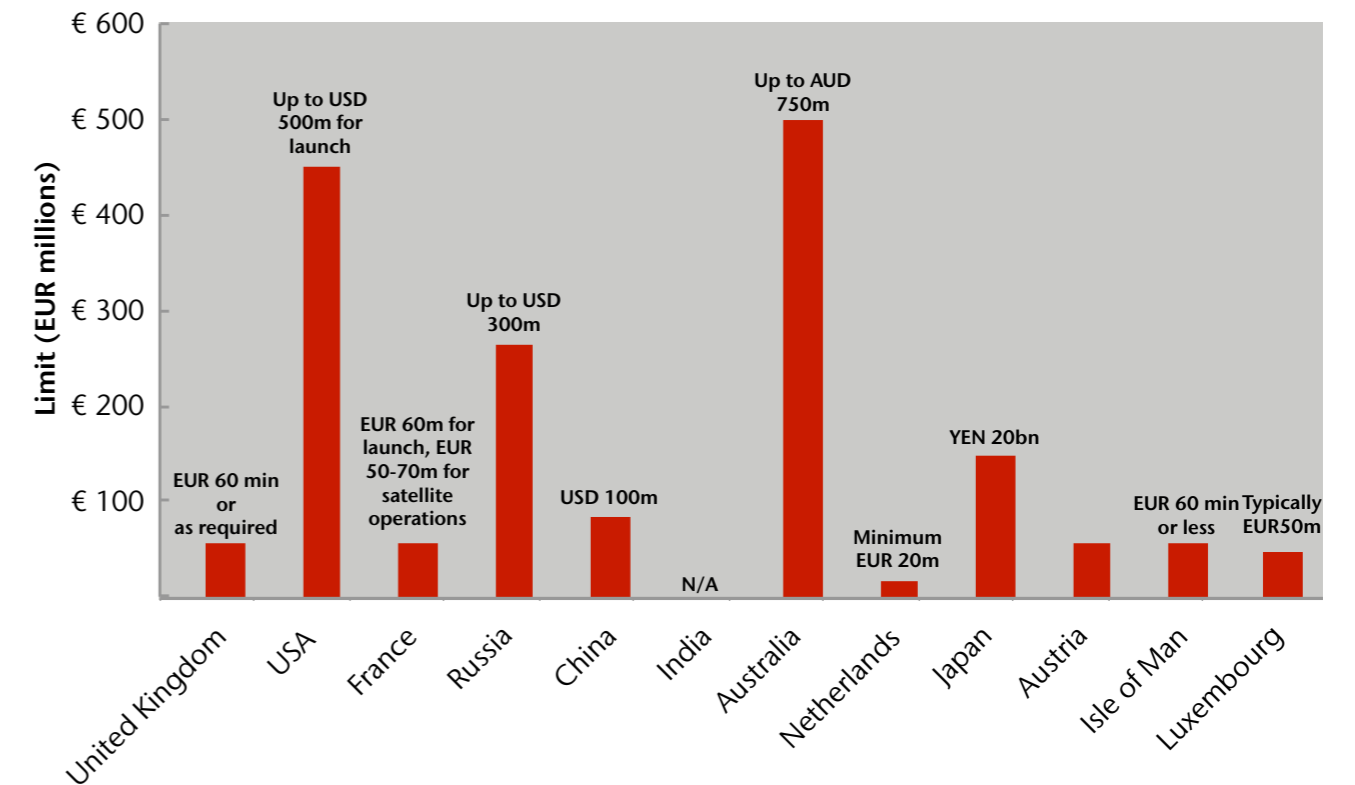


Figure 2: International legal & regulatory requirements for third party liability insurance by state  
Source: Aon UK Limited

Perils covered by a third party space liability policy include third party claims resulting from the launch vehicle causing contamination,<sup>25</sup> spent rocket parts returning to Earth or remaining in orbit as a collision risk, and damages caused by a satellite (belonging to the Insured) as a result of a collision.

The risk of exposure to third party liability is very small, as reflected by the few incidents or claims, none of which have resulted from an incident in-orbit<sup>26</sup>. While the sums insured under policies can be in excess of USD1 billion, premium rates are exceptionally low for both launch and in-orbit coverage.

<sup>21</sup> The Convention on International Liability for Damage Caused by Space Objects (1972) (hereafter the Liability Convention)

<sup>22</sup> The Liability Convention, *ibid* Art. II & Art. III, which provides for fault-based liability for damage caused to third parties in space and absolute liability for damage caused to third parties occurring on earth or in airspace.

<sup>23</sup> Outer Space Act 1986 Chapter 38, s 1

<sup>24</sup> loi n° 2008-518 du 3 juin 2008 relative aux opérations spatiales;

<sup>25</sup> For instance, in 2007, the launch of JSAT-11 on board a Proton rocket failed and caused approximately USD100,000 of environmental damage.

<sup>26</sup> In 2009 there was a collision between Iridium 33 and Kosmos-2251 which did not result in a claim.

### 3. Other space-related Insurance covers

#### 3.1 Launch Risk Guarantee

Launch service providers may offer a Launch Risk Guarantee (LRG) to their prospective clients for an additional sum, under which, in case of a launch failure, the launch service provider will provide for the full (or partial) cost of another launch if the satellite fails to reach its intended orbit or is destroyed, or if its functions are impaired as a result of a launch vehicle malfunction. Launch vehicle providers can insure these guarantees for the launch costs only.

#### 3.2 Satellite operations Loss of Revenue

Financial loss caused by a partial or total failure during the launching or operation of a satellite may be far greater than the material damage caused to the satellite itself if reduced operability ensues. A form of business interruption insurance, such a policy will only provide cover for financial loss actually sustained and not potential, future losses. A typical example of coverage would provide for a loss of contractually fixed revenue as a result of material loss or damage of a satellite transponder.

#### 3.3 Satellite manufacturer Incentive payment insurance

The contract for the manufacture of a satellite is subject to an extensive and detailed set of specifications in respect of the functions, performance and services of the satellite. The full purchase price for the satellite is often only made when it has been demonstrated that the satellite meets the specifications. A minimum, "basic" payment will be made prior to delivery, with further "incentive payments" making up the balance of the full purchase price made when the specifications are met during the satellite's lifetime. Manufacturers can obtain insurance to cover themselves for non- receipt of the payments in the event the satellite does not meet the specifications.

#### 3.4 Astronauts' Insurance

Personal Accident insurance is available for damage suffered by astronauts before, during or after a professional mission. The insurance cover will indemnify the astronaut or his/her legal successors in case of death or permanent invalidity following an accident. This insurance will provide cover without seeking any liability following an accident. No third-party liability insurance is required for damage caused by an astronaut to space objects, such as the International Space Station, as contracts generally contain cross-party waivers. Insurance relating to astronauts is typically underwritten by specialist Personal Accident insurers rather than insurance markets who cover commercial space risks.

#### 3.5 Space Tourism Insurance

Commercial access to space for members of the public is seen by many as the next logical step in commercialising space. Indeed, since Dennis Tito made the first trip to the International Space Station as a "space tourist" in 2001, many projects have emerged, with Virgin Galactic and XCOR Aerospace amongst those at the forefront of development of this sector. Whilst a bespoke "end-to-end" insurance solution for space tourism activities currently does not exist, if indeed space tourism becomes a reality, a suitable insurance solution will likely need to cover three aspects: first party property insurance covering the spacecraft and/or aircraft itself, where applicable; Personal Accident insurance, covering "tourists" and crew; and Liability insurance, covering Third Party Liability and passenger liability. As with traditional space risks, the key to making this venture insurable will be to establish reliability and safety.

## Characteristics of space insurance

In accordance with the very nature of space transport, the space insurance industry is a high-risk, high stakes venture, shaped by a number of forces which make it extremely complex and unique.

### Specialist insurers

Insuring space risks is a complex business which demands a specialized knowledge of the technology and processes of space transport. Indeed, many insurers and brokers employ individuals who have worked in some capacity for a launch services provider or satellite manufacturer. The large values insured, which can be as much as USD 500 million and beyond, often require the participation of a large number of insurers as most individual companies have neither the capacity nor the inclination to absorb the potentially catastrophic losses in case of a failure. The space insurance market is an international one with insurers located in the UK (London), France (Paris), the U.S.A., Germany and Switzerland, amongst others. Total market capacity, that is, the entire amount of coverage that insurance companies are willing to underwrite, is currently approximately USD 1 billion for any one risk with average rates for satellite risks at historic lows (Fig.4). This confirms that an inverse relationship appears to exist between capacity and rates, with similar trends observed in the past when capacity increased (Fig 4).

### Small homogeneous pool of risks

The space insurance industry does not benefit from a large homogenous exposure pool of risks. Whilst the insurance industry traditionally relies on the actuarial analysis of data by 'pooling' individual risks with similar characteristics in order to calculate the probability of loss of a given risk, there are, on average, only 30-40 insured commercial launches a year. Combined with the continual evolution of technology of the space industry, there are very few statistical events to accurately estimate the probability of failure. Instead, launch vehicle and satellite reliability, i.e. loss records are important rate determinants for insurers.

"Whilst the insurance industry traditionally relies on the actuarial analysis of data by 'pooling' individual risks with similar characteristics in order to calculate the probability of loss of a given risk, there are, on average, only 30-40 insured commercial launches a year.."

## High probability of large losses and wide-ranging consequences

Causes of loss are numerous (external and internal), random and regularly catastrophic (see Fig.3 and ‘The Insurance Covers’ for a discussion on the perils involved). It is for this very reason that insurance premium rates are comparatively high. Indeed, insurance constitutes the third-highest cost of a satellite project.

Although the now-retired American space shuttle flew a number of missions to rescue defective satellites,<sup>27</sup> nowadays the scope for repair and rescue in the event of a malfunction is extremely limited. With rescue missions considered more costly than the value of the satellite, a satellite must rely on the redundancy of its systems and the ingenuity of its engineers to find a solution in the event of a failure.

### Count of claims | Year: All

Subsystem- Cause of loss	\$0-50m	\$50m to \$100m	\$100m to \$200m	\$200m to \$300m	\$300m+
Null	5				
AOCS	8	1			
AOCS / Propulsion		4			
Communications payload	34	5	4		
Communications payload / terminal	1				
DHS	2				
Earth OBS payload	1				
Launch	56	11	11	13	2
Power	21	2	6	1	1
Power - battery	7	1	1		
Power - battery / communications payload	1				
Power - solar array	1				
Power - solar array	25	7	7	4	
Power - solar array / communications payload			1		
Propulsion	7	1	2	1	1
Propulsion - electric	3				
Propulsion - XIPS		1	1		
Thermal	1				
TTC	13	3			

Figure 3: Count of claims over time for insured missions  
Source: Aon UK Limited

<sup>27</sup> For example, the crew of the Endeavour space shuttle fitted the Intelsat 6-F3 with a new perigee motor which boosted the satellite into the correct transfer orbit in May 1992. Separately, the Westar 6 and Palapa B2 satellites were retrieved and brought back to earth after being stranded in useless orbits.

When a loss occurs, it has a profound effect, not only on the operator, who may need to find alternative ways of providing services whilst replacing a failed satellite, but also on the wider industry. Subsequent launches of the failed launch vehicle or satellite are suspended and a detailed analysis is carried out until the exact causes are determined. With launch vehicle and satellite reliability a critical underwriting determinant for insurers, the manufacturer of a failed vehicle or satellite and its current and future contracted clients will face additional insurance difficulties as a direct result of the associated decline in reliability. Available coverage may decrease and the insurance premium, already the third-highest cost of a project, will increase for potential future clients, making the satellite or launch vehicle less attractive for a prospective purchaser. The need to carry out the in-depth investigation must be balanced against time pressures, for operators are losing revenue the longer their asset is grounded.

Conversely, a suspension in activities also has a similar effect on insurers, as the premium charged for coverage is not earned until the moment of launch, which in turn affects revenues for the year. Since a space risks insurer’s profitability is measured by their premium-versus-claims ratio over the course of a calendar year, a delay will directly affect their yearly results.

Considering the large sums insured of satellites and that yearly premiums average USD700million- USD800million, it can take just two launch failures to change the market dynamic.

### Market sensitivity and cycles

History shows that the space insurance industry is extremely sensitive to events. This is unsurprising, considering that two large losses can wipe out premium generated in a year. For example, during the late 1980s, as the market emerged from a period of failures and the number of launches increased, total available capacity grew to a peak of USD1.3 billion, compressing premium rates. However, a combination of serial losses incurred in 1998 and 2001, most notably relating to generic failures on

the BSS-601 and BSS-702 satellite series, along with the economic repercussions of September 11, 2001 severely affected the space insurance market, leading to an immediate capacity decrease and a spike in premium rates (Fig. 4)<sup>28</sup>. This appears to confirm that the space insurance market behaves in a cyclical nature. During the ‘soft’ phase of the cycle, a buyer is able to obtain more favourable terms due to the excess capacity available. However, when profits fall, the market becomes ‘hard’ as insurers retain earnings in order to cover their claims. Consequently capacity decreases and premiums are raised to increase revenues.

“When a loss occurs, it has a profound effect, not only on the operator, who may need to find alternative ways of providing services whilst replacing a failed satellite, but also on the wider industry”

<sup>28</sup> Many space insurers share a common capital pool with aviation risks insurers, who were particularly affected by the events of September 11, 2001.



## Theoretical capacity and rates

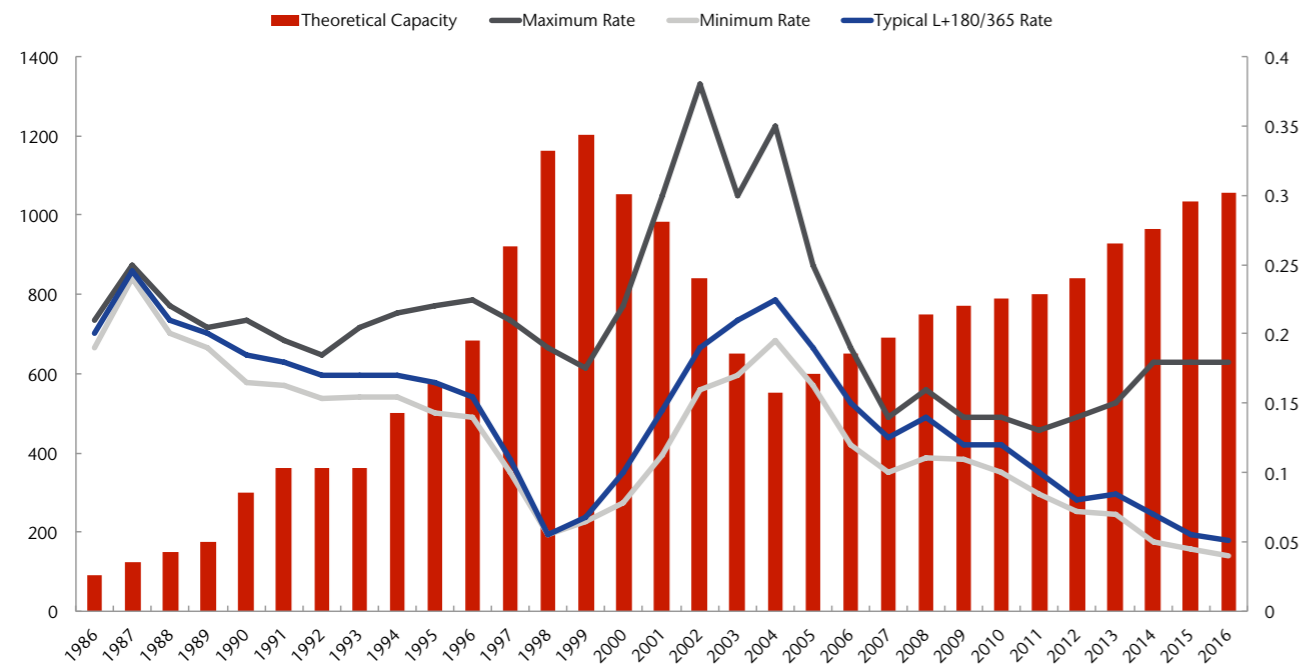


Figure 4: Theoretical capacity and rates  
Source: Aon UK Limited

Capacity has increased steadily in recent years (Fig.4), with investors attracted by a combination of a favourable premiums-to-claims ratio – the space insurance market has produced over a decade of successive positive results (Fig.5) - in addition to good yields in the form of comparatively high premium rates, particularly in the face of stagnant interest rates worldwide vis-à-vis alternative investments. This has led to historically low premium rates, with diminishing margins, making this very much a buyer's marketplace at present. In an attempt to counteract this, insurers give greater importance to the success rates of the diverse launch vehicles and satellites.

## Premium and claims

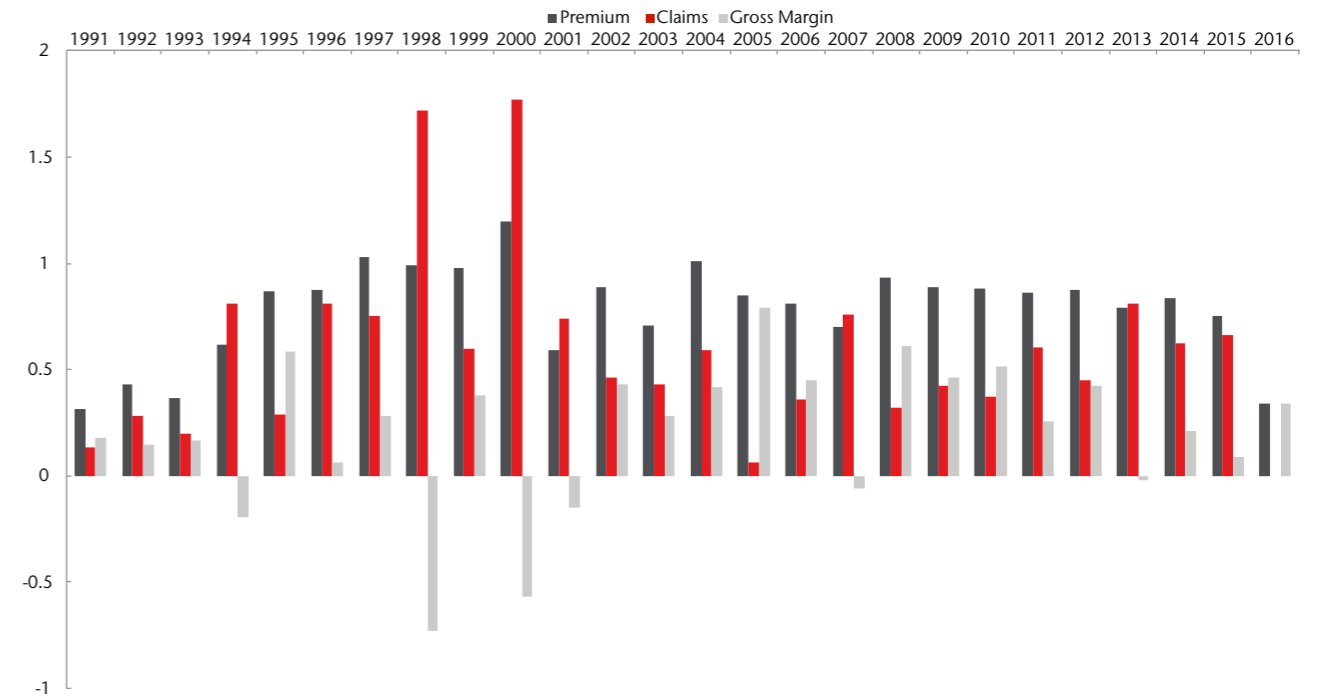


Figure 5: Premium vs claims over time  
Source: Aon UK Limited

► "The space insurance market has produced over a decade of successive positive results - in addition to good yields in the form of comparatively high premium rates, particularly in the face of stagnant interest rates worldwide vis-à-vis alternative investments"

# The insurance procurement process

The process for obtaining insurance for a space project is a long and complicated one involving a number of players. As insurance is primarily geared around protection of the satellite and launch vehicles, this section shall be discussed in that context; however, the process is generally the same for all space insurance policies.

## Appointment of a Broker

The process begins by the space operator (the Insured) appointing a dedicated insurance broker. Whilst the primary role of the insurance broker is to act as the intermediary between the Insured and insurers, the insurance broker will often act as consultants on risk management to the Insured, helping to evaluate and quantify risk exposures, identifying and facilitating the purchase of the insurance policy best suited to the Insured's needs; and managing the claims process in the event of a claim. Possessing an intimate knowledge of the insurance marketplace, including available coverages, prices and insurance providers, in-house engineering expertise and an acute sense of the needs of operators, space insurance brokers play a key role in the procurement of insurance.

## Presentation of the risk

The first step in obtaining an insurance policy is to organise the disclosure of the technical information required by insurers in order to evaluate the risk. Based on the principle of utmost good faith, which requires any entity seeking insurance to disclose all material facts,<sup>29</sup> the insurance broker, acting in its capacity as the Insured's primary agent, will present detailed reports on the risk to the various specialist insurers who offer coverage for space risks. Where the risk involves a launch, the insurance broker may organise a technical presentation with the assistance of the satellite manufacturer, launch service provider, and the Insured. This presentation will be followed by a question-and-answer session, thereby allowing the insurer to properly evaluate the risk for which insurance is sought. This is an important part of the process as a failure to disclose a material fact could lead to the insurance contract being voided ab initio, regardless of a valid claim being made. It is important to note that the duty of good faith continues throughout the period of the insurance contract until coverage terminates; any contract amendments, waivers and/or other technical issues that arise during the program and post-launch must be disclosed to insurers.

The insurance broker will then issue a request for quotation to the insurers on behalf of the future Insured, along with the Policy Wording and a terms sheet, which contains the pertinent details for the risk, such as the sum insured, coverage sought and loss definitions to the prospective insurers.

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<sup>29</sup> These are facts that would influence the judgment of a prudent insurer in fixing the premium or determining whether they will take on the risk.

## Risk Analysis, marketing and quotation

The underwriter (the individual working for the insurance company who analyses the risk) will then conduct an in-depth study of the risk, considering such factors as the heritage of the launch vehicle variant and/or the satellite models contracted,<sup>30</sup> the formulae used to calculate when a loss has occurred, the intended mission and the type of coverage requested. For example, in the case of a launch, the combination of a satellite model with a low historical failure rate and a launch vehicle with a high number of successful consecutive launches will, in theory, attract a more competitive rate than a new, unproven spacecraft model which launches on a launch vehicle with an inferior success rate. Other considerations that are taken into account include the value to be insured,<sup>31</sup> the risk portfolio currently underwritten by any given insurer, the year's claims-to-premium ratio, and the amount of cumulative capacity available (that is, the entire amount of coverage that insurance companies are willing to underwrite for a project). External factors such as worldwide capitalization and catastrophic events may also have a bearing.

Depending on the marketing strategy used by the insurance broker, the underwriters will, once their analysis is complete, each present their offer for coverage to the insurance broker. Each bid will state the capacity offered (i.e. what proportion of the total sum insured they are prepared to cover, otherwise known as 'line size'<sup>32</sup>), the premium rate for their share and the terms and conditions that they feel they can offer.

Before submission of the terms sheet and Policy Wording to insurers, the insurance broker will consider which marketing strategy to use in placing the coverage sought. Where a policy is placed on a 'horizontal' basis, the participating insurers underwrite the risk on the same terms and conditions, including price. Alternatively, if placed on a 'vertical' basis, each insurer will quote its own price for the risk independently of other competing insurers. Each strategy brings its own advantages and can be adopted depending on how the placement proceeds.

The insurance broker will also consider the prevalent conditions of the insurance marketplace before deciding on the timing of an insurance placement. Figure 6 illustrates how an external event, in this case the failure of a similar satellite or launch vehicle, can affect the premium rate. In such a case, where possible, the insurance broker may delay the placement in order to wait until conditions are more favourable to the Insured.

**In the case of a launch, the combination of a satellite model with a low historical failure rate and a launch vehicle with a high number of successful consecutive launches will, in theory, attract a more competitive rate than a new, unproven spacecraft model which launches on a launch vehicle with an inferior success rate"**

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<sup>30</sup> A 'proven' launch vehicle or satellite/component will be one which has been demonstrated to be successful over the course of a number of missions, with a low failure rate.

<sup>31</sup> The higher the sum insured, the more capacity will be required, with the rate increasing as a consequence.

<sup>32</sup> In a co-insurance, the liability of each insurer underwriting the insurance policy is several and is limited to the share of coverage taken.

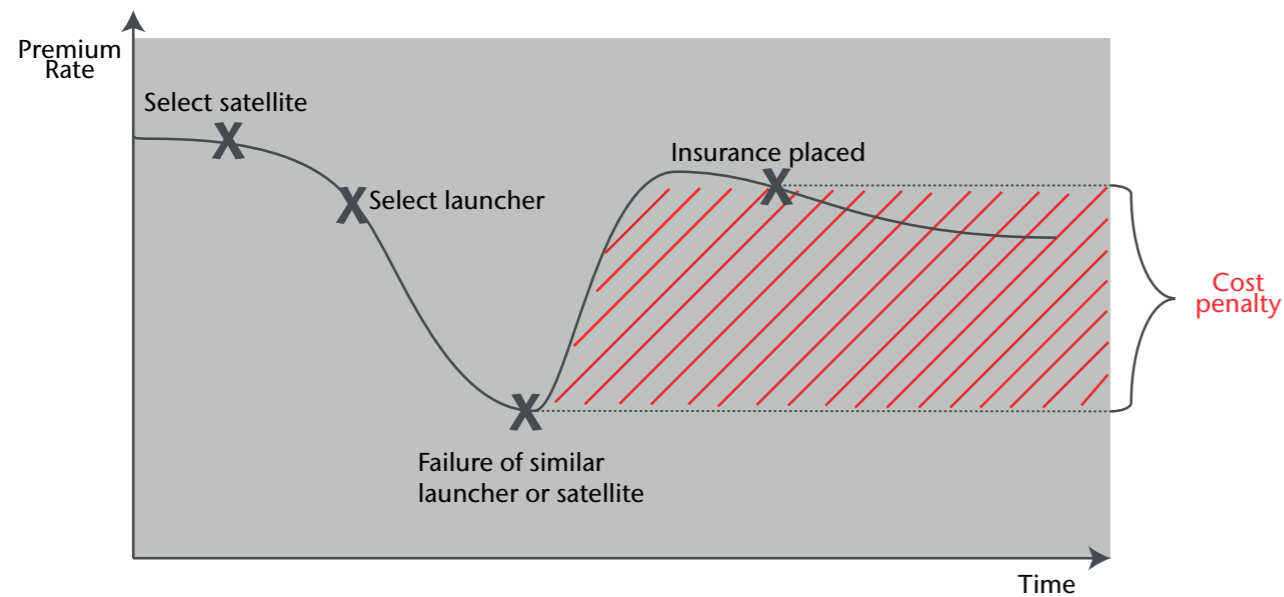


Figure 6: Impact of failures on premium rate  
Source: Weiss, Manikowski<sup>33</sup>

#### Presentation to the Insured and acceptance of an offer

The broker will gather the quotations received and present them to the Insured throughout the negotiation process. Depending on the results of the initial bidding process, the broker will make a recommendation to the Insured as how to proceed. If there is an oversupply of capacity offered (so that the bid offers total more than 100% of the agreed value to be insured<sup>34</sup>) for the risk or a specific insurer offers favourable terms and conditions, the insurance broker may recommend an additional round of negotiations in order to leverage a more favourable outcome for the Insured.

When the Insured agrees to the terms and conditions presented to it, it will issue a 'request to bind', that is to say, express authority to the insurance broker to accept the offers made by insurers on its behalf that it considers acceptable. In selecting which insurer quotation to accept, in addition to the premium rate offered, consideration will be given to the financial security of the insurer,<sup>35</sup>

any amendments or demands for specific clauses made, the insurer's claims payment history; and its expertise and experience in the space sector, amongst others. If there still remains an oversupply of capacity at this point, the Insured will 'sign lines'; that is, one or more insurers will be asked to participate for a lesser share than it has offered capacity for in order to total the 100% of the value sought to be insured.

The Broker will then re-approach insurers to formally obtain their agreement to the Policy Wording and transmit this to the Insured. In the event of a claim, the appointed Broker will also act as the primary agent in negotiations between the Insured and their insurers.

The process described above is the same for all types of cover and, depending on the risk profile can take anything from a couple of weeks to a number of months.

## Outlook and conclusion

Insurance has played a long-standing and important role in the development of space activities ever since the first policy was designed for Early Bird in 1965. Coinciding with the entry into the market of private entities, space insurance is now considered an integral part of the global space industry, providing protection against the unique and extreme perils associated with space activities and moving hundreds of millions of dollars in the process. Insurance is a key consideration not only for operators of satellites but also for the manufacturers and launch services providers, for whom the insurance community's perception can result in a sale or not of their hardware.

Yet whilst satellites, launch vehicles and the various space-based applications have evolved over the last fifty years, the transport and mechanisms have remained essentially unchanged; all being designed to fulfil a predetermined set of mission requirements and all launches having been performed using expendable launch vehicles. This has enabled the scope and design of insurance policies to keep pace despite remaining virtually the same.

However, a new range of applications and disruptive technologies are arriving onto the scene. From large constellations of "smallsats" operating in low-earth orbit to electric orbit-raising satellites and re-usable launch vehicle stages, different elements of risk are being introduced which require evaluations of existing policy wordings to ensure adequate protection continues to be provided.

Hazards such as space debris and so-called cyber risks, which include "hacking" and jamming of signals, are increasingly attracting more attention where they were once considered of little or no risk to satellite networks and third parties.

Looking to the future, insurance must evolve to enable mooted concepts such as in-orbit servicing, "space mining" and the nascent space tourism industry to become reality, for these will require insurance in order to succeed just as "traditional" space risks have done until now. History has demonstrated that the relationship between insurance and the development in the space sector is symbiotic: as long as private entities remain invested in the sector, insurance will continue to play a critical role in enabling its future success and growth.

<sup>34</sup> The capacity cannot total more than 100% or there will be over-insurance. This constitutes a moral hazard because the Insured may be tempted to make a false claim from a loss.

<sup>35</sup> This is assigned by one of the ratings agencies such as Standard and Poors, A.M. Best or Moody's.

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