

# Space Risks:

A new generation  
of challenges

An insurer's perspective from Allianz  
Global Corporate & Specialty

**Allianz** 

Foreword



**Thierry Colliot**  
Managing Director of SpaceCo and Head of Aviation and Space Underwriting for AGCS France

Space fascinates us. Since time began, we have looked up at the sky and seen it as a never-ending universe for exploration. Today, thanks to science and space technologies, what was once nothing but a dream has become a reality. We now have the capacity to travel and live in space, we can reach other planets and, most useful for our daily lives, we are able to successfully launch satellites and keep them in orbit. Satellites have become essential to establish a world of communication, as they transmit telecommunications, give us geographical positioning information and provide us with weather forecasts, to name but a few examples. They are also indispensable to understanding the physical universe and for modelling climatic change through astronomical observation and the study of the Earth.

Insurers have played a key role transforming these technological advances into new commercial ventures. They have supported space exploration by providing coverage for the most cutting edge projects, insuring spacecrafts from their design phase up to their launch, protecting satellite devices in orbit and ensuring the safety of installations on Earth. Insurers, therefore, are integral to the operational life cycle of satellites, typically becoming involved from the earliest stages of planning.

Through this key role, insurers have been actively involved in the development of the aerospace industry. Among the small community of insurers involved in space risks, SpaceCo, the dedicated subsidiary of Allianz Global Corporate & Specialty (AGCS), is one of the leaders and has been supporting its clients for more than 30 years. Its extensive experience and expertise lies in analyzing challenges of the sector. Space crowding, the extreme and stringent conditions of the environment, the difficulties surrounding working on spacecrafts in orbit, and the impact of space debris falling to Earth, are just some of the many challenges within the space industry that present concerns for our AGCS specialists.

Our aim is to draw attention to such newly emerging risks and to help our clients better anticipate and mitigate any consequences to their business.



**Thierry Colliot**  
SpaceCo - Allianz Global Corporate & Specialty  
Paris, June 2012

Our Specialists



**Thierry Colliot**  
Managing Director of SpaceCo and Head of Aviation and Space Underwriting at AGCS France

Thierry Colliot, who is based in Paris and holds degrees in economics, political science and law, has more than 20 years of experience in project finance, insurance and alternative risk transfer. He took on his current roles with SpaceCo and AGCS in 2008.



**Ludovic Arnoux**  
Aviation and Space Underwriter at AGCS France

Ludovic Arnoux joined SpaceCo in 2002 as a Space Underwriter, after working for nine years as a specialist engineer and Satellite Integration Manager for Arianespace. He became Aviation and Space Technical Referral at AGCS in 2010. He holds a postgraduate degree in Engineering and is based in Paris.



**James Jones**  
Third-party Liability Risk Underwriter at AGCS UK

James Jones has 25 years of experience in aviation and aerospace insurance. Based in London, he is AGCS's Aerospace Underwriter with responsibility for Space Third-Party Liability, and was the lead insurer for the MIR Space Station deorbiting project.



**Erick Morazin**  
Director of Global Accounts at Allianz Global Assistance

Erick Morazin is a specialist in travel insurance with more than 20 years experience in this industry. He joined AGCS's sister company, Allianz Global Assistance, in 2005 and is based in Paris.

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## Executive Summary

### Satellites and space debris – a rising population

- There are 370 active satellites in Geostationary Earth Orbits (GEOs) and 400 active satellites in Low Earth Orbits (LEOs). While LEO satellites are mostly for Earth observation and commonly run by militaries or governments, GEO satellites are operated by commercial telecommunications providers.
- The space around our planet is becoming increasingly congested. Since the beginning of space travel in 1957, objects left behind by humans continue to collide with each other and create fragments. Although it is now standard practice to deorbit all satellites at the end of their lifespan, thousands of objects remain floating in orbit.
- Some 16,000 objects larger than 10 cm cataloged in 2010 consist of fragmentation debris (57 percent), spent satellites (14 percent), satellites in operation (7 percent), rocket parts (11 percent) and other mission related debris (11 percent). In addition to these cataloged objects, there are millions uncataloged.
- With the rising amount of space debris and major uncertainties involved, assessing collision risks is difficult.

### Space debris and solar storms – serious risks for satellites

- Space debris fragments pose a serious collision risk to space missions and endanger operating satellites, particularly in the more densely populated LEO orbits. The current space debris situation has become irreversible, according to the Kessler Syndrome, which claims that the amount of debris is so high that atmospheric drag is not enough to burn up all the floating objects. In fact, debris amounts are increasing as objects continuously collide, producing more and more fragments.
- Beyond the collision risk of space debris, satellites can also be damaged by solar storms. These coronal mass ejections release huge amounts of radiation, which disrupts radio transmissions. This affects satellites and, in extreme cases, can disrupt their functionality. For example, the nine-month total loss of Galaxy 15 in 2010 was attributed to a high-energy solar flare. To protect against solar radiation, special designs, materials and redundancies are in place, so that critical electronic components are properly isolated and protected from a large and sudden influx of high-voltage solar particles.
- While the deorbiting of satellites often attracts a lot of public attention, the risk of space hardware falling back to Earth is very low, as most space debris burns up in the atmosphere and rains small harmless pieces over oceans.

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### High risks, high costs – insurance of satellites

- First introduced in 1965 with the launch of Intelsat 1, space insurance has been around for 47 years. Space is a high-tech industry with high levels of risk, which requires specialty insurance accidental damage and third-party liability.
- A satellite in LEO has an average insured value of \$40 million with an operational lifespan of five years, while those in GEO are valued close to \$200 million and operate up to 15 years.
- Fewer than 30 LEO satellites and less than 200 GEO satellites, combined worth more than \$20 billion, were insured in 2011. Satellites are usually insured against damage under “all risk except” type policies. Some policies also compensate for loss of revenues.
- Third-party liability regulations are governed by individual launching states and are based on the framework of two United Nations treaties.
- Insurance premiums for space risks were close to \$800 million with losses totalling approximately \$600 million in 2011.
- Future challenge for insurers includes rising launch values, a decreasing premium pool and increasing risk exposures.

## Introduction

With six failures in the last year, Russia’s space industry has had a run of bad luck. Its most recent disaster, the loss of the Meridian 5 military communications satellite, did not go unnoticed. Owing to a fault in its Soyuz carrier rocket, the satellite crashed in Siberia on December 23, 2011, not far from populated areas. But such events are extremely rare – the risk of a piece of space hardware falling back to the ground and causing extensive damage remains very low; chances of a collision between Earth and a large meteorite are greater. Most space debris, whether natural or man-made, burns up in the atmosphere and rains small, harmless pieces over the oceans, which cover two-thirds of the Earth’s surface.

Nonetheless, the Meridian 5 event is a reminder that space related risks, whether the result of human activity or not, can have harmful and even catastrophic consequences, despite constant efforts to mitigate and protect against them.

Other recent events have also brought such risks to the public’s attention. Last year, the American satellite UARS plunged into the Pacific off the Canadian coast after a 20-year mission to study the Earth’s atmosphere. The satellite’s uncontrolled spiraling re-entry made the point of impact difficult to predict. This was also the case with Russia’s Phobos-Grunt probe, whose re-entry path was only estimated at a late stage, as well as with Germany’s ROSAT astronomy satellite, whose residual debris fell into the Bay of Bengal. Such predictions are difficult because of the uncertainties associated with trajectory measurements made from the ground, combined with very high orbital velocities and many other unknowns that still persist, particularly in atmospheric density models.

Naturally, damages can ultimately be covered by insurance. This report examines space-related risks, their consequences and the extent to which they can be prevented and insured against.



A communications satellite beaming a signal down to Earth. Satellites have become essential tools for our interconnected world.



## Collision risks on the rise

**The space around our planet is becoming increasingly congested. Since the beginning of space exploration in 1957, mankind has been leaving behind debris that continuously collides, producing thousands of fragments. The amount of fragmented debris in Low Earth Orbits, or LEOs, is so dense that atmospheric erosion alone cannot solve the problem of overcrowding. For this reason, standard practice is now to deorbit all satellites at the end of their lives. But thousands of objects remain in these orbits, where they pose a serious collision threat to space missions.**

In 2010, and again in 2011, the crew of the International Space Station (ISS) was forced to evacuate on short-notice when a piece of space debris came perilously close to colliding with the space station. On both occasions, the object was detected too late for the crew to perform an avoidance maneuver. The space station is in a LEO, an orbit around our planet just above the atmosphere (see diagram on page 10). At altitudes between 300 km and 2,000 km, the risk of collision is mostly due to man-made debris, particularly defunct satellites and decommissioned launch vehicles in upper LEO levels, which have not been deorbited. More than 12,000 debris objects measuring at least 10 cm across have been cataloged in this part of space. The number of smaller items is even greater but they are too small to observe or track, making them all the more dangerous.

**“The space debris situation has become irreversible. Risks are actually increasing as objects collide and produce fragments.”**

**Thierry Colliot**  
Managing Director, SpaceCo and  
Head of Aviation and Space  
Underwriting, AGCS France

## Damage by debris

Objects in orbit travel at very high velocities – in the order of 10 kilometers per second. The kinetic energy generated is enormous and increases with the object’s mass. Its size, specifically its cross-section, determines the wider extent of damage on impact. Objects larger than 10 cm across can cause critical or catastrophic damage, as illustrated by the collision between the defunct Kosmos 2251 satellite and the operational Iridium 33 satellite in 2009. All such objects are tracked from the ground and cataloged by the North American Aerospace Defense Command (NORAD) as well as by various space agencies, including France’s Centre National des Etudes Spatiales (CNES).

Objects between 1 cm to 10 cm across are no less dangerous. In fact, they are arguably more so, since there are many more of them, are too small to track and have enough mass to cause serious damage. Estimates place the number of these “small” objects at around 300,000, compared with 16,000 cataloged items of “large” debris measuring more than 10 cm. These objects may be categorized as small but they can cause the total loss of an operational satellite.

The number of objects smaller than 1 cm is believed to be about 35 million (Source: CNES). These cause constant erosion and can also perforate surfaces with consequences, depending on what critical part of the satellite they hit.

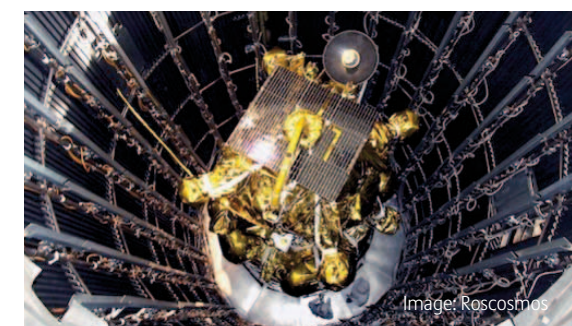
“The space debris situation has become irreversible,” says Thierry Colliot, Managing Director of SpaceCo. “The population of objects is now so high that it won’t decay on its own due to atmospheric drag. Instead, it’s actually increasing as objects collide and produce fragments, which in turn collide in a runaway chain reaction called the Kessler Syndrome.” The collision in February 2009 between Russia’s Kosmos 2251 satellite (out of service but not deorbited) and Iridium 33, an operational satellite in the American Iridium constellation, considerably contributed to the mass of objects in LEOs. Indeed, the cloud of debris it created continues to disperse around our planet to this day.

## Geostationary risks under close watch

The situation is less serious in Geostationary Earth Orbits, or GEOs – 35,786 km above the Equator along the equatorial plane – though this is where most damaged satellites are found. The number of inactive objects in GEOs is estimated at about 1,000, while approximately 300 active satellites exist in this part of space. Therefore, the risk of collision is lower, owing to the low level of congestion. Furthermore, each operator ensures its GEO satellites are correctly positioned within their respective orbital slots. Satellites in the geostationary arc are maintained in the same orbit and at a constant velocity. “A collision risk arises if an operator loses control of a satellite or if a satellite is no longer controlled because it has reached the end of its life,” explains Thierry Colliot. “In this case, its position naturally begins to drift due to the irregularities in Earth’s gravitational field combined with other perturbing forces, primarily solar winds and the gravitational attraction of the sun and moon.”

## Systematic deorbiting of satellites at end of life

End-of-life deorbiting has become a key issue for all geostationary operators. It is in their best interests to regulate traffic in this part of space and to help ensure that continued use of telecommunication satellite resources is sustainable. The deorbiting maneuver involves raising a satellite to a new “graveyard” orbit, 300 km above GEO. However, this transfer requires fuel and, as a result, effectively shortens the satellite’s operational lifespan. Nonetheless, it is now standard practice and may become law in the future, with sanctions for operators who fail to comply. Geostationary operators now also have a way to identify debris, thanks to a recently established collaborative orbital database, which



The risk of an uncontrolled space object falling back to Earth is highest just after launch. For example, on January 16, 2012, fragments of Russia’s Phobos-Grunt probe (shown above in the launch ferry) rained down into the Pacific after its Mars mission failed shortly after launch on November 9, 2011.

## Envisat increases debris threat

On April 8, 2012, the European Space Agency (ESA) lost contact with Envisat, an 8-ton Earth observation satellite, which flies in a sun-synchronous polar orbit at an elevation of 790 km and a 98.55 deg. inclination. Following the loss of communications with Envisat, attempts have continued to re-contact the satellite, though so far, without success.

Investigations have been performed to interpret status information collected about the spacecraft. Results show that the satellite is on its nominal orbit and in one piece, but in an unexpected orientation.

According to space debris experts, Envisat represents a major orbital debris threat. If the satellite remains inert, it will take up to 150 years for its orbit debris to decay naturally, given its orbit and its area-to-mass ratio. The ESA notes that there is a 30 percent chance of a collision between Envisat and orbital debris over this time-span, without the possibility of performing collision avoidance maneuvers. Were a collision to take place, it would create a large debris field depending on the characteristics of the collision, and would increase the threat of debris collision with other satellites significantly.

Envisat is considered the world’s most complex Earth observation satellite. It was launched in 2002 with a planned life of five years but has remained operational for more than 10 years. It weighs about 8,000 kg, and is approximately 9 m long and 5 m wide (without the solar panel).

predicts “conjunctions” or collision risks, and issues alerts when necessary. Orbital data are constantly updated by various operators involved in this initiative.

End-of-life deorbiting is also the rule in LEO. Here, all satellites must be disposed of within 25 years of mission’s end. This is achieved by a destructive re-entry into Earth’s atmosphere. Most of the structure burns up owing to drag and the intense heat it generates. The remaining unburned fragments typically fall into uninhabited parts of the world, such as the South Pacific. The 140-ton Russian MIR Space Station was destroyed in this way after a series of deorbiting maneuvers in March 2001, which dispersed the debris over the ocean. In 2008 and 2011, the ESA demonstrated its prowess in controlled destructive re-entries with the successive deorbiting of the ATV-1 and ATV-2 automated transfer vehicles, after they had completed their supply missions to the ISS.

Actively removing debris

Besides the systematic deorbiting of new satellites at the end of their lives, approximately 10 major debris objects, selected on the basis of their mass, altitude and orbit inclination, would need to be eliminated each year to reduce the debris population to a stable level. These estimates are based on studies by NASA, ESA and CNES, the French space agency. Several solutions have been put forward. One of the most widely advanced is the destruction of debris using a laser. However, the high power levels needed and the logistics of transporting such a tool into space make this concept challenging. Another possibility would be to use a docking satellite to latch onto objects and force them into destructive re-entry. Because of the costs involved, this method would be employed for only the largest systems.

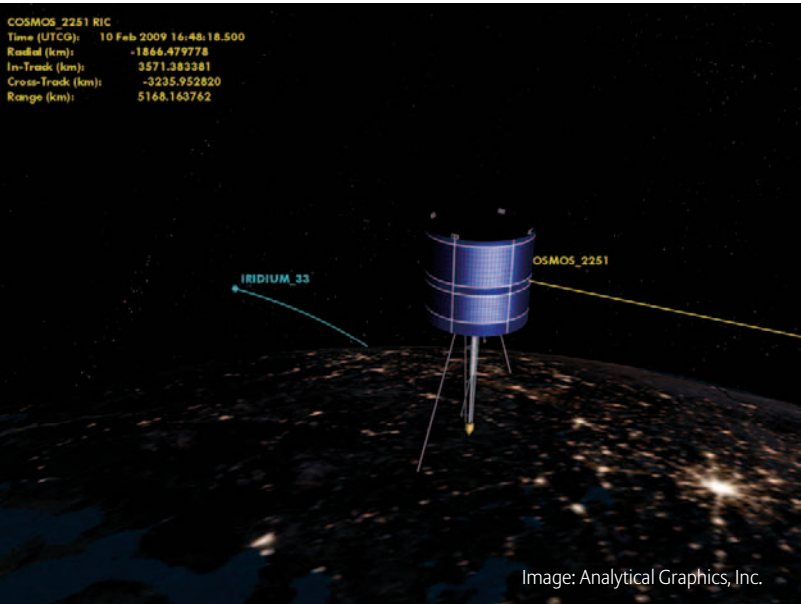
Space tethers are also being considered. These are electrodynamic cables several kilometers in length, which would be deployed from the satellite at the end of its life. As the cable moves through Earth’s magnetic field, the current generated creates a propulsive force, which could deorbit the entire system. This technique would have little impact on satellite design, owing to its low mass and simple mechanism, and would not require any additional energy. However, at this stage, it could only be used for small structures, such as nanosatellites. Lastly, Gossamer sails, made of thin lightweight material, are particularly well-suited for deployment in orbit and would effectively increase the surface area exposed to drag in LEOs, causing the satellite to burn up more quickly.

Ways to protect satellites

To avoid collisions or to mitigate their effects, various measures are employed. If the risk of collision is above a certain alert threshold and specified by the mission operator, avoidance maneuvers are initiated. However, since such objects travel at extremely high velocities and at similar altitudes, their trajectories cannot always be predicted reliably or early enough to allow avoidance maneuvers to be made. In the case of minor collisions, damage can be limited by protecting satellite structures with certain materials or impact absorption systems.

Here, a dynamic structure combining light-weight, yet sturdy beams and panels, play an integral role in the skeleton of a satellite. Insulation layers made of materials such as aluminum, Kapton or other polymers, are critical in providing a protective multi-layer skin for a satellite. More robust shields are another solution under consideration, but they are problematic because they add to the satellite’s launch mass. Some research is focusing on the reaction of satellite subsystems to minor collision. This effort is being made to improve the understanding of interactions within a satellite’s structure.

The concentration of space debris in different segments of near-Earth space are systematically taken into account when missions are planned. Local avoidance maneuvers are necessary when a trajectory cannot be altered to avoid high-risk areas. Such maneuvers are routine practice on the ISS, which operates in a very low orbit where debris concentration is highest. For each new space mission, risks are assessed on the basis of current observations and measurements, ground radar data and theoretical models produced by space agencies.



In February 2009, the first ever collision between two intact satellites – Russia’s Kosmos 2251 (out of service but not deorbited) and the American Iridium 33 (in operational service) – created more than 2,000 debris pieces in LEO. The highest average probability of a collision is at altitudes between 750 km and 900 km, and at particular orbital inclinations. Satellites in low-altitude orbits cover all Earth latitudes, since their trajectories are designed to provide coverage of specific areas. And, over the course of several revolutions, they sweep across most of the planet’s surface.

Faced with increasing threats of space debris, NASA, ESA, CNES, the German Center for Air and Space Travel (Deutschen Zentrum für Luft- und Raumfahrt, or DLR) and other space agencies are very much involved in developing technologies for a future space debris clean-up mission. The agencies are collaborating with numerous companies worldwide, such as ASTRIUM, Bertin Technologies, Thales Alenia Space, GMV, MacDonald, Dettwiler and Associates (MDA), Star Technology and Research, and Vivisat.

Debris removal technology

In order to solve this problem, a number of active debris removal concepts have been proposed, such as electromagnetic methods, momentum exchange methods, remote methods, capture methods and modification of material properties or change-of-material state. An example of a debris deorbiting project is the DEOS (Deutsche Orbitale Servicing Mission), an undertaking of DLR. The DEOS will focus on guidance and navigation, capturing cooperative and non-cooperative satellites, performing orbital maneuvers with conjoined or “coupled” systems, and the controlled deorbiting of such systems. The US-based company Star Technology and Research (STAR) is also developing deorbiting technology, namely the spacecraft vehicle EDDE, or ElectroDynamic Debris Eliminator. The project is being supported by NASA, which recently awarded STAR with nearly \$2 million for the venture. EDDE would

sail to a defunct satellite using a long, solar-powered tether line. EDDE then ejects a large net to swoop up the satellite, before descending with it into a lower orbit.

One alternative approach to decreasing space debris, is to extend the life of existing satellites that do not have enough fuel to continue their operations. The Mission Extension Vehicle (MEV) is a spacecraft proposed by ViviSat, a venture undertaking by aerospace firms U.S. Space and ATK. As its name suggests, the MEV is a small satellite-refueling vehicle capable of docking with virtually any satellite in a geosynchronous orbit (an orbital period that matches the rotation rate of the Earth), while avoiding any operation interruptions. The company MDA has also announced its plans to enter the space servicing business sector with a refueling craft. Its Space Infrastructure Servicing (SIS) vehicle is tentatively set to launch in 2015, though this plan is currently on hold.

The MEV and SIS use different approaches to completing their missions. Just as the SIS, the MEV docks with a satellite, but it does not transfer fuel. It instead makes use of its own thrusters to maintain the satellite’s orbiting altitude.

The international space community is actively engaged with the insurance sector in tackling these difficult challenges, though the technology required to deal with threats of space debris is still being developed.



Very low risk of collision on re-entry

Controlled destructive re-entries pose a very low collision risk. When an object is deorbited, little of it survives the journey back through the Earth’s atmosphere. Depending on the satellite’s construction and its re-entry trajectory, it is estimated that between 15 percent to 40 percent of its mass will impact the surface, usually in the ocean. “The risk of an uncontrolled space object falling back to Earth is also very low,” says Ludovic Arnoux. This is because such objects typically follow a spiraling trajectory, causing them to burn up slowly and almost completely in the upper layers of the atmosphere. The highest risk is a fault at launch. In 1996, a Chinese Long March 3B carrier rocket failed at launch, veered off course and exploded on the ground, causing extensive damage and, tragically, dozens of fatalities. The accident was the result of a failure in the rocket’s guidance system. However, such events are extremely rare today, as risks are usually controlled by stringent safety and prevention measures at the launch site.



As of December 31, 2011, The Meteoritical Society has classified a total of 41,600 known meteorites.

Meteorites: 70 asteroids threaten our planet

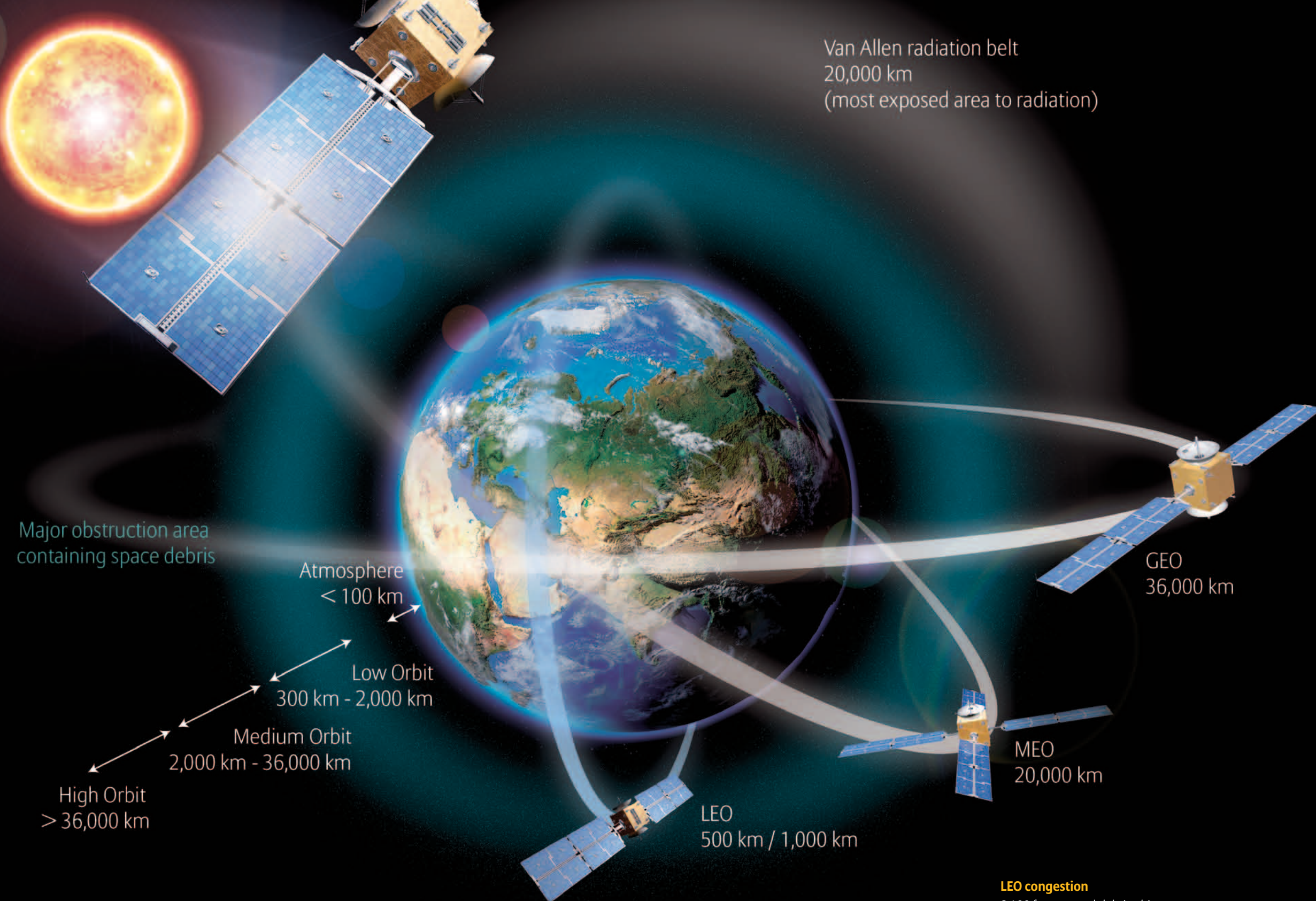
Several thousand meteorites weighing at least 1 kg fall to Earth each year, mostly over the oceans. These rocky or ferrous fragments typically come from asteroids, or more rarely, from the moon or Mars. Many meteorites have been recovered. Of these, about two-thirds were found in Antarctica. The largest ever observed, fell in the Sikhote-Alin Mountains of Russia on February 12, 1947. Estimated at more than 100 tons, it exploded into pieces, which themselves broke into smaller fragments due to the mechanical and thermal effects of friction on particles in the atmosphere. The risk of a large meteorite reaching Earth’s surface is real, but very low. The number of celestial bodies that, because of the high amount of kinetic energy involved, could potentially cause a major disaster is estimated at 70. Such strikes are difficult to quantify, both in terms of the likelihood of their occurrence and the severity of their consequences.

No data are available on the frequency of such risks, nor are any dates predicted. It is equally difficult to predict the potential damage that could result from a minor collision, such as a crater or a debris plume rising from the Earth’s crust. It is similarly difficult to predict the far more dangerous consequences of a tidal wave or tsunami generated by a meteor strike, which have the potential to carry a quarter of the energy released upon impact onto coastlines. ESA, in partnership with other research agencies, closely evaluates these risks through its Space Situational Awareness (SSA) program. This team is dedicated to monitoring potential asteroid and Near-Earth Object (NEO) collisions, and is working specifically on developing a system that measures and models such risks. This includes the accurate predictions of trajectories and an issue alert system. The asteroid Apophis – weighing an impressive 27 million tons – poses the greatest known threat to date, although the probability that it will strike Earth is estimated at one in 250,000. Apophis will cross Earth’s orbit in about 2030.

“The risk of an uncontrolled space object falling back to Earth is very low.”

Ludovic Arnoux  
Aviation and Space Underwriter,  
AGCS France





Debris Key Figures

- The 16,000 man-made objects consist of:
- 62 % fragmentation debris
  - 16 % spent satellites
  - 6 % operational satellites
  - 8 % rocket parts
  - 8 % other mission-related debris

- Distribution of space debris in different orbits:
- 12,000 cataloged in LEO
  - 1,000 cataloged in GEO
  - 100 cataloged in semi-synchronous orbits
  - More than 2,200 objects between 10 cm and 1 m uncataloged in GEO
  - Hundreds of uncataloged objects between LEO and GEO

- LEO congestion**
- 8,100 fragmented debris objects
  - 1,600 spent satellites
  - 400 operational satellites
  - 900 rocket parts
  - 1,000 other mission-related debris objects

- GEO congestion**
- 480 spent satellites
  - 370 operational satellites
  - 190 rocket parts
  - Estimated 60 mission-related debris objects
  - Several fragmented debris objects

Glossary

- Cataloged objects:** Space debris larger than 10 cm across that have been identified and given a unique international identification number.
- Deorbiting maneuver:** Operation to return LEO satellites to Earth, or to raise GEO satellites to a higher "graveyard" orbit.
- Geostationary Earth Orbit (GEO):** A circular geosynchronous orbit at an altitude of about 36,000 km above Earth's equator. A satellite in such an orbit has the same angular velocity as Earth, moves in the same direction and, thus, appears motionless.
- Geostationary Transfer Orbit (GTO):** A highly elliptical orbit at an altitude between 200 km and 36,000 km; so called because satellites are placed there before being transferred to GEOs.
- Low-Earth Orbit (LEO):** Circular orbits at altitudes between 300 km and 2,000 km. A satellite in such an orbit will circle Earth several times each day.
- Medium Earth Orbit (MEO):** Region of space around the Earth above LEO and below GEO, sometimes called Intermediate Circular Orbit (ICO).
- Solar flare:** Caused by the sun and observed as a sudden release of coronal mass (plasma) and intense radiation. On Earth, solar flares cause geomagnetic storms, solar radiation storms and disruption to radio communications.
- Space debris:** Man-made objects orbiting Earth that no longer have a useful purpose.



## Solar flares: major risks for satellites

**Geomagnetic storms caused by solar flares produce the spectacular Aurora Borealis, or Northern lights, but also disrupt communication transmissions in space and on the ground.**

On March 13, 1989, a solar flare tripped the circuit breakers for Quebec, Canada, which protect the electrical power grid, and caused a nine-hour blackout. Transmission equipment elsewhere on the continent was also seriously damaged. It was the most severe geomagnetic storm of the last half-century. What would happen on Earth and in space if such an event occurred today? And how could we best mitigate its effects and recover?

### Known incidents in orbit

Today's satellites are designed to withstand solar flares up to a certain point. Unpredictable and difficult to define, these coronal mass ejections release huge amounts of radiation, which disrupts radio transmissions. This is what affects satellites and, in extreme cases, results in the loss of their functionality. Even though better understood today and anticipated in the designs of space missions, the erosion of a satellite's solar arrays is a constant threat that significantly shortens its life. A major solar flare could cause the total loss of control of one or more satellites. This was the case with the geostationary satellite Galaxy 15, which remained out of control for almost nine months in 2010 after absorbing the impact of a high-energy solar flare.



Image: Shutterstock

"The risks associated with solar flares are closely monitored, since they could affect several satellites at the same time," says Thierry Colliot. "However, the probability of a major solar flare erupting, such as the one in 1859, remains low." It is often difficult to attribute a problem to this type of radiation event, rather than to a flaw elsewhere in the system. About 40 satellites are believed to have suffered critical or catastrophic mishaps as a direct result of a geomagnetic storm.

### Protection against solar radiation

These phenomena, while exceptional, are nonetheless a cause for concern. They can also have major effects on electrical supply grids, telecommunication networks, weather stations and other facilities on the ground. Any such failure could spark a chain reaction and cause other systems to fail and potentially lead to serious public health, social and economic problems. To protect against solar radiation, satellites retract their solar panels when passing through zones with high solar activity. To mitigate the risks associated with solar storms, critical satellite components are protected and isolated from an influx of high-voltage solar energy by special materials and designs.



Image: Orbital Science

The total loss of control of the Galaxy 15 geostationary satellite (pictured above before its launch) lasted nearly nine months in 2010, and was attributed to a high-energy solar flare. During this time, the satellite drifted along the geostationary arc, while operational satellites were carefully maneuvered to avoid a collision.



Image: Shutterstock

Aurora Borealis, or the Northern lights: While such radiation is the result of solar activity, it is not in step with the sun's 11-year cycle and often occurs randomly.

## South Atlantic Anomaly

Apart from solar flares, solar radiation is strongest in medium-Earth orbits, where it comes up against the Earth's magnetic field and becomes part of the Van Allen radiation belt. However, this phenomenon also extends to one particular Low Earth Orbit above the South Atlantic. Known as the South Atlantic Anomaly (SAA), it is the "Bermuda Triangle" of satellite operations. It covers a wide region in which satellites frequently encounter radiation-related incidents, though they are generally not serious.





The International Space Station's altitude varies by as much as 100 m per day, depending on the solar cycle.

“The latest satellites are designed to withstand extreme conditions including solar radiation, heat, pressure and orbital drift.”

**Thierry Colliot**  
Managing Director - SpaceCo and  
Head of Aviation and Space  
Underwriting, AGCS France

### A harsh environment

Satellites must be able to withstand extreme temperatures and counter orbital drift caused by the constant expansion and contraction of the Earth’s atmosphere in lower orbits.

During a launch phase, carrier rockets and satellites are subject to huge variations in temperature and pressure. Once in orbit, satellites and their internal subsystems are exposed to temperature extremes. Exposure to the sun varies and depends on the satellite’s orientation in reference to the sun. Also, the proximity of heat-sensitive components to satellite parts that generate high temperatures plays a critical role. To regulate temperatures inside a satellite, various inward and outward radiating techniques are employed, depending on the requirements of each subsystem. In addition, the satellite’s external housing is partially insulated with special protective materials.

Satellites in LEO are subject to the perpetual expansion and contraction of the atmosphere, caused by temperature variations linked to the solar cycle. During solar maxima, or periods of greatest solar activity, the atmosphere expands to reach higher altitudes. As a result, satellites encounter varying degrees of residual air drag, which has a braking effect. Satellites must, therefore, perform maneuvers to maintain their designated coordinates, which requires fuel. For this reason, it is important to understand thermal cycles and to keep track of how they vary to maximize a satellite’s operational lifespan. Indeed, this is a key objective of current efforts to model the space environment.

### High risks, high cover

Space is a high-tech industry with high levels of risk that requires specialty insurance to cover accidental damage and third-party liability. Insurance solutions are evolving rapidly in line with the development of the space market and the risks involved, as well as with changes to national and international regulations.

The number of active satellites in LEO and GEO is about the same, currently between 370 and 400 in each, yet only 21 satellites in LEO were covered by an insurance policy in 2011, compared with 167 satellites in GEO. “Most insured satellites are in GEO because this is where commercial telecom missions operate,” explains Ludovic Arnoux, Aviation and Space Underwriter at AGCS France. “LEOs are chiefly used by Earth Observation (EO) satellites as part of institutional missions, which are insured by governments. However, a growing number of companies are operating EO satellites to meet specific demands. For example, EADS Astrium, through its Spot Image subsidiary, provides satellite imagery for Google, while other companies supply imagery to governments for rapid land-use mapping and other applications. EADS Astrium has also rounded out its product offering with a whole series of smaller satellites (weighing between 100 kg and 1 ton) to meet demands in new countries with limited resources, like Brazil and Vietnam.”

#### Accidental damage: underwriting satellite performance

In LEOs, the average insured satellite has a value of \$40 million and an operational lifespan of five years. The value of all of these satellites is, however, directly related to its mission, its technology and its size. Big civil or military observation satellites, such as SPOT and the Helios family of satellites, or the recent Pléiades satellite, may have a value much higher than average. In GEOs, satellites are worth an average of \$200 million and operate for up to 15 years. They are insured against damage under “all risks except” type policies, which guarantee their ability to achieve their missions.

When a contract is taken out, the satellite and the services it will deliver are studied in detail, including the ability of its transponders to provide the necessary geographic coverage, its built-in redundancies to cope with component failures, and the various failure mode analyses. Should an incident occur that reduces the satellite’s operational capacity, insurance liability is assessed in proportion to the demonstrated level of loss. If revenues are generated by the degraded satellite after the claim is settled, a proportion may be repayable to the insurers under a “salvage” clause.

### Half a century of history

Space insurance was introduced in 1965 with the launch of Intelsat 1, the first-ever commercial telecommunications satellite, known as Early Bird, and insured for risks on the ground. Decommissioned in 1969, this pioneer of geostationary space missions is now part of the space debris population.

Space insurance took off in the mid-1970s with the first policies to cover all potential damage to a satellite, through to the end of its life. The market became more specialized in the 1980s and reached maturity in the 1990s. Since then, it has continued to develop as the space industry evolves. “Today, the number of insured satellites in orbit stands at about 180, with a total value of \$22 billion,” says Thierry Colliot. “Since 2000, between 20 and 25 new commercial satellites with insurance are launched each year.”

“In certain cases, clients also want to protect against the financial consequences of a loss of satellite communications,” says Ludovic Arnoux. “Through SpaceCo, AGCS proposes policies that compensate for the loss of revenues or contracts in the event one or more satellites is damaged.”

Assessing collision risks, which are rising due to the ever-increasing amount of space debris, is problematic. Major uncertainties exist, particularly in obtaining accurate measurements and in the inherent unpredictable nature of such risks. In this light, AGCS and SpaceCo work closely with their clients to raise awareness about prevention and security measures in the short- and long-term.



Most satellites launched from Kourou in French Guiana have primary insurance coverage from AGCS France.

Third-party liability:  
varying regulations around the world

With regard to third-party liability insurance, regulations are governed by each individual launching state. “Regulations are based on two United Nations treaties,” says James Jones, Third-party Liability Risk Underwriter at AGCS in the UK. “The Outer Space Treaty of 1967 established that launching states bear international responsibility for any damage caused by their space activities or the activities of companies under their jurisdiction. The Space Liability Convention of 1971 further expanded on the liability rules set forth in the Outer Space Treaty.”

In France – a main launching state – third-party liability insurance is mandatory for all operators, in accordance with Statute no. 2008-518 (June 3, 2008). Before this legislation, the French government underwrote all potential incidences relating to satellites launched from French soil, regardless of which nation built or operated it. It also covered potential damages caused by French satellites in other countries. “Since the implementation of the Space Law, French space operators and other countries operating from French soil, must have third-party liability insurance with a current limit of €61 million to protect against damages caused in the air or on the ground,” notes Ludovic Arnoux. “The limit ranges between €50 million and €70 million, and is eventually fixed through a formal license provided by the French state (mandatory under the Space Law). For amounts above that, the French state intervenes. In practice, the launch operator takes out a third-party liability policy for the launch phase and early in-orbit operations (one year), which it also extends to its customers, who own and operate the satellites.”

Maximum liabilities vary from one country to another. “While mandatory insurance is typically taken out for a duration of one year after launch, the UK government requires operators to continue to insure for third-party liability in orbit to a level of at least £100 million,” says James Jones. “In the United States, LEO operators must have liability insurance of \$500 million whenever they launch a satellite, which will eventually re-enter the atmosphere. It’s a way to take into account the growing congestion in space and the associated higher risk levels. Ideally, we’d like governments to impose similar rules for GEO operators in the future.”



A European satellite successfully launched by Arianespace in September 2011 did not reach its final orbit due to a technical failure. Instead, it was left stranded in a highly elliptical transfer orbit with an altitude ranging from 200 km to 36,000 km. It will re-enter the atmosphere in about 20 years. Cataloged and tracked by the NORAD network, it poses a potential risk of damage to other aerospace users. Third-party liability arising from such damage is underwritten by Allianz Global Corporate & Specialty.

“Space tourism will soon be a reality.”

**Erick Morazin**  
Director of Global  
Accounts at Allianz  
Global Assistance

Allianz & Space Tourism

“Space tourism will soon be a reality,” says Erick Morazin, Director of Global Accounts at Allianz Global Assistance. “By 2015, the potential market could be as much as 300,000 voyages per year (Source: International Space Transport Association), and we’ll be making our own contribution to these first suborbital flights.” Allianz Global Assistance is designing a contract for passengers with companies like Virgin Galactic – a new type of carrier which has already sold 450 tickets to space. Such an assistance contract offers peace of mind to future astronauts through a number of travel insurance guarantees, from health and medical coverage to support in the event of travel delays or cancellations.

About Allianz Global Corporate & Specialty

Allianz Global Corporate & Specialty (AGCS) is Allianz SE’s dedicated brand for corporate and specialty insurance customers. AGCS provides insurance and risk management consultancy across the whole spectrum of Marine, Aviation and corporate business, including Energy, Engineering, Financial Lines (incl. D&O), Liability and Property insurance, including International Insurance Programs.

Allianz Global Corporate & Specialty operates in more than 150 countries through the Allianz Group network and through network partners. It employs more than 3,400 people and provides insurance solutions to more than half of the Fortune Global 500 companies, writing a total of €4.9 billion gross premium worldwide in 2011.

About SpaceCo

SpaceCo, an Allianz Global Corporate & Specialty subsidiary, is a leader in the satellite insurance field. SpaceCo provides expertise in fields such as launch operations, orbit operations and deorbiting maneuvers to clients, who represent launch agencies, satellite operators and manufacturers, space industry suppliers and end-users.

The company has continued to develop since its beginnings as a pioneer in space insurance: providing simple launch insurance in the early years, it has developed a portfolio of services ranging from contract analysis and advice, through insurance program design and implementation to alternative risk transfer concepts and claim negotiation.

SpaceCo offers clients, through its association with AGCS, global reach and financial strength, while dedicating a small team that provides focused and specialized services. SpaceCo had Gross Written Premiums of \$116 million in 2011.

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