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RISK MANAGEMENT AND THE INSURANCE OF ON-ORBIT SERVICING. THE INSURANCE INDUSTRY AS A DRIVER OF RISKY SPACE INNOVATION.

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Abstract

These days we face the massive production of space debris, the rapid shrinking of orbital slots, as well as changes in the space business models requiring an ever more agile approach. All of these are not, however, solely within the circle of interest of the satellite operators. Just as involved are the regulators and public actors. On-orbit servicing, an exciting idea that has been present in the space industry for a long time, has a chance to become one of the tools for achieving the objectives of sustainable space development. This is also related to the risk management of such ventures and to one of its tools, namely insurance. It is well known that insurers have accompanied space ventures since the very beginning. Their special role is, however, not limited to supporting financial schemes. There can be no doubt that the insurance industry has a vital role to play in the risk management processes, as it initially developed the risk management concepts and tools that were subsequently applied in all the industries. This is also the case with on-orbit servicing. On-orbit services will need a protection with respect to both property damage as well as third party liability and other financial losses, but on the other hand, on-orbit servicing creates not only a challenge for insurers to cover new and risky activities, but also has the potential to become a new driver on the volatile space insurance market. Can insurance become such a driver of on-orbit servicing ?

Keywords: space insurance, risk management, OOS, active debris removal

Acronyms/Abbreviations

Active Debris Removal [ADR]
Business Interruption [BI]
Code of Federal Regulations [CFR]
On-orbit-servicing [OOS]
Property Damage [PD]
Total Constructive Loss [TCL]

1. Introduction

OOS seems to be a subject of fascination for all space enthusiasts, but it also, welcomed by space industry as well as space-faring countries. It looks like it has a potential of resolving at least some of the many sensitive issues. Massive production of space debris, rapid shrinking of the orbital slots as well as changes in the space business models requiring an ever more agile approach, cause that OOS is no longer an extravagant phantasy of the rich satellite operators. We can also expect that the regulators, the policy makers, and all those who see the necessity of achieving the sustainable space development become deeply involved. This is also a moment when we can start about safety of OOS ventures and the risk management thereof, including insurance. Though insurance is one of the oldest and most effective method of risk management, it is also known as not particularly innovative. Also in terms of space adventures, risk aversion and need of stability causes, that some insurers withdraw temporarily from supporting satellite business. Limited possibilities of insuring new types of space exploration may in turn hinder the financing of space missions.

Such contrasts when confronting OOS and insurance lead the author to the question about the role of the space insurance in the OOS missions and whether and how they can support each other in sustainable development.

2. Risk management of the OOS ventures

The OOS can be explained as "*on-orbit activities conducted by a space vehicle that performs an up-close* *inspection of, or results in intentional and beneficial changes to, another resident space object*" [1] or as "*the on-orbit alteration of a satellite or its orbit after its initial launch, using another spacecraft to conduct these alterations. Examples include relocating the satellite to a new orbit, refuelling, repairing broken parts, replacing parts, deploying systems that failed to deploy after launch, and cleaning components*."[2] Analysing OOS step by step in terms of the mission phases, it includes launching a servicing spacecraft, orbiting (orbital manoeuvring), getting in touch (or at least in the near proximity) with the target satellite, autonomous rendezvous and docking and then possibly de-orbiting. As regards the service actions, they may include robotic manipulation, modification, refuelling, commodities replenishment, repair, upgrade or correction of mechanical failures and assembly. [3] [4]. Even this short explanation shows that OOS includes a full range of already known space activities, as well as those that are completely new, and which will have to be taken into account in the risk management measures. In this respect it is however also stressed, that on-orbit servicing missions are still lacking of achieving critical mass to make realistic assessments.[5] [6]

The first issue to clarify when discussing risk management is the meaning of risk. It seems necessary to distinguish risk from the notion of peril or hazard, the latter mean the cause of a potential loss, and factors contributing to the occurrence of a loss, or increasing the severity of the loss or conditions affecting the perils. We can use various definitions of the risks, such as that one, which is included in the US Code of Federal Regulations ('CFR'), and describes the risk as 'a measure that accounts for both the probability of occurrence of a hazardous event and the consequence of that event to persons or property.'[7] [8] [9] Identifying the hazards, hazardous events risk factors and the subject matter of the risk is the first step in effective risk management and insurance.

For the purposes of risk management and insurance analytics, the risks may be divided into categories related to the object suffering the damage, i.e. by property and persons, mirrored accordingly in the category of property risks and casualties. These include the loss, damage or destruction of property related to a space project (i.e. satellite, launch vehicle, ground facilities), as well as the property of third parties, such as ships and aircraft (in the event of a collision during the launch), or any other property in the event of a space object hitting the ground, increased by the consequential loss of profits and pure financial loss.[10]. Damage to persons includes manned space flights, persons involved in some other way with the space activities (e.g. launch facility staff), as well as innocent by-standers.[11]. Altogether, the space hazards produce a risk to the assets, including spacecraft costs, launch vehicle costs, insurance and own capital costs, as well as third party liability, pure financial loss such as manufacturers' incentives, contract obligations and business interruption risks (operating and extra expenses, loss of revenues, etc.).

Considering the range of threats posing a potential danger, OOS would remain in the same category as ultra-hazardous activity where we face a mixture of technological, human and natural perils, as in other types of space activities. The probability of any of these hazards appearing is dynamic and changes during the space mission phase. The clue is that the risk related to the space missions cannot be avoided and in spite of the advancement of technology, and the best efforts of involved, though no doubt the possibilities of effective protection are increasing and satellites are designed to have high resilience to these perils. These perils are continuously assessed by insurers and categorised for example by Lloyd's of London in the RDS (Realistic Disaster Scenarios), which include four potential risks, i.e.: an anomalously large solar energetic particle event affecting many satellites, a generic defect causing undue space weather sensitivity in a class or classes of satellites, a generic defect causing unforeseen failures in a class or classes of satellites, and finally collision with debris.[12] The fact it cannot be avoided is, by the way, one of the most important reasons for implementing OOS (degradation of the solar panels, etc.) [13]

Specially important seems to be the risks related to the debris which. Risk management tools applied so far in that field consisted mainly of limiting the volume of the produced debris. Active debris removal concepts interact with the possibilities offered by OOS.[14] Apart from that, new types of hazards should be taken into account and distinguished, especially in the satellite operation stage. These mostly concern intentional interference and cyberattacks.

These and other threats will have an impact on the OOS as well. Though it seems that due to the robotic nature of OOS activity, we can assume that human risks will not play a substantial role in the overall risk assessment (as was the case in the early OOS missions which were performed with the help of space shuttles and astronauts).[15]. As regards the risk implications for the servicing spacecraft, the inherent nature of in-orbit risks could possibly be distinguished from those coming from OOS operations and the features of the target satellite. In this respect, the question arises whether the risks related to each of them are of such a substantially different type, if we consider the property damage, loss of revenues or liability, that it will change any of the risk management paradigms? This question should be answered by the engineers, so that risk managers may follow by adopting adequate measures.

It is worth noting that each of the space actors face slightly different risks in relation to satellite operations in-orbit, and in consequence each of them perceive OOS from slightly different perspective. The satellite operator's exposure concerns assets, revenues, expenses and liabilities, all those risks being concentrated during the in-orbit phase. Satellite manufacturers face the risk during the manufacturing process, especially until the legal transfer of the satellite to the operator, facing the risk to assets, liability, expenses, and financial incentives – depending on the contract with the client. Launch service providers are exposed to the liability and obligation to relaunch (under a relaunch guarantee). Even this rough outline shows that, despite having different roles and being directly exposed at different stages of the space project, the consequences of a misperformance at any of the pre-orbital stages cumulate at the in-orbit stage and involve all of them. As a result, each of them might be interested in applying OOS, even if only to protect their very particular business interests. Apart from that, the general interest concerns all of them, though the main pressure certainly comes from the policymakers, such as UN, space agencies, as well as academic circles, etc. It is related not only with the common belief in the 'heritage' represented by outer space, but also with the liability that is ultimately borne by the launching states.

The legal context seems to be equally important for the risk management and insurance. This is for several reasons. Firstly, this is due to imposing an obligation to apply the technical measures to avoid or mitigate the risk as a prerequisite of licensing [16][17], and secondly, by allocating the risk to specific entities. Thus, the (space) law can implicate a legal obligation to compensate damage suffered by a related party (known as a second party) or a third party in those situations where technical measures were not sufficient to avoid the damage, or were not applied properly. It may also exclude or limit the liability. The way such an allocation is made, on the basis of statutory (for example in France and the US) or contractual provisions, is an obvious risk management tool of a legal nature. As such, it has an impact on insurance, i.e. the insurable interest and the type of insurance coverage applicable. [18]

As regards OOS, no doubt both issues are to be resolved, i.e. the technical requirements being part of the licensing process,[19] as well as the liability regime. The question that should be answered is whether the measures applied at the moment are sufficient to encounter OOS activity in both aspects, or whether new concepts must be implemented. The subject certainly requires in-depth analysis and has been included in some academic research projects.[20] It should be assessed on a horizontal basis including the spectrum issues (as OOS will possibly not need an orbital slot), export control requirements and impediments (restricted transfer of data), the protection of intellectual property rights, and some others. With respect to the liability regime, the concepts of changing the fault-based regime into a risk-based regime during the in-orbit phase are multiplying. So far, under the existing regime it seems that OOS is just a type of space activity, as defined by the majority of the national space laws, so liability for damage is essentially fault-based, due to the core OOS operation being performed in-orbit. That is a result of the definitions of space activities included in the specific regime of the space law and authorisation requirements, which focus on the 'upstream' sector, to which OOS inevitably belongs. Doubts are raised, however, if the existing regime fits the features of OOS, both at a licensing level and with respect to the liability regime. The manner of structuring both of these aspects is part of the risk management process and will have an impact on the insurance of the risks related to the OOS in terms of the risk exposure for insurers. This may include, for example, the compulsory nature of TPL insurance for the in-orbit stage, which nowadays starts only emerging in the newer local space laws. The legal aspects of OOS in terms of the insurance industry entail also questions about the licensing of insurers, where they are to be involved in OOS. Is the existing regime sufficient, or should there be some 'legal incentives'?

3. Insurers as divers of space innovation

Insurance, known since the beginning of early space ventures, includes all the stages of the space missions, starting from the manufacturing process until reaching the in-orbit stage. Space underwriters, who are also space engineers, have developed a unique type of coverage and they can be perceived as deterrent to the growth of the industry. The insurance of space risks is very often a part of the financing scheme for the whole space mission.

When discussing the insurance of the OOS, it cannot be considered in isolation from the whole risk management process, but must form an inherent part of it, being just one of the tools. Though, I dare to say, due to the specifics of the space risks, a very special tool, which is due to the above mentioned impossibility of eliminating most of the space hazards, as well as due to the cost of the space mission, where self-insurance can be afforded by only few operators. Two sides of the same coin should be analysed in that respect: (1) whether OOS can help insuring satellites in terms of mitigating the risk insured, and (2) insuring the OOS mission as such. There are several issues to be considered in detail, such as whether OOS has a potential to help avoiding or reducing insurance claims, who will benefit from it, who should pay for it, who has the authority to approve a service mission; and finally whether insurers underwrite differently a satellite that has a reduced redundancy of components, but is cooperative with on-orbit servicing. Even a shallow analysis of the above may lead to the conviction that OOS has a potential to become a 'game-changing innovation', as most of the payments made by the insurers during in-orbit stage are due to component failures, deployment issues or expired resources (fuel, solar array/battery failure).

Insurers have developed the top expertise on the space risk assessment factors. It is, however, quite probable that they will be impacted by the OOS specific features and need revision. Such predictions concern both technological factors and the legal context, adding to that as well the insurance market conditions, which suffer from not improving volatility in spite of the technological progress. In the first stage, the need for an individual approach in underwriting OOS missions will probably even increase. Space insurance as a rule is tailored risk coverage, though in the long term it is clear that standardisation would be more than welcome. The risk assessment in space insurance works on the basis of a 'technology-based engineering analysis', rather than on the typical methods of risk measurement and statistics. This situation is due to the low quantity of risks of high value, i.e. the limited number of launches and satellites, which do not allow really meaningful statistics to be developed. This is increased by the diverse range of launch vehicles and satellites, which further narrow the possibility to act on the law of large numbers, so crucial for insurers. Thus, it may have an impact on the insurability criteria of the in-orbit stage of insurance, which now is practicable up to 10-15 years of in-orbit life, when the satellite's value drops substantially and represents no book value. Extending the satellite's life creates a potential for further insurance coverage, along with the operative value of the satellite despite the advanced lifetime.

We may also hope that it will have a positive impact on property PD insurance by lowering the exposure for property and revenue losses (BI insurance). Considering the above features of space insurance contracts, as well as the nature of the OOS activity, the interaction can be seen in several contexts. Depending on the technological and legal outcomes, a new type of risk may emerge, such as second party risks (contractual liability) and changes in the third party liability paradigm from fault liability into risk-based liability (regardless the place of the accident). [21] The OOS may also affect certain specific features of a space insurance contract, ensuring the insurer more control of the risk insured. At a minimum level, the OOS vehicle inspecting the non-functioning insured satellite, might have an impact on the loss adjustment. It will be easier to assess whether the malfunction is permanent or can be remedied. The other insurance consequence is the possibility of introducing new criteria of type of loss assessment, which lowers the risk of a total loss or TCL in terms of PD and BI insurance– in view of the emerging possibility of restoring the service of the insured satellite by the OOS spacecraft. No doubt, however, also new risks will emerge, this being related to the possibility of the servicing spacecraft damaging the target satellite, which would implicate the need to assess the (underwriting) exposure of PD, as well as liability. In the latter case, this also needs to be addressed in the OOS arrangements (e.g. as a type of knock-for-knock clauses).

Space insurance is based on the concept of all risk, which means that all the failures and losses described and defined in the contract of insurance are covered, without any reference made to the cause of such loss. The OOS may potentially lead to the replacement of the 'all risk' by 'named perils' coverage. Nowadays – even though all-risk insurance provides for certain exclusions, in practice space insurance can only set exclusions that can be tracked from Earth. As a result of an inspection being possible on the cause of loss, this situation may substantially change. For the same reason, the exposure assessment would be much easier, leading potentially to the change of the 'agreed value' insurance policies into more conventional ones, where the calculation of the loss is based on actual circumstances, as inspected with the help of OOS spacecraft. The same is true for the precautionary measures, which will be much easier to undertake once a problem has been identified. As the OOS can contribute to prolonging the satellite's lifetime, it may also result in the prolongation of the insurance period of cover.

Another issue that has been applied already successfully in practice and is increasingly worth considering is for insurers the possibility to salvage the satellites. Though the salvage is problematic under space law, under space insurance it can be applied upon the explicit terms of the policy. Technical possibilities in that respect could go hand in hand with the legal obligations imposed on the operators to remove the wreck from orbit (as a part of ADR schemes). This, in turn, may have an implication for liability and its insurance. A discussion regarding salvage would be useful from both regulatory and industry perspectives.

To sum up, we could say then that OOS could have an impact at least on: (1) damage mitigation, (2) risk assessment, (3) cause of damage detection, (4) applying 'named perils' insurance, (5) reducing the number of catastrophic losses or TCL. We must understand that no single solution of the above fits all, especially where different technical methods are emerging (e.g. with docking or without docking to the satellite). All these factors may play a vital role in stabilization of the volatile space insurance market. The other side- effect advantage, which however may become a leading one, is that with growing number of space risks covered, the law of large numbers would be easier to apply. This will be an unquestionable benefit to the space insurance market.

4. Conclusions

The OOS quite naturally provides also a place for insurers, though poses both advantages and challenges. Apart from securing the whole project and changing the game on space insurance market, bringing it closer to the conventional insurance, the OOS missions can provide useful tools for risk mapping. Though, applying the relevant risk management logic in the licensing requirements and liability regime surely is a challenge for the policymakers and regulators.

No doubt there will be new types of hazards and risks, the technology being unproven as regards its robustness and reliability. That can implicate the necessity for the underwriters to be involved in the design/ manufacturing phase of the projects with no place for standardized approach. On the other side, the insurance industry may profit from the regulations imposing for example obligation to insure the on-orbit stage and OOS missions as such. Possibility of involving NewSpace business in on-orbit projects may implicate more demand for insurance coverage. Specially that the specifics of the space missions risks narrows the range of the risk management tools – insurance being one of the proven one. Finally technological benefits of OOS may enable the change of some of the paradigms of space insurance policy terms, limiting the exposure of the insurers. All of these aspects can lead to the space insurance market becoming less volatile and more accessible for more insurers and more operators. This means that the space insurers in fact need the OOS missions for stabilizing the market, but also they seem to be well prepared to serve this new emerging concept and become its driver, by having strong impact on technical reliability of the operators – potential policyholders, as well as by lobbying the high standard of licensing requirements and compulsory insurance if not on international, then surely on local regulatory level.

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