Space Insurance — Market Review Oriented on the Main Factors Influencing Optional Demand for the Insurance Cover In 2021[1]

Petra Tisová » Prague University of Economics and Business, Faculty of Finance and Accounting, Department of Banking and Insurance. Email: Petra.Tisova@vse.cz

Jaroslav Daňhel » Prague University of Economics and Business, Faculty of Finance and Accounting, Department of Banking and Insurance. Email: Jaroslav.Danhel@vse.cz

1. Introduction

The insurance business has been traditionally considered conservative (Tisová, Ducháčková, 2021). It reduces the negative impact of the unpredictable and accidental events due to the fact the insurance companies take over the risks from the clients in exchange for the premiums (Daňhel, 2005).

As far as the exchange business could continue to the nearly win-win situation for the both sides, the insurance companies need to manage their activities properly, so that the financial stability would not been threaten. The transfer of the risks seems to be inevitable, therefore the insurance companies hand the risk (or a part of the part) to another subject, being the both, insurance or reinsurance companies. The reason for the reinsurance is not only the financial stability. If the insurance company transfer the risk further, the effect is also in building an extra capacity for the future business. The bigger capacity can be used for the expansion of the current products or for the development of the new ones. Nevertheless, this way how to stabilize the financial results is not bottomless, because the reinsurance players of this process could decline the risks and this have to be kept in mind (Carter, 1995).

As the conventional products are took into account, the proper loss history, other useful records of the insurers and common facts help the insurance companies — despite the exceptions — predict the future process quite exactly in these days, because the insurance mathematics and statistics use the law of large numbers (Šimon, 2021).

Additionally, the standard products do not evince big divergences as far as the base of the clients and their claims are considered. Thanks to the insurance companies' internal consensus among the relevant departments, the premium rates are priced in general as well as the limits and Terms & Conditions. When the others, let's say, unusual products are considered, the situation is more difficult, because the law of large numbers cannot be applied and deserve the back-to-root approach in the terms of the settling the premium rates, limits and Terms and Conditions (Wade, 2021). →

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The space insurance represents one of these products which have to be examined individually by the in-field-expert underwriters on the case-to-case basis. Premium incomes from the space insurance are tempted as the rates could be due to the sums insured high. On the other hand, the risks are significant and the losses could be very painful. It follows that the suppliers of the space insurance should be strong, confident and above all, capital well equipped companies only (Gubby, Wade, Hoffer, 2016; Malinowska, 2017).

To the best of our knowledge, aside of the business studies, only insufficient number of scientific researches was devoted to the space insurance market and the behaviour of the participants. For example, Manikowski and Weiss (2012) examined the space insurance market (or satellite insurance market respectively) from 1968 to 2008 to find out, that this suffers from the crises and booms in periodical repeat, which result into the cyclical premium rates and volatile and cyclical capacity. Before that, Manikowski (2004) also confirmed, that space insurance market requires an increase of the insured accounts, so that the predictability of the underwriting results and stability of the insurers would be better. To be influenced by the little existing cognitions of the space insurance market and the factors, which may impact the demand for the insurance covers, this study provides new insights into the matter. Main goal of the paper is to provide and evaluate the factors, which indicated demand for the space insurance cover of the year 2021.

The first section of the paper examines the characterization of the space insurance, which opens the theme, followed by the section describing the space insurance market review between the years 2019–2021 focused on the supply side of the business and the underwriting results mainly. Later section deals with the factors, which are considered to be relevant and significant. The results are discussed in the last section.

1.1 Characterization of the Space Insurance

The space insurance does not represent the standard type of the insurance cover, which buy the millions of clients. The number of the clients is limited as they are concentrated in the specialized business area, which is not widespread due to the logical requirements such as finance hub, sophisticated technical background and know-how. Although the commercialization of the space exists and new starts up firms have been operating in this field, which causing reduction of the costs, bigger expansion and therefore the new insurance chances are not presumable in the near future. In general, the third party liability insurance is ordinarily required by the license authorities, but the space insurance concerning the assets is optional for the subjects in charge. The premium rates are in the units of the per cents and on top of that still fluctuating, therefore only a minor part of all the space projects is insured. The insurers used to offer rather complex products before some time, but they realized this would not lead to sufficient incomes, because the clients have preferred only parts of the insurance cover, e. g. launch phase (Wade, 2021).

Instead of losing the clients, the insurance companies divided the space insurance products in few lesser independent products more or less shadowed by the phases of the assets' life. This act helped to stabilize the earnings of the insurance companies, but it is evident, that the gains of the insurance companies would be bigger while the insurance product is sold as a whole. The main reason why the insurance rates fluctuate quite often is because the underwriters treat each business account individually. The law of the large numbers cannot be applied, because so few launched spacecraft have been insured. While each business case is assessed separately, active involvement of the client is requested, because the process of the insurance cover arrangement takes a lot of time during answering to the tons of questions. In this procedure, the underwriters concentrate on looking for the similarities to the former spacecraft without

any defect and try to evaluate how new items have been tested to fly in space properly (Wade, 2021).

It follows, that the engineering backgrounds of the underwriters are essential for the insurance companies. This individually led procedure also signifies increasing operational costs of the insurers.

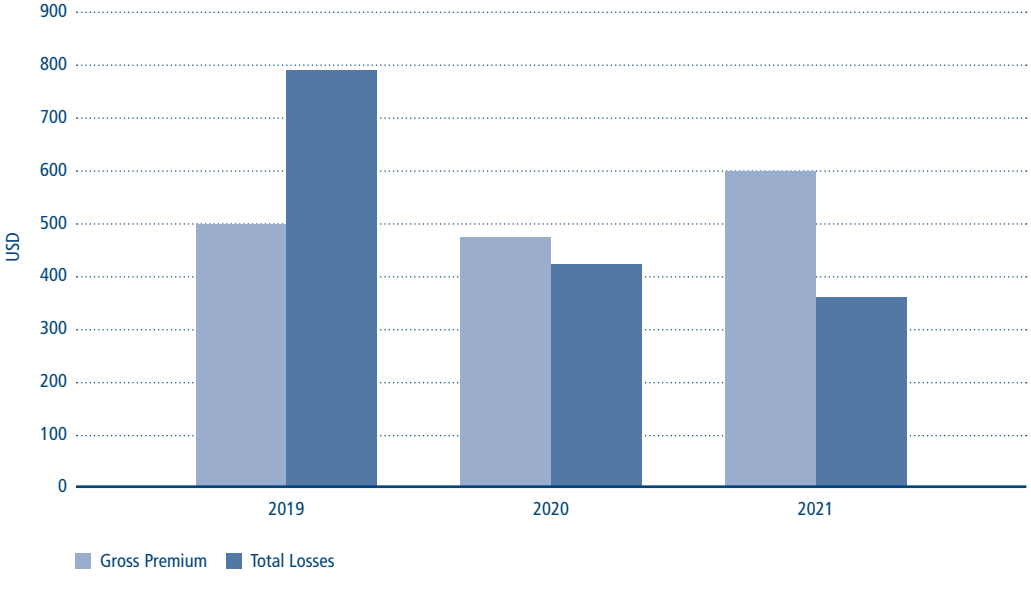
Another issue represents low valued spacecraft which can be associated particularly to the starts up producing the cubesats. For many insurers has not been effective to insure the cubesats only valued at perhaps USD 250k–500k, because the premiums would not sometimes cover the operational costs.

As the expenditure side of the insurance companies needs to be mentioned aside of the operational costs, the main focus should be fixed on the insurance indemnities. While the consequential phases of the spacecraft's life is insured, few of them, as a matter of fact, lie beyond the Erath's surface. The claims adjusters have therefore worsened work, because they cannot physically inspect the subject of the insurance and they need to rely on the data provided by the operator of this subject.

1.2 Space Insurance market review between the years 2019–2021

The space insurance market has gone through the rocky times recently. After the years without the serious claims, the year 2019 was a beginning of the new approach to the correction of the premium rates due to the momentous losses and the reduction of the space insurance capacities in consequence of the withdrawal of two main insurance players. It all started when Vega launch vehicle carrying on the board Falcon Eye 1 satellite failed totally, which resulted to the largest-ever claim in the market at the amount of the USD m 414, followed by the ChinaSat 18 total loss at the amount of the USD m 250. Beside these, other lesser losses were

Graph 1 » *Space Insurance Results since 2019*



Source: Own processing based on the Seradata (2021) and Industry premium estimates →

recorded in this year. Another significant shock for the market was caused by the insurer Swiss Re announcing its decision to withdraw the field, followed quite surprisingly by the AIG in 2020. The premium rates have been increasing since, although the exception exist. The Falcon 9 launch vehicle has proved its reliability, therefore the rate in 2021 fell slightly in comparison to the previous year (Todd, 2021).

According to Seradata SpaceTrak database (2021), the year 2020 was more favourable. The losses at the amount of USD m 424.6 did not exceed the estimated gross premium at the amount of the USD m 475. All these comments are shown in the Graph 1 below.

As a result of the increasing premium rates, the market's estimated total premium of the year 2021 is at the amount of USD m 600. According to the Seradata's SpaceTrak database (2021), 8 losses in the year 2021 are recorded at the amount of the USD m 360 USD approximately.

As of 2021, there were 36 insurers acting in the space insurance all over the world (Willis Towers Watson, 2021). Comparatively small quantity of the insurers in comparison to the other insurance fields and the fresh withdrawal of two big players affirm, that the space insurance is pretty boisterous place to be.

2. Considered factors influencing the Space Insurance Demand

As far as the insurance companies are generally supposed to predict the demand for the insurance cover on the basis of their assumptions arising from the experiences, few factors which could have influenced the space insurance demand in 2021 were picked and examined afterwards. Due to the nature of the space insurance business, where market has been changing swiftly, intentionally the year 2021 is considered only.

Considering the lack of relevant studies about the space insurance, and even those targeting to the space insurance demand, the objective of this article is to analyze the selected factors, which have the potential to influence the demand for space insurance cover. We work with the following research questions:

- RQ1: Is the ownership of the spacecraft influencing the demand for the insurance cover?
- RQ2: Is the value of the spacecraft influencing the demand for the insurance cover?
- RQ3: Is loss record of the companies owning the spacecraft influencing the demand for the insurance cover?
- RQ4: Is reliability of the launch vehicles influencing the demand for the insurance cover?
- RQ5: Are any other factors supposed to influence the demand for the insurance cover?

2. 1. Materials and Methods

Data used in this paper were mined from the Seradata's Spacetrack database, a world biggest storage of the information concerning the space issues. The set of the data consists of 158 launches of vehicles which carried 1 863 spacecraft during the whole year 2021. In total, 305 spacecraft were insured and 1 558 spacecraft were not insured. Methods vary as each predicted factor influencing the demand for space insurance cover has its own nature. Therefore, description of the method is provided for each factor separately in the following sections.

3. Results

3.1. Ownership of the spacecraft

There is an appreciable prerequisite, the insurance demand has been higher among the private owned companies in comparison to the State or Government owned companies. The reason is, State or Government owned companies have as a matter of fact almost unlimited inflow of the finance, if the project is approved and the will for continuation exists. The issue concerning the insurance can be therefore neglected, as the State is in many cases

ready to pay the potential losses from its own pocket. On the other hand, the private companies are not endowed with the similar advantages in comparison to the State, even while the banks' funding is involved in the process. The request for the insurance would be quite inevitable then. Data confirmed the hypothesis and show that 300 out of 305 insured spacecraft were owned by the private companies and 5 out of 305 insured spacecraft were owned by the public or government companies.

The method used in this factor is the ratio of the private owned spacecraft to total quantity of the insured spacecraft and the ratio of the public owned spacecraft to total quantity of the insured spacecraft. The ratio of insured private owned companies in the set is 0.9836, which means 98.36% insured spacecraft belonged to the private companies. Contrary, hardly 2% of all insured spacecraft were owned by the State or Government. All these figures are shown in the Table 1.

The main part of the uninsured spacecraft holds SpaceX, which is the private owned company. In total 995 its spacecraft were launched out of the Earth, while 989 were Starlink satellites and 6 spacecraft were for NASA ISS missions. This fact could deny the hypothesis above, but there is a clarification. SpaceX has a huge financial hub due to the Elon Musk's diverse activities and financial transfers among his companies. Above all, it is the SpaceX, which launch vehicles are considered to be the most reliable (this fact is proved further in the paper by the low insurance rates). In total 1 243 spacecraft out of 1 863 were carried by the rockets Falcon 9 or 5 or Heavy in 2021, which represents two thirds of all spacecraft.

Other entities, which did not decide to buy the space insurance for their spacecraft, are predominantly the State or Government owned, such as Ministries of Defence of various countries, NASA, universities, etc., which decidedly supports the hypothesis discussed in this section.

3.2. Value of the spacecraft

The second hypothesis is defined as a direct relation between the value of the spacecraft and the demand for the space insurance. This signifies a presumption, that the bigger the value of the spacecraft means also the bigger demand for the insurance cover.

For the confirmation of this hypothesis, following methodology was used. The set of the insured spacecraft during the year 2021 was mined as their costs at new were stated from the Seradata's Spacecraft database (2021). The costs were divided into eight ranges, while each range has particular quantity of spacecraft. Unfortunately, these costs were mentioned only about 295 spacecraft out of 305 spacecraft, therefore the Table 2 shows the narrower set of 295 spacecraft only.

As it is evident from the Table 2, the most numerous spacecraft belong to the range between USD 0–24.99 m. This corresponds to the new trend at the space insurance market. The satellites tend to be smaller and cheaper (and are also known as cubesats) nowadays, therefore the demand for the space insurance reflects this fact accordingly.

The main issue lays in the question, whether these cheaper satellites would even be attractive for the insurers in the long run. The first respect,

Table 1 » *Ownership of the spacecraft*

Ownership	Quantity of Spacecrafts	Ratio Ownership/ Total Quantity of Spacecrafts
Private owned companies	300	0.9836
State or government owned companies	5	0.0164

Source: Own processing based on the Seradata's SpaceTrak database (2021)

Table 2 » *Spacecraft Cost at New (m USD)*

Spacecraft Cost at New (m USD)	Quantity
0–24.99	284
25–49.99	0
50–99.99	0
100–149.9	1
150–199.9	7
200–249.99	0
250–299.99	1
300–349.99	2
Total	**295**

Source: Own calculation based on the Seradata's SpaceTrak database (2021)

which should be taken into the consideration, belongs to the fact, that the cubesats are more numerous in comparison to the bigger satellites. As their value is considerably lower, the production should be improving continuously by one to another, thus means that the insurance companies would cut down the potential loss payments.

The second regard deals with the probability that all the cubesats would fail at the same time or in the short period. According to the total loss history of the space insurance market, this incident would be highly unlikely, therefore the losses are supposed to be more scattered.

In other words, insurance of the cheaper and smaller satellites could be convenient in the terms of financial stability of the insurers. On the other hand, the process of the space insurance underwriting is time consuming, and therefore costly. If the insurance companies could simplify the process for this segment, the profitability should be guaranteed. The hypothesis about the direct relation between the higher value of the spacecraft and the bigger insurance demand was not proved, moreover it seems the relation is exact indirect.

3.3. Loss record of the companies

Another hypothesis claims, that companies, which have suffered any loss, tend to be more protective, therefore the demand for the insurance should be higher. It includes losses inside the company structure as well, that is why the losses of the predecessors, subsidiaries or joint ventures are considered. This hypothesis is divided into the two sub-hypothesis. The first one states that only former claims have the effect on higher demand for the space insurance cover. 14 spacecraft, which belong to the owner experienced the loss history, were insured in 2021, while the rest remain uninsured. This constitutes 4.6%, which could be neglected.

While anomalies and claims are taken into account together, the situation changes dramatically. The second hypothesis turned out well and can be confirmed, because there are in total 302 spacecraft out of 305 (99%) whose owner reported any anomalies or claims before.

To conclude the third hypothesis, the subject with a loss record or any reported anomalies would ask for the space insurance cover most likely, therefore the insurance companies need to check the loss history of the clients properly, before the deal would be done. Contrarily, the space projects

have been improving each and every year and what happened a time before can be left out, because the technological process may remove the former claims triggers, as the companies learned from the important lessons. There is no secret, that the insurance companies employ the experts, who have engineering backgrounds or ask the space engineers for advising them. These people can easily appraise the situation and act accordingly.

3.4. Reliability of the launch vehicles

The fourth hypothesis states, that the reliability of the launch vehicle plays a considerable part, whether the owner of the spacecraft asks for the space insurance cover. Ten launch vehicle families were used to carry the insured spacecraft up beyond the Earth in 2021. What is interesting at the first sight in the Table 3 below is a percentage of insured spacecraft in comparison to all the spacecraft (i.e. insured and uninsured) taken by these vehicle families.

The smaller percentage of the insured spacecraft to all the spacecraft carried by these families could induce bigger reliability of these vehicle families, thus signifies the lesser appetite for the space insurance cover. The front-runner, Falcon family, has a hardly a half of a percentage of the insured spacecraft on the board. To be accurate, Starlink project holds a big part of all spacecraft. If the Starlink and Mission Operations of SpaceX for NASA, are deducted, 248 spacecraft left. The ratio should be 2.4119% then, but it is a great result still. On the other hand, the bigger the percentage of the insured spacecraft to total spacecraft, the smaller reliability should be anticipated, which means the bigger demand for the space insurance cover. The families Proton, Soyuz/ Molniya/R-7 and Ariane 5 belong to this class. The reliability and therefore the hypothesis above could be confirmed explicit by both, the previous claims or the insurance rates as it is displayed in the Table 4, which is dedicated to the estimated rates for the launch only of the year 2021.

Unsurprisingly, the best estimated premium rate hold the launch vehicles from the vehicle family Falcon, while the worst rates are calculated for the vehicle family Proton. Curiously, the vehicle family Ariane 5 has the second best insurance rate, although according to the ratio insured spacecraft

Table 3 » *Insured spacecraft vs. vehicle family in 2021*

Vehicle Family	Quantity of Insured Spacecraft	Total Spacecraft (Insured & Uninsured)	Insured Spacecraft/ Total Spacecraft	Launches
LONG MARCH 1, 2, 3, 4	1	84	1.1905%	40
ANTARES	2	26	7.6923%	2
ARIANE 5	3	5	60.0000%	3
PROTON	3	3	100.0000%	2
KUAIZHOU/FEITIAN	2	5	40.0000%	4
H-2, H-2S, H-2A & H-2B	1	2	50.0000%	2
SOYUZ/MOLNIYA/R-7	284	336	84.5238%	22
VEGA	2	14	14.2857%	3
SPACESHIPS (VIRGIN GALACTIC)	1	2	50.0000%	2
FALCON 9, 5 & HEAVY	6	1243	0.4827%	31
TOTAL	305	1720	17.7326%	110

Source: Own calculation based on the Seradata's SpaceTrak database (2021)

Table 4 » *Estimated rates of the launch vehicle families in 2021*

Vehicle Family	Premium Rates 2021
LONG MARCH 1, 2, 3, 4	5
ANTARES	5,8
ARIANE 5	3,7
PROTON	11,1
KUAIZHOU/FEITIAN	NA
H-2, H-2S, H-2A & H-2B	4,2
SOYUZ/MOLNIYA/R-7	6,4
VEGA	9,3
SPACESHIPS (VIRGIN GALACTIC)	NA
FALCON 9, 5 & HEAVY	3,4

Source: Own processing based on the Seradata's SpaceTrak database (2021)

Table 5 » *Launch vehicle families — ratio insured/ total and est. rates*

Vehicle Family	Insured Spacecraft/ Total Spacecraft	Premium Rates 2021
FALCON 9, 5 & HEAVY	0.4827%	3,4
LONG MARCH 1, 2, 3, 4	1.1905%	5
ANTARES	7.6923%	5,8
VEGA	14.2857%	9,3
KUAIZHOU/FEITIAN	40.0000%	NA
H-2, H-2S, H-2A & H-2B	50.0000%	4,2
SPACESHIPS (VIRGIN GALACTIC)	50.0000%	NA
ARIANE 5	60.0000%	3,7
SOYUZ/MOLNIYA/R-7	84.5238%	6,4
PROTON	100.0000%	11,1

Source: Own calculation based on the Seradata's SpaceTrak database (2021

to all spacecraft on the board, the insurance rate should be higher. Other insurance rates respond to the ratios above which can be seen in the Table 5 below.

These slightly confirm the hypothesis about the direct relation between the reliability and the appetite for the insurance.

3.5. Other factors supposed to influence the demand for the insurance cover

The hypothesis, which could have been examined through hard data from the year 2021 were stated above. Aside of these, many other hypothesis and assumptions about the effects on the current space insurance demand exist. Unfortunately, they are described without the hard data due to the impos-

sibility to get them, because not all of the companies which have bought the space insurance contracts during the year 2021 were willing to release the inside information, therefore word comments are realized only. The impact of the bank involvement inside the company is a strong supposition about the direct influence on the higher demand for the insurance. It is quite obvious, that the bank loans need to be secured and banks insist on the insurance covers of the assets, which were bought by the bank's money.

While joint ventures, and another form of collaboration inside the field of the space projects exist, the possibility that one party would require the insurance cover from another participants is not negligible. It is quite logical, because the space projects are pretty expensive and the transfer of the risk to another subject can be a solution.

With this reflection is connected another assumption about the commencing companies at the space projects. The new ones without proper loss history and experiences would be tended to have an insurance cover. Firstly, because the bank involvement is presumptive, secondly because the insurance symbolizes the certitude in the terms of financial stability, even though the space insurance represents another portion of the costs, because of the higher rates which are used to be offer to a new client.

Well-established private or public companies with certain financial and technical background follow specific strategy. Instead of insuring the particular satellite, the company produces additional one with the same specification and launch them as "in-orbit spares". The operator is tended to buy just only the insurance cover for the launch phase and once the satellites are separated rely on these spares (Wade, 2021). This approach, which is finally less costly, than the insurance premium, is reserved to the biggest and most confident companies only.

Very specific case of the insurance demand lies in the co-operation between the government (or state) segment and commercial service providers. While the government agencies have been using the commercial companies in the space projects these days, the final payment from the agency is once effected the commercial companies successfully complete the mission. This gives the commercial companies an insurable interest to demand for the insurance to cover the value of the final milestone payment (Wade, 2021). The example are the CRS and CCtCap project. NASA cooperates with Northrup Grumman and SpaceX to deliver the cargo to the ISS.

The space insurance does not represent the standard type of the insurance cover, which buy the millions of clients. The number of the clients is limited as they are concentrated in the specialized business area, which is not widespread due to the logical requirements such as finance hub, sophisticated technical background and know-how.

As the expenditure side of the insurance companies needs to be mentioned aside of the operational costs, the main focus should be fixed on the insurance indemnities. While the consequential phases of the spacecraft's life is insured, few of them, as a matter of fact, lie beyond the Erath's surface. The claims adjusters have therefore worsened work, because they cannot physically inspect the subject of the insurance and they need to rely on the data provided by the operator of this subject.

Table 6 » *Factors influencing space insurance demand in the year 2021*

Factor	Increased Demand for the Insurance
Commercial ownership of the spacecraft	Yes
Higher value of the spacecraft	No
Previous loss history or anomalies of the spacecraft	Yes
Less reliability of the launch vehicle	Likely Yes

Source: own interpretation

4. Conclusion

The space insurance market is very tough and difficult place to do business in, because there has been enormous volatility. The range of the clients is limited due to the nature of the space projects as such, on top of that the operational costs are higher in comparison to the standard products, because the individual expert approach during the underwriting process is absolutely necessary. The matter of the losses is an issue on its own, because the insurance may cover the claims which could happen in orbit, therefore the physical inspection of the claims adjusters is impossible.

As for the insurers is essentially important to know, what could influence the demand for the insurance cover, while limited studies have been accomplished in this matter as of to date, this paper summarizes and examines the factors which influenced the demand for the space insurance cover in 2021.

Four main factors, which were able to test by using the hard data from the Seradata SpaceTrak's database, are mentioned in the Table 6 below with the result, whether there is a relation in the terms of increased demand for the insurance or not.

Commercial ownership of the spacecraft and previous loss history or anomalies of the spacecraft verifiably lead to the increase demand for the insurance. Quite surprisingly, the higher value of the spacecraft do not influence the demand for the insurance as the opposite would be more consequent. The explanation could lie in the present trends of the New Space projects (2019), where small and cheap cubesats have been preferable during the last years. With some wariness, the direct relation between the lesser reliability of the launch vehicle and the increased demand for the space insurance can be also confirmed.

Besides the four factors mentioned above, there are other factors on the demand for the space insurance cover, which cannot be examined through the dataset. According to the empirical observation, following factors were evaluated as relevant and increasing the optional demand for the space insurance:

- Bank involvement
- Commencing stage of the company
- Joint venture or other forms of collaboration
- Companies without sizeable financial and/or technical background
- Conditioned payment after successfully completed mission in the relationship between government and commercial companies

To sum up, most of the factors are logically predictable. As the study of the demand for the space insurance cover in the year 2021 was performed, we suggest to continue with further research in spite of the volatility of the space insurance market, as this seems to be more stable in the next years.

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ABSTRAKT

Pojišťovací aktivity zaměřené směrem na vesmírné aktivity jsou velmi specifické a zasluhují individuální přístup. Vzhledem k tomu, že pojišťovny přebírají rizika od svých klientů, musí být obezřetné, aby upisovací výsledky zůstaly předvídatelné a stabilizované. Cílem tohoto článku je zhodnocení vybraných faktorů (vlastnictví vesmírných prostředků, hodnota vesmírných prostředků, škodný průběh, spolehlivost nosných raket, úvěrové pozadí, počínající fáze podnikání společnosti vlastnící vesmírný prostředek, joint venture či jiné formy spolupráce, technické anebo finanční zázemí společnosti, podmíněnost plateb v případě úspěšně dokončené mise), které mohly mít potenciál ovlivnit poptávku po pojištění v roce 2021.

KLÍČOVÁ SLOVA

Vesmírný prostředek; poptávka po pojištění; pojistné krytí

Space Insurance — Market Review Oriented on the Main Factors Influencing Optional Demand for the Insurance Cover In 2021

ABSTRACT

The insurance business oriented on the space activities' issues is very specific and deserves individual approach. As the insurers take over the risks from their clients and need to be careful, so that the underwriting results remain predictable and stabilized, the main goal of this paper is to discuss the selected factors (ownership of the spacecraft, value of the spacecraft, loss history, reliability of the launch vehicles, bank involve- →

ment, commencing stage of the company, joint venture or other forms of collaboration, companies without sizeable financial and/or technical background, conditioned payment after successfully completed mission in the relationship between government and commercial companies), which have the potential to influence the demand for the space insurance cover in 2021.

KEYWORDS
Spacecraf; Insurance Demand; Insurance Cover

JEL CLASSIFICATION
M20; D22; G22; L11