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Background and Rationale for Study

NASA established its commercial LEO destinations (CLD) program to meet the agency’s long-term research and technology development needs in low-Earth orbit (LEO) in a cost-effective manner after the International Space Station’s (ISS) mission concludes. NASA hopes that commercial entities can establish a robust market in LEO for human spaceflight and other economic activities on a human-occupied platform where NASA is just one of many customers.

In 2020, NASA awarded Axiom Space (Axiom) a contract to provide at least one habitable module on ISS, and Axiom intends to transition from that ISS module to a free-flying destination in LEO in the future. In late 2021, NASA chose three additional teams, led by Blue Origin, Nanoracks, and Northrup Grumman, to develop plans for their own commercial destinations in LEO. (For the purposes of this memo, these four companies – Axiom, Blue Origin, Nanoracks, and Northrup Grumman – will be referred to collectively as “CLD providers” or “providers”).¹ Northrup Grumman has terminated their independent effort and joined the Nanoracks/Voyager team.

At a March, 2023 workshop, and in subsequent conversations, CLD providers conveyed to NASA Space Operations Mission Directorate (SOMD) that they were having difficulty obtaining insurance for their proposed destinations. They expressed their concern that, without insurance or some alternative way of addressing the risks of loss and liability, it may be difficult for investors or corporate boards to commit to an expensive undertaking such as a commercial LEO destination.

¹ In June, 2023, several other companies, including Sierra Space, SpaceX, ThinkOrbital, and Vast, entered into unfunded Space Act agreements with NASA to study their own plans for LEO destinations.

This study was conducted at the request of NASA leadership and SOMD to better understand the CLD providers' insurance and liability concerns, and to provide potential options for addressing those concerns.

Study Questions and Key Assumptions

The study's three primary questions are:

1. What are the specific insurance and liability challenges that CLD providers are facing?
2. What are the potential options for addressing those challenges?
3. What are the possible next steps for NASA?

The study's key assumptions:

1. NASA wants one or more CLDs deployed and operational by ISS's scheduled end of life in 2030 to enable a seamless transition for its LEO activities.
2. NASA wants to maintain a continuous human presence after ISS's end of life.
3. Given current and future fiscal constraints, NASA would prefer options to address insurance and liability challenges have little or no budgetary impact.

Methodology

To better understand the CLD providers' concerns, the study team engaged with the providers, several insurance brokers and underwriters that work with the providers on these issues, relevant NASA personnel in SOMD and OGC, and the Office of Management and Budget (OMB). The team supplemented these discussions with desk research on the space insurance market and on federal insurance/liability regimes for other high-risk markets (e.g., the Price-Anderson Nuclear Industries Indemnification Act and the Terrorism Risk Insurance Act).

Findings and Options

There are two types of insurance that are relevant to CLD providers, asset insurance and liability insurance.

Asset insurance would reimburse providers for damage to or destruction of their LEO destinations. For example, if a provider has asset insurance on a destination module, and that module is destroyed during a launch vehicle failure or otherwise fails to perform, an asset insurance policy would reimburse the provider for some or all of that loss.

Liability insurance would reimburse providers if they are found liable for damages caused to another party. For example, a liability insurance policy would pay out if a visiting astronaut is injured on a destination and the provider is found liable.

The following sections describe the challenges that providers are facing in insuring their assets against loss and potential liability, as well as options for addressing those challenges.

Asset Insurance

Asset Insurance Findings

Finding: CLD providers' most pressing current issue relating to insurance is a large gap that exists between their needs for asset insurance and what the market can provide at an affordable price.

The space insurance pool (the total amount of capital available to underwrite space insurance policies) is typically between \$400M and \$700M, yet most providers' destinations will likely cost well over \$1B. Insurers even expect the pool may shrink in the short term due to recent satellite failures and other technical delays.

The risks of launch are well understood, and the ISS has operated for decades without catastrophic failure. In theory, a CLD provider willing to pay a premium that covered the expected value of the requested insurance should be able to get that insurance even if their asset size is larger than the typical satellite. In practice, however, there is only a certain amount of capital allocated the space insurance pool and space insurers indicated it is not standard practice to reallocate their capital between pools (though this may be changing – see “Asset Insurance Options” section below).

One concern is the availability of reasonably priced² full asset insurance,³ but the level of that concern is varied. A lack of full asset insurance can create difficulty for providers to attract needed internal or external investment and thus could jeopardize the ability to finance a mission. On the other hand, while such insurance is desirable, providers may choose to move forward without it.

Finding: CLD Providers are worried that premium rates for on-orbit operations will be unaffordable, particularly during the first year after launch.

Multiple providers have been quoted premium rates of 10-20%/year of asset value for the commissioning phase (the first year post-launch). The providers claim these rates are unaffordable and unreasonable.⁴

² To the extent that alternative risk management actors from outside the current space pool (e.g., Berkshire Hathaway) would be willing to supplement that pool for a unique asset like a commercial LEO destination, the expectation is that they would charge extremely high premiums (20%+) that would likely be unaffordable to CLD providers.

³ “Full asset insurance” means that the policy would cover most or all of the cost of the asset, should the asset be completely destroyed.

⁴ “Unreasonable” in this case meaning that providers believed that the expected value of claims made during the first year is much lower than the premiums that were quoted.

There appear to be three primary reasons for these high rates. First, a large proportion of satellite failures tend to occur during a spacecraft's first year, so satellite insurance rates are typically higher for that year and insurers are making the same assumption about destinations. Second, the novelty and uncertainty associated with commercial LEO destinations is leading insurers to price premiums higher, at least until they better understand the risks involved. Third, space insurance premiums in general are rising in response to recent losses.

Some insurers believed that prices would drop over time as providers' plans became more concrete and if providers are able to show that their commissioning risks are lower than for satellites. Prices may also decrease if the broader industry has a few good years with minimal claims.

There is less concern premiums would be unaffordable after the commissioning phase was over, though without more details about the specific destination being covered (including information about what activities that provider intended to conduct on it), it is difficult to fully assess.

Asset Insurance Options

The paragraphs below describe and evaluate various actions that the government or industry could take to address providers' asset insurance challenges.

Government-Led Options

Information sharing. In the past NASA has engaged with insurers to help them better understand risks of space operations.⁵ Multiple stakeholders speculated that, at some point, similar engagement might help CLD providers by reducing the perceived risk of on-orbit operations. NASA may be particularly helpful in explaining how destinations' failure profiles differ from those of satellites, which could cause insurers to lower their premiums for the commissioning period.

Information sharing would be minimal cost other than time from the relevant experts, and may help reduce premiums to a certain extent. However, this option is unlikely to have any effect on the space pool capacity problem.

Government-backed insurance. Some insurers believed that some kind of government backing would likely be necessary if NASA wanted to significantly increase the size of the space insurance pool. One insurance broker was more sanguine, and believed that other pools might be accessed once providers were closer to launch and were genuinely seeking to purchase asset insurance.

⁵ For example, NASA provided risk data to help companies involved in private astronaut missions to ISS better understand risks of on-orbit operations.

The federal government could act as an insurer or reinsurer to supplement the existing space insurance pool and enable companies to purchase full asset insurance, though NASA does not currently have the authority to do this. One logical way to structure a program would be to allow companies that have purchased the maximum amount of asset insurance from the private sector to then buy additional insurance from the federal government at the same (or a slightly higher) rate.

With this structure, the federal government is not replacing the private sector, but supplementing it, and doing so in a way that does not subsidize the CLD providers. No other nations are known to have government backed insurance for space missions, so this would be a novel approach.

The federal government currently administers several insurance programs for high-risk endeavors. In most of these cases, Congress attempted to structure the programs to be budget neutral.

Under the Price-Anderson Nuclear Industries Indemnity Act, nuclear power plants that obtain the maximum amount of insurance available on the private market are not responsible for damages above that amount. Instead, the federal government pays using funds collected from the entire industry after an accident occurs.

The Terrorism Risk Insurance Act, administered by the Department of the Treasury, provides a federal reinsurance “backstop” in the event of a major terrorist action. This allowed insurers to continue offering policies that include coverage for terrorism. Payments made by the federal government can be recouped by Treasury through surcharges on insurance policies after the fact.

The National Flood Insurance Program, run by the Federal Emergency Management Agency (FEMA), offers flood insurance in communities that accept federal restrictions on building in flood hazard zones. Although the rates charged for this insurance were supposed to cover the program’s expected costs to make the program budget neutral, it now owes more than \$20B to the Federal government as a result of series of large hurricanes, including Katrina, Rita, and Sandy.

After the 9/11 terrorist attacks, the Department of Transportation’s Federal Aviation Administration’s (FAA) Aviation War Risk Insurance Program offered war risk insurance policies to airlines at rates no more than twice what the airlines were being charged prior to the attacks, effectively subsidizing insurance for the industry for a time. The program expired in 2014 after private insurance rates dropped low enough that most airlines canceled their government policies.

One important distinction between these programs and a program that would supplement the space insurance pool is that, in each of these non-space cases, the federal government has an entire industry (or, in the case of flood insurance, millions of policyholders) to recoup losses

from if an accident occurs. The entire industry eventually pays for losses that disproportionately impact a smaller subset of it. An insurance program covering LEO destinations would only have a limited number of participants, so while the federal government could charge actuarially-sound premiums, it would likely have no way of recouping losses from the rest of the industry if an accident occurs.⁶

Any insurance program would require legislative action, and government backing for insurance for commercial destinations would need buy-in from both the White house and Congress. It is unclear what agency would be willing or required to take on such a role and such a decision may be influenced by human spaceflight regulatory responsibilities. Should the regulation of human spaceflight vehicles on-orbit be given to FAA, as currently proposed by the White House, then the FAA could be asked draw on their expertise with regard to terrorism insurance for aircraft to develop an insurance program for CLDs.

The benefit of this type of program is that it directly addresses the issue some CLD providers have most complained about – not being able to obtain full asset insurance – without necessarily having a budgetary cost. As noted above, however, getting Executive and Legislative branch support is a challenge, and there may be other options for addressing this issue (see below).

Industry-Led Options

Self-insurance. Providers can avoid these asset insurance challenges by fully or partially self-insuring – accepting the risk of asset damage or loss. Self-insurance is common in the space industry, especially with companies that are either primarily funded by billionaires or are start-ups that would simply go bankrupt if faced with a catastrophic loss. While risky, self-insurance may give a provider an advantage over competitors that need to incorporate insurance costs into their pricing.

A related strategy would be to buy whatever asset insurance is available at a reasonable rate and accept the remaining risk. While \$500M of asset insurance would likely not be enough to replace an asset in the event of a catastrophic accident, it would presumably cover the cost of less serious equipment failures and cushion the blow of a bigger loss.

Incremental Build-Out: Another strategy that can help overcome the limited pool of insurance issue would be to launch the station in segments, each of which might be closer in total value to the available pool of space insurance. Providers who take this approach might construct a station of multiple modules each of which might be close to the expected available \$400-700M. This strategy would allow for each individual element to potentially be fully insured for launch sequentially.

⁶ This assumes that the government would not charge the rest of the space industry to cover losses to commercial LEO destinations, as such a proposal would likely provoke fierce opposition from the space industry as a whole.

This design choice might increase overall costs, especially when the expense of additional launches is included. It also does not address the risk of catastrophic loss in orbit after elements are combined.

Increased prices to pay for insurance: If providers are not able to self-insure or fully insure their assets using their incremental build-out options, they can address this issue by raising the prices that they charge their customers, including NASA, to cover the expected increased costs of insurance. As mentioned above, this may put those providers at a relative pricing disadvantage relative to providers who self-insure or do incremental build-outs, however, this is also only one pricing vector amongst many other elements related to CLDs.

Ground spares. Providers could produce critical ground spares while manufacturing their assets, which would make it faster and cheaper to respond to system failures regardless of how much asset insurance is available. This option could result in higher costs being charged to NASA and other customers to cover the additional expenditures on spares.

Cross-insurance line collaboration. Assuming that providers really are willing to pay asset insurance premiums that accurately reflect the expected probabilistic loss, the underlying cause of the capacity problem may be that destinations are a new class of asset that does not fit neatly within any one of the existing insurance lines of business.

The natural assumption has been that destinations should be covered as part of insurers' space lines of business, which have experience evaluating spacecraft. Because destinations could wind up being an order of magnitude more valuable than typical satellites and launch vehicles, and because they will have people living and working on them for extended periods of time, it may make just as much sense for them to be covered, at least in part, by other, larger, lines of business that contain other, more expensive, human-staffed assets, such as deep sea oil rigs or even skyscrapers.

One insurance broker has stated that their company had just started investigating whether it can combine the expertise and capital of multiple insurance lines to offer more asset insurance coverage to destination clients. With time and encouragement, it is possible that other space insurers could similarly pull in capital and expertise from their non-space colleagues to address the capacity issue.

A side benefit of this type of cross-line of business collaboration is that it could potentially reduce premium rates as well; the non-space insurance pools have presumably not been impacted by the recent string of satellite failures.

Asset Insurance Summary

While there are legitimate asset insurance challenges, there is some evidence that the private sector will be able to address them without substantial government assistance, and regardless,

the particular approach towards asset insurance by each provider is part and parcel of their competitive market offering. Cross-insurance line of business coordination in particular has promise because it could lead to insurers being able to offer full asset insurance coverage at a reasonable price. This will likely take time for insurers to arrange, and it is not certain that enough of them will make the effort, but any likely CLD launch is still several years away, so both the providers and the space insurance ecosystem have time to explore options.

NASA's best approach in the near-term may be to encourage the industry to pursue these innovative industry-led insurance options, while being ready to offer information about its own experience operating LEO destinations if requested.

Liability Insurance

Liability Insurance Findings

Finding: CLD Providers' primary concern relating to liability issues is the possibility that an accident could result in an enormous judgment against them that would bankrupt their company.

Providers have options to reduce their exposure to legal judgments resulting from on-orbit accidents.⁷ Cross-waiver regimes and consents to risk, where parties involved in a space activity agree to hold each other harmless should something go wrong, are common in the industry (and legally required in some cases). Liability insurance can also be obtained, which would at least partially cover most claims against providers.

These measures can lower providers' exposure to large judgments, but do not eliminate it. Most cross-waiver regimes have gaps⁸ and there are cases where consents to risk are either unavailable or uncertain. Liability insurance typically has a cap on the damages the insurer will pay on behalf of the insured; \$100M was mentioned as a possible cap for a destination liability insurance policy.

The fear that was consistently expressed by providers and insurers was that a destination venture may be bankrupted if a fatal accident happened to one or more of its passengers and a "billion-dollar plus" judgment was entered against the venture. Providers and insurers frequently recommended some kind of cap on damages to prevent such an occurrence. The Commercial Space Launch Act's (CSLA) limitations on liability for launch providers were often brought up as a helpful model, but as of present they do not extend to on-orbit CLD operations.

⁷ Most stakeholders were less concerned about liability arising from accidents during launch because such accidents would presumably be the fault of the launch provider, and because the Commercial Space Launch Act and other federal and state legislation limit launch-related claims.

⁸ "Gaps" in this context means that there are potential parties to a lawsuit that are not prevented by the cross-waiver regime from suing each other.

It should be noted that despite these fears, the potential for a large adverse judgment was not enough to stop any of the providers from moving forward with their projects, or to prevent insurers from offering insurance. It has also not stopped non-government orbital human spaceflight projects from moving forward. Moreover, established companies seemed to express more concern about the reputational damage caused by a fatal accident than the financial loss due to lawsuits.

NASA recently participated in an interagency effort to propose an effective regulatory regime for on-orbit activities with the Administration releasing its recommendations on November 15, 2023. This proposed legislation does not provide or require insurance, waiver, or indemnification. The proposed legislation says that the FAA can consider these items, but it should not be assumed that the current CSLA liability regime would be extended even if the legislation is passed and the FAA received the authorities therein.

The Department of Transportation's Federal Aviation Administration (FAA) currently has authority to oversee commercial human spaceflight during launch and re-entry. If the Administration's proposal is enacted, it will similarly authorize and supervise commercial human spaceflight in orbit as well.

Within the CLD stakeholder community, there appears to be a general consensus that issues relating to liability for accidents between launch and reentry during human spaceflight missions would eventually need to be addressed by whichever agency Congress eventually delegates on-orbit authority to (FAA, if the Administration's proposal is adopted).

Finding: There are several unresolved legal issues relating to the rights and responsibilities of providers and their passengers that are making it difficult for insurers and providers to evaluate future liability risks.

During the study, insurers often mentioned that the uncertain legal environment for commercial destinations made it difficult for them to accurately evaluate those destinations' liability risks. This, in turn, affected what kind of insurance they could offer and at what price.

The legal uncertainties that troubled insurers and providers fit into three categories.

- *Federal regulation and oversight.* Congress is still debating how on-orbit activities should be authorized and supervised. It is unclear if the CSLA liability and insurance regime will be modified or extended to cover activity in orbit. Current moratorium on commercial human spaceflight regulation also adds to uncertainty.
- *Legal status of waivers of claims.* Waivers of claims or implied consents to risk made by private astronauts may not be enforced by courts. It is unclear whether destinations will be able to implement effective cross-waiver regimes to prevent the proliferation of lawsuits in the event of an accident.
- *International complications.* The ISS Intergovernmental Agreement (IGA) was commonly referred to as an excellent model for using reciprocal waivers of claims to minimize international legal disputes. There is uncertainty, however, as to how to extend that

model to commercial destinations – or even if it can be extended - and about how courts would resolve disputes involving multinational ventures in space in general.

While interviewees expressed concern about these liability insurance issues, they were generally viewed as longer-term problems that were even more outside of NASA’s purview than the asset insurance issues.

Liability Insurance Summary

Most of the issues providers and insurers raised relating to liability, claims, and waivers for human spaceflight participants thus appear to be best addressed by FAA. NASA could advise providers to brief FAA about their concerns or consult with FAA directly as a courtesy.

There appears to be little NASA can do now to fully resolve the complex financial and legal issues that arise from commercial space ventures involving a new market with participants from multiple countries. The insurance market capacity does not yet exist and NASA lacks the legislative authority to resolve the issue directly. NASA can continue to encourage efforts by providers to pursue solutions and to encourage the space law community to better understand how international space law might apply to LEO destinations.

Conclusion and Next Steps

While there are legitimate uncertainties and questions still open related to insurance for CLDs – both for asset insurance and liability insurance – it is still early in the development of the relevant architectural concepts, business, and regulatory regimes, and there is a reasonable likelihood that the private sector will be able to address some of the challenges without substantial government action.

For asset insurance, while there are real challenges imposed by the current limited space insurance pool available, there are opportunities to expand that pool through the combined efforts of providers and insurance brokers to engage other insurance pools. Some providers may simply elect not to insure their asset, which is a legitimate business strategy.

Providers’ fears about the potential for large liability judgments to bankrupt their ventures are similarly genuine, but perhaps premature. The Executive and Legislative branches are just beginning to write the laws and rules governing commercial human spaceflight in orbit.

NASA itself should continue to monitor these issues, and provide information about its experiences operating LEO destinations as needed in the years ahead in order to assist with the market setting appropriately reasonable rates, in particular related to on-orbit operations.