GLOBAL RISK INTEL

Special Report

FORECASTING FUTURE SPACE RISKS: ENVIRONMENTAL, COMMERCIAL, AND MILITARY ASPECTS

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SPECIAL REPORT

Global Risk Intelligence

OCTOBER 26, 2018

Washington, D.C. · London · Singapore

www.globalriskintel.com

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Summary

This Special Report examines forthcoming industry issues related to space. Environmental risks are addressed, which covers space debris and its potential effects on the Earth as well as its surrounding atmosphere. Commercial risks are then covered, in which space tourism, mining, and other activities are mentioned as well as a preview to future power competition in the international system. Specific aspect of militarization are subsequently observed, which leads to related research resulting in Unmanned Space Vehicles and the furthering of autonomous systems. Select recommendations, key priorities, and future extrapolations conclude the report.

TAGS: AUTONOMOUS SYSTEMS, DEFENSE, DRONE, DRONES, ENVIRONMENT, GOVERNMENT, INTELLIGENCE, INTERNATIONAL AFFAIRS, INTERNATIONAL POLITICS, INTERNATIONAL RELATIONS, MILITARY, POLITICS, RISK, SECURITY, SPACE, UNMANNED SPACE VEHICLE, USV, DEFENSE AND SECURITY, GOVERNMENT AND INTERNATIONAL AFFAIRS.

List of Abbreviations:

GPS	**Global Positioning System**
ICJ	**International Court of Justice**
ISS	**International Space Station**
UNSC	**United Nations Security Council**
US/USA	**United States/United States of America**
USAF	**United States Air Force**
USN	**United States Navy**
USV	**Unmanned Space Vehicle**
WMD	**Weapon(s) of Mass Destruction**

Introduction

Space, long considered to be the final frontier, is no longer the foreboding void it used to be. It is very much the present and a domain that has been effectively integrated into the global economy for decades. Space-based technologies such as Global Positioning System (GPS) provide the backbone of modern navigational systems. Communications satellites relay messages from all over the world. Reconnaissance satellites enable the tracking of hurricanes and other dangerous weather phenomena, allowing for crisis responses that save lives.

Further technological advances will only deepen our reliance on space. The rollout of 5G wireless internet will depend in part on effective satellite coverage. Technologies such as self-driving cars and smart cities will in turn depend on 5G internet to perform effectively. GPS will be a necessity for self-driving cars, and will likely be used to help calibrate transactions for digital currency and other blockchain technologies in much the same way that it corrects the timing of conventional banking transactions at present. As drone technology develops, communications systems will be called upon to send relay information to unmanned systems working in conjunction around the world. All of these technologies will rely on the uninterrupted functioning of satellites in order to operate at maximum efficiency.

The development of space is not only a key piece of the puzzle in ensuring the implementation of technological advancements on earth, however. Space will be an environment for considerable scientific study as well. While we have some understanding as to the effects of space habitation on human biology, there is still a slew of information yet to be discovered. Such knowledge will be key to future efforts to develop bases on both the moon and on Mars, where environmental factors such as radiation and gravity will have serious impact on human health and functioning. An understanding of how to combat these factors will be necessary for any sustained extraplanetary mission, and could also lead to new approaches in treating disease and in mitigating the effects of aging. Furthermore, the study of viruses and bacteria from the upper atmosphere and

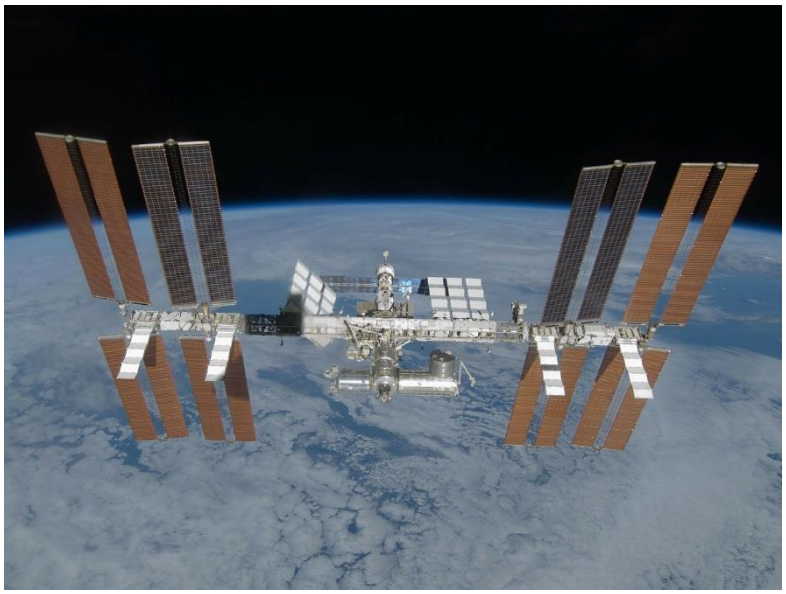
beyond will allow for a greater understanding of these organisms and will have downstream affects in biology, genetics, and medicine.

Finally, space offers massive potential for economic development as well. Increased intensity of solar radiation at the highest levels of the atmosphere allow for the possibility of massive solar power generation. If a reliable solution were developed for transporting that energy back down to earth, this could serve as an incredibly efficient form of energy production. Furthermore, organizations such as SpaceX, Blue Origin, and Virgin Galactic are for now focusing on space tourism, but the logistical and technological systems they are building provide a starting point for developing the sort of space transportation infrastructure that might one day allow for the shipping of materials into extraplanetary space as well as the retrieval of minerals from far reaches of the solar system. Not only might ventures like these play an important part in the transportation of material and personnel for space stations and lunar bases, but they offer a glimpse at the infrastructure that will one day be used for bringing in valuable minerals and other products of space mining operations. Asteroid mining has the potential to be a trillion-dollar industry, and the erection of reliable space transportation systems is a step towards making it a reality.

The future of space is indeed bright. However, its potential for commercial and scientific benefits is partnered with a wealth of opportunity for military applications. It is the military potential for space-based assets that has intensified the competition for space among the leading space-faring nations, and this competition is rapidly increasing the level of risk in what is already a difficult and inhospitable operating environment. It is likely that space will become an increasingly-contested environment as political tensions on the Earth's surface work their way up to the highest reaches of the atmosphere.

Environmental Risks

However, while the opening up of space provides for tremendous commercial and scientific opportunity, the domain is a hazardous operating environment. Not only is the steady accumulation of debris increasing the chances of dangerous accidents, but the environment itself is one to which humans are almost completely unsuited. Any defect or damage in an artificial environment like the International Space Station (ISS) can lead to the deaths of all those aboard. This delicacy constitutes a key downside of stationing humans in outer space. Serious efforts to develop space for commercial, scientific, or military purposes will have to bear in mind the difficulties of sustaining human life in this environment and weight the advantages against those provided by further satellites and future unmanned systems.



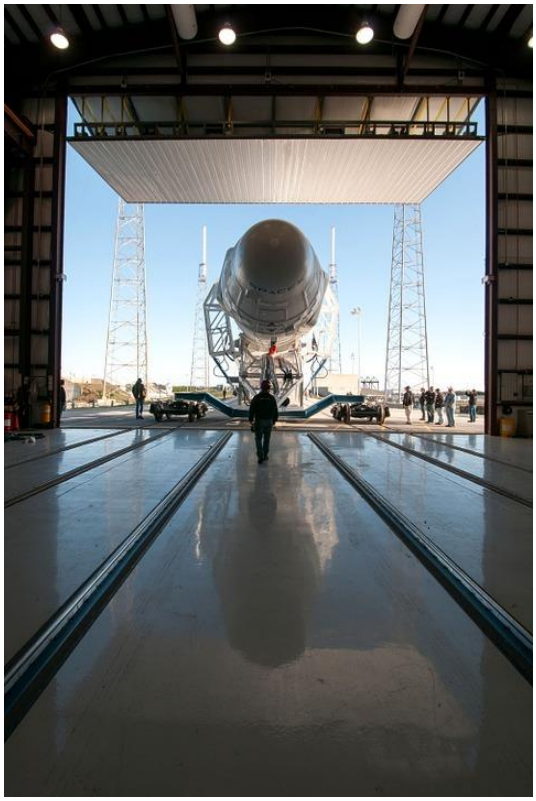
For those circumstances in which human presence makes sense, however, the matter of sufficiently-trained personnel arises. While industries providing services in private security or flying aircraft can draw on the experience of those who have honed their craft in the government sector, the pool of retired astronauts is miniscule in comparison. This lack of quality human capital is another hurdle that will need to be overcome by those seeking to exploit the space domain's potential for economic enrichment. To overcome this obstacle, astronauts must be loaned from willing governments, trained in higher numbers, or substituted in their duties by autonomous systems. Given enough actors in the domain, some number of spacefaring organizations will invest in unmanned systems to perform the bulk of their operations.

Also worth mentioning is the degree to which space debris could impact operations in earth's orbit. Small, dense chunks of former satellites, space stations, or other devices are steadily increasing in numbers. These pieces of material are liabilities that have already smashed into satellites and other equipment, and will continue to do so in the future. While no human casualties have resulted from these debris showers, a continued human presence in outer space will

guarantee that such an incident is an inevitability. Recent damage on the ISS is thought have been caused by a collision with such debris. The damage in question consisted of a small hole found in the hull, leading to a drop in air pressure. Impact with larger, denser debris could have lethal effects. It is as of yet unclear as to how exactly the hole was formed, though other explanations, such as deliberate sabotage, also provide a glimpse into potential future risks for operating in a space environment.

Commercial Risks

Historical trends allow for a testable model as to how the development of space will play out. The past 500 years have seen the rise of the maritime empires inclusive of the Portuguese, Dutch, Venetians, and British. These empires were built by those who with government sanction set off for distant worlds armed with the most advanced technologies of the time to build commercial networks and make their fortunes. With these fortune-seekers came the need for security, communication, and eventually political integration. A similar pattern is likely to emerge with the development of space travel. Companies like SpaceX, for instance, take in significant revenues from the United States (US) government. It is a strong possibility that organizations predicated on this model will do much of the heavy-lifting to develop the near-Earth infrastructure that will serve as a base for deeper exploration.



It is not likely that the model will be an exact match. It is unlikely that the US, China, or Russia will sanction some sort of lunar "East India Company". However, in practice, the result will not be too different, with the particulars of legal sanction and corporate governance differing based on the entity and the national affiliation. Certain countries already allow for private companies to legally own any resources they might find on asteroids that they claim. Luxembourg is one such nation, but perhaps more importantly, the US is as well. The US Space Act of 2015 allows for US citizens to lay claim to any resources they extract in the process

of engaging in commercial activity. This legal justification provides obvious cover for any potential space mining initiatives. But, there is some doubt as to whether this provision, enacted into US law, would be recognized under international law, which states that "celestial bodies" are to be used for the "benefit of all countries". If this discrepancy is not effectively addressed, then the first successful space mining operation is likely to trigger a serious legal battle on the international stage.

Such an occurrence would likely be unsuccessful, however. The enforcement of any case tried in the International Court of Justice (ICJ), where such a dispute could be debated, can be vetoed by any permanent member of the United Nations Security Council (UNSC). Given that the US has a keen interest in space mining and is likely to be a future hub of such activity, it is likely to defend its position in a such case, which all but guarantees that the US will veto any prohibitions on space mining operations. Space mining, despite being a *de jure* violation of international law is *de facto* almost certainly in the clear.

While only US citizens are covered by the 2015 Space Act, there is no reason why it might not be adjusted in the future to allow for foreign nationals flying a US flag to pay taxes to the US. In addition, other countries, eager to join in might adopt conventions similar to the "open registry" system found in maritime law, in which actors are free to register their ships in places like Panama, Liberia, or the Marshall Islands despite having no apparent connection to any of those locations. This allows corporations and individuals to pick and choose which legal system they would prefer to be subject to. This system has been heavily criticized and it shows the convolutions that could result if the US, Luxembourg, or any other country were to use similar methods to seize a portion of the future markets that will emerge in space.

If possible, this would be an extreme case though. Nonetheless, the combination of an open registry with the right to excavate water or valuable minerals is a potent legal enticement. Given

that the expertise required to successfully extract resources from asteroids or other celestial bodies will be limited to sophisticated corporations based out of technologically-advanced countries, it might very well be the case that foreign countries seeking to develop their own space mining companies will employ American corporations to do the heavy lifting in much the same way that American oil and gas companies operate in numerous countries all around the world.

However the legal and corporate aspects of space might ensue, it is guaranteed that the US will be a key player and very likely to be the dominant one. To this end, recent legislation has allowed for the opening up of spaceports and further investment in space capabilities will increase in the coming years. The US has interests in space beyond economic aspects however and other recent events, most notably the creation of the US Space Force, signal a more serious engagement with the military potential of space. Previous responsibilities for space operations had been dispersed across the military, mostly with the United States Air Force (USAF) and the United States Navy (USN), and the consolidation of space operations into one branch will be necessary as great power competition with China and Russia necessitate engagement in Earth's orbit.

Strategic and Military Risks

From a geopolitical perspective, space transportation lanes will be a strategic nexus of space activities in much the same way as sea lanes have been strategic choke points over the past several centuries. Sea lanes allowed for the cheaper and easy transportation of goods and people for both commercial and military purposes. Battles waged for control over them shaped the outcomes of great power conflicts and defined the course of modern history. The same principle will apply for control of satellite lanes and will in the very far future apply to control of interplanetary navigational routes.

Just as Great Britain relied on its control of the sea to maintain its empire, so too are we likely to see a space power enforce control over space

lanes to achieve a strategic advantage. As of yet, it is unclear whether it will be the US, China, Russia or some other power that will seize this newfound position. While the US is the dominant actor in space at present time, it is by no means the only one and the rise of other powerful actors has made the space domain a crucial arena of strategic competition. Geopolitical tensions on Earth will thus play out in space and the current rise of great power competition is dramatically altering the risk landscape in an arena which was previously an area of international co-operation. A significant dynamic in this competition is the relationship between the US and China. The rivalry between the two has escalated to sentiments analogous to hostility in recent years, playing out through mutual tariffs, naval maneuvers in the South China Sea, and the building of military bases in close proximity to those of the other[1]. Therefore, it is inevitable that this strategic competition will take place in space as well on the assumption that current economic trajectories of both countries facilitating space research will continue.

Military build-up in space is theoretically banned under the terms of the 1967 Outer Space Treaty. However, the treaty proper only applies to the placement of Weapons of Mass Destruction (WMDs) in orbit or on celestial bodies. Anti-satellite missiles, for instance, are not prohibited by this treaty despite their clear use as a means by which to project military force into space. The US, China, and Russia have all tested such missiles and it is likely that the usage of such hardware would be deployed in the event of a serious conflict.

Additionally, because the treaty only bans the placement of WMDs in orbit, weapons of more ordinary destruction are effectively unaddressed. Autonomous spacecraft capable of attacking other platforms are a very real possibility. In a recent case, a piece of unidentified debris labelled Object 2014-28E turned out to be capable of controlled movement. It was later discovered that 2014-28E was in fact a Russian spacecraft and there are fears that it is tied to a Russian satellite-killer program. It is thought that China is building similar systems as well, in order to be able to knock out enemy reconnaissance and communications ability in the event of a future war.

Furthermore, because kinetic weapons are not classified as a WMD, which is a classification that categorizes weapons predicated on chemical, biological, or radiological mechanisms, even kinetic weapons systems capable of causing significant destruction are effectively unaddressed.

[1] THE CHINESE FORMALLY OPENED ITS FIRST OFFICIAL OVERSEAS MILITARY BASE IN AUGUST 2017. LOCATED IN DJIBOUTI, THE BASE SITS AT A KEY STRATEGIC LOCATION ON THE RED SEA AND IS ONLY A FEW MILES AWAY FROM AN AMERICAN MILITARY BASE THAT SERVES AS A HUB FOR NAVAL AND AERIAL OPERATIONS IN THE HORN OF AFRICA.

Orbital bombardment systems, colloquially referred to as "Rods from God", which would work by dropping massive tungsten rods from orbit could cause havoc on the scale of small nuclear detonations, but without the fallout or environmental effects, though the international response to such a bombardment would nonetheless still be considerable. While the astronomical costs of putting 14-ton objects in space makes the system completely uneconomical, a nation with sufficient resources might still be tempted to build such systems anyway as a *force majeure*-style deterrent of comparable effectiveness to a nuclear deterrent. While the only nations with the potential to pull this off in the foreseeable future are those which already possess a nuclear deterrent, innovations in fuel efficiency and other breakthroughs in space transportation might lead less sophisticated actors to feel that they have a chance at build and deploy such devices.

However, in the short-term it will remain cheaper and more effective to deploy missiles to off-earth platforms. The US military has expressed interest in doing such a thing as a possible countermeasure against Chinese hypersonic missiles. The placing of anti-missile systems in space allows for a more rapid response to detected attacks and so the logic of competition will compel actors such as the US (and subsequently, its adversaries) to erect such defenses. Whether this will then compel all such actors to put missiles in orbit to avoid detection by these sorts of defenses is as of yet undecided, but in the absence of enforceable treaties against such actions, such an occurrence is likely.

It must be taken into account that these capabilities are thought to be limited to those countries that already possess serious space capabilities. This pool is effectively limited to Russia, China, and the US for now, though other countries with an interest in the space domain, like Israel or India, might develop such systems by this point in the future and add further volatility to the operating environment in space. The accumulation of satellites, debris, and military hardware will slowly increase the odds of the sort of accident or miscalculation that can lead to an international incident or worse. If sufficient military hardware is deployed to space, the situation will inevitably

arise in which an excuse is found for its use. This could prove catastrophic both on Earth and its surrounding atmosphere.

Unmanned Space Vehicles and Autonomous Systems

Unmanned technology has a key role to play in the development of space, especially with the involvement and shift towards autonomous systems. As mentioned before, the inhospitable nature of space makes it extremely costly to both construct and maintain spacecraft as well as satellites, in addition to a conceptualized livable human environment. In the meanwhile, astronauts are required to endure years of training and a rigorous selection process. Such hurdles provide hefty impediments against any possible increase in the number of humans in space, signifying that further mechanical assistance is needed. Hence, Unmanned Space Vehicles (USVs) and related technologies are likely to be the initiating sparks in the development of a new era space race for both economic and military purposes.

Drone systems based in space could perform reconnaissance much as satellites do, though for this function smaller, more efficient satellites might be the tool of choice. A satellite meant to convey radio signals can be built and used with less difficulty than a mobile satellite-killer drone disguised as a television satellite and hidden until the opportune moment. The advantage of more mobile systems is the enhanced mobility, the disadvantage is that movement requires fuel, which requires space and limits the effective lifespan of such a tool. However, the same equipment used for maintenance and repair can also be used for manipulation and sabotage. Satellite-killer devices might even be built primarily as maintenance devices, being used mostly to fix malfunctioning satellites and retire those that no longer serve their purpose. These maintenance drones could then be used in the event of war to attack target satellites or even in the event of an uneasy peace to disrupt enemy spy satellites. While these systems would be more complicated, more expensive,

and would likely need more direct involvement than merely deploying anti-satellite missiles to orbit, they have an element of surreptitiousness that large missiles lack and so will likely be deployed for clandestine purposes. Their placement in space would pose a risk to any satellites put in orbit, not just military ones.

Conclusion

Space has too much economic and commercial potential to ignore. The global economic system is already reliant on space-based technologies like GPS and satellite communications. This dependence will only grow with the development of more advanced technologies, and in time, entirely new industries such as asteroid mining will become massive economic sectors. Current political and legal structures are either active impetuses for this development, or impotent checks on the process. The global economy will inevitably become a solar economy with a presence on Earth, moon, and other celestial bodies. Control of transportation lanes, for both orbital and extra-orbital spacecraft, will be of importance to numerous actors, including but not limited to shipping and logistics corporations, communications providers, private security firms, and national militaries. All of these actors will involve themselves in the space domain, though it will almost certainly be national militaries that will most drive risk factors in the arena.

The militarization of space will be a deep driver of risk in the sector. Space-focused weapons will pose a hazard to satellites and other space objects, and space-based weapons have the potential to dramatically alter the strategic balance on earth. The competition for control of space will not just be a reflection of strategic competition on earth, it will also impact it significantly. The actor who manages to maintain space superiority will have a warfighting advantage with heft at least equal to and possibly greater than that of air superiority. All current actors in space are thus pursuing further space capabilities and newcomers are also likely to acquire them as well. Whether

the logic of deterrence will win out or whether the appeal of a decisive "first-strike" will triumph, competition in and for space is likely to escalate great power competition, which will in turn affect the risk environment on Earth's surface.

Space has the potential to massively elevate the human experience, but it also offers new ways to unleash considerable destruction. Managing these two outcomes will be a key priority of the coming century, because either way, the consequences are almost unimaginable.

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