

Space Products and Space-Made Products – Different Views on Space Manufacturing in Space and Patent Law

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In-Space Manufacturing (ISM) is a form of space activity that assumes the possibility of manufacturing, processing, and assembling products that use one or both of the following key elements: a) extraterrestrial raw materials as the basis for their production in part or in whole; b) natural phenomena and conditions occurring in extraterrestrial environments, such as microgravity, extreme temperatures or higher vacuum levels. This does not preclude the use of ISM terminology for production that does not use either raw materials or extraterrestrial conditions, but is production that occurs on board or with the use of a space object. For this reason, space production will come into contact with activities such as space mining or the use of space resources in-situ (ISRU), On-Orbit Servicing (OOS), or active disposal of space debris (Active Debris Removal, ADR), and over time will be intertwined with other activities in space. The subject matter of this paper is the term „space product”. This term is most often used, apart from legal terminology, for products based on research carried out in space, adapted for their possible introduction into economic circulation (such as fiber optics, cultured organs, metal alloys, ready-made parts and construction elements for satellites and surface stations). Legal considerations regarding the space product focus on two basic issues – first, the applicability of patent protection on board the facilities where production would take place; secondly, the legal status of a space product that would be located outside the manufacturing or assembly facility. Therefore, the aim of this paper is to seek an answer to the question – to what extent do the products of space production coincide with the space products proposed in the literature? What are the consequences of treating them as separate institutions in space law like patent law? What is a possible solution to such a problem?

Keywords: space manufacturing, space product, space object, space resources, patent law.

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Introduction

In-Space Manufacturing (ISM) is a type of space activity that involves manufacturing products beyond Earth, within or with the use of purposefully designed space objects. It is also the field of manufacturing which utilizes the specific phenomena occurring in outer space and on celestial bodies, such as microgravity (Gaertner, 2016), a wide range of temperatures, natural vacuum, or natural resources, such as minerals or volatiles. Products of such activity are most commonly known by the term “space products,” and they are widely discussed in publications in the fields of engineering, materials sciences, or even economics. They, however, are not much discussed in the works concerning space law. On the other hand, space resources and their commodification and has been broadly and deeply discussed in works on space law, though more as a form of wealth than a basis of any production, construction of Off-World logistics. Thus, the discussions on the legality of space resource activities are more focused on then interpretation of Article II and VI of the Outer Space Treaty of 1967, the concept of Common Heritage of Humankind and possible adoption of the Moon Agreement of 1979 as customary law, as opposed to discussing the in-space use of space resources. Thus nearly completely ignoring the case for ISM as part of small-scale ISRU or larger, industrial scale space mining operations. We can assume that in the 1970s and 1980s the notion of “space factories,” or “space manufacturing facilities,” revolved around humans and machines producing commodities in microgravity within said factories, which were treated basically as space objects, no different in their international impact than artificial satellites. Thus it was assumed – that what happens on board a space object, stays on said space object, with no concern to the international community. Any regulations regarding such factories and their operations was left to the states parties to the OST, based on Article VI and VIII of said treaty. They were of no immediate concern to the international law community, and discussions surrounding their regulation can be correlated with the development of reusable launch vehicles (such as the STS program, or modern reusable rockets and vechicles). Therefore little to no progress was made in the last years regarding the regulatory aspects of ISM and its products, as they were both heavily tied to the reusable launch capabilities of developed nations, as well as their basic operations was not much different from other space satellites in Earth orbit.

However, products of space manufacturing, being the effects of the operations of a space object possessing manufacturing capacities, have not been properly discussed in law studies. There are two instances, where ISM products are being mentioned or discussed. These are “space products” and “space-made products.” The term “Space products” refers to products of space manufacturing in relation to commodities produced using features or phenomena such as microgravity, which are being manufactured onboard space objects, yet are not suitable, designed, or considered for use beyond the object or in the environment of outer space. They are mostly being used to discuss the problem of patent protection in space object operations and importations of manufactured goods from space or between space objects. The term “space-made products” refers to products of space manufacturing made for the use in outer space, and most notably, with the use of space resources. These are basically “objects manufactured in space,” as they possess similar legal recognition to classical space objects.

This work will distinguish between space products and space-made products while discussing their similarities, differences and problems with their possible overlapping, or lack of thereof.

Space objects and space-made products

A space object is an artificial, anthropogenic¹ device launched into outer space or landed on a celestial body that is used in a space activity. The institution of a space object is deeply tied to the basis of international space law, especially the 1967's Outer Space Treaty, the Liability Convention, and the registration convention. According to Article VI of the OST, state parties are responsible for the authorization and supervision of space activities carried out by government agencies and private entities (nationals). They also bear political responsibility for the actions carried out by their nationals or authorized activities. Space activities are being carried out using space objects, which according to Article VIII of the OST are considered quasiterritories of their State of registry. This status allows state parties to the treaty to retain jurisdiction and control over space objects they carry in their registry. It needs to be recalled that ownership of a space object is unaffected by either its presence in outer space or its return to Earth². That said, a space object is a form of an appendage or pseudopod of the State which have authorized its operation in outer space and carries it on its space registry, while extending its jurisdiction and control only to the physical limits of that space object.

The definition of a space object and its form depends on the law and practice of the State of registry or the State which first authorized its operation. There are several problems with maintaining a proper registry of all space objects launched or obtained via ownership change (Von der Dunk, 2017). Some of them stem from inefficient bureaucracy, lack of proper regulations or purposeful neglect on behalf of a state. The most frequent cases of lapse in registration are undisclosed "spy satellites" (Hecht, 2001), or commercial satellites whose registration has been changed on the basis of intergovernmental contracts or change of ownership via purchase by foreign entities (Nelson, 2018). According to Article 1 of both the Liability and respectively, the Registration conventions, space objects are defined as space objects, their components as well as their launchers and their respective components. National space regulations range from "any object" launch into outer space to every object designed for use in outer space and launched into outer space (Hearsey, 2012). There are instances where states do not have definitions of space objects, yet use specific terms like "space vehicle," "space station" or "Space satellite" (Cheng, 1997). The term "spacecraft" appears in the 1968 Rescue Agreement. To be more precise, it is the lawmaker and the proper administrative bodies which decide whether certain devices can be registered as space objects. It can become complicated when a state provides different administrative and legal provisions for satellites and space vehicles and how jurisdiction and control are being regarded within those devices. Registration of a space object is performed as an administrative act, which is considered the creation of a space object, even if such an object is already present in outer

¹ In order to avoid the use of terms like man-made or human-made the term anthropogenic is applied, as it is used not only in relation to the human hands which manufactured a device, but the originator of the lineage of a device. Thus space objects manufactured by machines, which in turn were manufactured by different machines, that were then made by humans are to be considered anthropogenic. The other case for the use of this term is that any "non-human artifacts" that would be found in outer space, as discussed by SETI and SETA researchers will not be considered a space object, nor will any such artifact be considered a "celestial body." This includes artificial structures of complex indigenous organisms found beyond Earth. Artificial structures created (by desing) by Terrestrial organisms brought to the surfaces of celestial bodies beyond Earth might be treated as space objects, if appropriate national laws allow for their registration as such.

² Needs to be clarified, that article VIII may be interpreted as considering all objects, even those not registered as space objects.

space or has not been launched yet (Jakhu et al., 2018). The legal consequences of establishing a space object by the State turns this artificial object into a closed quasi-territory, subject to national jurisdiction, regulation and control, within the expanse of *ius spatiale*. Similarly, the modules which comprise the International Space Station, according to the Intergovernmental Agreement of 1998 (IGA), should be registered with their respective States. Though because of the number of modules, and the requirements of coordination and integrating, the station is subject to the provisions of the IGA and subsequent rules and standards set by contracting states and partners. States who are party to the Artemis Accords are committed to cooperate on maintaining proper registration of space objects which are involved in the Artemis program (Section 7, 2020).

However, any extension of space activity may become troublesome when employing new elements to existing space objects and systems. Especially if said elements are being manufactured or constructed using space resources. It begs the question of whether an object manufactured in outer space, can be treated as a space object. Currently, there is no binding act of international space law that would settle this issue outright. On the other hand, as the international space law community lacks any consensus on the proper interpretation of Article II in regard to space resource operations, there is still a lack of clarity on whether the term “constructed” used in Article VIII of the OST allows for treating elements of the space installation produced from space resources as an integral part of the space object.

Addressing this concern, the Hague Workgroup has created the term “space-made product,” which is defined as: “a product made in outer space wholly or partially from space resources” (Building, 2019). Article 6 of their building blocks states, “The international framework should provide that States have jurisdiction and control over any space-made products used in the space resource activities for which they are responsible.” This institution of “space-made product” was introduced in order to allow state parties to the OST the relevant basis for retaining jurisdiction and control over objects and components produced with the use of space resources. Therefore, a space-made product, whether working as an independent unit or becoming an integral part of another space object, would have been treated in a similar manner as traditional space objects. However, a question ensues from the very start: is the status of such space-made product effective erga omnes? And if so, will the space object registry be suitable in order to place an object not launched from Earth but created on a celestial body and most importantly, from its resources? Additionally, there is the issue of such an object manufactured in space lacking a “launching state,” as it was mostly created in situ or no means of launching were involved in its transportation or assembly. Yet one’s space-made products, especially complete devices such as rovers, robots, launchers, tugs, or satellites, might pose a risk to other state parties space objects, if there is no liability attached to them. That is the problem of contemporary space regulations and states neglecting the issue of possible collision risk and mitigating it by not registering a space-made product as a space object, which has been launched or deployed from a space or lunar platform.

As far as space law is concerned – it is up to the state party to determine whether their regulations allow or prohibit space manufacturing activities, especially involving the creation of space objects beyond Earth. An example of such national regulation might be found in the proposed, though never passed, *American Space Commerce Free Enterprise act* (H.R.3610, 2019). Its provisions included the definition of a space object, among which we find an object manufactured in outer space. Given that the SPACE Act of 2015 introduced the right of US persons to search, mine and utilize space resources, it is not unreasonable to view space-

manufactured objects as being a product of utilization of space resources. The condition stated in the proposed law was that the object is able to operate autonomously, i.e. outside and without the aid of the object which has manufactured it or assigned it. Any product intended for internal operation or to be dependent and tied with the “mother” space object is not to be considered a space object on its own, but rather an equipment of the initial object.

This poses the issue of whether any such space-made products or space-manufactured objects are to be considered space objects in the same manner as classical space objects referred to in the canonical space treaties comprising the International Space Law. Other state parties to the treaties might object to treating space-made products and their counterparts as space objects in accordance with both the liability convention or registration convention, thus the application of the provision of article VIII of the OST to them. Yet the moment they are introduced into the national space object registry, the ability of other state parties to object to the registration of such objects is very limited. It is the separate treatment of space manufactured objects or space-made products from space objects which creates a legal divide and the basis for other state parties to object to the treating of them as if they were equivalent to space objects. It is this small difference that creates a bigger issue, which will be discussed later in this work.

Space products

A space product does not appear in any binding act of law. Rather it is a concept that is being discussed in works regarding space-based economy (Engelbert & Harper, 2022; In-Space, 2022), materials and life science in outer space (Seoane-Viaño et al., 2022), orbital manufacturing (Bi et al., 2022) and patent law (Burk, 1991). Its relations to space law are minuscule, as manufacturing of a space product falls under national provisions for authorization and supervision under article VI of the OST – as they mostly do not affect any other space object besides their manufacturing space factory (Abeyta, 2017). In the legal context, space products are mostly, if ever, discussed through the lens of applying patent law into activities carried out onboard space objects (Farnesi, 2019). As patent law has strong relations to technology, manufacturing, substances, processes, methods and apparatuses, or even software and organisms can be patentable subject matter, it is reasonable to assume that patent protection should apply to technologies used in outer space, within the confines of a space object.

Thus space products are mostly considered articles of manufacture that are being produced during the process of manufacturing in outer space, but are not destined to function outside of a space object or as a separate entity. Their main role in the legal discussions is limited to discussing how patent law applies to space objects and their quasi-territorial status, as artificial extension of State’s national laws (Opinion, 2021). This narrows down the majority of discussions on the application of national patent laws to space objects to the interpretation of their doctrines, case law and regulations through the scope of the limitations set by space law (both national and international) and the environment of outer space. This involves the problems of import, export, infringement, exhaustion, permissible repair, and self-replication of products and technologies which are embodiments of a patent-protected invention. Thus space products can more frequently be seen as means for discussing method patent’s infringement on board of a US-registered space object or if such products are even eligible for patent protection, as some argue that use of space resources might be the reason to reject a patent application for an invention. On the other hand, we do have patent examination policies

providing that obtaining a terrestrially producible substance, such as a protein crystal, by means of microgravity manufacturing might be eligible for patent, even if the terrestrially produced variant of the substance is already protected by patent (Seide, 2002).

Can a space product also constitute a space-made product?

Taking into account our previous considerations, it is reasonable to try to answer the question – can space products and space-made products be the same thing? While both are products of ISM activities, and they most certainly do overlap, they aren't (initially) the same. A space-made product can be a device, tool, filament, structural element, which does not need to be used outside of a space object which manufactured it. A space product can constitute the material basis of a space-made product, which by that point would also serve as a functional extension to a space object or an integral component of such. Space-made products can be transported down to Earth, while space products can remain onboard or be traded between objects and crews as equipment and supplies for onboard use only.

This intersection and overlap, however, has its distinctions. A space product might not be registered as a space object or a space-made product, the same way as a space-made product might not constitute an embodiment of a patented invention. That said, we need to keep in mind that a space object might constitute both a patentable subject matter, a patent-protected invention, as well as the territory where said patent can be protected according to national patent law. One of the best examples for that might be a light sail, sometimes called a solar sail. A particular variant of a light sail might be eligible for patent protection as a method or apparatus, while at the same time, it constitutes a component of a space object, which according to Art VIII of the OST, shall fall under the jurisdiction and control of the State of the registry. Thus a space object can become both the physical area of protection of a patented invention in outer space, as well as the embodiment of the protected invention. This leads us to assume that no matter what the actual diameters and shapes and embodiment of a protected invention takes, it is protected on the whole physical area which constitutes the space object, as if it was being made or used or sold on the soil of the State of registry. To reiterate, a patent-protected invention of which the embodiment is not larger than a 10cm cube is protected on the entirety of a 400m long space object – including its structure, interior and exterior. Thus while a single embodiment of a protected invention might fall under the exhaustion, if the purchase was made with the patent holder or its licensee, manufacture and use of additional embodiments of a similar device on said space object, without the consent of the patent holder, will constitute patent infringement. Furthermore, the same protection applies on every space object under the jurisdiction of the State of registry (Agi, 2022).

Yet the question remains as follows – can a space product also be a space-made product or to put it differently: Can products of ISM activities become space objects? And if not, what status shall they bear? As we have presented earlier in the paper, space products are not a concept recognized by space law, and space-made products are only a proposal for space law. While these two institutions can be used interchangeably in discussing ISRU, OSAM, ISM and other activities constituting what was once called “Space Industrialization,” as a matter of space law, those two will remain separate intersecting entities. There is no provision in international space law that would prohibit states authorizing ISM activities from recognizing extensions and additional components to their space objects as artificial objects and installations over which they would retain jurisdiction and control. Even if said objects and components were produced

with the use of extraterrestrial minerals or the use of microgravity. However, it is up to their national law to properly ascribe the title of Space objects to them. This is because national regulations on registering space objects can be at odds with other fields of law, such as patent law. Suppose a State party decides to authorize space manufacturing activities. In that case, their authorization does not equal the registration of any or every product manufactured as space objects in the space objects registry. This, in turn, creates a loophole for one's nationals or foreign entities to exploit.

The legal status of a space object conveys a special status that is effective *erga omnes*. Alternatives to "space object" which are not registered as one might not be able to successfully project States jurisdiction and control over the artificial quasi-territorial object in question. Thus if national law provides that national protection of patents in outer space only on space objects registered within that State, then the terms of patent protection do not apply on material objects which are not registered as space objects. And that, in consequence, provides potential national entities with an opportunity to make, use or sell a patented invention, which would be qualified as a space product or space-made product in our reasoning without infringing on protected patents. This is because, if taken literally, patent protection does not extend to artificial objects placed or manufactured and assembled in outer space, which are not registered as space objects in the national registry of space objects. State party may circumvent this conundrum by enacting national laws which would provide that such "non-space objects" are to be treated as if they were national territories or space objects for the purposes of enforcing patent law or administrative provisions relating to other provisions, such as export control.

However, the lack of proper registration or difference in practice, such as assuming that objects created by space objects are automatically treated new space objects, over which the State of registry of the space object serving as a "factory" or the mothership will further retain jurisdiction and control, may cause further complications or lack of certainty in space activities involving ISM and ISRU operations. Creating additional registries for "space-made objects" or space products that are destined to become components of future space objects only solves the problem on the national scale, or operational scale, if such registries were to become the staple of lunar operations under the future developments of the Artemis Accords. Yet non-Artemis States or blocks might refuse to recognize space-made products or space-manufactured objects as conveying the same rights and obligations as "conventional" space objects.

Space products remaining outside of space objects

There is another issue to the relation between space products, space-made products and space objects. If space products do not constitute space objects, as they are neither registered as such nor become space-made objects in accordance to provisions of national ISM/ISRU law, then what are they? What is their status within space law?

The problem with space products placed intentionally or accidentally outside of space objects they were produced at resides upon the limitation of the scope of international space law. International space law finds, but does not describe in detail: outer space; celestial bodies; objects launched into outer space or space objects; astronauts; installations.

While the Moon Agreement of 1979 did provide that equipment shall be treated as space objects in accordance with the Rescue Agreement and shall be returned to the rightful owner, the treaty has not reached much acceptance among spacefaring nations, and recently some parties have begun to withdraw from it. That is not to say that some of its provisions regarding

space objects cannot be reused in future space treaties or contractual acts of space law (like the ISS IGA or the Artemis Accords). However, contemporary space law will face a challenge with unregistered space products, be it tools, processed materials or articles of manufacture being left outside of their respected storage, operation or manufacturing facility. As they are neither considered space objects nor space-made products, their status becomes property. International space law won't recognize space products as something between a space object and a celestial body, the same way it does not recognize any form of real property in outer space. It does, however, recognize chattel and movables. A case can be made that Article VIII of OST applies to objects manufactured in outer space in a specific manner – it does not provide space products with the status of space objects, yet it clearly states that ownership of an object won't be affected by its presence in outer space or landing on Earth. This does imply that any personal rights towards movable property in civil law states as well as chattel in common law states remain unaffected by the sole fact that a space product was placed outside of a space object. Space products not being recognized as space objects do not carry over the jurisdiction and control of a state, especially on whose registered space object their production or manufacturing has occurred. Only their owner retains any rights and might even allow third-party rights to be attached to them. That however does not convey application of patent protection on space products which would otherwise comprise a working space object, but have been assembled outside the space object of their creation.

That State of affairs causes one to recall Article VI of the OST and rethink the whole concept of authorization and supervision. While private entities in outer space are bound to national laws of the State of registry and the State which authorizes their space activity, States need to either require strict reporting of any space products on board of their respective space objects or prohibit “production without authorization” (Tatsuzawa, 1988). In the case of manufacturing products that might constitute elements of components and of space objects it might be more reasonable that every instance of such manufacturing to require prior authorization and reporting afterwards. In the case of onboard tools and spares such reporting is not of much importance, and especially, when a state authorizes numerous manufacturing stations or crewed stations serving other purposes are provided with onboard manufacturing capabilities (like 3D printers). In the lack of any proper authorization and supervision over miniscule manufacturing activities, which might amount to creation of “no-man's space objects,” consequences of neglect can (legally) be dire.

As we understand, the “astronaut's hand” does is a means of space activity, it does not create or assert any right to the astronaut, especially to a non-registered artificial object found in outer space (Anderson, 2008). While states which apply the extraterritorial doctrine to national patent law, might view the use by an astronaut of a foreign or non-registered device in outer space as “beneficial use,” said space product might not be considered one nation's property by the of one national, covered in a space object which is his space-suit, by the act of physical contact or operation. It may be controversially viewed as an instance triggering Title 35 art 105 (Shoemaker, 1999). However, said paragraph only applies to space objects under jurisdiction and control, and the mentioned space product does not constitute a space object.

Conclusions

Space products and space-made products, although connected via technologies and the place of their creation, come to be different topics of discussing the legal aspects of space

industrialization. Both of them pose challenges to space law, although in different areas. While space-made products pose a challenge to the idea that only space objects can serve as a medium of space activity and be treated as an extension of jurisdiction and control, space products create a different set of problems for state parties and private owners. The most reasonable and responsible for state parties authorizing ISRU and ISM operations would be to provide a proper regulatory framework and registry for objects and items produced in outer space, it is clear that such regulations will require international consultations and harmonization down the line.

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