

# FENCES IN OUTER SPACE: RECOGNISING PROPERTY RIGHTS IN CELESTIAL BODIES AND NATURAL RESOURCES

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## ABSTRACT

*The major space law treaties, agreed during the Cold War era, do not protect property rights crucial to responsible mining in outer space. While the technology to mine valuable resources in outer space is developing rapidly, international space law impedes outer space mining. This article evaluates the current legal framework and suggests two ways to recognise property rights in celestial bodies. The first, is for space miners to create a spontaneous order that will recognise and enforce each other's quasi-legal property rights. The second, is for States to establish an International Space Authority that will grant mining leases. Further, this article recommends amending the Outer Space Treaty to clearly recognise property rights in resources extracted for commercial purposes.*

## I INTRODUCTION

In Robert Frost's poem 'Mending Wall', one character remarks, 'good fences make good neighbours'.<sup>1</sup> His observation still holds true wherever people are found, whether on Earth or in outer space. Companies such as Planetary Resources and Deep Space Industries are planning to mine asteroids for valuable resources including: platinum group metals, industrial metals, silicates and water.<sup>2</sup> However, international space law

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<sup>1</sup> Robert Frost, 'Mending Wall' in Louis Untermeyer (ed), *Modern American Poetry* (Harcourt, Brace and Howe, 1919).

<sup>2</sup> Accenture, *Courage or Capital: The Final Obstacles for Sustainable Asteroid Mining* (2015) Accenture Consulting, 2 <[https://www.accenture.com/us-en/insight-final-obstacles-for-sustainable-asteroid-mining?c=res\\_nrfy15tw\\_10000003&n=smc\\_0715](https://www.accenture.com/us-en/insight-final-obstacles-for-sustainable-asteroid-mining?c=res_nrfy15tw_10000003&n=smc_0715)>; Deep Space Industries, *Space Resources* (2015) <<http://deepspaceindustries.com/space-resources/>>.

currently does not provide sturdy fences for neighbours in outer space to mine asteroids and planets. To encourage responsible commercial development of outer space, the law should limit the notion of outer space as *res communis* – the community's shared property.<sup>3</sup> By clearly recognising and delineating property rights in celestial bodies and extracted resources, the law would provide certainty to pioneers of outer space mining.

This article explains how current international space law impedes commercial mining development by categorising outer space as *res communis*. It then analyses how the law affects the ability to mine celestial bodies and to own extracted natural resources. This article proposes two alternative approaches to recognising property rights in celestial bodies: first, allowing a spontaneous order to arise among space miners; or, second, creating an international space authority that would grant mining leases. In addition, this article recommends the protection of property rights in extracted resources. Finally, it explains how a clear recognition of property rights can benefit all countries.

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In 2015, Planetary Resources successfully launched and deployed a demonstration spacecraft to test its asteroid mining technology: Planetary Resources, 'Planetary Resources' First Spacecraft Deployed' (Press Release, 16 July 2015). <<http://www.planetaryresources.com/2015/07/planetary-resources-first-spacecraft-deployed/>>. Outer space mining could begin within two decades: Philip T Metzger et al, 'Affordable, Rapid Bootstrapping of the Space Industry and Solar System Civilization' (2013) 26(1) *Journal of Aerospace Engineering* 18.

<sup>3</sup> See Yun Zhao, 'An International Space Authority: A Governance Model for a Space Commercialization Regime' (2004) 30 *Journal of Space Law* 277, 280.

## II COMMERCIAL DEVELOPMENT AND THE NOTION OF *RES COMMUNIS*

Describing outer space as ‘the province of all mankind’,<sup>4</sup> the *Outer Space Treaty* (*OST*) recognises outer space as *res communis*. Under art I States are free to explore and use outer space and to access all areas of celestial bodies.<sup>5</sup> Under art II outer space including the Moon and other celestial bodies ‘is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means’.<sup>6</sup> Thus, States have no right to own outer space.

The historical context of the *OST* helps explain why its drafters designated outer space as *res communis*. The major space treaties, including the *OST*, were concluded during the Cold War when States were the only actors in outer space. The space powers and other States

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<sup>4</sup> *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, opened for signature 27 January 1967, 610 UNTS 205 (entered into force 10 October 1967) art I. Herein referred to as (‘the Treaty’).

<sup>5</sup> According to art I of the Treaty:

The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.

Outer space, including the Moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.

There shall be freedom of scientific investigation in outer space, including the Moon and other celestial bodies, and States shall facilitate and encourage international cooperation in such investigation.

<sup>6</sup> According to art II of the Treaty:

Outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.

sought to prevent each other from asserting exclusive and conflicting claims to outer space.<sup>7</sup> They were hardly concerned about encouraging commercial private development of outer space.<sup>8</sup>

The notion of *res communis* hinders responsible commercial mining by promoting the tragedy of the commons.<sup>9</sup> When people can freely access and use a community's shared property, each person can exploit its resources for his or her maximum benefit yet spread the cost of exploitation, including future costs, across all users.<sup>10</sup> Consequently, individuals have no incentive to minimise shared costs. In contrast, owners of private property have an incentive to exercise good stewardship over their property. An owner who poorly manages a property bears the cost of its declining value; conversely, an owner who improves the property to yield future benefits profits from its increased value.<sup>11</sup>

Further, the notion of *res communis* discourages responsible mining by allowing people to free-ride on other people's labour.<sup>12</sup> Suppose Astrum, Nauta and Metallicus are three people interested in mining. If Astrum conducts surveys and tests to find a lucrative asteroid and opens a mine site, Nauta and Metallicus can take a 'free ride' on Astrum's investment by going straight to the mine site and helping themselves as quickly as

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<sup>7</sup> Bin Cheng, 'The 1967 Space Treaty: Thirty Years On' (1997) 40 *Proceedings of the Colloquium on the Law of Outer Space* 17, 22; See also Benjamin David Landry, 'A Tragedy of the Anticommons: The Economic Inefficiencies of Space Law' (2012-13) 38 *Brooklyn Journal of International Law* 523, 528-31.

<sup>8</sup> Ezra J Reinstein, 'Owning Outer Space' (1999) 20 *Northwestern Journal of International Law & Business* 59, 62.

<sup>9</sup> See Garrett Hardin, 'The Tragedy of the Commons' (1968) 162 *Science* 1243.

<sup>10</sup> See Ricky J Lee, *Law and Regulation of Commercial Mining of Minerals in Outer Space* (Springer, 2012) 218.

<sup>11</sup> Ludwig von Mises, *Human Action: A Treatise on Economics* (Ludwig von Mises Institute, 1998) 651.

<sup>12</sup> See Michael A Heller, 'The Tragedy of the Anticommons: Property in the Transition from Marx to Markets' (1998) 111 *Harvard Law Review* 621, 624.

possible to unextracted minerals there. All three people would therefore have little incentive to plan sustainable, long-term mining.

Investors in Astrum's position seek clear, secure property rights in mine sites and extracted resources so that they can reap the rewards of their risk-taking ventures.<sup>13</sup> Thus, property rights would motivate investors to commit the large sums of money required for outer space mining.<sup>14</sup> Further, property rights would encourage companies to pursue sustainable development rather than reckless, short-term gain.

### III PROPERTY RIGHTS IN CELESTIAL BODIES

International space law is currently inadequate to protect the real property rights required for long-term mining development. Commentators generally agree that the *OST*'s notion of space as *res communis* prohibits all property rights in the Moon and other celestial bodies. The *travaux préparatoires* support this view.<sup>15</sup> Further, the *Moon Agreement* ('*MA*') expressly prohibits property rights in the Moon and other celestial bodies within the solar system, other than the Earth.<sup>16</sup>

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<sup>13</sup> Virgiliu Pop, *Who Owns the Moon? Extraterrestrial Aspects of Land and Mineral Resources Ownership* (Springer, 2009) 116; Francis Lyall and Paul B Larsen, *Space Law: A Treatise* (Ashgate Publishing, 2009) 196; Fabio Tronchetti, *The Exploitation of Natural Resources of the Moon and Other Celestial Bodies: A Proposal for a Legal Regime* (Martinus Nijhoff, 2009) 237.

<sup>14</sup> See President's Commission on Implementation of United States Space Exploration Policy, *A Journey to Inspire, Innovate, and Discover* (2004) 34 <<http://govinfo.library.unt.edu/moontomars/docs/M2MReportScreenFinal.pdf>>.

<sup>15</sup> Pop, above n 13, 64-5.

<sup>16</sup> *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*, opened for signature 5 December 1979, 1363 UNTS 3 (entered into force 11 July 1984).

### A *Private Appropriation and the Non-Appropriation Principle*

A few commentators argue that *OST* art II prohibits only ‘national appropriation’ and permits private appropriation. According to Gorove, the *OST* ‘appears to contain no prohibition regarding individual appropriation’.<sup>17</sup> Thus, an individual, a private association or an international organisation can lawfully appropriate any part of outer space, including celestial bodies.<sup>18</sup>

Most commentators, however, argue that the *OST* implicitly prohibits private appropriation. Cheng writes that outer space, like the high seas, belongs to no State and is not appropriable by States or their nationals.<sup>19</sup> There are three main reasons for this view.

First, ‘national appropriation’ includes appropriation by non-governmental entities. Under *OST* art VI, States are internationally responsible for ‘national activities’ in outer space, including activities by non-governmental entities. States must also authorise and supervise the activities of non-governmental entities. Consequently, States cannot license non-governmental entities to privately appropriate what cannot be publicly appropriated.<sup>20</sup> If a State were to authorise a non-governmental entity’s appropriation under art VI, the appropriation would constitute national appropriation ‘by any other means’, violating art II.<sup>21</sup>

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<sup>17</sup> Gorove S, 'Interpreting Article II of the Outer Space Treaty' (1968) 11 *Proceedings of the Colloquium on the Law of Outer Space* 40, 42.

<sup>18</sup> *Ibid.*

<sup>19</sup> Bin Cheng, 'The Commercial Development of Space: The Need for New Treaties' (1991) 19(1) *Journal of Space Law* 17, 22.

<sup>20</sup> P M Sterns, G H Stine and L I Tennen, 'Preliminary Jurisprudential Observations concerning Property Rights on the Moon and Other Celestial Bodies in the Commercial Space Age' (1996) 39 *Proceedings of the Colloquium on the Law of Outer Space* 50, 53.

<sup>21</sup> Pop, above n 13, 65; Lee, above n 10, 166-7.

Second, *OST* art I, and possibly customary law,<sup>22</sup> implicitly prohibit property rights by protecting freedom of access to all areas of celestial bodies.<sup>23</sup> Returning to the hypothetical scenario above, Astrum cannot be said to have property rights in the mine site: Astrum has no control over access to the site and cannot exclude others from it. Since control over access is unlawful under art I, property rights in celestial bodies cannot exist.

Third, *OST* art II implicitly prohibits property rights by prohibiting State sovereignty in outer space. According to Lee, art II prohibits only the exercise of sovereign rights and does not address property rights in celestial bodies.<sup>24</sup> Nevertheless, the international community generally considers that property rights require a superior authority to enforce them.<sup>25</sup> Since art II and perhaps customary law<sup>26</sup> prohibit State sovereignty, no property rights can exist.<sup>27</sup>

The *MA*, which has only 16 State parties and thus has limited binding legal value,<sup>28</sup> repeats the *OST*'s prohibition of national appropriation.<sup>29</sup> In

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<sup>22</sup> He Qizhi, 'The Outer Space Treaty in Perspective' (1997) 25 *Journal of Space Law* 93.

<sup>23</sup> Pop, above n 13, 65.

<sup>24</sup> Lee, above n 10, 179, 199.

<sup>25</sup> Francis Lyall and Paul B Larsen, above n 13, 184; Pop, above n 13, 66; C Q Christol, 'Article 2 of the 1967 Principles Treaty Revisited' (1984) 9 *Annals of Air and Space Law* 217, 222-4; Lee, above n 10, 199.

<sup>26</sup> Manfred Lachs, *The Law of Outer Space: An Experience in Contemporary Law-Making* (Martinus Nijhoff Publishers, first published 1972, 2010 ed) 42; Lee, above n 10, 171.

<sup>27</sup> Pop, above n 13, 66; F G von der Dunk et al, 'Surreal Estate: Addressing the Issue of 'Immovable Property Rights on the Moon'' (2004) 20 *Space Policy* 149, 153.

<sup>28</sup> United Nations Office for Disarmament Affairs, *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies* <<http://disarmament.un.org/treaties/t/moon>>.

<sup>29</sup> *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*, opened for signature 5 December 1979, 1363 UNTS 3 (entered into force 11 July 1984) art 11(2).

addition, *MA* art 11 explicitly prohibits creating and asserting property rights over areas of celestial bodies.<sup>30</sup> Subject to an international regime to be established under art 11(5), the surface and subsurface of celestial bodies shall not become property of any governmental or non-governmental entity.<sup>31</sup>

To protect their investment, miners would wish to control access to and use of the mine site.<sup>32</sup> Such control would breach *MA* art 11. It may also violate the following provisions of the *OST*:

- art I by denying freedom of access and use to other entities;
- art II by asserting exclusive access amounting to national appropriation; and
- art IX by not having due regard to other States' corresponding interests in access to the resources.<sup>33</sup>

As a result, the *OST* and *MA* impede commercial mining of celestial bodies.

### B *The Meaning of 'Celestial Body'*

According to Pop, if objects such as asteroids and comets are not 'celestial bodies', they will evade the non-appropriation principle.<sup>34</sup> Although the *OST* and *MA* refer to 'celestial bodies', they do not define the term.

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<sup>30</sup> See Cheng, above n 19, 22; Lee, above n 10, 199.

<sup>31</sup> *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*, opened for signature 5 December 1979, 1363 UNTS 3 (entered into force 11 July 1984) art 11(3).

<sup>32</sup> Lee, above n 10, 165.

<sup>33</sup> *Ibid* 196-7.

<sup>34</sup> Pop, above n 13, 50.



Defining ‘celestial bodies’ is an ‘extremely intricate’ issue.<sup>35</sup> As the scientific reclassification of Pluto illustrates, a scientific definition would continually change with astronomers’ taxonomy.<sup>36</sup> Consequently, commentators propose four kinds of definitions that use other criteria: human interest, size, control and function. Nevertheless, each definition suggested by commentators has both merits and shortcomings.<sup>37</sup>

In any case, the non-appropriation principle arguably applies to asteroids and comets. As De Man points out,<sup>38</sup> art II of the *OST* is worded broadly, covering ‘[o]uter space, including the Moon and other celestial bodies’. Outer space in a broad sense encompasses material phenomena that are not celestial bodies. Consequently, it may be prudent for space miners to assume that the non-appropriation principle governs all naturally occurring objects in space.

#### IV PROPERTY RIGHTS IN EXTRACTED RESOURCES

Real property rights in a mine site would be worthless to miners without personal property rights, specifically ownership, in the extracted natural resources themselves. Although the *OST* and *MA* prohibit appropriation

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<sup>35</sup> Ibid 58.

<sup>36</sup> Ph De Man, ‘The Commercial Exploitation of Outer Space and Celestial Bodies—A Functional Solution to the Natural Resource Challenge’ in Mark J Sundahl and V Gopalakrishnan (eds), *New Perspectives on Space Law* (International Institute of Space Law, 2011) 43, 46.

<sup>37</sup> For a discussion of the human interest definition, see Lee, above n 10, 190-1. For a discussion of the spatialist definition, see Pop, above n 13, 52. For discussions of the control definition, see Pop, above n 13, 54-5; Lee, above n 10, 189-91. For a discussion of the functional definition, see Pop, above n 13, 55-6. One drawback of the functional definition is that it appears to assume an object can only be used in one way at any given time.

<sup>38</sup> See De Man, above n 36, 53.

of celestial bodies, they arguably allow commercial appropriation of natural resources extracted from celestial bodies.

#### A *Appropriation of Extracted Resources under the OST*

A few commentators argue that the *OST* prohibits appropriation of natural resources. Lafferranderie states that the *OST* does not distinguish between outer space and its natural resources.<sup>39</sup> As a result, the non-appropriation principle in art II applies to both outer space and its resources. Others argue that the *OST* allows appropriation of resources up to a certain threshold, but only for scientific purposes.<sup>40</sup> According to Brooks, ‘the exclusive use of a scarce resource ... would constitute an appropriation’.<sup>41</sup> Substantially depleting a celestial body’s mass by extracting large quantities of material may constitute appropriation by ‘destruction’ or ‘total consumption’, thus contravening *OST* art II (and *MA* art 11(2)).<sup>42</sup>

Other commentators argue that *OST* art II allows States and nationals to appropriate resources in outer space, but not to appropriate outer space itself.<sup>43</sup> The *OST* is a promotional and enabling instrument.<sup>44</sup> By analogy with the freedom of the high seas, the freedom in *OST* art I to explore and

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<sup>39</sup> G Lafferranderie, *Le regime juridique applicable aux materiaux provenant de la lune et des autres corps celestes - rapport introductif* (Groupe de travail sur le droit de l’espace du CNRS, 1970) 3, cited in Pop, above n 13, 136; See also Eugene Brooks, ‘Control and Use of Planetary Resources’ (1968) 11 *Proceedings of the Colloquium on the Law of Outer Space* 342.

<sup>40</sup> Brooks, above n 39, 346.

<sup>41</sup> *Ibid.*

<sup>42</sup> Lee, above n 10, 200; Oscar Fernandez-Brital, ‘Activities on Celestial Bodies, including Exploitation of Natural Resources’ (1969) 12 *Proceedings of the Colloquium on the Law of Outer Space* 195, 197.

<sup>43</sup> See, eg, Cheng, above n 19, 22.

<sup>44</sup> Stephen E Doyle, ‘Using Extraterrestrial Resources under the Moon Agreement of 1979’ (1998) 26 *Journal of Space Law* 111, 116.

use outer space includes the freedom to appropriate natural resources.<sup>45</sup> Thus, Hertzfeld and von der Dunk argue that '[a]nything taken from space and returned to earth becomes the property of the [entity] that performs the action'.<sup>46</sup>

Nevertheless, it is debatable whether customary international law recognises a right to commercialise extraterrestrial material. In the 1970s, the United States and the USSR appropriated and exchanged samples collected by the *Apollo* and *Luna* missions without objections from other States.<sup>47</sup> In 1993, Russia auctioned three small particles of lunar material collected by a Soviet probe, and no States objected.<sup>48</sup> Still, Tronchetti disputes the existence of State practice. He observes that the United States and the USSR took only small samples primarily for scientific information, unlike a large-scale removal of natural resources for profit.<sup>49</sup>

Thus, although the *OST* arguably permits entities to use natural resources for non-scientific purposes, it is generally acknowledged that the law lacks sufficient certainty for commercial mining.<sup>50</sup>

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<sup>45</sup> C W Jenks, 'Property in Moon Samples and Things Left upon the Moon' (1969) 12 *Proceedings of the Colloquium on the Law of Outer Space* 148, 148-9; Sylvia Maureen Williams, 'The Law of Outer Space and Natural Resources' (1987) 36 *International and Comparative Law Quarterly* 142, 147.

<sup>46</sup> Henry R Hertzfeld and Frans G von der Dunk, 'Bringing Space Law into the Commercial World: Property Rights without Sovereignty' (2005) 6(1) *Chicago Journal of International Law* 81, 83. See also S Hobe, 'Adequacy of the Current Legal and Regulatory Framework relating to the Extraction and Appropriation of Natural Resources' (2007) 32 *Annals of Air and Space Law* 115, 126.

<sup>47</sup> M G Markoff, 'Accords Particuliers et Droit International General de L'espace' (1972) 15 *Proceedings of the Colloquium on the Law of Outer Space* 67, 167; Gyula Gál, 'Acquisition of Property in the Legal Regime of Celestial Bodies' (1996) 39 *Proceedings of the Colloquium on the Law of Outer Space* 45, 47.

<sup>48</sup> Pop, above n 13, 140-1.

<sup>49</sup> Fabio Tronchetti, 'The Space Resource Exploration and Utilization Act: A Move Forward or a Step Back?' (2015) 34 *Space Policy* 6, 8.

<sup>50</sup> See, eg, Henry R Hertzfeld and Frans G von der Dunk, above n 46, 83; Tronchetti, above n 13, 224-5.

## B *The Effect of OST Art I(1) on Miners*

According to the majority view, the *OST* permits entities to use natural resources for non-scientific purposes so long as they comply with the provisions in the *OST*.<sup>51</sup> Article I(1) of the *OST* states, ‘The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development’. According to Jasentuliyana, art I aims to ‘require States to co-operate internationally in their space ventures’ by ‘calling attention to the essential needs of mankind and emphasizing the importance of co-operation’.<sup>52</sup>

Since art I(1) is worded vaguely,<sup>53</sup> the nature and extent of the cooperation obligation were long debated. Some argued that the ‘benefit’ must be specifically shared through transferring profits, materials or technology.<sup>54</sup> Others argued that the exploration and use of space need only be beneficial in a general sense – ‘which might even encompass merely being non-harmful’.<sup>55</sup> According to Jasentuliyana and Cheng, the obligation to cooperate constituted ‘more a moral and philosophical obligation’ than a legal requirement creating specific legal rights.<sup>56</sup>

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<sup>51</sup> Tronchetti, above n 13, 224.

<sup>52</sup> N Jasentuliyana, ‘Article I of the Outer Space Treaty Revisited’ (1989) 17 *Journal of Space Law* 129, 139.

<sup>53</sup> See *ibid*; Sylvia Maureen Williams, ‘International Law and the Exploitation of Outer Space: A New Market for Private Enterprise?’ (1983) 7(6) *International Relations* 2476, 2477.

<sup>54</sup> See M A Ferrer in Council of Advanced International Studies of Argentina (ed), *Legal Framework for Economic Activities in Space* (1982) 92.

<sup>55</sup> Francis Lyall and Paul B Larsen, above n 13, 63.

<sup>56</sup> Jasentuliyana, above n 52, 130; Bin Cheng, *Studies in International Space Law* (Clarendon Press, 1997) 234-5.

When negotiating art I, the major space-faring States agreed that it set ‘limitations and obligations to the use of outer space but did not diminish their inherent rights to determine how they shared the benefits and information derived from their space activities’.<sup>57</sup> According to the chief United States negotiator, art I was a statement of general goals.<sup>58</sup> The Soviet delegate to COPUOS stated that ‘the principle of international cooperation ... is given body through the conclusion of specialized treaties by States and international organizations’.<sup>59</sup>

Some commentators, including commentators from developing countries,<sup>60</sup> held a similar view. They argued that art I did not require a State which used a celestial body to ‘provide for equal opportunity and means for such use by all other States’ or to ‘share all benefits of its use with all other States’.<sup>61</sup> ‘Benefit’ was ‘an imprecise criterion’ that countries interpreted differently based on their own interests at various times.<sup>62</sup> Further, the benefit and interests of ‘all countries’ included the scientific and commercial benefit and interests of the State conducting the space activity in question.<sup>63</sup>

Other commentators, however, emphasised art I’s use of the plural word ‘interests’. They argued that States conducting space activities might have

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<sup>57</sup> N Jasentuliyana, ‘Ensuring equal access to the benefits of space technologies for all countries’ (1994) 10 (1) *Space Policy* 7, 8; *Treaty on Outer Space: Hearings Before the Senate Committee on Foreign Relations*, 90<sup>th</sup> Cong, 1st Sess 1 74 (1967).

<sup>58</sup> *Treaty on Outer Space: Hearings Before the Senate Committee on Foreign Relations*, 90<sup>th</sup> Cong, 1st Sess 133 (1967).

<sup>59</sup> Gennady Zhukov and Yuri Kolosov, *International Space Law* (1984) 77, cited in Jasentuliyana, above n 52, 140.

<sup>60</sup> See, eg, Luis F Castillo Argañarás, ‘Benefits Arising from Space Activities and the Needs of Developing Countries’ (2000) 43 *Proceedings of the Colloquium on the Law of Outer Space* 50, 57.

<sup>61</sup> Doyle, above n 44, 114.

<sup>62</sup> Williams, above n 53, 2478.

<sup>63</sup> Stephen Gorove, ‘Implications of International Space Law for Private Enterprise’ (1982) 7 *Annals of Air and Space Law* 319, 321.

to consider a particular set of identifiable interests of all States, not just the general interest of all States.<sup>64</sup> The obligation might require practical implementation through further guidelines, such as the *MA*.<sup>65</sup>

To settle the debate over the meaning of art I(1), in 1996 the United Nations General Assembly adopted the ‘Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries’.<sup>66</sup> The Declaration ‘can be regarded as an authoritative interpretation’ of art I(1).<sup>67</sup> Adding to art I, it provides that ‘[p]articular account should be taken of the needs of developing countries’.<sup>68</sup> It exhorts spacefaring States to cooperate with developing States to promote the development of space science and technology and its applications, to develop appropriate space capabilities in interested States and to exchange expertise and technology.<sup>69</sup> Cooperation should occur on ‘an equitable and mutually acceptable basis’.<sup>70</sup> Contracts in such cooperative ventures should be ‘fair and reasonable’ and fully comply with the parties’ legitimate rights and interests.<sup>71</sup> The Declaration thus encourages developing and developed countries to direct their efforts towards mutually valued cooperation rather than mere redistribution of existing resources. Consequently, art I(1) does not compel miners to

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<sup>64</sup> Lee, above n 10, 157, citing Cheng, above n 56, 234-5.

<sup>65</sup> Lee, above n 10, 158.

<sup>66</sup> GA Res 51/122, UN GAOR, 51<sup>st</sup> sess, 83<sup>rd</sup> plen mtg, Agenda Item 83, UN Doc A/RES/51/122 (13 December 1996).

<sup>67</sup> Hobe, above n 46, 126.

<sup>68</sup> GA Res 51/122, UN GAOR, 51<sup>st</sup> sess, 83<sup>rd</sup> plen mtg, Agenda Item 83, UN Doc A/RES/51/122 (13 December 1996) [1].

<sup>69</sup> *Ibid* [3]-[5].

<sup>70</sup> *Ibid* [2].

<sup>71</sup> *Ibid*.

redistribute their resources but instead articulates a general moral and philosophical obligation.

### C *Appropriation of Extracted Resources under the MA*

Article 11 of the *MA* states that subject to a future international regime, no natural resources ‘in place’ shall become property of any governmental or non-governmental entity.<sup>72</sup> In addition, the *MA* imposes a requirement of ‘equitable sharing’.

Some commentators state that the *MA* imposes a moratorium on exploitation for commercial purposes. Tronchetti argues that since art 6 only allows harvesting resources for scientific purposes, the *MA* prohibits harvesting for commercial purposes until the *MA*’s international regime is established.<sup>73</sup> In von der Dunk’s view, the moratorium applies only to States that are party to the *MA*.<sup>74</sup>

However, the text and drafting history of the *MA* suggest that no moratorium exists. Unlike the *UNCLOS*,<sup>75</sup> the *MA* does not specifically provide for a moratorium on exploitation.<sup>76</sup> In addition, during the *MA*’s drafting the United States repeatedly stated that the *MA* imposed no moratorium.<sup>77</sup> Since other States did not contradict the United States’ interpretation, its interpretation appears to express the views of the treaty’s drafters.<sup>78</sup> Further, natural resources that have been extracted can

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<sup>72</sup> *MA* art 11(3).

<sup>73</sup> Tronchetti, above n 13, 43.

<sup>74</sup> Frans G von der Dunk, 'The Dark Side of the Moon—The Status of the Moon: Public Concepts and Private Enterprise' (1997) 40 *Proceedings of the Colloquium on the Law of Outer Space* 119, 121-2.

<sup>75</sup> *United Nations Convention on the Law of the Sea*, opened for signature 10 December 1982, 1833 UNTS 3 (entered into force 28 July 1994).

<sup>76</sup> Leslie I Tennen, 'Towards a New Regime for Exploitation of Outer Space Mineral Resources' (2010) 88 *Nebraska Law Review* 794, 814.

<sup>77</sup> A/AC.105/PV.203 (3 July 1979) 22; see also the speech of Mr Petree, the US delegate to the Special Political Committee, A/SPC/34/SR.19 (1 November 1979) para 25.

<sup>78</sup> Bin Cheng, 'The Moon Treaty: Agreement Governing the Activities of States on the Moon and Other Celestial Bodies within the Solar System other than the Earth, December 18, 1979' (1980) 33(1) *Current Legal Problems* 213, 232.



arguably be appropriated for commercial purposes because they are no longer 'in place'.<sup>79</sup>

Nevertheless, such appropriation is subject to the principle of the common heritage of mankind, which requires '[a]n equitable sharing by all States Parties in the benefits derived from those resources'.<sup>80</sup> In 2005, it was reported that United States companies had decided not to use Australian territory for their mining expeditions for fear that Australia, as a party to the *MA*, might confiscate any minerals brought from outer space.<sup>81</sup> None of the major spacefaring countries are inclined to sign the *MA*, and 'well founded rumour has it that at least one ratifying state (Australia) has seriously contemplated withdrawal'.<sup>82</sup> Although the *MA* likely does not impose a moratorium on commercial exploitation, it has created enough uncertainty to deter miners.

## V PROPOSED LEGAL FRAMEWORK

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<sup>79</sup> Pop, above n 13, 146; Doyle, above n 44, 121; Tennen, above n 76, 813; Hobe, above n 46, 124.

<sup>80</sup> *MA* art 11(7)(d) requires the future international regime to ensure:

[a]n equitable sharing by all States Parties in the benefits derived from those resources, whereby the interests and needs of the developing countries, as well as the efforts of those countries which have contributed either directly or indirectly to the exploration of the Moon, shall be given special consideration.

It is beyond the scope of this paper to discuss art 11(7)(d), which was a major reason for the *MA*'s failure to gain international consensus: F G von der Dunk, 'The Moon Agreement and the Prospect of Commercial Exploitation of Lunar Resources' (2007) 32 *Annals of Air and Space Law* 90, 106. Doyle argues that *MA* art 11(7) contradicts *OST* art I(1) and *MA* art 4(1): Doyle, above n 50, 123.

<sup>81</sup> Henry R Hertzfeld and Frans G von der Dunk, above n 46, 92.

<sup>82</sup> Francis Lyall and Paul B Larsen, above n 13, 178-9.

### A *Sovereignty and Ownership of Celestial Bodies?*

To encourage responsible commercial development, some commentators advocate recognising ownership and State sovereignty over celestial bodies.<sup>83</sup> However, since non-appropriation is a fundamental principle in space law, it is unlikely that States will soon agree to recognise ownership rights. Further, recognising State sovereignty over celestial bodies may create international conflict.

Non-appropriation is ‘one of the most fundamental and universally recognised principles of international space law’<sup>84</sup> and possibly a norm of customary law.<sup>85</sup> Tronchetti believes that the commercialisation of outer space must not erode this principle.<sup>86</sup> However, the preambles to the *OST* and *MA* show that one purpose of the principle was to prevent conflict in outer space.<sup>87</sup> Pop argues that if the non-aggression tenets in the *OST* remain valid, perhaps the non-appropriation principle should be abrogated in its ‘sovereignty over natural resources’ context.<sup>88</sup>

If States denounce the non-appropriation principle, outer space would become *res nullius*:<sup>89</sup> States would be able to acquire sovereignty on celestial bodies and thus to recognise and enforce property rights, including ownership rights.<sup>90</sup> However, dividing celestial bodies into

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<sup>83</sup> See, eg, Kurt Anderson Baca, 'Property Rights in Outer Space' (1993) 58 *Journal of Air Law and Commerce* 1041, 1084.

<sup>84</sup> Lee, above n 10, 166. Tennen calls the non-appropriation principle ‘[a] cornerstone of international space law’: Leslie I Tennen, 'Article II of the Outer Space Treaty, the Status of the Moon and Resulting Issues' (2004) 47 *Proceedings of the Colloquium on the Law of Outer Space* 520, 520.

<sup>85</sup> Pop, above n 13, 38-9; Lachs, above n 26, 42; Francis Lyall and Paul B Larsen, above n 13, 71.

<sup>86</sup> Tronchetti, above n 13, 217.

<sup>87</sup> Pop, above n 13, 60. See also Tennen, above n 84, 522-3.

<sup>88</sup> Pop, above n 13, 107.

<sup>89</sup> *Ibid* 108.

<sup>90</sup> *Ibid*.

national portions would likely produce conflicts over the size and location of each portion.<sup>91</sup> An alternative is sovereignty on a first-come, first-served basis. Some commentators reject this method, arguing that it encourages explorers to inefficiently focus resources on reaching celestial bodies first rather than on developing the celestial bodies productively.<sup>92</sup> To address this issue, Baca advocates reasonable use as a basis for national appropriation,<sup>93</sup> but reasonable use is a vague concept that would be difficult to enforce. Further, State sovereignty may encourage States to hasten to claim valuable celestial bodies. It may create conflict among space powers and between developed and developing countries.<sup>94</sup>

Consequently, political difficulties preclude recognising State sovereignty. States are also unlikely to recognise ownership of celestial bodies in the near future. Nevertheless, since responsible commercial development requires property rights, States may be amenable to recognising lesser property rights, which would erode the non-appropriation principle to a lesser extent.

## B *A Spontaneous Order in Space*

In the Alaskan and Californian gold rushes, miners ‘spontaneously’ agreed on rules to establish and enforce property claims so that they could spend less time defending their claims.<sup>95</sup> Although the international

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<sup>91</sup> Ibid.

<sup>92</sup> David Collins, 'Efficient Allocation of Real Property Rights on the Planet Mars' (2008) 14 *Boston University Journal of Science and Technology Law* 201, 212-13; Robert P Merges and Glenn H Reynolds, 'Space Resources, Common Property and the Collective Action Problem' (1997) 6 *New York University Environmental Law Journal* 107, 117.

<sup>93</sup> Baca, above n 83.

<sup>94</sup> Tennen, above n 84, 523-4.

<sup>95</sup> Lawrence A Cooper, 'Encouraging Space Exploration through a New Application of Space Property Rights' (2003) 19 *Space Policy* 111, 116; Robert P Merges and Glenn H Reynolds, above n 92, 118-19.

community generally believes that property rights require sovereignty,<sup>96</sup> a ‘spontaneous order’ could conceivably arise without an international regime to govern property rights in space.<sup>97</sup>

Salter and Leeson argue that private parties can enforce property rights in outer space without involving any sovereign entity.<sup>98</sup> The ‘discipline of continuous dealings’ encourages parties to respect each other’s property rights. If Party A violates Party B’s property rights once, Party B will retaliate by violating Party A’s property rights. Thus, parties that continuously deal with each other will earn more in the long run by recognising rather than violating each other’s property rights.

Salter and Leeson’s economic analysis, which they illustrate using private arbitration of contractual disputes,<sup>99</sup> has limited application because contractual rights differ from property rights. Contractual rights that are *in personam* may be enforced against the contracting parties by an arbitrator chosen according to the parties’ contract. In contrast, property rights are *in rem* rights enforceable against the whole world by an authority whom the alleged violators of property rights have not necessarily chosen. Consequently, property rights cannot always be enforced through contractual rights. As Epstein states, ‘property rights ... are intended to bind the rest of the world, and thus cannot depend on specific and repetitive interactions between a small class of individuals with a close working relationship ... where denser understandings may

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<sup>96</sup> See above n 25.

<sup>97</sup> For an explanation of spontaneous order, see F A Hayek, *Law, Legislation and Liberty—Volume 1: Rules and Order* (Routledge, 1973); Peter G Klein, *The Capitalist and the Entrepreneur: Essays on Organizations and Markets* (Ludwig von Mises Institute, 2010) 183.

<sup>98</sup> Alexander W Salter and Peter T Leeson, ‘Celestial Anarchy: A Threat to Outer Space Commerce?’ (2014) 34(3) *Cato Journal* 581, 583.

<sup>99</sup> *Ibid* 590-2.

arise from custom or from a repeated course of dealing'.<sup>100</sup> Nevertheless, since there are currently many asteroids and few asteroid miners, the pioneer miners may well be able to create a spontaneous order that respects each other's quasi-legal property rights.

Salter and Leeson acknowledge that political problems could arise if individuals of particular nationalities claim property rights contrary to sovereigns' interpretations of the *OST*.<sup>101</sup> For a spontaneous order to function peacefully, the countries and private entities concerned must not resort to brute force to enforce their claims. Further, legal problems could arise because the *OST* appears to prohibit private appropriation of celestial bodies. Unlike the miners in the Alaskan and Californian gold rushes, space miners have to contend with a pre-existing legal framework—a framework that holds States internationally responsible for activities of non-governmental entities and that protects freedom of access to all areas of celestial bodies.

In the real world, a possible resolution may involve pioneer miners establishing mine sites and forming extra-legal associations and rules, regardless of international law. In response, powerful States may choose to ignore the dominant interpretation of the space treaties and to instead encourage space mining that benefits their own interests. Thus, international law may eventually incorporate the pioneers' extra-legal arrangements.

But if a powerful State or group of States objects to the miners' activities, that State or group of States may force a more immediate legal resolution. Spacefaring States could enact their own domestic legislation, such as the

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<sup>100</sup> Richard A Epstein, 'How Spontaneous? How Regulated?: The Evolution of Property Rights Systems' (2014-2015) 100 *Iowa Law Review* 2341, 2344.

<sup>101</sup> Salter and Leeson, above n 98, 583-4.

United States' *Commercial Space Launch Competitiveness Act*,<sup>102</sup> but competing claims under different national laws may lead to political conflict.<sup>103</sup> In such circumstances, it would be more appropriate for States to create an International Space Authority ('Space Authority') responsible for granting mining leases.<sup>104</sup>

### *C The International Space Authority*

In considering the role of a Space Authority, it is instructive to study the International Seabed Authority ('Seabed Authority'). Created under the *UNCLOS*, the Seabed Authority licences and regulates mineral exploration and exploitation of the deep seabed.

The Space Authority's method of allocating property rights would differ from the Seabed Authority's. The Seabed Authority grants exploration and exploitation applications for a fixed fee<sup>105</sup> on a first-come, first-served basis if several conditions are met.<sup>106</sup> In contrast, the Space Authority would grant leases to the highest bidder. Competition among bidders is likely the most efficient way to determine the price for a particular site because market prices would indicate the value that miners

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<sup>102</sup> *US Commercial Space Launch Competitiveness Act*, 51 USC (2012 & Supp 2016).

<sup>103</sup> Tronchetti, above n 49, 8.

<sup>104</sup> See, eg, Cheng, above n 19, 43; Tronchetti, above n 13, 244; Lee, above n 10, 295.

<sup>105</sup> See International Seabed Authority, *Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area* (13 July 2000) 2, 12-13 <<http://www.isa.org.jm/files/documents/EN/Regs/MiningCode.pdf>>.

<sup>106</sup> See *UNCLOS* art 162 para 2(x); annex III art 6 paras 1-4, art 10; *Agreement Relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982*, opened for signature 28 July 1994, 1836 UNTS 3 (entered into force 28 July 1996) annex s 1 paras 7, 13, s 6 para 7. See also Oxman, Bernard, 'Law of the Sea Forum: The 1994 Agreement on Implementation of the Seabed Provisions of the Convention on the Law of the Sea' (1994) 88 *American Journal of International Law* 687, 692.

place on the site.<sup>107</sup> The bidder's payments would fund the Space Authority's mining-related activities such as recording leases and adjudicating disputes. To deter operators from damaging the environments of outer space and Earth, the Space Authority could also require an environmental bond.

An issue similar to the 'paper satellite' problem could arise if entities file frivolous applications.<sup>108</sup> To discourage 'paper mines', the Space Authority could set a floor price for bids and limit the duration of the lease to a reasonable time. When the lease for a site expires, the Space Authority would grant a new lease to the highest bidder.

The Space Authority would have a more limited role than the Seabed Authority. Under the *UNCLOS*, an entity applying for a licence from the Seabed Authority must identify two areas of equal estimated commercial value.<sup>109</sup> The Seabed Authority allocates one of the areas to the successful applicant and reserves the other for the Enterprise, which is part of the Seabed Authority, or for the developing States.<sup>110</sup> In direct competition with licencees, the Enterprise can mine resources in the reserved area.<sup>111</sup> The Enterprise's profits are to contribute to the Seabed Authority's budget and to be shared with the international community, particularly the developing States.<sup>112</sup>

Although the Enterprise bears the same obligations as commercial ventures and is supposed to begin mining operations through joint

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<sup>107</sup> See F A Hayek, 'The Use of Knowledge in Society' (1945) 35(4) *American Economic Review* 519, 524-7.

<sup>108</sup> See Lee, above n 10, 288.

<sup>109</sup> *UNCLOS* annex III art 8.

<sup>110</sup> *Ibid.*

<sup>111</sup> *Ibid* art 170; Lee, above n 10, 248-9.

<sup>112</sup> *UNCLOS* art 173; Lee, above n 10, 249.

ventures,<sup>113</sup> it is superfluous, unfair and economically inefficient for a regulator to compete with those it regulates.<sup>114</sup> The Seabed Authority can use money paid by licencees to exploit areas discovered by the licencees.<sup>115</sup> Further, in October 2012 a Canadian company proposed to negotiate a joint venture with the Enterprise to develop certain reserved areas.<sup>116</sup> The joint venture proposal was to be finalised in 2015,<sup>117</sup> but as at 20 April 2016 the Enterprise has never entered into any joint ventures.<sup>118</sup> The absence of joint ventures so far suggests that the Enterprise venture system is unprofitable. Further, the system impedes resource development by locking up reserved areas that commercial entities would like to develop. Consequently, unlike the Seabed Authority, the proposed Space Authority would not be both the mining regulator and a miner. Instead, its role would be to facilitate mining by processing applications.

The Space Authority could be created by amending the *OST* in accordance with art XV. Some space powers have stated that they have no interest in negotiating a new space treaty.<sup>119</sup> An amendment to the

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<sup>113</sup> UNCLOS Agreement s 2 para 4.

<sup>114</sup> See Doug Bandow, 'UNCLOS III: A Flawed Treaty' (1982) 19 *San Diego Law Review* 475, 484-5; L E Viikari, 'The Legal Regime for Moon Resource Utilization and Comparable Solutions Adopted for Deep Seabed Activities' (2003) 31(11) *Advances in Space Research* 2427, 2431.

<sup>115</sup> Marlene Dubow, 'The Third United Nations Conference on the Law of the Sea: Questions of Equity for American Business' (1982) 4 *Northwestern Journal of International Law & Business* 172, 188.

<sup>116</sup> International Seabed Authority, *Proposal for a Joint Venture Operation with the Enterprise: Report by the Interim Director-General of the Enterprise*, 19th sess, UN Doc ISBA/19/C/4 (20 March 2013) 1.

<sup>117</sup> *Ibid* 2.

<sup>118</sup> International Seabed Authority <<https://www.isa.org.jm>>.

<sup>119</sup> Tronchetti, above n 13, 242.



*OST*, which has a high number of ratifications and signatures,<sup>120</sup> appears more likely to receive widespread acceptance than a new, separate treaty.

Some commentators suggest that the Space Authority should grant licences as the Seabed Authority does.<sup>121</sup> However, leases would likely encourage miners to use the sites more profitably because leases, unlike licences, are alienable.<sup>122</sup> For example, if a commercial operator encounters financial difficulty or lacks the ability to exploit certain resources in the leased area, the operator could assign the lease to another operator capable of using the area more productively.

Nevertheless, there are risks in vesting an international body with exclusive authority to grant and withhold property rights in lucrative resources. Even if the Space Authority were to have external and internal accountability mechanisms, those mechanisms would only be as rigorous as the people who implement them.<sup>123</sup> Further, as with any public authority, public officials would have incentives to unproductively increase the Space Authority's powers and expenditures. For the Space Authority to facilitate rather than hinder responsible space development, the people who carry out the Space Authority's functions must act fairly and efficiently.

#### D *Clarifying Property Rights in Extracted Resources*

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<sup>120</sup> United Nations Office for Disarmament Affairs, *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* <[http://disarmament.un.org/treaties/t/outer\\_space](http://disarmament.un.org/treaties/t/outer_space)>.

<sup>121</sup> See, eg, Lee, above n 288; Tronchetti, above n 13, 245.

<sup>122</sup> See Richard A Epstein, 'Property and Necessity' (1990) 13 *Harvard Journal of Law & Public Policy* 2, 4-5.

<sup>123</sup> It is beyond the scope of this paper to address the composition of the Space Authority.

In November 2015, the United States enacted the *Commercial Space Launch Competitiveness Act*. It provides that United States individuals and entities are entitled to property rights, including ownership, in any asteroid resource or space resource obtained for commercial purposes.<sup>124</sup>

Although the United States' unilateral approach may be inconsistent with *OST* arts I and II,<sup>125</sup> it may encourage other States to recognise property rights in resources extracted for commercial purposes. If other States do not object to the United States' approach and if they enact similar legislation, their conduct may support a customary norm recognising ownership rights in extracted resources.

Nevertheless, a clear international legal framework may be needed to resolve conflicting claims between entities operating under different countries' laws. To clarify the *OST*'s effect on property rights in extracted resources, States could amend it to provide that natural resources which are not 'in place' may become property of any entity.

## VI CONCLUSION: COMMERCIAL DEVELOPMENT FOR THE BENEFIT OF ALL COUNTRIES

By classifying outer space as *res communis* and failing to define key concepts, international space law currently hinders the responsible development of natural resources in outer space. The non-appropriation

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<sup>124</sup> *US Commercial Space Launch Competitiveness Act*, 51 USC § 51303 (2012 & Supp 2016) states:

A United States citizen engaged in commercial recovery of an asteroid resource or a space resource under this chapter shall be entitled to any asteroid resource or space resource obtained, including to possess, own, transport, use, and sell the asteroid resource or space resource obtained in accordance with applicable law, including the international obligations of the United States.

<sup>125</sup> Tronchetti, above n 49, 8.

principle, which applies to the undefined class of ‘celestial bodies’, prevents miners from securing exclusive access to mine sites. Nevertheless, the weight of authority indicates that the *OST* allows miners to gain property rights in resources that they extract without being compelled to redistribute their income, technology or resources. The *MA*, in contrast, requires an equitable sharing of benefits.

How real property rights should be recognised is a difficult question with no easy solution. A spontaneous order would require the countries and miners involved to be peaceful and reasonable rather than belligerent and disobliging. An International Space Authority that grants mining leases on a competitive basis would require its employees to be fair and efficient rather than biased and corrupt. The success of each solution ultimately depends on the people involved. As for property rights in extracted resources, amending the *OST* to clearly recognise personal property rights would provide legal certainty to miners.

Such recognition of property rights in celestial bodies and natural resources is consistent with carrying out the exploration and use of outer space ‘for the benefit and in the interests of all countries’.<sup>126</sup> Commercial development of outer space can ‘benefit all of humankind, directly or indirectly, as any other discovery or invention’.<sup>127</sup> Space technology innovations have already prompted inventions in fields such as medicine, transportation and consumer goods.<sup>128</sup> The extracted resources themselves may be used beneficially: for example, platinum group metals, which are scarce on Earth, are used in about a quarter of all

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<sup>126</sup> *OST* art I(1).

<sup>127</sup> See Pop, above n 13, 116.

<sup>128</sup> NASA Spinoff, *NASA Technologies Benefit Our Lives*  
<[https://spinoff.nasa.gov/Spinoff2008/tech\\_benefits.html](https://spinoff.nasa.gov/Spinoff2008/tech_benefits.html)>.

manufactured goods.<sup>129</sup> The business of extracting resources would also create jobs in space technology and related industries.

Like other inventions, space technology is costly in its infancy. The car and the camera were once luxuries of the rich, but within decades entrepreneurs made them affordable for ordinary people.<sup>130</sup> With improvements in technology, space missions now cost less than they did during the space race.<sup>131</sup> Commercial activities such as mining would encourage technological development and likely reduce costs further. Meanwhile, entities in developing countries can and do pool their resources for joint space activities.<sup>132</sup> Developing countries have benefited and continue to benefit from the exploration and use of outer space – without the law compelling any redistribution of resources. Supported by a legal framework that provides good fences, neighbours in outer space have the potential to improve the lives of people around the world.

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<sup>129</sup> Accenture, above n 2.

<sup>130</sup> John Micklethwait and Adrian Wooldridge, *The Company: A Short History of a Revolutionary Idea* (Modern Library, 2003) 77.

<sup>131</sup> Pop, above n 13, 133; Francis Lyall and Paul B Larsen, above n 13, 473.

<sup>132</sup> Pop, above n 13, 155. See also Doyle, above n 80, 118-19; Marietta Benkö and Kai-Uwe Schrogl, 'History and Impact of the 1996 UN Declaration on 'Space Benefits'' (1997) 13(2) *Space Policy* 139, 143; José Monserrat Filho, 'Brazilian-Chinese Space Cooperation: An Analysis of its Legal Performance' (1996) 39 *Proceedings of the Colloquium on the Law of Outer Space* 164.