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Owning Outer Space

*Ezra J. Reinstein**

I. INTRODUCTION

What do we want from space?

We want the knowledge we can gain from scientific research; we can learn much about the Earth and its inhabitants, as well as the universe around us, by studying space.

We want to explore, to satisfy the thirst for adventure and conquest imagined in countless science fiction books and films.

We want to improve our collective lot down here on Earth.

Space offers the potential for practically limitless wealth, some already being exploited, some we may only harness in the distant future, and undoubtedly some we cannot begin to guess. Already the wealth of space is being developed in the form of telecommunications and remote satellite observation. The private-sector investment in telecommunications satellites *alone* was projected to total \$54.3 billion (including launch) between 1996 and 2000¹ -- and this figure doesn't include other commercial space ventures, nor does it include investment in Russian and Chinese satellites. A further \$70 billion was projected to be invested in satellite communications ground stations over the same period.² Research in materials science is uncovering phenomena unique to the low- and no-gravity environment of space, and the space-based processing of these new alloys, composites, ceramics and polymers may soon become an important industry.³ The field of biotechnology is also taking advantage of zero-gravity conditions to manu-

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¹ Office for Outer Space Affairs, Highlights in Space: Progress in Space Science, Technology and Applications, International Cooperation and Space Law, Ann. Rep. 1 (1996). (hereinafter Highlights 1996).

² *Id.*

³ United Nations, Office for Outer Space Affairs, Highlights in Space: Progress in Space Science, Technology and Applications, International Cooperation and Space Law, U.N. Doc A/AC.105/618 98-99 (1995).

facture protein crystals, which the pharmaceutical industry can use to create drugs that are able to "turn off" a protein, thereby regulating metabolic processes.⁴ Engineers have considered the possibility of capturing solar energy in massive quantities by laying out giant cells in space and on our moon.⁵

Perhaps the most lucrative area of development is the mining of celestial bodies. On the moon, an assay of only 30 km² of the lunar surface during Apollo-17 turned up deposits of Helium-3, a radiation-free fusion reactor fuel, practically nonexistent on Earth, that is more efficient than any radioactive fuel currently available.⁶ So-called near-Earth asteroids ("NEAs"), six are closer to Earth than our moon and more than 50 closer than Mars,⁷ might also be optimal targets for early development. The smaller of these asteroids have negligible gravitational fields, which would reduce fuel costs far below what is necessary for a lunar mission. Many of these NEAs seem to be rich in raw materials that are either rare and valuable on Earth, or common on Earth, needed in space, but expensive to launch.⁸ For instance, there is accumulating evidence that some NEAs contain gold, rhenium, germanium, and platinum-group metals -- platinum, palladium, iridium, osmium, rhodium, and ruthenium -- at concentrations of up to 100 times those that are mined on Earth.⁹ Glenn Reynolds¹⁰ has observed, "The smallest known near-Earth metal asteroid contains more metal than has been mined by humanity since the beginning of time."¹¹ It has been estimated that 2,000 NEAs larger than 1 km in diameter exist.¹²

Finally, space colonization, though on the distant horizon, is not necessarily a fantasy. Colonization -- pushing humanity's living room beyond its "surly bonds" -- might, depending on how it's implemented, represent a complete answer to the potential disaster of overpopulation and its effects.

Until very recently, harvesting the bounty of space in *any* of the aforementioned ways has been precluded by technological and financial consid-

⁴ Highlights 1996, *supra* note 1, at 90-91.

⁵ See *infra* note 21 and accompanying text.

⁶ Jeffrey S. Kargel, *Digging For Gold: U.S. National Aeronautics and Space Administration's Plans For Mining Extraterrestrial Resources*, ASTRONOMY, Dec. 1997, at 48. See also *Apollo Astronauts Call For New Space Exploration, Private Funding* in Deutsche Presse-Agentur, Dec. 11, 1997.

⁷ William Barton and Michael Capobianco, *Harvesting the Near-Earthers*, AD ASTRA, Nov. 1989, at 27.

⁸ Kargel, *supra* note 6, at 48.

⁹ *Id.*; see also Barton and Capobianco, *supra* note 7, at 30.

¹⁰ Glenn Reynolds is a law professor at the University of Tennessee, and co-wrote the influential book, GLENN H. REYNOLDS AND ROBERT P. MERGES, *OUTER SPACE: PROBLEMS OF LAW AND POLICY* (2nd ed., 1997).

¹¹ Glenn Reynolds, *quoted in* Keay Davidson, *\$15.99 for 1,800 On The Moon Plus Lunar Tax: Entrepreneurs Going Where No Capitalist Has Gone Before*, S.F. EXAM., Feb. 15, 1998, at A1.

¹² Kargel, *supra* note 6, at 48 (citing study by David Rabinowitz and Eugene Shoemaker).

erations. Recent price estimates of launching material into orbit costs approximately \$10,000 per pound;¹³ \$25,000-30,000 per pound of material to launch to our moon.¹⁴ The tremendous cost of launch, retrieval, and return means that “[i]f there was gold in low Earth orbit and all the shuttle had to do was go up and open its cargo bay doors and let [the gold] fall in, it wouldn’t be worth it, even then.”¹⁵

In the not-too-distant future, however, many of these activities may become economically feasible. The price of launch has decreased¹⁶ due to improved technology and increased competition.¹⁷ The price tag on robotic space missions, likely to be the avant garde of space mining endeavors, is one-fourth of what it was six years ago.¹⁸ Several real-world companies have begun to plan for the day that launch costs fall to a level at which they could profit from space mining. SpaceDev, a Colorado-based provider of commercial space missions and small commercial launch vehicles, is currently traded on the over-the-counter stock market.¹⁹

If a firm is eventually able to bring ore down to Earth, the total wealth available to humanity will be increased. The estimated Helium-3 reserves on our moon would create, in a controlled fusion reaction, 10 times as much energy as is contained in Earth’s recoverable coal, oil, and gas *combined*.²⁰ What is stopping these companies now, perhaps more than the money or technology, is the uncertainty of the legal regime. If exploitation of outer space’s bounty is our goal, we must establish a space property legal system that creates both incentives and predictability. Space development is a highly risky endeavor, as well as mind-bogglingly expensive. Who would expend the effort in developing a space colony, if they were not certain of the project’s legality? Valuable projects -- energy collection, mining, and colonization -- are by no means inevitable. If the law of outer space rejects such uses, or even makes their legality uncertain, it is unlikely that the nec-

¹³ Lawrence Roberts, *Ensuring the Best of All Possible Worlds: Environmental Regulation of the Solar System*, 6 N.Y.U. ENVTL. L.J. 126, 127 n.2, citing *Parametric Cost Estimating Reference Manual, U.S. Expendable launch Vehicle data for Planetary Missions* (visited April 29, 1998) <http://www.jsc.nasa.gov/bu2/ELV_US.html>; Davidson, *supra* note 11, at A1, quoting Comment of Robert Park (spokesperson for the American Physical Society, the world’s largest organization of physicists). For current launch rates, see SpaceDev, *Homepage* (visited Nov. 11, 1999) <<http://www.spacedev.com>>.

¹⁴ Earl C. Herkenhoff, *Moon Mining*, ENGINEERING & MINING J., June 1990, at 16M, cited in Roberts, *supra* note 13, at 160.

¹⁵ Davidson, *supra* note 11, (quoting Comment of Robert Park).

¹⁶ See *infra* notes 128-130 and accompanying text.

¹⁷ Public and private launch agencies in Europe, Japan, and Russia have broken the monopoly on launch services once held by the governments of the United States and U.S.S.R. Kargel, *supra* note 6.

¹⁸ *Id.*

¹⁹ SpaceDev, *Homepage* (visited Nov. 11, 1999) <<http://www.spacedev.com>>, OTC trading symbol: SPDV.

²⁰ RICHARD S. LEWIS, SPACE IN THE 21ST CENTURY 143 (1990).

essary technology would ever be created. A promising solution to our ever-growing energy needs involves setting up giant banks of solar panels in Earth's orbit and on the moon's sunny side, using the solar energy to power space development projects, and then beaming the excess down to Earth as microwave energy for terrestrial use.²¹ Will a private electric company be willing to develop such a lunar solar collection system? Not without a field of space law that permits exploitation and a strong rate of return on investment. Unless we can impose a rule of law that eliminates uncertainty while permitting the highest possible rate of return, we may be denied access to the fruits of space for a long time to come.

II. THE NEED FOR A LAW OF PROPERTY

Commercialization of space is no longer technologically unimaginable. But it may be illegal. The most fundamentally important document in space law for the last three decades has been the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Outer Celestial Bodies (better known as the "Outer Space Treaty" or "OST").²² The Outer Space Treaty was hashed out in a politically tense environment. Negotiations began on the heels of the Soviet Union's earthshaking Sputnik launch in 1957. Each side of the Cold War was concerned that the other might gain irreversible advantage by militarizing outer space.²³ The OST grew up as much a document of prevention as one of hope. The U.N. General Assembly Resolution 1348 (XIII) of October 17, 1963, on which parts of the OST were based, explicitly intended to "avoid the extension of present national rivalries into this new field."²⁴ The U.S. Representative to the U.N. General Assembly remarked at a U.N. plenary session during OST negotiations,

We of the United States regard this treaty as an important step toward peace... Therefore, as we stand on the threshold of the space age, our first responsibility as governments is clear: we must make sure that man's earthly conflicts will not be carried into outer space... [The Outer Space Treaty] responds to that desire and hope.²⁵

²¹Kargel, *supra* note 6.

²²Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Outer Celestial Bodies, *opened for signature* Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205.

²³Glenn H. Reynolds, *International Space Law: Into the 21st Century*, 25 VAND. J. TRANSNAT'L L. 225, 229 (1992).

²⁴Eric Husby, *Sovereignty and Property Rights in Outer Space*, 3 J. INT'L L. & PRAC. 359, 362-363 (1994) *quoting* G.A. Res. 1963, U.N. GAOR, 18th Sess., at 206.

²⁵December 17, 1966 statement of U.S. Representative to the General Assembly Arthur J. Goldberg, *quoted in* Staff Report, U.S. Senate Comm. on Aeronautical and Space Sciences, Treaty On Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies 15 (1967).

The lion's share of discussion dealt with arms control provisions, jurisdiction over spaceships, deciding which military activities are banned by the "peaceful purposes" clause,²⁶ and the like. In fact, the atmosphere was so contentious that the U.S. and U.S.S.R. representatives bickered even as to which side originated the OST's basic ideals.²⁷ Creating a space property law supportive of private development was not a priority. Each side of the Cold War was hoping to prevent the other from advancing as a sovereign into outer space and achieving an insurmountable military and geographic superiority. As a result, the OST is at best ambiguous, and at worst hostile, to the privatization and commercialization of space resources.

Why is a definitive property law needed? There are at least three reasons.

A. Division of limited resources

Space may be vast, but many of the most valuable resources -- especially those convenient to Earth -- are limited. Our moon is one example. It may be one of the most promising sites for mining,²⁸ energy-capture projects,²⁹ and spaceship refueling,³⁰ but a limited amount of usable land exists, with an even more limited quantity of usable water.³¹ For another example,

²⁶Outer Space Treaty, art. IV, requires that celestial bodies be used only for peaceful purposes. For an example of this sort of analysis, see Daniel Goedhuis, *Some Comments of the United Nations' Outer Space Treaty of January 1967*, lecture given on Sept. 28, 1967.

²⁷The story of the Outer Space Treaty may be briefly told. Its parentage is disputed. The Soviet Union regards it as a late and grudging acceptance by others of their thesis that the first step to be taken was, as they had proposed in 1958, an international treaty on cooperation in the exploration and peaceful use of outer space. The United States regards it as an expansion of their proposal or a treaty governing the exploration of the moon and other celestial bodies, which was made by President Johnson on May 7, 1966, but enlarged to cover activities in outer space.

H.G. Darwin, *The Outer Space Treaty*, 42 B.Y.I.L. 278 (1967), quoted in Husby, *supra* note 24, at 359 (n. 8).

²⁸The moon is thought to contain quantities of titanium, aluminum, and sodium. Jack Green, *Lunar Materials Processing*, in *THE INDUSTRIALIZATION OF SPACE: ADVANCES IN THE ASTRONAUTICAL SCIENCES* 447 (Richard A. Van Patten ed. 1978). Helium-3 is also promising. See Kargel, *supra* note 6, and Lewis, *supra* note 20.

²⁹Kargel, *supra* note 6.

³⁰See *infra* note 132.

³¹Warren E. Leary, *Craft Sees Signs of Water as Ice in Moon Craters*, N.Y. TIMES, Mar. 6, 1990, at A1, A12 (noting that although "the Moon may have enough water... to sustain lunar colonies and provide fuel for rockets," experts caution that it is thinly dispersed as ice crystals among the lunar dust and that "finding water is one thing, [but] coming up with an economically feasible way of extracting it from a harsh and unforgiving environment is another"). However, more recent data from NASA's Lunar prospector seems to indicate that the "up to 3 billion tons of water may be buried at each [lunar] pole, most of which is concentrated in 2-m thick, localized deposits that make it much easier to reclaim than the thin frost-like layer suggested by the initial analyses." HIGHLIGHTS IN SPACE: PROGRESS IN SPACE

the Geo-Stationary Orbit ("GSO") is probably the most valuable of all space resources to date. The GSO is a loop of space above Earth's equatorial surface.³² Satellites placed in GSO orbit the Earth at the same rate and in the same direction as the Earth's rotation.³³ Thus, objects in the GSO can stay fixed above a single point on Earth's surface. The GSO's inherent usefulness for observation (e.g. weather, military intelligence) and communications links has led to big business. The GSO, however, limited to a narrow band 35,800 km above the equator,³⁴ is already cluttered, both with electromagnetic interference from rival satellites³⁵ -- of which there are more than 750³⁶ -- and with "space-junk," debris from past launches that threatens to rip holes in the orbiting equipment.³⁷

This problem is not limited to the GSO and the moon; in truth, every resource is limited. The question, then, is who, if anyone, should have the rights to the riches of space? A system of space law, if it is to be successful, must provide an answer.

B. The rights of less-developed nations

The rights of less-developed nations create a concern that is both political and moral in character. As a matter of political reality, the less-developed nations wield considerable power, due in no small part to majority voting systems in the major international regulatory bodies.

Some feel, and developing nations argue, that it is morally imperative to take the interests of the non-space-capable nations into account when designing a system of space property law. A regime based on the "right of grab," the first-come, first-served theory of property acquisition, should be feared. By the time space-incapable nations develop the technological prowess and capital reserves to fund meaningful development of outer space, the earlier space-faring nations, left unchecked, might already have locked up the most accessible and valuable resources. Present inequities of

SCIENCE, TECHNOLOGY, AND APPLICATIONS, INTERNATIONAL COOPERATION AND SPACE LAW, OFFICE FOR OUTER SPACE AFFAIRS, ANN. REP. 17 (1998).

³²Office of Technology Assessment, UNISPACE '82: A Context for International Cooperation and Competition 42 (1983), cited in Fred Kosmo, *Note: The Commercialization of Space: A Regulatory Scheme That Promotes Commercial Ventures and International Responsibility*, 61 S. CAL. L. REV. 1055, 1059 (1988).

³³*Id.*

³⁴*Id.*

³⁵Gorove, *The Geostationary Orbit: Issues of Law and Policy*, 73 AM. J. INT'L. L. 444, 445 (1979), cited in Kosmo, *supra* note 32, at 1059-1060.

³⁶Jonathan McDowell, The Harvard Smithsonian Center for Astrophysics, (visited April 20, 1998), <<http://hea-www.harvard.edu/QEDT/jcm/space/jsr/geo.log/>>.

³⁷Reynolds, *International Space Law: Into the 21st Century*, *supra* note 23, at 225 (remarking that orbiting debris and GSO crowding are "pressing" problems that will soon escalate to "alarming" levels).

global wealth distribution thus would be carried forward into the space age.³⁸

C. Protection of the environment in space and on Earth.

If protection of the environment were our only goal, perhaps the best rule would be to forbid humankind from expanding beyond Earth, whether personally or by mechanical proxy. But restricting ourselves to Earth is not on the table. Current debate on humanity's future vis-a-vis space does not regard such a policy, however noble, as a possibility.

Nevertheless, protection of the environment in space ranks high on the list of policies to be considered.³⁹ The importance of an environmentalist ethos in this context derives, in part, from the concerns we already deal with on Earth: the *preservation* of the natural environment for its own sake and for our communal survival, as well as the *conservation* of natural resources. Other environmental concerns particular to space exist also. Orbiting litter may soon seriously hinder our ability to maintain a global communications link. Waste disposal and resource maintenance techniques may determine whether the moon's limited water supply will be contaminated and the moon will remain a dead satellite. Environmental considerations are, and must be, a factor in any system of space law.

The root causes of Earth's environmental problems are limited resources, limited waste disposal sites, and limited living space. Commercial development of space might be an effective solution. If minerals are extracted from dead asteroids floating through our solar system, perhaps there would be one less strip-mined rain forest. If solar energy is captured and beamed down to Earth's electric grid, that could be one less oil spill in our oceans. And if other worlds are colonized, then overpopulation can be allayed, possibly forever. But we are left with the question: "*Which* legal regime will best satisfy the needs of the terrestrial and extraterrestrial environments?"

III. CURRENT LAW AND ITS PROBLEMS

The United Nations' Committee on Peaceful Uses of Outer Space ("COPUOS") has developed the current law of space, such as it is, in a se-

³⁸Interestingly, the International Telecommunications Union ("ITU"), an international body with the duty of assigning Geostationary Orbit ("GSO") positions and communications frequencies, operates on what is basically a first-come, first-served basis. The ITU permits anyone to place a satellite in the GSO as long as it does not interfere with an existing satellite. Although the ITU, at the insistence of developing nations, has modified slightly the system so that the GSO needs of all nations should be considered, the principle remains the same. Kosmo, *supra* note 32, at 1062-1063.

³⁹*See, e.g.,* Roberts, *supra* note 13, at 126 *et seq.*

ries of treaties.⁴⁰ Any look at the property law of outer space must begin with the Outer Space Treaty ("OST"). The OST was the first binding international agreement on the law of space, and it still provides the guiding principles of space property law.⁴¹ One-hundred and two nations, including the United States and Russia, ratified the OST,⁴² and this wide acceptance has given it the character of binding international law even on those countries who have not ratified it.

As we have seen, the OST was born, along with most other space law, in the context of Cold War paranoia. The "value" of space law, according to Robert Crane, the then-Director of the Duke University Space Institute, was "as an instrument to deny control of outer space to any single power."⁴³ In our post-Cold War world, old rivalries and simple inertia must not be permitted to prop up a legal system. We must take a fresh look at the Outer Space Treaty, and re-write it.

The Outer Space Treaty's take on property law is oddly conflicted. On the one hand, the OST seems to endorse some property rights in space. At the very least, it pays lip service to the "exploration and use" of outer space in its Preamble and Article I.

On the other hand, the OST declares that all such exploration and use "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."⁴⁴ Thus the Outer Space Treaty seems to acknowledge the rights of nations and persons to exploit space, but subjects it to vague qualifications about benefiting all nations and mankind generally.

It is from these vague qualifications that thorny problems arise. What does the OST mean by permitting use of space only for the "benefit...of all countries?" Will the United Nations step in and seize the profits derived from private use of space, if it determines that the usage has not benefited all nations?

⁴⁰The Outer Space Treaty, *supra* note 22; Agreement on the Rescue of Astronauts, the Return of Astronauts and Return of Objects Launched into Outer Space, *opened for signature* Apr. 22 1968, 19 U.S.T. 7570, 672 U.N.T.S. 119; Convention on International Liability for Damage Caused by Space Objects, *opened for signature* Mar. 29, 1972, 24 U.S.T. 2389; Registration of Objects Launched into Outer Space, *opened for signature* Jan. 14, 1975, 28 U.S.T. 695; Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (hereinafter the Moon Treaty), G.A. Res. 34/68, 34 U.N. GAOR Supp. No. 46 at 77, U.N. Doc. A34/46 (1979).

⁴¹The Moon Treaty, *supra* note 40, explores space property law more deeply. However, it has only been ratified by nine nations, and by none of the major space powers. See *Multi-lateral Treaties Deposited with the Secretary General*, U.N. ST/LEG/SER.E/15 p. 883 (1997). It therefore lacks the necessary legitimacy to be considered binding international law. For more discussion of the Moon Treaty, see *infra* notes 47-50 and accompanying text.

⁴²DEPARTMENT OF STATE, TREATIES IN FORCE 439 (1997).

⁴³ROBERT D. CRANE, PLANNING FOR SPACE LEGAL POLICY 1 (1961).

⁴⁴Outer Space Treaty, *supra* note 22, Art. I.

There is widespread disagreement regarding the force of this phrase. One school interprets the phrase as being no more than a non-binding guide, a moral exhortation, for each state party.⁴⁵

Others read "for the benefit...of all countries" as packing a powerful legal mandate. The characteristic hermeneutic arising from "fear by the have-not nations"⁴⁶ is to read this phrase in light of the Moon Treaty.⁴⁷ Those who hold this interpretive position, hostile to private property rights and national sovereignty in space,⁴⁸ see the two Conventions as requiring that a system be imposed whereby all development is undertaken by a unified international organization, with profits spread amongst all nations without regard to involvement.⁴⁹ So it was, that during the negotiation of the Moon Treaty, the Group of 77 demanded a share of all earnings from space enterprises.⁵⁰

This reading is not exclusive to developing nations. In fact, evidence indicates that the U.S. Senate, while debating whether to ratify the OST, also understood this phrase to require an equitable division of space-borne wealth among all nations.⁵¹ The validity of this interpretation of "for the benefit...of all countries" is strengthened by language in U.N. Resolution 1962-XVIII.⁵² Adopted unanimously by the General Assembly, Resolution 1962-XVIII helped form the basis of the OST. The Resolution states that

⁴⁵ See, e.g. Kosmo, *supra* note 32, at 1067. See also *Treaty on Outer Space: Hearings Before the Senate Committee on Foreign Relations*, 90th Cong., 1st Sess., 1, 74 (1967).

⁴⁶ Reynolds, *International Space Law: Into the 21st Century*, *supra* note 23, at 229.

⁴⁷ The Moon Treaty, completed in 1979, was meant to clarify the Outer Space Treaty, especially with regard to property law. Some of the Moon Treaty's more radical language includes: Article 11: "The moon and its natural resources are the common heritage of mankind... Neither the surface nor the subsurface of the moon...shall become property of any state." Article 4: Allocations of property, if they are to occur, must heed "the need to promote higher standards of living and conditions of economic and social...development." The Moon Treaty thus rejects wealth maximization in favor of wealth redistribution. The Moon Treaty, *supra* note 40. The Moon Treaty was championed by the developing nations, but has not yet been signed by any of the space powers.

⁴⁸ Reynolds, *International Space Law: Into the 21st Century*, *supra* note 23, at 230.

⁴⁹ This philosophy is followed primarily by the Group of 77, in whose view ownership of all space property would vest in an international body which would oversee its use. Husby, *supra* note 24, at 370, citing GEORGE S. ROBINSON & HAROLD M. WHITE, JR., ENVOYS OF MANKIND 186 (1986). It is this ideology that the Moon Treaty was meant to support.

⁵⁰ Davidson, *supra* note 11.

⁵¹ The Staff Report to the Committee on Aeronautical and Space Sciences wrote, in its commentary on Article I, "International cooperation rather than national rivalry is the policy adopted for exploring and using the outer space environment. Instead of space activities being regarded as a monopoly of those nations able to afford the expense of launching satellites, all nations are to share in the benefits of space exploration without regard to their level of economic or scientific development." Staff Report, *supra* note 25, at 22 (emphasis added).

⁵² Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, Dec. 13, 1963, reprinted in J. E. S. FAWCETT, INTERNATIONAL LAW AND THE USES OF OUTER SPACE 69 (1968).

the "use of outer space should be carried on for the betterment of mankind and for the benefit of States *irrespective of their degree of economic or scientific development.*"⁵³ It is not unreasonable to understand this language, with its strong egalitarian flavor, as requiring that we read "for the benefit...of all countries" as creating a legal mandate for wealth redistribution.

Such a system would likely devastate the development of space. An international body -- a necessarily political body -- would determine what degree of wealth sharing is fair to "all countries."⁵⁴ The parties that take the initiative to create and improve technology, and take the financial and physical risks that are part and parcel of the pioneering development of space, would be required to defer to international political consensus. Must all development be held hostage while this cumbersome commission is designed, negotiated, and ratified? Might not such a system be more politics-driven than profit-driven, inevitably leading to inefficient pork-barreling? Should private parties worry that profits earned at great personal risk, expense, and effort be stripped and spread, equitably or otherwise, "for the benefit...of all countries?" It is no wonder that the Moon Treaty, which represents the apex of the philosophy of forced wealth sharing, was opposed by both the United States and the Soviet Union, and has been ratified by only nine relatively minor nations.⁵⁵

The Outer Space Treaty also states, in article I, that space is "the province of all mankind." In what way does *this* phrase limit the ways that space can be explored and used? The difficulty is that "mankind" is not a defined term in international law.⁵⁶ As Adrian Buekling observes, the use of the term "mankind" causes "the relevant clauses of the Space Treaty [to] offer little guidance as to what states may derive from them. Neither can it be satisfactorily established what rights a state not involved in space exploration might have in the achievements of the space powers."⁵⁷

The U.N. Convention of the Law of the Sea ("LOS") describes the deep sea-bed in similar terms, as the "common heritage of mankind."⁵⁸ The meaning of this clause, similar in wording and character to that in the OST, is likewise unclear; "depending on the interpretation accepted, the unilateral

⁵³ *Id.* (Emphasis added).

⁵⁴ Husby, *supra* note 24, at 371-372.

⁵⁵ Australia, Austria, Chile, Mexico, Morocco, The Netherlands, Pakistan, Philippines, and Uruguay have ratified the treaty. Multilateral Treaties Deposited with the Secretary General, *supra* note 41. See also Davidson, *supra* note 11.

⁵⁶ Husby, *supra* note 24, at 364.

⁵⁷ Adrian Buekling, *The Strategy of Semantics and the "Mankind Provisions" of the Space Treaty*, 7 J. SPACE L. 15, 20 (1980).

⁵⁸ Convention of the Law of the Sea, U.N. Doc. A/Conf. 62/122, 21 I.L.M. 1261 (1982). For more on the Law of the Sea, see *infra* notes 94 through 102 and accompanying text.

exploitation of the resources of the deep sea-bed may or may not be permissible..."⁵⁹

The OST goes on, in article II, to specify that nations are forbidden from "appropriating" any part of outer space, whether by "claim of sovereignty, by means of use or occupation, or by any other means." The OST thus attempts to draw a line between appropriation of outer space territory, which article II forbids, and the exploitation of that same territory, which article I permits. Glenn Reynolds and Robert Merges believe that the "the restrictions of Article 2's no-sovereignty provision...do not bar the exploitation of space resources, but merely the staking of exclusive claims to tracts of celestial bodies or space."⁶⁰ But, as H. G. Darwin notes in his groundbreaking article, "many types of 'use' or 'exploitation'...are inconceivable without appropriation of some degree at least of any materials taken."⁶¹ In other words, it is not at all farfetched to say that the OST actually installs a blanket prohibition on many beneficial forms of development.

Darwin's thesis can be clarified by considering a hypothetical development project. Let's say that SpaceCorp, an imaginary U.S. corporation, has located massive quantities of plutonium on Pluto. Having decided that Earth's plutonium markets support the project, SpaceCorp sends up a mining ship, and builds a base on Pluto above the plutonium jag. The base consists of the spaceship, living quarters and life support systems, the sealed and environment-controlled mining site, and a field of solar panels. The company serendipitously discovers that the gravity on Pluto is perfect for the manufacture of superconductors. A factory is built. Mining goes on for many, many years; it is a motherlode of plutonium. More living quarters are developed as the mine expands. A hospital is built. The work becomes long-term, and families move onto the site. Soon there is a demand for various services -- plumbers, a pub, a house of worship or two -- and a Main Street develops. A school is built, along with other municipal necessities. Eventually, the plutonium begins to dry up, but the superconductor factory's business is going gangbusters, and many decide to stay. A space colony has been born.

This, it would seem, is an ideal use of space. SpaceCorp makes money. The miners and factory workers earn a living, as do the service providers on Main Street. Humanity as a whole receives the benefit of abundant plutonium, the space-manufactured superconductor component, diminution of terrestrial mining and pollution, more jobs, and a less

⁵⁹ Lieutenant Martin A. Harry, *The Deep Seabed: The Common Heritage of Mankind or Arena for Unilateral Exploitation*, 40 NAVAL L. REV. 207 (1992), cited in Husby, *supra* note 24, at 368 (n.55).

⁶⁰ REYNOLDS & MERGES, OUTER SPACE: PROBLEMS OF LAW AND POLICY, *supra* note 10, at 82 (discussing Carl Q. Christol, *Article 2 of the 1967 Principles Treaty Revisited*, 9 ANNALS OF AIR & SPACE LAW 217 (1984)).

⁶¹ Darwin, *supra* note 27, at 282-83.

crowded Earth. In short, everyone wins. This sort of development, I argue, must be encouraged. At the very least it ought to be permitted.

But is it permitted? In the hypothetical Plutonian plutonium mine colony, under current law, SpaceCorp, and by extension the United States, would own the plutonium, once extracted.⁶² Moreover, the United States would have sovereign jurisdiction over the spaceships, the mining enclosure, the living quarters and Main Street shops, (which, after all, are no more than stationary spaceships under the U.S. flag), and the occupant nationals themselves.⁶³ If an interloper tried to break through the mining enclosure to get at the un-mined plutonium, the United States would be justified in prosecuting for, at the very least, breaking and entering.

This illustration shows how easily usufruct turns into de facto appropriation.⁶⁴ It is *appropriation* that is forbidden; long-term use and permanent occupation, to the exclusion of all others, surely constitutes appropriation.

In other words, this hypothetical example of the ideal development of space for humanity's greater good might be exactly what the OST forbids as "appropriation...by any other means." SpaceCorp's project, however beneficial, seems to violate the spirit and letter of the current OST. At the very least, excluding someone from a private factory or dwelling would be a literal breach of the OST requirement that there be "free access to all areas of celestial bodies."⁶⁵ As Ogunsola O. Ogunbanwo puts it, the end result of the restrictions the OST places on appropriation and exclusion is that "[c]elestial bodies are incapable of occupation."⁶⁶

This is unfortunate for the very real, if misguided, clients of Dennis Hope's Lunar Embassy. Mr. Hope, founder of Lunar Embassy, purports to sell 1,800-acre tracts of land on the moon for \$15.99 (plus a "lunar tax").⁶⁷ Of course, no system of property law should permit and protect Lunar Embassy's "business." But there are far more serious and potentially wealth-creating businesses, such as SpaceDev,⁶⁸ that are just as jeopardized by the OST as Mr. Hope's novelty venture.

⁶²This is the common understanding of the right to use space guaranteed by the Outer Space Treaty, art. I, 18 U.S.Ct. 2410, 2412.

⁶³The Outer Space Treaty, article VIII, provides that "[a] state party to the treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a *celestial body*." (emphasis added), *Id.* at 2415.

⁶⁴This problem is also discussed in Husby, *supra* note 24, at 365 *et seq.*

⁶⁵Outer Space Treaty, art. I.

⁶⁶OGUNSOLA O. OGUNBANWO, INTERNATIONAL LAW AND OUTER SPACE ACTIVITIES 78 (1975).

⁶⁷Davidson, *supra* note 11.

⁶⁸SpaceDev perceives a threat to its plans for space exploration and mining in the current space law. *Id.*

Could the OST be reinterpreted to permit long-term use? As it stands, the Treaty leaves even the most loyal supporters of the OST in a cloud. As OST apologist, Ogunbanwo, equivocates, the fact that the OST effectually prohibits a “the acquisition of absolute title does not mean that States are prohibited from exercising any rights over these areas.”⁶⁹ “However,” he continues, “it must be regrettably admitted that the Space Treaty lacks definite and specific legal rules” defining these nebulous rights.⁷⁰ Once again, we have a choice between interpreting the OST as truly hostile to private development, or merely vague.

The Outer Space Treaty is riddled with ambiguities. It is silent, outside of affirming freedom of “exploration and use,” as to what *sort* of rights parties can claim in celestial bodies. It is silent as to the *circumstances* under which these unspecified property rights might vest, that is, what a person must do to gain whatever property rights are available. For example, even as to the right of short-term usufruct (which a consensus of scholars agree is granted by the OST), Glenn Reynolds has said,

Suppose you land your spacecraft on Mars and your little robot drives around and picks up stuff. Does that mean you own Mars? Nah, that seems unreasonable, to claim a whole planet. But could you claim, say, that you own the [resources within a] quarter of a square mile in which your robot rolled around? The exact size of it is uncertain.⁷¹

A legal system that is unclear as to the rights of developers in the land they develop is almost as prohibitive of positive development as a system forbidding development altogether. A SpaceCorp-type company will not spend the millions, perhaps billions, of dollars it would take to travel to the ends of the solar system and develop a mine, a factory, and a colony, if the governing law is unclear as to whether they may keep their plutonium and their profits. Furthermore, the colony itself would be yanked out from under them should a majority of the international community deem it not to be in the best interests of mankind.

This was not a pressing concern in 1967, when the Outer Space Treaty was ratified. It was perfectly acceptable at the time to consign a deeper discussion of property rights to future negotiation, as the United Nations did.⁷² The prospect of space development seemed distant. Now it is upon us. And the problem is even worse. Beyond the ambiguous and oddly contradictory language already noted, the OST has *nothing more to say about property law*. No other binding treaty elaborates the OST’s befogged law

⁶⁹Ogunbanwo, *supra* note 66, at 69. See also GEORGE V. D’ANGELO, AEROSPACE BUSINESS LAW 105 (1994) (“It is not clear [under the OST] whether natural resources in space can be appropriated by a state or private entities.”)

⁷⁰*Id.* at 68.

⁷¹Glenn Reynolds, *quoted in* Davidson, *supra* note 11.

⁷²Ogunbanwo, *supra* note 66, at 70-71.

of real property. We are thus left with a legal void, a wasteland of indeterminacy and instability.

Right now, reservoirs of great wealth sit untapped in space. Unless people and nations are encouraged to exploit the riches of space, humanity will never know their benefit. And the more we are able to exploit, the more humanity stands to benefit. If commercialization is to be successful, space law must encourage investment in outer space development. But to do so, space law must work as a comprehensive regulatory scheme, with maximum predictability and minimum regulatory interference, that both rewards space development and accounts for the rights of all nations and individual participants.⁷³

What is needed is an amendment to the Outer Space Treaty, one that both clarifies and expands property rights in space.

IV. PROPOSAL: APPROPRIATIVE OWNERSHIP OF REAL PROPERTY

The ideal legal regime should create maximum incentives for efficient development of space, in recognition of the fact that the potential wealth in space will not drop into our laps.

But as much as commercial development of space would benefit all mankind, it is just as important that the development be controlled. We must learn from mistakes of the past. Any legal regime should guard against inefficient exploitation, waste, and environmental despoliation. Furthermore, space should not become the next Wild West. Destruction and sabotage must be discouraged.

My proposal, which will be developed throughout this essay, is to maximize incentives by giving developers comprehensive property rights. Humanity's welfare demands that we alter the current law to allow real estate *ownership* -- not just usufructary rights -- to those who would best develop land in space.⁷⁴ The potential wealth of outer space, in the form of minerals, energy, living space, etc., doesn't do us any good unless we are able to harness it. And, as Jeffrey Kargel, a planetary scientist at the U.S. Geological Survey, has written, "if you want to cross the bridge into the 21st century of space [development], then space must pay its way and give private investors a handsome early return on investment."⁷⁵

What do we mean by "ownership?" Property is commonly recognized as being a "bundle" of disparate rights regulating relations between people with respect to things. The bundle of rights can be unpacked. It includes: the right to possess, the right to use, the right to exclude, and the right to transfer.⁷⁶ These rights are not on/off affairs; they can each be limited or

⁷³ Kosmo, *supra* note 32, at 1057-1058.

⁷⁴ Of course, this rule must be limited, as will be discussed below.

⁷⁵ Kargel, *supra* note 6.

⁷⁶ JESSE DUKEMINIER AND JAMES E. KRIER, PROPERTY 86 (3d ed., 1993).

expanded along a continuum. I use the term "ownership" to describe a state of affairs wherein a person has all four of these rights to their maximum extent with respect to a piece of property.

Current space law ostensibly respects the right to use real property in space and to collect and own its fruits. Historically, this has been known as the usufructary right.⁷⁷ But the current law doesn't even provide this right freely; it seems to be limited by several clauses of the Outer Space Treaty (e.g. use "for the benefit...of all countries").⁷⁸

Nor does the OST recognize the right to exclude, as is evidenced by article I's prohibition on appropriating what it recognizes as being "the province of all mankind," the guarantee in the same article of "free access to all areas of celestial bodies," and article XII's requirement that "[a]ll stations [and] installations...shall be open to representatives of other States Parties to the Treaty on a basis of reciprocity." Likewise, as illuminated in the SpaceCorp hypothetical, the prohibition on appropriation seems to negate a long-term right of possession. Without the right to exclude or possess, of course, a legal system need not provide the right to transfer real estate. Anyone else may simply help themselves. In sum, the OST demands that "[n]o State can obtain such possessions as will entitle it to claim ownership or sovereignty over them... There can be no exclusive appropriation of [celestial bodies] and any part thereof as a result of their 'use'..."⁷⁹ Under current law, space cannot be owned.

A new law of space real property must enliven and support all four rights that comprise ownership.

First, there must be a right to permanent possession: barring some extraordinary circumstance or the enforcement of a judgment, no one should face dispossession of his real estate on Earth or in space. This rule supplies a needed measure of certainty, in two ways: (1) it's a *definite* rule and almost any such rule is better than the fogginess of the current regime, and (2) it moves the presumption away from public conversion of private lands, and therefore makes it clear that the OST's statement, that space development must be "for the benefit...of all countries," is a moral exhortation and not a loophole through which the United Nations can dispossess a private party of his site.

Second, I suggest that the right to use be unlimited, except by environmental regulations and the developer's domestic law. This rule is a recognition that humanity's fortune is best enhanced not by a centralized command-and-control system, but by private development making market-driven decisions.

⁷⁷L. F. E. Goldie, *Note: Title and Use (and Usufruct) – an Ancient Distinction Too Oft Forgotten*, 79 AM. J. INT'L L. 689, 691-692 (1985).

⁷⁸Outer Space Treaty, *supra* note 22, art. I.

⁷⁹Ogunbanwo, *supra* note 66, at 78.

Like the right to perpetual possession, the third right -- the right to exclude -- creates the certainty vital to an optimal investment environment. As noted, the current system precludes such a right, for it would certainly run afoul of the prohibition on appropriation and the requirement that there be "free access to all areas of celestial bodies."⁸⁰ Without the right to exclude, however, pioneer investors would be at the mercy of free riders. After investing countless hours in (or paying someone else for) a survey of the real estate, after setting up a mining colony at great expense, the pioneer would have no recourse if another party took advantage of the pioneer's research and began a copycat mine on the very same site. So the right to exclude must form a part of the new legal system.

Finally, the right to transfer must accompany the rights of exclusion and perpetual possession. The Coase Theorem of economics tells us that, in a legal environment supportive of bargaining, property rights will be allocated to the party who values them most, i.e. the most efficient user of the property.⁸¹ When transaction costs are high enough to prevent bargaining, property rights only end up in the most productively efficient hands if the law happens to initially assign them that way.⁸² Without any right to transfer, transaction costs are infinite, and no bargaining can occur. In order to avoid the inevitably inefficient solutions of a command-and-control regime of property usage, the right to transfer -- alienability -- must be a part of our system.⁸³

All these rights together -- possession, use, exclusion, and transfer -- make up ownership. And it is ownership that the modern law of space real property needs.

A. Three Arguments for Ownership

Space is an international zone, and so is, in a sense, the heritage of all humanity. We must not forget, when considering the governance of outer space, that the rules should first and foremost attempt to maximize the benefit to all humankind. So, ideally, celestial bodies should be put to the uses most beneficial to humanity. This is guaranteed by a system that puts land in the hands of those for whom the territory is most profitable. It is a matter of elementary economic theory. Whoever can use a site to humanity's greatest benefit will be the one who can profit most from the site; whoever can profit most from the site will be the one for whom the site is most valuable. Thus the person who can put a site to humanity's greatest

⁸⁰ Outer Space Treaty, art. 1.

⁸¹ ROBERT COOTER AND THOMAS ULEN, LAW AND ECONOMICS 78-84 (2nd ed., 1997).

⁸² *Id.* at 84-87.

⁸³ Furthermore, costs of bargaining should be reduced as much as possible, to minimize the possibility that transaction costs would inhibit the most efficient user from owning a site. Possible treatments of this potential problem are considered *infra* at section VI.

benefit will be the one willing to spend the most to own the site.⁸⁴ This is the bargain theory of economics, and will form the basis for all that follows.

1. Ownership will reduce wasteful use

Ownership, and the attendant right of alienability, would promote the *efficient* use of space resources.

Again, a hypothetical will help illustrate: a Martian site has been identified as being rich with manganese and silicon. Manganese Mining Co. ("M.M.Co."), interested in the manganese and the manganese alone, decides to send up a team of miners. They begin operations, develop shipping routes, and build a sustainable mining colony.

Without the right of ownership, M.M.Co. has no reason not to blast through and obliterate silicon deposits in order to more quickly uncover the manganese. Furthermore, once the manganese is depleted, there is no reason for them to leave the colony's structures and life support systems intact.

If, on the other hand, space law grants ownership to M.M.Co., then M.M.Co. has incentive to act with greater over-all efficiency. There is incentive to preserve the silicon deposits, because silicon will increase the amount for which Silicon Mining Co. ("S.M.Co.") is willing to purchase the site from M.M.Co. Along similar lines, there is also incentive to preserve the shipping routes and the colony structures and life support systems.

So M.M.Co. receives the benefit of the manganese deposits, and is further rewarded for developing the mining colony and transportation routes, and for preserving the silicon deposits and the colony itself when it sells the site. Because M.M.Co. owned the site, there would be reason for it to prospect for silicon and advertise its presence to interested parties, even though M.M.Co. did not itself have an interest in mining the silicon. Thus S.M.Co. receives the benefit of M.M.Co.'s mineralogical research. S.M.Co. also need not waste resources setting up new routes, mines, and colonies; it could purchase them intact.

Under such a system, people are better rewarded for pioneering efforts and pioneers have incentive to research and preserve that which they find and build. The second-comers receive the benefit of the pioneers' efforts; they need not reinvent the wheel. And, in the end, people on Earth receive the benefit of plentiful manganese *and* silicon, instead of, as would result in a non-ownership system, just manganese.

2. The right to transfer (alienability) would compensate for positive externalities, thereby creating added incentive to productively develop space

Another advantage of an ownership regime over a use regime can be found in the following hypothetical situation. Suppose the bark of a tree

⁸⁴ Cooter and Ulen, *supra* note 81, at 72-74.

found only deep in the Amazon has cancer-curing properties. Whoever first attempts to harvest the tree bark would be required to build a road to the grove, at tremendous expense. All subsequent pharmaceutical harvesters would have use of the road and consequently be able to turn a much larger profit on the harvested bark. The problem arises, then, that no company would want to make the costly first trek.

What problem does this situation present? Because, since no company would rationally sacrifice itself in the quest for bark, the rest of us will have to do without this life-saving cure.

The cause of the problem is an uncompensated positive externality. The right of use does not, by itself, reward the first company for the positive externality it produces, *i.e.*, the road.

One way of rewarding that first company's pioneering effort would be to grant it ownership of the grove. So if company A made the first trek to the grove, the right of ownership would let them decide whether to utilize their exclusive rights to the trees in perpetuity, or to sell the grove to company B for a price that accounts for the expense of building the road. Either way, ownership allows company A to internalize the positive externality.

The same problem exists in space development. The early developers will encounter huge costs, many of which will produce positive externalities (*e.g.* improved site assaying techniques). In space, as in the jungle, ownership rights can help a company internalize its positive external effects.

3. Colonization

Colonization might be necessary to long-term and far-reaching development of space. Additionally, colonization can help solve one of our most pressing problems: overpopulation of the Earth. There cannot be viable, long-term colonization if property law does not permit ownership -- and the certainty it imparts -- of the territory on which the colony stands.

V. THE RIGHT OF OWNERSHIP: PROBLEMS AND RESPONSES

A. Problem: Would additional incentive to develop space unleash environmental havoc?

The current space law governing environmental responsibilities is well-meaning, but not effective enough. It is composed of OST article VII and the Convention on International Liability for Damage Caused by Space Objects (the "Liability Convention").⁸⁵ Article VII of the OST asserts that

[e]ach State Party to the Treaty that launches or procures the launching of an object into outer space is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object...

⁸⁵ See *supra* note 40.

The Liability Convention limits liability to "fault."

Space environmental law, as it stands under these two treaties, is deeply flawed. The Liability Convention supplies no definition of fault. Both treaties refer only to harms caused by launched objects; while these might be interpreted to include harms caused by unlaunched installations constructed on celestial bodies, such an interpretation is by no means certain.⁸⁶ A detailed dispute resolution procedure neither has been described nor has arisen.⁸⁷ Even if the liability standards fashioned by these two treaties can remedy localized and evidentially attributable injuries, they cannot redress those harms which are communal or otherwise unattributable.⁸⁸

One reason for the inadequacy of the current law might be that its formulators did not correctly foresee the course space development would take. The approach taken by the OST and Liability Convention resonates with the expectation that space activity would remain limited to periodic governmental exploratory missions.⁸⁹ I suggest two ways to bring space environmental law into the modern space age of ubiquitous commercial activity.

First of all, an approval process, overseen by an international organization, must precede any actual development. This would be similar in function to the International Telecommunications Union ("ITU"), an organization whose most essential duty is to certify that proposed communications satellites will not interfere with each other.⁹⁰ Any party wishing to engage in the development of space would first present a proposal to the overseeing organization. The organization would then only grant project approval after an environmental review, ensuring that the project complies with environmental standards agreed to by COPUOS.

Making approval dependent on environmental compliance does not destroy the dual goals of efficient usage and wealth maximization. Far from it. Environmental safeguards embody the recognition that environmental degradation harms humanity in very real ways: it can endanger our health and lives, and can ruin a site's utility. It doesn't bear belaboring this point; an example should suffice. Without environmental precautions, a mining corporation might dirty a distant planet's lone water supply, forever deadening a world that might have grown into a great and productive colony. Similar has happened on Earth many times. It can happen in space.

Another way to solve the problem of space environmental ruination is by accepting the right of ownership into our system of space law. It would be a simple but effective step in the right direction. As Lawrence Roberts

⁸⁶ Roberts, *supra* note 13, at 145.

⁸⁷ *Id.*

⁸⁸ *Id.*

⁸⁹ *Id.*

⁹⁰ H. L. VAN TRAA-ENGELMAN, COMMERCIAL UTILIZATION OF OUTER SPACE 83 (1993).

has written, the current law "is rather damaging from an environmental perspective," because "without a means to secure control of a resource in the ground," *i.e.* without ownership, "each individual developer will seek to maximize his or her own gain by extracting as much value as quickly as possible without regard to the effect on the communal resource."⁹¹

Ownership creates a strong incentive to act with an environmentalist ethos. As owner of a site, SpaceCorp would want to maximize the site's value. This self-interest protects the environment in two related ways. First, because SpaceCorp is not just a squatter on a plot of celestial territory, because it will have more than an expiring usufructary interest, SpaceCorp will avoid wanton despoliation of the land. Despoliation would reduce the value of the property to a purchaser, and thus SpaceCorp's potential revenue. Poor land management might also harm SpaceCorp's current interests, if its actions contaminate its own site to the point that its settlement loses viability. Second, SpaceCorp will avoid ripping through the site; instead, it will either preserve materials it does not use to maximize the site's resale value, or it will itself use the site as fully and efficiently as possible. SpaceCorp will either use the site with preservationist techniques, sparing the site from wasteful destruction, or it will use the site as a conservationist, *i.e.* wholly and completely, sparing other sites from exploitation. The incentive to use space non-wastefully, discussed above in the context of economic efficiency, clearly has positive environmental repercussions. An owner has an interest in keeping his own site clean, as well as using it with minimal waste and maximum efficiency, because if he wants to eventually sell the property, any despoliation will devalue it. This carrot, because it is self-executing, is better than any stick.

Of course, the right of ownership would not make an environmental violation whose harm extends onto *another* site less likely -- but it wouldn't make it more likely, either. As under the current system, lawsuits should still be available to remedy harms. Hopefully the requirement of environmental review would act as a prior restraint to prevent these harms. And ownership, by creating an incentive to care about one's own property, protects the interests of others: both those nearby (who instantly feel the effects of more care given to, *e.g.*, waste disposal and water management), and those who come later.

B. Problem: What about the concerns of developing nations?

Developing nations have reason to oppose incorporating rights of ownership into the property regimes governing international zones. First, developing nations do not want to be permanently disadvantaged just because they lag in space-capability right now. This is an extremely potent critique, and will be discussed momentarily.

⁹¹ Roberts, *supra* note 13, at 141.

The second rationale is more historical. It is a deep-seated distrust of colonial imperialist doctrine such as that which the world faced in previous centuries. It is a readily understandable distrust: most, if not all developing nations were harmed by European nations who treated the non-European lands as theirs for the taking.

The difference here, however, is that there are no (known) occupants native to outer space.⁹² The colonialist “right of grab” policy was morally objectionable because it ignored the property rights (and other rights) of those already occupying the “discovered” lands.⁹³ In the absence of prior existing property rights, however, there seems to be nothing inherently immoral about a right of grab.

Except, perhaps, that it may severely disadvantage the lower-tech nations in future. Developing nations fear that by the time they gain the wealth and technology necessary to become players in the space game, the most readily available resources will have already been claimed as private property and be under sovereign control of other nations. The developing nations argue that they will again be left in the economic lurch. This argument against a right-of-grab-based system gains salience when one considers that the reason the developing nations are not yet space-capable may well be attributable to past wrongs the developed nations inflicted on them. The perpetuation of past wrongs thus makes the right of grab doubly objectionable in the eyes of developing nations.

There are two short answers to this concern. First, the universe, for practical purposes, is not finite. Whenever developing nations become space-capable, there will be plenty of available unused space real estate. Second, corporations based in space-incapable nations could, of course, contract out to a space launch company from a space-capable nation. Developing nations can take advantage of space development without themselves being space-capable.

Perhaps less straightforward is the notion that ownership rights, by incentivizing the development of outer space, would fund intense R&D of launch technology. Launches would become more reliable and cheaper. In this way, ownership rights might hasten the day that developing nations are able to afford hiring a launch company, or even to have their own space programs (see *infra* section VII (b)).

Nevertheless, developing nations will likely continue to oppose rights of ownership in space. This is a political problem, and requires a political solution. For further discussion on this point, see section VII, *infra*.

We can learn how *not* to solve the problem from the legal and diplomatic wrangling that has been going on regarding mining of Earth’s deep

⁹²If humans ever come into contact with intelligent extra-terrestrial life, much of our space law, and human thought as we know it, will have to be revised.

⁹³As we shall see, there are also economic reasons to oppose an unfettered right of grab.

seabed. Exploitation of the deep seabed, like exploitation of space, is a very risky and expensive proposition. And the deep seabed, like space, is considered an international zone. In December, 1982, 120 nations signed the LOS.⁹⁴ The LOS establishes an "Authority" and an "Enterprise."⁹⁵ Mining companies must receive approval from the Authority. Approval, in the form of a license, is only granted if the applicant company satisfies a set of rigorous conditions. The applicant must present two sites of equal value, one of which will be reserved by the Authority for development by the Enterprise.⁹⁶ The applicant must fully disclose information regarding mining equipment, methods, and technology.⁹⁷ The applicant must pay an initial sum of \$500,000, an annual fee of \$1 million until production begins, and (once mining has begun) either \$1 million or a percentage of the market value of recovered materials, whichever is greater.⁹⁸ Finally, and in addition to any domestic taxes incurred, the Authority levies 35 to 70 percent of the net profits.⁹⁹

The United States, along with several other industrialized nations including the Federal Republic of Germany, France, Great Britain, Japan, and the Soviet Union, refused to ratify the LOS because of the deep seabed mining provisions.¹⁰⁰ There was a strong perception that the treaty's harsh regulations were an attempt to ruin commercial mining projects that would be in potential competition with the dry-land mines of developing nations. As Marne A. Dubs, spokesperson on seabed mining for the American Mining Congress, saw it, if the LOS was enforced "there will be no U.S. ocean mining industry."¹⁰¹ Instead, the United States passed a domestic law, the Deep Seabed Hard Mineral Resources Act, which recognized the rights of U.S. mining ventures to the full profits of their labors.¹⁰²

If space law follows the LOS's lead and asks developed nations to make similarly-excessive sacrifices for the benefit of developing nations, the same political impasse with the resultant disparate and incoherent legal regimes will no doubt reoccur.

⁹⁴Multilateral Treaties Deposited with the Secretary General, U.N. ST/LEG/SER.E/15 (1997).

⁹⁵LOS, *supra* note 58, at arts. 137(2), 153, 156-57, 170.

⁹⁶*Id.* at annex III, arts. 8, 9.

⁹⁷*Id.* at art. 5.

⁹⁸*Id.* at art. 13.

⁹⁹*Id.*

¹⁰⁰Kosmo, *supra* note 32, at 1077.

¹⁰¹Marne A. Dubs, quoted in Van Dyke & Yuen, "Common Heritage" v. "Freedom of the High Seas": Which Governs the Seabed?, 19 SAN DIEGO L. REV. 493, 496 (1982), cited in Kosmo, *supra* note 32, at 1077.

¹⁰²Deep Seabed Hard Mineral Resources Act, 30 U.S.C. §§ 1401-1605 (1980); see also Reynolds, *supra* note 23, at 234.

C. Problem: Would ownership rights create inappropriate incentives, leading to inefficient development?

Any property system based on the right of the first comer creates artificial value unrelated to the property's inherent worth. This skews the economic efficiencies of the market. We might call this the "get it while you can" problem.¹⁰³ A concrete example might help explain. Suppose a site is worth \$1 million. CorpA, operating alone, would not commence on a mission to exploit the site until it felt that there was enough demand, and cheap enough exploitation technology, to carry the mission out. However, operating in competition with CorpB and CorpC, CorpA will recognize that it might not be able to harness the site's value at all if CorpB or CorpC get to the site first. Thus CorpA will feel compelled to zoom up to the site, using today's less efficient technology, simply because of the artificial value of being the first-in-time.

Does the possibility that an ownership-based property regime that could lead to less efficient development mean that we should reject such a system? I believe the answer is no, for two reasons. First, the most efficient and effective way to spur the development of better space technology is to encourage private commercial space flights. Government funding was no doubt needed at the inception of the space program, because there was no understanding of space's commercial value. Now, however, tremendous amounts of private money are being invested in space-oriented projects,¹⁰⁴ and that's without ownership rights. Ownership rights would speed up space development, which would pump even more money into space technology R&D. Furthermore, money would go to R&D in needed areas, not pork-barrel projects. The industry could become self-sufficient, free of the need for government funding. Pioneering space flights may have many positive externalities, but this would be perhaps the most important one of all. So even though the prospect of ownership might stimulate some early space projects into a premature, and less efficient, start-date than would otherwise be the case, these early endeavors bring the future of space technology a great deal closer to the present.

Second, it is impossible to know, *ex ante*, how much space flight technology will improve. Surely hindsight will show that development could have achieved greater efficiency, in some cases, by waiting five years. On the other hand, should property law let a governmental authority force a company to wait five, ten, or fifty years on a project on the belief that fusion engines are just around the corner? If fusion engines never materialize, humanity will have been deprived for no reason. Do we wish to put the de-

¹⁰³Grier C. Raclin, *From Ice to Ether: The Adoption of a Regime to Govern Resource Exploitation in Outer Space*, 7 J. INTL. BUS. 727, 757 (1986) (using the phrase in a somewhat different context).

¹⁰⁴Highlights 1996, *supra* note 1, at 1.

cision in the hands of a centralized politics-driven authority, who has no personal stake in the development projects? No. It is better to let individual companies, experts in their fields, decide when to take risks and when to wait for improved technology.

D. Problem: Will the right of ownership, by creating an additional incentive, lead to *inefficient* development?

When thinking about inefficient development, we need not worry about the possibility that a company might spend more money on a project than it eventually earns. Although this net loss might be termed "inefficient" for the company to have undertaken, we need not be concerned.

We should assume, as a starting point, that companies will act rationally, in their best interests. A company would not rationally engage in a development project if it expected a net loss. Let's say that CorpA expected a net profit, but, to their dismay, the project was a net loser. This is still of no concern, because all that has occurred is a transfer of wealth within the system. CorpA's revenue (money it took in from consumerA, consumerB, et al.) was less than its costs (money it paid to supplierA, supplierB, et al.) Humanity, as a whole, has not lost anything; wealth has merely been shifted around.

However, there is a means by which a project can decrease humanity's total wealth. When SpaceCorp buys rocket fuel from CorpB, nothing has been lost to the system; that's a wealth *transfer*. But when SpaceCorp burns the rocket fuel, they've *depleted* humanity's wealth. That fuel is gone, lost to the system. Humanity's aggregate wealth has declined by exactly as much as the value of the unrecyclable materials that were exhausted. From this we can derive a meaningful definition of "inefficient development." In a mining context, a legal system operates inefficiently if the prospect of ownership leads SpaceCorp to expend more of humanity's wealth (fuel, un reusable rockets, human capital, etc.) than it extracts as ore. Since we are concerned with creating a legal system that maximizes the total social welfare, increasing humanity's aggregate wealth as much as possible, we should be concerned if the legal system encourages inefficient projects, i.e. projects that cause humanity's aggregate wealth to decline.

But can ownership rights really cause inefficiencies? Another example will help illustrate why they cannot. Assume that ownership rights are assigned on a "right of grab" basis. Let's say that \$1 billion of uranium has been found on Uranus. It costs \$2 billion in fuel to make the journey. But CorpA decides that ownership of the Uranian plot is worth \$1.1 billion over and above the value of the ore; that is to say, CorpA believes that it can sell the site to CorpB for that amount after the uranium has been extracted. Ordinarily we are not concerned about costs of projects (the salaries, the raw materials, the taxes), because wealth is merely being transferred from one party to another. However, we can see, in the example, that CorpA will use \$2 billion of Earth's resources (the fuel), and only return \$1 billion (the

uranium). With these numbers, the system has lost a net of \$1 billion. And this loss, it seems, has been caused by the right of ownership. Without ownership rights, CorpA would never have undertaken the project, as it would have lost money. But with ownership rights, the project, seemingly inefficient to the Earth as a whole, becomes profitable to CorpA. To put it more generally, the incentives created by rights of ownership seem to make projects profitable to individuals, even though the project delivers a net loss to the world's wealth.

But this inefficiency is an economic illusion. A false assumption has been made: that ownership has "artificial" value inherent. The fact is, rights of ownership can have no value outside of what it's worth to mankind, so-called "real" value. That is, SpaceCorp's ownership rights will not be worth \$1.1 billion, or anything at all for that matter, unless *someone else is willing to purchase the site for that amount*. And, of course, no one will purchase the land unless it contains something of value to humanity, e.g. another type of mineral.

Another example may help. Again assume ownership is achieved by right of grab. An asteroid contains manganese and silicon deposits worth \$1 and \$3 billion respectively. Fuel costs to the asteroid are \$1.5 billion per round trip. Manganese Mining Co. (M.M.Co.), expert only in mining manganese, is able to secure ownership rights to the asteroid. Without ownership rights, it has no cause to make the journey; it will not waste \$1.5 billion in fuel to retrieve \$1 billion in manganese. However, Silicon Mining Co. (S.M.Co.) values the asteroid at (\$3 billion of silicon) - (\$1.5 billion fuel) = \$1.5 billion. Thus, with ownership rights, M.M.Co. can sell the asteroid's remains to S.M.Co. for a split-profit price of \$0.75 billion. This gives M.M.Co. a \$0.25 billion profit, and leaves S.M.Co. \$0.75 billion in the black. Both projects would happen, but there's no inefficiency: \$4 billion of ore is gained at a cost of \$3 billion of fuel = \$1 billion increase in humanity's total social welfare. What if fuel costs were higher? If a round trip cost \$2.5 billion, would M.M.Co. acquire ownership rights to the asteroid? Not unless it could sell the property rights for (\$2.5 billion of fuel) - (\$1 billion of manganese) = \$1.5 billion. Which M.M.Co. could not do: S.M.Co. would only be willing to bargain to a maximum of (\$3 billion of silicon) - (\$2.5 billion of fuel) = \$.5 billion. M.M.Co. could not profitably sell ownership rights, and consequently would have no incentive to "grab" the asteroid. With M.M.Co. out of the picture, S.M.Co. could acquire sole ownership and make a \$0.5 billion profit. There is a principle at work here, analogous to physics' Conservation of Momentum. The right of ownership cannot cause humanity's aggregate wealth to decline.

On the other hand, although the right of ownership can't cause *inefficient* development, it can cause what seems to be *less* efficient behavior. In the examples just given, humanity is enriched by M.M.Co. and S.M.Co.'s projects. However, humanity would have been even *better* off had M.M.Co. not done anything. In each case, our total social welfare would

have had a greater net increase had S.M.Co. acted alone. It was only the right of ownership that led M.M.Co. to execute what is not, in itself, a fruitful mining venture.

There are several responses to this. First, space exploitation, in the long run, is aided by increased spending in space travel. Although M.M.Co.'s operation did not increase humanity's aggregate wealth, it did inject money into the space flight industry. This increased demand, if on a large scale, might spur more companies to become space flight suppliers. Increased competition will bring about an increased investment in research and development. The more money we pump into space flight in the near term, the more efficient space flight will be in the long term. Also, not to beat a dead horse, but M.M.Co.'s venture will likely bear other positive externalities as well. Together, these side effects of hastened development will likely more than make up for any ownership-driven efficiency losses.

Second, bargaining theory might turn aside much of the weight of this critique. If M.M.Co. was in a position to secure ownership of an asteroid by engaging in an unprofitable mining venture, a conversation between M.M.Co. and S.M.Co. might go like this:

M.M.Co.: "We know the asteroid is worth \$3 billion to you. We have a fast new ship, so we'll get there first and grab ownership. When we're finished extracting the manganese, we'll be willing to sell the asteroid to you for, oh, \$1.5 billion?"

S.M.Co.: "Look, first of all, why should you get all the profits? Clearly we should meet somewhere in the middle, say, at \$0.75 billion. But why should we go on with this charade? Let's speak frankly. We know that there's not enough manganese on the asteroid to make up for your fuel costs. The only reason you're planning to mine the manganese is so that you can attain ownership of the asteroid and sell it to us. I have a better idea. Why don't we pay you not to fly up there at all?"

M.M.Co.: "You mean, avoid the danger and hassle of space flight, and not waste \$1.5 billion of fuel to get \$1 billion of manganese?"

S.M.Co.: "That's right. Of course, we wouldn't pay you \$0.75 billion, because we know your total investment and risk are much lower than what they would otherwise be. But I'm sure we can work out a fair price."

By "buying off" M.M.Co., S.M.Co. can save money for itself. By persuading M.M.Co. not to pursue ownership, this buy-off also improves humanity's net wealth increase.

VI. CENTRALIZED COORDINATION OF DEVELOPMENT: THE UNSER SYSTEM

On what basis should ownership be awarded? The legal system's answer to this question is crucial, because it determines what commercial actors will do. If the rule of ownership was no more than "first come, first served," with ownership going to the first person to grab a celestial body, an

unmitigated land-rush would ensue. Of course, the amount of wealth dependent on being first-in-time would doubtless breed the criminality and outright sabotage witnessed in the American West of the gold rush era. This, along with efficiency concerns, dictates that the legal regime must not operate on a pure principle of first come, first served.

Clearly there must be a measure of centralized organization. I am not suggesting that private industry cede its independent judgment to an inter-governmental command-and-control planning board. What I am suggesting is that an international body, carrying the legitimacy of the United Nations, *coordinate* private industry so that the market forces can operate most efficiently. We might call it the United Nations Space Exploitation Registry, and it might be founded on a document like this (commentary in bracketed italics):

A. The U.N. Space Exploitation Registry (“UNSER”)

1. Definitions

“Author” is defined as the person, corporation, or governmental body that designs and plans to execute a space development project.

2. Provisions

- 1) Prior to commencing any use or exploitation of any part of any celestial body, authors need to receive UNSER’s approval.
[This provision is necessary to prevent a party from evading the UNSER system. A party thus cannot, e.g., embark on an environmentally hazardous project by deciding to forgo ownership and settling for usufruct. Ownership will accompany all use, but there will be no usage outside of UNSER regulation.]
- 2) UNSER will grant approval only upon
 - a) receiving a completed project plan,
 - b) reviewing the project plan to determine whether it conflicts with any prior project,
 - c) reviewing the plan for environmental violations, and
[UNSER must also be enabled to perform periodic on-site checks of projects, to make sure that environmental codes are being continually upheld]
 - d) confirming that the project plan doesn’t endanger the life or health of any person or the security interests of any nation.
- 3) Project plans shall be public documents, available on request.
- 4) A complete project plan shall include
 - a) a demarcation of the project site’s boundaries,
 - b) a detailed business plan, including expected revenues and sources of revenues, and

[This information should include an explanation of why the project author believes the site to be valuable. E.g., the mineral content of the site, the fact that the site is located over a quantity of water, the fact that the site has the ideal gravity for processing materials.]

c) a detailed description of launch technology.

[Making this information public is an important step in advancing the space-capability of developing nations, as well as in advancing the state of the art of space flight overall. On the other hand, we should probably let authors keep secret the technology specific to space mining, colonization, energy-capture, materials processing, et al. Although such information is indubitably valuable to developing nations, project authors might be so unwilling to give up their trade secrets to everyone, including their industry rivals, that they would be discouraged from undertaking the project, or even from supporting the UNSER system in the first place.]

5) Projects shall be prioritized based solely on the date that the completed project plan is received by UNSER.

6) If the proposed project conflicts with another project, UNSER shall refuse approval to the project submitted later-in-time.

[This provision describes UNSER's most important function: creating a public registry of prioritized space projects. In this way, UNSER forestalls potentially conflicting projects before they progress too far. By enforcing an absolute privilege for prior projects, UNSER can help avert lawsuits and wasted funds. In other words, the right to exclude is given to the author of the prior project and is enforced by UNSER. The incentive to sabotage is thereby reduced.]

7) If the author of a project does not commence on the project within x (amount of time), then the project loses UNSER's approval. The author may re-apply for approval, but the project will be prioritized based on the date of the re-application.

[This provision is necessary to prevent parties from proposing projects on everything in sight, just to get priority and an exclusive right to develop.]

8) UNSER shall be funded by states party. The funding shall be paid by states party in proportion to the total amount of income each state party derives from its space projects, yearly. The total amount of income each state party derives from its space projects shall be calculated as the sum of all net income (post-expenses) earned by all authors, both governmental and private, located within the state.

Obviously, many details must be hammered out in negotiations over and drafting of an UNSER convention (e.g. composition, voting procedures). The above is meant only to be a rough outline of the most important

powers and controls UNSER would have over space development. Note that UNSER has no power to propose development projects of its own. Regulation is kept to a minimum, and development is left in the hands of private industry and individual governments.

To summarize, UNSER wards off much litigation and potentially dangerous competition by imposing a system of prioritized registration. This is necessary, in any property regime based on the right of the first comer, to ward off sabotage. Space must be developed, but not at the expense of civil relations. It will also eliminate private space races. In a space race, two companies vie for the same site. One company inevitably must arrive second and return empty-handed, with nothing to show for its massive resource expenditures. The UNSER approval process would prevent such waste.

The UNSER approval process screens for environmental violations, reduces waste and lawsuits, and provides necessary control to protect long-term growth.

Since project plans, once submitted, are public documents, information about sites and projects spreads. This is an economically significant point. A major element of transaction costs is imperfect information. Specifically, when it's difficult for parties who want to purchase sites to unearth information about the sites, or even who it is that owns the sites, they will not necessarily be able to purchase the site they would find most valuable. When knowledge about the properties for sale in a real estate market is less than perfect, the costs of property transfer rise and real estate tends to end up in less efficient hands. UNSER acts as a sort of clearing-house. It centralizes information about sites and owners. This would lower the cost of finding the right property. And that means we get closer to an efficient allocation of resources.

And by requiring launch processes to be described in publicized project plans, developing nations will be better able to design and build space-ships of their own.

B. The Banking Problem

What if SpaceCorp, calculating that the value of owning Earth's moon outweighs the cost of setting up a bogus project, decides to mine the *entire moon* for dust. In doing so, SpaceCorp hopes to "bank" the moon and reap great rewards in the real estate market down the road.

Such banking must be prevented. It is a tremendously wasteful activity that creates little or no wealth. It even discourages development by others: SpaceCorp, a monopoly owner of moon resources, could charge monopoly rents on those who would purchase moon sites to develop, and would therefore decrease production to monopoly levels.¹⁰⁵ SpaceCorp should not be rewarded for such a project with ownership of the moon. The moon is of

¹⁰⁵ PHILIP AREEDA AND LOUIS KAPLOW, ANTITRUST ANALYSIS 17-18 (5th ed., 1997).

potentially great value to humanity. We already have enough dust. A legal regime that rewards such activity is guilty of instigating massively inefficient behavior.

The problem illuminated by this example can be restated more generally: Aside from applying for UNSER approval, what must one do to achieve ownership? The problem of asset banking is a difficult one, and I cannot offer a definitive answer. I will review four possible ways to combat banking, and recommend one.

C. The Four Systems

1. *Acreage tax.*

Under this system, UNSER would levy a tax based on the geographical scope of the proposed project. The LOS deep seabed mining provisions use a similar tactic. As a result of the tax, companies would find it less financially attractive to occupy huge tracts of land. If a company was not utilizing the land productively, the tax would represent a huge onus. The dust-miner from the previous example would pay a tremendous tax for ownership of the entire moon. The longer the dust-miner had to wait before selling the real estate, the more expensive ownership would prove to be.

Another advantage to an acreage tax, aside from quashing banking, is that it would help fund the infrastructure necessary to support large-scale space exploitation. For instance, an international space police force and an environmental code enforcement team will be necessary, at the very minimum. Furthermore, it would be a tax directly proportional to use, so those benefiting the most from the infrastructure would be the ones paying the most for it.

The disadvantage to such a system is that it raises the price of development. For projects with comfortable expected profit margins, the acreage tax will not be prohibitive. There will inevitably be a number of projects, however, that would have been borderline-profitable (and positive-externality-producing), but instead will be pushed into the red by the acreage tax. The danger is that an acreage tax might end up being a prohibitive burden on so many projects that the tax will do more harm (*i.e.* wealth not harvested from space) than good (*i.e.* preventing banking).

There is reason to think that the tax would, in fact, have such an effect. As mentioned, the LOS levies an acreage tax on deep seabed mining.¹⁰⁶ As a result of the exorbitance of that tax, alongside the many other expenses the LOS tacks onto all developments, industry leaders have doubted that *any* deep seabed mining could be carried out profitably under the Convention.¹⁰⁷ Moreover, the political motives that led to the excessive costs of

¹⁰⁶ LOS, *supra* note 58.

¹⁰⁷ See, *e.g.*, Harry, *supra* note 59.

mining under the Convention -- the developing nations' fear that the minerals extracted from the deep seabed would compete with the minerals they mined on land and relied on for wealth -- would likely play a role in the space context. Regardless of whether minerals and energy might be collected more efficiently with less environmental destruction in space, the Group of 77 nations might try to push the acreage tax to a level beyond that which is necessary to prevent banking, in order to crush any competition space industries present.

All in all, an acreage tax is a formally-simple solution with several attractive features. But because it is set by a governmental body and not the market, the tax cannot respond to rapid economic shifts, and could as a result endanger the success of space development.

2. Productive use analysis.

We might foreclose space territory banking schemes by adding one to the list of conditions required for UNSER approval: "2) UNSER will grant approval only upon ... e) confirming that the plan is financially justified." This clause goes to the heart of the banking problem. No longer would a company be able to waste resources in pursuit of unproductive ownership. Productivity would be a prerequisite for ownership.

This solution is extremely problematic. First, there are definitional issues. When is a project productive? Is simple profitability the correct measure? How can we calculate and factor in positive externalities? Is a \$1 expected profit enough to justify ownership? It also becomes tough to define the scope of the project. What if SpaceCorp wanted to mine the entire moon for diamonds? If there was a single, 1km² diamond vein but SpaceCorp insisted that the whole moon was part of the project, what arguments might be made to limit the claim?

Even worse, the bureaucratic costs of this added step would be mind-boggling. Each project plan would require an in-depth financial review. Technical experts would be needed to give their opinions about the plan's feasibility and industry experts would be needed to speculate on the plan's profitability. Each project proposal would open up a firm to a full audit. Aside from the costs inherent in conducting this sort of review, there are the costs of delay. An analysis of this nature might take months, during which time financing might be lost, the firm might go bankrupt, and the time value of money takes its toll. And should a project be rejected, the process must begin all over again.

Worse still, a productive use analysis essentially takes the decision to develop out of the hands of private industry. There will surely be disagreements as to profitability between private CFOs and UNSER analysts. Do we want to take the decision to develop out of the hands of the developers? Should UNSER analysts have the power to veto a project on financial grounds, when the company itself is willing to take on the risk of space development, perhaps as a result of greater technical expertise or an under-

standing of its market not apparent to UNSER? Litigation would proliferate.

3. *Post hoc productive use analysis*

The problems, just discussed, with analyzing profitability *ex ante* can be sidestepped by postponing productivity analysis. Perhaps UNSER should permit the utilization of space without initial regard to productivity, but only grant ownership rights to the site if, eventually, the project shows an *actual* profit. This would put control of the project back into the hands of the risk-taking developers.

This solution, however, has its own problems. There is simply too much riding on showing a profit. If a project shows a profit, the developer would receive an additional windfall: ownership. If a project turns out to be a money-loser, whether \$1 billion or \$1, then the developer -- already reeling from the unsuccessful project -- would take another hit: no ownership rights. This post hoc productivity analysis magnifies the risk and generates investment-hostile uncertainty. What's more, post hoc analysis would encourage corruption. If a company needs another \$1 million of profit to secure ownership rights worth \$1 billion, it would feel overwhelming pressure to cook its books or to manufacture fraudulent contracts.

4. *Auction*

An auction of ownership rights, held by UNSER, would be a much better solution. Under such a regime, anyone, at any time, could request an auction of any unowned site. Ownership rights to the site would go to the highest bidder.

Even after acquiring ownership via auction, the owner should not be permitted use of its site until UNSER approvals have been obtained.

The auction system has significant advantages. An auction would, by its very nature, put territory into the hands of the firm that values it most. Also, by creating a single market, transaction costs, in the form of information costs, are reduced. Without a centralized auction, a property might be sold at the fringes of the market where only a few buyers ever learn of the sale. A diffuse market with imperfect information means that the party who values a property the most will not always be able to take part in the bargaining. Thus it would be wise to require *all* sales -- even resale of pre-owned space property -- to be conducted at UNSER auctions. By creating a clearing-house through which all properties are advertised and sold, allocative efficiency would be heightened.

An auction system would also solve the banking problem. In order for the dust-miner to gain ownership of the entire moon, he would have to outbid everyone else (even groups of investors and international consortia) who had any interest in any of the moon. Even if the dust-miner succeeded in purchasing the moon, he would never be able to turn a profit. If half the moon was worth \$1 billion to A, and the other half worth \$1 billion to B,

then A and B would have together driven the auction price up to a minimum of \$2 billion. Thus the dust-miner would have had to pay more than \$2 billion for ownership rights that he could only sell for \$2 billion. The auction eliminates the incentive to bank property.

Obviously, under an auction regime there is no need for UNSER's prioritization scheme. There is no need to police against a sabotage-infested land rush. Once a site is purchased, ownership rights (including the right to exclude) vest in the owner. The law automatically prioritizes the claim of the purchaser/owner over all others.

Auctions, and space exploration in general, might be facilitated by bestowing rights on prospectors. We might make a rule: if a prospector submits information about a site to UNSER, the prospector shall get a percentage of the purchaser's earnings from that site. Such information would be made available to the public prior to auction. Of course, the rule will have to specify the requisite type of information and degree of detail. Bob Zubrin suggests that any private company using remote sensing to explore a portion of a celestial body with gamma ray spectrometer chemical analysis and photography to a resolution of 1m^2 per pixel deserves a royalty of 10 percent of all resultant profits.¹⁰⁸ Higher percentages might be warranted by more detailed analysis. Prospector percentenaries should not affect the auction, since each bidder will be affected equally, and all will adjust their willingness-to-pay downward in proportion to the amount of profits that go to the prospector.

It is clear that the prospector's "take" must be calculated based on eventual profits, not on the initial auction price. Although the initial auction price is easier to collect and is more certain, it also creates a significant danger of corruption. If the prospector takes a percentage off the auction price, it is in the prospector's best interest to inflate the price, even by misrepresenting the results of his exploration. By restricting the prospector to a percentage of actual earnings, the incentive to fraudulently inflate the auction price by falsifying data is eliminated.

Building prospector rights into the property law creates an additional benefit: specialization. By rewarding space prospecting, the auction-based legal system makes it possible for companies to specialize in space exploration. A mining company could thus concentrate on mining techniques without concerning itself with remote sensing technology. Ordinarily, this could be accomplished through private bargaining: a company interested in learning about a site could contract with a private prospecting company. Within a public auction regime, however, if prospecting were left to the private market, CorpA could pay the prospector to deal exclusively with CorpA and not disclose information to competing bidders. As a result of

¹⁰⁸ Bob Zubrin, *Opening Space Exploration to Private Enterprise*, AD ASTRA, Jul./Aug. 1994, at 27.

the non-disclosure contract, CorpB and CorpC would either be forced to hire prospectors of their own (a huge waste of resources), or would be locked out of the auction for lack of information. In order to ensure that the auction runs competitively -- with maximally efficient results and minimum costs -- relevant information must be disseminated. But if prospectors are enjoined by law to disclose their research publicly, they are in no position to bargain for a fee for their services. If the law requires prospectors to "tell all," the law must also compensate them for their services. A percentenary, if set to a level that approximates a fair bargain between the prospector and the recipient of the information, should suffice. Zubrin suggests yet another benefit. At this time, exploration and prospecting are within current technological capabilities. Extensive space mining is not, however; therefore there is little incentive for the private sector to invest in space exploration. If prospectors were given rights at an auction, however, space exploration would have market value *now*. There might well be speculators willing to invest \$100 million to assay an asteroid on the gamble that its percentenary would mature, when space mining becomes feasible and practical, to \$10 billion or more.¹⁰⁹ Already, companies are planning to launch prospecting missions. SpaceDev, stating that they're "going to use common-sense business tactics to explore deep space," plans to launch a robotic Near Earth Asteroid Prospector ("NEAP") in the foreseeable future.¹¹⁰ The NEAP will embark on a search for valuable asteroids, the information about which SpaceDev will then sell for "a profit."¹¹¹ By reserving future financial rights for space prospectors, the legal regime would magnify the current value of prospecting, thereby stimulating private funding of space exploration.

In a fundamental way, an auction regime embodies a different path from those we have so far examined. It rejects the right of grab and the first come, first served policy altogether. The auction occupies the middle ground between *laissez faire* privatization of space development and a belief that space is the equal birthright of all humanity.

Under every other system of ownership so far suggested, a concern has always been that developers seem to be acquiring exclusive rights to something -- outer space -- that should be owned by all. Throughout this essay I have attempted to respond to these issues, pointing out that development by the few is actually in the best interests of the many, and that ownership rights are an important way to incentivize development in the right way.¹¹²

Nevertheless, distributional justice concerns may still loom. Distributional justice has not been the guiding principle of this property law, nor, I

¹⁰⁹ *Id.*

¹¹⁰ *Connected: Prospectors Launch Bid For Cosmic Profit*, THE DAILY TELEGRAPH, Sept. 16, 1997, at 2.

¹¹¹ *Id.*

¹¹² See *supra* notes 92-102 and accompanying text.

believe, should it be. Robert Cooter and Thomas Ulen have argued that if wealth redistribution is a goal, it should be accomplished by means of taxation, not property rights.¹¹³

Even accepting this analysis, there may still be politically-driven distributional justice concerns. The dilemma we are faced with, if we do desire to redistribute the wealth of space, is that no international body has the power to tax the spacefaring nations' space profits. The auction and acreage tax regimes create a centralized pool of money that could then be redistributed.

Thus we discover another reason to prefer the auction system. It requires developers to compensate "all humanity" by paying for their sites. By treating auction proceeds as a common fund, UNSER would be able to redistribute funds in any way that the international community determines to be fair and just. In this way, such a regime would help relieve both efficiency *and* distributional concerns. Everyone is happy: spacefaring nations get ownership, and developing nations get a share of the pie.

D. Problem: What if the hypothetical company SpaceCorp, instead of mining the moon for dust, discovers that the moon is filled with valuable minerals and authors a proposal to mine the entire moon?

Assuming the project is very profitable, neither the acreage tax, nor the productive use analysis, nor the auction would prevent SpaceCorp from owning the entire moon.

But should we fear such lunar domination? This author thinks we should not. If SpaceCorp is so adept at space mining that it is capable of profitably mining the entire moon in compliance with the environmental safeguards, time limits, and other conditions of gaining UNSER approval, more power to them. Whatever the source, the people of Earth will benefit from the influx of resources, the expanded job market, and all the other secondary benefits I've been discussing throughout.

In general, we should not worry about SpaceCorp, or a few companies, or a nation dominating any part of space. As soon as CorpB finds a more profitable way to use part of SpaceCorp's land, CorpB will purchase that part. If SpaceCorp can earn \$1 billion/acre on the moon, and CorpB's new lunar project would earn it \$2 billion/acre, then SpaceCorp and CorpB would have every reason to bargain to a purchase agreement.

E. Sovereignty

The issues addressed in this paper raise many further important questions that are beyond the scope of the current project. One of these is sovereignty, about which I will say only a few words.

¹¹³ Cooter and Ulen, *supra* note 81, at 104-06.

Sovereignty over land has been said to include two powers: the power of a state to apply its rule of law, and the power to exclude all other states from exercising their authority.¹¹⁴ Development in space must not occur in a lawless environment. Some government must be sovereign over each owned parcel of space real estate, so that rule of law is applied. Without it, space would most likely be rife with crime against property and person.

On what basis should the law of space assign sovereign power? Perhaps the developer's nationality should be determinative; after all, the developer's home state already has jurisdiction over the spaceships and its crew.¹¹⁵ In the case of multi-national corporations, their national affiliations would be stipulated by the articles of incorporation.

Sovereignty can create problems for property transfers. For example, years from now Israeli corporations might create a large space colony. To support the function of this colony, Israel builds an infrastructure: roads, hospitals, police, water districts, etc. What will happen when the Israeli owner of a site near the colony's center wishes to sell? Will the sale be restricted to Israeli buyers? Economic theory tells us that the person who most values a site must be able to purchase it, regardless of their nationality, or the system will lose efficiency. But if a site at the center of the Israeli colony would come under, *e.g.*, Nigerian sovereignty as a result of its sale, the Israeli colony's infrastructure would be imperiled, and the Nigerian enclave might be cut off without services.

We have faced this same problem on Earth since time immemorial. States have traditionally responded in one of two ways: (1) by restricting land ownership to nationals, or (2) by allowing non-nationals to purchase but retaining sovereignty. However, both policies would injure developing nations. If developing nations could not gain sovereignty over space territory by purchasing it, then they would be much less able to overcome the developed nations' head start in space. I will only note that this dilemma exists and must eventually be resolved.

When policy-makers eventually attempt to solve the problem of sovereignty, it is imperative that they acknowledge an inevitability: space colonies will eventually desire self-government. The yoke of distant government has, throughout history, been thrown off. As space colonies grow, they will ultimately demand self-rule and independence. Modern negotiators would do well to recognize this as they begin to formulate a law of sovereignty.

VII. ACCOMPLISHING CHANGE

The Outer Space Treaty, as noted, would need substantial revision and amendment to accommodate the suggestions made in this paper.

¹¹⁴ JOHN KISH, *THE LAW OF INTERNATIONAL SPACES* 52 (1973).

¹¹⁵ Outer Space Treaty, art. VIII.

How can the changes suggested herein be effected? It's not within the scope of this essay to deliver a complete analysis of international political and negotiational strategies. U.N. politicking is a topic all its own. However, I will make two suggestions that might help bring about the reformation of space property law.

A. Submit the GSO to appropriation

The GSO is part of what we might call "space itself," *i.e.*, not part of a celestial body. This essay has not suggested a right of ownership over space itself, for several reasons, the most basic and fatal of which is that there would be no way to define static boundaries. However, the GSO is in many ways more like celestial bodies than space itself. Like celestial bodies and unlike space itself, the GSO has great value, but is in limited supply. Like celestial bodies but unlike space itself, the GSO has easily-delineable borders. Like celestial bodies but unlike space itself, the GSO is very sensitive to environmental decay.¹¹⁶ Plus, unlike most areas of space itself, which I believe should remain non-appropriable and developed and regulated only by an international body with the goal of permitting safe and unfettered transportation, development of the GSO will benefit from appropriation and ownership.

There is, of course, a threshold issue: is the GSO a part of space? The term "outer space" is undefined in international law. The initial doctrinal problem, then, is deciding whether the GSO is a part of terrestrial airspace or outer space. United States policy espouses a "functional" definition of outer space: wherever a preordained set of outer space activities takes place is "outer space."¹¹⁷ Orbiting satellites would be counted as an outer space activity. The "spatial" theory, a popular alternative to the functional definition, prefers to draw a line above which everything is considered to be outer space.¹¹⁸ The standard boundary line is approximately 96 to 110 kilometers above the Earth's surface, which is the lowest altitude at which a satellite can currently maintain orbit.¹¹⁹ Both theories, then, would consider the GSO to be part of outer space. Aside from the persuasive merits of these competing arguments, it can of course be stipulated, by treaty, that the GSO is a part of space.

To make ownership of the GSO an effective political tool, ownership must be granted on a basis different from those heretofore outlined. Instead

¹¹⁶Unlike the vast reaches of undifferentiated space, the GSO and celestial bodies can accumulate debris very easily, have the potential to attract large numbers of competing EM-producing entities into a very limited area, and, most importantly, are exhaustible resources.

¹¹⁷Kosmo, *supra* note 32, at 1061-62, citing CARL Q. CHRISTOL, *THE MODERN INTERNATIONAL LAW OF OUTER SPACE* 524 (1982) and Jakhu, *The Legal Status of the Geostationary Orbit*, *ANNALS OF AIR & SPACE L.* 333, 337-41 (1982).

¹¹⁸*Id.*

¹¹⁹Kosmo, *supra* note 32, at 1062.

of granting ownership to those who would use the GSO or to those who would purchase it at auction, we would grant ownership on a theory of terrestrial property rights extended upward, from a negotiated floor (beginning above airspace) up to a negotiated ceiling (perhaps 130,000 km). Assigning ownership by tracing one's borders to the sky has roots deep in Roman law. Thus each nation sitting below the GSO would own a piece to either sell or lease out for colossal profits.

This inducement would be extremely politically advantageous to a property-rights reform movement. Many of the nations that currently support the Moon Treaty and oppose private ownership would be the beneficiaries if the GSO were divvied up. In fact, there is already evidence that such a policy would be a welcome change. In 1976, Brazil, Colombia, Congo, Ecuador, Indonesia, Kenya, Uganda, and Zaire -- every equatorial nation but two -- issued the Bogota Declaration.¹²⁰ The Bogota Declaration argued that orbits are caused by Earth's gravitational pull; thus the orbits above the equator, including the GSO, are natural resources owned by the nations supplying the gravity, *i.e.* the equatorial nations.¹²¹ Whatever the merits of this argument,¹²² it evinces a clear desire by these nations to have political and, more importantly, financial control over the portions of the GSO overlying their territories. There is thus a strong indication that what basically amounts to the bribing of equatorial nations would not fall on deaf ears.

Several of the equatorial beneficiary nations represent political powerhouses within the Group of 77 (*e.g.* Brazil, Indonesia). Thus, the compromise policy of permitting appropriation of the GSO would go a long way towards easing the developing nations' resistance to the suggested property-rights reforms.

Would we need to supplement GSO ownership with a compulsory licensing system so that equatorial nations would not be able to price-gouge? Probably not. First, equatorial nations would be in price competition with each other. Second, much of the GSO lies above international waters, and so would remain free. Then again, the GSO is not fungible for some uses. For example, a satellite transmitter for a German communications network might need to be above Congo. In this case, a natural monopoly would form, and Congo would be able to charge monopoly rents on the German transmitter. Monopoly rents eliminate the lower end of the market, and reduce the total utility produced.¹²³ Therefore, in cases of natural monopolies

¹²⁰ Gabon and Somalia did not ratify the declaration. Christol, *supra* note 117, at 895.

¹²¹ Bogota Declaration, December 3, 1976, *reprinted in* Christol, *supra* note 117, at 891-895.

¹²² In fact, this position has been widely rejected. According to accepted science, the GSO is created by the combined gravitational pulls of the earth, sun, moon, and more distant bodies. Christol, *supra* note 117, at 452.

¹²³ Areeda and Kaplow, *supra* note 105, at 17-18.

we might need a compulsory licensing system with maximum price restraints to maximize the total social welfare.

There is another advantage to authorizing ownership of the GSO. The GSO is fast becoming seriously polluted. The numbers of orbiting objects, including satellites and debris, along with interference created by EM-waves, is starting to pose problems for both the ITU and the International Telecommunications Satellite Organization ("INTELSAT") (a private organization devoted to the regulation and maintenance of a global telecommunications satellite system).¹²⁴ If equatorial states owned the GSO and were in the business of renting it out, then these states would have a national interest in keeping the GSO clean to protect their source of income. The equatorial states, as well as the states with satellites in the GSO, would thus have an interest in sanctioning (via litigation or international agreement) states that litter the GSO.

B. Trickle-down economics, trickle-down technology.

The changes to the OST proposed in this essay would encourage and hasten the conversion of potential wealth-in-space into actual wealth-on-Earth. As already argued, bringing wealth into a system is an absolute good, aiding all humanity (however indirectly), including developing nations.

But there is another, more direct way in which low-tech nations can benefit. As ownership rights boost the incentive to exploit outer space's resources, more developers will jump at the chance. And the more people jumping at the chance and flying up into space to glean the space-borne profits, the cheaper and safer it will become to carry out such space projects. That is, the more profitable it becomes to exploit space, the greater the impetus will be to develop new technology that permits easier access to space. And among the prime beneficiaries of more accessible space travel will be those nations -- the developing, low-tech nations -- who are currently not space-capable.

This, of course, will work with, and be facilitated by, the openness of plans under the UNSER system. We should not force the space-capable nations to share their wealth (as is required by the Moon Treaty, and as developing nations are pushing for in interpreting the OST), for to do so would discourage exploitation and space travel, and thus make space projects *less* regular, and thus less affordable and safe. Instead, by supporting the development of new technology in an efficient, free market environment, we thereby give developing nations the chance to go into space on their own. In this way we can increase everyone's access to space. And that's one of the designated goals of the OST itself.

¹²⁴ van Traa-Engelman, *supra* note 90, at 112-133.

VIII. CONCLUSION

The notion that our future in space is reserved to the superpowers, or even to governments, has passed. Private commercial space investment, unforeseen at the inception of the Outer Space Treaty's dominion, has grown apace, while governmental investment has shrunk.¹²⁵ Commercial activities in space now generate more revenues than government contracts.¹²⁶

The time has come to reject the old space law whose "pro-state, anti-private-enterprise hue...darkly colors space activities to this day."¹²⁷

I believe that *some* changes, whether the ones outlined in this essay or others I have not considered, are necessary, if we are to push our species out to the stars. Thanks to the development of a new generation of "single-stage-to-orbit" launchers, launch costs may drop by 30 percent in the just next few years.¹²⁸ Companies are researching opportunities in new uses of the GSO, in mining, even in tourism: a consortium including Lunacorp and Carnegie Mellon University hopes to send two camera-equipped rovers to the moon, not for geological surveying, but to let virtual tourists experience a lunar drive.¹²⁹ The recent discovery of large quantities of water on our moon might cut the cost of lunar missions in half again: the water, converted into liquid hydrogen and liquid oxygen, could satisfy fuel needs for return flights.¹³⁰ The moon could even end up as a refueling station for more distant journeys.

Space law must take into account private needs and build on private opportunities; to do this, it must embrace the principle of private property. If humanity hands control of the exploitation of space over to an international political body in an effort to use space development as a wealth-redistribution mechanism, the entire project is likely to fall on its face and there won't be any wealth to redistribute. Humanity will lose out on knowledge, adventure, living room, and resources. In contrast, the greatest good for the greatest number will occur if property rights are expanded and clarified in the ways suggested throughout this essay.

One small legal step permitting the private ownership of space territory would be one giant leap for mankind.

¹²⁵ Highlights 1996, *supra* note 1, at 1.

¹²⁶ F. James Sensenbrenner, Jr. (R-Wisc.), *Viewpoint*, AVIATION WEEK & SPACE TECH., Oct. 20, 1997, at 90 (citing a study conducted by KPMG Peat Marwick and SpaceVest).

¹²⁷ Nathan C. Goldman, *The Maturing Law of Outer Space*, TRIAL, Dec. 1995, at 42.

¹²⁸ Kargel, *supra* note 6.

¹²⁹ *Id.*

¹³⁰ Seth Borenstein, *Seeing Moon in New Light: The Find Could Change Way People Travel Through Space*, ORLANDO SENTINEL, Mar. 6, 1998, at A1.