These Aren't the Asteroids You Are Looking For: Classifying Asteroids in Space as Chattels, Not Land

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I. INTRODUCTION

"The truth is I don't know what we're going to find. But I know that everything will be different. It will be like Cecil Rhodes discovering diamonds in South Africa."

"He didn't discover the mine," she said. "He just made the most money."

"I could live with that."[1]

Space, as the saying goes, is the final frontier. We humans first ventured beyond the atmosphere in 1961, under the threatening cloud of the Cold War.[2] Since that time, we have made a number of stunning accomplishments in outer space. We established a permanent presence in outer space through the International Space Station, where scientists and astronauts continue to work on research to benefit both humanity on Earth and the future of humanity's activities in space.[3] American presidents from both sides of the aisle have expressed a strong interest in sending Americans back to the Moon and beyond.[4] Humanity has achieved some of its

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1. Reid Malenfant, a driven protagonist that would make Ayn Rand proud, speaking about sending a mission to an asteroid. STEPHEN BAXTER, MANIFOLD: TIME 26 (2000).

2. Yuri Gagarin was the first human to enter outer space, flying on the Vostok 1 mission under the Soviet Union's space program. FRANCIS FRENCH & COLIN BURGESS, INTO THAT SILENT SEA: TRAILBLAZERS OF THE SPACE ERA, 1961–1965 (2007).

3. The International Space Station (ISS) was recently completed and had its operational life extended from 2016 to 2020. *See* Brittany Sauser, *Space Laboratory Open for Business*, TECH. REV. (Nov. 17, 2010), http://www.technologyreview.com/computing/26748/?p1=MstRcnt&a=f.

4. President George W. Bush set a timetable to go back to the Moon by 2020 and launch missions to Mars from the Moon, but President Barack Obama has changed the focus of the United States' space program from the Constellation program to a more general investment in technology. *See Space to Thrive*, ECONOMIST, Feb. 4, 2010, *available at* http://www.economist.com/node/15450

greatest triumphs in space, and it has suffered some of its greatest tragedies.[5] Although the public interest in space exploration has subsided since its height during the 1960s, many Americans continue to pay close attention to the National Aeronautics and Space Administration (NASA) and events with space exploration significance.[6]

Humanity's push deeper into space creates new issues, opportunities, and problems in the legal arena. These issues present opportunities for many different actors to influence the regime of outer space law—the *corpus juris spatalis*. Justice William J. Brennan, Jr., declared that resolving the legal issues facing humanity's activities in space are "monumental tasks" that will need to be overcome.[7] He foresaw that there would be difficulty in determining what law would govern in outer space, who would regulate it, how property would be acquired, and what relationship terrestrial governments would have with societies in outer space.[8]

The Outer Space Treaty provides the backbone of the *corpus juris spatalis*, though it contains problematic, ambiguous clauses.[9] The treaty

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607; William Harwood, *Obama Ends Moon Program, Endorses Private Spaceflight*, THE SPACE SHOT, CNET NEWS (Feb. 1, 2010), http://news.cnet.com/8301-19514_3-10445227-239.html.

5. The first Moon landing by Neil Armstrong stands out among the many achievements in outer space. Lives have also been tragically lost via spaceflight, with the Challenger and Columbia missions marking low points for human exploration in outer space. *See generally* RICHARD S. LEWIS, CHALLENGER: THE FINAL VOYAGE (1988); BEN EVANS, SPACE SHUTTLE COLUMBIA: HER MISSIONS AND HER CREWS (2005).

6. Recent images and discoveries of the Mars Landers have captured the minds of people across the globe. *See Mars Exploration Rover Mission*, JET PROPULSION LABORATORY, NASA, http://marsrovers.jpl.nasa.gov/home/index.html (last visited Oct. 9, 2011). NASA also made international headlines with its December 2010 announcement that researchers had discovered a terrestrial bacteria that based its DNA structure on arsenic rather than phosphorous, a revelational discovery. *See* NASA Press Release 10-320, Dwayne Brown & Cathy Weselby, NASA-Funded Research Discovers Life Built with Toxic Chemical (Dec. 2, 2010), http://www.nasa.gov/home/hqnews/2010/dec/HQ_10-320_Toxic_Life.html. This research, however, has been heavily criticized in the scientific community. *See* Marc Kaufman, *Study on Arsenic-Based Life Takes a Beating on the Web*, WASH. POST, Dec. 17, 2010, at A10, *available at* http://www.washingtonpost.com/wp-dyn/content/article/2010/12/16/AR2010121606472.html.

7. William J. Brennan, Jr., *Space Colonization and the Law*, 3 HARV. J.L. & TECH. 7, 9 (1990). Justice Brennan was speaking to the Bicentennial Conference of Judges of United States Courts of Appeals about "what prospect there is for involvement of the law and courts and lawyers in the still mysterious but surely burgeoning evolution of humankind's effort to conquer the far reaches of the Universe." *Id.* at 7.

8. *Id.* at 9.

9. The Outer Space Treaty entered into force on October 10, 1967, after being (1) signed in London, Moscow, and Washington, D.C.; (2) advised for ratification by the U.S. Senate on April 25, 1967; and (3) ratified by President Lyndon B. Johnson on May 24, 1967. Outer Space Treaty Narrative, U.S. State Department, http://www.state.gov/www/global/arms/treaties/space1.html (last visited Oct. 20, 2011) [hereinafter Outer Space Treaty Narrative]. The Outer Space Treaty binds all the major spacefaring nations, including China, France, Germany, India, Japan, Russia, the United Kingdom, and the United States.

emphasizes the peaceful exploration of outer space and equal sharing of outer space resources by stating that "exploration and use of outer space . . . shall be carried out for the benefit and in the interests of all countries . . . and shall be the province of all mankind."[10] This ambiguous provision has spawned a great deal of debate over how it should be interpreted.[11]

Given the ambiguity of the current treaty scheme, no workable property regime exists to allocate space resources.[12] This uncertainty hinders meaningful expansion and progress in development and resource mining.[13] Nations and entrepreneurs looking to expand and profit in outer space have a variety of targets for potential use. Of these, the Moon and Mars are particularly fertile possibilities. The Moon is rich in helium-3 (deuterium), an element that could be used with great efficiency in fusion

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10. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, art. I, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty].

11. A great amount of recent scholarship has analyzed the problem of property allocation in outer space. Some scholars argue that there is room within the current treaty regime for private property allocation as long as some work is done to clarify these rights. *See generally* Alan Wasser & Douglas Jobes, *Space Settlements, Property Rights, and International Law: Could a Lunar Settlement Claim the Lunar Real Estate It Needs to Survive?*, 73 J. AIR L. & COM. 37 (2008) (arguing that the current treaty regime prohibits only state, not private, appropriation); Kelly M. Zullo, Note, *The Need to Clarify the Status of Property Rights in International Space Law*, 90 GEO. L.J. 2413 (2002) (finding that the current treaty regime provides an adequate basis for private ventures in outer space). Others argue that there is not and should not be private property allocation, but rather that future uses of outer space should serve the established "common heritage of mankind" concept. *See, e.g.*, Jeremy L. Zell, *Putting a Mine on the Moon: Creating an International Authority to Regulate Mining Rights in Outer Space*, 15 MINN. J. INT'L L. 489, 506–09 (2006). Still others see an inevitable breakdown of the current treaty scheme. *See, e.g.*, Carol R. Buxton, *Property in Outer Space: The Common Heritage of Mankind Principle vs. the "First in Time, First in Right" Rule of Property Law*, 69 J. AIR L. & COM. 689, 707 (2004) ("Right now, man simply seems unprepared for [the common heritage of mankind] concept."). Even more scholars have suggested creating a fair system of allocation that would also spur development of the private sector. *See generally* Robert P. Merges & Glenn H. Reynolds, *Space Resources, Common Property, and the Collective Action Problem*, 6 N.Y.U. ENVTL. L.J. 107 (1997) (proposing a system of limited "first in time, first in right" property allocation); Sarah Coffey, Note, *Establishing a Legal Framework for Property Rights to Natural Resources in Outer Space*, 41 CASE W. RES. J. INT'L L. 119 (2009) (advocating a new treaty providing for a system of credits that would be allocated to all nations enabling them to take a corresponding tonnage of resources from the Moon); Lynn M. Fountain, Note, *Creating Momentum in Space: Ending the Paralysis Produced by the "Common Heritage of Mankind" Doctrine*, 35 CONN. L. REV. 1753 (2003) (arguing for a free-market system under an international regulatory authority).

12. *See* Ezra J. Reinstein, *Owning Outer Space*, 20 NW. J. INT'L L. & BUS. 59, 71 (1999) ("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."); Rosanna Sattler, *Transporting a Legal System for Property Rights: From the Earth to the Stars*, 6 CHI. J. INT'L L. 23, 27–30 (2005); Jonathan Thomas, Note, *Privatization of Space Ventures: Proposing a Proven Regulatory Theory for Future Extraterrestrial Appropriation*, 1 INT'L L. & MGMT. REV. 191, 202–12 (2005).

13. Thomas, *supra* note 12, at 206–07.

reactors.[14] Mars is likely rich in minerals that would have great value on Earth or for use in other activities in outer space.[15] Permanent bases on the Moon or Mars would greatly benefit from a clearly articulated property regime that provides the necessary certainty for governments and private parties.[16]

Asteroids, the focus of this Comment, are also particularly lucrative targets for development. The usual proposal is for mining—some asteroids are potentially worth billions of dollars.[17] Asteroids can also be used as the location of a base or facility.[18] Such installations could provide necessary defense from incoming meteorites or provide a readily available shelter for astronauts.[19]

There are key differences, however, between developing on the Moon or Mars and on an asteroid. Asteroids come in a variety of shapes[20] and sizes,[21] while the Moon and Mars are large spheroid objects analogous to the Earth. Further, asteroids could be considered mobile

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14. *See* Mark Williams, *Mining the Moon*, TECH. REV. (Aug. 23, 2007), http://www.technologyreview.com/Energy/19296; Coffey, *supra* note 11, at 120.

15. *See generally* Michael D. West & Jonathan D. A. Clarke, *Potential Martian Mineral Resources: Mechanisms and Terrestrial Analogues*, 58 PLANETARY & SPACE SCI. 574 (2010) (describing what minerals are likely to be available on Mars). Mars might also be valuable for its water, deuterium, or helium-3. *See* David Collins, *Efficient Allocation of Real Property Rights on the Planet Mars*, 14 B.U. J. SCI. & TECH. L. 201, 203 (2008).

16. President George W. Bush advocated for a permanent U.S. base on the Moon from which to launch other missions, and more recently, some scientists proposed sending astronauts to Mars who would then establish a base and stay there long-term, for better or worse. *See* Mark Baard, *Mars Plan Envisions Comfy Colony*, WIRED (July 27, 2005), http://www.wired.com/science/space/news/2005/07/68311; *Space to Thrive*, *supra* note 4.

17. *See* John Adolph, Comment, *The Recent Boom in Private Space Development and the Necessity of an International Framework Embracing Private Property Rights to Encourage Investment*, 40 INT'L LAW. 961, 976 (2006) (describing the potential value of 3554 Amun and other asteroids).

18. A recent proposal for defending the Earth from the disastrous impacts of an incoming meteor or comet would utilize asteroids placed into LaGrange points around the Earth as locations for tracking equipment. These asteroids could also be hollowed out to shelter astronauts from radiation or mined for their minerals. If needed, the asteroids would then be steered into the path of dangerous objects to deflect them away from the Earth. John Rather et al., *New Technologies and Strategies to Exploit Near Earth Asteroids for Breakthrough Space Development*, 1208 AIP CONFERENCE PROCEEDINGS 566 (Jan. 28, 2010); *see also infra* note 42.

19. *See* Rather et al., *supra* note 18, at 569–70.

20. Asteroids range from extremely irregular shapes, like 216 Kleopatra, which is shaped like a dog bone, to near perfect spheres, like Ceres. ENCYCLOPEDIA OF THE SOLAR SYSTEM 352 (Lucy-Ann McFadden, Paul R. Weissman & Torrence V. Johnson eds., 2d ed. 2007) [hereinafter ENCYCLOPEDIA].

21. One of the largest, 4 Vesta, is about 530 km in diameter, while the smallest are only a few meters across. *Jet Propulsion Laboratory Small-Body Database Browser*, NASA, http://ssd.jpl.nasa.gov/sbdb.cgi?sstr=vesta;orb=0;cov=0;log=0;cad=0#phys_par (last visited Oct. 9, 2011); ENCYCLOPEDIA, *supra* note 20, at 351. Objects smaller than a few meters in diameter are called meteoroids, *see infra* note 194, and while not specifically the subject of this Comment, are so similar to asteroids that they are included in this discussion.

objects because their location and orbit can be moved by human effort,[22] while moving the Moon, Mars, or the Earth is simply not currently feasible.[23]

The differences between asteroids and other celestial bodies provide a basis for conceptualizing asteroids as different from real property, which was developed for plots of land on the Earth. This Comment argues that an evolution in *corpus juris spatalis* that recognizes the unique physical form of asteroids, and designates asteroids as chattels, would simplify outer space property law and help spur the development of asteroid use and exploitation. Chattels are personal property, characterized as moveable objects,[24] and are accordingly free of many of the idiosyncrasies of real property. A system of property that conceptualizes asteroids as chattels would provide these benefits without entirely abandoning well-established property schemes.

In Part II, this Comment will explore why asteroid exploration is essential, emphasizing the benefits of private ownership of asteroids. Many asteroids contain extremely valuable resources that, under the right conditions, could be mined at a great profit or put to use in a variety of other ways. In Part III, this Comment will then discuss the current state of outer space law—the *corpus juris spatalis*. The *corpus juris spatalis* is based in large part on the Outer Space Treaty but has also been informed by a great deal of scholarship. This scholarship, with a few notable exceptions, gives no special consideration to the status of asteroids and instead generally treats asteroids the same as any other celestial body. Part IV will argue for the proposition that asteroids be treated as chattels, rather than as real property. Treating asteroids as chattels would avoid many significant problems that arise from attempts to analogize asteroids to real property and stay within a familiar property scheme. Part V will briefly conclude.

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22. There are many proposals for how larger asteroids might be moved, while the smallest ones could potentially be moved by a human hand. *See* Scott Snowden, *Aussie has Answer to Save Earth from Asteroid Attack*, REGISTER (Aug. 24, 2008), http://www.theregister.co.uk/2008/08/24/aussie_saves_earth_from_meteorite_collision_catastrophe/.

23. The Moon is almost four times the size of the largest asteroid, Ceres (which this Comment excludes as too large as explained *infra* in the text following note 199). *See* ENCYCLOPEDIA, *supra* note 20, at 227, 351. Accordingly, the Moon occupies approximately 64 times the volume of Ceres, and because they are made of similar materials, it would take approximately 64 times the force to move Ceres to move the Moon. It is certainly possible that humans will be able to move the Moon or the planets one day with ease, but we can cross that bridge when we get there.

24. *See infra* note 158.

II. WHY ASTEROID EXPLORATION IS ESSENTIAL

So we'll start—we'll start by sending astronauts to an asteroid for the first time in history . . . . And a landing on Mars will follow. And I expect to be around to see it.[25]

This Part will focus on the potential uses of asteroids through mining and development. The unique location of asteroids in orbit means that there are massive challenges to their exploitation, but there are significant benefits if humans can overcome these hurdles.[26] Asteroids have vast potential to provide raw materials for use in outer space or for sale on Earth.[27] Asteroids could also be used as the foundations for space stations.[28] The potential benefits of asteroid development are tremendous, and effectively leveraging these benefits will likely be a significant part of humanity's future, especially as we continue to expand throughout space.

Outer space has interested many generations of religious scholars, scientists, philosophers, and entrepreneurs. This interest is especially strong today. C. S. Lewis wrestled with the implications for Christianity if we were to discover rational life from other planets.[29] Galileo used one of the earliest telescopes to discover the moons of Jupiter in 1610.[30] Today, entrepreneurs have also had many grand schemes for how to profit in outer space.[31] Interest in outer space is again peaking, especially now that President Barack Obama has heavily involved the private sector in developing space technologies and capabilities.[32] President Obama intends to send astronauts to an asteroid before the Moon,[33] and at least one

25. President Barack Obama, Remarks by the President on Space Exploration in the 21st Century (Apr. 15, 2010), *available at* http://www.nasa.gov/news/media/trans/obama_ksc_trans.html [hereinafter President Obama's Remarks]. This is the first step in President Obama's plan to return to the Moon and send astronauts to Mars by the mid-2030s. *Id.*

26. *See infra* text accompanying notes 44–64.

27. *See infra* text accompanying notes 44–64.

28. *See infra* text accompanying notes 65–71.

29. Lewis was of the opinion that life on other planets did not pose a threat to Christianity's fundamentals. C. S. LEWIS, *Religion and Rocketry*, *in* THE WORLD'S LAST NIGHT AND OTHER ESSAYS 83–92 (1960).

30. Richard Cavendish, *Galileo Observes the Satellites of Jupiter*, HIST. TODAY, Jan. 2010, at 8. After hearing of the first telescopes, Galileo soon developed his own improved prototype on the technology that he gifted to the city of Venice. *Id.* Soon thereafter, he began making discoveries in outer space. *Id.*

31. In addition to the aforementioned mining schemes, private companies have formed to try to profit from such activities as space tourism, transportation to space via a space elevator, and space-based solar power. VIRGIN GALACTIC, http://www.virgingalactic.com/ (last visited Oct. 9, 2011); LIFTPORT GROUP, http://www.liftport.com/ (last visited Oct. 9, 2011); SPACE ENERGY, http://spaceenergy.com/s/Default.htm (last visited Oct. 9, 2011).

32. *See* Harwood, *supra* note 4.

33. President Obama's Remarks, *supra* note 25.

private company is seriously exploring that option.[34] China has especially made huge strides to compete in spaceflight: it recently launched its first space laboratory module, a precursor to its planned space station.[35]

Entrepreneurs are racing to be the next titans of industry in space.[36] A Russian company called Orbital Technologies recently stated that it intends to have an orbiting hotel in operation by 2016, racing to beat competitors to the punch.[37] In 2004, Scaled Composites won the $10 million Ansari X PRIZE by achieving space flight twice in one week with their spacecraft SpaceShipOne.[38] Scaled Composites has since been acquired by Virgin Galactic, leading to the development of SpaceShipTwo and launching Virgin's quest to establish itself as a leader in commercial space flight.[39] The Sierra Nevada Corporation is also looking to make the orbital jump with its Dream Chaser spacecraft, which recently won $20 million from NASA in a competition for transport of astronauts to the International Space Station.[40] The X PRIZE Foundation is currently administering the $30 million Google Lunar X PRIZE, a competition in which twenty-nine teams from all over the planet are competing to privately fund and send a robot to the Moon.[41] Spaceport America is also nearing completion of a commercial spaceport in New Mexico, with Vir-

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34. *See* Josh Hopkins et al., *Plymouth Rock: An Early Human Mission to Near Earth Asteroids Using Orion Spacecraft*, LOCKHEED MARTIN (June 2010), http://www.lockheedmartin.com/data/assets/ssc/Orion/Toolkit/OrionAsteroidMissionWhitePaperAug2010.pdf.

35. Denise Chow, *China Launches 1st Space Lab Module Into Orbit for Docking Tests*, SPACE.COM (Sept. 29, 2011), http://www.space.com/13121-china-launches-space-lab-module-tiangong-1.html.

36. The "titans of industry" encompass a variety of business magnates whose visions allowed them to "create[] or transform[] industries and in the process changed the world." Richard S. Tedlow, *What Titans Can Teach Us*, HARV. BUS. REV., Dec. 2001, at 70, 72. A leader who is able to successfully build an enterprise through the exploitation of space resources would likely fit within this category, joining such giants as John D. Rockefeller, Andrew Carnegie, Henry Ford, Thomas J. Watson, and Sam Walton.

37. Las Vegas-based Bigelow Aerospace and the Spanish Galactic Suite Space Resort have also recently announced plans to launch a commercial space station within the next few years. Alexander Marquardt, *Out of This World: Russians Plan to Put Hotel in Orbit*, ABC NEWS (Sept. 30, 2010), http://abcnews.go.com/Technology/russians-launch-plan-space-hotel-orbit/story?id=11763787&page=1.

38. *See* Alan Boyle, *SpaceShipOne Wins $10 Million X Prize*, MSNBC.COM (Oct. 5, 2004), http://www.msnbc.msn.com/id/6167761/.

39. *See* Clay Dillow, *Construction Begins on America's First Commercial Spaceship Factory*, POPSCI (Nov. 10, 2010), http://www.popsci.com/technology/article/2010-11/construction-begins-americas-first-commercial-spaceship-factory; VIRGIN GALACTIC, *supra* note 31.

40. David Kushner, *Launching Into the Era of Private Spaceflight*, DISCOVER MAG., Sept. 2010, *available at* http://discovermagazine.com/2010/sep/18-launching-into-age-of-private-spaceflight/article_view?searchterm=dream%20chasers&b_start:int=4.

41. *See* X PRIZE Foundation, *Google Lunar X Prize Announces Official Roster of Teams Competing in the $30 Million Race to the Moon* (Feb. 17, 2011), http://www.xprize.org/press-release/google-lunar-x-prize-announces-official-roster-teams-competing-30-million-race-moon; GOOGLE LUNAR X PRIZE, http://www.googlelunarxprize.org/ (last visited Oct. 9, 2011).

gin Galactic as the anchor tenant and other firms committed to basing their space activities at the spaceport.[42]

As access to space becomes cheaper, many more opportunities will open for private investment.[43] One major candidate for private investment is asteroid mining. Near-Earth Objects (NEOs), which are mostly asteroids, provide a great opportunity for potential use.[44] Some of these Near-Earth Asteroids (NEAs) are metallic, composed of metals like iron and nickel, similar to the center of the Earth.[45] One of these asteroids is 1986 DA,[46] a metallic NEA 1.2 miles wide that is likely composed primarily of iron and nickel with significant amounts of gold and platinum.[47] Estimates show 1986 DA contains approximately 10,000 tons of gold and 100,000 tons of platinum,[48] which if completely recovered would be valued on today's market at $460 billion and $5.6 trillion, respectively.[49] Including the value of the iron and nickel, 1986 DA could be worth between $6 and $7 trillion.

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42. *See* SPACEPORT AMERICA, http://www.spaceportamerica.com/about-us/faqs.html (last visited Oct. 9, 2011).

43. Launch costs are especially prohibitive for start-up companies, as evidenced by SpaceX, one of the companies NASA has partnered with to develop private human spaceflight. Tiffany Kaiser, *SpaceX to Develop Reusable Launch System for Cheap Spaceflight, Mars Settlement*, DAILYTECH (Sept. 30, 2011, 12:22 AM), http://www.dailytech.com/SpaceX+to+Develop+Reusable+Launch+System+for+Cheap+Spaceflight+Mars+Settlement/article22890.htm. SpaceX is developing low-cost rockets for launching humans into orbit, with a long-term goal of getting humans to Mars. *Id.* These newer, cheaper rockets still cost $50–$60 million, excluding many of the development and technology costs. *Id.* These are also fully reusable rockets; traditional rockets could be used only once. *Id.* This drive to reduce launch costs illustrates how important rockets are to developing a private spaceflight industry.

44. NEOs are objects whose orbit brings them within 1.3 AU of the sun. *NEO Groups*, NASA, http://neo.jpl.nasa.gov/neo/groups.html (last visited Oct. 9, 2011).

45. JOHN S. LEWIS, MINING THE SKY: UNTOLD RICHES FROM THE ASTEROIDS, COMETS, AND PLANETS 191–93 (1997).

46. Asteroids are provisionally named with the year of discovery, followed by a letter indicating the half-month of discovery and a second letter indicating the order of discovery within that half-month. *New-Style Provisional Designations*, INT'L ASTRONOMICAL UNION MINOR PLANET CTR., http://www.minorplanetcenter.net/iau/info/OldDesDoc.html (last visited Mar. 27, 2011). Under this system, 1986 DA is the first asteroid discovered in the second half of February 1986. The IAU has set strict procedures for permanently naming asteroids, such as prohibiting purely commercial or advertising names, discouraging pet animal names, and requiring that objects that come near or cross Earth's orbit receive mythological names. *Names of Minor Planets*, COMM. ON SMALL BODY NOMENCLATURE, http://www.ss.astro.umd.edu/IAU/csbn/mpnames.shtml (last visited Oct. 30, 2011).

47. S. J. Ostro et al., *Asteroid 1986 DA: Radar Evidence for a Metallic Composition*, SCIENCE, June 7, 1991, at 1399–1404.

48. *See Gems in Space–Undreamed Treasures in a Passing Nugget*, SEATTLE TIMES, June 8, 1991, *available at* http://community.seattletimes.nwsource.com/archive/?date=19910608&slug=1287853.

49. As of November 1, 2011, platinum is valued at $1,520 per troy ounce (31.1 grams), and gold is valued at $1,725 per troy ounce. *See Futures*, YAHOO! FINANCE, http://finance.yahoo.com/futures?t=metals (last visited Nov. 1, 2011).

Many asteroids, including 1986 DA, could be mined. Of over 8000 NEAs, at least 1258 pass close enough to Earth to be categorized as Potentially Hazardous Asteroids (PHAs),[50] which are asteroids greater than 150 meters in diameter that pass close enough to Earth.[51] In addition, there are over 2000 NEAs that are less than 100 meters in diameter,[52] which means that there are likely hundreds, if not thousands, of non-PHAs that skim Earth's orbit.[53] Just within the past year, over 900 new NEAs were either discovered or classified as NEAs, and the rate of discovery has increased over the past decade.[54] The most attractive feature of NEAs, and PHAs especially, is that their orbits bring them close to Earth, making rendezvous missions easier than missions elsewhere in the solar system.[55] Some of these asteroids are so close that they are easier to reach than the Moon.[56] Therefore, by virtue of close proximity, the costs of sending missions for mining and resource exploitation are significantly reduced.[57]

Besides the immediate cost-savings advantage, mining asteroids in outer space makes sense for the long-term future of development in outer space. One of the greatest economic prohibitions on mining an asteroid is the problem of getting the ore, raw or processed, to the surface of the Earth.[58] Similarly, getting materials into orbit can be prohibitively expen-

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50. *See NEO Discovery Statistics*, NASA, http://neo.jpl.nasa.gov/stats/ (last visited Oct. 22, 2011).

51. *NEO Groups*, *supra* note 44. "[A]steroids that can't get any closer to the Earth . . . than 0.05 AU (roughly 7,480,000 km or 4,650,000 mi) or are smaller than about 150 m (500 ft) in diameter . . . are not considered PHAs." *Id.*

52. *NEO Discovery Statistics*, *supra* note 50.

53. *See NEO Groups*, *supra* note 44.

54. In the year 2000, 337 NEAs were discovered; in 2005, 566 NEAs were discovered; and in 2010, 921 were discovered, though discovery of large NEAs (greater than 1 km in diameter) has significantly slowed from a peak in 2006. *See NEO Discovery Statistics*, *supra* note 50.

55. It would take a total Delta-v of 6.1 km/s to reach the lunar surface, compared to 4.3 km/s to reach the nearest asteroid. LEWIS, *supra* note 45, at 124. The real savings, however, are in the return trip, since it would take a Delta-v of 3.0 km/s to return from the moon, and 1.0 km/s or less to return from one of these close asteroids. *Id.*

56. It takes an approximate Delta-a of 4.1 km/s to reach lunar orbit and 6.2 km/s to reach the lunar surface. SPACE SETTLEMENTS: A DESIGN STUDY fig.2-2 (Richard D. Johnson & Charles Holbrow eds., 1977), *available at* http://www.nas.nasa.gov/Services/Education/SpaceSettlement/75SummerStudy/figure2.2.gif.

57. Delta-v has significant impact on the mass/fuel ratio for building a spacecraft, so mission designers almost universally try to minimize Delta-v. *See* Jerrod E. Marsden & Shane D. Ross, *New Methods in Celestial Mechanics and Mission Design*, 43 BULL. AM. MATHEMATICAL SOC'Y 43, 46 (2005).

58. Returning the payload to Earth would require complicated maneuvering, manufacture of shielding to use the atmosphere to slow down, and/or use of extra propellants to reduce the speed of the ore payload. Mark J. Sonter, The Technical and Economic Feasibility of Mining the Near-Earth Asteroids, Presentation at the 49th IAF Congress (Sept. 28–Oct. 2, 1998), http://www.spacefuture.com/archive/the_technical_and_economic_feasibility_of_mining_the_near_earth_asteriods.shtml.

sive, with the rate recently estimated at $5,000 per pound.[59] The large expense from transferring the materials from an asteroid to the surface of the Earth means that any structure being built for use in outer space would likely be much cheaper if the bulk of the materials came from an asteroid. Though automating construction in outer space would require sophistication beyond what is available today, it is likely that launching robots to mine and construct the bulk of future facilities in outer space would be considerably less expensive than construction on Earth that is launched and then assembled in outer space.[60]

The mining of some NEOs could also yield great quantities of volatiles: hydrogen, helium, and water especially.[61] These materials could be used to fuel human spacefarers—in the International Space Station or elsewhere—relieving the need to be refueled or resupplied from Earth. More specifically, mined water might be extremely useful as rocket fuel or as a fuel for other power and propulsion systems.[62] Because fuel makes up the greatest weight of rockets, the ability to produce fuel in space would provide much-needed flexibility to survive in outer space and explore the depths of the solar system.[63]

In addition to mining, asteroids present the possibility of use as the foundations for space stations. An asteroid-based space station could be highly beneficial to research and development, as it would provide con-

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Additionally, a group recently estimated that a robotic mission to return just 500 grams of material from Mars would cost $4.5–$8 billion. *Top Dollar Rocks*, NEW SCIENTIST, July 19, 2008, at 7.

59. Amina Elahi, *A Cannon for Shooting Supplies into Space*, POPULAR SCI. (Jan. 15, 2010, 11:30 AM), http://www.popsci.com/technology/article/2010-01/cannon-shooting-supplies-space.

60. One study examining automated construction of a space-based solar power plant recognized that in regards to automated construction technology, "the conceptual study is very preliminary." Markoto Nagatomo et al., *Conceptual Study of a Solar Power Satellite, SPS 2000*, Proceedings of the 19th International Symposium on Space Technology and Science 469 (May 1994), http://www.spacefuture.com/archive/conceptual_study_of_a_solar_power_satellite_sps_2000.shtml. For a more detailed survey of the state of automated construction on Earth, see Han Hoang, Automated Construction Technologies: Analyses and Future Development Strategies (2005) (unpublished M.S. thesis, Massachusetts Institute of Technology), *available at* http://dspace.mit.edu/bitstream/handle/1721.1/33016/62082029.pdf?sequence=1.

61. *See* Marlowe Hood, *Ice Asteroids Likely Source of Earth's Water*, DISCOVERY NEWS (Apr. 28, 2010, 3:50 PM), http://news.discovery.com/space/asteroid-ice-organics.html. Volatiles are organic compounds that decay at room temperature into liquid or gaseous forms and are extremely important for life and various technologies, the most important of which are water and oxygen. *See Glossary*, PLANETARY SCIENCE RESEARCH DISCOVERIES, http://www.psrd.hawaii.edu/PSRDglossary.html (last visited Oct. 22, 2011).

62. Liquid oxygen and liquid hydrogen are two main components of some of the most common rocket fuels. *See Countdown! NASA Launch Vehicles and Facilities: Propellants*, NASA (Oct. 1991), http://www-pao.ksc.nasa.gov/kscpao/nasafact/count2.htm (last visited Oct. 9, 2011).

63. Proposals to send a human to Mars often feature the idea of sending a rocket in advance of the humans to draw fuel from the Martian atmosphere, preventing the mission from using the time and resources to deliver a fully fueled rocket to Mars. *See* ROBERT ZUBRIN, THE CASE FOR MARS 3–14 (1996).

ditions that cannot easily be replicated on Earth, such as zero-gravity environments,[64] freedom from atmospheric interference,[65] and nearly continuous sunlight for solar power.[66] Asteroids can provide a convenient source of materials for construction[67] and protection from dangerous radiation that permeates outer space, without the construction of large and elaborate radiation shielding.[68] Radiation shielding is one of the primary concerns of long-term space flight,[69] so a readily available source of shielding would allow astronauts to survive for much longer periods of time in outer space and undertake missions such as a Mars landing.[70]

Even though the prospects for profit and development in space are enticing, the current *corpus juris spatalis* has slowed the race to develop private space capabilities. The reason for the slow pace is because the current *corpus juris spatalis* is unsettled and unclear. Understanding how the law currently stands is essential to understanding how it might be improved.

III. WHAT DOES THE LEGAL LANDSCAPE OF OUTER SPACE LOOK LIKE NOW?

The cosmic perspective reminds us that in space, where there is no air, a flag will not wave—an indication that perhaps flag waving and space exploration do not mix.[71]

The current *corpus juris spatalis* is confusing, complicated, and likely outdated.[72] This Part will first discuss the treaty regime that in-

64. The Zero Gravity Research Facility in Cleveland, Ohio is "the largest facility of its kind in the world and continues to be the nation's most modern research tool for exploring weightlessness, or microgravity, on Earth." *Zero Gravity Research Facility*, NASA (May 2006), http://facilities.grc.nasa.gov/documents/TOPS/TopZERO.pdf. This facility is limited to a microgravity time-period of 5.18 seconds. *Id.* An asteroid-based facility would be able to conduct much more extended microgravity experiments.

65. In just one example of how this can be beneficial, NASA's Kepler Telescope launched in 2009 with a mission of finding Earth-sized planets orbiting other stars. Dennis Overbye, *In a Lonely Cosmos, a Hunt for Worlds Like Ours*, N.Y. TIMES, Mar. 3, 2009, at D1. Researchers needed a telescope to aid in finding such a planet because atmospheric interference prevents ground telescopes from making the precise measurements required. *Id.*

66. Satellites are especially well-positioned to benefit from solar power since the drawbacks of ground-based solar power (clouds, topography, seasons, etc.) are not present. O. Glenn Smith, *Harvest the Sun—From Space*, N.Y. TIMES, July 23, 2008, at A21.

67. Many asteroids are mostly composed of regolith, which could be repurposed into building materials for a space station. ENCYCLOPEDIA, *supra* note 20, at 357–59.

68. *See* Rather et al., *supra* note 18, at 569.

69. *See* Hopkins et al., *supra* note 34, at 33–36.

70. David Shiga, *Hitch Hike to Mars Inside an Asteroid*, NEW SCIENTIST (Oct. 23, 2006, 5:45 PM), http://www.newscientist.com/article/dn10358-hitch-hike-to-mars-inside-an-asteroid.html.

71. Neil deGrasse Tyson, *The Cosmic Perspective*, NAT. HIST. MAG., Apr. 2007, http://naturalhistorymag.com/universe/201367/cosmic-perspective.

forms outer space law, particularly the parts that speak to property rights in outer space. The treaty regime is premised primarily on the Outer Space Treaty, though the United Nations lists five treaties that inform nations on their rights and responsibilities in outer space.[73] This Part will then briefly examine recent scholarship on property rights in outer space, taking special note of when property rights to asteroids are implicated and highlighting the lack of consideration for asteroids in the current legal landscape.

A. International Treaty Regime

The *corpus juris spatalis* is a relic of the Cold War era.[74] Nations worldwide did not wish for the race to the Moon to become hostile, and they also wanted to ensure that outer space remained international in character.[75] The United States and the Soviet Union were particularly worried about the potential for weapons of mass destruction to be stationed in space or installed on celestial bodies.[76] After each nation agreed on the scope of the potential treaty, and agreed to address the issue of nuclear weapons in outer space separately from other issues of disarmament, the General Assembly of the United Nations passed a unanimous resolution calling for a ban on the use of weapons of mass destruction in outer space.[77] As a result, the United States and Soviet Union came to a satisfactory treaty by the end of 1966.[78] The Outer Space Treaty, ratified and entered into force in 1967, remains the governing authority in outer space.[79]

The Outer Space Treaty was modeled upon another international treaty, the Antarctic Treaty.[80] The Antarctic Treaty was signed in 1959.[81] It first prohibits "any measures of a military nature,"[82] while also prohibiting any claim of territorial sovereignty to Antarctica.[83] The preamble states that the purpose of the treaty is to further "the interests of science

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72. The Outer Space Treaty entered into force in 1967 and has not been updated or amended since. Outer Space Treaty Narrative, *supra* note 9.

73. U.N. OFFICE FOR OUTER SPACE AFFAIRS, U.N. TREATIES AND PRINCIPLES ON OUTER SPACE, at v–vi, U.N. Doc. ST/SPACE/11, U.N. Sales No. E.02.1.20 (2002), *available at* http://www.oosa.unvienna.org/pdf/publications/STSPACE11E.pdf.

74. *See* Outer Space Treaty Narrative, *supra* note 9.

75. *See id.*

76. *See id.*

77. *Id.*

78. *Id.*

79. *Id.*

80. *Id.*

81. Antarctic Treaty, Dec. 1, 1959, 12 U.S.T. 794, 402 U.N.T.S. 71.

82. *Id.* art. I.

83. *Id.* art. II.

and the progress of all mankind."[84] Like the Antarctic Treaty, the Outer Space Treaty is a "nonarmament" treaty meant to prevent self-seeking exploitation and military action.[85] The preamble recognizes the "common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes."[86] It states that "exploration and use of outer space should be carried on for the benefit of all peoples"[87] and promotes "broad international co-operation in the scientific as well as the legal aspects of the exploration and use of outer space."[88]

The most important provision of the Outer Space Treaty in regards to ownership and property in outer space is the first paragraph of Article I, which states that "exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries . . . and shall be the province of all mankind."[89] This is reinforced by language from Article II, which states that "[o]uter space . . . is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."[90] This language is meant to enforce a peaceful vision for outer space.[91] A more controversial, though plausible, interpretation is that this language blocks appropriation of any celestial bodies for any means.[92]

The Moon Agreement informs outer space law to a lesser extent than the Outer Space Treaty.[93] The Moon Agreement, which the United Nations entered into force on July 11, 1984, attempts to clarify lingering

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84. *Id.*

85. Outer Space Treaty Narrative, *supra* note 9. "Armament" is defined as "a military or naval force; the aggregate of a nation's military strength; weapons, arms; the process of preparing for war." MERRIAM-WEBSTER.COM, http://www.merriam-webster.com/dictionary/armament (last visited Nov. 6, 2011). A "nonarmament" treaty is one that emphasizes peace as an overriding goal. *See* Cynthia B. Zhang, *Do as I Say, Not as I Do—Is Star Wars Inevitable? Exploring the Future of International Space Regime in the Context of the 2006 U.S. National Space Policy*, 34 RUTGERS COMPUTER & TECH. L.J. 422, 435 (2008) (The Antarctic Treaty and the Outer Space Treaty were "nonarmament" treaties. These treaties sought to prevent conflicts and preserve international peace by dedicating areas to the exclusive domain of "peaceful and scientific" purposes "for the common interest of all mankind.") (footnotes omitted).

86. Outer Space Treaty, *supra* note 10, pmbl.

87. *Id.*

88. *Id.*

89. Outer Space Treaty Narrative, *supra* note 9, art I.

90. *Id.* art. II.

91. *See id.*

92. *See* Leslie I. Tennen, *Towards a New Regime for Exploitation of Outer Space Mineral Resources*, 88 NEB. L. REV. 794, 804–05 (2010). If this interpretation is correct, it would mean any discussion about the classification of asteroids as real property or chattels is moot, but an analysis of the proper interpretation is beyond the scope of this Comment. Even if property rights cannot be acquired in the current treaty scheme, conceptualizing asteroids as chattels can inform future reform efforts.

93. *See* Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, July 11, 1984, 1363 U.N.T.S. 3 [hereinafter Moon Agreement].

questions from the Outer Space Treaty and other minor treaties regarding outer space.[94] Nations submitted papers to the United Nations Committee for the Peaceful Uses of Space (UNCOPUS) in the early 1970s, after the Soviet Union submitted a draft proposal of a treaty.[95] As other nations presented various comments to the draft, the United States introduced "common heritage of mankind" language to its proposed draft,[96] but it later submitted a version explicitly stating a goal of allowing commercial exploitation of the Moon.[97] The "common heritage of mankind" language was particularly troublesome, as the Soviet Union's ideology would not allow it to agree to private exploitation, while the United States desired some sort of regime that would allow for resource exploitation.[98] The provision allowing for exploitation was left out and the common heritage language was included in the final document,[99] along with language similar to the Outer Space Treaty regarding exploration and use of outer space as the "province of all mankind."[100] While the Soviet Union proposed the first major document in the Moon Treaty drafting process and the United States helped move along this agreement, the final agreement was largely championed by developing nations after the Moon landings.[101] Though officially recognized by the United Nations, the Moon Agreement has failed to gain support among space-faring nations.[102] This lack of support means that the Moon Agreement has little influence in international law.[103] But the Agreement at least sheds light

94. *Id.* The pertinent language from the preamble states the following: "*Taking into account* the need to define and develop the provisions of these international instruments in relation to the Moon and other celestial bodies, having regard to further progress in the exploration and use of outer space." *Id.* The Moon Agreement is not binding on any nation that has not signed it, including the United States, Russia, China, Japan, and a majority of the European nations. *See Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*, U.N. TREATY COLLECTION, http://treaties.un.org/pages/ViewDetails.aspx?src=UNTSONLINE&tabid=1&mtdsg_no=XXIV-2&chapter=24&lang=en [hereinafter Moon Agreement Status]. But because it is an official U.N. treaty and strongly supported by developing nations, the Moon Agreement serves as a basis for what future treaties could look like.

95. Scott F. Cooper, *The 1979 Agreement Governing the Activities on the Moon and Other Celestial Bodies: Does it Create a Moratorium on the Commercial Exploitation of the Moon's Natural Resources?*, 5 J.L. & TECH. 63, 71–72 (1990).

96. *Id*. at 73.

97. *Id.* at 74.

98. *Id.* at 73–74 n.59.

99. Moon Agreement, *supra* note 93, art. 11, § 1.

100. *Id*. art. 4, § 1.

101. *See* Cooper, *supra* note 95, at 72–77.

102. Of the seventeen parties to the treaty, the most significant space powers are Australia, France, and India. Moon Agreement Status, *supra* note 94.

103. *See* Wasser & Jobes, *supra* note 11, at 42–43. A treaty seeking to regulate outer space that is not binding or followed by any nations who can go to outer space has accordingly little effect on the *corpus juris spatalis*.

on what the Outer Space Treaty did *not* do—prohibit private ownership.[104]

The *corpus juris spatalis* therefore is based almost entirely on the Outer Space Treaty, especially with respect to property rights. The Outer Space Treaty does leave lingering questions when interpreting how the use and exploration of space would be "for the benefit and interests of all nations . . . and shall be the province of all mankind."[105] And though there is no national appropriation, there is an open question of what processes are available for appropriation by other means. Scholars have attempted to answer these questions, occasionally touching on how to classify asteroids and other celestial bodies.[106] It is important to understand how property is viewed in outer space to understand how classification of asteroids as chattels would aid the *corpus juris spatalis* in settling on a rational property system.

B. Asteroids in Legal Scholarship

We are on the verge of another space boom.[107] Like the launch of the first satellite, the first man in space, and the first moon walk, humanity experienced a number of firsts in the past decade: the continual occupation of the International Space Station;[108] the wild successes of the Mars rovers, Spirit and Opportunity;[109] and perhaps most significantly, the achievement of the first private spaceflight.[110] This boom has correlated with a strong interest in the legal community to modernize the legal regime surrounding space law.[111]

Legal scholarship on the topic of space law has focused on three topics. The first revolves around space tourism.[112] Such scholarship is

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104. *See id.* at 43.

105. Outer Space Treaty, *supra* note 10, art. I.

106. *See infra* Part III.B.

107. *See supra* text accompanying notes 29–41.

108. *See* ROBERT ZIMMERMAN, LEAVING EARTH: SPACE STATIONS, RIVAL SUPERPOWERS, AND THE QUEST FOR INTERPLANETARY TRAVEL 446–59 (2003).

109. *Mars Rovers Reach Fifth Anniversary*, NEW SCIENTIST, Jan. 3, 2009, at 19.

110. *See* Boyle, *supra* note 38.

111. *See, e.g.*, Coffey, *supra* note 11, at 128; Fountain, *supra* note 11, at 1774–75; Sattler, *supra* note 12, at 30.

112. *See generally* Frank J. Balsamello, *When You Wish Upon a Falling Billboard: Advertising in an Age of Space Tourism*, 98 GEO. L.J. 1769 (2010) (arguing that limited advertising to space tourists in outer space will likely be beneficial to humanity); Julie C. Easter, *Spring Break 2023–Sea of Tranquility: The Effect of Space Tourism on Outer Space Law and World Policy in the New Millennium*, 26 SUFFOLK TRANSNAT'L L. REV. 349 (2003) (arguing that the current *corpus juris spatalis* is inadequate to resolve inevitable issues with outer space tourism); Steven Freeland, *Up, Up and . . . Back: The Emergence of Space Tourism and Its Impact on the International Law of Outer Space*, 6 CHI. J. INT'L L. 1 (2005) (examining various legal issues presented by outer space tourism); David Malfitano, *Space Tourism: The Final Frontier of Law*, 35 RUTGERS COMPUTER & TECH. L.J.

primarily concerned with the status of international travelers and what bodies of law would apply if something were to happen to them.[113] The second topic involves the potential weaponization of space.[114] The Outer

203 (2009); Catherine E. Parsons, *Space Tourism: Regulating Passage to the Happiest Place Off Earth*, 9 CHAP. L. REV. 493 (2006) (cautioning against excessive regulations for the space tourism industry, and advocating incorporating the industry into the Federal Aviation Administration regulation scheme); R. Thomas Rankin, *Space Tourism: Fanny Packs, Ugly T-Shirts, and the Law in Outer Space*, 36 SUFFOLK U. L. REV. 695 (2003) (advocating for commercial space law to align with commercial aviation law, and examining the applicability of criminal law to space tourists); Rebekah Davis Reed, Ph.D, *Ad Astra Per Aspera: Shaping a Liability Regime for the Future of Space Tourism*, 46 HOUS. L. REV. 585 (2009) (arguing for a limited liability scheme similar to the one that governed early commercial air transportation to encourage growth of the space tourism industry); Marla Stayduhar, *Flying the Friendly Skies May Not be so Friendly in Outer Space: International and Domestic Law Leaves United States' Citizen Space Tourists Without a Remedy for Injury Caused by Government Space Debris*, 7 U. PITT. J. TECH. L. & POL'Y 3 (2006) (noting that the current liability scheme does not fully protect outer space tourists who might be injured, and arguing that the Federal Tort Claims Act especially needs amendment to fully address these claims).

113. *See, e.g.*, Freeland, *supra* note 112, at 10–11 (noting that the status of space tourists is "an issue that should be clarified" and that it is unclear what rules of liability would apply should a tourist become injured).

114. *See generally* Michel Bourbonnière & Ricky J. Lee, *Legality of the Deployment of Conventional Weapons in Earth Orbit: Balancing Space Law and the Law of Armed Conflict*, 18 EUR. J. INT'L L. 873 (2008) (arguing that space law treaties and state practice needs to change in the face of new possibilities of the weaponization of space and the development of Earth-based weapons that can reach outer space); Gérardine Meishan Goh, *Softly, Softly Catchee Monkey: Informalism and the Quiet Development of International Space Law*, 87 NEB. L. REV. 725, 740–43 (2009) (describing the informal ways in which United Nations members have informally developed; David A. Koplow, *ASAT-isfaction: Customary International Law and the Regulation of Anti-Satellite Weapons*, 30 MICH. J. INT'L L. 1187 (2009) (advocating for the use of customary international law, developed centuries ago for very different purposes, as a way to prevent untrammeled development and use of anti-satellite weapons); Anand Mohan, *Legal Issues in the Deployment of a Dedicated Satellite for the Indian Navy*, 74 J. AIR L. & COM. 25 (2009) (noting that international agreements provide the main hurdles to deployment of a military satellite for the Indian Navy); Jackson Nyamuya Maogoto & Steven Freeland, *Space Weaponization and the United Nations Charter Regime on Force: A Thick Legal Fog or a Receding Mist?*, 41 INT'L LAW. 1091 (2007) (arguing that the current *corpus juris spatalis* is unprepared to handle nations' developing weapons programs and that existing principles could be used for reform); Adam G. Quinn, *The New Age of Space Law: The Outer Space Treaty and the Weaponization of Space*, 17 MINN. J. INT'L L. 475 (2008) (proposing principles to guide development of the *corpus juris spatalis* to prevent the weaponization of outer space); Major Robert A. Ramey, *Armed Conflict on the Final Frontier: The Law of War in Space*, 48 A.F. L. REV. 1 (2000) (arguing that laws of war for outer space will be unique—not an extension of rules of engagement for air combat—and so will draw on laws of war from land, air, and sea and will also require unique laws where applicable); Lori Scheetz, *Infusing Environmental Ethics into the Space Weapons Dialogue*, 19 GEO. INT'L ENVTL. L. REV. 57 (2006) (arguing for a new treaty for outer space that would ban or heavily restrict weapons in outer space in order to protect the commons and environments of outer space); Nina Tannenwald, *Law Versus Power on the High Frontier: The Case for a Rule-Based Regime for Outer Space*, 29 YALE J. INT'L L. 363 (2004) (advocating for a strengthened legal regime—a space sanctuary scheme incorporating comprehensive security, equal protection, and equity in access to space—and arguing that other outcomes will not lead to a stable situation in outer space); Major Elizabeth Seebode Waldrop, *Integration of Military and Civilian Space Assets: Legal and National Security Implications*, 55 A.F. L. REV. 157 (2004) (examining issues surrounding the intersection of military and commercial uses of outer space capabilities and assets);

Space Treaty limits nations to peaceful uses of outer space and expressly forbids weapons of mass destruction, yet there is ongoing speculation on how weapons may be used in outer space.[115] The third topic, and most pertinent to this discussion, is property rights to land and resources in outer space.[116] The general consensus is that the current regime governing outer space property rights is idealistic and unworkable in practice if humanity is to expand and make effective use of extraterrestrial bodies.

Legal scholarship on outer space property rights ranges in focus from general regimes to specific issues, such as lunar resources and land rights on Mars. Some authors propose entirely new regimes for outer space, while others propose solutions that would fit within the current regime. But all recognize the current system has created a "reversed tragedy of the commons,"[117] and the future *corpus juris spatalis* should promote the use of outer space by private parties.[118] This discussion will review the scholarship that would influence property rights to asteroids. Generally, the unique features of asteroids go unnoticed as they are lumped in with other celestial bodies, a problem that can be corrected by conceptualizing asteroids as chattels.

The first set of proposals focuses on the ancient doctrines of discovery and conquest. John Adolph and Jonathan Thomas both propose similar systems, in which interested parties would find a sponsor state to grant them a charter,[119] which they would then use to discover,[120] claim,[121] and possess[122] a piece of property in outer space. Perfecting

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Zhang, *supra* note 85 (examining the reactions and implications of the United States' 2006 National Space Policy and proposing possible ways to address the weaponization of outer space).

115. *See* Outer Space Treaty Narrative, *supra* note 9; Ramey, *supra* note 114, at 84 n.353.

116. The Outer Space Treaty, on its face, seems to prohibit any ownership of outer space. Outer Space Treaty, *supra* note 10, art. II ("Outer space . . . is not subject to national appropriation . . . .").

117. Benjamin D. Hatch, *Dividing the Pie in the Sky: The Need for a New Lunar Resources Regime*, 24 EMORY INT'L L. REV. 229, 257 (2010). A "tragedy of the commons" occurs when too much access to a common resource creates competition for that resource, depleting it to the point where it becomes unusable. All of the competitors deplete the resource even when conservation of the resource is in their long-term interest because whether or not others make the efforts to conserve the resource, competitors will benefit from taking more than their fair share. The reverse situation is where access is so restricted that the resource is wasted or unused.

118. *See id.*; Collins, *supra* note 15, at 202 ("[T]he opportunity for private profit, in one form or another, is an essential incentive for the advancement of space exploration . . . ."); Tennen, *supra* note 92, at 798 ("The use of space resources for commercial enterprise will require a unique approach . . . ."); Thomas, *supra* note 12, at 194 ("Ultimately, states must abandon these treaties . . . because of their inability to work in tandem with emerging realities of privately funded extraterrestrial appropriation and expansion.").

119. Adolph, *supra* note 17, at 981; Thomas, *supra* note 12, at 220–28.

120. Adolph, *supra* note 17, at 981; Thomas, *supra* note 12, at 220–30.

121. Adolph, *supra* note 17, at 982; Thomas, *supra* note 12, at 230–32.

122. Adolph, *supra* note 17, at 982; Thomas, *supra* note 12, at 232–34.

these three elements would grant property rights to that particular part of outer space.[123] This scheme might aid developing nations, as they could provide charters to corporations and benefit from the ensuing relationship.[124] Such a system would also recognize well-established Lockean theories of property endowment.[125]

Also building off of Lockean theories, David Collins proposes a land claim system based on a limited form of first possession.[126] Groups landing on Mars would receive claim to a limited area around the landing site that is put to productive use.[127] Like the discovery theories, this scheme would spur a wave of development by organizations that would race to be among the first to make use of celestial bodies,[128] while also leaving unused tracts of land available for claims by later organizations.[129] Probably the best feature of these proposed systems is that they require the claimants to actually maintain possession of the land,[130] which would encourage actual development rather than rewarding speculative investments.[131] Though these Lockean theories are geared toward systems of real property, the basic Lockean principles of discovery, claim, and possession would apply equally well to asteroids as chattels. Should the international community embrace one of these Lockean approaches to property rights in outer space, the chattel designation will fit within the scheme while helping to solve the problems discussed in Part IV of this Comment.

A similar concept is proposed by Rosanna Sattler: the creation of Exclusive Economic Zones (EEZs) that would mimic the EEZs set up by the United Nations Convention on the Law of the Sea (UNCLOS).[132] UNCLOS allows countries to claim an EEZ extending a certain distance offshore from each country's borders.[133] In doing this, the UN grants the country exclusive rights to the natural resources in its EEZ.[134] Sattler proposes extending this concept so that once a nation builds a structure in

123. Adolph, *supra* note 17, at 982; Thomas, *supra* note 12, at 234.

124. Thomas, *supra* note 12, at 227.

125. Adolph, *supra* note 17, at 981.

126. Collins, *supra* note 15, at 210–11, 213–15.

127. *Id.* at 215.

128. *Id.* at 216.

129. *Id.*

130. *Id.*; Adolph, *supra* note 17, at 982; Thomas, *supra* note 12, at 229–30.

131. Companies already do business selling deeds to lunar and other celestial real estate. *See, e.g.*, THE LUNAR REGISTRY, http://www.lunarregistry.com/ (last visited Oct. 24, 2011); LUNARLANDOWNER.COM, http://www.lunarlandowner.com/ (last visited Oct. 24, 2011); THE LUNAR EMBASSY, http://www.lunarembassy.com/ (last visited Oct. 24, 2011); MOON ESTATES, http://www.moonestates.com/ (last visited Oct. 24, 2011).

132. Sattler, *supra* note 12, at 41–44.

133. *Id.* at 42.

134. *Id.*

outer space, it would be allowed to claim an EEZ of a predetermined size around that structure.[135] The biggest difference from the previously examined schemes is that this would not grant ownership of any land on a celestial body, though it would grant many rights that come with property ownership.[136] Sattler's approach also contemplates a nation-centered exploration model and may be more preferable to those who wish to avoid granting full property rights. Because one of the most attractive uses for asteroids is for their valuable minerals, EEZs could be used to simply grant mining rights. Under this system, it is largely irrelevant whether asteroids are considered chattels or real property because there would be no ownership of the asteroid. It is unlikely, however, that any system that fails to grant ownership of any property in outer space would last indefinitely. Outer space is simply too vast to be regulated by EEZs forever; when humanity agrees on a system of property to govern outer space, the designation of asteroids will be relevant.

Scott Shackelford presents a nuanced version of the first possession doctrine, one "reminiscent of the Homestead Act."[137] Under this scheme, initial investors who arrive at a celestial body would have access to a free market auction of property rights once they have established possession, made improvements to the area, and begun sharing the benefits of the area to satisfy the common heritage language of the Outer Space Treaty.[138] Presumably, investors would have the choice of what sorts of property rights they would purchase: fee simple absolute, temporary mining rights, or some other suitable combination. This approach would raise money to help fund international enforcement, infrastructure, and environmental protection schemes in outer space.[139] Alternatively, Shackelford postulates that limited leasehold rights would be successful without giving up the commons to private ownership.[140] Limited leasehold rights would give investors exclusive tradable rights to an area for a set period of time.[141] While it might not be best for economic development, Shackelford's main objective with these schemes is to protect the commons from the environmental disasters that a tragedy of the commons scenario would entail.[142]

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135. *Id.* at 43.

136. *Id.* at 42.

137. Scott J. Shackelford, *The Tragedy of the Common Heritage of Mankind*, 28 STAN. ENVTL. L.J. 109, 164 (2009).

138. *Id.*

139. *Id.*

140. *Id.*

141. *Id.*

142. *Id.* Climate change is a perfect example of a tragedy of the commons. Nations have unfettered access to a common resource—the atmosphere—and use it to store vast amounts of carbon dioxide, despite the collective irrationality of humanity's greenhouse gas emissions.

In contrast to the caution and restraint showed by Shackelford and other authors to private development of outer space, Ezra Reinstein proposes a system to "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."[143] This system is tempered by a recognition that environmental problems, inefficiencies, destruction, sabotage, and waste can occur if they are not guarded against.[144] In order to unlock this vast potential wealth, Reinstein argues for an auction scheme where interested parties could request a public auction of a particular site.[145] After winning an auction, the interested party would then be required to submit a development plan to an international registry agency for approval.[146] This conceptually simple yet robust scheme would promote all sorts of investment and development in outer space.[147]

The biggest difference between Reinstein's and Shackelford's proposals is that Shackelford would require actual possession prior to the ability to acquire any property rights. Although Shackelford's requirement would benefit from the added clarity of ownership that would accompany actual possession, Reinstein's proposal likely would produce more productive activity in outer space because companies would have the certainty of property rights prior to making the investments necessary to actually possess the property. Neither scheme presents a problem with treating asteroids as chattels.

Leslie Tennen's proposal to create enterprise rights for NEOs is perhaps the most pertinent to this Comment's discussion because her system is specifically designed with asteroids in mind.[148] Her system builds off of currently established enterprise rights schemes, such as those for grazing livestock, harvesting timber, and leasing offshore oil platforms.[149] Tennen argues that a company would need to own an asteroid only if it planned to profit from the fact of ownership and the rights this would entail.[150] With enterprise rights to an asteroid, a company could theoretically lease the mining rights to the asteroid for a period of time without actually owning the asteroid.[151] This exploitation scheme

143. Reinstein, *supra* note 12, pt. IV.

144. *Id.*

145. *Id.* pt. VI.C.4.

146. *Id.*

147. *Id.* Reinstein particularly focuses on the likely role that prospectors could play in discovering and facilitating use of outer space resources.

148. *Id.* at 798.

149. *Id.* at 799.

150. *Id.*

151. *Id.*

would likely require only a new international agency to allocate enterprise rights, avoiding the need for a significant new treaty.[152]

Examination of these proposed schemes shows the potential direction that the *corpus juris spatalis* may take in the future. It might be an extremely pro-property rights regime, or it may attempt to delicately balance development interests against the need to protect the commons from private ownership. The next Part will examine how the classification of asteroids as chattels will work to improve these proposed schemes and resolve some of the property rights issues inherent to the unique features of different celestial bodies.

IV. ASTEROIDS AS CHATTELS: THE CHATTEL/PROPERTY DISTINCTION

All that is Earth has once been sky;
Down from the sun of old she came,
Or from some star that travelled by
Too close to his entangling flame.[153]

This Comment submits a different approach to clarifying the *corpus juris spatalis* by focusing on the legal status of one of the primary targets for space development. Asteroids are likely to be one of the first targets for development, due to their attractiveness in terms of both proximity and value.[154] The question of property rights on Mars or the Moon is largely one of international law, especially concerning the distribution of property, because the rights have well-developed analogues in different systems of real property on Earth.[155] Land rights on Mars or the Moon will likely be substantially similar to those for land on Earth, as legal scholars have almost universally decried the unworkability of a strict "common heritage for all of mankind" interpretation.[156] Yet, it is not so

152. Tennen, *supra* note 92, at 810.

153. C. S. LEWIS, *The Meteorite*, *in* POEMS 99 (Walter Hooper ed., Houghton Mifflin Harcourt 2002) (1964).

154. *See supra* text accompanying notes 45–70.

155. The physical characteristics of the Moon and Mars more closely mirror those of the Earth than do asteroids. *See infra* Part IV.A.

156. *See* Hatch, *supra* note 117, at 256–57 ("Taken seriously, applying the Common Heritage Doctrine would impose a requirement that one country expend massive amounts of money to reach the Moon, and then be a proprietary interest in lunar resource reserves. Furthermore, it would be obligated to allow other states to share equally in the management of, and benefits derived from, the area. In other words, the Common Heritage Doctrine perversely rewards free riders, as states that bear neither risk nor cost gain managerial power and benefits for free, simply because their citizens happen to share the same DNA with the citizens of the state(s) that made the investment. The result is predictable—no state wants to bear the high cost of developing its space program to confer equal benefits on free riders . . . . To remedy the economic problem of the reversed tragedy of the commons, and to preempt many of the conflicts that will naturally arise in the coming lunar expeditions,

simple for asteroids. Asteroids have some key differences that encourage different treatment. As Tennen points out, property rights in outer space will need to be unique and not "burdened by historical restrictions and semantic dilemma . . . ."[157] This does not mean, however, that traditional forms of property cannot substantially inform property rights in outer space. Treating asteroids as chattels recognizes their differences from real property on Earth while using traditional notions to inform their status. The chattel designation would allow freer use of contract law, promote efficiency, provide flexibility, and prevent idiosyncratic issues of property law from arising, such as the extent of subsurface and air rights.

The first difference between asteroids and the Moon or Mars comes from the basic difference between chattels and real property: a chattel is moveable, while real property is not.[158] It is not currently possible for humans to move the Moon, Mars, or the Earth in any meaningful way, but humans could move asteroids given the proper motivation.[159] Scientists have made proposals for how to move dangerous asteroids out of collision courses with the Earth to protect humanity from the perils of a meteorite impact.[160] These large asteroids pose a significant threat to the Earth but would be harmless if their orbits were shifted a few kilometers one way or the other.[161] More pertinently, with enough money and will, it is currently possible to move a smaller asteroid into orbit around the Earth, especially to one of the LaGrange points.[162]

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a new body of law is necessary to regulate the natural resources of the Moon."); Daniel A. Porras, *The "Common Heritage" of Outer Space: Equal Benefits for Most of Mankind*, 37 CAL. W. INT'L L.J. 143, 172–73 (2006) ("In sum, the "Common Heritage" to be enjoyed by all mankind may be seen modernly as a hybrid of: equitable access for all, some equitable benefits for all . . . , and equitable rights to peace in space."); Shackelford, *supra* note 137, at 163 ("If the [Common Heritage of Mankind principle] is not only to survive, but thrive, it must be modified by marrying it to limited property rights . . . ."); Fountain, *supra* note 11, at 1786–87 ("[I]ndustry is forced to operate within the narrow confines of the current space law regime, and an outdated philosophy known as the Common Heritage doctrine. Unless we take a different path—adopt a free-market approach operating under an international regulatory umbrella—there will be little incentive for private industry to invest in outer space.").

157. Tennen, *supra* note 92, at 798.

158. Black's Law Dictionary defines a chattel as "moveable or transferable property; personal property." BLACK'S LAW DICTIONARY (Pocket) 98 (3d ed. 2006). It further defines personal property as "any movable or intangible thing that is subject to ownership and is not classified as real property," while defining real property as "land and anything growing on, attached to, or erected on it, excluding anything that may be severed without injury to the land" and land as "an immovable and indestructible three-dimensional area consisting of a portion of the Earth's surface, the space above and below the surface, and everything growing on or permanently affixed to it." *Id.* at 406, 574.

159. *See* Rather et al., *supra* note 18, at 569.

160. *See, e.g.*, *id.*

161. *Id.*

162. *Id.* LaGrange points are spots where the pull of gravity between two different forces levels out and creates a gravitational dead-spot that requires little to no effort to stay in that spot. The Earth-Moon LaGrange points already have some debris in them, but they could comfortably fit aste-

Movability is the clearest argument for designating asteroids as chattels. Real property is defined by plots, coordinates, or landmarks based on a (relatively) stationary and immobile map.[163] Boundaries can be set and recorded with great precision.[164] Certainly, boundaries could be recorded upon an asteroid, but the nature of asteroids makes boundary drawing much more difficult. While some are spherical like the Earth, others are shaped like a dog bone[165] or might even be two bodies of rock loosely stuck together.[166] The potential for boundary disputes, should the real property system be applied to asteroids, is vast. Lines could be drawn but with much less precision than on the Earth. The curvature of a typical asteroid presents an additional layer of complexity. A chattel designation would avoid the boundary problem by conceptualizing the asteroid as a three-dimensional object, rather than a surface upon which lines need be drawn. The chattel designation would allow parties to more accurately allocate the valuable parts of an asteroid. The designation allows the asteroid to be split by cross sections, apportioned by volume, or allocated by any other number of approaches an owner deems as appropriate. This flexibility is a key advantage of the chattel approach.

The chattel approach to asteroid ownership not only makes sense given the physical differences between asteroids and celestial bodies but it also places the burden of control on private ownership entities.[167] For instance, asteroids require tracking.[168] Tracking asteroids as they float through the darkness of space will be necessary to know who owns what. If an owner has an inclination to split the asteroid, the entirely new piece of property would also need to be tracked. Tracking asteroids is already a tricky business; many times an asteroid is identified multiple times and given different designations, only to be later discovered as the same asteroid.[169] Systems of real property need centralized tracking to function:

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roids for mining or for permanent placement as a base or station. *What are LaGrange Points?*, EUROPEAN SPACE AGENCY, http://www.esa.int/esaSC/SEMM17XJD1E_index_0.html (last visited Oct. 15, 2011).

163. JOSEPH W. SINGER, PROPERTY LAW: RULES, POLICIES AND PROCEDURES 779–80 (4th ed. 2006). Government surveys, metes and bounds, and township plats are examples of a few of the ways real property is demarcated. *Id.*

164. Global Positioning Systems are widely used by cartographers and can be accurate within a meter. Cheryl Pellerin, *United States Updates Global Positioning System Technology: New GPS Satellite Ushers in a Range of Future Improvements*, WASH. FILE (Feb. 3 2006), http://www.america.gov/st/washfileenglish/2006/February/20060203125928lcnirellep0.5061609.html (last visited Oct. 15, 2011).

165. ENCYCLOPEDIA, *supra* note 20, at 352.

166. *Id.* at 294.

167. Though there are registration systems for some forms of personal property, such as cars or boats, none is as centralized or formalized as the deed system for real property.

168. *See NEO Groups*, *supra* note 44.

169. *See* Rather et al., *supra* note 18, at 567.

official deeds must be recorded or an owner risks losing title to the land.[170] Chattels are free from this centralization. For chattels, possession creates a presumption of ownership that must be rebutted by the other party.[171]

Treating asteroids as chattel puts the onus on their owners to make sure they know where their particular asteroid is and where it is going. The asteroid becomes an object owned and controlled by the company or individual, rather than land that is owned by the company or individual. This is a significant conceptual difference. In either scenario, the asteroid will likely be registered with an international authority, but treating it as a chattel would likely reduce centralization of tracking and registration, and ensure that both the rights and responsibilities stay with the owner.

Despite these advantages, decentralized tracking could create more problems than it solves. Companies would likely hire a third party to track their asteroids or try to create their own tracking systems, likely a significant research and development cost. It is an open question whether centralized or decentralized tracking would be more efficient.[172] A decentralized market might provide various innovative solutions for keeping track of large and smaller asteroids, while one single international authority might be able to streamline the process on a scale wide enough to work for everyone at a lower cost.[173] NASA currently runs a program designed to find and track all NEOs, but asteroid development will likely expand well beyond just NEOs.[174] A scheme similar to the United States' current health care system will likely be more successful: private networks serve the various needs of private actors with support from centralized government initiatives where necessary.[175]

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170. *See* 23 AM. JUR. 2D *Deeds* § 6 (2011).

171. *See* 29 AM. JUR. 2D *Evidence* § 295 (2011).

172. Privatization versus centralization has long been a fierce debate in education, health care, and more recently, space development. *See* Sean Cavanagh, *GOP Lawmakers Press Voucher Expansion in States*, EDUC. WEEK, Apr. 27, 2011, at 22, 28 (education); *The American Exception*, THE NATION, May 14, 2011 (health care); Jeremy A. Kaplan, *Star Wars: Neil Armstrong, Obama Spar Over NASA's Future*, FOXNEWS.COM (Apr. 14, 2010), http://www.foxnews.com/scitech/2010/04/14/obama-vs-neil-armstrong-nasa-constellation/ (space development). There is no reason to believe that tracking asteroids would be any different.

173. A comparison of the American and Canadian health care systems is illustrative: Canada's single-payer system costs significantly less money, but the American system might be better in terms of post-surgery recovery. *See* Gordon Guyatt et al., *A Systematic Review of Studies Comparing Health Outcomes in Canada and the United States*, 1 OPEN MED. 27, 28, 39 tbl.2 (2007).

174. *See NEO Discovery Statistics*, *supra* note 50.

175. In the context of asteroid tracking, it is worth contemplating the potential problem of asteroid pirates. Though it would be extremely difficult and dangerous, a team of pirates could potentially move an asteroid and hide it from its owners. After their heyday in the fifteenth century, pirates stubbornly refused to go away, and they still cause disruptions. *See generally* ANGUS KONSTAM, PIRACY: THE COMPLETE HISTORY (2008). It would be unusual if this trend did not eventually carry into outer space, where enforcement of laws will likely be difficult, a key factor that

In addition to redistributing the control burden to private owners, the chattel approach might benefit subsurface and airspace apportionment disputes. The general maxim in American real property jurisprudence has long been that the surface owner owns everything below the surface to the core of the Earth and everything above to the heavens.[176] Since the days of airplanes, this maxim has been rejected as far as airspace is concerned[177] and has recently been challenged for subsurface rights.[178] Though real property owners can no longer believe they own everything to the "center of the Earth," such owners still enjoy subsurface rights to an extent, as well as airspace rights to the extent necessary for occupation.[179] These rights translate well to the Moon or to Mars, which are large, round spheroids with atmospheres, but creating a consistent system of subsurface and airspace rights to asteroids is problematic.

The unique shapes of asteroids will likely cause problems for traditional approaches to subsurface and airspace rights to asteroids that contract law would help solve. Many minable asteroids are spheroids, but many are also irregularly shaped.[180] Asteroids may be oblong, wedge-shaped, or two masses seemingly stuck together.[181] It would certainly be possible to fairly apportion real property rights under a "center of the rock" scheme, but the transactional costs would likely be high in the many cases where the rights would need to be adjusted to a particular

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helps give rise to piracy. A team could work a surprise attack on a third party that is mining an asteroid, destroy or jam the third party's communication abilities, and move the asteroid to a secure location. A decentralized tracking market might be more susceptible to such corruption and could provide cover for some of these pirates. Though this scenario is fanciful and unlikely to happen anytime in the near future, it is a problem that outer space law will likely have to prepare for and deal with at some point. No other frontier has been free of criminals and piracy; it is likely that outer space will be no different.

176. John. G. Sprankling, *Owning the Center of the Earth*, 55 UCLA L. REV. 979, 983–92 (2008). Sprankling notes:

> Blissfully ignorant of subsurface geology, English and American courts repeated this center of the earth dictum over the ensuing decades, often in cases where subsurface rights were not even in dispute. Authors of legal treatises and legal dictionaries similarly adopted the dictum, using it broadly to help define the meaning of "land," or to explain the scope of property rights that were conveyed by a deed. By the end of the nineteenth century, frequent repetition had transformed Blackstone's naked assertion into a supposed rule of American law.

Id. at 983.

177. *See* Hinman v. Pac. Air Transp., 84 F.2d 755, 757 (9th Cir. 1936).

178. Sprankling demonstrates that the "center of the Earth" theory is not ancient law as espoused by some scholarship and judges, and it is not always upheld in modern cases. Sprankling, *supra* note 176, at 982–92. He argues that subsurface rights should be clarified to allow for efficient allocation of subsurface rights as technologies for utilizing the center of the Earth grow more sophisticated. *Id.* at 1021–39.

179. *See id.*

180. ENCYCLOPEDIA, *supra* note 20, at 294, 352.

181. *Id.*

asteroid.[182] Utilizing a chattel approach, if company *A* owns an asteroid and company *B* wishes to mine a different section than the one already in use, *B* could simply draw up a contract to purchase a three-dimensional chunk of the asteroid. The chattel approach would be more efficient than drawing up a contract that involved the complex assignment back and forth of subsurface rights that had been predetermined by a court.[183] The chattel approach would allow companies to rely on the business-friendly confines of contract law to determine how a given asteroid would be sliced, rather than the often-archaic realm of real property.[184] Classifying asteroids as chattels would increase flexibility and therefore profitability for companies.[185]

When considering airspace rights, the real property approach is similarly problematic. Under modern law, property owners are given airspace rights to the extent they can use them with normal usage of the land.[186] It is unclear just how far from the asteroid these rights would extend. It is also unclear whether or not a competing corporation would be allowed to station a satellite over a rival's operation to gain data without the rival corporation's approval or knowledge.[187] This might be considered airspace, or it could be an orbital slot.[188] It is also difficult to seriously call it "airspace" when asteroids are not large enough to have an atmosphere capable of supporting air.[189]

The problem of ensuring the right to secure the space around one's asteroid is more effectively solved by treating asteroids as chattels and invoking the Outer Space Treaty to protect this right. The Outer Space

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182. It is plausible that a "center of the rock" scheme would work in many situations. But there would likely be intense negotiation over a reallocation of these rights in some contracts, while other situations would lead to fierce litigation over these rights. With the chattel approach, two parties would need to split the asteroid, automatically building the subsurface rights into the contract. For further discussion on the "center of the rock" scheme and its deficiencies, see Sprankling, *supra* note 176, at 982–1020.

183. *See* SINGER, *supra* note 163, at 292 (discussing the possible effects of courts choosing the outcome in nuisance cases, and noting that "if the court chooses the inefficient result, transaction costs may be so high as to prevent the parties from correcting the mistake by a subsequent bargain").

184. *See, e.g.*, Citizens for Covenant Compliance v. Anderson, 906 P.2d 1314, 1318 (Cal. 1995) (describing the law of covenants and servitudes as "an unspeakable quagmire") (quoting EDWARD H. RABIN, FUNDAMENTALS OF MODERN PROPERTY LAW 489 (1974)).

185. This does raise a problem of how to ensure that structures built on or inside of asteroids are guaranteed the support beneath them to stay standing. Support rights are a key element of subsurface rights, but they can also be addressed in the drafting of contracts and architectural plans.

186. *See* Hinman v. Pac. Air Transp., 84 F.2d 755, 757 (9th Cir. 1936).

187. The International Telecommunications Union (ITU) apportions geosynchronous slots and other orbital slots around the Earth. *See* Sattler, *supra* note 12, at 31. It is unclear whether this or a different authority would be charged with the ability to grant orbital slots around other celestial bodies.

188. *See id.*

189. *See* ENCYCLOPEDIA, *supra* note 20, at 294.

Treaty has provisions protecting those operating in outer space from interference in location.[190] These provisions allow a nation to prevent other nations from harmfully interfering with its activities in space, a protection that would likely extend to private entities.[191] Though the Outer Space Treaty requires that facilities be open to inspection by other nations upon receiving adequate notice,[192] the protection from interference should adequately cover what airspace rights are meant to protect on Earth.[193]

There are good reasons for establishing a distinction between asteroid-like celestial bodies and forms of real property, though it must be acknowledged that in some cases the differences run out. Meteoroids,[194] comets,[195] Kuiper Belt objects,[196] and rocky bodies in the rings of gas

190. Outer Space Treaty, *supra* note 10, art. IX; *see also* Tennen, *supra* note 92, at 815–16.

191. Outer Space Treaty, *supra* note 10, art. IX.

192. *Id.* art. XII. Article XII exemplifies the open character of outer space that the Outer Space Treaty attempts to create. Article V instructs nations to immediately notify the United Nations if the nation discovers any phenomena that could pose a threat to astronauts. *Id.* art. V. Article IX directs nations to "be guided by the principle of co-operation and mutual assistance" and instructs nations to consult with the international community if it thinks its actions could harm other nations' activities in outer space. *Id.* art. IX. Article IX also allows nations that think another nation's activities are or will be harmful to request a consultation. *Id.* Article X suggests that nations should honor as best as they can requests by other nations to view their space flights, and Article XI tells nations to inform the world of their activities in outer space "to the greatest extent feasible and practicable." *Id.* art X, XI.

193. A problem that might be encountered when treating asteroids as chattels is that of environmental regulation. A discussion of the potential environmental regulatory schemes is beyond the scope of this Comment, but I will briefly address the counterargument that chattels would be incompatible with environmental regulation. A key aspect of the development of real property is the environmental standards one generally must meet to protect the community. These standards are tied to development rights and are especially heightened when a developer seeks to change the character of the land. Chattels, however, generally do not have the same restrictions. Owners can generally do what they please with their personal property without consulting local committees concerned about the environment. It is possible that if asteroids are classified as chattels rather than real property, environmental regulations and enforcement would be weakened. There is much to be said about whether more or less environmental enforcement would be beneficial in outer space, but nevertheless, environmental issues are a concern.

The problem of weakened environmental regulations is also not a major hurdle. Environmental regulations already are enforced on a large number of chattels. Vehicles must meet emissions standards. There are strict requirements for the disposal of toxic products. There are regulations on energy consumption for everyday items. Satellites in orbit are closely scrutinized to minimize space debris and avoid catastrophic returns to the Earth. In sum, there are existing schemes for ensuring that personal property falls under environmental regulation, and a system that treats asteroids as chattels would have plenty of tools to enforce environmental standards.

194. Meteoroids are bodies moving throughout the solar system that are larger than an atom but smaller than an asteroid. *International Meteor Organization*, METEOR SCIENCE GLOSSARY, http://www.imo.net/glossary (last visited Oct. 15, 2011).

195. Comets are bodies composed primarily of water ice and usually have highly eccentric orbits around the sun. ENCYCLOPEDIA, *supra* note 20, at 562.

196. Kuiper Belt objects inhabit the outer reaches of the solar system and are likely made of comet-like cores. *Id.* at 605.

giants[197] all exhibit similar characteristics to the asteroids already discussed. A proposal for a demarcation of what is real property and what is a chattel is the hydrostatic equilibrium. The hydrostatic equilibrium is the point at which a celestial body's mass is so great that its gravitational forces compress the object into a spheroid shape.[198] Ceres is the only known asteroid large enough to be past the hydrostatic equilibrium.[199] Objects beyond this point are large enough that they much more closely resemble the Earth than the smaller irregular asteroids previously discussed. It is possible that a smaller demarcation would work, but speculating on where this line would be drawn would be arbitrary. The hydrostatic equilibrium has the benefit of being a clear line drawn by the laws of physics.

Asteroids, if treated as chattels, would carve out their own niche in international law. If auctions of property rights are held, it would be clear as to what exactly an investor would be receiving: an entire asteroid with all the associated rights. Similarly, if a company lands on an asteroid and begins making use of its resources, it would have possession of the whole celestial body. Free-market principles would still apply to prevent parties from making land grabs and then doing nothing with the property.[200] In addition, the chattel designation would also work well under a leasing system, as it would entail nothing that would make leasing any more difficult.

The chattel designation would be especially important for providing certainty and resolving disputes. Chattels are conceptually simpler than real property, and this simplicity would ease the risk and uncertainty surrounding development in outer space.[201] A well-defined property system developed on Earth and used in an innovative manner would help asteroids be the primary target for early development in outer space.[202] This clarity provided by the chattel designation is essential for investors if they are to plan and invest in the use and exploration of outer space.

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197. Planetary rings are made of many compositions including water ice, rocky bodies, and mixtures of ammonia and methane ice coated with carbon. *Id.* at 509.

198. Mark V. Sykes, *The Planet Debate Continues*, SCIENCE, Mar. 28, 2008, at 1765.

199. ENCYCLOPEDIA, *supra* note 20, at 352.

200. *See* Collins, *supra* note 15, at 216–17 (arguing that the free market and existing legal mechanisms, such as adverse possession, nuisance law, and the natural desire for corporations to profit where they can, would prevent inefficient allocation of outer space resources under a system of property that utilizes traditional property schemes).

201. *See supra* note 118.

202. *See* President Obama's Remarks, *supra* note 25. While Obama is merely planning a visit to an asteroid, greater clarification for the property status of asteroids will aid in establishing permanent operations sooner.

V. CONCLUSION

The United States must be, and must become, unequivocally committed to space exploration and exploitation . . . . Our very survival requires no less.[203]

Asteroids are extremely important to the future of humanity. They could provide the materials to fuel humanity's continued expansion and development on Earth, and throughout the solar system. Perhaps even beyond. Asteroids will also likely be a target for development of extraterrestrial facilities as colonists, scientists, and militaries seek to gain the advantages such a base might provide. As the future unfolds and additional research and development are put into expanding humanity's capabilities in space, especially through private entrepreneurs, these dreams will become realities. Humanity will establish colonies on other planets, other moons, and amongst any other celestial body on which it can find a foothold. The legal regime must be prepared to meet that reality.

The current legal regime is inadequate to support any such development in outer space. The ambiguity surrounding property rights continues to be a major roadblock in establishing the future of outer space development. The Outer Space Treaty provides a solid foundation, but it was written for a different era. Now that it is not only nations but also large, well-funded, and driven private entities rushing to develop outer space, private property rights must be accounted for. "For the province of all mankind" is an idealistic notion that can be captured by spurring the development that outer space can provide. Precisely by clarifying property rights in outer space, the international community can help spur the development that will benefit people of all nations.

Treating asteroids as chattels would help accomplish this goal. This conceptual distinction will work in whatever future *corpus juris spatalis* comes to pass. Conceptualizing asteroids as chattels would simplify ownership while providing tools to achieve efficient use and exploration of celestial bodies. It would also increase investment in exploration and spur technological development. Treating asteroids as chattels would be one small step into a better future.

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203. Brennan, *supra* note 7, at 10.