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Amir H. Khoury

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INTELLECTUAL PROPERTY AND THE RED PLANET: FORMULATING IP POLICIES TOWARDS THE SUCCESSFUL COLONIZATION OF MARS

Amir H. Khoury*

Human colonization of the planet Mars is not a question of "if" but rather of "when," or "how soon?" The challenges ahead are immense but so too are the perceived benefits. This article addresses an aspect that, thus far, has been largely unexamined: the interaction between intellectual property laws on Earth and the mammoth Mars mission ahead. Specifically, this article discusses how IP laws and their structure and use can assist humans in reaching Mars and colonizing the Red Planet.

* Dr. Amir H. Khoury, Senior Lecturer, Faculty of Law, Tel Aviv University.

I. INTRODUCTION

When discussing intellectual property (IP) law, scholars tend to focus on present and future issues that pose regulatory challenges to the existing IP system. Instead, this article examines how IP laws and legal systems can assist in the greatest of human endeavors to this day: the human colonization of Mars. This article looks at IP laws and looks at ways in which they can be altered to facilitate a successful mission to Mars.

This paper is comprised of two sections. The first section discusses the technical aspect of a mission to colonize Mars. The second section analyzes the contribution of IP laws towards this mammoth project, and proposes that certain elements in IP law need improvement to further assist in the successful colonization of Mars, and presents suggestions for improvement.

II. THE CHALLENGES OF REACHING AND COLONIZING MARS

Mars is the closest planet to Earth. Many of its parameters, relatively speaking, resemble those of Earth. Specifically, Mars is almost half the size of Earth, and its gravity is also almost half of that on Earth,[1] and it has substantial quantities of water.[2] According to The National Air and Space Agency (NASA) and other sources, Mars had conditions suitable for life in its past.[3] NASA believes this

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[1] *See* David R. Williams, *Mars Fact Sheet*, NASA, https://nssdc.gsfc.nasa.gov/planetary/factsheet/marsfact.html, (last updated Dec. 23, 2016). For more comparisons and similarities between Earth and Mars, see *Mars/Earth Comparison Table*, PHOENIX MARS MISSION, http://phoenix.lpl.arizona.edu/mars111.php (last visited Oct. 25th, 2017).

[2] *See Mars Ice Deposit Holds as Much Water as Lake Superior*, NASA (Nov. 22, 2016), https://www.jpl.nasa.gov/news/news.php?feature=6680 ("Water ice makes up half or more of an underground layer in a large region of Mars about halfway from the equator to the north pole. The amount of water in this deposit is about as much as in Lake Superior. It was assessed using a radar aboard a NASA spacecraft orbiting Mars."); Nola Taylor Redd, *Water on Mars: Exploration & Evidence*, SPACE (Oct. 7, 2015, 5:11 PM), https://www.space.com/17048-water-on-mars.html.

[3] *See* David S. McKay et al., *Search for Past Life on Mars: Possible Relic Biogenic Activity in Martian Meteorite ALH84001*, 273 SCI. 924, 929 (1996) (finding evidence from meteorite compatible with past life on Mars); Kathleen C. Benison & Brenda B. Bowen, *Acid Saline Lake Systems Give Clues About Past Environments and the Search for Life on Mars*, 183 ICARUS 225, 225 (2006)

planet can help humanity "learn more about our own planet's history and future."[4] Perhaps its exploration "could uncover evidence of life on Mars, answering one of the fundamental mysteries of the cosmos: Does life exist beyond Earth?"[5]

A human-related presence on Mars is already a reality, including the unmanned mission of NASA's Curiosity Rovers;[6] its spectacular landing and photo-rich mission from Mars has effectively begun the countdown to humans landing on Mars. It is no longer a question of if, but of when. In accordance with the bipartisan 2010 NASA Authorization Act and the 2010 U.S. National Space Transportation Policy, NASA has set goals aimed at developing the capabilities needed to send humans to an asteroid by 2025, and to Mars by 2030.[7] NASA is utilizing existing assets, such as the Low-Earth Orbiting International Space Station with its crew of astronauts, to prepare for deep space exploration—including to Mars.[8] These preparations include not only developing technologies and communications systems necessary for human missions into deep space, including Mars, but also developing our understanding of how the body

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(looking to acid saline lake systems in Australia and their microbial life as an analog to formations on Mars).

4 *Benefits to You*, NASA, https://www.nasa.gov/topics/benefits/overview/index.html (last updated Aug. 3, 2017).

5 *Id.*

6 Adam Mann, *Why We Can't Send Humans to Mars Yet, and How We'll Fix That*, WIRED (May 31, 2013), http://www.wired.co.uk/article/getting-to-mars.

7 *Policy Documents*, NASA, https://www.nasa.gov/offices/olia/policydocs/index.html (last updated Aug. 3, 2017); *NASA's Journey to Mars*, NASA, https://www.nasa.gov/content/nasas-journey-to-mars (last updated Aug. 4, 2017).

8 *International Space Station Enables Interplanetary Space Exploration*, NASA (Dec. 4, 2014), https://www.nasa.gov/mission_pages/station/research/news/orion_tests_technology. For an expansive overview of how existing assets in space are assisting in expanding into human deep space exploration, see Jason Davis, *How NASA Plans to Land Humans on Mars*, PLANETARY SOC'Y (Nov. 20, 2014), http://www.planetary.org/blogs/jason-davis/2014/20141119-how-nasa-plans-mars.html; Mike Wall, *Here Are All the Red Planet Plans in the Works,* SPACE (Oct. 12, 2016, 10 AM), https://www.space.com/34365-mars-missions-by-nasa-spacex-and-more.html; NASA, PIONEERING NEXT STEPS IN SPACE EXPLORATION (2015), https://www.nasa.gov/sites/default/files/atoms/files/ journey-to-mars-next-steps-20151008_508.pdf.

changes in space and how to protect astronauts' health—and even life—during such a project.[9] In this regard, NASA has been developing Solar Electric Propulsion, which is needed to send cargo as part of human ('manned') missions to Mars.[10] NASA aims to one day have humans "live and work on Mars, and safely return home."[11] NASA is not alone in this goal, as the private spaceflight company SpaceX has also made great strides in its endeavor to get people to Mars.[12] NASA has formulated a Global Exploration Roadmap (GER) that is intended to define the stages of a successful exploration of Mars.[13] NASA is also collaborating within the GER "with international partners and the U.S. commercial space industry on a coordinated expansion of human presence into the solar system, with human missions to the surface of Mars as the driving goal."[14]

A manned mission to Mars will face many challenges and hurdles, including both technical and human challenges.[15] One of the most notable hurdles includes simply leaving Earth's gravity.[16] In

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[9] Richard B. Setlow, *The Hazards of Space Travel*, 4 EMBO REPORTS 1013 (2003); *see also* Johan Rockström et al., *Planetary Boundaries: Exploring the Safe Operating Space for Humanity*, 14 ECOLOGY & SOC'Y 32, 34 (2009); F. A. Cucinotta et al., *Space Radiation and Cataracts in Astronauts*, 156 RADIATION RES. 460, 464 (2001).

[10] The ORION NASA robotic mission plans to capture and redirect an asteroid to orbit the moon. *NASA's Journey to Mars*, NASA, https://www.nasa.gov/content/nasas-journey-to-mars (last updated Aug. 4, 2017). Astronauts aboard the Orion spacecraft will explore the asteroid in the 2020s, returning to Earth with samples. *Id.* According to NASA, human missions to Mars will rely on Orion and an evolved version of SLS that will be the most powerful launch vehicle ever flown. *Id.*

[11] *Id.*

[12] *Id.*

[13] *Id.*

[14] *Id.*

[15] These challenges are discussed in this section below. For more on the expected challenges of such a mission to Mars, see generally Mark Strauss, *How Will We Get Off Mars?*, NAT'L GEOGRAPHIC (Oct. 2, 2015), http://news.nationalgeographic.com/2015/10/151002-mars-mission-nasa-return-space/.

[16] Mann, *supra* note 6 ("There is no rocket in existence that can take off from the Earth's surface and escape its gravitational pull to reach space carrying the weight of a large spacecraft, astronauts and all the supplies and materials needed

this regard, NASA's Space Launch System (SLS), promised to be the largest rocket ever flown, could assist with getting the necessary supplies and components into space.[17] Furthermore, SpaceX is also working on its new craft, the Falcon Heavy Launch Vehicle, which is likely to contribute greatly to this endeavor.[18] Such a mission would also require a massive volume of fuel, which must survive extreme temperature fluctuations (i.e., the heat of the sun and then the unheated blackness of space); these temperature fluctuations, while the mission is in low Earth orbit, would happen every 90 minutes.[19]According to Adam Mann, these fluctuations cause "liquid hydrogen and oxygen—rocket fuel—to vaporize."[20] He further cautions that "[u]nless tanks are regularly vented, containers holding these materials are liable to explode."[21] NASA is attempting to resolve this challenge by creating new in-space cryogenic loading and transfer; a sort of gas depot in orbit.[22]

However, the hurdles to such a mission do not end here; rather, they start here. For even if it were possible to launch and assemble a mission to Mars in space (near earth orbit), the challenge of propulsion still looms. Indeed, while supplies can be propelled

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to get to Mars. Most likely, rockets would have to make several trips to drop off supplies and pieces for a vehicle into low-Earth orbit.").

[17] The rocket is even bigger than the Saturn V that carried astronauts to the moon. *Id.* NASA estimates that about 70 to 80 launches would be needed to get the required supplies, people, and hardware into space. *Id.*

[18] For more on the Falcon and its contribution to Mars Exploration, see generally Tariq Malik, *Elon Musk Says SpaceX's First Falcon Heavy Launch Will Lift Off in November*, SPACE (July 30, 2017, 7:40 AM), https://www.space.com/37668-spacex-first-falcon-heavy-launch-in-november.html.

[19] Mann, *supra* note 6. For more on coping with heat in low earth orbit, see generally John J. Chapter, *Spacecraft Thermal Environments*, 10 J. Spacecraft & Rockets 93 (1973); KEITH BEDINGFIELD, RICHARD D. LEACH & MARGARET B. ALEXANDER, SPACECRAFT SYSTEM FAILURES AND ANOMALIES ATTRIBUTED TO THE NATURAL SPACE ENVIRONMENT (1996).

[20] Mann, *supra* note 6.

[21] *Id.*

[22] *See* William Notardonato et al., *In-Space Propellant Production Using Water,* AM. INST. AERONAUTICS & ASTRONAUTICS SPACE CONF. & EXPOSITION 1, 1 (2012); Clara Moskowitz, *NASA Wants Gas Stations in Space*, SPACE (Aug. 5, 2011, 6:20 PM), https://www.space.com/12560-nasa-space-gas-station-contracts.html.

towards Mars at low speeds, it is imperative to propel manned crafts at much higher speeds to minimize exposure to radiation and to reduce space travel time.[23] NASA is attempting to address this issue.[24] Indeed, solar electric propulsion, which shoots ionized gas technology for advanced propulsion, is already in use today.[25] However, even stronger propulsion is needed to get to Mars.[26] Still, even after all of these hurdles are overcome, next is the challenge of landing on Mars. Indeed, "the thin Martian atmosphere can't quickly inflate very large parachutes, such as those that would be needed to slow a spacecraft big enough to carry humans."[27] With that said,

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[23] With respect to the risks of space radiation, see generally Marco Durante & Francis A. Cucinotta, *Heavy Ion Carcinogenesis and Human Space Exploration*, 8 NATURE REVS. CANCER 465 (2008) ("[b]efore the human exploration of Mars or long-duration missions on the Earth's moon, the risk of cancer and other diseases from space radiation must be accurately estimated and mitigated."); NASA, HUMAN HEALTH AND PERFORMANCE RISKS OF SPACE EXPLORATION MISSIONS: EVIDENCE REVIEWED BY THE NASA HUMAN RESEARCH PROGRAM, 3405 (2009).

[24] Francis A. Cucinotta & Marco Durante, *Cancer Risk from Exposure to Galactic Cosmic Rays: Implications for Space Exploration by Human Beings*, 7 LANCET ONCOLOGY 431, 431–34 (2006); E. R. Benton & E. V. Benton, *Space Radiation Dosimetry in Low-Earth Orbit and Beyond*, 184 NUCLEAR INSTRUMENTS & METHODS PHYSICS RES. SEC. B: BEAM INTERACTIONS WITH MATERIALS & ATOMS 255, 257 (2001); G. D. Reeves et al., *Electron Acceleration in the Heart of the Van Allen Radiation Belts*, 341 SCI. 991, 993 (2013).

[25] NASA's Dawn and the Japanese Hayabusa spacecraft have used this method. Mann, *supra* note 6. For more on this technology, see generally Joseph R. Cassady et al., *Recent Advances in Nuclear Powered Electric Propulsion for Space Exploration*, 49 ENERGY CONVERSION & MGMT. 412 (2008); Eric J. Lerner, *Plasma Propulsion in Space*, 6 INDUS. PHYSICIST 16 (2000).

[26] Examples of such powerful propulsion technologies include Nuclear Energy; Solar Electric Energy; and Metal CO2 Energy. *See* CLAYTON W. WATSON, NUCLEAR ROCKETS: HIGH-PERFORMANCE PROPULSION FOR MARS, LOS ALAMOS NATIONAL LABORATORY (1994); *see also* J. M. HICKMAN ET AL., SOLAR ELECTRIC PROPULSION FOR MARS TRANSPORT VEHICLES (1990); Evgeny Shafirovich & Arvind Varma, *Metal-CO2 Propulsion for Mars Missions: Current Status and Opportunities*, 24 J. Propulsion & Power 385 (2008).

[27] Mann, *supra* note 6. For comparison, the largest object that has been placed on Mars (NASA's Curiosity Rover) weighed under a ton (0.9 ton), while human-scale missions would require landing 9 to 36 tons. *Id.*; *see also* Nancy Atkinson, *The Mars Landing Approach: Getting Large Payloads to the Surface of the Red Planet*, UNIVERSE TODAY (July 17, 2007), https://www.universetoday.com/7024/the-mars-landing-approach-getting-large-payloads-to-the-surface-of-the-red-planet/.

according to calculations, the Mars "atmosphere is just substantial enough that a lunar-style vehicle using downward-facing rockets couldn't land without creating too much turbulence."[28] Two technologies are being developed to combat this: Hypersonic Inflatable Systems[29] and Supersonic Retropropulsion.[30] While the Hypersonic Inflatable Systems' parachute-type contraptions might be able to slow a spacecraft on its way to the surface of Mars, its anticipated incoming speeds—even after the deployment of these mechanisms—will exceed the speed of sound.[31] This is where the technology of Supersonic Retropropulsion comes in. SpaceX has been developing reusable rocket tanks that descend from orbit and land back at their launch pad.[32] This will enable reuse of rockets, save time to reload payload and drastically expand the number and scope of space launches. Furthermore, if more than one craft is used (perhaps one for supplies and another for humans) the proximity of the crafts on the surface of Mars is a crucial component in

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[28] Mann, *supra* note 6.

[29] NASA is developing gigantic balloon-like objects that would expand and stiffen to become something like a super-rigid parachute. Karl T. Edquist et al., *Development of Supersonic Retro-Propulsion for Future Mars Entry, Descent, and Landing Systems*, 51 J. SPACECRAFT & ROCKETS 650, 653 (2014); Ashley M. Korzun, Juan R. Cruz, & Robert D. Braun, *A Survey of Supersonic Retropropulsion Technology for Mars Entry, Descent, and Landing*, IEEE AEROSPACE CONF. 929, 933 (2008); Walter E. Bruce III et al., *Aerothermal Ground Testing of Flexible Thermal Protection Systems for Hypersonic Inflatable Aerodynamic Decelerators*, 9th INTERNATIONAL PLANETARY PROBE WORKSHOP 16, 18 (2012), https://ntrs.nasa.gov/search.jsp?R=20120011663; *see also* David M. Bose et al., *The Hypersonic Inflatable Aerodynamic Decelerator (HIAD) Mission Applications Study*, AIAA AERODYNAMIC DECELERATOR SYS. TECH. CONF. & SEMINAR (2013), https://arc.aiaa.org/doi/abs/10.2514/6.2013-1389.

[30] Thomas J. Horvath et al., *Advancing Supersonic Retro-Propulsion Technology Readiness: Infrared Observations of the SpaceX Falcon 9 First Stage*, AM. INST. AERONAUTICS & ASTRONAUTICS SPACE & ASTRONAUTICS F. & EXPOSITION (2017).

[31] Robert D. Braun & Robert M. Manning, *Mars Exploration Entry, Descent and Landing Challenges*, IEEE AEROSPACE CONF. 4, 10 (2006); *see also* Grant William Wells et al., *Entry, Descent, and Landing Challenges of Human Mars Exploration*, 29th Ann. Am. Astronautical Soc'y Guidance & Control Conf. 1, 4 (2006).

[32] Horvath, *supra* note 30, at 2.

facilitating an operational mission where the human crew and their supplies and hardware are in close geographical proximity.[33]

Setting aside the technical issues pertaining to the actual journey to Mars, other challenges still exist, including the health of the crew and their ability to survive on Mars. As mentioned above, the sun's radiation constitutes a grave health danger to humans traveling to Mars. According to Adam Mann, "[o]nce outside the protective magnetic field of our planet, solar radiation would accumulate in an astronaut's body, raising his or her risk of cancer."[34] The risk of exposure is significant, given that the duration of a Mars trip would be between seven and nine months.[35] But the total time of a trip to Mars would be even longer (approximately thirty months) given the need to launch at a relevant time in terms of the positioning of the two planets.[36] Another risk associated with a thirty-month trip to Mars is the microgravity;[37] the human body is not designed to thrive

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[33] Mann, *supra* note 6. Adam Mann explains that "Curiosity also had a relatively large landing ellipse. That is, researchers could be reasonably sure where the rover would touch down, but only within an ellipse seven by twenty kilometers." *Id.* While this is satisfactory for a single craft mission, it just is not feasible when more than one craft is involved. *Id.* Mann challenges us to consider the following scenario: "Imagine if a human descent vehicle touched down on Mars and then the astronauts' supplies came down twenty km away. It would be quite a schlep just to go pick up your extra oxygen." *Id.*

[34] *Id.* ("Recent data from NASA's Curiosity spacecraft have helped quantify just how risky background radiation levels are. Massive explosions like solar flares or energetic particle events could throw potentially lethal doses of radiation right at a spaceship."). It is worth noting that this issue of radiation has prompted timing the private manned mission, Inspiration Mars, to flyby Mars in 2018 coinciding with low activity from the sun to minimize the chances of encountering a solar outburst. *Id.* Other than timing the journey, shielding the craft by a layer of water or a mini-magnetic field are further steps to consider but are not presently financially or technologically feasible. *Id.*

[35] *Id.*; *see also* J. C. Buckey Jr., *Preparing for Mars: The Physiologic and Medical Challenges*, 4 EURO. J. MED. RES. 353, 359 (1999).

[36] For more on the NASA projected timeline, see Paul Rincon, *Nasa Outlines Manned Mars Vision*, BBC NEWS, http://news.bbc.co.uk/2/hi/science/nature/7116834.stm (last updated Nov. 28, 2007); *see also* ERIK SEEDHOUSE, MARTIAN OUTPOST: THE CHALLENGES OF ESTABLISHING A HUMAN SETTLEMENT ON MARS 156 (2009).

[37] Mann, *supra* note 6. Mann points out that living in zero gravity for a prolonged period of time can cause "bone and calcium degradation, muscle loss, and a recently-identified issue that may stem from swelling of the optic nerve. If

in an environment that does not have Earth's gravity. Limitations on human's survival in such an environment include detrimental effects on the eyes, spatial orientation,[38] spine, muscles, and even individual cells.[39] Last but not least, astronauts would also struggle with social isolation.[40] NASA is experimenting with the impact of long stays in space by deploying astronauts for one year on the International Space Station.[41] It is not clear if life on this station can mitigate the psychological impact on astronauts who will travel to Mars, considering the vast distances and deep social isolation the extended trip will entail.[42]

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left unchecked, astronauts arriving on Mars could be weak, brittle-boned, and possibly blind." *Id.*

[38] Spatial disorientation or spatial unawareness is the inability of a person to correctly determine his/her body position in space. Alan J. Benson, *Spatial Disorientation in Flight*, ERNSTING'S AVIATION MEDICINE E 4, at 433 (2006). For more on this challenge to humans in space, see generally Ronald J. White & Maurice Averner, *Humans in Space*, 409 NATURE 1115 (2001).

[39] For the impact of non-Earth like gravity on humans, see generally A. Cogoli, A. Tschopp & P. Fuchs-Bislin, *Cell Sensitivity to Gravity*, 225 SCI. 228 (1984); Gerard K. O'Neill, *The Colonization of Space*, 27 AM. INST. PHYSICS 32 (1964); Hermann Schone, *On the Role of Gravity in Human Spatial Orientation*, AEROSPACE MED. 765 (1964); B. L. Davis & P. R. Cavanagh, *Simulating Reduced Gravity: A Review of Biomechanical Issues Pertaining to Human Locomotion*, 64 AVIATION, SPACE, & ENVTL. MED. 557 (1993); David Williams et al., *Acclimation During Space Flight: Effects on Human Physiology* 180 CAN. MED. ASS'N J. 1317 (2009).

[40] For a discussion about the similarities of social isolation on earth in settings such as distant outposts, submarines, and prisons, see generally Peter Suedfeld & G. Daniel Steel, *The Environmental Psychology of Capsule Habitats*, 51 ANN. REV. PSYCHOL. 227 (2000); Kate S. Brasher et al., *Occupational Stress in Submariners: The Impact of Isolated and Confined Work on Psychological Well-Being*, 53 ERGONOMICS 305 (2010); KATHARINE RIDGEWAY ET AL., NASA, COUNTERMEASURES TO MITIGATE THE NEGATIVE IMPACT OF SENSORY DEPRIVATION AND SOCIAL ISOLATION IN LONG-DURATION SPACE FLIGHT (2012).

[41] For a discussion on the psychological impact of a human mission to Mars, see generally Dietrich Manzey, *Human Missions to Mars: New Psychological Challenges and Research Issues*, 55 ACTA ASTRONAUTICA 781 (2004); Nick Kanas et al., *Psychology and Culture During Long-Duration Space Missions*, 64 ACTA ASTRONAUTICA 659 (2009).

[42] Compounding the isolation, travelers to Mars would not have the option to abort the mission and would endure an ever-increasing time delay in communication with Earth. *See* Peggy Wu et al., *Maintaining Psycho-Social*

Once on Mars, colony sustainability becomes the main challenge. One prime example of sustainability issues is supplying food. Carrying sufficient foods to Mars to sustain a small colony is spatially impossible and financially infeasible.[43] A new colony would need to tap into Mars' surface to harvest minerals, water, oxygen, and food to survive; the colony would have to live off the land. This is a viable option given the wealth of minerals and substances on the surface of Mars.[44] This concept is referred to as In-Situ Resource Utilization (ISRU);[45] without it, the notion of long-term settlement is theoretical at best. Fortunately, Mars' soil is mineral-rich and has notable quantities of water locked up in ice.[46]

Health on the Way to Mars and Back, PROC. 2015 VIRTUAL REALITY INT'L CONF. 1, 1 ("In future long duration Mars exploration missions, network limitations and the lack of real-time communication capabilities will impact various aspects of space crew performance as well as behavioral health."); *see also* V. Gushin et al., *Some Psychophysiological and Behavioral Aspects of Adaptation to Simulated Autonomous Mission to Mars.*, 70 ACTA ASTRONAUTICA 52, 57 (2012).

[43] For more on the sustainability challenges facing a human mission to Mars, see generally A. E. Drysdale, M. K. Ewert, & A. J. Hanford, *Life Support Approaches for Mars Missions*, 31 ADVANCES IN SPACE RESEARCH 51 (2003).

[44] *See* Benton C. Clark et al., *Chemistry of the Martian Surface-Resources for the Manned Exploration of Mars*, CASE FOR MARS 197, 200 (1984) ("Mars is a bonanza in useable natural resources, while the moon is impoverished. For this reason, on Mars, many materials and equipment will be more economically manufactured on site than transported from earth. A survey of natural resources is conducted, taking into account water, carbon atoms, oxygen atoms, nitrogen atoms, phosphorus atoms, sulfur and chlorine atoms, mineral concentrates, and heavy elements. Questions regarding the processing of raw materials are discussed. Problems of purification are examined along with suitable approaches to manufacturing, and the employment of solar irradiance, geothermal heat, nuclear fission reactors, and wind power as energy sources. The utilization of the obtained products is also considered, giving attention to construction, construction materials, the need for blasting explosives, approaches for producing rocket fuel and rover fuel, and the growing of food on Mars.").

[45] Mann, *supra* note 6 ("A machine could be sent to Mars ahead of astronauts that might extract oxygen from the carbon dioxide atmosphere. Or elements in the soil could be isolated and then used for building materials or rocket fuel.").

[46] *Id.* With respect to water being found on Mars, see Michael H. Hecht, *Metastability of Liquid Water on Mars*, 156 ICARUS 373, 376 (2002); Harry Y. McSween, *Water on Mars,* 2 ELEMENTS J. 135, 135 (2006) ("Water on Mars exists at the poles and in the subsurface. It has interacted with crustal rocks, providing geomorphological, geochemical, and mineralogical insights into Mars'

This, in turn, could help to establish farming on Mars. Protecting a colony from exposure to possible microbiological or viral organisms currently on Mars is another challenge. Current technology cannot at present prove or disprove the existence of such organisms.[47] Because of this uncertainty, humans on Mars could contaminate the red planet or be contaminated by a Martian organism.[48] Finally, another serious consideration is exposure to dust, which can be intrusive, corrosive, and potentially toxic.[49]

The challenges to the long-term success of a Mars mission necessitates proactive problem-solving. In this context, the IP environment on Earth could contribute to alleviating these challenges. This article is intended to show how a healthier IP regulative régime could contribute to the success of a Mars mission. The next section will discuss elements of IP regulation that, if

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geological history and inferences about its biological potential. The roles of water are revealed through studies of altered materials using orbiting-spacecraft imagery and spectroscopy, instruments mounted on rovers, and laboratory measurements on Martian meteorites."). On the issue of food production on Mars, see generally Lynn J. Rothschild, *Earth Analogs for Martian Life. Microbes in Evaporites, A New Model System for Life on Mars*, 88 ICARUS 246 (1990); Michele H. Perchonok, Maya R. Cooper & Patricia M. Catauro, *Mission to Mars: Food Production and Processing for the Final Frontier*, 3 ANN. REV. FOOD SCI. & TECH. 311 (2012).

[47] On the existence of or nonexistence of Martian organisms, see generally Carl Sagan, Elliot C. Levinthal, & Joshua Lederberg, *Contamination of Mars: Since a Significant Chance of Contamination Exists, Mars-bound Spacecraft Should be Sterilized Carefully*, 159 SCIENCE 1191 (1968); Andrew C. Schuerger et al., *Survival of Endospores of Bacillus Subtilis on Spacecraft Surfaces Under Simulated Martian Environments,* 165 ICARUS 253 (2003); A. Debus, *Estimation and Assessment of Mars Contamination*, 35 ADVANCES IN SPACE RES. 1648 (2005).

[48] These realistic fears regarding bilateral contamination have prompted NASA (in the US) and other spacefaring nations to agree upon planetary protection standards. J. D. Rummel & L. Billings, *Issues in Planetary Protection: Policy, Protocol and Implementation* 20 SPACE POL'Y 49, 51 (2004); *see also* Wayne L. Nicholson et al., *Migrating Microbes and Planetary Protection*, 17 TRENDS IN MICROBIOLOGY 389, 390 (2009); André Debus, *The European Standard on Planetary Protection Requirements*, 157 RES. IN MICROBIOLOGY 13, 13 (2006).

[49] The dust particles on Mars (much like the ultra-sharp and abrasive moon soil) are likely to clog up machinery and damage basic functions. Mann, *supra* note 6 ("Curiosity and a previous mission, the Mars Phoenix lander, proved that the Martian soil is chock full of chemicals called perchlorates.").

formulated correctly, could ultimately contribute to a successful mission. Indeed, many of the technological developments which were initially viewed as a threat to traditional IP rights, such as peer-to-peer (P2P) communications and 3D printing, are posited to play a crucial role.

III. HOW IP LAWS AND SYSTEMS CAN HELP GET HUMANS TO MARS

IP laws are primarily invoked by owners trying to protect their respective innovations and creative works. These owners use offensive legal measures to prevent or deter others from infringing their IP rights. In this regard, IP rights are viewed through the prism of commercial self-interest. Undoubtedly, this perspective is a legitimate component in the IP regime, but it focuses primarily on self-interest usually serving immediate interests.[50] However, a complete picture of IP laws portrays another characteristic of IP in that it facilitates the expansion of innovation, knowledge, and the empowerment of the collective.[51] This is especially relevant in the case of Mars exploration. Much of what will be achieved on Mars by humans hinges on IP laws that promote creativity, innovation, and the proliferation of technology and knowledge. This section explains how different IP systems can be utilized to assist a future human mission to the Red Planet.

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[50] For more on the ongoing tug-of-war between the private domain and the public domain in IP, see generally Keith Aoki, *Authors, Inventors and Trademark Owners: Private Intellectual Property and the Public Domain-Part II*, 18 COLUM-VLA J.L. & ARTS 191 (1993); Lester C. Thurow, *A New System of Intellectual Property Rights*, 75 HARV. BUS. REV. 94 (1997).

[51] For more on the significance of the public domain and why it needs to be preserved and enhanced, see generally Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research.*, 280 SCI. 698 (1998); Robert P. Merges, *A New Dynamism in the Public Domain,* 71 U. CHI. L. REV. 183 (2004).

A. *The Funding Element: Branding the Mission and Crowd Funding*

Crowdfunding has become an effective and widespread method for raising funds and financial support for a given project.[52] Ethan R. Mollick states that "[c]rowdfunding allows founders of for-profit, artistic, and cultural ventures to fund their efforts by drawing on relatively small contributions from a relatively large number of individuals using the internet, without standard financial intermediaries."[53] Mollick observes that "personal networks and underlying project quality are associated with the success of crowdfunding effort."[54] If this works at the micro level, why should one not expect it to work on the macro level? Indeed, consider a scenario in which the public could buy into or invest in the mission to Mars. Such investors would be buying into potentially new IP generated from such a mission. Indeed, Mars colonization and exploration is not merely about establishing an additional home for humanity; it is also possibly a new window into scientific exploration and discovery.[55] It could yield benefits to humanity back on Earth—benefits that could easily be translated into IP rights with tangible commercial value. This could include scientific developments and innovations, as well as new understanding of space and life outside of planet Earth.[55] As such, crowdfunding could be utilized (as an investment option) for providing financial leverage to a Mars Mission.[56] This idea of leveraging through

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[52] Crowdfunding centers on turning to the masses for financial support for a given project and has been in existence for a few decades. *See, e.g.*, David Freeman & Matthew Nutting, A Brief History of Crowdfunding (last updated Nov. 5, 2015) (unpublished manuscript), http://www.freedman-chicago.com/ec4i/History-of-Crowdfunding.pdf.

[53] Ethan Mollick, *The Dynamics of Crowdfunding: An Exploratory Study*, 29 J. BUS. VENTURING 1, 1 (2014), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2088298.

[54] *Id.*

[55] *See* Jessica Orwig, *5 Undeniable Reasons Humans Need to Colonize Mars,* BUS. INSIDER (Apr. 21, 2015, 9:45 AM), http://www.businessinsider.com/5-undeniable-reasons-why-humans-should-go-to-mars-2015-4.

[55] *Id.*

[56] On April 5, 2012, the Jumpstart Our Business Startups (JOBS) Act was signed into law by President Barack Obama. Tanya Prive, *Inside the JOBS Act: Equity Crowdfunding*, FORBES (Nov. 6, 2012, 11:57 AM),

crowdfunding is not novel and has been discussed in other contexts, including raising equity[57] and analyzing the role of traditional venture capitalists.[58]

Beyond traditional crowdfunding campaigns is the concept of brand-funding. This concept allows owners of brands to support projects in return for their brand's visibility on the final product.[59] For example, a Mars-bound space rocket would have on it (in addition to its formal insignia) the logos or brands of the entities that sponsored the mission. The exposure of said brand *en route* to Mars clearly supersedes any exposure that *any* brand could hope to receive (through conventional advertising) here on Earth. While crowdfunding is an avenue with demonstrated success, brand-funding could also be utilized to fund a mission to Mars. Further, these strategies extend beyond traditional advertising purposes. The impact of such brand-funding will extend beyond the takeoff of the rocket or rockets and well into the actual colonization of Mars. Consider Mars as a new territory. Consider the publicity impact, here on Earth, by applying the proposed planet-wide protection for brands and other IP subject matter for a few decades on Mars. This can be achieved by a licensing agreement for sole use or shipment of items to Mars during a given period. There is no doubt that if Mars colonization is successful—and there is a high likelihood that it will be—that such brand-funding will generate massive revenues

https://www.forbes.com/sites/tanyaprive/2012/11/06/inside-the-jobs-act-equity-crowdfunding-2/#5079248b4b2e. The Act required the SEC to write rules and issue studies on capital formation, disclosure, and registration requirements. For more on the idea of crowd funding, see Thomas E. Vass, How Crowd Funding Solves One of the Biggest Capital Market Gaps in America: Unleashing a Torrent of Growth Capital for Small Private Established Technology Firms, (Mar. 29, 2012) (unpublished manuscript), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2031051.

[57] J. Robert Brown, Jr., *Selling Equity Through Crowdfunding: A Comment*, (U. Denver Legal Stud., Res. Paper No. 14–11, 2014), http://ssrn.com/abstract=2386278.

[58] Ryan Kantor, Why Venture Capital Will Not Be Crowded Out by Crowdfunding (December 4, 2013) (unpublished manuscript), https://ssrn.com/abstract=2400082.

[59] Consider sponsorship for car races wherein brands are visibly placed on the racing cars. *See* Joshua Carlyle et al., *British American Tobacco and Formula One Motor Racing*, 329 BMJ 104 (2004).

both on Mars and even more so on Earth. Imagine the implication of being the owner of the *first* toothpaste, soft drink, coffee, or car brand used on Mars. The potential is boundless and out of this world! Indeed, it is reasonable to assume that commercial entities would compete to buy into a Mars mission, which would facilitate massive funding campaigns.[60] Crowdfunding and brand-funding would be a very effective source of funding and might even be sufficient to finance the entire mission, which would make the mission much more financially attainable. This is a utopic yet feasible use of brands, wherein their commercial impact on the public can be leveraged in a positive way to help in the funding of the mammoth Mars mission.

Further, a branding auction could serve as the legal vehicle for securing the dominance of those brands that participate in the funding of the mission. An entity working on a Mars mission could offer brand visibility to those who provide funding and support, much like Formula One and other sports events.[61] An entity could auction out spots to the 100 brands that bid the highest to have their products used on Mars and the brands would commit to planet-wide coverage for a period that would depend on the level of funding they provide. For example, for a specified price unit, a brand would be guaranteed visibility for a specific time period. Each general category of goods and/or services could allow leading brands within the category to compete for auction spots. These categories could include shoes, apparel, alcoholic beverages, foods, dentists, pens, sports gear, software, doctors, phones, watches— the list of subcategories of goods and services is lengthy. Thus, each sector of

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[60] Consider how such large corporations are deeply involved in broadly visible events such as sports games, races, the motion picture industry. For more on the participation of brand owners in said industries, see generally Robert Copeland, Wendy Frisby, & Ron McCarville, *Understanding the Sport Sponsorship Process from a Corporate Perspective*, 10 J. SPORT MGMT. 31 (1996); Jennifer Rowley & Catrin Williams, *The Impact of Brand Sponsorship of Music Festivals*, 26 MARKETING INTELLIGENCE & PLAN. 781 (2008). Chris Gratton, Simon Shibli, & Richard Coleman, *The Economic Impact of Major Sports Events: A Review of Ten Events in the UK*, 54 SOCIOLOGICAL REV. 41 (2006).

[61] Anne Millan & Mairead Ball, *The Use of Social Media as a Tool for Consumer Brands to Leverage Sponsorship of Sporting Events*, 13 INT'L J. SALES, RETAILING & MARKETING 27, 31 (2012).

the market could compile a list of brands which have "bought in," and those brands would be allowed the first chance to advertise on Mars.[62] The end result would be an immensely powerful marketing tool here on Earth. To market as the only running shoes used on Mars or the only toothpaste brand, for example, would be very impactful for consumers here on Earth.[63] Such an impact of first-comers to the space market could draw the attention of consumers here on Earth. This is very similar to the use of celebrity images when marketing a brand. In both cases, these tools attract great public attention and hence facilitate sales. This brand publicity, coupled with the sensationalism of space travel and Mars astronauts, could produce a powerful advertising mechanism which would justify the brands' investment in funding of the mission. Finally, after the pre-determined allotted advertising periods, the Mars market would be open to other brands as life on the red planet becomes less-captivating for humans back on Earth. Until such time, collective human interest in following this amazing mission would generate a powerful advertising machine that is literally out of this world. Additionally, this business model is in-line with the idea of sole ownership of brands as well as licensing mechanisms allowed by trademark law.[64] Further, in a broader IP context, patent auctions are not a new phenomenon and have been in place for many years now.[65] Patent auctions help in connecting a patent owner who is willing to sell his patent and a buyer who is willing to invest in

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[62] Set prices would depend on how lucrative a particular sector is and, in the end, a list of 100 brands would be compiled. These would be the only brands allowed on the planet for an amount of the time agreed upon by the parties.

[63] Kurt A. Carlson, Margaret G. Meloy & J. Edward Russo, *Leader-Driven Primacy: Using Attribute Order to Affect Consumer Choice*, 32 J. CONSUMER RES. 513, 517 (2006); *see also* Smita Sharma, *Celebrity Endorsement-Is It the Only Survival Recipe for Marketers?*, 36 INDIAN J. MARKETING, 3, 7 (2006).

[64] *See* Agreement on Trade-Related Aspects of Intellectual Property Rights, art. 16(1), Apr. 15, 1994, 1869 U.N.T.S. 299, 33 I.L.M. 1197 (1994) [hereinafter TRIPS] ("The owner of a registered trademark shall have the exclusive right to prevent all third parties not having the owner's consent from using in the course of trade identical or similar signs for goods or services which are identical or similar to those in respect of which the trademark is registered where such use would result in a likelihood of confusion.").

[65] *See* H. Niioka, *Patent Auctions: Business and Investment Strategy in IP Commercialization*, 1 J. INTELL. PROP. L. 728, 730 (2006).

acquiring the patent because of its perceived potential value. There is no reason why the above-mentioned trademark licensing (for territory domination) cannot also be utilized.

It is worth noting that the concept of risk-sharing is not new; notable examples include insurance industry and venture capitalists.[66] Even less revolutionary is the ancient method of seafaring, where ships would sail into the unknown and shipmaster, vessel owner, and owner of the cargo on board would share in the risks and rewards of the voyage.[67] According to Mandelbaum,

> [t]raditionally, through Roman law, the Middle Ages with its 'Law Merchant,' the laws of Visby, of Oleron and the Hansa Cities, the merchant and the ship owner each shared in the dangers—the voyage was considered a common adventure. Merchants often accompanied their goods on board. The shipowner was bound to furnish a seaworthy vessel and a competent crew, but if the vessel was lost due to perils and dangers of the sea, shipowner and merchant suffered together.[68]

Ultimately, if these funding mechanisms are adopted and applied to the Mars project, it is likely that brand funding could secure revenue for the project, thereby working as indirect crowdfunding.

B. *The Development Element: Ensuring Full Collaboration by Applying the Negative Trade Secrets Model*

Mars exploration is a scientific endeavor, a possible gift to humanity, but it is also a commercial endeavor spearheaded by national and commercial entities including NASA, SpaceX, USA, Indian Space Research Organization, United Arab Emirates,

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[66] *See* F. Ewald, *Insurance and Risk, in* THE FOUCAULT EFFECT: STUDIES IN GOVERNMENTALITY (1991); Edwin H. Anderson, *Risk, Shipping, and Roman Law*, 34 TUL. MAR. L.J. 183 (2009); *see also* Amir H. Khoury, *Of Trucks, Trains and Ships: Relative Liability for Cargo Loss and Damage*, 14 RICH. J. GLOBAL L. & BUS. 45 (2015).

[67] Khoury, *supra* note 66.

[68] Samuel R. Mandelbaum, *International Ocean Shipping and Risk Allocation for Cargo Loss, Damage and Delay: A U.S. Approach to COGSA, Hague-Visby, Hamburg and the Multimodal Rules*, 5 J. TRANSNAT'L L. & POL'Y 1, 3 (1995); *see also* Robert Rendell, *Report on Hague Rules Relating to Bills of Lading*, 22 INT'L L. 246, 247 (1988); *see also* Y. Rapoport, *Admiralty and Maritime Laws in the Mediterranean Sea (ca. 800–1050): The Kitab Akriyat al Sufun vis-a-vis the Nomos Rhodion Nautikos by Hassan S. Khalilieh*, 21 J. ISLAMIC STUD. 131, 131–32 (2010).

ESA, China National Space Administration, Inspiration Mars, and Mars One.[69] As one might expect, a modern space race, or a "Mars-race," has developed amongst them. Such a competition could entail separate development and foster an environment of secrecy. This would be a rational approach for each entity that is trying to reach Mars. Indeed, one would expect that each entity would attempt to keep its knowledge and know-how to itself lest it lose the edge in the race. This is exactly what trade secret protection does.[70]

> Broadly speaking, any confidential business information which provides an enterprise with a competitive edge may be considered a trade secret. Trade secrets encompass manufacturing or industrial secrets and commercial secrets. The unauthorized use of such information by persons other than the holder (of said information or knowledge) is regarded as a violation of trade secret. Depending on the legal system, the protection of trade secrets forms part of the general concept of protection against unfair competition or is based on specific provisions or case-law dealing with the protection of confidential information.[71]

Such an outcome will not—or at least should not—occur for a few reasons. First and foremost, the cost of the project and the risks involved in going to Mars are immense, and the project is complex.[72] Second, the current scientific and commercial environment is distinct from that of the 1960s and 1970s space-race.[73] If a secrecy approach is ultimately chosen, then I predict that the likelihood of success of the Mars mission would be diminished. The Mars project must be a *joint* effort, including sharing of knowledge at all levels. In this regard, the practice of trade secrecy—as recognized by

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[69] Jacob Aron, *Private Space Race Comes of Age*, 219 NEWSCIENTIST 8, 9 (2013); *see also* ERIK SEEDHOUSE, THE NEW SPACE RACE: CHINA VS. USA (2010); Tessaleno Devezas et al., *The Struggle for Space: Past and Future of the Space Race*, 79 TECH. FORECASTING & SOC. CHANGE 963, 967 (2012).

[70] Amir H. Khoury, *The Case Against the Protection of Negative Trade Secrets: Sisyphus' Entrepreneurship*, 54 IDEA: INTELL. PROP. L. REV. 431, 453 (2014) ("[A] given business in a race to develop a product will be inclined not to share information of any kind with its competitors lest they make up for lost time and catch up with him. This is true not only in the national sphere, but even more so in the international.").

[71] WIPO, What Is a Trade Secret?, http://www.wipo.int/sme/en/ip_business/trade_secrets/trade_secrets.htm.

[72] FREDERIC W. TAYLOR, THE SCIENTIFIC EXPLORATION OF MARS 253–83 (2010).

[73] *Id.* at 23–49, 84–119.

various IP laws as well as Article 39 of the TRIPS agreement—cannot be invoked.[74] A Mars mission can only be achieved through *full* cooperation and sharing of knowledge and know-how. This includes information pertaining to avenues of failure, referred to as the negative trade secrets paradigm. This section will explain why failure in R&D should be shared throughout the industry and with competitors, and why it should not be protected by trade secrecy laws.

The case for sharing information about failures of experiments or scientific research, or the case *against* protecting negative trade secrets, simply holds that the laws that protect trade secrets should not tolerate hiding failure under the pretense of trade secrecy. Generally, trade secrets encompass any type of information that a business keeps confidential.[75] Such "negative" information (or failure) constitutes "negative trade secrets" and as such should not be protected as regular trade secrets. Placing such "negative trade secrets" in the public domain would essentially revitalize and invigorate entrepreneurship, research, and development.[76] This is especially crucial in the human endeavor to reach and to settle Mars. This section proposes that specifically-tailored IP (trade secrecy) policies could help humans get to Mars.

Entrepreneurship is all about innovation: navigating uncharted worlds (in this case, deep space) and forging new paths. By its definition, it is counter-productive for entrepreneurs involved in Mars exploration to engage in research that someone else has already conducted, especially if that research failed or reached a dead-end. It is unwise and inefficient to engage in activity that only

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[74] TRIPS, *supra* note 64, art. 39.

[75] *See* Michael Risch, *Why Do We Have Trade Secrets*, 11 MARQ. INTELL. PROP. L. REV. 8 (2007) (giving an expansive discussion of the origins and justifications of trade secrets); *see also* Economic Espionage Act of 1996, 18 U.S.C. § 1839(3) (2017) (defining trade secrets broadly as "all forms and types of financial, business, scientific, technical, economic, or engineering information, including patterns, plans, compilations, program devices, formulas, designs, prototypes, methods, techniques, processes, procedures, programs, or codes, whether tangible or intangible, and whether or how stored, compiled, or memorialized physically, electronically, graphically, photographically, or in writing.").

[76] Khoury, *supra* note 70.

replicates others' mistakes and failures. Thus, in order to enhance effective entrepreneurship, it is imperative that the laws protecting trade secrets do not protect the details of failure in previous avenues of research. In this regard, "negative trade secrets" should be treated differently than other secret information and should be placed in the public domain. This argument may initially seem counter-intuitive and contradictory to rational business practices, which are customarily motivated by self-interest and shirk from helping save competitors' time.[77] However, where mammoth undertakings are involved (i.e., Mars exploration), opening the market of negative information to all could eliminate previous failures from being replicated, thus evading *Sisyphean* undertakings.[78] This would benefit entrepreneurs and ultimately society at large.[79] Indeed, a market for such information could also be established.[80] This practice would help entrepreneurs avoid research that is pre-destined to fail and would embody the view that "[c]hance favors the connected mind."[81] In a previously published paper, I explained

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[77] *See* JAMES POOLEY & DANIEL P. WESTMAN, TRADE SECRETS (1997); *see also* John C. Stedman, *Trade Secrets*, 23 OHIO ST. L.J. 4, 9 (1962) (providing the rationale behind protecting information as a trade secret).

[78] As the Legend goes, Sisyphus was the son of King Aeolus of Thessaly and Enarete, and the founder and first king of Ephyra (supposedly the original name of Corinth). King Sisyphus was an avaricious and deceitful king. As a punishment for his trickery, the gods forced King Sisyphus to roll a huge boulder up a steep hill. Before he could reach the top, however, the massive stone would always roll back down, forcing him to begin again which ended up consigning Sisyphus to an eternity of useless efforts and unending frustration. Thus, pointless or interminable activities are sometimes described as "Sisyphean." In experiments that test how workers respond when the meaning of their task is diminished, the test condition is referred to as the Sisyphusian condition. The two main conclusions of the experiment are that people work harder when their work seems more meaningful and that people underestimate the relationship between meaning and motivation. *See generally* ALBERT CAMUS, THE MYTH OF SISYPHUS, AND OTHER ESSAYS (1955). *But c.f. id.* at 119–120 (elevating Sisyphus to the status of absurd hero).

[79] What is more, by not protecting negative information under trade secrecy laws, employees would be at liberty to share all research failures they have encountered. Khoury, *supra* note 70, at 454.

[80] *Id.*

[81] Steven Johnson, *Where Good Ideas Come from*, TED TALKS (July 2010), https://www.ted.com/talks/steven_johnson_where_good_ideas_come_from; *see*

why, despite the basic inclination to the contrary, trade secrecy protections should not extend to data pertaining to failures of research.[82] This proposed model would best facilitate innovation and fruitful research as well as effective entrepreneurship. Further, I have also provided a workable business model that generates income from such negative information, thus reducing losses for the seller and allowing the buyer to evade similar failures.[83]

Trade secrets complement patent protection and provide and an additional tool to businesses.[84] Trade secrecy is a cheap and accessible alternative to protecting a business, thus allowing that business to focus on research and development.[85] Trade secrecy laws also foster trust and loyalty within the business because employees are bound to keep said information discreet and not to disclose it at will.[86] Further, trade secrecy laws allow the workforce (within a business or research entity) to work in-sync without having to contentiously request clearance to share information amongst

also THOMAS S. KUHN, THE STRUCTURE OF SCIENTIFIC REVOLUTIONS (1962) (arguing for the need for a lively discourse and interaction). Kuhn opened the study of science to new disciplines. *Id.* He contended that the evolution of science was in part sociologically determined and that it did not operate under the simple logical laws put forward by the logical positivist school of philosophy. *Id.* Significantly, Kuhn described the development of scientific knowledge not as a linear increase in truth and understanding, but as a series of periodic revolutions which overturned the old scientific order and replaced it with new orders (what he called "paradigms"). *Id.* Kuhn attributed much of this process to the interactions and strategies of the human participants in science rather than its own innate logical structure. *Id.* While I find it hard to accept Kuhn's view in its entirety, I do find myself agreeing with the premise that cooperation among scientists can propel research forward at a greater pace. Sharing failure, in my view, is the most significant embodiment of this cooperation.

[82] Khoury, *supra* note 70, at 445.

[83] *Id*. at 465–75.

[84] Elisabetta Ottoz & Franco Cugno, *Patent-Secret Mix in Complex Product Firms*, 10 AM. L. & ECON. REV. 142, 145 (2008).

[85] *Id*.

[86] Marjorie Chan, *Corporate Espionage and Workplace Trust/Distrust*, 42 J. Bus. Ethics 45, 45–48 (2003*); see* David R. Hannah, *Should I Keep a Secret? The Effects of Trade Secret Protection Procedures on Employees' Obligations to Protect Trade Secrets*, 16 ORG. SCI. 71, 77 (2005) (supporting the concept that sharing trade secrets helps to foster relationships).

themselves.[87] Trade secrets are recognized internationally as a form of intellectual property and most clearly in the TRIPS agreement.[88] As a direct result of TRIPS, they have also been adopted into the laws of many countries.[89]

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[87] For more on the conducive nature of trade secrets in the employer and employee construct, see generally Peter JG Toren, *The Prosecution of Trade Secrets Thefts Under Federal Law*, 22 PEPP. L. REV. 59 (1994).

[88] *See* TRIPS, *supra* note 64, art. 39 ("Natural and legal persons shall have the possibility of preventing information lawfully within their control from being disclosed to, acquired by, or used by others without their consent in a manner contrary to honest commercial practices so long as such information: (a) is secret in the sense that it is not, as a body or in the precise configuration and assembly of its components, generally known among or readily accessible to persons within the circles that normally deal with the kind of information in question; (b) has commercial value because it is secret; and (c) has been subject to reasonable steps under the circumstances, by the person lawfully in control of the information, to keep it secret.").

[89] *See* HOGAN LOVELLS INT'L LLP, REPORT ON TRADE SECRETS FOR THE EUROPEAN COMMISSION (Sept. 23, 2011), http://ec.europa.eu/internal_market/iprenforcement/docs/trade-secrets/120113_study_en.pdf (providing a comprehensive study of the trade secrets laws across the European Union); Security of Information Act, R.S.C. 1985, c. O-5 (Can.); HANPO WANG, DEVELOPMENT OF LAW ON TRADE SECRET PROTECTION IN CHINA, http://www.us-china-cerc.org/pdfs/Development_of_Law_on_Trade_Secret_Protection_in_China_WANG_HANPO.pdf; Decreto No. 9.279, de May 14, 1996, D.O.U. (Braz.); RESTATEMENT (FIRST) OF TORTS § 757 cmt. b (Am. Law Inst. 1939) (defining trade secrecy in United States as something that "may consist of any formula, pattern, device, or compilation of information which is used in one's business, and which gives him an opportunity to obtain an advantage over competitors who do not know or use it . . . [A] substantial element of secrecy must exist, so that, except by the use of improper means, there would be difficulty in acquiring the information."). As of July 1994, forty states had adopted the Uniform Trade Secrets Act (Drafted by the National Conference of Commissioners on Uniform State Laws, as amended 1985). KEITH E. MASKUS, INTELLECTUAL PROPERTY RIGHTS IN THE GLOBAL ECONOMY 50 (2000). Maskus refers to three basic differences between trade secrets and patents: "(1) An inventor might judge his creation to be unpatentable in legal terms but hard to imitate. (2) A firm could prefer not to disclose its process, as a patent requires, because disclosure could reduce expected profits. (3) A firm might wish to avoid the costs of patent filing." *Id.* For a discussion on the relationship between patents and trade secrets, see generally Jeanne C. Fromer, *Trade Secrecy in Willy Wonka's Chocolate Factory*, *in* THE LAW AND THEORY OF TRADE SECRECY: A HANDBOOK OF CONTEMPORARY RESEARCH (2011).

There are three primary justifications for a business to choose trade secrecy protection over traditional patent protection. The first (and most obvious) reason pertains to the cost-effective nature of trade secrets as compared to patents. Indeed, while obtaining a patent is contingent on a time-consuming and expensive registration process,[90] trade secrets require no registration and no public notice. Moreover, in some cases, the innovation might be relatively minor, not justifying the investment in patent registration. Second, trade secrets and patents only partially overlap in their potential coverage.[91] Thus, patent law does not directly apply to some assets of a business, such as customer lists, research plans, business plans, etc. Here, only trade secrecy law can provide protection for these bundles of information. The third reason why trade secrets might be preferred is the duration of protection. Patent validity is relatively short (generally 20 years from the date of filing the application);[92] conversely, trade secrets can be protected until they are either discovered through reverse engineering or through other legitimate means that constitute legally recognized defenses.[93]

Interestingly, an additional indirect cost of patenting (which might lead businesses to opt for trade secrecy protection) is the disclosure of information to competitors.[94] Patent applications require broad disclosure and description of the invention's "best

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[90] Gene Quinn, *The Cost of Obtaining a Patent in the US*, IPWATCHDOG (Apr. 4, 2015), http://www.ipwatchdog.com/2015/04/04/the-cost-of-obtaining-a-patent-in-the-us/id=56485/.

[91] For more on the complex relationship between patent and trade secrets, see generally Elisabetta Ottoz & Franco Cugno, *Choosing the Scope of Trade Secret Law When Secrets Complement Patents*, 31 INT'L REV. L. & ECON. 219, 223 (2011).

[92] According to TRIPS, *supra* note 64, art. 33, "[t]he term of protection available shall not end before the expiration of a period of twenty years counted from the filing date.".

[93] *See* David D. Friedman et. al., *Some Economics of Trade Secret Law*, 5 J. ECON. PERSPECTIVES 61, 62 (1991) (discussing and explaining the reasons as to why in some cases business entities might opt for trade secrecy protection rather than patent protection).

[94] Andrew Beckerman-Rodau, *The Choice Between Patent Protection and Trade Secret Protection: A Legal and Business Decision*, 84 J. PAT. & TRADEMARK OFF. SOC'Y 371, 375 (2002).

mode."[95] But given that a patent might not be sufficient to protect a patentee's invention and to prevent competitors from finding alternatives, it is often logical for inventors to avoid patent protection altogether.[96] This problem is compounded by the fact that patent registration is limited to a single country's jurisdiction and must be registered across borders in order to ensure protection elsewhere.[97] Therein lies a problem, for while patent applications in the US are kept confidential until the patent is awarded, the registration process in other countries (e.g., Japan and Europe) and even the process through the Patent Cooperation Treaty necessitates publication within a specified period (generally 18 months).[98] Thus, firms and innovators are often reluctant to pursue patent applications because if the patent application is ultimately rejected outside the United States, they are precluded from relying on trade secrecy protection due to their previous disclosures in the patent application.[99]

From a single business's perspective, employing trade secret protections seems to be a logical and rational choice. However, if an increasing number of firms opt for trade secrecy to evade disclosure, information disclosed in the public domain will decrease.[100] In fact, the restrictive consequences of trade secrecy have already been realized. Given the benefits associated with holding trade secrets,

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[95] Dan L. Burk, *Misappropriation of Trade Secrets in Biotechnology Licensing*, 4 ALB. L.J. SCI. & TECH. 121, 127 (1994).

[96] *Id.*

[97] Amir H. Khoury, *The End of the National Patent Office* 52 INTELL. PROP. L. REV. 197, 208 (2012).

[98] *How to Apply for a European Patent*, EUROPEAN PATENT OFFICE, http://www.epo.org/applying/basics.html (last visited November 13th, 2017).

[99] In this regard, see Paterson v. Chem. Eng'g, No. 82–10–1709, Mich. Cir. Ct., Cnty of Lewanee (1983), *aff'd*, 423 Mich. 859 (1985), *cert. denied*, 479 U.S. 828, 107 S.Ct. 109 (1986).

[100] Amir H. Khoury, *The Case Against the Protection of Negative Trade Secrets: Sisyphus' Entrepreneurship*, 54 IDEA: INTELL. PROP. L. REV. 431, 442–52 (2014). After all, the patent process also allows for reading and learning from registered patents. It appears that the probability that a firm will patent an invention has diminished due to the cost associated with said protection. *Id.* at 439.

their significance seems to be on the rise.[101] This choice has a scientific price that cannot be overlooked.[102] Trade secrets operate to create an invisible yet powerful legal shield for businesses, some of which exert significant control over the economy.[103] As such, trade secrets affect the economy on both microeconomic and macroeconomic levels.[104] Moreover, trade secrets are not only valued for protecting information but are also invoked for maintaining the lead in business competition and research.[105] With that said, trade secrets, as Maskus describes them, are "dichotomous."[106] That is, "There is full liability when the attempt

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[101] *See* David S. Almeling, *Seven Reasons Why Trade Secrets Are Increasingly Important*, 27 BERKELEY TECH. L.J. 1091 (2012).

[102] *See* Josh Lerner, 150 Years of Patent Office Practice (Nov. 1999) (unpublished manuscript), http://ssrn.com/abstract=196648. Lerner's empirical study concludes that the prevalence of patent based legal action (civil litigation) is just a little larger in propensity to trade secrecy based legal action (up to 43% of intellectual property cases in these cases were based on trade secrecy protection). Lerner's study is quite convincing in that it encompassed both large and small firms and focused on 530 firms in all based in one location in the US (Middlesex County, Massachusetts) over a four-year period. His study also showed that smaller firms are more inclined to opt for trade secrecy protection than patent protection because of the direct and indirect costs of patenting discussed above. *Id.*

[103] *Id.*

[104] The extent of the importance of trade secrets as an economic asset of strategic importance is evident in a recent White House report, produced to enhance the protection for US trade secrets. *See* EXEC. OFFICE OF THE PRESIDENT, ADMINISTRATION STRATEGY ON MITIGATING THE THEFT OF U.S. TRADE SECRETS (Feb. 2013). Indeed, over the past two decades governmental agencies have been devoting greater administrative resources to the prevention of trade secret theft. In the United States and other Western nations, intelligence agencies appear to be directly involved in thwarting trade secret spying by foreign industrial concerns even in "allied states." OFFICE OF THE NAT'L COUNTERINTELLIGENCE EXEC., FOREIGN SPIES STEALING US ECONOMIC SECRETS IN CYBERSPACE (Nov. 2011). In fact, this issue has been a source of tension between the US and some of its closest allies such as Germany and France. Claus Hecking, *Snooping Fears: German Firms Race to Shield Secrets*, SPIEGEL ONLINE (July 23, 2013 6:04 PM), http://www.spiegel.de/international/germany/german-firms-fear-industrial-espionage-after-snowden-leaks-a-912624.html.

[105] Jennifer Brant & Sebastian Lohse, *Trade Secrets: Tools for Innovation and Collaboration* (Int'l Chamber of Com. Innovation and IP Res. Paper No. 3, 2014), https://ssrn.com/abstract=2501262 or http://dx.doi.org/10.2139/ssrn.2501262.

[106] Maskus, *supra* note 89, at 50.

to learn a propriety process is illegal but no liability when the attempt is legal."[107] In Maskus' view, this could provide an incentive for learning which could then "stimulate greater dynamic competition."[108] Maskus' view reinforces the broader rationale as to why negative information (i.e., failure) should not be protected by trade secret laws.[109] Thus, the challenge in trade secrecy laws is not with regard to their conceptual legitimacy but instead in defining what the laws cover, or more importantly what they exempt.[110] In principle, trade secret laws are generally a tool for empowerment: they provide a cost-free legal protection for information as it is created or collected by its holder. But what happens when information that is protected by trade secrets law becomes a tool not only for competition but also for stagnation? In such a state of affairs, should the law of trade secrets be applied indiscriminately? No, trade secret protections should not apply when the aggregate social benefit is in favor of exposing the information hidden within a trade secret.[111]

In the context of a Mars mission, assume that company X, while engaged in R&D, makes mistake A. Now assume that corporation N pursues the same avenue of research, also making mistake A. Similarly, corporation N next makes mistake B. Company X then also comes to the same mistake B. The result is that these two entities have (collectively) made 2A and 2B mistakes. Given this situation, it makes sense for these two entities (N and X) to share the details of their failures. Through such collaboration, they could avoid mimicking existing mistakes, thus reducing the number of mistakes by half: from (2A+2B) to only (A+B). The benefits of

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[107] *Id.*

[108] *Id.*

[109] *Id.*

[110] *Id.* ("The task for policy makers . . . is to define the boundaries of legal attempts to learn a rival firm's trade secrets.").

[111] Economic analysis of trade secrecy law and a significant portion of legal discourse in this field has remained in large part confined to the traditional interests of trade secrets owners to protect their property from competitors in order to gain (and preserve) their competitive advantage. *See generally, e.g.*, Stefan Bechtold & Felix Hoffler, *An Economic Analysis of Trade-Secret Protection in Buyer-Seller Relationships*, 27 J.L. ECON. & ORG. 137, 144 (2011) (alluding to this fact and discussing the buyer-seller relationship in the field).

avoiding mistakes when developing such crucial technologies as rocket boosters, landing mechanisms, or even methods for harvesting oxygen from chemicals within the soil on the surface of Mars are certainly substantial.

Intellectual property laws seem to promote exclusivity over inclusivity.[112] The laws of intellectual property—including trade secrets, real property, privacy, and misappropriation—are prime examples of this focus.[113] Indeed, it could be said that human expertise is geared more towards building and guarding fences and gates than towards building bridges and sharing knowledge.[114] Thus, today's world values exclusivity over inclusivity, which in turn dictates the discourse and even our perceptions of the correct IP legal construct.[115] This viewpoint is problematic at best, and its

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[112] *See* Annette Kur & Jens Schovsbo, Expropriation or Fair Game for All? The Gradual Dismantling of the IP Exclusivity Paradigm (Max Planck Inst. for Intell. Prop., Competition & Tax L., Research Paper No. 09–14., 2009), https://ssrn.com/abstract=1508330 or http://dx.doi.org/10.2139/ssrn.1508330; *see also* Hanns Ullrich, *Intellectual Property: Exclusive Rights for a Purpose – The Case of Technology Protection by Patents and Copyright* (Max Planck Inst. for Intell. Prop., Competition & Tax L., Research Paper No. 13–01, 2012), https://ssrn.com/abstract=2179511; *in* WASNIOWSKA KLAFKOWSKA, PROBLEMS OF POLISH AND EUROPEAN PRIVATE LAW 425 (2012).

[113] One interesting example involves the contradiction of conduct on social media, especially Facebook. While people using this service readily share many of their activities, social lives, thoughts, etc., they are much less open to sharing their purchasing patterns with their friends. That was especially evident in users' antagonism towards Facebook using the Beacon application, which allowed other users to be informed of their friends' purchasing activities on the Internet (e.g. reporting that a person bought a movie ticket). *See* Chris Jay Hoofnagle & Jennifer King, Consumer Information Sharing: Where the Sun Still Don't Shine 2 (Dec. 17, 2007) (unpublished manuscript), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1137990. Hoofnagle and King discuss this issue and report on how an activism website initiated a protest about this reporting without prior consent of the user, which prompted Facebook to change its policy. This is indicative of how intensely Facebook users reject "sharing" information (without their prior consent) about their commercial activities online. *Id.*

[114] Obviously, analyzing the reasons for this state of affairs requires a much more in-depth look at the human condition, and as such is beyond the scope of this research.

[115] Maskus, *supra* note 89, at 2. Maskus discussed this view as to the need to preserve the competitive edge of firms even in the context of research data by allowing for a period of exclusivity like the five-year period in NAFTA. *Id.*

resulting obstacles are most evident in the context of the human endeavor to reach and settle on Mars.

Despite the potential wealth of research data harnessed by firms that could benefit research, innovation, education, and society at large, the "sharing conundrum" still inhibits dissemination of this data.[116] One plausible explanation comes from the underlying prisoner type dilemma that discourages firms from sharing information that they deem to be trade secrets. Again, consider two firms, X and N, which both aim to land on Mars. X and N respectively hold information Q and K. Ideally, both firms should aim to share their respective information to reduce the other's—and their own—time spent on futile or unnecessary research. But given the ability of each company to opt for trade secrecy protection, X and N will rationally choose to withhold that information for fear that they would disclose valuable knowledge and gain nothing in return. Because of this risk, divulging information becomes the less attractive option. The following table demonstrates this common scenario:

		Company N	
		SHARE	**NOT SHARE**
Company X	**SHARE**	WIN, WIN	(X)LOSE, (N)WIN
	NOT SHARE	(X)WIN, (N)LOSE	LOSE, LOSE

It is clear that if both X and N had communicated their optimal interests, engaged in bilateral sharing, and ensured their

Maskus states that "[f]ailing to provide such a period of exclusivity could absolve second comers of the costs of undertaking clinical trials, providing them with a competitive edge." *Id.* at 23. While in principle, I agree with the view in the context of information pertaining to a successful product, this cannot and should not apply to data information about a failed product or testing.

[116] *See* Christine L. Borgman, *The Conundrum of Sharing Research Data*, 63 J. AM. SOC'Y INFO. SCI. & TECH. 1059, 1064 (2012).

commitment to the same, both would ultimately opt to cooperate. However, given their inherent lack of knowledge as to how the other market player will opt to play, they are both likely to (logically) assume withholding of secret information by their counterpart. This scenario would permit the other company to reap benefits from their information while they gain nothing in return. This risk will lead both parties to a lose-lose outcome. This failure can only be mitigated by an external intervention through rules or incentives that shift the two players to the optimal (share-share) win-win outcome. It is worth noting that Verhoeff has suggested a similar use for game theory in the interactions between traders.[117] After all, both traders and researchers are prisoners in their own lack of information about how their competitors will conduct themselves, and about what their competitors have to offer them in return.[118] Kingston sees information as befitting Hardin's 'tragedy of the commons' approach.[119] Kingston explains that "information has all the characteristics of a commons, because there is no limit to the number of people to whom it can spread, who can have access to it, and whose knowledge it can change."[120] He then goes on to ask a question: "Why should anyone undertake the difficult and risky task of generating [information] if others, who have contributed nothing to this process, can then use it freely?"[121] From the outset, common sense dictates that not all information held by a business should be exposed. However, withholding certain types of information might

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117 Tom Verhoeff, The Trader's Dilemma: A Continuous Version of the Prisoner's Dilemma (May, 1992) (unpublished manuscript), http://www.win.tue.nl/~wstomv/publications/td.pdf.

118 *Id.*

119 *See* WILLIAM KINGSTON, BEYOND INTELLECTUAL PROPERTY: MATCHING INFORMATION PROTECTION TO INNOVATION 10 (2010); Garrett Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243, 1244 (1968). Hardin's discusses a situation where public land used for grazing of cattle is abused by a number of herdsmen each of whom was trying to maximize use of the land in order to produce more milk form his herd. As a result, the pasture is ultimately destroyed. Hardin at 1244. Thus, Hardin concludes that "[f]reedom in a commons brings ruin to all." *Id.*

120 KINGSTON, *supra* note 119, at 135.

121 *Id.*

be detrimental to economic growth, health, and competition.[122] Thus, not all information should be protected as a trade secret. Ultimately, one must reach the conclusion that protection for trade secrets should not be absolute.[123] Specifically, and in the context of information, there have been some cases in which governments have stepped in to take control of "trade secrets" where other social interests dictated such a need (e.g., flavoring additives in cigarettes).[124] Indeed, privately held information need not always remain in the private domain, and in some cases, public interest

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[122] Edwin C. Hettinger, *Justifying Intellectual Property*, 18 PHIL. & PUB. AFF. 31, 50 (1989). Hettinger asserts that:

> Trade secrets as well can stifle competition, rather than encourage it. If a company can rely on a secret advantage over a competitor, it has no need to develop new technologies to stay ahead. Greater disclosure of certain trade secrets—such as costs and profits of particular product lines—would actually increase competition, rather than decrease it, since with this knowledge firms would then concentrate on one another's most profitable products. Furthermore, as one critic notes, trade secret laws often prevent a former employee from doing work in just that field for which his training and experience have best prepared him. Indeed, the mobility of engineers and scientists is often severely limited by the reluctance of new firms to hire them for fear of exposing them-selves to a lawsuit. Since the movement of skilled workers between companies is a vital mechanism in the growth and spread of technology, in this important respect trade secrets actually slow the dissemination and use of innovative techniques.

Id. (citations and internal quotation omitted).

[123] In this regard, it is not much different from other relative protections granted to IP subject matter, such as when tools of eminent domain and compulsory licensing are employed. For more on the debate relating to the connection between both of these terms, see Daya Shanker, Korea, the Pharmaceutical Industry and Non-commercial use of Compulsory Licenses in TRIPS, (Sep. 15, 2003) (unpublished manuscript), https://ssrn.com/abstract=438880.

[124] *See* Richard A. Epstein, *Trade-Secrets as Private Property: Their Constitutional Protection* (John M. Olin Program in L. & Econ., Working Paper No. 190, 18–22 2003). Epstein discusses how the constitutional implications for disclosure of trade secrets requirements for pesticides governed by federal environmental statutes that was accepted in *Ruckelshaus v. Monsanto Co.*, 467 U.S. 986 (1984), should allow for forced disclosure of trade-secrets about flavoring additives in cigarettes that was correctly struck down *Philip Morris, Inc. v. Reilly*, 312 F.3d 24 (1st Cir. 2002).

dictates that it should be exposed and shared by all.[125] This position is not detached from conventional intellectual property legal thinking; the idea of sharing in intellectual property and trade is not new. Sharing exists in IP in various contexts.[126] Moreover, others have suggested a policy of sharing in the context of seeds and plant varieties.[127] This sharing theme also appears in regard to the human genome.[128] All of these areas of study share an important common thread: they are all imperative for human innovation, and must not be tucked away in the private domain lest they themselves become

[125] David S. Levine, *Secrecy and Unaccountability: Trade Secrets in Our Public Infrastructure*, 59 FL. L. REV. 135, 150–54 (2007).

[126] Such as in the context of copyright by sharing of mathematical formulas in innovation, and sharing of generic names in brands. On the exclusion of ideas from copyright protection, see JANE C. GINSBURG, *Overview of Copyright Law*, *in* OXFORD HANDBOOK OF INTELL. PROP. (Rochelle Dreyfus & Justine Pila, eds.) (forthcoming 2016); Michael Murray, *Copyright, Originality, and the End of the Scènes à Faire and Merger Doctrines for Visual Works*, 58 BAYLOR L. REV. 779, 785 (2006); *see also* Andrew Beckerman-Rodau, *Are Ideas Within the Traditional Definition of Property: A Jurisprudential Analysis*, 47 ARK. L. REV. 603, 615 (1994). On the exclusion of generic names from trade mark protection, see John F. Coverdale, *Trademarks and Generic Words: An Effect-on-Competition Test*, 51 U. CHI. L. REV. 868, 873 (1984).

[127] *See* Krishna Ravi Srinivas, *Intellectual Property Rights and Bio Commons: Open Source and Beyond*, 58 INT'L SOC. SCI. J. 319, 326 (2006). Srinivas advocates for the use of an open source model as an alternate intellectual property rights regime for seeds and plant varieties, which he refers to as "the BioLinux." As a justification for his approach, Srinivas traces the evolution of intellectual property rights and examines the current situation in the context of TRIPS and controversies over patents on genetically modified plants. He examines the "freedom to operate" and anti-commons in germplasm and the importance of freedom to operate for plant breeding in public interest, introducing the idea of open source and use of open source licenses. In his view, the open source can provide workable models in non-software contexts, and participatory plant breeding and innovation by farmers can be combined with an open source approach to develop relevant plant varieties, to conserve germplasm and to propagate. *Id.*

[128] Donna M. Gitter, *International Conflicts over Patenting Human DNA Sequences in the United States and the European Union: An Argument for Compulsory Licensing and a Fair-Use Exemption*, 76 N.Y.U. L. REV. 1623 (2001); Kyle Jensen & Fiona Murray, *Intellectual Property Landscape of the Human Genome*, 310 SCI. 239, 239–40 (2005); Heidi L. Williams, *Intellectual Property Rights and Innovation: Evidence from the Human Genome,* 121 J. POL. ECON. 1, 24 (1992).

a hurdle to creativity, innovation, competition, or science. Crucially, these ideas are also found in the two substantial principles and objectives that underlie the TRIPS agreement.[129] And as it is with these things, so it is with "negative" information. In my view, negative information needs to be shared. By maintaining common access to such information, researchers could evade recurring mistakes and would be saved from replicating dead ends. Such a sharing model is imperative for the success of a future Mars mission.

Now that the principle has been established—that protection is not an absolute but rather a relative issue—my contention is that, much like harmful information that needs to be exposed publicly, "failure," or dead ends, in certain avenues of research cannot and should not find refuge in the dark vaults of trade secrets. Instead, this information should be allowed to freely flow into the public awareness and into the eyes and ears of competitors in the field and beyond it. It is, after all, part of the trial and error that is integral to science and discovery.[130] Importantly, error should not necessarily be a personal experience but rather be a collective experience, committed by one but shared by all. As such, even though a myopic business intuition seeks to preserve information and to prevent the information entering the public domain, when considered from a

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[129] TRIPS, *supra* note 64, art. 7 ("The protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations."); *see also id*. art. 8 ("1. Members may, in formulating or amending their laws and regulations, adopt measures necessary to protect public health and nutrition, and to promote the public interest in sectors of vital importance to their socio-economic and technological development, provided that such measures are consistent with the provisions of this Agreement. 2. Appropriate measures, provided that they are consistent with the provisions of this Agreement, may be needed to prevent the abuse of intellectual property rights by right holders or the resort to practices which unreasonably restrain trade or adversely affect the international transfer of technology.").

[130] TIM HARTFORD, ADAPT: WHY SUCCESS ALWAYS STARTS WITH FAILURE (2011) (citing compelling examples of innovation by trial-and-error); *see also* Sarah Rapp, *Why Success Always Starts with Failure*, 99U, http://99u.com/articles/7072/why-success-always-starts-with-failure (last visited Oct. 26, 2017).

broader macroeconomic position, it seems that this simplistic approach is inappropriate—even downright dangerous—for human progress. This is of special relevance when it comes to a task that is not contingent on individual talents of one person or corporation. Trade secrets are not strictly about exclusion, but more specifically about exclusion of certain bits of information.[131] Trade secrets are not about creating great hubs of secret information. Lemley aptly refers to such entities as "trade secret trolls."[132] Information in general, and especially "negative" information, should be viewed as part of what I would refer to as natural commons. I do not think that such information differs from the way that the law relates to ideas in copyright law, mathematical formulas in patent law, generic words in trademark law, or acquired knowledge in trade secrecy law. In fact, these elements are not protected by the respective laws, given that they are viewed as assets that need to remain in the public domain lest the property therein hamper the advancement of science and art. While some might see these as being part of the immediate domain of the specific research entity or group, I opt for the collective approach, looking at the research project as part of an ongoing collective human chain towards progress. Indeed, what might at a given point in time be the subject of property as well as fame and fortune will ultimately blend into a single whole which propels us forward as a species. Here too, we think in the context of property and market control, but decades later that same technology blends into the collective science hub of humanity at large, the public domain. Who today cares, in the legal property sense of the term, about who owns penicillin, dynamite, or electricity? While we hold great respect and admiration for the work of those inventors, their work-product is not theirs in the classic property sense, but

[131] For a discussion pertaining to the status of trade secrets in general IP framework, see Jonathan Stroud, *The Tragedy of the Commons: A Hybrid Approach to Trade Secret Legal Theory*, 12 CHI.-KENT J. INTELL. PROP. 232 (2013).

[132] For a discussion on which type of information needs to be protected as a trade secret, see Mark A. Lemley, *The Surprising Virtues of Treating Trade Secrets as IP Rights*, 61 STAN. L. REV. 311, 315 (2008). In Lemley's view, grating trade secrecy protection to things that are public, defeats the purpose of this field and give windfalls to people who may not be inventors, referring to them as a sort of "trade secret trolls." *Id.*

rather it is ours as a collective. And so it is with negative information. While it is tactically an important tool for a business that holds it, it is, strategically speaking, an asset that should be placed in the commons. Thus, in a more defined manner, my view as to the need to exclude negative information from trade secret protection is part of a larger project pertaining to the nature of intellectual property. My belief is that intellectual property—especially patents, copyrights, and trade secrets—are of a dual nature. While in the immediate sense they are about the private domain and property rights, they are ultimately about improving the collective human condition. Hence, the immediate interests of property and asset control must not cause us to lose sight of the ultimate goal of the entire IP purpose: human progress at large.[133] This is a pressing issue when it comes to space exploration and a future Mars mission. Make no mistake—the issue is complex and the dangers and risks so grave that we cannot afford to apply an exclusive IP system but rather, we must create an environment for an inclusive IP structure including trade secrets as discussed above. As alluded to earlier, this can be attained by voluntary disclosure of failure, by excluding legal protection for negative information type secrets, or by creating a market where failure and dead ends are shared for a price that serves to both reduce losses and to provide information that would save others from reaching the same mistakes.[134]

C. *The Social Element: The Value of Peer-to-Peer Communication*

As mentioned above, social isolation poses a great risk for those traveling to and living on Mars for extended periods of time, or indefinitely. Indeed, potential travelers to Mars would need to be

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[133] For a discussion of the social welfare side of intellectual property, see MICHAEL PERELMAN, STEAL THIS IDEA: INTELLECTUAL PROPERTY RIGHTS AND THE CORPORATE CONFISCATION OF CREATIVITY (2002); *see also* Amy Kapczynski, *The Access to Knowledge Mobilization and the New Politics of Intellectual Property*, 117 YALE L.J. 804, 808 (2008).

[134] I have discussed these potential models in a previous work on this subject. *See* Amir H. Khoury, *The Case Against the Protection of Negative Trade Secrets: Sisyphus' Entrepreneurship*, 54 IDEA: INTELL. PROP. L. REV. 431, 465–76 (2014).

tested not only for their physical abilities but also for their mental health. Scientists have examined the psychological impact of space travel.[135] For example, the Biosphere-2 experiments isolated a small group of eight people in the 1990's for two years at a time.[136] Reportedly, crewmembers in Biosphere-2 all agreed that the psychological issues were amongst the largest challenges that they faced.[137] The longest simulation in terms of duration to date has been the "Mars 500" in which a group of six people were confined together under observation in a sealed room for 500 days.[138] At the end of the experiment, the participants were lethargic and bored, and one was suffering from depression.[139] Only two of the six participants reported no significant problems and only one of the six participants maintained a busy and active life with no deterioration of cognitive performance.[140] Socialization is clearly of crucial importance.[141]

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[135] *See* Mathias Basner et al., *Psychological and Behavioral Changes During Confinement in a 520-day Simulated Interplanetary Mission to Mars*, 3 PLOS ONE 9, (2014); *see also* Dietrich Manzey, *Human Missions to Mars: New Psychological Challenges and Research Issues,* 55 ACTA ASTRONAUTICA 781 (2004).

[136] For more on the Biosphere Project, see Peder Anker et al., *Biosphere 2: Why an Eccentric Ecological Experiment Still Matters 25 Years Later*, EDGE EFFECTS (Dec. 15, 2016), http://edgeeffects.net/biosphere-2/; Anna Nowogrodzki, *How Living Inside Biosphere 2 Changed These Scientists' Lives*, MENTAL FLOSS (Aug. 11, 2016), http://mentalfloss.com/article/81553/how-living-inside-biosphere-2-changed-these-scientists-lives; Jordan Fisher Smith, *Life Under the Bubble*, DISCOVER MAGAZINE (Dec. 20, 2010), http://discovermagazine.com/2010/oct/20-life-under-the-bubble.

[137] *See* sources cited *supra* note 136.

[138] For an expansive discussion on the social effects of the Mars 500 experiment, see Carole Tafforin, *Time Effects, Cultural Influences, and Individual Differences in Crew Behavior During the Mars-500 Experiment*, 84 AVIATION, SPACE, AND ENVTL. MED. 1082, 1085 (2013); Carole Tafforin. The Mars-500 Crew in Daily Life Activities: An Ethological Study, 91 ACTA ASTRONAUTICA 69, 77 (2013); Igor Borisovich Ushakov et al., *Main Findings of Psychophysiological Studies in the Mars 500 Experiment*, 84 HERALD RUSS. ACAD. SCI. 106, 111 (2014).

[139] *See* sources cited *supra* note 138.

[140] *Id.*

[141] *Id.*

Given that human socialization today is done predominantly via virtual tools, peer-to-peer communication could drastically alleviate the sense of seclusion and isolation, thereby boosting morale and maintaining psychological health and well-being.[142] Peer-to-peer tools, which originated to circumvent Napster-like platforms, have now become an invaluable tool for people to communicate, reaching through time and space.[143] Peer-to-peer is the direct sharing of content between two computer users. It fundamentally changed the way in which we communicate information and connect with one another.[144] In my view, social networks will be a crucial factor in connecting the Mars travelers to their friends and family as well as society at large so as to give a real sense of belonging even across vast distances. This shows how developments in content sharing can benefit society (despite the negative price that it carries vis-à-vis copyright infringement). In fact, throughout history, many crucial developments in technology and innovation first seemed to defy conventional logic as to their legality, morality, and purpose, including peer-to-peer sharing ("P2P"), downloading, and recording of content.[145] As the name suggests, P2P software facilitates the sharing of files between computer users.[146] Using P2P software,

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[142] Mathias Basner et al., *Psychological and Behavioral Changes During Confinement in a 520-day Simulated Interplanetary Mission to Mars*, 3 PLOS ONE 9 (2014); *see also* Dietrich Manzey, *Human Missions to Mars: New Psychological Challenges and Research Issues*, 55 ACTA ASTRONAUTICA 781, 783 (2004); Gabriel G. De la Toree et al., *Future Perspectives on Space psychology: Recommendations on Psychosocial and Neurobehavioural Aspects of Human Spaceflight*, 81 ACTA ASTRONAUTICA 587, 588 (2012).

[143] *Id.*

[144] For more on the P2P system and its implications and impact, see Michael A. Carrier, *Copyright and Innovation: The Untold Story*, 2012 WIS. L. REV. 891, 896 (2012). Carrier explains that the defining characteristic of a P2P network is that the transfer of files is performed directly between users. *Id.* Such a system stands in contrast to the client-server model, in which the data flows from server to client. *Id.* In the client-server model, computer users request information from websites (servers) that is delivered to their computers (clients). *Id.*

[145] For more on the P2P model and its impact on copyright law, see generally Peter J. Alexander, *Peer-to-Peer File Sharing: The Case of the Music Recording Industry*, 20 R. INDUS. ORG. 151 (2002); Lori A. Morea, *The Future of Music in a Digital Age: The Ongoing Conflict Between Copyright Law and Peer-to-Peer Technology*, 28 CAMPBELL L. REV. 195 (2005).

[146] *Id.*

users can more easily share files between themselves.[147] Napster was among the first corporation to apply P2P file sharing.[148] Napster connected its users to multiple servers from which they could obtain files made available by other users.[149] Following the effective shut down of Napster that resulted from *A&M Records, Inc. v. Napster*,[150] new P2P platforms came into play including KaZaA, Grokster, and Streamcast.[151] These platforms were much less centralized than the Napster system, employing a system whereby users download software directly from other users' computers.[152] It is no longer clear if the 'notice and take down' provision will continue to stand the test of time, as evidenced by the recent *Viacom v. YouTube*.[153] The ability to share content (e.g., music, movies) over the internet has shaken the copyright industry—and the copyright owners trying to protect their rights.[154]

However, in hindsight, a flexible (rather than rigid) copyright regime has been conducive to innovation.[155] The courts repeatedly

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[147] *Id.*

[148] *Id.*

[149] *Id.*

[150] 114 F. Supp. 2d 896 (N.D. Cal. 2000).

[151] For a discussion of the P2P evolution, see Niva Elkin-Koren, *Making Technology Visible: Liability of Internet Service Providers for Peer-to-Peer Traffic*, 9 N.Y.U. J. LEGIS. & PUB. POL'Y 15 (2005).

[152] *Id.*

[153] *Viacom Int'l, Inc. v. YouTube, Inc.*, 676 F.3d 19 (2d Cir. 2012) (suing for copyright infringement due to YouTube allowing users to upload and view videos owned by Viacom without permission). For an analysis of the case, see Amir Hassanabadi, *Viacom v. Youtube - All Eyes Blind: The Limits of the DMCA in a Web 2.0 World*, 26 BERKELEY TECH. L.J. 405, 412 (2011); *see also* Peter S. Menell, *Judicial Regulation of Digital Copyright Windfalls: Making Interpretive and Policy Sense of Viacom v. YouTube and UMG Recordings v. Shelter Capital Partners* (U.C. Berkley Pub. L., Research Paper No. 2049445, 2012), http://ssrn.com/abstract=2049445.

[154] Stan J. Liebowitz, Will MP3 Downloads Annihilate the Record Industry? The Evidence So Far (June 2003) (unpublished manuscript), http://ssrn.com/abstract=414162; Pieter Kleve & Feyo Kloff, *MP3: The End of Copyright as We Know It?*, PROC. IASTED INT'L CONF. L. & TECH. 32, 37 (1999).

[155] For more on the idea of leniency in copyright law, see generally Glenn H. Reynolds & Robert P. Merges, *The Proper Scope of the Copyright and Patent Power*, 37 HARV. J. LEG., 45 (2000). *See also* Jane C. Ginsburg, *Essay - How Copyright Got a Bad Name for Itself*, 26 COLUM. J.L. & ARTS 61 (2002).

have been cautious in preventing innovation and have been reluctant to label new innovations as constituting a threat to creativity.[156] Indeed, many do not accept the idea of sharing digital media without immediately labeling the act "infringement."[157] In this context, Raymond Ku "argues against copyright protection for digital works because the economics of digital technology undercut prior assumptions about the efficacy of a private property regime"[158] Ku contends "that the argument for copyright is primarily an argument for protecting content distributors in a world in which 'middlemen' are obsolete."[159] In his view, "[c]opyright is no longer needed to encourage distribution because consumers themselves build and fund the distribution channels for digital content."[160] Furthermore, Ku is highly skeptical of the linkage between the right to reproduce and distribute copies and incentives for creation; his view is that free music and digital technology may, in fact, increase the financial rewards to artists.[161]

D. *The Sustainability Element: Establishing a Viable Existence on Mars Through Prior Art and 3D Printing*

Two more crucial considerations for a sustainable existence on Mars are (1) access to innovation and (2) the ability to create tools and objects necessary for a sustainable colony on that planet. This section will explain how IP regulation on Earth is crucial for establishing such access and production.

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[156] Patrick Gibbs, Video on Remand: A Second Viewing of Viacom's Feud with YouTube and the Case for Casting Off from the Safe Harbor (Feb. 2, 2011) (unpublished manuscript), https://ssrn.com/abstract=1760611.

[157] For more on the idea that copyright liability could be conducive to technology, see Peter S. Menell, *Indirect Copyright Liability and Technological Innovation*, 32 COLUM. J.L. & ARTS 375, 378 (2009); *see also* Kal Raustiala & Christopher J. Sprigman, *The Piracy Paradox: Innovation and Intellectual Property in Fashion Design*, 92 VA. L. REV. 1687, 1694 (2006).

[158] Raymond Shih Ray Ku, *The Creative Destruction of Copyright: Napster and the New Economics of Digital Technology*, 69 U. CHI. L. REV. 263, 263 (2002) (proposing a Digital Recording Act that would fund artists through a statutory levy scheme).

[159] *Id.*

[160] *Id.*

[161] *Id.*

1. *Enhancing Access to Innovation*

Every country has some form of patent law as well as a National Patent Office ("NPO") whose primary role is to register patents within its jurisdiction.[162] Typically, the NPO oversees the prosecution of applications and granting of patents as well as post-registration conflicts and miscellaneous issues such as renewal, abandonment, and cancellation.[163] However, an international patent system would assist in making innovation more accessible and knowledge more coherent.[164] In previously published research, I asserted that the "traditional" or conventional mode of operation in the form of multiple National Patent Offices is no longer compatible with the way in which innovations are being registered, patented,

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[162] For information on patent laws around the world and a list of National Patent Offices, visit the WIPO website at http://www.wipo.int/directory/en/. In addition, some regions have regional industrial property offices which allow for the registration of an intellectual property right covering the entire relevant region. *See, e.g.,* THE GULF COOPERATION COUNCIL PATENT OFFICE, http://www.gccpo.org/ (last visited Oct. 24, 2017); EUROPEAN PATENT OFFICE, https://www.epo.org/ (last visited Oct. 24, 2017); EURASIAN PATENT OFFICE, https://www.eapo.org/ (last visited Oct. 24, 2017).

[163] "Renewal," "abandonment," and "cancellation" are terms that describe various circumstances that can generate the termination of a patent registration. Maintenance fees or renewal fees are fees paid to maintain a granted patent in force. Some patent laws require the payment of maintenance fees for pending patent applications. Not all patent laws require the payment of maintenance fees and different laws provide different regulations concerning not only the amount payable but also the regularity of the payments. In countries where maintenance fees are to be paid annually, they are sometimes called patent annuities. More specifically, NPOs perform the following tasks: (a) Examining applications for patents to determine eligibility for patent protection; (b) Rendering decisions on competing applications (interference proceedings); (c) Rendering decisions on objections (oppositions relating to the patent application); (d) Granting patents if it determines that the applicant is entitled to such a patent; (e) Publishing issued patents or publishing pending patent applications at 18 months from the earliest filing date; (f) Recording assignments and license of patents; and (g) Maintaining a database of issued patents and copies of records, for public use and patent examination. *See* IBM, ROLE OF NATIONAL PATENT OFFICES, THE EUROPEAN PATENT OFFICE, AS WELL AS THE JAPANESE AND US PATENT OFFICES IN PROMOTING THE PATENT SYSTEM 5–21 (2003), http://ec.europa.eu/internal_market/indprop/docs/patent/studies/offices_en.pdf.

[164] *See* Amir H. Khoury, *The End of the National Patent Office*, 52 IDEA 197, 206 (2012).

protected, and enforced around the world. The role of the National Patent Offices has become largely overshadowed by an international patent system comprised of well-defined legal and administrative structures (i.e., TRIPS and PCT) as well as a patent prosecution highway.

The National Patent Office model needs to be changed for the benefit of promoting useful science and innovation around the world and beyond our planet.[165] This section will explain this model's crucial importance for exploring space and establishing human life on Mars and possibly beyond.

The "conventional" patent system, as it exists today, is characterized by a two-tier system: domestic and international.[166] The first is comprised of various national entities, including a national patent office (NPO).[167] The international component of the system comprises various unions and organizations that operate in accordance with a number of conventions, treaties, and agreements.[168] With that in mind, to conclude that the NPO is

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[165] This hypothesis in no way relates to the quality of the work that is done by NPOs.

[166] For a discussion as to how these two systems intertwine, see Peter K. Yu, *The International Enclosure Movement*, 82 Indiana L.J. 827 (2007).

[167] *See, e.g.,* THE UNITED KINGDOM INTELLECTUAL PROPERTY OFFICE, http://www.ipo.gov.uk/types/patent.htm/ (last visited Oct. 28, 2017); INTELLECTUAL PROPERTY INDIA: CONTROLLER OF PATENTS DESIGNS AND TRADEMARKS, http://ipindia.nic.in/ipr/patent/patents.htm/ (last visited Oct. 28, 2017); JAPAN PATENT OFFICE, http://www.jpo.go.jp/ (last visited Oct. 28, 2017); AFRICAN REGIONAL INTELLECTUAL PROPERTY ORGANIZATION (ARIPO), http://www.aripo.org/ (last visited Oct. 28, 2017); IP AUSTRALIA (IPA), https://www.ipaustralia.gov.au/ (last visited Oct. 28, 2017); RUSSIAN FEDERAL SERVICE FOR INTELLECTUAL PROPERTY, PATENTS AND TRADEMARKS (Rospatent), http://www.rupto.ru/ (last visited Oct. 28, 2017); UNITED STATES PATENT AND TRADEMARK OFFICE (USPTO), https://www.uspto.gov/ (last visited Oct. 28, 2017); STATE INTELLECTUAL PROPERTY OFFICE OF THE PEOPLE'S REPUBLIC OF CHINA (SIPO), http://english.sipo.gov.cn/ (last visited Oct. 28, 2017).

[168] *See, e.g.,* Patent Cooperation Treaty, June 19, 1970, 28 U.S.T. 7645; Strasbourg Agreement Concerning the International Patent Classification, Mar. 24, 1971, 26 U.S.T. 1793; Patent Law Treaty, June 1, 2000, S. Treaty Doc. No. 109-12.

dispensable is not necessarily to say that it has failed or that it is a rubber stamp in the hands of other market actors.[169]

It is worth noting that some states have already agreed to effectively surrender some of their patent examination sovereignty to external market actors, such as the European Patent Office ("EPO"), established by the European Patent Convention of 1973.[170] The goal of the EPO has been to harmonize the rules pertaining to the issuance of patents that are valid throughout the European Union.[171] But both the national and regional patent office cannot deliver what an International Patent Office will.

The main benefit of establishing an International Patent Office is that it will allow for a truly international registration of patents. Presently, WIPO administers the Patent Cooperation Treaty (PCT) which is intended to facilitate the registration of patents in member states around the world.[172] PCT enables nationals or residents of any country that is a member to this treaty to seek patent protection in any or all the other countries ("designated states") through a single "International" patent application.[173] The PCT process involves the

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[169] Mark A. Lemley & Bhaven N. Sampat, *Is the Patent Office a Rubber Stamp?*, 58 EMORY L.J. 101, 123–24 (2008). While the overall patent grant rate is held at 70%, the patent office "is not a rubber stamp" because it rejects a "small but nontrivial percentage of applications (15%–20%)." *Id.* The patent office also actively limits the scope of patent claims, rendering them more defined and effectively "weeding out bad patents," and the USPTO appears to be more cautious with respect to those industries that are "most identified with bad patents (computer software, hardware, and business methods)." *Id.* Establishing that the NPO is not a rubber stamp still does not provide sufficient cause for concluding its indispensability. It is logical to challenge the justifications of its existence in the face of changes that are taking place within the international innovation arena. *See* Mark A. Lemley, *Rational Ignorance at the Patent Office*, 95(4) NW. U. L. REV. 1495, 1497 (2001).

[170] For more on the development of the EPO, see generally Jonathan Eaton, Samuel Kortum, & Josh Lerner, *International Patenting and the European Patent Office: A Quantitative Assessment,* PAT., INNOVATION & ECON. PERFORMANCE: OECD CONF. PROC. 27 (2004).

[171] *Id.*

[172] Jay Erstling & Isabelle Boutillon, *The Patent Cooperation Treaty: At the Center of the International Patent System*, 32 WILLIAM MITCHELL L. REV. 1583, 1586 (2006).

[173] Patent Cooperation Treaty art. 4, June 19, 1970, 28 U.S.T. 7645, 1160 U.N.T.S. 231, reprinted in 9 I.L.M. 978 (1970) (according to the PCT today, the

filing of applications with a central receiving office that ultimately forwards them to the NPOs of the "designated" countries.[174] The PCT facilitates the conduct of a *Preliminary Search* and, in some cases, a *Preliminary Examination* of patent applications.[175] Although each national patent office is at liberty to examine the patent application independently, most elect to align themselves with the findings by the ISA and the IEA.[176] In practice, most NPOs apply the novelty condition around the world and in accordance with the standards that the agreement set.[177] Accordingly, the novelty requirement at its essence is of an international nature; each NPO that examines an application is also expected to rule out the existence of the relevant claimed innovation anywhere in the world.[178] This leads to an unnecessary overlap in resources that raises fears of unnecessary costs and the risk of reaching contradicting findings.[179]

In essence, the PCT simplifies the application process relating to the international registration of patents, making it cheaper and more efficient.[180] Furthermore, the PCT system provides the patent owner a longer span of time (up to 30 months) before entering the national phase.[181] This extension allows the owner of a patent more leeway in which to predict the potential patentability and commercial success of the invention and allows the inventor to

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"international" application can be filed with the NIPO (or with a regional patent office)).

[174] WIPO, *PCT Applicant's Guide*, http://www.wipo.int/pct/guide/en/gdvol1/pdf/gdvol1.pdf; *see also* Gene Quinn, *PCT Basics: Understanding the International Filing Process,* IP WATCHDOG (Nov. 3, 2011), http://www.ipwatchdog.com/2011/11/03/pct-basics-understanding-the-international-filing-process/id=19960/.

[175] For more on the mechanics and functioning of the PCT system, see Erstling & Boutillon, *supra* note 172, at 1594.

[176] WIPO, *supra* note 174; *see also* Quinn, *supra* note 174.

[177] *Id.*

[178] *Id.*

[179] *Id.*

[180] *Id.*

[181] *Id.*

withdraw his application before incurring unnecessary costs.[182] Thus, the PCT system simplifies the application process by requiring only one international application for all designated countries, further saving the owner of the mark from having to pay separate application fees in each of the designated countries.[183] The rising rate of PCT applications provides a clear indication of the success of this system.[184] It is not surprising that in the context of the international registration of patents, NPOs have become increasingly marginalized.[185] I would contend that the PCT is set to become the predominant method of filing a patent application.[186]

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[182] Gene Quinn, *PCT Basics: Understanding the International Filing Process,* IP WATCHDOG (Nov. 3, 2011), http://www.ipwatchdog.com/2011/11/03/pct-basics-understanding-the-international-filing-process/id=19960/.

[183] The strength of the PCT is now enhanced by the "Patent Prosecution Highway," wherein patent offices rely on each other's findings during patent examination in order to accelerate examination of corresponding patent applications in the other country. *See* Sandra P. Thompson, Commentary, *The Patent Application Superhighway: Opportunities to Fast-Track Patent Applications*, 6 INDUS. BIOTECH. 22, 22–24 (2010); *see also* Jeremy Phillips, *Outsourcing of IP Office Functions: No Longer a Joke*, 5 J. INTELL. PROP. L. & PRACT. 389, 396 (2010).

[184] Erstling & Boutillon, *supra* note 172, at 1584 ("Between 1995 and 2001, the filing of PCT applications increased by approximately 18% per year. The year 2001 saw the number of applications surpass 100,000, and by 2005, the figure jumped to more than 130,000. All told, more than one million PCT applications have been filed.").

[185] For more on this trend of expanding the use of PCT, see Gerald J. Mossinghoff, *Patent Harmonization Through the United Nations: International Progress or Deadlock*, 86 J. PAT. & TRADEMARK OFF. SOC'Y 5 (2004).

[186] *See* WIPO, THE INTERNATIONAL PATENT SYSTEM YEARLY REVIEW 38 (2008), http://www.wipo.int/export/sites/www/pct/en/activity/pct_2008.pdf (statistical tables). For information on the scope of use of the PCT system, see *Treaties Statistics*, WIPO, http://www.wipo.int/treaties/en/statistics.jsp (last visited Oct. 27, 2017); *see also* Summary of the Strasbourg Agreement Concerning the International Patent Classification (1971), WIPO. http://www.wipo.int/treaties/en/classification/strasbourg/summary_strasbourg.html (last visited Oct. 27, 2017). The Patent Cooperation Treaty established a system for attaining multiple registrations of patents around the world by using WIPO International Bureau. WIPO, *PCT Applicant's Guide*, http://www.wipo.int/pct/guide/en/gdvol1/pdf/gdvol1.pdf; *see also* Gene Quinn, *PCT Basics: Understanding the International Filing Process,* IP WATCHDOG

WIPO statistics show that countries are keen to join the PCT agreement, the same agreement that would form the backbone of my proposed International Patent Office system ("IPO"). Indeed, while the number of member states to the PCT was only 20 in 1978, that number has risen almost exponentially over the past 32 years, now standing at 152.[187] Notably, all major economies and world leaders in innovation are members to the PCT.[188] Furthermore, in 2016, over 233,000 PCT applications were filed.[189] Since 1978, over three million PCT applications have been filed—a staggering amount by any standard.[190] Indeed, it would be safe to assert that the PCT, with an average annual growth rate of over 7 percent, has become the dominant process for cross-border patent registration.[191]

(Nov. 3, 2011), http://www.ipwatchdog.com/2011/11/03/pct-basics-understanding-the-international-filing-process/id=19960/.

[187] *See The PCT Now Has 152 Contracting States*, WIPO, http://www.wipo.int/pct/en/pct_contracting_states.html (last visited Oct. 27, 2017) (updated list of member states). According to data presented by WIPO, over the past 32 years the membership of PCT has been on a continuous rise: 20 (in 1978); 30 (in 1980); 45 (1990); 108 (2000); and 142 (2010). *Id.*

[188] Thus, for example, the PCT membership list includes Australia; Finland; France; Germany; Israel; Italy; Japan; Netherlands; New Zealand; Norway; South Korea; Russian Federation; Spain; Switzerland; Sweden; United Kingdom; and, last but certainly not least, the United States. *Id.*

[189] WIPO*, Record Year for International Patent Applications in 2016; Strong Demand Also for Trademark and Industrial Design Protection* (Mar. 15, 2017), http://www.wipo.int/pressroom/en/articles/2017/article_0002.html.

[190] Catherine Jewell*, WIPO's PCT Publishes 3 Millionth International Patent Application,* WIPO (Feb. 2017), http://www.wipo.int/wipo_magazine/en/2017/01/article_0001.html.

[191] *WIPO Release Figures for 2016 PCT Applications*, CRUICKSHANK http://cruickshank.ie/news-blog/2017/09/04/wipo-release-figures-for-2016-pct-applications (last visited November 12th, 2017) ("2016 has seen huge increases in the number of international patent applications filed under the PCT, with a growth of 7.3%. It is estimated that 233,000 applications were filed last year."). Furthermore, the PCT has become a central arena for patenting, but it has also become the central hub through which the bulk of high-end innovation moves. *See* Vivek Wadhwa et al, *U.S.-Based Global Intellectual Property Creation*, KAUFMAN FOUND., October 2007, at 2. The authors show that "[t]he PCT patent applications filed in the United States arguably represent some of the most sophisticated inventions developed in this country. *Id.* Not only does the perceived need for international intellectual property protection indicate that the inventions are characterized by a higher level of sophistication than those submitted only to

The way in which we protect innovations internationally has a direct, and far-reaching effect, on many issues including competition; access to technology; access to medicines; term of protection; etc.[192] Thus, the proposed IPO model stems from the view that just as innovation is borderless, so too should be (and in fact is) its registration.[193]

Establishing an IPO would further enhance patent consistency by harnessing and accessing knowledge, or prior art. This is of great

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the United States Patent and Trademark Office (USPTO), but also the costly and time-intensive application process for PCT patents suggests that inventions described in these applications largely have market potential in multiple countries, global visibility, or diverse applications." *See id.*

[192] *See* Amir H. Khoury, *Measuring the Immeasurable – The Effects of Trademark Régimes: A Case Study of Arab Countries*, 26 J.L. & COM. 11 (2006–2007); Amir H. Khoury, *The 'Public Health' of the Conventional International Patent Regime & the Ethics of 'Ethicals'*, 26 CARDOZO ARTS & ENT. L.J. 25, 32 (2008); Amir H. Khoury, *A NeoConventional Trademark Regime for "Newcomer" States,* 12 UNIV. PA. J. BUS. L. 351 (2010); Amir H. Khoury, *Differential Patent Terms and the Commercial Capacity of Innovation*, 18 TEX. INTELL. PROP. L.J. 373, 378 (2010).

[193] In fact, all it does is alert to the existence of this change and to the need to reformulate the system in a manner that best reflects it. It is worth noting that the only real hurdle which I see to employing such an international registration system relates to the issue of inventions that could be labeled as secrets. That is to say, patents that would protect inventions that could impact national security. In this context, it is important to emphasize that my proposed IPO does not create a problem for classified, security-oriented innovations. This is because in any patent system other than a nationally secured system, it would be virtually impossible to provide protection for such innovation, because entities that are entrusted with such innovations would be reluctant at best to expose these secrets. However, it is important to realize that these innovations do and will continue to receive preferential treatment within their respective countries. In fact, even today, such innovations are privileged in a manner that allows for superseding regular patent laws. *See* Davida H. Isaacs & Robert Michael Farley, *Privilege-Wise and Patent (and Trade Secret)-Foolish?: How the Courts' Misapplication of the Military and State Secrets Privilege Violates the Constitution and Endangers National Security,* 23 BERKELEY TECH. L.J. 785, 792 (2009). Further, U.S.C. § 1498(a) provides, in relevant part, that "[w]henever an invention described in and covered by a patent of the United States is used or manufactured by or for the United States without license of the owner thereof or lawful right to use or manufacture the same, the owner's remedy shall be by action against the United States in the United States Court of Federal Claims for the recovery of his reasonable and entire compensation for such use and manufacture." 28 U.S.C. § 1498(a).

importance to a sustainable patent system because the conventional patent system manifests great differences among NPOs in this regard.[194]

Furthermore, a single international patent grant would also contribute towards reducing the complexity of patent claims and of understanding their meaning. In this regard, Lemley points out that when it comes to patent claims, there is no single method for interpreting its meaning.[195] The multiplicity of NPOs further exasperates this challenge. Presently, the NPO model renders technology as a fuzzy or even amorphous domain where neither patent holders nor new-comers have a clear idea of where they stand both legally and commercially in the innovation landscape.[196]

In my view, the PCT is not a satisfactory substitute to the proposed IPO. In this context, Wadhwa et al. have shown that only sophisticated patents are taken through the PCT track. Wadhwa et

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[194] For an example extensive research project highlighting differences among NPOs, see Josh Lerner, *150 Years of Patent Office Practice* (Nov. 1999) (unpublished manuscript), http://ssrn.com/abstract=196648. Lerner has examined the administrative practices of patent offices in sixty countries over a 150-year period. According to Lerner, "[p]atentees were more likely to face steeply sloped renewal fee schedules and to pay multiple renewal fees. They were also more often granted the flexibility to delay the examination of patent applications. Meanwhile, patent officials were less likely to be granted discretion to extend and otherwise modify awards in these settings. Responsibility for determining patent validity was increasingly divided between the patent office and the judicial system." *Id.* at 20–21. He concluded that "[i]n nations with more complex economies, where information asymmetries between patent office officials and applicants and between policymakers and the patent office were likely to be the most problematic, the workings of the patent systems differed substantially from one another." *Id.* at 20.

[195] For more on the challenges of interpretation that might even affect outcomes of patent conflicts, see Kimberly A. Moore, *Forum Shopping in Patent Cases: Does Geographic Choice Affect Innovation*, 83 J. PAT. & TRADEMARK OFF. SOC'Y 558 (2001).

[196] *See* Mark A. Lemley, *The Changing Meaning of Patent Claim Terms*, 104 MICH. L. REV. 101, 108 (2005). Specifically, Lemley observes the existence of various methods for interpreting patent claims in cases involving infringement as well as with respect to post-registration technology. *Id.* Following this, he argues that the patent terminology (especially in the patent claim) should have a fixed meaning throughout time and that meaning should be fixed at the time the patent application is first filed. *Id.*

al. hinge this state of affairs on the "costly and time-intensive application process for PCT patents."[197] In effect, the PCT has become a tool for rich innovators and for applications that have "market potential in multiple countries, global visibility, or diverse applications."[198] As such, some voices assert that the PCT fails to harness all knowledge and innovation and largely remains an exclusive club that is elusive to most innovators.[199]

The proposed IPO will carry great benefits. In the context of this research, the main benefit is that of creating a much more unified and coherent hub of human knowledge. This, in turn, will not only serve us here on Earth but will be a crucial element is exporting human knowledge, or prior art, to Mars because knowledge will be more organized, condensed, and coherent.[200]

In conclusion, territoriality should no longer be the default method for dealing with innovation. In this regard, Dinwoodie observes that the "[t]erritoriality is a principle that has always received excessive doctrinal purchase in intellectual property law."[201] He contends that the "force of the principle has declined as units of social and commercial organization have come to correspond less neatly with national borders, and as private ordering has weakened the capacity, and perhaps the claim, of the nation-state exclusively to determine the behavior of its citizenry."[202] Geller has called for the creation of open, global databases and the linking of local patent databases into a globally distributed database to

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[197] Wadhwa, *supra* note 191, at 2.

[198] *Id.*

[199] Zion H. Park, *What the PCT Can Learn from Two African Systems*, 6 J. MARSHALL REV. INTELL. PROP. L. 693, 701–702 (2006).

[200] Further, the fact that a PCT system already exists, will help off-set the transition costs. The existing NPOs will now be integrated into a web of offices that are all part of the IPO; essentially the different member states can still contribute to the search and examination, but their conclusions would ultimately be part of an IPO rather than the NPO in the (present) national phase.

[201] Graeme B. Dinwoodie, *Developing a Private International Intellectual Property Law: The Demise of Territoriality?*, 51 WM. & MARY L. REV. 715, 725 (2009).

[202] *Id.*

facilitate global searching.[203] Similarly, Noveck has argued that the Patent Office is the paradigmatic example of the regulatory challenge: how to make complex decisions without adequate information.[204] In her research, Chon proposes a "principle of global intellectual property—one that is responsive to development paradigms that have moved far beyond simple utilitarian measures of social welfare."[205]

From the above, it appears that the only way to advance a clear, equal-access, and sustainable patent system is by shifting to a full-fledged International Patent Office. This would contribute to the creation of a much more vibrant environment of human innovation; one that is borderless.

Clearly, the proposed IPO will have a very positive impact on human settlements on Mars. There, humans will be largely dependent on innovation back on Earth. Such innovation will be communicated to the new colony on Mars and will be updated from time to time. Having a full IPO would be a convenient method for harnessing and communicating such knowledge and would allow for research to flourish on both planets.

2. *Empowering Production Through 3D Printing*

Another element that is crucial for establishing sustainable life on Mars is Three-Dimensional (3D) Printing, also known as

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[203] *See* Paul E. Geller, *An International Patent Utopia?,* 25 EUR. INTELL. PROP. REV. 515, 516 (2003).

[204] *See* Beth S. Noveck, *Peer to Patent: Collective Intelligence, Open Review, and Patent Reform*, 20 HARV. J.L. & TECH. 123, 125 (2006) (observing that the distrust of scientific experts produces an information deficit results in poor quality patents, and advocating for an "open review" to combine the wisdom of expert scientific communities of practice with the legal determinations of a trained Patent Office staff).

[205] Margaret Chon, *Intellectual Property and the Development Divide,* 27 CARDOZO L. REV. 2821, 2823–35 (2006) (asserting that a "new principle of substantive equality is a necessary corollary to the formal equality principles of national treatment and minimum standards that are now imposed on virtually all countries regardless of their level of development . . . . Indeed, this principle is arguably the very core of a human development-driven concept of 'development.'").

Additive Manufacturing.[206] 3D printing allows for printing objects and for sharing object files digitally.[207] It has the hallmarks of a new industrial revolution, which I have referred to as the Individualized-Industrial Revolution (i.e., the I.I. Revolution).[208]

Generally, the process of 3D printing creates an object by laying down successive layers of material until the final product emerges.[209] Effectively, each of these layers is a single thin horizontal layer in a cross-section of the final object.[210] These 3D printers are not only capable of replicating the shape of a target object, but they are also able to replicate the target's function.[211] This functional printing is a reality; anyone with a 3D printer can already print wrenches,

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[206] Amir H. Khoury, *The Makings of an 'Individualized-Industrial' Revolution: Three-Dimensional Printing and Its Implications on Intellectual Property Law*, 16 SUFFOLK J. HIGH TECH. L. 1, 1 (2015) (". . . 'Additive Manufacturing'[] is a process of making three-dimensional solid objects from (generally) a digital file. In addition to its amazing potential, what is outstanding about this technology is that it will be accessible to most in the near future.").

[207] For more on the idea of file sharing in copyright and 3D printing, see Deven R. Desai & Gerard N. Magliocca, *Patents, Meet Napster: 3D Printing and the Digitization of Things,* 102 GEO. L.J. 1691 (2013).

[208] Khoury*, supra* note 206 at 17 ("This type of 'Decentralized Production' will make it more difficult for IP owners to enforce their rights because the laws in IP are essentially macro-industry geared and not micro industry proof! That is to say, these laws envision a clearly defined (and accessible) defendant with deep pockets. Such a defendant can be taken to court and legal remedies can be sought and enforced against him."); *id.* at 2 ("Every decade or so, a new innovation comes along that shuffles the cards as far as Intellectual Property law is concerned. Suffice it to mention: the printing press; home VCR; MP3; YouTube; P2P file sharing; and robust reverse engineering of medicines and machines. Now a dramatic new 'shuffler' is upon us. We are one foot in the door to the era of full 3D printing of physical items."). For more on the radical change facing the 3D printing industry, see generally CHRISTOPHER D. WINNAN, 3D PRINTING: THE NEXT TECHNOLOGY GOLD RUSH - FUTURE FACTORIES AND HOW TO CAPITALIZE ON DISTRIBUTED MANUFACTURING 245 (2013); HOD LIPSON & MELBA KURMAN, FABRICATED: THE NEW WORLD OF 3D PRINTING 46 (2013); CHRIS ANDERSON, MAKERS: THE NEW INDUSTRIAL REVOLUTION (2012).

[209] For more on the applications of 3D Printing, see generally Barry Berman, *3D Printing: The New Industrial Revolution*, 55 BUSINESS HORIZONS 155 (2012).

[210] Khoury, *supra* note 206, at 2.

[211] For an expansive technical review of 3D Printing and its capabilities, see *What Is 3D Printing,* 3DPRINTING.COM https://3dprinting.com/what-is-3d-printing/ (last visited Oct. 29, 2017).

handguns, and other tools and gadgets.[212] There is no longer any doubt: 3D printing is on a rapid rise and will soon take the world by storm.[213] 3D printing is set to dramatically alter the process of copying and replicating items, rendering individual production common-place.[214] This is referred to as the "Second Industrial Revolution."[215] In the context of this research, 3D printing will likely become an invaluable tool for expanding human existence to Mars.

3D printing is the reverse of slicing an object into thin horizontal slices.[216] When printing becomes three-dimensional (that is, when it allows the user to regenerate 3D objects) then the entire paradigm of printing changes. The individual can now not only see the object

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[212] *See* IB-PROCADD d.o.o., *ZCorp's 3D Printer Replicates Wrench*, YOUTUBE (Jul. 11, 2011), https://www.youtube.com/watch?v=jQ-aWFYT_SU.

[213] *See* Christopher Mims, *Additive Manufacturing: 3D Printing Will Explode in 2014, Thanks to the Expiration of Key Patents*, QUARTZ (July 21, 2013) https://qz.com/106483/3d-printing-will-explode-in-2014-thanks-to-the-expiration-of-key-patents/; *see also* Khoury, *supra* note 233, at 5 (internal citation omitted) ("[I]t is worth noting that 'the use of printing machinery to manufacture physical objects created digitally . . . [(e.g. Computer-Aided Design (CAD)) is not new,] . . . and it is actually the standard in many industrial fields, [such as] aeronautics and home furniture.' But this is only the beginning."). According to Margoni: "[t]he change in recent years that has the potential to be a paradigm-shifting factor is a combination between the popularization of such technologies (price, size, usability, quality) and the diffusion of a culture based on access to and reuse of knowledge. We will call this blend Open Design.") (quoting Thomas Margoni, *Not for Designers: On the Inadequacies of EU Design Law and How to Fix It*, 4 J. INTELL. PROP., INFO. TECH. & E-COMMERCE L. 225 (2013).

[214] *See* Catarina Mota, *The Rise of Personal Fabrication*, PROC. 8TH ACM CONF. ON CREATIVITY & COGNITION 279, 279 (2011) (observing that "[i]n recent years we have been witnessing the first stages of a democratization of manufacturing, a trend that promises to revolutionize the means of design, production and distribution of material goods and give rise to a new class of creators and producers. A disruptive technology and several cultural and economic driving forces are leading to what has already been called a new industrial revolution: public access to digital fabrication tools, software and databases of blueprints; a tech Do-It-Yourself movement; and a growing desire amongst individuals to shape and personalize the material goods they consume.").

[215] Khoury, *supra* note 206, at 17.

[216] For an expansive technical review of 3D Printing and its capabilities, see *What Is 3D Printing?,* 3DPRINTING.COM, https://3dprinting.com/what-is-3d-printing/ (last visited Oct. 29, 2017).

but can also possess and utilize it.[217] In a previously published paper, I have submitted that this new reality of 3D printing will also come to impact IP rights on Earth.[218] But in the context of Mars exploration and settlement thereon, 3D printing is indeed an immensely crucial tool that needs to be encouraged. Even now, 3D Printing is defying traditional concepts of dimensionality, almost printing objects into being.[219] But even here the situation is far from static, in fact, while this research is being conducted, already 4D technologies are on the way.[220] This new 4D technology reflects the ability to create self-changing objects, which employ nano-technology and biotechnology to program objects to change shape and properties and to build themselves.[221] These 3D printing machines are now able to print objects, tools, gun parts, and even human bone tissue and

[217] *Id.*

[218] Consider the impact of 3D printing on designs. How would one come to protect designs now that every individual is able to print whatever design that their heart desires? Also, in all other IP fields, challenges are anticipated. Consider for example: Khoury, *supra* note 208, at 15 fn. 96 ("The core patent bargain—sharing [the plans on] how to make something in exchange for exclusivity—may be meaningless in a world of digitized things."). *See also* Nathan Schissel, 3D Printing and Implications on Intellectual Property Rights, Tech. L. Advisor (Nov. 10, 2014), *archived at* http://perma.cc/7RDN-V7T6 (stating "[l]ike many new technologies, 3D printing raises a number of legal questions and challenges, particularly challenges related to the unauthorized reproduction of products protected by intellectual property (IP) rights."). Khoury, *supra* note 206, at 7 ("Imagine, if you will, the impact that this technology will soon have on large scale manufacturing, shipping, warehousing, outsourcing, mass production and others. All of these are set to dramatically plummet as the demand curve is altered given that individuals can now print (indeed create) much of what they need and effectively produce it at home.").

[219] James Grimmelmann, *Indistinguishable from Magic: A Wizard's Guide to Copyright and 3D Printing*, 71 WASH. & LEE L. REV. 683, 695 (2013).

[220] Skylar Tibbits, *The Emergence of "4D Printing"*, TED TALKS (Feb. 2013), https://www.ted.com/talks/skylar_tibbits_the_emergence_of_4d_printing.

[221] Already there is software called CAD-Nano that assist in this regard, and which assists in supporting the ability of physical objects to build themselves. Some of these objects are designed to react to water and others are designed to react to other substances. *See* Helena N. Chia & Benjamin M. Wu, *Recent Advances in 3D Printing of Biomaterials*, 9 J. BIOLOGICAL ENGINEERING 4 (2015).

human organs.[222] In essence, the replication of the inconceivable is now becoming a reality.[223] These machines are projected to become to the manufacturing industry what the digital camera was to the photography industry.[224] With the advent of 3D printing, gone are the days when the need for special machinery restricted people from producing complex items and designs.[225] 3D printers are fast becoming standard machines in homes.[226] Moreover, some websites already allow for downloading a massive selection of items—even for free.[227] In this regard, Lemley posits that 3D printing, along with three other developments (i.e., the Internet, robotics, and synthetic

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[222] *See* Alaadien Khalyfa et al., *Development of a New Calcium Phosphate Powder-Binder System for the 3D Printing of Patient Specific Implants*, 18 J. MATERIALS SCI.: MATERIALS MED. 909, 913 (2007); Christian Bergmann et al., *3D Printing of Bone Substitute Implants Using Calcium Phosphate and Bioactive Glasses*, 30 J. EUROPEAN CERAMIC SOC'Y 2563, 2570 (2010).

[223] *See* Kevin J. O'Neill, Is Technology Outmoding Traditional Firearms Regulation? 3-D Printing, State Security, and the Need for Regulatory Foresight in Gun Policy (May 3, 2012) (unpublished manuscript), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2186936; F. Rengier et al., *3D Printing Based on Imaging Data: Review of Medical Applications*, 5 INT'L J. COMP. ASSISTED RADIOLOGY & SURGERY 335, 342 (2010). For an interesting comparison between science fiction (then) and science (now), see Matthew Hollow, Confronting a New 'Era of Duplication'? 3D Printing, Replicating Technology and the Search for Authenticity in George O. Smith's Venus Equilateral Series (May 2013) (unpublished manuscript), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2333496.

[224] The digital camera directly impacted corporations such as Kodak. *See* David DiSalvo, *The Fall of Kodak: A Tale of Disruptive Technology and Bad Business*, FORBES (Oct. 2, 2011, 2:39 PM), http://www.forbes.com/sites/daviddisalvo/2011/10/02/what-i-saw-as-kodak-crumbled/.

[225] *See, e.g.,* Alexander Maund, *3D Printed '28-Geared Cube' - Printed Fully Assembled*, YOUTUBE (Apr. 9, 2013), https://www.youtube.com/watch?v=JqfWTJC2DvM; TopBestBox, *Top 5 Best 3D Printers to Buy USA*, YOUTUBE (Aug. 25, 2014), https://www.youtube.com/watch?v=n1jw7DX5B2A.

[226] Thierry Rayna & Ludmila Striukova, *From Rapid Prototyping to Home Fabrication: How 3D Printing Is Changing Business Model Innovation*, 102 TECH. FORECASTING & SOC. CHANGE 214, 216 (2016).

[227] This selection may outsize even that of Amazon's! For examples of the thousands of products available through market leaders, see SHAPEWAYS, www.shapeways.com (last visited Oct. 28, 2017); THINGIVERSE, https://www.thingiverse.com/ (last visited Oct. 28, 2017); MATERIALISE http://www.materialise.com/ (last visited Oct. 28, 2017); and THREEDING, http://www.threeding.com/ (last visited Oct. 28, 2017).

biology) can create a world without scarcity. In his view, "it is entirely plausible to envision a not-too-distant world in which most things that people want can be downloaded and created on site for very little money."[228]

While 3D printing could be scrutinized for its adverse effects on IP rights here on Earth, its potential for helping cultivate sustainable life on Mars necessitates discussion when formulating relevant laws.[229] Indeed, the benefits of this crucial technology for creating tools or spare parts on a distinct planet exceed narrow (albeit important and legitimate) IP rights here on Earth; and thus the cost-benefit comparison needs to recalibrate accordingly.[230] The relevance of 3D printing for life on Mars is not theoretical, and 3D printing is set to become a main method of creating needed items

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[228] Mark A. Lemley, *IP in a World Without Scarcity*, (Stan. Pub. L., Working Paper No. 2413974, 2014), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2413974; *see also* Desai & Magliocca, *supra* note 207 (observing that 3D printing is a general-purpose technology that will do for physical objects what MP3 files did for music).

[229] 3D printing is set to change the way we shop and will deeply impact demand and supply. The government-funded Hargreaves Review has already flagged the need to investigate 3D printing. According to their report, copyright issues associated with 3D reproduction need to be addressed before it becomes a widely-used technology if IP law is to enable, rather than inhibit the technology's potential to contribute to growth. *See* Kathleen Hall, *How 3D Printing Impacts Manufacturing,* COMPUTERWEEKLY (Feb. 2013), http://www.computerweekly.com/ feature/How-3D-printing-impacts-manufacturing. Scientists and the industry are clearly moving rapidly, towards the ability of empowering all to produce whatever they desire in their businesses or their homes. While this seems to be a great scientific leap forward, it does not come without cost. The risk of free-riding here is expected to rise exponentially, and the question is going to be if, in light of this new technology, IP rights will continue to be sustainable. For a discussion of the future of 3D printing, see David Bak, *Rapid Prototyping or Rapid Production? 3D Printing Processes Move Industry Towards the Latter*, 23 ASSEMBLY AUTOMATION 340 (2003).

[230] For an interesting survey of the potential impact of 3D printing on IP, see Desai & Magliocca, *supra* note 207, at 1691 ("Digitization has reached things. This shift promises to alter the business and legal landscape for a range of industries. Digitization has already disrupted copyright-based industries and laws. As cost barriers fell, individuals engaged with copyrighted work as never before. Business-to-business and business-to-consumer models of industrial copyright faltered and, in some cases, failed. Industries were forced to reorganize, and the foundations of copyright were re-examined.").

and tools on Mars.[231] This projected success of 3D printing on Mars is based on three conditions that can be relatively easily met; namely: the availability of precise 3D printers; access to materials for printing (the raw materials that can be harvested from the soil of Mars);[232] and the ability to create such objects and to share object files digitally, which could be cheaply transferred in memory cards to Mars. In this way, people living on Mars can, if necessary, print tools, spare parts, and other items.[233] The importance of 3D printing becomes evident when we consider the alternatives. Imagine having to ferry to Mars each and every tool, item, or object needed on Mars. In a more fanciful expression, 3D printing is the closest thing to teleportation that we know to this day.[234]

In conclusion, 3D printing will undoubtedly greatly impact the IP system.[235] 3D printing challenges the IP paradigm by facilitating

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[231] F. Ceccanti et al., *3D Printing Technology for a Moon Outpost Exploiting Lunar Soil,* 61ST INT'L ASTRONAUTICAL CONGRESS (2010).

[232] Amanda Morris, *New Method for 3D Printing Extraterrestrial Materials*, NW. U. SCH. ENGINEERING (Apr. 12, 2017), http://www.mccormick.northwestern.edu/news/articles/2017/04/new-method-for-3d-printing-extraterrestrial-materials.html; *see* Bahar Gholipour, *3D Printing on Mars Could Be Key for Martian Colony*, SPACE.COM (Oct. 3, 2013, 8:00 AM), https://www.space.com/23059-3d-printing-mars-colony.html.

[233] *C.f.* Benjamin Kading & Jeremy Straub, *Utilizing in-situ Resources and 3D Printing Structures for a Manned Mars Mission*, 107 ACTA ASTRONAUTICA 317 (2015) (discussing how 3D printing could be used to create habitable structures on Mars).

[234] Lucas Osborn, *Regulating Three-Dimensional Printing: The Converging Worlds of Bits and Atoms*, 51 SAN DIEGO L. REV. 553, 561 (2014), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2348894 (observing that the 3D printing technology "portends dramatic shifts in manufacturing, trade, medicine, and more, and will require a legal regime that integrates the legal concepts governing the digital and physical worlds").

[235] Catherine Jewell, *3-D Printing and the Future of Stuff,* WIPO, (Apr., 2013), http://www.wipo.int/wipo_magazine/en/2013/02/article_0004.html. Jewell rightly observes that:

> 3-D printing raises a number of regulatory challenges including in relation to intellectual property protection. Just as the digitization of creative content has forced change within the creative industries and fueled tensions around existing copyright law, similar debates are likely to emerge in relation to 3-D printing. Given the global scale of manufacturing, however, the stakes in this debate may be even greater.

Id.

the physical replication of objects. It allows for printing such objects 'at-will' and for the sharing of design files. This technology creates a deep-set connection between virtual designs and tangible objects and products.[236] Therefore, there is a need for formulating a deep understanding of this new era of 3D printing and its impact on the world around us.[237]

VI. CONCLUSION

Mars awaits humanity. Humans will eventually get there. Some argue that we must do so in order ensure the long-term survival of our species. However, the Mars project is a mammoth undertaking. It dwarfs all other human achievements thus far. The Mars mission will be unprecedented in its complexity, and laden with dangers and

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[236] Desai & Magliocca, *supra* note 207, at 1691 ("3D printing is a general-purpose technology that will do for physical objects what MP3 files did for music. The core patent bargain—sharing the plans on how to make something in exchange for exclusivity—may be meaningless in a world of digitized things. While these devices will unleash the creativity of producers and reduce costs for consumers, they will also make it far easier to infringe patents, copyrights, and trade dress.").

[237] Such ideas about the immense potential impact of 3D printing are already being debated. *See* THOMAS CAMPBELL ET AL., COULD 3D PRINTING CHANGE THE WORLD? TECHNOLOGIES, POTENTIAL, AND IMPLICATIONS OF ADDITIVE MANUFACTURING, ATLANTIC COUNCIL 1 (2011), https://info.aiaa.org/SC/ETC/MS%20SubCommittee/Alice%20Chow_3D%20Printing%20Change%20the%20World_April%202012.pdf ("3D Printing/Additive Manufacturing (AM) is a revolutionary emerging technology that could up-end the last two centuries of approaches to design and manufacturing with profound geopolitical, economic, social, demographic, environmental, and security implications."); Simon Bradshaw, Adrian Bowyer & Patrick Haufe, *The Intellectual Property Implications of Low-cost 3D Printing*, 7 SCRIPTED 5, 5 (2010) ("within the UK at least - private 3D printer owners making items for personal use and not for gain are exempt from the vast majority of IP constraints, and that commercial users, though more restricted, are less so than might be imagined."); Deven R. Desai, *The New Steam: On Digitization, Decentralization, and Disruption*, 65 HASTINGS L.J. 1469, 1473 (2014). As alluded to above, there is strong evidence to suggest that 3D printing is set to have a deep and lasting impact on IP. 3D printing is set to affect how IP can be used (and abused) and how IP rights can be (effectively) enforced in light of 3D design files (what I would refer to as - "3DDF"). These 3DDFs will become common place, and will be, as a matter of course, shared on Peer-to-Peer platforms. My research is intended, hopefully, to contribute towards filling that void.

toils; yet the human spirit of risk-taking, curiosity, ingenuity, and its collective will to persevere and survive will no doubt overcome all of the hurdles. This article offers the intellectual property legal system as a tool to enhance the chances of success of this mission, an additional stepping stone for the journey ahead. In a fast-moving technological reality, there is a need to make rapid determinations and to formulate rules to regulate the IP field in a way that ensures technological progress while retaining reasonable levels of protection to secure incentives.

The Red planet awaits us; let our collective knowledge and cooperation be the beacons that lead us there.