SE:SA

SPACE EDUCATION & STRATEGIC APPLICATIONS

VOLUME 2 • NUMBER 1 • FALL 2020/WINTER 2021

Melissa Layne, Ed.D. *Editor-in-Chief*

THE

INAUGURAL CONFERENCE ISSUE

PART 1

PSO

SPACE EDUCATION & STRATEGIC APPLICATIONS

SPACE EDUCATION AND STRATEGIC APPLICATIONS JOURNAL

VOL. 2, NO. 1 FALL 2020 / WINTER 2021

PSO

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Editorial

Melissa Layne
American Public University System

Dear *SESA* Readers,

The inaugural 2020 Space Education & Strategic Applications conference in October was certainly a testament to perseverance and commitment. Originally scheduled six months earlier in April as an in-person event, organizers were forced to postpone the conference to October using a virtual platform. Despite this rapid and dynamic pivot to hold a virtual conference, our sponsors, American Public University System (APUS) and Policy Studies Organization (PSO), were well-equipped to rise to the occasion. However, we were careful not to be *too* sure of ourselves lest something terribly wrong were to occur!

As the conference date was nearing, we continued to experience an increasing influx of presentations; so, what was supposed to be a one-day event, now became two full days for the space community to gather in "our virtual space."

Dr. Vernon Smith, Provost at APUS, served as our Master of Ceremonies by opening the conference with a lively and motivational introduction, and ended by expressing sincere gratitude to presenters, attendees, and organizers. Our presenters shared their extensive knowledge around a variety of space-related topics via sessions, roundtables, panels, fireside chats, and keynotes. As a newcomer to the space conference scene, SESA's plenary addresses were quite impressive, and included NASA's Julielynn Wong, Stacy Kubicek from Lockheed Martin, Natalie Panek of Mission Systems MDA, and Emily Calandrelli, host of the Emily's Wonder Lab. The most anticipated session was that of the Honorable Barbara Barrett, Secretary of the U.S. Air Force. For session video recordings go to https://whova.com/embedded/event/seasa_202010/?utc_source=ems

This issue highlights the truly outstanding work from some of our presenters—many of whom have expressed their excitement for the next SESA conference taking place on **September 23rd and 24th, 2021.** Mark your calendars!

The following pages provide a glimpse of some of our conference data in addition to attendee / presenter responses to our end-of-conference survey.

Melissa Layne, Ed.D.

Editor-in-Chief, SESA

doi: 10.18278/sesa.2.1.1

SESA Conference Fast Facts

- Over 500 registrants
- Over ten countries represented
- Five plenary speakers
- Session Attendance: Sessions averaged between 70-80 viewers
- Reporters / Editors in attendance: *Popular Mechanics, Sky and Telescope, and Aviation Week*

Presenter and Attendee Responses

"Best two days on space imaginable. The APU professors were impressive and so was everyone. What a great, great event."

"I couldn't agree more. Way superior to other online conferences I have seen."

"Congratulations again on a very successful conference!

I'm enjoying the presentations I've attended."

"Thank you very much for the honor and privilege of attending this year's space conference. I enjoyed it immensely. It was very informative and the speakers were excellent! I very much look forward to attending next year and possibly presenting."

"It was a pleasure speaking for your conference recently, and thank you so much for your lovely speaking gifts! I really enjoyed the most excellent SWAG from APUS."

"You have done a great job."

"Thanks again for a great conference; I really enjoyed the meetings - lots of great talks and information! Thank you for the opportunity to present there as well.

I like what you folks are up to, and I'm a little interested in AMU's programs."

"I would recommend this conference to others."

"Please invite me back directly next year—if you have a mailing list for SE:SA 2021 specifically, I would appreciate being included…Thank you for including me this year and hope you find value in my feedback."

“We recommend the conference to all of the students at my children’s elementary school. It would be great to develop a program that just speaks to students- they are the future of any space program.”

“The topics covered were important and relevant.”

“Keep doing what you are doing. You are building the next decade of thinkers.”

“I enjoyed the presentation from Susan IP, the Plenary session by Secretary Barrett, Kristen Miller's presentation, and many others. It was a fantastic variety of speakers!”

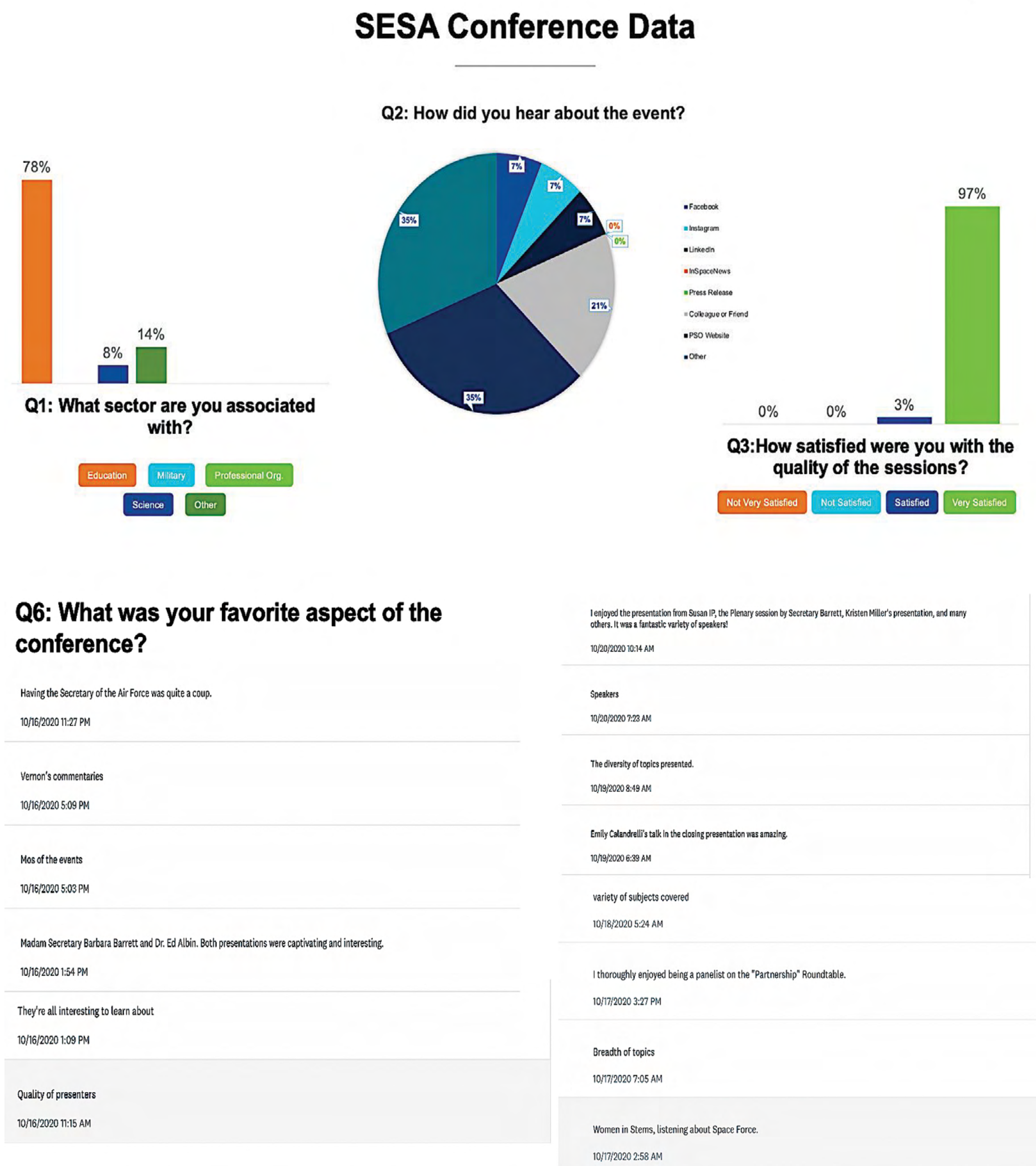
“The organizers for this conference did a fantastic job—especially since it was their first SESA conference!”

“I thoroughly enjoyed being a panelist on the "Partnership" Roundtable. It was a great conference for it being the first.”

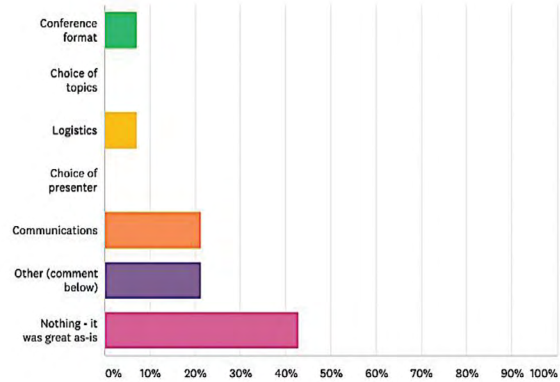
“I hope you will use the conference to continue to make the public aware of certificate and degree programs in space studies.”

“Presentations were captivating and interesting.”

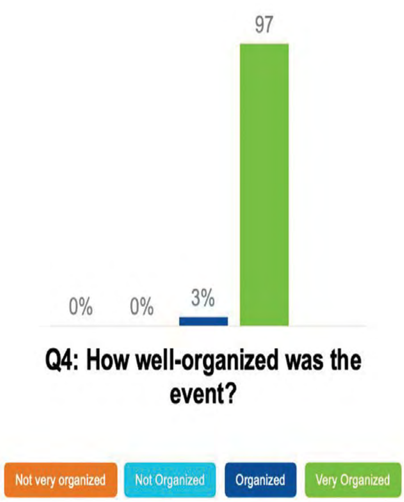
“I found a lot of the discussions to be extremely interesting (even if most was out of my realm of understanding).”

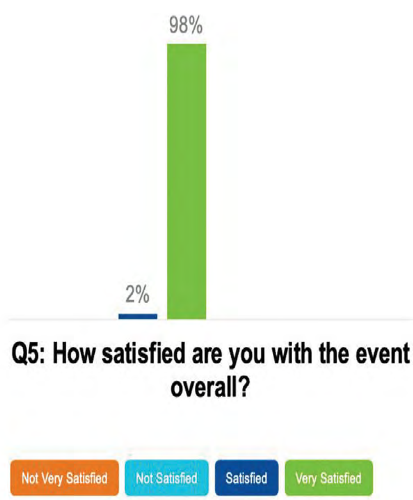

SESA Conference Data
Q2: How did you hear about the event?
7%
7%
7%
0%
0%
21%
35%
35%
Facebook
Instagram
LinkedIn
InSpaceNews
Press Release
Colleague or Friend
PSO Website
Other
78%
8%
14%
Q1: What sector are you associated with?
Education
Military
Professional Org.
Science
Other
97%
0%
0%
3%
Q3:How satisfied were you with the quality of the sessions?
Not Very Satisfied
Not Satisfied
Satisfied
Very Satisfied
Q6: What was your favorite aspect of the conference?
Having the Secretary of the Air Force was quite a coup.
10/16/2020 11:27 PM
Vernon's commentaries
10/16/2020 5:09 PM
Mos of the events
10/16/2020 5:03 PM
Madam Secretary Barbara Barrett and Dr. Ed Albin. Both presentations were captivating and interesting.
10/16/2020 1:54 PM
They're all interesting to learn about
10/16/2020 1:09 PM
Quality of presenters
10/16/2020 11:15 AM
I enjoyed the presentation from Susan IP, the Plenary session by Secretary Barrett, Kristen Miller's presentation, and many others. It was a fantastic variety of speakers!
10/20/2020 10:14 AM
Speakers
10/20/2020 7:23 AM
The diversity of topics presented.
10/19/2020 8:49 AM
Emily Calandrelli's talk in the closing presentation was amazing.
10/19/2020 6:39 AM
variety of subjects covered
10/18/2020 5:24 AM
I thoroughly enjoyed being a panelist on the "Partnership" Roundtable.
10/17/2020 3:27 PM
Breadth of topics
10/17/2020 7:05 AM
Women in Stems, listening about Space Force.
10/17/2020 2:58 AM

Q7: What could we improve?



ANSWER CHOICES	RESPONSES
Conference format	7.14%
Choice of topics	0.00%
Logistics	7.14%
Choice of presenter	0.00%
Communications	21.43%
Other (comment below)	21.43%
Nothing - it was great as-is	42.86%





SESA Keynote Speaker and 25th Secretary of the United States Air Force, Barbara Barrett

Melissa Layne
American Public University System

Figure 1. Secretary of the Air Force Barbara M. Barrett conducts her first Air Force TV interview with Airmen at the Pentagon, Arlington, VA on October 24, 2019. (U.S. Air Force photo by Wayne Clark)

Abstract

Despite Secretary Barrett's recent resignation (which preceded President Joe Biden's inauguration), the 25th U.S. Air Force secretary (and fourth female secretary), was a much-anticipated keynote speaker at October's inaugural Space Education and Strategic Applications (SESA) conference. As a SESA conference organizer and editor-in-chief for the associated SESA journal, preparing for Mrs. Barrett's keynote was nothing short of surreal. I was tasked to organize the date, time, duration of the keynote, and to develop 5 interview questions (which, I readily admit, went through roughly 5 iterations). Prior to drafting the questions, I had the once-in-a-lifetime opportunity to communicate with and organize our virtual conference logistics with her Public Affairs Advisor and Director of Engagements ... from the Pentagon ... vis-à-vis emails and phone calls.

 doi: 10.18278/sesa.2.1.2

Mr. Lou Cordia, Senior Advisor of Government Relations for American Public University System and friend to Barrett, was requested to introduce the Secretary, and present the interview questions. Presenters and attendees enjoyed listening to our esteemed guest who shared inspirational life experiences that helped shape her successful career with the U.S. Air Force. Needless to say, Barbara Barrett is quite a remarkable woman. Her biography documents her achievements, accolades, and appointments since 1976. In this article, I share the captivating stories behind the documents and interviews to unearth Barrett's views on the importance of work ethic, education, determination, and of course, space.

Keywords: Secretary Barbara Barrett U.S. Air Force, Space Education and Strategic Applications conference, journal, space, education, ethics, airmen, biography

Oradora principal de SESA y 25 ° Secretaria de la Fuerza Aérea de los Estados Unidos y Barbara Barrett

Resumen

A pesar de la reciente renuncia del secretario Barrett (que precedió a la toma de posesión del presidente Joe Biden), la vigésimo quinta secretaria de la Fuerza Aérea de los Estados Unidos (y cuarta secretaria) fue una oradora principal muy esperada en la conferencia inaugural de Educación Espacial y Aplicaciones Estratégicas (SESA) de octubre. Como organizador de la conferencia de SESA y editor en jefe de la revista asociada de SESA, la preparación para el discurso de apertura de la Sra. Barrett fue nada menos que surrealista. Se me asignó la tarea de organizar la fecha, la hora, la duración de la conferencia magistral y desarrollar 5 preguntas para la entrevista (que, lo admito, pasaron por aproximadamente 5 iteraciones). Antes de redactar las preguntas, tuve la oportunidad única de comunicarme y organizar nuestra logística de conferencia virtual con su Asesora de Asuntos Públicos y Directora de Compromisos ... del Pentágono ... vis-à-vis correos electrónicos y llamadas telefónicas.

Se pidió al Sr. Lou Cordia, Asesor Principal de Relaciones Gubernamentales para el Sistema Universitario Público Estadounidense y amigo de Barrett, que presentara al Secretario y presentara las preguntas de la entrevista. Los presentadores y asistentes disfrutaron escuchando a nuestra estimada invitada, quien compartió experiencias de vida inspiradoras que ayudaron a dar forma a su exitosa carrera con la Fuerza Aérea de EE. UU. No hace falta decir que Barbara Barrett es una mujer bastante notable. Su biografía documenta sus logros, reconocimientos y nombramientos desde 1976. En este artículo, comparto las cautivadoras historias detrás de los documentos y entrevistas para desenterrar las opiniones de Barrett sobre la importancia de la ética laboral, la educación, la determinación y, por supuesto, el espacio.

Palabras clave: Secretaria Barbara Barrett, Fuerza Aérea de los EE. UU., Conferencia sobre educación espacial y aplicaciones estratégicas, revista, espacio, educación, ética, aviadores, biografía.

SESA主题演讲者和美国空军第25秘书以及 Barbara Barrett

摘要

尽管巴雷特秘书最近辞职（在乔·拜登总统就职之前），但美国第25空军秘书（和第四位女秘书）还是在10月举行的首届太空教育和战略应用（SESA）会议上备受期待的主旨发言人。作为SESA会议的组织者和SESA相关杂志的主编，为巴雷特夫人的主题演讲做准备简直就是超现实。我的任务是组织主题演讲的日期，时间，持续时间，并制定5个面试问题（我很容易承认，经历了大约5次迭代）。在草拟问题之前，我有千载难逢的机会与五角大楼的公共事务顾问和参与总监（来自五角大楼）进行交流并组织我们的虚拟会议后勤……面对电子邮件和电话。

美国公立大学系统政府关系高级顾问，巴雷特的朋友楼·科迪亚（Lou Cordia）先生被要求介绍秘书，并提出面试问题。主持人和与会者很高兴听取我们尊敬的客人的声音，他们分享了鼓舞人心的生活经历，这些经历有助于塑造她在美国空军的成功事业。毋庸置疑，芭芭拉·巴瑞特（Barbara Barrett）是一位了不起的女人。她的传记记录了自1976年以来她的成就，荣誉和任命。在本文中，我分享了文件和访谈背后的迷人故事，以发掘巴雷特对职业道德，教育，决心以及空间的重要性的看法。

关键词：秘书芭芭拉·巴雷特，Barbara Barrett，美国空军，太空教育和战略应用会议，期刊，太空，教育，伦理学，飞行员，传记

Work Ethic & Education

"I grew up on a farm. I ended up being the sole source of income. I learned early on that you just work to get the job done. You pursue until you accomplish the mission.

You know growing up we didn't have much money was always in short supply. I kept a tobacco can that was my bank. I put money in that bank. And if anybody asked me what that was for, [I would say] I was saving it to go to college. My life education was the ticket to capability or the ticket to opportunity. And so, I got a bachelor's degree and then I went to night school to get a master's degree. I had to work five jobs at a time to get through to pay for this, but I got the education and that has been the doorway to opportunity. I would certainly not be here today, if it weren't for the education that I had to scrimp for." (Barrett, 1999).

Figure 2. The tobacco can where Barbara Barrett saved her money to go to college.

An Impressive Resume

Barrett's career started very early in life. One of Barrett's earlier resumes proudly displays her first job at McConnell's Riding Academy in Clarksburg, Pennsylvania. At the young age of 13, she shoed and trained horses and also taught people how to ride. To evidence her determination and grit, on the resume she described her responsibilities at the academy as "Whatever it Took. Ran the whole enchilada." (Barrett, 1999).

Following high school, she landed a scholarship to Arizona State University where she would earn not only her Bachelor of Science in Liberal Arts, but a Master of Public Administration in international business, and a Juris Doctor degree. She remembers a time when she stretched her funds to insure she could continue to go to college:

> "I recall that at one point I lived for two months on $2 and I had five jobs to have to pay tuition and buy books." (Barrett, 1999)

Professional Career

For nearly five decades, Barrett has held high-level positions in business, academics, professional organizations—and of course, government. Before the age of 30, she was an executive of two global Fortune 500 companies. However, one will notice a common thread throughout her career that places a distinct, and specialized focus on an industry that paved the way to her to her current position ... space. Space, aviation, aeronautics, science,

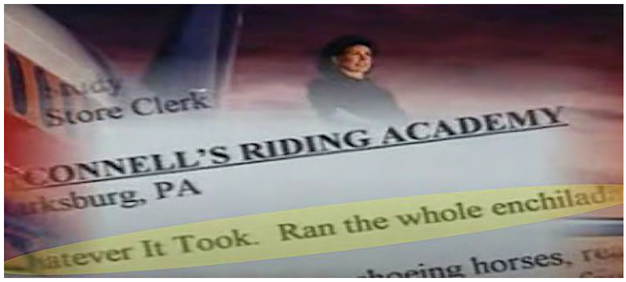


Figure 3. (L) Barbara Barrett as a young girl. ***Figure 4.*** (R) A description of Barrett's responsibilities at McConnell'S Riding Academy, "Whatever It Took. Ran the whole enchilada."

defense, and diplomacy she refers to as "home":

> "Aviation is a big part of my life and space is, too. For me, the Air Force is a very comfortable home and a place that feels like the right fit," she says. She adds that her position as the Secretary of the U.S. Air Force is "an extraordinary privilege." (Barrett, 2019).

Supporting United States Airmen

"I also know that every Airman, when they raise their hand to defend the country and the Constitution, is making a bigger commitment than I am. My job will be to give them the tools, give them the resources, give them the support, and get out of the way."

During her tenure at the Pentagon, Barrett emphasized her allegiance to removing unnecessary regulations and modernizing operations toward the goal of making "faster and smarter decisions." (Barrett, 2019).

This efficiency contributes to a much larger purpose: the U.S. Space Force. Even from conception, she had extremely high expectations for the U.S. Space Force as she firmly states,

> "We have to be first and best in space for the world's safety and especially the defense of America .... A United States Space Force is not just a good idea; I might even say it's overdue .... It's really time for us to be attentive to our dependence on space, the urgency of space, the importance of space, and the need for us to continue our lead in the warfighting domain." (Barrett, 2019).

This need to "lead" is not merely to be the best. Barrett details our nation's vulnerability and dependence on space:

> "We are vulnerable. For example, the U.S. and the global economy are totally dependent on satellites, most especially the GPS, which is operated by the Space Force. "It is a remarkable thing how completely dependent most Americans and people around the world are in our day-to-day lives on space. As I've said before, I think most people before their

Figure 5. A fully-trained astronaut, Barrett was a "back-up" astronaut for the Soyuz TMA-16 flight to the International Space Station.

first cup of coffee in the morning, they've used space. It's ubiquitous, but it's invisible. So, most people don't realize it. I mean, you may wake into an alarm clock that is set to a timer that is airborne. That is space-born. It's coming from a satellite. Our ATMs. You can't pump gas without using space. The news probably is derived from a space asset. Our weather predictions are coming from space assets; crop monitoring, environmental monitoring, these things are all dependent upon space. Just in summary, our information, our navigation and our communications are all space-dependent. It's ubiquitous, but it's invisible. We don't see those lines to space. If they were all tethered by some wires, we'd be wrapped up in it like Lilliputian, like Jonathan Swift. But in fact, we are dependent, but not conscious in many cases of how dependent we are. So, with that dependence, we built this system, the GPS system especially—as my predecessor in this role said, we built a glass house before we knew about stones, in that we have a vulnerable system, but we built it without consciousness of that vulnerability. So now those satellites, that GPS system upon which we depend, has been unprotected. We need to be able to protect that capability, and we need to deter others from attacking our GPS satellites, and we need to replace the current satellites with less vulnerable, more jam-resistant and protected satellites." (Forbes, 2020).

Bidding the USAF Farewell

Even though her tenure with the Air Force has ended, Barrett took the opportunity to share some parting words during her farewell ceremony on January 14th at Joint Base Anacostia-Bolling in Washington, D.C. She commended the "superstars" she led and mentored by accentuating their ethics, integrity, and drive to be a collective "best"—the same characteristics she had as a little girl raising cattle and training horses on a 100-acre farm back in Pennsylvania:

> "There is one eye-watering constant across the Air and Space Forces: the universality that these are good people," she said. "I have worked at numerous businesses, I have been a member of dozens of groups, and I have been part of myriad organizations, but I have never been part of any entity where there is such consistency of good intent and effort to be the best, together."

Figure 6. Secretary of the Air Force Barbara M. Barrett delivers remarks during her farewell ceremony at Joint Base Anacostia-Bolling, Washington, D.C., Jan. 14, 2021. As the 25th Secretary of the Air Force, Barrett was responsible for the welfare of more than 697,000 active duty, Guard, Reserve, and civilian Airmen and Guardians and their families. (U.S. Air Force photos by Eric Dietrich)

Additional interesting facts about the 25th Secretary of the U.S. Air Force, Barbara Barrett:

- She trained in her late 50s as an astronaut in Kazakhstan and then in Russia.
- She had to learn Russian while undergoing astronaut training.

- She was the first civilian woman to land in an F-18 fighter aircraft on a moving aircraft carrier.
- She has successfully held executive positions in both the private and public sectors.
- She served as our ambassador to Finland, where she engaged in a war game dog fight in the air in an F-18 against the head of the Finnish Air Force (the joust was a draw).
- At age 10 learned how to drive a car, milk a cow, and shoe a horse.
- At age 13, she became her family's bread-winner after her father suffered a heart attack.
- Each year she writes a life-list, which has included activities such as climbing Kilimanjaro, and exploring the Grand Canyon from rim to rim.
- One of her five jobs while attending Arizona State University was a paid internship at the state legislature where she also received credit hours and worked with Sandra Day O'Conner, the first woman to sit on the majority leader of the state senate.

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Commentary: Elon Musk (Space X) Has Gone Nuts

Bruce Gagnon

Global Network Against Weapons & Nuclear Power in Space

Images courtesy of SpaceX product website

Abstract

Elon Musk, and his company SpaceX, has a plan to take control of Mars. They want to "terraform" the dusty red planet to make it green and livable like our Mother Earth.

The topography of Mars is described as:

"A hypothetical program that will consist of a planetary engineering project or a concurrent project, with the purpose of transforming the planet from hostile life to life on earth so that it can sustainably accommodate humans and other unprotected or mediated life forms. Presumably, the process will involve restoring the existing climate, atmosphere and surface of the earth through various resource-intensive programs and the installation of one or more new ecosystems." (Wikipedia, 2021).

It is estimated that more than 10,000 nuclear bombs will be required to implement Musk's plan. A nuclear bomb will also make Mars radioactive. The nuclear bomb that Musk wants to build will be transported to Mars by the 1,000-spacecraft fleet Musk wants to build, similar to the nuclear bomb that exploded on December 9, 2020. Such radioactivity will undoubtedly incur long-term damage to Earth.

Keywords: Elon Musk, SpaceX, Mars, terrain, nuclear weapons, cost, morality, law, earth.

doi: 10.18278/sesa.2.1.3

Comentario: Elon Musk (Space X) se ha vuelto loco

Resumen

Elon Musk y su empresa SpaceX tienen un plan para tomar el control de Marte. Quieren "terraformar" el polvoriento planeta rojo para hacerlo verde y habitable como nuestra Madre Tierra. La terraformación de Marte se describe como

"Un procedimiento hipotético que consistiría en un proyecto de ingeniería planetaria o proyectos concurrentes, con el objetivo de transformar el planeta de una vida hostil a terrestre a una que pueda albergar de manera sostenible a humanos y otras formas de vida libres de protección o mediación. El proceso presumiblemente implicaría la rehabilitación del clima, la atmósfera y la superficie existentes del planeta a través de una variedad de iniciativas intensivas en recursos y la instalación de un sistema o sistemas ecológicos novedosos "(Wikipedia, 2021).

Se ha proyectado que se necesitarían más de 10.000 bombas nucleares para llevar a cabo el plan de Musk. Las explosiones de bombas nucleares también convertirían a Marte en radiactivo. Las bombas nucleares serían llevadas a Marte en la flota de 1,000 naves estelares que Musk quiere construir, similar a la que explotó el 9 de diciembre de 2020. En este comentario, analizo cuestiones importantes que deben considerarse en torno al costo, la ética , y las implicaciones legales que una devastación tan prolongada infligiría aquí en la Tierra.

Palabras clave: Elon Musk, Space-X, Mars, terraform, bombas nucleares, costo, ética, legal, Tierra

评论：Elon Musk（Space X）疯了

摘要

伊隆·马斯克（Elon Musk）和他的公司SpaceX计划控制火星。他们想"地形化"尘土飞扬的红色星球，使其像我们的地球母亲一样绿色宜居。火星的地形描述为

"一种假设的程序，该程序将由一个行星工程项目或一个并发项目组成，目的是将地球从敌对生命转变为地球生命，使其能够可持续地容纳人类和其他不受保护或调解的生命形

式。据推测，该过程将涉及通过各种资源密集型计划和安装一个或多个新型生态系统来恢复地球上现有的气候，大气和地表”（维基百科，2021年）。

预计实施马斯克的计划将需要10,000多枚核弹。核弹爆炸也会使火星具有放射性。马斯克想制造的核弹将由马斯克想要建造的1000艘飞船舰队运送到火星，类似于2020年12月9日爆炸的核弹。这样长时间的破坏将在地球上造成。

关键词：伊隆•马斯克（Elon Musk），Space-X，火星，地形，核武器，成本，道德，法律，地球。

Elon Musk, and his company SpaceX, has a plan to take control of Mars. They want to "terraform" the dusty red planet to make it green and livable like our Mother Earth.

The first time I can recall hearing about Terraforming Mars was years ago while on a speaking tour in Southern California. I picked up a copy of the *LA Times* and read an article about the Mars Society, which has dreams of moving our human civilization to this faraway planet. The article quoted Mars Society President Robert Zubrin (a Lockheed Martin executive) who called the Earth "a rotting, dying, stinking planet," and made the case for the transformation of Mars.

Imagine the cost. Why not instead spend money to heal our lush, beautiful, colorful home? What about the ethical considerations of humans deciding that another planet ought to be transformed for our "use?" What about the legal implications, as the United Nation's Outer Space Treaty forbids such egotistical domination plans?

I am immediately reminded of the *Star Trek* episode "Prime Directive." The Prime Directive, also known as Starfleet General Order 1, the Non-Interference Directive, was the embodiment of one of Starfleet's most important ethical principles: noninterference with other cultures and civilizations.

In other words, "Do no harm."

But Elon Musk wants to do big harm to Mars and whatever elemental life that might exist there.

In an article posted on CounterPunch, journalism professor Karl Grossman writes that Elon Musk, founder and CEO of SpaceX, has been touting the detonation of nuclear bombs on Mars, he says, "to transform it into an Earth-like planet."

As *Business Insider* further explains, *Musk* "has championed the idea of launching nuclear weapons just over Mars' poles since 2015. He believes it will help warm the planet and make it more hospitable for human life."

As space.com says: "The explosions would vaporize a fair chunk of

Mars' ice caps, liberating enough water vapor and carbon dioxide—both potent greenhouse gases—to warm up the planet substantially, the idea goes."

It's been projected that it would take more than 10,000 nuclear bombs to carry out Musk's plan. The nuclear bomb explosions would also render Mars radioactive. The nuclear bombs would be carried to Mars on the fleet of 1,000 Starships that Musk wants to build—similar to the one that blew up on December 9, 2020 (Figure 1).

Figure 1. SpaceX's Starship SNB prototype prior to exploding.
Image courtesy of SpaceX AFP via Getty Images

SpaceX also sells T-shirts emblazoned with the words "Nuke Mars."

Figure 2: Image courtesy of SpaceX product website

The fundamental UN treaty foundational to these questions is the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, or simply the "Outer Space Treaty." It was ratified in 1967, largely based on a set of legal principles the United Nations Office of Outer Space Affairs' (UNOOSA) general assembly accepted in 1962.

The treaty has several major points to it. Some of the key ones include:

- Space is free for all nations to explore, and sovereign claims cannot be made. Space activities must be for the benefit of all nations and humans. (So, nobody owns the moon or other planetary bodies.)

- Nuclear weapons and other weapons of mass destruction are not allowed in Earth orbit, on celestial bodies or in other outer-space locations. (In other words, peace is the only acceptable use of outer-space locations).

- Individual nations (states) are responsible for any damage their space objects cause. Individual nations are also responsible for all governmental and nongovernmental activities conducted by their citizens. These states must also "avoid harmful contamination" due to space activities.

Even NASA, which has been sending probes to Mars for many years, has stated that terraforming Mars is not possible. (NASA is most interested in mining operations on the Red Planet.) Their website states:

> Science fiction writers have long featured terraforming, the process of creating an Earth-like or habitable environment on another planet, in their stories. Scientists themselves have proposed terraforming to enable the long-term colonization of Mars. A solution common to both groups is to release carbon dioxide gas trapped in the Martian surface to thicken the atmosphere and act as a blanket to warm the planet.

However, Mars does not retain enough carbon dioxide that could practically be put back into the atmosphere to warm Mars, according to a new NASA-sponsored study. Transforming the inhospitable Martian environment into a place that astronauts could explore without life support, is not possible without technology well beyond today's capabilities.

In the end, Musk's call to "Occupy" and "Nuke" Mars could easily be described as typical "American exceptionalism" and supreme arrogance. His ambitions are mega-terrestrial and he seems to not understand how dangerous his ideas (like launching 10,000 nukes to Mars) really are to those of us still trying to survive on Earth, and to anyone who would be foolish enough to venture to Mars after such a mad scheme had taken place.

It is time for the adults in the room to sit the out-of-control and spoiled child down and inform him that he does not own the universe. No, Elon, you are not going to be the master of Mars.

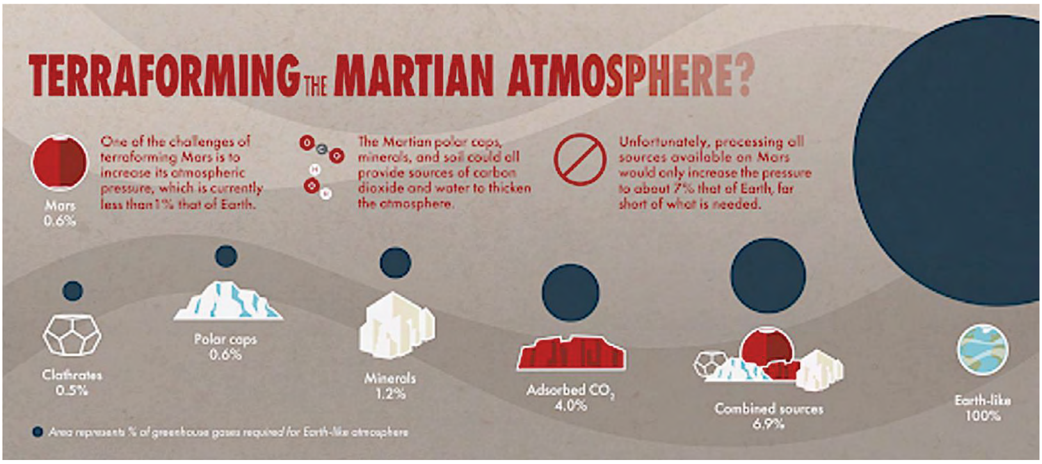

Figure 3. An infographic showing the various sources of carbon dioxide on Mars and their estimated contribution to Martian atmospheric pressure. Credits: NASA Goddard Space Flight Center.

Commentary: American Public University System: Nurturing Our Leaders and Future Leaders

Carl W. Starr
Mission Operations Manager for NASA's James Webb Space Telescope

Abstract

It is often a disaster or crisis that highlights our leaders and their leadership capabilities. Certainly, the current pandemic has caused us to scrutinize the abilities of our national and local leaders. How well or how bad a leader responded to the pandemic has become a benchmark for leadership evaluation. How are leaders created? Are they born to it? Sure, some required leadership skills are born from characteristic traits found in many people. These leadership characteristics include patience, caring, empathy, decisiveness, and efficient planning. What then, if they are born to it, but are never presented with an opportunity to actually lead? The answer is they remain in a state of potential.

Keywords: leaders, pandemic, COVID-19, leadership skills, characteristic traits, accountability, potential, forward-thinking, model

American Public University System: nutrir a nuestros líderes y futuros líderes

Resumen

A menudo es un desastre o una crisis que destaca a nuestros líderes y sus capacidades de liderazgo. Ciertamente, la pandemia actual nos ha llevado a escudriñar las habilidades de nuestros líderes nacionales y locales. Qué tan bien o qué tan mal respondió un líder a la pandemia se ha convertido en un punto de referencia para la evaluación del liderazgo. ¿Cómo se crean los líderes? ¿Han nacido para eso? Por supuesto, algunas habilidades de liderazgo necesarias nacen de rasgos característicos que se encuentran en muchas personas. Estas características de liderazgo incluyen paciencia, cuidado, empatía, decisión y planificación eficiente. Entonces, ¿qué pasa si nacen para ello, pero nunca se les presenta la oportunidad de liderar realmente? La respuesta es que permanecen en un estado de potencial.

doi: 10.18278/sesa.2.1.

Palabras clave: líderes, pandemia, COVID-19, habilidades de liderazgo, rasgos característicos, responsabilidad, potencial, con visión de futuro, modelo

美国公立大学系统：培养我们的未来领导者

摘要

通常，一场灾害或危机能突出我们的领导者及其领导能力。的确，当前的大流行让我们检视国家和地方领导者的能力。一名领导者的大流行响应举措有多好或多差已成为领导力评价的一个基准。领导者是如何诞生的？他们是天生的吗？从许多人中发现，一些必要的领导技能的确源于典型特征。这些领导力特征包括耐心、关爱、共情、决断力和高效规划。如果他们生来就具备这些特征，但从未获得机会发挥领导能力呢？答案是，他们保持处于潜在领导者的状态。

关键词：领导者，大流行，新冠肺炎（COVID-19），领导力技能，典型特征，问责，潜能，前瞻性思维，模范

Introduction

It is often a disaster or crisis that highlights our leaders and their leadership capabilities. Certainly, the current pandemic has caused us to scrutinize the abilities of our national and local leaders. How well or how bad a leader responded to the pandemic has become a benchmark for leadership evaluation. How are leaders created? Are they born to it? Sure, some required leadership skills are born from characteristic traits found in many people. These leadership characteristics include patience, caring, empathy, decisiveness, and efficient planning. What then, if they are born to it, but are never presented with an opportunity to actually lead? The answer is they remain in a state of potential.

Leaders Need Nurturing Too

New and current leaders must be nurtured if they are to grow and become effective. Especially now, in a pandemic, leaders are called upon to communicate, plan, organize, and implement solutions. Nurturing leaders and future leaders are exactly why American Public University System (APUS) matters. The University's core values of accessibility, innovation, integrity, learning, and quality can be seen as the building blocks for the leadership characteristics needed to effectively and bravely communicate challenges.

Thou Shalt Not Exclude

A good leader does not exclude. Rather, good leaders welcome all inputs and experiences to solve the problems at hand. By providing access to a diverse community, the University involves as many people as they can to make the educational experience accessible to all. The more inputs a leader has, the better decisions they can make. These decisions help drive innovation, which can be considered as *imaginative forward-thinking*. To be a good forward-thinker, one must think out of the box. That is, they must do what is not the norm. A forward-thinker does not look to merely get by. A forward-thinker challenges themselves and everyone around them to exceed expectations, which drives innovative ideas. Good leaders are compelled to explore new ideas and work out of their comfort zone.

Leaders Hold Themselves Accountable

Accountability in leadership ensures that individual leaders honor and respect the positions they hold because leadership can be revoked. Leaders must communicate and interact with their subordinates, peers, and their superiors. Discussion forums at APUS encourage and support interaction and communication. Forum interaction with instructors and other students provides a venue of fairness, honesty, and objectivity so that students learn to self-critique their own efforts. Since every leader is not always aware of their mistakes, self-critique and welcoming critiques from others allows leaders to better themselves.

Do As I *Say* and As I *Do*

Obtaining the characteristics of a good leader are only the first part of leadership. How does one, with good leadership characteristics, actually lead? The answer to the second part of leadership is to *set the example*. Setting the example means you conduct yourself above reproach and do not complain. Setting the example may sound easy but keeping that mindset throughout each day is a challenge. For example, it may be easy to tell your organization to wear a mask at all times, but you the leader must also wear a mask. Effective leadership means a leader makes informed decisions so that the organization continues to move forward. An example is after data are presented, true leaders inquire within the leadership body as a whole, and then, make a decision based upon the data.

Conclusion

In summary, there are many characteristics and traits that define a good leader. It is easy to recognize the good leaders from the bad ones, but it is much more important to encourage and promote the good leaders. The curricular format at APUS not only prepares students with the knowledge and skills to become a true leader in their field of expertise, the University enables leaders and future leaders to learn and interact with others in a respectful way—which seems to be a dwindling characteristic in the workplace and government, but can certainly be revived with the right education.

About the author: *Carl W. Starr is the Mission Operations Manager for NASA's James Webb Space Telescope. He leads a team of over 600 scientists and engineers in the execution of mission operations for the telescope.*

Commentary: Nukes in Space 2021

Karl Grossman
State University of New York/College at Old Westbury

Abstract

The use of nuclear in space is being pushed harder than ever. In July, an Associated Press dispatch declared the headline "US Eyes Building Nuclear Power Plants for Moon and Mars". Also in July, The White House National Space Council issued a strategy for space exploration that includes "nuclear propulsion methods." Additionally, "Space Policy Directive-6" was released by The White House last month titled "Strategy for Space Nuclear Power," elaborating on the U.S. desire for nuclear power and nuclear propulsion in space. And finally, Elon Musk, founder and CEO of SpaceX, has been touting the detonation of nuclear bombs on Mars to transform it into an "Earth-like planet." The rapid trajectory with which this growing support for nuclear in space, however, is quite concerning—especially given the potential of explosion whilst aboard a spacecraft, and even worse, the after effects on humans and the environment here on earth may experience. This article promotes the use of solar energy as an alternative.

Keywords: space, nukes, nuclear power, moon, mars, Elon Musk, SpaceX, solar energy

Comentario: armas nucleares en el espacio 2021

Resumen

El uso de la energía nuclear en el espacio se está presionando más que nunca. En julio, un despacho de Associated Press declaró el titular "Los ojos de EE.UU. están construyendo plantas de energía nuclear para la Luna y Marte". También en julio, el Consejo Nacional del Espacio de la Casa Blanca emitió una estrategia para la exploración espacial que incluye "métodos de propulsión nuclear". Además, la Casa Blanca publicó el mes pasado la "Directiva de política espacial-6" titulada "Estrategia para la energía nuclear espacial", que explica el deseo de Estados Unidos de disponer de energía nuclear y propulsión nuclear en el espacio. Y finalmente, Elon Musk, fundador y director ejecutivo de SpaceX, ha estado

doi: 10.18278/sesa.2.1.5

promocionando la detonación de bombas nucleares en Marte para transformarlo en un "planeta parecido a la Tierra". Sin embargo, la rápida trayectoria con la que este apoyo cada vez mayor a la energía nuclear en el espacio es bastante preocupante, especialmente dado el potencial de explosión a bordo de una nave espacial y, lo que es peor, las secuelas que pueden experimentar los seres humanos y el medio ambiente aquí en la Tierra. Este artículo promueve el uso de la energía solar como alternativa.

Palabras clave: espacio, armas nucleares, energía nuclear, luna, marte, Elon Musk, SpaceX, energía solar

评论文：2021年太空核武器

摘要

在太空中使用核能一事比以往任何时刻都更受到推动。2020年7月，一篇美联社报道宣布了标题为“美国考虑为月球和火星建设核电站”的文章 。同月，白宫国家太空委员会宣布一项太空探索战略，该战略包括“核动力推进方法”。此外，白宫于2020年12月披露了名为“太空核电战略”的“太空政策指令-6”，详细描述了美国对太空中的核电及核动力推动的渴望。最后，SpaceX的创始人兼首席执行官伊隆·马斯克（Elon Musk）一直在兜售对火星引爆核弹，以期将其转变为“像地球一样的星球”。不过，支持在太空中使用核能一事的快速增长轨迹令人十分担忧—尤其鉴于在飞行器中操作爆炸的潜在后果，甚至更坏的是，地球上人类和环境可能承担的后果。本文支持将太阳能作为替代物。

关键词：太空，核武器，核电，月球，火星，伊隆·马斯克（Elon Musk），SpaceX，太阳能

On its website, SpaceX sells t-shirts emblazoned with the words "Nuke Mars." Business Insider explains, Musk "believes it will help warm the planet and make it more hospitable for human life." As space.com similarly reports, "The explosions would vaporize a fair chunk of Mars' ice caps, liberating enough water vapor and carbon dioxide ... to warm up the planet substantially, the idea goes."

It has been projected that it would take more than 10,000 nuclear bombs to carry out the Musk plan. The nuclear bomb explosions would render Mars radioactive. The nuclear bombs would be carried to Mars on the fleet of 1,000 Starships that Musk wants to build—like the one that blew up in a fireball in December. "Fortunately," reported NBC's Nightly News host Lester Holt, "no one was aboard."

But *what if* nuclear materials had been aboard? *What if* one or more of those hydrogen bombs were aboard? *What if* a nuclear reactor which was supposed to be delivered to the Moon or Mars was aboard?

Be Careful What You Ask

My interest in nuclear space issues began 35 years ago from reading a U.S. Department of Energy newsletter about two space shuttles: the Challenger, which was to be launched the following year with plutonium aboard, and Atlantis.

The plutonium aboard the shuttles in 1986 was intended to be used as fuel in radioisotope thermoelectric generators (RTGs) that were meant to provide a small amount of electric power for instruments on space probes released from the shuttles once they achieved orbit.

Referring to the U.S. Freedom of Information Act as support, I asked myself what the consequences would be for an accident in the lower or upper atmospheres or an accident on launch—and the impacts of the dispersal of deadly plutonium. A few years earlier, I authored Cover Up: What You Are Not Supposed to Know About Nuclear Power, so I was quite familiar with plutonium—which is considered the most lethal radioactive substance

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"I contacted The Nation *magazine and asked whether they were aware that the next launch of the Challenger was directed as a nuclear mission. Shockingly, they did not. "*

—Karl Grossman

Searching for Answers

For ten months there was a stonewall of challenges to my FOIA request by DOE and NASA. Upon finally receiving the information, though heavily redacted, they responded that the likelihood of a shuttle accident releasing plutonium was "small." One document stated that:

"The risk would be small due to the high reliability inherent in the design of the Space Shuttle." NASA placed the odds of a catastrophic shuttle accident at one-in-100,000.

Then, on January 28, 1986, the Challenger blew up.

It was on its next mission, in May 1986, that it was slated to include a plutonium-fueled RTG aboard. I contacted The Nation magazine and asked whether they were aware that the next launch of the Challenger was to be a nuclear mission. They were not.

As this was a terrifying surprise to both of us, *The Nation* suggested that I author a front-page editorial to expose what we entitled "*The Lethal Shuttle.*"

> *"I found that accidents involving the use of nuclear power in space is not a 'sky-is-falling' threat."*
>
> *—Karl Grossman*

The editorial began, "Far more than seven people could have died if the explosion that destroyed Challenger had occurred during the next launch ...."

Incidentally, later in 1986, NASA drastically increased the odds of a catastrophic shuttle accident to one-in-76. It turned out the one-in-100,000 estimate was based on dubious guessing.

I found that accidents involving the use of nuclear power in space is not a "sky-is-falling" threat. Out of 26 U.S. space nuclear missions, there had been three accidents—the worst in 1964 involving a satellite which was powered by a SNAP 9-A radioisotope thermoelectric generator fueled with plutonium. The satellite disintegrated into the atmosphere as it came crashing back down to Earth—its plutonium dispersing as dust extensively on Earth. Dr. John Gofman, an M.D. and Ph.D., professor of medical physics at the University of California at Berkeley, formerly associate director of Lawrence Livermore National Laboratory, author of *Poisoned Power*, and involved in early studies of plutonium, long pointed to the SNAP 9-A accident as causing an increase in lung cancer on Earth.

The Writing on the Wall

The connection was becoming quite clear between NASA's use of nuclear power in space and the weaponization of space. The Ronald Reagan "Star Wars" scheme of the 1980s was predicated on orbiting battle platforms with nuclear reactors or "super" plutonium systems providing the power for hypervelocity guns, particle beams, and laser weapons. As declared Lieutenant General James Abramson, head of former president Ronald Reagan's "Star Wars" (formally called the Strategic Defense Initiative), "without reactors in orbit [there is] going to be a long, long light [extension] cord that goes down to the surface of the Earth" to power space weapons. NASA, although organized as a civilian agency, soon understood where the money exists in Washington, D.C.—the Pentagon. And over decades, has coordinated activities with the U.S. military.

> *"Without reactors in orbit [there is] going to be a long, long light [extension] cord that goes down to the surface of the Earth" [to power space weapons].*
>
> *—Lieutenant General James Abramson*

Alternatives to Nuclear Space

As more and more research has been conducted on this important topic, other alternatives to nuclear reactors on Mars and the Moon, have emerged. Here are some examples from both print and digital media documenting this new development:

- Solar power could provide all the energy for would-be settlements, reporting the headline in Universe

Today: "Solar Power is Best for Mars Colonies." The extensive article states how "a NASA-sponsored MIT think-tank has weighed up the future energy needs of a manned settlement on Mars and arrived at an interesting conclusion … solar arrays might function just as well, if not better, than the nuclear options."

- A Discover magazine piece, "How to Harvest Terawatts of Solar Power on the Moon," reported that Japanese corporation, Shimizu, were "gearing up to develop solar power on the Moon." The "photovoltaic cells themselves could be tissue thin, since the moon has no weather or air," said the article, "and half of the Moon is in sunlight at any one time." A huge amount of solar power energy could be generated on the Moon that could be beamed back to Earth, it related.

- *Popular Mechanics* headlined an article in November, "The Thermal Nuclear Engine That Could Get Us to Mars in Just 3 Months," which stated that promoters of nuclear propulsion claim it would get astronauts to Mars quicker.

Meanwhile, General Atomics Electromagnetic Systems developed a design for a nuclear propulsion reactor for trips to Mars.

As to the use of nuclear power for propulsion in space, I have written many pieces about a particular solar alternative: solar sails. In October, the *New Scientist* in October published a comprehensive piece entitled "The new age of sail." The subheading following with: "We are on the cusp of a new type of space travel that can take us to places no rocket could ever visit."

The article begins by discussing 17th Century astronomer Johanne Kepler's observation of comets and discovering "that their tails always pointed away from the sun, no matter which direction they were traveling." To Kepler, it meant only one thing: "[T]he comet tails were being blown from the sun." I further explain in the piece that, indeed, "the sun produces a wind in space" and "it can be harnessed. First, there are particles of light streaming from the sun constantly, each carrying a tiny bit of momentum. Second, there is a flow of charged particles, mostly protons and electrons, also moving outwards from the sun. We call the charged particles the solar wind, but both streams are blowing a gale—that's in the vacuum of space."

Japan launched its Ikaros spacecraft in 2010—sailing in space using this alternative solar energy from the sun. Last year, the LightSail 2 mission of The Planetary Society was launched—and it continues to remain in space, flying with the sun's energy.

New systems using solar power are being developed—past the current use of thin film such as Mylar for solar sails. The *New Scientist* article spoke of scientists "who want to use these new techniques to set a course for worlds currently far beyond our reach—namely the planets orbiting our nearest star, Alpha Centauri."

In terms of RTGs and their generation of electricity, in 2011 NASA launched the Juno space probe to Jupiter–which instead used three solar arrays to generate onboard electricity. Juno also remains in space, orbiting and studying Jupiter, where sunlight is a hundredth of what it is on Earth.

“The Elon Musk plan to explode 10,000 nukes over Mars epitomizes the insanity of this rush to move nuclear power into space.”

—Bruce Gagnon, Coordinator Global Network Against Power in Space

After the SNAP 9-A disaster, NASA stopped using RTGs for satellites and was instrumental in developing solar photovoltaic technology. All satellites launched today use solar—as does the International Space Station.

With the rocky transition between former U.S. President Donald Trump, and current President Joe Biden, one compelling question remains: *Will there be change in its use of nuclear power in space*? This very question was posed on the cover of the November 16, 2020 edition *Space News* entitled, “JOE BIDEN’S TURN, WHAT’S IN STORE FOR NASA & SPACE FORCE?”

It is no secret that President Biden is an advocate of “advanced” nuclear power, and a large segment of fellow members of the Democratic Party voted in the U.S. House of Representatives and Senate in 2019 for formation of a U.S. Space Force. The *Space News* cover article quoted a statement from the Washington aerospace and defense-consulting firm, Velos, that “’Biden has ‘expressed no plans for structural changes to U.S. space programs ... the Democratic Party national platform supports continuity within NASA and the Space Force.’”

The leading group since 1992 challenging the use of nuclear power in space is the Global Network Against Weapons and Nuclear Power in Space. The organization’s long-time coordinator, Bruce Gagnon (who also shares an article in the current issue of *SESA*), comments: “The Elon Musk plan to explode 10,000 nukes over Mars epitomizes the insanity of this rush to move nuclear power into space. The Department of Energy, which would be responsible for fabricating all of these various nuclear devices being considered for space operations, has a long, tragic record of worker and environmental contamination at their string of labs around the nation. Take, for example, the 1997 launch of the Cassini space probe that carried 72 pounds of toxic plutonium-238 aboard, Gagnon continues, “just prior to the launch, it was reported that Los Alamos National Laboratory in New Mexico had 244 cases of worker contamination while fabricating the plutonium generators for that mission. So, it is not just some theoretical equation that there might be some accident upon launch. The nuclear production process is killing us before any rocket lifts off from a launch pad.”

Gagnon further explains that “the plan to build nuclear-powered rockets to Mars, nuclear mining colonies on the planetary bodies and ultimately nuclear-powered weapons in space all signal the dangers and lunacy of those driving this mad rush to colonize space." These space entrepreneurs and the nuclear/military industrial complex have learned nothing since the atomic bombs were exploded over the heads of the people of Hiroshima and Nagasaki."

Exploring Space in the Spirit of Kinship

Michelle Hanlon

University of Mississippi School of Law

Abstract

Clearly, it has proven difficult for the international community to agree on space governance matters. However, the nations of the world have proved unanimous support of the protection of human heritage. There is no heritage more universal than lunar landing sites on the Moon, which represent both a milestone in human evolution and development, as well as the culmination of the work of humans throughout the world and throughout history. The human relationship to space is necessarily global and universal. "The famous Earthrise image, taken by astronaut William Anders in 1968 during the Apollo 8 mission, was perhaps the most influential environmental photo ever and has taught us humility as we understand our very precious space in our solar system." Few would argue that the site where humans first set foot on another celestial body should be recognized and protected less than any site on Earth. However, presently, the extraction and sale of space resources by private companies for their own profit. Since 2015, the United States has been instigating—on a bipartisan basis—an effort to address a lacuna in international space law and assure that commercial space mining companies may retain such property rights in the minerals and elements they extract from the Moon and other celestial bodies, as to be able to sell the resources to others for their own profit. With this in mind, this article implores the international community, through COPUOS, to initiate important processes to include reaching agreements on how to protect humanity's greatest treasure in space.

Keywords: space, exploring, kinship, space resources, international space law, property rights, minerals, elements, Moon

Explorando el espacio en el espíritu del parentesco

Resumen

Claramente, ha resultado difícil para la comunidad internacional ponerse de acuerdo sobre cuestiones de gobernanza espacial. Sin embargo, las naciones del mundo han demostrado un apoyo uná-

doi: 10.18278/sesa.2.1.6

nime a la protección del patrimonio humano. Y no hay herencia más universal que los lugares de aterrizaje lunar en la Luna, que representan tanto un hito en la evolución y el desarrollo humanos, como la culminación del trabajo de los humanos en todo el mundo y a lo largo de la historia. La relación humana con el espacio es necesariamente global y universal. "La famosa imagen de Earthrise, tomada por el astronauta William Anders en 1968 durante la misión Apolo 8, fue quizás la foto ambiental más influyente de la historia y nos ha enseñado la humildad al comprender nuestro precioso espacio en nuestro sistema solar". Pocos argumentarían que el sitio donde los humanos pisaron por primera vez otro cuerpo celeste debería ser reconocido y protegido menos que cualquier sitio en la Tierra. Sin embargo, en la actualidad, la extracción y venta de recursos espaciales por parte de empresas privadas para su propio beneficio. Desde 2015, Estados Unidos ha estado instigando, de forma bipartidista, un esfuerzo para abordar una laguna en el derecho espacial internacional y asegurar que las empresas comerciales de minería espacial puedan retener dichos derechos de propiedad sobre los minerales y elementos que extraen de la Luna y otros elementos celestes. cuerpos. como poder vender los recursos a otros para su propio beneficio. Con esto en mente, este artículo implora a la comunidad internacional, a través de COPUOS, que inicie procesos importantes que incluyan el logro de acuerdos sobre cómo proteger el mayor tesoro de la humanidad en el espacio.

Palabras clave: espacio, exploración, parentesco, recursos espaciales, derecho espacial internacional, derechos de propiedad, minerales, elementos, Luna

本着亲属的精神探索太空

摘要

清晰的是，对国际社区而言，就太空治理事务达成一致是困难的。不过，世界各国都对人类遗产保护表示一致支持。并且，没有什么遗产比月球登陆点更具有全体性，它代表了人类演变和发展中的里程碑，并且是贯穿世界和历史的人类行动顶点。人类与太空的关系必定具有全球性和全体性。"1968年，宇航员威廉·安德斯在执行阿波罗8号任务时拍摄的著名的地球升起图像，可能是至今最具影响力的环境图片，它让我们感到自身的渺小，当我们理解自身在太阳系中的准确位置时。"　几乎没有人会主张，人类在另一星球

上的首次登陆点应受到的认可和保护要比地球上的任意地点要少。不过，私人公司现在为一己之利而挖掘并出售太空资源。自2015年起，美国就开始煽动—在两党的基础上—应对国际空间法中的空白，并保证商业太空开采公司能保有从月球或其他星球上挖掘的矿物质及元素的所有权，进而能为获取一己之利将资源出售给他人。鉴于此，本文恳求国际社区通过和平利用外层空间委员会（COPUOS）发起重要程序，将"就如何保护人类最伟大的空间宝藏达成一致"包括在内。

关键词：太空，探索，亲属，太空资源，国际空间法，所有权，矿物质，元素，月球

I. Introduction

On September 10, 2020, Jim Bridenstine, Administer of the United States (US) National Aeronautics and Space Administration (NASA) revealed on Twitter that the NASA "is buying lunar soil from a commercial provider!"[1] Indeed, NASA announced that it will purchase 50g to 500g of lunar regolith, the equivalent of "three tablespoons to 2.5 cups," for which it "will pay between $15,000 and $25,000."[2] Hardly seems a trade to get excited about, especially when one considers that in 1993, just ".2 grams of lunar soil ... sold for $442,500."[3] Moreover, this will be an "in-place" transfer, meaning it will take place on the lunar surface.[4] Why the fanfare? Because this purely symbolic transaction seeks to set a controversial legal norm—namely, allowing the extraction and sale of space resources by private companies for profit. Since 2015, the United States has been instigating—on a bipartisan basis—an effort to address a lacuna in international space law and assure that commercial space mining companies may retain such property rights in the minerals and elements they extract from the Moon and other celestial bod-

1 Jim Bridenstine (@JimBridenstine), Twitter (Sep. 10, 2020, 8:31 AM, https://twitter.com/JimBridenstine/status/1304049845309669376

2 Cat Hofacker, *NASA Plans to Pay Companies to Extract Tablespoons of Lunar Regolith,*" Aerospace America (Sep. 10, 2020), https://aerospaceamerica.aiaa.org/nasa-plans-to-pay-companies-to-extract-teaspoons-of-lunar-regolith/#:~:text=NASA%20will%20pay%20between%20%2415%2C000,is%20turned%20over%20to%20NASA.

3 *How Much is That Vial of Moon Dust Really Worth?*, Tampa Bay Times (June 13, 2018), https://www.tampabay.com/news/science/How-much-is-that-vial-of-moon-dust-really-worth-_169133643/#:~:text=NASA%20assessed%20the%20value%20of,a%20gram%20in%20today's%20currency.

4 Jim Bridenstine, *Space Resources Are the Key to Safe and Sustainable Lunar Exploration,* NASA.Gov, (Sep. 10, 2020), https://blogs.nasa.gov/bridenstine/2020/09/10/space-resources-are-the-key-to-safe-and-sustainable-lunar-exploration/.

ies as to be able to sell the resources to others for their own profit.

International space law was born as a subset of public international law in 1963, when the United Nations General Assembly adopted a Declaration of Legal Principle Governing the Activities of States in the Exploration and Use of Outer Space.[5] The Declaration captured nine important principles which were ultimately carried into the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies[6] (the Outer Space Treaty), ratified in 1967. The Outer Space Treaty is often referred to as the *Magna Carta* of space and indeed as its name suggests, it offers only Guidelines and Principles—general "ground rules"[7]—rather than clear and specific rules and regulations. Thus, it is not surprising that the Treaty contains many gray areas, gaps and even internal inconsistencies. Chief among the open questions is the interpretation of Article II of the Outer Space Treaty which states in full: "Outer space, including the Moon and other celestial bodies is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."[8] While the international community largely agrees this means that no sovereign may make a claim to extraterrestrial territory, the question remains as to the status of resources extracted from such territory. Moreover, the provision is softened, some might say undercut, by following articles in the Treaty which indicate that States shall give "due regard"[9] to the activities of others in space, suggesting that some sort of right is to be respected.

There remains fundamental disagreement regarding how to implement an international regime to regulate the utilization of space resources. It is without question that the decisions made today will have far-reaching implications in respect to successful and sustainable exploration and use of space. But how permissive should it be? Some would argue space is a global commons and that all resources should be shared, precluding private sale. Other, of course, take the opposite approach, arguing space resources are open and available for the taking and any regulations would hinder innovation and possible slow or halt space resource extraction projects. This article does not offer an answer. It provides a path. Rather than starting at opposite ends of the spectrum, the international community should start with a concept that has already been accepted and honored by virtually every nation on Earth: the protection of cultural her-

5 G.A. Res. 1962 (XVIII) (Dec. 13, 1963).

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

7 Valentina Vecchio, *Customary International Law in the Outer Space Treaty,* 3 German Journal of Space Law 66, 501 (2017).

8 Outer Space Treaty, *supra* note 6, art. II.

9 *Id.* art. IX.

itage. The first step to consensus is to identify sites in space that the international community can agree need special recognition and use that agreement as a baseline to establish recognizable norms to balance the non-appropriation and due regard standards imposed by the Outer Space Treaty. Part II provides a summary and review of relevant portions of international space law. Part III discusses the importance of protecting cultural heritage and draws attention to efforts implemented on Earth. Part IV briefly summarizes current debate regarding property rights and resource utilization. Part V offers a new approach to the implementation of a governance model for space and Part VI provides some concluding thoughts.

II. The Outer Space Treaty Regime

A. The United Nations Committee on the Peaceful Uses of Outer Space

In October 1957, Sputnik 1 became the first human-made object to reach space.[10] Shortly thereafter, the United Nations (UN), "*[r]ecognizing* the common interest of [hu]mankind in outer space ... and that it is the common aim that outer space should be used for peaceful purposes [and] *[w]ishing* to avoid the extension of present national rivalries in this new field,"[11] created an ad hoc committee to, among other things, report on the "nature of legal problems which may arise in the carrying out of programmes to explore outer space."[12] The Committee on the Peaceful Uses of Outer Space (COPUOS) was made a permanent body in 1959.[13] COPUOS was the backdrop for negotiation and implementation the treaties which today govern space activities. Four other treaties related to sovereign space activities were negotiated in the wake of the Outer Space Treaty, colloquially known as the Rescue Agreement,[14] the Liability Convention,[15] the Registration Convention,[16] and the Moon Agreement.[17] As their names suggest, these agreements respectively offer more detailed guidance on how States should act in relation to the rescue of astronauts; responsibility and liability for damage caused by space objects; and the registration of objects launched or intended to be launched

10 *Sputnik 1,* NASA.Gov, https://www.nasa.gov/multimedia/imagegallery/image_feature_924.html

11 U.N.G.A. Res. 1348 (XIII) (Dec. 13, 1958).

12 *Id.*

13 U.N.G.A. Res. 1472 (XIV) (Dec. 12, 1959).

14 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, Apr. 22, 1968, 672 U.N.T.S. 119.

15 Convention on International Liability for Damage Caused by Space Objects arts. II-III, Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 [hereinafter Liability Convention].

16 Convention on Registration of Objects Launched into Outer Space art. I, Jan. 14, 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15.

17 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, Dec. 18, 1979, 1363 U.N.T.S. 3 [hereinafter Moon Agreement].

into orbit. The Moon Agreement, which suggests that States should consider developing a regulatory regime to govern lunar resource mining when such activity is likely to occur, has been ratified by only eighteen States. None of China, the U.S., or Russia has done so. And indeed, in April 2020, the US president released an Executive Order which made clear both: 1) the US unwillingness to enter into the Moon Agreement; and 2) the U.S. strategy to object to "any attempt to ... treat the Moon Agreement as reflecting or otherwise expressing customary international law."[18]

Negotiated during the Cold War essentially by the world's two superpowers, the four widely ratified treaties reflect a remarkable—and to date successful—détente. The overriding concern was, as the name of the COPUOS suggests, peace. As they hammered out the *Magna Carta* for peace in space, the negotiators cannot be faulted for not considering an environment where, as today, private entities could perform all the space activities once reserved for State actors—and very few State actors at that. As a result, peace, collaboration and freedom[19] are the regime's key principles while more mundane matters, including cultural heritage preservation and private resource mining and utilization are unaddressed.

That said, the activities of private entities are not entirely overlooked. Article VI of the Outer Space Treaty makes it quite clear that States bear "international responsibility for national activities in outer space ... whether such activities are carried on by governmental agencies or by non-governmental entities."[20] The Article further indicates that States must assure that all "national activities are carried out in conformity with the provisions set forth"[21] in the Treaty.

B. Appropriation "By Any Other Means"

Article II of the Outer Space Treaty indicates that "[o]uter space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation or by any other means."[22] It is a principal so embedded in the bedrock of space exploration as to be considered by many to be not just a treaty obligation but customary international law.[23] However, the concept of "by any

18 Exec. Order No. 13914, 85 Fed. Reg. 20,381 (Apr. 6, 2020), https://www.govinfo.gov/content/pkg/FR-2020-04-10/pdf/2020-07800.pdf.

19 The first Article encompasses three foundational aspects of all space activities: the exploration and use of space is the "province" of all humankind; space, including the Moon and other celestial bodies "shall be free for exploration and use by all States;" and "States shall facilitate and encourage international co-operation" in scientific investigation. Outer Space Treaty, *supra* note 6, art. I. Article IV avers that "the Moon and other celestial bodies shall be used ... exclusively for peaceful purposes." *Id.* art IV.

20 *Id.* art VI.

21 *Id.*

22 *Id.* art II.

23 Fabio Tronchetti, The Non-Appropriation Principle Under Attack: Using Article II of the Outer

other means" conflicts with other provisions of the Treaty. Pursuant to Article VIII, objects left in space remain under the ownership and control of the State that put them there.[24] In fact, pursuant to Article VII of the Outer Space Treaty and Article III of the Liability Convention, States are "internationally liable" for damage caused to an object in space belonging to another State.[25] Yet leaving the objects *in situ*, or giving them wide berth in order to avoid liability, essentially results in perpetual occupation of the surface upon which they rest. Certainly, this runs afoul of the non-appropriation principle encapsulated in Article II.

C. Due Regard

In addition, Article IX of the Outer Space Treaty requires all activities in outer space be conducted with "due regard" to the corresponding interests of other States,[26] which suggests that States should not interfere with or otherwise despoil the objects of another. But "due regard" is a standard that remains undefined. It is also used in the United Nations Convention on the Law of the Sea which states that freedom of the high seas "shall be exercised by all States with due regard for the interests of the other states in their exercise of the freedom of the high seas."[27] An arbitral tribunal considered the meaning of "due regard" in 2015 and determined that:

> the ordinary meaning of "due regard" calls for the [first State] to have such regard for the rights of [the second State] as is called for by the circumstances and by the nature of those rights. *The Tribunal declines to find in this formulation any universal rule of conduct.* The Convention does not impose a uniform obligation to avoid any impairment of [the second State's] rights; nor does it uniformly permit the [first State] to proceed as it wishes, merely noting such rights. *Rather, the extent of the regard required by the Convention will depend upon the nature of the rights held by [the second State], their importance, the extent of the anticipated impairment, the nature and importance of the activities contemplated by the [first State], and the availability of alternative approaches.*[28] (emphasis added)

Space Treaty in Its Defence, 50 Proc. L. Outer Space 526, 530 (2007).

24 Outer Space Treaty, *supra* note 6, art. VIII.

25 *Id.* art. VII. Liability Convention, *supra* note 15, art. III. To compound matters, both the Outer Space Treaty and Liability Convention liability is not based on ownership of the object, but on status as a so-called "launching state." Per the treaty regime, any one of four States may be considered a "launching State" for liability purposes: 1) the State which launches; 2) the State which procured the launch; 3) the State from whose territory the object was launched; and 4) the State from whose facility the object was launched. Liability Convention, *supra* note 15, art. I.

26 *Id.* art. IX.

27 United Nations Convention on the Law of the Sea art. 87(2), Dec. 10, 1982, 3 U.N.T.S 1833.

28 The Chagos Marine Protected Area Arbitration (Mauritius v. U.K.), Case No. 2011-03, Award,

Under this interpretation, "due regard" requires a balancing test, taking into consideration the rights of the State that have been impinged by the contested activity, the extent of the impairment, the nature and importance of the contested activity, and the availability of alternative approaches. This balance will produce different outcomes on a case-by-case basis, an uncertainty which in and of itself is enough to make States and their nationals consider carefully their international obligations in respect of space activities.

There are already many objects on the Moon, Mars and other celestial bodies—and soon to be many more. What does it mean to show those objects "due regard?" Arguably, when approaching an object which is conducting scientific experiments or undertaking commercial activity, showing "due regard" would require maintaining a certain distance to assure the activity is not affected either directly or indirectly by another actor.

But what does it mean for non-operational objects? In the one extreme, they can be treated the same as operative objects and given wide-berth. But then, arguably, a State is violating Article II of the Outer Space Treaty by keeping its non-operational objects strewn about the Moon and other celestial bodies and thereby claiming territory by an "other means." On the other extreme, because the objects are non-operational, it is not possible to do harm to them, so they may be removed from their resting areas and, ostensibly, returned to their owners. But what if the object is a cultural artifact with unquestionable historic significance? Imagine if objects found at the site where Luna 2—the first human made object to impact another celestial body lies, or Mare Tranquillitatis—the site where humans took their first off-world footsteps—were removed by private entities? Even if they were returned to Russia and the U.S. respectively, scores of details that belong on the historical record would be irretrievably lost.

And what about the first bootprints ever left by humans on another celestial body? Unlike their counterparts on Earth, cultural heritage and sites in space enjoy no protection whatsoever under any law.

III. Protecting Human Heritage

A. A Cradle of Civilization

In April 1959, the Egyptian Minister of Culture contacted the United Nations Educational Scientific and Cultural Organization (UNESCO)[29] with an "agonizing dilemma." In order to promote and accelerate industrialization and the modernization of its economy, Egypt needed to harness the power of the Nile River.[30] Unfortunately, the plan to build what is now known as the Aswan High Dam would result in the creation of a

¶ 519 (Perm. Ct. Arb. 2015).

29 Fekri A. Hassan, *The Aswan High Dam and the International Rescue Nubia Campaign*, 24 The African Archaeological Rev., 73, 79 (September/December 2007).

30 *Id.* at 75.

vast lake which would assure the obliteration of 3,000 year-old temples and monuments—footprints of an ancient civilization known as Nubia.[31] In October of that same year, the Sudan sent a similar plea to UNESCO.[32] Neither country had the money or the capability to protect these historic sites.

The response was swift. UNESCO spearheaded a global international effort to rescue the Nubian heritage that its Director-General, Vittorino Veronese, knew humanity could not afford to lose. As Veronese himself noted,

1. It is not easy to choose between heritage and the present well-being of people.
2. Treasures of unrivalled value are entitled to universal protection.
3. The rescue operations will not just preserve something which may otherwise be lost but will, in addition, bring to light to as yet undiscovered wealth for the benefit of all.[33]

It became the greatest archaeological rescue operation of all time. Even as humans waged a bitterly Cold War, raced to the Moon and fought for civil rights, the call to preserve our history was not ignored. It is estimated that US$80 million was raised from 47 UNESCO-member nations and a number of private entities from around the globe.[34] International panels of experts from five continents convened to develop and then implement strategies to save 23 temples and architectural complexes—some of them relocated brick by brick.[35] In short, the international community came together to save treasures they recognized belonged, not just to Egypt or the Sudan, but to humanity as a whole.

In the words of UNESCO Director-General Amadou-Mahter M'Bow, the International Rescue Nubia Campaign "will be numbered among the few major attempts made in our lifetime by the nations to assume their common responsibility towards the past so as to move forward in a spirit of brotherhood towards the future."[36]

B. The World Heritage Convention Protects Outstanding Universal Value

The success of the Nubia Campaign spawned other campaigns to save monuments of universal value including, among others, Venice and its Lagoon in Italy, the Archaeological Ruins of Moenjodaro in Pakistan and the Borobodur Temple Compounds in Indonesia.[37] More important, the Nubia Campaign created the foundation for

31 Veronese, *supra* note 11.

32 Hassan, *supra* note 12 at 82.

33 *Id.* at 80.

34 *Id.* at 83-4.

35 *Id.* at 84.

36 Amadou-Mahtar M'Bow, *A Single, Universal Heritage,* The UNESCO Courier, 4 (March 1980).

37 Hasan, *supra* note 12 at 89.

an international convention on world heritage—a convention that builds and strengthens what the Honorable Russell E. Train, who has been called a "founding father of the World Heritage Convention,"[38] identified as "a sense of kinship with one another as part of a single, global community."[39] Formally titled the Convention Concerning the Protection of the World Cultural and Natural Heritage,[40] the Convention was adopted on November 16, 1972. With 194 States Parties, it ranks as one of the most-ratified international treaties.[41] That means nearly every nation on Earth agrees "that deterioration or disappearance of any item of the cultural or natural heritage constitutes a harmful impoverishment of the heritage of all the nations of the world ...[42] and that collective effort must be undertaken to protect cultural heritage of "outstanding universal value."[43]

The World Heritage Convention defines cultural heritage as, among other things, "works of [hu]man or the combined works of nature and[hu]man, and areas including archaeological sites which are of outstanding universal value from the historical, aesthetic, ethnological or anthropological point of view."[44] Outstanding universal value is further defined as having significance "which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity. As such, the permanent protection of this heritage is of the highest importance to the international community as a whole."[45]

The Operational Guidelines for the Implementation of the World Heritage Convention[46] (Heritage Guidelines) provide even more specific guidance. In order to be considered to have Outstanding Universal Value, the site or property must meet on or more of ten specific criteria including:

> (i) represent a masterpiece of human creative genius
>
> (ii) exhibit an important interchange of human values, over a span of time or within a

38 *The Director-General Pays Tribute to Leading US Conservationist and One of the Fathers of the World Heritage Convention*, UNESCO.org, https://whc.unesco.org/en/news/939 (last visited Aug. 30, 2020).

39 *Abu Simbel: The Campaign That Revolutionized the International Approach to Safeguarding Heritage,* UNESCO.org, https://en.unesco.org/70years/abu_simbel_safeguarding_heritage (last visited Aug. 30, 2020).

40 Convention Concerning the Protection of the World Cultural and Natural Heritage, Nov. 16, 1972, 27 U.S.T. 37, 1037 U.N.T.S. 151 [hereinafter World Heritage Convention].

41 https://whc.unesco.org/en/statesparties/

42 World Heritage Convention, *supra* note 40 at Preamble.

43 *Id.*

44 *Id.* art. 1.

45 Operation Guidelines for the Implementation of the World Heritage Convention, ¶49 (July 10, 2019).

46 Operation Guidelines for the Implementation of the World Heritage Convention, (July 10, 2019).

> cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design;
>
> (iii) bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared;
>
> (iv) be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history; ...[47]

Moreover, the Heritage Guidelines anticipate the recognition of cultural landscapes: "[c]ultural properties [that] represent the "combined works of nature and [hu]man . . . [that] are illustrative of the evolution of human society and settlement over time, under the influence of physical constraints ...[48]

C. Sites of Outstanding Universal Value on the Moon?

It is estimated that there are more than one hundred sites on the Moon that host evidence of human behavior.[49] They each bear witness to humankind's ingenuity and confirm our species as "natural wanderers, the inheritors of an exploring ... bent that is deeply embedded in our evolutionary past."[50] While this predisposition to explore is not unique to homo sapiens, "[w]hat makes us different from other expansionary species is our ability to adapt to new habitats through technology: We invent tools and devices that enable us to spread into areas for which we are not biologically adopted."[51]

Dirk Spanneman suggests that we should "sketch human evolution as a sequence of key psychological and technological developments."[52] Of course, it starts with the ability to walk on two limbs instead of four, freeing hands to craft tools and carry those tools, as well as food, from place to place. Other milestones include:

> overcoming the fear of fire innate to animals and developing control of it as a tool (some 300,000 years ago): overcoming the fear of stretches of open water innate to primates (some 60,000+ years ago); transmission of complex

47 *Id.* ¶77.

48 *Id.* ¶47.

49 Michelle L.D. Hanlon, *Apollo 11 Brought a Message of Peace to the Moon – but Neil and Buzz Almost Forgot to Leave it Behind,* The Conversation, https://theconversation.com/apollo-11-brought-a-message-of-peace-to-the-moon-but-neil-and-buzz-almost-forgot-to-leave-it-behind-112851#:~:text=More%20than%20one%20hundred%20sites&text=There%20are%20more%20than%20a,experiments%2C%20they%20hold%20invaluable%20data.

50 Ben R. Finney & Eric M. Jones, *The Exploring Animal, in* Interstellar Migration and the Human Experience 15, 15 (Ben R. Finney & Eric M. Jones, eds. 1985).

51 Ben R. Finney & Eric M. Jones, *supra* note 41, 15

52 Dirk H.R. Spennemann, *The Eithcs of Treading on Neil Armstrong's Footprints,* 20 Space Policy 279, 283 (2004).

> thought by means of language (some 30,000 years ago as evidenced by complex rock art); becoming cognizant of not being controlled by nature but of our own ability to control it (through domestication of animals and plants, some 9,000–12,000 years ago); and being cognisant of our ability to destroy our planet (first deployment of an atomic bomb, 1945).[53]

"Having humans leaving this planet and stepping onto Moon," Spanneman continues, "ranks among these key developments."[54]

Even more, throughout our evolution, we have compounded our learning across cultures and centuries, developing and perfecting tools as they are distributed through diverse societies.[55] We know this because of the cultural artifacts we have found around the globe. Take, for example, the Ishango bone, a 20,000-year-old baboon fibula recovered in what is today the Democratic Republic of the Congo.[56] Originally believed to be just a tally stick, its three columns of deliberate marks running its length are now thought to indicate an understanding of various mathematical relationships and perhaps "the first tool upon which some logic reasoning seems to have been done."[57] Humans would not have made it to be Moon without math.

Similarly, while little is known about the first attempts to make glass, it is generally believed that glassmaking was discovered 4,000 years ago, or more, in Mesopotamia.[58] Glass is not only used in arts but also lenses and optics. It is crucial for observational astronomy, not to mention windows and spacesuit helmets. In short, spaceflight, whether originating in the United States, Russia, China, Japan or any other one of the handful of nations that are truly spacefaring, would not have occurred without the earliest innovations of our common ancestors, and the curious intellect of stargazers with names like Galileo, Copernicus, Ibn al-Haytham. Friedrich George Wilhelm Struve and countless others whose names have been forgotten by time.

Surely, every landing site on the Moon—soft or otherwise—is a memorial to centuries of human perseverance and ingenuity. They are unique expressions of the cumulative nature of science

53 *Id.*

54 *Id.*

55 The author would like to thank Dr. Marlene Losier for sharing her as yet unpublished research on heritage segmentation and human activity on the Moon. Both of the examples mentioned in the text originated with her analysis. The results of her work will be available through the website forallmoonkind.org in 2021.

56 Ross Pomeroy, *Is the 20,000-Year-Old Ishango Bone the Earliest Evidence of Logical Reasoning?*, RealClearScience (Nov. 23, 2015), https://www.realclearscience.com/blog/2015/11/the_earliest_evidence_of_logical_reasoning.html

57 *Id.*, quoting Vladimir Pletser of the European Space Research and Technology Centre.

58 History of Glass, http://www.historyofglass.com/

and engineering. Each deserves consideration as exhibiting "outstanding universal value." To a one they "represent a masterpiece of human creative genius ... exhibit an important interchange of human values over a span of time ... bear a unique testimony to a civilization [ours] which is living ... and [are] an outstanding example of a ... technological ensemble or landscape which illustrates (a) significant stage[] in human history."[59]

Of course, humanity's greatest technological achievement—putting not just one, but twelve of our own on the Moon and bringing them home safely—are memorialized on the lunar surface where six Apollo missions left behind everything from lunar modules to scientific experiments to mementos, both globally symbolic and personal. For example, Apollo 11 astronauts Neil Armstrong and Buzz Aldrin left a golden olive branch and a tiny disc containing messages of peace from 94 nations; Apollo 16 astronaut Charlie Duke, left a photo of his family. The Apollo sites are a veritable treasure trove of insight into human culture, ingenuity, evolution and society.

Archaeologists tell us that "the Apollo landing sites are not only significant because of their importance to scientific achievement but also because they are the only sited in human history that have sat frozen in time."[60] Indeed: the "lack of atmospheric conditions on the Moon [have] created ... almost perfectly preserved site[s] because [they have] dealt with little interference since" humans last left the Moon in 1972."[61]

Comparable sites on Earth are well-recognized and protected. In Laetoli, Tanzania, a trail of about 70 footprints, believed to be the oldest footprints of early bipedal humans are recognized as part of the Ngorongro Conservation Area as a World Heritage site,[62] having "outstanding universal value." In the Vézère Valley in France, Lascaux cave is among a network of caves preserved because, among other things, it showcases drawings made by our prehistoric ancestors.[63] In total, there are currently 1121 properties spread over 167 nations that are recognized on the World Heritage List.[64]

59 Operation Guidelines for the Implementation of the World Heritage Convention, ¶77 (July 10, 2019).

60 Joseph Reynolds, *Legal Implications of Protecting Historic Sites in Space, in* Archaeology and Heritage of the Human Movement into Space 111, 112 (Beth Laura O'Leary & P.J. Capelotti, eds. 2015).

61 Joseph Reynolds, Legal Implications of Protecting Historic Sites in Space, *in* Archaeology and Heritage of the Human Movement into Space 111, 112 (Beth Laura O'Leary & P.J. Capelotti, eds. 2015).

62 United Nations Educational, Scientific and Cultural Organization, *Ngorongoro Conservation Area,* https://whc.unesco.org/en/list/39/

63 United Nations Educational, Scientific and Cultural Organization, *Prehistoric Sites and Decorated Caves of the Vézère Valley,* https://whc.unesco.org/en/list/85.

64 United Nations Educational, Scientific and Cultural Organization, *World Heritage List*, https://whc.unesco.org/en/list/.

It is noteworthy that recognition and protection, pursuant to the World Heritage List, does not operate in a vacuum. Indeed, as noted, the genesis of the World Heritage concept was found in the need to balance the development of Egypt with the protection of Nubian heritage. Thus, in every case "there is need to have a holistic approach in order to retain the outstanding universal values of the property while addressing the needs of communities from conceptual processes to operationalization."[65]

In short, protecting human history in space is not anti-development. Indeed, a by-product of such protection will be to lay the foundation for the certainty entities need to move forward in the development of a thriving space economy.

Though the process by which a site is designated World Heritage is not perfect, it is rigorous. A State must prepare a nomination file which. In the case of cultural heritage, is evaluated by the International Council on Monuments and Sites (ICOMOS). Once nominated and positively evaluated it is sent to the World Heritage Committee which meets once a year to decide which sites will be inscribed on the World Heritage List.[66] Unfortunately for heritage sites located in space, a nominated property must occur "on the territory of a single State Party, or ... on the territory of all concerned States Parties having adjacent borders."[67] As discussed above, the terms of the Outer Space Treaty preclude the possibility of nomination through this process as Article II specifically prohibits territorial claims by any State in space. And so we cannot apply the World Heritage Convention to sites in space.

IV. Of Safety Zones and Related Measures

While NASA is willing to pay for Moon dust in an effort to support commercial space resource utilization, that does not address the tension between non-appropriation and due regard. In addressing this dichotomy in the Outer Space Treaty, nongovernmental organizations, lawyers and policymakers have suggested the implementation of so-called safety zones. The Hague International Space Resources Governance Working Group,[68] (Hague Working Group) in

65 World Heritage Committee, 43rd Session, Item 7 of the Provisional Agenda, 35 (June 30-July 10, 2019). It is also worth mentioning that designation as a World Heritage Site also can benefit the local economy through increased tourism. While this author believes that lunar tourism will become quite popular in the future, this article will not address the benefits of tourism as the cost alone will prohibit mass tourism. Ultimately, another reason to recognize or protect certain landing sites is to assure that they are not plundered by the very wealthy few so that one day, anyone may be able to draw inspiration from the sites of these incredible achievements.

66 Operation Guidelines for the Implementation of the World Heritage Convention, ¶¶ 120-168 (July 10, 2019).

67 *Id.* at ¶ 134.

68 "The Hague International Space Resources Governance Working Group was established in 2016 with the purpose to assess the need for a governance framework on space resources and to lay the groundwork for such framework." https:/www.universiteitleiden.nl/en/law/institute-of-public-law/institute-of-air-space-law/the-hague-space-resources-governance-working-group.

particular, urges the implementation of an international framework that would

> permit States and international organizations responsible for space resource activities to establish a safety zone, or other area based safety measure, around an area identified for a space resource activity as necessary to assure safety and to avoid any harmful interference with that space resource activity. Such safety measure shall not impede the free access, in accordance with international law, to any area of outer space by personnel, vehicles and equipment of another operator. In accordance with the area-based safety measure, a State or international organization may restrict access for a limited period of time, provided that timely public notice has been given setting out the reasons for such restriction.[69]

The United States government also appears ready to endorse the concept of safety zones. In disseminating "principles" to guide the execution of bilateral agreements regarding space activities, the U.S. indicated that "deconfliction of activities" is a key goal.[70] To support this goal, the U.S.

> and partner nations will provide public information regarding the location and general nature of operations which will inform the scale and scope of 'Safety Zones.' Notification and coordination between partner nations to respect such safety zones will prevent harmful interference, implementing Article IX of the Outer Space Treaty and reinforcing the principle of due regard.[71]

There can be no doubt that safety zones are not only a good idea, but a necessity arguably mandated by the due regard provision of the Outer Space Treaty. However, there is not clear path to implementation of such zones. The Hague Working Group urges the development of an international framework, a move, the international aspect of which is clearly supported by the Outer Space Institute and a multitude of "distinguished signatories" from around the world who "urge States to present for adoption at the United Nations General Assembly, a resolution which would request UNCOPUOS to negotiate, with all deliberate speed, a draft multilateral agreement on space resource exploration, exploitation and utilization for consideration by the

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Members included "major stakeholders from government, industry, universities, civil society and research centres." *Id.*

69 Building Blocks For The Development Of An International Framework On Space Resource Activities, ¶11.3 (2019), https://www.universiteitleiden.nl/binaries/content/assets/rechtsgeleerdheid/instituut-voor-publiekrecht/lucht--en-ruimterecht/space-resources/bb-thissr-wg--.

70 *The Artemis Accords,* NASA, https://www.nasa.gov/specials/artemis-accords/index.html#:~:text=International%20space%20agencies%20that%20join,which%20facilitates%20exploration%2C%20science%2C%20and (last visited Sep. 7, 2020).

71 *Id.*

General Assembly."[72] The U.S. is adopting a bilateral approach, some would argue they seek to force agreement with the safety zone concept, and its accompanying understanding that entities may stake a claim on the Moon, by dangling the opportunity "to join in America's Moon mission."[73]

Underlying the differing approaches to implementation of safety zones is the U.S. disavowal of the concept that space is a global commons. This sentiment was first captured in the Commercial Space Launch Competitiveness Act,[74] signed into law by President Obama, that recognizes commercial properly rights in resources extracted from celestial bodies. The Trump Administration punctuated this statement with the 2020 issuance of an Executive Order which makes quite clear that "the United States does not view [outer space] as a global commons," but as a "legally and physically unique domain of human activity."[75] Moreover, it is incontrovertible that while the Moon Agreement, ratified by only eighteen States, avers that the Moon "and its natural resources are the common heritage of [hu]mankind"[76] the much more popular Outer Space Treaty states that "the exploration and use of outer space ... shall be the province of all [hu]mankind."[77] Many scholarly articles have been written that explore the concept of a global commons[78] and the difference between "common heritage" and "province." Ultimately, the terms have many connotations, but like the concept of due regard itself, they provide little guidance regarding space resource utilization activity.

Implementing a safety zone regime in space would remove many of the uncertainties in the Outer Space Treaty and eliminate the guesswork in the balancing act presupposed by the concept of due regard. However, the fact is that a bilateral approach, as espoused by the U.S. feels exclusive and, if does not garner widespread adoption, it will leave many sites—both operable and heritage—vulnerable. Similarly, an international effort to address these important issues through the COPUOS will undoubtedly take many years, if not decades to reach conclusion.[79]

72 http://www.outerspaceinstitute.ca/docs/InternationalOpenLetterOnSpaceMining.pdf.

73 Robert Cochetti, *Who Can Own the Moon*, The Hill (June 24, 2020), https://thehill.com/opinion/technology/504289-who-can-own-the-moon.

74 U.S. Commercial Space Launch Competitiveness Act, H.R. 2262, 114th Cong. (2015).

75 Exec. Order No. 13914, 85 Fed. Reg. 70 (Apr. 10, 2020).

76 Moon Agreement, *supra* note 17, art. 11.

77 Outer Space Treaty, *supra* note 6, art. I.

78 For an excellent review of the concept, see Henry R. Hertzfeld, Brian Weeden & Christopher D. Johnson, How Simple Terms Mislead Us: The Pitfalls of Thinking about Outer Space as a Commons, 58 Proc. Int'l Inst. Space L. 533 (2015).

79 It took nine years for delegates to the United Nations Committee on the Peaceful Uses of Outer Space to agree to twenty-one nonbinding guidelines supporting the long-term sustainability of outer space activities and the delegates have yet to agree on even the definition and delimitation of outer space–after decades of consideration.

V. A New Approach

A. History at Risk

While it may be argued that we have some time before actual mining operations begin on the Moon or any other celestial body, the fact is that the concept of due regard for objects already on the lunar surface needs to be addressed on a much swifter timetable. Cultural artifacts on the Moon are vulnerable to any activity on the Moon. Indeed, the NASA recognized this in 2010 when it organized a team solely to address questions regarding the protection of historic sites on the Moon. The team developed and released its report, "NASA's Recommendations to Space-Faring Entities: How to Protect and Preserve the Historic and Scientific Value of U.S. Government Lunar Artifacts" (NASA Guidelines), in July 2011. [80] The NASA Guidelines recommend the implementation of a two kilometer "exclusion radius" around significant lunar heritage sites. Per the Guidelines, no vehicle should overfly or attempt to land on the Moon within a two-kilometer radius of any so-called United States Government heritage lander, defined to include the Apollo and Surveyor lunar landing sites.[81] The distance was chosen primarily to alleviate the destructive potential of the regolith ejecta effect in the lunar environment.[82] Essentially, any activity that will stir the lunar surface, whether a rover or a lander, will cause the very abrasive regolith to impact any hardware within a certain radius with the potential of causing severe damage.[83]

These Guidelines, which are not binding or enforceable, even against US nationals,[84] highlight the vulnerability of cultural heritage on the Moon, especially in the face of increased activity.

B. So Put History First

Clearly, it has proven difficult for the international community to agree on

80 NASA, NASA's Recommendations to Space-Faring Entities: How to Protect and Preserve the Historic and Scientific Value of U.S. Government Lunar Artifacts 12 (Jul. 2011), https://www.nasa.gov/sites/default/files/617743main_NASAUSG_LUNAR_HISTORIC_SITES_RevA-508.pdf [hereinafter NASA Guidelines].

81 *Id.* at 7.

82 *See* Michelle L.D. Hanlon & Bailey Cunningham, *The Plume Effect: An "Aggravation and Frustration" That Imperils Our History and Our Future,* 43 J. Space Law 309 (2019).

Research indicates that upon approach and landing, lunar lander engine exhaust will blow, rocks, soil and dust at high velocities. This lander ejecta can severely damage hardware even tens of kilometers away from the landing site. Building berms or using terrain obscuration to obstruct or curtail the ejecta each offer only partial solutions to this potentially mission-ending issue because large landers can send ejecta into high trajectories that cannot be successfully blocked. Indeed, it has been shown that it is even possible for ejecta to damage or destroy spacecraft orbiting the Moon.

Id. at 309.

83 *Id.* at 312-313.

84 The One Small Step to Protect Human Heritage in Space Act would require entities licensed by the United States to comply with NASA's Guidelines. One Small Step Act, S. 1694, 116th Cong. (2019). The Act passed the U.S. Senate unanimously in 2019 but has yet to be considered by the U.S. House of Representatives.

space governance matters. However, the nations of the world have proved unanimous support of the protection of human heritage. And there is no heritage more universal than lunar landing sites on the Moon, which represent both a milestone in human evolution and development as well as the culmination of the work of humans throughout the world and throughout history. The human relationship to space is necessarily global and universal. "The famous Earthrise image, taken by astronaut William Anders in 1968 during the Apollo 8 mission, was perhaps the most influential environmental photo ever and has taught us humility as we understand our very precious space in our solar system."[85] More than 600 million people "tuned into watch or listen to the Apollo 11 lunar landing."[86] Few would argue that the site where humans first set foot on another celestial body should be recognized and protected less than any site on Earth.

With this in mind, rather than embark upon the development of an entirely new legal regime to govern space resource utilization and flesh out the specifics of due regard, the international community, through the COPUOS should initiate the important process by reaching agreement on how to protect humanity's greatest treasures in space. Starting with humanity's firsts on the Moon—Luna 2, first hard landing, Luna 9, first soft landing, Apollo 11, first crewed landing—the international community can consider each level of deference to be given to certain objects and sites. The COPUOS should solicit expert testimony from geologists and engineers who can describe the effects and trajectory of the plume effect. Then taking the science into consideration, agree to the establishment of safety zones, barring access to any of these sites until humans have the technology to approach them without destroying them. And, given the strong ownership structure of Article VIII of the Outer Space Treaty, any approach must be with the approval of the State that retains the ownership of the objects. These parameters will serve as the baseline, the most severe and rigorous protections any site on the Moon can enjoy. It is an ideal starting point to: 1) make the international community comfortable with the concept of safety zones; and 2) build the scientific understanding and knowledge necessary to combat both foreseen (intentional intrusion) and unforeseen (plume effect) hazards to objects on the Moon.

Beyond these three firsts, there will no doubt, be required debate over the status of other sites and objects. But these can be addressed in a manner similar to the process adopted by the World Heritage Convention. As a matter of first instance, the COPUOS

85 M. Ann Garrison Darrin, *The Impact of the Space Environment on Material Remains, in* Archaeology and Heritage of the Human Movement into Space 13, 27 (Beth Laura O'Leary & P.J. Capelotti, eds., 2015).

86 J. Reynolds, *Legal Implications of Protecting Historic Sites in Space, in* Archaeology and Heritage of the Human Movement into Space 13, 27 (Beth Laura O'Leary & P.J. Capelotti, eds., 2015).

must agree to a definitive list and location of all the sites and objects on the Moon. A digital catalog of these items is maintained by the nongovernmental organization, For All Moonkind, and would be an excellent starting point.[87] Once affirmed, sites and objects should be categorized. The two extreme categories would be: 1) debris or trash, available for inspection, and even recycling and reuse upon negotiation with the State which is the owner of the object; and 2) cultural heritage of universal value. The COPUOS may initiate a nomination process and invite States to nominate their object and the sites upon which they sit for consideration of universal value. Subsequent categories may include an identification of operative equipment used for scientific purposes and operative equipment used for commercial purposes. Finally, the COPUOS will need also to consider commercial property that has no purpose. For example, companies like Astrobotic are offering to take private object to rest on the Moon as part of their DHL Moonbox™ kit,[88] and Celestis[89] promises to take human remains to the lunar surface. What should "due regard" entail for these items? Viewing all of these sites from the prism of history will provide new perspective on all these matters.

A final benefit of approaching the task of implementing due regard through the establishment of a safety zone regime is that the entire process will be accomplished from a baseline of conservation rather than exploitation. As we have learned on Earth, development need not be halted by preservation efforts; however, humans have been given a unique gift in the 50-year gap between crewed visits to the Moon. The site of one of our own momentous evolutionary accomplishments sits pristine, waiting for our return. We will never know where our ancestors took their first bipedal footsteps, where we first harnessed fire, or where we made our first tools. But we know where exactly our first human-made object impacted the Moon, and where our first off world footsteps were taken. These sites will forever hold the remnants of our birth as a spacefaring community, the cradle of our spacefaring species.

VI. Conclusion

It is appealing to consider this our generations Nubia moment, which the author has done in the past.[90] Like Nubia, the cradle of our spacefaring future is threatened by the need for development, here the development of space resource utilization, specifically on the Moon. However, unlike Nubia, saving our history on the Moon will not cost $80 million, nor will it require moving shrines and temples. It simply requires formalizing and oralizing a tacit un-

87 https://moonregistry.forallmoonkind.org/

88 https://www.astrobotic.com/moon-box

89 https://www.celestis.com/

90 Michelle Hanlon, *Our Nubia Moment,* SPACEWATCH.GLOBAL, https://spacewatch.global/2018/02/spacewatchglthemes-space-archaeology-nubia-moment-michelle-hanlon/

derstanding that there are sites on the Moon that deserve recognition and protection for their universal value to humanity.

But this builds on the concept of heritage protection awakened by Nubia and takes it to (forgive me) new heights both literally and figuratively. As we embark on the next stage of our evolutionary development, we have the unique opportunity to manage that development with care we never considered in the past. But of even more import to the commercial space industry, opening discussion from a place of agreement—preservation of heritage—will speed the process needed to address the uncertainty inherent in the balancing proposition required by the concept of due regard. Not to mention the fact that it will help to preserve for generations to come the sites that create a seemingly bottomless well of inspiration for space entrepreneurs and dreamers.

Finally, recognizing heritage outside the norm of sovereign territory will provide one more unique and matchless gift: the chance to recognize incredible technological achievements not as national triumphs, but human triumphs. As Neil Armstrong descended the ladder of the lunar module at Tranquility Base and planted his boot in the regolith, he completed a journey that started with a human who decided to stand up on two feet. A new journey is starting for humanity, one that is truly without boundaries; one that should be explored outside the confines of our Earthly sovereign paradigms. We can take that first step now. Let this be our major attempt of our lifetime to assume common responsibility towards the past so as to move forward in the spirit of kinship to the future.

Evaluating Space as the Next Critical Infrastructure Sector

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Abstract

When one considers critical infrastructure protection, the default discussion too often becomes discussing cyber vulnerabilities as the only way to defend the homeland without considering whether all correct critical infrastructure (CI) was identified. When created, the Department of Homeland Security (DHS) protected those critical U.S. infrastructure categories identified by the executive branch with all military space infrastructure becoming part of the category called Defense Industrial Base. Other potential space sectors including television, satellite manufacturing, commercial launch, and global positioning disappeared into other CI categories such as critical manufacturing, communications, or information technologies. Just as military space required a separate armed service in the Space Force, the time appears right to implement a space CI sector including from commercial satellite manufacturing through launch and ground control to on-orbit missions as critical to U.S. public health, public safety, economic benefit, and national security. Starting with historical approaches to selecting and protecting CI, this paper expands to what sectors are currently protected, which space infrastructure matters most, and provides a qualitative CI sector comparison based on a hypothesis-based design.

Keywords: evaluating space, critical infrastructure (CI), sector, Department of Homeland Security

Evaluación del espacio como el próximo sector de infraestructura crítica

Resumen

Cuando se considera la protección de la infraestructura crítica, la discusión predeterminada con demasiada frecuencia se convierte en discutir las vulnerabilidades cibernéticas como la única forma de defender la patria sin considerar si se identificó toda la infraestructura crítica (CI) correcta. Cuando se creó, el Departamento de Seguridad Nacional (DHS) protegió las categorías críticas de in-

doi: 10.18278/sesa.2.1.7

fraestructura de los EE. UU. Identificadas por el poder ejecutivo y toda la infraestructura espacial militar se convirtió en parte de la categoría denominada Base Industrial de Defensa. Otros sectores espaciales potenciales, como la televisión, la fabricación de satélites, el lanzamiento comercial y el posicionamiento global, desaparecieron en otras categorías de CI, como la fabricación crítica, las comunicaciones o las tecnologías de la información. Así como el espacio militar requería un servicio armado separado en la Fuerza Espacial, parece que es el momento adecuado para implementar un sector de CI espacial que incluya desde la fabricación de satélites comerciales hasta el lanzamiento y el control terrestre hasta misiones en órbita que son críticas para la salud pública, la seguridad pública y la economía de los EE. UU. beneficio y seguridad nacional. Comenzando con enfoques históricos para seleccionar y proteger la IC, este documento se expande a qué sectores están actualmente protegidos, qué infraestructura espacial es más importante, y proporciona una comparación cualitativa del sector de la IC basada en un diseño basado en hipótesis.

Palabras clave: espacio, infraestructura crítica (CI), evaluación, sectores espaciales, infraestructura cualitativa, crítica

关于太空作为下一个关键基础设施部门的评价

摘要

当个体考量关键基础设施（CI）保护时，默认的辩论时常将网络脆弱性作为保卫国土的唯一方式加以探讨，而不考量是否识别了所有正确的关键基础设施。国土安全局（DHS）成立时，对那些被行政分支所识别的关键美国基础设施类别加以保护，所有军事空间基础设施都属于国防工业基地这一类别。其他潜在的空间部门，包括电视业、卫星制造、商业发射、全球定位等，转移到其他关键基础设施类别，例如关键制造、传播、或信息技术。正如太空军中的军事空间要求一个单独的军事服务，是时候启用一个包括从商业卫星制造、发射、地面控制到轨道任务（on-orbit missions）的空间关键基础设施部门，它对美国公共卫生、公共安全、经济利益和国家安全至关重要。从选择和保护关键基础设施的历史方法出发，本文扩展研究了哪些部门正在受到保护、哪些空间基础设施最重要、并基于一项基于假设的设计，提供了一个关于关键基础设施部门的定性比较。

关键词：太空，关键基础设施（CI），评价，太空部门，性

1. Introduction

The most terrible threat for any strategic planner is suffering a Pearl Harbor type event exceeding all previous expectations due to a lack of proper preparation. In all critical infrastructure (CI) debate, cyber vulnerabilities have reigned supreme as a panacea to protect the homeland. However, many systems vulnerable to cyberattacks have other inherent weaknesses demanding unique protections best addressed by dedicated bodies of experts. The central question then becomes whether analysts and strategic planners planning for homeland defense identified all correct critical infrastructure areas. Today, the answer should be no. Space infrastructure demonstrates critical contributions to U.S. public safety, provides clear economic benefit, and national security value but remains unaddressed by the Department of Homeland Security as a holistic sector. To understand why space critical infrastructure should be included, one starts with how DHS selects critical infrastructure, which existing areas are protected, identifying critical space capabilities, and validating U.S. benefits. As the Space Force's creation validates, if the U.S. fails defend space infrastructure, we will lose many benefits our citizens value today.

CI ownership has long been solely the executive branch's responsibility with informed opinions occasionally used to review and revise processes, usually when administrations change. Despite adding the Department of Homeland Security (DHS) as a cabinet member, CI history and selection process are largely administratively driven by administrative decisions. The DHS defines critical infrastructure as "systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of these matters"(DHS, 2020). Sixteen sectors currently constitute the Critical Infrastructure and Key Resources (CIKR) identified by the DHS and seconded to the Cybersecurity and Infrastructure Security Agency (CISA). Rather than individually assessing each sector in detail, the employed method measured the sectors as groups against a potential space category. The five combined sectors are hazardous materials, life sustaining support, manufacturing, digital spaces and governance. Each sector was previously assessed as having sufficient impact to require protection with budget, dedicated groups, and processes to accomplish those goals. The five groups were compared to space with three hypotheses, first, comparing public health and economic benefits, second, comparing national security benefits, and finally, evaluating a counter-hypotheses that space facilities are sufficiently protected by other sectors as to not require unique protections.

This paper demonstrates space shows enough common characteristics in national security, economic benefit, public health, and public safety with other critical infrastructure areas to merit consideration as a separate function. Other sectors each cover portions of potential Space sector vulnerabilities through defending cyberspace networks, physical locations, and logistics transport yet fail to offer sufficient protection to space infrastructure. When first created, the Department of Homeland Security identified selected areas correlated from previous administrations as central to U.S. protection. All military defense requirements for acquisition, manufacturing and services were categorized as part of the Defense Industrial Base. This assumed all commercial-produced items necessary for military success were built in individual facilities or distinguishable within other facilities. As the Space Force begins operations, the time appears right to propose a space sector, from commercial build and ground control to on-orbit employment, should be considered a critical infrastructure area for the United States.

The next step to evaluating space as a separate sector considers two facets, what functions would be considered space infrastructure, and what risks do those facilities face? The first space function for considerations should the launch facilities, ground control, and satellites. Without launch, there is no space but without control, any derived value may be greatly reduced. en different, U.S. located, spaceports are currently licensed by the FAA (FAA, 2018). Although the list begins in 1998, the newest construction was Spaceport America in New Mexico (America, 2020). Any list must also include the manufacture and transportation of space goods and services. Finally, any space infrastructure includes the communication networks required to communicate between ground and on-orbit devices. The equation's other half considers potential risks as the threats and vulnerabilities faced by space CI. Threats to ground-based infrastructure likely remain the same as for other sectors while space will also inherit threats in the manufacture and communication sectors. Unique to space are features like space weather, orbital debris, direct action by adversaries, limited orbital slots, commercial interference as well as potentially unknown events. This area also considers whether the existing Space Information Sharing and Analysis Center (ISAC) provides sufficient protection to space facilities

Finally, the paper finishes through evaluating each hypothesis, discussing evidence, and making a recommendation for space as future critical infrastructure. Each hypothesis was be qualitatively evaluated as an aggregate and individual sectors before comparing to the same results for space. These comparisons provide research integrity through demonstrating where each sector might stand during any future process. Additionally, the counter hypothesis offers a contrary opinion to see if other sectors may indeed provide sufficient coverage for space. While eventual decisions will lie at the federal level, comprehensive analysis should add substance any discussions. This last section makes some recommendations for further studies, protection theory, and potentially merging existing CI sectors to create additional budget room for space facilities.

2. History of Critical Infrastructure?

The critical infrastructure theory states identified structures are systems the American people depends on for daily life sustaining or improving services. Incapacitating or paralyzing any CI system either individually or in aggregate function could seriously damage the homeland through degrading national security, the U.S. economy, or public health. These parameters have changed over the years so David Reidman's clarifying work to assess fourteen different policy documents since 1986 uncovers common terms across multiple documents (Reidman, 2016). Although CI protection has been relatively common recently, the first federal usage for CI occurred less than 25 years ago. Reidman's search looked for key words including "nationally significant," "provide vital service," "interdependent system," "debilitating impact," and "safety of public." While these terms are useful during an assessment, this paper uses the definition for CI from the 2001 Patriot Act, Title X, Sec 1016 H, "systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters" (Congress, 2001). This definition was selected as it also forms the basis for the DHS mission as a governmental agency. One can see the slight language variance from Reidman's study although the only major difference lies only in the term," interdependent."

Interdependence normally refers to the international relations viewpoint advocated by Joseph Nye and Robert Keohane (Keohane & Nye, 1997). The concept builds from when organizations demonstrate multiple connections, show a lack of hierarchy among those connections, and deemphasize military force. When applying interdependence to CI, one can use all three qualifications from a slightly different perspective. Critical infrastructure components offer a backbone to societal processes through multiple connections at various hierarchical levels. As an example, a recent Department of Treasury memo lists essential financial services as all those who process financial transactions and services, insurance services, financial operations, security and all underlying third-party providers (Mnuchin, 2020). The volume of included personnel demonstrates the multiple connections, and at the same time, the lack of hierarchy in which aspects work with which other connections and when. The memo reinforces the third point through the absence of any Department of Defense resource references.

Advocating for change to existing governmental processes like the DHS's Critical Infrastructure and Key Resource (CIKR) listing requires first discussing how previous changes occurred. Many believe Federal CI protection begins with the Patriot Act and 9/11 attacks, but the first attempts to protect U.S. infrastructure began five years earlier during the Clinton Administration.

President Bush used his mandate to make some significant changes, President Obama made more, and the recent administration continued the trend through President Trump's creation of the Cybersecurity and Infrastructure Security Agency (CISA). Change typically occurs at the point where an administration changes as well as several times during each administration depending on how internal and external pressures are applied.

The first, formal federal "critical infrastructure" definition was 1996 when President Clinton signed Executive Order 13010 (Listes, 2018). In typical government fashion, EO 13010 designated 10 agencies to contribute to a commission who reported to a Principal committee in the National Security Council structure. The order identified eight critical areas as vulnerable to either physical or cyber-attacks (Clinton, 1996).[1] The commission returned the report the following year and highlighted five sectors of each area most vulnerable to attack as; information and communications, energy, banking and finance, physical distribution, and vital human services. Several vulnerability areas overlap sectors as CI although were not treated as a distinct area at the time.

Two years later, in 1998, President Clinton signed Presidential Decision Directive 63 (PDD-63). PDD-63's aimed to develop improved protection capacity for U.S. CI and marks the first time cyber was defined as a CI component. Further, PDD-63 designated federal agencies as lead for each specific sector in coordination with equivalent Sector Liaisons designated from private industry (Clinton, Presidential Decision Directive/NSC-63 "Critical Infrastructure Protection, 1998). This proved to be a continuing bedrock concepts for today's CI planning and will likely continue as vital for the space industry as large elements including launch and control shift into the private sector.

In 2001, the 9/11 attacks redefined the how the U.S. government defined protection, and CI was no exception. The 2001 Patriot Act discussed the requirements for CI protection and information sharing while leaving out calling for any specific areas. The 2002 Homeland security act adds definitions for key resources which were then used to write the Homeland Security Presidential Directive -7 (HSPD-7). Further, HSPD-7 reduces the CI sectors to five which were designated as information technology, telecommunications, chemical, transportation systems, emergency services and postal while including dams, government facilities, and commercial facilities as key resources. The directive adds several other requirements and coordination elements to homeland security including mandating the government responsible agents would liaise independently to each sector's private institutions. The Department of Homeland Security was also designated as the agency to change, modify, or otherwise update CI any re-

1 The eight identified sectors were: telecommunications, electrical power systems, gas and oil storage and transportation, banking and finance, transportation, water supply systems, emergency services (including medical, police, fire, and rescue), and continuity of government.

quired elements (Bush, 2003). While the DHS continued to monitor and track changes from below the policy level, the next significant change was 2013 when Presidential Policy Directive 21 (PPD-21) outlined federal infrastructure protection roles through clarifying functional relationships, enabling efficient information exchange, and implementing an integration and analysis functions (Goss, 2014). This directive accomplished two other key functions, establishing an independent analysis center for physical effects on infrastructure, and another center for cyber effects. Further, PPD-21 expanded the critical sectors to 16, where the number stands today.

The next CI security change was launching the Cybersecurity and Infrastructure Agency (CISA) as a DHS branch. On November 16, 2018, President Trump signed the 2018 Cybersecurity and Infrastructure Security Agency Act into law which elevated the former National Protection and Programs Directorate (NPPD) within DHS to establish CISA and included the National Cybersecurity and Communications Integration Center (NCCIC). CISA's priorities are federal network protection, comprehensive cyber protection, infrastructure resilience and field operations, and emergency communications. rior to CISA, NCCIC had realigned in 2017 to integrating like functions previously performed by the U.S. Computer Emergency Readiness Team (US-CERT) and the Industrial Control Systems Cyber Emergency Response Team (ICS-CERT) independently (CISA, 2020). The changes might lead one to consider whether any physical CI protection, or independent cyber defense are still being considered as vital components for the sixteen CI families, an interesting topic but outside this paper's scope.

Although the agency remains new, the assumed responsibilities include all features previously managed by DHS as the National Security Agency assumes all signal intelligence responsibilities for the Department of Defense. CISA's budget for 2020 was $2B with the planned budget for 2021 as $1.75B (DHS, Cybersecurity and Infrastructure Security Agency: Budget Overview, 2020). This contrasts sharply with the formal DHS budget for 2020 of $51B (DHS, FY2020 Budget in Brief, 2020). CISA was included as part of the overall DHS budget but has the lowest budget rating of all designated areas. The CISA numbers match the budget requirement for the U.S. Secret Service but are surpassed by "Other" at 4% and then U.S. Citizenship and Immigration Services at 5%. The two highest budget areas for DHS are the Federal Emergency Management Agency at 31% and U.S. Customs and Border Protection at 23% (DHS, FY2020 Budget in Brief, 2020). The miniscule $2B overall budget is only .5% when compared to the interest paid on national debt and only 30% of launch revenues as the lowest producing economic sector for space (Amadeo, 2020).

While centrally managing CI as a U.S. federal responsibility for almost 25 years, no consistent method exists to evaluate whether to included new CI areas discard old ones. Neither has any discussion emerged regarding how sectors are categorized and evaluated as each set of approvals was recommended by congressional inquiry and then validated by Executive Order or Presidential Policy Directive from the four most recent Presidents. Seven of the sixteen areas are assigned directly to DHS and two more are shared, or were, prior to CISA's emergence. The Department of Health and Human Services owns one area and shares one, while the Departments of Defense, Energy, Treasury, and the Environmental Protection Agency each focus on one area. A framework similar to the one used later in the paper to evaluate space CI hypotheses could be equally enacted by a simple mandated congressional reporting structure based on economic value, public health, and national security to score yearly or biannually to validate infrastructure protection needs.

3. Comparing CI Sectors

Sixteen infrastructure protection categories currently exist and evaluating each in depth would take many more pages than available during each discussion so instead, this paper treated those functions largely as aggregated functions for hazardous materials, manufacturing, life sustaining services, digital spaces, and government and governance functions. Each section has been aggregated to cover 2-4 of the existing sectors based on their similarity to other functions. Only a top level look is considered for individual functions without considering individual economic revenues or unique capabilities. Multiple ways probably exist to parse the existing sixteen sectors for different factors or integrations, and even parsed, some of the sectors are likely large enough to require multiple liaisons from government and commercial domains. Hazardous materials as the first grouping includes the chemical and nuclear sectors which covers a requirement to safely transport products. Both sectors contribute to space sector usefulness in terms of fuel or power while neither creates a direct dependent link. A second grouping designation would be life sustaining for water and wastewater, dams, food and agriculture, and energy. Dams and energy both provide power in a different manner from nuclear and requiring less waste transport although still support daily needs. At the same time, water and food again deliver necessities for daily life through public health and safety. The life sustaining grouping would more likely supply secondary dependent links to those working in space areas such as supporting ground control and manufacturing. Current satellites usually receive power from either internal fuel or solar power once launched. The below chart (Table 1) describes the grouping for all five aggregated sectors.

The third grouping, manufacturing includes commercial facilities, critical manufacturing, and the Defense Industrial Base. All three sections would tie tightly to space infrastructure aspects although no specific cross coordination emerges. The Cyber and Infrastructure Security Agency lists the four critical manufacturing components as primary metals, machinery, electrical

Table 1: Aggregated Groups for the Dept. of Homeland Security Critical Infrastructure Sectors

CI Group	CI Sectors
Hazardous	Chemical
	Nuclear Reactors, Materials and Waste
	Energy
Life Sustaining	Waste and Wastewater
	Dams
	Agriculture
Manufacturing	Critical Manufacturing
	Commercial Facilities
	Defense Industrial Base
Digital Spaces	Communications
	Information Technology
	Financial Services
Government and Governance	Emergency Services
	Government Facilities
	Healthcare and Public Health
	Transportation Systems

equipment and transformation equipment while commercial facilities has eight sub-sectors (CISA, Critical Manufacturing Sector, 2020).[2] Commercial facilities would more likely be tied to the private presentations associated with space commercial foundations or retail sites selling space-associated products. Finally, the Defense Industrial Base contains all those subsections who work under contract to the Department of Defense. This section would likely include the entire government space industry although like the other elements, no separate distinction appears just for space infrastructure. In 2018, the U.S. spent $47.5B on all space services while the global space, ground services market alone was $60B (FAA, 2018). A fourth grouping, Digital Spaces, would include communications, information technology (IT) , and Financial services. Communications involves all forms of voice and data transmission while the IT sector coordinates services provided by hardware and software components. The Financial sector depends on the previous two working successfully to push through their regular functions contributing to U.S. eco-

2 Eight sub-sectors are Entertainment and Media (e.g., motion picture studios, broadcast media), Gaming (e.g., casinos), Lodging (e.g., hotels, motels, conference centers), Outdoor Events (e.g., theme and amusement parks, fairs, campgrounds, parades), Public Assembly (e.g., arenas, stadiums, aquariums, zoos, museums, convention centers), Real Estate (e.g., office and apartment buildings, condominiums, mixed use facilities, self-storage), Retail (e.g., retail centers and districts, shopping malls), Sports Leagues (e.g., professional sports leagues and federations).

nomic benefit. Like the third grouping, space will heavily depend on this sector but no specific identification for space related ground links, satellite television, or Global Navigation Satellite System (GNSS) are included in the initial discussions for these areas.

The last grouping for comparison would be government and governance. This section includes emergency services, government facilities, healthcare, and transportation. All of these are government provided mitigation for daily concerns. These areas have little to nothing to do with any space CI sector although space might be potentially regulated under transportation systems through the aviation subsector for transportation (CISA, Transportation Systems Sector, 2020). Today, the Federal Aviation Administration (FAA) holds the responsibility for all space commercial transportation. Finding the FAA branch and webpage which manages space takes a little more difficulty. No links existed from the main page and the item required multiple specific searches on the page to locate the FAA's space page. U.S. space launch and transportation were categorized as \$1.7B in the FAA's 2018 Annual Space Compendium versus \$5.5B for global launch services (FAA, 2018). The largest commercial space providers in the U.S., SpaceX, claims their 2018 launch revenues topped \$2B, more than overall total for all 2017 launches, reaffirming space mission's economic impact. (Sheetz, 2019)

Categorizing the various sectors leads to considering how one assesses risk. Although a common definition for risk suggests any total risk equals threat multiplied by vulnerability, other definitions may be used. Systemic protection for CI can skip right past risk assessments to focus on immediate protection shortfall like physical fences or background checks for employees. As another risk framework example, the European CI protection framework uses four pillars: readiness, detection, recovery, international cooperation, and information technology. These pillars are assessed against four protection levels each as primary loop, control loop, analyzing feedback and planning (Roman, 2016). Comparatively, the North American Electric Reliability Corporation (NERC) provides 11 standards for Critical Infrastructure Protection (CIP) but only for electric power. The NERC risk assessment occurs their standard, CIP 014, including performing an initial assessment, conduct third party review, notify owners, evaluate threats and vulnerabilities for physical attack, develop a plan, and have a third party review the plan. If Space becomes an additional CI sector, corporations and agencies within that sector will likely have to develop risk and industry standards for protection.

Space is not currently a CI sector although various industry pieces fall under different, currently protected areas. No government standard exists for comparison between CI sectors, so this paper uses a high-level qualitative assessment to compare space benefits to the other sectors. This assessment is based on two primary hypotheses and a counter hypothesis, included below.

H1. If space industry infrastructure is protected than significant value will be preserved to the general public safety, health and economic outcomes for U.S. citizens.

H2. If space industry infrastructure is protected than significant value will be preserved to the national security outcomes for U.S. citizens.

H3. If space industry infrastructure is currently protected by other DHS Critical Infrastructure and Key Resource than a unique designation is not required.

Each hypothesis was compared on a binary basis for the existing CI groups and for space. H1 examined the evidence supporting the U.S. population deriving economic and public health benefits from space sector. Economic benefit can be calculated through comparing to Gross Domestic Product numbers as reported by the U.S. Department of Commerce's Bureau of Economic Analysis (BEA) (Howells, Morgan, & Aversa, 2020). The BEA tracks 22 different sectors which overlap some, but not all, CI sectors. In this case, substantial positive revenues were used as evidence of economic benefit. Public health measurements are more difficult to measure and will be qualitatively assessed based on a binary summary of whether the various space sectors contribute to overall public well-being. The Center For Disease Control Foundation defines public health as, "the science of protecting and improving the health of people and their communities ... achieved by promoting healthy lifestyles, researching disease and injury prevention, and detecting, preventing, and responding to infectious disease" (Foundation, 2020). Strictly based on the definition, space contributes little to public health but neither do many other CI sectors are likely similar.

The second hypothesis evaluated whether space increased positive national security outcomes. Again, a qualitative response was used to comparing the various sectors to space. The qualitative structure allowed determining whether space contributes to security relatively rather than defining an absolute value based on a measurable characteristic. The recently commissioned Space Force establishes national spacepower as, "the totality of a nation's ability to exploit the space domain in pursuit of prosperity and security ... comparatively assessed as the relative strength of a state's ability to leverage the space domain" (U.S. Space Force, 2020). This definition does establish a way to examine space contributions to national security although terms like relative strength and leveraging would have to be more concisely defined. Publicly, many space contributions are likely overlooked on a daily basis including functions such as satellite television, positioning services, and even timing.

The final hypothesis explores the counter position, one where the argument becomes whether any existing CI sectors already provide sufficient protection for space infrastructure. The two aggregate sectors likely to have the most overlap are Digital Spaces and Manufacturing with the other three having significant less. Government and

Governance would likely have the next most coverage with Life Sustaining and Hazardous having little to no direct overlap to space functions. This hypothesis will also be considered as a qualitative response based on existing CISA coverage definitions for each section. This final sector will be evaluated by comparing scores to other sections and assessing whether those sectors provide similar benefits to space.

The final evaluation step scored the three hypotheses. While using a qualitative standard, scores were produced form the a binary assessment of yes (1) or no (0) and then averaged across the board. Each section will be evaluated subjectively for whether significant damage to the sector from a threat or an attack could critically impact one of the four criteria. The four criteria from the critical infrastructure definition are public health, public safety, economic benefit, and national security. Each CI sector was evaluated as either a positive or negative for each category. Although each category was scored, the first three were grouped together based on the hypothesis structure. Positive results were scored as one while negative scores were regarded as zero. Scores were recorded for individual as well as the aggregated sectors. This provides the ability to objectively compare various sectors. A more extended or quantitatively focused study could establish monetary or other impact criteria within those sections for a more quantified comparison. Having established a method, the next step must be to consider what space industry aspects could be considered as critical infrastructure.

4. What Should be Space Critical Infrastructure?

When compared to other CI sectors, one must consider what elements are space infrastructure. Any infrastructure evaluation should start through the North American Industry Classification System (NAICS). NAICS provides a Federal agency standard to classify businesses with two-digit classifications and adds additional numbers up to six numerical digits for sub-sectors. This classification becomes the basis for collecting, analyzing and publishing statistical data about the economy with a category revision published every 5 years since 1997 (U.S. Census Office). A keyword search for "space" in the 2017 NAICS catalog finds 24 results from space simulation chambers (332313) to space research services, [for] government (927110). In selecting a topic from each aggregated sector for comparison, one can find four results for "Dam," 26 for "nuclear," 27 for communications, 87 for "health," and 7,232 for "manufacturing."

The broader space categories from the NAICS structure includes nine two-digit elements which make up the 24 six-digit elements to highlight contributed aspects and overlap. The current 24 elements are contained in broader two-digit elements for manufacturing (33), wholesale trade (42), transportation (48), Professional services (54) and public administration (92). Two sections are clearly missing from the broader category, information (51) and construction (23) with the possible addition of accommodation and food services (72). Each of these sectors could include multiple other sectors for evaluation. Construction would cover building satellite receiving stations and launch facilities while Information would cover satellite telecommunications and most navigation or timing systems. The last addition for accommodation and food services covers the possibility of developing and deploying commercial residence or other forms of space tourism (Highfill, Georgi, & Dubria, 2019). These assessments are contained in a new BEA project launch document aiming to compile more detailed space economic references by late 2020 (Highfill, Georgi, & Dubria, 2019).

A more logical separation for space infrastructure would consider launch, ground control, orbital functions, and manufacturing as separate sub-sectors. Globally, the 2018 FAA Compendium of Commercial Space Transportation refers first to satellite and non-satellite industry as a roughly 3-1 margin globally, $260B to $84B. In a further breakdown, the same chart lists global investments as satellite television ($97B), government budgets ($82B), satellite ground equipment ($60B), navigation ($52B) fixed satellite service ($17B) satellite manufacturing ($13B) and launch ($5.5B) (FAA, 2018). One of the biggest problems appears again as multiple government evaluators select different comparisons across the space industry. Regrouping these functions puts the global value as roughly $160B for orbital functions, $82B for government space, $73B for ground control, and $5.5B for launch. As government space functions were not segregated through this study the best option would likely consider government space a different section for infrastructure.

Over the next several years, space access and functions will probably decrease in per capita value while increasing overall space assets numbers. This cost reduction increase space functional impacts across societies as space-based possibilities emerge for previously unconsidered commercial solutions. A National Defense University presentation suggests increasing launch rates by a factor of 9 creates a 3x cost reduction per kg of payload (Stockdale, Aughenbaugh, & Boensch, 2018). This decrease will match with a lowering of individual asset costs and decreases in associated support costs as insurance and financing for space becomes better understood. Even further, new business models will likely open paths for investment and implementation opportunities which are not yet even envisioned, similar to if one could invest in digital music or smartphones in the 1980s (Partnership for Conflict, Crime, And Security Research, 2016).

In its present form, the National Space Council (NSC) was established in 1989 under the Bush administration, closed under the Clinton Administration and did not reappear under 2016 under the Trump administration. The Secretary of Commerce is a key member of this board whose designed mirrors previous National Security Council structures to raise space issues to the executive branch level within the government. Under most administrations, conflict between the DOD for military space, and the National Aeronautics and

Space Administration were key blockers to a unified U.S. policy (Vedda, 2016). The NSC looks to enact U.S. space policy for commercial development, sustainable human presence, and expanding opportunity for Americans to live and work in space. This matches long-term goals to achieve these same results not only in Earth orbits but also creating a human presence on the Moon, Mars and further (Office of Space Commerce, 2020). This governmental structure could be key to space's reconsideration as a critical infrastructure area.

Further evidence supporting establishing a U.S. space critical infrastructure sector was the recent establishment of a Space Information Sharing and Analysis Center (ISAC) (Space ISAC, 2020). The Space ISAC was added to the national council of ISACS which establishes cross-sector coordination for sharing information about cyber and physical threats, mitigation strategies, and bringing partners together (Miller, 2020). This organization looks to identify possible threats to the supply chain, business systems and missions associated with space. The early establishment of this ISAC could help reduce cost and administrative difficulties in nominating a space infrastructure sector. ISACs were established as part of the original critical infrastructure protection plan by PPD-63 (Clinton, Presidential Decision Directive/NSC-63 "Critical Infrastructure Protection, 1998). Some suggest the original ISAC intention was only to coordinate on cyber threats but the NCI mission statement suggests both cyber and physical threat information are routinely reviewed (National Council of ISACs, 2020). As some organizations seem to exist to protect some space aspects, the next consideration should be what threats would routinely be faced by space critical infrastructure.

The term, "threat" drives protection discussion sbut thoroughness demands one also evaluate vulnerabilities. Active threats usually are driven by state, non-state, or criminal actors who intend to damage U.S critical infrastructure as part of economic or political goals. State actors are nations who can afford more advanced means to commit kinetic and non-kinetic actions either in orbit or against terrestrial sites (Bateman, 2020). High entry barriers to space conflict suggests the most likely U.S. opponents would be Russia or China (Edmonds, 2020). Non-state actors as terrorist groups, other political activists, or even corporate entities may also have unique goals for the space environment from destruction to establishing resource-yielding norms regarding extraterrestrial development. John Klein's close examination of terrorist group's potential capability to operate in the space environment proved largely negative (Klein, 2020). Criminal groups seek to obtain an illegal economic advantage through group. Terrorists and criminals are equally deterred from direct orbital actions based on the high entry costs for orbital operations but could still use cyber-attacks, sabotage, or influences on earth-based infrastructure to achieve desired effects.

The other half of risk, vulnerabilities, arise from the difficulties found naturally in the space environment.

Klein reflects three required functions shaped by orbital vulnerabilities: minimizing debris, coordinating proximity operations, and reducing electromagnetic interference (Klein, 2020). Some vulnerabilities may be caused from cascading events from threats or completely derived from external, and frequently unalterable, influences. All listed vulnerabilities are made more significant by distance since all space-based assets reside at least 62 miles above sea level. From the terrestrial side, either ground control installations or on-orbit functions means the vast distances create a vulnerable attack surface where threats may interject detrimental effects. Orbital debris from objects either snagged by Earth's gravity or manmade pieces remaining in orbit from either intentional or unintentional collisions can pose dangers to future mission. Coordinating space objects for mission events also poses dangers. All space objects possess velocity from their position and changing those vectors to maneuver near or around other objects can pose significant danger. These maneuvers can become more dangerous as one considers proximity and debris. Finally, space begins outside Earth's atmosphere which minimizes the protection terrestrial objects receive to interplanetary electromagnetic interference from celestial bodies or artificial signals (Moltz, 2019).

Any risk discussion would be remiss if not considering Black Swan principles. Accepted risks and vulnerabilities are largely based on known knowns or known unknowns, those concerns previously proven true or suspected to occur. Black Swan methodologies, from Nassim Taleb, are those actions which cannot be predicted from previous events with any reasonable certainty (Taleb, 2010). An excellent example is Japan's 2011 earthquake measuring 9.1 on the Richter scale and the fourth largest quake since seismologists began recording in 1900 (Live Science Staff, 2011). Reconstructed seismic events from historical records suggest this was the first 9.0 or larger earthquake to ever hit Japan with the next largest event being a 8.6 quake in 1707 (Live Science Staff, 2011). The 2011 earthquake reshaped all previous assessments and the impact on protection appeared through the Fukushima nuclear reactor at Fukushima. The reactor successfully withstood the quake's initial impact but other safety estimates were based on being located 5.7m above sea level. The tsunami which hit the site was measured at 15m, rocking the site, and rendering it still unusable today (World Nuclear Association, 2020). This event shows how one Black Swan event can change all previous estimates.

The final risk step address mitigation by developing the means to reduce or eliminate risk. Establishing space as a CI sector would grow the consolidated structure to discuss and suggest future mitigations. The ISAC may be the first step towards those goals but additional coordination will certainly be necessary. Terrestrial mitigation will likely prove easier than reducing orbital risk although the imposition of industry standards and communication could accelerate these processes. recent congressional report to Congress on Space

Traffic Management even states the Department of Commerce should assume this responsibility from the DoD due to increasing orbital expansion. The report views the DoD as not capable of handling the expanded scale necessary to deal with orbital debris and control, then classified Space Situational Awareness as a public good (Hitchens, 2020). Mitigation works best when more views are involved and growing new federal and commercial partnerships could help develop excellent solutions to space's inherent threats and vulnerabilities.

5. The Case for Space

Making a case for space as an independent CI sector requires evaluating the three hypotheses. For the first hypothesis, a subjective assessment was made as to whether each sector contributed to public health, public safety, and an economic benefit. Public health was evaluated as to whether the general health and well-being of the public would deteriorate if the sectors were unavailable. Public safety was assessed as whether a lack of standardization, control, or limited resource usage would be detrimental to overall public safety. The final element, economic benefit, again considered subjectively whether the area proved beneficial to overall U.S. finances and production capability. The below chart collates the scores to evaluate the first two hypotheses and then ranks both aggregate and individual sectors for comparison.

The first hypothesis, H1, considers if space infrastructure provides beneficial public health, safety and economic results. Space was evaluated as making no contribution to public health, a positive benefit to public safety and a positive benefit to the overall economy.

H1. If space industry infrastructure is protected than significant value will be preserved to the general public safety, health and economic outcomes for U.S. citizens.

This resulted in a combined score of .7 for the H1 hypothesis. Compared to the aggregated sectors, Space ranks above all except Digital Spaces, ranking two among the six aggregated categories. When compared to individual sectors, the rank for space scores below Energy, Communications, and Information Technology while ties with four of the remaining thirteen and outranks the final nine.

Space cannot currently be considered as beneficial to public health. No direct benefits derive from space which make public health better daily. However, GNSS must be considered beneficial to daily public safety from a navigation and mapping perspective. Most relate to GNSS through the more common aspect, Global Positioning Systems (GPS) as related to electronic mapping services. In 2019, global GNSS revenues were estimated at $97B, just short of one-third of the overall space revenue (Satellite Industry Association, 2020). While individual navigation revenues may be limited, the RTI International group estimated that GPS has generated $1.4T in economic benefits since its

Table 2: Critical Infrastructure Evaluation

CI Group	CI Sectors	Public Health	Public Safety	Economic Benefit	Score (H1)	National Security (H2)	Combined	Aggregate Rank	Sector Rank
Space		0	1	1	0.7	1	1.7	1	2
Hazardous		0.3	1	0.3	0.5	0.3	0.8	4	
	Chemical	0	1	0	0.3	0	0.3		5
	Nuclear Reactors, Materials and Waste	0	1	0	0.3	0	0.3		5
	Energy	1	1	1	1.0	1	2.0		1
Life Sustaining		0.7	0.7	0	0.5	0	0.5	5	
	Waste and Wastewater	1	1	0	0.7	0	0.7		4
	Dams	0	1	0	0.3	0	0.3		5
	Agriculture	1	0	0	0.3	0	0.3		5
Manufacturing		0	0.3	0.7	0.3	0.3	0.6		
	Critical Manufacturing	0	1	1	0.7	0	0.7		4
	Commercial Facilities	0	0	0	0.0	0	0.0		6
	Defense Industrial Base	0	0	1	0.3	1	1.3		3
Digital Spaces		0.7	1	1	0.9	0.7	1.6	2	
	Communications	1	1	1	1.0	1	2.0		1
	Information Technology	1	1	1	1.0	1	2.0		1
	Financial Services	0	1	1	0.7	0	0.7		4
Government and Governance		0.5	0.75	0	0.4	0.5	0.9	3	
	Emergency Services	1	1	0	0.7	1	1.7		2
	Government Facilities	0	0	0	0.0	0	0.0		6
	Healthcare and Public Health	1	1	0	0.7	0	0.7		4
	Transportation Systems	0	1	0	0.3	1	1.3		3

creation in the 1980s. They further assessed any loss of GPS services could result in a billion dollars per day loss to the U.S. economy. These results were commissioned by NIST in an interest to discover how GPS affected the ten U.S. economic sectors which used GPS on a day to day basis (Coraggio, 2019).

In addition to GPS' economic benefits, the space industry continues to expand other economic sectors which contributed to the positive score. One of the biggest global space economic sectors deals with improved communications. As an example, global satellite television was evaluated at $92B in 2019 (Watson, 2019). The overall global pay T.V market in 2020 was evaluated at $225B. Satellite TV in the U.S was tracked in 2017 as $33.4B (Dziadul, 2020). This shows satellite television's importance as a U.S. market and global economic contributions. Satellite television offer significant entertainment as well as a means to communicate during external chaos which remains only minimally susceptible to terrestrial interference.

Overall, labelling and protecting space CI should be considered as a positive benefit for U.S. citizens and two of the three required areas for H1, proving this hypothesis as true. Space provide safety and economic benefits with this hypothesis score for space ranking significantly ahead of more than 50% of the remaining sectors. If this consideration alone was used, space should be added to the DHS CI listing as a funded protection area. The next hypothesis moves beyond public good to consider how space provides benefits to national security in protecting U.S. citizens from state and non-state threats.

The second hypothesis, H2, evaluates the benefit each CI sector brings to national security. A research inconsistency emerges here as space has no subsectors to consider so received a single score in a single sector.

H2. If space industry infrastructure is protected than significant value will be preserved to the national security outcomes for U.S. citizens.

Every aggregated section received a lower score than spaces their composite scores were averaged by the number of sectors. No aggregated sector appeared where all subsectors were assessed as having a positive benefit to national security. For the individual sectors, six sectors subjectively show importance to national security, when those scores are combined and averaged, no other section scores as high as space's full point. Of note, the critical manufacturing individual sector was considered not vital to national security as the Defense Industrial Base sector is assumed to encompass any manufacturing areas which directly contribute to national security.

The seminal work by James Clay Moltz, *The Politics of Space Security*, suggest there are three areas where space contributes to national security; space science and exploration, space utilities, and military applications (Moltz, 2019). Advancing zero gravity manufacturing, unique experiments, and the harsh environments has directly contributed to many inventions initially featured as national security now contributing to public welfare daily. A short list of items derived from infrastructure would include solar cells, water filtration, LASIK surgery, insulin pumps, artificial limbs, camera phones, LEDs (Green, 2019). Many of these items are part of a number of U.S. citizens daily life.

The second contribution for national security, space utilities, includes previously discussed areas like communications, satellite TV and global positioning. Space utilities would likely extend into networked command and control, and Earth monitoring activities short of direct military applications. Future aspects could include transmitted power, orbital manufacturing, and coordinated frequency management. In the future, the potential exists to develop habitable and self-sustaining environments in orbit, on the Moon, or as far out as Mars. Expanding humanity beyond a single biome should certainly be considered vital for national security.

The last contributing area for national security, military applications, evaluates the direct potential space brings to U.S. military strategy and implementation. The most significant gain from holding the ultimate high ground arrives from the advantage in reconnaissance, being able to observe the enemy and shorten one's own OODA loop for military actions.[3] As of 2020, the U.S. possesses the only Space Force stood up as an independent military branch. Russia previously established an independent service arm as a Russian Space Force, but this was merged into the overall Aerospace Forces (VKS) in 2015 and never a fully independent service (Ministry of Defense of the Russian Federation, 2015). Finally, maintaining a space presence allows for early warning of adversary attacks and provides a command and control loop outside terrestrial interception. These three advantages combine to make space CI vital to national security and prove H2 as true.

The third hypotheses counters the previous two by stating the establishment of a space CI sector remains unnecessary as all required functions are covered by other sectors. If this evaluation were proved true than the H1 and H2 evaluation areas would be common across the scoring metric.

H3. If space industry infrastructure is currently protected by other DHS Critical Infrastructure and Key Resource than a unique designation is not required.

During the evaluation, space scored as positive for safety, health, economic benefit, and national security. Of the other 16 sectors, only three show positive in the same areas; energy, communications, and Information Technology. Comparing the individual scores for each sector, the previous three areas again outscore space while space also ties with emergency services. A combined aggregate score of the previous two hypotheses places space as a the number one ranking, with the highest score, while the digital spaces score immediately behind.

Full spectrum analysis allows the possibility space may be ranked incorrectly by the combined scoring and lean towards an individual ranking. During the individual ranking, sectors with the same score were scored as tied. The top-three scoring sectors, and, ranked higher than space CI, were energy, communications, and information technology. Space tied for second place with emergency services and the remaining eleven infrastructure sections were all ranked lower. Some space aspects may be covered by either communications or infrastructure technology, those sectors are software and hardware, respectively. All CI aspects likely require some overlapping coverage from those two sectors just as all functions require energy. Additionally, economic scoring based on a quantitative metric might yield different results.

Space's unique structure means the cyber requirements under software

3 OODA is a common term in decision making processes and stands for Observe, Orient, Decide, and Act. In military tactics, the key is to able to complete one's own OODA loop before the enemy. Intelligence operations like reconnaissance make the OODA loop smaller than the adversaries and allows one to complete more cycles, faster.

and hardware for this sector may need to be considered differently. The Space ISAC establishment discussed earlier in the paper justifies this approach. Further, for any space orbital resources, much of their energy remains independent of terrestrial sources as orbiting satellites have the most direct solar potential and do not require as much support as ground-based energy sources. All ground-based stations and capabilities do require power with most sources from the terrestrial energy sector. The Defense Industrial base and critical manufacturing sectors currently cover some space aspects although these could be likely managed more efficiently as a direct space CI responsibility. Lacking any central governing body devoted to Space CI protection means unique facilities for launch, command and control, and positioning are likely left unprotected under current CI protection. All of these aspects lead to evaluate H3 as false since space CI does not appear to be effectively protected by overlapping CI sectors.

Conclusion

In conclusion, this paper evaluated a brief history of the CI process, to determine when CI was established and what factors were used to determine individual sectors. The next step proposed a method to evaluate whether space CI was needed and the metrics used before moving to consider what constituted space infrastructure. Those considerations lead to evaluating three hypotheses; whether space contributes to public safety, health, and the economy, whether space contributes uniquely to national security, and if space CI today is sufficiently covered by other national resources. The first two proved to be true with space ranking number one in combined scoring and ranking above 11 of the remaining sectors during individual scoring. The third hypotheses was evaluated as false since no other sector adequately covers space CI. Some overlap does occur although those same areas also overlap numerous other CI sectors with none precisely matching space.These areas lead to the three recommendations, establishing a model for space CI interactions, developing a regular process for evaluating CI, and finally, including space as a CI sector as soon as possible. Finally, remaining potential gaps and areas for future study will be discussed.

One of Moltz's recommendations suggests any model for space should be a netocracy. his netocracy would be international, transparent, commercially lead, networked, with small resilient platforms and bottom-up innovation (Moltz, The Changing Dynamics of Twenty-First-Century Space Power). Several of these characteristics could benefit any future space CI protection structure. The first characteristic, international, does not translate to CI protection however international norms will be needed to manage orbital space both physically and electromagnetically. Standards must be established to control orbital debris as well as to manage orbital frequency usage to prevent losing control of functions vital to public health and national security. Transparency between commercial and government sectors helps drive to the commercially led partnership similar again to other forms of CI. The last three elements clearly speak to building efficient CI protection for space through utilizing commercial successes to increase resilience through networking and innovation.

Moltz's clear path establishes while an agency may lead for protection, the commercial involvement will drive eventual success. The companies and development of local spaceports means the demand for space will continue to grow. As the demand grows, the sector must be protected and that protection between commercial and federal assets calls for efficient CI protection at all levels. Many companies today use complex, non-networked platforms which lack resiliency, coordinating U.S. efforts could increase control, and the economic return. While federal and commercial bodies exist to regulate various space functions, no central agency or networking function as required for CI protection. This body could also alleviate some responsibilities as the U.S. Space Force stands up, similar to how the Department of Commerce intends to assume Space Traffic Management responsibilities.

One key gap during this study was the lack of any coordinated body established to review and assess CI security areas for the U.S as an aggregate function. The areas selected since 1996 do not appear to undergo any active review or renewal process. Infrastructure changes, the pace of commercial technology like Space X, and even the growing Internet of Things suggest a more frequent and objective process is needed rather than the political vagaries from administration to administration. While the federal government must establish the process and timelines, the true work to defend U.S. space CI will likely fall mostly on the commercial sector. This will happen for two reasons, first, cyber actions will likely occur more under contractors and delivered equipment than as government actions. Second, expansions into the commercial market, private space travel for tourism, and the ease of maintaining low-cost satellites will create enhanced interest. Current satellite databases show just over 2500 satellites orbiting Earth but Space-X plans to launch over 42,000 in the next decade as part of their Starlink expansion (Union of Concerned Scientists, 2020); (Sheetz & Petrova, Why in the next decade companies will launch thousands more satellites than in all of the history, 2019).

As a final recommendation, the expansion of space, and the results of this evaluation suggest space should be included as soon as possible as a CI element for DHS. The study demonstrated space poses significant benefits to public safety through global navigation services and communication. The expanding space sector will continue to increase overall economic benefits as more and more corporations seek to secure space-based services. If nothing else, the sheer value of space-based assets to U.S. national security demand this sector should be evaluated and promoted to a DHS CI sector within the next 12 months. Any argument suggesting other sectors adequately cover space industry is insubstantial at best, and a strawman at worst as any significant losses to the space industry will critically affect the United States safety, economy, and national security.

Any reasonable study should suggest other areas for future research. While this study measured space qualitatively against other CI sectors, a more detailed look could occur between space and any one other sector. Additionally, an examination could effectively measure whether CI considerations should be measured as aggregated and multiple sectors, using multiple links between the elements instead of a government liaison and commercial representative. A third and final recommendation would be to develop a metric, such as direct economic benefit, and use those considerations to provide a more detailed look into sector by sector comparison.

Overall, this study effectively used three hypotheses to demonstrate why space industry should be considered critical infrastructure by the Department of Homeland Security. This study used a qualitative comparison to demonstrate space shows more benefit to public health and safety, economic benefit, and national security than the majority of the current CI sectors. The study showed the need to establish a clear model for evaluating space infrastructure, working with federal agencies to create a body to regularly evaluate continuing need for all the CI sectors, and to include space infrastructure as a protected, and budgeted element of either CISA or DHS's consolidated infrastructure list. Space poses the ultimate high ground, with the commercial incentives and U.S. Space Force elevation, we should not let this sector be bypassed simply because it has not yet been included on a governmental list.

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A Planetary Perspective of Earth Systems Sustainability: Reframing Climate Change Implications from Agricultural Adaptations in Maya Milpa Farming Communities in Belize

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Abstract

In a case review of climate-smart agriculture practices in Mayan milpa farming communities in Belize (Central America), this paper reframes how small-scale agriculture practices can influence larger Earth systems sustainability. In what has been a sustainable form of farming for hundreds of years, the milpa has become less sustainable due to global climate change, forest loss, soil degradation, population growth, and other factors. This article reviews the findings of a 2020 study of positive socio-ecological systems (SES) influences—environmental, economic, socio-cultural, and technological—from climate-smart practices on local resource sustainability. SES considers several multidisciplinary linkages of human and ecological factors in the agroecological system. SES considers several multidisciplinary linkages of human and ecological factors in the agroecological system. SES influences from small-scale climate-smart agriculture (CSA) practices can have both micro-scale impacts as well as macro-scale implications for SES sustainability and food security. Understanding the implications of small-scale farming on larger Earth systems can inform global climate change mitigations and government policy and action needed to promote CSA practices. This is important for the resilience of vulnerable populations such as Belizean milpa farming communities and others who rely directly on resource sustainability for their food and livelihood security.

Keywords: Climate-smart agriculture, socio-ecological systems, planetary, milpa, sustainability

 doi: 10.18278/sesa.2.1.8

Una perspectiva planetaria de la sostenibilidad de los sistemas terrestres: replanteamiento de las implicaciones del cambio climático a partir de adaptaciones agrícolas en comunidades agrícolas mayas milpa en Belice

Resumen

En una revisión de caso de las prácticas agrícolas climáticamente inteligentes en las comunidades agrícolas de milpas mayas en Belice (América Central), este documento replantea cómo las prácticas agrícolas a pequeña escala pueden influir en la sostenibilidad de los sistemas terrestres más grandes. En lo que ha sido una forma de agricultura sostenible durante cientos de años, la milpa se ha vuelto menos sostenible debido al cambio climático global, la pérdida de bosques, la degradación del suelo, el crecimiento de la población y otros factores. Este artículo revisa los hallazgos de un estudio de 2020 sobre las influencias positivas de los sistemas socioecológicos (SES) —ambientales, económicos, socioculturales y tecnológicos— de las prácticas climáticamente inteligentes sobre la sostenibilidad de los recursos locales. SES considera varios vínculos multidisciplinarios de factores humanos y ecológicos en el sistema agroecológico. SES considera varios vínculos multidisciplinarios de factores humanos y ecológicos en el sistema agroecológico. Las influencias del SES de las prácticas de agricultura climáticamente inteligente (CSA) a pequeña escala pueden tener impactos tanto a microescala como implicaciones a macroescala para la sostenibilidad del SES y la seguridad alimentaria. Comprender las implicaciones de la agricultura a pequeña escala en los sistemas terrestres más grandes puede informar las mitigaciones del cambio climático global y las políticas y acciones gubernamentales necesarias para promover las prácticas de CSA. Esto es importante para la resiliencia de las poblaciones vulnerables, como las comunidades de agricultores de milpas de Belice y otras que dependen directamente de la sostenibilidad de los recursos para su seguridad alimentaria y de sus medios de vida.

Palabras clave: Agricultura climáticamente inteligente, sistemas socioecológicos, planetario, milpa, sostenibilidad

从地球视角看待地球系统的可持续发展：从伯利兹玛雅米尔帕耕种社区的农业适应过程中重新定义气候变化意义

摘要

通过对中美洲伯利兹玛雅米尔帕耕种社区的气候智能型农业实践进行案例回顾，本文重新定义了小型农业实践如何能影响更大的地球系统的可持续发展。几百年来，传统米尔帕耕种实践一直是可持续的，但如今可持续性却因一系列因素而减少，包括全球气候变化、森林减少、土壤退化、人口增长，以及其他因素。2020年的一项研究发现，气候智能型实践对地方资源的可持续发展具有积极的社会-生态系统（SES）影响（包含环境、经济、社会-文化以及技术方面），本文对此进行了审视。SES考量了农业生态系统中人类因素和生态因素的多学科联系。从小型气候智能型农业（CSA）实践中产生的SES影响能为SES的可持续发展以及粮食安全产生微观影响和宏观影响。理解小型农业对更大的地球系统产生的影响能促进全球气候变化缓解，并影响推动CSA实践所需的政府政策及行动。这对脆弱群体的复原力而言是重要的，例如伯利兹的米尔帕耕种社区和其他直接依赖资源可持续发展以获取粮食安全和生计安全的那些群体。

关键词：气候智能型农业，社会-生态系统，地球，米尔帕，可持续发展

Introduction

This paper reviews the Drexler (2020) findings of positive socio-ecological system impacts from climate-smart agriculture practices in Mayan milpa farming communities in Belize, Central America and reframes it to a planetary perspective of how these adaptations can influence larger Earth systems sustainability as a space environment. Earth systems integrate biophysical cycles and human (e.g., socioeconomic) interactions in the atmosphere, hydrosphere, cryosphere, biosphere, geosphere, and anthroposphere "in both spatial—from local to global—and temporal scales, which determine the environmental state of the planet within its current position in the universe" (Rockström, et. al., 2009). Thus, human communities are a part of, and not apart from, the Earth system; humans experience impacts from climate change and can be more vulnerable to associated increases in resource loss and degradation (Drexler, 2020; Flint, 2015; Oremo, 2013; Young, 2008).

Planetary-level impacts from climate change have been observed from space for more than 40 years; these observations are central to monitoring and understanding how the dynamics of the Earth systems work (Durrieu & Nelson, 2013; Johannessen, 2009). Small-scale agriculture can also have planetary implications on Earth systems sustainability (Altieri, 2008). This paper will examine socio-ecological systems (SES) impacts of climate-smart agriculture (CSA) adaptations of milpa farming to reframe the issue to a planetary context.

SES considers multiple integrated human and ecological factors and linkages in the agroecological system. For example, adopting CSA practices in small-scale milpa agriculture has environmental, economic, socio-cultural, adaptive technology, and governance influences on local resource sustainability (Drexler, 2020; ERSI, 2008; Mazumdar, 2008). The nature of SES, especially from a planetary perspective, is inherently holistic and involves multi-disciplinary factors (Méndez, Bacon, & Cohen, 2013). Applying SES principles from one small region to the larger SES can and inform reasonably foreseeable climate change impacts (on both micro and macro levels) and promote mitigation policies in other regions of the globe (Uusitalo, et. al., 2019), with implications on resilience and food and livelihood security in more vulnerable and marginalized communities (Drexler, 2020; Tandon, 2014).

Planetary Sustainability

As defined by the National Aeronautics and Space Administration (NASA) the term "planetary sustainability" includes multi-perspectival factors (ecological, economic, social) includes three global visions (NASA, 2014); this paper will examine the first two as they directly relate to climate change impacts on planetary sustainability: 1. All people have access to abundant water, food and energy, as well as protection from severe storms and climate change impacts; and 2. All people have healthy and sustainable worldwide economic growth from renewable products and resources. Planetary sustainability also recognizes two sustainability conditions to determine safe operating space for human survival on Earth: 1. Respecting Earth system boundaries, such as biodiversity, atmospheric composition, freshwater resources, and other planetary boundaries (Galli & Losch, 2019; Rockström, et. al., 2009) and 2. Expanding our instruments and people into space (Galli & Losch, 2019; Pass, et. al., 2006).

Directly related to global policy toward planetary sustainability, there are 17 United National Sustainable Development Goals (SDGs), with an 18th potential goal (Figure 1) called "Space Environment" (Galli & Losch, 2019). The SDGs demonstrate multi-perspectival and socio-ecological system symbiosis, applicable to both local and planetary levels.

Figure 1. The UN SDGs with a potential 18th goal added (Galli & Losch, 2019).

Most SDGs are directly linked with global food systems and food security. Transformative policy and action to include the SDGs in examining non-food (i.e., alternatives to fossil fuels) and food-related strategies (less meat consumption, promoting government Extension services) are needed to facilitate climate-smart agriculture practices, resource sustainability, and food security for a growing global population (Campbell, Hansen, Rioux, Stirling, & Twomlow, 2018; Chaudhary, Gustafson, & Mathys, 2018; Pérez-Escamilla, 2017).

Climate Change, Food Insecurity, and Climate Justice

Climate change is one of the greatest threats to the people and economies of Earth (Marino, et. al., 2016; Vermeulen, Campbell, & Ingram, 2012). Agriculture is a key driver contributing to climate change (Campbell, et. al., 2017; FAO, 2013; Uusitalo, et. al., 2019). Climate change adversely and disproportionately impacts the rural poor who depend directly on natural resources for their food and livelihood security; these impacts exacerbate existing socio-economic (socio) and biophysical (ecological) conditions (Adger, 2003; Aminzadeh, 2006; John & Firth, 2005; Morton, 2007; Oremo, 2013; Schmidhuber & Tubiello, 2007; Vermeulen, Campbell, & Ingram, 2012). Climate change is not just an environmental issue, but increasingly an economic, socio-cultural, and justice issue, with implications on community resilience, food security, health, and livelihood security (Aminzadeh, 2006; Vermeulen, Campbell, & Ingram, 2012). Improvements in agriculture and the overall food system can be significant step toward planetary sustainability, food security, and climate justice (Campbell, et. al., 2017; Wezel, et. al., 2009).

Socio-Ecological Systems (SES) Framework

Socio-ecological systems (SES) is a theoretical framework which can examine multi-disciplinary and complex issues such as climate change impacts on agricultural landscapes and human communities (Drexler, 2020; Oremo, 2013). Climate change and food security studies are complex, systemic, cumulative, and intertwined with human systems (Molnar & Molnar, 2000). SES is a flexible framework which considers the interrelationships, linkages, and synergies between multiple trans-disciplinary factors (i.e., social, economic, environmental, cultural, governance, health, justice) and community-based partnerships and adaptive management (Olsson, Folke, & Berkes, 2004; Ostrom, 2009; Parrott, Chion, Gonzalés, & Latombe, 2012). A socio-ecological system is a linked network where an impact on one part of the system—climate change impacts from storm erosion, for example—can affect the larger system, such as food security and farmer livelihoods (Lal, 2008; Levasseur & Olivier, 2000; Molnar & Molnar, 2000; Selomane, Reyers, Biggs, & Hamann, 2019). Understanding these system relationships—and how each factor functions in the complex whole of the SES—is important as each decision a farmer makes to adopt CSA practices can advance the entire milpa agriculture system further (Koutsouris, 2008; UC Davis, n.d.).

A paradigm shift toward SES systems-thinking, described by Ratima, Martin, Castleden, and Delormier (2019) as a more "Indigenous way of thinking about the interconnected and interdependent web of the natural world" is needed to examine and understand complex SES linkages and dynamics, to manage resources and system vulnerabilities, and to facilitate policy changes on sustainability (Drexler, 2020; Sikula, Mancillas, Linkov, & McDonagh, 2015). A systems perspective is important in making climate mitigation and adaptation policies which contribute to positive outcomes of sustainable food systems; considerations should include equity, resilience, renewability, responsiveness, transparency, scale, and evaluation as well as SES indicators such as food security, health, environmental integrity, equity, and profitability (Niles, Ahuja, Esquivel, Mango, Duncan, Heller, & Tirado, 2017).

Climate Change Vulnerability in Belize

Focusing on Belize, there is evidence of climate change including a lack of rain, increased heat and sun exposure, offset rainy seasons, increased storm intensity, and an increase in pests and crop diseases; these changes were perceived to have direct and indirect impacts to resident health, livelihoods, resource security, cultural traditions, and compounding environmental impacts (Drexler, 2019). Communities in Belize are vulnerable to these direct impacts, which are compounded by factors such as deforestation, agriculture activity (i.e., the use of chemical inputs of pesticides and fertilizers), biodiversity loss, poverty, population growth, land degradation, and farming on degraded soils (Drexler, 2020; Flint, 2015; Oremo, 2013; Young, 2008; Meerman & Cherrington, 2005 as cited in Chicas, Omine, & Ford, 2016; Young, 2008).

Because milpa farmers depend upon the ecosystem for their basic needs, whole communities are impacted from system change; thus, there are implications for community food and livelihood insecurity from climate change impacts (Lozada, 2014). “The impacts of climate change are expected to threaten the sustainability of social, economic, and ecological systems” in Belize (Richardson, 2009, p. 8). Large-scale climate and ecosystem changes in southern Belize have distinct impacts on the environment, economy, food security, public health, culture, and other factors in Belizean milpa communities (Chicas, Omine, & Ford, 2016; Drexler, 2020); these impacts perpetuate a cycle of environmental degradation, poverty, and vulnerability to climate and ecosystem changes (Wildcat, 2013).

The Milpa Farming System

A milpa is a small-scale shifting cultivation system of subsistence farming (Downey, 2009; Nigh & Diemont, 2013) traditionally involving slash-and-burn and/or slash-and-mulch practices (Johnston, 2003; Thurston 1997). The milpa is a significant aspect of Maya culture and tradition as Maya identity, ceremony, community, and livelihood are all rooted in the milpa (De Frece & Poole, 2008; Falkowski, Chankin, Diemont, & Pedian, 2019). Milpa crop production is used for subsistence and selling at local markets (Downey, 2009; Emch, 2003; Levasseur & Olivier, 2000; Nigh & Diemont, 2013). Milpa practices include clearing small areas of forest to plant a diversity of crops—primarily corn, beans, and squash—on nutrient-rich soil (Emch, 2003; Mt. Pleasant, 2016).

For centuries, the traditional practice of milpa farming has been sustainable and reliable as the major food and livelihood source for Maya milpa communities in southern Belize (Altieri & Toledo, 2011; Benitez, Fornoni, Garcıa-Barrios, & López, 2014; Ford & Nigh, 2016; Nigh & Diemont, 2013) as farmers allow areas to regenerate to a mosaic of forest succession stages and crop diversity (Daniels, Painter, & Southworth, 2008; Isakson, 2007; Mt. Pleasant, 2016; Shal, 2002). In the last 50 years, however, the slash-and-burn aspect of milpa farming has become less reliable and less sustainable due to hydroclimatic changes (i.e., droughts, flooding, hurricanes), forest loss, pests and crop disease, soil degradation, and social factors such as poverty, population growth, land tenure, marginalization, and other factors (De Frece & Poole, 2008; Downey, 2009; Drexler, 2020; Levasseur & Olivier, 2000; Lozada, 2014; New Agriculturist, 2005; Shal, 2002; Steinberg, 1998).

Planetary Benefits of Climate-smart Practices on Milpa Farms in Belize

Small-scale farms practicing climate-smart agriculture can have a planetary-scale system benefit, including to global climate change and related impacts (Altieri, 2008). Climate-smart agriculture (CSA) practices aim to “increase productivity in an environmentally and socially sustainable way, to strengthen farmers' resilience to climate change, and to reduce agriculture's contribution to climate change" (Oremo, 2013, p. 14). Examples of CSA practices already proposed or being practiced on a small-scale in southern Belize include mulching and soil nutrient enrichment. Adopting CSA in Belize practices can enhance small farmers' adaptation to climate change and sustainably mitigate climate change impacts and support food security under a changing climate (FAO, 2013; Hellin & Fisher, 2019; Kongsager, 2017; Mugambiwa & Tirivangasi, 2017).

By examining climate-smart adaptive practices of Belize milpa farmers, one can see system influences of the small-scale practices with both micro-scale impacts (i.e., less site erosion, lower input costs) and macro-scale implications on Earth systems sustainability. Promoting the increase of CSA practices on traditional milpa practices such as mulching and soil nutrient enrichment can have overall positive environmental, economic, and socio-cultural influences and adaptive technology potential on milpa sustainability and resilience, as perceived by milpa farmers and Extension officers (Drexler, 2020; Ong & Kho, 2015).

Conclusion

It is critical for governments to implement planetary sustainability measures, taking into account the SDGs and socio-ecological systems framework, to mitigate future climate change impacts on both micro- and macro-levels. The socio-ecological system impacts of climate-smart agriculture adaptions to small-scale milpa agriculture in Belize has implications for sustainability on an Earth system level. Although milpa farming has been sustainable for centuries, global climate change and other factors such as poverty, population growth, and forest loss have made the practice less so over the last 50 years. Promoting the increase of CSA practices such as mulching and soil nutrient enrichment has overall positive environmental, economic, and socio-cultural influences and adaptive technology potential on milpa sustainability and resilience, as perceived by milpa farmers and Extension officers (Drexler, 2020).

With the ability of space-based observation to predict climate change impacts and mitigation, the technology potential of space-based observations will be critical for food and livelihood security of not just Belize milpa farmers as found in this case, but other global farmers as well. Since farmers rely directly on SES systems (water, climate, soil nutrients, markets, governance and policies), they are invested stakeholders and should partners in solution-finding processes. CSA adaptive practices at the milpa farming community-level have positive SES indications that can be applied at the planetary systems level with wider implications for more sustainable global farming systems, food and livelihood security, and resiliency to climate change impacts.

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National Space Policy: International Comparison of Policy and the 'Gray Zone'

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Abstract

The 'Space Race' started as a competition between two nations, the United States and the Soviet Union. The Soviet launch of Sputnik in 1957 sparked swift expansion of new U.S. federal guidelines and systems (Stine, 2011). The rise of space-faring nations has triggered the expansion of national-level policy development and international cooperation. Policy development further expanded global markets and protected respective national security interests. International cooperation has allowed like-minded nations to discuss intentions and capability in the space domain. This research describes, analyzes, and reviews contrasting space policies and their application to the space domain. Furthermore, this research presents an international comparative analysis regarding the impact of Gray Zone activity to space policies, or lack thereof, in regards to U.S., China, and India.

Keywords: national space policy, gray zone, international, space race, space domain, United States, China, India

Política espacial nacional: Comparación internacional de política y 'Zona gris'

Resumen

La "carrera espacial" comenzó como una competencia entre dos naciones, Estados Unidos y la Unión Soviética. El lanzamiento soviético del Sputnik en 1957 provocó una rápida expansión de las nuevas directrices y sistemas federales de EE. UU. (Stine, 2011). El auge de las naciones que navegan por el espacio ha desencadenado la expansión del desarrollo de políticas a nivel nacional y la cooperación internacional. El desarrollo de políticas expandió aún más los mercados globales y protegió los respectivos intereses de seguridad nacional. La cooperación internacional ha permitido a naciones con ideas afines discutir las intenciones y la capacidad en el ámbito espacial. Esta investigación describe, analiza y revisa las políticas espaciales contrastantes y su aplicación al dominio espacial. Además, esta investigación presenta un análisis comparativo internacional sobre el impacto de la actividad de la Zona Gris en las políticas espaciales, o la falta de las mismas, en lo que respecta a EE. UU., China e India.

Palabras clave: política espacial nacional, zona gris, internacional, carrera espacial, dominio espacial, Estados Unidos, China, India

国家太空政策：政策和“灰色区域”的国际比较

摘要

“太空竞赛”以美国和苏联两国之间的竞争展开。1957年苏联斯普特尼克卫星发射一事触发了美国联邦新指导方针和系统的迅速扩大（Stine, 2011）。太空强国的兴起已引发了国家层面的政策发展和国际合作的扩大。政策发展进一步扩大了全球市场，并保护各自的国家安全利益。国际合作允许志同道合的国家探讨太空领域中的意图和能力。本研究描述、分析、审视了截然不同的太空政策，以及这些政策在太空领域中的应用。此外，本研究提出一项国际比较分析，以美国、中国和印度为例，分析了“灰色区域”（Gray Zone）活动对太空政策产生的影响，或是没有产生影响。

关键词：国家太空政策，灰色区域，国际，太空竞争，太空领域，美国，中国，印度

I. Introduction

The ‘Space Race’ started as a competition between two nations, the United States and the Soviet Union. The Soviet launch of Sputnik in 1957 sparked swift expansion of new U.S. federal guidelines and systems (Stine, 2011). The rise of space-faring nations has triggered the expansion of national-level policy development and international cooperation. Policy development further expanded global markets and protected respective national security interests. International cooperation has allowed like-minded nations to discuss intentions and capability in the space domain. This research describes, analyzes, and reviews contrasting space policies and their application to the space domain. Furthermore, this research presents an international comparative analysis regarding the impact of Gray Zone activity to space policies, or lack thereof, in regards to U.S., China, and India.

The U.S. and U.S. Intelligence Community is faced with a difficult and complex problem. Although currently policy and doctrine exists to help examine the space domain, it is vital to examine how particular threats are within the gray area of the space domain. Space systems encompass an array of capabilities from non-kinetic to kinetic effects. However, the complexity of space and its connection to critical national security infrastructure pose significant vulnerabilities to the international community. The rapid growth of space-faring nations and indigenous capabilities leave nations and their allies susceptible to space-centric targeted attacks. National level policy and strategic direction by senior military and political leaders is continually developed to ensure the protection of national infrastructure. Nevertheless, adversarial nations continue to blend hard and soft power tactics to achieve strategic objectives.

The blending of these tactics, or Gray Zone activities, allows nations to remain below the threshold of conflict and absolute war. Dalton et al. (2019) explain Gray Zone threats are "sharp power, political warfare, malign influence, irregular warfare, and modern deterrence" (n.p). The competition for space dominance is an elusive domain where space activity is ambiguous and susceptible to non-kinetic threats (Wright, 2018). Nations are employing these Gray Zone activities to destabilize and influence adversaries in an effort to shift the balance of power regionally and internationally.

As the capacity of space-faring nations has increased, the corresponding threats in the space-domain have expanded exponentially. Historically, the U.S. was faced the threat of communism and primarily focused on the Soviet Union. The launch of Sputnik shocked the U.S., triggering the Space Race. In contrast, the political unrest in China caused a cultural upheaval, impeding Chinese space program expansion (Drozhashchikh, 2018). The lag of China's space program fueled China's ambition to catch-up to the U.S. and Russia's space capabilities. Similarly, India was able to enter the space enterprise but through the development of rockets and nuclear capabilities. Nevertheless, India's nuclear program testing in the late 1970s caused China to place sanctions on India affecting their ability to construct a space launch pad (LeLe, 2017). This delay showcases China's strategy to achieve regional dominance by preventing nations, within the region, from expanding space capabilities. Although, each nation holds a different strategic purpose these nations are affected by a new common enemy, the Gray Zone. In turn, it may influence their respective decision-making abilities.

As the space domain becomes more advanced, it is crucial to examine the factors associated with Gray Zone activities. Space policy is not prepared to handle the challenges associated with Gray Zone activities. Space policy must reflect on Gray Zone challenges to implement an effective space strategy. The ambiguity of the space domain creates the ideal breeding ground for Gray Zone activities. However, for nations to successfully manage, deter, and mitigate Gray Zone activity, these nations must critically assess their space policy or lack thereof. Policy is the foundation for the implementation of strategy.

Creating a structured, sound strategy requires more than establishing objectives. It requires critically thinking about threats associated with activities outside of red lines. Furthermore, it requires effectively employing a strategy with clarity, precision, and advancement in space and counterspace technologies. Gray Zone challenges require a multifaceted approach to include examining policy, strategy, and cooperation agreements. However, to develop an effective strategy, nations must consider the value of cooperation agreements.

The Gray Zone requires nations to create policy that allows nations to defend their interests while outlining strategic goals in the space domain. Although having a space program is vital, it is not efficient enough to support the space warfighting domain. Nations must seek to establish polices to maintain balance and order within the space domain. Furthermore, establishing national level space policy allows nations to be proactive by addressing Gray Zone challenges in the space domain and set expectations across the space enterprise.

II. Defining the Gray Zone

Various scholars have attempted to define Gray Zone activities, concluding they are inherently ambiguous in nature. For example, Brands (2016) states Gray Zone activities are "coercive and aggressive in nature, but are deliberately designed to remain below the threshold of conventional military conflict and open interstate war" (n.p.). These gray activities present a greater challenge for the creation and implementation of space policy because of the connection between space assets and critical national security infrastructure. Harold et al. (2017) argues that "although space systems are designed to operate in harsh environments, they are vulnerable to other phenomenon" (p. 78). While there are various definitions of the Gray Zone, for the purpose of this research, Morris et al.'s (2019) definition will be utilized. Morris et al. (2019) states:

> The Gray Zone is an operational space between peace and war, involving coercive actions to change the status quo below a threshold that, in most cases, would prompt a conventional military response, often by blurring the line between military and nonmilitary actions and the attribution for events (p. 7).

III. Space Policy Foundations

The two largest space domain competitors in the world today are the U.S. and China. As a result, establishing space dominance is essential to global market stability and economic growth. First, the U.S. established an official U.S. National Space Policy (NSP), which was intended to expand global markets, influence capitalism, extend benefits of space, and promote safe operations in space while supporting national security by integrating intelligence (NSP, 2018). National leaders have recognized freedom of movement in space is not assured, thus the establishment of the NSP (Wilson, 2017). The NSP provides guidelines for how the U.S. government operates in the space domain and establishes directives to carry out the strategy.

The U.S. has established a national space policy to inform the international community of the goals and objectives within the space domain. Furthermore, U.S. NSP supports the growth of the space industry, expands U.S. markets, and increases access to foreign markets. Additionally, the U.S. NSP indicates the Director of National Intelligence (DNI) shall "identify and characterize current and future threats to the U.S. space mission for the purposes of enabling effective protection, deterrence, and defense" (U.S. NSP, 2010, p. 14). However, the DNI has failed to identify intelligence requirements for the Intelligence Community related to Gray Zone activity. As stated by James Clapper (2010), "Intelligence is not just about things and not just about places. It is about things in places." It is imperative for the U.S. Intelligence Community to examine the developments in space and the challenges associated with those developments. The lack of foresight on Gray Zone activity causes a direct connection to the vulnerabilities in the implementation of the U.S. NSSS.

However, U.S. policy fails to identify the threshold for unacceptable activity within the space domain. Although agreements exist to promote the peaceful use of outer space, the art of war is complex. For example, China employs Gray Zone tactics to expand their campaign of influence in the South China Sea (Brands, 2016). Still, the broad and ambiguous nature of the Gray Zone compels nations to define it based on the threat environment.

In direct comparison to the U.S., China entered the "Space Race" for the purposes of research and development. China has not established an official national level policy, but outlined the China Space Dream. For example, Acuthan (2006) explains China's space activity principles are determined by their significance and ability to protect national interests. Furthermore, identifying Gray Zone activity in the space domain would not be conducive for achieving China's Space Dream.

For instance, China utilizes Gray Zone activities to strengthen its military position. For example, China's continual efforts to establish control and undermine international law advanced with the creation of artificial islands and militarized facilities in the South China Sea (Hicks, Federici, & Akiyama, 2019). In contrast to the U.S., China is not attempting to gain dominance in the space domain to promote capitalism. China is attempting to dominate the space domain through regional control over commerce and economics in Asia. The Space Dream is highlighted by President Xi as an important aspect of space dominance and national rebirth (Pollpeter, Anderson, Wilson, & Yang, 2017). However, becoming a global power requires more than a grand strategy. China's lack of a national space policy leaves room for costly error when devising a space dominance strategy.

The U.S. and China utilize two different ideological underpinnings to establish themselves as dominant space powers. However, nations such as India have no desire, presently, to become a superpower in the space domain. In contrast, the desire is to obtain space-based capabilities to enhance human-kind and societal growth. India suffers internally from poverty and societal challenges, but views space capabilities as a way to improve socioeconomic growth while providing strategic benefits (LeLe, 2017, p. 27). Science and Technology has deep roots in the culture of India paving the way to India's early investments in the space arena. The philosophical view of India is to eliminate poverty by enhancing sections of its general population (LeLe, 2017). The space domain has provided a path to socioeconomic growth within India and the ability to grow knowledge within their populace.

Examining the strategic view of the U.S., China, and India's space policies is important to understanding the strategy used within the space domain. Official policy, determined by senior national and military leaders, creates a framework to support national interests while enhancing international presence. The U.S. has a strategic advantage because the establishment of the U.S. NSP allows for the incorporation of directives into strategy. For example, the U.S. NSP led to the U.S. National Security Space Strategy (NSSS). The policy created a standard for the U.S. government to operate from by laying out purpose and expectations. The strategy "draws upon all elements of national power" and sets the requirements for active leadership within the space domain (NSSS, 2011, p. 5). However, the NSSS (2011) fails to identify the factors associated with Gray Zone activities in the space domain.

In comparison, the China Space Dream does not explore conducting predictive analysis on other space-faring nations to deter or enable an appropriate response to potential Gray Zone activities. Additionally, the lack of an official space policy for China creates difficulty in determining the direction of China's space program. The concept of the Gray Zone requires nations to understand how and when such activities would be utilized. The nature of the space domain is ambiguous; therefore, it requires proactive policies and established objectives to deter, mitigate, and/or prevent such activities.

In contrast, India has taken a different approach. India understands the importance of space-based capabilities. However, India's foundational principles stem from philosophical thinking based on the improvement of its populace. The lack of a national space policy leaves India with a smaller budget for space capability development. LeLe (2017) notes India utilizes only 1% of their budget for space-based development. The goal of India can be construed as backwards, but the philosophical standpoint is to improve knowledge which in-turn will improve India's socioeconomics.

Although, it is imperative to understand the policy foundations of each nation, it is equally important to understand how these policies, or lack thereof, impact strategic planning. The following section will explore and analyze space strategy based on established priorities. The objective is to understand how these nations develop and implement strategy based on national interests, regional influence, and domestic survival. Furthermore, this analysis examines the strengths and weaknesses of respective strategies when factoring in Gray Zone activities.

IV. Implementation of Strategy

While, U.S. policy is focused on the peaceful use of space it imperative to recognize the threat competing powers. As such, the NSSS (2011) outlines U.S. reliance on space-based capabilities thus the need for a strategy to prevent and deter aggression within the space domain. The U.S. has focused on the incorporation of an intelligence posture into the space enterprise to assess current and emergent threats to the domain. This approach is critical to defending U.S. interests and the peaceful use of space. An example actualizing the protect and defend element of the national strategy is the creation of the Joint Task Force Space Defense (JTF-SD) under U.S. Space Command. The JTF-SD executes this policy and strategy through the National Space Defense Center (NSDC) providing protection of critical U.S. and allied space assets.

The growing number of space-faring nations should constitute a re-examination of what happens in case of a Gray Zone conflict. The intelligence community has entered a challenging time and defining Gray Zone activity is essential for successful implementation of strategy. For example, the National Security Strategy (NSS) emphasizes the challenges associated with access to the space-domain. The NSS explains these challenges include the ability for governments and private organizations to access space endeavors previously unavailable. The U.S. IC must examine this unfettered access to space and its associated challenges. It requires thinking longer and harder about what is considered to be Gray Zone activity.

In comparison, China has focused its efforts on the established Space Dream. The strategy within the Space Dream is to build China into a space power in all respects (White Paper, 2016). Furthermore, President Xi has implemented Chinese ideology into the Space Dream ensuring the survival of Chinese socialism. The space strategy of China is designed to influence the Chinese people by demonstrating the Chinese Communist Party is the greatest group to the run the country (Pollpeter, 2017). Similar to the U.S., China's space strategy connects leaders to all facets of China's business and international policies (Bowe, 2019). Although, China's ideology is inspired by total control, the underpinnings of how the U.S. and China implement strategy is fundamentally similar.

As China continues to implement the Space Dream with economic and security interests in mind, it has found an opportunity to employ its Belt and Road Initiative (BRI). As China continues to gain regional influence in order to obtain global dominance, the BRI provides a mode to increase connectivity while implementing strategy. The space projects related to the BRI may boost partaking nations economic dependence on China, giving Beijing superior influence over them (Rolland et al., 2019). The China Space Dream links directly to the BRI allowing China to gain space power while strategically positioning themselves around the region.

Scholars argue the BRI is not a strategy but rather a process. The broad over-reaching concepts within the BRI do not provide strategic focus. For example, the BRI addresses China's intentions to expand its trade into an estimated 65 countries (Hillman, 2017). However, it lacks a detailed plan of the desired outcome and the challenges associated with handling 65 countries. Moreover, Mauk (2019) argues China's new geopolitical and economic strategy to has provided opportunity to build fifty special economic zones. However, the BRI is just a blueprint outlining the approaches China desires to take in regards to expanding its dream across Indo-China.

In contrast to the U.S. and China, the implementation of India's space strategy is a matter of necessity. India is focused on socioeconomic growth and the defense against domestic challenges. Therefore, India must continue to develop a strategy that eases influence and deters nations, such as China, while reducing domestic poverty. India refocused their attention to address national security concerns. India began the development of new capabilities and while addressing and enhancing legacy capabilities (Rajagopalan, 2018). India understands the philosophical thinking of China and its tactic of exploiting weaker countries. For example, India spoke out against the BRI explaining China's intent was to create unmanageable obligations for the Indian Ocean neighbors to establish power of regional choke points (Chatzky & McBride, 2020). In response, India developed indigenous counterspace capabilities as a strategic deterrent capable of enhancing India's socioeconomic position.

India wanted to establish their name on the international stage in response to the rapid growth of space-faring nations. In 2019, India focused its strategic efforts by conducting a successful Anti-Satellite (ASAT) test (Masih, 2019). The test of India's ASAT capability made India the fourth country capable of destroying an enemy satellite. This test created a unique strategic opportunity for India to display a unique power possessed by few nations. India intended to prove to China their ability to hold China's space assets at risk, if needed (Tellis, 2019). Overall, in contrast to the U.S. and China, India's ASAT test and strategic thinking has restored strategic balance between India and China, whereas China and U.S. strategy implementation causes a flex a of strategic power.

Although India may have restored the balanced, it has failed to make significant progress in developing an effective space strategy. The Indian Space Research Organization (ISRO) has been the sole guardian of India's space program since the 1960s and is primarily focused on socioeconomic development (LeLe, 2019). As a space-faring nation, India must establish a space strategy to identify strategic objectives rather than relying on strategic capabilities. India's absence of a space strategy showcases India's lack of influence around the region. This shortage of influence exposes India to increased potential Gray Zone activity. Establishing a national space strategy could give India the strategic structure it needs to reduce the risk of increased Gray Zone activity.

Evidence suggests U.S. strategic thinking has showcased their space dominance through a structured framework that ensures political, strategic, and operational success. Conversely, China has incorporated a "one power fits all approach" by integrating the BRI into the China Space Dream. However, India has found a unique way to balance its national interests while strategically deterring China's influence on India's economic situation. Each nation must seek to critically examine space strategy to tackle Gray Zone challenges.

Finally, the analysis of strategy implementation showcases the importance of ensuring space dominance while promoting capitalism for the United States. However, there is no clear "red line" addressed in the NSSS leaving the U.S. to manage Gray Zone escalation in a space conflict quickly. In the same respect, China's ability to promote the Space Dream while embracing the Chinese Communist Party highlights China's goal of being the sole power in the region. Nonetheless, the lack of strategic consideration of Gray Zone activity could turn China's Dream into a nightmare. On the other hand, India strategically harnesses their ideology of enhancing socioeconomics by advancing their space capability. India's ability to conduct and successfully test their ASAT capability shocked not only the U.S. but heightened China's awareness to India's tolerance of the "Chinese Bully." Yet India is going to have to develop a space strategy capable of outlining Gray Zone deterrence mechanisms to prevent persistent gray activity from nations, such as China.

V. Policy Cooperation

Cooperation between nations is based on the concept of trust. As nations continue to strategically compete with potential adversaries, they must seek allies. Cooperation, in space, began in the late 1960s when the international community recognized the potential for militarization in space. In 1967, the U.S. signed the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, known as the Outer Space Treaty (OST) (Department of State, 2017). The concept behind the treaty was to ensure the use of space contributed to the prosperity of mankind.

Specifically, the OST is a "weapons specific treaty, which prohibits, inter alia, the placing or testing of nuclear weapons or any other kinds of weapons of mass destruction in outer space" (OST, 1967). Furthermore, in comparison to the U.S., China and India both signed the OST in 1967 to continue to show the international community their support for the peaceful use of the space domain. The OST provided the foundational framework for the international community's exploration and operations in the space domain. However, space capabilities have advanced and the Gray Zone is creating disputes over what is legal and acceptable in the space domain.

The U.S. has recognized Russia and China as crucial competitors. However, the U.S. has continued to seek allies from nations such as Europe, Canada, and India. As the title for space dominance continues, the U.S. has recognized the importance of establishing and working together with such allies. For example, in 2018 the establishment of the Combined Operations Space Center (CSpOC) represented the ability for nations such as the U.S., United Kingdom, Canada, and Australia to collaborate on space issues. The CSpOC "ensures the combined space enterprise meets and outpaces emerging and advancing space threats" (Public Affairs, 2018, n.p.). The establishment of the CSpOC provided a mechanism for the U.S. to work in partnership with coalition forces.

Furthermore, the U.S. has utilized its goal of expanding global markets to seek out stronger cooperation with India. As India continues to imprint themselves in the space domain, the U.S. has discovered India's space launch services appealing and of economic value (Bommakanti, 2019). Enhancing the U.S.-India relationship is vital to shaping and gaining influence in the Asian region. Furthermore, President Trump stated in his visit to India on 24 February 2020, he looks forward to expanding space cooperation with India (Howell, 2020).

Although China has agreed to peaceful operations in the space domain there is speculation about some agreements China has entered. For example, China entered an agreement with Latin America in 1987 and by 2017 opened a satellite tracking and control center in Patagonia (Klinger, 2018). As previously identified in China's Space Dream, this provides a mechanism for China to strategically achieve global space access. This particular area of Patagonia sits "directly south of Washington D.C. and therefore can spy on the geostationary satellites that serve the U.S. East Coast" (Klinger, 2018, p. 47). This cooperation with Latin America has provided China an avenue to expand economically, increase influence, and garner space access in the Western Hemisphere. It is this sphere of influence that allows China to continue Gray Zone activities to manipulate information and influence political relationships.

China rests their philosophical thinking on expanding Chinese thought but also recognizes the need for allied partners. In comparison to the U.S., China has established agreements with nations such as Russia to foster collaboration in satellite navigation and space mechanisms (White Paper, 2016). Establishing these agreements allows China to continue to expand their space capability production while enhancing current space-based capabilities. Furthermore, China and France engaged in bilateral cooperation for other exploratory space related programs (White Paper, 2016). Although, this is used for scientific purposes, in theory, China can use these space capabilities as a strategic advantage during conflict. Access to these capabilities provides China the ability to acquire information on weather, for instance, predicting the use of airborne assets.

Establishing these agreements allows China to not only improve its current capability, but also to potentially extend and realize their space objectives in a more expeditious manner. For instance, space assets may have access to tertiary trademarked property and open-source capabilities with unknown vulnerabilities (Bailey et al. 2019). Access to more space capabilities enable Gray Zone activity in the space domain. Partnering with different nations may provide China access to new development initiatives exposing unique vulnerabilities to space systems. These agreements allow China to assert their dominance using lawful agreements to gain influence among nations and the potential to expand Gray Zone activities.

India has also instituted agreements to establish allied cooperation in the space domain. In 2014, the IRSO launched "57 satellites for 21 different countries" (LeLe, 2017, p. 30). This allows India to be a major competitor in the aspect of space launch. These agreements of cooperation allow India to focus on development of their space program while enhancing socioeconomics. However, the relationship of the U.S. and India rests on India's nuclear program.

As India and the U.S. continue discussions, the U.S. is focused on identifying India's intent with their nuclear program. India is not a signatory of the NPT creating concern for the U.S. relationship with India (Bommakanti, 2019). Strategically navigating the space enterprise includes recognizing what is and is not acceptable regarding space operations. The continued development of India's nuclear program creates discourse for U.S.-India relations. Nevertheless, India should consider cooperation agreements that can influence the decision-making process of its adversaries, in particular China.

India must evaluate the current pressure of China and effectively manage a deterrence strategy. For example, in 2018 a report to India's National Security Council Secretariat (NSCS) found China was responsible for approximately 35 percent of cyber-attacks against India (Radziszewski, Hanson, & Khalid, 2019). Partnering with nations, such as the U.S., would allow India deterrence options by securing the trust of a nation with significant international influence. As India strategically considers conflict management, with regards to China, it is imperative India acquires allies who can influence a decrease in Gray Zone activities.

VI. Conclusion

This research highlights the U.S., China and India's lack of incorporation of Gray Zone challenges into a national space policy. The U.S. has implemented the NSP; however, the policy fails to identify the competing challenges of Gray Zone activities. China has no publicly released national space policy and fails to identify Gray Zone challenges overtly because China employs such activities to gain regional influence (Acuthan, 2006). India has not established a national space policy due its priority of enhancing socioeconomics to eradicate poverty. Space policy plays an integral role in maintaining, sustaining, and expanding as a nation in the space enterprise.

These three nations all have different strategic objectives; however, they will all face the challenges of Gray Zone activity. As the U.S. protects and defends vital national security infrastructure in the space enterprise it must consider how it will strategically maneuver Gray Zone activities. Furthermore, China continues to employ Gray Zone tactics to achieve regional dominance (Hicks et al., 2019). China has mapped out an ambitious space plan focusing on how the BRI will provide funding for China's space program. However, China must realize the challenges associated with gaining such influence around the region. Gray Zone activities could prevent the BRI from achieving its objectives thus reducing influence in the region rapidly. Lastly, India's lack of a space policy reduces the influence India may have in the region. Furthermore, with the many challenges India is facing domestically, a national space policy may just provide a strategic structure.

Policy is important, but creating a strategy to achieve those objectives outlined in policy is vital. The U.S. has a publicly released NSSS that outlines the goals and strategic approach the U.S. will utilize to maintain space superiority. However, the broad and ambiguous nature of space requires the Gray Zone be tackled in a strategy of its own. Conversely, China has placed high stakes in the BRI, showcasing China's will to gain regional influence while advancing their strategic objectives (Hillman, 2017). Yet China is relying on Gray Zone tactics to achieve regional dominance without examining how Gray Zone tactics can be employed against their own strategy. India has strategically placed themselves among the prestigious ASAT community anticipating it will deter influential nations, like China. But the inability of India to create an agenda outlining military and space objectives leaves India significantly vulnerable to Gray Zone activity.

Cooperation agreements are vital as nations continue to promote the peaceful use of space and implement space strategy. As the U.S. continues to gain large allied partners such as the U.K, Canada, and India, these agreements increase the influence the U.S. has on the international stage. However, the ambiguous nature of space requires nations to step forward and establish norms in the space domain (Wilson, 2017). The growing concern of Gray

Zone activities calls upon nations with significant influence, both regionally and internationally, to create operating standards in the space domain. The U.S. has partnered with nations large and small; however, it is time the U.S. begins discussion about Gray Zone activity and its impact to those cooperation agreements and space capabilities.

As China continues to seek out space capability cooperation agreements with regions such as Latin America, it imperative to identify the impact of Gray Zone activity. China has implemented the BRI in an effort to sustain and gain regional influence (Rolland et al., 2019). However, as China continues to expand its economic influence, they fail to identify the impact of Gray Zone activity on such initiatives. China succeeded in gaining regional influence through coercive tactics and international influence. However, China must be cautious on how it approaches the implementation of the BRI as nations, such as India highlights the financial burdens it imposes.

Conversely, India is working toward promoting and enhancing socioeconomics. However, the development of India's nuclear and missile program has created hesitation for nations, like the U.S., to enter bilateral space cooperation agreements (Bommakanti, 2019). India must evaluate the current tensions with China and assess the value of having space cooperation agreements with the U.S. A space cooperation agreement with the U.S. would not only enhance socioeconomics, but also potentially deter Gray Zone activity domestically. Furthermore, space cooperation agreements could possibly provide India with insight into a strategic framework for developing space capabilities and enhance India's space operations.

Although, agreements have been established to promote the peaceful use of space, space capability development, and data sharing agreements, nations must consider the challenges of the Gray Zone. The aim of Gray Zone activity is to influence or coerce other nations without directly violating legal agreements or directives (Dalton et al., 2019). Nations are doing exceptionally in creating agreements for the development of space capabilities and cooperation in Human Space Flight. However, as space capabilities begin to develop, acknowledging the Gray Zone is vital to maintaining, sustaining, and promoting the peaceful use space.

As the international community continues to promote space domain exploration and research, they must also reflect on Gray Zone activities and its impact to space policy. Although this research highlighted several different aspects to include strategy and cooperation, it is vital to see the interconnectedness these aspects play in the development of space policy. Furthermore, this research highlights areas in which nations such as the U.S., China, and India must seek to enhance and/or create space policy to tackle the challenges of Gray Zone activity. The space domain creates a breeding ground for Gray Zone activity. The ambiguous nature of space and its capabilities call upon all nations to protect and preserve the space domain and its contributions to society.

First, this research recommends nations such as the U.S., China, and India develop space policies that address the Gray Zone phenomenon specifically. Identifying these challenges and its impact to space capability development is vital to ensuring an effective space strategy is developed and implemented. Moreover, these nations should come together as a space enterprise community and seek guidance from one another to develop space cooperation agreements in regards to the Gray Zone. These discussions can potentially assist in shaping operating norms in the space domain. As some nations continue to seek space dominance, they must consider the consequences of ignoring the ambiguity of the space domain.

Next, nations must reevaluate their space strategy to effectively integrate the challenges of the Gray Zone when navigating the space domain. For example, although the U.S. has established the NSSS, it fails to clearly describe the challenges of the Gray Zone. Analyzing and evaluating the NSSS will allow for the U.S. to create a clear and precise operating picture when navigating Gray Zone activity (Brand, 2016). Although China is focusing on regional influence with the BRI, China fails to acknowledge Gray Zone activities due to the Gray Zone being the primary mode of gaining regional dominance for China. Finally, India has been a key player in the space enterprise and an evolving space-faring nation. However, India requires a national space policy that will provide India with a sound strategic framework to mitigate the Gray Zone tactics around the region.

As these nations continue to advance space capabilities, counterspace options, and cooperation agreements they must examine the challenges in the Gray Zone. It is imperative these nations identify Gray Zone challenges and incorporate these into national space policy. This will allow these nations to develop a strategy that encompasses the challenges of Gray Zone activities while ensuring the peaceful use of space development and operations. Nations must not wait for the opportunity to acknowledge Gray Zone activity in space—they must act on it before it's too late.

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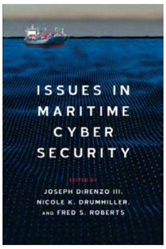

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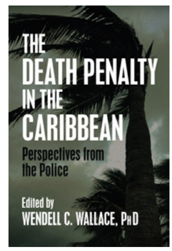

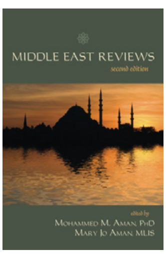

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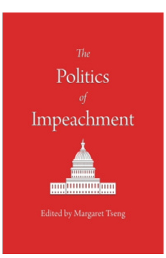
The book brings together reviews of books published on the Middle East and North Africa. It is a valuable addition to Middle East literature, and will provide an informative read for experts and non-experts on the MENA countries.

Unworkable Conservatism: Small Government, Freemarkets, and Impracticality by Max J. Skidmore

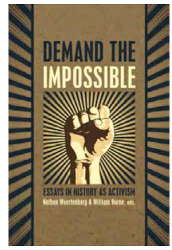
Unworkable Conservatism looks at what passes these days for "conservative" principles—small government, low taxes, minimal regulation—and demonstrates that they are not feasible under modern conditions.



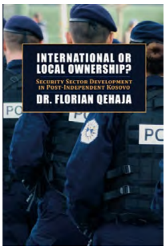
The Politics of Impeachment
Edited by Margaret Tseng

This edited volume addresses the increased political nature of impeachment. It is meant to be a wide overview of impeachment on the federal and state level, including: the politics of bringing impeachment articles forward, the politicized impeachment proceedings, the political nature of how one conducts oneself during the proceedings and the political fallout afterwards.

Demand the Impossible: Essays in History as Activism
Edited by Nathan Wuertenberg and William Horne



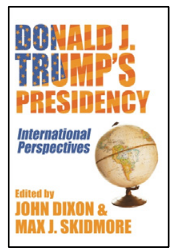
Demand the Impossible asks scholars what they can do to help solve present-day crises. The twelve essays in this volume draw inspiration from present-day activists. They examine the role of history in shaping ongoing debates over monuments, racism, clean energy, health care, poverty, and the Democratic Party.



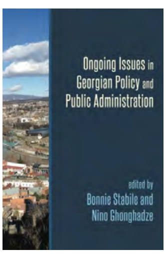
International or Local Ownership?: Security Sector Development in Post-Independent Kosovo
by Dr. Florian Qehaja

International or Local Ownership? contributes to the debate on the concept of local ownership in post-conflict settings, and discussions on international relations, peacebuilding, security and development studies.

Donald J. Trump's Presidency: International Perspectives
Edited by John Dixon and Max J. Skidmore



President Donald J. Trump's foreign policy rhetoric and actions become more understandable by reference to his personality traits, his worldview, and his view of the world. As such, his foreign policy emphasis was on American isolationism and economic nationalism.



Ongoing Issues in Georgian Policy and Public Administration
Edited by Bonnie Stabile and Nino Ghonghadze

Thriving democracy and representative government depend upon a well functioning civil service, rich civic life and economic success. Georgia has been considered a top performer among countries in South Eastern Europe seeking to establish themselves in the post-Soviet era.

Poverty in America: Urban and Rural Inequality and Deprivation in the 21st Century
Edited by Max J. Skidmore

Poverty in America too often goes unnoticed, and disregarded. This perhaps results from America's general level of prosperity along with a fairly widespread notion that conditions inevitably are better in the USA than elsewhere. Political rhetoric frequently enforces such an erroneous notion.

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