# Africa Contention

#### LEO is uniquely accessible to African industry due to cheaper launch and production costs – that solves Earth Observation, internet, national security, and spills over to enrich the economy

Samanga 21 Ruvimbo Samanga, Zimbabwean scholar and lawyer working with the Space Law & Policy, holds a BA Law (cum laude), an LLB and an LLM in International Trade and Investment Law from the University of Pretoria. "Why Africa Should Expand its Mega-Satellite Constellation Capacity." Space Legal Issues, 3 May. 2021, www.spacelegalissues.com/why-africa-should-expand-its-mega-satellite-constellation-capacity.

Since 1988, Africa has spent approx. USD$4 billion towards the launch of 41 satellites (excluding the cost of the RASCOM-QAF 1R replacement). 30 of these satellites fall into the Small Satellite market. The majority of satellites owned by African institutions typically involves satellites with less than 600kgs in fueled mass and 24 of these satellites have less than 200kg fueled mass. The reason for the interest in the miniaturized satellites? In a nutshell, they offer cheaper design alternatives, coupled with the ease of mass production. They are also significantly more versatile in certain applications, owing to their reduced size. For example, they are the satellite of choice for low data rate communications, being launched in large multi-coverage constellations in Low Earth Orbit (LEO). It comes as no surprise then that small satellites are growing increasingly popular amongst developing countries, no less within the region, for the accessibility. The growth of the small satellite industry is evident in commercial as well as large programs which exhibit steady growth. In 2019, 5 African countries launched 8 satellites, 6 of which were small satellites. It is expected that by the year 2024, 19 African countries would have launched additional satellites into space. These small, sometimes called nano-satellites, are really driving the African space program, especially in line with the African Union’s (AU) science and technology ambitions which are expected to reap huge benefits for the continent. Most importantly through the AU Science, Technology and Innovation Science Strategy for Africa – 2024 (STISA-2024). Small satellites are categorized as space systems of up to 600 kg (falling into the categories of Minisatellites, Microsatellite, Nanosatellite, Picosatellite, and Femto Satellites). They range across different applications (Satellite Communications, Imaging & Earth Observations, Space Situational Awareness, and Technology Development), and have different end users (Government & Defense, and Civil & Commercial). Of the 8 satellites launched in 2019, 6 were small satellites (3 Nanosatellites, 2 Microsatellites, and 1 Picosatellite). Satellite communications mega-constellations are on the rise, however this growing interest is not without its challenges and uncertainties. The biggest risks in the small sat interest in the coming years are mostly ascribed to investor’s rick assessment & funding availability; Securing customers & Return on Investment (ROI); Stronger regulations; Competition from heavier satellite, and reliability. This is also further compounded by the fact that establishing a satellite service industry which is sustainable requires adequate funding. Skillset deficit is also a prominent challenge. Even though Africa has and will in future have the largest population of young people, the youth are generally not interested in pursuing careers in STEM (science, technology, engineering and mathematics). You can expect more satellites to be launched despite these crises. As regards the African Small Sat market, the growth perspectives seem to point towards predominant university projects which demonstrates a capacity to operate Smallsats, also attesting to the affordability of the systems. This is also a sign of government effort to support the growth of this industry, and the contributions of the youth in satellite development. Indeed the manufacturing ability is extremely important, but also the service capability and development prospects. Despite these positive steps there is still quite a need for funding in this area. Of the overall revenue and results, Earth Observation is the most predominant small sat use, however it is expected in the next few years this may shift to internet broadband, but ultimately, creating value for users and enabling services that drive industry development will be the ultimate determining factor. Internet coverage allows people to create capacity and this might undoubtedly be Africa’s most prolific use of small satellite solutions. CubeSats which are around 50 kg, are the most popular and are only getting bigger because of the interest for carrying larger payloads. But in future it may become less stringent to use the restricted platform, but the threshold is bound to switch to a smaller regular platform. These services are enabled through satellite mega-constellations. Satellite mega-constellations operate in the Lower Earth Orbit which is described as the orbit located no more than 2,000 kilometers from the Earth’s surface. There is room for LEO regarding low-latency connectivity. But this does not mean that the Geostationary Orbit will become redundant, rather, and on the other hand GEO will remain an asset for broadband, because of its efficiency and coverage as well as less-sophisticated ground segments. Nevertheless, the LEO offers the most advantageous orbital resource to come and deserves much policy intervention to regulate, owing to the fact that it is a finite, scare resource. At the end of the day, whether Smallsats are launched in a constellation or as individual space systems, they offer a cost-effective alternative to traditional space objects, and would allow Africa the opportunity to release its potential in various areas of interest including but not limited to communications, global positioning and navigation, and Earth observation. Africa would be enriched by the ability to use this new technology to enable users through diverse services, to protect assets within the value chain, or simply to monitor areas of national security such as the environment and borders. These are all aspects which will have a substantial developmental impact in the African economy, and is well aligned to the African space policy which speaks towards increase of space and satellite capacity in an affordable and beneficial manner.

#### LEO Earth Science Observation Satellites uniquely solve a host of environmental threats – pollution, climate change, biod, defo, soil erosion

Ustin and Middleton 20 Ustin, S.L. [John Muir Institute of the Environment, University of California, Davis] , Middleton, E.M [NASA/Goddard Space Flight Center (Emerita)]. Current and near-term advances in Earth observation for ecological applications. Ecol Process 10, 1 (2021). https://doi.org/10.1186/s13717-020-00255-4

There is an unprecedented array of new satellite technologies with capabilities for advancing our understanding of ecological processes and the changing composition of the Earth’s biosphere at scales from local plots to the whole planet. We identified 48 instruments and 13 platforms with multiple instruments that are of broad interest to the environmental sciences that either collected data in the 2000s, were recently launched, or are planned for launch in this decade. We have restricted our review to instruments that primarily observe terrestrial landscapes or coastal margins and are available under free and open data policies. We focused on imagers that passively measure wavelengths in the reflected solar and emitted thermal spectrum. The suite of instruments we describe measure land surface characteristics, including land cover, but provide a more detailed monitoring of ecosystems, plant communities, and even some species then possible from historic sensors. The newer instruments have potential to greatly improve our understanding of ecosystem functional relationships among plant traits like leaf mass area (LMA), total nitrogen content, and leaf area index (LAI). They provide new information on physiological processes related to photosynthesis, transpiration and respiration, and stress detection, including capabilities to measure key plant and soil biophysical properties. These include canopy and soil temperature and emissivity, chlorophyll fluorescence, and biogeochemical contents like photosynthetic pigments (e.g., chlorophylls, carotenoids, and phycobiliproteins from cyanobacteria), water, cellulose, lignin, and nitrogen in foliar proteins. These data will enable us to quantify and characterize various soil properties such as iron content, several types of soil clays, organic matter, and other components. Most of these satellites are in low Earth orbit (LEO), but we include a few in geostationary orbit (GEO) because of their potential to measure plant physiological traits over diurnal periods, improving estimates of water and carbon budgets. We also include a few spaceborne active LiDAR and radar imagers designed for quantifying surface topography, changes in surface structure, and 3-dimensional canopy properties such as height, area, vertical profiles, and gap structure. We provide a description of each instrument and tables to summarize their characteristics. Lastly, we suggest instrument synergies that are likely to yield improved results when data are combined. Background Many environmental scientists have concluded that the Earth is at or near one or more perilous climate tipping points (Krieger et al. 2009; Lenton, 2011, Lenton and Williams 2013; Brook et al. 2013; Hickman et al., 2019). Climate change interacts with and exacerbates many other environmental and societal problems. These include air and water pollution that compound health issues (Harlan and Ruddell 2011; Kan et al. 2012), especially in poor communities (Schlosberg and Colins 2014; Hallegatte and Rozenberg 2017), widespread and/or frequent droughts linked to extensive fires (Amiro et al. 2001; Littell et al. 2016), diminished resources for drinking water and irrigation (Jackson et al. 2001; Oki and Kanae 2006), and large-scale biodiversity losses (Lindenmayer and Likens 2011; Pires et al. 2018) , including species extinctions (Cahill et al. 2013). Related factors include deforestation (Green and Sussman 1990) and soil erosion (Hill et al., 2009, consequences of over-exploitation of resources (Giri et al. 2007) due to massive global conversion of natural resources for human uses (Seto et al. 2002. Documentation of all of these problems and many others are of interest to the broader ecological community at scales from local to global. This can only realistically be accomplished with satellite observations in combination with process and statistical models to reveal patterns and trends that enlighten understanding about how current conditions have developed from past environmental drivers in order to predict future conditions.

#### Warming causes extinction

David **Spratt 19**, Research Director for Breakthrough National Centre for Climate Restoration, Ian Dunlop, member of the Club of Rome, formerly an international oil, gas and coal industry executive, chairman of the Australian Coal Association, May 2019, “Existential climate-related security risk: A scenario approach,” https://docs.wixstatic.com/ugd/148cb0\_b2c0c79dc4344b279bcf2365336ff23b.pdf

An existential risk to civilisation is one posing **permanent large negative consequences** to humanity which may never be undone, either **annihilating intelligent life** or permanently and drastically curtailing its potential.

With the commitments by nations to the 2015 **Paris** Agreement, the current path of warming is 3°C or more by 2100. But this figure does not include “long-term” **carbon-cycle feedbacks**, which are materially relevant now and in the near future due to the **unprecedented** **rate** at which human activity is perturbing the climate system. Taking these into account, the Paris path would lead to around 5°C of warming by 2100.

Scientists warn that warming of 4°C is incompatible with an organised global community, is **devastating** to the **majority of** **ecosystems**, and has a **high probability** of not being stable. The World Bank says it may be “**beyond adaptation**”. But an existential threat may also exist for many peoples and regions at a significantly lower level of warming. In 2017, 3°C of warming was categorised as “catastrophic” with a warning that, on a path of unchecked emissions, low-probability, high-impact warming could be catastrophic by 2050.

The Emeritus Director of the Potsdam Institute, Prof. Hans Joachim Schellnhuber, warns that “climate change is now reaching the **end-game**, where very soon humanity must choose between **taking** **unprecedented action**, or accepting that it has been left too late and **bear** **the consequences**.” He says that if we continue down the present path “there is a very big risk that we will just **end** **our** **civilisation**. The human species will survive somehow but we will destroy almost everything we have built up over the last two thousand years.”11

Unfortunately, conventional risk and probability analysis becomes useless in these circumstances because it excludes the full implications of outlier events and possibilities lurking at the fringes.12

Prudent risk-management means a tough, objective look at the real risks to which we are exposed, especially at those **“fat-tail” events**, which may have consequences that are damaging beyond quantification, and **threaten** **the** **survival** **of human** **civilisation**.

Global warming projections display a “fat-tailed” distribution with a **greater likelihood** of warming that is well in **excess of** **the** **average amount** **of warming** **predicted by** **climate** **models**, and are of a higher probability than would be expected under typical statistical assumptions. More importantly, the risk lies disproportionately in the “fat-tail” outcomes, as illustrated in Figure 1.

#### instability causes global war

**Mead 13** – (Walter Russell, Foreign Affairs Prof @ Bard, “Peace In The Congo? Why The World Should Care”, American Interest; http://www.the-american-interest.com/2013/12/15/peace-in-the-congo-why-the-world-should-care/)

The Congo war should be a reminder to us all that the foundations of our world are **dynamite**, and that the potential for **new conflicts** on the scale of the **horrific** **wars of the 20th century** is very much **with us** **today.** The second lesson from this conflict stems from the realization of how much patience and commitment from the international community (which in this case included the Atlantic democracies and a coalition of African states working as individual countries and through various international institutions) it has taken to get this far towards peace. Particularly at a time when many Americans want the US to turn inwards, there are people who make the argument that it is really none of America’s business to invest time and energy in the often thankless task of solving these conflicts. That might be an ugly but defensible position if we didn’t live in such a tinderbox world. Someone could rationally say, yes, it’s terrible that a million plus people are being killed overseas in a horrific conflict, but the war is really very far away and America has urgent needs at home and we should husband the resources we have available for foreign policy on things that have more power to affect us directly. The problem is that **these wars spread**. They may start in places that we don’t care much about (most Americans didn’t give a rat’s patootie about whether Germany controlled the Sudetenland in 1938 or Danzig in 1939) but they tend to **spread to places** that we do care **very much about**. This can be because a revisionist great power like Germany in 1938-39 needs to overturn the balance of power in Europe to achieve its goals, or it can be because instability in a **very remote place** triggers problems in places that we **care about** very much. Out of Afghanistan in 2001 came both 9/11 and the waves of insurgency and instability that threaten to rip nuclear-armed Pakistan apart or trigger wider conflict with India. Out of the mess in Syria a witches’ brew of terrorism and religious conflict looks set to complicate the security of our allies in Europe and the Middle East and even the security of the oil supply on which the world economy so profoundly depends. Africa, and the potential for upheaval there, is **of** **more** **importance** to American security than many people may **understand**. The line between **Africa and the Middle** **East is** a **soft** one. The weak states that straddle the **southern approaches** of the Sahara are **ideal petri dishes** for **A**l **Q**aeda **type groups** to form and attract local support. There are networks of funding and religious contact that give groups in these countries potential **access to funds**, **fighters**, **training** and **weapons** from the Middle East. A war in the eastern Congo might not directly trigger these other conflicts, but it helps to **create the swirling underworld** of **arms trading**, **money transfers**, **illegal commerce** and the rise of a generation of young men who become experienced fighters—and know no other way to make a living. It destabilizes the environment for neighboring states (like Uganda and Kenya) that play much more direct role in potential crises of greater concern to us. This is why the Clinton, Bush and Obama administrations (representing three very different kinds of American politics) have all been engaged in efforts like the peace keeping effort in the Congo. It is why, despite our budget problems at home and despite our often justifiable impatience with the complexities of dealing with international coalitions and the inadequacies of international institutions, we need to continue the slow and painstaking work that makes agreements like this one possible. The world we live in is an **explosive** one. There are **all kinds of things that can go horribly wrong**, and what happens in one corner of the world doesn’t necessarily stay there. Reducing the danger requires an active, global American foreign policy whether we like it or not. The potential for new communal and religious wars that kill millions of people and endanger American security and world peace is very real. The world seems safer than the world of the 1930s and 1940s in part because the United States and many of our friends and allies are working quietly around the world to contain outbreaks of violence, address the issues that exacerbate hatred and distrust, and in the last analysis are willing to provide the security guarantees and deterrents that prevent mass mayhem.

# Innovation Contention

#### Strong commercial space catalyzes tech innovation – progress at the margins and spinoff tech change global information networks

Joshua Hampson 2017, Security Studies Fellow at the Niskanen Center, 1-25-2017, “The Future of Space Commercialization”, Niskanen Center, https://republicans-science.house.gov/sites/republicans.science.house.gov/files/documents/TheFutureofSpaceCommercializationFinal.pdf

Innovation is generally hard to predict; some new technologies seem to come out of nowhere and others only take off when paired with a new application. It is difficult to predict the future, but it is reasonable to expect that a growing space economy would open opportunities for technological and organizational innovation. In terms of technology, the difficult environment of outer space helps incentivize progress along the margins. Because each object launched into orbit costs a significant amount of money—at the moment between $27,000 and $43,000 per pound, though that will likely drop in the future —each 19 reduction in payload size saves money or means more can be launched. At the same time, the ability to fit more capability into a smaller satellite opens outer space to actors that previously were priced out of the market. This is one of the reasons why small, affordable satellites are increasingly pursued by companies or organizations that cannot afford to launch larger traditional satellites. These small 20 satellites also provide non-traditional launchers, such as engineering students or prototypers, the opportunity to learn about satellite production and test new technologies before working on a full-sized satellite. That expansion of developers, experimenters, and testers cannot but help increase innovation opportunities. Technological developments from outer space have been applied to terrestrial life since the earliest days of space exploration. The National Aeronautics and Space Administration (NASA) maintains a website that lists technologies that have spun off from such research projects. Lightweight 21 nanotubes, useful in protecting astronauts during space exploration, are now being tested for applications in emergency response gear and electrical insulation. The need for certainty about the resiliency of materials used in space led to the development of an analytics tool useful across a range of industries. Temper foam, the material used in memory-foam pillows, was developed for NASA for seat covers. As more companies pursue their own space goals, more innovations will likely come from the commercial sector. Outer space is not just a catalyst for technological development. Satellite constellations and their unique line-of-sight vantage point can provide new perspectives to old industries. Deploying satellites into low-Earth orbit, as Facebook wants to do, can connect large, previously-unreached swathes of 22 humanity to the Internet. Remote sensing technology could change how whole industries operate, such as crop monitoring, herd management, crisis response, and land evaluation, among others. 23 While satellites cannot provide all essential information for some of these industries, they can fill in some useful gaps and work as part of a wider system of tools. Space infrastructure, in helping to change how people connect and perceive Earth, could help spark innovations on the ground as well. These innovations, changes to global networks, and new opportunities could lead to wider economic growth.

#### The government needs to endorse property rights in space – not enforce treaties that prevent private ownership

Jeff Greason and James C. Bennett 19, CTO of Electric Sky and CEO of Agile Aero, and Space Fellow of Economic Policy Centre in London, respectively, 6-5-2019, "The Economics of Space: An Industry Ready to Launch," Reason Foundation, https://reason.org/policy-study/the-economics-of-space/

Given a functioning transportation infrastructure, as the private sector develops space industry, government’s role changes to fostering that industry. What space commerce needs from government is a legal framework in which to operate that defines and defends property rights and research (especially on human health in space) that leads to more diverse space activities. Taking cues from agreements on the way various nations regard the bounty of the seas, government can ensure a sustainable and equitable free market environment. With models from other frontier exploration, government should focus on creating the legal framework to allow commerce and private endeavor to flourish. We cannot imagine how profoundly, comprehensively and quickly technological advancement—when it is commercialized—changes our everyday lives. Every single time, and by orders of magnitude, we underestimate its power to improve ordinary people’s lives once it becomes widely used through commercialization. For example, we cannot each own a jet, but today almost all of us can afford a plane ticket. This is due to the tangible effects of the synergy of technology and commerce. These effects occur so universally that any discussion of new technological frontiers should assume a blind but well-grounded expectation of manifold global rewards if only we have the foresight to encourage its proliferation. Examples from sea, land and air transportation, the Digital Age and countless other endeavors prove that technology combined with commerce triggers comprehensive advancement at a lower cost. America’s future success in space depends on restructuring our approach to accommodate such a vision. Commercialization Creates a Self-Sustaining Space Industry Despite the best current efforts of the private sector in this direction, it’s not yet an industry. Yet, launch companies have managed to create a profitable service focusing on occasional launches of very high-value payloads at very high prices. For example, the geosynchronous orbital position for telecommunications is so valuable that even our current highly inefficient way of accessing it is profitable. SpaceX’s Falcon 9 launch success at one-third the price of a traditional NASA-contracted launch demonstrates the private-sector capability to fulfill many current NASA functions at a fraction of the cost. Such achievement frees up NASA to concentrate on its core research and exploration missions in space and allows the private sector to invest in self-sustaining space-based industry. Developing the industry depends on a certain amount of infrastructure, which can pay for itself by freeing up funds currently used for NASA’s SLS (Space Launch System)/Orion program. This redistribution of current NASA funding is the key to paradigm change, although there are political problems with terminating the current SLS/Orion program in closely contested states in the 2020 presidential elections—states like Alabama and Florida. A compromise solution might be to push for increased spending on commercial service purchase, while SLS proceeds to flight status since the SLS will run out of surplus Shuttle engines by the early 2020s. Moving our funding of space activity from solely the exploration function to a mixture of privately funded commercial industry and publicly funded research is signaled by the private sector’s current capabilities, and the commercial-quality resources already identified in space that the current paradigm prevents us from harnessing. Also, changing to a commercial approach allows for efficiencies such as mass production of equipment and standardized designs that can carry cargo or humans with few modifications—which is much cheaper and more effective than what we do now. No matter how much money Congress sinks into status-quo space activities now, utility will continue to decline, making funding increasingly ineffective, and keeping the U.S. space program confined. The first step in progress is systemic change, beginning with policy change. Every single change that makes space operations more like airline operations bears fruit in lower costs, and those changes, in turn, trigger further reductions in costs.

#### Tech innovation solves every existential threat – cumulative extinction events outweigh the aff

Dylan **Matthews 18**. Co-founder of Vox, citing Nick Beckstead @ Rutgers University. 10-26-2018. "How to help people millions of years from now." Vox. https://www.vox.com/future-perfect/2018/10/26/18023366/far-future-effective-altruism-existential-risk-doing-good

If you care about improving human lives, you should overwhelmingly care about those quadrillions of lives rather than the comparatively small number of people alive today. The 7.6 billion people now living, after all, amount to less than 0.003 percent of the population that will live in the future. It’s reasonable to suggest that those quadrillions of future people have, accordingly, hundreds of thousands of times more moral weight than those of us living here today do. That’s the basic argument behind Nick Beckstead’s 2013 Rutgers philosophy dissertation, “On the overwhelming importance of shaping the far future.” It’s a glorious mindfuck of a thesis, not least because Beckstead shows very convincingly that this is a conclusion any plausible moral view would reach. It’s not just something that weird utilitarians have to deal with. And Beckstead, to his considerable credit, walks the walk on this. He works at the Open Philanthropy Project on grants relating to the far future and runs a charitable fund for donors who want to prioritize the far future. And arguments from him and others have turned “long-termism” into a very vibrant, important strand of the effective altruism community. But what does prioritizing the far future even mean? The most literal thing it could mean is preventing human extinction, to ensure that the species persists as long as possible. For the long-term-focused effective altruists I know, that typically means identifying concrete threats to humanity’s continued existence — like unfriendly artificial intelligence, or a pandemic, or global warming/out of control geoengineering — and engaging in activities to prevent that specific eventuality. But in a set of slides he made in 2013, Beckstead makes a compelling case that while that’s certainly part of what caring about the far future entails, approaches that address specific threats to humanity (which he calls “targeted” approaches to the far future) have to complement “broad” approaches, where instead of trying to predict what’s going to kill us all, you just generally try to keep civilization running as best it can, so that it is, as a whole, well-equipped to deal with potential extinction events in the future, not just in 2030 or 2040 but in 3500 or 95000 or even 37 million. In other words, caring about the far future doesn’t mean just paying attention to low-probability risks of total annihilation; it also means acting on pressing needs now. For example: We’re going to be better prepared to prevent extinction from AI or a supervirus or global warming if society as a whole makes a lot of scientific progress. And a significant bottleneck there is that the vast majority of humanity doesn’t get high-enough-quality education to engage in scientific research, if they want to, which reduces the odds that we have enough trained scientists to come up with the breakthroughs we need as a civilization to survive and thrive. So maybe one of the best things we can do for the far future is to improve school systems — here and now — to harness the group economist Raj Chetty calls “lost Einsteins” (potential innovators who are thwarted by poverty and inequality in rich countries) and, more importantly, the hundreds of millions of kids in developing countries dealing with even worse education systems than those in depressed communities in the rich world. What if living ethically for the far future means living ethically now? Beckstead mentions some other broad, or very broad, ideas (these are all his descriptions): Help make computers faster so that people everywhere can work more efficiently Change intellectual property law so that technological innovation can happen more quickly Advocate for open borders so that people from poorly governed countries can move to better-governed countries and be more productive Meta-research: improve incentives and norms in academic work to better advance human knowledge Improve education Advocate for political party X to make future people have values more like political party X ”If you look at these areas (economic growth and technological progress, access to information, individual capability, social coordination, motives) a lot of everyday good works contribute,” Beckstead writes. “An implication of this is that a lot of everyday good works are good from a broad perspective, even though hardly anyone thinks explicitly in terms of far future standards.” Look at those examples again: It’s just a list of what normal altruistically motivated people, not effective altruism folks, generally do. Charities in the US love talking about the lost opportunities for innovation that poverty creates. Lots of smart people who want to make a difference become scientists, or try to work as teachers or on improving education policy, and lord knows there are plenty of people who become political party operatives out of a conviction that the moral consequences of the party’s platform are good. All of which is to say: Maybe effective altruists aren’t that special, or at least maybe we don’t have access to that many specific and weird conclusions about how best to help the world. If the far future is what matters, and generally trying to make the world work better is among the best ways to help the far future, then effective altruism just becomes plain ol’ do-goodery.\*

# Aff Case

We concede their framing

#### Aliens don’t exist – if we win this they have

#### Fermi paradox.

Boree 18 (Liv Boeree, science communicator and TV host specializing in astrophysics, rationality, and poker. "Why haven’t we found aliens yet?," Vox, 7-3-2018, available at https://www.vox.com/science-and-health/2018/7/3/17522810/aliens-fermi-paradox-drake-equation, accessed 12-10-2019, HKR-cjh)

Where is everybody? In 1950, while working at Los Alamos National Laboratory, physicist Enrico Fermi famously exclaimed to his colleagues over lunch: “Where is everybody?” He had been pondering the surprising lack of evidence of other life outside of our planet. In a universe that had been around for some 14 billion years, and in that time developed more than a billion trillion stars, Fermi reasoned there simply must be other intelligent civilizations out there. So where are they? We still don’t know, and the Fermi paradox has only strengthened with time. Since the 1950s, humans have walked on the moon, sent a probe beyond our solar system, and even sent an electric sports car into orbit around the sun for fun. If we can go from rudimentary wooden tools to these feats of engineering in under a million years, surely there would have been ample opportunity in our 13.8 billion-year-old universe for other civilizations to have progressed to a similar level — and far beyond — already? And then, surely there would be some lingering radio signals or visual clues of their expansion reaching our telescopes.

#### Overwhelming evidence we’re alone and unreachable -- newest models

Bloetscher 18 (Dr. Frederick Bloetscher -- Professor and Associate Dean at Florida Atlantic University& received his Ph.D. from the University of Miami, https://sci-hub.tw/10.1016/j.actaastro.2018.11.033, 23 November 2018, `Using predictive Bayesian Monte Carlo- Markov Chain methods to provide a probablistic solution for the Drake equation, Pgs. 25-28)

No specific answer on the likelihood of intelligent life on another planet communicating with Earth is possible despite attempts to create models that provide such answers. However, using predictive Bayesian methods, a probability distribution can be created to accomplish same. This approach involves the assignment of probability distributions to the underlying factors. When little or no data are available to specify the parameters of these distributions, probability distributions can then be assigned to the prior parameters within the initial distributions to determine the location and scale parameters of the factor distribution. Subjective information may then be used to create these prior distributions until such time as real data is developed or becomes available. Hence subjective data can be incorporated and the prior distributions and adjusted as new data emerges, something other statistical methods cannot do. In addition, as the data increases, the confidence in the underlying distributions increases, another feature lacking in the other methods discussed herein. As a result, the results of predictive Bayesian methods are robust and include factors for both uncertainty and variability.

For the Drake equations, a distribution for N was developed through using the Hierarchical Monte Carlo distributions for the factors of the equation run 10,000 times. Figure 1 shows the results of the probability density function and cumulative density functions each parameter using the priors note in Table 2. Table 3 outlines the probabilities of intelligent, communicative life at given probabilities developed from the Monte Carlo prior data. The mean and standard deviation were then input into the MCMC protocol for the predictive Bayesian method that solved for N. The solution is shown in Figure 2 (red datapoints). Of importance, there is nearly a 20% probability that we are alone in the galaxy. The graph indicates that there is a 95% probability that there are less than 100 communicating civilizations concurrent with Earth, and a 99% that there are 1,000 such civilizations.

Additional scenarios were run to see what differences might be, starting with the factors R and L because they might have a significant impact on the results for N. Reducing R by a factor of 2 (to 10 starts per year) reduced the mean to 1.6 and a 90% probability that we are alone in the galaxy (black datapoints).

The graph indicates that there is a 99% probability that there are less than 100 communicating civilizations concurrent with Earth, and virtually no probability that there are 1,000 such civilizations. Increasing the value of L by a factor of 10 (to 46,000) yielded a mean of 253 (a factor of 10 higher), which translated to a greater likelihood of concurrent civilizations, but still likely less that 10,000 total (blue datapoints). The subjective points noted in Table 1, graphed as a cumulative density function are also shown on Figure 2. Figure 2 shows the pdf and CDF result for the 3 scenarios. Figure 2 shows that there is only a 5 percent chance that the number of civilizations with which we can communicate at this time in the galaxy (N) is less than 1000, and that there is virtually no chance that there are more than 100,000 civilization at any time.

Added scenarios were run that altered variables by up to one magnitude noting that all of these distributions fall between 0 and 1. The results all fell within the range of a one magnitude change to L and R and the graphs mimic those shown on Figure 2. Of interest, the average is the only place were significant changes occur with the Bayesian approach and only L was a significant factor – larger L led to larger likelihood of concurrent civilizations. The distribution may flatten a bit (larger tails and a lesser slope in the middle of the graph), but the overall graphic remains consistent – an artifact of the predictive Bayesian approach. There is a consistently large percentage of results that indicate we are alone in the galaxy when using the averages noted in Table 2, or smaller numbers for these variables are used (See circles on Figure 2). Where the averages increase, large percentages remain showing us to be alone, while the extreme values increase a little (i.e. the 99.9 percentile increases slightly but remains below 1 million civilization unless the magnitudes of L are increased).

5.0 CONCLUSIONS

Despite major progress in the detection of other planets in the galaxy, humans have only scratched the surface of space exploration. The answer to the famous Fermi-paradox (“Where is everybody?”) is also missing because the distances across the galaxy are large and the factors that may be present are largely still uncertain [101, 102]. There is emerging data that can be useful in a probabilistic model to determine the likelihood of life beyond Earth using Predictive Bayesian statistics, which are designed to use limited, uncertain data, to develop results, and that can be updated as more data is collected. The results provide a probability curve of the likelihood of life in the universe that includes both uncertainty and potential variability within the result to provide a means to define the probability of life in the galaxy as well as life within proximity to earth.

It is clear from this analysis that based on the data we know today, and the subjective data of the author referenced herein, large numbers of planets with intelligent, communicative life forms are unlikely in the galaxy, and we are very possibly alone. The result provided an estimate of the number of civilizations concurrent with ours is less than 1000, a number that is smaller than many prior estimates. While the probability of other civilizations is not zero, the results provide some suggestion as to why SETI has not detected any civilizations near Earth. This however does not mean that we are wasting our time with ventures such as SETI. One barrier is that there are a limited number of stars within 25 light years (133 and many are not very bright). Hart [4] notes that 25-50 years might be the limit of reasonable space exploration. The truth is likely that the distance to the next civilization is beyond our communication era. For example, if the next civilization is 1200 years away, our signals will not reach that planet for another 1200 years (3300), and assuming that planet currently has a civilization that can receive our signal and can respond, they would need to survive another 1200 years to respond to us (4500). Who knows what state Earth will be in by the time we receive their signal in 4500. And who will remember we sent a signal? And how will we interpret it? Recall the Greeks were the greatest civilization on Earth 2400 years ago.

#### No phosphorus in Universe means alien life impossible

Paez 18 (Danny Paez -- Innovation staff writer at Inverse summarizing host of studies, “Lack of Cosmic Phosphorus Raises Doubts About Extraterrestrial Life”, https://www.inverse.com/article/43320-low-phosphorous-no-aliens, 5 April 2018)

Bad news Ancient Aliens fans: life in the cosmos might be even rarer than scientists once thought.

It’s all because the universe is lacking one key chemical element for life, phosphorus. The element — abbreviated as P on the periodic table — is a fundamental ingredient that enables cells to store and transfer energy. Without it, we wouldn’t exist and with so little of it floating around in space, the likelihood of finding extraterrestrial life is looking slim.

Astronomers from Cardiff University used the William Herschel Telescope in the Canary Islands to study the universe’s biggest producers of the chemical, supernovae. It turns out even literal P factories don’t produce much of it at all. Lead researcher Jane Greaves and Phil Cigan will present their findings at the European Week of Astronomy and Space Science.

Supernovae are the final stage of a massive stars’ lifespan. Once the stellar mass has used up all of the fuel that keeps it burning it begins to collapse into itself until it becomes so dense it can’t sustain its gravitational force. This result is an explosion that spits out massive clouds of gas, which was once thought to hold a ton of P.

A previous study found that a supernova remnant known as Cassiopeia A (Cas A) contained plenty of phosphorus. But when Greaves and Cigan observed parts of the Crab Nebula they found substantially less P, which suggests only certain supernovae produce a lot of the element. This would mean planets formed far away from P-producing supernovae would have little to no hope of developing life.

#### No intelligent aliens for next 26 million years

Engler and von Wehren 18 (John-Oliver Engler and Henrik von Wehrden -- Faculty of Sustainability @ Leuphana University, ‘Where is everybody?’ An empirical appraisal of occurrence, prevalence and sustainability of technological species in the Universe, https://www.researchgate.net/profile/John-Oliver\_Engler/publication/329311655\_%27Where\_is\_everybody%27\_An\_empirical\_appraisal\_of\_occurrence\_prevalence\_and\_sustainability\_of\_technological\_species\_in\_the\_Universe/links/5c011f62a6fdcc1b8d4b24dc/Where-is-everybody-An-empirical-appraisal-of-occurrence-prevalence-and-sustainability-of-technological-species-in-the-Universe.pdf, 30 November 2018, pgs. 9-11)

Lastly, we multiply by the number NAst as taken from Frank and Sullivan (2016), who refer to Fukugita and Peebles (2004), to obtain the number of technological species on different scales of interest (Table 2). We find that, as an absolute minimum, at least 7 technological species have likely arisen in the history of our galaxy 15 until today, while a number of up to 300 is likely under the most optimistic plausible parameter values. Our estimated range for A is notably narrower than what Maccone (2010) estimates for the number of civilizations currently living in the Milky Way (7453 ≥ A ≥ 0). The difference is due to the large value of 0.2 that Maccone assumes for fi and ft , which leads to a considerably larger value of fbt = 0.02 than 20 the range that we have provided above. For the observable Universe, our estimates mean that at least 500 billion technological species have likely arisen to this day. However, these numbers do not imply anything about the existence of extraterrestrial technological species right now, or that communication with them would be likely. For one, technological species may disappear shortly after they have arisen (Shklovsky and Sagan 1966, Sagan 2015) and even if they were sending signals, a 2017 study by Grimaldi has shown that the chance of us picking up their signals would basically be zero, regardless of how many technological species would actually 5 be transmitting (cf. Grimaldi 2017). A sensitivity analysis of our estimations can be found in Appendix A.

3.2 How long until the next technological species?

It is well possible that mankind is currently the only technological species in the Milky Way galaxy. If this were the case, how long would we have to wait for the 10 occurrence of another technological species in our galaxy? Recent findings suggest that the oldest known system of terrestrial-sized planets is about T = 11.2 · 109 years old (Campante et al. 2015), which is therefore the best possible guess as to how long evolution may already be at work elsewhere in the cosmos and therefore in our galaxy. We combine this number with our results for A from Table 2 to give 15 something like the ‘rate of occurrence’ or ‘birth rate’ λ of technological species in a given sphere of interest, i.e. λ = A T . Results can be found in Table 3.

Processes that have a known rate of occurrence may however be modeled by the Poisson distribution as discussed by Glade, Ballet and Bastien (2012).4 The probability of n events in the time period t with known rate of occurrence λ can be shown to follow

Pn(t) = e −λt(λt) n n! .(8)

Hence, the probability of at least one event in the time period t is

Pn≥1(t) = X∞ n=1 e −λt(λt) n n! = 1 − P0(t)

= 1 − e −λt (9)

and the expected waiting time to the next occurrence of a technological extraterrestrial species as a function of probability Pn≥1 = α becomes

t(α) = − 1 λ ln(1 − α) (10)

In words, if we were alone in our galaxy today, we would have to wait approximately t = 26 million (1 billion) years for a α = 50% chance that another technological species has arisen in our galaxy depending on whether the lowest or highest defensible estimate of ns is assumed in calculations (2.7 · 10−8 ≤ λ ≤ 6.7 · 10−10 10 , cf. Table 3). For α = 90%, these waiting times would be t = 86 million (3.4 billion). The ‘pessimistic’ scenario therefore encompasses waiting times much longer than Earth’s remaining window of habitability, which is determined by the life cycle of the Sun. Figure 1 illustrates the cumulative probability distributions for the re15 spective spheres of interest, as well as the ranges that result from optimistic and pessimistic assumptions on rate of occurrence λ, i.e. we plot equation (9) for the possible extreme values of λ.

#### All ET life trapped too far underground for contact

Clements 18 (Dr. David L Clements -- Astrophysics Group @ Blackett Lab @ Physics Department of Imperial College, “Life Before Fermi – Back to the Solar System”, https://arxiv.org/pdf/1811.06313.pdf, 15 November 2018, pgs. 4-5)

5. Discussion and Conclusions Since we have deemed that water is the essential environment for life, the implication of these numbers is that the icy moons of the outer Solar System can potentially host much larger ecosystems than the one that is present on the Earth. There are certainly other requirements, such as an adequate supply of energy, potentially from radiogenic or tidal heating, but we know such power sources are present from observations of the plumes on Europa and Enceladus.

Secondly, the history of life on Earth now seems to be showing us that life, albeit very simple prokaryotic monocellular life1 , emerged very rapidly once the Earth had become compatible with its existence.

What are the implications of these results for the Fermi Paradox?

If we put the two sets of results together we find the following:

- The rapid emergence of life on Earth suggests that life can emerge wherever there is a compatible environment

- There are large bio-compatible environments inside the icy moons of Solar System gas giants

- The size of the bio-compatible environments inside gas giant moons is much larger, both in sum and, in the case of the large moons like Ganymede and Titan, individually, than the biosphere of Earth

The conclusion of this analysis for our own Solar System is that the interior of the icy moons may be where the bulk of life in the Solar System is to be found. However, this life, intelligent or otherwise, would be locked beneath many kilometres of solid ice, only able to escape into the broader universe through catastrophic geyser eruptions such as those found on Enceladus and Europa.

There are already indications that moons exist around some exoplanets (Kenworthy et al., 2015), and there is no reason to think that moons around gas giant exoplanets should be any different from those seen in the Solar System. There may thus be a very large number of them. Given the discussion here, it could be that the subsurface oceans of gas giant exomoons are in fact the dominant home for life in the Galaxy, with life on Earthlike, terrestrial planets, being the exception rather than the rule. We note that the prospects for identifying more exomoons and for their detailed study in the next few years are very good (Peters & Turner, 2013; Kipping et al., 2009) using data from Kepler or the James Webb Space Telescope.

In the context of the Fermi Paradox, we know that species that live in water can evolve to a high level of intelligence – dolphins and octopuses are good examples (though it should be noted that dolphins are evolutionary returnees to the water). However, a liquid environment may be a limiting factor in the development of technology. The dominant concern in this context, though, is the location of these vast watery environments beneath tens or hundreds of kilometres of water ice. While there may be water geysers in some of these, the larger environments of Titan, Callisto and Ganymede in our own Solar System show no signs of escaping water since they are likely capped by an ice layer over 100 km thick. This probably presents an insurmountable obstacle to any intelligence dwelling there even knowing about the outside universe, let alone attempting to communicate with it.