# Evaluation and Synthesis of four Extraterrestrial civilization Classification Systems

**Ryan Schatzow**

*Received August 31, 2023*
*Accepted November 08, 2023*
*Electronic access November 15, 2023*

This paper explores classification systems of extraterrestrial civilizations, systems that attempt to predict and direct the advancement of life along certain paths. We examine four total schemes based on energy consumption, distance traveled, mastery of physics, and gene-editing capabilities. One of the most accepted classification systems for extraterrestrials is the Kardashev scale, which prioritizes energy consumption as the main metric for determining a successful civilization. However, we discuss similarities and differences between these four systems and evaluate the benefits and drawbacks of humanity progressing along with each of them. We use potential threats caused by both nature and threats that are inherent to technological advancement, such as war and climate change, as our evaluation metrics for each of the four schemes. By looking at levels in each classification system, we are essentially considering rungs of different ladders for humanity to climb, and are determining which ladders are better suited to ensure humanity's survival. Through this research, we suggest a new path for humanity that combines elements from each of the separate scales discussed as a more accurate representation of a successful civilization's progression.

## Introduction

As any civilization (human and extraterrestrial) pushes the boundaries of science and technology beyond their planet, the direction that it should evolve and progress into the space frontier becomes more relevant. Globally, we see humanity beginning to enter the space frontier, as economic investment into space has been on the rise, tripling from 2005 to 2020[1]. Furthermore, advances in blockchain technology, AI, 3D printing, and materials science, which would all be vital for space exploration technologies, are all pointing toward this trend[1]. Therefore, the space frontier and futuristic technologies are right on humanity's doorstep, making the question of our path into the future a worthwhile one to consider. This paper attempts to answer that question by delving into the realm of classification systems for extraterrestrial civilizations, with a focus on understanding their markers of success and the potential drawbacks they might entail. This exploration centers on four key classification systems: the Kardashev Scale, the Zubrin Scale, the Barrow Scale, and the Ivanov Modification System. These systems offer different perspectives on measuring civilization progression, from energy consumption and distance traveled to technological mastery and genetic modification capabilities. A crucial aspect of our analysis is the concept of "Great Filter Events," which represent obstacles that civilizations could face on their journeys[2]. (These survival threats will be discussed further later on in the paper). By examining how these classification systems intersect with these filters, we aim to uncover insights into which aspects of progression might lead to survival or potential decline. We also consider the implications for a society once all potential "Great Filter Events" are mitigated. Ultimately, our goal is to propose a new framework that combines elements from these systems to address the challenges posed by these filters. This new framework is a hypothetical path that humanity should take to avoid Great Filters.

## Mobile Classification Systems

The first two scales are grouped as "mobile" systems since they require physical expansion throughout space to advance.

### Kardashev Scale

The Kardashev classification system, produced by Nikolai Kardashev, is based solely on the metric of energy consumption. It was conceived under the premise that civilizations rely on energy to support their population and society, and that a continuously advancing civilization would be continuously increasing its energy consumption. It exists in three main stages or types. Type I civilizations are able to make use of the entire amount of energy available on their home planet. Type II civilizations are characterized by their ability to consume the entire energy offerings of their star. Type III civilizations are denoted by their ability to make use of the energy within an entire galaxy[1], therefore exponentially expanding beyond Type II, going from reaching one star to the billions of stars in a galaxy. Specifically, Type I is reached at a consumption

of $10^{16}$ W (Watts), Type II at $10^{26}$ W, and Type III at $10^{36}$ W. The equation

$$\text{Kardashev Type} = \frac{\log(P) - 6}{10}$$

where $P$ denotes power, provides a continuous graph showing what level is reached by a certain amount of energy. Figure 1 provides a continuous graph showing what level is reached by a certain amount of energy (Figure 1). For perspective, humanity is presently at level 0.7276, and projected to reach Type I by the year 2371 [1].

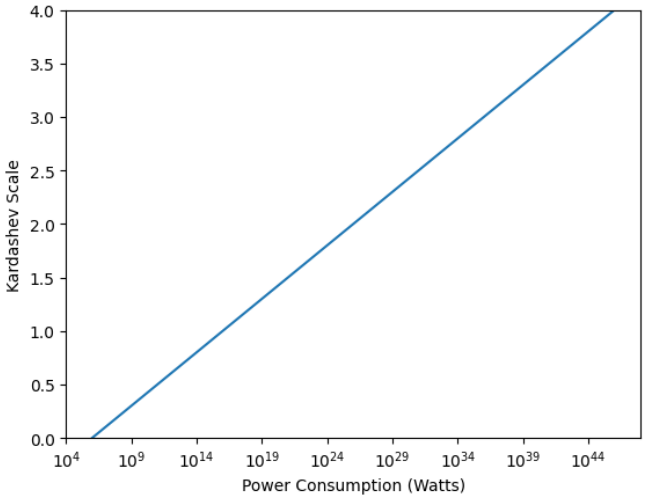


**Fig. 1** Graph depicting how much power consumption correlates to each Kardashev category

This low level energy consumption prior to reaching Type I can be achieved through using non-renewable energy like fossil fuels and natural gas, or through more renewable options like solar, hydro, and wind power, just as humanity has done [3]. To be able to surpass level I, a civilization must look toward making more effective use of energy from their star. Dyson Spheres and Dyson Swarms are some of a few proposed hypothetical structures that might achieve this [1]. By fully encompassing a star, Dyson spheres would allow a civilization to efficiently harness most of its energy. To be able to succeed in such a large-scale endeavor, a civilization might have to convert an entire planet into construction materials. Furthermore, to grow beyond Type II, a civilization needs to have interstellar travel capabilities to be able to reach and utilize the energy of stars outside their solar system. Once such stars are reachable for a civilization, the same process used to reach Type II could be implemented throughout their galaxy to exceed Type II and eventually achieve Type III.

The Kardashev system suggests that the primary objective of a civilization is to expand across the universe for the purpose of increasing its capacity for energy consumption. Although this expansion may inadvertently correlate with population growth, the Kardashev scale does not account for population; a Type II civilization with one thousand individuals is equally developed as a Type II civilization with one trillion individuals.

### Zubrin Scale

Very similar to the Kardashev Scale is the Zubrin Scale, another mobile classification system that depends upon the distance a civilization has traveled from its home planet. Just like Kardashev, Robert Zubrin thought of three main civilization types to fit in his system: Type I civilizations use resources from their homeworld, Type II civilizations utilize resources within their solar system, while Type III have expanded throughout interstellar space [4]. This distance traveled, though, does not necessarily offer a civilization any benefits as they move farther and farther from their homeworld. It is comparatively less meaningful for a Type III civilization to travel light years to another star than for a Type I to travel the relatively small distance to another planet in their system. It certainly may be important for a "young" civilization to be able to travel to and colonize a second planet in their system, just in case dangers local to their one original planet threaten extinction. The same goes up a level if a civilization's star is collapsing; in that case they need to be a Type II civilization in order to colonize a new star system. As Earth has experienced extinction events in the past and is now facing human-caused climate change, it is safe to say that planetary disasters are much more likely to occur before the eventual collapse of a star. Colonizing the second half of a galaxy offers less of a safety increase than colonizing a second star, which in turn is less vital than colonizing a second planet. Therefore, the relevance of the Zubrin Scale would be greater for younger, less expansive civilizations and much less for ones already far along in colonizing a galaxy. Humanity has not begun using resources outside of Earth, and is therefore at Type 1 on the Zubrin scale.

## Stationary Classification Systems

While both mobile classification systems based on energy and distance are dependent upon a civilization's ability to navigate space, the remaining "stationary" classification systems inherently do not correlate at all with colonization of space. Beginning with John Barrow's system, these scales take more of a qualitative rather than strictly quantitative approach to measuring a civilization's success.

### Microdimensional Mastery

John Barrow proposed a system to mark technological progress and a civilization's advancement based on the smallest size of matter they can control (consequently named microdimensional mastery). Leaving behind the status quo of three main types, his system includes seven landmarks of progress. They follow as such: a Type I-minus society can control large-scale objects (simple tools), Type II-minus civilizations can control genes (genetic engineering), Type III-minus can control molecules, Type IV-minus culture can control atoms (mastery of nanotechnology and the ability to create artificial life), Type V-minus culture can engineer the nuclei of atoms, Type VI-minus can control elementary particles, and Type Ω-minus can control fundamental aspects of spacetime, attaining the ability alter space and time completely[5]. It is easy to see the growth from Type I-minus to Type II-minus, as jumping from something like using tools to editing DNA is quite a progression. However, this system may not be necessarily linear as humans have performed nuclear fission (Type V-minus) before creating true artificial life (Type IV-minus). Equating technological progress proportionally with the size of matter that can be controlled is logical due to precedents throughout human history. Over time, we advanced from mechanical, to chemical, to atomic, to nuclear level interactions, that each allowed for a new era of technology more improved than the last[6].

Type Ω-minus may be the limit to technological advancement. It is a highly speculative topic and theoretical level incorporated in Barrow's system just to include an endpoint in the size of matter control progression. Humanity has presently surpassed Type III-minus, and has started advancing into Type IV-minus with nanotechnology, into Type V-minus with nuclear physics, and Type VI-minus with particle physics. We haven't mastered them yet, and so our exact Microdimensional Mastery type is III-minus. At this point in humanity's understanding of science, we have no idea if it would be theoretically possible to completely alter space and time, making it an effectively final, potentially unapproachable endpoint for Barrow's system of technological advancements. As improvements in technology are only available with an increased understanding of physics, in general this system measures the capacity for technological advancement of a civilization. The smaller the size of matter a civilization can control, the more powerful they could be.

### Capacity to Fit in with Environment

In a paper arguing that any modification of one's environment (creating tools, computers, rockets) is less advanced than modifying oneself to fit in, Valentin D. Ivanov proposed a system that ranked this environment modification ability, following as such: For Class 0, the environment is used as is (animals); for Class 1, the civilization modifies the environment (creating clothes, buildings, etc.); Class 2 civilizations modify themselves to fit in with their environment (genetically improved humans); and Class 3 civilizations merge with the environment, converting the dead matter in the Universe into thinking matter[7]. Turning dead matter into thinking matter is a highly speculative and abstract idea. While Class 3 may appear to be a logical progression along this scale for life to fit in with its environment, the feasibility and purpose of reaching it may not be realistic.

The importance of the Ivanov system lies in its idea that modifying ourselves rather than the environment may better achieve the overarching objectives that drive the actions of life. Ivanov points out many examples for this, one position being that humans have evolved brains with insufficient computing capabilities considering the requirements of our current society. See reference citation for the rest of his argument[6]. Therefore, genetic improvements may allow an individual to adapt optimally to their environment, fulfilling the motivations that all life experiences as effectively as possible—these motivations being the innate biological instincts and drives inherent in all living creatures. As of now, humanity has only progressed to Class 1 on the Ivanov scale, which involves modifying our environment to achieve these overarching objectives.

Figure 2 shows humanity's level of advancement on each scale as a fraction of the maximum level we have discussed. Taking the Kardashev scale, for instance, humanity is at Type 0.7276, about 25% as a fraction of Type III (the highest level we explored).

## Similarities and Differences

Both the Kardashev and Zubrin classification systems place a central focus on a civilization's exploration and physical expansion throughout the universe. In essence, these scales measure the breadth of a civilization's influence, though they differ in the specific metrics used; Kardashev emphasizes energy consumption while Zubrin prioritizes the distance a civilization has traveled from its home planet.

A key similarity between these scales is that advancing on either scale necessitates an increase in the civilization's sphere of influence. As a civilization explores further and expands its boundaries, it inherently increases the maximum available energy (Kardashev) and the distance it has traveled (Zubrin).

In terms of technological milestones, both scales require a certain level of advancement, though they vary in specifics. For instance, the Kardashev scale requires a civilization to possess the capability to reach distant stars and build structures like Dyson Spheres around them. The Zubrin scale, on the other hand, mandates space travel capabilities but does not strictly require advanced technology for energy harnessing or megastructure construction. This means that, in theory, a civi-

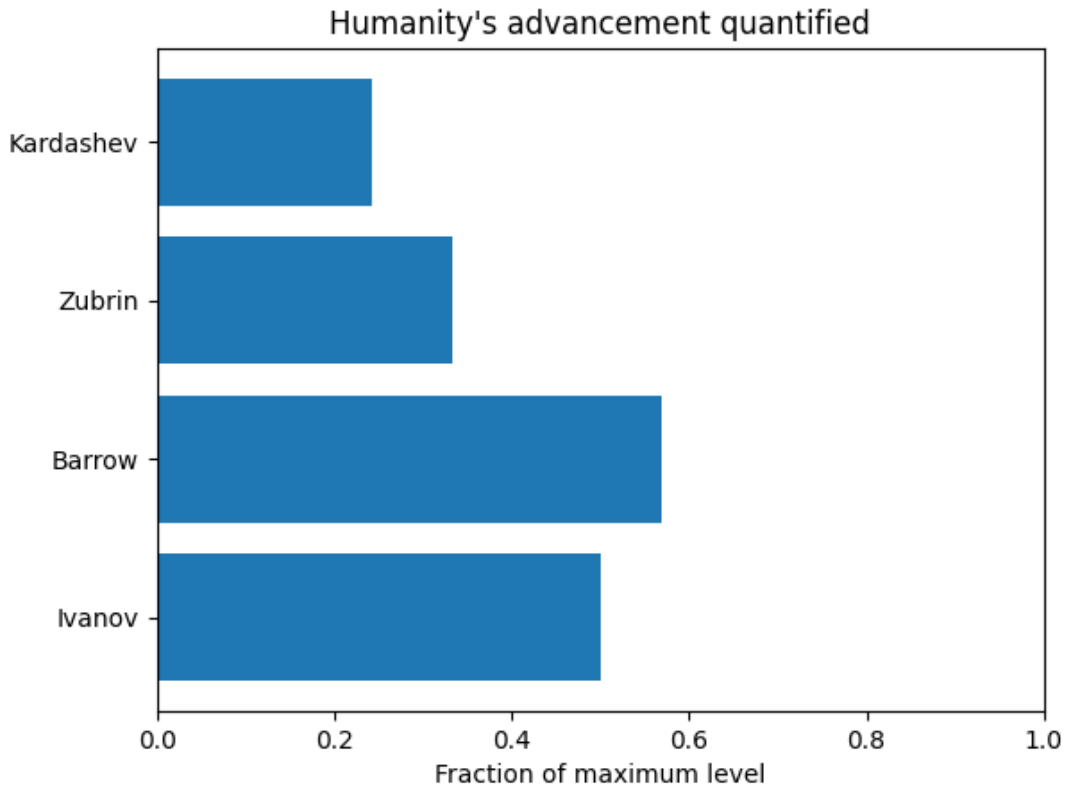


**Fig. 2** Humanity's progress of each metric: energy consumption, distance traveled, micro/particle control, capacity to fit in with environment - as a fraction of the maximum attainable level for each mechanism

lization could advance on both scales without continuous technological development. For example, Type II on the Kardashev Scale has already unlocked all the technology required to continue advancing (space travel and star energy collection). Similarly, Type II on the Zubrin scale also has no further need for technological advancement since they already would have achieved space travel as well. This contrasts sharply with the Barrow scale, which is primarily a progression of technological milestones.

The Barrow scale measures the smallest particle that a civilization can control, therefore outlining a potential progression of technological achievements from controlling large-scale objects (Type I-minus) to mastering the ability to alter space and time (Type Ω-minus). It sharply contrasts against the two "mobile" classification systems, as nowhere in the Barrow system is space colonization a necessary advancement.

The same goes for the Ivanov modification system, which also prioritizes the advancement of technology over wide-ranging colonization. Although traveling to and colonizing another planet to survive a climate crisis, for example, might fall under Class 1 (modifying the environment), the ability to explore space overall isn't a part of the system. In fact, the answer to this crisis for a Class 1 civilization may be to escape to another planet, while a Class 2 civilization would have the capability to modify themselves to survive in the new, impacted ecosystem. Since the Ivanov mechanism's metric is genetic modification, its Class 2 (modification of self) overlaps with the Type II-minus (gene editing) technology of the Barrow scale. As the Ivanov system is very broad in its Class 1 modification of the environment category, all other Barrow technologies besides gene-editing would have to fall into that category.

## Evaluation with respect to Great Filter Events and SETI observations

Because the efforts of SETI (Search for Extraterrestrial Intelligence)so far have failed to confirm the existence of extraterrestrial life, events to justify why life may not exist beyond Earth – called Great Filter Events – have been proposed[6]. Evaluating the civilization classification systems we have discussed compared to some filters allows us to hypothesize potential consequences at different stages of civilization advancement.

We include concepts that restrict life in our evaluation, including the Dark Forest Theory, climate change, and total war. In this section, we aim to answer how likely a civilization is to survive each filter while progressing according to each specific classification scale.

### Dark Forest

The Dark Forest is a proposed state of the universe, where life is actually abundant and civilizations of varying levels of general advancement exist. The reason that we would not have observed any of this life, though, is because the premise of this state is that all inter-species interactions occur with calculated mistrust. All life is fearful of being noticed and getting discreetly killed off, and therefore takes the opportunity to make any civilization they notice become extinct before the same happens to them[8]. This condition is impossible to prove true or untrue due to its unique nature. If we don't find life outside of Earth, we don't know if it's because it doesn't exist or if it is remaining hidden to ensure its survival. Either way, life being very abundant may or may not be an accurate overall representation of the universe, but it provides a potential reason for why any civilizations that do exist may not be interested in communicating with others and try to remain unnoticeable. While the Dark Forest appears very far-fetched and unlikely to be a law of the universe, evaluating it still offers insight into how interactions with hostile civilizations may play out. Even though an absolute Dark Forest condition may not exist, there will still be some threat that comes with any other life in the universe due to the eventual scarcity of resources. There are finite resources in the universe that are reachable to an observer at any given time (due to the expansion of the universe, certain events will eventually be beyond our light cone of causal connection), so taking into consideration potential hostilities between civilizations and analyzing each scale from such a perspective is insightful nevertheless.

In the Dark Forest state, civilizations either would not increase on the Kardashev or Zubrin scale for fear of being noticed, or would have been eliminated right when they began to. These two systems do not work well in a universe full of life as major expansion into space seen at Type 3 and even Type 2 on both mobile scales could appear very aggressive and hostile.

On the other hand, the two stationary classification scales allow means for life to advance according to their system while appearing for the most part no different from the billions of other stars and planets in a galaxy. For example, John Barrow's system not only allows a civilization to remain inconspicuous as it advances, but by prioritizing technological advancement and an understanding of physics it arms life to thrive on the offensive and defensive side of any Dark Forest conflict. Advancing to Class 3 on the Ivanov scale can be done without ever expanding throughout space as well, so it also does well in the Dark Forest state by not being expansive, therefore not appearing as a threat to an outsider.

### Climate Change

Furthermore, if actions are taken by a civilization to advance without regard for the potential effects of technological advancement or increased energy consumption, climate change may become an unavoidable filter event. This may be either a result of the civilization's negligence or an unavoidable effect beyond their control. There are internal factors that might lead a civilization to cause climate change through its advancement, such as burning fossil fuels to industrialize, or some other reason for consuming energy or changing the natural state of a planet There are also external risks like meteor impacts or volcanic eruptions that could result in climate change and extinction events[9]. These external factors are unrelated to the classification systems and the technological path a civilization might take.

Therefore, rather than solely considering which classification systems might inherently lead to climate change, it may be more revealing to weigh how different systems might render a civilization more susceptible to, or able to survive, climate change, whether internally or externally induced.

Climate change poses a significant threat to civilizations that lack the technology to terraform their planet and eliminate its effects. Terraforming ability, which encompasses any technology that could make a hostile environment suitable for life, is included in both the Ivanov and Barrow systems. The gene-editing technology featured at stage 2 and 2-minus of these systems, respectively, could theoretically offer a solution to climate change by allowing a species to alter themselves to fit into any possible environmental conditions. Therefore, at these levels, both the Ivanov and Barrow systems include measures for a civilization to adapt to a new environment by modifying themselves and their food sources to guarantee survival. However, these systems fall short when considering full planetary catastrophe since they don't require space travel and settlement outside of the home planet.

In contrast, a stage II civilization on the Zubrin or Kardashev scale might avoid a climate crisis or some other event rendering its whole planet uninhabitable entirely through its ability to colonize another planet, escaping the damage on its home planet.

A particular concern arises for Type I civilizations on the Kardashev scale, which seem the most susceptible to climate change. The climate crisis humanity is experiencing has been linked directly to our energy consumption methods. Therefore, for civilizations following a similar path, increasing energy consumption could exacerbate the climate crisis, potentially leading to their extinction if they lack space travel technology to escape a deteriorating home planet. It is possible

that climate change is a given prerequisite for any civilization attempting to achieve the full renewable energy of their star at Type II of the Kardashev scale. For example, this could be caused by burning fossil fuels to develop transportation in the case of humanity. Once Type I is surpassed, however, the climate change that would be inherent to such advancement wouldn't have an ability to wipe out the civilization since they would begin solely focusing on the renewable energy offered by their star.

By considering not only which systems might lead to climate change but also how they may respond to it, we are able to further compare and evaluate the civilization classification systems.

### Total War

This subsection discusses the potential of technological growth as a Great Filter itself— that technological advancement could be self regulating and actually increase the odds of a civilization getting wiped out the further they understand science and improve their technology [10].

So far to our understanding, and as humans have seen with the evolution of weapons progressing from chemical reactions in bombs to nuclear fission in nuclear weapons, destructive capabilities are proportional to scientific understanding; the more that is known about the laws of the universe, the more they can be utilized in deadly ways [10]. Technological advancement always comes at some risk that it will be used in war and possibly to such an extent that it could cause self-annihilation.

Microdimensional Mastery, Barrow's scheme, seems the most dangerous evaluated according to this heuristic, as it prioritizes scientific understanding and directly correlates with destructive capabilities. There may always be a chance for weapons to be used, and the more advanced a civilization is on this Barrow scale, the more potential a conflict has to end in their own extinction.

If a civilization could advance on the Kardashev and Zubrin scales at a certain rate so as to always be ahead of their own increasing destructive capabilities then they might be able to avoid a powerful weapon of their creation either purposely or accidentally destroying them. This might only work up until Type Ω-minus of the Barrow scale; the potential consequences of tampering with space and time could have unimaginable effects that even an entire galaxy wide civilization could not survive.

## Methodology

To conduct this research, we found the four most common civilization systems based on how often they appeared in our initial online review. The systems are inherently subjective. Although they are built upon assumptions and may be biased since they were each created individually, they are still accurate and legitimate potential paths of advancement.

To evaluate the systems with the intent of postulating humanity's future path, we used a simple heuristic: if a civilization's capabilities were only those specifically included at a certain level of a system or were an obvious prerequisite (i.e. space travel is required before a megastructure can be constructed), how would that skillset fare against a certain extinction threat, and would it exacerbate any possible extinction threats? We incorporated possible extinction threats that originated from ethical guidelines of governments (e.g. treaties and agreements preventing nuclear war or anthropogenic climate change) and from past extinction threats in Earth's history (meteors/natural climate change). We only discussed threats that would have a chance of wiping out an entire civilization; otherwise it would be difficult to evaluate threats against each other in a systematic way.

## Conclusion

By examining this spectrum of civilization classification scales and the types or classes they comprise, we have been able to pinpoint a more direct path for humanity leading into the near future and a possible path for extraterrestrials far more advanced than us. This path can be made up of the aspects of each of the scales that are overall beneficial when evaluated with Great Filters.

Advancing on the Kardashev and Zubrin scale is vital to avoid filter events local to one planet or one star system, like climate change or war. A young civilization's primary goal at first should be to guarantee survival by advancing technology to explore space. Past Type 2 (utilizing energy/resources from multiple stars) on both these mobile scales, the possibility for natural extinction events (star collapse, climate change, meteors, etc.) is nonexistent. Up until now, the danger from the Dark Forest concept and becoming noticed by hostile extraterrestrials does not override the need to expand to this point. However, at this point is where we break off from the quantitative, exponential growth models of the Zubrin and Kardashev scale. Continued space expansion, like trying to reach Type 3 on the Kardashev scale, would be an unnecessary risk of exposure since it does not offer anything other than more access to energy. We see the benefits of Type 3 on the Kardashev or Zubrin scale as being so minor, and with the slight chance of attracting hostile extraterrestrials, we conclude it to not be risk effective.

From this point, civilizations are now at a place where naturally occurring threats aren't an issue. From here, we propose that civilizations would focus on fitting in with their environment on an individual level according to the Ivanov system and by utilizing various technologies in the Microdimensional Mastery scale. This would look like reaching Class 2

on the Ivanov scale and using genetic modification or other techniques to achieve the overarching objectives that drive the actions of life. Perhaps they would create a virtual reality or live in a drug induced state of perfect contentment. The possibilities for fitting in with the environment in a biological/social perspective may be endless, but it logically fits for what a civilization would focus on after exceeding Type 2 on the Kardashev and Zubrin scales and ensuring their own survival.

In this journey for humanity to exceed Type 2 on the Kardashev and Zubrin scales, continued technological advancement is necessary. A requirement for reaching this state may be achievement of the maximum levels of the Microdimensional Mastery mechanism, ushering in the possibility for mass destruction. Finding a balance between potentially threatening and necessary scientific innovations will prove a challenge for the future as we continue to advance and aspire to reach the vital benchmark of Type 2 on the Kardashev and Zubrin scales.

## References


1 L. Signé and H. Dooley, *How space exploration is fueling the Fourth Industrial Revolution*, https://www.brookings.edu/articles/how-space-exploration-is-fueling-the-fourth-industrial-revolution/.

2 M. Bailey, *Could AI be the Great Filter? What astrobiology can Teach the Intelligence Community about Anthropogenic Risks*, arXiv e-prints.

3 A. Zhang, J. Yang, Y. Luo and S. Fan, *Civilization, Energy, and Progression of Mankind on the Kardashev Scale*, arXiv e-prints.

4 O. Lewis, *Comparing Different Civilizational Scales*, https://medium.com/swlh/comparing-different-civilizational-scales-35e98ee30c93.

5 M. Ćirković, *Serbian Astronomical Journal*, **191**, 1–15.

6 J. Gertz, *The Drake Equation at 60: Reconsidered and Abandoned*, arXiv e-prints.

7 V. Ivanov, J. Beamin, C. Caceres and D. Minniti, *Astronomy Astrophysics*, **639, A94**, year.

8 S. Hendricks, *Dark Forest theory: A terrifying explanation of why we haven't heard from aliens yet*, https://bigthink.com/surprising-science/the-dark-forest-theory-a-terrifying-explanation-of-why-we-havent-heard-from-aliens-yet/.

9 *What Causes Climate Change? Human and Natural Causes*, https://www.nrdc.org/stories/what-are-causes-climate-change#natural.

10 N. Bostrom, *Global Policy*, **10**, 455–476.