The Asymptote of Civilization

Humanity's Journey from Passengers to Pilots

James Oliver

February 21, 2025

Abstract

Humanity's historical trajectory has been defined by an unbroken expansion of agency—our increasing ability to control our environment, movement, and destiny. This paper argues that the logical culmination of this trend is the development of **mobile world-systems**—self-sustaining, navigable civilizations capable of steering their own cosmic trajectory.

Current space expansion strategies remain **base-centric**, relying on fixed planetary outposts that are constrained by resource dependence, static positioning, and vulnerability to external threats. In contrast, mobile world-systems eliminate these limitations by combining the resilience of natural ecosystems with the adaptability of engineered environments.

This framework introduces the **Cosmic Agency Ratio**, a quantitative model demonstrating that human survival depends on the continuous increase of control over our environment. We argue that intermediate states—partial agency without full cosmic mobility—are inherently unstable over long timescales, leaving civilizations vulnerable to existential threats. The only sustainable outcome is full agency: the ability to dynamically navigate space rather than being bound to planetary fate.

By synthesizing technological, societal, and philosophical imperatives, this paper presents mobile world-systems as not just a possibility, but an evolutionary necessity. The choice is clear: humanity can either remain passive passengers on a drifting planet, or seize control of its cosmic trajectory and take the helm of its own future.

I. Introduction

Humanity's journey is defined by a relentless expansion of agency—our ability to shape our environment and dictate our trajectory. From early survival in unforgiving landscapes to global control over ecosystems, we have never remained confined. Each stage of our progress has been marked by one fundamental trend: increasing mobility and autonomy.

This paper explores humanity's trajectory toward *The Asymptote of Civilization*—a theoretical limit where we approach complete cosmic agency, refining our mastery over movement and environment until civilization itself becomes mobile.

Viewed through the lens of agency expansion, history reveals a clear pattern: we are not destined to remain tethered to planets. The logical conclusion of our quest for autonomy is the emergence of mobile world-systems—self-contained, navigable civilizations capable of traversing the cosmos.

This is not speculation—it is the natural extension of humanity's evolutionary drive.

Current models of space expansion—planetary colonization, probe-based missions, and return trajectories—are transitional steps, constrained by physical, psychological, and logistical limitations. They tether humanity to fixed locations, restricting our ability to fully inhabit the cosmos. True cosmic habitation demands a paradigm shift: from planetary dependence to self-sustaining, dynamically mobile civilization.

The future of human space exploration lies in developing mobile world-systems powered by fusion energy, closed-loop ecosystems, and adaptive autonomy. This transition—from explorers to permanent cosmic inhabitants—is both a technological imperative and a philosophical one, reflecting our fundamental drive for control over our own destiny.

In the following sections, we will examine the historical progression of human agency, critique the limitations of current space expansion paradigms, and outline the theoretical framework of mobile world-systems. We will also explore the energy requirements, technological prerequisites, and strategic implications of this transition. Ultimately, this paper offers a new model for human progress—one that does not merely extend our presence into space, but transforms the very structure of civilization itself.

II. Historical Progression of Human Agency

The evolution of human civilization follows a consistent trajectory: the relentless expansion of control over both environment and movement. This progression, driven by advancements in energy mastery and technology, unfolds across distinct stages—each marking a qualitative leap in our agency.

Survival: Mastering Basic Tools and Energy

In our earliest days, survival dictated our relationship with the environment. Early humans adapted to harsh conditions by developing tools and harnessing fire.[1] Fire became the first controlled energy source, providing warmth, protection, and the ability to cook food. Simple tools improved hunting, gathering, and defense, laying the foundation for future progress.

Domination of the Local Environment: Agriculture and Settlement

With the domestication of plants and animals, humanity transitioned from survival to control. The Agricultural Revolution harnessed biological energy systems, enabling permanent settlements and the rise of complex civilizations.[2] Mastery over fire provided a foundation for metallurgy and technological advances, while stable food production supported population growth, social stratification, and large-scale coordination.

Expansion of Mobility: The First Steps Toward Global Reach

The domestication of animals and the invention of wheeled transport expanded human mobility beyond immediate settlements. Maritime exploration and trade networks facilitated cultural exchange and economic integration. The Industrial Revolution marked the next great leap, as steam and mechanical energy revolutionized transportation, manufacturing, and communication.[3] Human movement, once dictated by physical endurance and natural barriers, became increasingly autonomous.

Globalization and Total Earth Control

By harnessing mechanical and later atomic energy, humanity reshaped entire regions.[4] Powered flight, telecommunications, and expansive energy infrastructures interconnected the globe, shrinking distances and enabling near-instantaneous information exchange. The mastery of atomic energy introduced both an unprecedented power source and existential risks, reinforcing the need for responsible technological control.

Orbital and Interplanetary Reach: The Threshold of Cosmic Agency

The Space Age marked humanity's first deliberate steps beyond Earth. The advent of rocketry and orbital mechanics allowed us to escape our planetary cradle. Early space exploration—orbital missions, lunar landings, and robotic probes—laid the groundwork for humanity's next phase: the transition from planetary inhabitants to interstellar agents.

III. Paradigm Shift to Mobile Civilization

Humanity's current approach to space expansion is constrained by its reliance on **base-centric models**—fixed locations on celestial bodies that serve as operational hubs for exploration. While this strategy has enabled our initial forays into space, it remains fundamentally limited by return trajectories, resource dependence, and an inability to directly control our environment beyond local adaptations.

To fully inhabit the cosmos, we must transition from a static model of space expansion to an actively navigated, self-sustaining civilization. This shift requires moving beyond **natural world-systems** and the **base-centric paradigm** toward **mobile world-systems**—self-contained, navigable civilizations capable of steering their own cosmic trajectory.

Stage One: The Natural World-System

Earth and other planets function as natural world-systems, supporting complex ecosystems and habitability. However, they are entirely governed by external cosmic forces, offering no control over their movement or conditions. The limitations of natural worlds include:

- **Fixed Orbits:** Planets follow predetermined trajectories that cannot be altered.
- **Resource Constraints:** Although planets provide resources, they do not optimize their use—many remain inaccessible due to planetary composition and logistics.
- **Vulnerability to Cosmic Events:** Planets are passive objects in a dynamic universe, subject to asteroid impacts, solar radiation, and long-term environmental changes.

Table 1: Limitations of Natural World-Systems

Feature	Natural Worlds
Self-Sufficiency	High (ecosystem-driven, but non-optimized)
Mobility	None (fixed orbit)
Expansion Potential	None (bound to gravity wells)
Resource Utilization	Local, often inefficient
Survivability	Subject to cosmic hazards (asteroids, supernovae, climate shifts)

Stage Two: The Base-Centric Model

In an effort to expand beyond Earth, humanity has begun constructing base-centric space habitats, such as the International Space Station and future lunar or Martian colonies. These structures represent a transition from planetary dependence to engineered space environments, yet they remain limited by:

- **Static Location:** Bases are still tied to planetary surfaces or fixed orbital positions, restricting adaptability.
- **Resource Supply Chains:** Despite technological advancements, base-centric models require constant resupply from external sources.
- **Limited Expansion Capability:** Colonies may be scalable, but they remain bound to gravity wells and local environmental conditions.

Table 2: Limitations of the Base-Centric Model

Feature	Base-Centric Model
Self-Sufficiency	Low (reliant on supply chains)
Mobility	None (fixed location)
Expansion Potential	Limited (modular but restricted to one environment)
Resource Utilization	Requires constant resupply, inefficient extraction
Survivability	Isolated, dependent on backups, vulnerable to planetary hazards

Stage Three: The Mobile World-System as the Optimal Model

A mobile world-system is not a rejection of planets or base-centric models—it is their synthesis. It retains the self-sustaining resilience of natural worlds while incorporating the adaptability and engineering control of base-centric structures. By eliminating the constraints of fixed locations, mobile world-systems provide:

- **Navigable Trajectories:** Rather than being bound by gravity wells, these systems are designed to move intentionally, avoiding hazards and optimizing resource collection.
- **Full Self-Sufficiency:** Advanced closed-loop ecosystems, fusion power, and in-situ resource utilization allow for long-term sustainability.
- **Expansion Without Constraint:** Unlike planetary colonization, which is limited by available land and atmosphere, mobile world-systems can expand in any direction by adding modular habitats.
- **Survivability and Adaptability:** The ability to reposition in response to cosmic events ensures long-term resilience beyond the vulnerabilities of planetary dependence.

Table 3: Mobile World-Systems as the Optimal Model

Feature	Mobile World-Systems
Self-Sufficiency	Total (closed-loop, sustainable)
Mobility	Full (navigable trajectory)
Expansion Potential	Unlimited, scalable in any direction
Resource Utilization	Adaptive, optimized recycling and collection
Survivability	Maximized (hazard avoidance, redundancy)

The Paradigm Shift: From Passenger to Pilot

Although Earth is our current home, it is itself a mobile world—traversing space at 30 km/second along a predetermined orbit. Yet we have no control over this trajectory. Humanity today is like a passenger on a vast interstellar vessel with no access to the helm.

Current space strategies treat exploration as an extension of this passivity—deploying short-range missions while remaining gravitationally bound. The transition to mobile world-systems represents a fundamental rethinking: rather than continuing to explore from fixed bases, we become the navigators of our own cosmic journey.

We can either remain passengers on a drifting planet
or become pilots of our own trajectory.

This is not just a technological shift—it is a redefinition of what it means to inhabit the cosmos. The future belongs to civilizations that choose movement over stagnation, control over chance, and agency over uncertainty.

IV. Theoretical Framework: The Mobile World-System

The natural progression of human agency culminates in the creation of mobile world-systems—self-sufficient civilizations capable of controlled movement through space. Rather than merely exploring the cosmos from fixed outposts, our ultimate trajectory lies in actively inhabiting and steering our own cosmic future.

Definition and Key Characteristics

Mobile world-systems are fully autonomous, navigable civilizations engineered for long-term habitation and exploration beyond any single celestial body. They embody the pinnacle of human control over both movement and environment. Their defining characteristics include:

- **Complete Self-Containment**: The system must sustain all aspects of civilization—from food production and waste management to energy generation—without reliance on external supply chains.

- **Controlled Navigation**: These systems must be able to adjust their trajectories intentionally, allowing for hazard avoidance, optimized resource access, and strategic positioning in the cosmos.
- **Generational Sustainability**: Designed for long-term habitation, mobile world-systems must support life across multiple generations, adapting dynamically to changing conditions.
- **Scalable Resource Utilization**: Efficient recycling and repurposing of materials are essential, ensuring sustainable resource management in a closed-loop environment.

Energy Requirements and Technological Prerequisites

To transition from planetary dependence to self-directed cosmic mobility, humanity must develop new technologies in energy generation, propulsion, and environmental control. Key prerequisites include:

- **Advanced Propulsion Technologies**: Moving massive, self-contained habitats requires breakthrough propulsion systems—such as nuclear fusion or directed energy drives—that provide high energy density and sustained thrust.
- **Sustainable Energy Generation**: High-output, long-duration power sources are essential to support propulsion, life support, and infrastructure. Fusion energy, solar collection at scale, and emergent technologies will be central to these efforts.
- **Environmental Control Systems**: Maintaining habitability demands precision in atmospheric regulation, temperature control, artificial gravity, and radiation shielding.
- **Resource Extraction and Recycling**: Robust systems for in-space resource extraction (e.g., asteroid mining, comet harvesting) and ultra-efficient material recycling are critical to ensuring long-term sustainability.

Societal Structures and Governance

The success of mobile world-systems hinges not only on technological readiness but also on the evolution of governance, culture, and social organization. These civilizations must be designed to sustain long-term cooperation, innovation, and adaptive governance.

- **Adaptive Governance**: Traditional political models must evolve to support decentralized, self-regulating systems capable of managing long-term strategic planning and dynamic decision-making.

- **Innovation-Driven Society**: Continuous investment in research, technological development, and scientific exploration is fundamental to the longevity and adaptability of a mobile civilization.
- **Education and Cultural Evolution**: Future generations must be equipped with an exploratory mindset and the skills necessary for thriving in a dynamically evolving cosmic environment.

The shift to mobile world-systems represents not just an extension of human civilization but a fundamental redefinition of what it means to inhabit the cosmos. This framework provides the blueprint for transitioning from planetary dependence to self-directed cosmic agency.

V. Quantifying Cosmic Agency

To formalize our thesis, we introduce a mathematical model that quantifies the degree of control—or agency—that humanity exerts over its environment. This framework captures the essence of our progression from vulnerability to mastery.

The Cosmic Agency Ratio

We define the **Cosmic Agency Ratio**, R, as:

$$R = \frac{C}{E}$$

where:

- C represents the number (or magnitude) of environmental forces that humanity can control or mitigate.
- E represents the total number (or magnitude) of environmental forces affecting our existence.

By definition, R ranges between 0 and 1:

- $R \approx 0$ (Early Humans): Minimal control over natural events; high vulnerability.
- $R \to 1$ (Advanced Civilizations): Increasing technological mastery reduces external risks and enhances autonomy.

Interpreting the Ratio

- **Early Humans ($R \approx 0$)**: At this stage, nearly all environmental factors—climate, natural disasters, disease—were beyond human influence, leaving societies highly vulnerable.

- **Industrial and Space-Age Civilizations ($R > 0.5$)**: Innovations in infrastructure, medicine, and global coordination significantly reduce vulnerability, expanding our control over Earth.
- **Mobile World-Systems ($R \to 1$)**: The logical culmination of agency expansion, where civilizations become fully self-sufficient, mobile, and resilient to cosmic threats.

Vulnerability as a Function of Agency

Human vulnerability, V, is inversely proportional to agency:

$$V = 1 - R$$

As R increases, V decreases, reflecting reduced dependence on external stability and an increased capacity to dictate our cosmic trajectory.

The Asymptote of Civilization: Full Agency as a Limit

While complete mastery ($R = 1$) is an asymptotic limit, never fully attainable, civilization's trajectory is defined by its approach to this state. The closer we move toward $R = 1$, the more resilient and autonomous we become.

This model serves as a heuristic to illustrate the central thesis: as humanity's ability to control its environment expands, our vulnerability shrinks. The natural endpoint of this progression is the transition from planetary civilizations to mobile world-systems, ensuring long-term survival and full cosmic agency.

VI. The Asymptotic Nature of Progress

Human civilization's progress follows an asymptotic trajectory toward complete cosmic agency. Borrowing from mathematics, an asymptote is a boundary that a curve perpetually approaches but never fully reaches. Likewise, our pursuit of control over our destiny is an ongoing journey—an approach toward absolute mastery that remains perpetually unfinished unless we take the final leap.

Binary Outcomes: Control or Extinction

When viewed through the lens of increasing agency, human progress converges toward one of two stark outcomes: achieving controlled cosmic mobility or facing extinction. This binary dynamic arises from the inherent instability of intermediate states over cosmic timescales.

- **Full Cosmic Agency**: This represents the ultimate realization of human control. It marks the transition from passive existence to active cosmic stewardship—where civilization dictates its own movement, mitigates existential risks, and ensures long-term survival. In this scenario, our drive for adaptability and autonomy culminates in a civilization capable of navigating the cosmos.

- **Extinction**: Failure to overcome our current limitations will eventually lead to collapse. Whether through cosmic catastrophes, environmental degradation, or self-inflicted destruction, civilizations that do not achieve full agency remain vulnerable to forces beyond their control. Over long enough timescales, these vulnerabilities inevitably lead to extinction.

This dichotomy parallels the concept of the *Great Filter* in astrobiology, which suggests that advanced civilizations may face a critical threshold so formidable that only those that achieve full control over their destiny survive, while others perish.[5,6] In both cases, intermediate states are inherently unstable over cosmic durations, forcing civilizations toward either radical success or complete collapse.

Logical Conclusion: The Inescapable Trajectory

Human technological and societal evolution consistently follows a trajectory aimed at increasing control over our environment. This is not speculative but an observable historical pattern. The logical extension of this trajectory is the pursuit of full cosmic agency.

Just as a mathematical function approaches an asymptote without fully reaching it, humanity's continual striving for greater control reflects an unending pursuit. Each technological and societal advancement brings us closer to, yet never completely achieving, full mastery. However, over cosmic timescales, partial control is an unstable equilibrium—one that either resolves into full agency or collapses entirely.

The Instability of Intermediate States

Intermediate states—such as partial control over planetary environments or limited space expansion—are inherently unsustainable. These transitional phases leave civilization vulnerable to external forces beyond its control.

- **Partial Control = Increased Risk**: A civilization that has only partial mastery over its environment is exposed to cosmic threats it cannot mitigate. This creates an unstable equilibrium that pressures society toward either advancing or failing.

- **Technological and Societal Shifts Required**: Moving beyond these vulnerable intermediate states will require fundamental advancements in propulsion, closed-loop life support, governance, and long-term societal planning.

- **Inevitable Trajectory Toward Agency**: The only sustainable long-term outcome is full agency—where civilization becomes dynamically self-sufficient and navigates its own trajectory.

The Urgency of Progress

The asymptotic nature of progress implies that, over time, only two outcomes remain viable: either humanity evolves into a civilization capable of controlled cosmic mobility, or it faces extinction. This binary outcome, reminiscent of the Great Filter hypothesis, underscores the necessity of advancing our technological, philosophical, and strategic frameworks to ensure that our trajectory bends toward survival rather than collapse.

Humanity stands at a crossroads. The longer we remain in an unstable intermediate state, the greater the risk of catastrophe. Only by accelerating our transition toward full agency can we ensure a resilient, self-determining future.

VII. Implications, Challenges, and Future Research

The theoretical framework of mobile world-systems carries profound implications for space development, technological priorities, and long-term strategic planning. Recognizing that full cosmic agency is the ultimate trajectory of civilization allows us to better align research, innovation, and policy with this end goal. Recent developments highlight the urgency of this paradigm shift.

The Need for Mobile World-Systems: A Case Study

In February 2025, NASA's JPL Sentry System identified a near-Earth object designated 2024 YR4.[7,8] This asteroid, approximately 60 meters (196 feet) in diameter and currently 27 million miles away, has a nonzero probability of impacting Earth in December 2032. Depending on its composition, such an impact could result in either an atmospheric airburst or an impact crater—potentially causing destruction comparable to the Tunguska event.

This scenario starkly illustrates our current vulnerability: while deflection strategies exist, they rely on altering the trajectory of an uncontrollable planet. Our inability to directly steer Earth in the face of cosmic hazards highlights the fundamental limitations of a base-centric approach and underscores the necessity of developing mobile world-systems.

Research Priorities

To advance mobile world-systems and mitigate cosmic vulnerabilities, several research areas must be prioritized:

- **Fusion Energy Research:** Developing high-energy-density propulsion systems is crucial. Fusion energy holds the potential to power mobile world-systems and enable sustained cosmic mobility.[9]

- **Closed-System Ecological Technologies:** Advancing closed-loop ecosystems is essential for self-sustaining habitats.[10] This includes innovations in agriculture, waste recycling, and atmospheric control.
- **Integrated Propulsion and Habitat Design:** Propulsion systems must be seamlessly incorporated into large-scale habitats to ensure efficiency, sustainability, and long-term livability.
- **Resource Utilization and Manufacturing:** Research into asteroid mining, in-situ resource utilization, and autonomous manufacturing is critical for the sustainability of mobile world-systems.

Policy and Strategic Recommendations

To support the development of mobile world-systems, decision makers should focus on:

- **Long-Term Investment:** Secure sustained funding for research and development, engaging both public institutions and private-sector initiatives.
- **International Collaboration:** Spacefaring nations must pool resources, expertise, and infrastructure to accelerate advancements in propulsion, life support, and space construction.
- **Workforce Development:** Education and training programs in engineering, physics, biology, and space governance must be expanded to build the expertise required for mobile world-systems.
- **Regulatory Frameworks:** Establish governance structures for space resource utilization, habitat expansion, and ethical considerations surrounding human settlement beyond Earth.

Challenges and Objections: Addressing Key Concerns

While the vision of mobile world-systems is ambitious, several challenges must be addressed:

- **Technological Feasibility:** Critics argue that the engineering challenges are insurmountable. However, history has shown that technological breakthroughs emerge from sustained effort. Challenges in propulsion, closed-loop ecosystems, and large-scale space habitats are engineering problems—not physical impossibilities.
- **Resource Allocation:** Some may question the justification for dedicating resources to

such a long-term goal. However, investments in mobile world-systems drive innovations in energy and material science technologies with immediate terrestrial benefits.

- **Ethical Considerations:** The development of mobile civilizations raises questions about governance, resource distribution, and long-term societal structures. These concerns must be preemptively addressed through robust policy and adaptive legal frameworks.

Future Research Directions

While this paper establishes the theoretical foundation for mobile world-systems, further research is required to translate this vision into reality. Key areas include:

- **Experimental Closed-Loop Habitats:** Testing fully self-sustaining ecosystems in space through long-duration lunar or Martian habitats.
- **Fusion Propulsion and Energy Systems:** Developing and scaling nuclear fusion for space propulsion and high-output power generation.
- **Modular and Scalable Space Structures:** Engineering adaptable habitats that can be expanded, repaired, and maintained autonomously.
- **Societal and Governance Models:** Researching governance systems suited for multi-generational, self-sustaining civilizations.
- **Asteroid Resource Utilization:** Developing technologies for in-situ manufacturing, mining, and 3D-printing in space.

A Necessary Transition

The transition from planetary dependence to cosmic mobility is not a luxury—it is an evolutionary necessity. Our current vulnerabilities, from planetary hazards to resource limitations, reinforce the urgency of advancing toward full cosmic agency.

Mobile world-systems are not a speculative ideal; they are the logical outcome of humanity's historical drive toward greater autonomy. The technologies, policies, and research initiatives outlined here are not distant abstractions—they are the essential stepping stones toward ensuring humanity's long-term survival and self-determination.

The choice is clear: remain bound to fragile planetary systems or take control of our cosmic trajectory. The longer we hesitate, the greater the risk of stagnation—or worse, extinction. The imperative is not just progress—it is survival.

VIII. Conclusion

The progression toward mobile world-systems is not speculative fiction—it is the logical culmination of humanity's relentless pursuit of agency over its environment and destiny. This paper has presented a theoretical framework asserting that the asymptote of civilization is the attainment of full cosmic agency through self-contained, navigable civilizations. This vision is not rooted in abstraction, but in the observable trajectory of human progress—from early survival to planetary dominance—and in the unbroken pattern of expanding control over movement and environment.

At its core, human progress is defined by our increasing mastery over our surroundings. Every leap in energy, technology, and mobility has brought us closer to autonomy. The transition to mobile world-systems is not a radical departure from history—it is the natural extension of our evolutionary drive. These systems will elevate us from passive passengers on a drifting planet to active navigators of our cosmic trajectory.

We have long operated under the illusion of a static home, yet as we read these words, Earth hurtles through space at 30 km/second. Our current condition—living on a planet whose motion we do not control—is inherently precarious. A mobile world-system is not a thought experiment; it is the logical safeguard against existential threats and the next evolutionary step in securing humanity's long-term survival.

Though the concept of an engineered, mobile civilization may feel unfamiliar, this unease stems from an illusion: the illusion that our current home is fixed. In reality, we are already adrift in space. The question is whether we remain passive passengers, subject to cosmic forces beyond our control, or take command of our own trajectory.

As we stand at the threshold of the cosmos, the choice is clear. We can either drift or navigate. We can either accept vulnerability or seize control. The transition from planetary dependence to full cosmic agency is not just a technological challenge—it is a philosophical imperative.

Ad astra per scientiam.

Key Takeaways

- **Humanity's trajectory is one of ever-increasing agency:** From early survival to planetary dominance, every step has expanded our control over movement and environment.
- **Mobile world-systems are the inevitable next phase:** They are not speculation but the logical extension of humanity's historical drive for autonomy and control.
- **Intermediate states are unstable:** Partial control over our environment is unsustainable over cosmic timescales—civilizations must either advance toward full agency or face extinction.
- **Our current space strategies are incomplete:** Base-centric expansion leaves us vulnerable; true cosmic habitation demands navigable, self-sustaining world-systems.
- **This is not a question of possibility—it is a question of will:** The longer we delay, the greater the risk of stagnation or catastrophe. The future belongs to those who seize control of their cosmic trajectory.

Falsification Check

As Richard Feynman famously stated:

> "It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong."

The core premise of this framework is simple:

> **Human progress follows an unbroken trajectory of increasing agency.**

If this premise holds, then the logical outcome is the eventual development of mobile world-systems—civilizations that fully control their movement and environment. If this premise is false, then the entire trajectory collapses, and humanity's long-term future may be dictated by forces beyond our control.

Falsification Criteria

This framework is falsifiable under one of two conditions:

- If historical evidence demonstrates a sustained, long-term reversal in human agency—where civilizations consistently abandon control over their environment rather than expanding it—this premise would be invalidated.
- If an alternative framework demonstrates a more stable or effective model for long-term human survival that does not involve increasing agency, this premise would need to be reconsidered.

Scientific Integrity and Adaptation

Until one of these conditions is met, this framework must be provisionally accepted as the best available explanation of humanity's trajectory.

Science is not about defending ideas—it is about refining understanding. If this framework is falsified or refined, that is not a loss but a gain. It means we have advanced our knowledge even further.

References

[1] Harmand S, Lewis JE, Feibel CS, Lepre CJ, Prat S, Lenoble A, et al. 3.3-million-year-old stone tools from Lomekwi 3, West Turkana, Kenya. Nature. 2015;521(7552):310-5.

[2] Bocquet-Appel JP. When the world's population took off: the springboard of the Neolithic Demographic Transition. Science. 2011;333(6042):560-1.

[3] Alacoque LR, Bulliet RW, James KA. Reconstructing the invention of the wheel using computational structural analysis and design. Royal Society Open Science. 2024;11(10):240373.

[4] Allen RC. The British Industrial Revolution in Global Perspective. Cambridge, UK: Cambridge University Press; 2009.

[5] Hanson R. The Great Filter – Are We Almost Past It?; 1998. Online Essay (updated Sept. 15, 1998).

[6] Haqq-Misra J, Kopparapu RK, Schwieterman E. Observational Constraints on the Great Filter. Astrobiology. 2020;20(5):572-9.

[7] Wasser ML. NASA Shares Observations of Recently-Identified Near Earth Asteroid; 2025. NASA Planetary Defense Official Blog.

[8] Wasser ML. NASA Continues to Monitor Orbit of Near-Earth Asteroid 2024 YR4; 2025. NASA Planetary Defense Official Blog.

[9] Abu-Shawareb H, et al. Lawson criterion for ignition exceeded in an inertial fusion experiment. Physical Review Letters. 2022;129:075001.

[10] Nelson M, Pechurkin NS, Allen JP, Somova LA, Gitelson JI. Closed Ecological Systems, Space Life Support and Biospherics. In: Wang LK, Ivanov V, Tay JH, editors. Environmental Biotechnology. vol. 10 of Handbook of Environmental Engineering. Totowa, NJ: Humana Press (Springer); 2010. p. 517-65.

Appendix: From Passenger to Driver

Imagine you're in an Uber. As you settle into your seat, you realize you have no control over the route, the speed, or the destination—everything is dictated by the driver and the GPS. Now, picture that Uber not as a car, but as our planet, Earth, hurtling through space under the relentless pull of gravity. We are passengers on a cosmic Uber, where gravity is the silent driver and the laws of physics determine our route.

Earth is our vehicle—a massive ship moving through the cosmos at approximately 30 km/second. As passengers, we might observe the journey, but we remain entirely at the mercy of forces we can neither choose nor control. This is humanity's current condition: a passive role, confined to a planet whose trajectory is dictated by cosmic forces beyond our influence.

Now, consider our efforts in space exploration. To this point, we have sent out small probes—essentially extending our hands out of the Uber's windows to get a brief sense of our surroundings. We have not yet gained the ability to steer the vehicle itself.

Now, imagine taking the wheel.

Transitioning from passengers to active navigators would be as revolutionary as the moment early humans first built ships and set their own course across uncharted waters. This shift defines the essence of mobile world-systems: rather than being confined to a planet on autopilot, we would engineer self-contained civilizations capable of controlled movement.

This is not about theoretical megastructures or speculative sci-fi fantasies—it is the logical extension of our historical trajectory toward greater agency. Just as obtaining a driver's license transforms you from a passive rider into someone who determines their own path, mobile world-systems enable us to shape our cosmic journey rather than merely endure it.

The key insight is this: our current existence as passive occupants of a moving Earth is an illusion of stability. In reality, we are already in motion. The true question is whether we remain passengers—watching from the back seat—or whether we seize control and become the pilots of our own cosmic future.

Acknowledgments

This work reflects a collaborative effort: the human author originated and refined the ideas, while generative AI systems assisted in drafting and structuring the text.

The intent of sharing these ideas is not personal recognition but to contribute to the collective advancement of human knowledge. The goal is to make these insights as accessible as possible for all, ensuring they can be freely explored, refined, and applied.

Ethical Considerations and Competing Interests

The author declares no financial, commercial, or institutional conflicts of interest related to this work. No external funding was received for the preparation of this manuscript. The research presented is based on publicly available data and does not involve human subjects, requiring no additional ethical approval.

License