The Cyclical Civilization Hypothesis: A Technogenic Reset of the Great Filter

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Abstract

This paper proposes the Cyclical Civilization Hypothesis (CCH) as an integrative framework addressing aspects of the Fermi Paradox. The hypothesis posits that highly developed but regionally isolated technological civilizations—termed Autonomous Separated Systems (ASS)—may have repeatedly emerged throughout Earth's geological history. These systems are suggested to have failed to achieve planetary integration and to have encountered a Technogenic Critical Point (TCP), a threshold at which technological capability exceeded the capacity for effective social, ethical, and cognitive regulation, resulting in systemic collapse.

Within this framework, the Great Filter is reinterpreted not as a singular cosmic event, but as a recurring technological barrier intrinsic to intelligent technological evolution. The absence of clear evidence for prior civilizations is attributed to their localized spatial scale and to geological erasure processes, including erosion, plate subduction, and biogeochemical recycling over timescales of 1–5 million years. By contrast, contemporary *Homo sapiens* civilization represents the first globally integrated technological system, approaching a planetary-scale TCP facilitated by the rapid advancement and infrastructural integration of Artificial Superintelligence (ASI). The hypothesis is explicitly falsifiable, generating testable predictions amenable to geological, geochemical, and archaeological investigation.

Keywords: Fermi Paradox, Great Filter, Silurian Hypothesis, Technogenic Critical Point, Autonomous Separated Systems, technosignatures, Artificial Superintelligence, existential risks

JEL Classification: O31, O33, D81, D83

1. Introduction: Fundamental Paradoxes

The Fermi Paradox highlights the tension between the high statistical probability of technological civilizations in the observable Universe and the persistent absence of observable

evidence for their existence. Traditional explanations invoke either the rarity of intelligent life or the near-inevitability of systemic collapse.

The Cyclical Civilization Hypothesis introduces two further considerations: (1) the potential locality and temporal separation of technological civilizations across deep time, and (2) the recurrence of a technogenic barrier independent of biological substrate or geological epoch.

Under CCH, the Great Filter is conceptualized as a structural feature of technological development, manifesting cyclically rather than as a unique bottleneck.

1.1 Relation to Existing Frameworks

CCH builds upon the Silurian Hypothesis (Schmidt & Frank, 2019), which examines the detectability of an industrial civilization in the geological record after millions of years. That work demonstrates that even a short-lived industrial episode would leave only subtle, ambiguous traces due to erosion, subduction, bioturbation, and geochemical cycling. CCH extends this perspective by proposing not a single hypothetical case, but a recurrent pattern of regionally confined systems.

Similarly, Wright (2018) explores technosignatures of prior indigenous technological species within the Solar System, noting that plate tectonics would subduct most surface evidence over geological timescales. Recent modeling of Earth's own technosignatures (Sheikh et al., 2025; Haqq-Misra et al., 2025) reinforces that detectability is limited even for contemporary civilization, supporting the plausibility of localized, erased predecessors.

2. Evidence Base: Locality and Separation of ASS

2.1 Regional Scale and Geological Erasure

A core premise of CCH is that prior technological civilizations, if they existed, were confined to regional rather than planetary scales. Their environmental impacts would therefore lack globally synchronous stratigraphic markers.

Research associated with the Silurian Hypothesis indicates that an industrial-level civilization could become nearly undetectable in the geological record after 1–5 million years owing to physical erosion, plate tectonics, and geochemical recycling (Schmidt & Frank, 2019; Vakarelska et al., 2020).

2.2 Geographic Separation

Oceans, deserts, mountain ranges, and climatic zones could have isolated ASS, impeding technological diffusion and global unification. Historical parallels exist in early Holocene human civilizations (e.g., Mesopotamia, Indus Valley, China, Mesoamerica), which developed largely independently (Cline, 2014).

2.3 Biological Variability

CCH does not presuppose anatomically modern humans in deep prehistory. ASS may have arisen among other hominin lineages (e.g., *Homo erectus*, *H. neanderthalensis*) possessing sufficient cognitive capacity but constrained by social organization or ecological factors (Leakey, 1979; Johanson & Edey, 1981).

3. The Cyclical Mechanism: The Technogenic Critical Point (TCP)

The Technogenic Critical Point is defined as the developmental stage at which technological capability growth outpaces the evolution of institutional, ethical, and cognitive mechanisms for its governance.

A minimal formal dynamic model of this mismatch can be expressed as follows:

Technological capability growth:

$$\frac{dT}{dt} - \alpha T$$

Regulatory adaptation:

$$\frac{dR}{dt} - \beta$$

Critical point condition:

$$T(t) - k\,R(t)$$

Here, T(t) represents technological capability (exponential growth with rate α), R(t) denotes regulatory capacity (linear growth with rate β), and k is a proportionality constant reflecting the threshold beyond which regulation fails to contain technological risks. The solution shows that TCP occurs at time $t_c = \frac{1}{\alpha} \ln\left(k\frac{\beta}{\alpha T_0}\right)$ (assuming initial conditions $T(0) - T_0, R(0) - 0$). This simple model illustrates the structural inevitability of mismatch under exponential vs. linear dynamics, without specifying particular modalities.

Table 1. Primary TCP Modalities and Potential Geological Signatures

TCP Type	Mechanism	Potential Geological Signature
Uncontrolled materials science	Self-replicating nanotechnologies ("grey goo")	Local anomalies of synthetic compounds, monochiral polymers
Hyper-energetic release	Extreme energy-density experiments	Vitrified or anomalously melted rocks, unusual isotopic ratios
AI autonomy	Loss of control over goal alignment	Minimal direct signatures; possible indirect resource/climate anomalies
Resource/nuclear exhaustion	Overexploitation leading to conflict	Transuranic spikes, heavy-metal enrichments, faunal turnover

In regionally isolated ASS, TCP-induced collapse would remain localized, producing no global extinction signal and permitting biosphere recovery.

4. Falsifiable Predictions of CCH

CCH yields empirically testable predictions. Negative results across multiple independent proxies and sites would constitute strong falsification.

Table 2. Testable Predictions and Falsification Criteria

Test	Method	Supporting Result	Falsification Criterion
Local synthetic polymers	Mass spectrometry / pyrolysis-GC-MS	$>10^3$ ppm anomalies in pre-Quaternary strata	Consistent absence in extensive, widely distributed samples
Rock vitrification	SEM, microstructural analysis	Non-volcanic melting patterns	Full consistency with volcanic or metamorphic processes
Atypical isotopic ratios	High-precision isotopic analysis	Artificial isotopic distributions (e.g., transuranics)	Natural geochemical or astrophysical explanation
Metal/REE anomalies	ICP-MS	Uncorrelated Pb, Cr, PGE enrichments	Correlation with known natural cycles

5. Discussion: A Global Risk for *Homo sapiens*

Modern civilization constitutes the first fully integrated planetary system. This integration introduces systemic fragility, wherein localized perturbations can propagate into cascading global failures (Centeno et al., 2023).

The contemporary manifestation of a potential TCP is likely associated with Artificial Superintelligence that has not achieved adequate value alignment. Unlike the localized failures posited for prior ASS, such a misalignment could precipitate a planetary-scale existential risk (Bostrom, 2014; Russell, 2019; Ord, 2020).

Recent assessments of Earth's technosignatures indicate that even present-day civilization remains detectable only at limited interstellar distances (Sheikh et al., 2025), underscoring the challenge of identifying erased regional predecessors.

6. Conclusion

The Cyclical Civilization Hypothesis identifies a structural vulnerability inherent in technological evolution. If the hypothesis is correct, humanity represents the first civilization capable of addressing this vulnerability at planetary scale.

Strategic implications for risk governance include prioritization of safety in advanced technology development, establishment of international oversight of autonomous systems, and recognition of value alignment challenges. Addressing these factors may offer opportunities to mitigate risks associated with approaching a global TCP.

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