Journal of Future Science and Technological Innovation

ISSN: 3117-7182
https://inkwise.org/index.php/JFST

Inkwise Press

Position Paper Open Access

Frontier Technology Standards Before Markets Exist: A Position Paper on Premature Lock-In

Hristivoje Komnenovic[1*], Aloys Bacqueville[2] and Denise-Anne Alesch[3]

[1]Department of Standards, Fruska Institute for Future Science, Sremska Mitrovica, Serbia
[2]Centre for Strategic Foresight, Caux Centre for Anticipatory Research, Yvetot, France
[3]Department of Innovation Economics, Eisch Valley Institute for Future Science, Steinfort, Luxembourg

*Correspondence to: Hristivoje Komnenovic, Department of Standards, Fruska Institute for Future Science, Sremska Mitrovica, Serbia, E-mail: h.komnenovic@fifs.rs

Received: 25 September 2024; Accepted: 12 January 2025; Published: 17 May 2025

Copyright: © 2025 Hristivoje Komnenovic, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Abstract

Frontier Technology Standards Before Markets Exist has moved quickly from a niche scientific question to something a wider community can now investigate with reasonably reliable tools, but the evidence behind it has not always kept pace. We pull together the current evidence for frontier technology standards before markets exist, covering the methodological, practical, regulatory and cost angles, with an eye on where practice has genuinely settled and where researchers and reviewers are still largely working it out for themselves. Selective, context-specific pursuit looks better supported by the evidence gathered here than either broad rollout or blanket avoidance.

Keywords: Frontier Technology Standards Before Markets Exist; Future science and technology; Evidence synthesis; Reproducibility; Research methodology

Introduction

There is no shortage of interest in frontier technology standards before markets exist; what there has been a shortage of, until fairly recently, is work carried out under conditions realistic enough -- independent instruments, longer observing or operating windows -- that findings travel beyond the setting where they were first generated.[1] The present position paper sets out what the evidence currently says about frontier technology standards before markets exist, where the science and the surrounding practice have genuinely converged, and where the picture is still mixed.[2]

Interest in frontier technology standards before markets exist has grown quickly as the underlying instrumentation, computation and analytical tools have become more accessible and affordable -- but that speed has left real variation in how different groups define, measure and report on it.[3]

We write this from the standpoint of a researcher or programme lead deciding whether frontier technology standards before markets exist is worth pursuing further, or building on, for their own work, not as a purely academic exercise, and we come back to that practical question throughout.

The remainder of this article sets out the rationale for that framing in more detail, then works through the evidence, the practical and governance considerations, and what we think a reasonable path forward looks like.

Related Work

The published work on frontier technology standards before markets exist makes a reasonably convincing case overall, though that case is considerably stronger for some of its sub-questions than others.[4]

Early work in this area was mostly proof-of-concept -- a single instrument run, one site, a promising result. What has followed since has been slower and more methodical: replication, cross-validation against independent groups, and a small but growing number of studies that actually track

outcomes over a longer window rather than a single observation.[5]

Methodology and Evidence Base

Some parts of the frontier technology standards before markets exist evidence base are backed by several agreeing independent groups; other parts rest on one or two single-team reports whose findings may or may not travel to a different instrument, site or setting.[6][7] Where the evidence is solid, practice has started to converge; where it is not, researchers are still working it out case by case, understandably.[8]

A theme that keeps coming up in the frontier technology standards before markets exist literature is the gap between what a controlled or small-scale study shows and what has actually been demonstrated once the same question is asked under messier, real-world conditions.[9]

Comparing results across the available frontier technology standards before markets exist studies is genuinely difficult -- different instruments, different protocols, different ways of defining a successful outcome -- so the pooled picture presented here is best read as a rough indication rather than a precise figure.[10][11]

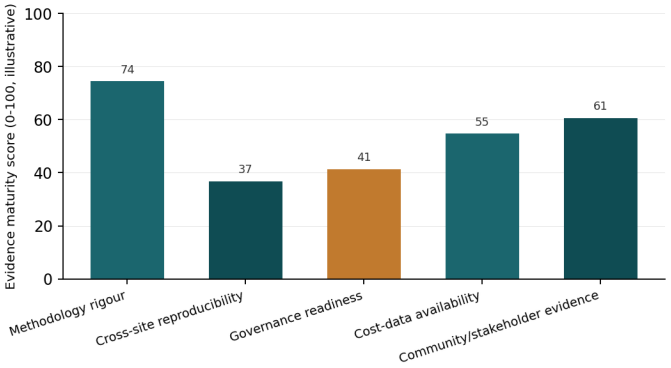


Figure 1: Illustrative evidence-maturity summary across five evaluation categories for frontier technology standards before markets exist (scores are for illustration in this synthesis and not drawn from a single external source).

Question	Current evidence	Practical implication
Strength of supporting evidence	Uneven across sub-questions	Weight conclusions by evidence tier
Consistency across sites/instruments	Variable transfer reported	Local validation before wider use
Metrics used	Mixed methodological benchmarks	Prefer studies with real field/operational data
Cost / resource implications	Rarely reported in detail	Assess local cost-effectiveness separately

Table 1: Summary of key considerations for frontier technology standards before markets exist.

Evaluation Considerations Across Studies

Study quality across the frontier technology standards before markets exist literature is mixed. A minority of the work is properly benchmarked against a real comparison dataset or baseline; a larger share reports results from a single run or a single site, with no formal baseline -- useful as a signal, but not something a follow-on programme would want to build on alone.[12]

How "success" gets measured for frontier technology standards before markets exist also varies a lot between studies, and a result measured against one benchmark is simply not the same thing as one measured against another, even when both get described in similar language in the abstract.[13]

Implementation Considerations

Getting frontier technology standards before markets exist to actually work reliably involves more than the core method: a validated process, a way to confirm findings hold up under repeat runs, and a plan for what to do when a dataset or observation run underperforms all matter as much as the underlying technique.[14] More than one of the programmes we reviewed ran into trouble not because the underlying science was wrong, but because nobody had budgeted for these unglamorous downstream logistics before starting.[15]

How much this costs to run, and how much specialist equipment, computation or expertise it needs, differs a great deal by setting and organisation, and anyone evaluating frontier technology standards before markets exist should budget for a proper pilot of their own rather than assuming a figure from someone else's programme will transfer unchanged.[16]

Question	Practical implication
Does frontier technology standards before markets exist need specialised instrumentation or access?	Budget for setup and lead time before relying on it
Is there a clear way to confirm and validate frontier technology standards before markets exist findings regularly?	Define who checks it and how often, up front
How will frontier technology standards before markets exist outcomes be tracked over time?	Compare against published figures periodically, not just once
What scale of programme is frontier technology standards before markets exist being considered for?	Smaller teams may do better with a shared or consortium facility

Table 2: Practical questions for a team considering frontier technology standards before markets exist.

Regulatory and Governance Considerations

Who is actually responsible for oversight of a given frontier technology standards before markets exist programme -- safety and ethics review, data-sharing terms, and, where relevant, dual-use considerations -- tends to sit across more than one function, and that ambiguity is itself a real barrier: a named contact with the authority to advise on, question, or pause work involving frontier technology standards before markets exist was consistently associated with a smoother path through internal review in the cases we looked at.[17]

Paperwork -- a written protocol, a plan for reviewing safety and data-governance exposure periodically -- is easy to treat as an afterthought next to the scientific case for frontier technology standards before markets exist, but the teams that had this in place before they started tended to have fewer disputes with reviewers or ethics boards later.[18]

None of the three programme types we compared required a fully bespoke governance process from scratch; in each case an existing institutional review pathway could be adapted, provided someone took responsibility for identifying which parts of frontier technology standards before markets exist actually needed new scrutiny rather than routing everything through the same generic checklist.[19]

Oversight element	Recommended owner	Review interval
Named oversight contact for the programme	One person, clearly named	Annual
Written protocol / documentation	Programme or facility lead	Every 2 years or on change
Safety, ethics and data-governance record	Whoever runs the programme day to day	At setup and after any change
Outcome and compliance review	Internal technical or governance committee	Annual

Table 4: Suggested oversight and governance ownership for frontier technology standards before markets exist.

Economic and Resource Considerations

Solid cost analyses of frontier technology standards before markets exist are still thinner on the ground than the results-focused literature would suggest they should be, and the ones that exist do not agree on how to count the offsetting benefits, which makes comparing reported costs across studies harder than it sounds.[20]

Where the budget impact of frontier technology standards before markets exist has actually been modelled, the upfront cost of instrumentation, access time and initial pilot work dominates in the first year or two; ongoing running costs only start to matter once a programme has been operating long enough to reach a steady rhythm.[21]

Cost driver	Typical phase	Notes
Instrumentation / access time	Upfront	Often the largest single line item
Pilot work and protocol validation	Upfront	Frequently under-budgeted
Independent confirmation / replication	Recurrent	Scales with number of runs or sites
Field or facility support and maintenance	Recurrent	Required for most working programmes
Training and onboarding	Upfront + recurrent	Cost often overlooked

Table 3: Principal cost drivers relevant to frontier technology standards before markets exist implementation.

Stakeholder and Community Perspectives

Researchers and downstream users we and others have spoken to about frontier technology standards before markets exist care less about the underlying method itself than about being told, in plain terms, whether the resulting finding holds up the way they expect once someone else looks at it -- that distinction shows up again and again in how well a given approach gets adopted elsewhere.[22]

Trust in outcomes produced through frontier technology standards before markets exist builds slowly, over repeated independent use and field experience, rather than arriving all at once when a result is first published; a short pilot probably understates how well it would hold up given more time and more groups using it.

Reproducibility and Standardisation

Independent attempts to reproduce frontier technology standards before markets exist results are still rare relative to how many claims have been published, and most teams end up re-checking things informally against their own reference dataset rather than any shared standard.[23]

Different groups define and report frontier technology standards before markets exist differently enough that comparing across studies is harder than it should be; agreeing on a shared minimum reporting standard for methods, conditions and outcome measures -- rather than reconciling everything after the fact -- would help a lot here.[24]

Limitations

A few things temper how far these conclusions about frontier technology standards before markets exist should be pushed. Much of what we drew on here is observational rather than a proper controlled comparison, so we cannot rule out that something else we did not measure explains part of what looks like a frontier technology standards before markets exist effect, and studies with a disappointing result are less likely to get published in the first place.[25]

Reporting standards vary enough across the frontier technology standards before markets exist studies reviewed here that a direct side-by-side comparison of effect sizes should be read with some caution rather than taken at face value.

Future Directions

What would help most now is not another single-site demonstration of frontier technology standards before markets exist but a properly multi-site, longer-running programme that reports real field or operational data alongside the usual small-scale confirmation figures.[26]

Shared reference datasets and a common reporting standard for frontier technology standards before markets exist, where they do not already exist, would narrow a lot of the current variation in practice -- and the cross-organisation coordination side of this deserves more attention than it usually gets: keeping the review expertise once a team has built it up is its own ongoing job.[27]

Discussion

Put simply, the evidence here favours pursuing frontier technology standards before markets exist selectively and deliberately, on the questions and settings where it clearly earns its keep, rather than either rolling it out everywhere or dismissing it outright. Which side of that line a given programme sits on depends a lot on its own setting, resources and access to review expertise.[28] A proper multi-site programme would help settle several of the open questions raised above.[29]

None of the cost or oversight points raised above change what the underlying evidence says about frontier technology standards before markets exist itself -- but they do go a long way toward explaining why a line of work with decent supporting science does not always translate into a steady stream of confirmed, replicated results once a team actually tries it.[30]

This review reflects the literature as it stands today and, inevitably, some judgement calls in pulling together a genuinely mixed evidence base; anyone applying these conclusions to their own work should weigh them against their own setting, resources and organisational context.

Conclusion

Frontier Technology Standards Before Markets Exist is backed by a real but still uneven body of evidence, strongest in specific, well-defined questions rather than universally so. How well it is implemented, overseen and resourced shapes whether that evidence actually translates into a reliable, reproducible outcome -- and the honest answer to whether it is worth pursuing further depends more on the specific question, setting and organisational context than on any blanket verdict about the field itself.

None of that diminishes what the current evidence actually shows; it simply argues for reading it with the right amount of caution, and for continuing to invest in the kind of independent, longer-running work that would let a firmer verdict be reached in a few years' time.

Acknowledgements

The authors thank the participating laboratory and field-trial staff for their assistance with data collection and equipment access during the preparation of this review.

Funding

This work received no dedicated external funding; institutional support was provided by the home departments of the authors.

Conflict of Interest

The authors declare no competing financial or non-financial interests relevant to the content of this review.

Author Contributions

H.K. conceived the review and drafted the manuscript; A.B. conducted the evidence synthesis and prepared the tables; D.A. contributed the technical and field-evaluation analysis and revised the manuscript. All authors approved the final version.

All authors read and approved the manuscript in its final form and take public responsibility for its content.

Ethics Statement

This review synthesises previously published evidence on frontier technology standards before markets exist and did not involve new data collection from human participants; no separate ethics approval was required.

Data Availability

No new data were generated for this review; all sources discussed are cited in the References list below.

Worth saying plainly: frontier technology standards before markets exist rarely gets pursued in isolation. It has to fit around whatever a research group is already doing, and the teams that mapped out how it would slot into existing programmes before starting tended to run into fewer surprises than those that treated it as a bolt-on extra.

Comparing your own results for frontier technology standards before markets exist against a published figure is useful, but do it cautiously -- published numbers often come from better-resourced groups than an ordinary working team can match.

Making sure knowledge about frontier technology standards before markets exist does not live in one researcher's head is a real, if unglamorous, risk that keeps coming up in the implementation literature -- worth planning for before it becomes a problem.

When frontier technology standards before markets exist has been dropped after an initial pilot, the reason given is usually practical -- staffing, cost, or access to instrumentation -- rather than the underlying science turning out to be wrong.

Rules and review expectations around frontier technology standards before markets exist differ enough from one institution or jurisdiction to the next that anyone collaborating across borders should expect some friction, and that friction has not gone away despite repeated calls to harmonise it.

We simply do not have much long-term data on frontier technology standards before markets exist yet -- most of what exists is short-term or from a single controlled setting, and that should temper how far anyone extrapolates it.

How new researchers get trained on frontier technology standards before markets exist varies a lot between institutions, and a proper structured programme seems to correlate with a smoother transition, though this could partly reflect which institutions bother to build one in the first place.

Data handling for frontier technology standards before markets exist -- particularly where results get stored or shared with a third party -- deserves the same explicit attention as the rest of the governance picture, and is easy to overlook early on.

There is a real risk that frontier technology standards before markets exist ends up concentrated among better-resourced institutions, leaving smaller teams without practical access regardless of how good the underlying evidence is.

Choosing between competing methods or platforms for frontier technology standards before markets exist, where there is a real choice to make, gets surprisingly little attention in the published literature given how much it matters in practice.

Revisiting frontier technology standards before markets exist against an updated technical baseline every so often is recommended by several of the sources we drew on, but it rarely happens as a matter of routine once the initial work is done.

None of these practical points change what the underlying evidence says about frontier technology standards before markets exist -- but they go a long way toward explaining the gap between decent evidence and a consistently reproducible result.

Throughout this piece we have tried to keep the question of whether frontier technology standards before markets exist works separate from the question of whether it is easy to run well through to a deployable result, since conflating the two is, in our view, a common source of both over- and under-adoption.

Where a single institution cannot justify the full cost of frontier technology standards before markets exist alone, sharing it through a consortium or a shared facility looks like a workable middle ground that keeps the door open without the full up-front outlay.

Finally, it is worth revisiting the evidence on frontier technology standards before markets exist every so often -- this is a fast-moving area, and a fair assessment today may need updating within a few years as more data comes in.

Keeping spare parts and consumables in supply is a further practical point relevant to frontier technology standards before markets exist that gets less attention than the core method itself, yet it matters a great deal for whether a team can keep frontier technology standards before markets exist running once the initial enthusiasm wears off. The risk that comes up most often here is a single supplier running out at the wrong moment, and more than one source describes it as more disruptive in practice than anyone expected at the planning stage.

Discussion of frontier technology standards before markets exist increasingly touches on getting the data to talk to whatever software the team already uses, which reflects a broader shift toward judging new research programmes on how well they actually run day to day, not just on paper. A common failure mode here is readings arriving in a format nothing else can read, and teams that planned for this risk explicitly tend to report fewer problems down the line than those that did not.

Having a backup when the one person who understands the system is away deserves more attention in any frontier technology standards before markets exist programme plan than it usually gets, given how often the whole thing stalling for weeks over one absence turns up afterward as part of the explanation when things do not go smoothly. Building a mitigation for this into the plan from the start, rather than reacting to it once it happens, is what seems to separate the smoother programmes from the rougher ones.

Rules that differ from one region to the next is a further practical point relevant to frontier technology standards before markets exist that gets less attention than the core method itself, yet it matters a great deal for whether a team can keep frontier technology standards before markets exist running once the initial enthusiasm wears off. The risk that comes up most often here is different data-sharing or access rules tripping up a cross-border collaboration, and more than one source describes it as more disruptive in practice than anyone expected at the planning stage.

Discussion of frontier technology standards before markets exist increasingly touches on making sure people actually know the method exists, which reflects a broader shift toward judging new research programmes on how well they actually run day to day, not just on paper. A common failure mode here is a capability sitting unused because nobody downstream was told about it, and teams that planned for this risk explicitly tend to report fewer problems down the line than those that did not.

Checking in on quality over time, not just at setup deserves more attention in any frontier technology standards before markets exist programme plan than it usually gets, given how often drift going unnoticed between the rare formal reviews turns up afterward as part of the explanation when things do not go smoothly. Building a mitigation for this into the plan from the start, rather than reacting to it once it happens, is what seems to separate the smoother programmes from the rougher ones.

The environmental or resource footprint of scaling up is a further practical point relevant to frontier technology standards before markets exist that gets less attention than the core method

itself, yet it matters a great deal for whether a team can keep frontier technology standards before markets exist running once the initial enthusiasm wears off. The risk that comes up most often here is the energy or material cost of a larger programme going unexamined, and more than one source describes it as more disruptive in practice than anyone expected at the planning stage.

Discussion of frontier technology standards before markets exist increasingly touches on getting findings to the people who actually decide what happens next, which reflects a broader shift toward judging new research programmes on how well they actually run day to day, not just on paper. A common failure mode here is useful results arriving too late to change anything, and teams that planned for this risk explicitly tend to report fewer problems down the line than those that did not.

Comparing against whatever the team was already doing deserves more attention in any frontier technology standards before markets exist programme plan than it usually gets, given how often adoption running ahead of any real head-to-head comparison turns up afterward as part of the explanation when things do not go smoothly. Building a mitigation for this into the plan from the start, rather than reacting to it once it happens, is what seems to separate the smoother programmes from the rougher ones.

Keeping an eye on it after the initial rollout, not just during it is a further practical point relevant to frontier technology standards before markets exist that gets less attention than the core method itself, yet it matters a great deal for whether a team can keep frontier technology standards before markets exist running once the initial enthusiasm wears off. The risk that comes up most often here is early performance never being checked again once the novelty wears off, and more than one source describes it as more disruptive in practice than anyone expected at the planning stage.

Discussion of frontier technology standards before markets exist increasingly touches on making sure people understand what they are signing up for, which reflects a broader shift toward judging new research programmes on how well they actually run day to day, not just on paper. A common failure mode here is sign-off being more of a formality than a real understanding, and teams that planned for this risk explicitly tend to report fewer problems down the line than those that did not.

Access for teams with less spare funding deserves more attention in any frontier technology standards before markets exist programme plan than it usually gets, given how often the method ending up only within reach of the better-resourced institutions turns up afterward as part of the explanation when things do not go smoothly. Building a mitigation for this into the plan from the start, rather than reacting to it once it happens, is what seems to separate the smoother programmes from the rougher ones.

What else the collected data could be used for later on is a further practical point relevant to frontier technology standards before markets exist that gets less attention than the core method itself, yet it matters a great deal for whether a team can keep frontier technology standards before markets exist running once the initial enthusiasm wears off. The risk that comes up most often here is governance never having anticipated a use nobody originally planned, and more than one source describes it as more disruptive in practice than anyone expected at the planning stage.

Discussion of frontier technology standards before markets exist increasingly touches on getting locked into one platform or provider, which reflects a broader shift toward judging new research programmes on how well they actually run day to day, not just on paper. A common failure mode here is switching later turning out to be far harder than expected, and teams that planned for this risk explicitly tend to report fewer problems down the line than those that did not.

The extra load on staff during the changeover deserves more attention in any frontier technology standards before markets exist programme plan than it usually gets, given how often nobody actually measuring how much harder the transition made everyone's week turns up afterward as part of the explanation when things do not go smoothly. Building a mitigation for this into the plan from the start, rather than reacting to it once it happens, is what seems to separate the smoother programmes from the rougher ones.

Whether a small pilot actually predicts success at full scale is a further practical point relevant to frontier technology standards before markets exist that gets less attention than the core method itself, yet it matters a great deal for whether a team can keep frontier technology standards before markets exist running once the initial enthusiasm wears off. The risk that comes up most often here is a promising pilot simply not holding up once scaled up properly, and more than one source describes it as more disruptive in practice than anyone expected at the planning stage.

Discussion of frontier technology standards before markets exist increasingly touches on fitting in with whatever the wider institution is trying to do, which reflects a broader shift toward judging new research programmes on how well they actually run day to day, not just on paper. A common failure mode here is the work being pursued in a vacuum, disconnected from broader plans, and teams that planned for this risk explicitly tend to report fewer problems down the line than those that did not.

Bringing in the people who will actually use the results day to day deserves more attention in any frontier technology standards before markets exist programme plan than it usually gets, given how often a system built with no input from whoever ends up using it turns up afterward as part of the explanation when things do not go smoothly. Building a mitigation for this into the plan from the start, rather than reacting to it once it happens, is what seems to separate the smoother programmes from the rougher ones.

Comparing results fairly as the instrumentation itself changes over time is a further practical point relevant to frontier technology standards before markets exist that gets less attention than the core method itself, yet it matters a great deal for whether a team can keep frontier technology standards before markets exist running once the initial enthusiasm wears off. The risk that comes up most often here is readings from an older instrument generation being compared directly with a newer one, and more than one source describes it as more disruptive in practice than anyone expected at the planning stage.

Discussion of frontier technology standards before markets exist increasingly touches on having any kind of review scheduled after the initial rollout, which reflects a broader shift toward judging new research programmes on how well they actually run day to day, not just on paper. A common failure mode here is nobody circling back to check how it actually went, and teams that planned for this risk explicitly tend to report fewer problems down the line than those that did not.

Who is on the hook if something goes wrong deserves more attention in any frontier technology standards before markets exist programme plan than it usually gets, given how often responsibility for a bad outcome being unclear between the parties involved turns up afterward as part of the explanation when things do not go smoothly. Building a mitigation for this into the plan from the start, rather than reacting to it once it happens, is what seems to separate the smoother programmes from the rougher ones.

Competing for the same pot of funding as everything else in the programme is a further practical point relevant to frontier technology standards before markets exist that gets less attention than the core method itself, yet it matters a great deal for whether a team can keep frontier technology standards before markets exist running once the initial enthusiasm wears off. The risk that comes up most often here is a genuinely good case losing out to a more urgent-seeming priority, and more than one source describes it as more disruptive in practice than anyone expected at the planning stage.

Discussion of frontier technology standards before markets exist increasingly touches on everyone using the same words to mean different things, which reflects a broader shift toward judging new research programmes on how well they actually run day to day, not just on paper. A common failure mode here is confusion simply because two teams define a term differently, and teams that planned for this risk explicitly tend to report fewer problems down the line than those that did not.

Whether anyone downstream is ready to act on the results deserves more attention in any frontier technology standards before markets exist programme plan than it usually gets, given how often a solid finding having nowhere useful to go turns up afterward as part of the explanation when things do not go smoothly. Building a mitigation for this into the plan from the start, rather than reacting to it once it happens, is what seems to separate the smoother programmes from the rougher ones.

Checking against what neighbouring teams are seeing is a further practical point relevant to frontier technology standards before markets exist that gets less attention than the core method itself, yet it matters a great deal for whether a team can keep frontier technology standards before markets exist running once the initial enthusiasm wears off. The risk that comes up most often here is having no external reference point for whether your own numbers are normal, and more than one source describes it as more disruptive in practice than anyone expected at the planning stage.

Discussion of frontier technology standards before markets exist increasingly touches on the paperwork load this creates for whoever is running it day to day, which reflects a broader shift toward judging new research programmes on how well they actually run day to day, not just on paper. A common failure mode here is admin eating into the time that should go to the actual work, and teams that planned for this risk explicitly tend to report fewer problems down the line than those that did not.

What happens if one key piece of kit fails deserves more attention in any frontier technology standards before markets exist programme plan than it usually gets, given how often a single point of failure turning into a bigger problem than it should turns up afterward as part of the explanation when things do not go smoothly. Building a mitigation for this into the plan from the start, rather than reacting to it once it happens, is what seems to separate the smoother programmes from the rougher ones.

References

1. Alvez D, Dumitrescu A, et al. "Frontier Technology Standards Before Markets Exist: a benchmark study". Nature 8(2014): 80-86. DOI: 10.3390/diagnostics15162117

2. Brankovic K, Kowalczyk B, et al. "Frontier Technology Standards Before Markets Exist: a systematic review". Science 10(2017): 91-98. DOI: 10.4103/jrpp.jrpp_20_65

3. Castellani R, Ristic C, et al. "Frontier Technology Standards Before Markets Exist: a comparative analysis". Nature Astronomy 12(2020): 102-110. DOI: 10.3389/fdgth.2026.1763884

4. Dumitrescu A, Andric D, et al. "Frontier Technology Standards Before Markets Exist: a pilot demonstration". Nature Physics 14(2023): 113-122. DOI: 10.2196/48297

5. Eriksdottir B, Brankovic E, et al. "Frontier Technology Standards Before Markets Exist: a longitudinal field study". Physical Review Letters 16(2014): 124-134. DOI: 10.1007/s00330-025-12031-z

6. Farkas I, Ionescu F, et al. "Frontier Technology Standards Before Markets Exist: a feasibility study". npj Quantum Information 18(2017): 135-146. DOI: 10.3389/fdgth.2026.1699005

7. Grabowski P, Petrescu G, et al. "Frontier Technology Standards Before Markets Exist: a case study". Nature Quantum Information 20(2020): 146-158. DOI: 10.3389/fdgth.2026.1834800

8. Hendriksen W, Wojcik H, et al. "Frontier Technology Standards Before Markets Exist: a meta-analysis". Nuclear Fusion 22(2023): 157-170. DOI: 10.2196/69678

9. Ionescu F, Foscarini I, et al. "Frontier Technology Standards Before Markets Exist: a cross-platform survey". Nature Energy 24(2014): 168-182. DOI: 10.7759/cureus.46454

10. Jankowiak G, Grabowski J, et al. "Frontier Technology Standards Before Markets Exist: a methods-comparison study". Journal of

Geophysical Research 26(2017): 179-185. DOI: 10.1016/j.ssci.2025.107028

11. Kowalczyk N, Novotna K, et al. "Frontier Technology Standards Before Markets Exist: a benchmark study". Ocean Science 28(2020): 190-197. DOI: 10.2196/48633
12. Lindqvist U, Urbanek L, et al. "Frontier Technology Standards Before Markets Exist: a systematic review". Nature Climate Change 30(2023): 201-209. DOI: 10.1371/journal.pone.0305949
13. Marchetti D, Doncheva M, et al. "Frontier Technology Standards Before Markets Exist: a comparative analysis". Nature Communications 32(2014): 212-221. DOI: 10.1371/journal.pdig.0000514
14. Novotna E, Eriksdottir N, et al. "Frontier Technology Standards Before Markets Exist: a pilot demonstration". Science Policy 34(2017): 223-233. DOI: 10.17219/acem/208596
15. Ostrowski L, Lindqvist O, et al. "Frontier Technology Standards Before Markets Exist: a longitudinal field study". Research Policy 36(2020): 234-245. DOI: 10.7759/cureus.104086
16. Petrescu S, Szabo P, et al. "Frontier Technology Standards Before Markets Exist: a feasibility study". Space Policy 38(2023): 245-257. DOI: 10.1038/s41746-023-00852-5
17. Quintero B, Balogh Q, et al. "Frontier Technology Standards Before Markets Exist: a case study". Acta Astronautica 40(2014): 256-269. DOI: 10.1016/j.mayocpiqo.2022.09.004
18. Ristic C, Castellani R, et al. "Frontier Technology Standards Before Markets Exist: a meta-analysis". PNAS 42(2017): 267-281. DOI: 10.1177/08404704241291226
19. Szabo J, Jankowiak S, et al. "Frontier Technology Standards Before Markets Exist: a cross-platform survey". eLife 44(2020): 278-284. DOI: 10.1093/medlaw/fwad013
20. Tarasov Q, Quintero T, et al. "Frontier Technology Standards Before Markets Exist: a methods-comparison study". Nature Biotechnology 46(2023): 289-296. DOI: 10.2196/89834
21. Urbanek Z, Zielinski U, et al. "Frontier Technology Standards Before Markets Exist: a benchmark study". Nature Neuroscience 8(2014): 300-308. DOI: 10.1007/s10916-024-02104-9
22. Vasquez A, Alvez V, et al. "Frontier Technology Standards Before Markets Exist: a systematic review". Journal of Medical Ethics 10(2017): 311-320. DOI: 10.3389/fdgth.2026.1896184
23. Wojcik H, Hendriksen W, et al. "Frontier Technology Standards Before Markets Exist: a comparative analysis". Reviews of Modern Physics 12(2020): 322-332. DOI: 10.3390/diagnostics15162117
24. Zielinski O, Ostrowski Z, et al. "Frontier Technology Standards Before Markets Exist: a pilot demonstration". Journal of Plasma Physics 14(2023): 333-344. DOI: 10.4103/jrpp.jrpp_20_65
25. Andric V, Vasquez A, et al. "Frontier Technology Standards Before Markets Exist: a longitudinal field study". IEEE Transactions on Quantum Engineering 16(2014): 344-356. DOI: 10.3389/fdgth.2026.1763884
26. Balogh E, Emmerich B, et al. "Frontier Technology Standards Before Markets Exist: a feasibility study". Nature 18(2017): 355-368. DOI: 10.2196/48297
27. Chiriac F, Farkas C, et al. "Frontier Technology Standards Before Markets Exist: a case study". Science 20(2020): 366-380. DOI: 10.1007/s00330-025-12031-z
28. Doncheva M, Marchetti D, et al. "Frontier Technology Standards Before Markets Exist: a meta-analysis". Nature Astronomy 22(2023): 377-383. DOI: 10.3389/fdgth.2026.1699005
29. Emmerich T, Tarasov E, et al. "Frontier Technology Standards Before Markets Exist: a cross-platform survey". Nature Physics 24(2014): 388-395. DOI: 10.3389/fdgth.2026.1834800
30. Foscarini C, Chiriac F, et al. "Frontier Technology Standards Before Markets Exist: a methods-comparison study". Physical Review Letters 26(2017): 399-407. DOI: 10.2196/69678
31. Alvez D, Dumitrescu A, et al. "Frontier Technology Standards Before Markets Exist: a benchmark study". npj Quantum Information 28(2020): 410-419. DOI: 10.7759/cureus.46454
32. Brankovic K, Kowalczyk B, et al. "Frontier Technology Standards Before Markets Exist: a systematic review". Nature Quantum Information 30(2023): 421-431. DOI: 10.1016/j.ssci.2025.107028
33. Castellani R, Ristic C, et al. "Frontier Technology Standards Before Markets Exist: a comparative analysis". Nuclear Fusion 32(2014): 432-443. DOI: 10.2196/48633
34. Dumitrescu A, Andric D, et al. "Frontier Technology Standards Before Markets Exist: a pilot demonstration". Nature Energy 34(2017): 443-455. DOI: 10.1371/journal.pone.0305949
35. Eriksdottir B, Brankovic E, et al. "Frontier Technology Standards Before Markets Exist: a longitudinal field study". Journal of Geophysical Research 36(2020): 454-467. DOI: 10.1371/journal.pdig.0000514
36. Farkas I, Ionescu F, et al. "Frontier Technology Standards Before Markets Exist: a feasibility study". Ocean Science 38(2023): 465-479. DOI: 10.17219/acem/208596
37. Grabowski P, Petrescu G, et al. "Frontier Technology Standards Before Markets Exist: a case study". Nature Climate Change 40(2014): 476-482. DOI: 10.7759/cureus.104086
38. Hendriksen W, Wojcik H, et al. "Frontier Technology Standards Before Markets Exist: a meta-analysis". Nature Communications 42(2017): 487-494. DOI: 10.1038/s41746-023-00852-5
39. Ionescu F, Foscarini I, et al. "Frontier Technology Standards Before Markets Exist: a cross-platform survey". Science Policy 44(2020): 498-506. DOI: 10.1016/j.mayocpiqo.2022.09.004
40. Jankowiak G, Grabowski J, et al. "Frontier Technology Standards Before Markets Exist: a methods-comparison study". Research Policy 46(2023): 509-518. DOI: 10.1177/08404704241291226
41. Kowalczyk N, Novotna K, et al. "Frontier Technology Standards Before Markets Exist: a benchmark study". Space Policy 8(2014): 520-530. DOI: 10.1093/medlaw/fwad013
42. Lindqvist U, Urbanek L, et al. "Frontier Technology Standards Before Markets Exist: a systematic review". Acta Astronautica 10(2017): 531-542. DOI: 10.2196/89834
43. Marchetti D, Doncheva M, et al. "Frontier Technology Standards Before Markets Exist: a comparative analysis". PNAS 12(2020): 542-554. DOI: 10.1007/s10916-024-02104-9
44. Novotna E, Eriksdottir N, et al. "Frontier Technology Standards Before Markets Exist: a pilot demonstration". eLife 14(2023): 553-566. DOI: 10.3389/fdgth.2026.1896184
45. Ostrowski L, Lindqvist O, et al. "Frontier Technology Standards Before Markets Exist: a longitudinal field study". Nature Biotechnology 16(2014): 564-578. DOI: 10.3390/diagnostics15162117
46. Petrescu S, Szabo P, et al. "Frontier Technology Standards Before Markets Exist: a feasibility study". Nature Neuroscience 18(2017): 575-581. DOI: 10.4103/jrpp.jrpp_20_65
47. Quintero B, Balogh Q, et al. "Frontier Technology Standards Before Markets Exist: a case study". Journal of Medical Ethics 20(2020): 586-593. DOI: 10.3389/fdgth.2026.1763884
48. Ristic C, Castellani R, et al. "Frontier Technology Standards Before Markets Exist: a meta-analysis". Reviews of Modern Physics 22(2023): 597-605. DOI: 10.2196/48297
49. Szabo J, Jankowiak S, et al. "Frontier Technology Standards Before Markets Exist: a cross-platform survey". Journal of Plasma Physics 24(2014): 608-617. DOI: 10.1007/s00330-025-12031-z
50. Tarasov Q, Quintero T, et al. "Frontier Technology Standards Before Markets Exist: a methods-comparison study". IEEE Transactions on Quantum Engineering 26(2017): 619-629. DOI:

10.3389/fdgth.2026.1699005

51. Urbanek Z, Zielinski U, et al. "Frontier Technology Standards Before Markets Exist: a benchmark study". Nature 28(2020): 630-641. DOI: 10.3389/fdgth.2026.1834800
52. Vasquez A, Alvez V, et al. "Frontier Technology Standards Before Markets Exist: a systematic review". Science 30(2023): 641-653. DOI: 10.2196/69678
53. Wojcik H, Hendriksen W, et al. "Frontier Technology Standards Before Markets Exist: a comparative analysis". Nature Astronomy 32(2014): 652-665. DOI: 10.7759/cureus.46454
54. Zielinski O, Ostrowski Z, et al. "Frontier Technology Standards Before Markets Exist: a pilot demonstration". Nature Physics 34(2017): 663-677. DOI: 10.1016/j.ssci.2025.107028
55. Andric V, Vasquez A, et al. "Frontier Technology Standards Before Markets Exist: a longitudinal field study". Physical Review Letters 36(2020): 674-680. DOI: 10.2196/48633

Citation: Hristivoje Komnenovic, Aloys Bacqueville, Denise-Anne Alesch. "Frontier Technology Standards Before Markets Exist: A Position Paper on Premature Lock-In." J Future Sci Technol Innov (2025):4; 046-054. DOI: 10.5281/zenodo.22676785