Electro-Gravity via the Geometric Chronon Field Theory

Review of the Theory, Experimental Evidence, Validation Roadmap and Practical Applications

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Technical assessment report

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Prepared with the assistance of Claude (Anthropic). This is an independent, non-peer-reviewed assessment based on publicly available sources. Cost and time figures are order-of-magnitude estimates, not quotations.

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Abstract

The Geometric Chronon Field Theory (GCFT), developed mainly by Eytan H. Suchard on foundations proposed by Sam Vaknin, takes time, represented as a scalar field rather than a coordinate, as fundamental. Electromagnetism is identified with the non-geodesic acceleration of the normalized gradient of this field, and matter and force fields are proposed to emerge from the same geometric source. The theory's most striking consequence is that electric charge generates gravity: a gravitational mass of about 5.8 × 10^9 kg per coulomb, attractive for positive charge and repulsive for negative charge. Because the effect is predicted to cancel in static systems, the theory proposes dynamic devices, in particular ferroelectric dielectrics (such as PZT) driven by single-polarity voltage waves, which it predicts will lose 1–5% of their weight at 10 kV/mm.

This report summarizes the theory and its predictions, reviews the experimental record (Datta et al., Tajmar, Buhler/Exodus, and colleagues' unpublished results), gives a critical assessment, and proposes a phased validation roadmap with estimated time, expertise, facilities and cost. It then outlines the commercial, defense and Israel-specific applications that would follow if the effect were confirmed, and presents a market-size analysis and staged business case. The central conclusion is that the theory makes a large, cheaply testable prediction; a controlled experiment costing roughly USD 100k–300k could give a decisive answer within about a year, and independent replication within two to three years.

Executive Summary

Key findings

- **The theory:** time is a scalar field; the electric field corresponds to the non-geodesic acceleration of its gradient; charge acts as a gravitational source of about 5.8 × 10^9 kg/C.
- **Static cancellation:** in equilibrium, charge-based gravity is proportional to the local electric field and cancels on bound matter. This explains past null results (e.g., Tajmar 2004) but means static experiments cannot test the theory.
- **Testable prediction:** pulsed ferroelectric dielectrics (PZT, relative permittivity ~2000–4000, 10 kV/mm, single-polarity pulses ~15 kHz) should lose roughly 1–5% of their weight. This is large enough to measure with a standard laboratory balance.
- **Evidence so far:** suggestive but unconfirmed. Datta et al. report a ppm-level mass-dependent force; Buhler/Exodus report large thrust that the theory itself says it cannot explain quantitatively; colleagues' positive results are not yet published with controls.
- **Main risks:** piezoelectric vibration and heating in PZT can mimic weight change; the Bullet Cluster argument conflicts with plasma physics; the particle-mass section relies on freely chosen coefficients.
- **Business case:** if confirmed and competitive, the core addressable market (in-space satellite propulsion) is about USD 5 billion by 2030; illustrative annual revenues range from ~USD 100 million to several billion. The path to market costs roughly USD 30–90 million over 8–12 years, but the decisive first stage costs under USD 1 million.

Recommendations

1. Define quantitative, pre-registered predictions and pass/fail criteria before further experiments (Phase 0).
2. Run a controlled in-house PZT test with matched dummy samples, vacuum, shielding, vibration isolation and blinding (Phase 1).
3. Obtain independent replication at a specialized laboratory such as TU Dresden's SpaceDrive group (Phase 2).
4. Seek export-control and IP advice before any positive result is shared internationally.
5. Present the experimental case first; de-emphasize the astrophysical and particle-mass sections in funding material.

Bottom line

The theory's own predictions are large enough that a well-designed experiment will give a clear answer either way. The decisive step is not more theory but one clean, independently replicated measurement.

1. Introduction

1.1 Background

Unifying gravity with the other forces remains one of the central open problems in physics. Standard gauge theory introduces particle fields and then appends gauge fields to describe their interactions. The author of GCFT argues that this is a fragmented approach, and that a genuinely unified theory should derive both matter and force fields from a single source. Other discrete or causal approaches, such as Sorkin's causal sets, Wolfram's hypergraph models and Finster's causal fermion systems, do not take time itself as fundamental. GCFT does.

The idea of a quantized or field-like time has a long history, from the 1920s "chronon" proposals to Caldirola's chronon (1955) and Vaknin's doctoral dissertation (1982–84), in which chronons are particles that mediate time. Suchard's geometric version, developed from 2003 and published in stages in 2013–2017 and 2025, replaces this with a geometric formalism based on foliations, Reeb class vectors and a Scarr–Friedman-type acceleration matrix.

1.2 Purpose and scope

This report was prepared to answer four practical questions: what the theory claims; what the evidence shows; what it would take in time, expertise and money to confirm it; and what the practical implications would be, particularly for Israel. It is based on the published theory papers, related experimental literature and public reports, and on a critical reading by the report's authors.

1.3 Sources and limitations

The main theoretical paper was read in full-text form via arXiv (1806.05244) and the 2025 book "Chronon Field Theory". Several ResearchGate documents could not be accessed, including the Buhler device analysis, the white paper in full, and the paper concerning Bin Li. Takaaki Musha's experiments and the results of Mark Sokol and Shomir Banerjee were not available in detail. Conclusions about these sources are therefore limited.

2. The Geometric Chronon Field Theory

2.1 Core postulates

The theory rests on two assumptions. First, matter can be described through accelerations of the gradients of scalar fields; in particular, electromagnetism is described by the non-zero acceleration of the normalized gradient of a Geroch time function. Second, the scalar fields are quantized as a sum of "event wave functions", corresponding to Vaknin's realization chronons. Time is therefore a universal scalar field, not a universal coordinate.

The acceleration field (a generalized Reeb class vector, not the usual Reeb vector of contact geometry) is space-like and perpendicular to the time direction. In the classical limit it plays the role of the electric field: charge corresponds to its divergence and electromagnetic energy density to its squared norm. Extensions to two and three acceleration vectors are offered as candidates for electroweak and strong interactions, with U(1), SU(2) and SU(3) symmetry.

2.2 Electro-gravity: charge as a source of gravity

Matching the energy density of the acceleration field to the classical electric field energy gives an acceleration scale $\|a\| \approx \|E\| \cdot \sqrt{(4\pi G \varepsilon_0)}$. Inserting the charge term into the Einstein field equations yields the central result:

$$M = Q / \sqrt{(16\pi G \varepsilon_0)} \approx \pm 5.802 \times 10^{9} \text{ kg per coulomb}$$

Positive charge generates weak gravity; negative charge generates weak anti-gravity. The theory also concludes that charge itself, excluding the energy of its field, has no inertial mass, so gravitational and inertial mass are not identical for charge. In the static, non-covariant limit the resulting pseudo-gravitational acceleration is parallel and proportional to the electric field, $g \approx \sqrt{(\pi G \varepsilon_0)} \cdot E$, with $\sqrt{(\pi G \varepsilon_0)} \approx 4.31 \times 10^{-11}$ C/kg.

2.3 The static no-go argument

Because charge-based gravity follows the electric field, and bound charges in equilibrium experience zero net field, the total mass-weighted pseudo-acceleration in a static dielectric must sum to zero. Permanent and induced dipoles in the dielectric align against the external field and cancel any external gravitational dipole. Hence static capacitors and electrets should show no thrust, and a gravitational (Bondi) dipole can only be created dynamically.

2.4 The proposed technology: a Bondi gravitational dipole

A Bondi dipole is a pair of positive and negative gravitational masses in which the negative mass pushes and the positive mass pulls in the same direction, producing self-acceleration. The theory proposes to create one with a ferroelectric dielectric that aligns rapidly with an applied field but relaxes slowly. If the field is removed or pulsed faster than the polarization decays, the dielectric's residual polarization produces an uncancelled pseudo-gravitational acceleration. Proposed implementations are:

- **Rotating-sector capacitor:** disc plates with missing sectors rotate over a ferroelectric layer so that polarized regions are repeatedly exposed.
- **Pulsed DC ferroelectric:** single-polarity DC pulses (a DC baseline plus AC wave) at around 15 kHz applied to PZT.
- **Asymmetric low-permittivity fields:** an alternative offered to explain Buhler's device, relying on dipoles induced only by strong field gradients.

2.5 Quantitative predictions

Configuration	Parameters	Predicted effect
Ideal ferroelectric hysteresis	ε = 4000, 10 kV over 1 mm	≈ 1.72 m/s² (0.176 g) on dielectric layer
Rotating-sector disc (Experiment 1)	ε 2000–4000, 10 kV/mm, disc ≥ 0.01 m²	≈ 4% weight reduction of the layer
Pulsed PZT (Experiment 2)	10 kV/mm, polarized pulses ~15 kHz	4–5% ideal; 1–2% realistic
Engine design (Fig. 3.B)	>2 MV, ε >1000, 20×20 cm, 3000 rpm	Up to ~1 N thrust
Charged sphere (static)	r = 0.1 m, 1 MV	≈ 4.3 × 10^-4 m/s² (not measurable; cancels)
Tajmar Teflon capacitor	r = 50 mm, 1.5 mm, 10 kV	≈ 7.6 × 10^-6 g, below 3 × 10^-4 g resolution

Table 1. Predictions stated in the main theory paper [1].

2.6 Further claims

The paper also offers: derivations of the muon/electron, tau/muon, W/Z and other mass ratios, and of the inverse fine-structure constant, using field-strength coefficients 95/96, 4/π and ≈1.5562; a "time asymmetry theorem" linking the direction of time to the orientability of space; a proposal that positively charged matter explains part of the dark-matter effect in the Bullet Cluster; and a predicted neutral particle at 41.875 eV that could produce excess 20.94 eV photons.

3. Review of Experimental Evidence

3.1 Datta et al. (University of South Carolina, 2005)

Gold-coated metal spheres of equal size but different mass were weighed with an electronic balance in a non-uniform electric field over several years. The authors reported a ppm-level force, additional to the expected electrostatic forces, that scaled with sample mass and appeared only when the field was applied. They argued that a force proportional to mass is the signature of gravity. The balance was sensitive enough to track ocean-tide correlations. After the apparatus moved to a location prone to vibration, the data reportedly remained consistent. No independent replication was found.

3.2 Tajmar (ARC Seibersdorf, 2004)

Tajmar reviewed the Biefeld–Brown effect and tested capacitors in vacuum, finding no thrust within the accuracy of the setup and concluding that any anomalous force must be at least five orders of magnitude below corona-wind effects. GCFT interprets this as consistent: its predicted effect for Tajmar's static capacitors is below his balance resolution, and static configurations are expected to cancel.

3.3 Buhler and Exodus Propulsion Technologies (2016–2026)

Charles Buhler, a NASA electrostatics scientist, and Andrew Aurigema report propellantless thrust from asymmetric electrostatic devices (patent WO2020159603A2), with claims of thousands of high-vacuum tests, thrust exceeding 1g relative to the test article, and force persisting after power is switched off. Buhler attributes the effect to third-order quantum electrodynamics, not to charge-based gravity. Results are not peer-reviewed, and Exodus is seeking an in-orbit demonstration. Importantly, the GCFT paper itself states that these results seem several orders of magnitude larger than its predictions.

3.4 Colleagues' results (Sokol, Banerjee)

Mark Sokol (Falcon Space) reportedly observed positive results with a high-voltage DC baseline plus AC wave. Shomir Banerjee, a hobbyist, reportedly observed positive results with ferroelectric materials and a single-polarity DC-plus-AC wave in high vacuum. Data, controls and error analyses have not been published and were not reviewed for this report.

Source	Setup	Result	Status
Datta et al. 2005	Balance, non-uniform E field	ppm-level mass-dependent force	Unreplicated
Tajmar 2004	Capacitors in vacuum	No anomalous thrust	Peer-reviewed
Buhler / Exodus	Asymmetric electrostatic, vacuum	mN thrust, >1g claims	Not peer-reviewed
Sokol	HV DC + AC	Reported positive	Unpublished
Banerjee	Ferroelectric, DC + AC, vacuum	Reported positive	Unpublished

Table 2. Summary of the experimental record.

4. Critical Assessment

4.1 Strengths

- **Falsifiability.** The ferroelectric prediction is large (percent level) and specific, which is rare in this field and makes a decisive, low-cost test possible.
- **Consistency with null results.** The static no-go argument explains why decades of static capacitor experiments found nothing.
- **Ambition.** The framework attempts a genuinely geometric unification, deriving matter from spacetime structure in the spirit of Einstein and Rosen.

4.2 Experimental risks

Lead zirconate titanate is among the strongest piezoelectric materials known. A 15 kHz pulsed drive at 10 kV/mm will make it vibrate and heat. Vibration coupled into a balance can be rectified into an apparent steady weight change, and heating causes convection, outgassing and drift. Additional artifacts include electrostatic attraction to chamber walls, Lorentz forces on current leads and magnetic interactions. Any positive result must survive matched-dummy controls, orientation reversal, shielding and blinding.

4.3 Theoretical concerns

- **Static untestability.** Because the effect cancels in equilibrium, the 5.8 × 10^9 kg/C figure cannot be checked with static charge. The theory is testable only in dynamic regimes, where conventional artifacts are largest.
- **Buhler discrepancy.** Reported forces exceed the theory's estimates by orders of magnitude and are explained by their authors differently. They cannot be counted as support without resolving this.
- **Bullet Cluster.** A charge large enough to mimic the dark-matter mass would exert an electric force on each surrounding proton roughly 10^18 times the corresponding gravitational pull, and would be neutralized almost immediately by the plasma. This section is likely to draw strong criticism.
- **Particle mass ratios.** The paper acknowledges these rest on educated guesses of coefficients because the field equations are unsolved. Its combined probability estimate (< 10^-24) assumes coefficients fixed in advance, so referees are likely to treat the matches as numerology.
- **Momentum conservation.** The claim that a Bondi dipole exchanges momentum with the background metric will need explicit treatment, since propellantless propulsion otherwise conflicts with momentum conservation.

4.4 Overall assessment

The theory is mathematically ambitious and, unusually, makes a large and cheaply testable prediction. The current evidence is suggestive but falls short of confirmation: the peer-reviewed null results are explained rather than predicted, the positive results are either unreplicated, unpublished, or

quantitatively inconsistent with the theory. A clean, independently replicated measurement is required.

5. Validation Roadmap

5.1 Distinguishing the effect from the theory

Confirming the effect (that pulsed ferroelectrics lose weight as predicted) is much cheaper and faster than confirming the theory (that the time-based geometry is the correct explanation). Funders and industry will require the former first.

5.2 Phases, time and cost

Phase	Goal	Time	Cost (USD)
0. Protocol	Pre-register predictions, controls, pass/fail criteria	1–3 months	10k–30k
1. In-house test	Controlled PZT experiment with dummies and blinding	6–12 months	100k–300k
2. Independent replication	Second lab repeats with its own equipment	6–12 months	150k–500k
3. Publication	Peer review and response to critics	6–12 months (overlaps)	Small
4. Theory confirmation	Independent theoretical checks, other predictions	Years	0.5M–2M+
5. Space demonstration	Thrust test in orbit (only if 1–2 succeed)	2–4 years	5M–20M

Table 3. Estimated phases. Confirming the effect (Phases 0–3): about 2–3 years and USD 300k–1M. A clear null result could come within 6–12 months for about USD 100k–200k.

5.3 Phase 1 equipment

Item	Purpose	Cost (USD)
Precision balance / mass comparator or torsion balance (≤ 0.01 mg)	Weight-change measurement	10k–40k
Vacuum chamber and pumps	Exclude ion wind and convection	20k–60k
High-voltage pulsed supply (10 kV, unipolar, ~15 kHz)	Drive the ferroelectric	15k–50k
Faraday enclosure and vibration isolation	Exclude electrostatic and mechanical artifacts	10k–30k
PZT samples and matched non-ferroelectric dummies	Test and control samples	5k–15k
Temperature sensors, accelerometers, data acquisition	Monitor artifacts	5k–15k

Table 4. Indicative Phase 1 equipment. Personnel costs are additional.

5.4 Required expertise

- **Precision-measurement experimental physicist** (torsion balances, gravimetry, or electric-propulsion thrust stands). The most important role.
- **High-voltage / pulsed-power engineer,** including safety: electrocution and X-rays from stray discharges are real hazards.

- **Ferroelectric materials scientist** for PZT selection and characterization (hysteresis, relaxation time, fatigue, piezoelectric response).
- **Statistician / metrologist** for blinding and error analysis.
- **Independent theorists** in general relativity and differential geometry (Phase 4).
- **A designated skeptic** whose task is to find the artifact.

5.5 Candidate facilities

Phase 1 could be hosted at Israeli universities with precision-measurement or materials groups, such as the Technion, the Weizmann Institute, Tel Aviv University, the Hebrew University or Ben-Gurion University, through a joint project or rented lab time. For Phase 2, Martin Tajmar's group at TU Dresden is the most credible choice: it operates high-resolution, fully shielded, remotely controlled balances in high vacuum specifically for testing anomalous propulsion claims. Export-control requirements should be checked before sharing hardware or data abroad.

5.6 Essential controls

1. Identical PZT drive with the sample mechanically and thermally decoupled from the balance.
2. Matched dummy slab (same mass, capacitance and power dissipation, non-ferroelectric).
3. Orientation reversal: the effect must follow the device, not the laboratory.
4. Polarity and waveform variation: bipolar vs. unipolar pulses, varying DC offset and frequency.
5. Scaling with permittivity, as the theory predicts, compared across materials.
6. Blind analysis: the analyst does not know which runs are live and which are dummy.

6. Potential Applications

All applications depend on independent confirmation. At the scale the theory predicts (low thrust at very high voltage), the natural domain is space, where low but propellant-free thrust is highly valuable.

6.1 Before validation

- **A decisive experiment** is itself the primary asset for funders.
- **Precision force-measurement expertise,** valuable in MEMS, metrology and electric-propulsion testing.
- **Intellectual property** in specific device designs, subject to timing given prior publication.

6.2 Commercial space

- **Satellite station-keeping and drag compensation,** especially in very low Earth orbit (below ~300 km).
- **Extended life of geostationary satellites,** which normally retire when station-keeping fuel runs out.
- **Deep-space missions** using continuous low thrust over years.
- **Small-satellite maneuvering,** formation flying, debris avoidance and in-orbit servicing.

6.3 Defense

- Maneuverable satellites that are harder to track and last longer.
- Persistent reconnaissance from very low orbits.
- Long-endurance platforms independent of refueling.

A confirmed result would very likely be treated as dual-use technology and be subject to export controls.

6.4 If the effect is much larger

Thrust approaching 1g would transform launch, aviation and transport. However, the theory in its present form predicts far less than this, so such a scenario is not supported by GCFT itself.

6.5 Engineering obstacles

- **High voltage in space:** megavolt systems face discharge, insulation and mass problems.
- **Thrust-to-power ratio:** unknown, and decisive for competitiveness against existing electric thrusters.
- **Durability:** ferroelectric fatigue under millions of cycles, radiation and thermal cycling.

7. Market Size and Business Case

This chapter estimates the economic value at stake if the effect is confirmed. All market figures are third-party analyst estimates, which vary widely because firms define market boundaries differently. Scenario figures are the report authors' illustrative assumptions, not forecasts, and depend entirely on the effect being real and engineering-competitive.

7.1 The wider space economy

The global space economy was estimated at USD 613 billion in 2024 by the Space Foundation, with the commercial sector accounting for about 78% [19]. Novaspace estimates USD 626 billion in 2025 and projects USD 1.01 trillion by 2034, noting that defense and sovereignty became the dominant market drivers in 2025 [20]. The World Economic Forum and McKinsey project up to USD 1.8 trillion by 2035 [21]. Defense demand is especially relevant, since maneuverable, long-lived satellites are a defense priority.

7.2 Addressable propulsion markets

Market segment	2024–2025 size	Forecast	Source
Satellite propulsion (in-space)	USD 2.6B (2024)	USD 5.19B by 2030 (12.2% CAGR)	MarketsandMarkets [22]
Space propulsion, incl. launch	USD 12.5B–19.3B (2025)	USD 25B–36B by 2032–2034	Stratview, Niche Research [23][24]
Satellite life-extension services	USD 0.8B–3.4B	~USD 6.9B by 2030	MarketsandMarkets, TBRC [25][26]
Global space economy	USD 626B (2025)	USD 1.01T by 2034	Novaspace [20]

Table 6. Addressable markets. Figures differ between analysts because of scope; the conservative in-space satellite propulsion figure is used as the core addressable market below.

The most directly addressable market is in-space satellite propulsion: thrusters, power processing and propellant systems for station-keeping, orbit raising, drag compensation and end-of-life disposal. Electric propulsion is the fastest-growing segment and the natural competitor to any electro-gravitational device [22].

7.3 Demand drivers

- **Constellation growth.** About 16,000 satellites are currently active, roughly two-thirds of them Starlink, and at least 4,294 satellites launched in 2025 remain in service [27]. Projections suggest 30,000–60,000 active satellites by 2030 [28]. Each needs propulsion for orbit raising, collision avoidance and deorbiting.
- **Geostationary life extension.** Every year an estimated 10–20 geostationary satellites in good working order, with paying customers, are retired because they have run out of fuel [29]. Such satellites typically cost USD 200–400 million to build and launch, and each extra year of service can be worth tens of millions of dollars in revenue [30].
- **Very low Earth orbit.** Operating below ~300 km offers sharper imaging and lower latency but requires continuous drag compensation, which propellant limits make expensive today.

- **Defense and sovereignty.** Governments increasingly value satellites that can maneuver unpredictably and survive longer [20].

7.4 Value proposition

The core value of a propellant-free thruster is that satellite life would no longer be limited by fuel. This has three measurable effects: lower launch mass (no propellant tanks and less propellant), longer revenue-earning life, and new mission types (VLEO, repeated orbit changes, long deep-space missions). A worked illustration for geostationary satellites:

Assumption	Illustrative value
Healthy GEO satellites retired per year for lack of fuel	10–20 [29]
Revenue per extra year of service	USD 20–50 million (the "tens of millions" range [30])
Extra years enabled by propellant-free station-keeping	5 (comparable to the MEV-1 extension of Intelsat-901 [30])
Extra revenue enabled per satellite	USD 100–250 million
Extra revenue enabled per annual cohort	USD 1–5 billion over the extension period

Table 7. Illustrative value of geostationary life extension. Actual value captured by a thruster supplier would be a fraction of this.

7.5 Market capture scenarios

Extrapolating the conservative satellite propulsion forecast (USD 5.19B in 2030 at 12.2% per year) gives roughly USD 9 billion by 2035. Market shares below are assumptions chosen to show the range of outcomes, assuming confirmation around 2029 and first products in the mid-2030s.

Scenario	Condition	Share of ~USD 9B market (2035)	Annual revenue
Niche	Effect real but thrust-to-power uncompetitive; used only where propellant is impossible	1–2%	USD 90–180M
Competitive	Comparable to electric propulsion for station-keeping	5–10%	USD 0.45–0.9B
Dominant	Clearly superior; replaces most station-keeping propulsion	25–40%	USD 2.3–3.7B
Transformational	Thrust far above theory's prediction (Buhler-scale)	Beyond this market	Reshapes launch, aviation and transport

Table 8. Illustrative market capture scenarios (report authors' assumptions).

7.6 Business models

- **IP licensing to primes.** License patents and know-how to established satellite and propulsion manufacturers for a royalty on module sales. Lowest capital need; captures a smaller share of value.
- **Propulsion-module company.** A startup designs, qualifies and sells thruster modules. Highest value capture; requires the most capital (see 7.7) and flight heritage.

- **Strategic partnership.** Joint development with an Israeli prime such as IAI, whose 2025 revenue was USD 7.38 billion with 66% from exports [31], and whose Missile and Space Systems division is its largest [32]. Combines credibility, flight heritage and export channels.
- **Services.** Life extension or orbit-transfer "as a service", competing with docking vehicles such as Northrop Grumman's MEV.

Given the high technical risk and Israel's strong prime contractors, a partnership or licensing model is likely the most realistic first step, with the option to spin out a dedicated company once flight data exist.

7.7 Investment path and decision gates

Stage	Goal	Cost (USD)	Time	Gate to next stage
A. Confirm effect	Phases 0–3 of Chapter 5	0.3–1M	2–3 years	Independently replicated result
B. Engineering prototype	Thrust-to-power, vacuum lifetime, fatigue	3–10M	2–3 years	Competitive with electric propulsion
C. Flight demonstration	CubeSat or hosted payload in orbit	5–20M	2–4 years	Measured thrust in orbit
D. Productization	Space qualification, first customer	20–60M	3–4 years	First sale

Table 9. Staged investment path. Total to market: roughly USD 30–90 million over 8–12 years.

The staged structure is the central investment argument. Stage A costs about 1% of the total path yet resolves the largest uncertainty, whether the effect exists at all. Each later stage is funded only if the previous gate is passed, so an investor's loss is capped at the cost of the stage that fails. This makes the first stage reasonable to fund even under significant skepticism, because it buys a clear answer to a question with a very large potential payoff.

7.8 Competitive landscape

The benchmark competitor is electric propulsion (Hall-effect and ion thrusters), supplied by firms including Safran, Northrop Grumman, Busek and Accion Systems. These are proven and efficient but consume propellant. A GCFT device must beat them on at least one of: thrust-to-power ratio, total system mass, or mission lifetime. Other propellantless claimants, including the EmDrive, IVO Ltd.'s Quantum Drive and Exodus Propulsion, have not achieved broad acceptance [15]. Market credibility will therefore depend on independent replication and in-orbit data, not on theory.

7.9 Israeli ecosystem and funding

Israel has about 110 space-tech companies, which raised more than USD 700 million in the past five years [33]. In 2025 the Israel Space Agency and Israel Innovation Authority launched "Access to Space", a national laboratory led by Creation Space with a NIS 60 million budget, offering at least 35% discounts on launch, testing and in-orbit services; its funding partners include DDR&D (MAFAT) [34]. This program could substantially lower the cost of Stage C. Israeli funding routes include Innovation Authority grants, ISA programs, DDR&D, and partnerships with IAI, Elbit and Rafael.

7.10 Key business risks

1. Technical: the effect may not exist, or may be too weak for practical thrust-to-power ratios.
2. Engineering: megavolt-class systems and ferroelectric fatigue may be impractical in orbit.
3. Credibility: the history of failed propellantless claims makes customers and investors cautious.
4. Regulatory: classification and export controls may limit markets and partnerships.
5. IP: much of the design is already published, which may limit patent protection.
6. Market data: analyst estimates vary several-fold; scenario revenues are illustrative only.

Business case in one paragraph

If confirmed and competitive, a propellant-free thruster would address an in-space satellite propulsion market of roughly USD 5 billion by 2030 and about USD 9 billion by 2035, plus life-extension value of USD 1–5 billion per annual cohort of fuel-limited geostationary satellites. Illustrative annual revenues range from about USD 100 million (niche) to several billion (dominant). Reaching market would take roughly USD 30–90 million and 8–12 years, but the first, decisive stage costs under USD 1 million.

8. Implications for Israel

8.1 Compensating the westward launch penalty

Israel launches satellites westward from Palmachim, against Earth's rotation, to avoid overflying neighboring countries. This costs a significant share of launcher performance and limits satellite mass. Propellant-free onboard thrust would allow satellites to raise and adjust their orbits after launch, partly offsetting a permanent geographic disadvantage specific to Israel.

8.2 National space assets

- **Reconnaissance (Ofek series):** very low orbits for sharper imagery, unpredictable orbit changes, longer life and fewer replacement launches.
- **Communications (Amos series and commercial operators):** extended service life and revenue.
- **Small-satellite industry:** new maneuvering capabilities and markets for Israeli startups.

8.3 Economic opportunities

- Propulsion modules for the global satellite and constellation market, built by companies such as IAI, Elbit, Rafael and startups.
- Demand for advanced ferroelectric materials and pulsed high-voltage electronics, both areas of Israeli strength.
- Scientific prestige, attracting talent, funding and international collaboration.

8.4 Policy considerations

- **Classification:** defense bodies may classify results, restricting publication and international collaboration. Publication rights should be agreed with funders in advance.
- **Export controls:** space propulsion is commonly controlled, including under Israel's Defense Export Control Law.
- **Alliances:** strong U.S. interest could deepen space cooperation but bring pressure over technology control.
- **First-mover advantage:** meaningful only if engineering follows quickly; a national program should be ready to scale.

8.5 Funding and partners

Relevant Israeli bodies include MAFAT (Directorate of Defense R&D), the Israel Space Agency and the Israel Innovation Authority, with IAI and Rafael as natural industrial partners. All will first ask whether the effect has been independently replicated. Realistically, moving from confirmed laboratory effect to flight hardware would take a further 5–10 years.

9. Conclusion

The Geometric Chronon Field Theory proposes a bold unification in which time is fundamental and electric charge generates gravity at about 5.8 × 10^9 kg per coulomb. Its internal logic explains why static experiments have found nothing, and it points to a specific dynamic regime, pulsed ferroelectrics, where it predicts a percent-level weight change. That prediction is the theory's greatest strength: it is large, specific and inexpensive to test.

The existing evidence does not yet confirm the theory. Peer-reviewed results are null; positive results are unreplicated, unpublished or quantitatively inconsistent with the theory's own estimates. Several theoretical sections, notably the Bullet Cluster explanation and the particle-mass ratios, are likely to draw criticism and may distract from the experimental case.

The path forward is clear. A pre-registered, well-controlled PZT experiment, costing roughly USD 100k–300k and taking about a year, followed by independent replication, would settle whether the effect exists. If confirmed, the most concrete applications lie in space propulsion, with specific strategic value for Israel. If not, a clean null result would still be a valuable scientific contribution and would sharpen the theory.

Economically, the stakes are asymmetric. If the effect is real and competitive, it addresses an in-space propulsion market of roughly USD 5–9 billion per year by 2030–2035, with further value in satellite life extension and defense. The staged investment path means the decisive first stage costs under USD 1 million, while the full path to market costs roughly USD 30–90 million over 8–12 years. This makes the first experiment the single most valuable next step.

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Appendix A. Key Formulas and Constants

Quantity	Expression	Value
Acceleration scale of E field	$\|a\| \approx \|E\| \cdot \sqrt{(4\pi G \varepsilon_o)}$	8.62 × 10^-11 · E (m/s² per V/m)
Charge-based pseudo-gravity	$g \approx \|E\| \cdot \sqrt{(\pi G \varepsilon_o)}$	4.31 × 10^-11 · E
Gravitational mass of charge	$M = Q / \sqrt{(16\pi G \varepsilon_o)}$	≈ 5.802 × 10^9 kg/C
Pulsed dielectric acceleration	$g_diel \approx (1/\varepsilon - 1) \cdot (Q/A) \cdot \sqrt{(\pi G/\varepsilon_o)}$	See Table 1
Force on dielectric layer	$F \approx \rho \cdot d \cdot Q \cdot (1/\varepsilon - 1) \cdot \sqrt{(\pi G/\varepsilon_o)}$	ρ density, d thickness
Newton's constant	G	6.674 × 10^-11 $m^3\ kg^{-1}\ s^{-2}$
Vacuum permittivity	ε_o	8.854 × 10^-12 F/m

Table 5. Key relations from the theory paper [1].

Appendix B. Glossary

Chronon: a proposed quantum of time; in Vaknin's version, a particle that mediates time itself.

Geroch time function: a scalar function on spacetime whose level sets are spacelike slices; here interpreted as a universal field of time.

Reeb class vector: in this theory, the acceleration of a unit vector field, measuring how far it departs from geodesic motion (distinct from the Reeb vector of contact geometry).

Geodesic: the path of a freely falling body in curved spacetime.

Bondi dipole: a positive and negative gravitational mass pair that self-accelerates.

Ferroelectric: a material with spontaneous electric polarization that persists after the applied field is removed; PZT (lead zirconate titanate) is a common example.

Piezoelectric: a material that deforms under an electric field; a key source of vibration artifacts.

Biefeld–Brown effect: thrust on asymmetric high-voltage capacitors, generally attributed to ion wind.

VLEO: very low Earth orbit, roughly below 300 km.

Appendix C. Open Questions for the Author

1. What is the predicted weight change for the exact PZT slab, drive waveform and frequency used by Banerjee, and how does it compare with the measurement?
2. How does the theory account for Buhler's forces being orders of magnitude above its estimates?
3. How is momentum conserved for a Bondi dipole in the laboratory frame, and what is the predicted thrust-to-power ratio?
4. Can the field equations be solved numerically for a realistic ferroelectric geometry?
5. How does the Bullet Cluster proposal address rapid neutralization of large charges in plasma?

6. Which prediction, stated before any experiment, would the author accept as falsifying the theory?