

01 / RESEARCH MODEL / DECISION BRIEF

Alpha 1, made testable.

A quantitative external-field hypothesis, a photon-force reference model, and a protocol designed to distinguish force from artifact.

Recommendation: request a scoped technical review. Do not describe this package as proof of a propulsionless drive. The model is ready to inspect; the claimed new interaction remains unestablished.

Deliverable	What it establishes
A1-Y candidate model	A specified field equation and force law with unknown coupling b and interaction range λ . It is a proposed operationalization, not a recovered or validated NetPhysics law.
A1-EM reference model	A conventional external-light calculation that provides a known-force benchmark and a potential spacecraft-control direction.
Decision protocol	A double-reversal measurement, declared uncertainty assumptions, quality gates and independent replication requirements.

Two numbers a reviewer can reproduce

For a 10 W external beam, an assumed 80% deflection efficiency and a 30° reflected order, the calculated lateral force is **13.343 nN**. For the hypothetical field at a 0.20 m center separation, the specified source and target yield **0.6952 nN per unit b** . The first is standard photon momentum; the second is conditional on an unknown coupling.

Prepared for Christopher Hill, founder of Metric Flight. AI-assisted formulation, calculations and writing. No independent scientific review, measured Alpha 1 map, working drive, partner commitment or NASA endorsement is claimed. Version 0.1.0.

Define the claim before the instrument.

The supplied Alpha 1 narrative describes geometry and a mappable vector field, but does not provide a force law, source density, coupling coefficient, measured field dataset or validated propulsion result. This package fills the mathematical specification gap with an explicit **candidate**; it does not fill the experimental evidence gap.

Layer	Hypothesis	Status
H0: known physics	The measured force is explained by photons, gravity, electromagnetic coupling, gas, temperature and instrument response.	Default reference.
H1: external Alpha 1	A finite-range scalar potential produces a vector acceleration field; a material state changes its coupling to that field.	New, testable ansatz. Coupling mechanism unproved.
H2: isolated drive	Internal boundary changes continuously accelerate a complete closed apparatus.	Not supported by H1 or by the reference model. Requires a different, complete theory.

What is new in this document

The A1-Y label, its proposed state-dependent coupling, the chosen benchmark geometry, the reversal protocol and the planning scenarios are developed here for Metric Flight. Yukawa potentials, scalar-field equations, photon recoil and diffraction forces are established mathematical or experimental topics, not Metric Flight inventions. [1-5]

What “mappable” now means

Given sources, boundary conditions, material coupling and a specified range, the field equation predicts a spatial vector field. An experimental map would require identifiable parameters and held-out spatial measurements. At present, source coupling and target coupling are degenerate: the force experiment identifies their product b, not a unique universal field.

A more comprehensive original Alpha 1 theory, if supplied later, must be compared with this model explicitly. It must not be treated as equivalent merely because both use the word “field.”

03 / TECHNICAL REVIEW / ALPHA 1 v0.1

A minimal field equation.

A1-Y uses a real scalar potential ϕ whose gradient is the candidate Alpha 1 vector field. This is one restricted, curl-free candidate; it is not a complete theory of spacetime or a general vector field. Use SI units and the weak-field, low-velocity regime.

$$\nabla^2\phi - c^{-2}\partial_t^2\phi - \lambda^{-2}\phi = 4\pi G\rho q$$

$$\mathbf{A}_1 = -\nabla\phi, \qquad U_t = m q_t \phi, \qquad \mathbf{F}_1 = -m q_t \nabla\phi$$

A possible free-field and interaction Lagrangian density is:

$$\mathcal{L}_\phi = \frac{c^{-2}(\partial_t\phi)^2 - |\nabla\phi|^2 - \phi^2/\lambda^2}{8\pi G} - \rho q \phi$$

Symbol	Units / meaning
ϕ ; A_1	m^2/s^2 ; m/s^2 . Potential and candidate acceleration field.
ρ ; q	kg/m^3 ; dimensionless. Mass density and hypothesized effective coupling per mass.
λ ; c	m ; 299,792,458 m/s . Finite interaction range and chosen propagation speed.
G	$6.67430 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$. Normalization to Newtonian strength, not evidence that this is gravity.
$q_t(s) = q_0 + s q_1$	$s = \pm 1$ denotes a specified reversible material state. No nonzero q_1 has been established.

Boundary condition for the laboratory example: ϕ approaches zero far from the isolated source; use the stationary solution after transients. A controller that changes q must supply or recover interaction energy and be included in the full energy budget. No microscopic boundary-to- q law is derived here. The action makes the conditional model inspectable; it does not establish a new field. [1,2]

04 / TECHNICAL REVIEW / ALPHA 1 v0.1

Geometry enters through an integral.

For stationary sources the Green-function solution is a screened potential. This specifies what must be mapped and prevents the arbitrary addition of forces from nested cavities.

$$\phi(\mathbf{x}) = -G \int \rho(\mathbf{x}') q(\mathbf{x}') \frac{e^{-|\mathbf{x} - \mathbf{x}'|/\lambda}}{|\mathbf{x} - \mathbf{x}'|} d^3x'$$

For two nonoverlapping uniform spheres with uniform effective couplings, the finite-radius correction is analytic. Let r be center separation and R_s, R_t the radii. [2]

$$f(x) = \frac{3(x \cosh x - \sinh x)}{x^3}, \quad f(0) = 1$$

$$K(r, \lambda) = \frac{GM_s m}{r^2} \left(1 + \frac{r}{\lambda}\right) e^{-r/\lambda} f(R_s/\lambda) f(R_t/\lambda)$$

Define $b = q_s q_1$. Reversing target state changes the signed source-attraction component by $2\mathbf{bK}$; the double-odd force estimator is $\mathbf{D} = \mathbf{bK}$. The state-independent interaction $q_s q_0$ is outside this primary test. A null result on b cannot rule out every field or a coupling that does not change between the chosen states.

Material and geometry assumptions

The 10 kg source and 0.1 kg target are ideal homogeneous spheres with density 19,300 kg/m³: $R_s = 49.825$ mm and $R_t = 10.735$ mm. Density is a planning input, not a measured sample property. At $\lambda = 0.10$ m the combined finite-radius multiplier is 1.02623. A real patterned shell requires its measured geometry and spatial coupling in the volume integral; uniform-sphere numbers cannot simply be assigned to it.

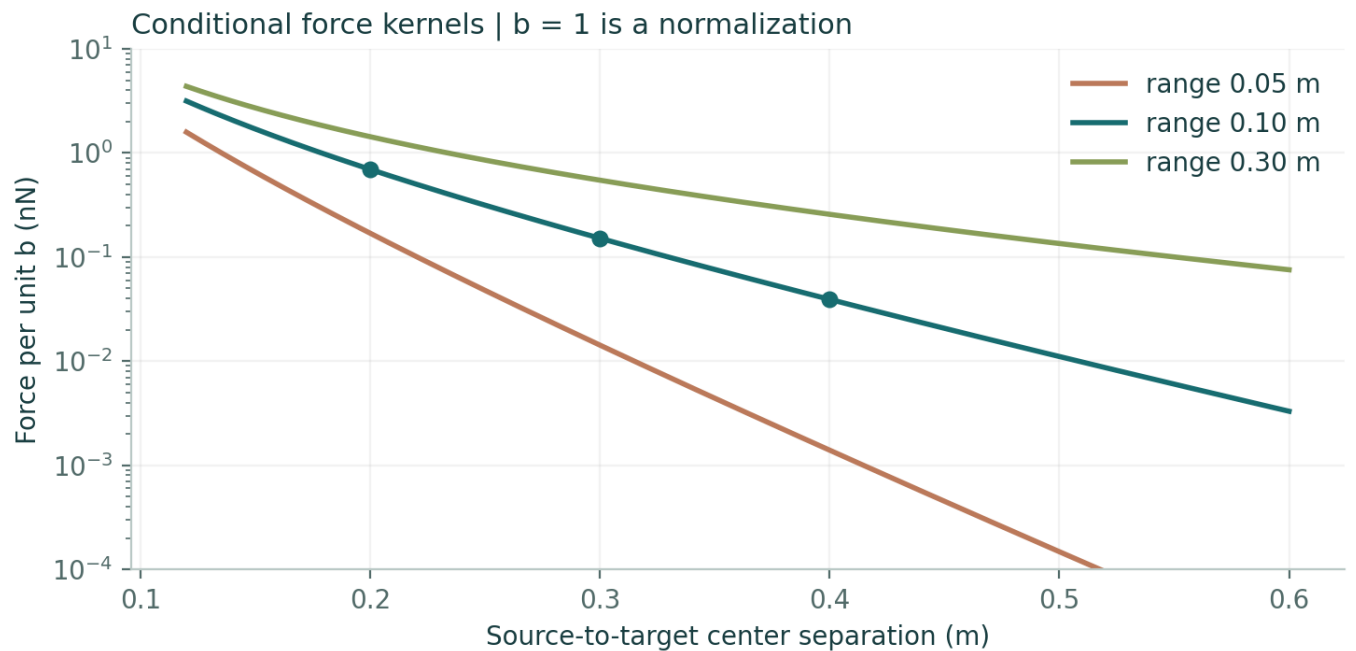
Critical unresolved physics: why would changing a boundary change q_1 ? A microscopic coupling model and comparison with existing fifth-force constraints are required before this becomes a hardware development claim. A name or geometric pattern does not supply that mechanism.

05 / TECHNICAL REVIEW / ALPHA 1 v0.1

Conditional predictions, not discoveries.

The reference range is $\lambda = 0.10$ m. The table uses the same 10 kg source and 0.1 kg target throughout. $b = 1$ is a unit normalization; it is neither an estimated coupling nor a claim that such a value is experimentally allowed.

Center separation	Newtonian attraction	A1-Y force per b	State difference per b
0.20 m	1.6686 nN	0.6952 nN	1.3904 nN
0.30 m	0.7416 nN	0.1516 nN	0.3031 nN
0.40 m	0.4171 nN	0.03920 nN	0.07841 nN



Example: if b were 0.01, the 0.20 m double-odd signal would be 6.952 pN. If $b = 0$, the model predicts no Alpha 1 contribution. The distance dependence, source reversal and state reversal must all agree; a force that follows only electrical power is insufficient.

Existing inverse-square-law experiments already strongly constrain ordinary, universal Yukawa interactions. The proposed state-dependent coupling must be translated into the couplings and materials tested in those experiments. This packet does not establish an unconstrained region or a competitive new limit. [1]

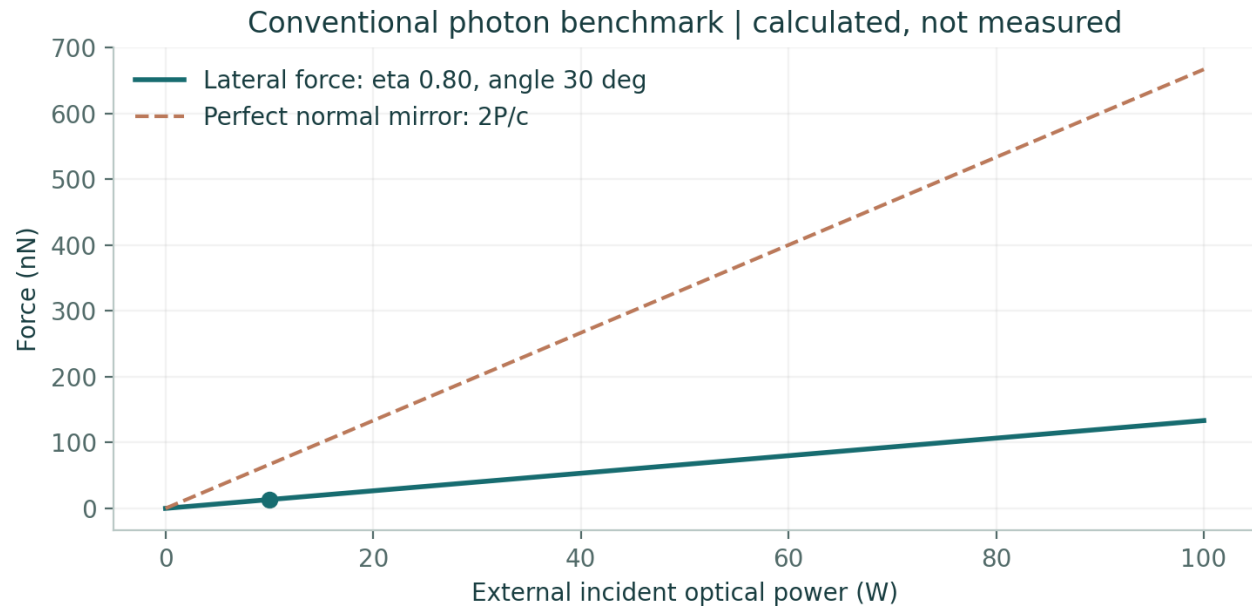
06 / TECHNICAL REVIEW / ALPHA 1 v0.1

A known-force benchmark first.

A1-EM is a separate, conventional optical reference. An external beam enters along +z. A fraction η reflects into direction $(s \sin \theta, 0, -\cos \theta)$, a fraction R reflects specularly, and a fraction A is absorbed; $\eta + R + A = 1$. Thermal reradiation is accounted for separately. Diffraction-mediated lateral force has experimental precedent. [3,4]

$$F_x = -s \frac{\eta P}{c} \sin \theta, \quad F_z = \frac{P}{c} (1 + R + \eta \cos \theta)$$

Planning input	Calculated result
$P = 10 \text{ W}; \eta = 0.80; \theta = 30^\circ$	$ F_x = 13.343 \text{ nN}$
$A = 0.02; R = 0.18$	$F_z = 62.471 \text{ nN}; \text{absorbed power} = 0.20 \text{ W}$
Reverse reflected order s	Lateral difference = 26.685 nN
Example 1,064 nm wavelength	First-order grating period = 2.128 μm at normal incidence. Efficiency 0.80 is assumed, not predicted by this period.



This is a reduced-order momentum calculation, not a Maxwell solver or a manufactured metasurface design. A measured scattering distribution or a verified electromagnetic solver must supply efficiency, losses and angles for a real specimen. Optical progress does not establish the A1-Y coupling.

07 / TECHNICAL REVIEW / ALPHA 1 v0.1

Close the momentum ledger.

For a vacuum control surface enclosing the apparatus, electromagnetic forces follow stress flux and changing stored field momentum. Mechanical supports, cables, gas and external fields must be added where they cross the boundary. [5]

$$\mathbf{F}_{EM} = \oint_{\Sigma} \mathbf{T}_{EM} \cdot \mathbf{n} dA - \frac{d}{dt} \int_V \epsilon_0 \mathbf{E} \times \mathbf{B} dV$$

System boundary	Expected consequence
Illuminated coupon alone	Deflected external photons carry the momentum opposite its lateral force.
Coupon plus co-mounted collector	Capturing all outgoing light on the same balance cancels the net lateral force. External incident light still delivers normal momentum.
Onboard emitter, reflectors and absorber	In a closed repeating cycle with no outgoing radiation or other external interaction, no sustained net translation is predicted. Escaping heat counts as radiation.
Target plus external A1-Y source	The target and source exchange equal and opposite quasistatic forces. Bringing the source onboard makes this an internal interaction, not an isolated drive.

Why Casimir plates do not provide a shortcut

At equilibrium, a translation-invariant two-body interaction depends on relative position. Its gradient gives opposite forces on the two bodies; their assembly has zero net force. Adding internal cavities changes stresses and energy, not the center-of-mass result. Actual Casimir geometries require material dispersion, loss, temperature and many-body scattering rather than a simple cavity count. [6]

Published nonequilibrium nonreciprocal-plate theory describes a thermal engine with an external partner and heat flow. It does not establish a free-space reactionless vehicle. [7] A real anomaly would require a complete alternative account of momentum and energy, not merely subtraction of an inconvenient force term.

Specify the experiment in two gates.

Gate	Configuration	Required output
A / qualify metrology	Calibrated optical force, passive reference mirror, patterned coupon and co-mounted optical collector.	Power and angular scattering measurements; agreement with photon momentum; verified force calibration and uncertainty.
B / test A1-Y	External source in symmetric left/right positions; target in independently specified +/- states. Three center separations.	A source-by-state interaction force, a distance law, a measured nuisance budget and an independently repeated result.

The target state is a real design gate

No particular material, excitation frequency or geometry is asserted to change Alpha 1 coupling. Before Gate B, choose a reversible state with a microscopic coupling hypothesis and predicted q_1 dependence. Keep total mass, center of mass, temperature and ordinary electromagnetic properties characterized. The spherical target calculation is an ideal reference, not a fabricated state-switching device.

Equipment and expertise

A vacuum-compatible torsion balance with interferometric readout; traceable optical power and angular-scatter measurement; thermal, pressure, magnetic and vibration diagnostics; independently supported source positioning; calibration hardware; and synchronized raw data. Add finite-element gravity and instrument models for the complete moving geometry. Selection of vacuum level, isolation and sensor resolution must follow a measured error budget. Cryogenic operation is not assumed necessary. [8,9]

$$J\ddot{\psi} + \gamma\dot{\psi} + \kappa\psi = \ell F_x + \tau_{nuisance}$$

Identify J , damping γ , torsional stiffness κ and lever arm ℓ by calibration. Acquire stationary windows after verified settling; use transient data only with a separately validated dynamic model. The photon benchmark may share a force sensor, but changing load or configuration requires recalibration. No equipment procurement, lab access or test completion is implied.

09 / TECHNICAL REVIEW / ALPHA 1 v0.1

Extract the force that must reverse twice.

Let $z = \pm 1$ identify source side and $s = \pm 1$ identify target state. A scalar force measurement along the source axis can be written as follows; offsets and known backgrounds must remain in the data record.

$$y_{z,s} = a + zN + sE + zs bK + \delta_{z,s} + \varepsilon$$

$$D = \frac{y_{+,+} - y_{+,-} - y_{-,+} + y_{-,-}}{4} = bK + D_{sys}$$

The combination removes constant offsets, source-only Newtonian force and state-only actuator offsets. It **does not** remove a nuisance that also changes sign with both source and state. Those cross-effects require independent controls.

Sampling design

At each of 0.20, 0.30 and 0.40 m, use 16 balanced eight-window blocks: a random permutation of the four states followed by its reverse. Every state occurs twice; the interaction estimator is orthogonal to constant and linear drift within a block. The example totals 384 stationary windows. Do not infer a campaign duration until settling and correlation times are measured.

$$\hat{b} = \frac{K^T C^{-1} D}{K^T C^{-1} K}, \quad u_b = (K^T C^{-1} K)^{-1/2}$$

Freeze the analysis before experimental data

Use $\lambda = 0.10$ m as the primary conditional test; report other ranges as exploratory or apply a declared multiple-testing method. Estimate temporal correlations from qualified controls. Examine residuals and model adequacy, not only a coefficient or a p-value. Freeze calibration, exclusions, sample count, stopping rule and code hash before unblinding physical data. This document is a draft protocol, not a public preregistration.

Only $b = q_s q_1$ is identifiable in this design. A fitted residual is not by itself evidence of a new force. Nonzero claims additionally require source-mass scaling, orientation and separation tests, artifact perturbations, and independent replication.

10 / TECHNICAL REVIEW / ALPHA 1 v0.1

An uncertainty budget that can fail.

For planning only, assume 0.8 nN independent standard noise per stationary window. Averaging 16 eight-window blocks gives 0.07071 nN statistical uncertainty per separation. Add a 0.05 nN common source-by-state systematic as a Gaussian scenario, not as a measured bound.

$$C = (0.07071 \text{ nN})^2 I + (0.05 \text{ nN})^2 \mathbf{11}^T$$

The resulting conditional forecast is $u_b = \mathbf{0.1194}$, with a nominal 95% interval half-width of **0.234**. This is a sensitivity calculation, not an experimental exclusion. Real systematic errors may be bounded, correlated or non-Gaussian and must replace this illustrative covariance.

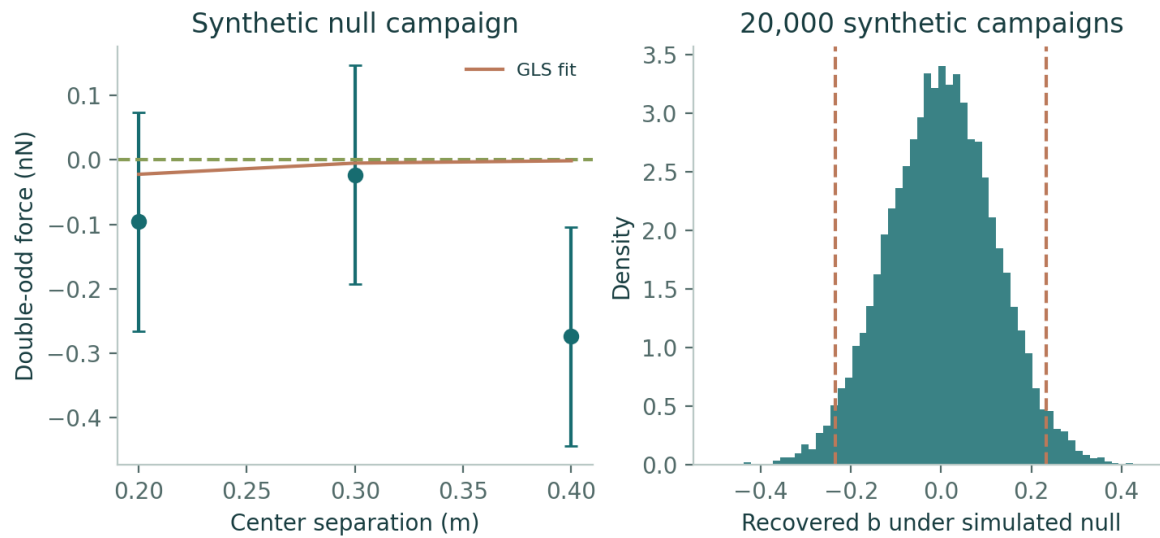
Potential confound	Discriminator / acceptance requirement
Thermal recoil and expansion	Matched heater controls, temperature lag and orientation sweeps; quantify the component odd in both factors.
Electrostatic / magnetic coupling	Charge, potential and field monitoring; shielding and controlled perturbations. Reversal alone is insufficient.
Source motion and gravity multipoles	Acquire after settling; model all moving masses, support tilt and target-state changes in mass distribution.
Gas / outgassing / radiometric force	Pressure and temperature perturbations, blanks and leak checks; no unmeasured pressure independence claim.
Readout, cables, drift and memory	Before/after calibration, blocked controls and correlation analysis; recalibrate on configuration changes.

Optical caution: 0.20 W of absorbed power has a worst-directional-emission recoil bound of 0.667 nN, already larger than the assumed 0.05 nN systematic target. Only 15 mW of directed radiant power gives 0.05 nN. These are momentum bounds, not predictions of the actual heat pattern. The optical input uncertainties alone contribute 0.155 nN at the 10 W benchmark. [4,9]

11 / TECHNICAL REVIEW / ALPHA 1 v0.1

The software must reject bad-looking data.

The package passes **19 analytical and numerical checks**, including independent volume quadrature, force as the derivative of interaction energy, limiting cases, photon momentum closure, reversal cancellation and noiseless recovery of a prescribed coupling. These are software checks, not experimental validation.



Synthetic result	Interpretation
Null input $b = 0$; fixed seed 20261020	Recovered $b = -0.0319$; illustrative nominal 95% interval $[-0.2659, 0.2020]$.
Residual quality gate	$\chi^2 = 10.718$ for 2 degrees of freedom; $p = 0.0047$. This realization fails the proposed $p < 0.01$ adequacy gate.
20,000 separate null simulations	Nominal 95% interval coverage: 94.845% before quality selection, under the assumed Gaussian covariance.

Keep the failed example. The fixed-seed run is not presented as a successful exclusion. A failed quality gate means investigate and report the failure; do not discard inconvenient runs or repeatedly collect data until a favorable result appears.

The reported simulation coverage applies to the unconditional toy estimator. It does not certify coverage after quality selection, model changes or real-world nuisance fitting. An experimental analysis must validate its full reporting and stopping procedure. Every CSV row is labeled SYNTHETIC_NOT_MEASURED.

A mission path with honest limits.

The immediate applied opportunity is a measured boundary-response atlas for light-driven force and torque. Its value would be predictive performance on unseen geometries or operating conditions, lower mass or losses, or better control authority against existing designs. NASA has already supported diffractive solar sailing; novelty cannot be claimed for diffraction itself. [3,10]

Illustrative solar-control envelope	Calculated value / limitation
10 m ² illuminated area; 1,361 W/m ² at 1 AU	13.61 kW incident sunlight. Irradiance and area are scenario inputs.
Spectrum-averaged lateral momentum factor = 0.40	18.16 μN lateral force; this factor must be measured over the solar spectrum and incidence angles.
20 kg total spacecraft mass	0.908 μm/s ² lateral acceleration. About 28.7 m/s over one year if illumination and direction were held constant. Not a trajectory solution.
1 m effective lever arm	18.16 μN·m torque. Mission-specific disturbance torques and all axes still require analysis.

The Alpha 1 branch has no flight-performance forecast

For the laboratory A1-Y model, force falls with source distance and range. No ambient Alpha 1 field has been measured and no usable onboard state modulation established. The example cannot be extrapolated to launch, levitation, interstellar transit, instantaneous maneuvering or continuous deep-space acceleration. A source carried inside the vehicle does not create net propulsion.

A rigorous mapping product

For the optical branch, map geometry, wavelength, incidence angle, polarization, temperature and measured scattering into force and torque with uncertainty. Train or interpolate on one subset and evaluate held-out measurements. For A1-Y, first establish whether a reproducible nonzero b exists and what creates it; only then attempt spatial inversion. A map without identifiable coupling is not a navigation system.

No full electromagnetic, finite-element thermal, spacecraft attitude or orbital solver is included. Each is a later verification step, not a capability attributed to the present reduced-order model.

13 / TECHNICAL REVIEW / ALPHA 1 v0.1

Nine months, with explicit stop decisions.

This is a proposed sequence, not a funded schedule. Advance only after the preceding gate. No facility, equipment price, staff appointment or third-party commitment has been secured.

Window	Work and deliverable	Stop / go decision
Months 1-2	Independent physics review; derive or reject a microscopic state-coupling law; translate existing fifth-force constraints; compare optical prior art.	Stop the new-field hardware branch if no credible coupling or allowed test region emerges.
Months 2-4	Qualify the force sensor with known forces and matched blanks; characterize scattering, thermal response and correlations.	No Alpha 1 inference until calibration and nuisance thresholds are demonstrated.
Months 4-6	Freeze physical protocol; complete the permitted source-by-state campaign and report all runs, including failures.	Advance only if controls, geometry dependence and full uncertainty accounting support further study.
Months 7-9	Independent setup, analyst and replication; held-out optical map comparison; mission-level trade study.	Publish a bounded result or reproducible null; pursue engineering only after validation.

People required

A theory lead with field-theory and precision-gravity expertise; a precision-force experimentalist; an optical/materials engineer; thermal and mechanical modeling support; and an independent statistician or analyst. Christopher Hill is identified as founder and program sponsor. These technical roles are requirements, not claimed members of the team.

What would make this fundable

A bounded mission benefit, differentiated technical contribution, qualified principal investigator, institution or eligible company, real facilities and costs, and a work plan that fits the current solicitation. This packet supplies mathematical and testing structure; it does not certify eligibility, scientific novelty or award readiness.

NASA pathway: seek technical routing through Naseem Saiyed, with an Administrator-level summary for awareness. Ask which research or technology program is appropriate after the physics and mission gates. Do not imply that an Administrator referral substitutes for competitive review. [11,12]

14 / TECHNICAL REVIEW / ALPHA 1 v0.1

The review request and the evidence record.

Requested NASA decision

Identify an appropriate technical reviewer or program office to assess three questions: Is the candidate coupling physically defensible and already constrained? Can the proposed force measurement separate it from ordinary interactions? Does the optical mapping branch offer a useful, differentiated mission capability?

Record	Current status
Candidate equations and numerical kernels	Specified and reproducible; not independently peer reviewed.
Actual Alpha 1 coupling, spatial map or thrust data	Not supplied or generated by this work.
Optical material efficiency / complete hardware	Assumed scenario inputs; no manufactured device claimed.
Data and software	Python source, deterministic outputs, planning covariance, synthetic CSVs and 19 checks included.
Outreach and submission	Email draft prepared separately. No message sent, grant submitted or NASA partnership established.

Reproduction

From the package directory, install the requirements and run **python model/alpha1.py**. It regenerates results/summary.json, prediction and sensitivity tables, the normalized spatial map, synthetic data and plots. Run **python build_report.py** to rebuild the PDFs using Matplotlib's bundled fonts. The package manifest records file hashes. Exact plotting pixels can vary by platform; numerical outputs are the scientific comparison.

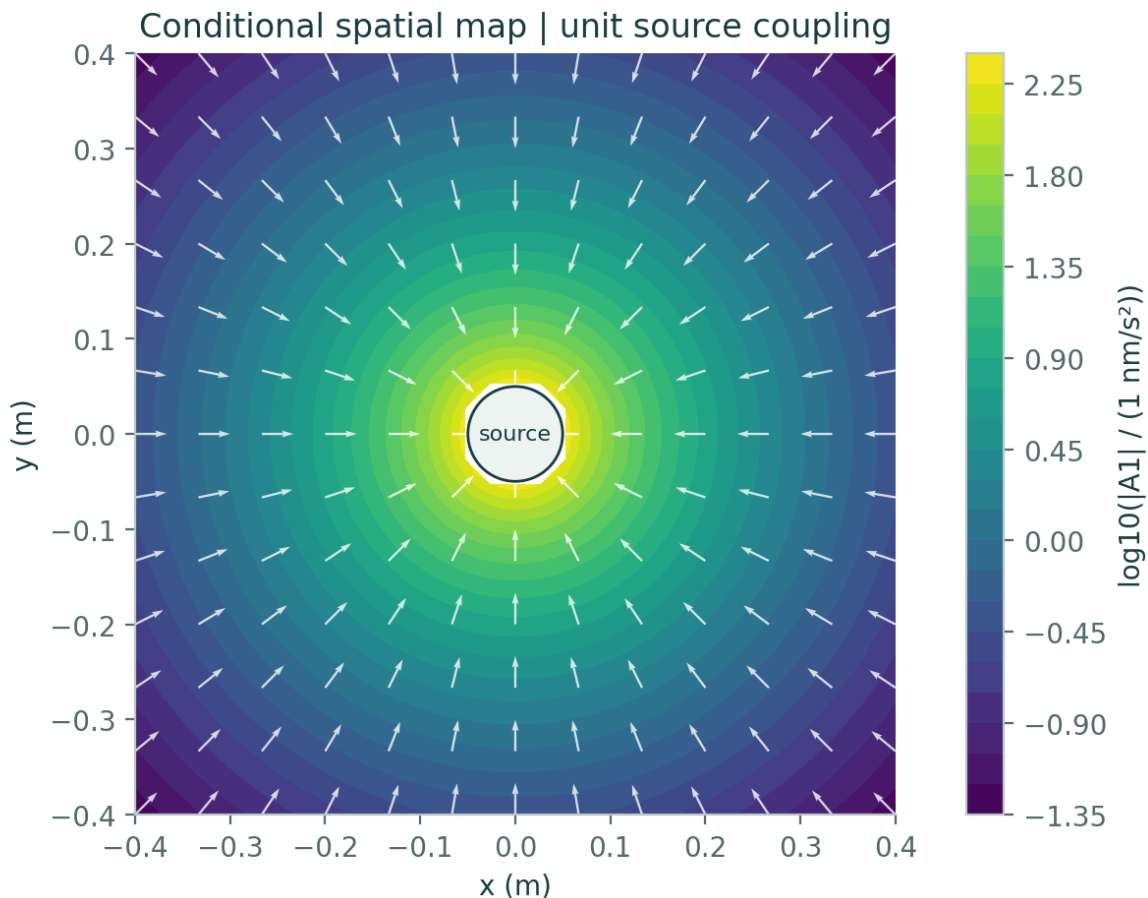
Provenance and responsibility

Model v0.1 was developed with AI assistance at Christopher Hill's request on October 20, 2026. Its candidate field is an explicitly proposed formulation, not a claim to derive an unpublished original theory. References establish context, methods and constraints; they do not endorse Metric Flight. A qualified independent physicist should review the action, couplings, identifiability and constraints before experimental or funding claims are made.

15 / MODEL-GENERATED FIELD / NOT A MEASUREMENT

A spatial map with declared inputs.

This slice is the stationary external A1-Y acceleration field for the 10 kg homogeneous source, $\lambda = 0.10$ m and unit source coupling $q_s = 1$. The arrows show direction only; the color encodes magnitude on a logarithmic scale. No physical Alpha 1 map has been measured.



The source interior is excluded because this implementation evaluates the exterior solution. The included `normalized_field_map.csv` gives x, y and the two acceleration components in SI units. Multiplication by an assumed q_s scales the field; a point target's acceleration additionally depends on its q_t . The finite target correction used in the force table is separate.

This is what mathematical mappability establishes: a computable field **conditional on inputs**. It does not identify the inputs, prove the field exists, or show that material geometry can control its coupling.

16 / PRIMARY SOURCES / LINKS

Sources and review scope.

[1] J. G. Lee et al. (2020). New Test of the Gravitational $1/r^2$ Law at Separations down to 52 μm . *Physical Review Letters* 124, 101101.

[Open primary source](#) · Author abstract reviewed. Existing Yukawa constraints; not a test of Metric Flight.

[2] P. Fayet (2026). Hyperbolic form factors for Yukawa interactions, and applications to the Earth. *arXiv:2603.21275*.

[Open primary source](#) · Author preprint and form-factor expression reviewed. Spherical correction independently checked by quadrature [here](#).

[3] Y.-J. L. Chu, E. M. Jansson and G. A. Swartzlander Jr. (2018). Measurements of Radiation Pressure Owing to the Grating Momentum. *Physical Review Letters* 121, 063903.

[Open primary source](#) · Publisher abstract reviewed. Prior experimental lateral diffraction force.

[4] P. A. Williams et al. (2013). Use of radiation pressure for measurement of high-power laser emission. *Optics Letters* 38, 4248-4251.

[Open primary source](#) · NIST publication record reviewed. Radiation-pressure calibration precedent, not this instrument's sensitivity.

[5] MIT OpenCourseWare, 22.105 (2005). Chapter 3: Dynamics of the Electromagnetic Fields.

[Open primary source](#) · Course notes reviewed for field momentum and Maxwell-stress balance.

[6] S. J. Rahi et al. (2009). Scattering Theory Approach to Electrodynamic Casimir Forces. *Physical Review D* 80, 085021.

[Open primary source](#) · Author record/abstract reviewed. Boundary-force methods; no proof of net isolated thrust.

[7] D. Gelbwaser-Klimovsky et al. (2021). Near Field Propulsion Forces from Nonreciprocal Media. *Physical Review Letters* 126, 170401.

[Open primary source](#) · Publisher abstract reviewed. Nonequilibrium heat-engine setting and momentum partner required.

Access date: October 20, 2026. References are linked for review; no third-party paper or figure is reproduced. All plots in this package are generated from the included calculations.

17 / PRIMARY SOURCES / LINKS

Sources and review scope.

[8] J. E. Polk et al. (2017). **Recommended Practice for Thrust Measurement in Electric Propulsion Testing.** *Journal of Propulsion and Power* 33, 539-555.

[Open primary source](#) · Author-hosted full paper reviewed for instrument dynamics, calibration and errors; does not certify nanonewton performance.

[9] M. Tajmar, O. Neunzig and M. Weikert (2022; online 2021). **High-accuracy thrust measurements of the EMDrive and elimination of false-positive effects.** *CEAS Space Journal* 14, 31-44.

[Open primary source](#) · Open paper reviewed. Thermal, mechanical and electrical artifacts can imitate thrust.

[10] NASA (2022). **NASA-Supported Solar Sail Could Take Science to New Heights.**

[Open primary source](#) · Official program context. Diffractive sailing has prior NASA support; no novelty or endorsement inferred.

[11] NASA. **SBIR/STTR Program Year 2026 Information Hub.**

[Open primary source](#) · Official current program route checked October 20, 2026. Open topics and eligibility must be verified at submission.

[12] NASA. **EVM Working Group.**

[Open primary source](#) · Official page lists Naseem Saiyed and the provided nasa.gov email. A listing does not establish grant authority.

[13] L. Michaeli et al. (2025). **Direct radiation pressure measurements for lightsail membranes.** *Nature Photonics* 19.

[Open primary source](#) · Author repository abstract reviewed. Microscopic optical-force metrology context; reported sensitivity cannot be transferred to this apparatus.

[14] NASA (October 8, 2026). **NASA, Energy Department Advance New Era of Nuclear-Powered Exploration.**

[Open primary source](#) · Official current record identifies Administrator Jared Isaacman. Used only to verify the requested routing.

Access date: October 20, 2026. References are linked for review; no third-party paper or figure is reproduced. All plots in this package are generated from the included calculations.