CryoPulse P2.2 - overnight research prototype

Scientific mechanisms, engineering layout, conditional vehicle projections and a first experimental design. Prepared 11 November 2026. All twelve original work packages are retained.

The direct cold-pressure model predicts 180.1 N of stationary pressure force after 600 s for a sealed 0.03 m2 pan, a 1 L cold core and the stated finite ice-bath/wall inputs. This is a prediction to test, not a measured holding rating.

The vehicle force-envelope model projects 22.67 m from 100 km/h under its assumed rolling-suction map, against a reference calibrated to 28 m. That result depends on unmeasured maps and ideal control knowledge.

Completed work: actual transient finite-volume CFD, coupled thermodynamic models, 84 vehicle cases, geometry/kinematic checks, STEP/GLB layout solids, image-generated concepts, finite-resource calculations and an experiment specification. Physical measurements: zero.



CryoPulse — concept mockup.

Image-generated concept illustration. It is not a photograph or a manufacturing CAD rendering.

What the original pressure intuition means in physics

Cooling a gas can reduce its pressure. Surrounding air then exerts a larger force on the outside of a connected suction footprint. That is a physically meaningful route from the original "empty region pulls back" idea to a measurable mechanism.

A pressure deficit is a gradient, not a new energy source. The absolute gas pressure remains positive. Negative gauge pressure and a negative reference free energy do not imply an unlimited energy supply.

For cold gas volume Vc at Tg and ambient dead volume Va at Ta, shared pressure is p = m R / (Vc/Tg + Va/Ta). Installed pressure-force reference is F = (pa - p) Aeff. Real seal preload, hose forces and leaks require calibration.

The static model tracks gas temperature, gas inventory, vessel-wall temperature and finite ice-bath enthalpy. Incoming gas brings enthalpy; wall cooling and bath warming consume cold availability. The optional bellows tracks work and resistance separately.

For the static reference, energy and entropy balances close numerically. A large stationary normal force is compatible with a small amount of available displacement work, because an unmoving force performs no mechanical work.

First bench: three temperatures and a finite cold store

The fast chamber model and the first static proof are different experiments. The original low-active-mass cycle remains in thermoflow/. The slower static proof includes a 0.8 kg assumed vessel-wall mass at 500 J/kg/K plus 4 J/K inserts.

Nominal assumptions: 1 L cold gas; 150 mL total ambient dead volume; 0.03 m2 effective contact area; 0.8 m seal perimeter; 3 mm seal land; gas/wall conductance 0.45 W/K; wall/bath conductance 10 W/K; initial bath 0.1 kg ice and 0.2 kg liquid water at 0 C.

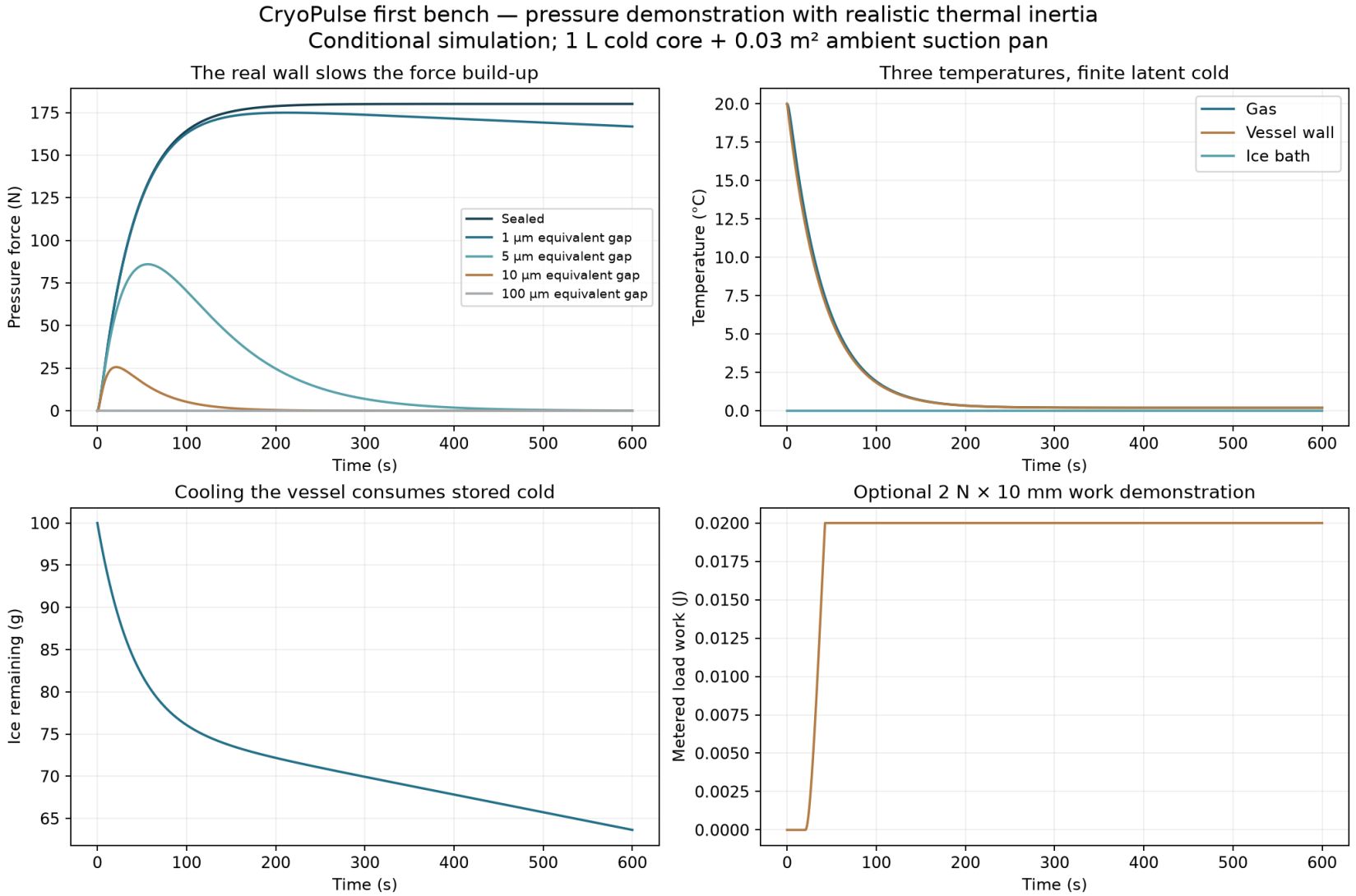
Those masses, volumes and conductances are design inputs. A real bath/jacket, supplier vessel and gas-line volume must be measured and substituted before comparing a built rig.

Nominal sealed prediction at 600 s: pressure deficit 6005 Pa, pressure force 180.1 N, bath heat absorbed 12127 J and ice melted 36.4 g. The gas and wall are near 0.20 C; the remaining ice holds the bath near 0 C.

The result is highly seal-dependent. A 5 micrometre equivalent gap has a transient force peak but almost no sustained force at ten minutes. A road surface cannot be assumed to provide the sealed-bench condition.

Equivalent gap	Peak force (N)	Force at 600 s (N)
Sealed	180.137	180.137
1 micrometres	174.997	166.871
5 micrometres	86.025	0.128
10 micrometres	25.683	0.000
100 micrometres	0.034	0.000

Cold-to-suction response and leakage



All traces are coupled-model predictions. The optional 2 N x 10 mm bellows delivers 0.020 J in the assumed low-stiction model; no work is assigned to static holding.

How to make the first demonstration scientific

Two approximately 0.5 L commercial vessels rated for the intended external-pressure/vacuum and temperature range; weigh and measure their actual internal and thermal capacities.

Thermal interfaces connect the gas vessels to a finite 0 C ice/water cold store. Record actual ice/water mass, vessel temperatures and any circulation/heater electricity.

A separate ambient-temperature contact pan or four annular shoes connect by compliant gas hoses. Measure total hose, valve and pan dead volume.

A calibrated tensile load cell, rigid crosshead and metal links connect mechanically to the pan/shoe housings. The gas hoses do not serve as the force load path.

An independent stage and fixed ambient contact plate set normal displacement and seal preload. Record stage position and seal contact condition; pressure force and pull-off force are separate observations.

Optional calibrated bellows/piston connects to a low-force load and displacement encoder. Meter integral F dx; record spring/stiction and reset work.

Predeclared controls and measurements

Does the cold treatment create a pressure deficit exceeding three combined standard uncertainties relative to paired null trials?

Does force versus pressure agree with the independently calibrated effective area after seal-preload/hose corrections, within the stated uncertainty?

Does any moving-load work exceed three combined standard uncertainties, with the complete energy/reset ledger reported?

Can mass and energy discrepancies be explained by measured leakage, heat leaks, thermal mass and instrument uncertainty without adding an unknown energy term?

Channel	Specification target, not purchased equipment
Differential pressure	0-10 kPa range; standard uncertainty <=20 Pa after calibration
Absolute/ambient pressure	Record both core and ambient pressure; absolute scale traceable
Force	500 N tension/compression channel; standard uncertainty <=0.25 N after fixture calibration
Bellows work force	Separate low-range channel or calibrated deadweight; target uncertainty <=0.01 N around 2 N
Temperature	Gas at multiple positions, both vessel walls, bath and contact plate; target standard uncertainty <=0.1 K
Displacement/time	<=10 micrometre displacement uncertainty for the optional 10 mm stroke; synchronized logging >=10 Hz for this slow test
Cold and electrical energy	Weighed ice/water and bath calorimetry; meter every pump, heater, fan, controller and reset input

Experimental sequence

Test	Purpose	Method
T0	Fixture and sensor calibration	Calibrate pressure, load, displacement and temperature independently. Apply known pressure deficits with a separate calibration source and measure effective force area, seal preload and hose-force offsets. Isolate that source for cold-only trials.
T1	Warm/null cycles	Begin with all gas volumes at ambient pressure and temperature. Run the valve/timing/fixture sequence with no temperature difference. Repeat with a vent open while applying the cold treatment to expose thermal drift or freezing-adhesion artefacts.
T2	Sealed cooling mechanism	Reset to ambient, close the vent, apply the cold interface, and log pressure, temperatures and force for 600 s. Use at least five independent cold cycles interleaved in randomized order with five null cycles.
T3	Leak and surface sensitivity	At stable gas temperature measure pressure relaxation separately. Repeat cold trials with characterized leak restrictions and defined dry/wet/rough contact coupons. Equivalent uniform gaps are a model parameter, not a measurement of a real seal.
T4	Moving-load work	Use the calibrated low-force load module. Integrate measured force over measured stroke, subtract its independently measured spring/friction baseline, and meter the complete reset. Static holding force alone is not work.
T5	Powered suction comparison	With the thermal circuit isolated, characterize a rated external blower and the same complete shoe/pan on a load cell. Record installed net force, pressure, flow and electrical power over seal gaps and surface coupons.
T6	Unpowered wheel kinematics	Use a stationary supported rig, stopped wheels and a rated slow actuator. Verify support loads, docking clearance, pre-lift, continuous sweep, locks and sensor interlocks before adding any rotating impeller.
T7	Later vehicle evidence	Only after measured fan, leakage, tyre/pad and actuator maps exist, replace the assumed maps and compare matched stopping and trajectory tests. No road demonstration is claimed by this package.

A small work output is a separate measurement

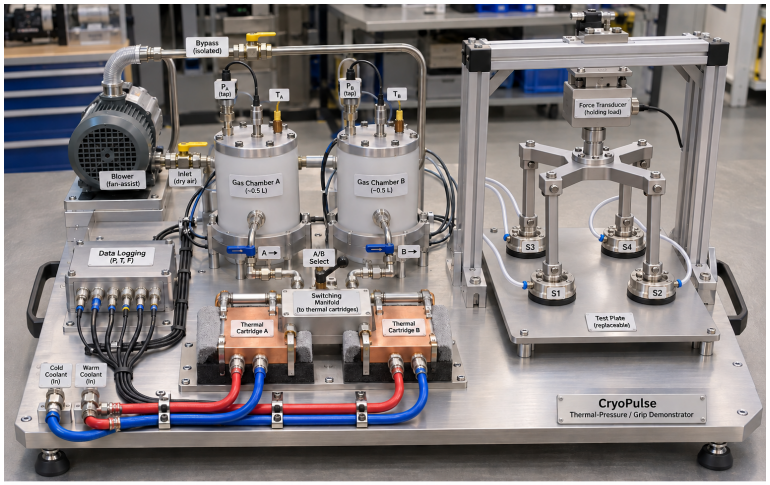
The optional bellows reference predicts 0.020 J of load work for a 2 N load over 10 mm. The model includes a finite stroke and resistance; it does not infer power from holding force.

Use a calibrated low-range force measurement or a weighed load and a displacement encoder. Record the actual bellows effective area, spring curve, stiction, line losses and full reset work.

Illustrative force uncertainty near 6 kPa: 20 Pa differential-pressure uncertainty, 1% effective-area uncertainty and 0.25 N force-channel uncertainty combine to about 1.91 N. This is an assumed instrument budget, not an experimental confidence interval.

The gas contact plate stays near ambient temperature. This separates cooling-induced gas pressure from freezing adhesion, condensation effects and temperature drift in the fixture or load cell.

Blank recording templates are supplied. No simulated values have been placed in the experimental data file.



CryoPulse — thermal-pressure bench concept

Illustrative bench concept. The rigid force crosshead is separate from the gas hoses; commercial component envelopes still need supplier selection.

Spatial thermal CFD: what was actually solved

OpenFOAM v2412 buoyantPimpleFoam solved compressible perfect-gas, laminar buoyant flow in a closed horizontal cylinder of nominal 0.50 L, initially 293.15 K and 101325 Pa. All gas walls were set to 273.15 K. No mass-flow boundary or external pump was imposed.

The retained runs use six pressure/enthalpy outer correctors, no equation under-relaxation and a maximum 0.005 s step. Coarse and fine meshes contain 8,160 and 65,280 cells. The imposed wall has no physical thermal mass; the separate bench model accounts for wall and finite-bath costs.

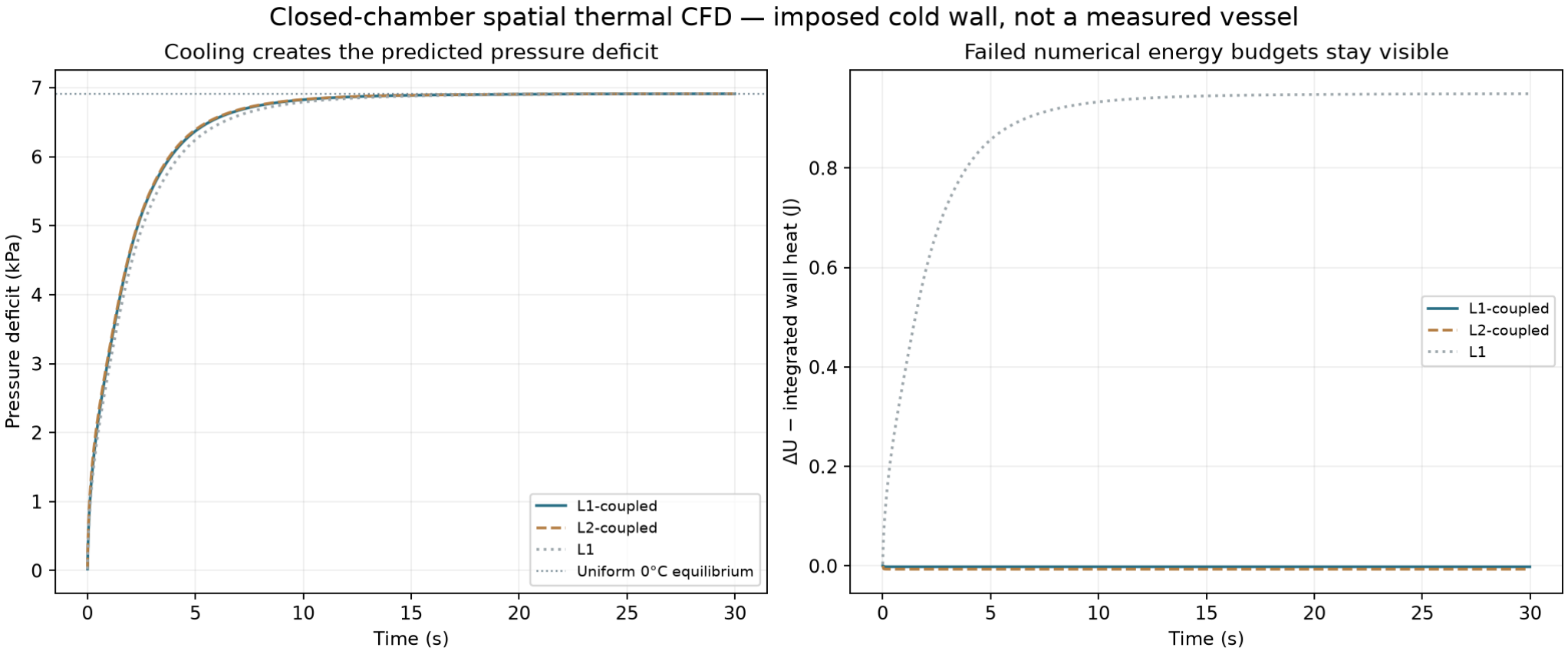
Initial looser runs reached a plausible final pressure but missed the heat ledger by about 11%. They are retained as failed diagnostics. Both tighter 30 s runs pass the declared numerical mass/heat/entropy checks.

At 30 s the two retained mean pressures differ by -0.059 Pa. This is a two-mesh sensitivity, not a grid-convergence certificate or experimental validation.

The audit reads fields in double precision and uses the exact gas constant of the retained OpenFOAM runtime. A constant mismatch and a startup exception-trapping banner were corrected in the audit, without changing the solved fields.

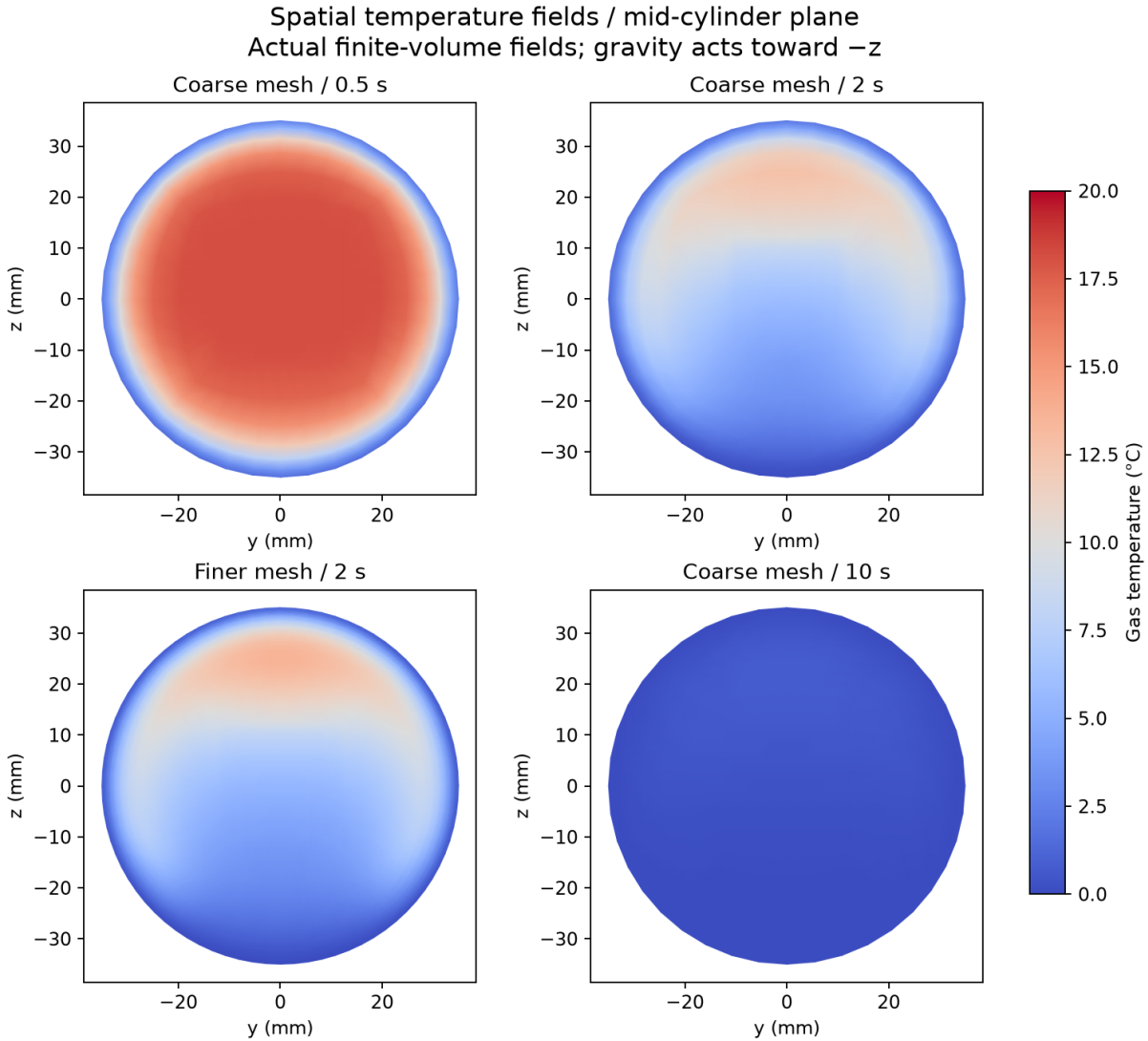
Run	Cells	Heat-ledger discrepancy	Final pressure (Pa)	Numerical budgets
L1-coupled	8160	0.0209%	94413.669	Pass
L2-coupled	65280	0.0769%	94413.609	Pass

The failed and retained heat budgets



The grey diagnostic is not used as validated heat-transfer evidence. Pressure agreement alone is insufficient when the energy ledger fails.

Resolved temperature fields



Mid-cylinder sections from actual saved finite-volume fields. Cooling, buoyant motion and thermal gradients are resolved; no quantum or negative-energy term is present.

Original thermal pulse engine remains a separate branch

The P2.1 timed two-chamber model, valve logic, thermal routing, regenerative ideal comparison and cycle sweeps remain in thermoflow/. They have not been replaced by the stationary suction proof.

For the retained moderate 0/40 C dry-air example, the specified two 0.5 L chambers predict milliwatt-scale gross expander output under the optimistic active thermal-mass inputs. The minimum cold reset is larger than that output in the stated case.

That does not imply every CryoPulse function is equally weak: direct suction uses pressure over area, while a thermal engine must produce flow and displacement work. The two tasks need different metrics.

A perfect-regeneration reference shows why extra gross work from a colder cold side cannot be treated as free: reversible cold restoration cancels that advantage in the stated ideal-cycle comparison. Real regeneration, valve losses and vessel heat capacity must be measured.

Liquid nitrogen: reuse the cold along one honest state path

The revised N2 reference pumps saturated liquid from ambient pressure to 2 MPa, optionally provides upstream cold service, receives waste heat, expands, and then uses remaining downstream cold. Each kilogram follows one exclusive path.

CoolProp 8.0.0 supplies equilibrium nitrogen states. Pump and expander efficiencies are assumed 0.65, expander inlet 313.15 K, heater source 333.15 K and downstream 273.15 K service with a 5 K approach.

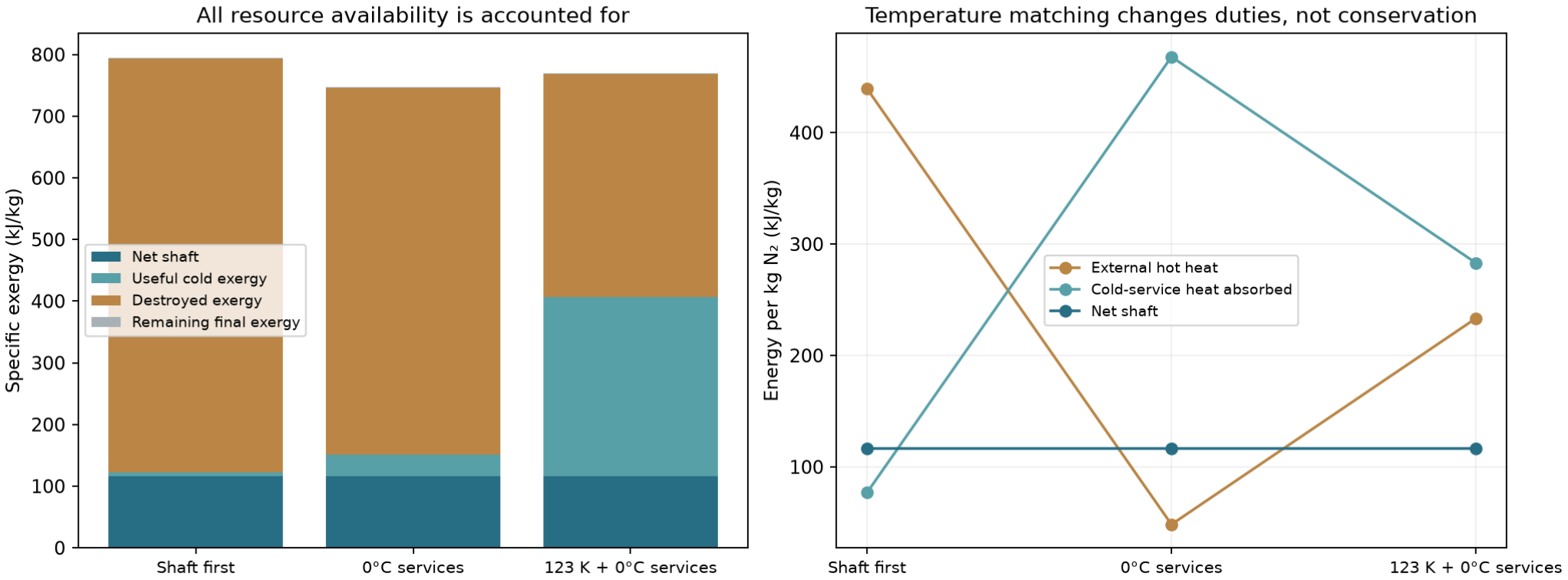
The 123 K upstream-service case is useful only if a real compatible load exists at that temperature. It is an option to explore, not a claimed vehicle requirement.

Full cooling-only capacity is never added again to an already expanded kilogram. N2 is not N2O or NO2; the latter substances receive no transferred phase/material result.

Exclusive path	Net shaft (kJ/kg)	Hot heat (kJ/kg)	Cold-service heat (kJ/kg)	Useful cold exergy (kJ/kg)
shaft-first	116.4	439.6	76.9	5.6
0C-service-before-and-after	116.4	48.4	468.1	34.3
graded-123K-and-273K-services	116.4	233.4	283.0	290.2

Temperature matching and the cryogenic resource ledger

Original cryogenic routing refined: exclusive N_2 paths with finite resources
State-point references; useful loads and hardware remain unverified



Net shaft, useful cold exergy, remaining exergy and destroyed exergy close against initial liquid plus hot-source availability. This is a state-point reference, not a built engine.

Finite resource sizing: no continuous free supply

At the assumed efficiencies, supplying a 2047 W electrical fan from the 0 C pre/post-service path would require 0.0195 kg/s (70.4 kg/h) of liquid nitrogen. One kilogram lasts about 51.2 s under that steady duty.

That state path also requires about 945 W of external hot heat and 9147 W of compatible cold-service heat input. These services must actually be available; finite exchangers and phase stability have not been demonstrated.

The reversible pure-N2 liquefaction/reset lower bound at the same ambient reference is about 14494 W at that flow, before real production, separation, storage and auxiliary losses.

The rolling suction model currently uses a separate finite DC store. It is not powered for free by the cold-core calculation. A common resource controller must allocate real measured flows, heat duties and stored energy.

Through-body airflow: retain shape as a design variable

The vehicle keeps the rounded body, broad paired elliptical intakes, twin through-passages and turbine bypasses from the original plan. The air path and outside shape are co-designed; conventional-car drag is not imposed on the proposed shape.

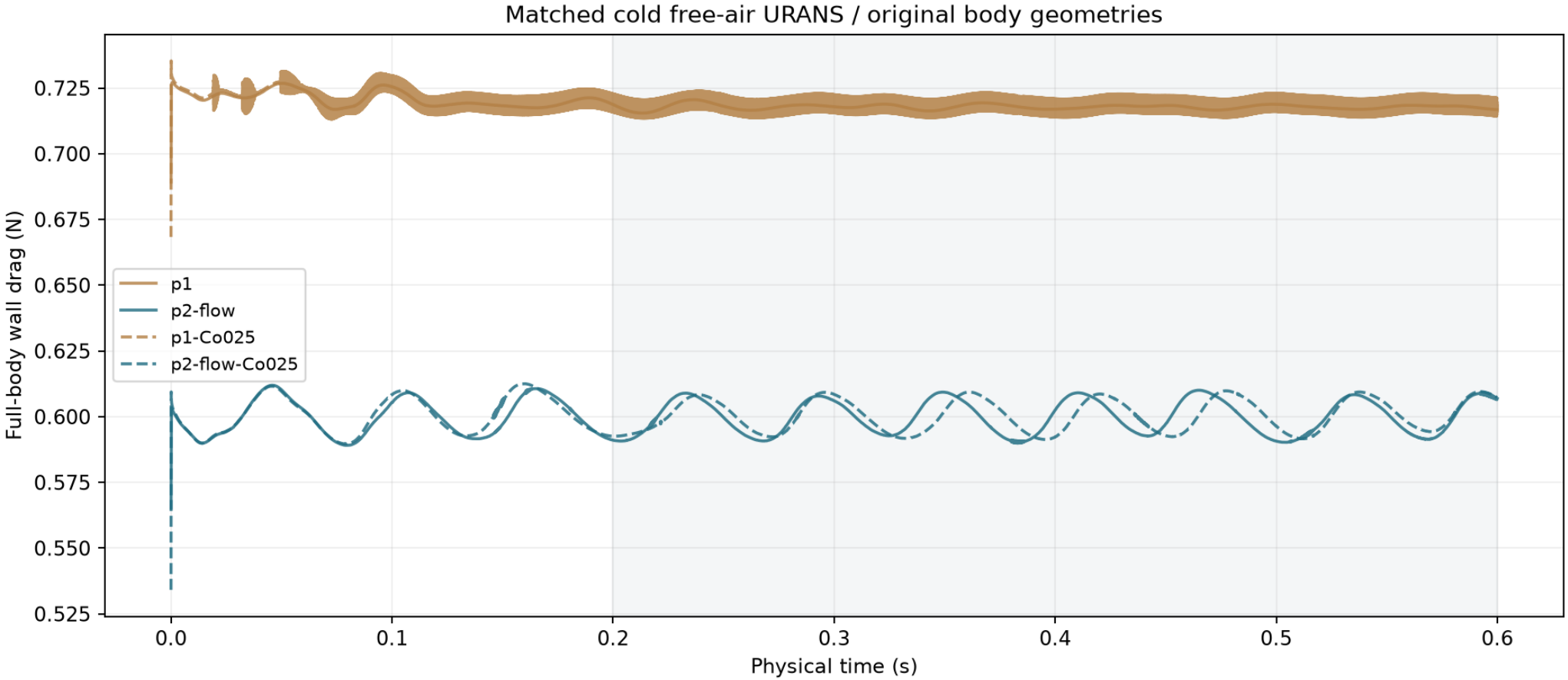
The existing P2 charge/powered actuator cases remain preliminary sensitivities. Added rotor reaction must be included with wall forces; fluid work and generator losses are separate from total propulsion power.

Overnight matched physical-time URANS runs compare the original P1 and P2 cold free-air bodies at 10 m/s on retained L4 meshes. Courant limits 0.5 and 0.25 provide a time-step sensitivity.

These calculations do not establish high-end full-scale road drag, cooling benefit or an integrated turbine map. Reynolds number, moving ground, wheel rotation, unresolved wall layers and extended concave-cell mesh failures remain.

Maximum Courant	P1 mean drag (N)	P2 mean drag (N)	Conditional change
0.5	0.71784	0.59992	16.43% lower
0.25	0.71847	0.60052	16.42% lower

Matched transient airflow histories

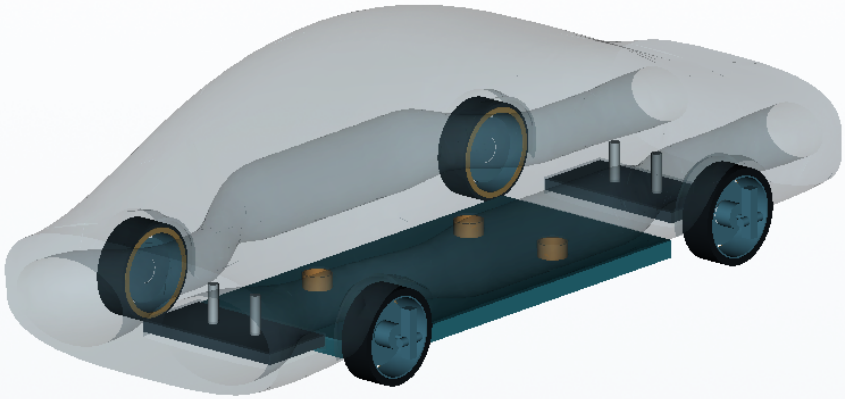


Physical-time wall forces multiplied by two for the half-domain models. The shaded 0.2-0.6 s interval is the averaging window. No road-suction force or turbine output is added to these body comparisons.

Actual CAD: rolling tyre contact and underfloor pressure

FRONT THREE-QUARTER

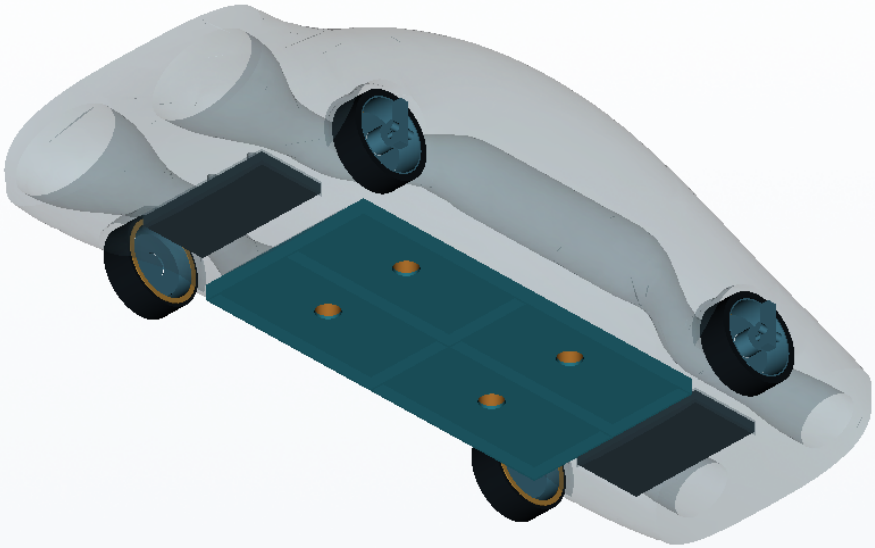
Nominal road contact



STEP geometry / unbuilt layout

UNDERSIDE / PRESSURE CELLS

Nominal road contact



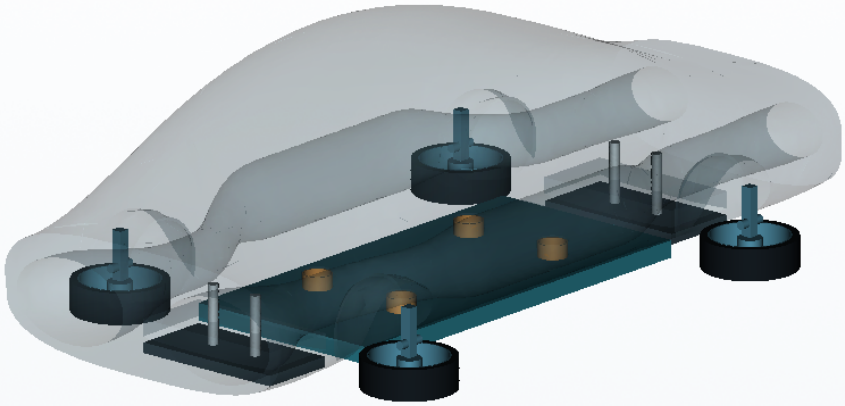
STEP geometry / unbuilt layout

Actual STEP-derived view: four-cell machined tray, separate support pads and feed-port references. Body transparency shows packaging. Detailed fan docking/manifold interfaces remain unresolved.

Actual CAD: supported outward wheel-shoe pose

FRONT THREE-QUARTER

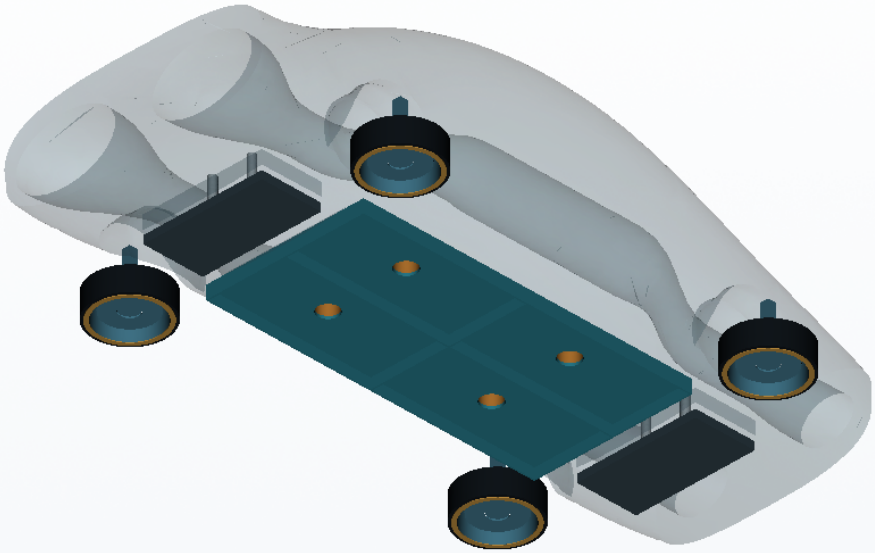
Stationary wheel-shoe layout



STEP geometry / unbuilt layout

UNDERSIDE / PRESSURE CELLS

Stationary wheel-shoe layout



STEP geometry / unbuilt layout

The same source is proposed to switch from the underfloor cells to local annular wheel shoes. Reference disks are not qualified impeller blades. This pose is a stationary layout, not a tested road transition.

Geometry and mechanism constraints are explicit

The original wheel-sweep body passed 47,952 surface-mesh enclosed-point tests, with zero sampled points inside the body. A separate exact Boolean check found zero intrusion into the protected nominal duct envelopes.

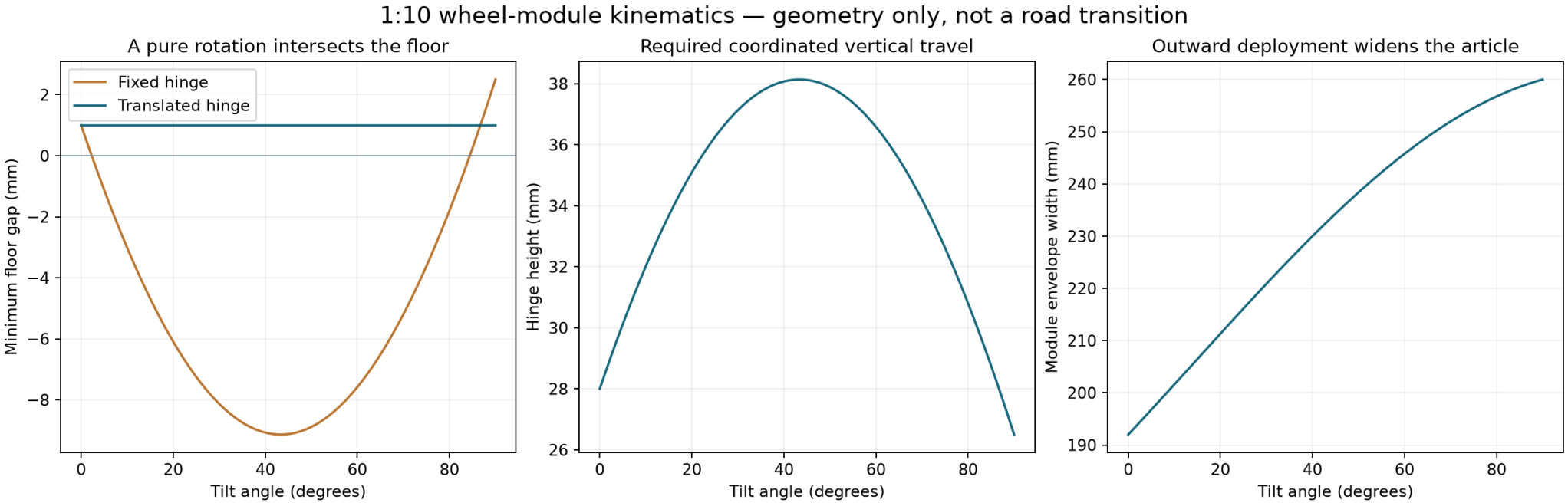
A pure fixed hinge intersects the ground. The proposed coordinated slider/tilt path needs at least about 12.54 mm of hinge travel at 1:10 before tolerance and bearing allowances. The road-contact export includes a separate 1 mm unloaded pre-lift before that clearance path.

The new tray has four internal cells of 123.5 x 58.5 mm, total effective area 0.028899 m2 and total seal perimeter 1.456 m. Those actual CAD values drive the latest vehicle pressure map.

Support pads are placed fore and aft of the pan, retract above the road clearance and extend at rest. The body is still a flow-exclusion/layout envelope, not a solid structural carbon body or a mass certificate.

STEP masters, coloured GLB view meshes, nominal road/deployed poses and standalone tray/ports are supplied. New body pockets have not inherited the original P2 CFD drag result.

Wheel trajectory and clearance law



Deterministic kinematic analysis. Sampled and padded clearances do not replace a continuous tolerance, stiffness, fatigue, hose or bearing assessment.

Vehicle projections: benchmark, assumptions and fairness

The generic 1500 kg high-performance reference is calibrated to the manufacturer-published Koenigsegg One:1 stopping figure of 28 m from 100 km/h. This identifies one equivalent longitudinal parameter; it does not recreate Koenigsegg tyres, geometry, ESC or aerodynamic balance.

The prototype adds an assumed 170 kg hardware target, matched aerodynamic drag, a finite 100 kJ fan store and pressure force from an assumed 3 kPa stall / 1 m3/s full-size total fan map. Actual fan pressure/flow, area, leakage and tyre/pad maps remain unmeasured.

The model solves planar longitudinal/lateral/yaw motion with steering response, friction-circle limits, approximate load sensitivity, quasistatic normal transfer and a common ideal yaw-priority brake allocator. Both reference and prototype are granted exact grip/state knowledge.

There is no wheel-spin ABS state, suspension roll/pitch dynamics, sensor error, friction estimation delay or road-certified deployment mechanism. Treat these as conditional force-envelope projections, not achieved stopping distances.

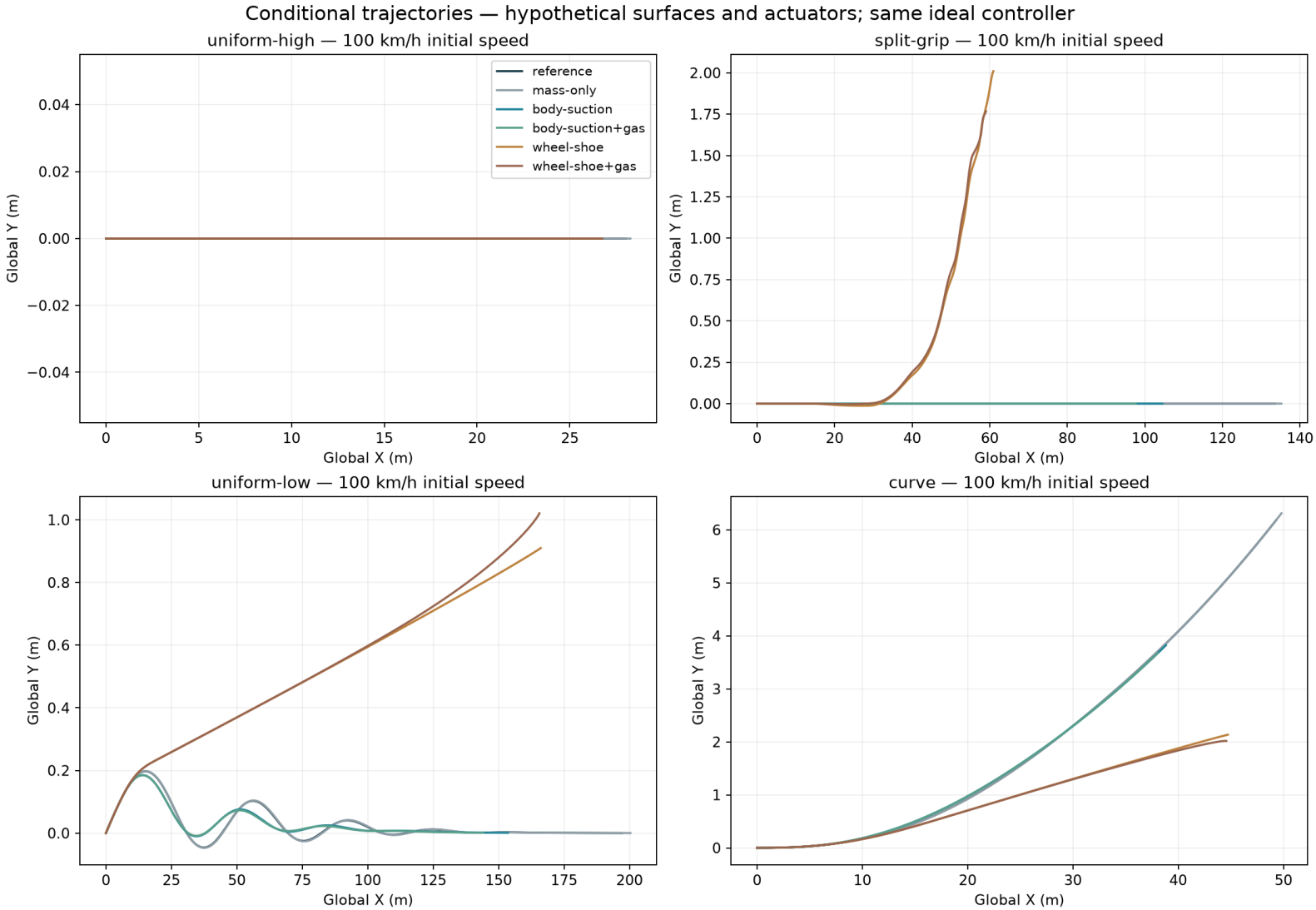
84 cases cover 100 and 120 km/h, uniform high/low grip, split grip, a curve, a low-grip patch, crosswind and a pressure-channel failure. Surface factors are hypothetical multipliers rather than measured weather coefficients.

100 km/h conditional comparison: preserve steering

Scenario	Mode	Path (m)	Max path error (m)	N2 used (kg)	Example stability limits
uniform-high	reference	28.00	0.00	0.00	Pass
uniform-high	body-suction	22.67	0.00	0.00	Pass
uniform-high	body-suction+gas	22.67	0.00	0.00	Pass
uniform-low	reference	197.00	0.20	0.00	Pass
uniform-low	body-suction	153.59	0.19	0.00	Pass
uniform-low	body-suction+gas	144.15	0.18	2.50	Pass
split-grip	reference	133.47	0.00	0.00	Pass
split-grip	body-suction	104.57	0.00	0.00	Pass
split-grip	body-suction+gas	97.59	0.00	2.50	Pass
curve	reference	49.80	0.10	0.00	Pass
curve	body-suction	39.09	0.07	0.00	Pass
curve	body-suction+gas	38.32	0.07	2.00	Pass
low-patch	reference	53.02	0.00	0.00	Pass
low-patch	body-suction	47.80	0.00	0.00	Pass
low-patch	body-suction+gas	47.80	0.00	0.00	Pass
crosswind	reference	47.03	0.03	0.00	Pass

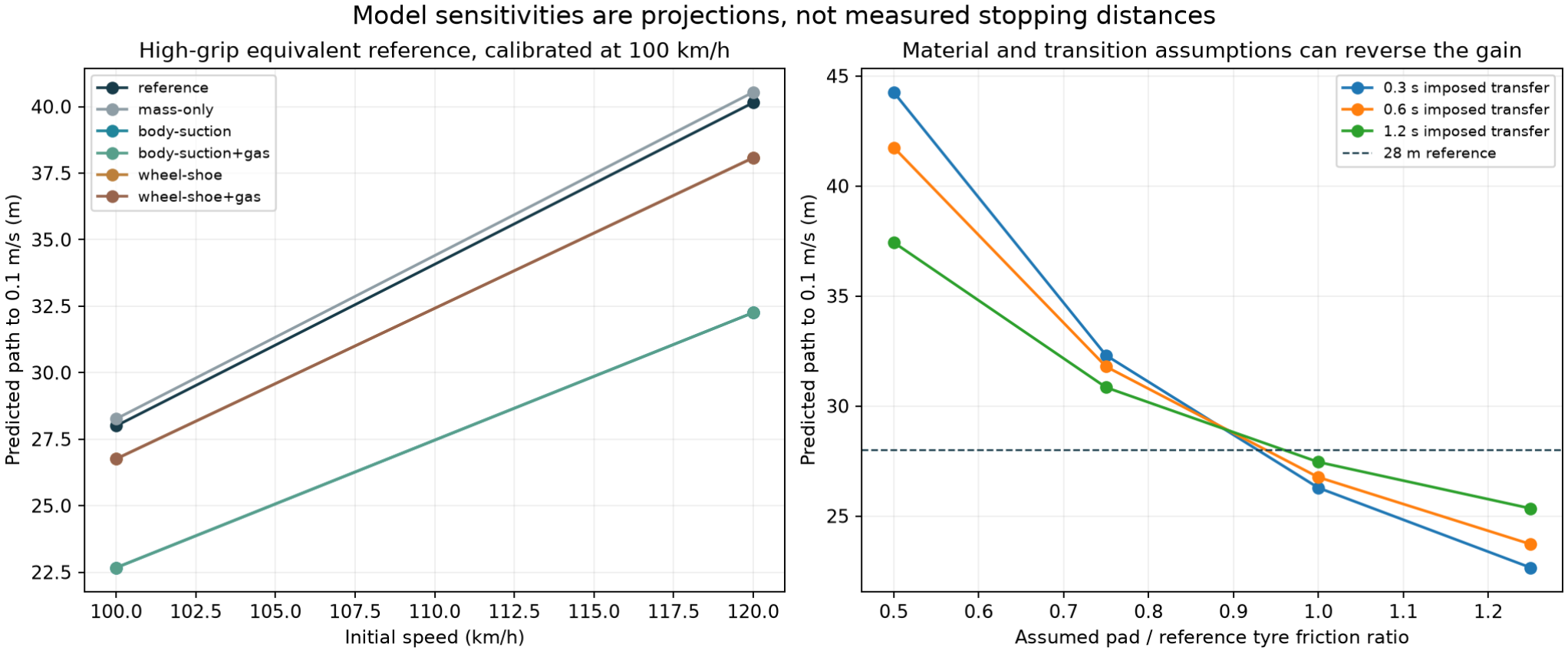
Scenario	Mode	Path (m)	Max path error (m)	N2 used (kg)	Example stability limits
crosswind	body-suction	37.18	0.02	0.00	Pass
crosswind	body-suction+gas	36.66	0.02	0.79	Pass
one-shoe-pressure-loss	reference	46.07	0.00	0.00	Pass
one-shoe-pressure-loss	body-suction	37.53	0.00	0.00	Pass
one-shoe-pressure-loss	body-suction+gas	37.28	0.00	0.63	Pass

Trajectory comparisons and failure cases



All paths are simulations on hypothetical surfaces. Forced wheel-shoe modes that shorten the path while spinning fail the illustrative stability limits and are excluded from improvement claims.

Unknown materials and timing can reverse a gain



Pad friction ratios and imposed transition durations are unmeasured sensitivities. An expensive material is not automatically a higher-grip material.

What failed, and what the revised architecture does

17 forced wheel-shoe cases fail the example stability limits. Some show shorter path distance while developing very large sideslip or spin. Counting them as improved braking would be misleading.

The revised rolling mode keeps the tyres steering while the same fan source draws from a four-cell underfloor plenum. Only at rest does the proposed supported sequence undock and turn the wheels out into local suction shoes.

Proposed sequence: verify low speed and stable support; lower/load-check pads; stop fans; isolate pressure lines; retract docking adaptors; pre-lift; tilt and lock; select local cavities; ramp fan pressure. Reverse and verify the road locks before moving.

A stale or low-confidence road estimate should trigger a controlled stop using measured motion and a selected feasible travel corridor. Straightening is a trajectory/control objective, not a guarantee that an unseen curved road remains underneath the vehicle.

Continuous road-wheel tilting remains an original research branch and is retained in the stress tests. The stationary sequence is the next mechanism test because it avoids removing steering during the most demanding brake phase.

Hydraulics, gyro loads and the structural scale problem

Magnetically driven hydraulics means an electrical motor or solenoid drives pressure in an independent hydraulic circuit. Permanent magnets do not supply continuing cycle work. Source, pump efficiency, leaks and actuator work must be recorded.

At 100 km/h a representative 25 kg road-wheel assembly of radius 0.27 m and inertia 0.91 kg m2 has angular momentum near 94 N m s. A 1.5 rad/s tilt can impose roughly 141 N m of gyroscopic constraint torque per wheel. These are illustrative inertia/rate inputs, not a bearing specification.

Mirrored outward tilts can cancel final vertical road-wheel momentum while transferring the original common pitch-axis momentum to the chassis/supports. Gyroscopic torque is perpendicular to ideal tilt motion, so peak torque multiplied by tilt angle is not automatically drive work.

Do not blindly scale the bench tray thickness tenfold. Conversely, a full-size unstiffened thin roof can deflect enough to destroy the seal. For a simply supported one-way 2 mm aluminium strip at 3 kPa, a 0.585 m span gives a linear deflection estimate near 0.10 m, outside small-deflection validity; support spacing near 0.1 m reduces that estimate below 0.1 mm.

These mechanics screens identify loads and supports to measure/design. They do not qualify a pressure roof, wheel rotor, hydraulic mechanism or crash structure.

Packaging and resource assumptions that still need to close

The yaw-jet reference starts with 3 kg of precharged gaseous N2 at 2 MPa and 313.15 K. Its ideal-gas tank volume is about 139.4 L. Vessel mass, certified hardware, pipework and this volume must fit a real manufacturer package.

Adiabatic blowdown, converging-nozzle mass flow/pressure thrust and a 0.5 kg reserve are included. The soft-closing valve model prevents using more than the allowed 2.5 kg. The gas store is not an unlimited yaw actuator.

The N2 state-path expander that exhausts near ambient pressure cannot simultaneously feed the 20 bar jet source. Either use separate storage, allocate an upstream branch or redesign the pressure path and count the lost shaft/cold service.

The 170 kg installed mass and the full-size fan map remain targets. No full vehicle bill of materials, range benefit or all-mode optimum is established by this package.

Original freezing-water idea: calculate the complete cycle

The original expansion-of-freezing-water proposal is retained as WP9. An equilibrium piston reference follows liquid and ice Ih along the melting curve, freezes at high pressure and melts at low pressure. The enclosed pressure-volume area gives complete cycle work.

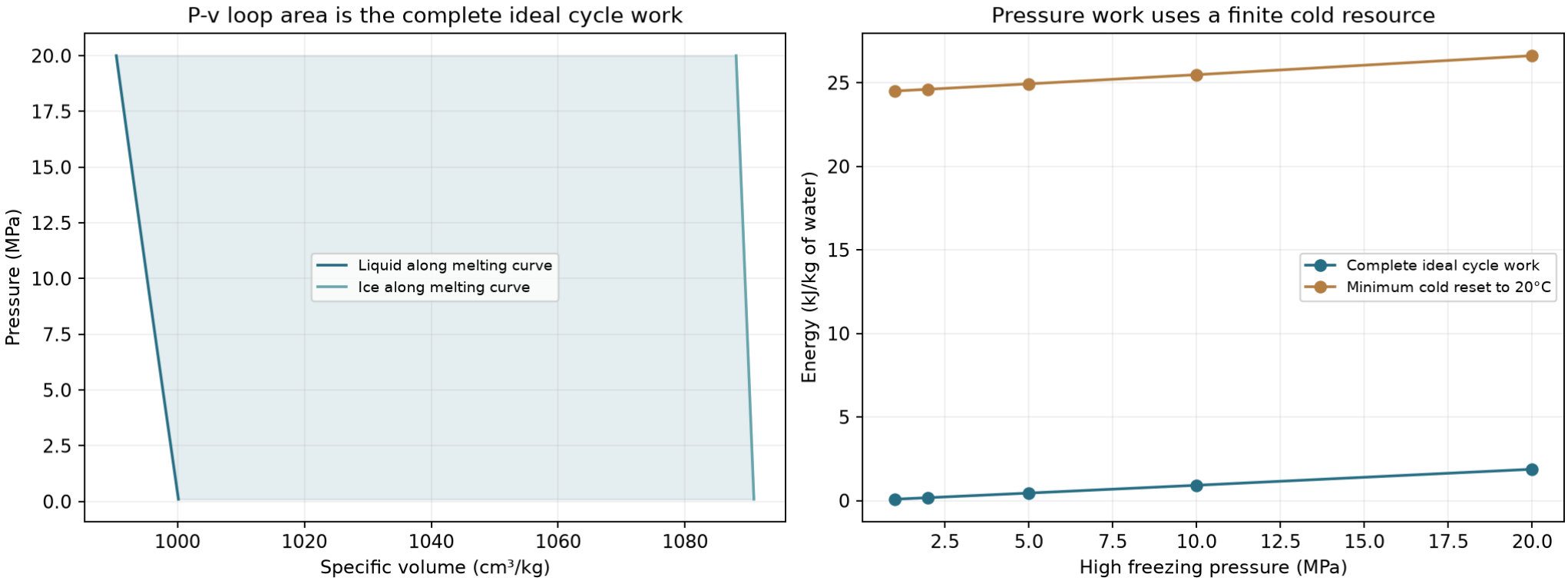
At 20 MPa high pressure and ambient low pressure, the calculated freezing temperature is 271.612 K. The high-pressure freezing leg gives 1953 J/kg; the complete ideal cycle gives 1875 J/kg, or 0.521 Wh/kg of water only.

The hot/cold duties are about 337.6/335.7 kJ/kg. Cycle efficiency 0.555% remains below the two-reservoir Carnot limit 0.564%. Minimum cold restoration to 20 C is about 26.6 kJ/kg.

The IAPWS melting-line verification point is reproduced and the water/ice property packages are recorded. No cycle rate, nucleation control, pressure-vessel design, ice-jamming solution or practical pressure store has been demonstrated.

Freezing-pressure cycle and reset

Original freezing-water idea: a phase-change heat engine, with the full reset counted
Equilibrium calculation; high-pressure hardware and power rate remain unverified



The loop gives positive work in an ordinary phase-change heat-engine reference. A peak pressure in a fixed bottle is not a measured work output.

Original magnetic collision mitigation: a cooperative test

WP10 is retained as a cooperative magnetic-force study. The model uses opposing currents in two coaxial air-core circular coils. Exact mutual-inductance and independent Neumann-integral/force-gradient calculations are cross-checked.

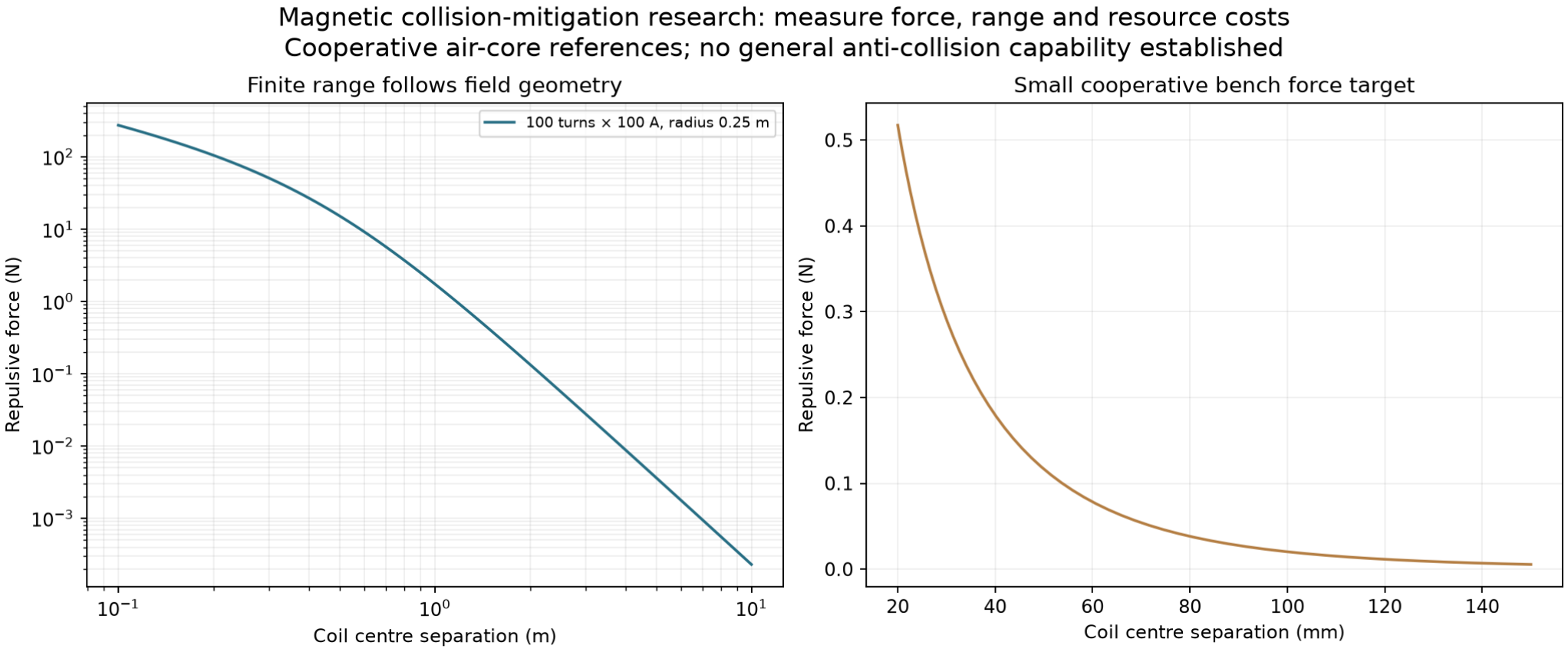
For the illustrative radius 0.25 m, 100-turn, 100 A coils, the fixed-current approach work from 10 m to 0.1 m is 33.77 J. One 1500 kg vehicle at 100 km/h has about 578.7 kJ of kinetic energy.

Raising current changes force quadratically but also changes electrical loss, field energy, driver exchange and mechanical stress. At fixed current, the force integral is not automatically the decrease of field energy; both current regulators exchange energy as mutual flux changes.

A small cooperative bench reference, radius 40 mm, 100 turns and 5 A, predicts 0.517 N at 20 mm separation. Use rated current-limited coils and independent force/distance metrology; this is not a vehicle protection rating.

An arbitrary unmodified obstacle is not assumed to provide repulsion. Alignment, vehicle steel, finite winding size, current dynamics and practical mounting remain unresolved.

Magnetic force falls with separation



Analytical cooperative-coil references. Cryogenic cooling may reduce resistance, but that is a resource and materials question rather than an automatic range/force benefit.

Premium materials are specified by function

Use new unused traceable stock, manufacturer/lot documentation, inspected machined sealing faces and documented composite storage/cure records. No salvaged parts or purchases are implied.

Grip is a measured interface property depending on surface, water/ice, temperature, speed, pressure, wear and compound. Expensive base material alone is not assigned a friction improvement.

The moderate-temperature proof keeps cold vessels separate from the ambient contact plate. A later true-cryogenic module needs its own supplier-rated materials, seals and phase/thermal design.

Function	Candidate specification / qualification
Rated gas vessels/fittings	New traceable 316L stainless commercial vacuum-compatible components; supplier temperature and external-pressure rating govern
Thermal inserts	New oxygen-free copper interfaces with documented mass and thermal contact; mechanically removable from the gas envelope
Pan/tray and brackets	New traceable 6061-T6/T651 or functionally equivalent machinable aluminium, with inspection of the actual sealing face
Thermal breaks	PEEK or G10 candidates in moderate-temperature mounts; grade and creep/contact load verified before purchase
Replaceable seals/contact coupons	Fresh documented elastomer grades selected for the measured surface, water, temperature and wear conditions. Price is not assigned a friction gain.
Later cryogenic loop	Separate supplier-qualified cryogenic seals, pressure equipment and compatible materials. Moderate-temperature elastomers receive no assumed liquid-N2 qualification.

All twelve original work packages: 1-6

ID	Original work package	What this revision supplies / what remains
WP1	Body and duct co-design	P1/P2 cold body CFD and through-passage CAD; new full integration still requires moving-ground/rotor/thermal tests.
WP2	AirDrive and heat-assisted flow	Timed thermal chamber model, real-N2 references and new spatial cooling CFD; no measured turbine/exchanger map.
WP3	GTBS aerodynamic braking	Pressure/leakage fan-shoe maps, underfloor tray and wheel-shoe layout; assumed fan inputs require installed force tests.
WP4	Road and trajectory aware braking	84 planar scenarios and stability filtering; real ABS, grip estimation, sensors and full vehicle dynamics remain.
WP5	DDTC and pulse stores	Original pulse/store branch retained; shared duty allocation and finite-source interfaces need hardware maps.
WP6	Suspension and contact surfaces	Slider/tilt law, sampled clearance tests, nominal road contact and supported pose; bearings/locks/loads need qualification.

All twelve original work packages: 7-12

ID	Original work package	What this revision supplies / what remains
WP7	Heat recovery and electrical storage	Finite electrical/gas stores and heat/exergy accounting; production/reset losses remain separate.
WP8	Cryogenic thermal routing	Exclusive graded N2 state paths; N2O chemistry/materials remain a separate unresolved option.
WP9	Freezing-water pressure store	IAPWS water/ice equilibrium pressure-volume cycle and Carnot/reset checks; no practical high-pressure phase actuator.
WP10	ECRS electromagnetic mitigation	Cooperative-coil force/range/driver-energy screen and small bench target; no general anti-collision guarantee.
WP11	Joint optimization and fault arbitration	Proposed mode/resource sequence and failure gates; a measured-map supervisor remains to be implemented.
WP12	Manufacturer package and research paper	This manufacturer/research review package and a focused paper route; no submission or peer-reviewed result.

Claims that the evidence can and cannot carry

Supported within the stated models: cooling a finite gas inventory lowers pressure; pressure over a sealed area can create a useful static force; leakage and wall thermal mass materially limit the response; finite cold availability is consumed.

Conditional engineering projections: rolling underfloor suction can add normal load and reduce the stopping path under the assumed installed fan/leak/tyre inputs. Shape co-design changes calculated cold-flow drag in the retained body models.

Not demonstrated: a built CryoPulse prototype, measured net energy gain, self-replenishing cold, real high-end-car superiority, safe high-speed wheel deployment or universal magnetic collision avoidance.

Next decisive evidence: calibrated cold-only pressure/force trials, a moving-load work measurement with reset costs, installed fan/seal maps and stationary actuator/clearance tests. Then replace the assumed maps and repeat vehicle comparisons.

The practical research contribution should be framed as a testable thermal-pressure/ground-grip architecture with resource allocation, rather than a claim that an energy void creates new energy.

A focused scientific paper route

Working title: Cooling-induced pressure deficits for distributed suction: coupled thermal-mass, leakage and vehicle force-envelope references.

Possible abstract: We formulate a finite-reservoir thermopneumatic suction architecture and examine its energy, entropy and leakage limits. A lumped gas/wall/ice-bath model is compared with closed-chamber compressible finite-volume cooling calculations. Static holding and finite displacement work are distinguished. A manufacturer-oriented vehicle study uses assumed installed pressure maps and a benchmark-equivalent planar model, explicitly excluding spin-driven stopping reductions. The work provides reproducible numerical references and a predeclared experimental design; no physical performance is claimed.

Before submission: establish the specific original contribution against thermopneumatic pumps, suction vehicles, cryogenic exergy systems and existing suction/freezing grippers; complete the numerical sensitivity discussion; add physical evidence if claiming demonstrated hardware; obtain an appropriate scientific review.

The arXiv submission overview requires a topical, refereeable scientific contribution and author preparation/verification. Registration, possible endorsement, moderation and a distribution licence apply. The supplied technical booklet is a research package, not an already accepted or submitted paper.

Reproduction and artifact map

Start with output/p22-prototype.html. It contains the interactive CAD and trajectory review. Exact CAD masters are in cad/; the original full plan remains at ../../cryopulse-expanded-plan/plan.json in the workspace and is copied into the package.

Run scripts/static_cold_bench.py, ground_module.py, cold_grip.py, nitrogen_cascade.py, freezing_cycle.py, magnetic_screen.py and vehicle_study.py in the recorded scientific Python environment. Set MPLCONFIGDIR to a writable temporary directory.

CFD cases retain initial fields, mesh-generation inputs, dictionaries, logs, function-object time series and frozen run scripts. The compact archive omits bulky reconstructed/processor volume fields; the full workspace cases retain them. OpenFOAM v2412 and a compatible MPI build are required for reruns.

The environment requirements and exact package versions are recorded. Geometry is produced with Gmsh; VTK generates STEP-derived view meshes and independent field/clearance audits. Original GPL notices in copied OpenFOAM dictionaries are retained.

The package includes SHA-256 integrity records, blank experimental templates and explicit evidence labels. Images are concepts; CAD, CFD, thermodynamic calculations and measurements are distinct evidence classes.

Primary sources and related work

Source	Use	Direct link
arXiv submission overview	Submission process and scientific scope	https://info.arxiv.org/help/submit/index.html
Koenigsegg One:1 technical specifications	28 m benchmark calibration only	https://www.koenigsegg.com/technical-specifications-one1
CoolProp nitrogen properties	Nitrogen equilibrium EOS and reference literature	https://coolprop.org/fluid_properties/fluids/Nitrogen.html
IAPWS melting/sublimation release	Water/ice phase-boundary model and verification point	https://iapws.org/technical-guidance/release/MeltSub
NIST DLMF 19.34	Mutual inductance of coaxial circles	https://dlmf.nist.gov/19.34
MIT inductance and magnetic energy	Circuit field-energy context	https://web.mit.edu/viz/guide/Chapter-11-Inductance%20and%20Magnetic%20Energy.pdf
OpenFOAM thermal solver	Solver description; exact retained runtime/source version is recorded locally	https://doc.openfoam.com/2212/tools/processing/solvers/rtm/heat-transfer/buoyantPimpleFoam/
NASA compressible mass flow	Nozzle mass-flow reference	https://www.grc.nasa.gov/www/k-12/airplane/mflchk.html
Vehicle 3DOF equations	Planar force/moment model context	https://www.mathworks.com/help/vdynblks/ref/vehiclebody3dof.html
Air leakage and seal roughness study	Real contact leakage is more complex than a uniform gap	https://arxiv.org/abs/2108.02063
Existing dual-mode suction/freezing gripper	Related work; no world-first claim is made	https://advanced.onlinelibrary.wiley.com/doi/10.1002/adrr.70170