



LOUDGEARS

NEURAL FEA SYSTEM

PHYSICS-INFORMED NEURAL FEA SYSTEM

CUSTOM FORGED WHEEL ENGINEERING WHITE PAPER

VERSION 1.2

**Find real-road stress risks
before cutting metal.**

End the trade-off between factory FEA and an expensive in-house team. Turn real-world fracture lessons into a road-load simulation model. In a typical 2–3 minutes, put engineering decisions back in the brand's hands.



01 / THE ENGINEERING DILEMMA

The engineering dilemma

Costly in-house CAE vs inconsistent factory FEA

Custom forged wheels depend on striking designs and variable fitment parameters: offset (ET), bolt pattern (PCD), spoke cutouts and local weight reduction. A 1 mm thickness change can move the load path and stress concentration. Brands face two difficult options for structural validation.

Dilemma 1 / Building an in-house CAE team

Expensive software

COST 01

Commercial general-purpose FEA licenses (Ansys / Abaqus) can cost \$20,000–\$40,000 per seat per year.

High staffing cost

COST 02

A dedicated structural engineer adds a full salary on top. Maintaining even a basic in-house analysis function typically costs \$100,000+ per year.

Slow design feedback

COST 03

General-purpose CAE tools are complex; one case can take hours. Designers cannot use them directly, and design changes become detached from verification.



01 / THE ENGINEERING DILEMMA

Dilemma 2: factory FEA

'Fake FEA' and blind machining

RISK 01

Many smaller factories have neither structural engineers nor professional CAE software. Some claim to have analyzed a wheel or reuse generic screenshots, while machining relies on shop-floor experience.

Inconsistent load setup

RISK 02

Even where a report exists, load points, directions and boundary constraints may be set ad hoc. Without a common engineering procedure, results lose their value as a reference.

Bench pass, road fracture

RISK 03

A factory may tune a wheel to pass impact or fatigue bench tests. Those tests cannot replace pothole impacts, cornering roll and multiaxial cyclic road loads. Some wheels still fracture after entering road use.

LoudGears bridges the gap: road-grade structural verification in the hands of wheel designers and brand owners, fast, standardized and validated against real failures.

02 / REAL-WORLD VALIDATION

Road loads, checked against real fractures

'We do not simulate merely to pass a test. We model the real road.'

Built with our partner wheel manufacturer: a road-load model calibrated on real vehicle conditions and checked against track and road fractures.

Full road-load dynamics

The model covers extreme impact and bending fatigue, while representing cyclic road loads and vehicle lateral acceleration.

TÜV wheels, track and road fractures

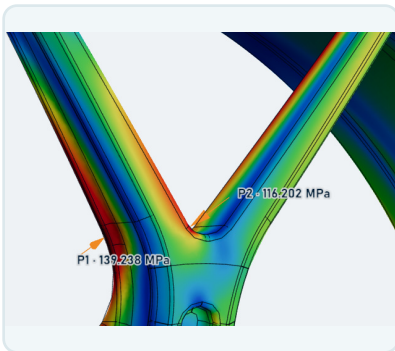
Calibrated on multiple TÜV-certified partner wheels; track cracks compared A/B, and road fractures replayed without prior crack locations.

Case A / spoke-fork root fracture

After aggressive driving, a crack appeared at the root. Under the corresponding load case, LoudGears reproduced a 139.2 MPa stress concentration at the P1 hotspot.



Physical crack / root transition



VM replay / corresponding hotspot



02 / REAL-WORLD VALIDATION

Case B: two fractures, two hotspots

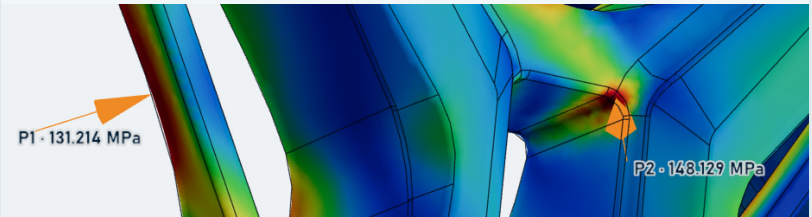
Road use produced cracks at a spoke edge and its connecting bridge. The model identified two risk regions at 131.2 MPa and 148.1 MPa (P1/P2 hotspots).



Physical crack 1 / P1 region



Physical crack 2 / P2 region



Retrospective check: crack regions correspond to VM hotspots.

Both cases are earlier-generation wheels from our partner manufacturer. What they taught is built into today's designs and into LoudGears itself.

03 / PHYSICS-INFORMED ARCHITECTURE

Physics constraints, not AI guesswork

Purely data-driven AI can fit image features without preserving physical continuity. At critical load points, this can shift or miss a stress hotspot.

LoudGears couples Graph Neural Operators with a differentiable Tet10 finite-element layer and applies physical constraints throughout the analysis:

Dual-engine mechanics

01

A 3D geometry neural operator supports millisecond-scale inference. Stress tensors and limiting deformation are derived under material constitutive laws and continuum mechanics, rather than generated as arbitrary images.

Hard boundary guardrails

02

Fixed supports and bolt-flange faces receive hard displacement constraints. This prevents spurious motion at fixed regions and enforces force and moment balance.

Physical self-check

03

After inference, the engine checks consistency with conservation and classical equilibrium conditions. Only cases that pass are accepted for reporting.

Safety confidence index

04

Aggressive cutouts outside familiar engineering experience trigger a confidence warning, giving teams a clearer risk boundary before committing to machining.

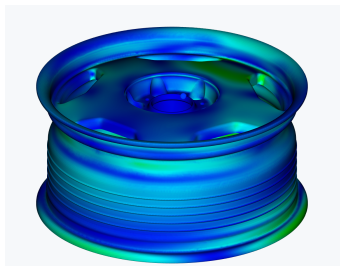


04 / BENCHMARK

<1% difference in a 5 mm CAE case

A benchmark uses the same CAD geometry, 6061-T6 material, loads and constraints with a standard 5 mm element size.

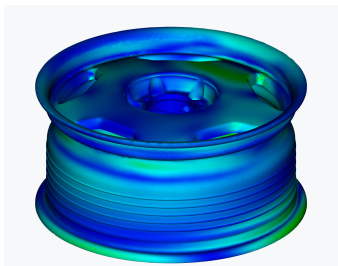
MAINSTREAM CAE



Free-surface Von Mises peak

93.035 MPa

LOUDGEARS 5 MM



Free-surface Von Mises peak

93.377 MPa

0.37%

Relative VM peak difference

Hotspots at the same spoke fillet

End-to-end time: an experienced analyst typically needs an estimated 45–90+ minutes in mainstream CAE, often hours. LoudGears takes a typical 2–3 minutes for a STEP wheel of moderate complexity on a supported GPU: roughly 15–45 times faster. Page 08 explains why.

This is one case, not a universal accuracy claim. Production and safety decisions still require company standards, engineering review and applicable physical testing.

05 / SPEED

Why it is 15–45x faster

The speed does not come from cutting corners on physics. It comes from removing the manual work and starting the solver close to the answer.

Automatic cleanup, repair and meshing

01

Industry estimates put up to 80% of a typical CAE simulation into preparing the model: cleaning and repairing the CAD, then meshing it by hand. LoudGears does it automatically, fast and accurately, checks every mesh before it solves, and applies the vehicle loads. No meshing expertise needed.

AI warm start

02

A Graph Neural Operator trained on wheel structures predicts the displacement field first, so the solver starts close to the answer instead of from zero.

Physics finishes the solve

03

A preconditioned solver on the local CPU, or GPU when available, drives the true finite-element residual below the convergence threshold. The AI shortens the solve; it never replaces it.

Built only for wheels

04

Wheel-specific load templates, structural-region recognition and mesh rules replace the setup a universal CAE package has to ask you for.

How much the warm start saves varies with mesh size and hardware; convergence is always judged on the recomputed true residual.

06 / WORKFLOW

Road-load simulation in 2–3 minutes

Professional structural analysis becomes accessible to brand designers and engineers without manual meshing or complex boundary-condition setup.

Step 1 / Import wheel CAD

INPUT

STEP, IGES or Parasolid X_T. Common export defects are repaired automatically; no manual geometry stitching or meshing.

Step 2 / Select the vehicle and material

SETUP

A built-in vehicle database matches loads, directions and boundary conditions. Pick forged 6061-T6 aluminium or AZ80A-T6 magnesium, then review the radial load and wheel torque before you run.

Step 3 / Get an engineering report

RESULT

Review full-field stress, 3D deformation, failure hotspots and a clear verdict, with advice on where to add material and where to save weight.

Designers, project sales teams and engineering managers can get an assessment in a typical 2–3 minutes to support quotations and design release decisions.

Staggered fitments: a front and a rear wheel in one file run as two wheels, and the rear is half price when both share the outer diameter (within 1.5%) and spoke count.

07 / ENGINEERING ADVICE

Not just a verdict

Every result comes with rule-based engineering advice read from the verified stress field, so the designer knows the next move.

Design Advisor: where to add material**BELOW TARGET**

For each region below the material's safety-factor target (3.0 for 6061-T6, 2.5 for AZ80A-T6 magnesium), LoudGears names where it is and suggests a sized fix: a larger fillet radius, more spoke depth or width, or a locally thicker flange, bead seat or barrel wall.

Weight Advisor: where to save weight**ABOVE TARGET**

When a design passes, it shows where weight can come out: pocket the PCD back pad, thin the barrel and flanges, slim the spokes, keeping every region at or above that target; savings follow the material's density.

A report for the customer**REPORT**

A branded PDF with the verdict, stress views marking the peak, a plain-language reading of every number and one revision page per region; the weight-reduction PDF lists each change with its estimated saving.

Advice never changes the verdict. Check every change with an engineer and a new run.



08 / LOCAL SECURITY

Keep CAD local and under your control

Original wheel designs and product patents are core assets for custom-forged brands.

Drawings stay local

PRIVATE

Geometry parsing, 3D meshing and mechanical solving run on the local CPU, or an NVIDIA GPU when available. STEP, IGES and X_T files are not sent to the cloud.

A standard PC is enough

LOCAL

Windows 11 (64-bit), 8 cores and 16 GB RAM. A graphics card is optional: an NVIDIA RTX 3060 or better only adds speed. Teams use the PCs they have rather than buy remote compute. The installer is signed.

Free during the beta

CREDITS

Beta places are free. A failed mesh, an aborted run or a service error never consumes a credit.

The CAD file remains on the brand's workstation or internal network; the brand controls the analysis workflow.



09 / COMMERCIAL COMPARISON

Four ways to deliver wheel FEA

Factor	Factory FEA	In-house CAE	External CAE	LoudGears
Annual cost	No stated fee; fracture and recall exposure.	\$100,000+ a year for software and engineers.	Thousands per job; edits compound costs.	Free during the beta; uses local hardware.
People / access	Shop-floor expertise varies.	Needs dedicated structural engineers.	Relies on external staff; edits take coordination.	Designers and engineers can use it directly.
Road-load fidelity	Basic bench cases, detached from road use.	Lab standards without road-failure history.	Standard cases applied per job.	Calibrated to real fracture cases and dynamic road loads.
Iteration time	Cross-factory feedback often takes 2-3 days.	Each geometry change can take hours to solve.	Scheduling and scoping can take 3-7 days.	Results in 2-3 min typical; iterate on demand.
CAD security	New designs circulate in factory chats and PCs.	Internal, but expensive to maintain.	Core drawings leave for a third party.	Local compute; CAD stays on the internal network.
Design advice	Pass / fail at best.	Depends on the analyst.	Extra fee per revision.	Where to add material and save weight.



10 / BETA PROGRAM

Join the free brand validation beta

Do not make road use the first test of wheel safety.

LoudGears is opening a limited free beta for custom-forged wheel brands.

Choose a wheel already in production, or a design that had a road or bench issue. Run a blind check in a typical 2–3 minutes and see whether LoudGears identifies the structural weak points.

Apply for a beta slot

loudgears.com