

Battery Physical Parametrization with ECM and P2D Models

Powered by APEX AI OS – Physics

4,000+

REAL-LIFE TESTS

>10M

SYNTHETIC MATERIAL CONFIGS

< 2%

ERROR FOR EXTRACTED KPIS

>80%

PARAMETERIZATION TIME REDUCTION

While developing highly accurate Equivalent Circuit Models (ECM) and Pseudo 2-Dimensional (P2D) models is critical for advanced battery design, manual parameterization remains a massive engineering bottleneck. Testing teams currently spend weeks painstakingly analyzing complex charge/discharge data and manually curve-fitting parameters across varying temperatures, SOCs, and C-rates – a process that introduces human error and severely delays time-to-market. Automated parameterization with **APEX AI OS – Physics** eliminates this friction by rapidly ingesting raw cell data to generate fully validated, ready-to-use models. By automating the extraction process and outputting directly into seamlessly integrated formats (Simulink, FMU, or BMS-ready code), engineering teams can drastically accelerate battery development, guarantee robust performance across all operational windows, and confidently rely on comprehensive validation reports.

HOW IT WORKS

1

Pipeline Setup

Trained on 4,000+ real-life cycling tests and >100M material configurations, effectively learns how to optimize both ECM and P2D parametrization of cells under test.

2

Fine-Tuning

Minimal model adaptation to your specific cell chemistries and test protocols. Develop a customer specific high-accuracy model to build IP and your battery intelligence.

3

Inference

Feed beginning-of-life data characterization data (OCV, EIS, DCIR, ...) and cycling data if available to obtain optimized parametrization of both ECM and P2D models.

EXAMPLE: AUTOMATED PARAMETRIZATION OF P2D MODELS WITH VOLTAGE CURVE VALIDATION



USE CASES & BENEFITS

Rapid Cell Material Screening & Optimization

Automatically extracts parameters from test data to help evaluate how physical changes – like electrode thickness, porosity, or active material composition – impact cell performance across varying operating conditions..

Standardized Cell Supplier Benchmarking

Ingests raw characterization data from multiple different cell suppliers to remove subjective manual curve-fitting bias, giving cell test engineers a strictly quantitative, apples-to-apples comparison to confidently select the best cell for their application.

Advanced Aging and Degradation Analysis

Isolates specific degradation mechanisms early in the testing phase, allowing engineers to pinpoint exactly how and why a cell is failing under specific thermal or SOC conditions.

Seamless Digital Twin Creation for Cell Testing

Eliminates the manual data-wrangling phase between physical cell testing and digital simulation, allowing engineers to instantly validate empirical test results against theoretical cell models.

ENGAGEMENT & PRICING

1

Parametrization as a service

Automated parametrization model tested with your data. Flexible configuration of experimental fitting with either ECM or P2D models.

2

Integration

Customization of automated parametrization according to your business and expected insight generation. All IP remains with you, run on your premises.

3

Deployment & License

Private cloud or on-premises within your infrastructure. Possible integration and run with other Sphere's offering, e.g.: testing, data management, etc.

Initial Setup & Fine-Tuning Fee

One-time: POC, data integration, automated parametrization pipeline.

Annual License Fee

Platform access, updates, new cell onboarding, support.

ROI: 80% OpEx savings and faster decisions

80% efficiency boost to parametrization routines · Minutes to optimal parametrization instead of hours · One unified battery intelligence

Requirements Processing & Understanding

Powered by APEX AI OS – Specification Extraction

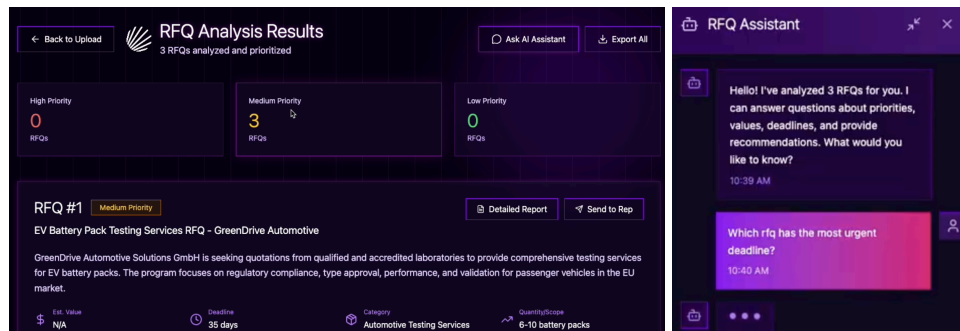
100x <small>FASTER PROCESSING</small>	>99% <small>RETRIVAL ACCURACY</small>	<1% <small>DIFFERENCE FROM HUMAN ANNOTATION</small>
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While meticulously analyzing massive, 50+ page engineering specifications is vital for securing new projects, relying on manual review creates severe operational bottlenecks and heightens the risk of misinterpreting critical project features. Teams currently lose valuable time extracting hidden details, often operating in silos without transparency into previous, similar offers. **APEX AI OS – Specification Extraction** tools effectively eliminate these friction points by rapidly digesting lengthy documents, automating the retrieval of buried requirements, and instantly surfacing relevant historical data. By leveraging **APEX AI OS – Specification Extraction** to accelerate retrieval, cross-reference of documents, engineering teams can drastically reduce analysis time, minimize human error, and confidently uncover hidden risks before communicating the outcomes of the document inspection.

HOW IT WORKS

<p>1 AI Solution Architecture</p> <p>An optimized pipeline was trained and validated with 1000+ documents to develop an AI-assisted solution for requirements and specifications extraction from lengthy documents .</p>	<p>2 Customization</p> <p>Adapt the architecture to process documents with structure and scope inherent to your business case. Develop a customer specific pipeline for extraction of key performance indicators of interest.</p>	<p>3 Inference</p> <p>Feed a batch of documents with specification targets and obtain in less than 5 minutes the response on the extracted information at different levels of details and compare with existing documents for insights generation.</p>
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EXAMPLE: OUTCOME OF REQUEST FOR QUOTATION (RFQ) PROCESSING



USE CASES & BENEFITS

<p>Rapid Document Triage</p> <p>Summarize core requirements, and route specific pages to the right engineering teams. Slashes initial review time from days to hours, preventing team fatigue before the deep analysis even begins.</p> <p>Hidden Requirement Extraction</p> <p>Automated search and retrieval targets technical details, testing parameters, or unusual clauses that are typically overlooked. It reduces the risk of costly misinterpretations, missed features, and downstream project scope creep.</p>	<p>Historical Cross-Referencing</p> <p>Compares new requirements document against a database of previous, similar offers to surface past quotes, margins, and technical solutions. Speeds up the drafting process of responses and insights generation.</p> <p>Automated Compliance & Risk Flagging</p> <p>Cross-checks the extracted client specifications against your company's standard production capabilities and risk tolerances.</p>
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ENGAGEMENT & PRICING

<p>1 Proof of Concept (POC)</p> <p>Base model fine-tuned with a sample of your data. Testing capabilities and results on KPIs of interest based on your business.</p>	<p>2 Fine-Tuning</p> <p>Customer-specific development and adaptation using extensive historical data to enhance cross-referencing and risk flagging.</p>	<p>3 Deployment & License</p> <p>Private cloud or on-premises within your infrastructure. Ongoing updates, new functionalities onboarding, and continuous on-demand improvement.</p>
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<p>Initial Setup & Fine-Tuning Fee</p> <p>One-time: POC, data integration, solution adaptation.</p>	<p>Annual License Fee</p> <p>Platform access, updates and support.</p>
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ROI: Efficient specifications retrieval and faster insights generation
 100x faster extraction of relevant requirements · Minutes to information extraction from documents instead of hours

Battery Lifetime & Performance Simulation

Powered by APEX AI OS – Battery Intelligence

4,000+

REAL-LIFE TESTS

>10M

SYNTHETIC MATERIAL CONFIGS

< 2%

SIMULATION ERROR

30%

TEST REDUCTION

Development of battery powered products demands extensive physical testing across temperatures, C-rates, SOC windows and usage profiles – taking 12–18 months and costing hundreds of thousands to millions annually. **APEX AI OS – Battery Intelligence** consolidates all available test data – even from legacy systems – into one unified battery intelligence. It learns from every test ever run to simulate cell aging and performance under any conditions. One model that captures your entire organization's battery knowledge and grows smarter with every new test. Using only the first 50-100 cycles of a new cell test as “prompts”, the model can then simulate performance until end of life under various conditions, already early in the development phase, saving cost and time.

HOW IT WORKS

1

Pre-Training

Trained on 4,000+ real-life cycling tests and >100M material configurations, combined with physics-based P2D frameworks, the model learns the correlation between cell physics and aging.

2

Fine-Tuning

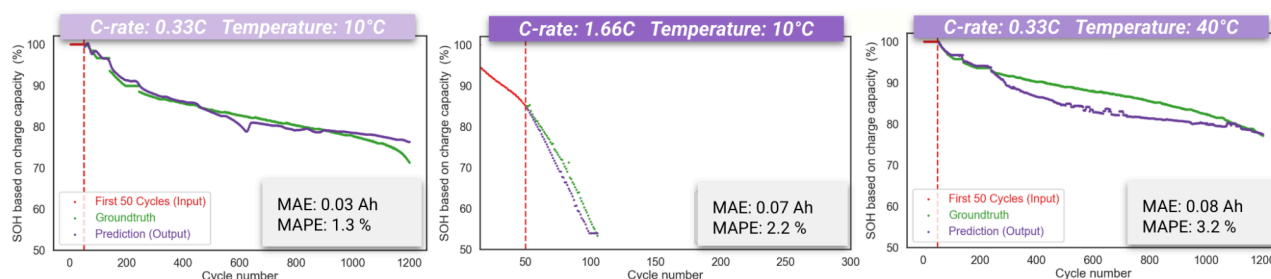
Model adapted to your specific cell chemistries and test protocols. Develop a customer specific high-accuracy model to build IP and your battery intelligence.

3

Inference

Feed beginning-of-life data (50-100 cycles) to get instant SOH predictions, aging curves, and performance simulations for any operating conditions, e.g.: temperature, C-rate, SOC, usage profile, etc.

EXAMPLE: SIMULATION RESULTS for 21700 high power cell – Predict Aging Under Various Conditions – Mean Absolute Percentage Error (MAPE) 1.3–3.2%



USE CASES & BENEFITS

Faster Engineering Decisions

Reliable lifetime predictions after just weeks of cycling data. No more waiting 12+ months for full test results before making design, sourcing, or certification decisions.

Automated P2D & ECM Parametrization

Automatically parametrize Pseudo-2D and Equivalent Circuit Models from initial test data. Eliminates weeks of manual fitting – production-ready physical models in a fraction of the time.

Reduced Test Matrix (DOE)

Simulate untested combinations of temperature, C-rate, SOC window and usage profiles. AI identifies which experiments can be replaced – typically 30% fewer physical tests.

Virtual Cell Qualification

Simulate end-of-life behavior for new cell candidates before committing to full testing. Pre-screen suppliers and chemistries with AI-powered predictions from minimal data.

ENGAGEMENT & PRICING

1

Proof of Concept (POC)

Base model fine-tuned with a sample of your data. EoL prediction within weeks with full model insights and explainability metrics.

2

Fine-Tuning

Customer-specific model on your proprietary data. All IP remains with you, run on your premises.

3

Deployment & License

Private cloud or on-premises within your infrastructure. Ongoing updates, new cell onboarding, continuous improvement and quarterly fine tunings.

Initial Setup & Fine-Tuning Fee

One-time: POC, data integration, model training.

Annual License Fee

Platform access, model updates, cell onboarding, support.

ROI: Payback in Months, Not Years

30% fewer physical tests · Weeks to first prediction instead of months · One unified battery intelligence

Sphere Energy

www.sphere-energy.eu | info@sphere.energy

AI-Assisted Crash Simulation

Powered by APEX AI OS – Crash Intelligence

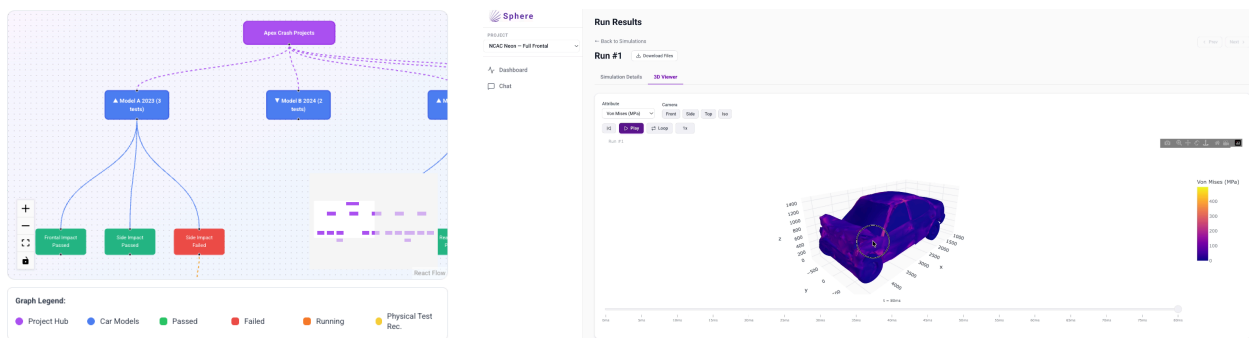
100+ SYNTHETIC AND REAL TESTS	>70% FASTER INSIGHT GENERATION	30% SAVINGS OF COMPUTE COST
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While high-fidelity crash simulations are critical for vehicle safety certification and structural optimization, analyzing the output data they generate remains a massive bottleneck for CAE teams. Safety engineers currently spend countless hours manually post-processing complex animation files and reviewing thousands of energy and force curves to identify numerical errors, mesh instabilities, or physical anomalies – a tedious process that delays design iterations and wastes expensive compute resources. **APEX AI OS – Crash Intelligence** automates data extraction and anomaly detection to eliminate this friction by rapidly ingesting raw simulation results and systematically flagging unphysical behaviors, contact errors, and statistical outliers. By automating the post-processing pipeline and instantly highlighting critical anomalies, CAE teams can drastically reduce manual review time, prevent broken models from influencing design decisions, and confidently accelerate vehicle safety development.

HOW IT WORKS

<p>1 Database Harmonization</p> <p>Consolidated data pipeline strategy to enable formation of a unique harmonized database comprising multi-modal data from real crash or simulated crash measurements.</p>	<p>2 Model Pre-training & Fine-tuning</p> <p>Trained on 100+ synthetic and real crash test simulations to take into account dynamics of vehicle parts under specified crash conditions. Model adaptation to your specific designs.</p>	<p>3 Part design screening and analysis</p> <p>Feed design and crash test specification along with metadata to enable harmonized database ingestion, AI supported anomaly detection and comparison with historical tests.</p>
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EXAMPLE CRASH SIMULATION RESULTS WITH STRESS DISTRIBUTION PREDICTION AND KNOWLEDGE GRAPH GENERATION



USE CASES & BENEFITS

<p>Build a crash test knowledge graph</p> <p>Automated comparison of crash tests and simulation results. Enables data & documents to be easily accessible and foster cross-team collaboration within different projects.</p> <p>Systematic anomaly detection</p> <p>Automatically check new simulation for anomaly based on historical data and similar comparison.</p>	<p>Crash test insights</p> <p>Pinpoint root causes by delivering detailed reports about comparison insights and detected anomalies. Find out components or properties that have led to unexpected behaviour.</p> <p>Agentic workflow with data and tests</p> <p>Chat assistant to deep dive into the simulation results. Retrieve relevant information across simulations and explanations of results.</p>
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ENGAGEMENT & PRICING

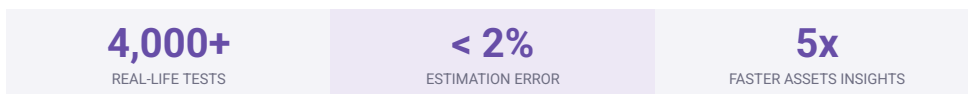
<p>1 Proof of Concept on data harmonization</p> <p>Build an ad-hoc pipeline to support multi-modal (documents, videos, images, CAD ...) data ingestion and consolidation for real and simulated crash tests.</p>	<p>2 Fine-Tuning</p> <p>Customer-specific fine-tuned model on your proprietary data. Screening and anomaly detection logics tuned to use case of interest.</p>	<p>3 Deployment & License</p> <p>Private cloud or on-premises within your infrastructure. Ongoing updates, continuous improvement of reasoning capabilities and quarterly fine tunings.</p>
<p>Initial Setup & Fine-Tuning Fee</p> <p>One-time: POC, data integration, model fine-tuning.</p>	<p>Annual License Fee</p> <p>Platform access, model updates, reasoning upgrades and support.</p>	

ROI: Payback in Months, Not Years

One unified platform for real and simulated crash data · 70% faster insight generation

AI-Assisted Battery State of Health (SOH) estimation

Powered by APEX AI OS – Battery Foundation

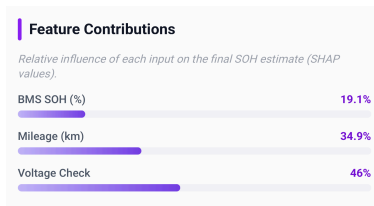
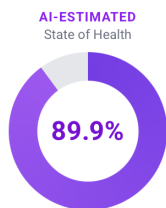


Whether powering an electric vehicle, a grid-level Energy Storage System (ESS), or an industrial fleet, accurate State of Health (SOH) estimation is the deciding factor in asset valuation and operational safety. However, traditional SOH testing tools are fundamentally flawed: they struggle to map non-linear battery degradation and consistently fail to accurately estimate dynamic internal resistance without operationally unscalable, full-cycle testing. Relying solely on standard Battery Management System (BMS) readouts is equally deceptive. **APEX AI OS – Battery Intelligence** overcomes these limitations by utilizing a flexible, data-driven framework which extracts existing system data and refines it dynamically using time-series data captured during a routine, rapid charge measurement. By progressively layering this data, the model delivers independent, lab-grade accuracy that seamlessly scales to match the specific time constraints and accuracy requirements of any integrated battery application.

HOW IT WORKS

<p>1 Pre-Training</p> <p>Trained on 4,000+ real-life cycling tests and >100M material configurations, the model has learnt to process data recorded as part of a routine battery charging process.</p>	<p>2 Fine-Tuning</p> <p>Augment model capabilities with historical operational data and additional use case-specific inputs. Develop a customer interface to monitor and estimate the SOH of independent assets.</p>	<p>3 Inference</p> <p>Feed real-time data to obtain instantaneous SOH predictions as well as expected aging curves. Benchmark independent assets and obtain comparative information.</p>
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EXAMPLE: GENERATED STATE-OF-HEALTH REPORTS AND CORRESPONDING INSIGHTS



DEVIATION VS VOLTAGE-CHECK SOH ↑ AI above BMS

+0.76%

Voltage curve analysis indicates higher actual capacity than BMS reports. The BMS may be underestimating remaining battery capacity.

USE CASES & BENEFITS

<p>Electric Vehicle Ecosystems</p> <p>The model establishes a baseline by contextualizing standard BMS readouts and mileage against historical fleet averages. It then refines this estimate using time-series data from a rapid, 10-minute dynamic voltage check.</p> <p>"Zero-to-One" Model Deployment (Lab Data Modality)</p> <p>Allows OEMs and diagnostic companies to roll out functional SOH estimation tools for new vehicle platforms immediately, without waiting years to collect real-world aging data.</p>	<p>Grid-Level Energy Storage Systems</p> <p>Leveraging the ESS's continuous operational logs, standard BMS data, and short charging to accurately monitor the health of specific modules without interrupting grid services, ensuring stability and preventing thermal events.</p> <p>Few-Shot Field Calibration (Full-Cycle Modality)</p> <p>Drops the SOH estimation error from 5% down to a highly precise 2.5%, ensuring warranty decisions and valuations are based on mathematically rigorous, field-calibrated truths.</p>
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ENGAGEMENT & PRICING

<p>1 Proof of Concept (POC)</p> <p>Base model tested with a sample of your data. AI-assisted SOH estimations on your historical data along with insights generation for benchmarking.</p>	<p>2 Fine-Tuning</p> <p>Customer-specific model on your proprietary data. All IP remains with you, run on your premises. Full validation with your assets.</p>	<p>3 Deployment & License</p> <p>Private cloud or on-premises within your infrastructure. Ongoing updates, new data onboarding, continuous improvement and quarterly fine tunings.</p>
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<p>Initial Setup & Fine-Tuning Fee</p> <p>One-time: POC, data integration, model training.</p>	<p>Annual License Fee</p> <p>Platform access, model updates, cell onboarding, support.</p>
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ROI: Payback in Weeks, Not Months

Real-time SOH estimation · Asset-specific insights for preventive maintenance and resell value estimation

Automatic CAD Processing & Feature Extraction at Scale

Powered by APEX AI OS – CAD Designer

+60k

CAD - PARTS IN TRAINING

> 350

AUTOMATED CAD MODEL GENERATED

< 5%

FEATURE EXTRACTION ERROR

95%

ENGINEERING TIME REDUCTION

Despite modern engineering organizations managing thousands of CAD parts, most geometry data remains unstructured and underutilized. Manual feature extraction, classification, and validation consume valuable engineering time and introduce inconsistencies. **APEX AI OS – CAD Intelligence** automatically processes and scales CAD part analysis, converting raw geometry into structured, searchable, and actionable data. The system extracts geometry features, classifies components, detects anomalies, and prepares clean datasets for downstream applications such as costing, manufacturability analysis, and design optimization. One unified AI engine that learns from every processed CAD model – becoming more accurate, faster, and more robust over time.

HOW IT WORKS

1

Pre-Training

Trained on 66k synthetically generated CAD models to teach fundamental design elements such as: holes, cut-outs, bends, flanges joining features etc.

2

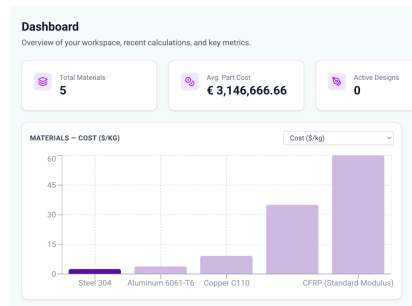
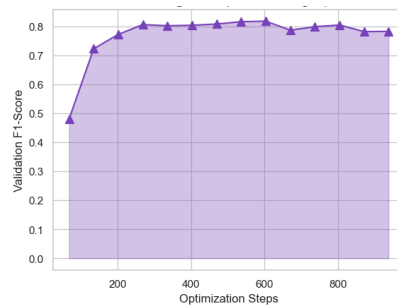
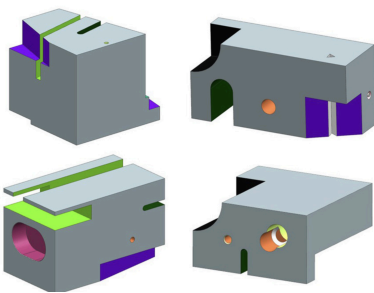
Fine-Tuning

The model is fine-tuned on customer-specific CAD datasets and desired model outputs such as cost relevant features, company specific part classifications.

3

Manage your intelligent CAD database

For any new CAD model, the system automatically predicts the desired outputs. Save and manage all Models in one tool.



USE CASES & BENEFITS

Automated Feature Extraction

Instantly identify cost- and manufacturing-relevant geometry attributes. Prevents redundant redesigns, cleans up cluttered databases, and allows engineers to instantly retrieve existing parts instead of starting from scratch.

Design optimization enablement

Couple automated geometry analysis with evaluation engines to enable closed-loop design optimization.

Intelligent Part Classification

Automatically group parts by function, structure, or production method. Accelerates the quoting process and improves pricing accuracy by eliminating the manual, subjective counting of features and material requirements.

Anomaly & Error Detection

Detect missing features, inconsistent geometry, or deviation from design rules. Ensures that downstream tools and manufacturing teams only receive clean, validated datasets, preventing expensive delays on the production floor.

ENGAGEMENT & PRICING

1

Proof of Concept (POC)

Base model fine-tuned with a sample of your data. Part classification and design of downstream tasks of interest.

2

Fine-Tuning

Customer-specific model on your proprietary data. All IP remains with you, run on your premises. Models tuned with extended parts and design components.

3

Deployment & License

Private cloud or on-premises within your infrastructure. Ongoing updates, new design onboarding, continuous improvement and quarterly fine tunings.

Initial Setup & Fine-Tuning Fee

One-time: POC, data integration, model training.

Annual License Fee

Platform access, model updates and support.

ROI: 95% reduction of engineering time

30% more efficient design · Automated optimization via part classification · Unified tool for design screenings