AI-Based Ballpark Quotation Tool

Checkpoint 3: Results & Agents

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Project Objective

- Develop an AI-based tool for fast ballpark R&D estimations
- Automatically extract key information from PR Excel files
- Use historical PR–Offer pairs as training data
- Predict **function-level** R&D effort breakdown
- Allow Customer Managers and Function Owners to refine results

Value Proposition

- **For the Customer Manager:**
  - **Speed:** Instant preliminary estimations replace days of manual analysis.
  - **Accuracy:** Data-driven predictions improve consistency across all quotations.
  - **Efficiency:** Drastic reduction in manual workload, allowing focus on high-value tasks

- **For the Business:**
  - **Agility:** Faster "Go/No-Go" decisions accelerate the sales cycle.
  - **Standardization:** A unified process across all functions and departments

Sustainable Development Goal

- **SDG 9: Industry, Innovation and Infrastructure**
  - *Enhancing industrial capability through digitalization and AI-driven automation.*

- **SDG 12: Responsible Consumption and Production**
  - *Reducing "Engineering Waste" by minimizing duplicated efforts and optimizing resource planning*

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Product Request

Input: Excel File

	PRODUCT REQUEST	PR 21031 Rev G

Title: CWL New Model 100 hp

Platform: CWL	**Plant: PLANT-LE**
Engine: E3F6	**Tier: STAGE V**

Vehicle Models:
Mac CE C.WhL

Description:
Mac CE C.WhL: E3F6, STAGE V, Boosted Curve : Rated Power : 71.9 kw @ 2200 RPM, Peak Power : 83.8 kw @ 2000 RPM, Max Torque : 453 Nm @ 1400 RPM
Mac CE C.WhL with E3F6 3.6L SCR-T 72kW Stage V engine with related compliant ATS (same concept of Mac CE T.LB in term of rating, ATS as Mac AG SPE vehicle) for Europe.

Mac CE C.WhL E3F6 3.6L SCR-T 72kW Tier4b engine with related compliant ATS (same concept of Mac CE T.LB in term of rating, ATS as Mac AG SPE vehicle) for NAFTA.

Engine controller will be ECU1. Dataset configured at 500kbps (no auto-baud rate) both for Stage V and T4B.

Replace oil Sump from Mac CE T.LB version to current CWL

Because of the necessities to have a dedicated PTO for emergency steering we need to adopt a

solution similar to SPE1 Tractors trought engine gearbox.

The change require to remove current oil fill tube and relocate it as per SSL solution with:
tube; Plug

The current oil fill tube will be plugged by COMPANY . CUSTOMER will fitup on EU units the Adaptor and pump for emergency steering

The change is required for stage V engine but the same modification can be extended to tier4B in order to manage one engine hardware.

Other change required is to relocate the relief valve currently installed on head cover where will be placed oil fill tube.

CUSTOMER officiallized investments for metal RACKs to support engines logistic transportation. Engine price should be revise consequently (no wooden pallet)

Updated Volumes + Added 1 DU

Evaluate the possibility to have one engine + ATS only, Stage V version, for EPA and ECE homologation on both EU and NA market. The volumes will remain the same

COUNTRIES SOLD TO: Europe, North America, ANZ (Australia, New Zeland)

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Proposed Quote

Function Level R&D

Engineering Activity Summary and R&D expenses forecast (PE.02)

PE Function		Program Main Activities Description	Effort [hrs]			K€
			Manpower	Bench	Vehicle	
Project Management		• Activity tracking and deliverable readiness	1170			100
Design	Base Design	• Release 4 new p/n of engine in PRP new drawings of engine (eVGT and WG), new flywheel, new exhaust flap orientation, new wiring harness (2), new fan pulley (1,4) ratio • Basic tech for ATS CFD, vibration and torsional analysis, verification for front PTO and calculation for 2 front end	2500 950			83
	ATS	• Installation checks of ATS and sensors ; assessment of full exhaust line, Kit ATS release, fluids analysis	840			
	EMS	• Analysis of E/E system architecture and customer requirements according to Functional Safety approach • Verification of vehicle Interface functions	1600			20
	OBD	• OBD verification according to Stage V / Tier4B, support for OBD verification on bench, support for field test	960			48
Bench	Dev & Rel	• Calibration development for top power specific rating with specific base combustion with 1 HW of engine and 1 Kit ATS OBD verification	1080	1080		460
		• E15x1 overload (gamma)	160	500		66
		• E2 (thermal shock)	600	1800		239
		• E39 test (gamma)	1100	3300		438
		• E46 test (gamma)	250	750		99
		• E75 test (gamma)	500	1500		199
		• DF test	2300	4000		812
		• Homologation tests for USA	160	160		50
		• Homologation tests for EU	240	240		80
Application		• QG readiness and dataset release, (4 rating) calibration optimization on 2 vehicles, installation and functional checks (application sign off) / field test support →mid light classification top rating, 1 light and 2 super light • Dataset release	8800			194 18
Supplier R&D		• SupplierB related functions calibration, installation and functional verification on machine for DeNox and FIE • ATS Canning skin temperature for different layout, shaker test for new top rating, release drawing and validation for new DOC and SCROF				150 160
Technical Certification		• Managing official test for Homologation activities for EU/USA (1 parent)	400			30
Materials & Travels		• Materials • travels				40 10
					TOTAL	3.296

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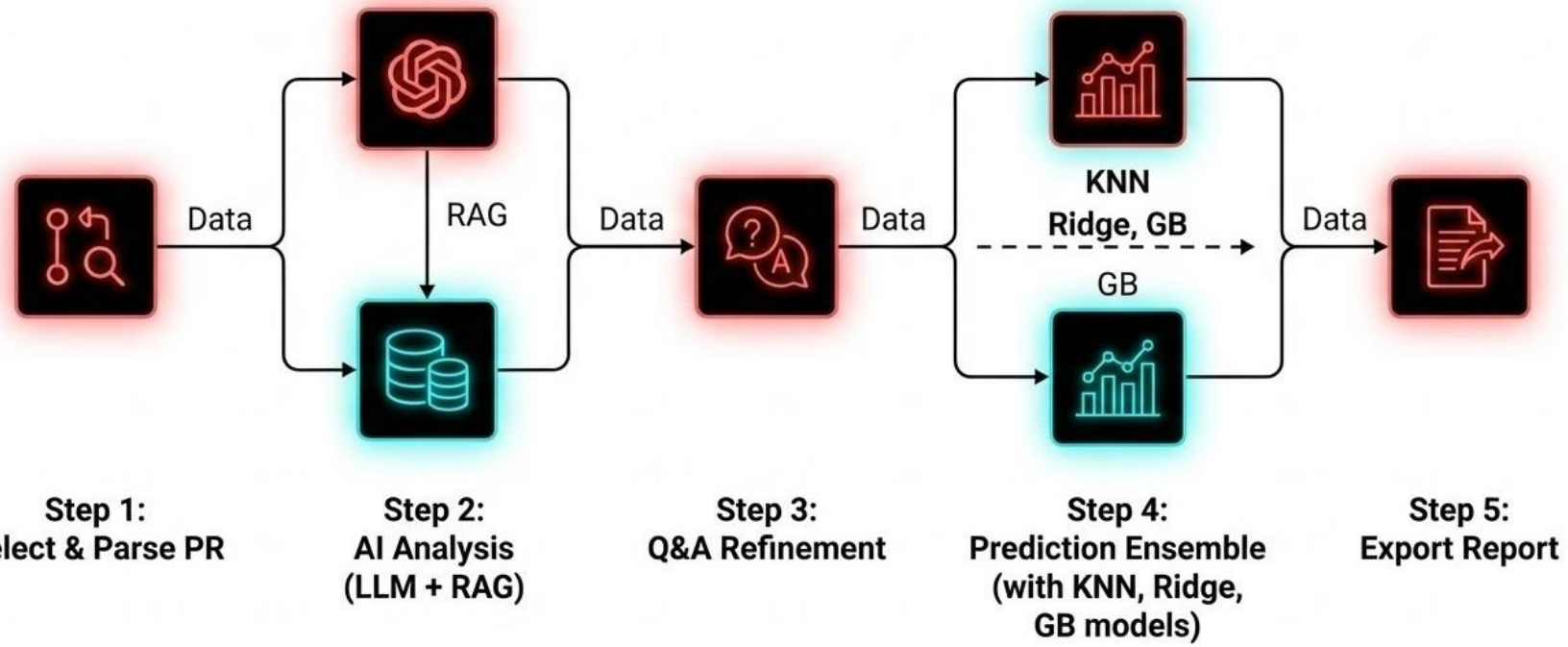
Research Questions

- **RQ1 - The "Small Data" Challenge:** How can we build a reliable prediction model with only 37 historical samples?
- **RQ2 - Architecture Selection:** Is a standalone regression model sufficient for business decision-making?
- **RQ3 - Scalability & Future Proofing:** Will this architecture hold up when IVECO digitizes more data?
- **RQ4 - Explainability:** How can we make AI decisions transparent for engineers?

LLM Based Pipeline and Interface for Tool



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RQ1

Methodology

Data Pipeline & Feature Engineering

- **Dataset Foundation**

  Our methodology began with a meticulously curated dataset of **37 historical Project Records (PRs)**, ensuring a clean and reliable base for model training.

- **Transformative Feature Engineering**

  A critical step involved advanced feature engineering, including Log-Transformation to address significant variance (e.g., €7k vs. €10M projects).

- **Enhanced Project Complexity**

  We generated **12 new** features, such as 'Calibration Ratio', to more accurately capture and represent project complexity within the model.

RQ1

Retrieval Engine

Grounding Predictions via Qdrant

- **Mechanism:** Semantic Search using Vector Embeddings
- **Database:** Qdrant stores historical project vectors
- **Action:** For each cost cluster, finds Top-3 "Nearest Neighbors"
- **Grounding:** Prevents hallucinations by anchoring predictions in real historical data
- **Value:** Provides analogical reasoning - "This project is similar to these 3 past projects"
- **Confidence:** Historical context increases stakeholder trust in estimates
- Retrieval acts as data amplification in low-sample settings

RQ2

The Ensemble Engine

Hybrid ML + RAG Prediction Architecture

- **ML Model:** Hierarchical Conformal Quantile Ensemble
  - Learns patterns from feature engineering
  - Captures non-linear relationships
- **RAG Model:** Historical Average from Top-3 Neighbors
  - Learns from specific analogies
  - Grounds predictions in reality
- **Hybrid Formula:** Final Cost = α(ML) + β(RAG)
  - Optimal weighting balances statistical rigor with historical grounding
- **Performance: $R^2 = 0.88$**
  - Explains 88% of variance in real project costs
  - Best performance achieved on actual historical data

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RQ2

RAG System

Contextualised Cost Justification

Beyond Numerical Guesses

Our AI tool doesn't just provide cost figures; it offers depth and justification, moving beyond mere numerical predictions.

Retrieval from Qdrant

The Retrieval Augmented Generation (RAG) system actively searches and retrieves the top-3 most similar 'Reference Projects' from our Qdrant vector store.

Providing Context & Confidence

These retrieved projects provide invaluable historical context, enabling the AI to justify the estimated cost and enhance stakeholder confidence.

RQ3,4

The Analyst Agent

DeepSeek V3 Reasoning Layer

- **Role:** Synthesis & Reasoning (not just numerical output)
- **Input:** ML predictions + RAG context + historical patterns
- **Processing:** DeepSeek V3 analyzes and synthesizes all signals
- **Output:** Business-ready report explaining "Why" the cost is high
- **Intelligence Features:**
  - Flags risks and anomalies (e.g., "Calibration hours 2x historical average")
  - Provides confidence intervals and uncertainty bounds
  - Generates executive summary with key drivers
  - Recommends mitigation strategies for high-risk areas
- **Value:** Transforms raw predictions into actionable business intelligence

RQ4

Comprehensive

Output: The Excel Report

The final output of our AI-Based Ballpark Quotation Tool is a detailed, user-friendly Excel report, designed to provide comprehensive insights briefly.

Executive Summary

Detailed Cost Breakdown

Confidence Intervals

Clearly defined confidence levels for the estimation, providing a realistic range and aiding in strategic decision-making.

Model Benchmarks

- **Baseline:** Linear Regression (R^2= 0.81) — *Good baseline, stable performance.*
- **Iteration 2:** Random Forest (R^2 = 0.89) — *Tried boosting, but performance dropped slightly.*
- **Final (HCQE):** Ensemble + Decomposition (R^2 = 0.88) — *High accuracy achieved (Ours).*

Model	Within 30%	Within 50%	MAE (K€)	R²
Linear Regression	39.4%	66.7%	1,344	0.81
Ridge (α=10)	36.4%	63.6%	1,341	0.81
Lasso	39.4%	66.7%	1,336	0.81
SVR (Linear)	42.4%	69.7%	1,125	0.79
Decision Tree	75.8%	84.8%	973	0.76
AdaBoost	45.5%	66.7%	1,491	0.63
Random Forest	48.5%	75.8%	911	0.89
Extra Trees	69.7%	84.8%	797	0.89
HCQE (Ours)	**78.8%**	**84.8%**	**625**	**0.88**

Live Demo

Manage – Gantt (updated)

: Completed

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THANK YOU

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WE GO BEYOND