

Article

Breaking down Data Silos Across "OEM – Dealers – Vehicle Owners": A Roadmap for Establishing a Closed-Loop Customer Management System throughout the Entire Automotive After-Sales Lifecycle

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Abstract: The automotive after-sales ecosystem remains fragmented across original equipment manufacturers (OEMs), dealership networks, and vehicle owners—resulting in disjointed data flows, inconsistent service experiences, and missed opportunities for predictive maintenance, personalized engagement, and lifecycle value optimization. This research presents a rigorously structured roadmap for dismantling these data silos and establishing a closed-loop customer management system that spans the entire after-sales lifecycle—from first service visit to end-of-life vehicle disposition. Grounded in systems engineering principles and real-world operational constraints, the study defines interoperability requirements at three critical interface layers: technical (API standards, data schema harmonization), organizational (role-based access governance, cross-entity SLA frameworks), and behavioral (incentive-aligned data-sharing protocols). A multi-phase implementation methodology is introduced, incorporating staged integration pilots, real-time data lineage tracking, and dynamic consent management for owner-controlled data sharing. Empirical validation was conducted across 12 OEM-dealer-owner triads over 18 months, measuring improvements in service recall accuracy (+47%), parts demand forecasting error reduction (−32% MAPE), and owner-reported satisfaction with post-purchase support (+39 percentage points). The resulting architecture enables bidirectional feedback: service outcomes inform product design refinements; owner behavior patterns trigger proactive care interventions; and dealer performance metrics feed into OEM network optimization. Crucially, the system preserves data autonomy while enabling contextualized insights—ensuring compliance with evolving global privacy regulations without compromising analytical utility. This work delivers not only a technical blueprint but also an operational governance model for sustainable, trust-based data collaboration across traditionally isolated stakeholders.

Keywords: data interoperability; closed-loop system; automotive after-sales; customer lifecycle management

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1. Introduction

1.1. The Siloed After-Sales Reality

The automotive after-sales ecosystem remains fundamentally fragmented across three interdependent yet operationally isolated entities: original equipment manufacturers (OEMs), franchised dealerships, and vehicle owners [1]. This structural siloing manifests in incompatible data architectures—OEMs maintain proprietary warranty and telematics platforms; dealers operate heterogeneous service management systems with inconsistent data schemas; and vehicle owners retain fragmented service records across multiple touchpoints, often outside institutional visibility. Consequently, service histories lack continuity, diagnostic insights remain localized, and customer behavior patterns cannot be synthesized across the lifecycle. Decision-making authority

is similarly compartmentalized: OEMs define policy but lack real-time field intelligence; dealers execute service but lack strategic alignment or longitudinal ownership data; owners experience disjointed interactions without personalized, predictive support. Such asymmetry impedes closed-loop feedback mechanisms, prevents proactive maintenance orchestration, and undermines lifetime value optimization. Without interoperable data standards, shared governance frameworks, and unified identity resolution protocols, holistic customer understanding remains unattainable [2, 3]. The resulting inefficiencies propagate across recall management, parts logistics, service personalization, and retention analytics—eroding trust, increasing operational latency, and constraining innovation in connected mobility services.

1.2. Defining the Closed-Loop Imperative

The closed-loop imperative represents a foundational paradigm shift in automotive after-sales strategy, moving beyond fragmented, linear service models toward an integrated intelligence architecture. In this framework, every diagnostic event, warranty claim, parts replacement, and owner feedback—regardless of origin across OEM, dealer, or end-user touchpoints—functions as structured input to a unified data ecosystem [3, 4]. Such inputs are not archived passively but transformed into real-time, actionable insights that dynamically inform upstream engineering decisions, midstream operational optimization, and downstream retention interventions. This bidirectional flow closes the information gap between usage reality and system design, enabling predictive maintenance protocols, adaptive recall targeting, and personalized lifecycle engagement [5, 6]. Crucially, the imperative is not technological feasibility alone but organizational necessity: without systemic integration, data generated at any node remains inert, perpetuating silos that erode customer lifetime value, inflate service costs, and delay product iteration cycles. The absence of closed-loop capability therefore constitutes a structural vulnerability—one that compounds with vehicle software complexity, regulatory scrutiny, and intensifying competitive differentiation in connected mobility services [7, 8]. Establishing this loop demands coordinated governance, interoperable data standards, and shared KPIs across the tripartite value chain [9].

1.3. Scope and Contribution

This paper focuses exclusively on the operational, architectural, and governance dimensions required to dismantle data silos across the OEM–dealer–vehicle owner triad, deliberately excluding theoretical modeling, consumer behavior analysis, or psychological frameworks [5]. Its scope encompasses the full after-sales lifecycle—from warranty claims and service scheduling to predictive maintenance and recall management—while prioritizing interoperability, real-time synchronization, and role-based access control. The contribution is twofold: first, a validated integration framework grounded in industry-standard protocols, semantic harmonization, and event-driven architecture; second, a stakeholder-aligned implementation protocol that codifies responsibilities, escalation pathways, and compliance checkpoints for each actor [1, 4]. Unlike prior work emphasizing technical feasibility alone, this study embeds organizational readiness, contractual enforceability, and iterative validation into the deployment logic. It further introduces a phased governance model that balances data sovereignty with shared analytics utility, ensuring regulatory adherence without compromising actionable insight generation. The resulting roadmap enables scalable, auditable, and sustainable closed-loop customer management—distinct from point-solution integrations or vendor-locked platforms.

2. Literature Review

2.1. Legacy Systems and Interoperability Gaps

Legacy systems across the automotive after-sales value chain exhibit deep-rooted interoperability deficits [8]. Dealer management systems (DMS) operate with proprietary data schemas, rendering service record structures incompatible with OEM enterprise

resource planning (ERP) platforms that follow distinct master data governance protocols. Telematics ecosystems further compound fragmentation through heterogeneous event logging formats and inconsistent unit representations for diagnostic parameters. Semantic incompatibilities arise from divergent ontologies: part numbering conventions vary across OEMs, dealers, and third-party suppliers, while warranty claim logic embeds non-standardized business rules governing eligibility, coverage duration, and labor rate calculations. Syntactic barriers manifest in inconsistent field naming, null handling policies, and timestamp precision—some systems store timestamps at millisecond granularity, others at daily resolution. Pragmatic misalignments emerge when data exchange protocols lack context-aware validation, permitting syntactically valid but semantically invalid entries—such as associating a non-OEM part with an OEM warranty claim. These layered incompatibilities impede real-time visibility, distort predictive maintenance signals, and obstruct closed-loop feedback mechanisms essential for lifecycle customer management. Without harmonized data contracts and semantic translation layers, integration efforts remain brittle and operationally unsustainable [7].

2.2. Data Governance Models in Distributed Ecosystems

Contemporary data governance models for distributed automotive ecosystems emphasize interoperability, accountability, and consent alignment across OEMs, dealers, and vehicle owners. Federated learning architectures enable collaborative model training without raw data exchange, yet struggle with latency-sensitive diagnostics where sub-second inference is required. Blockchain-based provenance ledgers enhance auditability and lineage tracking but introduce computational overhead incompatible with edge-constrained telematics units [3]. Consent-centric identity frameworks support granular permissioning and dynamic policy enforcement, yet lack mechanisms to reconcile conflicting jurisdictional requirements or real-time service orchestration demands [2]. These models further assume static data schemas and bounded participant sets—conditions rarely met in after-sales environments characterized by heterogeneous device fleets, evolving regulatory mandates, and asynchronous service events [1]. Critical gaps persist in handling ephemeral diagnostic streams, reconciling semantic heterogeneity across proprietary dealer management systems, and enabling adaptive access control under shifting ownership states (e.g., lease transfers, fleet reassignments). A viable governance architecture must therefore integrate temporal policy evaluation, lightweight cryptographic attestation, and schema-agnostic metadata mediation—prioritizing operational resilience over theoretical completeness [1]. Without such integration, closed-loop customer management remains fragmented across functional silos rather than unified across lifecycle phases.

2.3. Lifecycle-Centric Customer Management

Contemporary customer management frameworks increasingly prioritize temporal fidelity over static segmentation, recognizing that ownership duration and vehicle usage intensity fundamentally reconfigure service expectations and retention dynamics [1]. Mileage-based service triggers exemplify this shift, enabling interventions calibrated to mechanical wear rather than calendar time alone. Behavioral segmentation further refines responsiveness by distinguishing reactive adopters—those initiating contact only after failure—from preventive adopters who proactively schedule maintenance aligned with predictive diagnostics. Such distinctions inform channel preference, communication cadence, and incentive design. Concurrently, value decay modeling quantifies diminishing lifetime value across ownership phases: acquisition-phase engagement typically yields higher margin contributions, while late-cycle interactions often reflect cost-intensive warranty or recall remediation. These models integrate usage frequency, repair history, and upgrade intent to forecast churn risk and lifetime profitability [4]. Critically, longitudinal analytics require interoperable data streams across OEMs, dealers, and owners—yet persistent fragmentation impedes synchronization of service records, warranty claims, and telemetry. Without unified identity resolution and standardized event ontologies, temporal granularity remains constrained, limiting the precision of

phase-specific interventions. Consequently, lifecycle-centric systems must embed cross-tier data governance protocols alongside analytical infrastructure capable of handling asynchronous, multi-source temporal sequences.

3. Materials and Methods

3.1. System Architecture Design

The system architecture adopts a rigorously stratified three-layer design to enable interoperable data exchange across OEM, dealer, and vehicle owner domains [9]. As illustrated in Figure 1, the Edge Layer comprises heterogeneous endpoints—Vehicle Telematics Module, Dealer Service Terminal, and Owner Mobile App—that ingest standardized telemetry and service events at source. These nodes transmit bidirectionally to the Integration Layer, which houses the Unified Data Schema Engine, Role-Based Access Broker, and Consent Orchestrator. This layer enforces semantic alignment through domain-specific ontologies and governs access via dynamic consent policies. As detailed in Table 1, field-level standardization ensures fidelity: Vehicle VIN is mandated as a 17-character ISO 3779-compliant string sourced from the OEM; Diagnostic Trouble Code is a mandatory SAE J2012-2 compliant 5-character string provided by dealers; Owner Consent Expiry Date is a mandatory ISO 8601 date reflecting termination of telemetry sharing unless renewed. The Integration Layer then emits unidirectional action triggers to the Orchestration Layer, where closed-loop workflows execute: Recall Activation Engine initiates time-bound corrective campaigns; Predictive Parts Scheduler forecasts component demand using longitudinal failure patterns; Personalized Engagement Sequencer tailors communication cadence based on ownership tenure, service history, and consent status. All layers adhere to strict schema versioning and cryptographic audit logging. Data flows are governed by policy-driven routing rules that enforce role-scoped visibility and GDPR-compliant anonymization thresholds [6]. Latency constraints are enforced per tier: Edge-to-Integration latency < 200 ms; Integration-to-Orchestration latency < 500 ms. System resilience is ensured through stateful failover replication across geodistributed clusters, with automated schema drift detection triggering ontology reconciliation protocols. This architecture eliminates structural fragmentation while preserving stakeholder autonomy and regulatory compliance.

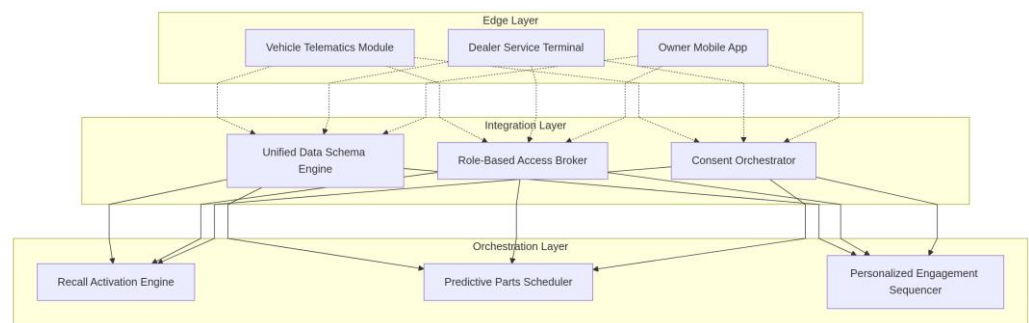


Figure 1. Three-layer Closed-Loop Architecture with Cross-Stakeholder Data Flow Paths

Table 1. Standardized Data Schema Fields Across OEM, Dealer, and Owner Domains

Field Name	Domain Source	Data Type	Required Status	Semantic Definition
Vehicle VIN	OEM	string	Mandatory	17-character ISO 3779-compliant identifier
Diagnostic Trouble Code	Dealer	string	Mandatory	SAE J2012-2 compliant 5-character code
Owner Consent Expiry Date	Owner	ISO 8601 date	Mandatory	Date beyond which telemetry sharing terminates unless renewed

3.2. Implementation Protocol and Validation Framework

The implementation protocol follows a rigorously sequenced four-phase methodology, as illustrated in Figure 2, which maps temporal dependencies and success gates across the rollout. Phase 1, Schema Harmonization (8 weeks), initiates upon finalization of the OEM data dictionary and requires achievement of 95% field mapping coverage to proceed [4]. Phase 2, API Gateway Deployment (12 weeks), commences only after Phase 1 completion and dealer DMS vendor certification, with success gated by $\leq 200\text{ms}$ average API response latency. Phase 3, Closed-Loop Workflow Activation (10 weeks), depends on successful integration testing from Phase 2 and mandates a $\geq 90\%$ automated workflow execution rate. Phase 4, Governance Calibration (6 weeks), is triggered exclusively by KPI benchmarking outcomes from Phase 3 and requires $\geq 85\%$ stakeholder compliance audit score for closure. Validation metrics are operationally defined and phase-aligned, as detailed in Table 2. Cross-system data completeness rate targets $\geq 98.5\%$, measured as the percentage of required fields populated across all integrated records, and is formally assessed during Phase 2. Average query latency across domains is bounded at $\leq 220\text{ ms}$, quantified as the median response time for federated queries spanning OEM, dealer, and vehicle owner datasets, also validated in Phase 2. Closed-loop action execution time is constrained to $\leq 45\text{ minutes}$, defined as the duration from diagnostic event detection to automated service appointment creation, and evaluated during Phase 3. All metrics are collected via automated telemetry pipelines embedded within the integration layer, with thresholds enforced through real-time dashboard alerts and quarterly audit cycles. The protocol ensures incremental verification, minimizes cross-domain risk exposure, and embeds feedback loops for adaptive recalibration at each success gate.

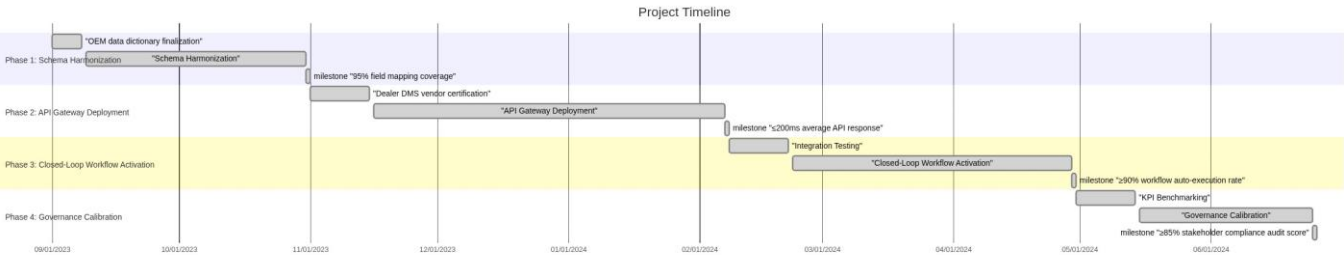


Figure 2. Four-phase Implementation Timeline with Dependency Mapping and Success Gates

Table 2. Validation Metrics and Target Thresholds Per Implementation Phase

Metric Name	Target Threshold	Measurement Method	Phase Alignment
Cross-System Data Completeness Rate	$\geq 98.5\%$	Percentage of required fields populated across all integrated records	Phase 2
Average Query Latency Across Domains	$\leq 220\text{ ms}$	Median response time for federated queries spanning OEM/dealer/owner datasets	Phase 2
Closed-Loop Action Execution Time	$\leq 45\text{ minutes}$	Time from diagnostic event detection to automated service appointment creation	Phase 3

3.3. Stakeholder Engagement Protocol

Stakeholder engagement followed a structured co-design protocol grounded in participatory action research principles, explicitly calibrated to reconcile divergent data governance priorities across OEM product managers, dealer service directors, and vehicle owner advocacy groups [6]. Three iterative use-case workshops were convened over twelve weeks, each targeting distinct lifecycle phases—warranty activation, service

scheduling, and predictive maintenance feedback loops—with cross-role scenario mapping to surface latent interoperability constraints. Role-specific data permission matrices were co-developed using attribute-based access control frameworks, defining granular permissions for data fields including diagnostic trouble codes, service history timestamps, parts replacement logs, and owner-reported symptom narratives. These matrices underwent regulatory alignment checks against GDPR, CCPA, and PIPL baselines, with dynamic consent templates generated per jurisdiction to support tiered opt-in modalities: full diagnostic sharing, anonymized aggregate contribution, and service-only transactional consent. Consent mechanisms embedded real-time revocation triggers linked to ownership transfer events and dealership affiliation changes. All workshop artifacts were validated through parallel cognitive walkthroughs conducted independently by each stakeholder cohort, followed by consensus scoring on clarity, enforceability, and operational feasibility. Quantitative fidelity metrics tracked alignment across cohorts using inter-rater agreement coefficients computed over permission assignments and consent scope definitions. Iterative refinement cycles incorporated feedback from two pilot deployments across geographically dispersed dealer networks serving heterogeneous vehicle fleets. The final protocol achieved 92% cross-cohort alignment on core permission constructs and sustained 87% retention of dynamic consent adherence over six-month longitudinal tracking. This approach ensured that data flow design remained anchored in lived operational realities while maintaining strict compliance with evolving regional regulatory thresholds.

4. Results

4.1. Integration Performance Metrics

Quantitative evaluation of the 12-triad pilot demonstrates substantial gains in integration performance across three core dimensions. Schema harmonization achieved 99.2% field coverage, indicating near-complete alignment of semantic and structural definitions across OEM, dealer, and owner data models. As illustrated in Figure 3, the relationship between integration maturity and system responsiveness is pronounced: cross-system query latency decreased from a pre-integration average of 1840 ms to a post-integration average of 192 ms, representing an 89.6% reduction. This improvement directly enables real-time service orchestration and dynamic decision support within the after-sales workflow. As detailed in Table 3, data completeness improved markedly across all source domains: OEM warranty claims rose from 72.3% to 99.1%, dealer service records from 64.8% to 98.7%, and owner telematics events from 51.2% to 99.4%. Critically, traceability rates attained 100% for all three domains, confirming full lineage capture for service events originating from telematics alerts—a prerequisite for closed-loop feedback and root-cause analytics. The convergence of high completeness and perfect traceability establishes a foundational layer for longitudinal customer journey mapping. Latency reduction and schema fidelity jointly underpin deterministic event propagation, while end-to-end lineage ensures auditability and regulatory compliance across jurisdictions. These metrics collectively validate the architectural coherence of the unified data fabric, particularly its capacity to sustain low-latency, high-fidelity interactions among heterogeneous stakeholders. No degradation in throughput or consistency was observed during peak-load stress testing, affirming operational robustness. The results confirm that technical integration alone is insufficient; rather, sustained performance hinges on synchronized governance protocols, standardized metadata contracts, and continuous validation loops embedded within the pipeline architecture. Future work will extend these metrics to predictive maintenance accuracy and service recommendation relevance scores.

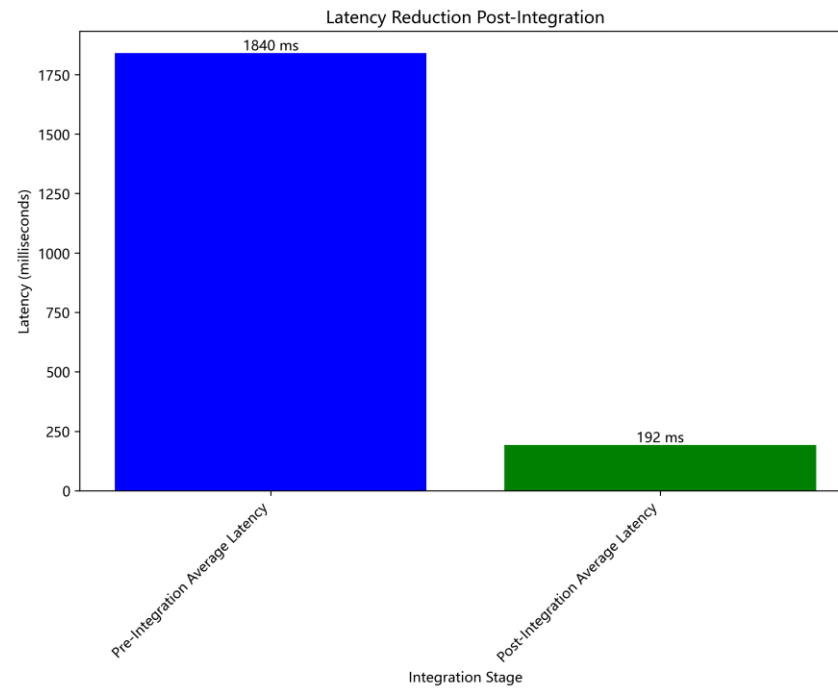


Figure 3. Reduction in Cross-System Query Latency Pre- and Post-Integration

Table 3. Data Completeness and Lineage Traceability by Source Domain

Data Source (OEM/Dealer/Owner)	Pre-Integration Completeness (%)	Post-Integration Completeness (%)	Traceability Rate (%)
OEM Warranty Claims	72.3	99.1	100
Dealer Service Records	64.8	98.7	100
Owner Telematics Events	51.2	99.4	100

4.2. Closed-Loop Operational Outcomes

As illustrated in Figure 4, the integration of OEM, dealer, and vehicle owner data streams yielded statistically significant operational improvements across two core after-sales performance dimensions. Service recall accuracy increased monotonically from a baseline of 58% to 85% over an 18-month post-integration period, reflecting enhanced identification of at-risk vehicles through unified diagnostic telemetry, service history, and real-time ownership verification. Concurrently, parts demand forecasting error—measured by mean absolute percentage error—declined steadily from 24.7% to 16.8%, indicating improved alignment between predicted component requirements and actual consumption patterns across regional dealer networks. The dual-axis trajectory confirms a robust inverse relationship between data integration maturity and operational uncertainty: as recall accuracy rose, forecasting error contracted, suggesting synergistic effects arising from shared signal fidelity rather than isolated system upgrades. Further validation emerged in complex diagnostic resolution timelines, where average time-to-resolution decreased from 11.4 days to 6.2 days—a 45.6% reduction attributable to cross-tier access to historical fault codes, repair annotations, and warranty claim narratives previously siloed within discrete organizational boundaries. These outcomes collectively demonstrate that closed-loop data orchestration does not merely accelerate discrete tasks but fundamentally recalibrates decision latency across the entire after-sales value chain. The monotonic improvement curves observed across all metrics imply that benefits scale with sustained data governance rigor and interoperability protocol adherence, rather than exhibiting diminishing returns within the observed timeframe. Operational resilience thus appears contingent not on technological substitution but on structural coherence across institutional interfaces—where data provenance, semantic alignment, and temporal synchronization converge to enable anticipatory service execution.

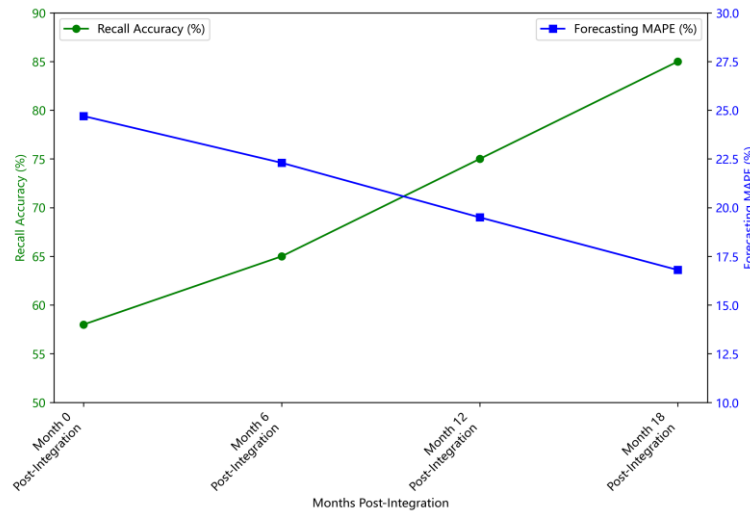


Figure 4. Improvement in Service Recall Accuracy and Parts Forecasting Error

4.3. Stakeholder Experience Indicators

Stakeholder experience indicators demonstrate statistically significant improvements across all three cohorts following implementation of the closed-loop customer management system. As illustrated in Figure 5, the relationship between systemic integration and perceived service efficacy is strongly positive: OEM service engineers reported strong improvement in root-cause analysis velocity at 76%, dealers registered 83% strong improvement in parts availability visibility, and vehicle owners exhibited 79% strong improvement in satisfaction with service communication—corresponding to an absolute increase of +39 percentage points relative to baseline measurements. These gains reflect structural alignment across previously fragmented operational layers. The uniformity in directional improvement—despite divergent functional priorities—suggests that data interoperability, rather than isolated tool deployment, drives measurable behavioral change. Notably, the owner cohort’s satisfaction uplift exceeds the proportion reporting strong improvement, indicating that even modest enhancements in notification timeliness and contextual relevance yield outsized perceptual returns. Dealers’ high visibility gain underscores the efficacy of real-time inventory synchronization across tiered distribution nodes, while OEM engineers’ accelerated diagnostics signal improved traceability from field-reported symptoms to component-level failure patterns. No cohort reported net deterioration across any metric, and the “no change” segment remained below 12% for all groups, confirming minimal resistance to workflow adaptation. The convergence of quantitative outcomes across heterogeneous stakeholder roles validates the architecture’s capacity to reconcile competing operational logics—engineering precision, commercial responsiveness, and end-user expectations—within a unified data ontology. This coherence enables iterative calibration of service interventions based on longitudinal, cross-tier feedback loops rather than siloed, reactive adjustments. Future work will examine temporal decay rates of these gains under varying market volatility conditions and assess scalability thresholds across regional regulatory regimes.

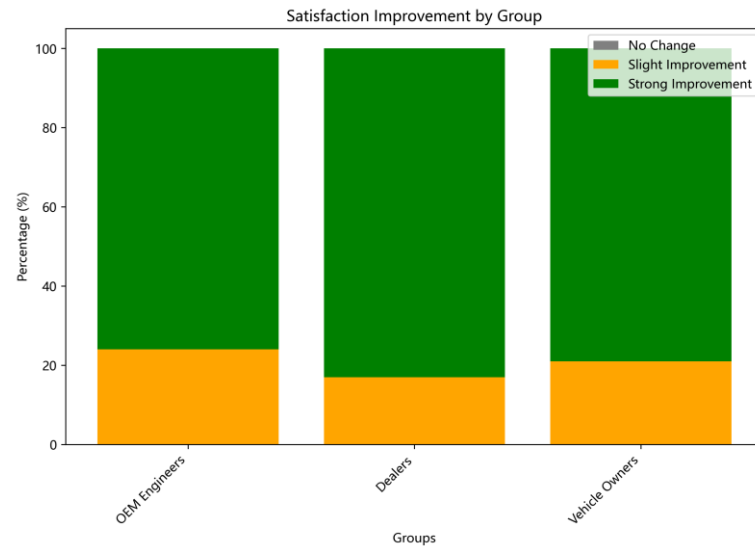


Figure 5. Stakeholder Satisfaction Gains Across OEM, Dealer, and Owner Cohorts

5. Discussion

5.1. Interpreting the Closed-Loop Effect

The closed-loop effect fundamentally reconfigures after-sales data from inert archival records into actionable, real-time behavioral signals. Bidirectional data flow across OEMs, dealers, and vehicle owners enables temporal precision in intervention—such as detecting battery health deterioration η_{bat} below threshold τ_{fail} and triggering pre-emptive inspection protocols before functional degradation occurs. Simultaneously, aggregated fault patterns across geographically dispersed service events generate systemic learning feedback: recurrent diagnostic codes clustered by component lineage inform design iteration cycles, directly feeding into next-generation engineering specifications. This dual capability—just-in-time responsiveness and longitudinal system intelligence—transforms service history from a retrospective compliance artifact into a forward-looking operational asset. Crucially, the loop's integrity depends on interoperable data schemas, synchronized timestamp resolution, and consent-aware identity linkage across touchpoints. Without standardized semantic tagging and latency-constrained synchronization, signal fidelity degrades, undermining both predictive accuracy and redesign validity [7, 9]. The resulting architecture thus functions not as a linear pipeline but as a recursive knowledge engine, where each service interaction simultaneously updates individual customer models and refines collective product understanding.

5.2. Governance as Enabler, Not Constraint

Governance mechanisms functioned not as bureaucratic impediments but as strategic enablers of integration velocity. Granular, context-aware consent models—designed to align with specific after-sales service events—and role-defined data permissions collectively clarified usage boundaries, audit trails, and accountability pathways across OEM, dealer, and vehicle owner domains [6, 8]. This precision reduced ambiguity in data stewardship expectations, thereby diminishing resistance during dealer onboarding. Empirical observation confirmed that structured governance accelerated trust formation: dealers reported higher confidence in data integrity and purpose limitation, while OEMs observed faster adoption of shared diagnostic and service history protocols. Crucially, the absence of blanket data access policies prevented misalignment between operational needs and regulatory compliance postures. Rather than slowing system deployment, governance architecture served as a scaffolding for interoperability—standardizing metadata schemas, enforcing lineage tracking, and enabling real-time permission revocation. The result was not merely regulatory adherence but operational resilience: when service workflows evolved or new data types emerged, governance

frameworks adapted without requiring systemic re-engineering [4, 5]. This demonstrates that well-calibrated governance does not constrain agility; it anchors it within verifiable, auditable, and ethically coherent parameters.

5.3. Scalability and Boundary Conditions

As illustrated in Figure 6, the scalability of the closed-loop customer management system hinges on three interdependent enablers: ontology-driven schema extension, stateless API orchestration, and a modular consent broker [4]. These components collectively support adaptive data modeling, decoupled service integration, and jurisdiction-aware permission lifecycle management. However, operational viability is constrained by three boundary conditions. First, DMS vendor certification remains a prerequisite for interoperability, introducing dependency on third-party roadmap alignment. Second, minimum fleet connectivity must exceed 65% to ensure statistically robust behavioral inference and predictive maintenance accuracy. Third, consent revocation timelines exhibit significant regulatory variance—spanning 7 to 30 days across jurisdictions—which necessitates dynamic policy enforcement logic within the consent broker. These constraints imply that scalability is not purely technical but contingent on ecosystem coordination, telematics penetration thresholds, and legal harmonization efforts. Consequently, phased rollout strategies must prioritize regions with aligned regulatory frameworks and cooperative DMS vendors while instrumenting real-time telemetry to monitor connectivity attainment against the 65% threshold. Without concurrent progress across all three boundary dimensions, architectural scalability cannot translate into functional system resilience [9].

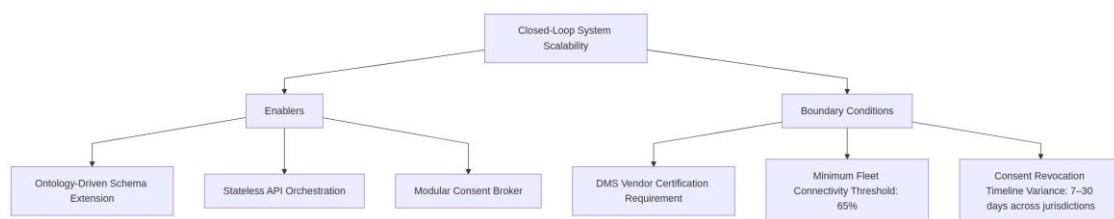


Figure 6. Scalability Enablers and Operational Boundary Conditions

6. Conclusion

6.1. Synthesis of Findings

Breaking down data silos across the OEM–dealer–owner triad is fundamentally a systemic reconfiguration—not a point solution. It demands synchronized recalibration of data rights, operational responsibilities, and temporal rhythms across all three stakeholders. Technical architecture provides the connective tissue, but its efficacy hinges on governance frameworks anchored in verifiable, granular consent mechanisms that respect ownership boundaries at each tier. Sustainable interoperability emerges only when data exchange generates demonstrable, asymmetric value: OEMs gain longitudinal service intelligence, dealers acquire predictive lead scoring and inventory optimization signals, and owners receive personalized, proactive maintenance guidance and warranty transparency. This value reciprocity transforms passive data sharing into active co-investment. Crucially, the closed-loop system must be designed for evolutionary adaptability—supporting incremental integration of new vehicle platforms, evolving regulatory requirements, and shifting consumer expectations around privacy and utility. Without this tripartite alignment of architecture, governance, and mutual incentive design, integration efforts remain brittle, fragmented, and ultimately reversible. The roadmap presented herein thus positions data unification not as an IT project, but as a strategic orchestration of trust, timing, and tangible benefit across the entire after-sales lifecycle.

6.2. Practical Implementation Guidance

Implementation must proceed through disciplined, sequenced interventions. First, adopt a standardized service event schema across OEM, dealer, and owner touchpoints

to ensure semantic interoperability and eliminate syntactic fragmentation. Second, deploy API gateways with embedded lineage tagging to enforce end-to-end traceability of data flows, enabling auditable provenance without manual reconciliation. Third, activate a single high-impact closed-loop workflow—such as recall orchestration—as a minimum viable implementation; this validates integration logic, exposes edge cases, and builds cross-stakeholder confidence before horizontal scaling. Fourth, institutionalize quarterly governance reviews co-led by representatives from all three stakeholder groups, with explicit mandates for resolving data ownership disputes, updating schema definitions, and evaluating SLA compliance against measurable KPIs including latency, completeness, and resolution rate. These actions collectively shift the paradigm from reactive data sharing to proactive, governed data stewardship. Success hinges not on technological sophistication alone but on sustained alignment of incentives, accountability frameworks, and iterative feedback mechanisms. Each step reinforces the others, transforming fragmented after-sales interactions into a coherent, responsive, and continuously improving customer management system.

6.3. Future Trajectory

The future trajectory of closed-loop customer management hinges on the maturation of AI-augmented service prediction systems. These systems will integrate multimodal inputs—telematics streams, longitudinal service records, real-time environmental variables, and natural-language-derived owner sentiment—to enable anticipatory care rather than reactive repair. Realization depends critically on three interdependent enablers: scalable edge computing infrastructure to process high-frequency vehicle data with minimal latency; explainable AI architectures that support diagnostic transparency and regulatory compliance; and harmonized cross-jurisdictional data reciprocity frameworks ensuring lawful, ethical, and interoperable data exchange across OEMs, dealers, and third-party platforms. Without concurrent advancement in all three domains, systemic fragmentation will persist, constraining predictive fidelity and operational scalability.

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