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Zero-Defect Quality Assurance: Domain-Driven Intelligence with Human-in-the-Loop Governance in Aerospace

Written by:

Mukesh Dialani
Research Vice President, IDC

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By leveraging agentic AI and a unified quality digital thread, aerospace manufacturers can move from reactive defect management to predictive, self-healing quality systems — unlocking first-time-right quality systems at enterprise scale. This paper spotlights Cyient's role in enabling this transformation.

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Introduction

The aerospace industry operates in an environment where the margin for error is effectively zero. Every non-conformance incident, whether discovered on the factory floor, or at a supplier's facility, has direct cost consequences, schedule risks, and, in certain scenarios, safety implications. However, for most aerospace OEMs and tier 1 suppliers, quality management currently remains fundamentally reactive. Defects are detected after they occur, root cause analysis is manual and time-consuming, and the product life-cycle management (PLM), enterprise resource planning (ERP), quality management system (QMS), and manufacturing execution system (MES) systems that hold quality data remain disconnected silos that inhibit a unified view of product and process quality.

The economic consequences are significant. The cost of poor quality (COPQ) in aerospace manufacturing due to rework, scrap, and red-tag inventory consumes resources that should be invested in engineering and innovation. A large percentage of non-conformances in the aerospace sector originate in the supply chain, yet most organizations lack real-time visibility and predictive capability to intervene before quality issues occur.

Non-conformance and root cause analysis workflows remain heavily human-dependent and slow, creating bottlenecks that frustrate engineering teams, delay production, erode supplier relationships, and carry significant business consequences. The challenge is not human involvement itself — it is that human expertise is consumed by manual data correlation and reactive problem-solving rather than the judgment-intensive work where it matters most.

At a glance

Key takeaways

- Data fragmentation is a core challenge: Quality data is scattered across various systems, making unified AI-driven quality management difficult without a purpose-built data layer.
- AI-enabled predictive quality can significantly reduce the cost of poor quality, moving organizations toward first-time-right quality at scale.
- Scaling beyond pilots requires data and governance: Many AI pilots fail to scale due to messy enterprise data and insufficient governance; success depends on resolving foundational data and establishing robust human-in-the-loop frameworks.

Advances in agentic AI, domain-trained small language models (SLMs), and integrated data fabrics are creating a credible path from the current state that is reactive, siloed, and manual to a target state of predictive, continuous, and AI-augmented quality management. In this target state, human quality engineers shift from interrogating disconnected systems to overseeing intelligent workflows, validating AI-generated recommendations, and applying expert judgment to complex or novel quality situations. The aspiration is not incremental improvement but a pivot to building zero non-conformance infrastructure — one where autonomous intelligence and human expertise operate as a system.

The critical question aerospace manufacturers now face is not whether quality must improve, but how quickly they can transition to this model — and what capabilities, architectures, organizational changes, and human-AI governance frameworks are required to make it work at scale.

Situation overview

Legacy infrastructure and the reactive quality problem

Aerospace manufacturers have invested heavily in digital tools such as computer-aided design/computer-aided manufacturing (CAD/CAM), PLM, advanced MES platforms, and enterprise QMS systems over the past two decades, yet the quality challenge persists because these investments have largely been made in parallel silos. A quality engineer managing an open non-conformance report must navigate between the PLM system for design context, their ERP system for production history, the QMS for corrective and preventive action (CAPA) workflows, and the MES for process parameters, and is forced to manually correlate data across systems that were never designed to communicate with each other.

The consequence is that non-conformance management remains an inherently reactive discipline. Quality problems are discovered after the fact, root cause analysis is constrained by the analyst's ability to manually interrogate disconnected systems, and corrective actions, if and when they are implemented, mostly address symptoms rather than root causes. The same situation occurs across product lines, suppliers, and production cycles because the institutional data and insight required to prevent them proactively is locked in legacy infrastructure that cannot sense, learn, and respond in real time.

Supply chain quality: the largest unresolved risk

In aerospace, the supply chain is the largest source of quality risk. Sixty to seventy percent of non-conformances originate with suppliers at tier 2 and tier 3 levels that are often the furthest from the OEM's direct quality governance. Most aerospace manufacturers have supplier quality processes that include scorecards, audits, corrective action requirements, but these are typically periodic, backward-looking, and insufficiently integrated with real-time production data.

The AS9100 and MIL-STD (Military Standard) certification requirements that govern aerospace supply chains establish minimum floors for supplier quality management, but certification alone does not prevent quality misses. What is missing is the real-time visibility, risk classification, and predictive intelligence that will, in real time, allow a quality organization to identify a supplier at risk of an impending quality issue before it impacts the production schedule. There is a significant gap between where most aerospace supply chains operate today and where they must be.

The underlying data problem

Behind every quality challenge in aerospace manufacturing is a data challenge. Quality data is generated continuously across design, manufacturing, and the supply chain. It occurs in CAD models, inspection reports, coordinate-measuring machine (CMM) measurements, MES event logs, process failure mode and effects analysis (PFMEA) records, CAPA documentation, and supplier quality notifications. This data is fragmented, inconsistently structured, and governed by different systems with different data models, making it effectively inaccessible to AI tools and systems that require clean, contextualized, and well-structured inputs.

Across aerospace and all other industries, organizations that have attempted to deploy AI for quality management without first resolving the underlying data foundation have consistently encountered the same failure pattern: models that perform adequately in controlled pilots but fail to sustain reliability in production environments where data is noisy, incomplete, or arrives from systems that were never designed to interoperate. This is not an AI problem. It is an AI operating model problem that lacks a unified data layer and governance framework that makes AI trustworthy at enterprise scale.

Challenges

- Non-conformance management remains reactive and heavily human-dependent, with root cause analysis bottlenecked by disconnected systems and manual workflows.
- Supply chain quality escapes are detected downstream rather than prevented at source, exposing OEMs and tier 1 suppliers to schedule risk and program cost overruns.
- Quality data is fragmented across PLM, ERP, QMS, and MES systems, creating the data foundation gap that prevents AI from operating reliably at enterprise scale.
- The cost of poor quality represents a structural cost burden that erodes margins, consumes engineering capacity, and diverts resources from innovation and new program development.

What's important

Buyer expectations are shifting toward outcome accountability

Aerospace OEMs and tier 1 suppliers evaluating quality transformation engineering services partners no longer require just capability demonstrations or technology showcases. The organizations that are furthest along in their quality transformation journeys expect their engineering services and technology partners to bring three things: deep domain expertise that can translate quality engineering challenges into AI architectures; a proven platform that eliminates the need to assemble point solutions into a complex integration effort; and a business model that aligns the engineering partner's incentives with the buyer's outcomes.

The shift toward outcome-based and risk-reward engagement models is accelerating in the aerospace quality management market. Buyers who have experienced the frustration of AI pilots that performed in a controlled environment but failed to scale into production are specifically seeking services partners willing to share the financial risk of transformation including technology-led innovation. This is a timely and meaningful differentiator in a market where most technology vendors and many engineering services firms still operate on time-and-materials or fixed-price-by-milestone models that do not align partner incentives with the customer's business metrics.

The agentic AI inflection point

The transition from generative AI copilots that assist human decision-makers, to agentic AI systems that orchestrate decisions autonomously represents a meaningful inflection point for aerospace quality management. The distinction matters operationally: An SLM or large language model (LLM) that helps a quality engineer write a CAPA report is useful, but it does not change the throughput constraint. An agentic system that autonomously triages incoming non-conformances, retrieves historical precedents, recommends dispositions with confidence scores, routes complex cases to the right approver, documents the action, and closes the loop with the corrective action system that changes the economics of quality management.

The prerequisite for agentic AI that is trustworthy in a safety-critical aerospace environment is the same data foundation, domain knowledge graph, and governance architecture that makes AI reliable in the first place for any other industry use case. Human-in-the-loop governance frameworks, where agentic systems operate autonomously within defined parameters and escalate to human decision-makers for high-risk or high-uncertainty situations represent the practical implementation model that aligns AI capability with the risk tolerance of an aerospace quality organization.

Role of Cyient in enabling this transformation

Thirty years of aerospace quality expertise, now AI-augmented

Backed by more than three decades of aerospace quality expertise, Cyient DET is a global lifecycle engineering company with $658 million in revenue and 15,000+ associates, headquartered in Hyderabad, India. Its aerospace practice spans product engineering, manufacturing support, quality assurance, and regulatory compliance. Cyient's clients include leading global aerospace OEMs, whose quality standards rank among the most demanding in manufacturing.

Within aerospace quality specifically, Cyient brings over 2,500 aerospace subject matter experts, 450+ quality engineers, 44 quality notification approvers, technical authorities, 25+

concession assessors, and direct participation in material review board (MRB) processes. This operational depth is consequential because it means that when Cyient builds AI models for non-conformance management, concession assessment, or PFMEA automation, the models are trained on and validated against real aerospace quality workflows by practitioners who have operated those workflows at scale.

Engineering Intelligence Platform: the architectural foundation

Cyient's Engineering Intelligence Platform is a purpose-built, seven-layer AI operating system for engineering domains. It addresses directly the AI operating model problem, that is the gap between isolated AI pilots and enterprise-scale, production-grade AI deployment which prevents most aerospace quality AI initiatives from scaling beyond proof of concept.

The EIP architecture separates the intelligence layer that includes agents, models, and orchestration from the foundational layer that includes data ingestion, knowledge base, and connectivity, enabling each to evolve independently. This separation of concerns is operationally important, and it means that as the underlying AI models improve, they can be updated without disrupting the data pipelines and enterprise integrations that feed them, and vice versa.

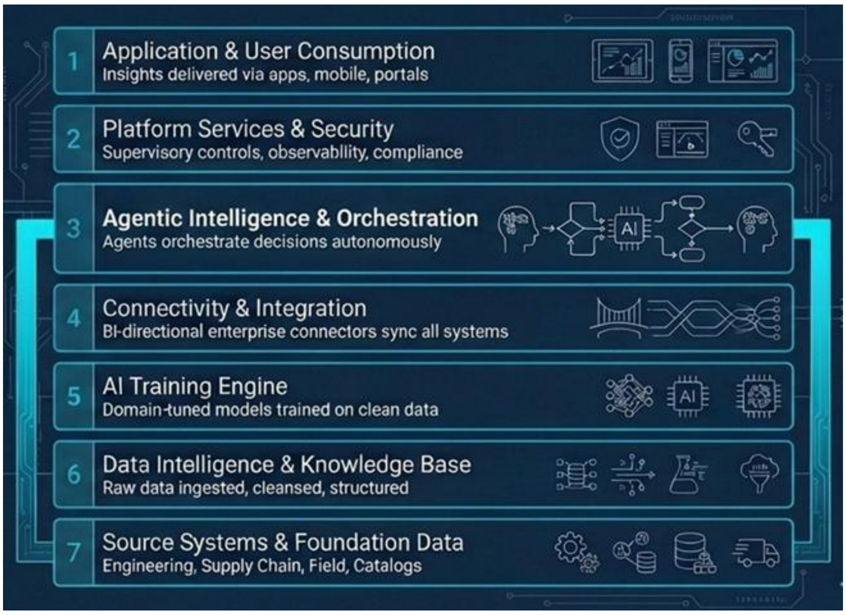
The following represent seven layers of Cyient's EIP operating as a coherent stack (see Figure 1):

- Layer 7 — Source Systems and Foundation Data: Multimodal ingestion from engineering tools (CAD, PLM, QMS), IT systems (SAP, ALM), and unstructured data sources (tribal knowledge, manuals). Automated pipelines achieve data quality scores above 98% before data enters the intelligence layer.
- Layer 6 — Data Intelligence and Knowledge Base: Raw data is structured into an engineering knowledge graph using Cyient's domain ontology, enabling AI agents to understand parts, requirements, supplier relationships, and compliance rules natively rather than treating them as undifferentiated text.
- Layer 5 — SLM Training Engine and Model Repository: A curated portfolio of SLMs, fine-tuned on aerospace engineering data, can outperform generic LLMs in accuracy, latency, and enterprise data security. Models run securely within the customer's environment — on-premises or at the edge.
- Layer 4 — Connectivity and Integration Model Context Protocol (MCP): Bidirectional, read/write connectors to SAP, ServiceNow, PLM, SCADA, and QMS platforms allow agents to not only retrieve information but also to execute workflow actions — updating non-conformance records, triggering CAPA workflows, and routing dispositions within existing enterprise systems.
- Layer 3 — Agentic Intelligence and Orchestration: Specialized agents including NC Assist, Root Cause Analysis, Predictive Quality, Supplier Quality Assist, CAPA Automation collaborate under an orchestration framework to resolve complex quality workflows autonomously, with continuous evaluation and to ensure scalable performance.
- Layer 2 — Platform Services and Security: A context-aware governance engine that automatically escalates high-risk actions to human-in-the-loop review, with multistage

validation chains ensuring compliance-ready AI outputs aligned with DO-178C, AS9100, and other aerospace standards.

- Layer 1 — Application and User Consumption: Intelligence delivered via portals, mobile applications, PLM interfaces, and dashboards ensure instant adoption across quality, engineering, and supply chain personas.

Figure 1: ***Cyient's Engineering Intelligence Platform***



Source: Cyient, 2026

Path to zero-defect assurance: a three-phase road map

Cyient's Target Operating Model for zero-defect quality transformation is structured as a three-phase, 36-month journey could vary depending on maturity (see Table 1). Each phase builds on the capabilities established in the prior phase, delivering measurable value while laying the foundation for the next level of intelligence. The agile factory delivery model — use case grooming, rapid prototyping, user validation, pilot deployment, feedback, and mass scale — is applied within each phase to ensure that investments are validated before they are expanded.

Table 1: ***Zero-defect quality transformation journey***

Phase 1 (6–12 months)	Phase 2 (12–24 months)	Phase 3 (24–36 months)
Foundation & Risk Mitigation *Establishing quality confidence* » Concession resolution agents and NC tracking » Benchmark process capability agents » Supplier scorecard analytics and ERP/SAP QM integration » Basic data normalization and quality DMS integration	**Integration & Predictive Intelligence** *Breaking down silos for continuous intelligent assurance* » Digital PFMEA agents and CAPA Assist » MRB advisory agents for rework/scrap disposition » Integration of PLM, engineering, and supply chain databases » Vector DB structuring and fine-tuned SLM models	**Zero-Defect Assurance** *Agentic AI as a valuation multiplier* » Integration of process capability agents into MBD workflows » Continuous process verification and remediation agents » MCP integration, supervisory audit, and agents orchestration » Knowledge graph, observability setup, and security hardening

Source: Cyient, 2026

The phased approach reflects a critical delivery principle: each use case is validated for business potential before it scales. Cyient's investment in the proving phase where fuzzy requirements are sharpened into definite scope and rapid prototypes are validated against real user workflows reduces the risk of the most common enterprise AI failure mode, which is building at scale before building correctly.

IDC perspective

Aerospace quality management is approaching an inflection point that IDC believes will separate organizations that achieve sustained quality competitiveness from those that remain trapped in the reactive, manual paradigm that has characterized this discipline for decades. The building blocks are in place: AI models capable of understanding complex engineering contexts, platform architectures that can integrate across historically siloed enterprise systems, and a growing pool of aerospace stakeholder organizations with the digital maturity to deploy agentic systems in production environments.

Cyient's approach to this market is grounded in a sequencing logic that IDC views as operationally sound. Rather than leading with AI capability demonstrations that cannot survive contact with real enterprise data, Cyient starts with the data foundation ingestion, normalization, knowledge graph construction and builds intelligence on top of a stable and strong foundation. This approach consistently produces more reliable production outcomes, and it reflects the institutional knowledge that comes from 25+ years of experience across aerospace quality functions.

Their Engineering Intelligence Platform architecture's separation of platform from intelligence is relevant for aerospace services buyers who are looking for AI systems that can be updated and improved without disrupting the production quality workflows that depend on them.

Cyient's approach to engage in outcome-based and risk-reward commercial models sharing financial exposure on COPQ reduction targets and first-pass yield improvements demonstrates their willingness and ability to achieve their client's expected business metrics. This is the commercial model that aerospace buyers will appreciate, and it is a differentiator in a market where most services vendors continue to price on input rather than output.

Challenges faced by customers

Data fragmentation across the quality stack

The most pervasive challenge aerospace quality organizations face is that their quality data lives in systems that do not communicate with each other. PLM holds design intent and change history, ERP holds the production and procurement record, QMS holds the CAPA and audit documentation, and MES holds the real-time process parameters. None of these systems were designed to provide a unified view of quality across the product life cycle, and integrating them without a purpose-built data layer is an engineering project that most organizations lack the internal capacity to execute. Even if they did, it would be time consuming.

Organizational resistance to quality transformation

Aerospace quality functions are staffed by engineers whose professional identity is built around deep domain expertise and rigorous manual review processes. Introducing AI systems automates portions of these processes. Disposition decisions and root cause analysis require careful change management processes that address concerns about accountability, regulatory compliance, and role clarity particularly around decisions traditionally managed by a quality engineer. Organizations that attempt to deploy AI in quality functions without addressing these organizational dynamics encounter deployment and operations failures that have nothing to do with technology capability.

Regulatory compliance and audit trail requirements

Aerospace quality management operates within a regulatory environment that requires complete, accurate, and auditable records of every quality decision. Any AI system deployed in this environment must be capable of generating full audit trails that include documenting the data inputs, the reasoning applied, the decision reached, and the human review or approval obtained in a format that satisfies regulatory auditors and customer quality representatives. The governance architecture of AI systems in aerospace quality is not an optional feature, but a prerequisite for regulatory deployment.

Scaling beyond the pilot

The aerospace quality AI landscape is populated with proof-of-concept deployments that have not scaled beyond initial pilots. The consistent failure pattern is that pilots are designed around controlled data environments that do not reflect the messiness of enterprise-scale quality data. Also, the architectures built for pilots cannot accommodate the integration complexity, governance requirements, and change management demands of production deployment. Buyers evaluating AI platforms for quality management should specifically probe how potential partners have solved the scaling problem, not just the pilot problem.

Guidance for technology and services buyers

For CIOs, chief technology officers (CTOs), engineering VPs, and chief quality officers evaluating AI-enabled quality transformation in aerospace, the following priorities reflect what IDC views as the critical success factors for programs that will scale from pilot to enterprise value.

Resolve the data foundation before committing to AI scale

Aerospace organizations that attempt to build AI quality systems on top of fragmented, inconsistently governed quality data will consistently encounter the same failure: models that perform in pilots but degrade in production as data quality issues surface at scale. Before committing to enterprise-scale AI quality programs, aerospace technology leaders should commission a rigorous data quality assessment across their PLM, ERP, QMS, and MES environments, mapping data completeness, consistency, and governance gaps against the requirements of AI-driven quality workflows. The outcome of this assessment should drive the data foundation investment that precedes AI model deployment.

Select partners on aerospace domain depth, not AI capability alone

The aerospace quality management market is attracting AI platform vendors whose technology is genuinely capable but whose understanding of the domain, that is, the nuances of AS9100 compliance, the dynamics of MRB review, the specific risk profiles of concession assessment, is limited. AI that is accurate in a general engineering context but imprecise in an aerospace quality context will consistently generate recommendations that require more human review, not less, eroding the productivity case for the investment. Domain expertise is a compulsory requirement for AI that performs reliably in aerospace quality workflows.

Define human-in-the-loop governance Before deployment

Before deploying agentic AI systems in aerospace quality environments, organizations must clearly define quality decisions:

- which can be delegated to autonomous systems
- which require human review
- which must remain under direct human control

This governance framework should be encoded in the AI platform's policy engine and not managed through external procedures that users can bypass.

Demand outcome-based commercial structures

Aerospace quality transformation programs must focus on commercial structures where the engineering services partner shares financial exposure on outcome metrics such as COPQ reduction, first-pass yield improvement, CAPA closure rate, and non-conformance recurrence reduction. These structures align partner incentives directly with buyer outcomes and provide a natural governance mechanism: if the partner is not delivering the agreed outcomes, the financial consequences are shared. Buyers should treat willingness to engage on outcome-based models as a signal of a partner's confidence in its ability to deliver at scale.

Guidance for business buyers

For COOs, chief quality officers, manufacturing VPs, and supply chain executives in aerospace, the zero-defect quality agenda is ultimately a business performance agenda and the decisions that determine whether AI-enabled quality programs succeed or fail are as much organizational and commercial as they are technical. IDC identifies four priorities that business leaders must own personally if quality transformation is to deliver sustained enterprise value.

Anchor the program to operational outcomes, not technology milestones

Aerospace quality transformation programs that are defined by just technology deliverables a deployed QMS module, an integrated data pipeline, a live AI model routinely produce implementations that are technically functional but operationally irrelevant. The more productive approach is to define the program by the quality performance outcomes the business needs to evolve. Examples include reduction in non-conformance cycle time, improvement in first-time-right rates, contraction in supplier quality escape frequency, or measurable COPQ reduction as a proportion of program cost. When these outcomes are defined first and made the basis of the engineering services partner engagement, every technology and process decision has a clear performance test.

Take personal ownership of the supplier quality agenda

Supply chain quality is the largest single source of non-conformance risk in aerospace, yet it is frequently managed as a procurement or quality engineering function rather than a business leadership priority. The shift to AI-enabled supplier quality management that includes real-time scorecards, predictive risk stratification, automated non-conformance routing from tier 2 and tier 3 suppliers requires business leaders to set the strategic direction and provide the executive sponsorship that cross-functional supplier quality programs need to overcome organizational inertia.

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Govern AI decision authority explicitly from the start

As agentic AI systems take on greater responsibility in aerospace quality workflows and start triaging non-conformances, recommending dispositions, routing CAPA actions, the question of decision authority becomes a business governance issue, not just a technical configuration choice. Business leaders must establish, before deployment, a clear framework that specifies which quality decisions AI systems may resolve autonomously, which require engineer validation before execution, and which carry sufficient safety or regulatory weight to require senior quality authority sign-off regardless of AI confidence levels.

Treat the workforce transition as a program deliverable

The introduction of AI into aerospace quality functions will change the nature of the quality engineer's role, shifting emphasis from manual data interrogation and reactive non-conformance processing toward oversight of AI-generated recommendations, management of agentic workflows, and higher-order judgment on complex or novel quality situations. Organizations that treat this workforce transition as an afterthought and deploy AI systems while expecting adoption to follow are likely to encounter resistance that slows value realization and undermines the business case. Business leaders should treat workforce readiness as a formal program deliverable, with defined competency frameworks, structured training pathways, and change management resources budgeted alongside the technology investment.

Conclusion

The move from reactive non-conformance management to autonomous quality intelligence in aerospace is not a distant aspiration. The technology building blocks including agentic AI, domain-trained SLMs, knowledge graphs, and integrated data fabrics are sufficiently mature to support production deployment today. The organizations that are investing now in the data foundation, platform architecture, and governance frameworks that make AI-driven quality management reliable at enterprise scale are building a structural competitive advantage that will compound over time.

However, the path from pilot to production-grade autonomous quality intelligence remains blocked for most aerospace organizations by the same structural challenges: fragmented data, disconnected systems, organizational resistance, and the absence of partners willing to share the risk of transformation. Resolving these challenges requires an approach that starts with the data foundation, builds intelligence on a stable platform architecture, governs AI decisions with the rigor that aerospace environments demand, and aligns commercial structures with the outcomes that matter to quality organizations.

The question for aerospace quality leaders is not whether agentic AI will transform quality management. It definitely will. The real question is whether their organizations will lead that transformation or follow it. In this target state, human quality engineers become the governing intelligence that validates, directs, and continuously improves the autonomous systems operating beneath them.

About the IDC analyst

Mukesh Dialani
Research Vice President, IDC

Mukesh Dialani is a Research Vice President for IDC's Worldwide Digital Engineering and Operational Technology Services research. He is responsible for executing field research and custom research projects across the entire life cycle of hardware and software products. His core coverage areas include product engineering services, OT services, industrial IoT, computer vision, robotics, AR/VR, and digital transformation pertaining to engineering services. He is based in the United States.

More about Mukesh Dialani

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Across the Aerospace and Defense Industry, Cyient addresses quality non-conformance constraints impacting production scalability, cash flow, regulatory compliance, and program execution. Its AI-enabled Zero Defect operating model is built on the Engineering Intelligence Platform (EIP). EIP is a seven-layer architecture that embeds predictive, preventive, and autonomous intelligence across engineering, manufacturing, supplier quality, and aftermarket operations. EIP is powered by AI agents for MRB Disposition, Supplier Quality & Performance, CAPA Assist, and Continuous QMS Compliance. The platform accelerates decision-making, enhances operational resilience, and strengthens compliance with AS9100 standards.

Learn more about **Cyient**

IDC Research, Inc.

One Beacon Street, Suite 33100, Boston, MA 02108, USA

T +1 508 872 8200

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