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Supplier Quality Enhancement and Delivery Reliability in Aerospace Manufacturing: A 4IR Technologies Case Study of Aerospace Company

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Abstract

This research focused on Fourth Industrial Revolution (4IR) technologies exploration in addressing the challenges that is connected to supplier at Aerospace Company, a leading South African of high-quality spacecraft parts manufacturer. With mixed-methods approach application, data analysis combination, structural interviews with procurement, production, and staff quality assurance, the research reveals major challenges and proposes a technology-driven framework. The objective of this research is to enhance supplier collaboration, performance, and traceability using blockchain, IoT, AI, and real-time analytics. The main outcomes reveal that 4IR technologies implementation can result in improved supplier reliability, lead times reduction, and quality control improvement. This research enables a practical framework for Aerospace Company to support smarter, faster, and more reliable decision-making in the aerospace industry.
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Keywords
Fourth Industrial Revolution technologies, industrial engineering, supply chain management

1. Introduction
In today's fast-paced and highly competitive aerospace industry, manufacturers like Aerospace company face mounting pressure to deliver high-quality components on time, every time. The ability to meet stringent customer specifications and contractual obligations is not merely a matter of operational efficiency it is central to building trust, securing future contracts, and sustaining long-term competitiveness. As a pioneering South African aerospace manufacturer specializing in high-reliability components and subsystems for satellites and spacecraft, XYZ serves government space agencies, commercial satellite operators, and research institutions globally. These customers demand uncompromising quality, strict adherence to delivery deadlines, and absolute reliability. Despite its advanced manufacturing capabilities and skilled workforce, XYZ has recently encountered persistent challenges within its supply chain, particularly frequent shipment delays. These delays are predominantly driven by supplier-related issues, including inconsistent delivery schedules, non-conforming components, inadequate quality assurance at supplier facilities, and slow response to disruptions. These problems extend beyond missed deadlines they contribute to increased production costs, resource inefficiencies, reputational damage, and project risks in a precision-driven sector where timing is critical to mission success. The complexity of XYZ supply chain further compounds these issues. It comprises multiple tiers of highly specialized suppliers delivering precision-engineered components, all of which must comply with rigorous specifications and quality standards. However, current supplier management practices at XYZ lack the real-time visibility, data integration, and proactive quality control required to prevent late detections and disruptions. Communication gaps between internal teams and external suppliers further hinder swift resolution of quality or logistics problems.

Amid these growing challenges, the Fourth Industrial Revolution (4IR) presents a unique and transformative opportunity. Technologies such as the Internet of Things (IoT), artificial intelligence (AI), and blockchain have the potential to fundamentally reshape supply chain operations and supplier performance management. For instance, IoT sensors can enable real-time monitoring of shipment conditions and part quality during transit. AI-powered systems can predict potential failures, optimize supplier risk profiles, and support early decision-making. Blockchain offers a secure, transparent, and immutable digital record of transactions, enabling greater traceability, accountability, and compliance across the supply chain.

The primary research objective is to develop a 4IR-enabled framework that enhances supplier quality assurance and on-time delivery performance at XYZ. The study seeks to answer the following research questions:

a. What is the main supplier-related problems affecting XYZ's aerospace manufacturing operations?
b. How can 4IR technologies (IoT, AI, blockchain) proffer solution to these issues and ensure supplier performance improvement?
c. What are the critical success factors for a 4IR-enabled supplier management framework implementation at XYZ?

This research aims to investigate how XYZ company can effectively leverage these 4IR technologies to improve supplier quality assurance and enhance on-time delivery performance. The study adopts a mixed-methods approach: quantitatively analyzing historical supplier performance data and qualitatively gathering insights from procurement, production, and quality assurance personnel. The goal is to propose a practical, scalable 4IR-enabled framework tailored to XYZ operational environment. By integrating digital tools into its supply chain processes, XYZ can increase resilience, reduce dependency on reactive problem-solving, and strengthen its position as a global leader in high-reliability aerospace manufacturing.

2. Literature Review

The growing complexity of global supply chains, especially in high-reliability sectors like aerospace, has prompted organisations to explore digital transformation through the Fourth Industrial Revolution (4IR). 4IR is characterized by the convergence of emerging technologies such as Artificial Intelligence (AI), Internet of Things (IoT), blockchain, big data analytics and cyber-physical systems. These innovations offer unprecedented opportunities to enhance transparency, predictive control and traceability across supply networks (Dhlamini and Mofokeng, 2022). While existing studies highlight the transformative potential of 4IR technologies, there is a notable disparity in adoption rates and outcomes across industries and regions. For instance, studies in developed economies demonstrate significant improvements in supply chain efficiency through IoT and AI (Hawashin, 2024), whereas research in emerging economies like South Africa reveals slower adoption due to infrastructure and skill gaps (Mhlongo and Mavetera, 2023).

2.1 The Role of 4IR in Modern Supply Chains

The Fourth Industrial Revolution (4IR) is fundamentally transforming global manufacturing and supply chain operations through the adoption of advanced digital technologies. Core components of this revolution include artificial intelligence (AI), the Internet of Things (IoT), blockchain, cyber-physical systems, and machine learning. These technologies are redefining how industrial firms manage supplier relationships, assess performance, and respond to disruptions. 4IR technologies are enabling greater levels of automation, data-driven decision-making, and end-to-end supply chain transparency (Fernandez-Carames and Fraga-Lamas, 2024).

For organizations like Aerospace company, operating within the highly specialized and time-sensitive aerospace sector, the application of 4IR tools is particularly valuable. Aerospace manufacturing depends on tight coordination between internal processes and external suppliers, where even minor delays or quality deviations can lead to costly setbacks. 4IR technologies empower companies to shift from reactive problem-solving to proactive supply chain management. AI and machine learning algorithms can detect supplier risks before they escalate, forecast delivery delays, and recommend optimal sourcing strategies based on real-time data.

IoT and Real-Time Monitoring for Quality Assurance

IoT technology has become a cornerstone of modern industrial systems, enabling the continuous collection and transmission of real-time data from machines, transport assets, and supplier interfaces. Within the supply chain context, IoT allows manufacturers to gain unprecedented visibility into the movement, condition, and handling of components as they transit through various stages of production and delivery. This real-time data flow enhances operational transparency and creates new opportunities for predictive maintenance, proactive inventory management, and the early detection of quality deviations. Sensors embedded in supplier shipments or factory equipment can continuously monitor variables such as temperature, humidity, shock exposure, and geographic location all of which are critical in industries like aerospace where component reliability is paramount (Hawashin, 2024).

Comparative studies suggest that IoT adoption in aerospace supply chains can yield greater benefits when integrated with blockchain technology, enhancing both real-time monitoring and long-term traceability (Kache and Seuring, 2017). However, challenges remain in implementing these technologies in resource-constrained SMEs (Mhlongo and Mavetera, 2023)

2.2 Blockchain for Transparency and Supplier Accountability

Blockchain technology provides a decentralized, secure, and immutable platform for recording transactions and sharing data across a distributed network. Unlike traditional databases, blockchain ensures that all records are cryptographically secured and time-stamped, making it impossible to alter historical data without detection. This feature makes blockchain particularly valuable in aerospace supply chains, where trust, authenticity, and traceability are critical. In an industry governed by rigorous compliance standards and high-value, safety-critical components, the ability to verify the origin, movement, and quality of parts is essential for operational integrity and regulatory assurance.

Blockchain integration enhances traceability across the supply chain, automates compliance verification, and helps prevent the infiltration of counterfeit components a persistent risk in global aerospace procurement. Using smart contracts organizations can automate enforcement of supplier agreements, ensuring that payments, inspections, and deliveries are executed only when predefined conditions are met (Kache and Seuring, 2017). This reduces the reliance on manual documentation and accelerates transactional efficiency.

Mhlongo and Mavetera (2023), further demonstrated that the convergence of blockchain, IoT, and unmanned aerial vehicles (UAVs) can significantly improve supply chain auditability and inventory control. Their research illustrated how each movement or change in custody of a component can be logged on a blockchain ledger in real time, supported by sensor data collected from IoT devices and physical verification via UAV surveillance. This multi-layered visibility enhances system trustworthiness and responsiveness.

In the case of Aerospace company, integrating blockchain with IoT-enabled logistics can produce a tamper-proof digital thread that captures every stage of a component's journey from supplier dispatch to final assembly. In the event of a delay, packaging anomaly, or non-conformance report, decision-makers can access an instant, validated audit trail.Studies comparing blockchain implementation in aerospace supply chains highlight its superiority in ensuring compliance and traceability over traditional systems (Saberi et al., 2019). However, interoperability with existing systems and standardization remain critical challenges (Naicker and Pillay, 2023).

2.3 South African Context and SME Readiness

While the Fourth Industrial Revolution (4IR) offers transformative potential for improving supply chain agility, efficiency, and resilience, its adoption within South Africa has been marked by uneven progress across industries and organizational sizes. The disparity in implementation stems from a combination of technological, organizational, and socio-economic factors that continue to hinder the widespread deployment of advanced digital tools. In a pivotal study through the University of South Africa (UNISA), the barriers to 4IR adoption among small and medium-sized enterprises (SMEs) were examined in depth (Mhlongo and Mavetera 2023). The findings identified three primary obstacles: underdeveloped digital infrastructure, limited workforce digital literacy, and internal resistance to change.
Many South African firms especially SMEs in industrial sectors struggle to access affordable high-speed connectivity, modern IT infrastructure, or cloud computing platforms, all of which are prerequisites for technologies like IoT, AI, and blockchain. Additionally, the shortage of digitally skilled workers capable of managing, interpreting, and leveraging these technologies presents a significant operational gap. Even when technological tools are available, entrenched organizational cultures and fear of job displacement often result in passive or active resistance from employees, managers, or even suppliers.

2.4 Gaps in Literature and Industry Application

Although the benefits of Fourth Industrial Revolution (4IR) technologies in enhancing supply chain visibility, traceability, and quality control are widely acknowledged in existing literature, there remains a significant gap in research focused on the contextual application of these technologies within high-reliability, highly regulated sectors such as aerospace. While global case studies have demonstrated success in sectors such as automotive, consumer electronics, and general manufacturing, few studies have developed applicable frameworks tailored to the aerospace industry, especially within the emerging economies of the Global South (Mtetwa and Khumalo, 2023). In the South African context in particular, research addressing how 4IR tools can be holistically implemented in the local aerospace manufacturing ecosystem where precision, compliance, and supplier control are paramount is notably scarce.

Furthermore, there is limited integration in the literature of supplier quality feedback loops, predictive analytics, and real-time traceability within a single, unified system. Many frameworks focus on siloed solutions, addressing either delivery reliability or quality assurance, without considering the compounding benefits of merging these functionalities through interoperable digital tool (Naicker and Pillay, 2023). This fragmentation leaves a critical opportunity unexplored: the design of an end-to-end digital collaboration framework that supports proactive supplier monitoring, traceable component history, and data-informed decision-making under a single operational structure (Saberi etal., 2019).

3. Research Methodology

This section presents the methodology adopted for the study using the Research Onion framework by Saunders et al. (2019). The research onion provides a multi-layered model to help structure methodological choices logically and systematically, beginning from philosophical positioning and progressing to specific techniques and procedures (Saunders etal., 2019).

This research incorporates both Human Participant Research and Secondary Data Research. Human Participant Research involves gathering primary qualitative data through semi-structured interviews with Aerospace company employees in procurement, quality assurance and operations. Secondary Data Research involves synthesizing existing academic literature, company performance reports, supplier records and industry documentation to contextualize the findings and support the framework development. These complementary methods allow a well-rounded understanding of current challenges and opportunities for improvement through 4IR.

This study is grounded in the interpretivist research paradigm, which prioritizes understanding phenomena through the subjective experiences and social contexts of the individuals involved. Interpretivism holds that knowledge is not an objective, fixed reality but is instead socially constructed through interactions, meanings, and interpretations. This philosophical stance is particularly appropriate for research aiming to explore real-world challenges within complex environments such as supplier performance in aerospace supply chains. The interpretivist lens enables the researcher to delve deeply into how different stakeholders' procurement managers, engineers, operations staff perceive and make sense of the impact and effectiveness of Fourth Industrial Revolution (4IR) technologies in their daily work (Serumaga-Zake and Van der Poll, 2021).

To capture the complex, context-rich nature of supply chain performance and technology adoption, a qualitative multi-method design is adopted. This approach combines primary data collection through human participant research with secondary data analysis, thereby strengthening the study's validity through methodological triangulation.

The primary data collection consists of semi-structured interviews with key stakeholders across procurement, engineering, and operations functions. These interviews facilitate an in-depth exploration of participants' perceptions of current supply chain challenges, their experiences with 4IR technologies, and their views on organizational readiness for digital transformation. The open-ended nature of semi-structured interviews encourages participants to share detailed insights, stories, and examples, which enrich the understanding of complex social and technical dynamics.
A purposive sampling strategy was used to select 15-20 participants with relevant experience and expertise in supplier management and 4IR technologies. Interviews were audio-recorded, transcribed verbatim, and analyzed using thematic analysis to identify patterns and themes

Secondary data research complements this by analyzing internal documentation such as supplier performance reports, defect records, delivery incident logs, and risk assessments. This archival data provides an objective record of historical performance trends and issues, grounding qualitative findings in factual evidence. Academic and industry literature are also reviewed to benchmark Aerospace company' practices against global standards and emerging best practices (Strydom and Retief, 2022). Ethical approval was collected from the relevant institutional review board, and informed consent was obtained from all participants. Confidentiality and anonymity were ensured throughout the research process. By integrating these multiple sources, the research enhances credibility and depth, providing a holistic view of the problem space and enabling a more comprehensive development of the conceptual framework. A single-case study strategy is selected to enable an in-depth, contextualized investigation of supply chain management practices within Aerospace company. Case study research is well suited to exploring complex, contemporary phenomena within their real-life settings particularly when the boundaries between phenomenon and context are not clearly evident.

Aerospace company serves as an exemplary case because of its position within the aerospace industry, which demands stringent supplier coordination, traceability, and precision engineering. The company's ongoing efforts to implement 4IR technologies offer a rich context to examine the interplay between technological innovation, organizational culture, and supply chain performance.
Primary (Human Participant Research): Semi-structured interviews will be conducted with stakeholders from procurement, engineering and operations teams. Open-ended questions will explore current supply chain issues, quality concerns, technology usage and perceived readiness for 4IR integration (Sutherland and Botha, 2023). Secondary (Secondary Data Research): Internal reports on supplier performance, late delivery incidents, defect records and risk assessments will be analysed. Additionally, academic publications and industry reports will be used to extract theoretical models and benchmark practices.

The research onion framework provides a coherent structure for aligning research philosophy, design and execution. Through a qualitative, abductive and interpretivist approach, this study aims to develop a practical 4IR-informed solution to Aerospace company' supplier quality and delivery problems. By combining human perspectives and secondary insights, the methodology supports the development of a relevant, evidence-based and context-specific framework that can drive operational improvements.

4. Results and Discussion

This chapter presents the research findings derived from both primary and secondary data. The findings are organized into four sections: supplier performance metrics, analysis of supplier quality issues, stakeholder perspectives from semi-structured interviews and a thematic synthesis.

4.1 Overview of Supplier Delivery Performance

Aerospace company currently sources over 70% of its components from external suppliers, many of whom are Tier 2 SMEs located both locally and internationally. Supplier evaluation reports for the past financial year (April 2024 – March 2025) presented in Figure 1 to Figure 4 reveal consistent issues with late deliveries and unreliable supply patterns.
Key Findings

- Average On-Time Delivery (OTD) over 12 months was 78%, against the company's benchmark of ≥95%.

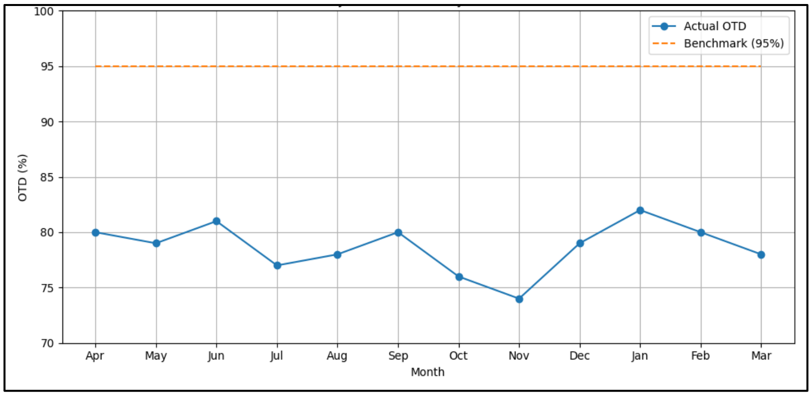

Figure 1. Monthly On-Time Delivery vs Benchmark

- 22% of monthly production batches experienced delays due to late or incomplete component deliveries.

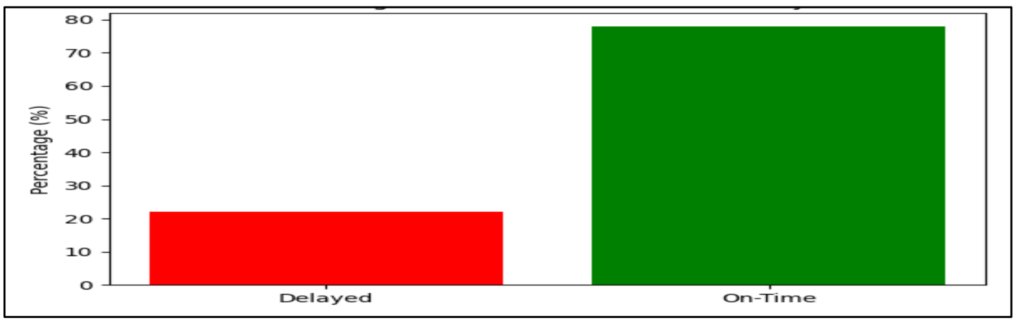

Figure 2. Percentage of Production Batches Delayed

- Average supplier lead time variance was ±7 days, with some orders arriving more than two weeks late without advance notification.

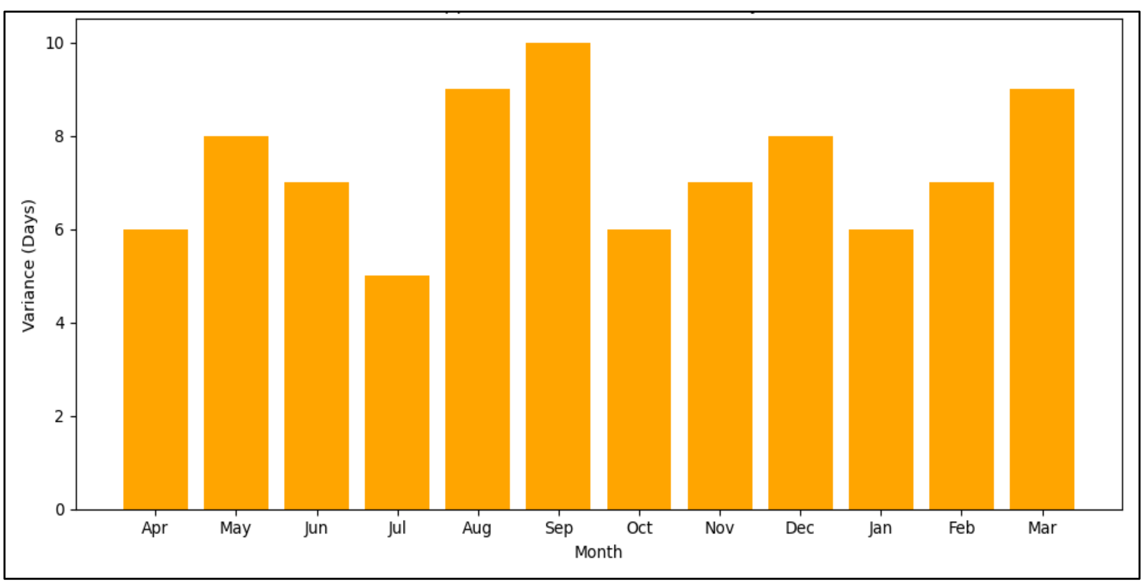

Figure 3. Supplier Lead Time Variance

- Delivery inconsistency was most common among suppliers of:
  - Torque rods
  - Printed circuit board assemblies (PCAs)
  - Custom aerospace-grade fasteners

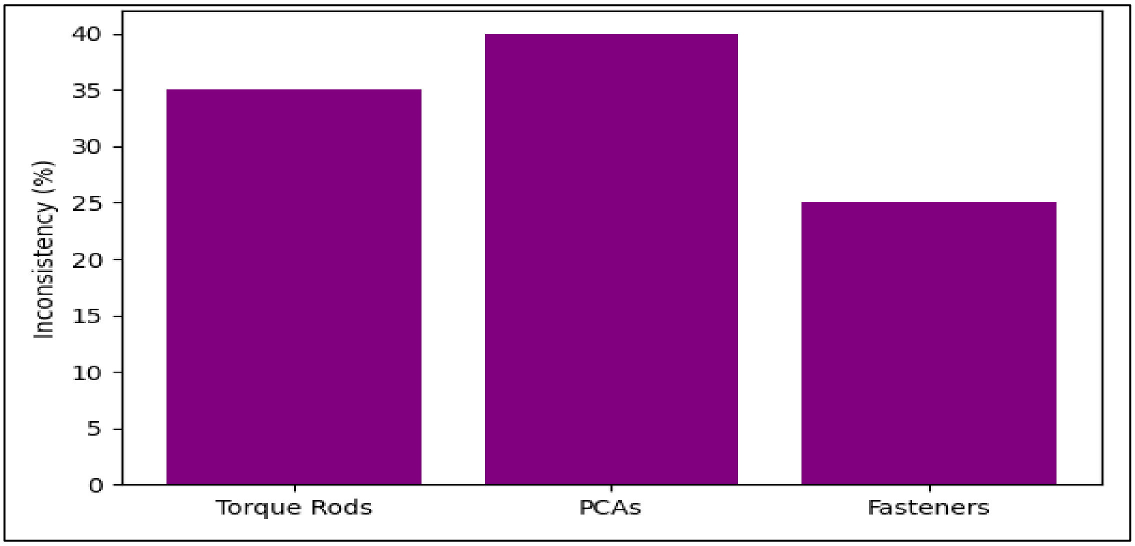

Figure 4. Delivery Inconsistency by Component Type

Internal Impact:

- Late deliveries directly caused line stoppages, particularly in cleanroom assembly areas where parallel production cannot proceed without all certified components.
- This resulted in an estimated 12% increase in production downtime and R1.3 million in expedited logistics costs over the period.

4.2 Supplier Quality Issues and Defect Trends

The organisations quality department maintains NCR (Non-Conformance Report) records and FPY (First Pass Yield) data across all supplied components. A content analysis of these (Tables 1 and 2) and (Figure 5 to Figure 7) records identified multiple recurring defects and weak links in supplier quality assurance.

Table 1. Summary of Common Supplier Defects (12-month period)

Component	Defect Type	Reported Incidents	Root Cause (based on CAPA)
PCAs	Cold solder joints, short circuits	17	Manual soldering without IPC inspection
Connectors	Bent pins, incorrect crimping	12	Lack of final QC & packaging issues
Mechanical Casings	Dimensional variation, surface flaws	9	Tool wear, absence of in-process checks
ESD-sensitive parts	Packaging failures, ESD damage	7	No ESD audit or training at supplier

Trends Identified

- Over 65% of quality issues were not detected until components reached final inspection at NewSpace.
- Many suppliers lacked digitized traceability of production batches, making root cause identification time-consuming.
- Feedback loops were inconsistent and corrective actions were often delayed or incomplete.

Table 2. Components Inspected over 10days

Components inspected over 10 days					
Day	Units Produced	Units with Defects	Detected During Process	Detected at Final Inspection	% Defects at Final Inspection
1	200	30	8	22	73%
2	180	25	6	19	76%
3	220	40	12	28	70%
4	210	35	10	25	71%
5	190	28	9	19	68%
6	200	32	10	22	69%
7	205	36	11	25	69%
8	195	30	9	21	70%
9	215	38	13	25	66%
10	200	34	12	22	65%

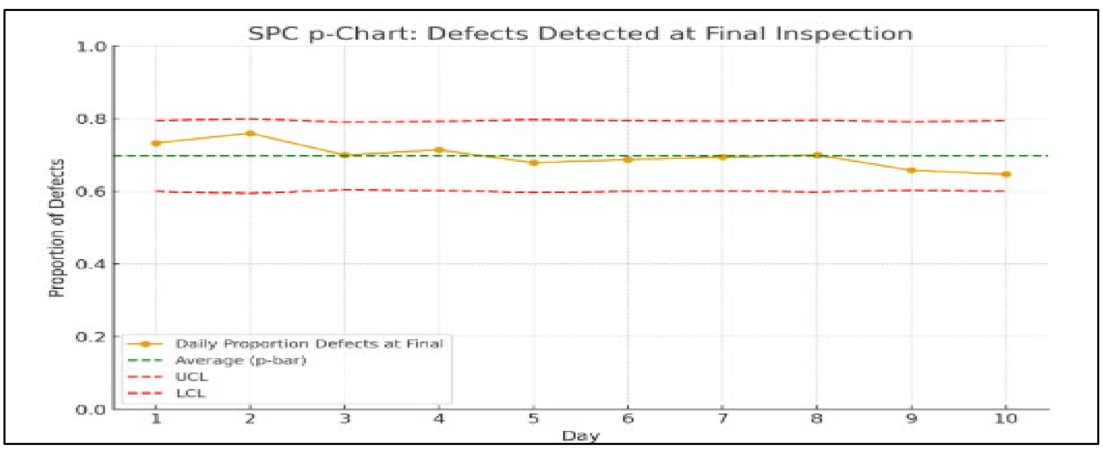

Figure 5. SPC p-Chart: Defected at final inspection

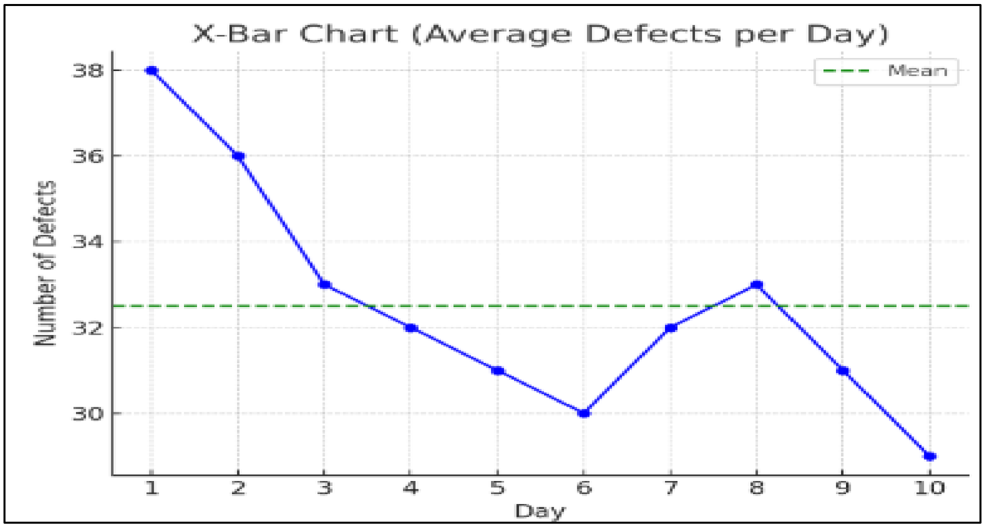

Figure 6. SPC: X-Bar-CHART: Average defects per day

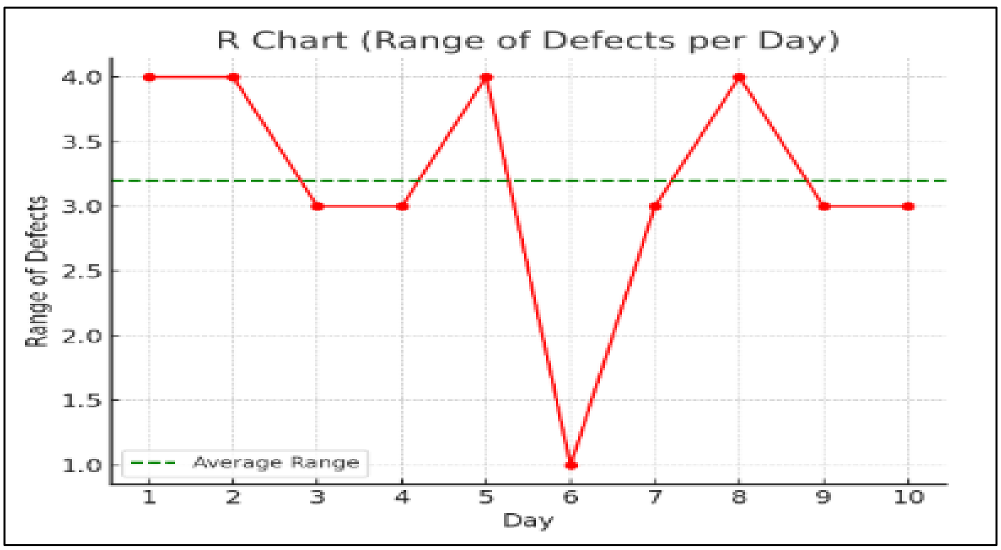

Figure 7. SPC: R Chart: Range of Defects per day

4.3 Interview Findings: Stakeholder Insights

To understand the practical challenges in supplier management, semi-structured interviews were conducted with 8 employees across procurement, quality, engineering and operations departments.
Thematic Findings and Diagnostic Insights

The first major theme that emerged is the lack of real-time visibility across XYZ's inbound supply chain. As one participant (P1) stated, "Once a PO is raised, we go blind. We usually wait for the shipping notice and pray it is on time." Supplier updates are primarily shared via email or phone calls, without any automated integration into XYZ's ERP or procurement systems. There is currently no use of GPS or IoT-based tracking for in-transit goods, leaving significant gaps in shipment visibility and delivery assurance (Tang and Veelenturf, 2019).

The second theme highlights a reactive approach to quality management. One quality team member (P2) noted, "Most quality problems are found during incoming inspection or even worse, during assembly." This points to a breakdown in early detection and proactive supplier engagement. Suppliers do not share inspection or testing data in real time, and XYZ's Incoming Quality Control (IQC) processes are overburdened, resulting in delays and production bottlenecks.

A third theme is the disconnection between XYZ's internal systems and supplier technologies. Despite having an ERP system in place, suppliers are not connected to it. As one respondent (P5) remarked, "We use ERP, but suppliers are not plugged into it. Even the good ones send updates manually." There is no shared portal or collaborative dashboard in place, and the use of AI or advanced analytics to predict supplier performance trends is minimal.

The fourth theme focuses on supplier training and capability gaps, especially concerning compliance with aerospace standards. A participant from procurement (P3) explained, "Some suppliers don't understand our aerospace standards, especially ECSS and ESD protocols." Many local suppliers operate outside of ECSS compliance and lack proper traceable documentation for quality. Supplier audits have also revealed low levels of digital maturity, particularly among smaller partners.

These themes, supported by both interview data and performance analysis, reveal three core diagnostic challenges. First is limited digital integration and monitoring. The organisation lacks a centralized platform to provide end-to-end visibility of supplier status, delivery progress, or quality metrics. The absence of IoT sensors, live dashboards, or system integration makes it difficult to detect issues early or intervene proactively.

Second, quality control remains fragmented and largely manual, relying heavily on post-delivery inspections. This reactive approach causes delays in fault detection and exposes production to significant risks. Advanced tools such as blockchain for tamper-proof traceability of component handling and quality checks are currently not implemented.

Third, there is a lack of predictive and prescriptive decision-support tools. While the organisation collects historical data on supplier performance, this information is not processed through AI-driven models that could anticipate late deliveries or defect trends. As a result, the organization remains stuck in a reactive mode, unable to shift toward preventive supplier management (Waller and Fawcett, 2013).

4.4 Implications for the Proposed Framework

The findings confirm that XYZ's current supplier systems are insufficiently integrated and fall short of the standards required in modern digital supply chains. The proposed 4IR-enabled framework should address these gaps by enabling real-time tracking of all inbound supplies using IoT technologies, incorporating predictive analytics to forecast performance and risks, deploying blockchain for secure and transparent traceability of quality records, and establishing cloud-based platforms to enhance supplier collaboration and real-time KPI monitoring. This framework aims to build resilience, agility, and accountability within XYZ's supply chain while aligning with best practices in digital transformation and industrial engineering.

5. Recommendation

Building upon the diagnostic insights presented in the previous chapter, this section introduces a Fourth Industrial Revolution (4IR)-enabled framework designed to enhance supplier performance and quality assurance at Aerospace company. The proposed framework addresses critical challenges identified through data analysis and stakeholder interviews—namely, delivery delays, inconsistent quality, limited traceability, and fragmented communication. It integrates advanced digital technologies including the Internet of Things (IoT), Artificial Intelligence (AI), blockchain, and cloud computing to enable real-time data visibility, predictive analytics, and secure, collaborative supplier engagement (World Economic Forum, 2023).

The framework is guided by five core objectives. Firstly, it seeks to establish real-time visibility of supplier activities and shipment status, allowing early detection of delays or non-compliant conditions. Second, it aims to facilitate predictive quality monitoring by leveraging both live sensor data and historical supplier records. Third, the framework improves traceability and accountability in component handling and certification through immutable blockchain records. Fourth, it provides cloud-based platforms for seamless collaboration between internal departments and suppliers. Lastly, it is designed to integrate efficiently with XYZ's existing ERP infrastructure, ensuring continuity of operations and reducing implementation barriers (Unisa,2022).

Structurally, the framework is conceptualized as a modular, four-layer architecture, with each layer fulfilling distinct roles enabled by specific technologies. The foundational layer is the IoT system, responsible for capturing real-time data from physical environments. This includes GPS and RFID tracking of shipments, as well as environmental sensors that monitor critical conditions such as temperature, humidity, and shock exposure. This data supports early warnings of non-compliant packaging, electrostatic discharge (ESD) risks, or delays during transit (Zhang etal., 2022).

The second layer is powered by AI and focuses on predictive analytics and risk modelling. Machine learning algorithms analyze both real-time sensor data and historical supplier performance to identify patterns that may signal potential disruptions or defects. These insights support risk-based supplier segmentation and allow the organisation to shift from reactive to proactive quality management. AI tools also assist in forecasting lead time variability, enabling better production planning and resource allocation (Dhlamini and Mofokeng, 2022). The blockchain layer ensures transparency and data integrity across the supply chain. Smart contracts and distributed ledgers are used to document inspection results, audit outcomes, and component handover events in a tamper-proof manner. This strengthens supplier accountability and simplifies regulatory compliance by automating verification processes and providing an immutable audit trail that aligns with global aerospace standards.

The final layer is the cloud-based collaboration platform, which centralizes supplier data and facilitates real-time interaction between stakeholders. This platform offers live dashboards for tracking shipments and supplier performance, integrated document-sharing capabilities, KPI alerts, and seamless connectivity with XYZ's ERP system. Cloud infrastructure supports remote access, scalable deployment, and synchronized decision-making across procurement, engineering, and quality assurance teams (Fernandez-Carames and Fraga-Lamas, 2024).

To demonstrate the framework's practicality, several operational use cases are explored. In one example, a critical torque rod shipment is monitored using IoT and GPS sensors. When a delay is detected at a customs checkpoint, AI calculates the risk of late delivery based on historical trends. A smart contract flags the issue, triggering an alert on the ERP dashboard and prompting procurement to engage a backup supplier. Another use case involves sensors detecting humidity spikes in transit, prompting AI to flag the shipment as potentially compromised. The system alerts the quality team before the batch arrives, allowing for prioritization of incoming inspections. A third scenario illustrates long-term supplier performance monitoring, where AI detects rising defect rates and lead time variability. Corrective actions are initiated through smart contracts, and the supplier receives performance feedback via the cloud platform.

Implementation of the framework is structured in four strategic phases. The first phase involves conducting a digital readiness assessment of suppliers and internal systems, identifying gaps in connectivity, data formats, and training needs. The second phase launches a pilot program using IoT and dashboard tools with selected high-impact suppliers. During the third phase, blockchain and AI systems are integrated into existing ERP modules, and machine learning models are trained on supplier datasets. The final phase involves full-scale rollout, with change management, cross-functional training, and continuous improvement mechanisms embedded throughout the organization (Mtetwa and Khumalo, 2023: Naicker and Pillay, 2023).

Expected benefits of the framework are both quantitative and qualitative. On-time delivery is projected to improve from 78% to over 90%, while the supplier defect rate is expected to drop from 5.2% to below 3%. Risk response times could be reduced from 2–3 days to under 12 hours, and lead time variability narrowed from ±7 days to ±2 days. In terms of compliance, manual audit processes will be replaced by real-time blockchain verification. Additionally, intangible benefits include improved supplier trust, stronger cross-departmental collaboration, and better alignment with industry regulations and customer expectations.

Despite these advantages, implementation may face risks such as supplier digital immaturity, ERP integration challenges, cybersecurity threats, and resistance from internal or external stakeholders. A mitigation strategy is outlined to address each risk. This includes conducting readiness audits, deploying modular middleware solutions, enforcing strong cybersecurity protocols, initiating low-cost pilot projects, and managing change through structured training and feedback loops.

In conclusion, the proposed framework offers a practical, scalable, and technology-driven solution to Aerospace company' supplier quality and delivery issues. By leveraging 4IR technologies in a layered and integrated manner, the framework transforms supply chain operations into a predictive, transparent, and collaborative ecosystem. Its phased implementation approach and alignment with existing systems make it feasible for adoption in high-reliability aerospace environments. The next chapter will evaluate the framework's effectiveness through expert validation, scenario testing, and alignment with industry benchmarks.

6. Conclusion

This research study explored the application of Fourth Industrial Revolution (4IR) technologies in improving supplier performance in the aerospace manufacturing sector in South Africa. The outcomes reveal that technologies integration like as block chain, AI, blockchain, and cloud platforms into supplier management processes can substantially enhance predictability, traceability, and visibility. These technologies implementation demands an adequate framework, stakeholder engagement, and organizational readiness. The study emphasises on the needs for collaboration, trust, and a readiness to learn in bringing systems to life. Aerospace company's internal readiness and the potential for pilot programs, feedback loops, and shared wins provide a foundation for successful implementation.

The research recommends that South African manufacturing companies can leverage 4IR technologies for competitiveness enhancement and resilience in global supply chains. The research outcome is applicable for organizations seeking for supplier performance improvement and quality assurance in high-reliability sectors. The study offers a tailored framework for the company and similar organizations to improve supplier quality and delivery reliability. It also highlights critical success factors for 4IR technology implementation in South African manufacturing SMEs.

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Biographies

Kem Ramdass has worked as a work-study officer, industrial engineer, production/operations manager and skills development facilitator in the clothing, electronics, and textile industries between 1981 and 1999. He joined the academic profession in 1999 as a lecturer with Technikon South Africa. He later moved to UNISA'S Department of Business Management in 2006 lecturing in operations management. He is currently in the Department of Industrial Engineering based at Unisa, Florida Campus. He started studying in 1985 and achieved the NATIONAL DIPLOMA IN ORGANIZATION AND WORKSTUDY on 1990, a HIGHER DIPLOMA in Production Management in 1992, THE BTECH QUALITY in 2000, MTECH in 2003 and PhD in 2009 with all qualifications being done part-time while employed and with a family. Prof Ramdass has simultaneously improved his academic stature from lecturer to Full Professor at age 60. He is a process, performance and operations specialist with a driving passion for improving optimizing processes in all aspects of production, quality and competitiveness. He has authored and presented approximately 65 journal and conference papers both nationally and internationally and is a peer reviewer for numerous publications. He has achieved Fellow member status at SAIIE and is a member of PICMET and IEEE and received the President's award in 2021, IEOM best conference contributor in 2024 and Risk Champion award in 2024. He is a team member of the Identification of Engineering Work (IDOEW) at the Engineering Council of South Africa and appointed on Council at Orbit College. He currently is heading numerous projects in quality management at different levels of the University of South Africa while responsible for modules in Industrial Engineering. He has just been appointed as member of Council for the Engineering Council of South Africa by the Minister of Public Works. In addition, he is now appointed as a member of the FAEO (Federation of African Engineering Organizations) - External Relations committee.

Dr. Temitayo Mufutau Azeez worked as a Production Manager at Betta Glass (Subsidiary of Frigoglass Group) before joining academia in 2013. He holds a bachelor's degree in mechanical engineering (Second Class Upper Division) from Ladoke Akintola University, Ogbomoso, Nigeria (2007), a master's degree in design and production engineering from the University of Lagos, Akoka Yaba, Nigeria (2011), and a Ph.D in Industrial and Production Engineering from Ladoke Akintola University, Ogbomoso, Nigeria (2011).He joined Afe Babalola University, Ado Ekiti, Nigeria as a Lecturer II in 2013, was promoted to Lecturer I in 2015, and Senior Lecturer in 2021. He is currently a Postdoctoral Research Fellow at the University of South Africa (UNISA), Department of Industrial Engineering and Engineering Management (2025).Dr. Azeez is a prolific researcher with over 80 publications, including 64 Scopus-indexed articles and book chapters. He has supervised three MSc graduates and co-supervised two Ph.D students. His research interests include design simulation and numerical formulation of industrial processes. He is a corporate member of the Nigerian Society of Engineers and COREN, and serves as a reviewer for several high-ranking journals, including Elsevier, Springer, and Taylor & Francis. He is currently a Sectional Editor for the Nigerian Journal of Technology.Dr. Azeez has received recognition for his research contributions, including being ranked among the top 500 researchers in Nigeria by Scival in 2023/2024 and 2024/2025. He has also served in various capacities at Afe Babalola University, including as Assistant SIWES (Student Industrial Work Experience Scheme) Director (2022-2024) and member of the Laboratory Development Committee (2022).