In the Name of God, the Most Compassionate, the Most Merciful

ADCM-360: Airline Digital Core Modernization 360° Framework

A KPI-Governed and Leadership-Driven Method / Technical Report for Intelligent, Connected, Predictive, and Human-Governed Autonomous Airlines

SeyyedAbdolHojjat MoghadasNian
Tarbiat Modares University
email: S14110213@gmail.com

Abstract

Airlines increasingly compete through the maturity of their digital core, not only through fleet size, routes, pricing, and service quality. Yet many airline digital initiatives remain fragmented across enterprise resource planning, passenger service systems, departure control, maintenance and engineering, operational control, customer relationship management, finance, procurement, business intelligence, cloud platforms, and artificial intelligence pilots. ADCM-360 is a Design Science method and technical reference model for transforming fragmented legacy airline environments into intelligent, connected, predictive, and human-governed autonomous operating models. The model integrates seven layers: systems integration; data governance and intelligence; process modernization; AI and predictive operations; governance, risk, compliance and AI assurance; performance and value realization; and leadership, transformation, capability and adoption. Its core principle is Universal Core + Adaptive Execution: all airlines require the same modernization logic, but the implementation pathway must be calibrated to airline type, fleet complexity, digital maturity, budget, regulatory environment, vendor dependency, workforce capability, and strategic priorities. The method does not claim completed empirical validation. Instead, it provides a structured artifact, KPI architecture, maturity trajectory, pilot-to-production governance logic, and validation protocol for expert review, case-based demonstration, maturity assessment, and future empirical testing.
Keywords: Airline digital transformation; airline digital core; aviation artificial intelligence; data governance; KPI governance; enterprise architecture; predictive operations; AI governance; Design Science Research; human-governed autonomy.

1 Input Diagnosis and Safe Claim Boundary

The artifact is a conceptual Design Science method rather than a completed empirical validation study, following established design science research logic for artifact construction, evaluation planning, and scholarly positioning (Gregor & Hevner, 2013; Hevner et al., 2004; Peffers et al., 2007). The available evidence consists of the author's ADCM-360 draft manuscripts, the conference formatting guideline, a legacy-airline problem context covering ERP, data governance, BI, KPI governance and AI readiness gaps, and a reference-support file containing literature-search outputs. Safe claims are therefore design, integration, operationalization, maturity, and validation-protocol claims. The report must not claim statistical effects, completed Delphi validation, causal performance improvement, or universal implementation success until such evidence is collected.

2 Problem Statement

The central problem is not the absence of technology in airlines. The literature and industry discourse show that airline digital transformation increasingly depends on digital infrastructure, integrated data, modern retailing, and business-model adaptation, yet these streams often remain fragmented across technical and organizational domains (Daft & Albers, 2013; Heiets et al., 2022; International Air Transport Association [IATA], 2021, 2022, n.d.; Taneja, 2017, 2019). This concern is also consistent with the author's prior airline digital transformation research, which treated AI, data-driven strategy, and KPI governance as connected rather than isolated modernization domains (MoghadasNian, 2025a; MoghadasNian & Manafi, 2024). The problem is the absence of a KPI-governed, leadership-driven, cross-functional, and airline-specific digital core modernization method capable of connecting digital architecture to measurable operational, financial, customer, safety, cyber-resilience, and AI value. In traditional airlines, ERP and reporting tools may exist, but data ownership, master data control, process rules, workflow governance, KPI accountability, BI reliability, and AI readiness often remain immature. Without a governed digital core, modernization becomes a set of disconnected technology projects rather than an operating-model transformation.

3 Core Definition

ADCM-360 is an enterprise-wide, KPI-governed and leadership-driven airline digital modernization method, aligned with aviation enterprise-architecture thinking, API-based integration, and airline re-platforming logic (Higginbotham, 2021; Sultanow et al., 2016; Taneja, 2019), that integrates systems, data, processes, artificial intelligence, governance, performance, and transformation capability to enable intelligent, connected, predictive, and human-governed autonomous airline operations.

4 Design Principles

- DP1 - Universal Core + Adaptive Execution: use one common modernization architecture, but calibrate implementation intensity and sequence to airline context, because airline business models and operating configurations differ significantly (Daft & Albers, 2013; Taneja, 2017).
- DP2 - Architecture before automation: connect ERP, PSS, DCS, MRO, OCC, CRM, finance, procurement and BI before scaling advanced AI, using aviation reference-architecture and API-design principles where appropriate (Higginbotham, 2021; Sultanow et al., 2016; Taneja, 2019).
- DP3 - Governed data before AI: require data ownership, master data, data quality rules, lineage, and certified datasets before AI production, consistent with digital airline and AI-risk-management requirements (IATA, 2021; National Institute of Standards and Technology [NIST], 2023).

- DP4 - Process before digitization: redesign and simplify workflows before automating inefficiency, because airline re-platforming and digital operating models require process transformation rather than tool deployment alone (Taneja, 2017, 2019).
- DP5 - Human-governed autonomy: keep decision rights, risk acceptance, and safety-critical accountability under explicit human governance, particularly for safety-sensitive and AI-enabled aviation use cases (European Union Aviation Safety Agency [EASA], 2023, 2024; NIST, 2024).
- DP6 - KPI value realization: link each digital investment to OTP, CASK, aircraft availability, AOG reduction, disruption recovery, customer value, revenue uplift, procurement efficiency, cyber resilience or digital ROI, using KPI-governance logic consistent with aerospace digitalization measurement and airline data-analytics performance work (Krol et al., 2020; MoghadasNian & Manafi, 2024).
- DP7 - Pilot-to-production discipline: move AI use cases through readiness, architecture fit, oversight, MLOps/LLMOps, value realization and scale/revise/retire gates, because enterprise AI value is increasingly associated with disciplined scaling rather than tool adoption alone (Boston Consulting Group, 2025; Maslej et al., 2025).
- DP8 - Assurance and auditability: treat cybersecurity, AI assurance, compliance, vendor governance and audit trail as operating-model requirements rather than late-stage controls (International Civil Aviation Organization [ICAO], 2019; International Organization for Standardization [ISO], 2023; NIST, 2023, 2024).

5 ADCM-360 Visual Architecture

Figure 1 shows the seven-layer architecture and the two cross-cutting control logics: leadership control and KPI governance.

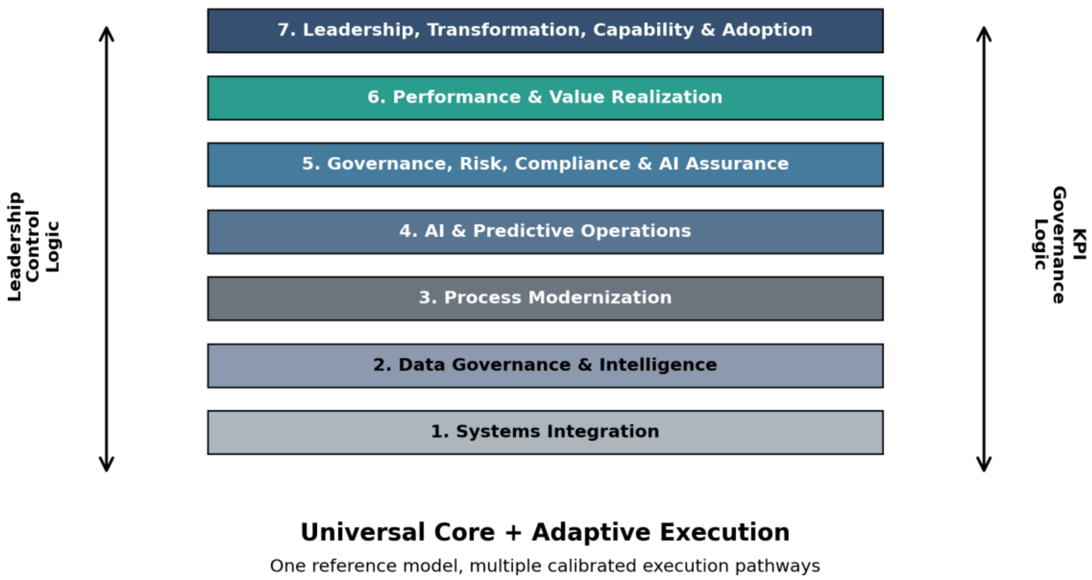

Figure 1. ADCM-360 conceptual architecture.

Figure 2 defines the maturity trajectory from fragmented legacy operations toward AI-assisted adaptive airline operations with governed autonomy.

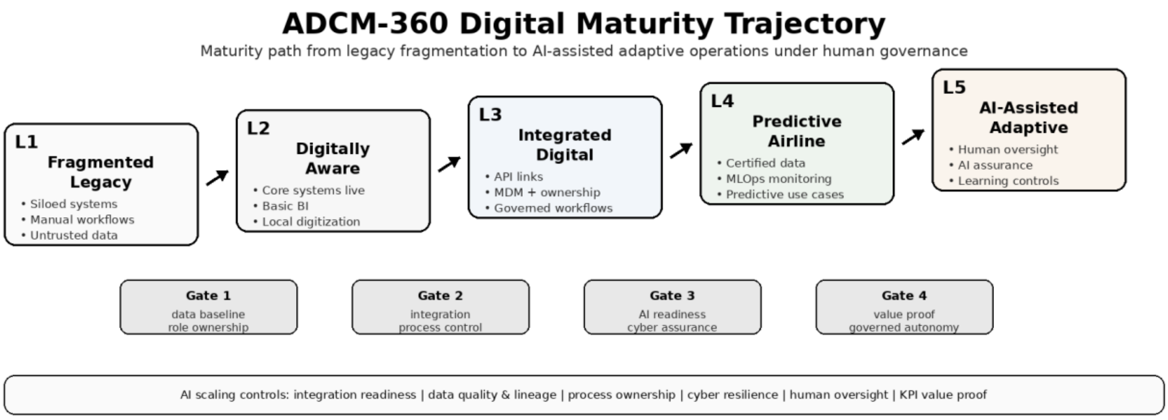

Figure 2. ADCM-360 digital maturity trajectory.

Figure 3. ADCM-360 Pilot-to-Production Governance Logic for Human-Governed AI Scaling

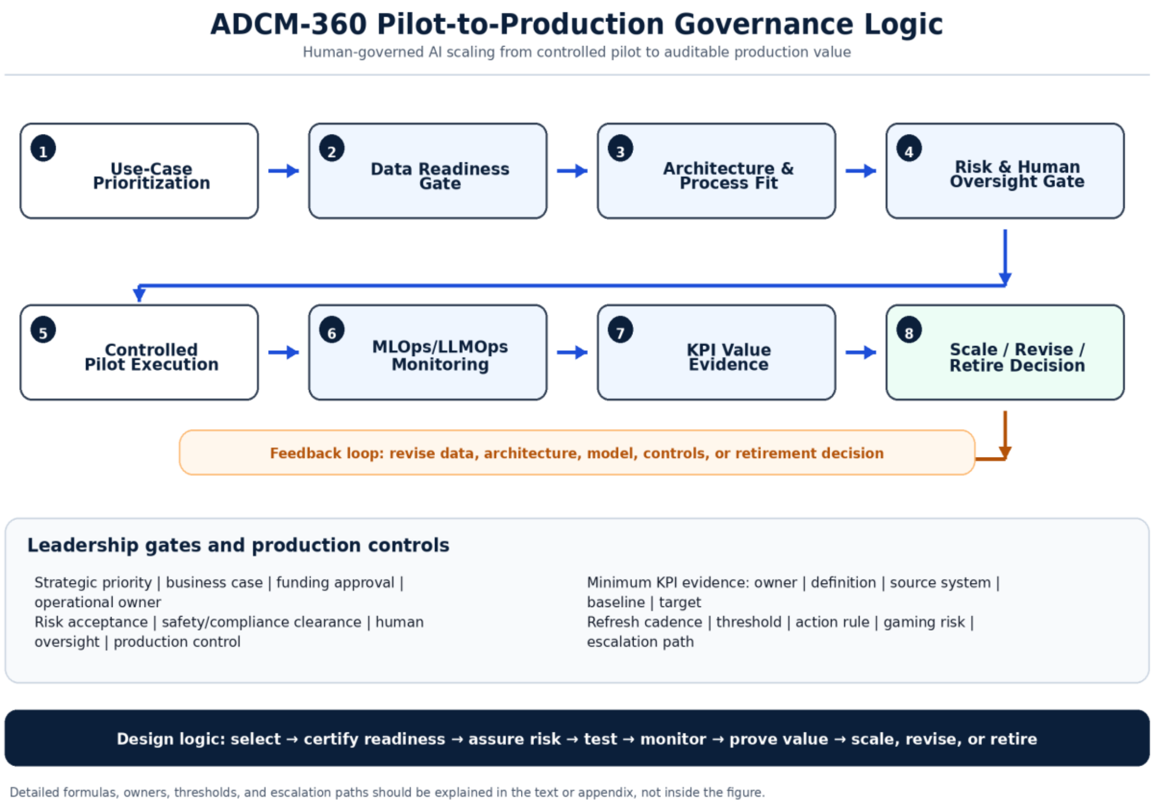

Figure 3. ADCM-360 pilot-to-production governance logic for human-governed AI scaling.

Figure 4 maps recurring legacy-airline digital and operating risks to the corresponding ADCM-360 control layers.

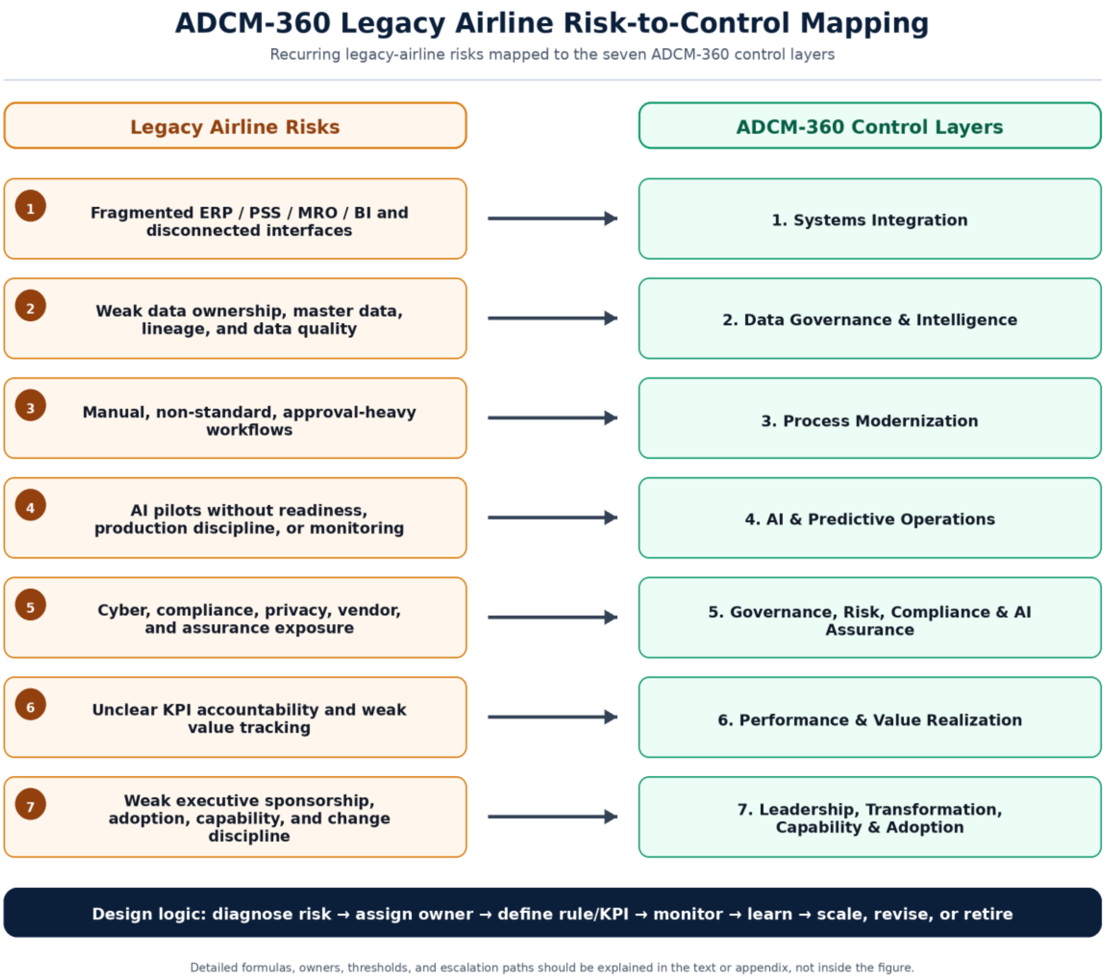

Figure 4. ADCM-360 legacy-airline risk-to-control mapping.

6 The Seven Layers of ADCM-360

6.1 Systems Integration Layer

Connects ERP, PSS, DCS, MRO/M&E, OCC, CRM, finance, procurement, BI, revenue management, crew, loyalty, cargo, AODB and relevant airport interfaces into an integrated architecture. This layer draws on aviation reference architecture, airline re-platforming, and API/microservice design logic (Higginbotham, 2021; Sultanow et al., 2016; Taneja, 2017, 2019). Key outputs include integration roadmap, API strategy, system ownership matrix, legacy map and rationalization plan. KPIs include API integration coverage, critical-system connectivity, interface failure rate and legacy retirement progress.

6.2 Data Governance and Intelligence Layer

Transforms fragmented airline data into trusted, governed and decision-ready intelligence. The layer is aligned with digital airline data strategy, AI risk management, and AI management-system requirements (IATA, 2021, 2022; ISO, 2023; NIST, 2023). Outputs include data owner matrix, data steward network, master data governance, data dictionary, business glossary, lineage map, data catalog, data SLA, data quality dashboard and certified enterprise datasets. KPIs include data quality score, master data compliance, lineage coverage, duplicate rate, invalid format rate and certified dataset coverage.

6.3 Process Modernization Layer

Redesigns airline processes before automation. This follows the re-platforming and design-science logic that the artifact must address business processes, decision rights, and operational routines rather than merely adding tools (Peffers et al., 2007; Taneja, 2017, 2019). Priority processes include procurement-to-pay, AOG response, maintenance planning, repair order management, contract approval, disruption management, crew recovery, refunds, customer complaints and route profitability review. Outputs include process maps, bottleneck analysis, workflow governance, approval matrix, exception rules and process KPI dashboards.

6.4 AI and Predictive Operations Layer

Moves the airline from descriptive reporting to predictive and prescriptive decision support. The layer is supported by aviation AI use-case literature, airline disruption-management research, and the author's prior predictive-maintenance and agentic-AI work (EASA, 2023, 2024; Geske et al., 2024; MoghadasNian, 2025b; MoghadasNian & Kashian, 2025; Pilon, 2023). Use cases include predictive maintenance, disruption prediction, crew recovery, spare-parts forecasting, supplier-risk prediction, dynamic pricing, demand forecasting, fraud detection and customer personalization. Outputs include AI use-case portfolio, value-feasibility matrix, model governance, human-in-the-loop rules, model monitoring dashboard and AI risk register.

6.5 Governance, Risk, Compliance and AI Assurance Layer

Ensures that modernization is safe, compliant, accountable, auditable and strategically governed. This layer is grounded in aviation cybersecurity, AI assurance, AI risk-management, and AI management-system references (EASA, 2023, 2024; ICAO, 2019; ISO, 2023; NIST, 2023, 2024). Outputs include steering committee charter, decision-rights map, cybersecurity dashboard, vendor governance model, data privacy controls, AI assurance controls, risk register and escalation rules.

6.6 Performance and Value Realization Layer

Converts digital modernization from system deployment into measurable value. The layer draws on aerospace digitalization KPI logic, airline data-analytics KPI work, enterprise AI value-realization evidence, and broader AI-adoption benchmarking (Boston Consulting Group, 2025; Krol et al., 2020; Maslej et al., 2025; MoghadasNian & Manafi, 2024). Outcomes include OTP improvement, CASK reduction, aircraft availability, AOG reduction, disruption recovery time, revenue uplift, customer value, procurement efficiency, cost avoidance, cyber resilience and digital ROI. The layer requires baseline, target, owner, cadence and action logic for each KPI.

6.7 Leadership, Transformation, Capability and Adoption Layer

Provides the executive control logic for adoption, capability building and cross-functional transformation. The emphasis on leadership reflects the evidence that AI and digital transformation value depend on governance, workflow redesign, talent, operating-model maturity, and disciplined scale-up rather than AI tools alone (Boston Consulting Group, 2025; Maslej et al., 2025; MoghadasNian & Kashian, 2025). Outputs include roadmap, governance cadence, capability model, training plan, adoption dashboard, change-risk register and transformation portfolio control. Leadership does not replace technical architecture; it governs it.

7 KPI Architecture

ADCM-360 uses a layered KPI architecture. This KPI logic builds on aerospace digitalization measurement, airline data-analytics KPI governance, and the author's prior KPI-driven airline performance work (Krol et al., 2020; MoghadasNian & Manafi, 2024). Each KPI must define owner, operational definition, calculation logic, source system, refresh cadence, threshold, action rule, gaming risk, and escalation path. KPIs are not decorative metrics; they are decision controls. Core KPI families include systems integration, data quality, process modernization, AI scaling, cyber resilience, value realization and adoption.

- Systems: API integration coverage, system availability, interface error rate, legacy retirement progress.
- Data: data quality score, completeness, validity, duplication rate, lineage coverage, master-data compliance.
- Process: cycle-time reduction, approval lead time, automation rate, exception resolution time, workflow compliance.
- AI: model accuracy, model drift, AI recommendation adoption, false positive rate, human override rate, production control pass rate.
- Cyber and assurance: MTTD, MTTR, incident containment time, access violation rate, vendor risk closure rate.
- Value: OTP improvement, CASK reduction, aircraft availability, AOG avoidance, schedule recovery time, revenue uplift, customer value and digital ROI.
- Transformation: training completion, adoption rate, roadmap delivery rate, capability maturity score and change-resistance index.

8 Application to Traditional Airlines

In a traditional airline, the model should not start with advanced AI. This sequencing is consistent with airline digital transformation literature, AI governance guidance, and the author's prior work on airline digital transformation, KPI-driven analytics, and predictive maintenance (EASA, 2023, 2024; Heiets et al., 2022; MoghadasNian, 2025a, 2025b; MoghadasNian & Manafi, 2024; NIST, 2023, 2024). It should start with an As-Is diagnostic covering ERP gaps, data quality, process mapping, KPI audit, dashboard trust, role clarity and AI readiness. The first execution wave should focus on business and data readiness: Data Owner and Data Steward appointment, master-data standardization, KPI dictionary, data dictionary, business rules, dashboard requirements and RACI. The second wave should enable ERP and technology:

data warehouse, API integration, workflow engine, rule engine, metadata repository, audit trail, RBAC, BI platform and AI platform. The third wave should scale AI only after readiness gates are satisfied.

9 Validation Protocol

The current ResearchGate version should be registered as a conceptual Design Science method and technical report. Empirical validation should be executed in future work through a four-stage protocol grounded in design-science evaluation logic: expert Delphi review, case-based demonstration in at least one airline or airline unit, KPI and maturity assessment, and longitudinal value tracking (Gregor & Hevner, 2013; Hevner et al., 2004; Peffers et al., 2007). The validation should test clarity, completeness, relevance, applicability, feasibility, risk controls, KPI measurability and implementation sequencing. Claims about performance improvement should only be made after operational data are collected.

10 Limitations

- The model is a reference architecture, not a vendor-specific implementation blueprint.
- The present version does not claim completed empirical validation.
- KPI thresholds must be calibrated to airline size, business model and data availability.
- Safety-critical and regulated use cases require additional aviation-specific assurance and compliance review.
- Legacy carriers with weak data quality may need a longer readiness phase before AI production.

11 ResearchGate Method Description

ADCM-360 v1.1 applies a Design Science and enterprise-governance methodology (Gregor & Hevner, 2013; Hevner et al., 2004; Peffers et al., 2007). It begins with the diagnosis of airline digital fragmentation, maps core systems and data domains, defines governance and ownership structures, redesigns processes, selects AI use cases through value-feasibility logic, connects KPIs to performance outcomes, and controls the movement from pilots to production through leadership gates, human oversight and MLOps/LLMOps monitoring. The method is designed for airline executives, CIOs, COOs, CFOs, MRO leaders, commercial leaders, procurement leaders, customer-experience leaders, safety managers, data leaders and transformation offices.

12 Contribution Statement

ADCM-360 contributes by (1) conceptualizing the airline digital core as a governed enterprise decision infrastructure, (2) integrating systems, data, process, AI, governance, performance and transformation capability into one artifact, (3) operationalizing digital transformation through KPI and maturity logic, and (4) providing a pilot-to-production governance mechanism for human-governed AI scaling in airline environments.

13 Relationship to Prior Author Works

The ADCM-360 method is positioned as a consolidation and extension of the author’s prior aviation-oriented research stream. Earlier work on digital transformation and AI in airline management established the need to align agility, innovation, and data-driven strategy (MoghadasNian, 2025a). Work on airline performance analytics and KPI governance developed the measurement logic that ADCM-360 now embeds at enterprise level (MoghadasNian & Manafi, 2024). Prior predictive-maintenance work informs the AI and predictive operations layer (MoghadasNian, 2025b), while the agentic-AI airline management study contributes the human-governed autonomy and KPI-controlled AI scaling logic (MoghadasNian & Kashian, 2025). These works are treated as conceptual lineage and research-program continuity, not as empirical validation of ADCM-360 itself.

14 Declarations

Funding: No external funding is declared for this method publication.

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Ethics and Data Availability: No human-subject or passenger-level data are analyzed in this version. Future empirical validation should follow applicable organizational permissions, privacy, confidentiality and data-governance requirements.

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References

Boston Consulting Group. (2025, September 30). Are you generating value from AI? The widening gap. Boston Consulting Group. https://www.bcg.com/publications/2025/are-you-generating-value-from-ai-the-widening-gap

Daft, J., & Albers, S. (2013). A conceptual framework for measuring airline business model convergence. Journal of Air Transport Management, 28, 47-54. https://doi.org/10.1016/j.jairtraman.2012.12.010

European Union Aviation Safety Agency. (2023). EASA Artificial Intelligence Roadmap 2.0: A human-centric approach to AI in aviation. https://www.easa.europa.eu/en/document-library/general-publications/easa-artificial-intelligence-roadmap-20

European Union Aviation Safety Agency. (2024). EASA Artificial Intelligence (AI) Concept Paper Issue 2: Guidance for Level 1 and Level 2 machine-learning applications. https://www.easa.europa.eu/en/document-library/general-publications/easa-artificial-intelligence-concept-paper-issue-2

Geske, A. M., Herold, D. M., & Kummer, S. (2024). Integrating AI support into a framework for collaborative decision-making (CDM) for airline disruption management. Journal of the Air Transport Research Society, 3, Article 100026. https://doi.org/10.1016/j.jatrs.2024.100026

Gregor, S., & Hevner, A. R. (2013). Positioning and presenting design science research for maximum impact. MIS Quarterly, 37(2), 337-355.

Heiets, I., La, J., Zhou, W., Xu, S., Wang, X., & Xu, Y. (2022). Digital transformation of airline industry. Research in Transportation Economics, 92, Article 101186. https://doi.org/10.1016/j.retrec.2022.101186

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. MIS Quarterly, 28(1), 75-105.

Higginbotham, J. (2021). Principles of web API design: Delivering value with APIs and microservices. Addison-Wesley Professional.
International Air Transport Association. (2021). Digital & Data Think Tank White Paper. https://www.iata.org/globalassets/iata/programs/innovation-hub/2021-ddtt-wp---final.pdf
International Air Transport Association. (2022). Digital Think Tank White Paper 2022. https://www.iata.org/contentassets/a46387f9bc6b42368c0a72664f6f930f/digital_think-tank_white-paper_2022.pdf
International Air Transport Association. (n.d.). Airline retailing: A world of Offers and Orders. Retrieved June 10, 2026, from https://www.iata.org/en/programs/airline-distribution/retailing/
International Civil Aviation Organization. (2019). Aviation Cybersecurity Strategy. https://www.icao.int/aviation-cybersecurity/strategy
International Organization for Standardization. (2023). ISO/IEC 42001:2023: Information technology - Artificial intelligence - Management system. https://www.iso.org/standard/42001
Krol, F., Saeed, M. A., & Kersten, W. (2020). A holistic digitalization KPI framework for the aerospace industry. In W. Kersten, T. Blecker, & C. M. Ringle (Eds.), Data Science and Innovation in Supply Chain Management: How Data Transforms the Value Chain. Hamburg International Conference of Logistics. https://www.econstor.eu/handle/10419/228940
Maslej, N., Fattorini, L., Perrault, R., Gil, Y., Parli, V., Kariuki, N., Capstick, E., Reuel, A., Brynjolfsson, E., Etchemendy, J., Ligett, K., Lyons, T., Manyika, J., Niebles, J. C., Shoham, Y., Wald, R., Walsh, T., Hamrah, A., Santarlasci, L., Betts Lotufo, J., & Shi, A. (2025). Artificial Intelligence Index Report 2025. Stanford Institute for Human-Centered Artificial Intelligence. https://hai.stanford.edu/ai-index
MoghadasNian, S. A. H. (2025a). *Digital transformation and AI in airline management: Aligning agility, innovation, and data-driven strategies*. SSRN. https://doi.org/10.2139/ssrn.6137987
MoghadasNian, S. A. H. (2025b). *AI-powered predictive maintenance in aviation operations*. SSRN. https://doi.org/10.2139/ssrn.6117408
Moghadasnian, S. A. H., & Kashian, H. (2025, August 1). *Agentic AI in Airline Management: A KPI-Governed Architecture for Trust-Based Autonomy, Strategic Co-Leadership, and Operational Excellence*. SSRN. https://doi.org/10.2139/ssrn.6033194
MoghadasNian, S. A. H., & Manafi, F. (2024, September 29). *Elevating airline performance with data analytics: A strategic guide to key performance indicators*. SSRN. https://doi.org/10.2139/ssrn.6236539
National Institute of Standards and Technology. (2023). Artificial Intelligence Risk Management Framework (AI RMF 1.0) (NIST AI 100-1). https://doi.org/10.6028/NIST.AI.100-1
National Institute of Standards and Technology. (2024). Artificial Intelligence Risk Management Framework: Generative Artificial Intelligence Profile (NIST AI 600-1). https://doi.org/10.6028/NIST.AI.600-1
Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. Journal of Management Information Systems, 24(3), 45-77. https://doi.org/10.2753/MIS0742-1222240302
Pilon, R. V. (2023). Artificial intelligence in commercial aviation: Use cases and emerging strategies. Routledge. https://doi.org/10.4324/9781003018810
Sultanow, E., Brockmann, C., Schroeder, K., & Breithaupt, C. (2016). Lufthansa aviation standard: Developing an Open Group reference architecture for the aviation industry. In H. C. Mayr & M. Pinzger (Eds.), INFORMATIK 2016, Lecture Notes in Informatics, 259, 825-836. Gesellschaft für Informatik.
Taneja, N. K. (2017). 21st century airlines: Connecting the dots. Routledge. https://doi.org/10.4324/9781315107028
Taneja, N. K. (2019). Re-platforming the airline business: To meet travelers' total mobility needs. Routledge. https://doi.org/10.4324/9780429429101