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Original Article

SkyStore: web-based aircraft spare-part inventory monitoring using rapid application development

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Abstract

Aircraft maintenance operations require accurate and traceable spare-part information, yet satellite-warehouse monitoring may remain dependent on spreadsheets even when an enterprise system is available. This study developed SkyStore, a web-based operational inventory application for a satellite warehouse at PT GMF AeroAsia Tbk. Requirements were identified through non-participant observation, a semi-structured interview with a warehouse supervisor, document review, and analysis of receiving, issuing, return-to-warehouse, in-transit, bin-location, and shelf-life processes. The application was developed through Rapid Application Development using Laravel and MySQL. SkyStore consolidates warehouse transactions, reference data, user permissions, dashboard summaries, import-export functions, and shelf-life notifications without replacing the corporate SAP platform. Functional evaluation covered 59 black-box scenarios across 15 modules, all of which produced the expected results. White-box basis-path evaluation covered 13 independent paths: three in login, five in incoming, and five in shelf-life processing, with cyclomatic complexity values of 3, 5, and 5. All tested paths conformed to the expected outcomes. The findings demonstrate functional and logic-path conformity, but do not establish improvements in processing time, inventory accuracy, or user acceptance because those outcomes were not measured.

Keywords: warehouse traceability, shelf-life control, dashboard analytics, Laravel, aviation maintenance

Introduction

Maintenance, repair, and overhaul operations depend on the availability, identity, and condition of the correct spare part. Digital traceability is increasingly used to connect part identity, movement history, and supply-chain records, including in aircraft-part contexts [1], [2]. Digital maintenance research also emphasizes the need for reliable operational data, while aircraft supply-chain and lean-maintenance studies show that material availability and information flow directly influence maintenance readiness [3]-[5].

Inventory management requires coordinated receiving, storage, movement, and control information [6]. RFID research has documented warehouse applications, benefits, implementation constraints, and integration requirements [7], [8]. More recent warehouse studies describe the role of Internet-of-Things technologies, real-time RFID monitoring, barcode-supported data capture, and warehouse management systems in improving visibility and supporting sustainable operations [9]-[12].

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PT GMF AeroAsia Tbk uses SAP as its corporate platform for logistics transactions. At the satellite-warehouse level, however, the observed staff still used spreadsheets as an additional operational layer for summaries, routine reporting, and consolidated monitoring. This arrangement created duplicate-entry risk, inconsistent local records, slower report preparation, and additional reconciliation work when spreadsheet data did not correspond with the physical material or corporate records. SkyStore was therefore positioned as an operational monitoring layer and not as a replacement for SAP.

Shelf-life control was especially important for materials with limited storage periods, particularly chemicals. Evidence from expiry-sensitive supply chains shows that weak monitoring can allow stock to remain unused until expiry or be treated as available after its valid period [13]. The observed warehouse therefore required date validation, remaining-life monitoring, status visibility, and notifications in addition to incoming and outgoing records.

Open-access inventory studies have implemented centralized recording, warehouse data collection, and Laravel-based stock applications [14]-[17]. Other studies have applied Rapid Application Development (RAD) to inventory and web information systems to support iterative prototyping and faster requirement refinement [18], [19]. These studies support the feasibility of web-based inventory development, but they do not combine aircraft-part traceability, return-to-warehouse records, in-transit monitoring, bin mapping, dashboard summaries, and shelf-life control in one satellite-MRO warehouse application.

This study aimed to design, implement, and functionally evaluate SkyStore using RAD, Laravel, and MySQL. The contribution is a centralized operational application that consolidates warehouse monitoring needs while retaining SAP as the corporate transaction source. Evaluation was limited to functional conformity and selected internal decision paths; productivity, before-and-after accuracy, and user acceptance were not measured.

Methods

Research setting and requirement elicitation

The research used a case-study approach in a satellite warehouse of PT GMF AeroAsia Tbk. Case-study guidance supports investigating a software artifact within its organizational and operational context while documenting the evidence and evaluation boundaries [20]. Data collection combined non-participant observation, a semi-structured interview, document review, and literature analysis. Observation covered receiving, issuing, putaway, return-to-warehouse, in-transit monitoring, spreadsheet entry points, routine reports, and shelf-life review.

A warehouse supervisor was selected purposively because the role oversees material movements and routine controls. The interview addressed mandatory transaction attributes, spreadsheet limitations, use of SAP, in-transit communication, shelf-life risks, and reporting requirements. The findings were translated into functional requirements and checked against the process descriptions and test evidence documented in the SkyStore thesis. Sensitive corporate transaction records were not reproduced.

Rapid application development and system design

SkyStore followed four RAD stages: requirements planning, user design, construction, and implementation. Requirements planning identified existing workflows and information gaps. User design translated the findings into process models, database relationships, and interface prototypes. Construction implemented the approved design with Laravel and MySQL. Implementation included data preparation, functional verification, and deployment-oriented configuration. This iterative pattern is consistent with open-access RAD implementations in inventory and web information systems [18], [19].

The database separated users and access control, incoming and outgoing movements, return-to-warehouse records, in-transit records, shelf-life data, bin locations, reference data, and notifications. Figure 1 summarizes the implemented information flow. Warehouse transactions and SAP exports enter the web application, are validated by the relevant modules, and are stored in the centralized operational database. Dashboard, filters, reports, and notifications use these stored records as their data source.

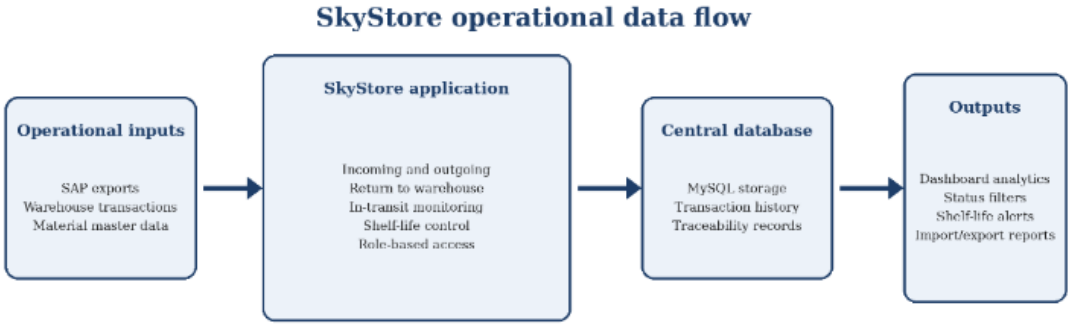

Figure 1. SkyStore operational data flow

Functional and structural evaluation

Black-box testing evaluated observable behavior for valid, invalid, and boundary-oriented inputs. White-box testing examined the internal decision structure of login, incoming validation, and shelf-life processing. Open-access testing research distinguishes these complementary perspectives and supports basis-path evaluation through control-flow and cyclomatic-complexity analysis [21]-[24]. Cyclomatic complexity was calculated as $V(G) = P + 1$, where P is the number of decision nodes.

The black-box scope comprised 59 scenarios across 15 modules: login, dashboard, incoming, outgoing, return to warehouse, shelf life, in-transit, bin location, notifications, users, roles, line and aircraft data, import, export, and logout. The white-box model contained 13 independent paths. Login had two decisions and $V(G) = 3$; incoming had four decisions and $V(G) = 5$; shelf life had four decisions and $V(G) = 5$. The shelf-life paths tested empty required fields, invalid date order, expired material, critical material, and active material, matching the thesis test evidence.

Results and Discussion

Implemented operational functions

SkyStore provides one web interface for the activities identified during requirement elicitation. Incoming records capture receipt and putaway information; outgoing records preserve issuing and delivery status; return-to-warehouse records store returned-material condition and destination; and in-transit records monitor incomplete movements. Supporting modules manage shelf life, bin locations, line and aircraft references, notifications, users, roles, and data exchange.

Table 1 groups the implemented modules into four areas. The scope shows that SkyStore is not only a stock-entry form: it combines logistics transactions, return handling, inventory monitoring, and administrative governance in one operational application.

Table 1. Functional scope of SkyStore

Area	Modules	Operational purpose
Logistics operations	Incoming, outgoing	Record receipts and issues, validate required data, and update transaction status.
Return handling	Return to warehouse	Record returned material, its condition, and its destination bin.
Inventory control	Shelf life, in-transit, bin location	Monitor movement status, storage position, and remaining storage life.
Administration and reporting	Dashboard, notifications, users, roles, line and aircraft, import/export	Summarize activity, control access, maintain reference data, and exchange reports.

Dashboard analytics and shelf-life monitoring

The dashboard consolidates date filters, transaction summaries, and activity indicators in one screen (Figure 2). Dashboards can make operational measures easier to review when they are selected and presented for a defined management purpose [25]. Warehouse digitalization and real-time supply-chain dashboard studies likewise emphasize integrated information and timely visualization rather than isolated spreadsheet summaries [26], [27]. In SkyStore, the dashboard visualizes stored operational records; it does not perform predictive forecasting.

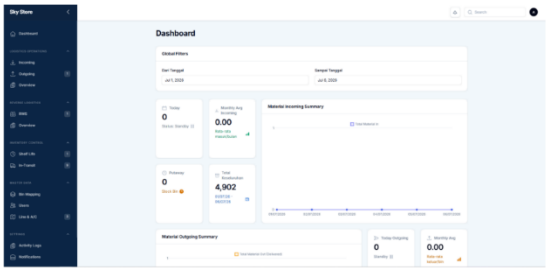

Figure 2. SkyStore dashboard analytics interface

The shelf-life module validates manufacturing and expiry dates, calculates remaining life, and supports material-status monitoring (Figure 3). In the thesis white-box model, valid non-expired and non-critical records follow one active path. Presentation labels used by the interface may further distinguish safe active materials for operational review, but they were not counted as additional independent paths. This distinction preserves consistency with the documented five-path shelf-life test.

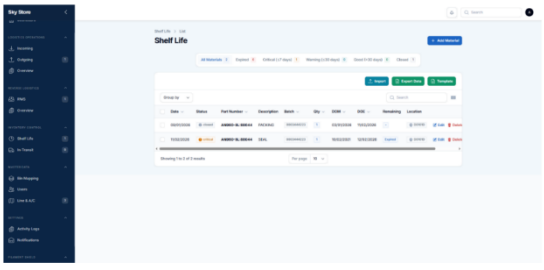

Figure 3. Shelf-life monitoring interface

Black-box and white-box results

All 59 black-box scenarios produced the expected result. Table 2 preserves the scenario totals recorded for the four test groups. The scenarios covered authentication, required-field validation, quantity and date validation, transaction processing, filtering, status updates, import validation, report export, role control, and access termination after logout.

Table 2. Summary of black-box testing

Test group	Included modules	Scenarios	Passed
Authentication and access	Login, users, roles, logout	13	13
Core inventory operations	Incoming, outgoing, return to warehouse, bin location, line and aircraft	22	22
Monitoring and information	Dashboard, shelf life, in-transit, notifications	16	16
Data exchange	Import and export	8	8
Total	15 modules	59	59

The white-box evaluation produced 13 independent execution paths, all of which matched the expected outcomes (Table 3). Login covered empty input, invalid credentials, and successful authentication. Incoming covered empty required fields, non-positive quantities, putaway without a bin location, valid putaway with a bin location, and a valid non-putaway transaction. Shelf life covered empty required fields, invalid date order, expired material, critical material, and active material.

Table 3. Summary of white-box basis-path testing

Process	Decision nodes	V(G)	Independent paths	Passed
Login	2	3	3	3
Incoming	4	5	5	5
Shelf life	4	5	5	5
Total	10	-	13	13

These results demonstrate conformity between implemented functions, specified outputs, and the selected internal paths. They do not demonstrate that SkyStore reduces processing time or improves inventory accuracy in live operations. Such conclusions require before-and-after measures, reconciliation audits, performance testing, and user evaluation.

Discussion

SkyStore adapts generic inventory-system concepts to the operational requirements of aircraft spare parts. The system retains common warehouse functions such as recording, status monitoring, and location control, while adding aircraft and line references, return-to-warehouse handling, in-transit monitoring, and shelf-life control. These elements respond to the traceability and maintenance-information needs identified in prior aircraft-part and digital-maintenance research [1]-[5].

The application also extends the centralized-recording and Laravel implementations reported in previous open-access studies [14]-[17]. Its contribution is not a new framework, but the integration of those technical components within a satellite MRO warehouse workflow. RAD supported repeated translation of observed activities into prototypes and functional modules [18], [19].

The testing evidence is internally consistent with the thesis after retaining 13 white-box paths: three for login, five for incoming, and five for shelf life. Separating user-interface labels from the five-path thesis test model prevents an unsupported increase in cyclomatic complexity. Nevertheless, future publications should link each requirement, code decision, and test case in a traceability matrix to avoid ambiguity when the interface evolves.

Limitations and Future Work

The study was limited to one satellite-warehouse context. SkyStore was not directly integrated with SAP; users prepare and import data through the application template. The evaluation did

not include user-acceptance testing, before-and-after productivity measurement, inventory-accuracy auditing, penetration testing, load testing, or long-term reliability assessment. Consequently, causal claims about efficiency, accuracy, and decision quality are outside the available evidence.

Future work should compare task time, reporting delay, and reconciliation errors before and after deployment; conduct structured user-acceptance testing; evaluate security and concurrent performance; and investigate authorized SAP integration. Mobile or handheld-scanner support may strengthen data capture at storage locations, while external messaging services may improve the delivery of shelf-life alerts.

Conclusion

This study developed SkyStore as a web-based operational inventory application for aircraft spare parts in a satellite warehouse of PT GMF AeroAsia Tbk. The system was produced through Rapid Application Development using Laravel and MySQL after requirements were identified through observation, a supervisor interview, document review, and analysis of warehouse activities. The implemented scope consolidates incoming and outgoing transactions, return-to-warehouse records, in-transit monitoring, bin locations, shelf-life information, notifications, dashboard summaries, users, roles, reference data, and import-export functions without replacing the corporate SAP platform. Functional evaluation covered 59 black-box scenarios across 15 modules, and all scenarios produced the expected results. White-box basis-path evaluation covered 13 independent paths: three in login, five in incoming, and five in shelf-life processing, with cyclomatic complexity values of 3, 5, and 5. The shelf-life paths consisted of empty required fields, invalid date order, expired material, critical material, and active material. These results establish conformity between the selected requirements, functions, and logic paths. The centralized interface also provides a coherent operational view of records that were previously reviewed through separate spreadsheets and transaction screens. Nevertheless, the evidence remains limited to implemented functionality and selected control paths. It does not establish measurable improvements in efficiency, inventory accuracy, reporting speed, or user acceptance because those outcomes were not evaluated. Future work should therefore conduct controlled operational comparisons, reconciliation audits, structured user-acceptance testing, security and concurrent-performance assessment, and authorized SAP integration. A requirement-to-test traceability matrix should also be maintained when status rules or interface categories are revised. Within these limitations, SkyStore provides a structured foundation for inventory traceability, warehouse monitoring, and shelf-life control in an aircraft-maintenance environment.

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