

Design of a Departure Message Automation System Using the Change Data Capture Method

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Abstract

Air Traffic Service (ATS) messages are crucial elements in providing flight information, both in the context of air navigation services and airline operations. One of the most important types of ATS messages is the departure message (DEP message), which must be delivered immediately after a flight departs. The ATS unit of the departure airport is responsible for sending the DEP message in accordance with the guidelines set out in ICAO Doc. 4444 on the handling of ATS messages. This research aims to develop a system design that automatically produces DEP message data as a mitigation step against issues that arise in the management of ATS messages, particularly DEP messages, when anomalies occur in the Air Traffic Control (ATC) automation system (ATCAS). The research method used is the research and development (R&D) method. Data collection was carried out using interview techniques and direct observation to observe the phenomena that occur and to find out the needs that will be used as the basis for product design. The result of this research is the design of an Automated Departure Message System that produces DEP messages automatically without having to be retyped by the on-duty officer. The system design can function well according to the need assessment of the users in this research. The urgency of this research is as a mitigation step against issues that arise in the management of ATS messages, particularly DEP messages. This research aims to create a system engine design that automatically produces DEP message data. The targeted output includes the system design and the publication of an article in a SINTA-indexed journal.

Keywords: *Departure Message, Automation System, ATCAS*

INTRODUCTION

Air transportation constitutes one of the most critical components of the modern transportation system, and research into the characteristics of flight traffic flow has therefore become increasingly significant. Traffic flow is generally defined as the number of aircraft crossing a specific point or route within a given period (Zhang et al. 2020), and the regulation of this flow forms an integral part of air navigation service provision, in which flight data and information serve as essential supporting variables.

Air Traffic Services (ATS) Messages represent one of the principal and safety-critical components in the delivery of flight information, both for air navigation service provision and for airline operational purposes. Among the various types of ATS Messages, the Departure Message (DEP message) is regarded as one of the most important, as it must be transmitted by the ATS unit of the departure aerodrome immediately after a flight becomes airborne. The DEP message conveys real-time confirmation that a flight has departed and is required to activate the corresponding flight plan within the Air Traffic Control (ATC) Automation System (ICAO 2008). It further serves as the primary reference for estimating flight duration and arrival time at the destination aerodrome, and functions as one of the key performance indicators of an ATS unit. Because of these functions, transmission of the DEP message by the departure ATS unit is mandatory, as stipulated in ICAO Document 4444 governing the handling of ATS Messages.

The exchange of flight plan information among stakeholders inevitably occurs through ATS/flight plan messages, and differing stakeholder requirements can affect interoperability between systems, particularly when two distinct systems attempt to exchange flight plan information through ATS Messages (Chisholm 2019). Given the substantial volume of flight data involved, accurate management and interpretation of this data are essential to prevent

aviation accidents and mitigate human-factor risks, since pilots and flight navigators rely on this information alongside safety, meteorological, and NOTAM messages (Yousefzadeh Aghdam et al. 2021). The continuous growth in air traffic volume has driven decades of development in aviation automation facilities aimed at enhancing air traffic controller (ATC) capability (Zakaria and Lye 2022; Wang et al. 2021), resulting in ATC Automation Systems that have undergone substantial functional advancement to support traffic-handling activities previously unavailable (Bestugin 2020).

Despite these advancements, field operations frequently reveal instances in which DEP messages are not transmitted by the existing ATC Automation System (Praptiningsih et al. 2024), preventing the required flight information from being processed and thereby disrupting air navigation service operations (Ferdula n.d.). The absence of a DEP message gives rise to several operational consequences: the destination aerodrome and other relevant parties lack timely initial information regarding a departed flight, and in some ATC Automation Systems the corresponding flight plan fails to activate automatically; automatic calculation of estimated flight time and arrival time cannot be performed; adjacent countries are unable to estimate and calculate traffic flow, since Air Traffic Flow Management (ATFM) systems depend on the DEP message as the initial reference for such calculations; and the air navigation charge billing process is hindered due to the absence of a required evidentiary variable.

Preliminary investigation identified that one of the underlying causes of undelivered DEP messages is the practice whereby, whenever a flight lacks an automatically generated DEP message, ATS Reporting Office (ARO) personnel must manually compose and transmit the message (Praptiningsih et al. 2024). This manual process introduces additional workload and increases the likelihood of transmission errors due to manual data entry. Consequently, an automated system capable of generating DEP messages is needed to support the transmission process and reduce the potential occurrence of missing DEP messages (Praptiningsih et al. 2024).

Based on the background outlined above, the present study addresses the following research problem: how can an automated departure message system be designed to support the DEP message transmission process? Accordingly, this study aims to design a Departure Message Automation System using the Change Data Capture (CDC) method—an approach that tracks data changes in real time through timestamped records (Suprayogi, Dachlan, and Aswin 2016)—as a continuation of previous research, with the objective of reducing the potential occurrence of missing DEP messages during the DEP message transmission process at the Jakarta Air Traffic Service Center.

RESEARCH METHODS

This study employed a Research and Development (R&D) approach, defined as a scientific method used to investigate, design, produce, and validate the feasibility of a resulting product (Sugiyono 2015). Following the four-level classification of R&D proposed by Sugiyono (2015), this study was conducted at Level 1, in which the research is limited to producing a product design and validating its feasibility, without proceeding to full-scale production or field implementation testing. The development procedure adopted the Waterfall model (Arikunto 2019), which requires several sequential stages: requirement analysis, system design, implementation, and verification and validation.

At the requirement analysis stage, data were collected through a purposive sampling technique to determine the needs underlying the system design. Data collection was carried out through unstructured interviews and observation involving four key informants selected for their expertise in ATC automation systems and flight data processing: the Manager of ATFM & ATS Systems, the Manager of Aeronautical Communication, an ATS System Specialist, and an

Aeronautical Communication Officer (ACO). Each interview session lasted approximately one hour.

During the system design stage, the researcher, assisted by two research aides, developed the system architecture over a six-day period, with eight hours of design work conducted per day. At the implementation stage, the resulting design was translated into program code—developed using JavaScript-based programming in conjunction with the Change Data Capture (CDC) method described in the theoretical review—and integrated into a complete system aligned with the identified requirements. It should be noted that, at this stage, the system was tested using representative sample data rather than real operational field data, as full field deployment testing fell outside the scope of this study.

The verification and validation stage involved testing the developed system to determine whether it functioned properly and met the previously agreed requirements. Three expert validators—the Manager of ATFM & ATS Systems, the Manager of Aeronautical Communication, and an ATS System Specialist—assessed the system and provided feedback on its strengths and limitations, each validation session lasting approximately two hours. Validation data were obtained through an expert questionnaire and analyzed using a rating-scale technique, in which the resulting percentage scores were categorized into four feasibility levels ranging from "not feasible" to "very feasible." A product was considered feasible for implementation, without requiring further revision, if it achieved a validation score above 75%.

RESULTS AND DISCUSSION

Following the ten-stage Research and Development model of Borg and Gall as cited in Sugiyono (2016)—covering potential and problem identification, data collection, product design, design validation, design revision, product trial, product validation, usage trial, product revision, and mass production—this study, due to time constraints and its stated objective, was limited to the design validation stage.

At the initial stage, a preliminary study was conducted using gap analysis (Sentoso and Ruseno 2021) to identify the discrepancy between the expected and actual capability of the existing ATC Automation System in producing departure messages, as summarized below.

Table 1. Preliminary study gap analysis

Aspect	Ideal Condition	Current Condition	Impact	Proposed Solution
ATC Automation System capability in managing flight data, particularly ATS messages (ICAO Preliminary Reference System/Subsystem Specification; Kementerian Perhubungan 2015)	Automatic and consistent production of departure messages as required by air navigation service users	The system produces departure messages automatically but inconsistently, due to underlying faults	Failure to deliver departure messages to related ATS units, disrupting downstream flight information processing and navigation operations	Development of a system that automatically produces departure messages

Building on this gap analysis, requirement data were gathered through unstructured interviews with four informants selected through purposive sampling for their expertise in ATC automation and flight data processing. The specificity and consistency of their responses were considered sufficient to establish the system requirements, consistent with the view that a small number of purposively selected experts can yield adequately detailed input (Timotic, Netjasov, and Cicevic 2020). The resulting operational requirements are summarized below.

Table 2. Operational requirements for the DEP message automation system

No.	Requirement
1	Capture data changes from the main data warehouse
2	Automatically produce departure messages from the captured data
3	Format the departure message according to the applicable document requirements
4	Display the departure message text on the application dashboard in real time
5	Allow the departure message text to be copied and pasted for manual transmission when needed

These requirements subsequently guided the product design stage. The system was built on a Change Data Capture (CDC) approach, an integration technique that identifies, captures, and transmits only the changes made at a data source, thereby improving integration efficiency and reducing latency compared to full data transfer (Barkaway 2009; Tank et al. 2010). A Pull-based CDC model was adopted, in which the ETL tool periodically requests updated data rather than receiving continuous pushes. Two dummy servers—modeled on the actual operational environment—were configured for this purpose: one functioning as the data source that captures changes from the ATC Automation System database, and the other functioning as the server responsible for automatically producing DEP message data from the captured changes.

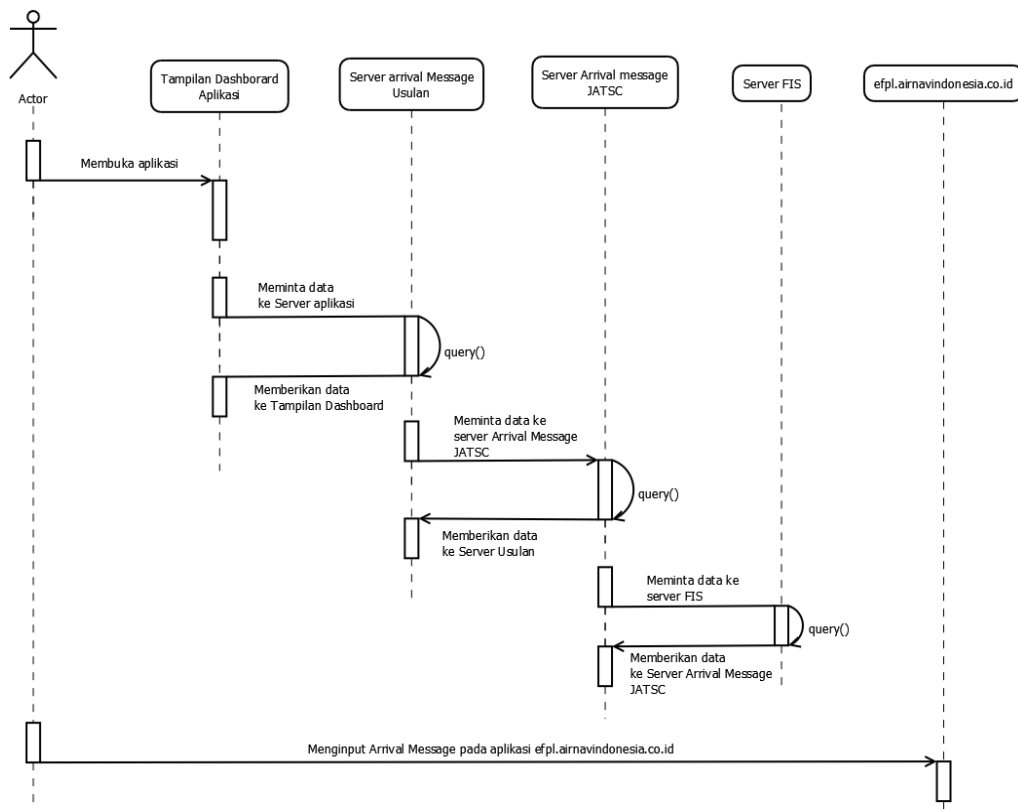


Figure 1. Sequence diagram of the DEP message automation system

The interaction flow illustrated in the sequence diagram shows that, upon opening the application, the user is presented with a dashboard displaying departure messages in real time. The dashboard communicates with the system server to request and receive this data, while the system server periodically retrieves updates from the JATSC ATC Automation System data warehouse, which in turn is fed by the main ATC Automation System server. In the event that a departure message fails to transmit automatically through the AFTN network, the user retains the option of copying the displayed message and submitting it manually through the efpl.airnavindonesia.co.id platform. This design reflects a deliberately preliminary interaction pattern that is expected to evolve as user feedback informs further development.

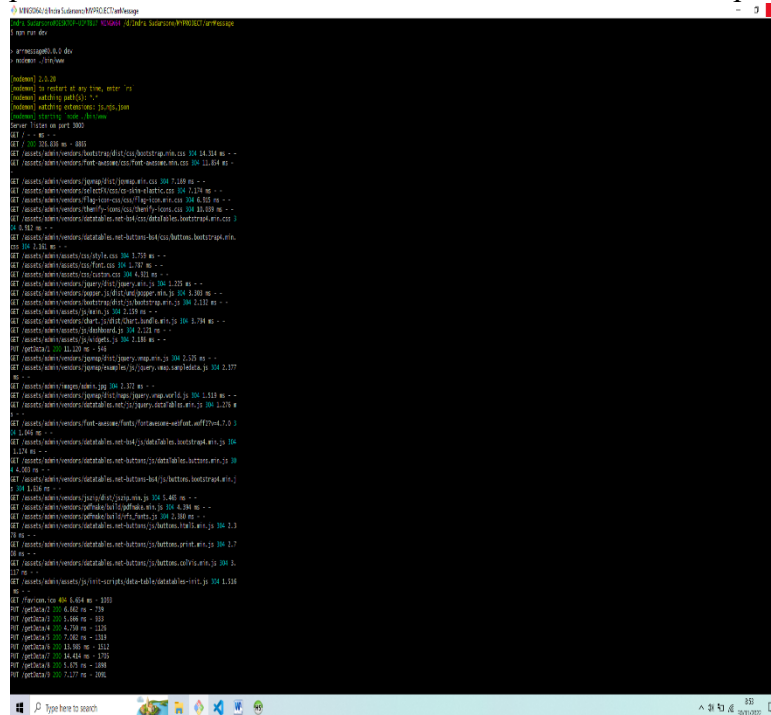


Figure 2. Dashboard text-display design for the departure message

During implementation, the data-capture process operated continuously, drawing changes from the main ATC Automation System data warehouse and relaying them to the dashboard display, and was designed to run uninterrupted except in the event of a system failure such as a power outage. Captured data were subsequently processed and stored in a relational database, from which departure messages were produced automatically in the required format through a dedicated script that converts stored data into departure message text (Dou 2020). The system was developed using JavaScript, chosen for its extensive global developer community and consequent ease of future maintenance, together with Prisma for database management and Visual Studio Code as the development environment to support debugging and error handling.

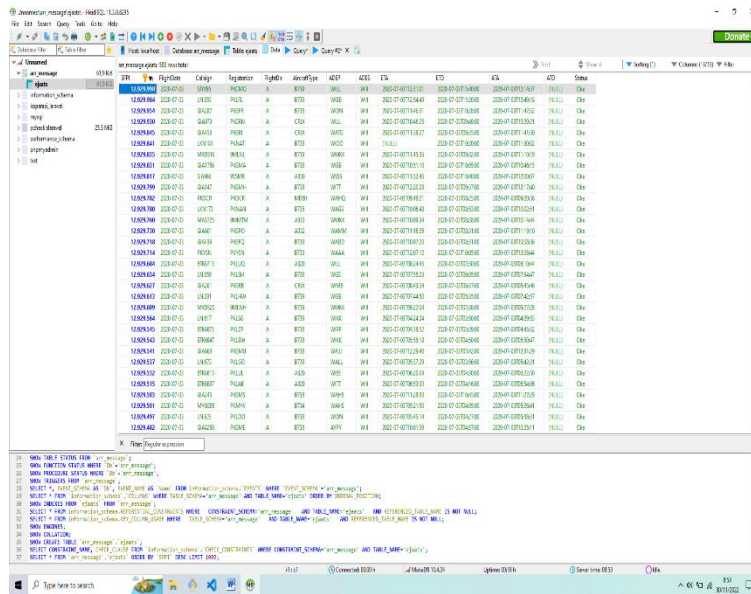


Figure 3. Database structure and automatically generated departure message output

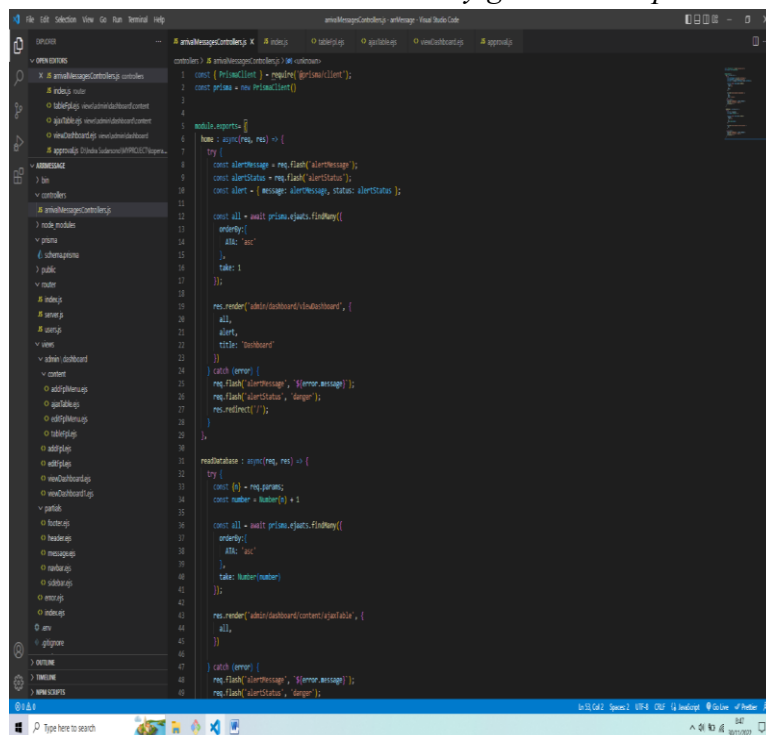


Figure 4. Source code excerpt of the DEP message automation

The resulting design was then evaluated at the design validation stage by three experts representing ATS service and ATFM operations, flight data processing, and air traffic control programming, as listed below.

Table 3. List of design validators and areas of expertise

Code	Validator	Area of Expertise
A	Manager, ATFM & ATS System	ATS service operation, ATFM operation
B	Manager, Aeronautical Communication	Flight data operational processing
C	ATS System Specialist	Flight data processing, air traffic control programming

Validation was carried out using a questionnaire covering five statements derived directly from the operational requirements identified earlier, addressing the system's capability to capture data changes, automatically generate departure messages, format them correctly, display them in real time, and support manual copy-paste transmission.

Table 4. Design validation instrument for the DEP message automation system

Dimension	Indicator	Statement
ATC Automation System capability (ICAO Preliminary Reference System/Subsystem Specification)	Data capture and departure message production	The system captures data changes required from the main data warehouse and encodes automatic departure message production from the captured data
ATS message operational management (ICAO Doc. 4444, 16th ed., 2016)	Departure message formatting and display	The system encodes correctly formatted departure messages, displays them in real time, and allows the text to be copied and pasted for manual transmission

Each validator rated all five statements at the highest point on the applied rating scale, and the resulting validation score fell within the highest feasibility band, indicating that the design was assessed as highly feasible and consistent with the previously established requirements at table below. Because the outcome already met the "highly feasible" threshold, no design revision was required, and the development process proceeded directly to product finalization.

Table 5. Product feasibility criteria based on validation percentage

Achievement Level	Category
76–100%	Highly feasible
51–75%	Feasible
26–50%	Less feasible
<25%	Not feasible

Overall, the design outcome supports the initial premise that automating departure message production can address the recurring failure of the existing ATC Automation System to transmit this message consistently. This finding aligns with earlier work emphasizing that reliable automation of ATS message handling is essential to safe and efficient air traffic management, whether through failure-effect evaluation of automation systems (Li et al. 2017), formal modeling of ATS message exchange between heterogeneous systems (Chisholm 2019), or platform-based organization of flight safety messages (Yousefzadeh Aghdam et al. 2021). The present design contributes a complementary, practically oriented solution by targeting the specific operational gap of missing departure messages through a CDC-based automation approach.

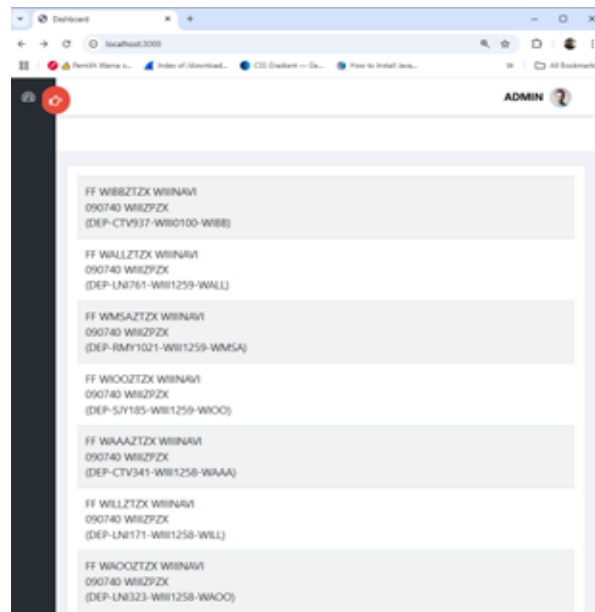


Figure 5. Final dashboard interface of the DEP message automation system

The study nonetheless has limitations. The data used to design and test the system were representative samples rather than real-time operational data, meaning the results may not fully capture the variability encountered in live conditions. In addition, budgetary constraints limited the resources available for accessing certain technologies or datasets, which may have influenced the scope of the design achieved.

CONCLUSION

This study demonstrates that an automated departure message system can be effectively designed using the Change Data Capture (CDC) method, grounded in operational requirements identified through in-depth consultation with relevant subject-matter experts. The resulting design enables the automatic production of departure messages directly from data captured within the flight data warehouse, allowing on-duty Aeronautical Communication Officers to retrieve and transmit the message manually through a simple copy-and-paste action whenever automatic delivery through the ATC Automation System fails, thereby eliminating the need to retype the message from scratch. The design was found to align closely with the operational needs established at the outset of the study and was assessed by expert validators as highly feasible for implementation, confirming that a CDC-based automation approach offers a practical and reliable solution to the recurring problem of undelivered departure messages in air navigation service operations.

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